



European  
Commission

# Interim Evaluation of the Direct Actions under the Euratom Research and Training Programme

2014 - 2018



Joint  
Research  
Centre

INTERIM EVALUATION OF  
THE DIRECT ACTIONS UNDER  
THE EURATOM RESEARCH  
AND TRAINING PROGRAMME  
(2014 - 2018)

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# FOREWORD BY THE CHAIR

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Chairing an evaluation panel for the Joint Research Centre (JRC), in this year of the 60th anniversary of the signature of the Treaties of Rome, was a special honour for me. I am very pleased to introduce this interim evaluation report on the research actions of the JRC, which has been the home base for Community research in nuclear fission since it was created by the Euratom Treaty in 1957.

Besides identifying the usual kinds of improvement areas in this evaluation, we were pleasantly surprised to see how relevant the work of the JRC is. Many examples showed how the organisation is able to lead through coordination in this field, bringing together its own research efforts with those in the Member States. With all nuclear activities now concentrated in one directorate, the organisation is much better prepared to come to grip with its Euratom activities as whole.

Our familiarity with the full Euratom research programme pushed us towards making a plea for a 'rapprochement' between direct and indirect research actions. In the report, we encouraged Commission initiatives in this direction, convinced that a combined management for this programme will bring synergy and more effectiveness.

At the end of the evaluation we all agreed that the JRC could play more of a leading role, like 60 years ago but differently. There is no other body within the EU Institutions that can address the different aspects of nuclear energy with such a high level of expertise and knowledge. I am very much attached to the panel's wish that the JRC should develop itself into the voice of the EU on technical nuclear matters, and reach out in the nuclear field to become visible as the public expert organisation of the EU. I personally believe that this should even be mentioned in the JRC's mission.

It has been a very stimulating experience to conduct this evaluation with a group of such distinguished nuclear-energy experts and I am grateful for the opportunity given to me.

On behalf of the full panel, I want to thank Pieter van Nes for his constant support for our work, and the Director General Vladimír Šucha and his colleagues in the JRC for their expertise, their openness, and their help during the many exchanges throughout the evaluation.

**Jean-Pol Poncelet**

# EXECUTIVE SUMMARY

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This report presents an interim evaluation of the direct actions of the Joint Research Centre (JRC) of the European Commission under the Euratom research and training programme (2014 - 2018), conducted halfway through the programme by a panel of high-level independent experts between October 2016 and April 2017. The panel had extensive knowledge and experience in matters of Euratom research and the wider responsibilities of the European Commission related to nuclear safety and security in a European and an international context. This summary offers a preview of the main thrust of the findings, inviting to read further, detailed observations in the report.

## The performance of the JRC

The JRC performed well during the reporting period, maintaining a diverse programme of scientific and technical work in relation to nuclear safety and security, which supports the Commission to meet the needs of the EU and ensure a global influence.

The JRC has shown the ability to lead through coordination, bringing together its own research efforts with those in the Member States. Its new strategy should become as ambitious for its nuclear task as for its other activities.

It concentrated its nuclear work in one directorate and more in general the JRC has given successful follow up to recommendations from previous evaluations. To further enhance performance, the panel encourages the JRC to continue improving its programming, project management, organisational and resource management, and to prepare a demonstration of its cost-effectiveness for future assessments.

## Coherence between research in the JRC and in the Member States

What started as a single Euratom research effort in 1957 has become a programme with distributed management

and governance of separate funding for research in the JRC (direct actions) and in the Member States (indirect actions). There is a growing awareness that Euratom fission research would benefit from a 'rapprochement' between the direct and the indirect actions of the programme. Therefore in its recommendations the panel encourages the Commission to seek ways towards close integration of the content and the management of the direct and the indirect research parts of the Euratom programme.

## The European knowledge manager for nuclear safety and security; the European voice for nuclear

Responsible for the largest single nuclear research effort of the European Atomic Energy Community, the JRC shows its frontline position in this area in all modesty. There is no other body within the EU Institutions that can address the different aspects of nuclear energy with such a high level of expertise and knowledge.

As the European Commission's science and knowledge service, the JRC has an excellent position to communicate reliable information on nuclear matters, not only to the nuclear organisations, but also to the other stakeholders, notably the politicians and the public.

Therefore, and as the voice of the EU in technical matters, the JRC should also reach out in the nuclear field and become more visible as the public expert organisation of the EU in questions about nuclear matters, and as reliable source for balanced information about nuclear energy.

The positive conclusions and recommendations at the end of this report should help the JRC and the Commission preparing sound proposals for a Council regulation for the Euratom research and training programme 2019 - 2020 and for the next Euratom programme (2021 - 2025)

# INTRODUCTION

This report presents the interim evaluation of the direct actions under the Euratom research and training programme (2014 - 2018)<sup>1</sup>. Because the panel attaches great importance to the cohesion of the entire Euratom research and training programme, it needs to be clear upfront that the programme finances two kinds of actions: direct and indirect.

- The “direct actions” concern **direct research**, carried out by the European Commission in its Joint Research Centre (JRC) and concern nuclear safety, safeguards and nuclear security in the broadest sense, including support to the relevant policies of the Union. The direct actions of the JRC focus entirely on nuclear fission research.
- The “indirect actions” concern **indirect research** that is carried out by pan-European project consortia of private and public research groups. They address the safety of nuclear systems, waste management, radiation protection, but also the feasibility of fusion as a power source. Hence the indirect actions of the Euratom research programme concern both nuclear fission and nuclear fusion.

The Euratom programme (2014 - 2018) foresees a budget of EUR 559 million for direct research and EUR 315 million for the indirect research in nuclear-fission, safety and radiation-protection. In addition there is another EUR 728 million in the budget for indirect research in nuclear fusion.

The Council regulation<sup>1</sup> of the Euratom Programme stipulates that the direct and the indirect actions ‘shall be subject to separate evaluations’. Hence this report deals with the direct research actions of the JRC, while the indirect actions are evaluated in parallel by a different panel, which publishes a separate report<sup>2</sup>.

## The JRC 2030 Strategy

The current evaluation is marked by the adoption of a new JRC 2030 Strategy<sup>3</sup> in spring 2016, confirming the key task of the JRC today: to support EU policies with independent evidence, serving primarily as the European Commission’s science-and-knowledge service.

The strategy aligns the JRC stronger than before with the EU priorities, enhances its role as knowledge producer and as knowledge manager in the Commission. It covers aspects of governance and organisation, aiming at increased collaboration with internal and external partners, interdisciplinarity and enhanced efficiency.

These developments led to a thorough restructuring of the JRC in July 2016, shortly before the start of the evaluation. The reorganisation replaced the structure with geographically bound institutes of the past with a structure of functional departments, one of which is the knowledge-production department with six theme-orientated research directorates. The directorate for Nuclear Safety and Security brings all nuclear research activities together.

The JRC’s nuclear activities have been relatively stable in volume over the last 20 years and constitute a steady part of the JRC’s work programme and around 30 % of its resources. With all tasks concentrated in the ‘nuclear’ directorate, including the decommissioning activities, this is the biggest scientific directorate of the JRC.

The strategy pledges support to maintaining nuclear competences in Europe with JRC activities that complement those of the Member States, but contains no significant considerations regarding future options for this largest single area of the JRC’s work programme.

<sup>1</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

<sup>2</sup> Interim Evaluation of the Indirect Actions under the Euratom Research and Training Programme (2014-2018)

<sup>3</sup> The European Commission’s science and knowledge service: [JRC Strategy 2030](#)

## Evaluation methodology

The overall goals of the interim evaluation are stated in the terms of reference (cf. Annex 1), i.e. to improve the implementation of the direct actions of the Euratom Programme and to provide input for preparing the extension of the Euratom Programme for the period 2019 - 2020. The panel applied the following methodology to deliver on these goals.

A desk-analysis was performed on the background documents provided by the JRC and listed in Annex 2. The panel examined the final reports of the two preceding mandatory evaluations under the Seventh Framework Programme (FP7), i.e. the FP7 Interim Evaluation<sup>4</sup> and the Ex-post FP7 Evaluation<sup>5</sup> of the direct actions of the JRC (2007 - 2013). This led to the unanimous view that both previous panels produced very useful and in-depth reports and the panel soon agreed that the current evaluation should focus a good part of its attention on the follow-up given to the recommendations in the two previous reports.

The panel took note of an analysis of the JRC's research performance<sup>6</sup> in the period 2007 - 2015. This bibliometric analysis used widely accepted publication and citation based impact metrics derived from Thomson Reuter's InCites platform. It focussed on peer-reviewed articles in the field of Nuclear Science and Technology (NST), a field that covers 80 % of the JRC's 1023 nuclear research publications. It showed that the JRC standard is well above average with a respectable productivity. More than 15 % of the JRC publications are among the top 10 % highly cited articles<sup>7</sup> in the NST field, which places the JRC around 50 % above the world average on this metric. Hence the JRC ranks well amongst peer organisation like CEA, Oak Ridge Laboratory and Argonne National Laboratory.

The panel then agreed to examine the achievements in the various parts of the JRC work programme interactively with the JRC. For this purpose the JRC organised a number of hearings at the four JRC sites with nuclear activities, i.e. in Geel, Karlsruhe, Petten and Ispra. These physical site visits showed the reality of the

geographical spread of the staff and the research and laboratory infrastructure.

To facilitate a closer examination of the achievements, the JRC presented its activities according to the five work programme areas, which largely follow the division of activities necessary to achieve the programme objectives of Euratom Regulation. Table 1 presents the precise relation between the work programme areas and the objectives in the regulation. The five areas in the right-hand column have been distributed over twelve (sub)areas to split the activities in manageable parts for the evaluation. For previous evaluations the JRC nuclear activities were distributed in twenty-two projects.

The JRC produced activity reports for each of these twelve subareas (cf. Annex 3). The panel addressed a number of questions of an evaluation grid (Annex 4) for each area activity report, pertaining to the rationale and relevance, partners, implementation, deliverables and achievements for the different areas. Each activity report was analysed by at least two experts. Based on the various pieces of information gathered also during the hearings, the panel produced the most detailed qualitative part of the exercise, i.e., an assessment of the performance of the JRC in the different areas of activity in the Euratom Programme.

The visits to the research facilities and laboratories and the exchanges of views with management and staff, led to a list of findings and issues for the final report and the recommendations.

The recent restructuring of the JRC made some aspects of the evaluation more complex for the panel. While the reorganisation did not involve any physical movement of infrastructure or people, it did change the organisation and the JRC that presented itself to the panel was not the one that carried out the work during the period under evaluation. It is better to deal with one directorate than with three or four institutes with (some) nuclear activities. However, it was complicated for the JRC and the panel to find all the right translations and transformations of indicators and statistics from before and after the reorganisation.

<sup>4</sup> Interim Evaluation of the Seventh Euratom Framework Programme (2007-2011): Direct actions of the Joint Research Centre

<sup>5</sup> Ex-post Evaluation of the direct actions of the Joint Research Centre under the Seventh Framework Programmes 2007- 2013

<sup>6</sup> Bibliometric analysis of the research performance of the JRC under the Euratom Research and Training Programme (2007 - 2015)

<sup>7</sup> The percentage of publications in the 'top 10 % highly cited articles' in a field is an indicator of 'excellence'; a measure of high quality of research output in this field.

| ACTIVITIES TO ACHIEVE THE PROGRAMME OBJECTIVES STIPULATED IN THE EURATOM REGULATION (2014-2018) FOR THE DIRECT ACTIONS OF JRC  | JRC EVALUATION STRUCTURE: FIVE WORK PROGRAMME AREAS DISTRIBUTED OVER TWELVE SUB-AREAS OF ACTIVITY   |
|--|---|
| Improving nuclear safety including: <ul style="list-style-type: none"> <li>• Nuclear reactor and fuel safety</li> <li>• Waste management including final geological disposal as well as partitioning and transmutation</li> <li>• Decommissioning, and emergency preparedness</li> </ul> | Area 1: Nuclear safety <ul style="list-style-type: none"> <li>1.1 Nuclear reactor safety</li> <li>1.2.1 Safety of nuclear fuels and fuel cycle: Conventional nuclear fuels</li> <li>1.2.2 Safety of nuclear fuels and fuel cycle: Innovative nuclear fuels and fuel cycles</li> <li>1.3 Radioactive waste management</li> <li>1.4 Nuclear emergency preparedness and response</li> <li>1.5 Environmental monitoring &amp; radiation protection</li> </ul> |
| Improving nuclear security including: <ul style="list-style-type: none"> <li>• Nuclear safeguards</li> <li>• Non-proliferation</li> <li>• Combating illicit trafficking, and nuclear forensics</li> </ul>  | Area 2: Nuclear security <ul style="list-style-type: none"> <li>2.1 Nuclear safeguards</li> <li>2.2 Non-proliferation</li> <li>2.3 Nuclear security and prevention of CBRN hazards</li> </ul>   |
| Increasing excellence in the nuclear science base for standardisation  | Area 3: Standards for nuclear safety, security and safeguards   |
| Fostering knowledge management, education and training   | Area 4: Knowledge management, training and education  |
| Supporting the policy of the Union on nuclear safety and security  | Area 5: Non-energy applications of radionuclides and technologies   |

Table 1 Mapping of the activities in the Euratom Regulation onto the JRC work-programme areas

The methodology did not incorporate any questions regarding cost-effectiveness in a quantitative way. This requires complete, consistent and systematic information on input, output, results and impact of the activities and the panel reiterates what previous panels have said: if the JRC wants an external assessment of its cost-effectiveness, then it should take on the burden of proof. In other words, the convincing information that the work is carried out in a cost-effective way has to come from the JRC.

Finally, with the results of the desk analysis, the account of the follow-up given to the previous evaluations and the performance assessment in the various programme areas the panel had enough material to situate the JRC's effort in a broader context and to contribute constructive consideration on the way forward as requested in the terms of reference.

## Outline of the report

Following this introduction, Chapter 2 of the report discusses the follow up that the JRC has given to previous evaluations. Chapter 3 presents the panel's detailed assessment of the activities in the various areas of the JRC work programme. Chapter 4 presents the panel's views of future developments and opportunities that the JRC should focus on, while Chapter 5 complements a summary of findings and conclusions with a summary of strategic recommendations for improvements.

A glossary at the end of the report is followed by a set of annexes, covering the panel's terms of reference (Annex 1), a list of reference documents (Annex 2), the executive summary of the JRC's activity reports on the five areas of the JRC work programme (Annex 3), and the evaluation grid used for the area assessment (Annex 4).



## FOLLOW-UP TO PREVIOUS EVALUATIONS

The FP7 interim evaluation report of the JRC's Euratom activities<sup>4</sup> in 2010 sharply identified the essential issues of the direct actions. It recommended that the JRC should: improve the governance of its nuclear activities<sup>8</sup>, develop an ambitious 2030 vision and strategy<sup>9</sup> and report better and clearer on its results, achievements and impact<sup>10</sup>.

The ex-post FP7 evaluation report<sup>5</sup> in 2015 considered all JRC activities and made one high-level recommendation regarding the Euratom programme, i.e., that the upcoming interim evaluations for the Euratom Programme (2014 - 2018) should address the combined effects of the direct and indirect nuclear-fission research actions in the programme. It also made a number of useful suggestions in the running text, to which the current report will refer, where relevant.

The panel examined the follow-up that the JRC has given to these recommendations and the following sections summarise the findings.

### 2.1 A transparent, effective and efficient governance for the nuclear activities

#### 2.1.1 Improve and record formal customer consultations

The JRC reports a number of mechanisms in place to ensure that its nuclear research and training activities are in line with and complement the research and training needs of EU Member States. To enhance transparency,

the JRC established a policy of concluding agreements with key stakeholders and seeking active membership of the appropriate forums.

It is noted that the JRC participation in indirect research of the Euratom programme offers the functionality of a two-way transparent window that allows both the JRC and the institutions in the Member States to see what is happening on both sides of the window. The associated collaborative interaction with scientists in the Member States encourages alignment between the JRC's direct actions and the indirect actions to avoid unnecessary duplication and develop complementary competences. In addition, it facilitates access of scientists from the Member States to use the JRC infrastructure (expertise, facilities, knowledge and products) which are an integral part of the European Research Area (ERA).

On behalf of the Commission, the JRC and the Directorate General for Research and Innovation (DG RTD) participate in the meetings of the Council's Atomic Questions Working Party, where Council decisions regarding Euratom policy are prepared.

Since 2014, the JRC actively participates in the meetings and all relevant working groups of the Euratom's Scientific and Technical Committee (STC) with representatives of the Member States and Associated Countries. As good practice the JRC now hosts an STC meeting on its premises once per year to

<sup>8</sup> Enhance the transparency, effectiveness and efficiency of the governance of nuclear activities through:

a) Improving and recording formal customer consultations with respect to the definition, planning and implementation of the Euratom programme;  
b) Adopting a management structure that clearly assigns the overall responsibility for all nuclear activities in the JRC;  
c) Minimising the bureaucratic burden of quality management.

<sup>9</sup> Develop an ambitious 'Vision 2030' and associated strategy for its nuclear activities, which:

a) Starts from a stock-take of the impact of the JRC's past work;  
b) Builds on the Strategic Research Agenda (2009) of the Sustainable Nuclear Energy Technology Platform (SNETP);  
c) Defines a 10-20 year outlook for its nuclear-research-facility infrastructure with an associated implementation plan.  
d) It is recommended that the development of the vision and strategy include substantive consultations with external experts.

<sup>10</sup> Place more emphasis on transparent reporting of results, achievements and impacts. This would be facilitated by the use of specific, measurable, achievable, relevant, time-related (SMART) objectives at every level of the programme.

offer more visibility to its activities and supports STC working groups where necessary.

