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EU strategy for E&T in nuclear

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EXECUTIVE SUMMARY

The European nuclear sector is entering a decisive phase. Ambitious plans for new nuclear construction, long-term operation, decommissioning, and rapidly expanding non-power applications will drive a significant increase in demand for highly skilled professionals in the coming decades. This demand cannot be met without a coherent and future-oriented European framework for education, training, and knowledge management.

Globally, momentum for nuclear energy is accelerating. At COP28 in 2023, twenty-two countries pledged to triple nuclear capacity by 2050, which will require millions of new professionals worldwide. In Europe, several Member States are planning major new nuclear programmes, while others must address large-scale decommissioning projects. Beyond energy, nuclear competencies are equally critical in medicine, industry, and space applications, further broadening the skills demand

Yet Europe faces several challenges. Even under the current conditions, when few new nuclear projects are being built across the continent, the sector is already experiencing a shortage of qualified personnel. This situation may become critical once large-scale construction, and new deployments start in multiple countries. Loss of workforce may appear by migration of specialists outside the Europe towards regions with a strong deployment of new nuclear projects. In recent years the aging trend seems to start being reversed but many sites are still in the process of recruitment. On the other, the attractiveness of nuclear careers for young people has declined after decades of political uncertainty, limited investment, the growing appeal of other technological fields (such as artificial intelligence, advanced robotics, big data, etc.), combined with a preference for more flexible and less demanding jobs, and negative public perceptions following events such as Fukushima. Without decisive actions, Europe risks losing critical know-how, facing shortages of qualified staff, and weakening its competitiveness in the global race for nuclear expertise.

While important initiatives exist – including the SET-Plan E&T Roadmap, the EHRO-N workforce observatory, ENEN-led mobility projects, and various Euratom funding instruments – they remain fragmented, project-based, and insufficient to meet future needs. Crucially, the European Union (EU) has not yet adopted a dedicated and comprehensive strategy for nuclear education and training; existing frameworks are embedded within broader energy or research agendas and lack a nuclear-specific, long-term vision. A new, integrated strategy is therefore required to secure Europe's nuclear knowledge base, align education with industry and societal needs, and provide long-term stability for training pathways.

This strategy puts forward a clear vision: to position Europe as a global leader in nuclear education, training, and innovation. Its priorities include:

- safeguarding the European knowledge base and ensuring effective transfer between generations,
- attracting, developing, and retaining new talents through mobility, scholarships, and outreach,
- strengthening collaboration between national governments and agencies, academia, VET training centres, R&D organisations, TSO, industry, regulators, and hospitals,
- securing stable, long-term financing that goes beyond project cycles,

- and embedding innovation (SMRs, Gen IV, digitalisation, AI) into education and training.

By acting now, Europe can inspire the next generation of nuclear professionals, ensure that nuclear competencies remain a cornerstone of its clean energy transition, and maintain leadership in advanced technologies and non-power applications. Failure to act risks fragmentation, shortages, and the erosion of Europe's competitive edge at a moment when global demand for nuclear expertise has never been higher.

LIST OF ACRONYMS

SET-Plan	Strategic Energy Technology Plan
E&T	Education and Training
EHRO-N	European Human Resources Observatory (Nuclear)
ENEN	European Nuclear Education Network
EU	European Union
VET	Vocational Education and Training
R&D	Research and Development
TSO	Technical Safety Organisation
SMRs	Small Modular Reactors
AI	Artificial Intelligence
JRC	Joint Research Centre
RTD	Research and Technological Development
HR	Human Resources
DOE	Department of Energy (USA)
IAEA	International Atomic Energy Agency
OECD	Organisation for Economic Co-operation and Develop.
NEA	Nuclear Energy Agency of the OECD
EIB	European Investment Bank
EMSNE	European Master of Science in Nuclear Engineering
MSCA	Marie Skłodowska-Curie Actions
STEM	Science, Technology, Engineering and Mathematics
IT	Information Technology
ETKM	Education, Training and Knowledge Management
INMA	International Nuclear Management Academy
EMINE	European Master in Innovation in Nuclear Energy
RWMD	Radioactive Waste Management and Decommissioning
NROS	Nuclear Reactor Operation and Safety
ESTA	ENEN Student and Teacher Assembly
I2EN	Institut International de l'Énergie Nucléaire
EUR-ACE	European Accredited Engineer
PPPs	Public-Private Partnerships
ICT	Information and Communication Technology

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1 INTRODUCTION

Nuclear energy occupies a strategic position in the European Union's efforts to achieve climate neutrality, strengthen energy security, and uphold technological leadership in line with the European Green Deal. As one of the largest providers of low-carbon electricity in Europe, nuclear power is expected to play an essential role in the transition towards a sustainable and resilient energy system. Yet the long-term contribution of nuclear energy depends not only on technological developments but also on the capacity to educate, train, and retain a highly skilled workforce.

At the international level, momentum for nuclear deployment is accelerating. During COP28 in Dubai in December 2023, twenty-two countries pledged to triple global nuclear power capacity by 2050, expanding from approximately 370 GWe today to more than 1,100 GWe. This unprecedented growth implies a massive demand for human resources: extrapolations suggest that around 2.5 million new nuclear professionals - on average 100,000 per year - will be required worldwide to build, operate, and decommission nuclear facilities. National projections, such as those developed by the U.S. Department of Energy 2023 [1] and GIFEN in France in 2023 [2], confirm the scale of this challenge.

Europe must respond to this global shift. Several EU Member States - including Bulgaria, the Czech Republic, France, Hungary, Lithuania, the Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden -and the United Kingdom are advancing ambitious plans for new nuclear construction [3]. At the same time, nuclear regulations, decommissioning, spent fuel management, and radioactive waste disposal represent domains that also demand highly trained experts. The nuclear field, like other high-tech industries, depends on a wide range of competencies: nuclear engineering, digital technologies, materials science, medical applications, project management, regulations, and safety culture.

However, the European nuclear sector faces a dual challenge. First, the workforce is ageing, with many experienced professionals approaching retirement. Second, the attractiveness of nuclear careers for younger generations has declined, reflecting decades of underinvestment in nuclear education and training. Simultaneously, the emergence of new technologies - such as small modular reactors (SMRs), Generation IV systems, advanced digitalisation, and medical isotope production - requires a new wave of specialists equipped with innovative skills.

Several initiatives have been undertaken at EU level to address these needs. The SET-Plan roadmap on Education and Training [4], the studies of the European Human Resources Observatory for the Nuclear Sector (EHRO-N) [5], and multiple ENEN-led projects have provided valuable input [6]. The Joint Research Centre (JRC) has also contributed through programmes on safety, safeguards, decommissioning, and knowledge management [7]. Despite these efforts, Europe still lacks a coherent and holistic strategy for education and training (E&T) in nuclear, covering the full spectrum of competencies from academia to industry, research, regulations and medical applications.

This gap underlines the importance of Task 3.5. The objective is to revise the existing EU framework, identify its weaknesses, and formulate recommendations for new initiatives that better reflect the needs of the European nuclear industry and stakeholders. This includes exploring innovative partnerships between academia, industry, and hospitals through public-private schemes, promoting mobility and recognition of qualifications, and ensuring a sustainable talent pipeline for the decades to come. By addressing these

challenges in a coordinated manner, the EU can secure the knowledge base required to maintain competitiveness, meet climate and energy commitments, and remain at the forefront of nuclear innovation.

