European Commission

JRC in Euratom Research and Training Programme 2014-2020

Joint Research Centre

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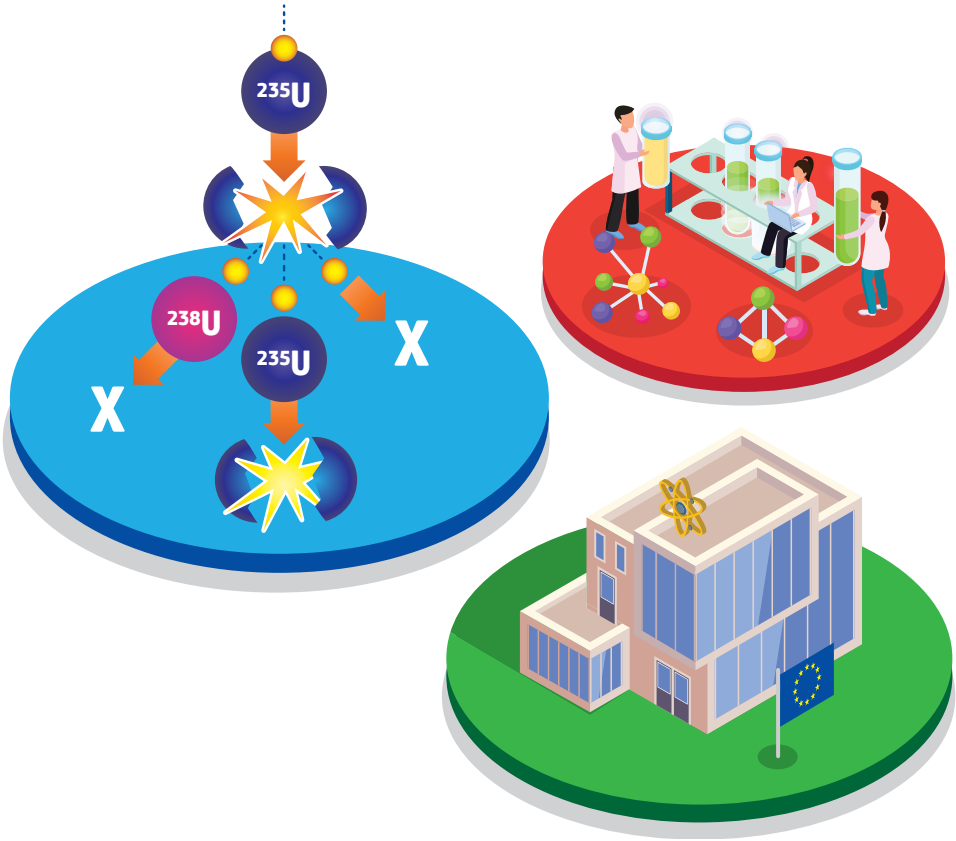


Abstract

The Euratom Research and Training Programme 2014-2018 and its extension 2019-2020 (the Euratom Programme) is implemented, in fission, through direct actions– i.e. research performed by the Commission's Joint Research Centre (JRC), and through indirect actions– i.e. via competitive calls for proposals, and in fusion – i.e. through a comprehensive named-beneficiary co-fund action managed by the Commission's Directorate-General for Research & Innovation (RTD).

> The general objective of the Programme is
> "to pursue nuclear research and training activities with an emphasis
> on the continuous improvement of nuclear safety, security and radiation protection,
> in particular to potentially contribute to the long-term decarbonisation
> of the energy system in a safe, efficient and secure way."

The Programme is an integral part of Horizon 2020, the EU Framework Programme for Research and Innovation. The direct actions implemented by the JRC pursue specific objectives covering: nuclear safety, radioactive waste management, decommissioning, emergency preparedness; nuclear security, safeguards and non-proliferation; standardisation; knowledge management; education and training; and support to the policy of the Union on these fields.

The JRC multi-annual work programme for nuclear activities allocates about **48%** of its resources to nuclear safety, waste management, decommissioning and emergency preparedness, **33%** to nuclear security, safeguards and non-proliferation, **12%** to reference standards, nuclear science and non-energy applications and **7%** to education, training and knowledge management.