However, the planning behind the use of the various mechanisms and tools remains unclear and structured records or reports on formal consultations with relevant partners and beneficiaries regarding the definition, planning and implementation of the Euratom programme are missing. The JRC expects to further improve here through the development of new tools, and through the role and mission of the newly created Directorate for Knowledge Management.

The panel reiterates the message in this recommendation that there is scope for more accessibility to contents and the results of consultations with partners and beneficiaries regarding the definition, planning and implementation of the JRC Euratom work programme.

### 2.1.2 A streamlined management structure

Between 2010 and 2016 the JRC made a few attempts to implement the recommendation to adopt a management structure that assigns more clearly the overall responsibility for all nuclear activities. However, none of them addressed the root obstacle at the time, which was that the management was structured around geographic location rather than around themes or subjects. With nuclear activities distributed over Ispra, Karlsruhe, Geel and Petten and with each local institute manager responsible for nuclear activities carried out in his/her institute, a clear overall responsibility is hard to achieve and coordination mechanisms between them are more reassuring than effective.

Therefore the panel welcomes the new organisational structure of the JRC with one directorate responsible for the implementation of the Euratom work programme and the decommissioning of the JRC nuclear liabilities. The creation of this single 'nuclear' directorate largely meets the recommendation made in 2010.

The reorganisation has not given rise to any transfer of activities between the different JRC nuclear sites; they remain where the suitable facilities and expertise are

located. Diversity of sites and research infrastructure comes at a cost, but it is also an asset for a pan-European organisation like the JRC.

While the concentration of all nuclear research activities in one directorate appeared more natural, with coherent research teams during the hearings at the different sites of the JRC, the multifaceted programming of the JRC is handled in a different part of the JRC, by the directorate for 'strategy and work programme coordination' in Brussels. This work programme covers both nuclear and non-nuclear activities<sup>11</sup> and the directorate hosts amongst others a Work Programme Unit and a Euratom Coordination Unit.

The additional separated coordination and programming services are inherent to the international political environment of the JRC and maintain a certain level of complexity in the planning and the execution of the nuclear research programme. Political processes are different from research and knowledge production. Hence, the nuclear directorate focusses on the implementation and execution of the research; the Euratom Coordination Unit focusses on coordination with the Member States, coordination of policy support and the internal and external negotiation process for the Euratom programme.

The panel was concerned that the research-implementation and the programme-coordination parts of the JRC were not always aligned during the evaluation process. The panel will return to this issue in Chapter 4.2.3.

The concentration of the nuclear activities in one directorate since July 2016 led to the panel's conclusion that the JRC implemented this part of the recommendation. The immediate gains from all nuclear research under one umbrella were noticeable and of benefit for this evaluation. In the new setting, the panel's concern is that there has to be full alignment between the 'Directorate for Strategy and Work Programme Coordination' with its 'Euratom Coordination Unit' and the 'Directorate for Nuclear Safety and Security'.

<sup>11</sup> Commission Implementing Decision C(2016) 730 final, on the adoption of multi-annual work programmes under Council Decision 2013/743/EU establishing the specific programme implementing Horizon 2020 – The Framework Programme for Research and Innovation (2014-2020) and under Council Regulation (Euratom) No 1314/2013 on the Research and Training Programme of the European Atomic Energy Community (2014-2018) complementing the Horizon 2020 Framework Programme for Research and Innovation, to be carried out by means of direct actions by the Joint Research Centre for the period 2016 – 2017.

### 2.1.3 A minimised bureaucratic burden of quality management

Based on the legislative requirements in relation to nuclear The panel concludes that the JRC has taken steps to implement this part of recommendation, taking care that quality assurance requirements mentioned above do not impose undue burdens on JRC delivery. Continuation in this direction is encouraged. activities and facilities, dedicated integrated management systems are required in all nuclear sites. Accredited activities inevitably require an appropriate quality system and compliance to international standards (e.g. ISO 17025).

Since such management systems have to follow strict standardised rules, a certain administrative burden is unavoidable. By preparing a JRC-wide Integrated Management System within the entire organisation the JRC tries to keep this to a minimum. Moreover, this gives the nuclear directorate the freedom to apply a certified quality-management only when certification is a formal requirement.

In addition, having all nuclear activities in one directorate is an asset for streamlining key processes and reducing the overall burden from document control by synergy effects from the merger of similar activities.

The panel concludes that the JRC has taken steps to implement this part of recommendation, taking care that quality assurance requirements mentioned above do not impose undue burdens on JRC delivery. Continuation in this direction is encouraged.

## 2.2 An ambitious vision and associated strategy for the nuclear activities

Following failed attempts to establish an overall JRC strategy after the ex-post FP6 evaluation, the current leadership of the JRC successfully handled a corporate strategy as a matter of priority. Drawing amongst others on the ex-post FP7 evaluation<sup>5</sup> of the JRC, the JRC Director General presented a fully-fledged 2030 Strategy<sup>3</sup> that was endorsed by the Commission in spring 2016. The panel was pleased to see the clarity of the strategy with a sharply formulated vision 'To play a central role in creating, managing and making

sense of collective scientific knowledge for better EU policies' and the associated mission 'To support EU policies with independent evidence throughout the whole policy cycle, as the science and knowledge service of the Commission'.

The new JRC 2030 strategy foresees a firm place for the JRC's work in the nuclear field for decades to come, but keeps a low profile at the same time:

**'Attitudes to nuclear power vary across the Member States, but it is vital, at the very least, to maintain the safe and secure operation of existing and new plants and, where operation ceases, to undertake their safe decommissioning'**

**'The application of safeguard measures will continue to be a high priority, as will the fight against illicit trafficking of nuclear and radioactive materials and radiological protection. Maintaining nuclear competences in Europe is therefore essential. The JRC is playing its part in this. Its nuclear activities complement those of Member States'**

The JRC's view on its role in nuclear is not of the same clarity as the rest of the strategy. The fact that its role is driven by the Euratom Treaty does not mean that it does not need a vision. On the contrary, this panel supports the idea that the JRC should show ambition and vision in its nuclear work, as suggested in the previous evaluations. Eventually, its new strategy should become as ambitious for its nuclear task as for its other activities.

The Euratom Regulation attributes clearly defined research and training activities to the JRC; they constitute more than 25 % of the JRC's portfolio or 30 % of its combined Euratom and H2020 budget. However, what could be proudly demonstrated as a major competence is scattered over key orientations in a work programme that apparently needs to be organised according to the areas set out in the Commission's agenda for jobs, growth, fairness and democratic change. Taking the point of view of the Euratom programme, for the panel this is the opposite of the JRC showing ambition and vision in its nuclear work. The consolation is that all nuclear research activities are now concentrated in one directorate.

A few months after the restructuring of the organisation it is still early days to assess the actions of this new setting of the JRC. Nevertheless, the panel is encouraged by the JRC's explanation during the presentations that it started reflections on a more comprehensive approach to its nuclear activities and the associated infrastructure. With hindsight it may indeed be better that the JRC has its overall strategy in order first, before it can tackle the more specific task of developing a vision and a strategy for its nuclear activities. The challenge is there, because the JRC should embrace and, at the same time, be part of the Euratom strategy for this field, making use of its research infrastructure located in the four JRC sites Petten, Geel, Karlsruhe and Ispra. This is the reason why it should include substantive consultations with external experts from the Member States.

The panel observes that the JRC has not established anything like an ambitious long-term vision or a strategy for its nuclear activities, recommended in the previous evaluation reports. Up to now, the JRC is underexposing the significant share of nuclear work in its programme and its competence in this field. With the benefit of hindsight one can argue that the global JRC 2030 Strategy and the associated new organisational structure are prerequisites to bring the JRC in a position to start working on a coherent approach to its nuclear activities. The current report will address scope and modalities for this in Chapter 4.

### 2.3 Transparent reporting of results, achievements and impacts

In its account regarding actions taken on the recommendations of previous evaluations the JRC described some improvements since 2011, notably regarding defining, monitoring and disseminating the JRC Work Programme (WP) and its output for the benefit of an increased transparency of the programme.

As of January 2014, in accordance with the European Commission's rules to allow unrestricted access to research results under Horizon 2020, JRC researchers publish their peer-reviewed research papers in journals that are compliant with this Open Access policy. Hence JRC articles in peer-reviewed publications with a JRC

staff member as first or corresponding author are freely and publicly available. Opening access to all scientific articles is one more step in broadening the JRC's Open Access policy. More recently the JRC applies this policy also to data and databases.

This regards the access to results, but regarding transparent reporting on programme results, programme achievements and programme impact the panel has some concerns. The JRC presented its activities to the panel in twelve (sub)areas of activity, which are neither a one-to-one mapping of the objectives of the Euratom regulation, nor of the areas in the work programmes, nor of the organisational structure of the nuclear directorate. Moreover, the objectives in the 2014 work programme are different from the ones in the regulation. Then, they are adjusted in the 2015 and again in the 2016 work programme. Frequent changes in the objectives and the basic programme structures needs to be accompanied by accurate and detailed reporting to allow standard monitoring and evaluation protocols. Overall, the impression is that the JRC's nuclear programme should have a more target-oriented implementation. In the panel's view the reporting would benefit from a more industry-like approach to the projects with systematic performance evaluation (with detailed objectives, performance indicators, result analysis, shared evaluation, etc.). Hence, like in the previous evaluations, reporting of results, achievements and impact leaves something to be desired.

The panel noticed that the administrative data were disturbed by the changes due to the reorganisation, which are quite significant. **Before**, the nuclear activities were distributed over three institutes and four JRC sites and did not reflect the programme structure; **after**, the nuclear activities are in one directorate. In addition the structure that is offered for the evaluation, which is also the programme structure, is not reflected in the new organisational structure. Until three months before the evaluation, the JRC worked with headings for budgeting and the programming different from the headings of the 12 evaluation areas that have been used to present the results for the evaluation. Consequently, the resource allocation presented for the different areas for the period (2014 - 2016) were inconsistent.

Rigorous application of project-management techniques in the implementation of the Euratom programme would help achieving a clearer programming and

facilitate resource management at large. A systematically applied project-based approach with clear milestones and deliverables will achieve the maximum efficiency in the programme.

The panel found an improved programming, clearer objectives and clearer reporting, but the JRC has not achieved the rigorous programming and execution envisaged in the previous evaluations. From now onwards it should keep the areas stable for the rest of the programme and create clarity in its resource allocation. Rigorous application of project-management techniques in the implementation of the nuclear programme would be beneficial for the transparency and the effectiveness of the programme.

### 2.4 Synergy between the interim evaluations of the direct and indirect actions

The ex-post FP7 evaluation panel noted in their final report that the Council Regulation on the Euratom Research and Training Programme (2014 - 2018) stipulates that 'direct and indirect actions of the Euratom Programme shall be subject to separate evaluations'. In line with this, both evaluations are currently (end 2016) in progress, one for the direct actions and one for the indirect actions of the programme, carried out by two distinguished expert panels.

To give the appropriate follow-up to this recommendation the JRC and RTD started working in close consultation on the interim evaluations and decided to introduce both as one entry in the Commission's Agenda Planning. Eventually, in the course of 2017 DG RTD and the JRC will submit one package to the Commission's Regulatory Scrutiny Board and to the Council, which will contain both interim evaluations and a legislative proposal for the extension of the Euratom Programme 2018 - 2020. The package will address both direct and indirect actions. The JRC and DG RTD also agreed with the Commission's Secretary-General that the interim evaluations reports from the respective panels shall be covered by two Commission Staff Working Documents, one for each report, where applicable accompanied by other supporting documents (e.g. results from a public consultation).

This is like in the past: DG RTD and the JRC jointly prepare the proposals for the extension 2019-2020 and for the Euratom research programme of FP9 (2021 - 2025) and for this the JRC is also in closer contact with the STC.

Chapter 4.2 of this report reflects on the Euratom programme and its separation of the nuclear fission research in the JRC from that in the Member States and the panel will argue in favour of more integration.

The JRC has properly dealt with this recommendation, promoting the necessary synergy between the interim evaluations of the direct and indirect actions in a sufficient way. However, in the view of the panel the actions should go much further than joint evaluation of the indirect and direct actions to ensure more effectiveness of the activities carried out between now and the next mandatory evaluation in 2022. Therefore, the report further reflects on this in Chapter 4.1.2.

# JRC ACTIVITIES IN THE EURATOM PROGRAMME

This chapter contains the panel's assessment of the twelve areas of activity as they were presented by the JRC. The twelve areas reflect the three nuclear pillars: safety, security and safeguards with a small offset between the objectives in the work programme and the objectives in the Euratom research programme regulation. The text boxes contain comments from the evaluators regarding the work in the respective areas.

## 3.1 Area 1: Nuclear Safety

JRC activities under the heading of 'nuclear safety' cover the following sub-areas: safety of nuclear reactors, safety of nuclear fuels and fuel cycle (one conventional and one innovative area), radioactive waste management, nuclear emergency preparedness and response, environmental monitoring and radiation protection. There are synergy effects from third party work and it is often hard to distinguish which elements are direct research, participation in indirect research and/or partnerships with third parties.

### 3.1.1 Nuclear Reactor Safety

The JRC contributes to the improvement of nuclear safety and safeguards in non-EU countries in partnership with local regulators and Technical Support Organisations (TSOs). The JRC addresses challenges related to the safety of advanced nuclear reactors, contributing to the development of codes, standards and test methods for advanced materials.

The specification of research and training needs is determined largely through a collaborative approach involving relevant organizations and networks. There seems to be a good level of alignment of JRC work with the interests of others.

Listed partners and stakeholders are credible and the information on deliverables and impact is available but should be more refined.

#### EVALUATORS' QUOTES FOR AREA 1.1

The JRC has particular laboratories and scientific staff dedicated to basic and applied research that is not normally available in the Member States.

Achievements in research and development are comparable with more advanced research teams with advanced equipment.

JRC results are often achieved in collaboration or in partnerships. In such cases it is difficult to make a meaningful evaluation of the enabling contribution alone.

The Euratom Treaty is not explicit regarding a mandate for nuclear safety. The JRC activities in this field are the result of later policy decisions. Some of them are very recent like the Regulations regarding nuclear safety, to ensure that Member States use the highest standards of nuclear reactor safety or the Commission Regulation establishing a framework for nuclear safety and cooperation with non-EU countries<sup>12</sup>.

These policies provide a broad mandate for work in the technical areas identified, i.e. structural integrity and accident modelling. The links to ageing assessment in relation to long term operation and accident analysis in relation to emergency preparedness and response confirm some direct relevance to the situation in the EU. The direct actions may have impacts on

<sup>12</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, respectively, COUNCIL REGULATION (EURATOM) No 237/2014 of 13 December 2013 establishing an Instrument for Nuclear Safety Cooperation

nuclear safety in Europe, but the impacts are not well explained. Moreover, in some cases the provided impact information relates to activities in indirect actions.

In the panel's view this area would undoubtedly benefit most from further integration of direct and indirect research, and this will become even clearer later on in Chapter 4.1.2.

The activities generated tangible impacts by producing generally applicable software tools for accident modelling and accident management, as well as specific elements of the nuclear reactor safety in non-EU countries and some discrete tangible impacts at down-to-earth technical level, like standards for material characterisation.

A strong case might be made for the JRC to remain active in the areas of structural integrity and accident analysis in order to be able to maintain the capability to provide policy advice on these key topics. Examples are:

- The Accident analysis group to provide information in a nuclear crisis event;
- The SARNET-FP7 project, for source term determination in severe accidents and progression;
- The Clearinghouse initiative for operational experience feedback even with non-European countries (17 countries participation).

This is an area where there is a need to provide policy advice on nuclear safety topics and to conduct research in this field. However, both activities usually require different competences and it was not clear how the JRC is organised to provide the appropriate technical support for the provision of policy advice.

### 3.1.2 Safety of Nuclear Fuels and Fuel Cycle

#### 3.1.2.1. Conventional Nuclear Fuels

The activities in this area serve two major objectives. One is to provide tools and data for the safety analysis of light water reactor fuel behaviour during normal operation and design-base incidents. The other one is to provide reference data and knowledge on the high-temperature behaviour of nuclear fuel during severe accidents in order to assess the conditions of corium formation and the interaction of fuel with the concrete reactor base materials. The activities indisputably benefit to nuclear safety.

The area report provides concrete information on deliverables and impact, which is credible and very satisfactory. The achievements compare well with what is achieved elsewhere in the world. The JRC has several laboratory facilities and skills that are unavailable in most if not all Member States

#### EVALUATORS' QUOTES FOR AREA 1.2.1

The JRC has unique facilities, the scientific staff, the resources, and the connections with the Member States to have success in this work.

With a longstanding experience and highly skilled staff the JRC is well placed for these activities.

The JRC activities appear well connected with the main national players as well as with the international relevant projects.

These activities are not designed to generate tangible short term impacts on EU policies; they provide cutting-edge information to help increasing the fuel safety of the current nuclear fleet.

Knowledge about nuclear fuel is often proprietary; this might be a drawback to broaden the impact of the JRC activities in this domain.

The activities generate some immediate impacts for instance through the developments of software tools which increase the knowledge about fuel performance during normal and incidental conditions.

#### 3.1.2.2. Innovative Nuclear Fuels and Fuel Cycles

As Euratom's implementing agent of the Generation IV International Forum(GIF) Framework Agreement the JRC is active here on basic and applied research on the safety of fuels for five Generation-IV systems (SFR, LFR, GFR, VHTR, MSR), as well as on the four prototype reactors defined in the ESNII roadmap (ASTRID, ALFRED, MYRRHA, and ALLEGRO). While these activities are not immediately contributing to the broader EU strategic objectives, they are fully in line with the Commission decision to participate to the GIF and with the Council decision regarding the Euratom programme.

