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JRC EXTERNAL STUDY REPORT

Interim evaluation of the activities of the Joint Research Centre under Horizon Europe and Euratom 2021-2025

Final report of the evaluation panel

2023

Joint Research Centre

Contact information
Email: JRC-EVALUATION@ec.europa.eu

EU Science Hub
https://joint-research-centre.ec.europa.eu

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Rolf-Dieter Heuer	Chair Former Director General, the European Organization for Nuclear Research (CERN)
Adina Magda Florea	Vice Rector, Politehnica University of Bucharest, Romania
Margarita Herranz Soler	Professor for Nuclear Engineering, University of the Basque Country, Spain
Tomasz Janowski	Head of Department of Informatics in Management, Gdańsk University of Technology, Poland
Carina Keskitalo	Professor of Political Science, Umeå University, Sweden
Rob Maas	Senior scientific advisor for integrated environmental assessments, National Institute for Public Health and the Environment (RIVM), The Netherlands
Julie Oddou	Managing Director for European Affairs, Commissariat à l'énergie atomique et aux énergies alternatives (CEA), France
József Pálinkás	Professor, Department of Experimental Physics, University of Debrecen, Hungary
Henrik Wegener	Rector, University of Copenhagen, Denmark

Foreword by the Chair

In July 2022, the ex post evaluation of the activities of the JRC was published, covering the period 2014-2020. The interim evaluation of the JRC in Horizon Europe and the Euratom research and training programme 2021-2025 started end of 2022 and I had the honour and pleasure to also chair the panel of accomplished experts for this interim evaluation. Some members of the ex post panel were also serving on the interim panel ensuring continuity.

The Panel was presented with the work performed in 2021-22 as well as with the strategy for the remaining period and beyond. Despite the very short time between the two evaluations, two important remarks can be made. Looking backward, the Panel could see the positive evolution of the work performed by the JRC. Looking forward, the new way of working within the JRC through a portfolio approach as well as with the policy DGs can be considered as a promising way forward to master the future challenges in a more holistic way.

On a personal note, I would like to add that the new management under the leadership of the Director-General Stephen Quest is instrumental in these changes. This was also pointed out by stakeholders in our discussions.

These Panel internal discussions with stakeholders proved once more to be very informative and supported the Panel's own observations. We reiterate the recommendation of the panel for the ex post evaluation 2014-2020 to have such discussions in all future evaluations.

The JRC has shown agility, exemplified by deploying its capacity to address crises like COVID-19, the Russian war of aggression against Ukraine or the energy supply. All in all, there was big demand on the support from the JRC by the policy DGs and the JRC responded effectively based on scientific evidence. At the same time, the JRC has kept its strive for excellence and gives its researchers the opportunity for blue sky research. This is a very important aspect to attract the best researchers to the centre.

The Panel is confident that the JRC's transformation leads to something unique, perhaps a model for how science can advise policy in Europe and possibly beyond. It could become, in collaboration with the Scientific Advisory Mechanism of the European Commission, a model for Member States on how science can best inform policy.

The Panel appreciated the open and responsive attitude of the JRC with respect to the recommendations of the last ex post evaluation. All recommendations were at least partially accepted and the Panel was pleased to see that in several cases, the effect of the response was already visible, and in the other cases, the plans for changes were presented or were being formulated. From ex post to interim, we saw interesting developments, consolidating the JRC's role, and a stronger focus on impact on policies and partnerships. The JRC is increasingly focussing on social and institutional aspects, which was also an important recommendation of the ex post evaluation.

Although the Panel was pleased with the progress mentioned in the report, there is room for further improvement. There is a need to continue to step up the integration of institutional, social and behavioural aspects into the research projects.

The way of communication needs constant attention and improvement. Given the JRC's role in providing scientific advice to EU policymaking, and the obligation for transparency towards the public, it is particularly important to communicate clearly the gaps and uncertainties in its evidence – what we know, don't know and cannot know. This will also help the acceptance of scientific results by policymakers and the public.

Despite the role and impact of the JRC, the Panel has the impression that the JRC is not sufficiently well known in the Member States, its academic and policymaking institutions, as pointed out in the ex post evaluation. To remedy this, the Panel strongly recommends the JRC to intensify its cooperation with such institutions. In so doing, the

JRC should profile itself as a stepping stone for an international career, be it in research or in science for policymaking and develop the narrative around the JRC's mission and core strengths.

The interim evaluation comes at the time when preparations for the next College of Commissioners of the European Commission and for the EU's next research programmes are starting. During the mandate of the current College, the JRC's foresight activities have taken a more prominent role in the policymaking process. The JRC should build on this and use its foresight competences to help prepare the political agenda for the next College and the societal challenges which the research programmes in the next financing period could focus on.

The Panel reiterates the concern of the ex post evaluation about the budget reduction for the JRC's part in the Euratom programme. There will be an increasing need for specialists in the field of nuclear technologies in the immediate future.

I reiterate the recommendation of the panel for the ex post evaluation that the European Commission should help the JRC to find an administrative way to facilitate the interaction between Euratom and Horizon Europe-financed activities.

I greatly enjoyed working with so many distinguished colleagues on the Panel and I would like to thank them all for their commitment, their work, and their input. The Panel supports unanimously the report in front of you. On behalf of all members, I want to thank everybody in the JRC involved in this review, in particular Sari Lehto and Jens Otto for their constant support, help and patience, and Annabelle Kasiers for all the administrative preparations.

Rolf-Dieter Heuer

Executive summary

This report provides an assessment of the European Commission's Joint Research Centre (JRC) under Horizon Europe and the Euratom research and training programme 2021-2025, prepared by a Panel of nine independent experts for the two programme parts separately, with common conclusions and observations on the JRC's performance and future direction as a whole. The Panel's assessment will support the evaluation of the JRC's contribution to the overall research programmes and as the European Commission's in-house science service.

The assessment follows almost immediately after the ex post evaluation was completed in 2022. Thus the Panel was asked to evaluate activities under the current research programmes building on the results of the previous programmes. In line with its mandate, this Panel has also looked into what changes the JRC has implemented and what effects they have already had or are expected to have, and what could be further developed to enhance the agility, impact and efficiency of the JRC's policy support and to ensure EU decision-makers get the best possible scientific advice also in the future.

The Panel was satisfied with the performance of the JRC under both research programmes. Its work is deemed relevant and of high quality. Good examples were found in all Horizon Europe impact areas and the JRC's contribution to the Euratom programme.

The Panel also welcomed the recent investment in understanding and supporting digital transformation, by creating a dedicated department and addressing emerging issues, such as the use of AI and quantum technologies, very large online platforms and search engines.

Under the Euratom programme, the Panel generally agreed that the JRC has made significant contributions to a stronger and safer Europe.

The Panel's main conclusions and steer for future development are:

A new way of working closer with the policy DGs and a portfolio approach to designing and managing its work programme are considered a promising way forward. There is already evidence of more coherence and higher policy relevance, through integration and cooperation within the JRC as well as among the stakeholders. A closer interaction between Horizon Europe and the Euratom programme is observed (integration in several portfolios) although there is potential for more, for example in research for emergency preparedness. It is important to monitor if the new portfolio approach would require more time for internal meetings and reviews, and reduce the JRC's efficiency in terms of scientific output.

Interviews with stakeholders in the EU institutions have confirmed more effective interaction with policy DGs and better understanding of what the JRC can and cannot offer. The Panel acknowledges that the meetings with policy DGs in clusters before starting to plan the JRC work programme help to align it with policy needs, identify priorities for the coming years, and shape a more integrated response to such needs. **The JRC should also communicate and discuss changes in prioritisation of activities with the stakeholders sufficiently early, and appropriately communicate gaps and uncertainties in the evidence base for policymaking.**

Bringing about a real change has required a significant shift also in the culture of working together, and the JRC management has played an important role in providing the necessary leadership and empowerment of research staff.

Despite all the good work, the JRC remains largely invisible to the Member States' administrations and the general public, and to a certain extent also among policymakers of the EU institutions, as pointed out in the last ex post evaluation. In addition to enhanced communication, **the Panel therefore strongly recommends to strengthen cooperation with the Member States.** One avenue for overcoming this is engaging Member States' institutions in JRC initiatives targeted at the national level, and supporting them to take the most effective action given their knowledge of the national needs and circumstances. Such institutions, primarily ministries and universities, can offer their own expertise, and rely on the expertise from the JRC and other ministries and universities that join the initiative. The JRC-owned digital platforms could help scale up such initiatives. This avenue can also help attract new talent capable of bringing science to policy. Another avenue is to strengthen cooperation and involve national experts, host visitors and promote exchange opportunities to ensure two-way knowledge exchange.

> The panel strongly recommends to strengthen cooperation with the EU Member States.

In view of the major cuts in funding in recent years, the large demand for research and policy support and the importance of education and training for the availability of a competent and skilled work force for both research and public service in Europe, **the Panel supports the JRC's efforts to increase its funding through the Euratom programme to maintain its expertise, services and infrastructure. The Panel is of the opinion that the JRC is an important complement to the Member States' capacity to deal with nuclear issues from safety to non-energy applications. The Panel therefore calls on the College of Commissioners of the European Commission to make every effort to secure a more adequate funding for the JRC's activities under the Euratom programme.**

In response to the challenges facing the Euratom programme, the JRC has developed a strategy for its nuclear research activities. **As part of this strategy, the JRC should map the state of the JRC's nuclear infrastructures and make a plan for future development, as many of them are quite unique.**

In the unstable geopolitical environment due to, e.g., war, pandemic, global warming and democratic breakup, policies that address the causes and consequences of such instability must increasingly rely on evidence, capable institutions, and engaged society. **The JRC is advised to complement its research with a stronger focus on social dimensions and institutions, targeting policy DGs, Member State governments and other policy actors,** all relying on digital transformation to scale up their response from whole-of-government to whole-of-society.

The JRC is a unique resource for the European Commission and should strengthen its leadership at the EU level to become a model for how to make use of a broad range of research and science to inform policy decisions. For example, it should develop and communicate standards and guidelines for good science for policy practices for EU policymaking, taking into account a large variety and difference between research areas.

Implementation of the data strategy is essential, with **emphasis on data quality, dealing with uncertainties and potential biases, and on how data is organised and managed throughout its lifetime. Appropriate consideration should be given to qualitative data** which may include those from social media and crowdsourcing. The data strategy should also take into account that qualitative data may require to be treated differently from large-scale quantitative data, for example because of ethical concerns or compliance with data protection rules.

The Panel finds it is important for the JRC to **invest in generalists who are able to integrate between disciplines**. At the same time, it is important to **maintain specialist competencies and 'blue sky' research**, not only to allow innovation to flourish and to open up new avenues but also to keep scientists motivated and increase the attractiveness of the JRC to specialists. The JRC should maintain a healthy specialist-generalist balance (defined depending on the area) to ensure creativity, productivity, and ability to act proactively.

To be more effective, and to deliver on its new value proposition, **the JRC needs to continue developing its foresight capability**. The JRC is also encouraged to make better use of foresight and trend analysis for defining its own research and networks with other institutions in the Member States and globally to further enhance its efficiency. Past projections should be analysed and evaluated to improve the effectiveness and accuracy of future foresight work.

Systematic internal self-evaluations, developing key performance indicators for measuring the efficiency of science for policy support, mapping knowledge gaps, SWOT analyses and collecting regular feedback from the partner DGs are strongly encouraged, as a good practice for portfolio management together with collecting the experiences of individuals involved.

The JRC could **further increase its capacity in the digital transition** by looking at how new and emerging technologies, such as AI, large language models and quantum computing, will influence the development of industries and will impact society in general. Evaluations of past foresight studies could help to get feedback for future strategies and actions. The JRC would greatly benefit of leveraging the immense capacity of AI to do simulations (not predictions) to increase its anticipatory capabilities.

The list of topics that are to be addressed by the JRC urgently is continually growing and it remains unclear who sets priorities, what the JRC should address, at what moment and what can be done elsewhere. The panel for the ex post evaluation had a similar observation and made a recommendation to 'systematically develop and apply criteria in relation to its unique strengths and policy relevance for deciding whether or not to engage in a particular activity, and for disengaging from it'. As part of the process **for deciding whether or not a new topic is taken on board, a mapping is needed of what is being done by, e.g., Member States and what the specific value added of the JRC would be.** Therefore, it is important to be very clear to policymakers whether a new topic will indeed be taken up (possibly as part of a strategic dialogue on the JRC's work plan) and to communicate timely about delays and changes. It is also important that, in topics that the JRC takes on and that require knowledge from a broad array of disciplines, it is ensured that disciplinary bias in advice due to lack of resources or other factors is avoided.