1.1 Overview of Existing Nuclear-Specific EU Frameworks and Projects

Euratom has provided continuous support for research, doctoral networks, and access to infrastructures, coordinated in part through the Joint Research Centre (JRC). These activities include both indirect actions-research and training projects implemented through the Framework Programme (RTD)-and direct actions, carried out by the JRC. Training actions cover diverse areas, including safety, safeguards, decommissioning, radioactive waste management and disposal, fusion research and technologies, radiation protection, advanced materials for nuclear applications, emergency preparedness and response, and knowledge management. While these efforts are vital, they are mostly targeted at research-oriented personnel rather than the full spectrum of industry, regulatory, and medical needs.

Over the past two decades, several European-level initiatives have addressed education and training (E&T) in the nuclear field. While these efforts provide valuable foundations, they remain fragmented and insufficient to meet the upcoming surge in demand. The most relevant instruments include:

- **SET-Plan Education and Training Roadmap (2014)**

Adopted as part of the Strategic Energy Technology Plan, the roadmap aimed to harmonise nuclear E&T across Europe by adopting existing common reference systems such as ECTS (developed under the Bologna Process) and ECVET, establishing competence frameworks, and promoting stronger cooperation among Member States. It also designated the European Human Resources Observatory for the Nuclear Sector (EHRO-N) as the reference body for monitoring skills demand and supply. Despite these intentions, the roadmap lacked binding mechanisms and long-term funding, limiting its impact on structural change [4].

- **EHRO-N (hosted by the Joint Research Centre, JRC)**

The European Human Resources Observatory for the Nuclear Sector (EHRO-N), hosted by the Joint Research Centre (JRC) of the European Commission, plays a central role in assessing nuclear human resources in Europe. Established in 2010, its mission is to provide a clear and evidence-based understanding of the supply and demand of competencies across the nuclear sector. EHRO-N produces studies, surveys, and recommendations on workforce trends, including retirement profiles and skill shortages, while also promoting the harmonisation of qualifications and mobility across Member States. Unlike education networks or project-based training initiatives, EHRO-N operates as a permanent observatory and knowledge hub, offering structured data, forecasts, and guidance to policymakers, industry, and academia. However, it does not control funding nor directly coordinate the delivery of practical training, which limits the implementation of its recommendations despite its valuable analytical role [5].

The figure 1 illustrates the cyclical methodology applied by EHRO-N to assess and manage nuclear human resources in Europe. The process begins with mapping the current

workforce (Step 1), followed by an analysis of future demands (Step 2) based on policy goals, technological developments, and national nuclear programmes. Next, EHRO-N performs a mapping of the available HR supply (Step 3), identifying the capacity of education, training, and professional pipelines. This enables a systematic gap analysis (Step 4) between projected demand and existing supply. On this basis, an action plan or nuclear skills strategy (Step 5) is formulated, setting out measures to address identified shortages or mismatches. The plan then enters the implementation phase (Step 6), supported by cooperation among academia, industry, regulators, and EU institutions. Finally, the process is completed with a monitoring and review stage (Step 7), ensuring that progress is assessed, lessons are learned, and adjustments are made before restarting the cycle.

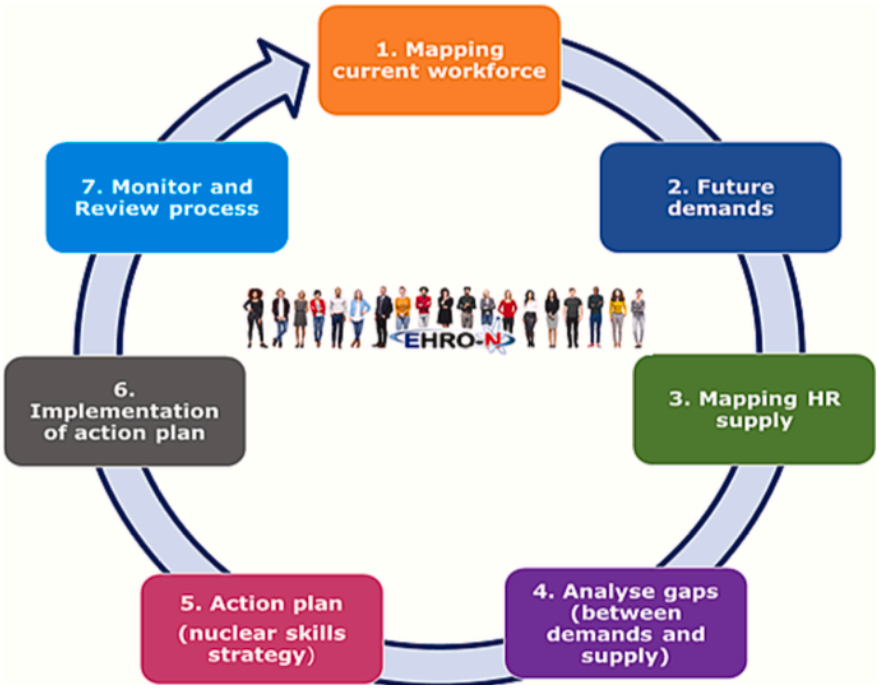

Figure 1 - Workforce capability and planning cycle [7]

- **ENEN Association and EU-funded projects**

The European Nuclear Education Network (ENEN) has been the driving force behind many pan-European training actions. Projects such as ANNETTE (focusing on nuclear safety culture and training for regulators), ENEN2plus (the largest nuclear mobility and training project to date), and a wide range of summer schools and specialised courses have supported thousands of students and young professionals. These projects significantly enhanced international mobility and visibility of nuclear careers. Yet they remain time-limited, project-based, and dependent on EU calls, which undermines long-term sustainability [6].

The European Nuclear Education Network (ENEN) plays a central role in fostering mobility, knowledge transfer, and a strong sense of community among the next generation of nuclear professionals in Europe. One of its flagship initiatives, the European Master of Science in Nuclear Engineering (EMSNE) Certification, is an illustrative example of how harmonisation can be achieved in a flexible and effective way. The EMSNE scheme requires laureates to complete a Master's degree with at least 300 ECTS, of which 60 must be in nuclear subjects, and importantly, to earn at least 20 ECTS through a mobility period at

another ENEN member institution. This requirement for international mobility ensures that students are exposed to different pedagogical approaches, technical infrastructures, and cultural contexts, enriching their professional and personal development. By embedding mobility into the certification, ENEN effectively promotes cross-border collaboration and the circulation of knowledge, which are key to building a competitive and resilient European nuclear workforce.

Although the number of EMSNE certifications temporarily declined during the COVID-19 pandemic, this was largely due to disruptions in mobility opportunities rather than a decrease in interest or relevance. In fact, ENEN has continued to expand its portfolio of mobility schemes, offering both short-term and long-term financial support for students and young professionals. These opportunities go far beyond simple academic exchanges: they allow students to gain hands-on experience in laboratories, nuclear power plants, and research centres across Europe, thereby bridging the persistent gap between theory and practice in nuclear education. At the same time, ENEN plays a crucial role in organising thematic summer schools, workshops, and international events, which not only provide specialised training but also bring together students from diverse backgrounds, fostering intercultural competencies and long-term professional networks.

