

# Nuclear Power, Fuel Cycle and Nuclear Science



**on-line training and education courses**  
hosted on **CLP4NET**

**34**

**active coordinated research projects**



## Participants of IAEA schools trained



**188**

Nuclear Knowledge Management school

**419**

Nuclear Energy Management school



**2 INPRO**

**Dialogue Forums**



**2 473 312**

**International Nuclear Information System users**

**3 667 620**

unique searches

**5 670 722**

page views



**publications in 2021**

## Internet Reactor Laboratory

**3** host institutions



**10** guest institutions



**17**  
peer review missions

**23**  
databases  
**23**  
modelling tools and simulators



**6** IAEA-designated International Centres based on Research Reactors

in **6** countries



**6** new Collaborating Centres

**14**

active IAEA Collaborating Centres within the Department of Nuclear Energy



# Nuclear Power

## Objective

To support Member States with existing nuclear power plants to enhance operating performance and safe, secure, efficient and reliable long term operation, including development of human resource capability, leadership and management systems. To support Member States embarking on new nuclear power programmes in planning and building their national nuclear infrastructures, including development of human resource capability, leadership and management systems. To provide methods and tools to support modelling, analyses and assessments of future nuclear energy systems for sustainable development of nuclear energy, and collaborative frameworks and support for technology development and deployment of advanced nuclear reactors and non-electric applications.

## Launching Nuclear Power Programmes

In 2021, 26 Member States were considering, planning or implementing a nuclear power programme. The Agency supported them in building awareness of the commitments



required for the decision making process and in the development of the required infrastructure in line with the Milestones approach.

Six virtual (Bangladesh, Ghana, Morocco, Nigeria, Sudan and Türkiye) and one in-person (Egypt) Integrated Work Plan–Country Nuclear Infrastructure Profile meetings were conducted to help establish priority areas for Agency support based on identified needs. The Agency conducted 16 training courses and workshops within the Integrated Nuclear Infrastructure Training programme, with theoretical sessions mostly organized virtually and practical sessions to follow in person.

In addition, the Agency conducted 29 virtual, hybrid and in-person training courses, workshops and expert missions in support of national nuclear infrastructure development. The Agency also organized a webinar entitled ‘Experiences of Member States in Building Regulatory Framework for the Oversight of New Nuclear Power Plants’ and three webinars as part of the series ‘Governing New Nuclear Programmes: Newcomer Success Stories’, where experiences and the benefits of Agency support were shared.

The lessons learned from INIR missions were compiled and published in *Integrated Nuclear Infrastructure Review (INIR): Ten Years of Lessons Learned* (IAEA-TECDOC-1947). The Agency also published *Experiences of Member States in Building a Regulatory Framework for the Oversight of New Nuclear Power Plants: Country Case Studies* (IAEA-TECDOC-1948).

Participants in the annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure, held virtually, discussed challenges and issues in developing infrastructure for the introduction or expansion of nuclear power. At the hybrid 12th Meeting of the Technical Working Group on Nuclear Power Infrastructure, participants made proposals on the further development of guidance and recommendations for new nuclear power programmes based on recent developments and best practices.

## Operating Nuclear Power Plants and Expanding Nuclear Power Programmes

The new publication *Application of Wireless Technologies in Nuclear Power Plant Instrumentation and Control Systems* (IAEA Nuclear Energy Series No. NR-T-3.29) provides an overview of the practices, experiences, benefits and challenges in using the technology in instrumentation and control systems of nuclear power plants and other facilities.



(Photograph courtesy of ©Xunxi/Alibaba.)

The new publication *Human Factors Engineering Aspects of Instrumentation and Control System Design* (IAEA Nuclear Energy Series No. NR-T-2.12) emphasizes an interdisciplinary approach for better human–system interfaces and improved human performance in nuclear power plants.

The Agency signed Practical Arrangements with the Nuclear Energy Institute (United States of America) on scientific and technical cooperation on the construction, operation and decommissioning of civil nuclear power plants, as well as with the National Centre for Non-Destructive Testing (Pakistan) on cooperation in non-destructive testing and structural integrity.

The publication *Thermal Performance Monitoring and Optimization in Nuclear Power Plants: Experience and Lessons Learned* (IAEA-TECDOC-1971) describes the essential elements of a thermal performance programme, providing guidelines on the design of the balance of plant systems for new plants and improvements to existing programmes for operating units.