1. Introduction

The JRC is one of the departments (DGs) of the European Commission. Its purpose is to provide independent, evidence-based knowledge and science, supporting EU policies to positively impact society.

Most of the JRC's funding comes from the Community research programmes, currently the Horizon Europe framework programme for research and innovation (2021-2027), and the Euratom research and training programme 2021-2025 complementing Horizon Europe. According to their legal bases (see Box 1), interim evaluations need to be carried out with the assistance of independent experts, no later than four and three years, respectively, after the start of programme implementation. Other specific inter-institutional and European Commission rules further frame this evaluation.

This report provides the assessment prepared by a panel of nine independent experts, for the two research programme parts separately with common conclusions and observations on the JRC's performance and future direction as a whole. The Panel's assessment will support the evaluation of the JRC's contribution to the overall research programmes and as the European Commission's in-house science service.

BOX 1: FRAMEWORK REGULATIONS ON FUNDING THE JRC'S ACTIVITIES

- Regulation (EU) 2021/695 establishing Horizon Europe – the Framework Programme for Research and Innovation
- Regulation (Euratom) 2021/765 establishing the Research and Training Programme of the European Atomic Energy Community for the period 2021-2025 complementing Horizon Europe – the Framework Programme for Research and Innovation.

Most of the funding is provided through 'direct actions' of the research framework programmes. The direct and indirect research concept is characteristic for the Community research programmes: all direct research activities under the framework programmes are pursued by the Commission in the establishments of the JRC, whereas indirect research is conducted in research centres, universities or undertakings, with financial support from the Commission spending programme, managed by DG for Research and Innovation.

2. About the JRC

The JRC was set up in 1957 by the Euratom Treaty to carry out 'the research programmes and other tasks assigned to it by the EC'. It was originally focused on nuclear standards and measurements but today, the JRC offers a broad variety of expertise and competencies across scientific disciplines in support of almost all EU policy areas, including 25% on nuclear research.

The JRC contributes to the overall objectives of the framework programmes and has a specific task to support policymaking. It directly responds to the demands of the European Commission's political priorities, and reports to the responsible Commissioners. This combination gives the JRC a unique character as a research organisation at the science-policy interface.

The JRC employs 2 700 staff[1], located at its sites in five Member States. Its annual budget is around EUR 400 million, accounting for 2.3% of the annual budget of the whole Horizon Europe programme and almost 40% of the Euratom programme 2021-2027[2]. Under the current research programmes, the JRC's funding has been cut, with a significant reduction by 20% for the part funded by Euratom[3].

In 2020, the JRC started a reflection on its strategy adopted in 2016. The 2-year process resulted in a reinforced commitment as a science service for policymakers and new ways of working, with a purpose to improve its capacity to anticipate new challenges and provide holistic solutions to the complex and interlinked challenges faced by the society[4]. The revitalised strategy aims to position the JRC as an organisation even more clearly focused on science for policy, which produces world-class science and is open for partnership.

The new direction is suggested in the JRC's value proposition. The JRC has identified its value proposition as anticipation, integration and impact, helping the European Commission to better anticipate policy needs, to work in a more integrated way across sectoral policies, and to achieve enhanced impact of its policies.

To enhance the relevance, coherence, efficiency and effectiveness of its actions, it has since 2023 organised the work under 33 portfolios (Figure 1) which make use of expertise across the whole JRC in multiple scientific fields and policy areas. Cross-cutting activities such as knowledge management, exploratory research, foresight, education and training run through all the portfolios as well as engaging actively with stakeholders.

The JRC has also devised a data strategy embracing the FAIR[5] principles, a new strategy for its nuclear research and policy support, and set up new directorates for digital transformation and innovation in science for policymaking.

A simplified diagram in Annex 1 shows the main elements of the JRC's intervention logic (causal link between reason for JRC to act, inputs and impacts).

1 1 January 2023 - 2 684 staff; 1 January 2022 - 2 759 staff; 1 January 2021 - 2 713 staff

2 Budget for 2026-2027 is based on provisional financial programming.

3 With 2% nominal inflation

4 Revitalising the JRC Strategy 2030, Publications Office of the European Union, Luxembourg, 2023, ISBN 978-92-76-59237-2, doi:10.2760/726726, JRC131698.

5 Findability, accessibility, interoperability, and reusability

Figure 1. 33 JRC portfolios in its 2023-2024 work programme and their allocation to relevant European Commission priorities.

Source: Joint Research Centre, Work Programme 2023-2024, JRC132599, 2023

3. Panel mandate

The purpose of this evaluation is to produce an independent external view on the relevance, efficiency, effectiveness, coherence and EU added value of the JRC's activities, in line with the criteria stipulated in the European Commission's Better Regulation Guidelines for evaluations.

The terms of reference (Annex 2) specified that the Panel should examine the JRC's activities through the impact areas defined for the overall Horizon evaluation (Resilient Europe; Digital and industrial transition; Green transition; Innovative Europe). A separate evaluation is needed for nuclear safety and security activities under the Euratom programme.

The terms of reference contain a list of evaluative questions which have guided the assessment of the performance of the JRC. In addition, the Panel was asked to give its views on what changes could be made to further enhance the JRC's impact and efficiency, taking into account the follow-up that the JRC has given to the ex post evaluation of its activities under the preceding research programmes and developments in the design of its work programme, its scientific facilities and working methods. A point of interest is also how the JRC's work compares to top-class work in the various fields done elsewhere.

4. Evaluation methodology

To arrive at an assessment, the Panel conducted desk research studying the legal bases, programme documents, past evaluations, performance reports, a JRC report on basic facts and figures, and publicly available materials. The Panel received also 60 case studies illustrating the impact of selected JRC activities on science, society and policymaking, assessed for impact by experts from academia, governmental organisations or industry, and subject to feedback of the policy DG recipients. Bibliometric data for benchmarking scientific performance were presented to complement Panel members' own experience in evaluating other organisations.

The Panel's fact-finding mission contained a series of hearings on activities under the specific impact areas and on cross-cutting topics. The hearings were organised both onsite and online. Two meetings organised at JRC research sites in Ispra (IT) and Karlsruhe (DE) allowed the Panel members meet staff face-to-face and visit JRC laboratories, including a roundtable on future challenges and the JRC's value proposition with the JRC top management.

To gain a deeper understanding of the JRC's standing as a science service within the European Commission and its added value, the Panel interviewed three members of the JRC's Board of Governors and eight of the key stakeholders from other Commission departments and the Committee of the Regions.

Three Panel members together with the Chair were responsible for the assessment of activities under the Euratom programme, having expertise in relevant areas, and the other five members shared the work on assessing activities under Horizon Europe. The Panel as a whole agreed on general and cross-cutting conclusions and observations.

The interim evaluation is required just after two years into the research programmes and follows almost immediately the ex post evaluation of Horizon 2020 and the Euratom programme and its extension (2014-2020), which for the JRC was completed in September 2022. Thus the Panel was asked to evaluate activities under the current research programmes building on the results of the previous programmes, in line with the evaluation of the overall research programmes and focusing on changes where appropriate. The ex post evaluation concluded with a number of recommendations and this Panel agreed to provide a first assessment of what changes the JRC has implemented and what effects they have already had or are expected to have. Instead of a list of new recommendations the Panel would highlight the areas for further action and formulate alternative ways forward.

5. The JRC's activities under Horizon Europe

5.1 General assessment

Under Horizon Europe, the JRC's task is to generate high-quality independent scientific evidence for efficient and effective good public policies while focusing its research on Union policy priorities.

The Panel found that the JRC has been successful in this respect. It has provided relevant scientific expertise and knowledge to support all headline ambitions of the European Commission. Its work is of high quality and compares well with top organisations focussing on research and/or research-based policy support. Judging by commonly used scientific impact indicators, its research is at the frontier in many areas.

Good examples of relevant support were found in its work linked to the different impact areas (Innovative Europe; Resilient Europe; Digital and industrial transition; Green transition). The Panel also welcomed the recent investment in understanding and supporting the digital transition, by creating a dedicated department and addressing emerging issues on the use of AI and quantum technologies, very large online platforms and search engines.

Through its contributions, the JRC promotes and enhances the coherence and effectiveness of EU policies. For instance,

- the JRC's foresight report on the twin transitions and the work on indicators provide a science-base for multiple policies.
- The JRC carried out the multidisciplinary impact assessment for the sustainable food chain, including economic, social and environmental impacts.
- Other examples are the support to the Nature Restoration Law and the Fit for 55 package.

Complementarity and synergies between the JRC's work programme and actions taken in the Member States and internationally are ensured by its wide networks and collaboration with top institutions worldwide such as UN, OECD, or US agencies and departments.

Further, the JRC's new approach to designing and managing the work through portfolios has shown potential for greater coherence and efficiency gains, by better coordinating the requests for support, by a more comprehensive and holistic problem definition and by making use of resources from across the whole JRC.

The panel was satisfied with the performance of the JRC under Horizon Europe. Its work is deemed relevant and of high quality.

The JRC's added value is demonstrated by, e.g., its interdisciplinary research capacity and ability to translate research for policymakers, where its independence, neutrality and networks help achieving solutions at EU level and where it represents EU interests in international fora.

The Panel's detailed observations below under the four impact areas provide more insights into the evaluation and its key findings.

5.2 Observations in the area of 'Innovative Europe'

Innovative Europe is one of the pillars of Horizon Europe and, together with the EU's regional policy, the main policy context for the JRC's innovation activities. Innovative Europe comprises three components – the European Innovation Council (EIC), the European Institute of Innovation and Technology (EIT), and the European Innovation Ecosystem. The context also includes the Horizon Europe's widening sub-programme which tackles the innovation divide, and the New European Innovation Agenda (NEIA), which brings together innovation-enhancing policies, instruments and investments from different policy areas, e.g., the Green Deal, Digital Decade, or global affairs. As part of the European innovation ecosystem, the JRC cooperates with EIT on NEIA, smart specialisation, and inter-territorial collaboration, and with EIC on strategic intelligence capacity through anticipatory approaches.

The JRC applies innovation to its own working methods. This includes the use of portfolios to design and manage its work programme, interaction with clusters of policy DGs to bridge silos, staff exchange programmes, and science-for-policy training. The JRC also helps the European Commission innovate on its working methods, e.g., on cross-organisational collaboration or internal communication, introduce better regulation through, e.g., tools and methods for ex ante or ex post evaluation, and integrate foresight into policymaking. Innovation is also well integrated into JRC portfolios, many of which include activities that enhance, or rely on, innovation.

The JRC has a well-established position in supporting the European Commission's innovation policy in 1) modelling and impact assessment of regional policies, 2) monitoring and analysis of the trends in industrial R&D investment, and 3) development of methodologies to support policy implementation, and other areas. Overall, it runs an effective portfolio of innovation relevant activities that combines established tools for impact analysis such as Regional Economic Modelling (RHOMOLO) or Regional Economic Monitor (REMO). There is the ongoing development of new methodologies like Partnerships for Regional Innovation (PRI) or Science, Technology, and Innovation (STI) for Sustainable Development Goals (SDGs), which build upon established approaches like smart specialisation strategies (S3). In all areas, the JRC collaborates with policy DGs and beyond.

The innovation supporting activities contribute to five political priorities of the von der Leyen Commission. They are embedded in several portfolios dealing with e.g., digital transition, economic governance, energy solutions, innovative policymaking and trustworthy AI, and some innovation initiatives serve several portfolios' goals. This shows a high level of coherence between innovation supporting activities and strategic and political objectives pursued by the JRC and the European Commission. Synergies are also enhanced by the one-JRC data principles and by the anticipation-integration-impact value proposition, which is well-articulated for the innovation theme: expansion of the data collection and modelling methods (anticipation), expanding the use of existing methodologies in other fields (integration), and more impact also beyond the EU borders (impact).

