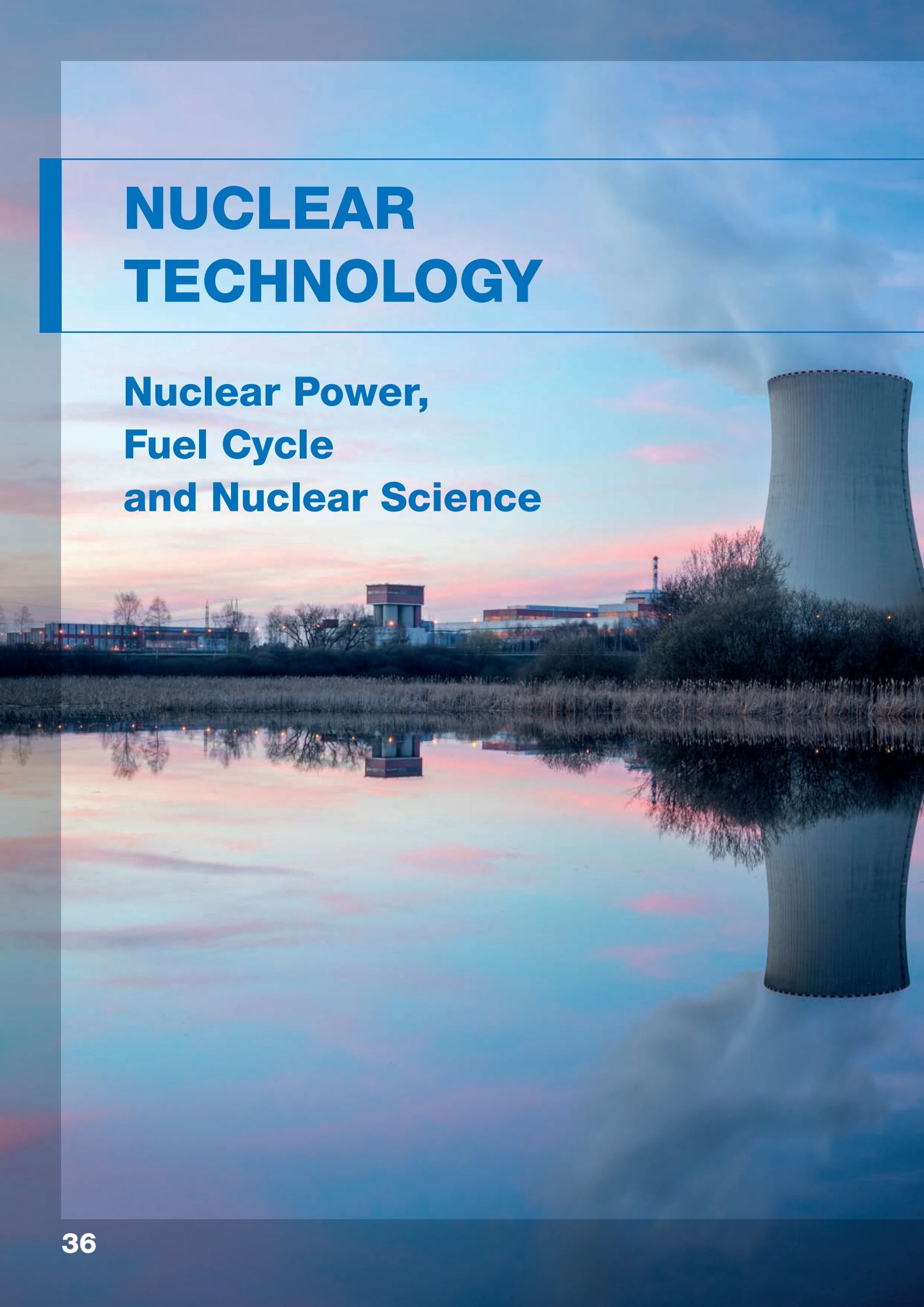
NUCLEAR TECHNOLOGY

Nuclear Power, Fuel Cycle and Nuclear Science



We must tackle climate change, but we must also ensure access for all to clean, secure, affordable and modern forms of energy. For sustainable development and prosperity, we need an abundance of clean and reliable energy. Nuclear power is clearly part of the solution.

Mikhail Chudakov
Deputy Director General
and Head of the Department of Nuclear Energy

Nuclear Power, Fuel Cycle and Nuclear Science

19 active Collaborating Centres within the Department of Nuclear Energy

23 peer review missions

22 active coordinated research projects (CRPs)