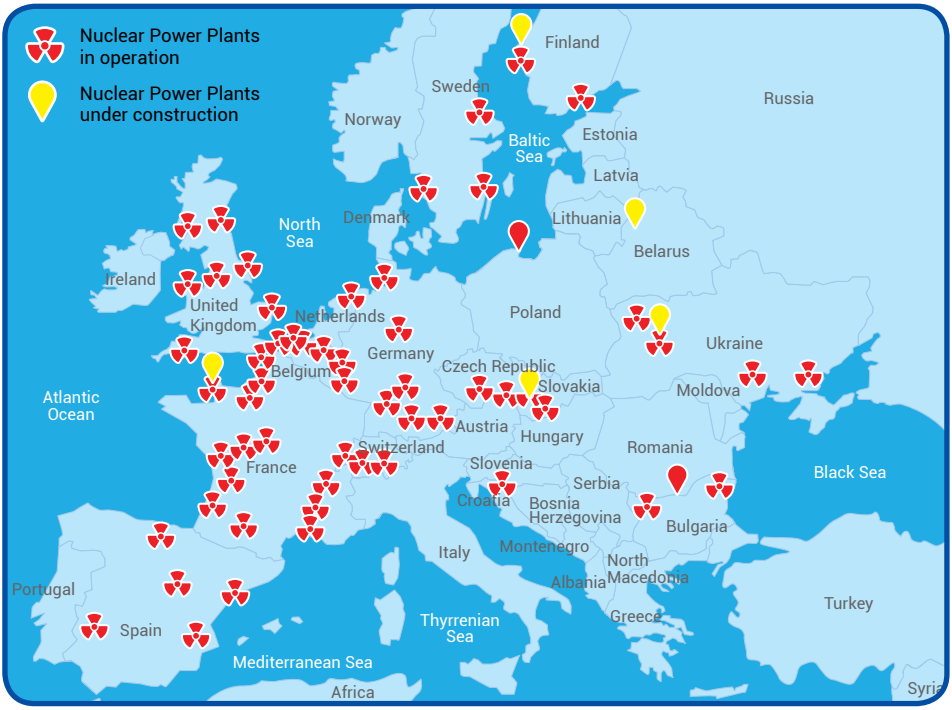
To ensure that direct actions are in line with and complement the research and training needs of Member States, JRC is continuously interacting with the main research and scientific institutions in the EU, and actively participating in several technological platforms and associations.
JRC also participates as part of the consortia in indirect actions, which allows JRC scientist to engage in top level scientific research, and yields maintaining and further developing JRC's scientific excellence. At the same time, the members of the consortia can have access to unique research infrastructure. New models of JRC participation in indirect actions are explored to increase the synergies obtained in the frame of the Euratom programme.
The document describes some of the achievements of recent JRC direct actions, with a focus on the interaction with EU MS research organisations, as well as some of the most important elements of the Commission Proposal for the next (2021-2025) Euratom Programme, particularly the new positioning of the JRC as regards its participation in indirect actions.

1. Introduction

Currently, thirteen Member States and UK, operate around 130 nuclear power reactors to generate over 25% of all electricity consumed in the EU, contributing to competitiveness, security of energy supply and limitation of CO2 emissions as part of the European Union energy and climate policy objectives. Regardless of the individual decisions on continuing, phasing out or embarking in new built nuclear power plants, nuclear energy will continue to be part of the energy mix in the European Union for the next decades. Indeed, in recent Communications on the Energy Union and on the European long-term vision for a prosperous, modern competitive and climate neutral economy, the European Commission recognises nuclear energy as an important player to achieve, together with renewable sources, a carbon-free European energy system.
Worldwide, about 450 nuclear power plants are in operation and around 50 more are under construction; several of them in EU neighbouring countries.

To ensure the highest levels of nuclear safety and security, the European Union needs to be at the forefront, not only in the development and implementation of the most advanced legislation, with the Euratom Directives[1,2,3,4,5] but also promoting nuclear research and training. Indeed, nuclear research and training is a key factor to help the European Union maintain the scientific and technological leadership in nuclear technologies, also in non-power applications.

The Euratom Treaty[6] establishes that the Commission is responsible for promoting and facilitating nuclear research in the Member States and for complementing it by carrying out a Community research and training programme. These programmes are proposed by the European Commission, and are discussed and adopted by unanimity in the Council.