The JRC offers a variety of tools that target different stages in the policy lifecycle, e.g. analysis and evaluation (RHOMOLO and REMO), implementation and refinement (PRI), formulation, implementation and evaluation (Handbook of Sustainable Urban Development Strategies), and monitoring and evaluation (EU Industrial R&D Investment Scoreboards). The tools also target different actors, such as policymakers, planners, authorities, public managers and community leaders, and different territorial levels – local, urban, regional, and national. To manage this complexity and increase utilisation, the JRC is advised to organise an assemblage of existing and emerging tools, help users discover the right tool for the context and problem at hand, highlight suggested usage scenarios, and promote synergy between tools, particularly when they focus on the same territorial levels and subsequent policy stages; they can form a policy value chain. The increased synergy between tools would help uncover new analytical capabilities, thanks to the integration and harmonisation of the underlying databases, and bring user

communities together, unleashing new collaboration opportunities and increasing the impact of the JRC.

The tools above are the outcomes of the JRC's own research-based innovation, which translates the JRC's research into practical applications. Subsequently, such tools can be adopted by other organisations as part of their own service, processes, and organisational, policy, governance or other innovations.

In general, institutional innovation involves changes to the structures and behaviours of organisations to enhance their operations and meet new requirements. Among them are digital, green and resilience transitions, all requiring innovation, and other societal challenges. **Thus, in addition to supporting innovation policies through various tools and guides, the JRC is advised to engage in institutional innovation research, i.e., research aimed at understanding the drivers, challenges, processes and impact of innovations within other organisations, particularly policy DGs, EU institutions, Member States' government agencies, and other actors involved in the EU policy lifecycle.** This would also help the JRC address the ex post recommendation to engage more in research for transformative societal challenges.

To increase its impact, the Panel encourages the JRC to clarify the role it wants to play in the EU innovation landscape, in e.g., decision support, capacity building, research-based innovation, and institutional innovation research, and what value proposition the JRC wishes to offer. In view of the preparation for the next funding period 2028+, it will be important for the JRC to analyse the findings of the upcoming interim evaluation of the relevant funding instruments to position itself in the EU support to regional innovation.

Social sciences approach to innovation, e.g., social innovation with non-monetary bottom lines, impact studies with multiple bottom lines, and qualitative innovation impact studies are unrecognised in the standard innovation policy frameworks. This constitutes an opportunity for the JRC, where an EU-level approach could be relevant. The JRC is encouraged to look at this opportunity and its capacity to tackle it.

5.3 Observations in the area of 'Resilient Europe'

The JRC plays an important role in contributing to a resilient Europe through activities that cover diverse fields:

- gathering data on disaster risk management, developing early warning systems and supporting research for emergency preparedness;
- climate modelling and assessment of risks of climate change;
- supporting the transition to a resource efficient and circular economy;
- assessing the resilience of critical infrastructures to various hazards;
- putting migration in the broader context of demographic changes, including issues like labour market imbalances, health care, urbanisation and the trust in institutions;
- monitoring and assessing health risks, including emerging infectious diseases, food fraud, and chemical hazards;
- developing tools and methodologies to analyse large data sets, such as geospatial data, satellite imagery and socio-economic data to foster digital resilience; and
- monitoring risks in the banking sector and supporting policies for improving the banking regulations.

The past years have reaffirmed the strategic importance of the JRC's work for the EU's resilience. In dealing with crises like the COVID-19 pandemic, the Russian war of aggression against Ukraine, disruptions in supply chains, migration, and the increasing risks to cybersecurity and financial stability, the JRC has shown its flexibility and ability to help building a resilient Europe. The JRC has proved capable of using its broad networks to adapt to new needs. The focus has had to shift from terrorism, the financial crisis and refugees, to COVID-19 and managing the impacts of the Russian war of aggression to energy and food security.

At the same time, the management of common disasters (forest fires, floods, droughts, and earthquakes) has required immediate policy support with up-to-date information, which is a core task of the JRC. The Emergency Response Coordination Centre works effectively, as was shown during the recent earthquakes in Türkiye and Syria. Data from Copernicus, open source epidemic data and AI technology are the basis for the JRC's early warning system.

The availability of detailed geographical monitoring networks and models gives the JRC a unique position and creates added value.

The JRC's attention is moving towards analysing what is happening after a disaster i.e. the political aftershock, the different human and political impacts. The JRC is also strengthening its foresight ability to prepare for, prevent and adapt to future risks. It works on a dynamic conflict risk model that links climate, conflict and humanitarian crises and tries to include social and political scientists in this field. Important future challenges are to further develop the capability to support pro-active policies, to analyse the drivers behind man-made disasters and geopolitical conflicts, to further develop the foresight activities and translate them into potential response strategies.

The relevance of the JRC's work should not be underestimated. Most of the resilience relevant work is effectively linked to policy development, often by several policy DGs.

For instance, the JRC is well connected to the policy debate on a new 'Beyond GDP'-indicator and on scientific discussion on how to measure wellbeing, sustainability and resilience beyond the traditional GDP indicator. This is a good step towards answering a suggestion in the recent ex post evaluation that the JRC should 'take a strong role in developing an alternative metric to GDP'. One of the first priorities for the JRC should be to link its work on the health data information system to the beyond GDP work. This would include collecting and distributing health data beyond cancer and rare diseases, and also monitoring and explaining differences in environment and life style-related diseases as well a mental illnesses. In particular, mental health is not well addressed yet, although the COVID-19 crisis showed the importance of psychological and emotional aspects during the lockdowns. Especially during a potential period of low or no-GDP growth, distributional and emotional aspects will become more important for a resilient Europe.

An important product of the JRC for the Member States is the resilience dashboard that identifies existing and emerging challenges and vulnerabilities of EU Member States, updated each year (the last update was in spring 2023). A broader dashboard of indicators has been developed and used to evaluate the EU's recovery and resilience strategy. The further development and updates of the Resilience Dashboard would require increased attention to data quality, including identification of inaccuracies, data gaps and biases; e.g., indicators related to emerging digital technologies and their impact are missing. The possibilities for underlying data access used for the Resilience Dashboard for both the Member States officials and the citizens should be assessed.

Further development of integrated assessment models for medium-term projections and analysis of policy scenarios could potentially enable the inclusion of beyond GDP thinking in actual policy choices. However, finding political compromises between conflicting targets and strategies would almost never be based on model results alone. Supporting policy negotiations would also require the JRC to perform an analysis of conflicting priorities and underlying world views as well as of the role of the institutional set- up, including the distribution of power.

On top of the traditional security issues, such as the critical and public infrastructures, terrorist attacks and airport controls, the JRC is preparing for new security threats, such as drones, cyberattacks and hybrid threats that undermine democracy, e.g., with misinformation. Foresight and anticipation are important elements for addressing cybersecurity and counteracting hybrid threats. Collaboration with national security organisations is part of the JRC's strategy to develop a European cyber shield. The JRC is well connected to research work on algorithms, AI, block chains, quantum technology, internet security and cybersecurity in the energy and

automotive sector. The knowledge on AI is important to remain on top of the developments, to develop a forward look on AI, to anticipate AI's influence on other emerging technologies, and how AI will impact the society in general. The JRC might want to rely more on its work on digital transformation to make institutions and, in turn, society more resilient. For instance, an effective management of hybrid threats needs scaling up readiness from whole-of-government to whole-of-society using technology and tech-enabled institutions and, **due to the risks of the digital transformation itself, research on sustainable digital transformation is needed.**

However, the list of topics that are to be addressed by the JRC urgently is continually growing and it remains unclear who sets priorities, what the JRC should address, at what moment and what can be done elsewhere. The panel for the ex post evaluation had a similar observation and made a recommendation to 'systematically develop and apply criteria in relation to its unique strengths and policy relevance for deciding whether or not to engage in a particular activity, and for disengaging from it'.

As part of the process for deciding whether or not a new issue **is taken on board, a mapping is needed of what is being done by, e.g., Member States and what the specific value added of the JRC would be.** Therefore, it is important to be very clear to policymakers whether a new topic will indeed be taken up (possibly as part of a strategic dialogue on the JRC's work plan) and to communicate timely about delays and changes.

5.4 Observations in the area of 'Digital and industrial transition'

The JRC conducts research and analysis in the areas related to digital technology development and its impact on various sectors and industries, and to the development of data policies and frameworks for secure and ethical use of data.

The JRC supports the European Commission on the development of digital regulations and standards, provides expertise on digital services and digital governance, and promotes digital skills and digital literacy across the EU.

It also analyses the conditions necessary for a more sustainable economy, including new technologies and innovative industrial practices, for the twin green/digital transition (e.g., through the 2022 Strategic Foresight Report), and for collaboration among stakeholders involved in the industrial transition.

Several activities include analysis of the economic impact of different policies and regulations, of paths to achieve the targets of the Digital Decade, definition of the technical use cases, interactions with Member States, and contribution to defining future digital skills for the Digital Education Action Plan (competence frameworks).

The JRC's role in developing databases, repositories and information systems, for example geographical data, space observation data, the Raw Materials Information System (RMIS) and the European Health Information Portal, is of paramount importance for supporting EU policies, analysis and evaluation of present and future trends, impact of policies and anticipation. The JRC offered support to the 2021-2027 digital and security policy frameworks, including the Digital Decade, Digital Europe Programme and the European Cybersecurity Strategy. The JRC is both aligning its activities with and contributing to such frameworks through support to legislative acts such as the Digital Services Act, the Digital Markets Act, the AI Act, the Data Act, and the Data Governance Act.

The effectiveness of the JRC in pursuing digital and industrial transitions is realised, inter alia, through the relevant knowledge and competence centres, such as the European Centre for Algorithmic Transparency (ECAT) and the EU Interoperability Centre for Electric Vehicles and Smart Grids. In particular, the recently created ECAT aims to accelerate accountability and

transparency audits in line with the Digital Service Act and the AI Act. It is expected to directly contribute to increasing the JRC's effectiveness.

As several JRC actions on the digital transition have been initiated only fairly recently, the Panel has a number of suggestions for the JRC to make use of new technologies in its work and to extend its support to the digital and industrial transition. The suggestions turn in particular around novel technologies, the benefits and risks they can bring to their users and the society at large, and their wider implications. This is especially important given the rapid pace of development of such technologies and their pervasive role as enabler and disrupter.

The JRC could further increase its capacity in this domain by looking at how new and emerging technologies, such as AI, large language models and quantum computing, will influence the development of industries and will impact society in general. The JRC should keep an open mind on which technologies to track given their potential and impact, and engage in ongoing observation of new and prospective technology. **Moreover, the JRC could retroactively evaluate its previous foresight studies and anticipated trends to get feedback for future strategies and actions.** The JRC would greatly benefit of leveraging the immense capacity of AI to do simulations (not predictions) to increase its anticipatory capabilities.

In particular, the JRC could make use of its position within the European Commission to support policies on the future large-scale use of AI in industry, health, and other areas. It could also advise the European Commission on how AI can help achieve priorities of other policy areas, e.g. how AI can help decarbonisation. It could also put more emphasis on the implications of AI for society (intellectual property rights, data protection), on foresight on future skills required for new jobs in the new AI area and on the digital divide that AI can bring. It could use AI analytics on the wealth of data gathered and produced towards this aim. It should investigate closer the mixed human-machine systems and the human-centred approach of digital transformation. In other words, the JRC should pay particular attention to embedding novel technologies such as AI across its activities. An example is given below on the data strategy.

The JRC's efforts to produce insights into the impact of quantum technologies are welcomed by the Panel. The Panel sees more potential for the JRC to carry out such studies. It could use its anticipatory capability to explore research on how to exploit AI (e.g. machine learning algorithms and large language models) on quantum computers, the impact of quantum computing on reducing energy consumption, provide evidence of the impact quantum technologies will have on other areas, be a frontrunner for standardisation and anticipate job skills needed for the quantum era.

The foresight activities could benefit from a closer interaction between the competence centre and laboratory-based work, making the approach more multi-disciplinary.

The JRC has developed a data strategy and made an implementation plan. The integration of data from different sources and the technologies to access this data, is desirable. More emphasis on data protection, regulation and management, beneficiaries of data and evaluations of how the data is used should be included in the strategy. **Ensuring data quality is essential and evaluation metrics to measure the quality should be developed during implementation.** The planned application programming interface (API) gateway needs to include AI techniques for intelligent search and for identifying data that can be used by AI algorithms. AI-enabled search facilities and analytics should be integrated into other JRC repositories, for example in the Resilience Dashboard and the JRC Publication Repository to increase the accessibility to all JRC data.

The Panel encourages the JRC to continue to pursue the case study approach in digital and industrial transition and enlarge the palette of subjects of case studies, to support evidence-based advice.

