

**HEADING 1A: Competitiveness for growth and jobs****Euratom Research and Training Programme****Lead DG: RTD**

Associated DGs: JRC

**I. Overview*****What the programme is about?***

The Euratom Research and Training Programme 2019-2020 <sup>(1)</sup> ('the Euratom Programme') is an extension of the 2014-2018 Euratom Programme <sup>(2)</sup> in terms of research objectives and scope of supported activities. Its primary aim is to enhance the safety of nuclear technologies by supporting research on all aspects of nuclear safety. The Euratom Programme also supports research on the assessment and demonstration of the safety aspects of future fission technologies. Euratom-funded research should also reduce the risks associated with radiation exposures from industrial or medical applications and support emergency preparedness in relation to accidents involving radiation.

Furthermore, the Euratom Programme contributes to advancing solutions for the management and disposal of spent fuel and radioactive waste and for the decommissioning of nuclear facilities. The Euratom Programme provides scientific and technical support for the implementation of EU policies and strategies in the field of nuclear safeguards, non-proliferation and nuclear security. Funding is also provided for the basic research necessary for the development of reference measurements, materials and data.

The substantial increase in the deployment of nuclear fission technologies worldwide requires collaboration with and technical support to the main international institutions, such as IAEA, in the field of nuclear safety and, particularly, in the field of nuclear safeguards by developing techniques and methods aiming at reducing nuclear security risks and for supporting nuclear non-proliferation efforts.

The Euratom Programme focuses also on the development of fusion energy, a possible future option for low carbon electricity production. Its feasibility must be demonstrated and, if found to be a viable energy source, it could contribute significantly to the well-being of future generations. Fusion research is a long-term endeavour, and the potential deployment of fusion power plants cannot be realistically foreseen until the latter part of the century. However, fusion science and technology development has now reached a stage where one can plan the design of a demonstration reactor (a DEMO). Consequently, the Euratom Programme funds research on fusion electricity production, which includes exploiting existing and future fusion facilities, especially ITER, to assess the viability of fusion. Furthermore, the funding covers development of new materials, technologies and conceptual design activities, which are required to prepare for future fusion power plants.

***EU added value of the programme***

The European added value of the Euratom Programme is the mobilisation of a wider pool of excellence and multi-disciplinary expertise in fission and fusion research than is possible at the level of individual Member States. This added value has also been underlined by its stakeholders. Through cooperative research and innovation, the Euratom Programme enables a Europe-wide approach to the improvement of nuclear safety and radiation protection in all areas of application. The Euratom programme also enables a broader coordination throughout Europe of education and training, the use of research infrastructures and international cooperation. This is of particular benefit to smaller Member States that can take advantage of the economies of scale afforded by the Europe-wide pooling effect.

Through the JRC, the Euratom Programme also provides services which are not available elsewhere. The JRC provides support for standardisation, open access for EU scientists to unique nuclear facilities, training activities in nuclear sciences (including safeguards, forensics and decommissioning) and the operation of the Clearinghouse on Operational Experience Feedback.

The JRC provides the Commission with scientific and technical support in preparing, implementing and monitoring EU policies in several areas:

- nuclear safeguards (supporting nuclear inspections of Member States' facilities in compliance with international treaties);
- nuclear safety and waste management (monitoring the technical implementation of the Nuclear Directives – Safety, Waste and spent fuel, Basic Safety Standards);
- and radiation protection (monitoring and measuring of radioactivity on our environment).

In addition, via the Euratom membership in the Generation IV International Forum, the JRC coordinates the European research effort on safety of advanced reactor technology, with contributions coming from the Euratom programme as well as from Member States.

<sup>(1)</sup> Council Regulation (Euratom) 2018/1563 of 15 October 2018 on the Research and Training Programme of the European Atomic Energy Community (2019–2020) complementing the Horizon 2020 Framework Programme for Research and Innovation, and repealing Regulation (Euratom) No 1314/2013 (OJ L 262/1, 19.10.2018).

<sup>(2)</sup> Council Regulation (Euratom) No 1314/2013 of 16 December 2013 on the Research and Training Programme of the European Atomic Energy Community (2014–2018) complementing the Horizon 2020 Framework Programme for Research and Innovation (OJ L 347, 20.12.2013, p. 948).

**Implementation mode**

The Euratom Programme is implemented through two different modes:

- ‘Indirect actions’: Research and innovation activities carried out by the beneficiaries of grants, prizes, procurement and financial instruments (all these instruments are managed by the Commission’s Directorate-General for Research and Innovation);
- ‘Direct actions’: Research and innovation activities that are directly carried out by the Commission’s Joint Research Centre (JRC).

**II. Programme Implementation Update****Implementation status (2017-2019)****Indirect actions (grants for collaborative projects):**

In fission research, four calls had been concluded by Autumn 2019, with 192 eligible proposals submitted, requesting a total Euratom financial contribution of EUR 726 million. Of these, 62 were selected for funding, with a Euratom contribution of EUR 271 million. In the end of 2019, a fifth call was concluded (closing date for applications was 25 September). In response to this call, 62 eligible proposals were submitted requesting a total Euratom financial contribution of EUR 265 million. At the end of the evaluation 31 proposals were put on a ranking list with Euratom contribution of EUR 133 million. Signature of grants is foreseen during 2020.