1850 online training and education courses hosted on CLP4NET

298 Participants in IAEA schools

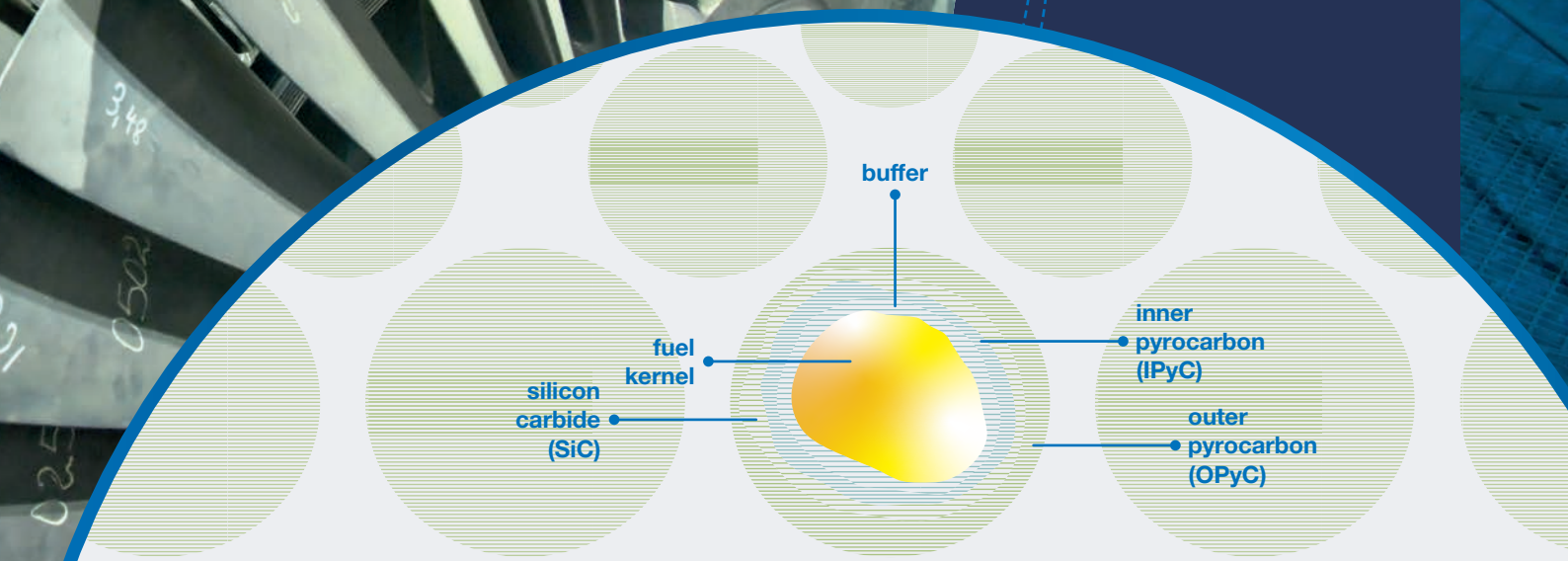
- **207** Nuclear Energy Management School
- **68** Nuclear Knowledge Management School
- **23** Regional Research Reactor School

7 IAEA-designated International Centres based on Research Reactors in 7 countries

11 research reactors under construction in 10 countries

24 databases

25 modelling tools and simulators



TRISO fuel particle

Tri-structural isotropic, or 'TRISO' particle fuel, an inherently safe technology that offers excellent retention of fission products, has been identified as one of the fuel options for SMRs.

In 2023, the Agency opened a call for proposals to start a CRP entitled 'Fuel Modelling Exercises for Coated Particle Fuel for Advanced Reactors Including Small and Modular Reactors'.

NUCLEAR POWER

OBJECTIVE

To support Member States with existing nuclear power plants (NPPs) to enhance operating performance and safe, secure, efficient and reliable long term operation, with a harmonized approach to human, technological and organizational aspects.

To support Member States embarking on new nuclear power programmes in planning and building their national nuclear infrastructures through coordinated assessment and assistance activities.

To support Member States in modelling, analysing and assessing future nuclear energy systems for sustainable development of nuclear energy and to provide them with collaborative frameworks and support for technology development and deployment of advanced nuclear reactors, non-electric applications, and integrated energy systems.

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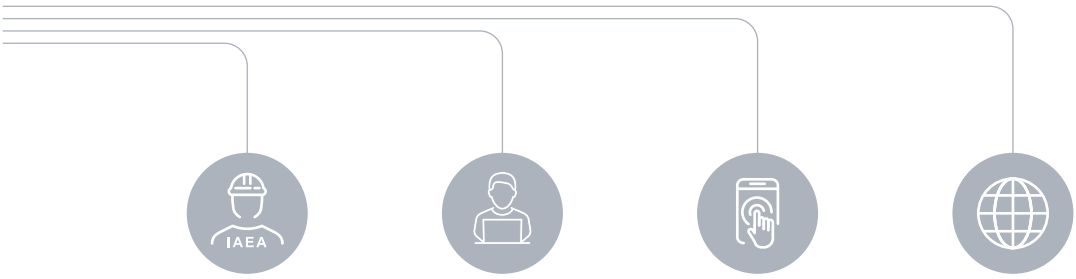
SNETP, together with the European Commission services and other stakeholders, is today actively involved in the new European Industrial Alliance on SMRs that aims at supporting the development, demonstration and deployment of SMRs and AMRs in Europe by early 2030. The close links we have built over the years with the IAEA teams, are an asset to support the revival of the nuclear sector, as it is strongly needed to reach our common goal to provide safe, efficient and competitive low carbon energy sources.

Bernard Salha
President of the Sustainable Nuclear Energy Technology Platform (SNETP)



2

INIR missions

Phase 1,
Estonia
Phase 1 follow-up,
Kazakhstan

17 000

new PRIS database users

540 000 hits

2

new platforms

CNPP
HOPS

2

new networks

ISOP
SANIS

KEY OUTPUTS

Launching Nuclear Power Programmes

With global energy demand on the rise, nuclear power — a low-carbon energy source for sustainable development — continues to play an important role in the energy mix of many countries. Global nuclear capacity is expected to grow, resulting in an increased demand for Agency services to support nuclear infrastructure development. In 2023, there were 27 Member States considering, planning or implementing a new nuclear power programme. The Agency continued to provide support to them in building awareness of the commitments required for the decision making process and in developing the required infrastructure in line with the Milestones Approach. Nine Integrated Work Plan meetings were held to identify priority areas for Agency support for embarking countries.

Operating Nuclear Power Plants and Expanding Nuclear Power Programmes

Interest in the long term operation of NPPs is growing, with a view to helping expand the role of nuclear power in the clean energy transition. A technical meeting in Gyeongju-si, Republic of Korea, allowed participants to share good practices and lessons learned from long term NPP operation, review a draft publication provisionally entitled *Good Practices and Lessons Learned from the Long Term Operation of Nuclear Power Plants* and conduct the first Steering Committee Meeting of the International Network on Life Management of Nuclear Power Plants.

The country nuclear power profile (CNPP) application process and website were overhauled in 2023, allowing for more comprehensive integration with the Power Reactor Information System (PRIS) database.

