



ORIENT- NM

Organisation of the European Research Community on Nuclear Materials

A Coordination and Support Action in Preparation of a Co-Funded European Partnership on Nuclear Materials



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Work Package 1 – Critical assessment of the added value of a EJP on nuclear materials (preliminary)

Deliverable D1.4

Critical assessment of the added value of a EJP on nuclear materials (preliminary)

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List of abbreviations

CEP	Co-funded European Partnership
E.G.	For example
EC	European Commission
EJP	European Joint Programme
EU	European Union
MS	Member State
NE	Nuclear Energy
NM	Nuclear Materials
ORIENT-NM	Organisation of the European Research Community on Nuclear Materials
POQ	Programme Owners Questionnaire
R&D	Research and Development
SRA	Strategic Research Agenda
WS	Workshop

Summary

The ORIENT-NM project addresses the possibility of establishing a Co-Funded European Partnership (CEP) to support a coordinated European research and innovation programme on nuclear materials. In this framework, the main activity of the Work Package 1 Task 1.3 is the critical assessment of the added value of a CEP on nuclear materials, which should positively impact Europe's competitiveness in the nuclear field at world scale.

This document is based on the input from tasks 1.1 and 1.2, from the workshops and from the other WPs, and corresponds to a preliminary report assessing the advantages of setting up and participating in a CEP¹ on nuclear materials (NM).

Introduction

The H2020 Euratom Project ORIENT-NM answered the Euratom WP 2019-20 call NFRP-08. The main objective is to explore the possibility of establishing a CEP on nuclear materials and to critically assess its added value.

Accordingly, the ORIENT-NM project pursues three main objectives:

- the preparation of a Vision Paper (VP)² and a Strategic Research Agenda (SRA)³ for structural and fuel materials for all nuclear fission reactor generations (until 2040);
- the implementation of an efficient CEP governance and legal structure, encompassing decision-making processes, intellectual property issues and promotion of innovation, as well as the analysis of potentially available resources, and the implementation of a scheme caring for quality assurance, SRA updating, knowledge, and data management, in different scenarios; and
- the identification of suitable ways of interactions between the CEP and different stakeholders, while addressing the issue of a coordinated use of nuclear materials infrastructures.

To this end, a close dialogue with both Member States (MS) and European Commission (EC), and other stakeholders has been established to meet their requirements and expectations from a possible CEP on nuclear materials, as well as to raise the interest of identified research owners and research managers, by demonstrating the added value of such CEP.

Two main workshops ("A possible future European partnership on nuclear materials", and "Organisation of the European Research Community on Nuclear Materials") have been organized in the course of the project. In these two events, the stakeholders have

¹ The CEP as a Horizon Europe instrument to fund R&D englobes and replaces the equivalent instrument of Horizon 2020 -denominated European Joint Programme (EJP).

² [file:///C:/Users/admin/Downloads/ORIENT-NM_Visionpaper_for_a_Co-funded_European_Partnership_\(CEP\)_on_nuclear_materials_5-2.pdf](file:///C:/Users/admin/Downloads/ORIENT-NM_Visionpaper_for_a_Co-funded_European_Partnership_(CEP)_on_nuclear_materials_5-2.pdf)

³ L. Malerba et al., *Energies* 2022, 15(5), 1845; <https://doi.org/10.3390/en15051845>.

come together to discuss the progress made in each ORIENT-NM work package, receive input for the development of key deliverables, and later evaluated the approval of the final output. More specifically, in the first workshop (WS1), the initial drafts of the various output documents have been presented to receive feedback, while in the second workshop (WS2) the support of at least some Member States was explicitly sought for. The outcomes of the two workshops have been summarized in the deliverables D5.5⁴ and D5.7⁵ respectively.

The WS1, hosted by the European Energy Research Alliance (EERA) in Brussels, was held on 22-23 November 2021, in online format. It was the main occasion for the ORIENT-NM Consortium to interact with Member States representatives, establishing a constructive dialogue, to gather input and suggestions, and to discuss the potential goals and impact of a European partnership on nuclear materials considering different visions and expectations.

The event was joined by official representatives from the European Commission and twelve countries, namely Belgium, Bulgaria, Czech Republic, Estonia, France, Germany, Hungary, Italy, Lithuania, Malta, Portugal, and Romania. Moreover, high-level stakeholders from agencies, research centres and universities also participated, coming from Belgium, Bulgaria, Croatia, Czech Republic, Finland, France, Germany, Italy, the Netherlands, Poland, Romania, Sweden, Slovakia, Spain, and Ukraine. In total, 20 countries were represented. The attendance list was completed by a few industrialists (EDF, Ansaldo Nucleare, Westinghouse) and one organisation that provides technical support to the regulator (Bel-V), i.e., a TSO.

WS2 was held on 31 May 2022, in hybrid (in-person and online) format, as part of FISA & EURADWASTE 2022, the 10th Euratom Conference on Fission Safety of Reactor Systems and Radioactive Waste Management (Lyon, France).

The workshop gathered official representatives from the EC and several MS, among which Croatia, France, Italy, Lithuania, the Netherlands, Portugal, Romania, Spain, and Sweden. Moreover, other stakeholders, which were also present at the conference, represented research organisations, nuclear associations, and industries.