For fusion research, following an independent evaluation, in 2014 the Commission awarded a 5-year grant to the EUROfusion consortium<sup>(3)</sup> of national fusion laboratories and institutes<sup>(4)</sup> to implement a European Joint Programme based on the fusion roadmap<sup>(5)</sup>. In 2019 the EUROfusion grant was prolonged until the end of 2022 following adoption by the Council of the regulation on the Euratom Research and Training Programme 2019-2020. The extension of duration beyond 2020 provides a smooth transition to the future Euratom Programme.

**Direct actions (research carried out by JRC)**

The work programme of the JRC covered research and training on the following areas defined by the specific objectives of the programme:

- nuclear safety (specific objective 9), including safety of reactor, fuel and fuel cycle, nuclear waste management, environmental monitoring and emergency preparedness and response. About 40 % of the available resources were allocated to this working area;
- nuclear safeguards non-proliferation and security (specific objective 10), including combatting illicit trafficking and nuclear forensics. About 25 % of the resources were allocated to this working area;
- basic science knowledge and standards and reference materials essential for nuclear safety, security and safeguards (specific objective 11), including research on non-energy applications of nuclear science as medical and space applications. This consumed around 13 % of the available resources;
- The research performed, and the experience accumulated, in the areas of nuclear safety, safeguards and non-proliferation, security and the provision of standards and references, bring the necessary capacities to deliver cross-cutting activities related to knowledge management tasks and to provide education and advanced training in nuclear fields (specific objective 12). The resources allocated to these activities were around 10 %.
- Moreover, the JRC provided the requested scientific and technical support to the EU related policies (Specific objective 13); 12 % of the available resources were allocated directly to providing the requested support.

**Key achievements****Indirect actions (grants for collaborative projects)**

All EU Member States generate radioactive waste, with national inventories ranging from single sources or small inventories, up to large and high activity inventories from those Member States with extensive nuclear programmes, some of them including spent nuclear fuel or large stockpiles of nuclear material from reprocessing activities. Regardless of size, they all have to manage radioactive waste safely in the long term. While the greater part of radioactive waste comes from nuclear power plants, nuclear medicine, agriculture and industrial activities produce also nuclear wastes. The new European Joint Programme on Radioactive Waste Management, EURAD, supported with Euratom funding of EUR 32.5 million (54 % of total costs, 5 years duration) represents a step change in European collaboration towards safe radioactive waste management, including disposal. The EURAD consortium, gathering Waste Management Organisations, Technical Support Organisations and Research Entities (REs) from 21 Member States and Ukraine and Switzerland, addresses key challenges in radioactive waste management. EURAD will support the

<sup>(3)</sup> Euratom programme contributes 55 % of the EUROfusion consortium funding.

<sup>(4)</sup> EUROfusion consortium, for more information see <https://www.euro-fusion.org/>

<sup>(5)</sup> ‘Fusion Electricity – A roadmap to the realisation of fusion energy’, <https://www.euro-fusion.org/eurofusion/the-road-to-fusion-electricity/>

implementation of the Waste Directive in EU Member-States, taking into account the various stages of advancement of national programmes. EURAD aims at supporting Member-States in developing and implementing their national RD&D programmes for the safe long-term management of their full range of different types of radioactive waste through participation in the Joint Programme. It also develops and consolidates existing knowledge for the safe start of operation of the first geological disposal facilities for spent fuel, high-level waste, and other long-lived radioactive waste, and supporting optimization linked with the stepwise implementation of geological disposal. Therefore, knowledge management and transfer between organisations, Member States and generations will be enhanced.

The project HARMONIC' ('Health Effects of Cardiac Fluoroscopy and Modern Radiotherapy in Paediatrics') was launched in 2019 with Euratom support of EUR 7 million. A total of 24 partners from 11 Member States and Ukraine and Switzerland are working to investigate the long-term health consequences of radiological and radiotherapeutic procedures for children and adolescents. The increasing use of radiation-associated diagnostic and therapeutic procedures have contributed to the improvements of early diagnosis and survival of paediatric patients. While benefits to the patient outweigh the radiation associated risk, the late effects of exposure of children are particularly important to understand in populations undergoing radiological and radiotherapeutic procedures. The HARMONIC project focuses on two distinct and complementary populations: (1) Paediatric patients undergoing modern radiotherapy (including proton therapy); (2) Paediatric patients undergoing interventional cardiology. The study will use an integrated approach of conventional epidemiology, based on state-of-the art dosimetry, complemented by non-invasive imaging and molecular epidemiology. Ultimately, HARMONIC will develop tools and allow definition of guidelines on optimization techniques to guide treatments toward reduction of patient doses in paediatric cardiology and oncology.

In fusion research, **the EUROfusion consortium had achieved 82 % of its project milestones foreseen in the work plan by 2018.** Particular examples of progress include: completion of the installation and initial operation of the shattered pellet injector (SPI) in JET; theoretical studies (computer simulations) complemented by experiments on TCV provided the first systematic assessment of possible power exhaust options for a fusion demonstration power plant (DEMO); tests of ITER type mono-blocks in EUROfusion devices dedicated to studying plasma wall interaction (PWI).