Human Resource Development and Management and Stakeholder Engagement Support

The Agency supports Member States that are operating, expanding or developing new nuclear power programmes in acquiring and maintaining competent staff for all nuclear organizations — including government agencies and owner/operators — and in engaging with stakeholders. The Nuclear Energy Capacity Building Hub, launched in 2023, offers Member States an online repository of tools and resources to support human resource development, training and qualification, knowledge management, stakeholder engagement, industrial involvement and innovation management.

Nuclear Reactor Technology Development

Nuclear power technology is evolving, with a focus on the development of advanced energy systems and the broadening of their applications. A technical meeting on compatibility between coolants and materials for fusion facilities and advanced fission reactors allowed participants to discuss related state-of-the-art technology. The experience accumulated through the maturing of fission power technology could be employed to accelerate the industrialization and commercialization of fusion power. Of special interest is experience in material R&D for Generation IV reactors, whose temperature and radiation damage characteristics are similar to those of anticipated fusion power facilities. In this regard, the Agency organized extensive consultations on a study relating to synergies between fusion technology developments and advanced nuclear fission technologies.

As part of the Agency's Open-source Nuclear Codes for Reactor Analysis initiative, a joint training workshop by the Abdus Salam International Centre for Theoretical Physics (ICTP) and the Agency on open-source nuclear codes for reactor analysis was conducted in Trieste, Italy, providing training on reactor neutronics, thermal hydraulics, and system analysis at various scales.

Technology development for advanced water cooled reactors

Water cooled reactors (WCRs) account for more than 95% of the world's operating commercial NPPs and contribute significantly to meeting global energy needs. Many of the lessons learned from the past 50 years of WCR operation continue to be applied to the design and operation of existing and advanced WCRs.

The Agency publication *Terms for Describing Advanced Nuclear Power Plants* provides Member States with up-to-date terms for describing advanced NPPs, draws distinctions between design phases and clarifies terms commonly used when describing advanced NPPs. Meanwhile, the revised *Nuclear Reactor Technology Assessment for Near Term Deployment* explains how reactor technology assessment enables decision making for nuclear power planning and implementation.

Small and medium sized or modular reactors, including high temperature reactors

Global interest in small and medium sized or modular reactors has been increasing due to their ability to meet the need for flexible power generation for a wider range of users and applications and replace ageing fossil fuel-fired power plants.

In 2023, the Agency launched a new coordinated research project to identify and enhance understanding of families of enabling technologies with the potential to either reduce small modular reactor (SMR) construction costs and schedules or better suit users' needs, thus facilitating and favouring the early deployment of such reactors.

The Director General visiting Huaneng's Shidao Bay high temperature gas cooled, pebble bed module (HTR-PM) demonstration project, China, May 2023.

During the 67th regular session of the General Conference, a side event on reactor technology assessment informed participants about how to perform SMR assessments using the Agency's Reactor Technology Assessment methodology and Advanced Reactor Information System database, which are integral parts of SMR Platform activities.

A technical meeting on the harmonization and use of industrial codes and standards for SMRs advanced harmonization efforts for near deployment reactors, in such areas as engineering standards, non-nuclear codes and serially produced components.

Lastly, the publication *Suitability Evaluation of Commercial Grade Products for Use in Nuclear Power Plant Safety Systems* provides information on approaches to such evaluation.

Fast reactors

The Agency redesignated the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland as a Collaborating Centre on modelling and simulation capabilities in the field of advanced reactors. One of the outputs of this cooperation was a workshop on open-source nuclear codes for reactor analysis, jointly organized with EPFL and ICTP, which offered a comprehensive overview of cutting-edge computational techniques for nuclear reactor analysis.

Non-electric Applications of Nuclear Power

The proven use of nuclear energy for non-electric applications, including district heating, desalination and direct provision of heat for various industrial processes, is one of the drivers of interest in nuclear energy to help decarbonize energy applications.

Within the framework of the SMR Platform, the Agency conducted an expert mission to Jordan to review a pre-feasibility study on SMR deployment for desalination. A number of factors were considered, including safety and security, siting, licensing and stakeholder engagement. Following the mission, the Agency delivered its final report and suggestions to the Jordan Atomic Energy Commission.

An interregional training course on specific design considerations of nuclear cogeneration projects using SMRs and microreactors, held in Moscow, trained participants on the fundamentals of cogeneration using such reactors. Meanwhile, a technical meeting allowed participants to exchange information on the most recent developments in high temperature hydrogen production projects worldwide and to discuss the potential for coupling these technologies with various types of nuclear plant.

Enhancing Global Nuclear Energy Sustainability through Innovations

National strategic and long term nuclear energy planning requires tools that increase awareness of the options available for sustainable nuclear energy development. The Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) supports its members in sustainable energy planning.

At the 32nd Meeting of the INPRO Steering Committee, INPRO members discussed new collaborative projects (fossil-to-nuclear and Framework for Modelling of Energy Systems model development), finalized the INPRO Subprogramme Plan 2024–2025, discussed updates to the INPRO Strategic Plan 2024–2029, and discussed the potential launch of a new INPRO advisory service on strategic planning for sustainable nuclear energy development. The publication *Comparative Evaluation of Nuclear Energy System Options* presents case studies of different approaches on this topic.

At a technical meeting on the INPRO collaborative project 'Legal and Institutional Issues of Prospective Deployment of Fusion Facilities', experts identified the need to develop a regulatory framework for fusion power plants that will support long term sustainability.

During the Joint ICTP–IAEA INPRO School on Strategic Planning for Sustainable Nuclear Energy Development, held in Italy, participants learned basic concepts, methodology and tools for modelling, analysis and sustainability assessment of nuclear energy systems.