The objective of WS2 was to present the work performed in ORIENT-NM to establish the SRA, the governance, and the implementation plan for the partnership, based on the input received in the WS1, as well as to introduce a plan of interaction with external stakeholders.

At the same time, the workshop was also another occasion to receive the comments, and especially the explicit support, of the attending MS representatives.

The present report is largely based on the direct results of the two above mentioned workshops. These results represent the critical assessment of the added value of a CEP on nuclear materials, based on considerations that do not only concern

⁴ file:///C:/Users/barba/Downloads/ORIENT-NM-D5.5_Public_summary_of_the_1st_workshop-v3-1.pdf

⁵ file:///C:/Users/barba/Downloads/ORIENT-NM-5%207_Public_summary_of_the_2nd_workshop-v4-final-2.pdf

convenience to face scientific and technical challenges, but also, as much as possible, socio-economic benefits.

Questionnaire outcomes

A possible future European partnership on nuclear materials

To address the objectives of the ORIENT-NM WP1 some questionnaires have been designed to establish a dialogue with MS and EC.

In the framework of the Task 1.3 the *Programme Owners Questionnaire* (POQ) was prepared, which was aimed to gather information about the MS requirements and their expectations related to the preparation of the CEP on nuclear materials and fuels. The POQ has been drafted on the basis of the outcomes of brainstorming meetings amongst the project partners involved in tasks T1.1 and on the inputs of Task 1.2, and other WPs.

During the WS1, the POQ has been subjected to MS through interactive virtual tools. In the Annex 1 of this report, the structure of the ORIENT-NM POQ has been reported together with a synthesis of the answers.

Based on the POQ results, across Europe there is a variety of actors directly and indirectly involved in the definition of contents and priorities of both the NE-R&D and the NM-R&D providing and managing the related funds. The entities always involved in these processes are the Ministries, mainly those in charge with activities related to Economy, Energy, Research and Environment. Also, Research centres and Institutes occupy an important place followed by Agencies, Industries, Universities and Regulatory Bodies. In some cases, one or more of these actors are also involved in the definition and coordination of the National NE- and NM-R&D programme when one or both exist.

A National NE-R&D Programme exists in Finland, Germany, and Romania. Moreover, the latter is the only country also having a National NM-R&D Programme (both defined and coordinated by RATEN - Technologies for Nuclear Energy State Owned Company, which is a strategic Romanian legal entity that coordinates R&D activities in the field of nuclear energy, while offering and developing scientific and technological support for the National Nuclear Energy Program).

Almost all the MS have experience with current EJPs in H2020, such as CONCERT, EURAD, EUROFUSION. In Belgium, Finland, Germany, the Netherlands, and Romania, a dedicated budget exists to finance the NE-R&D projects, which goes from a minimum of 5-10 M€/year to a maximum of more than 100 M€/year.

In this framework, a European R&D co-funded partnership on nuclear materials, with a contribution in the range of 25-70% by each country, could be a suitable instrument to promote NM-R&D across Europe. Several benefits are related to the involvement of countries in these projects, representing an added value for MS across Europe, such as promotion of research and development within international cooperation. MS

envisage that a possible CEP on NM could support materials qualification for the design of innovative nuclear systems, as well as materials solutions for safe long-term operation of current reactors. It could also promote the maintenance of nuclear power beyond 2040, and the development of innovative materials to improve both the nuclear energy sustainability and energy materials for extreme conditions of cross-cutting interest.

Therefore, a European partnership on NM, coordinating both Euratom and national relevant activities under the same umbrella, could be the first step towards the achievement of some fundamental requirements and the establishment of some strategies, namely:

- The continuity to R&D lines without fragmentations, duplications, and the filling of gaps within specific key subjects.
- The enhancement of the nuclear power plants safety, the sustainability improvement, the cost reductions, and the efficiency increase.
- More attention to nuclear material issues, aimed to accelerating the development of advanced or new materials solutions, including manufacturing processes and their qualification for use in harsh environments.
- The strengthening of efforts towards research activities addressed to requirements for enhancing and developing both current and future reactors, as well as for web-based materials data management, and non-nuclear energy technologies where materials operate under extreme conditions.
- The promotion of a structured dialogue between fusion and fission communities for a cross-fertilization of the two research areas.
- The identification of legal mechanisms ensuring the involvement of industries as active partners and targeted end-users in the CEP, in order to encouraging their financial support to the initiative.
- A 50/50 participation between the European Commission and the participating countries, also allowing the co-funding of the participating countries via in-kind work and investments.
- Other stakeholders should also be considered as possible partners, if legally and practically feasible, while regulators should ideally be represented in the advisory bodies of the partnership.

Organisation of the European Research Community on Nuclear Materials

During the WS2, considering the results provided by the WS1, the ORIENT-NM vision together with the first draft of the governance and structure have been presented, sketching the content of the SRA and listing the possible interactions of the future CEP with external stakeholders.

The ORIENT-NM vision includes the maintenance of nuclear power beyond 2040; small and medium size modular reactors development and advanced designs; the

strengthening of nuclear materials R&D efforts developing an integrated research programme with research lines transversal to all classes of nuclear materials; and the implementation of advanced digital techniques and suitable models to perform the "design and control" paradigm.