Nuclear power plants operating and under construction on the EU

2. The EURATOM Research and Training Programme

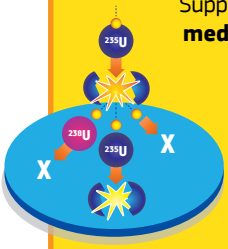
The overall objective of the Euratom Research and Training Programme 2014-2018 and its extension 2019-2020 (the Euratom Programme) is "to pursue nuclear research and training activities with an emphasis on the continuous improvement of nuclear safety, security and radiation protection, in particular to potentially contribute to the long-term decarbonisation of the energy system in a safe, efficient and secure way."
The Programme also sets specific objectives for both indirect actions (research activities carried out by consortia of research institutions from EU Member States and associated countries, partially funded by the EU research budget) and direct actions (research activities in nuclear fission carried out by the European Commission's Joint Research Centre), as well as for nuclear fusion research activities, which can be summarised:

Improving the safety of nuclear systems; including nuclear reactor and fuel safety as well as emergency preparedness, decommissioning

Contributing to the development of solutions for the **nuclear waste management** and for **NPPs decommissioning**, including final geological disposal as well as partitioning and transmutation

Fostering the development and sustainability of **nuclear expertise** and increasing excellence in the **nuclear science base** for standardisation.

Supporting **radiation protection** and the development of **medical applications of radiation**, including the secure and safe supply and use of radioisotopes



Moving towards demonstrating the feasibility of **fusion as a power source**, laying the foundations for future fusion power plants by developing materials, technologies and conceptual design; and promoting innovation and industrial competitiveness.

Ensuring the availability and use of **research infrastructures** of pan-European relevance.

Improving **nuclear security**, including: nuclear safeguards, non-proliferation, combating illicit trafficking, and nuclear forensics.

Supporting the **policy of the Union** on nuclear safety and security.

The extension of the Euratom Research and Training Programme for 2019-2020, carry over the activities of the 2014-2018 Programme, keeping the same strategy, scope and mode of implementation. The Programme's education and training activities will continue, reinforcing knowledge management and improving open access of scientists to JRC research infrastructure; it will pursue a further integration of direct/indirect actions programme; and it will increase synergies between the nuclear and the non-nuclear research in the field of nuclear science applications. Most of the challenges and research needs of the current programme will remain for the EU from 2021 onwards. Thus, the Commission proposal for the next framework programme, the Euratom Research and Training Programme 2021-2025 complementing Horizon Europe focus in nuclear safety, security, radioactive waste and spent fuel management, radiation protection and fusion. The programme will expand research into non-power applications of ionising radiation, and make further improvements in the areas of education, training and access to research infrastructure.
The proposal of the Commission establishes a common set of objectives for Direct and Indirect Actions, in order to better streamline the research activities, allowing the combination of instruments and assets, such as JRC's research infrastructure and knowledge base.

The programme is developed in four specific objectives:

- improve the safe and secure use of nuclear energy and non-power applications of ionizing radiation, including nuclear safety, security, safeguards, radiation protection, safe spent fuel and radioactive waste management and decommissioning;
- maintain and further develop expertise and competence in the Community;
- foster the development of fusion energy and contribute to the implementation of the fusion roadmap; and
- support the policy of the Community on nuclear safety, safeguards and security.

The proposal also includes a focus on non-power applications for medical and industrial use, which are clear synergies with Horizon Europe and opening Marie Skłodowska-Curie Actions to nuclear researchers.

3. European Commission's Joint Research Centre.

The Joint Research Centre is the European Commission's science and knowledge service. It employs scientists to carry out research in order to provide independent scientific advice and support to EU policy in areas such as agriculture, food security, environment, climate change, innovation, growth and nuclear safety and security.

Established as a Joint Nuclear Research Centre by the Euratom Treaty , the JRC draws on **60 years of scientific experience** and continually builds its expertise, sharing knowledge with EU countries, the scientific community and international partners. With time, the JRC broadened its field of research to non-nuclear disciplines, which now cover around 75% of its entire activities. It works together with over a thousand organisations worldwide in more than 150 networks whose scientists have access to JRC facilities through various collaboration agreements.

The JRC is dealing with growth and innovation; energy, transport and climate; sustainable resources; space, security and migration; health, consumers and reference materials; and nuclear safety and security as well as with knowledge management and competences.