#### EVALUATORS' QUOTES FOR AREA 1.2.2

The JRC activities rightly deal with fuels for liquid metal cooled fast reactors, gas-cooled reactors and liquid molten salts reactors.

The relevance of the support to thorium fuels identified in the activity report as "outside the nuclear mainstream" is less obvious.

The JRC is a credible partner for these activities mainly carried out at the international level.

Like for the conventional fuels the JRC is well placed to work in this field with highly skilled staff and well-equipped facilities. Similarly, the deliverables and impact described in the area are credible and very satisfactory. The level of achievement meets world standards. The list of partners is credible, scientific publications and trainings satisfactory.

There are no expectations that the development of innovative nuclear fuels and fuel cycles impact EU policies in the short or middle term. Supporting the development of advanced nuclear technologies in collaboration with key international partners should have impacts on long term EU policies insofar the EU will be able to give up its current ambiguity regarding the potential role of nuclear energy for a sustainable energy policy.

#### 3.1.3 Radioactive Waste Management

The activities of the JRC in the area of Radioactive Waste Management cover every aspect of research, policy support and training.

In research: the JRC investigates the spent fuel morphology, the different properties of the spent fuel rods, and also the aspects of geological disposal have to be mentioned. The extensive research programme on the materials, which are used in reactors and to store the spent fuels, is a prerequisite to improve the safety of the storage. Spent-fuel-rod impact and bending tests, study of corrosion in seawater and geological repositories and X-ray tomography investigation of cracks are vital elements of this programme. Together these activities address many basic concerns of a sound nuclear waste management strategy. The various technical aspects listed under the eight research objectives (i.e. corrosion, mechanical stability, etc.) are illustrative of the main issues that need to be solved to receive green

light from the safety authorities and hence the agreement of the public.

In policy support: the implementation and review of the Waste Directive in the Member States would not be possible without the JRC's contribution. However, the way in which the output and the anticipated impact are briefly described is not commensurate with the political impact of the task. The JRC can play a strategic role in supporting the European Commission with specialised knowledge in this field. It deserves more attention to find out whether policy services assess and use this knowledge appropriately and if not, why.

In training: the JRC's contributions are important for the whole EU community since the nuclear-technology knowledge and technological capacity in Europe is in a general decline. When the present reactors will be decommissioned there is a real danger, that there will be not enough human and technical capacity and knowledge for that.

The JRC should do this work because the present and future decommissioning and the possible development of nuclear energy needs a pan-European approach with the JRC as the central point in a network of institutions doing research and giving scientific advice on regulatory issues. A different opinion on the use of the nuclear energy does not reduce responsibility for the safe long term storage of the waste. Hence a common approach makes sense and by its nature the JRC is, and has to stay, the focal point of any joint strategy in this field. However, this implies that the strategy, the actions, the results and the recommendations to decision makers are duly shared by all stakeholders: this requests JRC to actively contribute to the dissemination of the knowledge and the achievements.

#### EVALUATORS' QUOTES FOR AREA 1.3

We need an institution which is the central point of a network of institutions doing research and giving scientific advice on regulatory issues.

JRC achievements in this field are comparable with the best in class.

The JRC training activity is important for the whole EU community since the nuclear technology knowledge and technological capacity in Europe is in a general decline.

There is not one and only technical way to close the nuclear fuel cycle. Reprocessing and once-through-cycle have their own merits, each solution offering undisputed advantages. Therefore JRC should avoid favouring one solution against the other and must ensure that its efforts are well balanced.

The legal and regulatory framework in the EU (especially Directive 2011/70/EURATOM of 19 July 2011) opens a way to a potential shared infrastructure for the safe disposal of nuclear waste. Very few efforts are made to bring this idea into maturity. It is unlikely to succeed without shared support in the EU. The Commission can mobilise this support with the help of the JRC, because a successful, even very limited demonstration that safe disposal is possible, will enhance public confidence. The JRC should dedicate time and energy to making this possible.

### 3.1.4 Nuclear Emergency Preparedness and response

In this area the JRC fulfils the Commission's legal obligations to provide information on the radioactivity levels in the environment. To this extent, JRC develops and implements IT systems like the European Radiological Data Exchange Platform (EURDEP) as a part of the European Community Urgent Radiological Information Exchange (ECURIE) system, allowing an effective exchange of information in the event of a nuclear emergency.

#### EVALUATORS' QUOTES FOR AREA 1.4

Great service for EU governments and citizens. Not much impact on policies.

This is evidently a worldwide leadership.

In cooperation with the IAEA and ENSREG the JRC could undertake an effort to harmonise evacuation criteria in the Member States in case of a nuclear emergency.

The activities are impressive even though many of them are more like a development of a technical capability or provision of a technical service – in JRC language 'scientific and technical support'.

The activities completed strongly support Member States' responsibilities in relation to the EU and the IAEA. The activities have tangible impacts for EU Members States in relation to legal obligations for reporting in the event of an

emergency. They support 5000 measurement systems in 39 countries with the potential for deployment beyond Europe.

It is not clear from the reporting whether feedback is received from EU Member States or IAEA on the impact; without feedback it is hard to evaluate the impact of an activity and to define any future activities in this field.

The JRC can, and with these activities indeed does act independently for the benefit of the Member States. It makes very well use of its mandate and its expertise developed over many years. Developing and maintaining pan-European information exchange on radiation levels perfectly fits the JRC's mission.

### 3.1.5 Environmental Monitoring & Radiation Protection

Under the Euratom Treaty, the JRC is responsible for collecting, validating and reporting information on artificial radioactivity in the environment from the Member States Competent Authorities.

The Environmental and Radiation Protection project, together with the Nuclear Emergency Preparedness and Response project cover the technical aspects and the policy support needs related to the field. The communication and collaboration with the main stakeholders (Commission DGs, the national laboratories and institutions in the Member States, and partners outside EU) is efficient and effective; as it is notably demonstrated with the list of interactions, advice and consultations taking place through, e.g. biennial national experts meetings, workshops, or practical training courses.

The comparison and validation of the radioactivity measurement of different national laboratories on key radioactive nuclei (EC ILC project) is a significant justification of the nuclear activity of JRC. At the same time the workshops and training programmes facilitate a coherent monitoring programme in Europe. The MetroERM project is also a key project to deliver metrologically sound measurements and provide harmonized data bases. This project also provides a constant pressure on the national laboratories for high level performance. The European Radiation Maps (Indoor Radon, Cosmic, Terrestrial, Water etc.) provide invaluable information, just as the European Atlas of Natural Radiation. The software developed in the ECURIE project and the data base of the EURDEP project are also invaluable in the field.

#### EVALUATORS' QUOTES FOR AREA 1.5

The JRC laboratories are clearly leading on these subjects and provide support to other institutions in Europe and worldwide.

The JRC should significantly increase its visibility for the public and the media to become 'the' non-contradicted reference when it comes to radiation monitoring. Nobody else has the authority to play such a role EU-wide.

The activities under the heading 'Environmental monitoring & radiation protection' are directly linked to explicit responsibilities of the EU under the Euratom Treaty: collecting, validating and reporting on the radioactivity levels in the environment (air, water, soil). As such, they also demonstrate effective support to various DGs in the achievement of their own objectives and policies, which is a sound demonstration of the valuable role of the JRC. The JRC also highlights its role to increase public awareness and help people and institutions correctly apprehend the risks of radiation.

The JRC is in the right position to do that work because it requires a European institution to standardize and coordinate such a complex activity. At the same time many of these activities are under the EU law, therefore it has to be an EU institution for implementation. Typically these activities have to develop EU-wide to ensure robustness and consistency of the data, as well to help the numerous labs to standardize their practice and their methods. The inter-laboratory comparisons described in the report and during the presentations illustrated the need for streamlining and coordination.

Many of these activities prove that the JRC and the Member States institutions monitor the radiation in the environment with extreme care, precision and responsibility. The radiation monitoring of the environment is probably the most effective and extensive. Still, the public remains suspicious about radiation and nuclear activities and it would be appropriate to inform them correctly about this, which of course needs highly professional communication.

The issue of radiation – either from natural or artificial sources – is one of the most sensitive aspects of the nuclear controversy. The benefits of having a supranational body achieving convincing data analysis and dissemination are invaluable.

## 3.2 Area 2: Nuclear Security

JRC activities in this field cover R&D, innovation, equipment development, modelling, standardisation and testing, education and training, in-field assistance and outreach projects in the areas of nuclear safeguards, non-proliferation and nuclear security.

### 3.2.1 Nuclear Safeguards

The Euratom Treaty gives a clear role to the Commission as regards nuclear safeguards and the JRC helps fulfilling this role. There are many Council documents inviting the JRC to work to support the Euratom safeguards and to help strengthening international safeguards.

The JRC's activities in this area serve the purpose to provide Euratom support to both European and IAEA safeguards. All research to support IAEA safeguards is carried out through Member States support programmes and the activities supporting IAEA undertaken by JRC make up the second largest programme after that of the US. The activities are fully aligned with EU strategic objectives and policies for nuclear safeguards within the EU and provide the basis for support to the effective and efficient implementation of safeguards in third countries.

#### EVALUATORS' QUOTES FOR AREA 2.1

The activities described are impressive and delivery of such results relies heavily on the skill and experience of the staff working in this area.

The JRC is working at the forefront of current developments worldwide and the capability developed by JRC can be deployed in other regions.

No doubt that the JRC is among the best actors in R&D for nuclear safeguards.

JRC has established and maintains good relationships with all major international players in the nuclear safeguards area and is relied upon to make substantial in kind contributions to the IAEA and to international collaborative projects. Fulfilling the Euratom Treaty obligations as well as the NPT obligations is essential. The deliverables and impacts from cooperation with the IAEA and with some other key partners such as the US and Japan are clear and they make timely and valuable contributions to the operation of the international safeguards regime.

The various internal reviews and customer reviews provide a good challenge to the programme of work and ensure that the activities with the greatest potential impact are selected and implemented.

### 3.2.2 Non-Proliferation

Under nuclear non-proliferation the JRC covers concepts and methodologies, tools for open source information collection, strategic trade analysis and export control. The activities completed strongly support EU and IAEA work on safeguards and non-proliferation. They are fully aligned with EU strategic objectives and policies for non-proliferation within the EU, including EU policy for export controls and outreach activities in third countries. The activities provide the capability to support the EEAS on high priority international non-proliferation issues such as those related to Iran and DPRK.

Continuously improving the assurance of nuclear non-proliferation is a major objective shared by all Member States and the EU Institutions. Indeed, at many recent occasions the Council underlined that non-proliferation 'must receive the greatest possible attention' and invited the JRC to contribute. Besides developing advanced technologies for nuclear safeguards, it requires working on export controls, illicit trafficking of nuclear materials and nuclear forensics.

The activities generated many examples of impacts on EU policies such as the improvement and harmonisation on EU export control system, the formulation of dual-use export control guidelines or the scientific support during the nuclear negotiations with Iran. The support to the IAEA also impacts the efficiency of the global non-proliferation regime.

#### EVALUATORS' QUOTES FOR AREA 2.2

JRC has established and maintains good relationships with all major international players in nuclear non-proliferation.

Comparisons with what is achieved elsewhere in the world indicate that the JRC plays a leading role.

Making a worldwide comparison is difficult for these activities. For instance the major players in this field keep the methods and the outcomes of their use of open source information for non-proliferation confidential. However, considering the

small size of the team involved and that the JRC contribution appears satisfactory, the activities are quite effective.

### 3.2.3 Nuclear Security

The involvement in the field of nuclear security has been presented along three major lines: (i) research and development, (ii) support to Member States and international organisations and (iii) capacity building activities, all focusing on the detection and response to the illicit trafficking of nuclear and other radioactive materials, including nuclear forensics.

#### EVALUATORS' QUOTES FOR AREA 2.3

No national initiative could reach the same goals with an equivalent performance.

The long list of interested partners as well as participants in the dissemination of experience and beneficiaries of technological improvements is impressive and very convincing.

The achievements in this field contribute to improving the international credibility of the EU, thanks to the quality and the performance of the detection processes and the instruments that are developed.

The JRC has a number of collaborations with leading EU member states in this field, and with the US and the IAEA, in which JRC plays an essential role.

The work done and the achievements obtained are of high quality and can withstand any international comparison.

The JRC activities are fully aligned with EU strategic objectives and policies for nuclear security within the EU and provide the basis for support to the development of infrastructure and capability in third/partner countries.

Many activities described under the heading 'Nuclear Security and Prevention of CBRNE Hazards' are directly in line with the EU's nuclear security and non-proliferation policies and lie at the core of JRC's missions for the benefit of DGs, Member States and industry. Direct support is provided to Member States and their dedicated services as well as to partner countries worldwide. The cooperation with industry is duly considered, as it is essential in order to test, benchmark and assess the

capability of detection equipment commercially available and help develop and improve their performance.

The JRC is the appropriate organisation to do this work:

- There is an ongoing need to build infrastructure and capability within the EU;
- The JRC works collaboratively with the US and the IAEA and is fully aware of global priorities in this field;
- The JRC has a range of collaborations with leading EU Member State Organisations.

The JRC's role in developing methods and identify the right parameters for nuclear forensics is typical of the involvement of JRC in R&D, in supporting Member States and international organisations, in contributing to capacity building and finally in reaching out to disseminate the experience through training of experts and professionals. No national initiative could reach the same goals with an equivalent performance.

The achievements in this field contribute to improving the credibility of the EU at international level as well as to enhancing global security thanks to the quality and the performance of the detection processes and the instruments that are developed. International standardization is also enhanced.

Nuclear security and CBRN hazards infrastructure and capability at the member state and international level are not as well developed as for nuclear safety, nuclear safeguards and non-proliferation. The JRC has made an essential contribution to developments over the past decade in this important area and a continuing demand for capacity building and related research and development is anticipated in the coming years. The JRC capability in this area, and its ability to support nuclear security work through related scientific and technical capability, will continue to be in demand.

### 3.3 Area 3: Standards for Nuclear Safety, Security and Safeguards

The JRC activities on harmonisation and standardisation are part of the Commission's efforts to promote harmonised and internationally acceptable standards for nuclear safety, safeguards and security. They underpin the Commission's strategic vision for European standards communicated to Council and Parliament in 2011 in which the JRC is positioned to provide scientific input in the field of standardisation and harmonisation in its areas of expertise. They

are anchored in the Euratom Treaty and embedded in the initiatives of international organisations like the IAEA and the OECD-NEA. The Member States directly benefit from the measurement infrastructures and data provided by JRC.

The responsible unit for this works in three domains:

- Nuclear data for safety of present-day and innovative nuclear energy systems;
- Radionuclide metrology for the harmonisation of the EU radioactivity measurement system;
- Metrological tools for safeguards, safety and security.

The JRC hosts some specialised large-scale nuclear facilities (particle accelerators, underground laboratory, nuclear-reference-materials laboratories) which are unique in Europe. The JRC produces and supplies state-of-the-art nuclear reference materials and measurements, conformity assessment tools, and nuclear training and education in all its areas of activity.

#### EVALUATORS' QUOTES FOR AREA 3

The JRC with its unique infrastructure and experience, is and should stay the European reference for measurements and as such further promote EU-wide standardization.

While this activity is not strongly linked with general EU policies, it has very important practical meanings.

The work done and the achievements obtained are of high quality and unique

Positive impression. Quite effective use of existing infrastructure.

Developing new measurement methods and standards is at the heart of the JRC's mission. Measurements of nuclear data could in principle be done elsewhere, but the JRC's infrastructure is unique. The long list of interested partners is very convincing.

### 3.4 Area 4: Knowledge Management, Training and Education

Knowledge management, training and education form the lifeblood of the European nuclear industry. It enables transfer of knowledge and skills between

countries, institutions and individuals on a European scale. This is mandatory since the era of independent development of nuclear technologies is over and the EU has to compete effectively and contribute to the world-wide progress through the combined effort of Member States. The JRC's activities in this area address the research and training needs of the European Atomic Energy Community.

The JRC has a clear mandate and gives the right priority to these activities. It is the right place to do this work as it has the expertise, the infrastructure, the programmes and the data bases to initiate broad knowledge management activity. In fact, there is a long list of relevant initiatives like the Clearinghouse for operational experience feedback, the EHRO-N observatory for monitor human resources needs, the ECVET Credit System for vocational Education and Training, the EUFRAT facilities for basic data measurements with open-user access, the ESARDA Safeguards research association, the NUCLEOS project for knowledge management, and contributions to the IAEA safety guide on knowledge management.

These activities of the JRC are of paramount importance, as long as it takes care not to compete with universities in the Member States. It should give the organisation and coordination of an EU-wide effort in nuclear knowledge management and training a central place, which is very much in the spirit of the Euratom Treaty.

The open access to the JRC infrastructure, programmes and data bases is an invaluable asset of the work of the JRC. It has to be emphasized that in this activity the JRC should apply different methods for the different target groups. While the direct action of the JRC is more important for handling the data bases, the training of students and staff has to be made via networking. The networking of institutions involved in nuclear technology training is extremely important, since the human resources in nuclear technology in general need significant improvement in Europe.

The activities have generated some well used tools, e.g. the famous Karlsruhe Nuclide Card; the Nucleonica website for nuclear and nuclide basic data; MOOC open online courses.

The panel commends in particular the Nuclear Energy Observatory (NEO) initiative to deliver an information system that makes the results of Euratom research available in a coherent, well linked format, with intuitive navigation between projects, partners, reports, and key parameters. In the panel's view such platform could have the broadest scope including for instance the breeding of new talent with PhD and postdoc positions. In the panel's view there is scope to offer JRC seminars on universities campuses of the Member States, as well as training and retaining knowledge on decommissioning and off-site environmental remediation for countries phasing out nuclear power.