In its support to regulation, the JRC is advised to look closely into the right balance between innovation and regulations, between market initiatives and the different EU acts.

5.5 Observations in the area of 'Green transition'

According to stakeholders consulted by the Panel, during the past two years, the JRC's contributions to the Fit for 55 package are policy relevant, highly valued and considered to be indispensable. The JRC has developed a more holistic approach to climate and energy policies: for example, social justice elements were included in the assessments, as well as the dependence of the green transition on critical raw materials. Drivers in the food chain were added and links were made with biodiversity targets, land use and bio-economy policies. The JRC has provided relevant input for instance to the green taxonomy debate, the development of the Carbon Border Adjustment Mechanism, and the Zero Pollution Action Plan for Air, Water and Soil.

The JRC has a long-standing leading role in life-cycle assessments of chemicals and materials. This knowledge is important for supporting the development of advanced materials, the transition of the chemical industry and the development towards a circular economy as part of the carbon neutrality strategy of the EU.

The JRC's own analysis of its scientific excellence in 2016-2020, based on Scopus/SciVal data, noted that 'Environment and climate change' stood out as the research area where the JRC published the most scientific articles. At the same time, the policy impact of the JRC is evidenced in many publications. The JRC 2021-2022 work programme further highlights its support for the Green Deal and the intention 'to embed climate action into all EU policies based on thorough interdisciplinary research'. Work is in line with von der Leyen Commission priorities around the Green Deal, focusing among others on the just transition and sustainable investment.

Presentations for this interim evaluation highlighted many developments in other impact areas that are relevant to the green transition. Among these are efforts to integrate energy issues with land use issues and to integrate climate and energy projections in tackling future risk, hybrid threats and concurrent risks.

The European Commission's innovation policy seems to become now more challenge led than growth focused, and the JRC plays a role in this policy change. In the past two years, the JRC has played a visible role in discussions within the EU on going beyond GDP. To the Panel, this is in the spirit of the suggestions in the ex post evaluation on the need to develop alternative metrics to growth.

Early involvement of the JRC in the support to policymaking proved to be highly important. The new portfolio approach to designing and managing the work programme, and cluster meetings with policy DGs, appear to be a good way of both developing and communicating in a more integrated and multi-disciplinary way. In particular, the food systems portfolio evidenced a method for mapping how the JRC competences match with a simplified but broad framework for analysis of food systems (see Box 2). This approach also allows to identify gaps in the JRC's knowledge and competences and, in a further step, to analyse how these could be added in-house, outsourced or acquired elsewhere. In addition, it highlighted a SWOT analysis that illustrated the ways in which the portfolio approach itself still needs to develop.

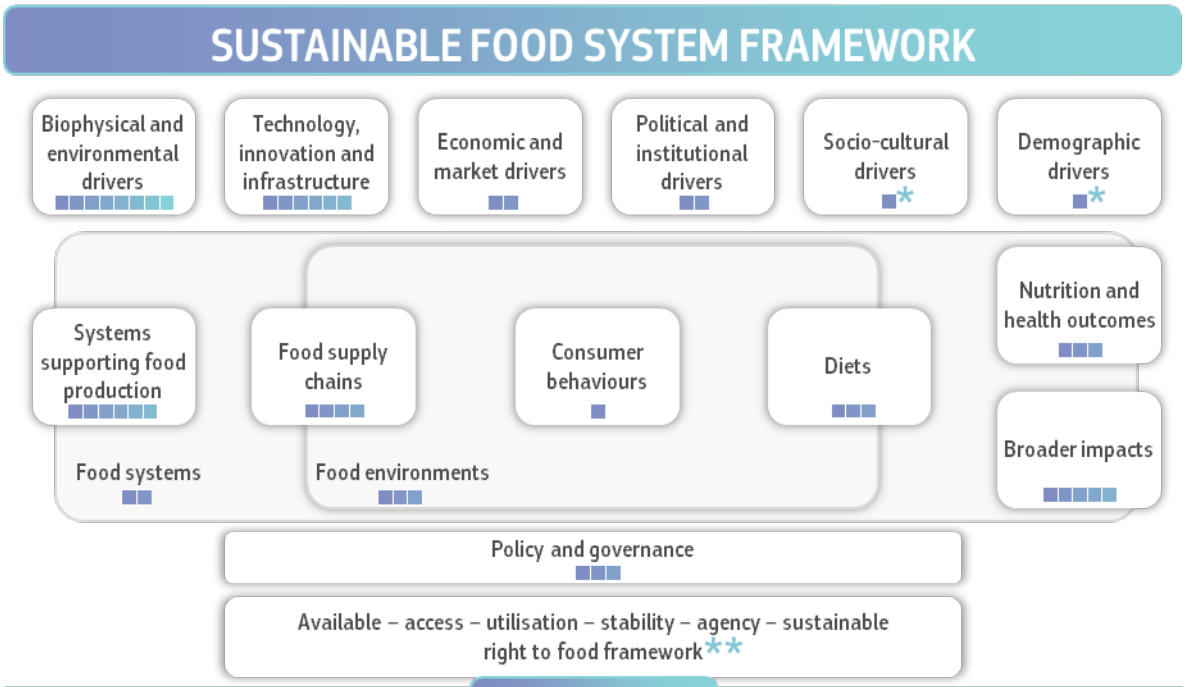
It seems relevant to extend this type of mapping approach across portfolios to better understand knowledge gaps, including where additional information relevant to institutional analysis is needed (including impacts for socio-economic groups relevant to the just transition, as well as options for behavioural change in e.g., mobility, food choice and energy use). Potential solutions can then be examined for how the gaps can be covered. The JRC could, for instance, recruit persons with large knowledge and networks in specific areas or make use of other strategies such as cooperation, as highlighted in the ex post assessment. **In addition, portfolio SWOT analyses could help highlight pros and cons of the new way of working, how to best adapt it and how to support further integration for multidisciplinary ways of working.**

BOX 2. MAPPING JRC COMPETENCES VERSUS A SIMPLIFIED FOOD SYSTEM FRAMEWORK

Food systems comprise a vast range of actors and activities from production to consumption and waste, and have significant impacts on the economy, jobs, environment, climate, food safety, and health and well-being of citizens. The JRC's portfolio on sustainable food systems is a good example of the new way of working at the JRC, and of how the JRC provides integrated and holistic policy support. Working together with 17 policy DGs and 3 agencies* and drawing from competencies from across the entire JRC, the portfolio aims to 'provide systemic analyses, responses and tools that anticipate and respond to food systems policy needs and integrate climatic, environmental, social, health and economic perspective; and nurture user-communities, via the relevant knowledge for policy services such as on soil, food security, food quality and nutrition.'

The simplified framework consists of drivers, food systems, food environments and policies and governance. The graph below maps JRC projects in the portfolio against this framework. It allows to identify what gaps there are for a holistic coverage of the framework.

*Partner DGs AGRI, CLIMA, EAC, ECHO, EEAS, ENV, ESTAT, INTPA, JUST, MARE, NEAR, OLAF, REFORM, RTD, SANTE, SG, TRADE; Other stakeholders ECHA, EFSA, ENRD



Projects	
Food Safety	Food Integrity
Market Authorisations	EU Soil Observatory
Food Reference Materials	Economics of Plant Health
Fiducial Ocean and Land Earth Observations	Sustainable Fisheries and Aquaculture
Safe and Sustainable Advanced Materials for One Health	Assessing Transitions to a Green and Fair Economy
Socio-Economic Analyses of Food System	Technical Support for Food and Nutrition Security
Food and Nutrition Security Assessment and Knowledge Management	European and Neighbouring Crop Production Monitoring and Forecasting
Technologies and Methods for Monitoring Micro- and Nano-Plastics Pollution	Improving the Environment and Climate Dimensions of EU Food Systems and Policies
Health Promotion – Towards Enabling Environments for Health and Sustainable Diets	Freshwaters and Anthropogenic Pressures Towards a Holistic Approach for Health Ecosystems
Coordination of the European Commission's Knowledge Centre for Bioeconomy and Knowledge Management	Integrated Modelling Platform for Agro-Economic and Resource Policy Analysis for Sustainable Food Systems

■ Each box indicates a project. *Represents topics partly addressed in some projects. **All projects refer to at least one of these dimensions. Source: JRC

From the work that the JRC presented to the evaluation panel, it nevertheless seems that JRC studies – although excellent – continue to focus more on technologies, data as more traditionally conceived in the JRC, materials and impacts, and less on behaviour, demand-limiting factors and broadly institutional factors; this constitutes a limitation in scope and breadth of its policy advice. The work on critical raw materials, for instance, does not look at the behavioural aspects of recycling. Similarly, work on climate adaptation seems to focus more on impacts, risks and climate mitigation technical measures than on behavioural and institutional changes. As the JRC 2021-2022 work programme highlights social aspects of the green transition as a key support initiative, the Panel notes that social and technological issues of the green transition must match up better. For instance, having and making available data will not support change if it is not matched with capacity at different levels and among different groups in the Member States and an understanding of these capacities and needs in society.

The new portfolio approach has shown to be capable of promoting a more holistic approach to the green transition. However, integration requires more than bringing various topics together in one multidisciplinary report. It also requires coherent data and an approach that enables to clarify linkages between thematic models and illustrates trade-offs between various policies to policymakers. Such linkages require interdisciplinary work, which is more than just cooperation. It requires people who can connect the dots, bridge builders who understand how outcomes of one model can be used in other models, how feedback mechanisms can be treated and how outcomes can be communicated to policymakers.

This more complex coordination and integration are increasingly required from the JRC. It will be necessary not only to show the ability to work on various topics, but also to gain access to and integrate information on relevant elements (including social aspects). For these reasons, follow-up on portfolio mapping and SWOT analyses is crucial. Nevertheless, the material presented and meetings with stakeholders have evidenced a number of examples where integration and coherence has highly improved under the current management.

6. The JRC's activities under the Euratom research and training programme 2021-2025

6.1 General assessment

The JRC's work programme is one of the main contributors to the general objectives of the 2021-2025 Euratom programme.

It covers nuclear safety, radioactive waste management and decommissioning, emergency preparedness, radiation protection, nuclear security, safeguards and non-proliferation, standardisation, knowledge management, maintaining and further developing expertise and competence in the nuclear field within the community, as well as complementing the achievement of Horizon Europe's objectives, in the context of the energy transition and in other areas.

A specific task for the JRC is to support the policies of the EU and its Member States. The 2021-2025 Euratom programme expands research into non-power applications of ionising radiation and aims for improvements in the areas of education, training and access to research infrastructures.

Examining the progress made by the JRC in 2021-2022, the Panel generally agreed that the JRC has made significant contributions to a stronger and safer Europe.

Its activities on nuclear safety and security remain highly relevant for implementing the Euratom Treaty and the Euratom programmes. Based on its long-standing competencies, the JRC provides excellent work and highly professional analysis and studies to Euratom and stakeholders worldwide on the whole spectrum of activities for nuclear safety, security and safeguards. The analyses of ways to treat, minimise or recycle nuclear waste and to evaluate their characteristics, evolution, behaviour and interaction with materials are of great importance for the European nuclear sector. The JRC is also a main contributor to the European Commission's support programme to the International Atomic Energy Agency (IAEA).

The JRC's projects on non-power applications are equally relevant and have far-reaching societal impacts. Research on targeted alpha therapy for cancer treatment contributes to the EU's Beating Cancer Plan, advancing an important EU policy goal, and the project on developing a radio-isotope power source is geared to enable deep space exploration for Europe.

The JRC's expertise is also deployed for a number of training and education actions, in an organised and systematic way optimising the use of scarce resources by e.g. train the trainers and e-learning courses. Its education and training programme has been designed and implemented in line with the needs of EU policymakers and the Member States, and adapted appropriately to accommodate changing societal challenges such as the COVID-19 pandemic and the Russian war of aggression against Ukraine.

Overall, the JRC education and training projects and policy support provide added value much beyond what is being done in Member States. They build a sound basis for monitoring nuclear activities, the surveillance of the trafficking of radioactive materials, and contribute significantly to maintaining and developing nuclear competencies in the EU and the Member States. In particular, training of law enforcement officers on radiological crime scene management and the advanced nuclear forensic analysis capability are of great value since the JRC is the only provider of these services in Europe.

