IPCEI on Innovative nuclear technologies
Scoping paper

1. Background and context of the initiative

Nuclear technologies can play a crucial role in addressing today's industrial and societal challenges. In the energy sector, nuclear provides a stable, low-carbon energy source essential for decarbonisation. This is particularly critical for many energy-intensive industries and hard-to-abate sectors, which call for a reliable, consistent and affordable baseload electricity and process heat to facilitate their transition away from fossil fuels. Acknowledging Member States' sovereignty over their energy mixes, nuclear technologies can greatly contribute to energy security and reducing dependence on fossil fuels and external supplies. Nuclear energy is and will continue to be a key pillar to contribute to the EU's ambitious policy targets, and as recognised by Regulation (EU) 2026/667, is expected to play an increasingly important role in the coming years to contribute to a diversified, resilient and low-carbon European energy system. Furthermore, nuclear technologies offer significant benefits in the field of non-power applications, such as the production of medical isotopes, and can contribute to addressing some major health challenges in the EU, such as the fight against cancer.

The global nuclear landscape is evolving fast. Many countries around the world are adopting ambitious nuclear strategies and programmes[1]. In this growing global market, there are major opportunities for the European nuclear industry. At the same time, the European nuclear industry is facing challenges; a significant share of Europe's existing nuclear installations is ageing, creating needs for refurbishment, long-term operation, life-time extension, replacement, or the deployment of new capacities. In parallel, the fast-paced phase-out of carbon-intensive electricity generation presses the need for low-carbon alternatives capable of ensuring system stability, energy security, and competitiveness. Nuclear technologies from both fission and fusion technologies provide a strategic innovation opportunity for Europe, combining net-zero electricity and heat production with market-opportunities, including high-value industrial, scientific and technological spillovers. Regarding medical applications, there is a growing challenge with rising cancer rates and the need to develop new treatments and improve early and accurate diagnosis, while radioisotope production capabilities are insufficient to meet domestic market demand. Innovations in this sector, such as the development of new radioisotopes or innovative means of radioisotopes production (through reactors, accelerator-based technologies and waste or spent fuel valorisation) and innovative services facilitating timely and cost-effective delivery of treatments, are crucial to strengthen the European supply chain for medical isotopes.

Several major trends are expected to shape the nuclear sector in the coming decades. These include in particular the development of innovative nuclear fission reactors, such as Small Modular Reactors (SMRs)[2]. These are aimed at delivering low-carbon electricity production, but also promise alternative

[1] As reported in the EU COM (2026) 117 on the Strategy for the development and deployment of Small Modular Reactors (SMRs) in Europe, in December 2025, the United States Department of Energy (DoE) announced grants totalling USD 900 million to support initial US deployments of Generation III+ SMR technologies. The US DoE had also provided approximately USD 450 million under the SMR Licensing Technical Support programme. In Canada, the province of Ontario is investing CAD 1 billion through the Building Ontario Fund, and the federal government is providing CAD 2 billion through the Canada Growth Fund to build Canada's first SMR. The UK government has established the Advanced Nuclear Fund totalling GBP 385 million for the development of a domestic SMR design and AMRs. The first SMRs are already operating in China and Russia.

[2] In line with the SMR strategy by the European Commission, the term small modular reactors (SMRs) refers to nuclear reactors that are designed (i) to be smaller in size and output compared to traditional nuclear reactors, and (ii) to be modular, meaning that the reactors or their components can be manufactured in a factory setting and transported to a site either for direct use or for assembly. A useful classification of SMRs encompasses 1) light water SMRs, which have typically been developed from existing water-cooled nuclear reactors, making best use of the reduced size that allows full deployment of inherently safe passive devices; 2) advanced modular reactors (AMRs),

applications, including district heating, industrial heat and hydrogen production. Their promise makes them easily linked with opportunities in other industries such as data centres, defence, marine propulsion, high-level waste reduction and space exploration. Similarly, nuclear fusion is emerging as a strategic long-term technology, increasingly bridging the gap between advanced research and early industrial applications. This development is supported by investments in large-scale research facilities and by an increasing industrial involvement. In parallel, the production and use of medical radioisotopes are becoming a strategic priority for Europe given their essential role in modern healthcare, like in for both cancer diagnosis and treatment, and considering the rapidly growing demand driven by advances in nuclear medicine, the need to strengthen European production capacities, supply security and value chain services in order to ensure better patient access.