The impact of these activities extends beyond individual careers. By enabling students to build contacts, access infrastructures, and engage directly in European collaborative projects, ENEN contributes significantly to Europe's competitiveness in the global nuclear sector. Mobility and networking opportunities make nuclear studies more attractive to young people, helping to counter the declining enrolment trends observed in nuclear engineering programmes across Europe. They also create pathways for the involvement of students and early-career professionals in EU-funded research and training projects, giving them first-hand exposure to international collaboration and project management. This, in turn, enhances Europe's capacity for innovation and strengthens the integration of young professionals into the broader European Research Area.

Furthermore, ENEN's activities serve an important function in terms of community building. By maintaining an active network of students, researchers, and professionals, the association ensures that young people do not perceive nuclear education as an isolated academic pursuit, but rather as an entry point into a vibrant European community with strong professional prospects. This is particularly relevant in the context of increasing demand for nuclear competencies, both in energy and non-energy applications, where professional mobility, adaptability, and cross-disciplinary skills are essential. ENEN's ability to combine academic excellence with practical exposure and networking thus represents a unique asset for Europe.

The ENEN+ project (1 October 2017 – 30 September 2021), funded under the Euratom Research and Training Programme represented one of the most ambitious initiatives to strengthen nuclear education, training, and mobility in Europe. Coordinated by the ENEN, it aimed to attract, develop, and retain new talents in nuclear fields by offering financial and organisational support for mobility actions across borders, disciplines, and sectors. The project covered a wide spectrum of learners – from secondary school students and undergraduates to PhD candidates and young professionals – with a strong emphasis on interdisciplinarity and gender balance. Through grants for internships, laboratory visits, summer schools, and participation in international events, ENEN+ project provided more than a thousand mobility opportunities across Europe and beyond. Beyond financial support, ENEN+ also contributed to community building, by linking students with industry,

regulators, and research institutions, thereby fostering long-term career perspectives in both nuclear power and non-power applications such as medicine and radiation protection. By combining training, networking, and outreach, ENEN+ project demonstrated how targeted EU-funded initiatives can both enhance the visibility of nuclear careers and create tangible opportunities for young people to join the sector, thus directly addressing the looming skills gap in Europe.

ENEN's mobility and certification programmes demonstrate that education and training initiatives are not only about transferring knowledge, but also about cultivating motivation, resilience, and a sense of belonging among future nuclear professionals. By sustaining these efforts and expanding their reach, ENEN contributes decisively to strengthening Europe's talent pipeline, maintaining competitiveness, and preparing the nuclear workforce to meet the complex challenges of the coming decades [8].

The EU possesses a patchwork of initiatives, each valuable in its domain, but none of them constitutes a comprehensive, integrated strategy. The absence of continuity and coordination across academic, industrial, and medical applications remains a systemic weakness.

1.2 Structural Weaknesses of the Current Approach

Despite several valuable initiatives, the current European approach to nuclear education and training continues to suffer from persistent weaknesses that undermine its effectiveness and long-term sustainability. Fragmentation across Member States remains evident, with significant differences in curricula, accreditation systems, and vocational training opportunities. Many initiatives are still heavily reliant on short-term project funding, which leads to discontinuity once projects end and prevents the establishment of stable, long-lasting programmes. The integration of emerging technology areas-such as advanced reactor concepts, small modular reactors, fusion energy technology, hydrogen production and cogeneration technologies, advanced digitalisation, artificial intelligence, decommissioning, etc.-into mainstream education and training remains limited, leaving a gap between current academic content and the skills required by industry. Furthermore, nuclear careers continue to struggle with low visibility and limited attractiveness among young people, reducing the sector's ability to compete with other high-tech industries for top talent. Collaboration between industry, research organizations, TSO, academia, and regulators in curriculum design and training provision is also weaker than it should be, resulting in misalignments between supply and demand of competencies. Finally, the absence of a fully operational EU-wide certification mechanism, such as a Nuclear Skills Passport, hampers cross-border mobility and recognition of qualifications, restricting the creation of a truly integrated European nuclear skills market.

Despite the progress achieved, several recurring weaknesses have been identified across EU reports, stakeholder consultations, and project evaluations:

1.2.1 Fragmentation of activities

Nuclear education and training (E&T) initiatives are distributed across a range of EU programmes, Member States, and organisations. Many of these are confined to specific domains such as reactor safety, radiation protection, or decommissioning, while others focus on particular geographic regions. This fragmented approach leads to duplication in certain areas, noticeable gaps in others, and ultimately uneven access for students across

Europe. Without an overarching framework to coordinate these initiatives, the sector remains siloed and struggles to generate synergies between existing efforts, reducing the overall efficiency and visibility of nuclear E&T at the European level.

1.2.2 Insufficient and unstable funding

Most training and mobility opportunities rely on short-term EU project cycles under Horizon Europe, Euratom, Erasmus+ or Marie Skłodowska-Curie Actions (MSCA). Once these projects end, courses, scholarships, and mobility actions are often discontinued, creating discontinuity and eroding institutional capacity. Long-term solutions such as permanent training centres, structured fellowships, or sustained funding instruments are still largely absent. This makes E&T capacity highly vulnerable to funding fluctuations and political priorities, which prevents the establishment of a stable and continuous pipeline of nuclear professionals across Europe.

At the same time, financing of full higher education programmes (education) varies widely across Europe and directly shapes access to nuclear studies. Some Member States operate tuition-free or low-fee models for domestic/EU students, while others apply substantial tuition, particularly at master's and doctoral levels. STEM-and nuclear in particular-also carries higher delivery costs (specialised laboratories and simulators, research-reactor access, licensed facilities, personal protective equipment, radiological monitoring, small cohort sizes), which can limit programme capacity or push costs onto students. To complement training and mobility grants, the strategy should therefore promote coordinated scholarship schemes and fee-support instruments: national/EU scholarships and living-cost stipends for nuclear degrees; targeted fee waivers or tuition co-funding (especially for cross-border joint degrees); industry-backed bursaries tied to apprenticeships; micro-scholarships for short laboratory placements; and portable funding that follows the student across ENEN partner institutions. Aligning these tools with Erasmus+/MSCA mechanisms, Just Transition reskilling (for entrants from fossil sectors), and ENEN's mobility pipelines would reduce financial barriers, widen participation, and stabilise enrolments in nuclear bachelor's, master's, and PhD programmes across the EU.

1.2.3 Low attractiveness of nuclear careers

Although the long-term decline in student enrolments in nuclear engineering has slowed down and recent initiatives suggest a stabilisation – even modest growth in some Member States – the sector remains a niche compared to larger high-tech domains such as IT or renewable energy. Nuclear careers therefore continue to face challenges in visibility and competitiveness. Young people often perceive nuclear energy as outdated, politically unstable, or too strongly associated with past accidents such as Fukushima. In parallel, competing high-tech sectors-digitalisation, aerospace, or renewable energy-are seen as more innovative and dynamic, making it harder for nuclear careers to attract top talent. This perception directly impacts not only university intake but also recruitment into industry, regulatory bodies, and medical institutions that depend on specialised nuclear competencies. This position is changing considering recent activities (such as ENEN initiative, NEA, IAEA activities etc.) in the European Union, and we are seeing a shift in the number of students, but compared to the major IT fields, it is still a rather minor focus.