**Operation of the SPI on JET has yielded crucial information for ITER, which has SPI as its baseline tool for mitigation of plasma disruptions.** Unless mitigated, disruptions could induce harmful vessel forces and so-called runaway electrons in ITER (runaway electrons can be accelerated to the multi MeV range and can cause serious damage to plasma facing components when they eventually impact on material surfaces). The new data from JET are important for the finalisation of the design of the ITER SPI system. In addition, the SPI experiments on JET have yielded unexpected positive results regarding mitigation of runaway electrons.

**A key issue identified in the EU fusion roadmap is the power exhaust of DEMO.** It is possible that an alternative divertor geometry than used for ITER is needed for DEMO. A number of possibilities exists. **A comprehensive assessment of the main alternatives was carried out by computer simulations and with input from the experiments carried out on the TCV tokamak.** The picture is now clearer and the obtained results should be valuable for a future gate review aimed at narrowing down to options for a DEMO design.

**ITER type mono-blocks, which will make up the components of the ITER divertor, were successfully tested in the linear MAGNUM-PSI facility in conditions mimicking those during planned full power operation in ITER.** Furthermore, testing of such mono-blocks also took place in the WEST device under real tokamak plasma conditions. **The obtained results are highly relevant for ITER.**

In the area of **fusion technology development**, the focus of activity has been on the DEMO department, which has been preparing for a design gate review to down select technologies that will pass to the Conceptual Design Activity in Euratom Programme 2021-2025. As input to the gate review, many design reviews have been carried out using external experts. This has been a very important exercise at this stage in the project as it gives a very clear state of play of the work and provides input and steerage for the design teams. Another major achievement has been the completion of the preliminary safety report for the Early Neutron Source (DONES) for which a coordination and support action has been launched for preparatory activities to inform on a construction decision in the first period of future Euratom Programme 2021-2025. The DONES materials test facility is an important milestone in the fusion roadmap and has been included in the European Strategy Forum on Research Infrastructures (ESFRI) roadmap.

Through EUROfusion more than 1300 researchers have had access to advanced research infrastructures. Support from the Euratom programme has led to the publication of more than 800 articles in peer-reviewed, high impact journals and over 750 PhDs in fusion physics and technology.

#### **Direct actions (research carried out by JRC):**

The direct actions of the programme contribute to the development of codes, standards and test methods for the safety analysis of nuclear reactors and provides reference data, software tools and knowledge on the behaviour of nuclear fuel in normal and accidental conditions. An example is the *operation of the Clearinghouse website and database* and issue of periodic reports (supported by French and German Technical Support Organisations) to disseminate the operating experience of nuclear power plants to nuclear safety authorities, in 2019 the quarterly reports analysed 16 selected events. Using the experience gained, the JRC participated in drafting the new IAEA nuclear safety guideline on Operating Experience Feedback for Nuclear Installations.

The direct actions have been contributing to the OECD and IAEA nuclear data libraries; certified reference materials for determination of radioactivity in metals were produced and spikes for determination of Uranium and Plutonium were delivered to Euratom safeguards.

The JRC provides technical support to the implementation of the *Council Directive establishing a Community framework for the nuclear safety of nuclear installations* <sup>(6)</sup>, *Council Directive on Responsible and Safe Management of Spent Fuel and Radioactive Waste* <sup>(7)</sup> and *Council Directive on the supervision and control of shipments of radioactive waste and spent fuel* <sup>(8)</sup>. It also supports the assessment of *ageing nuclear power plants for their long-term operation*, contributing to ensuring the same level of safety: JRC staff members participated in the Nuclear Safety Directive's Topical Peer Review on ageing management of nuclear power plants. The national reports of all participating countries of the TPR covering the different sub-topics were reviewed and the results were discussed at the TPR Workshop in May 2018. In 2019, a post-Fukushima Stress test Peer Review took place in Armenia and the preparation of works for coming review in Turkey was started.

The direct actions in the nuclear safeguards area *support the EU's strategic objective to reduce the risk of nuclear proliferation*. JRC provides new safeguards technologies, such as laser verification systems to facilitate the IAEA and DG ENER inspection of nuclear installations. To support the safeguards system in Europe, JRC *develops analytical techniques and operated the Euratom safeguards laboratories* and supported the yearly Physical Inventory Verifications in European fuel fabrication plants. *Training courses for Euratom inspectors to ensure an effective implementation of EU safeguards systems are also organised*. Similar support is provided to the IAEA through the Commission's safeguards support programme, 5 projects were finalised in 2019 and 40 projects are still ongoing.

The direct actions of the Euratom programme *support the EU nuclear security strategies, providing training* at the EU nuclear security training centre (EUSECTRA) and contributing to the enhancement of capacities in the EU Member States and neighbouring countries. In 2019, 14 one-week trainings and two additional workshops with experts from EU Member States were organised. JRC provided nuclear forensics support to EU Member States, in 2019 samples from three incidents in two Member States were analysed. In the framework of the EU CBRN Centres of Excellence network, JRC in collaboration with US Department of Energy and Kiev Institute for Nuclear Research developed nuclear security education & training activities for Georgia, Ukraine, Azerbaijan and Moldova participants, to enhance nuclear security in the Black Sea region.