The JRC directorates are spread across six sites in five European Union Member States: Brussels and Geel (B), Petten (NL), Karlsruhe (D) Ispra (I), and Sevilla (E).

3.1 JRC research and training in nuclear safety and security.

The Directorate for Nuclear Safety and Security employs around **500 scientists, technicians and administrative staff** in in Petten, Karlsruhe, Geel and Ispra.across six sites in five European Union Member States: Brussels and Geel (B), Petten (NL), Karlsruhe (D) Ispra (I), and Sevilla (E).
JRC allocates about 48% of its resources to research on nuclear safety, waste management, decommissioning and emergency preparedness. Examples on nuclear safety are the research on advanced mechanical tests methods to address creep fatigue or stress corrosion cracking and the severe accident modelling and analysis with computer codes such as the European software system ASTEC. The JRC operates the EU Clearinghouse on **Operating Experience Feedback**, a network that aim at enhancing nuclear safety through further use of lessons learned from Operating Experience. Another key activity is the development, operation and maintenance of EURDEP, EU system for almost real-time monitoring of radioactivity in the environment, and support to ECURIE, which is the technical interface of the EU early notification and information exchange system for radiological emergencies.
JRC also carries out research in safety of the nuclear fuel cycle, at in-core, storage and disposal, and under normal, abnormal and accidental conditions. JRC developed and further improves and maintains the TRANSURANUS computer code for fuel performance analysis. Complementing its European partners, JRC carries out research on safety and safeguards aspects of advanced and innovative designs for Generation IV reactors .
In the area of radioactive waste management, JRC focuses in non-destructive analyses techniques for the characterisation of waste packages; standardisation of free release measurements, development of novel techniques for mapping contamination, and for decontamination in high activity environments, methods for hard to measure nuclides, etc.

JRC activities in the field of nuclear security and safeguards focus in four main areas:

- effective and efficient safeguards (through research in, e.g. nuclear material measurements, containment and surveillance, process monitoring and on-site laboratories),
- verification of absence of undeclared activities (through e.g. trace and particle analysis, and development of in-field tools),
- nuclear non-proliferation (through e.g. export control, trade analysis, and studies)
- combating illicit trafficking (through, e.g. equipment development, testing, and validation, nuclear forensics, preparedness plans).

The JRC devotes 12% of resources to basic research for standardisation and non-energy applications research. The JRC is a main entity in reference measurements and data; basic and pre-normative research; and inter-laboratory comparisons. The JRC develops reference materials and is a major European provider of nuclear data and standards for nuclear energy applications to the Nuclear Data bank of the NEA-OECD and the IAEA, which provide open access to the data to scientific and engineers.

Activities in the field of nuclear science applications are accelerator-based nuclear measurements, and determination of basic properties of radionuclides and associated applications, supporting the authentication and preservation of cultural heritage and archaeological studies, use of tracers for climate modelling, nuclear medicine, such as targeted alpha-immunotherapy, food fraud detection, and space applications.

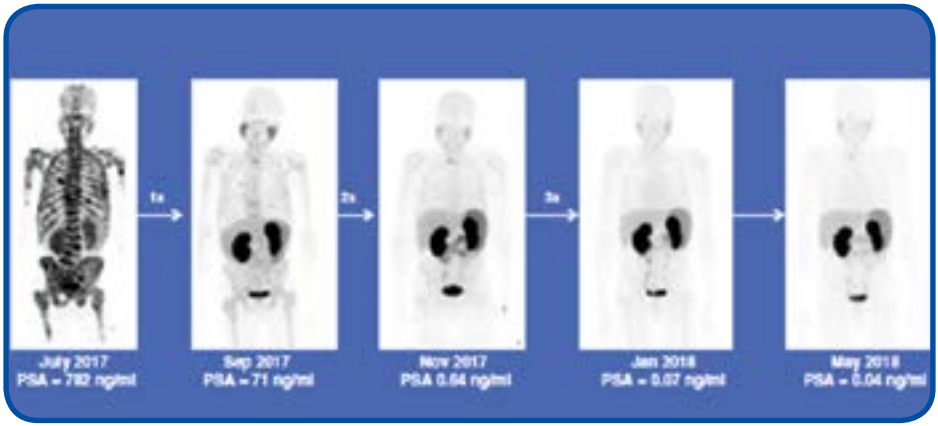


Figure 2. Targeted alpha-immunotherapy

The activities in knowledge management, education and training include organisation and participation in expert and scientific conferences and education and training initiatives such as the European Nuclear Security Training Centre (EUSECTRA), European Safeguards Research and Development Association (ESARDA), education and training of Euratom and IAEA nuclear inspectors, European Learning Initiatives in Nuclear Decommissioning and Environmental Remediation (ELINDER), as well as a number of other education and training courses in nuclear safety, security, nuclear data, etc.