1.2.4 Uneven situation among Member States

Significant disparities exist across Europe when it comes to nuclear E&T infrastructure and opportunities. Countries with established nuclear industries, such as France, the Czech Republic, and Finland, have robust national training pipelines supported by strong institutional frameworks and access to specialised facilities. Others, particularly new entrants like Poland or Estonia, lack comparable structures or resources. As a result, opportunities for hands-on training, summer schools, or exchange programmes vary considerably, creating an uneven playing field. This imbalance undermines the development of a coherent European nuclear workforce and risks concentrating expertise in only a few Member States.

1.2.5 Mismatch between cyclical industry demand and continuous education supply

The nuclear workforce is characterised by cyclical demand, which rises sharply during new-build phases, stabilises during long-term operation, and peaks again during decommissioning projects. By contrast, education systems function on a steady, continuous basis, producing graduates at a relatively constant rate. Without flexible mechanisms-such as modular training, cross-sectoral apprenticeships, or public–private partnerships-these cycles produce mismatches: shortages of qualified staff during peak demand, or underutilisation of graduates during slower periods. This structural misalignment between industry cycles and educational provision is one of the most critical weaknesses of the current system. This situation is particularly likely to arise in the coming years, when a number of Member States across Europe are planning to expand their nuclear programs.

1.3 Workforce Dynamics and Outlook

The challenge facing the European nuclear sector is not only qualitative-linked to skills, attractiveness, and training structures-but also profoundly quantitative. Over the next three decades, the sector will experience an unprecedented rise in demand for qualified professionals, driven by the global expansion of nuclear power, national new-build programmes, and the ageing of the current workforce. Available data [9; 10] already point to a steep and widening gap between projected needs and existing education and training (E&T) capacity.

1.3.1 Global context

At the COP28 Climate Conference held in Dubai in 2023, 22 countries-including many EU Member States-committed to tripling global nuclear power capacity by 2050. This represents an increase from roughly 370 GWe of installed capacity today to approximately 1,100 GWe mid-century. Such growth requires not only massive investment in infrastructure and technology but also in people. Based on extrapolations by the U.S. Department of Energy (DOE), this expansion would demand around 2.5 million new nuclear professionals worldwide, equating to approximately 100,000 new recruits every year. These professionals will be needed across the full spectrum of nuclear activities: design, licensing, construction, operations, regulation, fuel cycle, decommissioning, and waste management. The global race for nuclear talent will therefore intensify, with Europe competing directly with North America and Asia for scarce human resources.

1.3.2 European projections

For Europe, the global pledge translates into a need for tens of thousands of new professionals over the coming decades. Countries such as Poland, Romania, and the Czech Republic are launching first-of-a-kind or new-build projects, while France and Finland are expanding or modernising their existing fleets. Parallel to this, almost all Member States must plan for decommissioning of ageing facilities, requiring specialised technical and project management skills. Current educational capacity, however, is limited: only a few thousand students graduate annually in nuclear-related programmes across Europe. This mismatch between supply and demand raises the risk of workforce bottlenecks in critical phases of project implementation, potentially delaying the deployment of nuclear as a key contributor to Europe's climate-neutrality objectives.

1.3.3 France as a benchmark, Established Nuclear States, and Newcomers

France, Europe's largest nuclear country, provides a striking benchmark for the scale of the challenge. Industry associations such as GIFEN estimate that the French nuclear sector will require between 10,000 and 15,000 new recruits every year until 2030 [2; 11]. This represents more than 100,000 workers over the decade, spanning engineers, technicians, and skilled craft workers across the supply chain. These figures reflect not only the ambition to extend the operating lifetime of the existing fleet but also to prepare for new European Pressurised Reactors (EPR2) and small modular reactors (SMRs). Comparable numbers, when extrapolated to the wider European Union, underscore the magnitude of the challenge: tens of thousands of new professionals will be needed continent-wide, far beyond current training capacity.

Alongside France, several other Member States already operate nuclear reactors and in some cases are actively advancing plans for fleet expansion or lifetime extensions. Countries such as the Czech Republic, Slovakia, Hungary, Romania and Finland maintain nuclear power in their energy mix and are exploring further development. For instance, the Czech Republic has selected a contractor for new units at Dukovany and is considering additional capacity at Temelín. Such programmes create sustained demand for engineers, regulators, and construction specialists, reinforcing the need for steady education pipelines and specialised vocational training.

In parallel, a group of EU countries are entering the nuclear field for the first time, thereby creating an entirely new demand profile for human resources. Poland represents the most advanced newcomer, with ambitious plans for both large-scale nuclear power plants (with U.S. and Korean technology partners) and a domestic SMR programme. Estonia and other Baltic countries have also signalled interest in deploying nuclear as part of their decarbonisation strategies. Unlike established nuclear states, newcomers face the dual challenge of building institutional capacity from scratch-including regulatory bodies, training institutions, and industrial supply chains-while simultaneously developing a skilled workforce capable of delivering first-of-a-kind projects. This necessitates not only national training schemes but also extensive reliance on international mobility, partnerships, and knowledge transfer mechanisms coordinated at the EU level.

The loss of these experts implies not only a numerical deficit but also the erosion of tacit knowledge-experience and know-how that cannot be easily replaced by new graduates. The double burden of simultaneously replacing retirees and expanding the workforce to meet new-build and decommissioning demands creates an unprecedented pressure on

Europe's E&T systems. Without accelerated intake and new training models, the risk of a "knowledge cliff" is significant.

1.4 Synthesis

By 2050, Europe faces a critical human capital challenge of unprecedented scale. Tens of thousands of new professionals will be required not only to sustain nuclear's current contribution to climate neutrality, energy security, and technological innovation, but also to expand its role in line with ambitious EU decarbonisation targets. The expected growth of nuclear capacity, actual workforce refreshment, coupled with large-scale decommissioning and waste management needs, places simultaneous pressure on both expansion and dismantling activities. This dual requirement amplifies the demand for highly qualified experts across the full nuclear spectrum-from reactor operators and safety engineers to radiation protection specialists, decommissioning experts, digitalisation specialists, and nuclear medicine professionals.

Current European education and training (E&T) capacity is insufficient to meet these challenges. Universities and training centres graduate only a few thousand nuclear specialists each year, while projections indicate that annual recruitment both in direct and indirect jobs will need to be several times higher. Moreover, the existing system is fragmented and uneven, with strong national pipelines in some countries, but limited or non-existent structures in others. Without mechanisms to align national initiatives under a coherent EU framework, this imbalance will persist, leading to unequal opportunities for students and inefficiencies in knowledge transfer.

The absence of long-term financial stability further undermines progress. Most initiatives remain dependent on short-term EU projects or ad-hoc national funding. As a result, mobility programmes, specialised courses, and summer schools are vulnerable to disruption when calls end. This cyclical funding environment makes it difficult to build permanent structures such as dedicated training centres or to maintain consistent pipelines of scholarships and apprenticeships. Consequently, Europe risks entering the 2030s and 2040s without the robust, institutionalised E&T system that a century-long nuclear lifecycle requires.

If no coordinated strategy is adopted, several risks loom large. First, critical know-how accumulated over decades will be lost as senior professionals retire without adequate knowledge transfer mechanisms. Second, the nuclear sector will continue to struggle in attracting sufficient young talent, especially when competing with other high-tech industries such as digital technologies or aerospace that are perceived as more modern and dynamic. Third, Europe will likely encounter bottlenecks in both new build and decommissioning projects, delaying timelines, increasing costs, and undermining credibility. Fourth, in the face of global competition for nuclear expertise-particularly from rapidly expanding programmes in Asia, North America, and the Middle East-Europe's competitiveness and leadership could weaken substantially.