In 2014-2019 JRC scientists *published 1083 articles and conference contributions in peer-reviewed periodicals, 304 articles in monographs or other periodicals, 26 books with JRC editorship and 20 PhD theses*. The JRC organised 219 training courses for professionals and students from Member States and Commission services. In addition, JRC delivered reference methods and measurements, technical systems and scientific databases. Moreover, the JRC opened access to its nuclear research infrastructures and offers complementary research possibilities to external users from EU Member States.

JRC is a partner in 28 projects supported by the Euratom indirect actions. The knowledge and results provided by the related direct actions are obtaining synergies in benefit of the programme:

- In the context of the Strategic Research Agenda (SRA) of the European Sustainable Nuclear Energy –Technology Platform (SNE-TP), JRC contributed to the PELGRIMM: PELlets versus GRanulates: Irradiation, Manufacturing & Modelling project addressing Minor-Actinide (MA) bearing fuel developments for Generation IV Fast Reactor Systems.
- A second example is the JRC contribution to the MYRRHA project. MYRRHA is the very first prototype in the world of a nuclear reactor, driven by a particle accelerator with a significant thermal output. Safety relevant properties of highly radioactive materials for experiments on transmutation of fuels were investigated at JRC. The data obtained by JRC are fundamental for the safe operation of MYRRHA.

#### **Evaluation/studies conducted**

The key findings of the latest evaluation (Commission Report COM(2017) 697, (SWD (2017) 426 and 427) have been presented in the Programme Statement for 2020.

The interim evaluation of the Euratom programme concluded that the programme is highly relevant and it is achieving its results avoiding duplication, while providing added-value and coordination. The possible areas of improvement for indirect actions include: increasing synergies between direct and indirect actions, as well as between the Euratom programme and other thematic areas of the EU Framework Programme in order to address cross-cutting aspects such as medical applications of radiation, climate change, security and emergency preparedness; reinforcing Euratom education and training actions for developing competencies in the nuclear field which underpin all aspects of nuclear safety, security and radiation protection. The evaluation recommendations are already being addressed: JRC continues providing training courses (243) and opening the access to its research facilities to EU Institutions. Other actions have been taken, as briefly described in the section 'Programme Performance'.

<sup>(6)</sup> Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations

<sup>(7)</sup> Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste

<sup>(8)</sup> Council Directive 2006/117/Euratom of 20 November 2006 on the supervision and control of shipments of radioactive waste and spent fuel

**Forthcoming implementation**

*Indirect actions (grants for collaborative projects):*

In 2020 the Commission will finalise checks and preparations for a signature of grants for research projects selected following the 2019-2020 call for proposals (31 proposals with Euratom contribution estimated at EUR 133 million). The Commission will also continue implementation of other actions planned in the Euratom Work Programme 2019-2020 such as a pilot actions supporting knowledge management in the area of nuclear safety and open access to JRC research infrastructure.

*Direct actions (research carried out by JRC):*

The Euratom research & training programme 2019-2020 has the same specific objectives as the previous one. The JRC will thus continue the research on the fields of nuclear safety, safeguards and security, providing dedicated reference measurements and materials, delivering education and training and managing the generated knowledge to provide sound scientific and technical support to the EU policies in the nuclear field.

Euratom direct actions will seek to further develop knowledge management, education and training and to continue exploiting efficiently synergies with indirect actions in the area. To explore other ways of collaboration that increase the efficiency and effectiveness, three pilot projects are being developed together with nuclear fission indirect actions: JRC’s management of knowledge obtained by indirect actions in nuclear safety selected field; open access to JRC nuclear facilities; and road map of the access rights of the Jules Horowitz reactor. At the same time, JRC will seek for synergies between both the nuclear and the non-nuclear parts of its activities in areas as security of supply of medical radioisotopes and non-energy applications of nuclear science.

To improve the impact and tackle the challenges associated with nuclear safety and security, including training to maintain and develop the necessary skills, JRC will continue reinforcing the coordination with European research efforts, being in close liaison with stakeholders, to avoid duplication and ensuring the most efficient use of resources.

For the period starting as of 2021, the ‘Decommissioning of Nuclear Facilities and Management of Radioactive Waste’ <sup>(9)</sup> programme has the additional objective of enhancing the EU added value of the programme through dissemination of knowledge (thereby generated) to all EU Member States. The Euratom research & training programme will seek for obtaining synergies between both programmes in managing the knowledge obtained during the decommissioning processes and providing education & training on the field.

**Outlook for the 2021-2027 period**

In 2018 the Commission adopted its proposal (COM(2018) 437) for the Research and Training Programme of the European Atomic Energy Community for the period from 1 January 2021 to 31 December 2025.

Built largely on the success and the experience gained from previous Euratom Programmes, this programme is part of the legislative package for the ‘Horizon Europe’ Framework Programme for Research and Innovation. It is designed to implement the EU’s next long-term financial framework for 2021-2027, the priorities set out in the Commission’s Agenda for Jobs, Growth, Fairness and Democratic Change, and the Commission’s overall policy priorities (Horizon Europe).

The next Euratom programme, supporting nuclear research and training activities, will have an increased focus on non-power applications such as healthcare and medical equipment. It will also support the mobility of nuclear researchers under the Marie Skłodowska-Curie Actions, and access to fission and fusion research infrastructure.

Pending adoption of the regulation by the Council, the Commission will continue preparations for the implementation of the new programme, including drafting of the work programme in consultation with Member States and preparing new call for proposals.