#### EVALUATORS' QUOTES FOR AREA 4

The achievements of the JRC in this field are probably the best in the world.

The JRC plays the central role in the EU, mainly using the ENEN network as a vehicle.

They present a credible list of partners involved in external steering committees, networks, associations, and platforms.

The 'EU Science Hub' by JRC is a good start but I have found very few videos related to nuclear activities.

I would recommend adding 'outreach' to the name of the unit.

Previous evaluation panels recommended increasing the visibility of JRC activities. In this area of activities the JRC has taken some small steps in this direction, but there is a great need for accurate information about nuclear energy among the public. This opens a parenthesis on 'knowledge'.

Knowledge plays a far more important role in shaping public acceptance of nuclear energy than for other technological areas<sup>13</sup>. Here 'knowledge' refers to the extent to which people are informed about nuclear power, nuclear technologies, radiation protection and the operation and inspection of nuclear facilities. The better they understand nuclear inspection activities - for instance through education programmes of authorised organisations like the IAEA - the more positive their perception of nuclear energy.

With its nuclear responsibilities under the Euratom Treaty, the European Commission is also an authorised organisation that should educate the public on complicated matter and the panel sees a clear and serious challenge for the JRC. With 'making sense out of knowledge' as its vision, it should also disseminate objective information to achieve a higher level of knowledge about nuclear programmes and its relation with a clean energy production. The challenge is to do this in a credible way without being perceived as a promotor of nuclear energy. The JRC has the capabilities to do this for the many different target groups that it is already addressing in this area: European and national decision makers, power-plant managers and operators, national nuclear authorities, monitoring institutions, waste site managers, students and not in the least indeed the public.

In particular the panel felt that the JRC could do more to disseminate unbiased and understandable information on nuclear energy to the public. To achieve the largest possible impact, all traditional and modern communication channels can be used, including press, TV, internet services and social media, as well as various kinds of informative events to balance the public's overexposure to scary pieces of information. The events could be organised by different organisations in various countries, while the JRC could serve as a coordinator and the central hub. 'Hands on CERN' is a good example, where pupils and students simultaneously participate in exercises at several national laboratories, under the supervision of experts from CERN, connected via internet.

#### 3.5 Area 5: Non-Energy Applications of Radionuclides and Technologies

The two main fields of non-energy applications are (i) medical and (ii) electricity and heat generation for space applications.

While radiotherapies usually rely on other nuclear-related methods (e. g. proton therapy), the Targeted Anticancer Therapy (TAT) using alpha emitters is quite remarkable. Although cancer therapy is not in the main stream of the JRC's duties, these types of applications are certainly worth the support. The same applies for the development of energy sources for deep space explorations.

Both the general public and decision makers are hardly aware that some nuclear technologies are crucial for progress in top-level science as well as in the

quality of everyday life. Advertising these non-energy applications of JRC nuclear activities helps to enhance this awareness.

The panel was undecided on whether these activities satisfy the formal criteria of addressing the research and training needs of the European Atomic Energy Community and whether it is clear why these activities received JRC priority. On the one hand, the contribution of these activities to broad EU objectives seems obvious and impressive, as both fields are in front-line science, but it is not a substantive activity of the JRC. The Euratom Regulation for the (2014 - 2018) programme does not explicitly mention these non - energy applications under the 'activities necessary to achieve the programme objectives' for the JRC. On the other hand, with the stated vision to play a central role in creating, managing and making sense of collective scientific knowledge, why exclude important areas like nuclear medicine and space exploration from the programme?

Non-energy applications of nuclear (radionuclide) technologies are closely connected to energy related activities. The effect of the activity of the JRC is useful in these fields but not being included in the primary mandate of the JRC gives rise to supportive reactions for the achievements and reserved reactions because of the supplementary character, which should be better defined in the programming of the JRC.

#### EVALUATORS' QUOTES FOR AREA 5

Very small teams make top-science achievements of utmost importance for society.

It is not obvious that the JRC is the right place to do this work.

Involvement in front line research prepares the JRC for its policy-support mission. That these activities are at the periphery of the JRC programme should not be an obstacle, if they are realised in collaboration with leading European laboratories and industries

With all the nuclear technology capacity and knowledge in JRC it would be a pity not to use them for the benefit of these fields.

<sup>13</sup> Communicating about Climate Change and Nuclear Energy by Shirley Ho; Subject: Climate Change Communication Online Publication Date: Nov 2016; DOI: 10.1093/acrefore/9780190228620.013.440



# FUTURE OUTLOOK

## 4.1 The broader context

### 4.1.1 Nuclear energy policy in the EU

**'... 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<sup>14</sup>...'**

**'... putting the EU at the forefront of... the world's safest nuclear generation is central to the aim of turning the Energy Union into a motor for growth, jobs and competitiveness.'**

These are encouraging statements in the Commission's Communication on Energy Union<sup>15</sup>, but are there any policy measures in place to put the EU at the forefront of the world's safest nuclear generation? Is the EU technological leader in this field and are there programmes to maintain this leadership? The panel asked these rhetorical questions to illustrate the political ambivalence under which the nuclear energy community is operating.

On the one hand, half of the EU Member States have nuclear power plants, which produce nearly 30 % of the EU's electricity, and some of them have new nuclear power plants under construction or planned. Nuclear is and remains an important energy source for a substantial part of the EU and a serious option for countries that want to give a high priority to energy security and decarbonisation of its society. In fact, the whole world benefits from safe and secure nuclear energy on the market, also those countries which do not have nuclear plants on their territory.

On the other hand public opinion on nuclear energy has cultural and historic roots and varies throughout the continent. The dispersed attitude of Member States

regarding the use of nuclear energy makes it practically impossible to reach consensus on any European approach in this field. Add to this Germany's exit from nuclear energy and the UK's decision to leave the EU and Euratom and it becomes clear that today, it is more difficult than ever to agree on new initiatives in this field, to work on new concepts or to develop technologies for new nuclear power plants.

The Commission's White Paper on the Future of Europe presents five scenarios for how the Union could evolve by 2025. One option is to allow willing Member States to do more together in specific areas. This could open up new possibilities for policy action in the nuclear field, but it will not create a European attitude or a European approach towards nuclear energy.

Nevertheless, being the strongest regulated sector at international level, nuclear energy needs governments' support and oversight to operate at the highest level of safety. The principles of fair competition and a level playing field for different energy sources need to be respected. In this respect the JRC's activities in support of the sector are of utmost importance.

Where there is a need for an objective framing of the nuclear debate, the panel believes that it is the JRC mission to contribute to this debate and it encourages the JRC to be the voice of the EU when nuclear expertise is required. The JRC can assist when it has become too complex for both the public opinion and policy makers to value the merits of nuclear energy compared to those of other energy sources (cf. Section 3.4), providing accurate information on the contributions to decarbonisation and the benefits for climate action notably as part of its mission to disseminate independent knowledge. It has to assist in working towards policy measures that can realise the ambitions for nuclear energy technology in Europe, as displayed in the proposals for the Energy Union.

<sup>14</sup> See European Energy Security Strategy, COM (2014) 330

<sup>15</sup> Commission Communication on the 'Energy Union Package: A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy', COM (2015) 80 final

#### 4.1.2 A coherent Euratom programme for nuclear fission research

The Euratom programme for nuclear fission is one of the most relevant instruments to support the safety and security of nuclear energy in the EU and the world. It distinguishes direct research, carried out by the European Commission in its Joint Research Centre (JRC) and indirect research, carried out by pan-European project consortia that include SMEs, large companies, universities and research centres. Before drawing any conclusions on the future one has to understand exactly the situation of the JRC's activities in the Euratom programme today and in this broader context it seemed inappropriate to limit the panel's considerations to the direct actions of the JRC and deal with them in isolation.

With this year's sixtieth anniversary of the JRC in mind, the panel wondered how the focussed Euratom research programme from the 1950s has over the decades become a programme that separates nuclear fission research in the JRC so rigorously from that in the Member States. Having seen the quality and the span of the activities of the JRC in this field, the panel was surprised not to find more encouragement for deeper integration of the indirect and direct research, neither in previous evaluations of the JRC's direct actions, nor in the last ex-post FP7 evaluation of the indirect actions<sup>16</sup>.

To shed some light on these questions, the panel prepared a more detailed analysis of the Euratom programme as a whole, focussed on the budget, the content and the management to pave the way for policy makers to seek a coherent approach for Euratom's fission research programme.

##### 4.1.2.1. Budget

The Euratom programme (2014 - 2018) has a total budget of EUR 1.6 billion of which EUR 874 million for nuclear fission research. Two thirds of this nuclear-fission

budget go to the direct actions of the JRC and one third goes to the indirect actions of the Member States.

This is the simple way to present the number, but according to the Euratom Council regulation 'the JRC should continue to generate additional resources through competitive activities, including participation in indirect actions of the Euratom Programme...' The whole nuclear community knows that the JRC does participate in indirect actions and because of such an open-ended clause, there is concern and confusion over how much money exactly goes to the Member States (indirect actions) and how much to the JRC (direct actions).

The extent to which the JRC participates in indirect actions and which share it takes from the indirect actions was unknown to the panel. In fact, all necessary details about the indirect actions can be found via the [CORDIS Projects & Results Service](#). It is also hidden in the text of the Commission Implementing Decision on the JRC work programme<sup>16</sup> and it is not completely clear why this kind of information is not made available proactively. In the first part (2014 - 2016) of the programme, the JRC participates in 9 out of 23 indirect research projects. On average the JRC takes five per cent of the EU contribution to these nine projects. The total amount that the JRC received for this participation two-thirds through the programme, is just below EUR 1.9 million, i.e. less than one per cent of the total budget committed to indirect actions for fission research in this field. [Figure 1](#) shows the detailed distribution between fusion and fission, direct and indirect actions, including the JRC's share of one per cent extrapolated to EUR 3 million in the indirect actions.

The unknown size of the JRC's share only leads to wthe indirect actions, but certainly not the huge competitor for funds. Hence at this point the panel recommends absolute clarity about the JRC budget and the Commission should publish such numbers more clearly to avoid misunderstandings about the share of the JRC



<sup>16</sup> Ex-post Evaluation of indirect actions of the Euratom Seventh Framework Programme and of the Euratom 2012 - 2013 Framework Programme  
<sup>17</sup> Page 22 of the Annex to the Commission Implementing Decision on the JRC work programme (ref. 11)

##### 4.1.2.2. The content of the fission programme

The Council Regulation for the Euratom programme<sup>1</sup> specifies the various activities necessary to achieve the programme objectives for the direct and indirect actions. They are presented separately without any link, except that the JRC direct actions are tasked to seek synergies with cross-cutting initiatives, with the aim of optimizing human and financial resources and to avoid duplication of nuclear research and development in the European Union.

To develop a better feel for what is contained in the various activities of the direct and indirect actions, [Table 2](#) shows them side by side. This comparison shows that there is great potential for synergy between direct and indirect actions in the areas 1, 4 and 5 (nuclear safety, education and training and radiation protection and non-energy applications) and that the indirect actions do not address areas 2 and 3 (nuclear safeguards, nuclear security and non-proliferation).

| DIRECT ACTIONS FOR NUCLEAR FISSION RESEARCH WORK PROGRAMME JRC 2017  | INDIRECT ACTIONS FOR NUCLEAR FISSION RESEARCH ACTIVITIES OF THE INDIRECT ACTION   |
|--|---|
| Area 1<br>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; | Supporting the safety of nuclear systems; Contributing to the development of safe, longer-term solutions for the management of ultimate nuclear waste;  |
| Area 2<br>Improving nuclear security including: nuclear safeguards, non-proliferation, combating illicit trafficking, and nuclear forensics;   | -   |
| Area 3<br>Increasing excellence in the nuclear science base for standardisation;   | -   |
| Area 4<br>Fostering knowledge management, education and training;  | Supporting the development and sustainability of nuclear expertise and excellence in the Union; including activities to guarantee the availability of suitably qualified researchers, engineers and employees in the nuclear sector in the Union in the long term |
| Area 5<br>Non-Energy Applications of Radionuclides and Technologies  | Supporting radiation protection and development of medical applications of radiation  |

**Table 2** Activities for the direct and indirect actions for nuclear fission in the Euratom programme

##### 4.1.2.3. Management and governance of fission research

The management and governance of Euratom's fission research today looks as follows:

- The Commission manages the direct and indirect actions respectively in the JRC and in the Directorate General for Research and Innovation (DG RTD).
- The two Directorates General that are managing the nuclear fission research programme report to different Commissioners:
  - The direct actions fall under Commissioner Tibor Navracsics, who is responsible for the Commission Directorate General for Education and Culture (DG EAC) and JRC.
  - The indirect actions fall under Commissioner Carlos Moedas, who is responsible for DG RTD.
- The Commission is advised by the Euratom's Scientific and Technical Committee (STC) with representatives of the Member States and Associated Countries;

an organ established by the Treaty. DG RTD is responsible for the secretariat.

- The JRC implements the direct actions assisted by a Board of Governors established by Commission decision in 1984 with representatives of the Member States and Associated Countries.
- DG RTD implements the indirect actions supported by a Programme Committee with representatives of the Member States and Associated Countries.

What started as a single Euratom effort in the JRC in 1957 has become a dispersed programme with separated actions in Member States and in the JRC with a completely diverse management and governance.

#### 4.1.2.4. Synthesis

In the panel's view an effective Euratom fission programme should work with a coherent view of the activities in the JRC and in the Member States' organisations. This to achieve maximum synergy between the indirect and the direct actions and to fully exploit the potential for the highest efficiency within the programme and effectiveness of its results.

The ex-post FP7 evaluation of the JRC proposed that the current interim evaluations should look at the combined effect of direct and indirect actions, while for instance the evaluation panel for the indirect actions asked for more 'direct/indirect' coordination in the area of training. The demand for a synthetic and synergistic approach comes from various sides, but the need is for more than just that.

For example, the current construction that the JRC participates in different consortia competing for funding is an anomaly. The JRC should participate in every project where this has an added value, albeit only for knowledge management purposes.

Research output and results from direct and indirect actions of the Euratom programme are made available through scattered websites and sources. This fragmented situation hampers an overall evaluation and an impact assessment of the integral Euratom fission research programme as discussed in Section 2.4. The Euratom programme needs operational 'rapprochement' between direct and indirect research actions as soon as possible and the panel welcomes every step in this direction.

The JRC's initiative to develop a Nuclear Energy Observatory (NEO) to make the results of all Euratom research available (cf. Section 3.4) is an example of immediate effect without much programmatic or political implications, but the panel would really like to see things going one step further. Any significant improvement in efficiency and effectiveness has to come from operational integration of the content and the management of the direct and the indirect research parts of the Euratom programme.

In the panel's view even fully integrating the ex-post evaluations of both indirect and direct research of the Euratom programme in 2022 is far too late to influence the design of the nuclear part of the Ninth Framework Programme (FP9).

Therefore, the panel recommends that the Commission should already include one ex-post evaluation of the nuclear fission programme in 2022 in the proposal for the Euratom extension (2019 - 2020).

In the same spirit the panel recommends that the Commission should prepare an integrated, coherent proposal for the direct and indirect actions for nuclear fission research for the nuclear part of the Ninth Framework Programme (FP9) coordinated with the Member States programmes and managed consistently by the Commission services.

Moreover, for FP9 the panel believes that the only fruitful way forward is that Commission makes an integrated, coordinated, coherent proposal for the direct and indirect actions respecting the unique competence of the Commission and the JRC in areas like nuclear safeguards.

#### 4.1.3 The need to breed new talent

A realistic image of the coming decades for nuclear energy in the EU is that some new nuclear power plants will be constructed and - due to the high economic attractiveness of life extension - there will be intensive upgrades of nuclear power plants. As a matter of resilience, not only the nuclear-energy sector will need highly educated personnel with highly specific knowledge, skills and competences, also the increasing number of medical applications of radiation will need specialised and highly trained professionals.

The need for national and international research and training programmes is obvious. The adequate supply

of skilled people has to be ensured and the nuclear safety culture to be strengthened. The key concern of policy makers, regulators and industry worldwide is that human resources could be at risk, especially because of the high level of retirement expected in countries with nuclear installations and a lack of experience in newcomer countries worldwide. Indeed, countries will only seek advice and be influenced by those who are at the cutting edge of nuclear technology. If putting the EU at the forefront of the world's safest nuclear generation is part of the aims of the Energy Union<sup>15</sup>, then nuclear training and education has to be high on the agenda.

JRC research and training programmes contribute to maintain a high level of competence and expertise in the EU. Its nuclear infrastructure is of crucial importance for this purpose. Most academic institutions in the EU Member States do not have facilities for handling nuclear materials as might be needed to train students and young experts in the fields of safeguards, security, fuel cycle or physics and actinide chemistry. With the exception of France, such specialised facilities are very limited in Member States. Thus, the hands-on practical training and work experience that the JRC offers in its laboratories to students, young researchers, trainees and PhD students is essential to guarantee that the next generation of nuclear scientists in the EU has the skills and knowledge for key areas of nuclear technology.

The JRC lists numerous agreements with research and educational institutions within the EU and abroad and it is partner in a range of nuclear fission scientific networks. Through these contacts it is credible that the JRC is appropriately involved in the relevant processes and committees that discuss and define the research and training needs in the nuclear field including those of industry, regulatory authorities and other institutions in the Member States. Nevertheless, and it has been pointed out in other Euratom evaluation reports, training and education is the programme area with a high potential for synergy between direct and indirect actions. This needs to be exploited without delay.