To avoid these outcomes, a coherent European framework is urgently needed. Such a framework should align national initiatives, harmonise curricula and qualifications, and provide stable funding mechanisms that extend beyond short project cycles. It should also create attractive, modern pathways into nuclear careers by integrating cutting-edge technologies-such as SMRs, Generation IV systems, digital twins, and artificial intelligence-

into education. Strengthened mobility, stronger industry–academia collaboration, and visibility of career opportunities will be essential to attract the next generation.

Ultimately, the synthesis of existing analyses and stakeholder input points to one clear conclusion: Europe must act decisively and collectively. Only by moving from fragmented efforts to an integrated strategy can the EU ensure that the nuclear workforce of 2050 is large enough, skilled enough, and diverse enough to support its long-term energy and innovation objectives.

2 VISION AND STRATEGIC OBJECTIVES

For many years, the educational sector was neglected from relevant investments. The accent was put on providing fast solution to ad-hoc industry needs, disregarding the impact on future generations and future development of the sector. As a result, innovation and advancement in Europe was put to a stall, allowing other countries to face a steep increase in innovative solutions for the nuclear sector. Today, Europe needs a unified strategy that should tackle the issue of providing enough highly qualified people for the already present high demand of personnel and for future investments in the sector. The overarching ambition of this strategy is to build a sustainable, attractive, and future-oriented nuclear skills ecosystem in Europe. The overarching vision of this strategy is to establish Europe as a global leader in nuclear education, training, and innovation, ensuring that the continent develops and sustains a highly skilled workforce able to support the EU's ambitions in climate neutrality, energy security, and technological competitiveness. Europe must become the most attractive place for young people to pursue nuclear careers, while at the same time safeguarding and transferring the knowledge accumulated over decades of research, operations, and regulation.

Achieving this vision requires a clear set of strategic objectives. First, Europe must preserve its knowledge base, ensuring that the expertise of senior professionals is transferred to the next generation before large retirements occur. Second, the EU must attract, develop, and retain talents, making nuclear careers visible, appealing, and competitive with other high-tech industries. Third, it is necessary to strengthen the links between academia, industry, research organizations, regulators, and medical institutions, so that education is aligned with real workforce needs. Another priority is to harmonise curricula and qualifications across Member States, enabling smooth mobility and recognition of skills at the European level, which is currently lacking even for medical physicists.

To ensure continuity, the strategy must also secure long-term and stable financing for education and training, moving beyond short-term projects. In parallel, Europe should enhance international cooperation, building on its strong position in IAEA and OECD/NEA networks while deepening bilateral partnerships with global leaders. Another strategic objective is to promote multidisciplinary nuclear education, integrating technical, social, and ethical dimensions. This includes strengthening core nuclear sciences while also fostering understanding of the societal impacts of nuclear projects, stakeholder engagement, and ethical principles such as fairness, transparency, and inclusivity in technology deployment. Finally, by promoting mobility, innovation and research can be systematically integrated into education and training at national or international level, so that students and young professionals are prepared to co-work in multi-national teams on topics that are found attractive and with impact for newer generations, such as small modular reactors, Generation IV systems, artificial intelligence, digital twins, and other emerging technologies.

In addition, the strategy calls for the harmonisation of curricula and the mutual recognition of qualifications, for example through the development of an EU Nuclear Skills Passport that should be easily accepted by industry and widely recognized across EU. Long-term sustainability further depends on the establishment of stable financing mechanisms that go beyond short-term project cycles. Finally, Europe must continue to strengthen its international cooperation with partners such as the IAEA, OECD/NEA, and leading non-EU countries, ensuring that European professionals remain integrated into the global nuclear community.

3 CURRENT STATE AND CHALLENGES

The existing European framework for nuclear education and training builds on several key initiatives established over the past decade. Its foundation lies in the SET-Plan Roadmap on Education and Training (2014) [4], which was later reinforced by the SET-Plan Declaration of Intent for Action 10 – Nuclear (2016) and the corresponding Implementation Plan, including a dedicated chapter on Education, Training and Knowledge Management (ETKM), or the JRC's position on the training of nuclear experts. These policy documents set the stage for a coordinated approach to nuclear skills, though their impact has remained limited without binding mechanisms or long-term funding. To complement these efforts, the EU has developed additional support structures such as the European Human Resources Observatory for the Nuclear Sector (EHRO-N) [5], which monitors workforce trends and skill needs, the ENEN Association, which facilitates cooperation among universities and training institutions and operates extensive mobility schemes, and a wide range of Euratom-funded initiatives that provide scholarships, research training, and access to specialised infrastructures. Together, these instruments form a valuable but fragmented foundation for nuclear education and training in Europe.

4 STRATEGIC PRIORITIES

To translate the vision into practice, the strategy is organised into several interconnected pillars that address the most urgent and long-term challenges of nuclear education and training in Europe.

The first pillar concerns **mobility and access to infrastructures**. Hands-on experience is indispensable in nuclear education, yet access to reactors, laboratories, and simulation facilities remains uneven across Europe. The strategy therefore proposes to expand mobility schemes, strengthen support for travel and subsistence, and create a shared European catalogue of available infrastructures, building on existing initiatives such as the IAEA Research Reactors Database [12] and the Horizon Europe OFFERR project [13], which already provide structured access to nuclear research facilities across Europe and beyond. This will ensure that every student, irrespective of their country of origin, can access state-of-the-art facilities and gain practical experience in diverse nuclear contexts.

The second pillar focuses on **attracting and retaining talents**. The nuclear sector must compete with other high-tech industries for the best graduates. To do so, Europe should highlight the contribution of nuclear to the Green Deal, expand digital learning opportunities, and develop apprenticeships and dual programmes with industry. Early exposure to different technologies and cultures, combined with targeted scholarships and mentoring, will make nuclear careers more appealing and help retain professionals in the sector over the long term. In recent years, we have experienced that without the

involvement of secondary schools, we will not have enough students in the future in the nuclear field. One of the key players in the attraction of the new nuclear generation is the secondary school teachers, and the other is the parents. For the first case, the knowledge of secondary school teachers must be improved, and they must be introduced to the useful application of nuclear science through direct channels, so that they do not get their information from newspaper reports containing semi correct information.

The third pillar addresses **cooperation between academia, industry, research organizations and regulators**. Education and training must not remain isolated in universities but should reflect the evolving needs of employers and oversight bodies. The strategy recommends institutionalised partnerships, such as "industry chairs" at universities, as well as structured internship and secondment schemes in nuclear power plants, regulatory authorities, research organizations and hospitals. An annual EU Nuclear Career Forum could further reinforce dialogue and ensure curricula remain aligned with labour market requirements.

A fourth pillar is dedicated to **workforce foresight and planning**, building on the role of the European Human Resources Observatory for the Nuclear Sector (EHRO-N). EHRO-N should be strengthened to provide regular forecasts, identify skill gaps, and extend its coverage to new fields such as SMRs and other non-energy use of ionising radiation industries such as medical applications, space, agriculture, etc. Its evidence-based assessments would allow Member States and EU institutions to better match education outputs with workforce demand and to design funding mechanisms accordingly.