2. Relevance and goal(s) of the IPCEI on innovative nuclear technologies

Nuclear technologies already provide promising applications for Europe's industries, but the development of the most recent of these technologies still faces several challenges. Nuclear projects in general are characterised by high upfront capital costs, long development timelines, rigorous regulatory frameworks, constrained access to specific raw materials and fuels, safety, safeguards and strict security requirements as well as exposure to geopolitical and policy-related uncertainties. These constraints create additional barriers for market-introduction of promising innovative concepts in the EU. This contributes to make investment risks that are particularly high for first-of-a-kind projects and cannot be efficiently addressed at a company-level alone.

Enhanced cooperation and coordination at EU-level allows Member States and EU companies to pool financial resources, share risks, and coordinate investments to increase impact and speed up market introduction. It also facilitates common action and coordination to ensure secure and resilient access to nuclear-specific materials and build and strengthen a European nuclear fuel supply chain, covering the full nuclear lifecycle, including innovation in the fuel-cycle, nuclear facilities decommissioning and waste management aspects. This creates benefits as it allows Europe to address security of supply and geopolitical related challenges. **An IPCEI would provide a suitable instrument to mutualise efforts, foster cross-border industrial partnerships, create investor confidence with a multiplier effect on attracting additional private investments, all to accelerate the deployment of highly innovative nuclear technologies across the EU** while upholding the highest nuclear safety and safeguards standards in line with international best practices and obligations.

An IPCEI on innovative nuclear technologies can accordingly contribute to address **four key industrial and societal challenges for the EU**:

- **(i) climate neutrality, through the production of low-carbon energy**

This objective directly supports the European Union's target of climate neutrality by 2050, as established by Regulation (EU) 2021/1119 (*European Climate Law*). Consistent with the European Green Deal legislative framework, the EU should reach net-zero by 2050. European Member States will therefore have to complete an ambitious energy transition, substituting fossil fuels in the electricity sector, energy-intensive and hard-to-abate industries and the district heating sector with low-carbon energy, while also addressing emerging high-consumption users (e.g., electric mobility, computing load

which use innovative, next-generation (Generation IV) designs with different coolants (liquid metals, molten salt, or high-temperature gas) and novel nuclear fuel types; and 3) microreactors, which typically produce less than 10 megawatts of electric power, have long refuelling cycles and can be transported.

for AI training and use or data centres). SMRs possibly ensure a more flexible operation in response to grid demands. In the longer term, nuclear fusion could complement this contribution in support of climate neutrality, with ongoing development already generating relevant technological spillovers.

- **(ii) foster competitiveness and mobilise job creation, through strengthening EU industrial innovation and leadership in innovative nuclear technologies**

An IPCEI on innovative nuclear technologies can play a pivotal role in enhancing the EU's industrial competitiveness, innovation and labour market resilience in the long term. Supporting the development and first industrial deployment of innovative nuclear technologies can foster strategic value chains for high-tech manufacturing, engineering services, and nuclear supply industries - sectors that are essential to future low carbon energy systems and innovation ecosystems.

This aligns with the Commission's Competitiveness Compass and broader industrial policy framework, which emphasise innovation, strategic technologies and the creation of quality jobs and skill sets across Member States as core drivers of EU prosperity and competitiveness. Integrated European value chains for innovative nuclear technology can also attract skilled labour and drive job growth in R&D, start-up and scale-up activities, digital engineering and advanced manufacturing, thereby reducing external dependencies and strengthening the EU's strategic autonomy.

- **(iii) strategic autonomy and security of supply, reducing dependence on fossil fuels and exposure to external influences**

This objective is aligned with Article 194 TFEU, which provides that Union energy policy shall ensure the security of energy supply and promote the development of new forms of energy. It further supports the objectives of the European Green Deal and the REPowerEU Plan, both of which aim to reduce dependence on imported fossil fuels, enhance energy resilience, and strengthen the Union's strategic autonomy in a challenging geopolitical context. In relation to this framework, nuclear technologies can contribute to security of supply by providing reliable low-carbon energy, supporting long-term strategic autonomy, while respecting Member States' autonomy in choices in energy mix.

Moreover, the nuclear value chain involves high quality knowledge, critical components and materials, fuels and advanced manufacturing capabilities as well as highly skilled expertise. More European cooperation will help reduce dependencies on third country suppliers for components, fuel cycle services and technological know-how. The IPCEI would contribute to the strengthening of the domestic European nuclear industries and strengthen the market and knowledge position of Europe in these newly emerging technologies.