NUCLEAR FUEL CYCLE AND WASTE MANAGEMENT

OBJECTIVE

To support Member States in establishing effective, safe, secure and sustainable frameworks and solutions for the fuel cycle, radioactive waste management, decommissioning and life cycle management of related facilities, including research reactors, for nuclear programmes and nuclear applications.

To support Member States in strengthening their capabilities and human resources in the domains of fuel cycle, radioactive waste management, decommissioning and environmental remediation, and research reactors.

To be a platform to facilitate and strengthen international cooperation, coordination and information sharing among Member States.

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The Agency has provided important fora of technical information exchange on the front- and the back-ends of the nuclear fuel cycle in 2023 and is encouraged to pursue its efforts to support Member States' interest in nuclear power, especially after the declaration made at COP28 by several countries to triple their nuclear energy capacities by 2050.

Mr Zheng Mingguang
Chief Engineer for Nuclear Energy at China's State Power Investment Corporation, Chair of the Agency's Standing Advisory Group on Nuclear Energy

5

peer review missions conducted

1 DSRS-TeC
1 INIR-RR
3 OMARR

2

Collaborating Centre agreements signed

KINGS
Sogin

209

nuclear reactors permanently retired from service, **of which 22** fully decommissioned

519

research reactors decommissioned or undergoing decommissioning in **37 countries**

56 000

tonnes of uranium (preliminary data) produced globally

KEY OUTPUTS

Uranium Resources and Processing

Uranium is the primary fuel for nuclear reactors and must be managed properly, in a safe and sustainable manner. Participants in a training workshop on mineral exploration planning and management for uranium and thorium projects, held in 2023 in Espoo, Finland, acquired practical knowledge on techniques used for exploration.

Assurance of Supply

The IAEA Low Enriched Uranium (LEU) Bank in Kazakhstan, which provides an assurance of supply mechanism of last resort, continued safe operations at the Ulba Metallurgical Plant, with the first campaign of recertification of LEU-filled 30B cylinders carried out in June 2023. An LEU reserve in Angarsk, established following an agreement of February 2011 between the Government of the Russian Federation and the Agency, remained operational.

Nuclear Fuel Development

Nuclear fuel must be adequately designed and manufactured to enable the reliable and safe operation of NPPs. In 2023, participants in a technical meeting on advances in nuclear fuel fabrication technologies for power reactors exchanged the most up-to-date information on fuel developments to meet the needs of new reactors, including small modular reactors (SMRs).

Management of Spent Fuel from Nuclear Power Reactors

Managing the spent fuel arising from NPPs until its disposal is an important step in the nuclear fuel cycle, constituting the so-called ‘back end’. Participants in an international workshop on the chemistry of fuel cycles for molten salt reactor technologies, jointly organized in 2023 with the OECD/NEA, identified gaps, opportunities and needs relating to the deployment of molten salt reactors.

Radioactive Waste Management

A number of disposal options have been developed for final management of radioactive waste, including deep borehole disposal. To explore further options and solutions for radioactive waste management, new coordinated research projects (CRPs) were launched in 2023 on enhancing global knowledge about deep borehole disposal for intermediate and high level nuclear waste and on geopolymers as an immobilization matrix for radioactive waste.

Participants in a technical meeting on the high temperature processing of radioactive waste reiterated the importance of establishing waste acceptance criteria and defining the endpoint or disposal option, before a treatment process is selected. In addition, the publication *Policies and Strategies for Radioactive Waste Management was translated into French*.

Management of disused sealed radioactive sources

Radioactive sources are used worldwide in medicine, industry and research. Once they fall out of use, the safety and security risks increase if the sources are improperly managed.

The publication Management of Depleted Uranium Used as Shielding in Disused Radiation Devices presents relevant information on technical issues and factors, as well as specific Member State experience leading to the identification of potential options for the management of depleted uranium shields.

At the inaugural meeting of the Disused Sealed Radioactive Sources Network, held three years after its inception, participants exchanged information on the national status of disused sealed radioactive source (DSRS) management and discussed further needs and support in this area, and expressed strong interest in silo storage and disposal of DSRS.

Member States received training and assistance in managing DSRS, including technological and engineering support as part of the pilot borehole disposal project in Malaysia. Thirty-six Category 1 and 2 disused sources were removed from Bosnia and Herzegovina, Chile, Croatia, Ecuador, Nicaragua and Slovenia.

Decommissioning and Environmental Remediation

Decommissioning

Decommissioning is a normal part of a nuclear facility's life cycle and needs to be considered in its design. It includes activities such as planning and the physical and radiological characterization of the facility, including the associated land.

In 2023, the Agency conducted a series of technical meetings that allowed participants to share knowledge on the decommissioning of various nuclear facilities. A meeting held in Cadarache, France, in collaboration with the French Alternative Energies and Atomic Energy Commission and ITER, facilitated the collection, sharing and analysis of good practices and experiences in decommissioning and related waste management considerations for fusion facilities.

To ensure good decommissioning knowledge management, the Agency jointly developed *A Taxonomy for the Decommissioning of Nuclear Facilities* with the European Commission and the OECD/NEA.

The Biennial Forum of the International Decommissioning Network reviewed the Agency's decommissioning activities over the previous two years, paying specific attention to capacity building, human resources development and knowledge management.

A new Collaborating Centre on decommissioning was established with KEPKO International Nuclear Graduate School (KINGS) in the Republic of Korea. In addition, a new CRP on R&D to advance decommissioning of legacy reactors was launched.

Environmental remediation

The report *Determination of Environmental Remediation End States* provides guidance to assist Member States in decision making for environmental remediation of radioactively contaminated sites.

In 2023, the Agency expanded the work scope of Sogin, an existing Collaborating Centre in Italy, to include programmatic activities in environmental remediation.

Research Reactors

The Agency assists Member States with the planning, operation, utilization and fuel cycle of research reactors, which are used for research, testing, radioisotope production, education and training. It also provides assistance in the areas of capacity building and infrastructure development.