3.2 JRC nuclear research infrastructure.

The nuclear research experimental facilities of the JRC are distributed in the sites of Geel (B), Petten (NL), Karlsruhe (D) and Ispra (I).

JRC-Geel research infrastructure mainly focuses in nuclear data, radioactivity metrology, and nuclear reference materials:

a) The neutron time-of-flight linear accelerator (GELINA) is a pulse white spectrum neutron source with the best time resolution in the world, which can perform up to 12 different experiments simultaneously.
b) The tandem accelerator based fast neutron source (MONNET) is an electrostatic accelerator for the production of continuous and pulsed proton-, deuteron- and helium ion beams. The combination of both facilities GELINA and MONNET is producing the most accurate neutron data for nuclear energy systems safety assessments.
c) Radionuclide metrology laboratories: for high precision radioactivity measurements (RADMET laboratories) and ultra-sensitive radioactivity measurements (225 m deep underground) (HADES Laboratory).
d) Nuclear reference materials laboratories for certified nuclear reference materials and reference measurements (METRO) and characterised samples for nuclear data measurements (TARGET).

Figure 3. Tandem accelerator based fast neutron source (MONNET) and Neutron time-of-flight linear accelerator (GELINA)

JRC-Petten hosts and operates laboratories for the assessment of materials and components performance under thermo-mechanical loading, corrosion, and neutron irradiation:

a) The high flux reactor (HFR, owned by JRC but operated by the Dutch company NRG): a multi-purpose materials testing research reactor. The reactor provides a variety of irradiation facilities and possibilities as well as neutron beams.

b) The laboratory for the ageing of materials in light water reactor (LWR) environments (AMALIA) is a laboratory for aqueous corrosion and stress corrosion cracking investigations.
c) The Structural Materials Performance Assessment laboratories (SMPA) are used for the mechanical performance characterisation, life assessment and qualification of structural materials for present and next generation nuclear systems, in a wide range of temperatures.
d) The Microstructural Analysis Infrastructure Sharing laboratory (MAIS) for microstructural characterisation and materials degradation studies.

Figure 4. AMALIA laboratory.

JRC-Karlsruhe mainly focuses in properties of irradiated and non-irradiated nuclear materials, as well as research in fuel, fuel cycle, radioactive waste, security and safeguards. The Karlsruhe site has two nuclear licenses, one collective for glove box work with radioactive materials, and one for handling irradiated materials.

a) Fuels and materials synthesis and characterisation facility (FMSC): The facility comprises 3 shielded glovebox chains for U/Th, Pu and Am bearing samples respectively.
b) Hot cells (HC): 24 hot cells for irradiated fuels, cladding and nuclear material detailed scientific investigations, covering all aspects related to the safety of nuclear fuels during irradiation under normal and accident conditions.
c) Materials research laboratories (MRL): Series of unique, mostly home-built experimental installations dedicated to the study of thermodynamic and thermo-physical properties of actinides and nuclear materials.
d) Nuclear trace and analyses facility (NTA): Set of installations for all kind of chemical, physical and spectroscopic analysis of actinide and nuclear materials.
e) Fundamental properties of actinide materials under extreme conditions (PAMEC): State-of-the-art installations designed for basic research on behaviour and properties of actinide materials.

f) EUSECTRA is a training centre in the field of nuclear security and safeguards. Training areas include border detection, emergency response, nuclear forensics, radiological crime scene management and nuclear security awareness.
g) The large geometry secondary ion mass spectrometry laboratory (LG-SIMS) laboratory is equipped with a highly sensitive mass spectrometer to detect trace quantities of uranium/plutonium in micron-sized particles collected for safeguards purposes.