To address these challenges a perimeter of the CEP-NM activities has been envisaged defining the research lines, the main classes of materials to be considered, and the interaction with the fusion community. Therefore, it has been established what the Partnership aims at developing in a decade, namely:

- nuclear-oriented test-beds;
- nuclear-oriented materials acceleration platforms;
- advanced predictive methodologies;
- advanced materials health monitoring; and
- nuclear materials databases.

The envisaged governance structure is a standard one, with emphasis on scientific excellence and innovation and with a standard advisory body, formed by experts with scientific and technical backgrounds, and an innovation group composed by experts in entrepreneurship and commercialising technology, representing the industry.

The CEP model is similar to existing European Joint Programs, such as EuroFUSION, EURAD, CONCERT, etc. with an expected funding rate of 55% from EC and 45% from MS.

The simplified approach arising from a CEP will optimize the management of fund expenditure for nuclear materials-related projects.

Finally, a structured interaction of the Partnership with stakeholders and the harmonized use of infrastructures has been drafted to optimize the future activities.

At the end of the Workshop, six MS, namely Croatia, France, Italy, Romania, Spain, and Sweden, explicitly supported the launch of a partnership on nuclear materials.

Conclusions

The input collected from MS and stakeholders through the WS1, highlights the general agreement on the fact that materials play an essential role in the use and development of nuclear energy.

Therefore, a European R&D co-funded partnership on nuclear materials, based on a well-structured governance and on an effective management of funds, in agreement with the needs of the involved countries, could be a suitable instrument to promote NM R&D across Europe. This could, in fact, galvanize the interest in this area promoting the international cooperation towards development of new materials and technologies in the nuclear field.

The unifying vision developed in the framework of the ORIENT-NM project, and presented during the WS2, summarizes, and integrates all the input provided by the WS1 results. It received the approval of most of participants that explicitly supported the launch of a partnership on nuclear materials.

The results of these two events represent the critical assessment of the added value of a CEP on nuclear materials, based on considerations concerning both convenience to face scientific and technical challenges and socio-economic benefits.

ANNEX 1: ORIENT-NM Programme Owners Questionnaire

The questionnaire has been distributed in accordance with the rules of the General Data Protection Regulation (GDPR)⁶ as described in the ORIENT-NM Deliverables 1.2 and 7.1. It consists of 13 main questions integrated by 14 sub-questions. It has been designed to obtain from the MS relevant information encompassing the following areas of interest:

- management and responsibilities of the national R&D programme on NE;
- national R&D funding dedicated to NE;
- potential interest in a future CEP on NM;
- contact details of other national experts; and
- contact details of other national experts.

Eight responses were received from Belgium, Croatia, Finland, Germany, Italy, Netherlands, Romania, and Slovenia.

In the table below the structure of the questionnaire is reported, including for each question the number of the collected answers.

Table 1. ORIENT-NM Programme Owners Questionnaire structure

Questions
Section 1. Management and responsibilities of the national R&D programme on nuclear energy
1. Which actors mainly define the content of the R&D activities in the nuclear energy field in your country? [8/8 responses] <ul style="list-style-type: none"> a) One or more ministries Please provide the names of the bodies [allow comment] b) One or more agencies Please provide the names of the bodies [allow comment] c) One or more associations Please provide the names of the bodies [allow comment] d) One or more industrial companies Please provide the names of the bodies [allow comment] e) One or more Research Centres Please provide the names of the bodies [allow comment] f) One or more Universities Please provide the names of the bodies [allow comment] g) Others Please provide the names of the bodies [allow comment]
2. Which of these actors define the priorities, if any? [8/8 responses] <ul style="list-style-type: none"> a) One or more ministries

⁶ REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN>

<p>Please provide the names of the bodies [allow comment]</p> <p>b) One or more agencies Please provide the names of the bodies [allow comment]</p> <p>c) One or more associations Please provide the names of the bodies [allow comment]</p> <p>d) One or more industrial companies Please provide the names of the bodies [allow comment]</p> <p>e) One or more Research Centres Please provide the names of the bodies [allow comment]</p> <p>f) One or more Universities Please provide the names of the bodies [allow comment]</p> <p>2. Others Please provide the names of the bodies [allow comment]</p>
<p>3. Which organizations provide R&D funding (programme owners) <u>on nuclear energy</u> in your country? [8/8 responses]</p> <p>Please provide the names of the bodies. [allow comment]</p>
<p>4. Which organizations manage R&D funding (programme managers)⁸ for nuclear energy research in your country? [8/8 responses]</p> <p>Please provide the names of the bodies. [allow comment]</p>
<p>5. Is there a formally defined, possibly written R&D Programme on nuclear energy in your country? [8/8 responses]</p> <p>a) Yes i. Which body or organization defines and/or coordinates it? [allow comment] [3/8 responses]</p> <p>b) No</p> <p>c) I don't know</p>
<p>6. If the answer to question 5 is no, please answer this question: Is R&D on nuclear energy the result of scattered interests among the actors mentioned in questions 1 and 3? [5/8 responses]</p> <p>a) Yes 6.1 Please, provide the names of those actors: [allow comment] [2/8 responses]</p> <p>b) No</p> <p>c) I don't know</p>
<p>7. Is there a formally defined, possibly written R&D specific Programme on</p>

⁷ Programme Owners are the official responsible of national programmes/strategies/policies relevant to the envisaged European Joint Programme on Nuclear Materials (generally ministries).