New research reactor projects, infrastructure development and capacity building

Two Regional Research Reactor Schools, conducted in Argentina and Morocco, and the 18th EERRI Research Reactor Training Course, held in Austria, the Czech Republic and Slovenia, trained young professionals in a broad range of topics related to the safe operation and effective use of research reactors.

In addition, the Agency designated the National Centre for Nuclear Energy, Sciences and Technology in Morocco as an International Centre based on Research Reactor, providing nuclear education and training opportunities to students and young professionals from African countries.

Research reactor fuel cycle

In 2023, the Agency published *Post-irradiation Examination Techniques for Research Reactor Fuels*, which gives Member States an introduction to such techniques in support of LEU fuel development for high-power research reactors.

A technical meeting on proliferation resistance for research reactors allowed participants to share information and experience in incorporating intrinsic features in the design of new research reactors to minimize the potential of their use for nuclear proliferation.

Furthermore, a training workshop held in Lemont, United States of America, provided participants with practical information and guidance on establishing coupling schemes between neutronics and thermal-hydraulics codes to improve the design, operation, utilization and safety of research reactors.

Research reactor operation and maintenance

Operation and Maintenance Assessment for Research Reactors (OMARR) missions in the Islamic Republic of Iran and Thailand, and Agency missions in support of in-service inspections of research reactors in the Democratic Republic of the Congo, Indonesia and the Islamic Republic of Iran, helped these Member States to improve the operational availability and reliability of their research reactors.

Technical meetings on digital instrumentation and control systems and integrated management systems for research reactors, and a webinar on decommissioning considerations in the design and operation of research reactors, allowed participants to share experience in managing different life cycle stages of facilities and support Members States' continuous safe operation of their research reactors.

Agency mission in support of an in-service inspection of RSG-GAS research reactor in Indonesia, June 2023. (Photograph courtesy of Indonesia's National Research and Innovation Agency (BRIN))

The Director General visiting the Underground Research Laboratory of the French National Radioactive Waste Management Agency (Andra) to discuss the future construction of Cigéo, France's planned deep geological repository for high-level and intermediate nuclear radiological waste, November 2023. (Photograph courtesy of Andra)

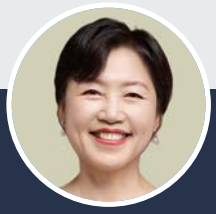
CAPACITY BUILDING AND NUCLEAR KNOWLEDGE FOR SUSTAINABLE ENERGY DEVELOPMENT

OBJECTIVE

To support Member States in strengthening their capacities for formulating robust energy strategies, plans and programmes, and to improve their understanding of nuclear energy's contribution to facilitating the clean energy transition, combating climate change and achieving the Sustainable Development Goals (SDGs).

To support Member States in strengthening their capacities for establishing, managing and using their nuclear knowledge base and to foster international networking.

To acquire, preserve and provide Member States with access to information in the area of nuclear science and technology and to facilitate sustainable information sharing among Member States.



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The IAEA remains an important partner for the Korea Atomic Energy Research Institute in the field of knowledge management, including human resources development. It enables us to acquire a broad overview of knowledge preservation activities in the nuclear sector at the global level.

Youngmi Nam
Principal Researcher at the Korea Atomic Energy Research Institute

6

Knowledge Management Assist Visits to Armenia, Egypt, Georgia, India Switzerland and Tunisia

6

Nuclear Energy Management Schools

3

Nuclear Knowledge Management Schools

4

International Nuclear Management Academy visits

KEY OUTPUTS

Energy Modelling, Data and Capacity Building

Energy planning remains at the heart of efforts to resolve the current energy and climate crises and ensure that countries' planned transition pathways meet the SDGs in the near-to-medium term, and the objectives of the Paris Agreement in the longer term. An increasing number of countries are assessing the option of using nuclear power, and integrating that option in energy planning allows these countries to decide on whether to embark on a nuclear programme. The Agency can provide technology-neutral advice on a country's energy planning, which might consist of different technology options, including nuclear energy, renewables, etc. Some of the energy planning training events organized in 2023 were focused specifically on small modular reactors or on supporting initiatives such as Atoms4NetZero, which aim to help Member States assess nuclear power as a means to decarbonize electricity, heat and hydrogen production. The Agency continued to assist Member States in energy planning to address sustainable development and climate change mitigation, and increasingly net zero transitions. At 51 capacity-building events, specialists from Africa, Asia, Europe, and Latin America and the Caribbean learned how to evaluate their energy needs, including by using the Agency's energy assessment tools.

Students working on a group project during the Joint ICTP-IAEA Nuclear Knowledge Management School in Trieste, Italy, October 2023.

Energy, Economic and Environmental (3E) Analysis

Meeting the goals of the Paris Agreement will require a substantial increase in the level of investment in clean energy technologies. Increased recognition of nuclear energy's climate credentials could open up sustainable financing options that are already accessible to other low-carbon technologies. In 2023, the Agency organized several workshops on nuclear financing and on the macroeconomic impacts of investments in the nuclear sector, as well as high-level panel sessions and events at the Second International Conference on Climate Change and the Role of Nuclear Power: Atoms4NetZero and at COP28, on financing nuclear investments and engaging with financial institutions. In particular, participants discussed the development of taxonomies that include nuclear power as part of sustainable activities, the use of climate models to inform financial institutions on the potential contribution of nuclear power to mitigate climate change, and the need for multilateral development banks to include nuclear power in their climate finance policies.

At COP28, the Agency released three booklets: *Nuclear Energy and Climate Change: Questions and Answers on Progress, Challenges and Opportunities*, part of the Agency's contribution to the first Global Stocktake; *Nuclear Energy in Mitigation Pathways to Net Zero*, which analyses the role of nuclear and gaps in the Intergovernmental Panel on Climate Change Sixth Assessment Report; and *Nuclear Energy in Climate Resilient Power Systems*, which examines the potential of nuclear power to support decarbonized, climate-resilient energy systems. These booklets provided background to several events organized by the Agency or its partners during COP28.