A new laboratory building, which will contain laboratories involving the handling of significant amounts of radioactive materials, is currently being constructed on site.

Figure 5. JRC hot-cells.

JRC-Ispra carries out research in safeguards and security

a) Laser laboratory for nuclear safeguards and security: Laser based systems to carry out containment and surveillance techniques for nuclear safeguards
b) Advanced safeguards, measurement, monitoring and modelling laboratory (AS3ML): Laboratory to measure nuclear material, to monitor the operation of facilities and to model the plant operations.
c) Performance laboratory / Pulse neutron interrogation test assembly (PERLA / PUNITA): Laboratory for the assessment and evaluation of performances for all non-destructive assay (NDA) techniques applied in the safeguards of nuclear materials.
d) Tank measurement laboratory / Solution monitoring laboratory (TAME / SML): Bulk handling facilities, which proposes challenges to the performances of inventory quantification and density characterisation.
e) Sealing and identification laboratory (SILab): Laboratory for the development, testing and commissioning of security systems used for nuclear and commercial applications.

Figure 6. Nuclear facilities verification laboratory

f) Illicit Trafficking Radiation Assessment Programme (ITRAP). The facility is dedicated to perform tests on radiological performances of radiation detection equipment used in nuclear security.

Figure 7. European Nuclear Security Training Centre (EUSECTRA)

3.3 Decommissioning and Radioactive Waste Management Programme.

The Commission's Joint Research Centre (JRC), as nuclear operator and/or owner under Belgian, Dutch, German and Italian laws, is responsible for the decommissioning of these installations and for the responsible and safe management from generation to disposal of the resulting spent fuel and radioactive waste.

The JRC's **Decommissioning and Waste Management Programme** launched in 1999 details all the activities that the JRC plans and carries out for the safe decommissioning and dismantling of its obsolete facilities and the decommissioning plans of its still operational nuclear research facilities. The programme also covers the management of the radioactive waste up to the disposal of all radioactive waste and unconditional release of the sites. The Commission issues a Communication to the Council and European Parliament on the progress of the D&WM Programme every four years (2004 , 2008 , and 2013).

In 2018, the Commission proposed a Council Regulation to establish a common instrument to address the decommissioning of nuclear facilities of the Kozloduy NPP units 1-4 (Kozloduy, Bulgaria), the Bohunice V1 NPP (Jaslovské Bohunice, Slovakia), and the JRC nuclear facilities and the management of the arising waste. **The objective is to optimise synergies and bring added value through becoming a benchmark within the EU for safely managing technological issues in nuclear decommissioning and disseminating knowledge to Member States.**

Figure 8. Barrel storage within the reactor dome. JRC-Ispra

3.4 International cooperation and support to EU policies.

Along the years, JRC has concluded and maintained agreements of different nature with relevant research institutions and associations within EU Member States. These agreements foster scientific exchanges and stimulates pursuing excellence, while ensuring that the research objectives of both parties are aligned and maintained relevant.
The JRC cooperation is not limited to within the European Union. The JRC engages with main nuclear research institutions in third countries and with international organisations such as the IAEA and OECD/NEA. These EU and international cooperation activities allows the JRC to be up-to-date of the nuclear research trends and challenges, and helps to reach the objective of contributing to maintain the EU competence and leadership in nuclear safety, nuclear security, and nuclear safeguards.

Building upon the scientific expertise and its work with the different partners, the JRC contributes to the development, implementation and monitoring of nuclear-related EU policy (EU Directives and Euratom Treaty obligations), and instruments (e.g. for nuclear safety and nuclear security), together with other European Commission services. In particular, and in addition to JRC's research work on the safety and safeguards aspects of innovative Generation IV reactors, the JRC has been entrusted to be the Euratom implementing agent of Generation IV International Forum, which is a co-operative international endeavour set up to carry out the research and development needed to establish the feasibility and performance capabilities of the next generation nuclear energy systems.

4. The way forward.

The long-term safe, secure and sustainable use of nuclear energy must be ensured by a consistent approach to safety (implementation of appropriate and commensurate common principles, rules and standards); safeguards (verification, reporting and non-proliferation commitments such as export controls) and security (prevention, detection and response), as well as international acceptance and mutual trust (transparency). This can only be achieved based on sound scientific evidence, reliable nuclear measurements and appropriate control tools, as well as on public involvement, which at the same time can only be guaranteed if competence and technology leadership are maintained within the EU.