- **(iv) innovative health solutions building on the medical applications of nuclear technologies**

This objective is aligned with the EU4Health programme 2021-2027, particularly the Europe's Beating Cancer Plan, and the Euratom R&T programme 2021-2027. The role of nuclear medicine for cancer treatment, through the use of ionising radioisotopes, was acknowledged by the launch of the Strategic Agenda for Medical Ionising Radiation Applications (SAMIRA) action plan in February 2021. Securing the supply of medical radioisotopes, and facilitating innovation and technological development in the value chain, will contribute to this objective, supporting the development of important health solutions. The European Radioisotope Valley Initiative and upcoming communication will further the objectives regarding the development and monitoring of medical radioisotopes production in the EU, contributing to resilience and strategic autonomy in this important field.

3. Identified workstreams of the IPCEI on innovative nuclear technologies

This IPCEI should encompass research, development and innovation (RDI) and first industrial deployment (FID) of technologies[3], focussing on the development of innovative technological designs or innovative technological addition to existing designs but also covering the value chain that supports the operationalisation and market introduction of these designs.

The fields covered include nuclear energy generation but also radioisotope production. To this end, **a three-workstream IPCEI** is proposed, designed to address the challenges of innovative nuclear technologies across all stages of the value chain, while ensuring coherence, maximising cross-border collaboration and generating EU-wide spillovers:

- **A first workstream focusses on innovative reactor technologies including reactors for production of low-carbon electricity, cogeneration or heat production, radioisotope production, propulsion uses and off-grid applications as well as radioisotope power systems.**
- **A second workstream focusses on innovation in the front and back-end of nuclear fuels, such as innovations in the production of nuclear fuels or the production of target materials[4] for medical applications, as well as innovation in the management and/or valorisation of spent fuel.**
- **A third workstream focusses on innovation in materials, components and services needed to develop, build, operate and decommission nuclear reactors or facilities, or value chain services for the timely delivery of radioisotopes.**

The proposed workstream structure could be adjusted following the outcome of the calls for expressions of interest and the match-making process. In this regard, it is recalled that only individual projects which comply with the eligibility criteria of the IPCEI Communication[5] may be included in the perimeter of this IPCEI.

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[3] IPCEIs cannot support the mass production phase, i.e. full commercial installation beyond the R&D and first industrial deployment phase. Other legal bases are applicable to assess State aid for projects during the mass production phase e.g., TFEU for SMRs or the Clean Industrial Deal State Aid Framework (section 6) for manufacturing of components for fission plants.

[4] Target material refers to substances introduced into the reactor (within the core or in dedicated irradiation positions) core specifically to be irradiated by neutrons exposed to neutron flux in order to induce specific nuclear reactions. Unlike fuel, whose primary function is to sustain the chain reaction which is consumed to keep the reactor running, target materials are used to produce radioisotopes for medicine and industry, for materials testing, or for scientific research.

[5] All requirements for direct participation in an IPCEI are detailed in the IPCEI Communication and the Technical guidance on conditions and process for participation in an IPCEI. They include:

- **Major innovation**: project must be highly innovative and must aim to considerably advance existing technologies or develop new technologies, going beyond the state of the art in the sector concerned.
- **Integration**: all individual projects participating in an IPCEI must be complementary to each other and together form an integrated IPCEI project. This integration is achieved through the establishment of effective cross-border collaborations among direct participants of the IPCEI.
- **Positive spillover effects**: the benefits of an IPCEI must not be limited to the companies or the sectors concerned but must be of wider relevance and application to the economy or society.
- **Funding gap**: the company has to demonstrate that its project would not be carried without State support because it displays a 'funding gap'.
- **Contribution to EU objectives and strategies**: each IPCEI aims to significantly add value to the EU economy and society.
- **Other requirements**: the project must contribute to overcome important or systemic market failures, the company has to contribute to the financing of its own project, the project has to comply with the 'Do no significant harm' principle, and the aid received must not lead to undue distortion to competition and trade.

1) **WS1: Nuclear reactors**

The first workstream "Nuclear reactors" will focus on the conception, design, development and first industrial deployment of innovative reactor designs, including those for production of low-carbon electricity, cogeneration or heat production, radioisotope production with reactors and accelerators-based technologies, as well as reactors for propulsion uses and off-grid applications. This workstream will also cover innovative technological addition to existing designs. Eligible fission technologies will primarily include innovative designs, e.g., light-water reactors (LWR), high temperature reactors (HTR), liquid metal cooled fast reactors (LMFR), molten salt reactors (MSR), some of which are currently supported under the European Industrial Alliance on SMRs as well as microreactors. First-of-a-kind reactor deployment would enable the early demonstration of these innovative reactor designs. The development of integrated designs for fusion reactors would also be covered within this workstream. Innovative designs for medical radioisotopes production based on nuclear reactors and radiological facilities (accelerators, for example) as well as the development of new radioisotopes useful in the medical segment will also be included in this category, as well as radioisotope power systems.