⁸ Programme Managers are the national research Institutes/organizations/bodies in charge for the execution of programmes/strategies/ relevant to the envisaged European Joint Programme on Nuclear Material (generally research organisations).

nuclear materials in your country? [8/8 responses]

- a) Yes [1/8]
 - 7.1 Which body or organization defines and/or coordinates it?
[allow comment] [1/8]
- b) No [6/8]
 - 7.2 Is R&D on nuclear materials part of the R&D Programme on nuclear energy
 - i. Yes [3/8]
 - ii. No [2/8]
 - iii. I don't know [1/8]
 - 7.3 Is the R&D on nuclear materials the result of scattered interests among the actors mentioned in questions 1 and 3?
 - iv. Yes [3/8]
 - v. No [2/8]
 - vi. I don't know [1/8]
- c) I don't know [1/8]

Section 2. National R&D funding dedicated to nuclear energy

8. Is there a dedicated budget to finance R&D projects on nuclear energy in your country? [8/8]

- a) Yes [5/8]
 - 8.1 Please, indicate its order of magnitude in M€/year, if possible
0-0.5, 0.5-1, 1-5, 5-10, 10-50, 50-100, >100
- b) No [2/8]
- c) I don't know [1/8]

9. Is there a dedicated budget to finance R&D projects on nuclear materials in your country? [8/8]

- a) Yes [2/8]
 - 9.1 Please, indicate its order of magnitude in M€/year, if possible
0-0.1, 0.1-0.2, 0.2-1, 1-2, 2-10, 10-20, >20
- b) No [4/8]
- c) I don't know [2/8]

Section 3. Potential interest in a future co-funded European partnership on nuclear materials

10. Do you have experience with any current European Joint Programs in H2020, e.g., CONCERT or EURAD? [8/8]

- a) Yes [7/8]
 - 10.1 Which one?
[allow comment]
 - 10.2 Based on your current experience, are you satisfied with the added value they bring to your country
 - i. Yes [7/8]
Please, indicate the reasons [allow comment]
 - ii. No
Please, indicate the reasons [allow comment]

b) No [0/8]

11. Do you consider that a European R&D co-funded partnership on nuclear materials, centred around and driven by research funders and other public authorities, would be a suitable instrument to promote nuclear materials R&D in your country? [8/8]

a) Yes [6/8]

11.1 Would your country be interested in participating and supporting the development and implementation of a future European R&D co-funded partnership on nuclear materials?

- i. Yes [5/8]
- ii. No
- iii. I do not know [1/8]

11.2 Do you think that a share of e.g., 50%/50% (MS/EU) would be sufficient to guarantee that the national priorities are correctly considered?

- iv. Yes [3/8]
- v. No [2/8]
- vi. I do not know [1/8]

11.3 Would your country be ready to support it with a higher share?

- vii. Yes [0/8]
- viii. no [4/8]
- ix. I do not know [2/8]

11.4 Please, provide your comments about an optimum co-funding scheme.
[allow comment] [5/8]

11.5 Please, specify the type of contribution your country is willing to commit to [6/8]

- x. Ear-marked funding [0/8]
- xi. In-kind contribution⁹ [2/8]
- xii. A mix of both options with preference for ear-marked funding [1/8]
- xiii. A mix of both options with preference for in-kind contribution [2/8]
- xiv. A mix of both with equal importance [1/8]
- xv. Other possibilities [specify] [0/8]

11.6 What could be the approximate contribution provided by your Member State to a European R&D co-funded partnership on nuclear materials? [6/8]

- xvi. Less than €50k/year [0/8]
- xvii. Between €50k/year and €100k/year [2/8]
- xviii. Between €100k/year and €500k/year [3/8]
- xix. Between €500k/year and €1M/year
- xx. Between €1M/year and €2M/year
- xxi. More than €2M [1/8]

⁹ National/regional funding for projects, resulting from the transnational calls, is counted as financial contributions. Any direct expenditure of a partner in the consortium (other than providing financial support to third parties) for activities of the partnership are, in principle, in-kind contributions. The coordination and management of a partnership or the use of a research infrastructure could be examples of such an activity. Institutional funding of research performing or governmental organisations, if they are implementing R&I activities in the partnership, can also qualify as in-kind contribution.

<p>b) No.</p> <p>c) I do not know [2/8]</p>
<p>12. In your opinion, which type of activities should the European R&D co-funded partnership on nuclear materials mainly support? [Multiple answers possible] [8/8]</p> <p>a) Materials solutions for safe long-term operation of current reactors [5/8]</p> <p>b) Materials qualification for the design of innovative nuclear systems [7/8]</p> <p>c) Development of innovative materials solutions to improve nuclear energy sustainability [5/8]</p> <p>d) Development of a methodology for autonomous optimization/discovery of nuclear materials [1/8]</p> <p>e) Energy materials for extreme conditions of cross-cutting interest [5/8]</p> <p>f) Other [specify] [0/8]</p>
<p>13. Would you be interested in contributing with your advice to the activities carried out under the ORIENT-NM project to explore the possibility of establishing a future co-funded partnership on nuclear materials, by taking part in dedicated workshops? [8/8]</p> <p>a) Yes [7/8]</p> <p>b) No [1/8]</p> <p>c) I do not know [allow comment]</p>
<p>Section 4. Contact details of other national experts</p>
<p>14. A second survey will be conducted to gather more information on national R&D programmes on nuclear materials, containing specific questions on different topics related to nuclear materials, such as technical R&D priorities and objectives, available associated costs, available nuclear facilities, etc. If someone else should answer this more specific survey, could you please provide the contact details of the most suitable expert(s)? [7/8]</p> <p>a) Name</p> <p>b) Surname</p> <p>c) Organization</p> <p>d) Email</p>