Considering the JRC's high level of competence in the various fields the panel sees ample scope for the organisation to foster an integrated approach between the nuclear safety, nuclear security and safeguards

communities (the three S's). Here as well, the JRC offers an excellent European infrastructure where these three S's meet and where Euratom can train and build nuclear engineers and scientists who understand how they interact.

What started as a single Euratom effort in the JRC in 1957 has become a programme with a distributed management and governance with separated actions in Member States and in the JRC. In the view of the panel a healthy programme for research and training in nuclear fission is mandatory and it recommends a strong Euratom programme to maintain the EU's capabilities in this field and to reinforce its capacity to manage nuclear safety and security through the JRC and the relevant research and training institutions in the Member States.

Therefore, the panel recommends an integrated, coherent proposal for the direct and indirect actions for nuclear fission research for the nuclear part of the Ninth Framework Programme (FP9) coordinated with the Member States programmes and managed consistently by the Commission services taking into account the unique competence of the Commission and the JRC in areas like nuclear safeguards. In anticipation, the Commission should already include one ex-post evaluation of the nuclear fission programme in 2022 in the proposal for the Euratom extension (2019 - 2020).

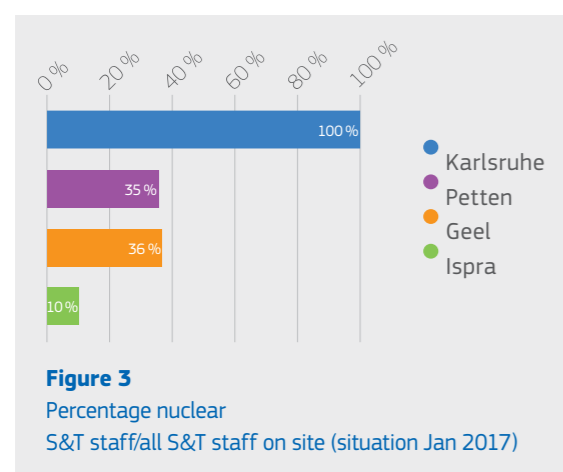
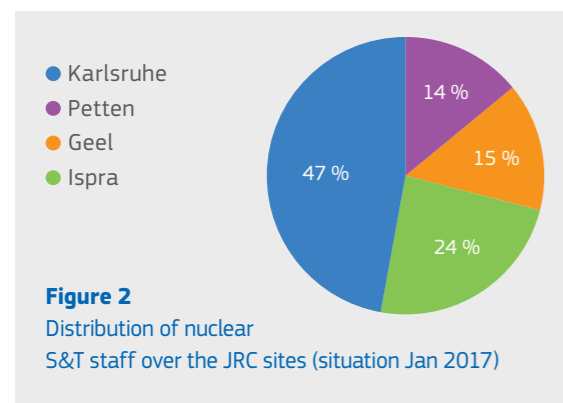
The need to ensure adequate supply of skilled people is obvious. National and international research and training programmes are necessary to strengthen the nuclear safety culture. JRC research and training programmes contribute to maintain a high level of competence and expertise in the EU. Its nuclear infrastructure is of crucial importance for this purpose. In general the panel recommends that the JRC continues and where possible reinforces its training and education activities.

## 4.2 The JRC and the Euratom programme

### 4.2.1 Resources

Whereas the budget allocations appeared relatively well under control, the panel found a complex staff situation in the JRC. The distribution of nuclear staff over the different sites is not just a matter of making a head count in the nuclear directorate. One also has to take into account corporate-level administrative staff members; they work ~30 % for Euratom. With most of the administrative staff based in Ispra this gives a distorted image: there is far more 'Euratom staff' in Ispra than expected based on the research infrastructure there. Then, a certain number of nuclear staff (~58) work for the decommissioning budget. Furthermore, some S&T staff members serve both Euratom and Horizon 2020 JRC projects.

To develop a feeling for the situation at the different sites the panel asked the distribution of nuclear S&T staff over the JRC sites in per cent and the ratio of nuclear scientists over the total number of scientist on the site. The results are given in Figure 2 and Figure 3



This is enough complexity on a year's basis, but how does the JRC deal with changing key orientations in the programme and did it cope with the recent reorganisation? Perhaps the completely new set-up of the nuclear directorate is responsible for the inconsistent staff numbers that the panel obtained for the different activities over the last three years. Nevertheless, the panel considers that there is an issue here in an otherwise well-functioning organisation: a detailed view of the staff situation on a year by year basis is missing, whereas accurate information on staff resources is vital, particularly when forced staff cuts are needed.

The announced Commission-wide staff cuts are affecting the JRC and they will continue, possibly even more severe as of the moment that the United Kingdom leaves the EU and Euratom (Brexit). Examples communicated during the hearings showed that the current staff reduction (one per cent per year for five years) looks still bearable in absolute numbers. However, sometimes during the visits to the research facilities the effects took a different dimension.

The nuclear directorate has a number of highly specialised laboratory skills with teams of five to ten highly skilled technicians. Some of these teams underwent staff cuts of two to four people, which in relative terms may come down to a reduction with more than half of the staff. At the level of the review, none of the activities were reported as being on a list to be phased out.

As for the panel it seemed very much that cuts were made by not replacing people who leave their post for retirement or other reasons. The oral statements during the evaluation have not been able to assure the panel that the JRC is entering the future with a well-thought-out staff-reduction plan for its nuclear directorate.

To know where to cut, management needs to have a documented view of the capabilities, staff resources and infrastructure. Therefore the JRC should make an inventory of the technical teams in its nuclear directorate, establish the critical limit for the size of each team and the priority class (1, 2, 3) of these teams. All this, to take action to maintain a certain capability or, if needed, to achieve an informed decision on which capability to suppress.

There was also some concern that full alignment with the Commission's staff policy forced the JRC to suppress existing constructions (e.g. JRC grant holders) to bring young academic talent to its laboratories. Indeed, the process to phase out these flexible staff engagements will start sometimes in the near future. However, the panel was pleased to learn that the extensive efforts of the JRC with the Human Resources Department of the Commission have secured new possibilities for hiring and bringing on site young (PhD) students. This includes a Collaborative Doctoral Partnerships (CDP) that will train a new generation of doctoral graduates in the JRC. In December 2016 the JRC launched a first call for an Expression of Interest from higher education institutions from Member States and countries associated to Horizon 2020 to participate such a CDP that will co-develop, co-host and co-supervise doctoral studies between higher education institutions and the JRC.

### 4.2.2 Infrastructure

The JRC manages and owns an important part of the European nuclear fission infrastructure. It does this in good coordination with the Member States, taking into account currently existing capacities and future developments of infrastructure in the Member States. The JRC has issued a short report to the STC with a description of existing infrastructure like accelerator-based neutron data facilities, laboratories for the preparation of nuclear reference materials, underground low-level radioactivity measurement laboratory, hot-cells, etc. The JRC infrastructure in Karlsruhe is currently being renovated to comply with the highest safety and security standards for such installations (as requested by the licensing authority) and with the EU 20/20/20 climate and energy goals. The Van de Graaff facility for nuclear data measurements has been replaced by a new Tandem accelerator facility that will be put in operation soon. The panel has seen the modernised peripheral equipment that will allow an efficient, reliable and durable open access policy for researchers from the Member States.

The valuable software infrastructure of the JRC may be added, like for example the TRANSURANUS thermo-mechanical code for fuel performance during normal and incidental conditions and its contribution to the development of the ASTEC reference European code for simulation of NPP severe accidents and management, and its improvement for severe accidents modelling and accidents management (CESAM project).

Other infrastructure, e.g. for nuclear target production and reference materials and measurements sometimes dating from the late 1960s require investments to be brought up to modern safety and security standards. The panel was informed that plans for an integrated nuclear laboratory - INS3L (Ispra Nuclear Safeguards, Security and Standardisation Laboratory) in Ispra were adopted, while laboratory facilities for materials performance and component integrity in Petten will be relocated and refurbished.

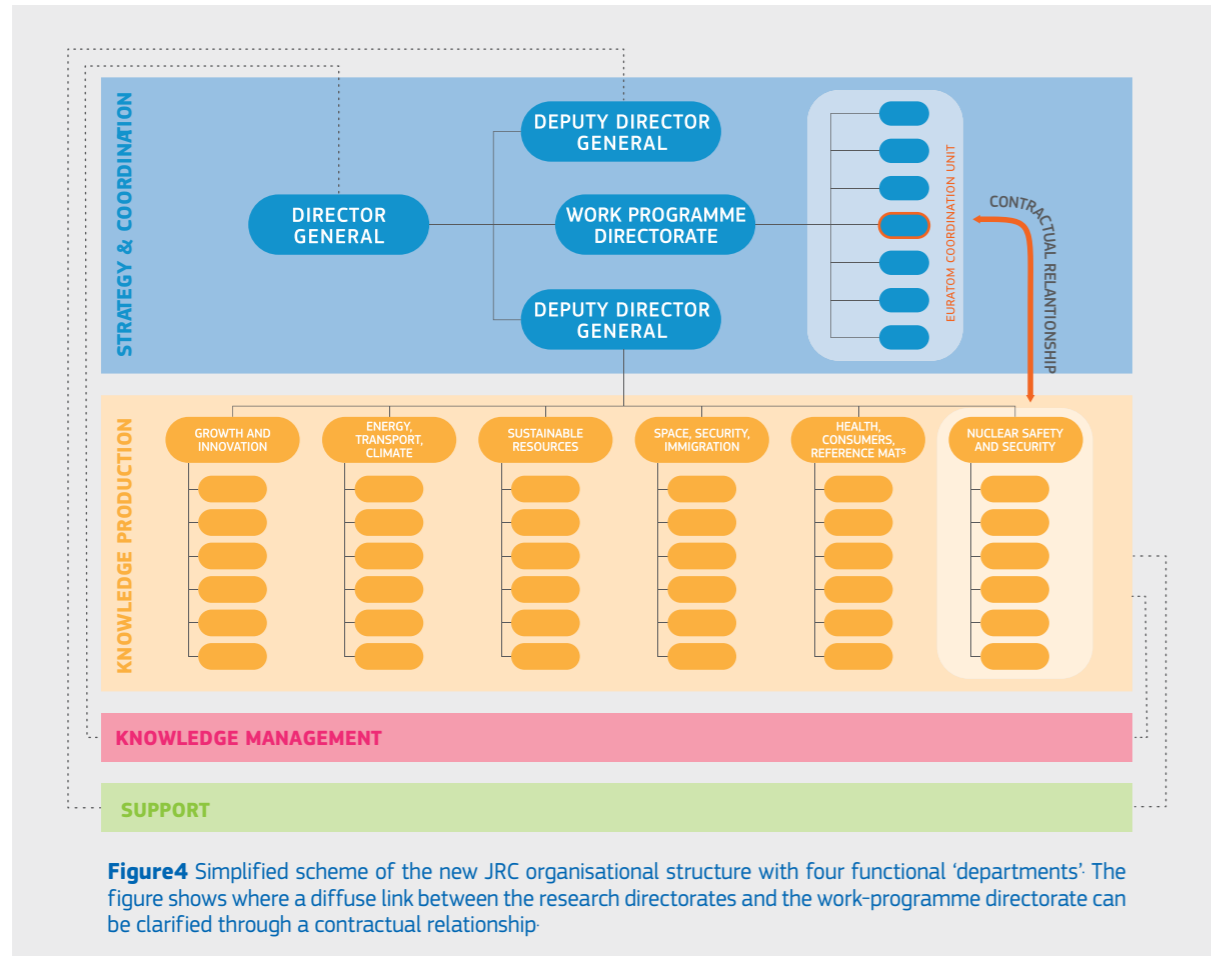
Several mechanisms and forums are in place to coordinate nuclear infrastructure in the EU with the Member States, including a working group of the STC. To some extent indirect actions facilitate European coordination and efficient use of fission facilities. Joint programming also contributes to sharing of results and indirectly infrastructures (e.g. the Joint Programme on Nuclear Materials of the EERA), all this to ensure an optimised use of nuclear fission research infrastructure.

Whereas there were no critical observation on this subject, the panel encourages the JRC to continue and further enhance its practice of open access to its research infrastructure for scientists from the Member States and abroad.

### 4.2.3 Organisation

The evaluation started a few months after a major transformation of the organisational structure. This new setting allows the JRC to face its future implementation of the Euratom fission research and training activities with confidence. The panel found the concentration of these activities in a single directorate one of the more striking improvements achieved, but during the various hearings of the evaluation it also noted some divergence where like-mindedness is required between the Euratom coordination unit and the Directorate for Nuclear Safety and Security (cf. Chapter 2.1.2). They play key roles in the establishment, coordination and implementation of the Euratom programme.

Figure 4 shows their positions in separate parts of the organisation, without direct link connected by diffuse interaction channels. Such relations may work out on their own, but in the practice of matrix management the harmonisation of agendas, priorities and ideas between interdependent cross-functional entities cannot always be taken for granted. Moreover, there are effective ways to achieve this nonetheless.



In this particular case, this concerns clarity between the knowledge production department and the strategy and coordination department. Managers in the programme directorate and the nuclear directorate have no direct links, formal communication and control is indirect, whereas the former represents the interests of the latter in the policy arena. It struck the panel that the relation between these two cross-functional entities has not been formalised beyond the general task descriptions for these entities.

Therefore, the organisational structure is not uncommon, and the panel has seen similar situations resolved through the establishment of a 'contractual relationship' between entities that are mutually dependent, but have no direct hierarchical relation within the organisation. The panel commends such contracts as a means to enhance intra-organisational, cross-functional relations. It will bring the benefit of a defined, agreed and therefore more effective interaction between different parts of the organisation.

Hence, the panel recommends the JRC to introduce as organisational improvement a contractual relationship

between the programme directorate with its Euratom Coordination Unit and the nuclear directorate responsible for research implementation in order to ensure an excellent relation between the two parts responsible for the achievement of its Euratom tasks.

#### 4.2.4 Vision 2030

The global JRC 2030 Strategy and the associated new organisational structure brought the JRC in a more favourable position to start working on a coherent strategy for its nuclear activities. However, it is clearer now than in 2010 that the need for the JRC's vision and the longer-term goals of its direct actions cannot be dissociated from a vision of Euratom's research programme for nuclear fission as a whole, with synergy between the objectives for the direct and the indirect actions.

The JRC may have kept a low profile on its nuclear tasks in its global strategy; it should do the opposite in the preparation for the next Euratom research programme (2021 - 2025).

The Commission is in the position to work on a shared vision with the Member States and the panel is pleased that the JRC confirmed that it is preparing practical steps in this direction. Indeed such a **shared vision 2030** is a *conditio sine qua non* for future success of the nuclear fission programme of the European Community for Atomic Energy.

Nevertheless the panel sounds a word of caution. The JRC reported well-intended consultations with Member States' experts, but the formal deliberations on the indirect actions take place elsewhere under different political leadership in the Commission. Therefore, the Commission needs to take care that there is closer integration between direct and indirect actions with more joint programming between the two. It means that scope and modalities for the management of the programme need to be re-addressed. It is important that the teams inside the Commission find the common ground to make an integrated proposal for the next Euratom research programme 2021 - 2025.

The panel believes that a vision 2030 could include the synergy between nuclear solutions and sustainable development goals (SDG). It is entirely appropriate to provide more active arguments that go beyond the usual explanation that nuclear energy must be safe and secure. The JRC is well-placed to make an objective comparison of nuclear energy generation with other sources. The 'non-nuclear' part of the JRC carries out this kind of work and includes nuclear energy in its broader energy analyses<sup>18</sup>. Accurate data on the contribution of nuclear energy to the decarbonisation of the economy are necessary to inform the public and policy makers, who should also be informed about the counterfactual. For this purpose the JRC is welcome to generate technical, environmental, and economical analyses of the consequences and implication of a denuclearised Europe and publicise this for the Member States.

Finally, the panel would like to encourage the JRC to include the development of new technologies for more efficient power plants in its 2030 vision.

The JRC needs an ever better view of its capabilities, staff resources and infrastructure to manage its nuclear assets for the future. It should for instance make an inventory of the technical teams in its nuclear directorate and

establish the critical limit for the size of each team and the priority class (1, 2, 3) of these teams. The panel encourages the JRC to continue and further enhance its practice of open access to its research infrastructure for scientists from the Member States and abroad.

Formalised relationships between interdependent, not directly connected cross-functional parts of the JRC will benefit the organisation. This specifically refers to creating a contractual relationship between the programme directorate with its Euratom Coordination Unit and the nuclear directorate responsible for research implementation to ensure the most effective achievement of its Euratom tasks.

The Commission is in the position to work on a shared vision with the Member States for the next Euratom Framework Programme (2021 - 2025) and the panel is pleased that the JRC confirmed that it is taking practical steps in this direction. It should also seek closer integration between direct and indirect actions with more joint programming between the two. It means that scope and modalities for the management of the programme need to be re-addressed. It is important that the teams inside the Commission find the common ground to make an integrated proposal for the next Euratom research programme 2021 - 2025.

The panel believes that a vision 2030 could include the synergy between nuclear solutions and sustainable development goals (SDG). The JRC is well-placed to make an objective comparison of nuclear energy generation with other sources. To inform the public and policy makers about the counterfactual, the JRC is welcome to generate technical, environmental, and economical analyses of the consequences and implication of a denuclearised Europe and publicise this for the Member States.

Finally, the panel would like to encourage the JRC to include the development of new technologies for more efficient power plants in its 2030 vision.

<sup>18</sup> Trends in global CO<sub>2</sub> emissions: 2016 Report Netherlands Environmental Assessment Agency (PBL), European Commission, Joint Research Centre

# CONCLUDING REMARKS

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## 5.1 Conclusions

At the end of the evaluation the panel received a good impression of what the JRC does to implement the direct actions of the Euratom programme. It is inherent to the purpose of such an evaluation that the panel focusses on identifying issues that work less well and need improvement. There is usually much less attention for the good parts of the work. Restoring the balance, the first conclusion of this evaluation the panel concerns the remarkable performance of the JRC.