Four types of market failures justify public intervention in this workstream. The first is the suboptimal level of private funding due to imperfect and asymmetric information between founders and investors regarding critical and uncertain success factors (such as regulatory aspects) and potential financial risks, and the commercial viability of the technologies involved. Second, the development of new reactors faces coordination challenges in investment, as the uncertainty of their development causes lacking development in upstream fuel cycle segment as well as demand by end users and energy operators. Third, the development of reactors is directly linked to the reduction of environmental externalities, which are not accounted as such by the market. And finally, the existence of positive externalities related to technological spillovers and cross-sectors innovation (such as in advanced manufacturing or disruptive digital technologies) that are not fully valued by the market.

2) WS2: Fuel and radioisotopes

The second workstream "Fuel and radioisotopes" will focus on innovation in production and management of nuclear fuels for energy generation, advanced and innovative fuel cycle solutions and target materials for medical applications. Different technologies require the development and industrial qualification of diverse innovative fuels, such as TRISO particles for HTR, fuel salts for MSR, MOX fuel for fast reactors, HALEU for advanced reactors and medical isotopes production, or deuterium, tritium (including breeding and handling), and lithium for fusion. In addition, this workstream will encompass projects related to the management and/or valorisation of radioactive waste and spent fuel, with a focus on the full lifecycle and on circular economy approaches, including the recovery and reuse of valuable materials for both the production of new nuclear fuels, as well as non-power applications such as the production of radioisotopes for medical or space applications. Furthermore, this workstream will also include RDI/FID projects related to the production of target materials used to generate promising radioisotopes for medical applications**:** this covers processing and testing facilities (to the extent used for the RDI/FID)[6] as for example separation, purification, labelling, or recovery of enriched materials facilities.

The nuclear fuel supply chain is facing several market failures, hindering its financing and autonomous emergence. Being tightly linked to nuclear energy production, the nuclear supply chain is indirectly

[6] For more details on eligible costs (e.g. instruments, buildings, contractual research), see annex of the IPCEI Communication.

subject to the associated technological development and deployment risks, and the uncertainty of future nuclear energy demand. Moreover, nuclear projects have a time horizon that is often too long for investors. Both those technological and financial risks are a source of uncertainty for investors and could have a negative impact on investments into such projects. Public support would therefore help mobilising the necessary funds, de-risking/reassuring private investors and the creation of a multiplier effect on private investments. Similarly, in the field of nuclear medicine, private investors are often reluctant to fund isotope production due to high upfront costs, long payback periods, and the regulatory requirements (asymmetric information) specific to health products.

3) **WS3: Materials, components and services**

The last workstream "Materials, components and services" will focus on the transversal industrial capabilities by providing innovation in the materials, components and services needed to design, develop, build, operate and decommission a nuclear asset, whether for power generation (electricity, heat, propulsion) or radioisotope production. It will encompass the transversal developments that support the entire sector (both fission and fusion), including the conception and realisation of radiation-resistant and high-performance materials, the implementation of innovative manufacturing processes (including digitalisation and automatisation, qualification and certification tools / facilities for new components), as well as the design and construction of pilot lines of innovative facilities to perform such activities. This workstream will cover the development of components especially suited for each reactor technology, from both fission and fusion designs. Specialised engineering services required for the deployment, maintenance and decommission of innovative reactors, or the innovative services for the prolongation, upgrade and decommission of existing nuclear assets will also be included. Furthermore, it will cover innovation in services pertaining to the medical radioisotopes and radiopharmaceutical distribution network, facilitating timely and cost-effective delivery of treatments.

Products and services supporting the nuclear sector relate to several market failures. First, there are significant coordination issues within the European nuclear supply chain, each economic agent waiting for the others to be the first to make substantial investment. Second, regarding transversal developments, such as the need for new materials, or new components, it can be difficult for economic operators to value R&D efforts without coordinated action, which therefore hinders innovation in the sector. Thus, the supply chain can face a vicious circle: investment cannot occur without a strong enough demand, but it should take place several years in advance to offer a reliable and operational solution when nuclear projects will emerge. Particular attention should be given to strengthening European and regional supply chains, including the development of manufacturing capacities in Member States.

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