Summary of the answers

In this section the answers provided by MS are collected. To facilitate reading and examination, each question, together with any sub-questions, has been reported before the relative answers. For each question the responses from all the MS have been grouped together to provide the reader an overview of findings related to each specific topic as implemented in the questionnaire.

Section 1: Management and responsibilities of the national R&D programme on nuclear energy

Answers to questions 1 (Which actors mainly define the content of the R&D activities in the nuclear energy field in your country?)

Based on the answers, the definition of nuclear energy R&D contents currently depends on a variety of entities across Europe. The main actors are Ministries, Agencies, Research Centres, Institutes, Universities, industrial companies, and Regulatory Bodies, as specified in the following:

- **Ministries:** Ministry of Economy SMEs, Self-Employed and Energy (**Belgium**); Ministry of Science and Education (**Croatia**); Ministry of Economic Affairs and Employment (**Finland**); Ministry of Economic Affairs and Energy, Ministry of Education and Research, Ministry of Environment, Nature Conservation and Nuclear Safety (**Germany**); Ministry of Ecological Transition, Ministry of Education, University and Scientific research (**Italy**); Ministry of Economic Affairs and Climate Policy (**Netherlands**); Ministry of Energy, Ministry of Research Innovation and Digitalization (**Romania**); Ministry of Environment, Ministry of Infrastructure, and Ministry of Science (**Slovenia**).
- **Agencies:** SCK CEN, ONDRAF-NIRAS (**Belgium**); Business Finland (**Finland**); ENEA - National Agency for New Technologies, Energy and Sustainable Economic Development (**Italy**); ANDR - Nuclear and Radioactive Waste Agency (**Romania**); ARRS - Slovenia Research Agency (**Slovenia**).
- **Research centres and/or Institutes:** VTT- Technical Research Centre of Finland (**Finland**); Federal Office for the Safety of Nuclear Waste Management, BfS - Federal Office for Radiation Protection, The Helmholtz Association of German Research centres, Fraunhofer Society for the Advancement of Applied Research (**Germany**); CNR- National Research Council, INFN- national Institute for Nuclear Physics, CIRTEN- Intra-University Consortium for Nuclear technology Research (**Italy**); NGR Petten (**Netherlands**); RATEN- State Owned Company (**Romania**); Jožef Stefan Institute (**Slovenia**).
- **Industrial companies:** TVO, Fortum, Fennovoima Posiva - disposal research (**Finland**); Gesellschaft für Anlagen-und Reaktorsicherheit (GRS) gGmbH, Kompetenzverbund Kerntechnik (**Germany**); Nuclearelectrica-SA-SNN-State Company (**Romania**).
- **Universities:** Lappeenranta University of Technology, Tampere University, Aalto, University of Helsinki (**Finland**); TU Delft University of Technology (**Netherlands**); University of Ljubljana (**Slovenia**).
- **Regulatory Bodies:** AFCN-FANC (**Belgium**); STUK-Radiation and Nuclear Safety Authority (**Finland**).

Romania and Slovenia provided some insights to their answers, as reported in the following:

- Romania
 - The Ministry of Energy is in charge with the elaboration of the Energy Strategy, including research priorities. It has in subordination the nuclear energy production and nuclear fuel fabrication (both under SNN administration), the nuclear and radioactive waste agency (ANDR), and the nuclear energy research that are managed by the State-Owned Company “Technologies for Nuclear Research” (RATEN).
 - The Ministry of Research, Innovation and Digitalization is in charge with the elaboration of the National R&D Strategy, which includes research in energy and environment.
 - The Nuclear and Radioactive Waste Agency is in charge with the elaboration of the Nuclear National Plan, including research objectives.
 - Nuclearelectrica SA-SNN-State Company is the owner of the two CANDU 600 MW units at Cervadove NPP and proposes research topics.

- RATEN research centre is the state-owned company and ensures the technical and scientific support organization for the National Nuclear Programme. RATEN elaborates the R&D strategy in the nuclear energy field, aligned to the National Energy Strategy and with the Nuclear National Plan. The strategy is implemented through annual R&D programmes.
- Slovenia
 - Occasional requests for specific research actions by the Ministry of Environment and Ministry of Infrastructure (responsible for Energy Strategy). Ministry of Science provides general guidance on the research priorities for annual calls for research projects, but doesn't provide specific guidance or priorities for R&D in NE.
 - Slovenian Research Agency executes the calls for research projects and programmes, including peer review and decision funding. The guidance on annual priorities issued by the Ministry of Science is implemented. No specific priorities or budget are given for NE-R&D.
 - Industrial companies do not invest directly in nuclear R&D. The nuclear utility does partly support projects selected and funded by the Slovenian Research Agency.
 - The Jožef Stefan Institute operates TRIGA Mark II research Reactor. It hosts about 50 researchers active in reactor physics, engineering, and nuclear chemistry. Research teams propose the research projects to the Slovenian Research Agency, which decides on the funding. Acceptance rate (generally including nuclear projects) is about 10-15%.
 - University of Ljubljana, Faculty of Mathematics and Physics, hosts M.Sc. and PhD programmes in nuclear engineering. There are some research activities which are closely connected with the Jožef Stefan Institute.