In an ongoing effort to meet the needs of the EU and ensure a global influence, the JRC maintains a diverse programme of scientific and technical work, which supports the Commission, meets EU Member States needs in relation to nuclear safety and security and sustains Commission projects in third countries. In reality the panel discussed that the JRC is actually performing much better than it expected. The reason for this can be twofold: (a) nuclear experts are not necessarily well- informed about the nuclear activities of the JRC, and (b) the JRC's reputation still detracts from its actual quality and performance. The JRC is not a competitor to Member States institutes (cf. Section 4.1.2.1). It takes a prominent position with many of its activities (cf. Chapter 3) and it could indeed help putting the EU at the forefront in nuclear safety, security and safeguards with its highly skilled and motivated staff. A better communication of the JRC's role, its knowledge and its competence in this field is needed and the panel has included recommendations to this effect. They are listed in the last section.

The panel also concludes that the JRC has taken to heart the recommendations from previous evaluations (cf. Chapter 2). Contents and results are more accessible than before, the gains from the concentration of all nuclear activities in one nuclear directorate were noticeable in this evaluation, and the programming shows clearer objectives and better reporting. However, there is scope for further improvement regarding:

- The transparency and the documentation of consultations with partners and beneficiaries about the definition, planning and implementation of the JRC nuclear activities;
- The relationship between the cross-functional parts in the organisation responsible for the achievement of the JRC's Euratom tasks;
- The JRC's project management for its nuclear activities is still not as rigorous as it should be; the detailed and accurate view of its capabilities, staff resources and infrastructure currently missing.

The report has formulated recommendations for further improvement where appropriate. They are listed in the last section.

The Euratom programme is perhaps the most concrete policy measure in support of the nuclear vision in the Energy Union. A pan-European approach needs the JRC with the Member States to integrate the wide range of activities in this field; the need for a 'rapprochement' between direct and indirect actions has been a pertinent issue to this report all the way through.

Therefore and being familiar with the indirect actions part of the Euratom research programme, the panel concludes, that the separate management of direct and indirect actions in the nuclear field over the years developed into a suboptimal solution. Combined management of both will create a more effective programme.

The extension (2019 - 2020) of the Euratom programme and in particular the future FP9 part of the programme (2021 - 2025) need to be more than a simple continuation of the H2020 nuclear complement. This is about a Euratom research programme that allows the JRC and the expert laboratories in the Member States to develop a shared vision taking into account the respective roles in safety, security and safeguard, to combine forces where necessary and to pioneer in certain innovative nuclear technology. The report has formulated recommendations to this effect addressed to the JRC and the Commission and listed below.

## 5.2 Recommendations

**1 Education and training:** The panel recommends that the JRC continues and where possible reinforces its education and training activities. The hands-on practical training and work experience that the JRC offers in its laboratories to students, young researchers, trainees and PhD students is essential to ensure that the next generation of nuclear scientists and engineers in the EU has the necessary skills and knowledge in key areas of nuclear technology.

**2 Communication and reaching out:** The panel recommends that the JRC reaches out to become more visible as a public expert organisation in this field. The JRC knowledge management activities should focus their efforts on good communication of nuclear matters, not only to the nuclear organisations, but also to the other stakeholders, notably the politicians and the general public. De facto the JRC is the voice of the EU in technical matters, and it should be more ambitious in this respect. There is no other body within the EU Institutions that can address the different aspects of nuclear energy with such a high level of expertise and knowledge.

**3 Programming:** The panel recommends that the JRC should systematically introduce project-management techniques in the implementation of the Euratom programme. The panel found an improved programming; clearer objectives, clearer reporting, but the JRC has not achieved the rigorous programming and execution of its Euratom activities envisaged in the previous evaluations. The JRC should build a project-management culture in order to achieve the greatest impact and ensure maximum efficiency in the programme.

**4 Resources:** The panel recommends that the JRC should establish a detailed documented view of the capabilities, staff resources and infrastructure of its nuclear directorate, with an inventory of its technical teams, the critical limit for the size of each team and the priority class (1, 2, 3) of these teams. All this, to take action to maintain a certain capability or, if needed, to achieve an informed decision on which capability to suppress.

**5 Organisation:** The panel recommends the JRC to introduce a contractual relationship between the programme directorate with its Euratom coordination unit and the nuclear directorate responsible for research implementation to ensure an excellent relation between the two cross-functional parts responsible for the achievement of its Euratom tasks.

**6 Cost effectiveness:** The panel recommends that the JRC should take on the burden of proof of its cost-effectiveness and for a future external assessment provide convincing information that the work is carried out in a cost-effective way.

**7 Euratom programme:** The panel is in favour of a strong Euratom programme to help putting Europe at the forefront of nuclear generation and to maintain its technology leadership as proposed in the Energy Union package. The panel recommends that this programme should:

- a. Support the EU's need to maintain the capability to manage nuclear safety, security and safeguards by the JRC and the relevant research and training institutions in the Member States.
- b. Bring a 'rapprochement' between the direct and indirect actions in fission research, which means that the Commission:
  - i. Implements a coherent programming of the two parts with a well-defined governance and decision-making processes, making full use of the competence and the unmatched position of the JRC, which no longer competes for funding under the indirect actions and participates in every project where this has an added value, albeit only for nuclear knowledge-management purposes.
  - ii. Proposes in the Euratom extension (2019 - 2020) one ex-post evaluation of the nuclear fission activities in the programme, to be conducted in 2022.

For this purpose, the JRC should start preparing a long-term vision for its own activities as part of an integrated, coherent proposal for the direct and indirect actions in the Ninth Euratom Programme for Research and Training, coordinated with the Member States and managed consistently by the Commission services.

**8 Synergy nuclear and non-nuclear:** The panel recommends the JRC to create more synergy between its nuclear and non-nuclear activities and include the results in its proposals for the next Euratom research programme (2021 - 2025) and the ninth framework programme. The panel welcomes the intention of the JRC strategy to exploit the potential for knowledge transfers in areas like energy policy, climate change, sustainable development goals (SDGs), security and emergency preparedness. Nevertheless, the panel strongly recommends that the JRC should maintain a clearly defined nuclear part in its work program.

# ANNEXES

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# ANNEX 1

## TERMS OF REFERENCE FOR AN EXPERT PANEL

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*Terms of Reference for an expert panel for the Interim evaluation of the direct actions under the Research and Training Programme of the European Atomic Energy Community (2014 - 2018)*<sup>19</sup>

### 1. Introduction

This document provides the terms of reference for a panel of experts that will conduct the interim evaluation of the JRC direct actions described in the Research and Training Programme of the European Atomic Energy Community (2014 - 2018) complementing the Horizon 2020 Framework Programme for Research and Innovation.

The overall task of the panel will be to carry out an evaluation of the quality of the research activities, the programme's implementation and management, and the progress towards the relevant objectives set in the Euratom programme. Where possible and as a kind of benchmarking, the panel is expected to give an expert view on the performance level of the relevant activities as they are carried out in the JRC.

For this purpose the panel of experts will analyse the nuclear activities of the JRC, and prepare a final report with conclusions and recommendations as regards the JRC's implementation of its direct actions under the Euratom Research and Training Programme (2014 - 2018).

### 2. Mandate, deliverables and timetable

#### 2.1 Legal basis

The Council Regulation on the Euratom Research and Training Programme<sup>1</sup> contains the provision for an interim review in the Article 22, which states that by 31 May 2017 the Commission shall carry an interim evaluation of the Euratom Programme with the assistance of independent experts. The evaluation concerns "the achievements [of the programme] at the level of results and progress towards impacts, of the objectives and continued relevance of all the measures, the efficiency and use of resources, the scope for further simplification, and European added value".

Specific inter-institutional and Commission requirements further frame this evaluation; in particular those related to the Financial Regulation (Article 6), the Implementing Rules (Article 27.3)<sup>20</sup> and evaluation standards<sup>21</sup>.

#### 2.2 Objectives and scope

Whilst fulfilling the obligations laid down in the legal basis of the Euratom Research and Training Programme (2014 - 2018) the objectives of this interim evaluation are:

- To assess the continued relevance of the programme's objectives;
- To review initial outputs and the early impacts of the programme, paying specific attention to the quality and the performance level of the various activities carried out by the JRC;

<sup>19</sup> 1314/2013 Council Regulation (Euratom) 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.

<sup>20</sup> Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002.

<sup>21</sup> "Responding to Strategic Needs: Reinforcing the use of evaluation", SEC(2007) 213.



- To assist the JRC senior management with specific orientations for the remaining part of the Research and Training Programme.

With the expiry of the Euratom research programme in 2018, the interim evaluation should facilitate upcoming decisions for continuing the programme beyond 2018 and build a fact base for future impact assessments of nuclear activities of the JRC. Following the recommendations in the Cunningham report the final results of the current evaluation will be integrated in a Communication from the Commission with a nuclear fission section to be prepared jointly by DG RTD and the JRC.

The scope of the interim evaluation encompasses the direct actions of the JRC carried out in the context of the Euratom Research and Training Programme during the first half of the programme.

### 2.3 Evaluation questions

The interim evaluation should provide substantive answers to the evaluation questions listed hereafter:

#### *Rationale / Relevance*

- To what extent do the JRC's direct actions address the research and training needs of the European Atomic Energy Community?
- To what extent are the nuclear research projects in the JRC work programmes in line with the objectives of the JRC?
- To what extent is the JRC transparent and accountable for the way in which it prioritises its activities and investments projects?

#### *Implementation / achievements*

- To what extent have the recommendations of previous evaluations been taken into account, regarding e.g.:
  - An ambitious "Vision 2030" for nuclear activities with a 10 - 20 year outlook for JRC's nuclear research facility infrastructure?
  - A management structure with a clear assignment of the overall responsibility for all nuclear activities in the JRC?
  - Effective arrangements for planning, monitoring, reporting?

To what extent is the JRC on track to achieve its objectives specified in detail in the annex I of the

programme decision regarding:

- Improving nuclear safety?
- Improving nuclear security?
- Increasing excellence in the nuclear science base for standardisation?
- Fostering knowledge management, education and training?
- Supporting the policy of the Union on nuclear safety and security?

#### *Performance level*

- How does the scientific output in the different working areas of the JRC compare to the one of top organisations in similar relevant fields?
- To what extent have the direct actions generated specific and/or tangible impacts on EU policies and for the (international) nuclear community?

### 2.4 Milestones and deliverables

The panel will carry out the interim evaluation from October to February 2017. The evaluation will start with a kick-off meeting to agree on the detailed workings of the panel and finish in a plenary session of the panel in October 2016. The panel chair will present draft conclusions and recommendations from the evaluation to the JRC Board of Governors.

The panel will deliver its report on the "interim evaluation of the nuclear activities of the JRC under the Euratom Research and Training Programme" in the first trimester of 2017. The main text of the report, counting a maximum of 30 pages - including an executive summary, excluding annexes - consists of an analysis of findings and a set of fact-based conclusions and recommendations. The JRC will make the final report available to its stakeholders and the public.

## 3. Operation of the panel of experts

### 3.1 Composition, identification and selection of experts

The JRC Director General will select six (or five) acknowledged experts, composing the panel in consultation with the Board of Governors.

An appropriate composition of the panel requires a balanced representation of expertise in the main areas of the JRC Euratom programme, a balanced spread over scientific, governmental, non-governmental and

private sector organisations, a spread in affiliation to the academic, public service and industry community, a certain geographical spread and equal gender opportunity. A minority of experts with experience from earlier JRC evaluation is an asset.

### 3.2 Working method

The experts participate in a personal capacity and will not represent the positions of the individual organisations for which they may work. They will base their findings on a desk analysis of achievements during the first part of the research and training programme, presentations of activities, interviews with JRC managers, staff, partners and stakeholders and visits of JRC sites. The full "evidence base" is specified in section 3.3 and will be made available to the experts in electronic form (through access to a dedicated web-site) in time before their first meeting. Upon request the JRC will provide hard copies of the general information documents.

At the kick-off meeting, the panel will review the role of the experts in the evaluation, validate the applicable methodology and discuss the management of its work, including possible JRC sites to visit. The chair will also establish how the function of rapporteur will be fulfilled in consultation with the panel and the JRC. The chair will be requested to ensure that the panel members and the supporting expertise are best exploited in the different areas of the JRC's nuclear activities. Subsequently, the panel may meet as often as necessary, also by using electronic means such as audio-video conferences and other electronic media for discussions.

The JRC's Adviser for Evaluation and Scientific Integrity assists the panel in organising all aspects of the evaluation, makes available a secretariat to the panel and assists in establishing the final report.

### 3.3 Evidence-base

The JRC will provide the panel with all necessary information, in particular:

#### **General information**

- The baseline against which the assessment will be made, i.e., the Euratom Research and Training Programme (2014 - 2018), JRC's Multi-Annual Work Programmes;

- General reports on progress (e.g. Annual Reports, Annual Activity Reports);
- Figures on human resources and budget implementation.
- Reports of previous Euratom FP Evaluations and Commission replies;

#### **Specific information**

- Statistical information on the implementation and results of the research activities;
- Detailed publication data from the PUBSY corporate data base.
- The panel has the possibility to interview selected beneficiaries of the direct actions of the Euratom programme.

### 3.4 Credits

The physical and intellectual works generated by the expert's assignment will remain the property of the Commission. The experts of this panel undertake not to use these works outside this assignment without the previous written agreement of the Joint Research Centre.

The published report will acknowledge the contributions of the members of the panel.

### 3.5 Administrative and financial aspects

The JRC will reimburse travel costs according to the division of labour and travel obligations amongst the panel members and according to the standard rules applied by the Commission. The financial means for the workings of the panel (expert fees, reimbursement of travel and accommodation costs) will be covered by the JRC's Euratom budget.

Members of the panel can be offered an expert contract in accordance with the Commission's arrangements for evaluation experts. The contract will provide the payment of fees for a number of days estimated at maximum 21 days for the chairperson, and 14 days for the other panel members. The preparation of such an appointment letter will require the registration of the experts concerned in the Commission's relevant expert database.

# ANNEX 2

## LIST OF REFERENCE DOCUMENTS

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The baseline against which the assessment was made

- Current Euratom Research Programme

Research and Training Programme of the European Atomic Energy Community (2014 - 2018) complementing Horizon 2020

- The JRC Work Programme (also include non-nuclear activities)

Commission implementing decision on the JRC Work Programme 2016 - 2017

Key orientations for the Joint Research Centre's multi-annual work programme for 2016 - 2017

Commission Implementing Decision on the JRC Work Programme 2014 - 2015

Key Orientations for the Multi-Annual JRC Work Programme 2014 - 2015

General reports on progress (e.g. annual reports, annual activity reports)

- JRC annual reports: 2014, 2015
- JRC annual activity reports: 2014, 2015

Previous evaluation reports and the documented responses

- Evaluation reports (dedicated to Euratom activities)

Interim Evaluation of the Seventh Euratom Framework Programme (2007 - 2011): Direct actions of the Joint Research Centre

Advice on JRC Nuclear Safety Research Activities (September 2014)

Bibliometric analysis of the research performance of the JRC under the Euratom Research and Training Programme (2007 - 2015)

Facts and figures of the JRC nuclear activities under the Euratom Programme (2014 - 2018)

- Evaluation reports (JRC general including Euratom activities)

Ex-post Evaluation of the direct actions of the Joint Research Centre under the Seventh Framework Programmes 2007 - 2013 (notably Chapter 4. on Euratom activities)

Thomson Reuters study on the research performance of the Joint Research Centre of the European Commission during the 7th Framework Programme (2007 - 2013)

Impact Analysis of JRC activities: special report for the 100th meeting of the Board of Governors

Specific information received from the JRC (some prepared at the request of the panel)

- A report from twelve (sub-) areas of the Euratom section of the JRC's work programmes for the evaluation period (cf. Annex 3 to this report);
- Statistical information on the implementation of the research activities (i.e. publications, patents, participation in indirect actions, etc.);
- A report on the follow-up to recommendations of the interim and ex-post FP7 evaluations conducted respectively in 2010 and 2015.

# ANNEX 3

## ACTIVITY REPORTS

### OF THE TWELVE AREAS

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#### 1. Area 1: Nuclear Safety

JRC activities in this area cover safety of nuclear reactors, fuels and fuel cycles, and radioactive waste management. They also include the generation of underpinning scientific knowledge as well as emergency preparedness, and environmental monitoring. There are synergy effects from work for third parties under contract.

All projects are aligned to Member States' needs and priorities as defined by, e.g. the Sustainable Nuclear Energy Technology Platform (SNETP) with the European Sustainable Nuclear Industrial Initiative (ESNII), the Nuclear Cogeneration Industrial Initiative (NC2I) and the Nuclear Generation II & III Association (NUGENIA), the Implementing Geological Disposal Technology Platform (IGDTP) and the European Energy Research Alliance's Joint Programme on Nuclear Materials (EERA-JPNM).

The work is carried out in collaboration with Member States' research organisations, nuclear technical support organisations (TSO), regulators, international standardisation bodies and with other parts of the JRC.

Non-EU links include the Generation IV International Forum (GIF), the International Atomic Energy Agency (IAEA), the OECD, the United States' Department of Energy (DoE), Japan's Central Research Institute of Electric Power Industry (CRIEPI) and the Japan Atomic Energy Agency (JAEA).

The experimental studies take full stock of the JRC's nuclear infrastructure and capabilities, which includes the High Flux Reactor (HFR) in Petten (NL), hot cells, accelerators and dedicated laboratories for studies on highly radioactive materials.