The JRC's processes for planning, monitoring, reporting and evaluation are appropriate, effective and transparent. In particular, the introduction of new ways of working by portfolios has been bearing fruit in that **activities are designed in a more integrated and complementary way**. There is more collaboration between expert teams leading to synergies and more integrated policy support.

The JRC's direct actions have significantly contributed to meeting the overall and specific objectives of the Euratom research and training programme 2021-2025.

Outside the EU, the JRC is well connected with European and international networks and organisations. This allows it to plan its work so that duplication of work is avoided and policy support for the partner DGs is effective. The direct actions also complement activities funded by the other parts of the Euratom programme.

The JRC makes efficient use of its unique nuclear infrastructures, combining expertise of the core research staff to address a wide array of activities, from safety and security to medical and space applications. The JRC's research infrastructures enable performing research in the EU, reducing dependence on research outside the EU but also responding to international demand. As operating nuclear infrastructure requires special licences, safety and security measures and expertise that is not available in all Member States, the JRC's open access and training schemes offer visiting EU researchers and border/law enforcement officers the opportunities they could not have anywhere else.

As part of its nuclear strategy, the JRC should map the state of the JRC's nuclear infrastructures and make a plan for future development, as many of them are quite unique. In this area, the panel highlights the need to complete the Wing M on the JRC's site in Karlsruhe, which will provide essential support to researchers and students with growing demand in the nuclear field.

The Panel noted that data and IT management including security issues have a central governance for better efficiency. The sharing of nuclear data, such as databases and libraries, is one of the important contributions of the JRC to the scientific community, especially for experimental/new facilities such as geological repositories and future systems like advanced modular reactors and small modular reactors (SMR). This work should be continued and supported to ensure further sharing of data with appropriate security measures.

While the Panel has taken a positive view to the JRC's nuclear actions in general, and while there is progress in planning joint activities between Horizon Europe and the Euratom programme in line with a finding of the ex post evaluation, it would expect to see stronger links and further integration of activities in view of the Green Deal and the digital transition, as recommended by the last ex post evaluation.

Communicating its work and offer to the Member States and the public remains a weak point for the JRC, as observed in previous evaluations. The JRC should make a greater effort to promote its programmes, activities, capabilities and possibilities for enhanced interaction with other actors in the nuclear sector to end-users. The JRC has demonstrated how it is enhancing its reputation through a more targeted communication. However, the JRC activities remain unknown to a large extent to the general public and the decision-makers in Brussels. To address these specific groups, the information should be tailored to demonstrate the added value and the uniqueness of the JRC expertise and infrastructures.

Using clear and meaningful indicators and figures to show the significant contribution of the JRC in many fields such as training, measurements and safeguards/security is key for convincing and targeted communication. Additional efforts should be dedicated to inform the public, especially the younger generation.

The Panel reiterates the ex post recommendation to increase the efforts in bringing the social sciences angle to the nuclear work programme. For doing this, the Panel indicated that part of success is to choose the right people willing to work together, to break silos and bridge soft sciences and STEM disciplines, for instance through cooperation between nuclear areas and broader JRC risk and crisis areas.

In view of the major cuts in funding in recent years, the large demand for research and policy support and the importance of education and training of a competent and skilled work force available both for research and public service in Europe, **the Panel supports the JRC's efforts to increase its funding through the Euratom programme to maintain its expertise, services and infrastructure. The Panel is of the opinion that the JRC is an important complement to the Member States' capacity to deal with nuclear issues from safety to non-energy applications.**

The more detailed assessments below outline further proposals for enhancing the impact of the JRC's work in specific areas.

6.2 Observations on nuclear safety, security, safeguards and non-proliferation activities

The JRC has performed many nuclear safety studies on fuels, on GEN IV and small modular reactors, on the back-end of the nuclear fuel cycle and also for non-energy applications. The results of these studies are essential for nuclear research and industry to ensure safe and secure use of nuclear material. The JRC's various competencies are also relevant for research on innovative materials and their behaviour in nuclear environments, and contribute to improving the safety of nuclear technologies. These unique and highly valuable contributions to the Euratom programme should be maintained and even strengthened if possible for the benefit of all stakeholders and the society in general.

As recommended by the ex post evaluation, the JRC is working on the safety/regulatory aspects of different designs of small modular reactors and advanced modular reactors. The JRC should contribute to analysing which are the most mature small and advanced modular reactor (SMR or AMR) designs, including in terms of fuel design, safety/security concepts and proliferation resistance, to better inform Member States and policy DGs prior to SMR deployment in Europe. Attention should also be given to potential standardisation of safety requirements and nuclear fuel behaviour compliant with safety requirements.

The support to the Ukrainian authorities through the risk and safety assessment of their facilities is of great significance for the safety and security of the EU citizen and should remain a priority. In this area, the multidisciplinary approach provided by the JRC, notably through the Instrument for International Nuclear Safety Cooperation (INSC), is essential for and capable of addressing all issues including nuclear safety, security and safeguards, and emergency preparedness and response.

Even if nuclear security is a Member State competence in terms of legal implementation, the JRC is contributing to it in the field of R&D activities, on material outside regulatory control and nuclear forensics. The JRC's contribution is especially valuable in the field of training on CBRN threats. The training centre called EUSECTRA, which trains 200-400 people every year coming from EU Member States, EU neighbouring countries and even worldwide, offers a variety of equipment and unique expertise. In addition, the nuclear forensics lab is one of the two labs only in the world (the other being in the US).

Activities of the JRC in safeguards and non-proliferation are mainly based on strong legal requirements of the Euratom Treaty and the trilateral agreements with the IAEA, where the JRC is involved as technical support for safeguards inspectors. The Panel commends the JRC on having carried out the safeguards measurements even during the COVID-19 pandemic thus ensuring the required implementation of non-proliferation principles without disruption.

The JRC is also the main contributor to the European Commission's nuclear safeguards support programme to the IAEA and is recognised for its significant added value. Cutting-edge R&D in nuclear safeguards is still needed to further improve the methodologies, to test new technologies or materials and to detect and counter potential new pathways of diversion. All these activities are barely publicised outside the safeguards community while they need very specialised competencies and contribute to international peace and security. Ways to better communicate about these important safeguards activities should be explored, especially emphasising their impact for worldwide peace and security.

The R&D conducted by the JRC is essential to develop novel safeguards approaches in field tests and to test new technologies and tools. Its cutting-edge research is allowing Euratom and the IAEA to stay ahead of the technological evolution (e.g., 3D mapping analysis for design information verification (DIV), authentication of safeguards casks, and optical physically unclonable functions for optical authentication and cryptography). This contribution helps to ensure that verification methods continue to be accurate and relevant for new technologies (including AMR, SMR and new fuels) and that confinement and surveillance measures cannot be circumvented. Important contributions were also made to the update of international target values (ITVs) on measurement uncertainties which set the minimum standard for the accountancy of nuclear material.

In the field of trade control, the JRC is contributing to the fight against illicit trafficking and proliferation. The competences acquired in this area have proved to be relevant for delivering advice on sanctions adopted in response to Russia's invasion of Ukraine.

The contribution of the JRC in the measurement of radioactivity, legally derived from Chapter 3 of the Euratom Treaty, should continue to benefit the European citizen through further improving measurements and calibration services offered to Member States laboratories, in close collaboration with the concerned laboratories.

The JRC possesses very valuable competences in the area of nuclear safety (including radio-protection and emergency preparedness and response), security, safeguards and non-proliferation. The technical assessment of nuclear energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852, written by the JRC, is a perfect example of making use of its broad range of expertise.

In addition, its experts are familiar with the legal framework of the Euratom Treaty and its secondary legislation. Funding allowing, the JRC therefore could help the EU Member States willing to develop nuclear energy or other nuclear applications through offering a service of specific JRC Euratom peer review (not duplicating the IAEA ones). This peer review could aim to give recommendations on how to better address the requirements of the Euratom Treaty and to make the best use of the Euratom programme funding for research and development, but also on how to tackle the waste management and decom-missioning issues and, if applicable, to better integrate nuclear power with other sources of energy taking into account the specificity of the Member States.

The Panel notes that taking into account the development of the fusion technology and the numerous worldwide projects in this area, the JRC could be in a position to use some of its already existing tools to provide limited support in selected areas of synergies between fission and fusion to the European Commission and the EU Member States.

6.3 Observations on radioactive waste management research

Within the field of management of spent fuel and radioactive waste, the JRC creates experimental data and knowledge for safety assessments. It studies the characterisation and conditioning of legacy waste using irradiated fuel samples from fast reactor irradiation programmes carried out in the 70s. Its studies on chemical separation of actinides and fission products from spent fuel are currently limited to selected molten salt applications, due to lack of resources and technical issues. However, a strong contribution is given to the recycling of plutonium, including multi-recycling in light water reactors and in advanced reactors. Moreover, studies on the possible recycling of fission products and use for hydrogen production are implemented as part of the non-energy application projects.

The JRC's analyses of methods to treat, minimise or recycle nuclear waste and studies on their characteristics, evolution, behaviour and interaction with materials are of great importance for the European nuclear sector.

A considerable number of European reactors are in the decommissioning phase, and the need for governments to find suitable sites for a repository is becoming urgent. As the 2022 ex post evaluation panel already recommended, the JRC should play an active role in this process by providing Member States with scientific knowledge to help them in the definition of their strategies and by promoting and assisting in the exchange of experiences, beyond its participation in interesting projects such as the European Joint Programme on Radioactive Waste Management (EURAD1 & EURAD2). The JRC's capacity to coordinate, and contribute to, the transfer of knowledge, and experiences between the different countries would enhance their cooperation. However, it is worth highlighting the JRC's contribution to supporting the implementation and monitoring of the Directive 2011/70/EURATOM on the responsible and safe management of spent fuel and radioactive wastes.

The JRC has a long and successful history of collaboration with some Member States on spent fuel disposal, in particular on the long-term corrosion behaviour of spent fuel under repository-relevant conditions. Although not directly linked to the siting of nuclear waste repositories, these projects contribute to reducing uncertainties and extend the knowledge basis in support of disposal programmes. In this domain, the JRC support to Member States is of key importance.

The Panel considers more resources should be invested in JRC projects on nuclear waste management, it should promote repository-related activities and foster relations and collaborations with countries and institutions involved in the definition and management of nuclear waste repositories. Hence, in line with the observations of the ex post evaluation on the adequacy of JRC's resources in the Euratom programme, the Panel invites to adapt the JRC's financing in this area to reflect the current importance of waste related studies, which is expected to increase in the coming years in the context of the planned decommissioning of European nuclear power plants.

6.4 Observations on non-power applications

The Euratom programme for 2021-2025 increased the emphasis on non-power applications of nuclear technology. In this domain, the medical field is the most prominent, where the Euratom programme is supporting the EU's Beating Cancer Plan and enabling developments which can be applied to other health conditions. There is also much potential for nuclear science to contribute to the EU's environmental goals and to power sources for space exploration.

Research into non-power applications of ionising radiation in the JRC has grown accordingly and the JRC has established itself as a key player in the development of targeted alpha therapy (TAT)

and of power sources for space exploration. Furthermore these activities couple strongly to maintaining and developing general nuclear skills and competences.

For TAT, the JRC has established a large network of hospitals, research centres and radio-pharmaceutical companies for joint development and clinical testing of alpha-emitter-labelled compounds in Europe and worldwide. In collaboration with the Steve Biko Academic hospital in Pretoria, to date, more than 300 South African prostate cancer patients have been successfully treated, often with lifesaving results. The JRC is also involved in international projects investigating novel production paths for actinium-225 to satisfy the expected future demand for treatment of metastatic cancer, contributing to the EU's Strategic Agenda of Medical Ionising Radiation Applications (SAMIRA).

The targeted alpha therapy activities are relevant and efficient, and exploit the uniqueness of the JRC's infrastructure and expertise. The effectiveness of this project can be clearly assessed, if one looks at the analysis of the peer-reviewed publications. In 2021-2022, three out of the JRC's five most-cited scholarly publications in the field of nuclear research report findings of TAT research.

For space exploration, the JRC is well-positioned to develop radioisotope power systems and is working towards a European space power source based on americium-241 for the European Space Agency (ESA), as an alternative to plutonium-238 to which Europe has no access and replacing Russian sources for this material. Since September 2022, the JRC also participates in the consortium PULSAR, on the build-up of a European production capacity and radioisotope power source based on plutonium-238. Also in this field, the JRC operates unique nuclear infrastructures.