The Director General with the President of Armenia, Vahagn Khachaturyan (left), and Kazakhstan's Minister of Energy, Almassadam Satkaliyev (right), at the Agency event 'Net Zero Needs Nuclear Power', COP28, December 2023.

The Net Zero Nuclear event 'Tripling Nuclear Energy by 2050', COP28, December 2023.

Nuclear Knowledge Management

Building, collecting, transferring, sharing, preserving, maintaining and utilizing knowledge is essential to developing and retaining the necessary technical expertise and competences required for nuclear power programmes and other nuclear technology. In this regard, the Agency helps Member States maintain and preserve nuclear knowledge.

Four International Nuclear Management Academy missions were implemented in 2023, at Sofia University in Bulgaria, KEPCO International Nuclear Graduate School (KINGS) in the Republic of Korea, the University of Idaho in the United States of America and Ontario Tech University in Canada, and three new members joined the Academy — KINGS, the University of Idaho and the University of West Bohemia, Czech Republic.

Two technical working groups, on nuclear knowledge management and human resource development, were merged to provide a more efficient, cost-effective service, with the first meeting of the new Technical Working Group on Managing Human Resources and Knowledge in the Field of Nuclear Energy held in 2023.

Furthermore, a technical meeting on the International Nuclear Management Academy provided a forum for university representatives to present the status of their existing or planned nuclear technology management programmes and share good practices and experiences.

The publication *A Nuclear Knowledge Management Course for University Master's Level Programmes* provides guidance to Member States, in particular universities, on establishing a master's level course in nuclear knowledge management.

Nuclear Information

The IAEA Library, renamed the IAEA Lise Meitner Library in March 2023, continued to meet the information needs of Member States by working with members of the International Nuclear Library Network.

Agency staff and Monica Frisch, grand-niece of Lise Meitner, at the renaming of the IAEA Library, March 2023.

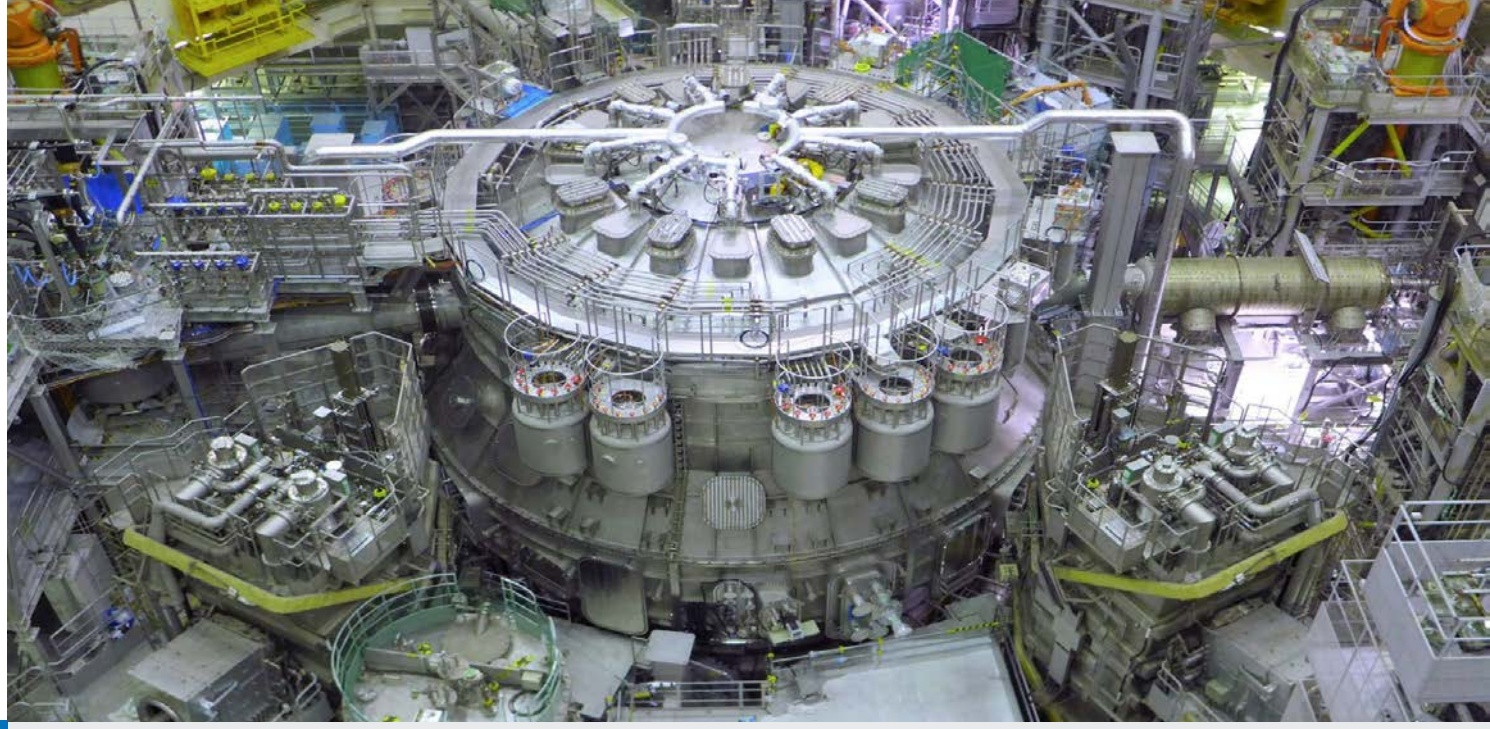
1.7 million
users accessed the INIS repository globally

2.6 million
unique INIS searches

15.5 million
full text downloads

4 million
pages viewed

130 000
new records curated, including **13 000** full-text documents



NUCLEAR SCIENCE

OBJECTIVE

To support Member States in strengthening their capabilities in the development and application of nuclear science as a tool for their technological and socioeconomic development.