Answers to question 2 (Which of these actors define the priorities, if any?)

All the MS, except Slovenia, answered this question. In all cases, except for Finland and Romania, the priorities in NE-R&D are defined only by the same ministries defining the contents (reported above).

In Finland all the entities involved in the definition of the NE-R&D contents are also involved in the definition of priorities.

In Romania, the priorities in NE-R&D are defined by: the Ministry of Energy through National Energy Strategy, by the Ministry of Research, Innovation, and Digitalization through the R&D Strategy, by the industrial company Nuclearelectrica SA, which makes proposals in the elaboration of the R&D strategy/programme according to the needs, and by the research centre RATEN, which operates through the R&D Strategy for Nuclear Energy and annual R&D.

Answers to question 3 (Which organizations provide R&D funding (programme owners) on nuclear energy in your country?)

Based on the answers to the question 3, in all the MS, except Finland and Slovenia, the NE-R&D funds are provided only by the same Ministries responsible for the definition of contents and priorities.

In Finland the NE-R&D funds are provided by the Ministry of Economic Affairs and Employment, and by VYR (Nuclear Waste Management Fund), VTT, Business Finland, and NKS (Nordic Nuclear Safety research).

In Slovenia only the Research Agency provides NE-R&D funds. This is accomplished by two main instruments: research programs and mid- or long-term funding. Performances and research priorities are evaluated (as proposed by the researchers)

every 6 years, and research projects proposed by researchers (whose duration is of 2-3 years) are evaluated/selected by the Agency on annual calls.

Answers to question 4 (Which organizations manage R&D funding (programme managers) for nuclear energy research in your country?)

In Belgium the NE-R&D funding management is only in charge to a Ministry (Economy SMEs, Self-Employed and Energy). For the remaining MS, other bodies, in addition to some of the already-mentioned entities, manage the funds as specified below:

- Croatia: Ruđer Bošković Institute, Institute of Physics, Institute for Medical Research and Occupational Health, and the Faculty of Science of the Zagreb University.
- Finland: VYR and Ministry of Economic Affairs and Employment (Nuclear Waste Management Fund) own the research programme and provide funding, and VTT which manages the funds by leading the programme.
- Germany: Gesellschaft für Anlagen-und Reaktorsicherheit (GRS) gGmbH, Karlsruhe Institute of Technology, Federal Office for the safety of Nuclear Waste Management, Federal Office for Radiation Protection.
- Italy: ENEA, CNR, INFN, and CIRTEN.
- Netherland: NRG Petten and TU Delft University.
- Romania: the NE-R&D programme is funded by the Ministry of Energy, is managed by RATEN, and is implemented by RATEN ICN (Institute for Nuclear Research Pitesti) and RATEN CITON (Centre for Nuclear Engineering and Design Bucharest). The NE-R&D projects (subject to competition) funded by the Ministry of Research, Innovation and Digitalization could be coordinated, a part of RATEN, also by other research institutes and universities with activities in nuclear field, such as: IFIN HH – Institute for Physics and Nuclear Engineering Horia Hulubei Bucharest; ICSI - Institute for Cryogeny and Isotopic Separation Rm. Valcea; ITIM - Institute for Isotopic and Molecular Technologies Cluj-Napoca; IMNR - Institute of Non-ferrous and Rare Metals, Bucharest; UPB – University Politehnica Bucharest; and UPIT – University of Pitesti.
- Slovenia: Jožef Stefan Institute managing the Reactor Engineering and the Reactor Physcs programmes, and other programmes are in part involved in nuclear R&D.

Answers to question 5 (Is there a formally defined, possibly written R&D Programme on nuclear energy in your country?)

Based on the answers, it results that in Belgium, Croatia, Italy, Netherlands, and Slovenia, it has not been defined nor written any NE-R&D Programme.

Finland, Germany, and Romania answered positively to this question providing the following information:

- in Finland the existing NE-R&D Programme is defined by the Ministry of Economic Affairs and Employment (MEAE) together with: TVO, Fortum Fennovoima, STUK, VTT, LUT, Aalto, and POSIVA (for the disposal programme). Instead, it is coordinated by VTT, mandated by MEAE via open competition, with all stakeholders in the Governing Board, where STUK has the chair position.
- In Germany the programme is defined and coordinated by the Federal Ministry of Economic Affairs and Energy.
- In Romania the R&D National Programme is defined and coordinated by RATEN. The annual R&D Programme (implementing the 2021-2025 RATEN Development Strategy (which sets up the research objectives and defined directions and activities needed to reach them, has been elaborated in 2015 and updated in 2021), contains 18 sub-programmes addressed to: nuclear safety, nuclear fuel and materials, CANDU system, life time extension, radioactive waste management, radioprotection, research reactors, advanced reactors and SMRs, radioisotopes

production, other non-nuclear applications of nuclear technologies, and international cooperation. For each sub-programme, a specific strategy is elaborated every 5 years, the current one covering the 2021-2025 period.