The fifth pillar highlights the role of **research and innovation as a driver of competencies**. Cutting-edge research not only advances technology but also serves as a powerful training ground for future professionals. EU-funded projects should therefore systematically include training components, linking students and early-career researchers to infrastructures and multidisciplinary teams. New doctoral programmes could focus on emerging areas such as digitalisation, advanced materials, and next-generation reactors, ensuring that innovation translates directly into skills development.

Another strategic priority is the **recognition of qualifications across Europe**. The absence of harmonised standards currently limits professional mobility. To overcome this barrier, the strategy proposes the creation of a European Nuclear Skills Passports, designed to be widely accepted and easily understandable by nuclear industries, accompanied by the development of transparent accreditation mechanisms for curricula. Mutual recognition of professional certifications at EU level - from radiation protection officers to decommissioning experts - would facilitate cross-border employment and optimise the use of scarce talents. At the same time, we should support the creation of a mechanism to be used for accreditation of the education and training received by a person outside EU countries. This should be achievable through an increased cooperation between EU and non-EU countries and relevant EU institutions that should ensure the process of recognition.

Finally, the strategy underscores the importance of **international cooperation**. Europe has long been an active partner in IAEA, OECD/NEA, and World Nuclear University activities. By reinforcing these collaborations and establishing targeted bilateral exchange programmes with global leaders such as the United States, Canada, Japan, and South Korea, Europe can both benefit from global expertise and assert its own leadership. Hosting

international summer schools and leadership academies in Europe would further enhance its visibility and attractiveness.

5 IMPLEMENTATION FRAMEWORK

Delivering on the vision and priorities of this strategy requires a robust and inclusive implementation framework that can transform strategic intentions into measurable outcomes. The framework must rest on four main pillars: governance, financing, timelines, and monitoring. Without strong structures in each of these areas, the strategy risks remaining aspirational rather than actionable.

Governance will be central to ensuring effective coordination across the European nuclear education and training (E&T) ecosystem. The European Nuclear Education Network (ENEN) Association is well positioned to act as the operational hub, given its long-standing mandate to preserve and further develop expertise in nuclear fields through higher education and training. ENEN's extensive academic and industrial partnerships, coupled with its experience in mobility and capacity-building projects, make it the natural backbone of implementation. The Joint Research Centre (JRC), as the host of the European Human Resources Observatory for the Nuclear Sector (EHRO-N), should complement this role by providing continuous evidence-based analysis of workforce supply and demand, ensuring that the strategy is responsive to real labour market needs. At the political level, the European Commission-particularly DG ENER, DG RTD, and DG EAC-will need to embed this strategy into broader EU policy frameworks and funding programmes. Member States remain key actors, as they control national curricula, accreditation systems, and apprenticeship schemes. Active participation from industry, regulators, and medical institutions is equally critical to align education pathways with evolving practical requirements. To ensure coherence and accountability, a Steering Committee comprising representatives of ENEN, EHRO-N, the European Commission (EC/EURATOM), and Member States could provide overarching governance and strategic direction for implementation.

Sustainable financing is another cornerstone of the framework. Current reliance on short-term project funding under Euratom or Horizon Europe is inadequate for a sector where the lifecycle of facilities extends over a century. A multi-source approach must therefore be developed. EU-level instruments such as Horizon Europe, Euratom, Erasmus+, MSCA and the Digital Europe Programme should continue to provide baseline funding. However, this must be complemented by national resources, particularly for scholarships, apprenticeships, and access to training infrastructures. Industry should contribute through public–private partnerships (PPPs), especially in areas such as plant-based apprenticeships, mobility to industrial facilities, and maintenance of specialised infrastructures. Establishing a dedicated EU "Nuclear Skills Fund" could provide continuity beyond project cycles and guarantee stability for long-term training pipelines.

Timelines must be realistic and differentiated into short-, medium-, and long-term horizons. In the short term (1–3 years), the focus should be on consolidating governance structures, initiating the Nuclear Skills Passport, and stabilising funding for mobility and training schemes. In the medium term (3–7 years), efforts should concentrate on scaling up E&T capacity, expanding international cooperation, and integrating emerging technologies such as SMRs, AI, and digital twins into curricula. The long-term horizon (up to 2050) should aim at ensuring intergenerational knowledge transfer, gender balance, and the

steady renewal of the workforce across all nuclear subfields, from power generation to medical applications.

Finally, **monitoring and evaluation** mechanisms must be embedded from the outset. EHRO-N, in close collaboration with ENEN, Member States, and industry partners, should develop a set of measurable indicators that capture both inputs and outcomes. These should include the number of graduates and trainees across qualification levels, mobility flows, diversity and gender balance metrics, adoption of the Nuclear Skills Passport, and employer satisfaction with workforce preparedness. Annual reporting to the European Commission, coupled with stakeholder consultations, will ensure transparency and accountability. Mid-term reviews every five years should provide opportunities to adjust the strategy, refine funding priorities, and incorporate emerging needs.

5.1.1 Governance

The governance of the strategy must build on existing European structures while strengthening coordination among key stakeholders. The European Nuclear Education Network (ENEN) Association will play a central role, as its mission since its creation has been the "preservation and further development of expertise in the nuclear fields by higher education and training" through the cooperation of universities, research organisations, regulators, industry, and other partners. ENEN's extensive network and project experience make it the natural hub for academic and training institutions.

The Joint Research Centre (JRC), as the host of the European Human Resources Observatory for the Nuclear Sector (EHRO-N), will provide analytical support, monitoring, and workforce foresight to guide policy and funding priorities. The European Commission will be responsible for embedding the strategy into EU policies and funding programmes. Member States will remain essential actors by integrating the strategy's recommendations into their national education and training systems, while the nuclear industry, medical institutions, and regulators will ensure alignment with practical needs and provide opportunities for hands-on training.

5.1.2 Financial Framework

Sustainable financing is critical to the success of this strategy. Education and training in the nuclear field cannot depend solely on temporary initiatives, as the lifecycle of nuclear technologies-from design and construction through operation, decommissioning, and waste management-extends over several decades, if not a century. Current dependence on short-term project funding under Euratom and Horizon Europe is not sufficient to guarantee continuity, scalability, or stability. Many successful initiatives, such as ENEN mobility programmes or specialised summer schools, are discontinued once projects end, leading to gaps in training opportunities and the loss of momentum. To overcome this structural weakness, a comprehensive and multi-source financial framework must be established.

At the **European Union level**, existing instruments should continue to provide the backbone of support. Horizon Europe and the Euratom Research and Training Programme have demonstrated their value by funding networks, doctoral programmes, and mobility actions. However, dedicated and earmarked funding lines are necessary to secure continuity for nuclear-specific education, mobility, and joint degrees. Erasmus+ offers a powerful mechanism to support mobility, joint curricula, and international partnerships,

but so far it has been underutilised for nuclear-specific programmes. Stronger coordination between ENEN, universities, and the European Commission could increase the share of Erasmus+ funding directed to nuclear education. In addition, the Digital Europe Programme could be leveraged to fund advanced training in areas such as artificial intelligence, digital twins, and cybersecurity, which are increasingly relevant to the nuclear sector.