**III. Programme key facts and performance framework**

**1. Financial programming**

Legal Basis	Period of application	Reference Amount (EUR million)
Council Regulation (Euratom) 2018/1563 of 15 October 2018 on the Research and Training Programme of the European Atomic Energy Community (2019–2020) complementing the Horizon 2020 Framework Programme for Research and Innovation, and repealing Regulation (Euratom) No 1314/2013	2019 – 2020	770,2

Financial Programming (EUR million)							
2014	2015	2016	2017	2018	2019	2020	Total Programme

<sup>(9)</sup> COM(2018) 467 final Proposal for a COUNCIL REGULATION establishing a dedicated financial programme for decommissioning of nuclear facilities and management of radioactive waste, and repealing Council Regulation (Euratom) No 1368/2013

Administrative support	115,8	114,7	115,1	114,5	112,4	132,8	138,9	844,1
Operational appropriations	169,0	187,4	202,0	226,3	240,5	240,8	258,8	1 524,8
<b>Total*</b>	<b>284,8</b>	<b>302,1</b>	<b>317,1</b>	<b>340,8</b>	<b>352,9</b>	<b>373,6</b>	<b>397,7</b>	<b>2 368,9</b>

\* From 2014 to 2018 included, Euratom is implemented under Regulation (Euratom) No 1314/2013. The total Programme in the table above is adding the years from 2014 to 2020.

## 2. Implementation rates

	2019				2020			
	CA	Impl. Rate	PA	Impl. Rate	CA	Impl. Rate	PA	Impl. Rate
Voted appropriations	373,575	99,25 %	365,910	90,26 %	397,665	41,19 %	416,691	8,42 %
Authorised appropriations (*)	415,206	92,62 %	427,293	83,48 %	428,703	38,48 %	485,399	9,61 %

(\*) Authorised appropriations include voted appropriations, appropriations originating from assigned revenues (internal and external) as well as carried-over and reconstituted appropriations; the execution rate is calculated on 15 April 2020

## 3. Performance information

### Programme performance

*The indirect activities are progressing towards the objectives. Five out of the 10 KPIs have already achieved their target and three KPIs are on track and one indicator presents slight delay.* For one indicator the results will be delivered by the end of the year. Therefore, it is not possible to report on the performance for this specific objective, at this stage.

Data available for the on-going nuclear safety projects launched since 2014 indicate that progress is generally as expected with most deliverables and milestones being achieved. Output from projects in the other technical areas also indicates that the Euratom programme is delivering, even though delays were encountered in the case of a few projects. These were delays due to the nature and unpredictability of cutting-edge scientific research, in particular the unavailability of key and often unique research infrastructures.

In 2014-2020 the Euratom programme has made substantial scientific and technological progress in all roadmap missions aimed at demonstrating the feasibility of fusion as a future energy source. The first priority of the programme in this area was to provide scientific support for ITER construction and its future exploitation. This progress has been achieved thanks to the new organisational structure established in 2014, involving all national fusion labs in Europe, for implementing a joint programme in line with the European fusion roadmap, based on shared planning and exploitation of research infrastructures, mobility of researchers, and competitive allocation of funds. This is a Europe-wide endeavour with strong international cooperation links, especially in view of the importance of the global ITER project. Since commercialisation of fusion energy is not expected until the second half of the century, most of the financial support today currently comes from public funds.

*From the information available so far, the results achieved for the direct actions of the Euratom programme, in accordance with the objectives, are encouraging. Two out of the 10 KPIs have almost achieved their target and four KPIs are on track. Four indicators present some delay and will have difficulties to achieve their targets.* It should be noted that the milestones 2020 indicated in the tables are calculated on yearly average and the 2019 figures are preliminary. However, some actions to improve the results to be obtained have already been taken, in line with the recommendations received on the interim evaluation of the Euratom programme. To fulfil the specific objective 12, foster knowledge management, education and training in the nuclear field on the EU, enhancing the impact of the activities carried out, an agreement was reached to combine resources from direct and indirect actions. An arrangement was signed to make possible the financial support to the external users of the JRC open access project. It is expected to increase the number of applicants and therefore the quality of proposals to use the JRC facilities. Another example is the agreement to improve the management of the knowledge obtained by the programme actions; JRC will use existing tools and will develop new ones with support of the RTD indirect actions, to optimise the use of the results of both direct and indirect actions of the programme.

To increase the synergies between direct and indirect actions as well as between nuclear and non-nuclear, several working groups have been established and are working to deliver results that will be implemented under Euratom Programme 2021-2025. The non-energy application of nuclear sciences are becoming more relevant in the programme obtaining a high number of scientific publications in its medical applications; they are getting special attention in a dedicated working group.

### General objectives

**General Objective 1:** To pursue nuclear research and training activities with an emphasis on continuous improvement of nuclear safety, security and radiation protection, notably to potentially contribute to the long-term decarbonisation of the energy system in a safe, efficient and secure way.

Indicator 1: 1.1 Reduction of greenhouse gas emissions at EU level compared to 1990								
Baseline	2014	2015	2016	2017	2018	2019	2020	Target

		Milestones foreseen						
			20 %					21 %
Actual results								
	23 %	22 %	22 %	22 %	23 %			

Source: <https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-6/assessment-3>

**Specific objectives**

**Specific Objective 1:** Supporting the safety of nuclear systems (societal challenges, excellent science, industrial leadership).