Answers to question 6 (If the answer to question 5 is no, please answer this question: Is R&D on nuclear energy the result of scattered interests among the actors mentioned in questions 1 and 2?)

A response has been provided by Croatia, Italy, Netherlands, and Slovenia. Between these, only Italy and Netherlands answered negatively. No answer has been provided by Belgium.

- In Croatia the actors having interests in the NE-R&D are the Ministry of Science and Education, the Ruđer Bošković Institute, the Institute of Physics, the Institute for Medical Research and Occupational Health, and the Faculty of Science of the Zagreb University.
- In Slovenia proposals of the research groups are evaluated and decided for funding by the Slovenian Research Agency. The selection is based on the quality of the proposals so that proposals on NE-R&D directly compete with other proposals related to e.g., energy, environment, applied physics etc.

Answers to question 7 (Is there a formally defined, possibly written R&D specific Programme on nuclear materials in your country? - 7.1 Which body or organization defines and/or coordinates it? - 7.2 Is R&D on nuclear materials part of the R&D Programme on nuclear energy? - 7.3 Is the R&D on nuclear materials the result of scattered interests among the actors mentioned in questions 1 and 2?)

The Belgium did not give an answer to questions from 7 to 7.3. About questions 7.2 and 7.3, Romania didn't provide any answer, while Croatia doesn't know the answer.

All the MS, except Romania, answered negatively to the question 7.

In Romania, based on the answer to question 7.1, a R&D specific Programme exists and is defined and coordinated by RATEN. The programme includes a series of sub-programmes, coordinated by RATEN ICN, dealing with nuclear materials, such as: CANDU Fuel Channel, CANDU Circuits chemistry, Steam Generator, Nuclear Fuels, NPP components and life extension, Advanced nuclear systems (focused on material behaviour in LFR and SCWR), and Materials Irradiation in TRIGA reactor.

Only Finland, Germany, and the Netherlands, answered positively to question 7.2 confirming that in their countries NM-R&D is part of NE-R&D Programmes. A negative answer was provided by Italy and Slovenia.

The question 7.3 was answered positively only by Finland, Germany, and Slovenia.

Section 2: National R&D funding dedicated to nuclear energy

Answers to questions 8 (Is there a dedicated budget to finance R&D projects on nuclear energy in your country?), 8.1 (Please, indicate its order of magnitude in M€/year, if possible [0-0.5, 0.5-1, 1-5, 5-10, 10-50, 50-100, >100]); and 9 (Is there a dedicated budget to finance R&D projects on nuclear materials in your country?), 9.1 (Please, indicate its order of magnitude in M€/year, if possible [0-0.1, 0.1-0.2, 0.2-1, 1-2, 2-10, 10-20, >20])

A synthesis of the answers to the questions 8 and 9 is reported in Table 2. It results that Italy and Slovenia don't have a NE-R&D dedicated budget, while it exists in Belgium (> 100 M€/year), Finland (5-10 M€/year), Germany (50-100 M€/year), Netherlands (5-10 M€/year), and Romania (5-10 M€/year). Croatia didn't know the answer.

With regard the answers to the question 9, only two MS have a NM-R&D dedicated budget: Finland (1-2 M€/year) and Romania (2-10 M€/year). Croatia and Netherlands didn't know the answer, and for Belgium, Germany, Italy, and Slovenia it results that no budget exists in these countries specifically dedicated to NM-R&D.

Table 2. NE- and NM-R&D dedicated budgets in the MS

Country	NE-R&D Budget	NM-R&D Budget
Belgium	> 100 M€/year	No dedicated budget
Croatia	No Response	No dedicated budget
Finland	5-10 M€/year	1-2 M€/year
Germany	50-100 M€/year	No dedicated budget
Italy	No dedicated budget	No dedicated budget
Netherlands	5-10 M€/year	No response
Romania	5-10 M€/year	2-10 M€/year
Slovenia	No dedicated budget	No dedicated budget

Section 3: Potential interest in a future co-funded European partnership on nuclear materials

Answers to questions 10 (Do you have experience with any current European Joint Programs in H2020, e.g., CONCERT or EURAD?), 10.1 (Which one?), 10.2 (Based on your current experience, are you satisfied with the added value they bring to your country?)

All the MS, except Netherland, answered to have experience with current European Joint Programmes in H2020, as listed below:

- Belgium: CONCERT, EURAD, EUROFUSION
- Croatia: CONCERT, EUROFUSION
- Finland: EURAD
- Germany: CONCERT (coordinated by BfS)
- Italy: EURAD, EUROFUSION
- Romania: EURAD
- Slovenia: CONCERT, EURAD, EUROFUSION

Based on answers to the question 10.2, all the above MS are satisfied with the added value that the EJPs bring to their own countries. The primary reasons concern various aspects such as benefits for research and development by open calls, and those arising from international cooperation and from the possibility to pursuing the national R&D needs and priorities, as well as the strengthening promotion of industrial research activities in nuclear energy research area.

Moreover, enhancements were pointed out in different areas such as that of the infrastructures (providing i.e., an inventory of existing, missing, or endangered ones), in the human resource connection among the research centres, agencies and Industries across Europe.