The Commission proposal for the next Euratom Research and Training Programme (2021-2025)

aims at focusing in the key research areas: nuclear safety, security, radioactive waste and spent fuel management, radiation protection and fusion energy. At the same time, the programme intends to expand research into non-power applications of ionising radiation, and make improvements in the areas of education, training, knowledge management and access to research infrastructure (including in particular the infrastructure operated by JRC), as well as to better exploit the complementarity between research carried out by Member States scientific institutions, and research carried out by the Joint Research Centre.

The proposal reflects the need to streamline and foster the complementarity between the nuclear research carried out by the Member States and the one carried out directly by the JRC by establishing a single set of objectives for both direct and indirect actions. It is also envisaged that projects can be drawn up by combining different instruments and assets, such as JRC's knowledge base and research infrastructure.

To increase the programme impact, it is proposed that the JRC participates in indirect actions complementing consortia's activities where the JRC has the necessary expertise or dedicated infrastructure without participating in competitive biddings against research institutions of the Member States.

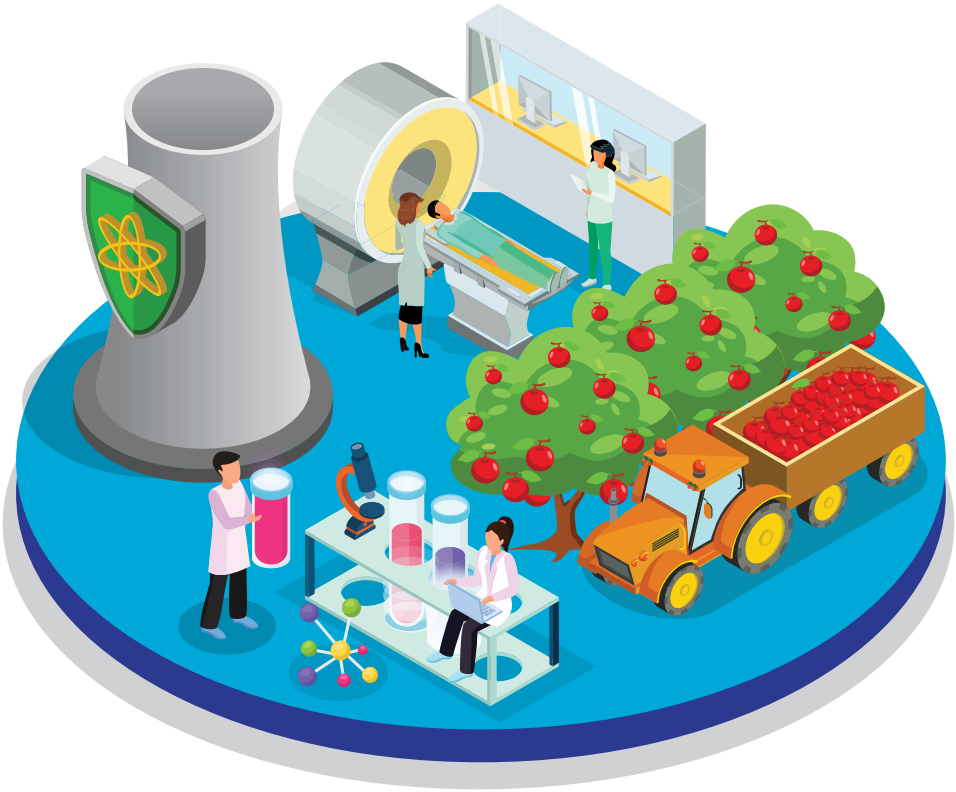
In preparation for this approach, three pilot projects on knowledge management in nuclear safety, open access to JRC research infrastructure, and roadmap for access to the Jules Horowitz Reactor, are exploring and testing this improved involvement of JRC in indirect actions, already under the current programme. In all these three pilot projects, JRC personnel costs as well as the operational costs of JRC research infrastructure will be covered exclusively by the JRC direct actions budget.

5. Conclusions

Regardless of the EU Member States decisions on continuing, phasing out or embarking in new built nuclear power plants, nuclear energy will continue to be part of the energy mix in the European Union for the next decades, and also in neighbouring countries.