**Indicator 1:** 1.1 The number of projects (joint research and/or coordinated actions) likely to lead to a demonstrable improvement in nuclear safety practice in Europe

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2012	Milestones foreseen							2020
41		7				29	44	44
	Actual results							
		9		23	28		47	

Comment: Target increased from 14 projects planned for 2018 due to extension of the Euratom programme (from 2014-2018 to 2014-2020) and an increased focus on the improvement of nuclear safety.

**Specific Objective 2:** Contributing to the development of safe, longer-term solutions for the management of ultimate nuclear waste, including final geological disposal, partitioning and transmutation.

**Performance**

Regarding the indicator ‘The number of projects contributing to the development of safe long term solutions for the management of ultimate nuclear waste’, since establishment of a European Joint Programme in Radioactive Waste Management (EURAD <https://www.ejp-eurad.eu/>), encompassing most of stakeholders in Europe and providing funding for a comprehensive research in this field, there is no need to launch medium-size projects addressing specific issues. Consequently, due to the joint programming the target of 14 cannot be reached.

**Indicator 1:** 2.1 The number of projects contributing to the development of safe long term solutions for the management of ultimate nuclear waste

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2007-2013	Milestones foreseen							2020
15		5				12	14	14
	Actual results							
		5		10	11		12	

Comment: Target increased from 8 planned for 2018 due to the extension of the programme from 2014-2018 to 2014-2020.

**Specific Objective 3:** Supporting the development and sustainability of nuclear expertise and excellence in the Union.

**Performance**

At this stage, it is not possible to report on the number of PhD students and postdoctoral researchers supported through the Euratom fission projects. Estimation of number of PhDs supported by Euratom will be possible after projects are finished. However, it should be highlighted that all actions funded by Euratom have made effort to encourage career development of young physicists and engineers. Indeed, 5 % of projects’ budget was devoted to education and training, mainly at PhD level or above. This helps preservation of knowledge and improves its transfer between generations and across national programmes in nuclear fission.

As regards fusion, EUROfusion actions supported by the Euratom Programme ensure the availability of appropriate human resources in the fusion research, in particular in view of the need to train an ‘ITER generation’ of scientists and engineers to operate and exploit ITER, and to ensure the right balance and competences of physicists and engineers for fusion technology development. Fusion research and technology development requires also staff with skills going beyond PhD level, therefore EUROfusion also supports post-doc grants to scientists and specialised engineering grants to encourage excellence and career development of young engineers. EUROfusion Researcher Grants & Engineering Grants provide funding for around 10 Post-doc and about 20 engineers, respectively. Support for these grants is constantly adjusted to the expected shortage of skills in specific missions of the fusion roadmap. This explains why the target of 50 will be not reached. However, it should be pointed out that to maintain the manpower of the fusion programme the EUROfusion consortium supports PhD students in the research institutions working on fusion-relevant

thesis subjects, i.e. mainly on fusion plasma physics and engineering. Preliminary data shows positive trend in number of PhDs (about 650 in 2014 and 750 in 2019).

**Indicator 1:** 3.1 Training through research – the number of PhD students and postdoctoral researchers supported through the Euratom fission projects

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2007-2013	Milestones foreseen							2020
200		500					1 000	1 000
	Actual results							

Comment: Data will be available after release of final reports from all fission projects, expected after 2020.

**Indicator 2:** 3.2 The number of fellows and trainees in the Euratom fusion programme

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2007-2013	Milestones foreseen							2020
27		30					50	50
	Actual results							
	17	28	31	33	32	32		

Comment: Fellows (at post-doc level) and trainees (engineers) are selected on the basis of applications submitted following a call for proposals. Number and suitability of candidates varies from year to year.

**Specific Objective 4:** Supporting radiation protection and the development of medical applications of radiation, including, inter alia, the secure and safe supply and use of radioisotopes.

**Indicator 1:** 4.1 The number of projects likely to have a demonstrable impact on regulatory practice regarding radiation protection and on development of medical applications of radiation

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2007-2013	Milestones foreseen							2020
33		1				4	6	6
	Actual results							
		1		2	3		6	

Comment: Target reduced from 25 planned for 2018, due to the establishment in 2015 of the European Joint Programme (EJP) in radiation protection research (<http://www.concert-h2020.eu/>) with a Euratom contribution of EUR 20 million. It should be noted that research projects launched within the framework of the EJP programme are not included in the statistics for this indicator, but only projects launched directly by the Commission are counted.

**Specific Objective 5:** Moving towards demonstrating the feasibility of fusion as a power source by exploiting existing and future fusion facilities.

**Indicator 1:** 5.1 The number of publications in peer-reviewed high impact journals

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2010	Milestones foreseen							2020
800			800	800			800	800
	Actual results							
	200	450	325	700	680	822		

Comment: The baseline figure for the fusion peer reviewed articles published under Euratom FP7 (2007-2013) cannot be directly compared to the target, nor can it be compared to the actual figures produced by the EUROfusion consortium. The new indicator shows only the peer reviewed articles resulting directly from the implementation of the fusion roadmap, while the old indicator (the baseline) covered all peer reviewed articles published by any fusion association.