#### 1.1 Nuclear Reactor Safety

The JRC contributes to the improvement of nuclear safety and safeguards in non-EU countries in partnership with local regulators and TSOs.

In the reporting period, the JRC has defined, reviewed and assessed nuclear safety projects, e.g. in Belarus, Latin America, Africa and South-East Asia, providing independent technical expertise and consultancy services covering reactor and other safety-relevant aspects.

The JRC supported NUGENIA in coordinating and integrating European research for the integrity and ageing assessment of Light Water Reactors (LWR). The JRC contributed to:

- IAEA plant life management activities;
- Round-robin exercises (e.g. for OECD-NEA) on degradation of nuclear materials and integrity assessment of reactor components; and
- CEN initiatives on harmonisation of LWR design codes and standards.

The JRC contributed in particular to the NUGENIA Global Vision (roadmap) document and to a position paper on environmentally assisted fatigue.

An accident analysis group capable to provide information in the event of a nuclear crisis was established. The group has provided sustained support to research efforts in the field of in-vessel melt retention (IVMR), coordinating an international benchmark for VVER-1000 reactors. Moreover, the JRC has supported the provision of generic models of all reactor types relevant in the EU for the latest version

of the European ASTEC software package developed jointly by the French Institute for Radiological Protection and Nuclear Safety (IRSN) and its German counterpart, the reactor safety authority GRS. These models have been validated.

The JRC addresses challenges related to the safety of advanced nuclear reactors, contributing to the development of codes, standards and test methods for advanced materials.

The JRC provided significant contributions to the preparation of the Vision Report of the European Energy Research Alliance's Joint programme on nuclear materials (EERA-JPNM), a reference document to define the Roadmap covering the coming five-year period.

## 1.2 Safety of Nuclear Fuels and Fuel Cycle

### 1.2.1 Conventional nuclear fuels

JRC activities address properties and behaviour of nuclear fuel (mainly LWR UO<sub>2</sub> and MOX) during normal operation in reactors, off-normal conditions and during severe accidents.

New insight was obtained on the properties of the high-burnup structure in LWR fuel. The knowledge generated by the experimental activities is integrated in the fuel performance code TRANSURANUS. A new version of the code was released, which contains a model for the large-strain approximation and fission-gas release as well as an interface necessary for simulation of design-basis accidents such as loss-of-coolant accidents and reactivity-initiated accidents.

Investigations of degraded/molten fuel from real accidents and of analogue materials produced in the laboratory unexpectedly showed that significant degradation of thermal diffusivity occurs as the fraction of Zr increases.

Laser-heating studies allowed determining the high-temperature solid/liquid transitions in the PuO<sub>2</sub>-UO<sub>2</sub>-ZrO<sub>2</sub> system and other corium sub-systems. Detailed analysis of a hot particle from the Chernobyl accident showed that the particle is in metallic form, suggesting the possible occurrence of a supercriticality event during the accident. Raman spectroscopy fingerprints have been established for the identification of plutonium hot spots in segregated corium.

Fuel fragmentation studies related to loss-of-coolant accidents indicated local burnup/temperature fragmentation thresholds of 71 MWd/kg HM/~920 K, in good agreement with results from other organisations. The partitioning of fission products over the aerosol-size fraction in case of dispersion from nuclear fuel was simulated successfully using a dedicated set up, showing that the volatile species concentrate in the small inhalable fraction.

### 1.2.2 Innovative Nuclear Fuels and Fuel Cycles

JRC activities include basic and applied research on the safety of fuels for five GenIV systems (SFR, LFR, GFR, VHTR, MSR), as well as on the four prototype reactors defined in the ESNII roadmap.

A synchrotron experiment has demonstrated that the spin and orbital magnetic moments on actinides can be determined directly by measuring the difference between x-ray absorption spectra measured for circularly polarized photons of opposite helicity.

A study combining inelastic X-ray scattering and first-principles simulations of the vibrational dynamics (phonons) of NpO<sub>2</sub> demonstrated that electronic structure calculations are able to simulate structural, mechanical, and thermodynamic properties of nuclear fuels with a high level of precision.

The SPHERE irradiation of Am-containing sphere-pac fuel in the HFR has been completed. Post-irradiation examination (PIE) revealed excess material transport across the annular hole in mixed oxide fuel (MOX) when operated at high linear power. Conversely, PIE of Mo-based (Pu, Am)O<sub>2</sub> ceramic-metal composite fuels (FUTURIX) showed excellent irradiation behaviour.

The melting and vaporisation behaviour of (U, Am)O<sub>2</sub> was studied in collaboration with CEA/DEN. Interaction tests of lead-bismuth eutectic with fast-reactor mixed (U, Pu)O<sub>2</sub> fuel demonstrated very good compatibility.

A thermodynamic database for the LiF-ThF<sub>4</sub>-UF<sub>4</sub> system has been developed based partly on new experimental measurements at JRC.

Fluoride salt mixtures have been prepared for the SALIENT irradiation experiment in the HFR (collaboration with NRG), which is probably the first molten salt fuel irradiation worldwide since the 1960s.

## 1.3 Radioactive Waste Management

The activities on radioactive waste management in the JRC are performed along R&D and policy support dimensions. The R&D covers spent-fuel and high-level-waste-form behaviour during storage and the long-term performance when disposed in a geologic repository.

Significant achievements in the reporting period include:

- the successful development and testing of new devices to study the integrity limits of spent fuel rods subjected to mechanical loading;
- the determination of a correlation between spent fuel corrosion rate in groundwater and the fuel irradiation history in the reactor;
- the assessment of radionuclide release from spent fuel in sea water in the context of the Fukushima accident;
- a new assessment of the stability of waste glass against self-irradiation;
- the development of innovative methods to characterize 'difficult' radionuclides; and
- the commissioning of a suite of surface analysis tools to investigate basic mechanisms.

In addition, new projects dedicated to R&D and education and training for nuclear decommissioning were implemented, reflecting a growing trend in the nuclear sector.

Policy-oriented activities in this area included

- Supporting the review of national reports in the frame of the implementation of the Nuclear Waste Directive;
- Defining a process to establish joint programming in the waste management domain among Member States organisations;
- Establishing a knowledge-management system to ensure proper dissemination and transfer of knowledge generated in European R&D programmes.

## 1.4 Nuclear Emergency Preparedness and Response

To support efforts in the area of nuclear emergency preparedness and response, the JRC has developed the [European Community Urgent Radiological Information](#)

[Exchange](#) (ECURIE) system and the automatic [EUropean Radiological Data Exchange Platform](#) (EURDEP).

Since 2013, EURDEP coordinates with the Incident and Emergency Centre (IEC) of the IAEA to test and establish the International Radiation Monitoring Information System.

Outside Europe, EURDEP has been recognized as a regional model to exchange environmental monitoring data rapidly during an emergency, e.g. in the Mediterranean Basin and in South East Asia.

The outcome of extra-EU activities included feasibility studies, training courses and road maps to enhance regional collaboration.

## 1.5 Environmental Monitoring & Radiation Protection

Under the Euratom Treaty, the JRC is responsible for collecting, validating and reporting information on artificial radioactivity in the environment from the Member States Competent Authorities.

The [Radioactivity Environmental Monitoring](#) (REM) group of the JRC fulfils this mandate through the online REM database and the preparation of annual monitoring reports. The REM database structure and the data submission tool have been partly re-engineered to be compatible with the latest software versions. This resulted in more functionality for the end users.

The automation of the monitoring report has been engineered in four main tasks allowing monitoring the status of the data, delivering on a continuous basis and producing grouped data analysis tables for the network areas involved. Two interlaboratory comparisons on the measurement of <sup>137</sup>Cs, <sup>134</sup>Cs, and <sup>131</sup>I in air filters were conducted.

## 2. Area 2: Nuclear Security

JRC activities in this field cover R&D, innovation, equipment development, modelling, standardisation and testing, education and training, in-field assistance and outreach projects in the areas of nuclear safeguards, non-proliferation and nuclear security.

Main stakeholders are the European Commission directorate generals for energy, for international cooperation and development, for migration and home affairs, for trade, and for taxation and customs union. Coordination with the Member States is ensured through the operation of the European Safeguards Research and Development Association (ESARDA) including R&D organisations, universities, Member State authorities and nuclear-facility operators.

The IAEA is the major international partner for this work, in particular its nuclear-safeguards and its nuclear-security divisions. The EU support programme to the IAEA is the second largest after that of the US and in line with the long term R&D strategy plan (2012 - 2020) of the IAEA. Other international collaboration agreements (with annual review meetings to set R&D priorities and review results) are implemented also with the US-Department of Energy (DoE), the Japan Atomic Energy Agency (JAEA) and others. Work under contract is executed worldwide in this area (e.g. South - America, North Africa, Central Asia, and South - East Asia).

This includes also all obligations related to the Non - Proliferation Treaty (NPT) and its application to EU non-nuclear weapons states (IAEA information circular INFCIRC/193).

### 2.1 Nuclear Safeguards

Regarding nuclear safeguards the JRC works in the field of nuclear materials measurements (non - destructive analysis and analytical measurements), process monitoring, containment and surveillance and verification technologies.

Key activities of JRC nuclear-safeguards work during the reference period includes R&D on <sup>3</sup>He- free-neutron-coincidence counters (e.g. LiZnS and BF<sub>3</sub>), improvements in radiometric techniques (medium resolution-gamma) and intercomparison of several instruments for analysis of nuclear materials. The JRC has designed and produced in collaboration with the IAEA and CAEN S.p.A, a prototype of a neutron collar for the verification of fresh nuclear fuel elements, based on liquid- scintillation technology and innovative electronics for real-time pulse-shape discrimination.

Significant progress was also made with respect to the use of the Pulsed Neutron Interrogation Test Assembly (PUNITA) focussing on differential die-away measurements and delayed gamma rays both to determine minute quantities of fissile materials and better characterise spent nuclear fuel or fuel debris. The refurbishment of the JRC drum monitor was completed. The instrument achieved CE-certification indicating readiness to return to field operation at nuclear facilities in Europe.

The JRC has developed the XFuelBuilder, which provides an effective support to the Euratom nuclear inspectorates for the analysis of active neutron coincidence collar (NCC) measurements and Monte Carlo simulation for fresh fuel assemblies used in boiling water reactors (BWR) and pressurized water reactors (PWR).

The capabilities for particle analysis were also greatly improved in the reference period by the optimisation of the Large Geometry – Secondary Ion Mass Spectrometry (LG-SIMS) with enhanced accuracy and precision and also better detection limits.

Support to DG ENER includes the operation of the Euratom on-site laboratories (OSLs) in La Hague and Sellafield. Around 2500 samples have been analysed with U/Pu content from highly active input solutions to separated Pu products. The labs require continuous maintenance and the JRC implements improvements such as the Semi-automated Separation Unit. With the use of the transportable analytical measurement system COMPUCEA (combined procedure for uranium concentration and enrichment assay) developed by the JRC during physical inventory verification (PIV) at European fuel fabrication plants, around 100 uranium samples (powder and pellets) were analysed with a concentration uncertainty of 0.2 %.

In the reference period the JRC finalised the design, installation and use of a fully innovative and unattended measurement-and-surveillance station in the Plutonium product store at Sellafield; a large improvement in the inspection efficiency and effectiveness. The JRC has pre-processed and analysed load cells and accountancy scale data sets from the Georges-Besse II (GBII) enrichment plants (GCEP) in the frame of the joint support task France-EC

to the IAEA. The JRC has first designed some tools to support the safeguards activities for the PIV of GBII. The next step was to develop an application, Inspector Studio GBII, to support the other activities of the inspectorates.

For the IAEA the JRC developed a backpack-mounted device to provide real-time location information and change monitoring inside nuclear facilities. The system arrived first in a world-wide competition on in-door localisation organised by Microsoft; it allows nuclear inspectors to associate all measurements and observations made during an inspection with the corresponding location within the nuclear facility and thereby facilitates subsequent analysis and future inspections. In addition the JRC developed advanced laser-based tools for containment verification and design- information verification, such as (i) the LMCV device, for 3D laser surface mapping of canister closure welds for the authentication and integrity check of dry storage containers (DSC) and (ii) the laser-surveillance system for monitoring a spent-fuel storage pond in La Hague.

During the reporting period the JRC developed a tamperproof ultrasonic bolt with optical fibre for verifying dry storage of spent nuclear fuel and an active optical loop seal (AOLS). The latter is a new low-cost electronic seal with unique features, like asymmetric public/private encryption keys and a fibre length up to 100 m. It has the potential to replace all electronic seals used by DG ENER, the IAEA and the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC). Furthermore, the development of an automatic video verification system for copper brass seals allowed a significant improvement in the operations of Euratom's nuclear inspectors.

The JRC is member of the IAEA's Network of Analytical Laboratories (NWAL) for the analysis of particle and bulk nuclear materials. The techniques used are ISO 17025 accredited, which provides for an excellent and stable performance level. Around 600 nuclear and environmental samples are analysed on an annual basis.

For the safeguards inspectors the JRC provided a large variety of training courses on non-destructive and

destructive analysis, containment and surveillance techniques (NDA, DA and CS), Mass / Volume determination and process monitoring, including a relatively new additional protocol exercise. The educational effort, through the ESARDA course of nuclear safeguards and non- proliferation, organised annually, continues to enjoy large interest.

A series of JRC capabilities in this field have gained interest from the international community in the context of the International Partnership for Nuclear Disarmament Verification.

### 2.2 Non-Proliferation

Under **nuclear non-proliferation** the JRC covers concepts and methodologies, tools for open source information collection, strategic trade analysis and export control.

The IAEA is redefining the way in which nuclear safeguards are designed and applied at state level within the so called 'state level concept' (SLC). The concept includes the use of both 'traditional' sources of information (states' declarations, onsite verifications) and 'new' ones (open source information, trade analysis, etc.). In the reporting period, the JRC investigated critical methodological issues of the IAEA SLC and the role of information analysis in supporting the SLC acquisition paths analysis step.

The JRC worked on providing better tools for nuclear designers to increase the safeguardability and proliferation resistance of future nuclear energy systems, making contributions to the IAEA 'Safeguards by design guidelines' and to the Proliferation Resistance and Physical Protection Working Group of the Generation IV International Forum (GIF PRPPWG).

It continued to develop tools for collecting and analysing open-source information coming from i.a. news sources and investigated how different types of open-source information can be used to inform the non-proliferation analyst. In support to the IAEA the JRC developed a Nuclear Security Media Monitor.

The JRC acted as reference for the Commission and the European External Action Service (EEAS) on nuclear - related technical aspects of the Iranian

nuclear file. The main beneficiaries were the EU negotiators, firstly in the nuclear technical negotiations for the E3/ EU+3 and Iran Joint Plan of Action and then for the E3/ EU+3 and Iran Joint Comprehensive Plan of Action. The JRC followed the nuclear file on North Korea (DPRK), performing open-source collection and analysis of DPRK nuclear-related sites and nuclear tests.

The JRC supported the IAEA and informed the EU policy for export controls and outreach activities with strategic trade analyses. Statistical and economic methods were tailored for R&D for this domain and dedicated IT tools were designed and used.

The JRC collected and analysed export licenses from the Member States and other trade data to support:

- The definition of the EU export-control policy,
- The assessment of the implementation of Council Regulation (428/2009) on dual-use items,
- Other related trade-restrictive measures.

This supported also the Commission's periodic reporting to the European Parliament on the implementation of the Regulation 428/2009 and the impact assessment of its ongoing recast. The JRC produced profiles of the dual-use-related trade by Third Countries to support the definition of the EU outreach programmes for export controls.

In the area of strategic export control, the JRC supported the harmonised implementation of dual-use items' export-control policies (Council Regulation 428/2009; restrictive measures against certain countries). For instance, the JRC helped the development of EU guidelines for harmonised implementation of the dual-use controls, performed periodical analyses of confidential denied export authorisations and operated 'the EU dual-use pool of experts'.

The JRC contributed to annual amendments to the 'EU dual-use control list', i.e. Annex I of Council Regulation 428/2009, and amendments deriving from international regimes.

The JRC provided technical support to the revision of annexes to EU sanctions regulations, e.g. the annexes to the EU's anti-nuclear proliferation sanctions on

Iran, which list items subject to restrictions under the measures. It supported the development of EU cooperative programmes with third countries and performed training for export control licensing and customs.

### 2.3 Nuclear Security

Although it is a Member States' competence, the **reference policies underpinning the activities for nuclear security** are: the Common Foreign Security Policy in the Treaty on European Union, the European Security Strategy (2003), the EU Strategy Against Proliferation of Weapons of Mass Destruction (2003), the EU Counter-Terrorism Strategy (2005) and the Council's 'New lines for action by the European Union in combating the proliferation of weapons of mass destruction and their delivery systems' (doc. 17172/08).

The involvement in the field of nuclear security can be presented along three major lines: (i) research and development, (ii) support to Member States and international organisations and (iii) capacity building activities, all focusing on the detection and response to the illicit trafficking of nuclear and other radioactive materials, including nuclear forensics.

The JRC **nuclear security** activities focus on combating illicit trafficking, detection, response and nuclear forensics. In all these areas there are R&D, training and in-field support activities.

Key activities in nuclear-security work during the reference period focus on detection methods and instrumentation, their evaluation, comparison and categorisation striving for harmonisation and standardisation (testing campaigns for the evaluation of detection equipment, testing of innovative sensors) in support to DG HOME and the Member States. This concerns for instance the management of the ITRAP+10 project (Illicit Trafficking Radiation Assessment Programme) for testing equipment used for the detection of radioactive/nuclear material against international standards, and the R&D and testing on <sup>3</sup>He alternative technologies for nuclear security (e.g. SCINTILLA project).