To support Member States in enhancing sustainable operation and effective utilization of particle accelerators and neutron sources, as well as effective utilization of research reactors, increasing opportunities for access to these facilities and their diverse applications, and in developing relevant qualified professionals.

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ANSTO is proud of its long-standing collaboration with the IAEA (…) there are many more opportunities ahead in which we can continue to advance the United Nations Sustainable Development Goals through the application of nuclear science and technology.

Dr Suzanne Hollins
Head of Research at the Australian Nuclear Science and Technology Organisation (ANSTO) and Director of the ANSTO Graduate Institute

16
coordinated research projects in progress

3
IRRUR missions to AEOI, Iran
INL, USA
and MIT, USA

3
Practical Arrangements signed with CNDC, China
HFIPS, China
and ITU

163
people received hands-on training in nuclear science and applications

9
terabytes of material downloaded from the Nuclear Data Services database

KEY OUTPUTS

Atomic and Nuclear Data

The Agency provides fundamental nuclear data for power and non-power applications, as well as atomic data for fusion energy research. In 2023, it released a number of new graphical user interfaces, notably TALYSworld and Data Explorer, for easy access to nuclear reaction data. Additionally, the International Nuclear Data Evaluation Network contributed to improved nuclear data for Plutonium-239 for advanced nuclear reaction simulations. The 21st International Conference on Atomic Processes in Plasmas, held in May 2023 with 127 participants, focused on atomic processes involved in the study of plasmas in fusion energy and other applications over a wide range of densities and temperatures.

Research and Applications with Accelerators and Neutron Sources

The Agency supports Member States with regard to research, infrastructure projects and education programmes on accelerators and neutron sources. In 2023, the Centre for Ion Beam Applications at the National University of Singapore was designated as a Collaborating Centre aiming to enhance the use of accelerator science and technologies in multidisciplinary applications.

The Agency continued its endeavours in the area of 'Atoms for Heritage' by organizing technical meetings and workshops, allowing numerous participants to enhance their knowledge about advances in nuclear analytical techniques for the characterization of heritage samples and objects. Following a joint technical briefing, the Agency and the United Nations Interregional Crime and Justice Research Institute proposed a cooperation platform on using nuclear techniques to combat illicit trafficking in cultural goods. Periodic training courses and workshops provided hands-on training on scientific experiments and practical applications at research reactor, ion beam and synchrotron light facilities. Research groups from around 20 Member States carried out experiments at Elettra Synchrotron Trieste, Italy, and the Ruđer Bošković Institute, Croatia.

The Agency publication *Specific Considerations and Guidance for the Establishment of Ionizing Radiation Facilities* is intended for use by managers, staff, decision makers at the national level and other stakeholders at institutions that are seeking or supporting the establishment of new ionizing radiation facilities. The publication *Advances in Boron Neutron Capture Therapy* comprehensively reports on the current state of the related science and the supporting technology. It covers accelerator-based neutron sources, beam design, physical dosimetry, facility design and operation, pharmaceuticals, radiobiology, dose calculation, treatment planning and clinical trials.

Nuclear Instrumentation

The safe and effective use of nuclear techniques requires reliable measurement, diagnostics and control instrumentation. Advanced nuclear instrumentation is used for many sophisticated applications, such as precision imaging systems for medical diagnostics, remote sensors for environmental safety or the probing and manufacturing of the most modern materials or objects.

More than 300 person-weeks of hands-on training took place at the Agency's Nuclear Science and Instrumentation Laboratory and at partner organizations, covering gamma spectroscopy, X-ray fluorescence, neutron science, radiotracer applications, radiological mapping and nuclear security. The majority of trainees benefited from the newly refurbished Multipurpose Building at the IAEA Seibersdorf Laboratories.

A joint ICTP–IAEA School on advanced nuclear instrumentation, held in Trieste, Italy, allowed trainees to familiarize themselves with professional software design tools and hardware platforms through tutorials and hands-on activities with an emphasis on practical applications of modern nuclear instrumentation.

The analytical capabilities of some 50 laboratories in 34 Member States were improved through proficiency tests.

In addition, as part of new partnership initiatives with the private sector, demonstration of diverse radiological mapping systems for radiation survey in field took place at the Nuclear Science and Instrumentation Laboratory in Seibersdorf.

An Agency Integrated Research Reactor Utilization Review (IRRUR) mission assessed the utilization aspects of three research reactors in the Islamic Republic of Iran. A further two IRRUR missions took place at research reactors of the Idaho National Laboratory and the Massachusetts Institute of Technology in the United States of America. (Photograph courtesy of the Atomic Energy Organization of Iran)

Portable macro X-ray fluorescence scanner dedicated to 2D non-destructive analysis of the elemental composition of different pigments in art pieces and artifacts of cultural and historical value. The device was designed and built as a result of a joint IAEA-ICTP project. (Photograph courtesy of ICTP)

Fusion Research

The Agency continued its support to Member States by accelerating fusion energy research and technology development to make fusion energy generation a reality.

In 2023, a new coordinated research project (CRP) was launched on the standardization of small specimen test techniques for fusion applications to facilitate actions towards the unification of terminology and the tools used in different parts of the fusion community.

The Agency organized a workshop on artificial intelligence for accelerating fusion and plasma science. The event provided a platform for researchers, developers, practitioners, entrepreneurs and policymakers to discuss AI applications to accelerate fusion and plasma science, including through joint initiatives and CRPs. In addition, the Joint ICTP–IAEA School on AI for Nuclear, Plasma and Fusion Science, organized in Trieste, Italy, provided young researchers with critical skills related to AI/machine learning and computational physics in nuclear, plasma and fusion science.