Source: Data from the Horizon 2020 impact assessment, SEC(2011) 1427, Annex 6, page 84.

**Specific Objective 6:** Laying the foundations for future fusion power plants by developing materials, technologies and conceptual design.



**Indicator 1: 6.1** The percentage of the Fusion Roadmap’s milestones established for a period 2014-2018 reached by the Euratom Programme

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
	Milestones foreseen							2020
	13 %	31 %	54 %	75 %			90 %	90 %
	Actual results							
	10 %	28 %	47 %	66 %	82 %			

Comment: The Fusion roadmap was adopted by the members of the European Fusion Development Agreement (EFDA) in 2012.

Availability of Data: Data not available yet – the Eurofusion report for 2018 will be submitted in 2019.

**Specific Objective 7: Promoting innovation and industry competitiveness.**

**Performance**

Technology transfer increases the involvement of industry in fusion research by allowing industry to further the research already performed in public laboratories. It also helps the research Community to retain scientific and technological leadership and excellence. Euratom Programme supports specific actions on technology transfer from fusion research labs to industry. This provides the short-term return on investment in fusion R & D by using, in other areas, the knowledge generated by fusion research, so-called spin offs. The EUROfusion consortium actively promotes technology transfer (FUTTA 2 project), which may also result in a higher number of spin-offs in the future. Research activities supported by the Euratom Programme resulted in about three patents on average per year.

Research by its nature, can create spin-offs or generate patent mainly toward the end of the projects. This is why the deadline for the target of six is not set for 2020 but to the end of Euratom projects. Consequently, we could consider that the indicators are on track.

Nevertheless, to strengthen promotion of innovation and industrial competitiveness, the Commission has launched recently a framework contract, which will allow the main European industrial partners to respond quickly to requests from EUROfusion for industrial expertise needed in the design of fusion power plant.

**Indicator 1: 7.1** The number of spin-offs from the fusion research under Euratom Programme

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2007-2013	Milestones foreseen							2020
4			5				6	6
	Actual results							
	1	2	2	2	3			

Comment: The target has been reduced from 10 planned for 2018. The new target is based on updated data on actual spin-offs from fusion research during 2014-2016. All actual figures are cumulative. The spin-offs from research are unpredictable – per definition they are a by-product of the main research activities.

**Indicator 2: 7.2** The patents applications generated and patents awarded on the basis of research activities supported by the Euratom Programme (average number per year)

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2007-2013	Milestones foreseen							2020
3		3	4				4	4
	Actual results							
	1	2	1	3	2			

Comment: No sufficient amount of meaningful data is expected for ‘patents awarded’ before 2020, because of the time necessary for a patent to be awarded.

Availability of Data: Data not available yet – the Eurofusion report for 2018 will be submitted in 2019.

**Specific Objective 8: Ensuring the availability and use of research infrastructures of pan-European relevance.**

**Indicator 1: 8.1** The number of researchers having access to research infrastructures through Euratom Programme support

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
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2008	Milestones foreseen							2020
800		800					1 200	1 200
	Actual results							
	872	958	1 039	909	1 350			

Comment: The 2008 figure concerns researchers using mobility scheme under the Fusion Programme. The target and milestones are based on the assumption that exploitation of the Joint European Torus (JET) will continue until 2020.

Availability of Data: the Eurofusion report for 2019 will be submitted in 2020.

**Specific Objective 9:** Improving nuclear safety including: nuclear reactor and fuel safety, waste management including final geological disposal as well as partitioning and transmutation; decommissioning, and emergency preparedness. The JRC will contribute to the development of tools and methods to achieve high safety standards for nuclear installations and fuel cycles relevant to Europe.

**Performance**

The programme is evolving to address innovative fields as accident tolerant fuels, small modular reactors or materials ageing for the long-term operation of nuclear power plants. These areas need to build new and reinforce existing competences and skills; this causes the temporary reduction of the results obtained, mainly in the number of publications that has a longer time cycle.

**Indicator 1:** 9.1 JRC policy support indicator – The number of occurrences of tangible specific impacts on Union policies resulting from technical and scientific policy support provided by the JRC

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2013	Milestones foreseen							2020
13		12±1	12±1	12±1	12±2	14±2	15±3	15±3
	Actual results							
	14	16	15	9	10	8		

**Indicator 2:** 9.2 The number of peer reviewed publications

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
average 2010-2013	Milestones foreseen							2020
72		72±4	72±4	72±4	72±8	60±8	50±8	50±8
	Actual results							
	90	80	45	62	72	36		

**Specific Objective 10:** Improving nuclear security including: nuclear safeguards, non-proliferation, combating illicit trafficking, and nuclear forensics.

**Indicator 1:** 10.1 JRC policy support indicator – The number of occurrences of tangible specific impacts on Union policies resulting from technical and scientific policy support provided by the JRC

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2013	Milestones foreseen							2020
15		14±1	14±1	14±1	14±2	18±3	22±4	22±4
	Actual results							
	16	22	19	11	12	11		

**Indicator 2:** 10.2 The number of peer reviewed publications

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
average 2010-2013	Milestones foreseen							2020
16		16±1	16±1	16±1	16±2	19±3	22±4	22±4
	Actual results							
	20	16	21	20	11	10		

**Specific Objective 11: Increasing excellence in the nuclear science base for standardisation.**

**Performance**

The results obtained in the JRC policy support indicator for this objective are below the expectations. The number of outputs delivered having an impact on the policies are mainly related to the provision of standards, which have a longer period to be accepted. It is expected that the number of standard measurements delivered and accepted will increase, as it is a cyclic process, reaching a higher percentage of the planned number of impacts. Considering the increasing importance of non-energy applications of nuclear science, it is worthy to highlight the high number of publications related to non-energy applications, mainly Targeted Immunotherapy against cancer.