National sources must also be mobilised. Member States bear primary responsibility for education systems and should therefore contribute directly to implementing the strategy. Ministries of education, research, and energy can provide scholarships, support for dual education models (linking universities and industry), and dedicated apprenticeships in nuclear facilities. National nuclear operators and agencies often co-finance training centres or simulation laboratories; these examples should be scaled up and shared across borders. Furthermore, in countries launching new nuclear programmes (e.g., Poland, Estonia, the Netherlands), governments should allocate targeted funds to build domestic training capacity while integrating their efforts into the European framework.

Industry co-funding and support is indispensable. The private sector is the ultimate beneficiary of a well-prepared workforce and must play a more active role in financing E&T. Public–private partnerships (PPPs) should be developed to cover apprenticeships, internships, and on-the-job training at nuclear power plants, fuel cycle facilities, regulatory bodies, and hospitals. Industrial contributions could also support the maintenance of specialised infrastructures such as research reactors, hot laboratories, and training simulators, ensuring that students have access to state-of-the-art facilities. In return, industry would benefit from access to a steady pipeline of qualified recruits trained to meet their needs.

To ensure continuity beyond the lifetime of individual projects, the establishment of a **long-term European instrument** should be considered. This fund could pool resources from multiple sources-EU programmes, national contributions, and industry co-funding-into a single stable mechanism dedicated to nuclear education and training. Its mandate would be to guarantee continuity of mobility schemes, maintain permanent training centres, and provide predictable financial support for scholarships and apprenticeships. Contributions to the fund could be calibrated to reflect both Member States' nuclear ambitions and industry participation, creating a balanced responsibility-sharing model.

Finally, **innovative financing mechanisms** should be explored. For instance, the European Investment Bank (EIB) could extend loans or guarantees for training infrastructure projects, while philanthropic and regional development funds could support initiatives in less developed Member States. The EU's Just Transition Fund could be used to reskill professionals from carbon-intensive industries, such as coal, into nuclear and other clean energy sectors. Blended finance, combining grants, loans, and private investment, may also provide a viable pathway for scaling up training infrastructures and mobility.

In summary, sustainable financing requires moving from a fragmented, project-dependent model to an integrated and diversified framework. Only by pooling resources across EU, national, and industrial levels-and by anchoring them in a long-term instrument-can Europe guarantee the continuity and expansion of its nuclear education and training capacity. Without such a stable financial base, even the best-designed strategies will fail to deliver on their objectives.

5.1.3 Monitoring and Indicators

Monitoring progress is essential to ensure accountability and continuous improvement. EHRO-N, in cooperation with ENEN and Member States, will collect, analyse and report data on a regular basis. Key indicators will include:

- **Numbers of graduates and trainees** in nuclear-related programmes at bachelor, master, doctoral, and vocational levels.
- **Mobility figures**, including student and staff exchanges, internships, and access to facilities across borders.
- **Diversity metrics**, such as gender balance and inclusion of underrepresented groups.
- **Adoption of the Nuclear Skills Passport**, measured by the number of individuals and institutions using the tool.
- **Employer satisfaction and workforce alignment**, assessed through surveys and industry–academia dialogue.

Annual reporting to the European Commission and a comprehensive mid-term reviews every five years will provide opportunities to adjust priorities and funding. This monitoring framework will ensure that the strategy meet their goals, remains relevant, responsive, and effective in meeting Europe's long-term workforce needs. The EHRO-N should lead this activity, acting as the central body responsible for data collection, coordination, and evaluation of progress at the EU level.

Policymakers could offer recommendations based on monitoring results to improve funding allocation, mobility programs, or outreach strategies

6 RECOMMENDATIONS

To address the identified weaknesses and to align the EU's nuclear education and training (E&T) strategy with the evolving needs of industry, regulators, and society, a set of concrete recommendations is proposed. These recommendations go beyond isolated project actions and aim to establish a sustainable and forward-looking framework capable of supporting Europe's long-term ambitions in nuclear energy and non-power applications.

6.1.1 Create sustainable funding instruments

Financial sustainability is a prerequisite for long-term success. Current reliance on short-term Euratom or Horizon Europe calls undermines continuity. To guarantee resilience, Europe should:

- Establish a dedicated Nuclear Skills Fund pooling EU, national, and industry contributions;
- Introduce long-term scholarships and fellowships to attract top talent into nuclear programmes, modelled on Marie Skłodowska-Curie Actions;
- Secure permanent funding for key infrastructures, mobility actions, and specialised summer schools;
- Create a dedicated EU fund aimed at continuously support educational institutions to provide the needed nuclear background of their students
- Explore synergies with the Just Transition Fund to retrain professionals from fossil-based sectors into nuclear.

This would ensure training capacity remains stable even during downturns in new-build cycles, preventing loss of expertise.

6.1.2 Strengthen industry-led training programmes

Hands-on training is essential to prepare students and professionals for complex nuclear environments. Public–private partnerships (PPPs) should be expanded to allow:

- Apprenticeships and internships in nuclear power plants, research centres, hospitals, and industrial facilities applying nuclear technologies (e.g., in space, agriculture, or material processing);
- Industrial co-funding of training infrastructures such as simulators, mock-up facilities, or hot labs;
- Tailored short courses designed jointly by academia and industry to address emerging skills needs (e.g., SMRs, fusion, additive manufacturing).

These partnerships would accelerate skill acquisition, reduce mismatches between curricula and industry needs, and improve employability of graduates.

6.1.3 Integrate new nuclear technologies into curricula

Emerging technologies require a fundamental shift in how nuclear education is designed. Curricula must evolve to cover:

- **Small Modular Reactors (SMRs)** and **Generation IV systems**, including safety, licensing, and supply chain aspects;
- **Fusion energy** and its associated challenges in plasma physics, materials, and tritium handling;
- **Digitalisation and artificial intelligence**, including digital twins, predictive maintenance, and cybersecurity;
- **Advanced manufacturing techniques**, such as additive manufacturing, robotics, and automation;
- **Cross-cutting fields** like nuclear data science, social and ethical aspects, system integration, and climate modelling.
- **Theranostic isotopes** in medical applications, encompassing their production, safe use, transportation, radioactive waste management, and patient safety.

Embedding these topics into formal curricula and professional training will ensure that the next generation of experts can support both current and future technologies.

6.1.4 Expand mobility and cooperation opportunities

Mobility is one of the most effective tools to build a European identity among nuclear professionals. Existing programmes such as Erasmus+, Marie Skłodowska-Curie Actions, and mobility scheme from ENEN2Plus should be expanded to provide:

- Broader access to research reactors, fuel cycle laboratories, and waste management facilities;
- Joint degrees and double-degree programmes between leading European universities;

- Financial support for both short-term (summer schools, workshops) and long-term (master's, PhD, post-doc exchanges) mobility;
- Inclusion of non-power applications such as radiation medicine (nuclear medicine, radiation therapy and diagnostic procedures) and medical and other industrial uses of radiation.

Expanding mobility strengthens networks, facilitates knowledge transfer, and ensures that students, regardless of their home country, can access state-of-the-art infrastructures.

6.1.5 Enhance workforce foresight and planning

Europe must strengthen its capacity for strategic workforce planning. EHRO-N should be given an enhanced mandate and stable funding to:

- Provide regular forecasts of workforce demand and supply, updated every 2–3 years;
- Identify critical skill gaps in emerging technologies and medical applications;
- Facilitate coordination between national education systems to align with EU-level projections;
- Support Member States in designing targeted training and retraining schemes.