The Panel encourages the JRC to communicate to institutions and representatives of Member States the unique possibilities of the non-power applications of nuclear technology, especially the TAT and the radioisotope power systems. Their added value to the EU is evident since only the JRC has the infrastructure to contribute to these projects.

6.5 Observations on education and training

The growing lack of personnel with nuclear competences is a general problem in the Member States. The JRC acknowledges correctly that nuclear industry relies heavily on a specialised and well-trained workforce. Furthermore, there is a growing need of well-trained work force in nuclear safety, security, safeguards, controlling non-proliferation, environmental monitoring, radiation protection and nuclear forensics.

The JRC's education and training programme responds to these needs by accepting students at master and PhD level in the JRC's research programmes and by training nuclear security, safety and safeguards personnel of the Member States. Its programmes have been designed and implemented in line with the needs of EU policy-makers and the Member States, in particular the goal of a stronger and safer Europe. The programme is relevant and reacts appropriately to the technical and societal challenges, among which to maintain in the EU a high level of education and training in the nuclear field and, at the same time, preserve the existing skills which are of interest to all EU Member States, regardless of their energy mix.

The JRC's education and training programme is efficient, especially if one takes into account the limited financial resources. Its impact is difficult to quantify, but the number of training courses and the response to unforeseen events provides evidence of its effectiveness. In particular, the JRC reacted very effectively to the new needs and challenges which emerged due to the Russian invasion of Ukraine.

A prime example of the education and training work of the JRC is the European Nuclear Security Training Centre (EUSECTRA). The outstanding feature about the EUSECTRA training programme, not available in national programmes, is the possibility for trainees to practice with real

nuclear and radioactive materials embedded in realistic scenarios. Some 20 training sessions of typically one week duration have been provided annually.

The core activities of the trainings are field and hands-on exercise based. The COVID-19 pandemic, however, restrained the hands-on trainings and the JRC made significant efforts to develop EUSECTRA remote, interactive e-learning courses. The Panel noted that the remote e-learning courses are not intended to replace face-to-face hands-on training, which remains EUSECTRA's core activity, and of which 2 were provided in the last quarter of 2021 and 11 in 2022. The JRC efforts in training and education in the nuclear field also included several regular courses that take place at its laboratories and facilities.

In the reporting period, the JRC organised seminars, workshops, table-top and field-exercises with EU Member States and partner countries. Some of the events were conducted under the restrictions of the pandemic, and performed with live streaming or video recording.

The education and training programme of the JRC has the necessary coherence. The different projects work together effectively and complement each other without significant overlap. There is the necessary internal cooperation and holistic approaches to be able to provide policy support for the partner DGs.

The European added value in the JRC education and training programme is clear in every respect. It provides training and open access to facilities not available in the Member States. This is well demonstrated in the field of nuclear forensics. Most of the EU Member States do not have an advanced analytical capabilities for nuclear forensics and rely on the JRC for scientific-technical support and training. Thereby, the JRC contributes to the Security Union, ensuring that Member States' authorities and the European Commission are well positioned to deal with nuclear security threats and to investigate and properly respond to incidents.

The JRC is the operating agent of the European Human Resources Observatory for the Nuclear Energy Sector (EHRO-N) providing the necessary infrastructure and technical support, analyses capabilities and long-term stability. The JRC is also proposing initiatives to strengthen nuclear human resources capacity in EU. Since 2020, EHRO-N broadened its analysis to competences management and its scope to include non-energy applications needs. The main activities carried out in the reported period focused on national nuclear workforce assessment and on the analysis of the nuclear HR supply of European higher education in the EU and the Member States.

The JRC has also strengthened collaboration with important European networks and organisations. There is great value in this work and the Panel proposes the JRC consider continuing to coordinate efforts of EU Member States to promote the collection of information at state level for analysing the needs of human resources in the different areas of the nuclear sector at European level, with the objective of designing actions to cover these needs.

The open access to nuclear research infrastructure of the JRC for the European nuclear community also can be regarded as an added value for maintaining nuclear skills in the EU. The JRC has decided to open 11 of its high-value nuclear research facilities to external users. In this frame, access to the JRC nuclear facilities is free of charge for Member States and countries associated to the Euratom programme promoting education, training and mobility between universities, research centres and industry and the JRC. In this way it contributes to maintain multi-disciplinary nuclear competences at the highest levels in the EU.

The JRC should enhance its education and training programmes by expanding its cooperation with research institutions and universities of the Member States. With a better communication of the unique possibilities of the JRC, the institutions and universities of Member States may be willing to finance longer stays of students and send more staff to the special training. The Panel also finds it important to increase the education and training activity on targeted alpha therapy.

6.6 Observations on knowledge management

The creation of the JRC Competence Centre for Foresight in 2018 is an important development to make the required JRC anticipation activities a reality. Deep dives on nuclear topics were carried out in 2021-2022, with partner DGs and other organisations, from micro nuclear reactors to floating nuclear reactors. However, it is still too early to judge what impact this centre will have on the nuclear sector and nuclear policy.

In 2021-2022, the JRC has been developing PIKNUS, a web-based tool to improve accessibility to Euratom funded research results, as a collaboration platform for European research community and to improve synergies between Euratom direct and indirect actions. The platform has now reached the final testing phase. It is expected that this project and the Semantic Text Analyser (SeTA) tool that is being developed will have a great relevance in the area of knowledge management. The whole action can have a big impact on the nuclear community both at scientific and stakeholder level.

The Panel took note that the JRC is also tasked to organise knowledge management in the area of decommissioning and waste management through a separate EU funding programme which is out of scope of this evaluation.

The JRC should make its knowledge management systems and resources better known and as widely used as possible, not only internally, but also by others. However, the Panel observed that the transfer of information towards the end users is not always adequate, sometimes remaining at the institutional level.

Knowledge management is an integral part of the JRC's nuclear programme. A number of activities are underway, but it is too early to judge their results and scope. However, it is important that an effort is made to clearly integrate these actions in the different portfolios to help communicate the JRC's role in knowledge management in the nuclear sector and to ensure synergies between the different activities.

7. Follow-up to the recommendations of the ex post evaluation

The ex post evaluation in 2022 covering JRC's performance in the period 2014-2020 made a number of recommendations to highlight areas where the JRC could make further progress. As a follow-up, the JRC has developed an action plan and used the findings to inform its revitalised strategy.

The recommendations can be roughly grouped around the following topics:

- being involved at an early stage in the setting of policy priorities;
- using more holistic approaches in designing the work programme and responding to policy needs;
- the inclusion of social sciences, including institutional perspectives, in JRC activities;
- giving anticipation a high priority;
- developing and implementing an organisation-wide data strategy;
- effective communication;
- developing and nurturing the work force and diversity; and
- monitoring and promoting impact and efficiency.

Throughout this evaluation, the Panel has seen new developments that directly address the recommendations. The time span after the ex post evaluation is very short, making it difficult to assess whether the planned actions are sufficient to produce the intended effects. However, the Panel has noted already **good progress in developing more anticipatory, integrated and holistic scientific advice for policies**, for instance in the area of climate and energy policies. An example is the impact assessment for the European Commission's proposal on the sustainability of the food chain, which the JRC carried out in its entirety using competences from across the JRC. In some presentations to the Panel, a closer interaction between teams working under the Horizon Europe and Euratom programmes was observed and several portfolios contained projects from both of these research programmes, facilitating synergies and integration.

Progress has also been made to facilitate the JRC's early involvement in policymaking, by working together with clusters of policy DGs, rather than individually, to define and prioritise their evidence needs. This will allow making better use of the JRC's resources and approaching the challenges from multiple angles, eventually leading to more holistic solutions and policies with positive impacts. The JRC management has shown strong leadership in taking the JRC one step further toward its ambitions, developing co-design of activities and bridging the silos within and outside the JRC.

The new portfolio approach has the potential to provide solutions to many issues raised by the previous evaluations. For instance, the new approach can improve the coherence of the JRC's activities, reduce fragmentation and increase synergies and efficiency. Each portfolio connects scientists from different areas with diverse competencies, contributing to multi- and interdisciplinary research efforts and better understanding of complex societal phenomena. The portfolio construction also enables rapidly reacting to urgent needs and adapting to new priorities in an agile way.

Examples for the progress in anticipatory advice are:

- support to the foresight mandate of the Vice-President and the yearly European Commission Strategic Foresight Reports. The JRC foresight activities underpinning the 2022 Strategic Foresight Report were focused on technologies for twinning the green and digital transitions. In 2023 the focus lays on social and economic choices in sustainability transitions within a fair and sustainable Europe 2050;
- organisation of a foresight exercise to develop a long-term vision for EU's rural areas (COM (2021) 345 final) which is being implemented through the EU Rural Action Plan and the Rural Pact;
- yearly horizon scanning exercises on nuclear safety and security.

The JRC has also developed two foresight tools for the European Commissions' Better Regulation Toolbox to inform impact assessments: a megatrends exploration tool and a set of reference scenarios.

More is needed, however, to better balance anticipation/reactivity, and this was mentioned several times also by the stakeholders interviewed by the Panel.

Since the ex post evaluation, the JRC has also put in place a comprehensive **data strategy** and an implementation plan, centred around governance, culture, infrastructure, service and community. **The Panel noticed gaps in the strategy regarding a framework for quality assurance of data, for dealing with potential bias and for communicating uncertainties.** The Panel saw little progress of the JRC making its data more readily available for others e.g. for academic research but plans for a collective data platform were presented. Additional suggestions for the data strategy are given in the next section.

Social sciences are gradually being taken up in relevant JRC studies and examples were found in the nuclear field, defining frameworks for beyond GDP indicators, climate adaptation and work on SDGs. Yet, **there is a need to step up the integration of institutional, social and behavioural aspects into the research projects**, to enhance the positive impact of both the JRC's policy support and of EU policies.

In particular, the ex post evaluation highlighted the importance of institutional analysis. Institutions are often seen as sets of formal and informal rules, ranging from legislation and organisational forms down to social norms, that shape how we work in the world. Institutional analysis highlights that crucial operating functions of institutions such as the market, government or codes of conduct that create the incentives in different sectors must be understood for change to be incentivised.

Different from systemic perspectives, institutional analysis reveals that it may not be possible to easily remove barriers to sustainability, as they may be part of such crucial operating functions, which serve to sustain not only a single system but linked systems or organisations and motivate their multiple users. Institutional analysis thus emphasises this interlinked perspective and, further, that analysis must thereby go beyond the level of individual or participatory functions only, as lock-in may exist between different organisations or levels in the systems. This kind of perspectives are crucial not the least in relation to a higher **focus in the EU on research that requires an understanding of how to incentivise change.**

In its follow-up plan to the ex post recommendations, the JRC has committed to **develop indicators for monitoring and evaluation of efficiency and impact**. It has already put in place, since 2021, a case study approach which gathers information of and analyses all different ways the JRC has influenced policymaking, scientific knowledge, public debate or wider societal aspects. Feedback from policy DGs and an assessment by external experts bring an outside-in view to the assessment. The JRC has also planned development of success criteria and impact indicators at portfolio level. The Panel reiterates the recommendation of the ex post evaluation in this regard, namely to pursue these actions and to promote a more qualitative evaluation of scientific outputs besides the mere metrics used, at the level of the EU. The Panel also encourages a broader use of gathering feedback from

stakeholders, beyond the cluster meetings and the case studies.

For measuring its efficiency, the JRC is planning to carry out comparative studies with similar organisations and identify a set of indicators that could be used as a proxy. Measuring the efficiency of the JRC's science-for-policy support could rely on comparative analysis with a thematic focus e.g., digitalisation, resilience, or sustainability and contributions from multiple scientific fields. While similar organisations to the JRC may be hard to find, thematic case studies could uncover how the Member States arrange scientific support for their policy decisions, and what is the performance of such arrangements.

To attract, retain and develop talent and to increase the diversity of the work force, the JRC has put in place a range of actions such as special training programmes on science for policy and leadership, and a 20% agile working time allocation to projects outside a staff member's usual remit. The JRC's recruitment and communication plans address acquiring skilled work force for social sciences as recommended by the ex post evaluation panel, and for nuclear research, especially with a view to improve the gender balance. To overcome challenges in meeting the interests of the right people, there is a need to continue efforts to profile the JRC as a stepping stone for an international career, be it in research or in science for policymaking and develop the narrative around the JRC's mission and core strengths. In addition, the Panel found that the JRC should also make an effort to recruit generalists who can steer the multi-disciplinary way of working in the portfolios, combine knowledge from different disciplines and models and who can translate the relevant findings into a coherent evidence base for policymakers.