The EU must ensure that Member States use the highest standards of safety, security, waste management and non-proliferation. The EU should also ensure that it maintains technological leadership in the nuclear domain so as not to increase energy and technology dependence. Efficient research and training at EU level are key elements to achieve these objectives.

The JRC is a very important partner in European research, which aims at complementing the nuclear research and training carried out by the research institutions of EU Member States through its scientific expertise and research infrastructure. **JRC's areas of work cover ample disciplines in the field of nuclear safety, nuclear security, nuclear safeguards, and nuclear science applications ranging from basic research up to ready to use applications, as well as development of reference measurements and supply of reference materials.** To this end, the JRC operates cutting-edge laboratories and research infrastructure, in many cases with unique characteristics and capabilities.



Although cooperation in nuclear research has been always a key objective in the work programme of the JRC, the Commission proposal for the next **Research and Training Programme**, which is still under discussion, has taken further concrete actions towards a more efficient alignment of the research and training activities of Member States and those of the Joint Research Centre. The JRC, together with its partners is getting ready to this new approach by proposing a new way of implementation, in which the JRC will not bid with research institutions of the Member States in competitive processes, but rather will form part of those projects for which the knowledge and capacities (including infrastructure) of the JRC are significant or relevant. This new way of implementation is being tested through three specific pilot projects on knowledge management, open access to JRC research infrastructure, and access rights to the Jules Horowitz Reactor.

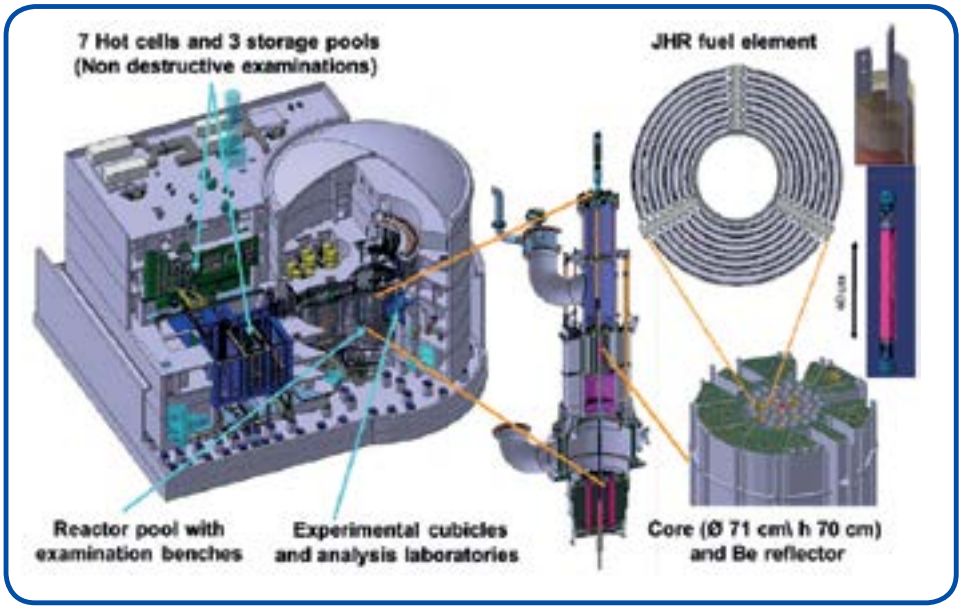


Figure 9. A technical scheme of the Jules Horowitz Reactor

For more than 60 years, the Joint Research Centre has developed a sound knowledge base and expertise in nuclear matters, continually pursuing scientific excellence. It shares its know-how and achievements with EU Member States, the scientific community, and international partners. It works together with over a thousand organisations worldwide in more than **150 networks** whose scientists have access to JRC facilities through various collaboration agreements. The JRC will continue being a relevant actor in the nuclear research arena, focusing on nuclear safety, responsible and safe management of radioactive waste and spent fuel, radiation protection, nuclear science applications, nuclear security, nuclear safeguards, and standardisation as the challenges of today will still outstand in the next years. The next Euratom Programme will, in addition, reinforce JRC education and training as well as knowledge management activities, increase synergies with non-nuclear activities, further develop nuclear science applications, and improve access of scientists to JRC research infrastructure.

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JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

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