Improved foresight would help avoid mismatches between cyclical industry demand and continuous education supply, ensuring smoother transitions between generations of professionals.

6.1.6 Mainstream recognized cooperation programs in higher education

The IAEA's International Nuclear Management Academy (INMA) has developed a globally recognised framework for master's programmes in nuclear technology management, combining technical knowledge with leadership, project management, economics, and safety culture. Several universities worldwide already offer INMA-accredited programmes, providing graduates with interdisciplinary competencies highly relevant for industry, regulatory bodies, and medical institutions. Within the EU, the uptake of INMA has so far been limited. We recommend supporting and scaling up INMA-aligned programmes across European universities, with EU co-funding to cover scholarships, mobility, and teaching resources. Integrating INMA into the EU education landscape would directly address the need for new types of competencies - particularly project management and cross-sector leadership skills - and would strengthen partnerships with industry and hospitals through tailored curricula, case studies, and internships. Promoting INMA within the EU would also facilitate public–private collaboration, since curricula are designed in close cooperation with stakeholders, thereby ensuring that graduates meet the practical needs of different nuclear fields.

The EMINE joint master Program between KTH University, UP Catalunya, Grenoble INP and Paris Tech based on a strong collaboration with industrial players such as EDF, AREVA, Vattenfall and ENDESSA ensures also access to research labs of EDF and CEA. The Master program is supported by InnoEnergy.

The SARENA Erasmus Mundus Program (Safe and Reliable Nuclear Applications) is a prestigious two-year Master's degree funded by the EU, designed to cultivate top-tier professionals in nuclear engineering. Delivered by a consortium of four leading European

universities—IMT Atlantique (France), Universidad Politécnica de Madrid (Spain), LUT University (Finland), and University of Ljubljana (Slovenia)—the program emphasizes nuclear safety, radioactive waste management, and reactor operation. It offers a comprehensive 120 ECTS curriculum taught entirely in English, blending foundational science with advanced technical training and industry engagement. Students follow a mobility track across multiple countries, beginning with core studies at IMT Atlantique, then branching into two specialization paths: RWMD (Radioactive Waste Management and Decommissioning) and NROS (Nuclear Reactor Operation and Safety). The final semester is dedicated to a thesis, typically conducted in collaboration with industry or research institutions, ensuring practical exposure and dual academic supervision. Graduates earn dual degrees and benefit from accreditations such as I2EN, ASIIN, and EUR-ACE, positioning them for careers in nuclear safety, energy transition, and international research.

The ESTA of ENEN, an initiative between institutions from France, Italy, Romania and Czech Republic aimed at providing necessary competences for the SMR & AMR with support from international institutions such as IAEA.

6.1.7 Communication and outreach strategy

Finally, the EU strategy should include a dedicated communication pillar aimed at improving the attractiveness of nuclear careers. This could involve coordinated outreach campaigns starting at national levels, the creation of nuclear ambassadors and role models, collaborations with schools and media, and the promotion of nuclear's contribution to climate neutrality and medical progress. Enhancing the visibility of nuclear competencies will be essential to inspire the next generation of professionals.

7 SYNERGIES AND CROSS-LINKS

The proposed EU Strategy for Nuclear Education and Training should be formulated through collaborative engagement, rather than in isolation. Its success depends on how effectively it can build bridges with wider European policy frameworks and with sectors beyond energy.

At the policy level, the strategy is closely aligned with the European Green Deal, which identifies climate neutrality as a central objective for 2050. Nuclear power, as a major provider of low-carbon electricity, will be indispensable to reaching this target, and a well-trained workforce is the key enabler. Similarly, the Net-Zero Industry Act explicitly recognises nuclear among the strategic technologies required to achieve net-zero emissions, highlighting the need to scale up domestic industrial capacity - which in turn requires a secure pipeline of skilled professionals. In parallel, the Digital Europe Programme and broader EU digitalisation strategies provide opportunities to integrate advanced tools such as artificial intelligence, digital twins, and cybersecurity training into nuclear curricula, ensuring that the sector keeps pace with technological change. In addition, fostering cooperation with the IAEA, OECD/NEA, and non-EU partners to share best practices, harmonise standards, and promote mobility of nuclear professionals could be considered.

Beyond the energy domain, nuclear competencies have broad applications that should be harnessed in the implementation of this strategy. As an example, for the medical applications, including diagnostics, cancer therapy, and isotope production, represent one

of the most visible interfaces between nuclear technology and society. Training programmes must therefore expand to include medical physics experts, nuclear medicine specialists, radiopharmacists, and radiation protection experts. Industrial uses of radiation, such as material testing, sterilisation, and advanced manufacturing, similarly depend on nuclear-trained professionals and provide opportunities for cross-sectoral training initiatives. Finally, nuclear competencies extend to space exploration, where radioisotope thermoelectric generators and radiation shielding are essential for long-term missions. By integrating these non-energy applications into the education and training framework, Europe can diversify career pathways, broaden the appeal of nuclear professions, and ensure resilience against cyclical demand in the power sector alone. Since the regulatory authority has a significant impact in developing the nuclear strategy in the EU, it would be very important to involve them at least in vocational nuclear education and training, which would greatly facilitate communication in the future. It would be useful for lawyers, economists, communication professionals and others involved in nuclear regulation to have a high-level nuclear competencies, thus avoiding many misunderstandings.

This cross-cutting approach will help position nuclear education and training not only as a tool for energy transition, but also as a key enabler of Europe's competitiveness in health, industry, and space innovation.

8 CONCLUSIONS AND CALL TO ACTION

Europe is at a decisive moment when it comes to energy security and tackling environmental issues. To secure its energy supply, the continent faces an urgent need to replace retiring nuclear professionals, attract new generations into the field, and align education and training with the technologies that will define the coming decades. The benefits of coordinated action are clear: a secure and highly skilled workforce capable of supporting climate neutrality, ensuring energy security, and maintaining Europe's global leadership in nuclear innovation.

The risks of inaction are equally stark. Without a coherent EU-wide approach, Member States will face fragmented and uneven workforce development, persistent shortages of qualified staff, delays in new build and decommissioning projects, and a gradual erosion of Europe's knowledge base. The global competition for nuclear talent is intensifying, and Europe cannot afford to lag behind.

This strategy therefore issues a clear call to action. National governments, in cooperation with the European Commission, must commit to long-term investment in nuclear education and training and integrate the strategy's priorities into national roadmaps. The European Union must provide policy alignment, stable financing instruments, and monitoring mechanisms to ensure that progress is sustained over decades. The nuclear industry and regulators must take an active role in shaping curricula, offering apprenticeships and mobility opportunities, and co-investing in training infrastructures. Finally, universities, research centres, and hospitals must continue to innovate in teaching, open their facilities to European students, and work together to harmonise qualifications.

By acting now, Europe can secure its nuclear future, inspire the next generation of professionals, and ensure that nuclear education and training remain a pillar of the continent's energy transition, health innovation, and technological leadership.

The revision of the existing EU nuclear E&T framework must move beyond fragmented projects towards a coherent, long-term strategic agenda. By addressing weaknesses, promoting public-private partnerships, and aligning E&T with emerging technological needs, Europe can secure its nuclear knowledge base and maintain competitiveness. ENEN and its partners, together with the European Commission and Member States, should lead this process to ensure that nuclear education, training, and knowledge management remain a cornerstone of Europe's clean energy future.

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