The ex post evaluation panel advises the JRC to improve its **communication** at different levels, both within the JRC and with its stakeholders. The JRC's **visibility in the Member States** especially was considered to be in need of improvement. This seems to be work in progress, with a new strategic communication plan and targeted campaigns. Improvement was noted also by the stakeholders interviewed.

Beyond communication, the Panel feels that there is also scope for the JRC to improve its **cooperation with Member States** and the use of its work by them. For instance, it could increasingly consider the Member States as knowledge users when planning its activities. The JRC annual reports provide examples but not necessarily a strategic, systematic and developed outreach to the different Member States. Partial evidence showed that several Member States experts appreciate JRC support in fields like life cycle analysis and energy, climate and air pollution. In general, this assessment echoes that of the JRC's Board of Governors ad hoc group on the JRC organisational transformation which is of the opinion that there is scope for improved collaboration with the Member States, neighbourhood and associated countries, and that the Board of Governors could be asked to play a more active role in making JRC knowledge more known in the Member States.

8. Outlook for 2025+

To prepare for future challenges, the JRC has undertaken a comprehensive organisational transformation, re-defined its strategies and reorganised its management structures. These changes have already led to many positive effects, recognised also by stakeholders, and are expected to deliver more benefits.

The Panel had a task to propose actions that could make the JRC even more future-proof.

To be more effective, and to deliver on its new value proposition, **the JRC needs to continue developing its foresight capability**. The JRC is also encouraged to make better use of foresight and trend analysis for defining its own research and networks with other institutions in the Member States and globally to further enhance its efficiency. Past projections should be analysed and evaluated to improve the effectiveness and accuracy of future campaigns.

In general, the Panel sees two steps for embedding foresight work into the JRC's/European Commission's way of working:

- The JRC should work with the policy DGs to ensure that the foresight work is translated into policy and overall increase anticipatory capabilities of the European Commission. The JRC should also monitor the impact of its foresight work for policymaking.
- The JRC should use foresight to map and anticipate future policy/scientific challenges to help prepare and shape the agenda of the next College of Commissioners of the European Commission and the next research programmes. In fact, this interim evaluation comes at a time when the preparations of the next College and the next financing period are about to start. These are two opportunities which the JRC should seize in the short term.

The social dimension and institutional analyses in the JRC's studies need to be strengthened. This includes institutional innovation research, i.e. research aimed at understanding the drivers, challenges, processes and impact of innovations in institutions. Areas where the JRC has already commenced work and which were considered valuable by the Panel are low/no-growth economy and beyond GDP thinking. Further development of integrated assessment models for medium-term projections and analysis of policy scenarios could enable the inclusion of beyond GDP thinking in actual policy choices and implementing the EU's policy on social fairness, also during periods of low or no GDP growth. The resilience dashboard will become even more important and should be extended to include the social and health dimensions.

The Panel also suggests to:

- focus more on the socio-economic drivers, for instance behind inequities in risks and in adaptation costs between and within countries;
- take up foresight to inform the JRC's activities for/using AI given its rapid development and pervasive nature; and
- look at emerging technologies, such as AI and large language models and the wealth of data they are producing, as a way to increase its capacity for anticipation and foresight.

Implementation of the data strategy is essential, with emphasis on data quality, uncertainties and potential biases, and on how data is organised and managed throughout its lifetime. It is important for a more integrated JRC organisation that there be an appropriate response to the high variation in the new types of disciplinary understanding and the associated variation in data that become relevant for policy needs.

While the JRC has a new data strategy and the revitalised strategy launched in 2022 has a special focus on data, **attention should be paid to the requirements and transparency needs for qualitative data that may differ from those for quantitative data**, as indicated in the ex post evaluation. In particular, the Panel observed that the focus remains on data as traditionally

conceived from a technological and natural sciences focus, while social sciences and humanities foci will include a broader range of data which needs to be treated appropriately. One option for proceeding along these lines is that the JRC links increasingly with other actors in fields that seem to have been less emphasised in the JRC.

Systematic internal self-evaluations, developing key performance indicators for measuring efficiency of science for policy support, mapping knowledge gaps, SWOT analyses and collecting regular feedback from the partner DGs are strongly encouraged, as a good practice for portfolio management together with collecting the experiences of individuals involved.

Despite all the good work, the JRC remains almost invisible to the Member States administrations and the general public, to a certain extent also among policymakers of the EU institutions. In addition to enhanced communication, **the Panel therefore strongly recommends to strengthen cooperation with the Member States.** One avenue for overcoming this is engaging Member States' institutions in JRC initiatives targeted at the national level, and supporting them to take the most effective action given their knowledge of the national needs and circumstances. Such institutions, primarily ministries and universities, can offer their own expertise, and rely on the expertise from the JRC and other ministries and universities that join the initiative. The JRC-owned digital platforms could help scale up such initiatives. This avenue can also help attract new talent capable of bringing science to policy. Another avenue is to strengthen cooperation and involve national experts, host visitors and promote exchange opportunities to ensure two-way knowledge exchange.

The panel strongly recommends to strengthen cooperation with the EU Member States.

A big challenge for the JRC, and in general, is to **invest in generalists** who are able to integrate knowledge from various disciplines. The JRC is aware of this, and has initiated programmes to equip its staff with new skills and consider those needs in recruitment planning. At the same time, it is important to **maintain specialist competencies and 'blue sky' research**, not only to allow innovation flourish and to open up new avenues but also to keep scientists motivated and increase the attractiveness of the JRC to specialists. A healthy specialist-generalist balance, defined depending on the area, will ensure creativity, productivity, and ability to act proactively. The JRC's internal initiative allowing staff allocate 20% of their time to work outside their usual topic can advance all these goals, and should be maintained.

On JRC's nuclear research programme, the Panel is of the opinion that **the JRC is an important complement to the Member States capacity to deal with nuclear issues from safety to non-energy applications**. In particular, the open access schemes and training and education actions have a high EU added value and together with top research facilities ensure independence of research carried outside Europe. The Member States representatives, research institutions and universities should be made more aware of these opportunities to make optimal use of the JRC's offer and to increase cooperation within EU at all levels.

With the JRC's broad competencies and collaborations with major European and international players in the field, the European Commission can rely on relevant and up-to-date advice on policies, and its capacity to act in urgent situations such as the Russian war of aggression against Ukraine. Innovative solutions are needed to guarantee this capacity, together with prioritisation and an infrastructure plan as outlined in the JRC's new nuclear strategy.

In particular, the Panel sees a role for the JRC in fostering collaboration between countries and institutions involved in the definition, selection and management of nuclear waste repositories, in the context of the planned decommissioning of many European nuclear power plants. Another

important emerging need to address is standardisation of safety requirements and related studies on nuclear fuel behaviour.

In view of the major cuts in funding in recent years, the large demand for research and policy support and the importance of education and training for the availability of a competent and skilled work force both for research and public service in Europe, **the Panel supports the JRC's efforts to increase its funding through the Euratom programme to maintain its expertise, services and infrastructure. The Panel calls on the College of Commissioners of the European Commission to make every effort to secure a more adequate funding for the JRC's activities under the Euratom programme.**

The Panel was also sensitive to the JRC's ambition to find the right balance between performing (operational excellence) and transforming (innovation excellence). This balancing act is needed for the JRC to remain responsive to the changing policy needs while ensuring efficient delivery of existing commitments. Balancing should be subject to explicit decisions and part of the JRC's strategic planning process, relying on e.g., the consolidating, adjusting, expanding and transforming actions of the commonly used strategy taxonomy.

As the JRC's work is in high demand, the Panel encourages the JRC to **focus on core business** areas where it has or should have critical mass. Shifts in priorities to ensure taking up emerging needs such as studies on new AI technologies, should be accompanied by discontinuing others in its still very broad scope of activities.

Finally, the JRC's ability to create new knowledge, not only manage the knowledge created by others, and act proactively, not only react to the policy agenda set by the European Commission, should be further developed.

9. Concluding remarks

The Panel has seen that the JRC continues to perform well and provides relevant and increasingly effective policy support in many areas where it is active. Its scientific reputation remains high, publishing work in high-quality journals and producing studies and tools, taken up by EU decision-makers and world-leading institutes.

It has played a central role in formulating and implementing policies in many areas such as COVID-19 crisis, the Green Deal, supply chain management, emergency management, city climate policy, beyond GDP thinking, regional innovation, Africa, Earth observation, security and digitalisation.

The Panel commends the JRC's revitalised strategy, and the way it has taken up recommendations of the ex post evaluation so far.

A new way of working closer with the policy DGs and a portfolio approach to designing and managing its work programme are considered a promising way forward. There is already evidence of more coherence and higher policy relevance, through integration and cooperation within the JRC as well as among the stakeholders helping break silos. The portfolios, are well linked to policy priorities and enable more generalist and policy relevant conclusions. A closer interaction between Horizon Europe and Euratom is observed (integration in several portfolios) even if there is potential for more.

Interviews with stakeholders have confirmed more effective interaction with policy DGs and better understanding of what the JRC can and cannot offer. The Panel acknowledges that the meetings with policy DGs in clusters before starting to plan the JRC work programme help to align with policy needs, identify priorities for the coming years, and shape a more integrated response to such needs. To ensure good continuation, **the JRC should communicate and discuss also changes in prioritisation of activities with the stakeholders sufficiently early, and appropriately communicate gaps and uncertainties.** More strategic dialogues on the future work plans and what the JRC should do in-house and what can be tapped from elsewhere or outsourced should take place, within the JRC and with its stakeholders.

Bringing about a real change has required **a significant shift also in the culture of working together**, and the JRC management has played an important role in providing the necessary leadership and empowerment of research staff.

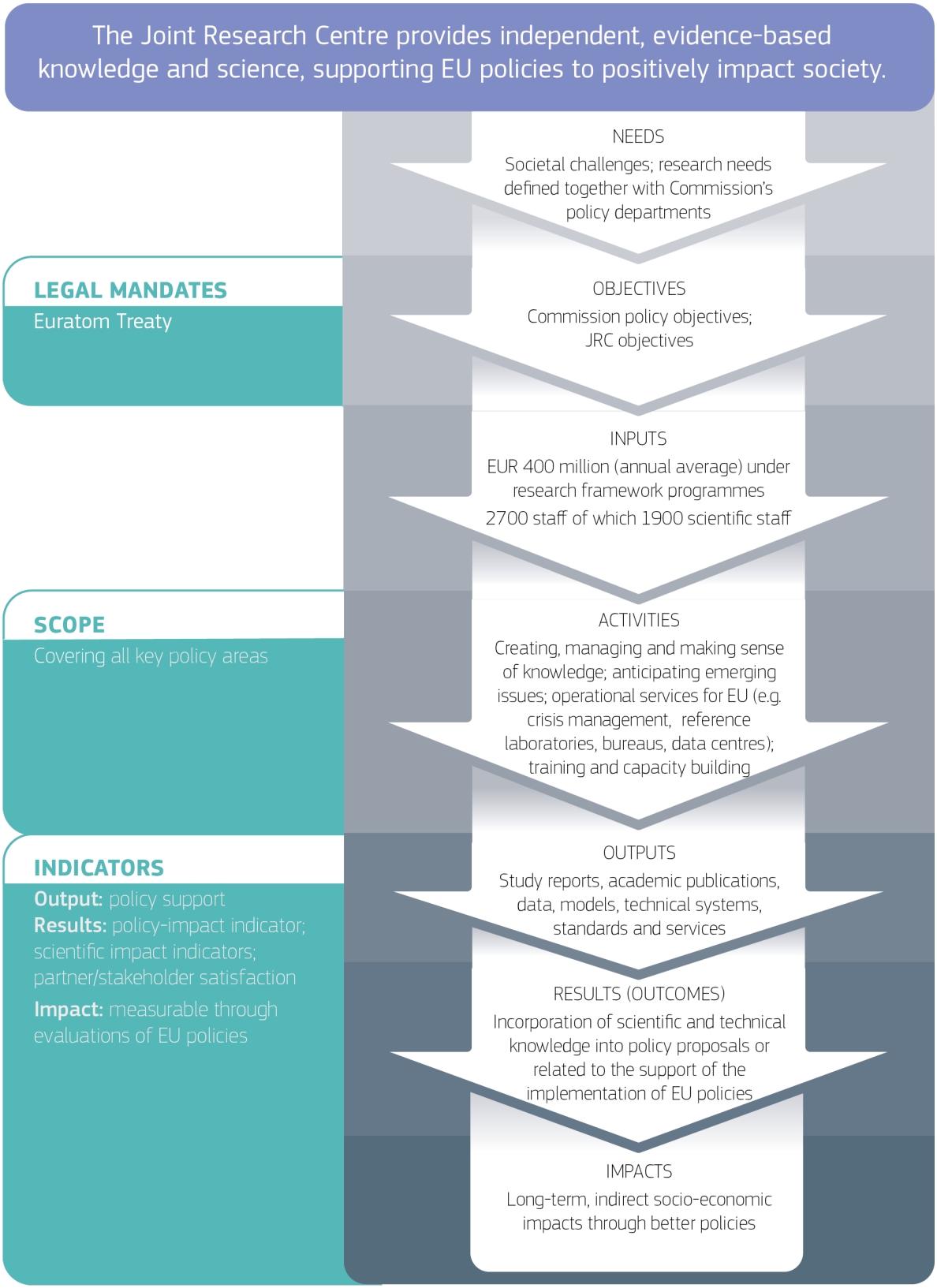
In the unstable geopolitical environment due to, e.g., war, pandemic, global warming and democratic breakup, policies that address the causes and consequences of such instability must increasingly rely on evidence, capable institutions, and engaged society. The JRC is advised to complement its research with a **stronger focus on social dimensions and institutions**, targeting policy DGs, Member States' governments and other policy actors, all relying on digital transformation to scale up their response from whole-of-government to whole-of-society.