The Fifth IAEA Technical Meeting on Fusion Data Processing, Validation and Analysis, organized in Gent, Belgium, provided a forum for fusion researchers to discuss a set of topics relevant to fusion data processing, validation and analysis with a view to identifying extrapolation needs for next-step fusion devices such as ITER.

The 8th ASEAN School on Plasma and Nuclear Fusion, organized by the Thailand Institute of Nuclear Technology in cooperation with and supported by the Agency, helped to raise awareness of fusion energy and plasma research in Southeast Asian countries and promoted interaction between young talent and leading researchers from around the world. In addition, the 12th ITER International School, also organized in cooperation with and supported by the Agency, allowed participants to get acquainted with physics of energetic particles in fusion plasmas.

In 2023, the Agency designated the Plasma Science and Fusion Center of the Massachusetts Institute of Technology (PSFC) as its first Collaborating Centre in the field of fusion. This partnership will help the Agency deliver its fusion research and technology activities for an initial period of four years (2023–2027). It will enable the Agency to access PSFC expertise in artificial intelligence applied to fusion and plasma science by bringing together these innovations in an integrated manner, while training a new generation of fusion scientists at the same time.

In addition, the Agency and the Hefei Institutes of Physical Science, Chinese Academy of Sciences, an integrated research entity in China that includes a fusion research institute, signed Practical Arrangements in physics, technology, training and education in fusion research.

Lastly, the Agency released a high-level textbook for graduate students entitled *Fundamentals of Magnetic Fusion Technology,* which covers a wide range of topics and is useful for teaching at master's degree level.

The Director General with the Director of MIT's Plasma Science and Fusion Center (PSFC), Dennis Whyte, and PSFC Research Scientist, Cristina Rea, at the signing of the PSFC Collaborating Centre agreement, September 2023.

42 publications in 2023

17 Nuclear Fuel Cycle and Waste Technology

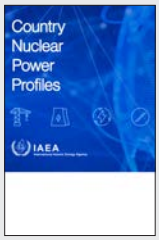
21 Nuclear Power

4 Planning, Information and Knowledge Management

www.iaea.org/publications

176 440 online views of NE publications in 2023

MOST POPULAR PUBLICATION



Country Nuclear Power Profiles

10 471 online views

Nuclear Power, Fuel Cycle and Nuclear Science

Second International Conference on Climate Change and the role of Nuclear Power 2023: Atoms4NetZero

October 2023, Vienna

Participants: **496** in person and **530** online, from **88** Member States

This event provided a forum for Member States, representatives of relevant low carbon energy sectors, international organizations and other stakeholders to exchange information on the role of nuclear power in the energy transitions towards net zero emissions, consistent with the objectives of limiting global warming to 1.5 degrees Celsius by the end of the century.

International Symposium on Uranium Raw Material for the Nuclear Fuel Cycle

May 2023, Vienna

Participants: **176** in person and **229** online, from **63** Member States

This event allowed participants to analyse supply–demand scenarios and to present and discuss the latest developments and innovations in uranium geology, exploration, mining, processing and site decommissioning to ensure a sustainable supply of uranium for use as nuclear fuel.

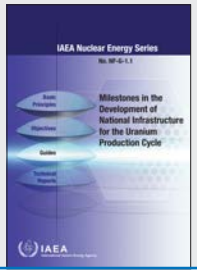
29th IAEA Fusion Energy Conference

October 2023, London

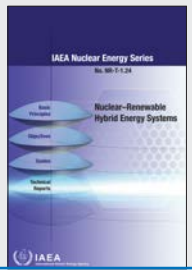
Participants: **1006** in person and **1609** online, from **81** Member States

This event provided a forum for the discussion of key physics and technology issues and innovative concepts relating to the use of fusion as a future source of energy. Participants presented the outcomes of R&D efforts in national and international fusion projects, covering topics such as experiments and theory, fusion technology and materials, and socioeconomic aspects, highlighting advances made.

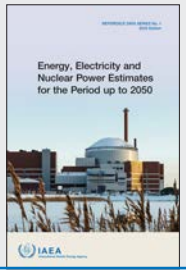
Guidance on evaluating progress towards establishing or re-establishing a national uranium production programme and planning the steps necessary to develop national infrastructure requirements for uranium production.



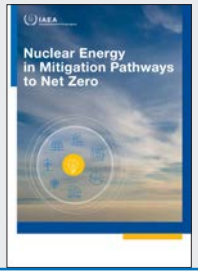
Describes the potential use of nuclear and renewable generation in coordinated configurations to support various applications beyond electricity production.



Contains estimates of energy, electricity and nuclear power trends up to the year 2050, including global and regional nuclear power projections presented as low and high cases.



Addresses the contribution of nuclear energy in global climate change mitigation pathways put forth by the Intergovernmental Panel on Climate Change and the International Energy Agency.



IAEA PUBLICATIONS AND CONFERENCES IN 2023

International Symposium on the Deployment of Floating Nuclear Power Plants – Benefits and Challenges

November 2023, Vienna

Participants: **141** in person and **20** online, from **45** Member States

This event explored and discussed the potential deployment of FNPPs to enhance the contribution of nuclear energy to achieving net zero carbon emissions. It highlighted the need for closer cooperation between the Agency and the International Maritime Organization and maritime classification societies, and the need to consider safety, security and safeguards in the early design stages.

International Conference on Nuclear Decommissioning: Addressing the Past and Ensuring the Future

May 2023, Vienna

Participants: **403** in person and **188** online, from **69** Member States

This event covered achievements, challenges and lessons learned in the decommissioning of nuclear facilities, highlighting current priority needs and sharing information on strategies and approaches that enhance the safe, secure and cost-effective implementation of programmes.