An added value also arises from the maintenance of competences through the promotion of PhD projects. This attracts the young generation of scientists towards the nuclear field, carries on research at the highest scientific level strengthening existing competence, and developing new ones. Finally, the participation of MS to the EJPs increases the national visibility of related research improving the awareness on the EU wide research topics among the decision makers like ministries and research agencies.

Answers to question 11 (Do you consider that a European R&D co-funded partnership on nuclear materials, centred around and driven by research funders and other public authorities, would be a suitable instrument to promote nuclear materials R&D in your

country?), **11.1**(Would your country be interested in participating and supporting the development and implementation of a future European R&D co-funded partnership on nuclear materials?), **11.2** (Do you think that a share of e.g., 50%/50% (MS/EU) would be sufficient to guarantee that the national priorities are correctly considered?), **11.3** (Would your country be ready to support it with a higher share?), **11.4** (Please, provide your comments about an optimum co-funding scheme), **11.5** (Please, specify the type of contribution your country is willing to commit to ? [Multiple specific answers possible]), **11.6** (What could be the approximate contribution provided by your Member State to a European R&D co-funded partnership on nuclear materials? [Multiple specific answers possible]).

All the respondents, except for Croatia and the Netherlands (which didn't provide an opinion), gave a positive answer to the question 11. All these MS, except Italy, which doesn't know the answer, replied positively to question 11.1 highlighting the interest of their country in participating and supporting the development and the implementation of a European R&D co-funded partnership (CEP).

About the question 11.2, Belgium, Germany, and Italy agreed with the fact that a share of 50% between MS and EU would be sufficient to guarantee a right consideration of the national priorities, Finland and Romania disagreed with this scenario while Croatia and Netherlands didn't give an opinion about it. Slovenia didn't know the answer.

Concerning question 11.3, Finland, Germany, Italy, and Romania answered that their countries would not be ready to support a European R&D co-funded partnership on nuclear materials with a share higher than 50%. About this question, Belgium and Slovenia didn't know the answer, and Croatia and Netherlands have not given answers.

Based on the comments about the question 11.4, an optimum co-funding scheme related to the CEP were provided by five MS. Belgium (suggesting an in kind and cash contribution), Finland (70% MS and 30% EU), Germany (to state its views about this is waiting for further adjustment on any such implementing parts of Euratom Programme in the light of the Council outcome on the underlying Euratom Regulation on Research and Training 2021-2025), Italy (40% MS and 60% EU), and Romania (25% MS and 75% EU, due to the fact that R&D on NM should be quite expensive in terms of experimental work, and the National Programme would not be able to cover the costs). No related comments were provided by the remaining MS.

Only six MS gave an answer to questions 11.5 and 11.6. Based on the answers, Belgium and Finland prefer a *mix of both options with preference for in-kind contribution*; Germany a *mix of both with equal importance*; Italy and Romania indicated the *in-kind contribution as an option*, while Slovenia prefers a *mix of both options with reference for ear-marked funding*.

The approximate contribution they indicated are:

- Belgium: more than 2M€
- Finland and Italy: 50-100 k€/year
- German, Romania, and Slovenia: 50-500 k€/year

Answers to question 12 (In your opinion, which type of activities should the European R&D co-funded partnership on nuclear materials mainly support? [Multiple specific answers possible])

This question asked to MS to choose between six specific possible answers. All MS have selected one or more options, as specified below:

- Belgium, Croatia, Finland, Italy, Netherlands, Romania, and Slovenia: *materials qualification for the design of innovative nuclear systems.*
- Finland, Germany, Netherlands, Romania, and Slovenia: *materials solutions for safe long-term operation of current reactors.*
- Belgium, Finland, Italy, Romania, and Slovenia: *development of innovative materials solutions to improve nuclear energy sustainability.*
- Finland: *development of a methodology for autonomous optimization/discovery of nuclear materials.*
- Belgium, Finland, Italy, Romania, and Slovenia: *energy materials for extreme conditions of cross-cutting interest.*

Answers to question 13 (Would you be interested in contributing with your advice to the activities carried out under the ORIENT-NM project to explore the possibility of establishing a future co-funded partnership on nuclear materials, by taking part in dedicated workshops?)

All MS, except Netherlands, have expressed their availability in contributing to this activity.

The following comments have been provided by three MS respondents:

- Belgium is available to attend only virtual/remote meetings,
- Romania is interested to take part in dedicated workshops and even to organize one; and
- Netherlands' respondents explained that they think to have not enough knowledge on the nuclear materials to be able contributing with their advice.

Section 3: Contact details of other national experts

Answers to question 14 (A second survey will be conducted to gather more information on national R&D programmes on nuclear materials, containing specific questions on different topics related to nuclear materials, such as technical R&D priorities and objectives, available associated costs, available nuclear facilities, etc. If someone else should answer this more specific survey, could you please provide the contact details of the most suitable expert(s)?)

The following organizations with the related person of contact were indicated by:

- Belgium: Directorate-General for Energy.
- Croatia: Ministry of Interior Affairs.
- Finland: VTT.
- Germany: PT GRS.
- Netherlands: NRG Petten.
- Romania: RATEN.
- Slovenia: Jožef Stefan Institute.

No information has been provided by Italy.



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