The JRC is a unique resource for the European Commission and should strengthen its leadership at the EU level to become a model for how to make use of a broad range of research and science to inform policy decisions. For example, it should develop and communicate standards and guidelines for good science for policy practices for EU policymaking, taking into account a large variety and difference between research areas.

Abbreviations and definitions

AI	artificial intelligence
AMR	advanced modular (nuclear) reactor
API	application programming interface
CBRN	chemical, biological, radiological and nuclear (material that may pose a hazard)
College	College of Commissioners; the political leadership of the European Commission
DG	Directorate-General, a department of the European Commission
DIV	design information verification for nuclear safeguards
ECAT	European Centre for Algorithmic Transparency
EHRO-N	European Human Resources Observatory for the Nuclear Energy Sector
EIC	the European Innovation Council
EIT	the European Institute of Innovation and Technology
ESA	European Space Agency
EU	European Union
Euratom	European Atomic Energy Community
EUSECTRA	European Nuclear Security Training Centre
IAEA	International Atomic Energy Agency
INSC	International Nuclear Safety Cooperation
ITV	international target values for measurement uncertainties in safeguarding nuclear materials
JRC	Joint Research Centre
NEIA	New European Innovation Agenda
RHOMOLO	Regional Economic Modelling
REMO	Regional Economic Monitor
RMIS	Raw Materials Information System
PRI	Partnerships for Regional Innovation
Scopus	abstract and citation database of publisher Elsevier
SciVal	analytics tool for research performance of publisher Elsevier
STI	Science, Technology, and Innovation
SDG	Sustainable Development Goals
S3	smart specialisation strategies
SAMIRA	EU's Strategic Agenda of Medical Ionising Radiation Applications
SeTA	semantic text analyser
SMR	small modular (nuclear) reactor
TAT	targeted alpha therapy
OECD	Organisation for Economic Co-operation and Development
UN	United Nations

Annex 1. The intervention logic



Source: JRC

Annex 2. Terms of reference for the panel of external experts

TERMS OF REFERENCE FOR THE INTERIM EVALUATION OF THE JOINT RESEARCH CENTRE IN HORIZON EUROPE AND THE EURATOM RESEARCH AND TRAINING PROGRAMME (2021-2025)

BACKGROUND

As the science and knowledge service of the European Commission, the Joint Research Centre (JRC) has the mission to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle. Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.

The JRC is funded mainly through the framework programmes for research and innovation and the Euratom research and training programme. The JRC also generates revenues (around 15-20% of its budget) from dedicated tasks at the specific request of other Commission departments under an administrative arrangement.

LEGAL BASIS

According to the provisions in the regulations on Horizon Europe and on the Euratom programme for research and training, interim evaluations have to be carried out no later than four and three years, respectively, after the start of programme implementation, with the assistance of independent experts.

Specific inter-institutional and Commission requirements further frame this evaluation. The Commission's Internal Control Principle number 12 commits the Commission to evaluate all the different types of activities it undertakes. It requires that: 'The impact assessment and evaluation of expenditure programmes, legislation and other non-spending activities are performed in accordance with the guiding principles of the Commission's better regulation guidelines, to assess the performance of EU interventions and analyse options and related impacts on new initiatives'.

The monitoring and performance frameworks in the above regulations applies to the entire funding programmes, and hence also to the JRC.

PURPOSE OF THE EVALUATION

The purpose of the evaluation is to produce an independent external view on the effectiveness, efficiency, coherence, EU-added value and relevance of the JRC activities, to the extent that results from the current programmes are available, and taking into account the follow-up that the JRC has given to the ex post evaluation of the direct actions by the JRC.

The evaluation should also provide a forward look with recommendations for further strengthening the impact of the JRC, taking into account ongoing developments in the design of its work programme, its scientific facilities and working methods.

The Commission will be informed on the outcome of the evaluation through the Panel's final report and include it in the communications to the relevant EU institutions on the evaluation of the overarching programmes.

SCOPE

The evaluation addresses all direct actions conducted by the Joint Research Centre in the frame of its part in the specific programme of Horizon Europe and in the Euratom research and training programme 2021-2025. The JRC is to contribute to the programme objectives of Horizon Europe, with a specific mission to provide scientific evidence and technical support to Union policies, focussing on EU priorities. Actions under the Euratom programme aim, in particular, at the continuous improvement of nuclear safety, security and radiation protection, notably to potentially contribute to the long-term decarbonisation of the energy system in a safe, efficient and secure way.

The evaluation addresses activities carried out with support of revenues other than those from the framework programmes for research, to the extent that they complement the actions financed by the former.

EVALUATION QUESTIONS

The evaluation follows the 'Better Regulation Guidelines' and toolbox, structuring the questions around the five evaluation criteria of relevance, efficiency, effectiveness, coherence and EU added value. Specific questions have been added for the forward-looking perspective.

- Relevance: assessment of whether the objectives of Horizon 2020 and Euratom research and training programmes have been met;
- Efficiency: the relationship between the resources used and the changes it is generating;
- Effectiveness: how successful the direct actions have been in achieving or making progress towards its objectives;
- Coherence: how well or otherwise the different projects work together, internally and with other EU interventions/policies;
- EU added value: assessment of the value resulting from the direct actions that is additional to that which could result from interventions that would be carried out at regional or national levels.

The overarching evaluation questions concern the impact of the JRC on EU policymaking and the quality of its scientific output.

RELEVANCE

- Was the programme designed and implemented in line with the needs of EU policymakers, in particular the political priorities of the Commission 2020-2024? Did the JRC anticipate, and react appropriately to new policy needs and societal challenges?

IMPLEMENTATION: EFFICIENCY

- Has the JRC attributed the funding effectively (in terms of output, quality of research and impact)?

EFFECTIVENESS

- Regarding the achievements of the direct actions, to what extent have they:
- Contributed to meeting the overall and specific objectives of Horizon Europe and Euratom 2021-2025?
- Are the JRC's processes for planning, monitoring, reporting and evaluation appropriate, effective and transparent?
- The relevant experts should give their judgement on how the JRC's work compares to top-class work in the various fields done elsewhere.

COHERENCE

- How coherent are the direct actions in terms of synergies, overlaps and complementarities with the activities funded by the other parts of the research programmes?

– To what extent has JRC achieved its aim of more holistic approaches and more internal cooperation for policy support?

EU ADDED VALUE

– To what extent does the JRC research and policy support provide added value beyond what is being done in Member States?

A FORWARD LOOK

The evaluation should be completed with a forward look in which the Panel should assess:

– To what extent has the JRC implemented the improvements proposed in the recommendations of the JRC ex post evaluation of Horizon 2020 and the Euratom research and training programme?
– To what extent are the current strategic directions fit for enhancing the impact, effectiveness and efficiency of the JRC?
– What changes in priorities, organisation, processes or working methods could be made to further enhance the agility, impact and efficiency of the JRC's policy support?

EVALUATION METHODOLOGY, PANEL, DELIVERABLES AND TIMETABLE

The panel will consist of up to 10 high-level experts, including a Chair. Because of the different timelines for the interim evaluations of Horizon Europe and the Euratom programme, the panel will split into two sub-panels for each programme, with however the same Chair. There will be six panel members for Horizon Europe and four for the Euratom programme.

The Panel will build its assessment largely on written information provided by the JRC, complemented by its impressions from JRC presentations with some targeted interviews and/or site visits to investigate specific issues. The panel can make use of the assessments carried out under the ex post evaluation and may interview stakeholders to complement its findings. Apart from a joint kick-off meeting, the sub-panels should complete their assessment during one or two central meetings with one joint final meeting.

Each panel will make a separate report which should form distinct parts of the final report. The final report should not exceed 20 pages - excluding annexes - with an analysis of the findings and a set of conclusions and recommendations. The sub-panels should deliver final reports in July 2023, with the joint report due in October 2023.

The JRC will provide a secretariat to assist the Panel in organising all aspects of the evaluation, including in establishing the final report.

The JRC will make the final report available to its stakeholders and the public. The findings of the report will be included in the JRC's contribution to the Commission's interim evaluation of the Horizon Europe and Euratom programmes.

The panel will carry out the evaluation according to these terms of reference. Thematically, the evaluation of Horizon Europe and the Euratom programme will consider the following clustering of impact areas:

– Sub-panel 1: Innovative Europe; Resilient Europe; Digital and Industrial Transition; Green Transition;
– Sub-panel 2: Nuclear safety and security (Euratom).

Horizontal topics such as impact on policymaking, scientific excellence or innovation should be covered under each theme.

The panel is free to organise itself for covering these themes.

The JRC Director-General will select the panel and its Chairperson from a list of independent external experts in consultation with the Board of Governors and nominate them through expert contracts. In line

with the Commission Decision on expert groups (C(2016) 3301 final), the panel composition requires a balanced

- representation of expertise in JRC areas of activity,
- geographical spread and
- representation of gender.

Members can come from scientific, governmental, non-governmental and private sector organisations. Experience from earlier JRC evaluations is an asset.

Under the governance framework for Horizon Europe, the Common Policy Centre '...is responsible for planning and coordinating the approach to Horizon Europe interim and ex post evaluations, as well as their execution where appropriate'. It has established an operational road map which foresees that the panels need to complete their work by November 2023 (Horizon Europe), and July 2023 for Euratom, in order for the Commission staff to draft the relevant staff working documents in time.

AVAILABLE SOURCES

- Official reference documents
- Horizon Europe, the EU Framework Programme for Research and Innovation
- The Euratom Research and Training Programme (2021-2025)
- Annual Activity Report
- Specific evaluation data from JRC
- Ex post evaluation of the direct actions of the Joint Research Centre in Horizon 2020
- JRC Annual Reports
- Review and Revitalisation of the JRC's Strategy 2030 (2022)
- The JRC's Nuclear Strategy (2022)
- Case studies on the impact of the JRC
- Bibliometric analysis
- Follow-up given to the ex post evaluation 2014-2020

STANDARDS

The Commission's evaluation standards aim to ensure relevant and timely evaluations of high quality and that their evaluation results are communicated to decision-makers and other relevant stakeholders in a clear and transparent manner to facilitate the use of evaluation results.

The evaluation standards are an integral part of the Commission's Better Regulation Guidelines and Toolbox which means that they are binding and that the way they are implemented may be audited on this basis.

ADMINISTRATIVE AND FINANCIAL ASPECTS

The JRC will reimburse travel costs according to the standard rules applied by the Commission.

Members of the panel can be offered an expert contract in accordance with the Commission's rules. The contract will provide the payment of fees for a maximum number of 24 days for the Chair and 14 days for the other panel members. The preparation of the contract will require the registration of the experts concerned in the Commission's relevant expert database.

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