Development of measurement methods, data interpretation techniques and the identification of characteristic

parameters are also carried out for nuclear forensics, including classical forensics on contaminated evidence. The JRC conducts forensic analysis of nuclear material discovered out of regulatory control as a service to Member State authorities. In the reporting period, seven illicit trafficking incidents were subject to nuclear forensic analysis.

In 2009 the Commission adopted a communication on strengthening chemical, biological, radiological and nuclear (CBRN) security in the European Union and proposed an EU CBRN Action Plan. In accordance with this plan the JRC has established the European Nuclear Security Training Centre (EUSECTRA) which instructs front-line officers, trainers and experts on how to detect and respond to illicit trafficking of nuclear or other radioactive materials. Since its first pilot in 2009 a large set of training courses on nuclear security for front line officers and train-the-trainers is being provided with partners such as the Commission's Directorate General for Taxation and Customs Union (DG TAXUD), the Member States, the IAEA and the US Department of Energy.

In support of the EU's nuclear security policies, the JRC contributed to the Commission's outreach activities of DG DEVCO by implementing nuclear-security projects in the CIS countries, North and Sub-Saharan African countries, Central Asia and South East Asia. The JRC operates in close coordination with the IAEA, the US Department of Energy and the Department of State in the Border Monitoring Working Group, which celebrated its tens anniversary in December 2015. It also provided substantial support to the CBRN Centres of Excellence.

Finally, in this area the JRC played a part in the Nuclear Security Summits in 2014 and 2016 with dedicated preparatory workshops and by presenting results of joint EU-US projects, such as the organisation of the 'Countering Nuclear and Radiological Smuggling Workshop' and the ITRAP+10 project respectively.

On behalf of the EU as part of the Global Initiative to Combat Nuclear Terrorism (GICNT) the JRC took care of the organisation of the nuclear detection and nuclear forensics workshop and table-top exercise 'Radiant City' focusing on how both technical and non-technical nuclear detection capabilities can support an investigation into illicit trafficking of radiological and nuclear

materials, as well as how nuclear forensic science can effectively support those investigations.

### 3. Standards for Nuclear Safety, Security and Safeguards

The JRC activities on harmonisation and standardisation of nuclear measurements play a strategic role in the JRC's policy support in the nuclear field. They are a substantial part of the Commission's efforts to promote harmonised and internationally acceptable standards for nuclear safety, safeguards and security. They underpin the Commission's strategic vision for European standards communicated to Council and Parliament in 2011 in which the JRC is positioned to provide scientific input in the field of standardisation and harmonisation in its areas of expertise.

The standardisation and harmonisation activities have a firm mandate anchored in the Euratom Treaty and they are also well-embedded in the global initiatives of international organisations like the IAEA and the OECD-NEA.

The JRC's activities for nuclear measurement and standardisation are grouped in the cross-cutting Unit 'Standards for Nuclear Safety, Security and Safeguards' (Unit G.2), operating in three working domains:

- Nuclear data for safety of present-day and innovative nuclear energy systems;
- Radionuclide metrology for the harmonisation of the EU radioactivity measurement system;
- Metrological tools for safeguards, safety and security.

The JRC hosts some specialised large-scale nuclear facilities (particle accelerators, underground laboratory, nuclear-reference-materials laboratories) which are unique in Europe. This nuclear research infrastructure allows the production of accurate neutron reaction and nuclear decay data that serve the needs of safe operation of nuclear reactors and safe handling of nuclear waste. This part of the JRC also produces and supplies state-of-the-art nuclear reference materials and measurements, conformity assessment tools, and nuclear training and education in all its areas of activity.

Following recommendations of the Ex-post FP7 evaluation panel to connect better with Member States activities and share infrastructure, the JRC

has enhanced its active open access programme [EUFRAAT](#) (European Facilities for Nuclear Reaction and Decay Data measurements). This programme provides quality-based open access of external users to this particular nuclear measurement infrastructure of the JRC. A Programme Advisory Committee with external stakeholders evaluates the proposals from external users. The JRC substantially increased the production of unique high- quality actinide targets on demand of researchers in Member States and international institutions as CERN, Oak Ridge National Laboratory (ORNL), and the Japan Atomic Energy Agency (JAEA). The JRC is the major provider in Europe of neutron data for nuclear energy applications. These data are delivered to international open access nuclear data libraries of the OECD-NEA and the IAEA.

The JRC provided safeguards authorities and the nuclear industry with standards for environmental sample analysis and for measurements of samples from all stages of the nuclear fuel cycle. In addition it developed standards and quality control tools for measurements in the field of nuclear forensics and nuclear security. Work in this field included conducting primary standardisations of radioactivity, producing reference materials for monitoring of radioactivity in food and enhancing emergency preparedness, and organising laboratory comparison amongst radioactivity monitoring laboratories.

Other noteworthy achievements during the period 2014 - 2016 were the successful development and demonstration of an innovative technique for elemental and isotopic characterisation of molten fuel together with the JAEA at the JRC's [GELINA](#) facility in Geel. This success was honoured in 2016 with the award for distinguished technology development of the Atomic Energy Society of Japan. In this domain the JRC also organised the International Conference on Nuclear Data for Science and Technology (ND2016) in Bruges, under auspices of the OECD-NEA with more than 500 participants representing 47 different countries.

#### 4. Knowledge management, training and education

Operating, expanding or developing new nuclear-power programmes depends on acquiring and maintaining competent staff for all nuclear organisations and

for all phases of the life cycle of a nuclear facility. Several reports express concern about continuity of new talent ('nuclear newcomer' countries and aging nuclear workforce) while it is of key importance for the safety and security in this field. A large number of legal and policy documents emphasise the needs for knowledge management, training and education in the nuclear field, some of them even giving a relevant mandate to the JRC.

Since a decade, the JRC strengthened its role by providing access to its research infrastructure, disseminating knowledge, offering courses and coordinating knowledge management, education and training in the nuclear field for both Member States and the relevant Directorate Generals in the European Commission.

Following the recommendations of the Ex-post FP7 evaluation panel the JRC designed a specific project on knowledge management, training and education with the aim to integrate and give higher visibility to its activities in this field. More recently a full Unit has been charged with this mission.

The JRC focused on four major tasks:

1. Monitor the situation of nuclear-educated human resources in Europe, assess the trends and suggest policy options for improvement and focus on the development of a European scheme of nuclear qualifications and mutual recognition;
2. Sustain and facilitate (open) access to JRC infrastructures;
3. Provide education and training courses for students and professionals;
4. Support the development and implementation of EU policy and legislation on nuclear safety on a knowledge basis and integrate and exchange knowledge both in the JRC and in the Commission internally and with Communities of Practices (COPs).

The JRC manages the [European Human Resources Observatory in the Nuclear Energy Sector](#) (EHRO-N), which has published studies on the 'Top-down

workforce demand from energy scenarios' and 'Post-Fukushima analysis of HR supply and demand'. It also contributed to the definition and qualifications for decommissioning in the context of the European Credit system for Vocational Education and Training (ECVET). It strengthened its contribution to the European education-and- training efforts in various fields by delivering open access to its research infrastructures and data through several projects and initiatives.

Furthermore it organised and delivered series of trainings in nuclear safety, security and safeguards, including the development of tools like hands-on exercising, massive open online courses (MOOC), classroom lectures and involvement of MSc and PhD students in JRC's research programmes. A further dimension is addressed through JRC support to and involvement in European Joint Initiatives, in particular in the field nuclear waste management.

Continuous knowledge support to the Commission and the Member States encompassed ad-hoc support to DG ENER (follow-up of the EU stress-test, long term operations and nuclear power plants' life extension, participation to the revision of the IAEA safety standards and ad-hoc working groups of the OECD-NEA, etc.) and the European Clearinghouse on operational experience feedback. The Clearinghouse brings together nuclear regulatory authorities from Member States, operating nuclear power plants to facilitate the exchange of information on operational events and share lessons learnt. A feasibility study has been launched to develop a platform for hosting synthesis reports on the topical areas of Euratom research.

An essential element in collaboration is the involvement of stakeholders. This is mainly ensured through:

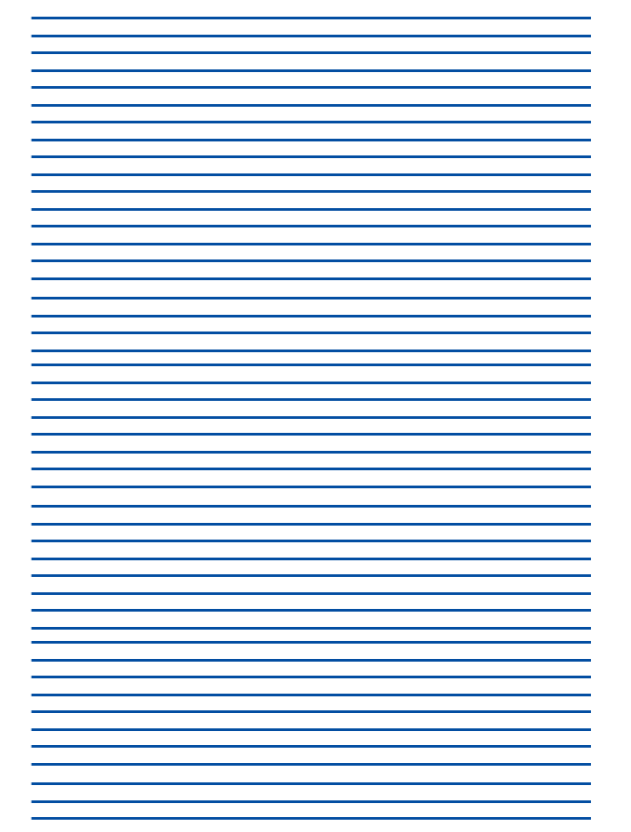
- The establishment of external steering committees, e.g. EHRO-N, Clearinghouse;
- Participation in networks and associations, e.g. European Nuclear Education Network (ENEN);
- The European Safeguards Research and development Associations (ESARDA); and
- Feedback from JRC participation in platforms like NUGENIA, SNETP and the SET-Plan.

Knowledge management, Training and Education is also integrated in most bilateral agreements of the JRC with external institutions.

Collaboration with international institutions such as the IAEA, OECD-NEA and involvement in working groups, committees, etc. is another essential element in the JRC collaboration strategy. Collaboration with IAEA's knowledge management department is being reinforced as part of the key actor in Communities of practice.

#### 5. Non-Energy Applications of Radionuclides & Technologies

The key activity in this area is developing the application of alpha-emitting radionuclides for the treatment of cancer. It is focused on the development of novel approaches and their translation into standardised protocols for routine application in hospitals. In this context a breakthrough has been achieved with the development of a novel therapy for treatment of metastatic prostate cancer. In addition, training in the safe handling of alpha emitters in clinical settings is provided to hospitals staff to improve radiation protection for patients and staff. In collaboration with international organisations such as IAEA and CERN, the JRC's expertise on nuclide production is transferred to research institutes and commercial organisations.



# ANNEX 4

## EVALUATION GRID

### JRC RESEARCH ACTIVITIES

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#### *Rationale / relevance*

**1.** Do the activities in this area address the research and training needs of the European Atomic Energy Community?  
(Yes to a large extent / to some extent / not at all)

**2.** Is it clear why these activities received JRC priority?  
(Yes to a large extent / to some extent / not at all)

**3.** Do these activities contribute to broader EU strategic objectives and policies  
(Yes to a large extent / to some extent / not at all)

**4.** If yes describe what objective / policy / strategic programme, and how.

**5.** Is the JRC the right place to do this work?  
If possible explain your reply.

**6.** Other general comment (if any)

#### *Implementation / achievement*

**7.** Are the activities in line with and on track to achieving the JRC programme objectives regarding:

- Improving nuclear safety
- Improving nuclear security
- Increasing excellence in the nuclear science base for standardisation
- Fostering knowledge management, education, and training

- Supporting the policy of the EU on nuclear safety and security?

For each bullet indicate: Yes to a large extent / to some extent / no

**8.** Are the listed partners/stakeholders credible? If negative please comment.

**9.** Do the activities provide concrete information on deliverables and impact?

**10.** Do the activities raise any considerations of cost-effectiveness?

**11.** Other general comment (if any)

#### *Performance level <sup>22</sup>*

**12.** Have the activities generated tangible impacts on EU policies and/or for the international nuclear community?

**13.** How do the achievements in this field compare to what is achieved elsewhere in the EU respectively the world?

**14.** Other general comment (if any)

<sup>22</sup> Scientific output of all nuclear activities is assessed in bibliometric study



# GLOSSARY

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|           |   |
|-----------|---|
| ALFRED    | Advanced Lead Fast Reactor European Demonstrator                            |
| ALLEGRO   | First Gas-cooled Fast Reactor Demonstrator                                  |
| ASTEC     | Accident Source Term Evaluation Code  |
| ASTRID    | Advanced Sodium Technical Reactor for Industrial Demonstration              |
| CDP       | Collaborative Doctoral Partnerships   |
| CEA       | Commissariat à l'énergie atomique et aux énergies alternatives              |
| CERN      | European Organization for Nuclear Research                                  |
| CESAM     | Code for European Severe Accident Management                                |
| CORDIS    | Commission Research and Development Information System                      |
| CRIEPI    | Central Research Institute of Electric Power Industry (Japan)               |
| DG        | European Commission Directorate General                                     |
| DG EAC    | Directorate General for Education and Culture                               |
| EC        | European Commission   |
| ECURIE    | European Community Urgent Radiological Information Exchange                 |
| ECVET     | European Credit System for Vocational Education and Training                |
| EEAS      | European External Action Service  |
| EERA      | European Energy Research Alliance   |
| EERA-JPNM | Joint Programme on Nuclear Materials  |
| EHRO-N    | JRC European Human Resources Observatory for the Nuclear Sector             |
| ENEN      | European Nuclear Education Network  |
| ENSREG    | European Nuclear Safety Regulators Group                                    |
| ERA       | European Research Area  |
| ESARDA    | European Safeguards Research and development Associations                   |
| ESFRI     | European Strategic Forum for Research Infrastructures                       |
| EU        | European Union  |
| Euratom   | European Atomic Energy Community  |
| EURDEP    | European Radiological Data Exchange Platform                                |
| EUSECTRA  | JRC European Nuclear Security Training Centre                               |
| FP7       | 7th Framework Programme, EU's Research and Innovation funding for 2007-2013 |
| GFR       | Gas-cooled fast reactor   |
| GIF       | Generation IV International Forum   |
| H2020     | HORIZON 2020, EU's Research and Innovation funding programme for 2014-2020. |

|          |  |
|----------|--|
| IAEA     | International Atomic Energy Agency                               |
| JAEA     | Japan Atomic Energy Agency                                       |
| JRC      | Joint Research Centre  |
| KM       | Knowledge Management   |
| LFR      | Lead-cooled fast reactor   |
| MetroERM | Metrology for radiological early warning networks in Europe      |
| MOOC     | Massive Open Online Courses (free online courses)                |
| MSR      | Molten salt reactor  |
| MYRRHA   | Multi-purpose Hybrid Research Reactor for High-tech Applications |
| NEA      | Nuclear Energy Agency of the OECD                                |
| NEO      | Nuclear Energy Observatory                                       |
| NPP      | Nuclear Power Plant  |
| NPT      | Non-Proliferation Treaty   |
| NST      | Nuclear Science and Technology                                   |
| NUGENIA  | Nuclear Generation II & III Association                          |
| NULIFE   | Network of Excellence on nuclear plant life management           |
| OECD     | Organisation for Economic Cooperation and Development            |
| PhD      | Doctor of Philosophy, Doctorate or Doctor's degree               |
| R&D      | Research and Development   |
| S&T      | Scientific and technical   |
| SARNET   | Network of Excellence on severe accidents                        |
| SDG      | Sustainable development goals                                    |
| SET-Plan | Strategic Energy Technology Plan                                 |
| SFR      | Sodium-cooled fast reactor                                       |
| SMEs     | Small and medium enterprises                                     |
| SNETP    | Sustainable Nuclear Energy Technology Platform                   |
| TAT      | Targeted Anticancer Therapy                                      |
| TSO      | Technical Support Organisation                                   |
| UK       | United Kingdom   |
| US       | United States of America   |
| US-DoE   | United States Department of Energy                               |
| US-DoS   | United States Department of States                               |
| US-NRC   | United States Nuclear Regulatory Commission                      |
| VHTR     | Very high temperature reactor                                    |

## Interim Evaluation of the Direct Actions under the Euratom Research and Training Programme (2014 - 2018)

European Commission  
Joint Research Centre  
<https://ec.europa.eu/jrc/>

### Abstract

This report presents an interim evaluation of the direct actions of the Joint Research Centre (JRC) of the European Commission under the Euratom research and training programme (2014 - 2018), conducted halfway through the programme by a panel of high-level independent experts. The panel had extensive knowledge and experience in matters of Euratom research and the wider responsibilities of the European Commission related to nuclear safety and security in a European and an international context.

During the reporting period the JRC has shown the ability to lead through coordination, bringing together its own research efforts with those in the Member States. The JRC concentrated its nuclear work in one directorate and more in general the JRC has given successful follow up to recommendations from previous evaluations.

The European knowledge manager for nuclear safety and security; the European voice for nuclear; Responsible for the largest single nuclear research effort of the European Atomic Energy Community, the JRC shows its frontline position in this area in all modesty. As the European Commission's science and knowledge service, the JRC has an excellent position to communicate reliable information on nuclear matters, not only to the nuclear organisations, but also to the other stakeholders, notably the politicians and the public.

The positive conclusions and recommendations at the end of this report should help the JRC and the Commission preparing sound proposals for a Council regulation for the Euratom research and training programme 2019 - 2020 and for the next Euratom programme (2021 - 2025).

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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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