**Indicator 1: 11.1 JRC policy support indicator – The number of occurrences of tangible specific impacts on Union policies resulting from technical and scientific policy support provided by the JRC**

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2013	Milestones foreseen							2020
15		14±1	14±1	14±1	14±2	13±2	12±2	12±2
	Actual results							
	10	9	6	12	11	7		

**Indicator 2: 11.2 The number of peer reviewed publications**

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
average 2010-2013	Milestones foreseen							2020
58		58±4	58±4	58±4	58±8	57±8	55±8	55±8
	Actual results							
	118	63	50	56	57	40		

**Specific Objective 12: Fostering knowledge management, education and training.**

**Performance**

The programme is providing training to EU students and professionals in the field of nuclear safety, (as fuel modelling and decommissioning), nuclear safeguards and security (as training for nuclear safeguards inspectors, nuclear security for front-line officers), nuclear science for standardisation (metrology, reference materials). Training course are being developed, although the impact on the EU policies presents some delay related to the target; one reason is that the training for professionals in nuclear security and nuclear safeguards depends on the needs of the JRC partners, as DG ENER, IAEA or Member States. The collaboration between direct and indirect actions of the programme will enhance the impact of the JRC programme on open access to its nuclear research infrastructures, optimising its use and fostering education & training activities and developing better tools and systems for knowledge management.

**Indicator 1: 12.1 JRC policy support indicator – The number of occurrences of tangible specific impacts on Union policies resulting from technical and scientific policy support provided by the JRC**

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2013	Milestones foreseen							2020
13		12±1	12±1	12±1	12±2	12±2	10±2	10±2
	Actual results							
	12	13	9	9	6	6		

**Indicator 2: 12.2 JRC scientific productivity indicator – The number of peer reviewed publications**

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
average 2010-2013	Milestones foreseen							2020
35		34±2	10±2	10±2	10±4	14±4	18±4	18±4
	Actual results							
	20	7	15	16	19	10		

**Specific Objective 13: Supporting the policy of the Union on nuclear safety and security.**

**Performance**

The JRC’s expertise obtained through the research programme allows providing support to the related EU policies. It includes support to the implementation of the nuclear Directives on safety, waste management and waste shipment, to instruments as the Instrument for nuclear safety cooperation as well as the Instrument contributing to security and peace through the implementation of the CBRN-E action plan. JRC is collaborating in the related scientific areas with key partner countries (USA, Japan) and is the Euratom implementing agent in the Generation IV International Forum. Important support was provided to the Euratom nuclear safeguards system and to the implementation of the EC support programme to IAEA. For both indicators, the milestones are almost achieved.

**Indicator 1:** 13.1 JRC policy support indicator – The number of occurrences of tangible specific impacts on Union policies resulting from technical and scientific policy support provided by the JRC

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
2013	Milestones foreseen							2020
7		6±1	6±1	6±1	6±1	12±2	18±2	18±2
	Actual results							
	11	7	13	7	11	10		

**Indicator 2:** 13.2 JRC scientific productivity indicator – The number of peer reviewed publications

Baseline	2014	2015	2016	2017	2018	2019	2020	Target
	Milestones foreseen							2020
			10±5	10±5	10±5	9±4	7±3	7±3
	Actual results							
		15	7	8	4	5		

**4. Contribution to Europe 2020 Strategy and mainstreaming of policies**

**Contribution to Europe 2020 headline targets**

*Table Contribution to Europe 2020 headline targets*

75 % of the population aged 20-64 should be employed
3 % of the EU’s GDP should be invested in R & D
The ‘20/20/20’ climate/energy targets should be met (including an increase to 30 % of emissions reduction if the conditions are right)

**Contribution to mainstreaming of climate action**

**Justification**

While the Euratom Programme aims at pursuing nuclear research and training activities with an emphasis on the continuous improvement of nuclear safety, security and radiation protection, it potentially contributes to the long-term decarbonisation of the energy system in a safe, efficient and secure way.

**Gender mainstreaming**

The Commission implements and monitors the gender dimension as follows:

Indirect Actions:

The Commission aims at improving gender balance in decision-making, in order to reach the target of 40 % of the under-represented gender in panels and groups and of 50 % in advisory groups. To date, women make up 19 % of experts in call evaluation panels and 52 % in advisory groups.

Direct Actions:

JRC manages the European Human Resources Observatory for the Nuclear Energy Sector (EHRO-N) in order to ensure the availability of data on human resources, including gender balance. In its Strategy 2030, the JRC declares itself as an equal opportunities employer committed to the objective of being fully gender balanced. This has been further developed in 2017 by issuing a gender balance strategy. The JRC has set-up a talent management programme developed taking into consideration the specificities of JRC and the female colleagues needs.