A toolkit was launched to help Member States navigate national and international requirements for supply chain management and quality. A related Technical Meeting on Recent Issues in Supply Chain Management shared experiences, including with regard to the COVID-19 pandemic. The Agency also conducted eight webinars on nuclear supply chain topics, ranging from procurement and management, to counterfeit items, commercial products in safety systems and managing the supply chain in the context of the COVID-19 pandemic.

## Human Resource Development and Management and Stakeholder Involvement Support

The Agency published *Systematic Approach to Training for Nuclear Facility Personnel: Processes, Methodology and Practices* (IAEA Nuclear Energy Series No. NG-T-2.8), which includes good practices, recommendations and application examples. In addition, four webinars were conducted as part of the series ‘Training and Qualification for Nuclear Facility Personnel’.

The publication *Stakeholder Engagement in Nuclear Programmes* (IAEA Nuclear Energy Series No. NG-G-5.1) provides guidance on developing a stakeholder engagement programme and associated activities. At the Technical Meeting on Stakeholder Involvement, participants discussed Agency outreach products and their adaptation for engaging national stakeholders.

Students and professionals from around the world will benefit from a new Agency Collaborating Centre agreement with the National Institute for Nuclear Science and Technology, France, in the area of education and training in nuclear sciences and applications, nuclear energy, and nuclear safety and security.

## Nuclear Reactor Technology Development

The Agency’s Open-source Nuclear Codes for Reactor Analysis initiative facilitates an international collaboration framework for the development and application of open-source multiphysics simulation tools to support research, education and training for the analysis of advanced nuclear power reactors.

An Agency webinar on artificial intelligence (AI) entitled ‘AI for Nuclear Energy’, conducted as part of the International Telecommunication Union’s AI for Good Global Summit 2021, drew over 1000 registrations and showcased progress in AI to enhance the development and deployment of nuclear power, paving the way for future activities in this area.

### *Advanced water cooled reactors*

The Agency conducted a Technical Meeting on the Market Readiness of Advanced Nuclear Technologies. Participants discussed evolutionary and innovative nuclear power reactors under development as well as obstacles to their adoption. The Agency published *Hydrogen Phenomena During Severe Accidents in Water Cooled Reactors* (Training Course Series No. 72), which includes an overview of hydrogen risks, analysis, measurement, and mitigation strategies, and focuses on descriptions of hydrogen properties as well as its generation, distribution and combustion.

The Agency concluded a coordinated research project (CRP) entitled ‘Methodology for Assessing Pipe Failure Rates in Advanced Water Cooled Reactors’ and its results were summarized in a publication *Technical Insights from Benchmarking Different Methods for Predicting Pipe Failure Rates in Water Cooled Reactors* (IAEA-TECDOC-1988).

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

The Agency organized the first Technical Meeting on the Status, Design Features, Technology Challenges and Deployment Models of Microreactors. The event was followed by a high level on-line dialogue with the Director General’s participation. The Agency also organized a Regional Meeting on Small Modular Reactors and Microreactors: Design, Cogeneration, Applications, Refuelling Schemes, Transport Options and Deployment Pathways.

The four-year CRP ‘Development of Approaches, Methodologies and Criteria for Determining the Technical Basis for Emergency Planning Zone for Small Modular Reactor Deployment’, which concluded in 2021, enabled participating Member States to enhance their understanding of adopting appropriate policies for determining the technical basis for emergency preparedness and response arrangements, including emergency planning zones. The results of the CRP will be reflected in a future publication.

The Workshop on High Temperature Gas Cooled Reactor Technology resulted in the transfer of the knowledge base and code package system for high temperature reactors to the Agency from Germany’s Jülich Research Centre.

### *Fast reactors*

The publication *Benefits and Challenges of Small Modular Fast Reactors* (IAEA-TECDOC-1972) presents a detailed overview of small modular fast spectrum concepts and highlights their technological, economic and safety features. The Agency also published *Structural Materials for Heavy Liquid Metal Cooled Fast Reactors* (IAEA-TECDOC-1978), which presents summaries of the technical and group sessions, conclusions and recommendations of a Technical Meeting held on this topic, as well as the papers presented at the event.

Participants in the Ninth Joint IAEA–GIF Technical Meeting/Workshop on the Safety of Liquid Metal Cooled Fast Reactors (LMFRs) discussed the harmonization of safety approaches, requirements, design criteria and design guidelines for next generation advanced LMFRs.

## **Non-electric Applications of Nuclear Power**

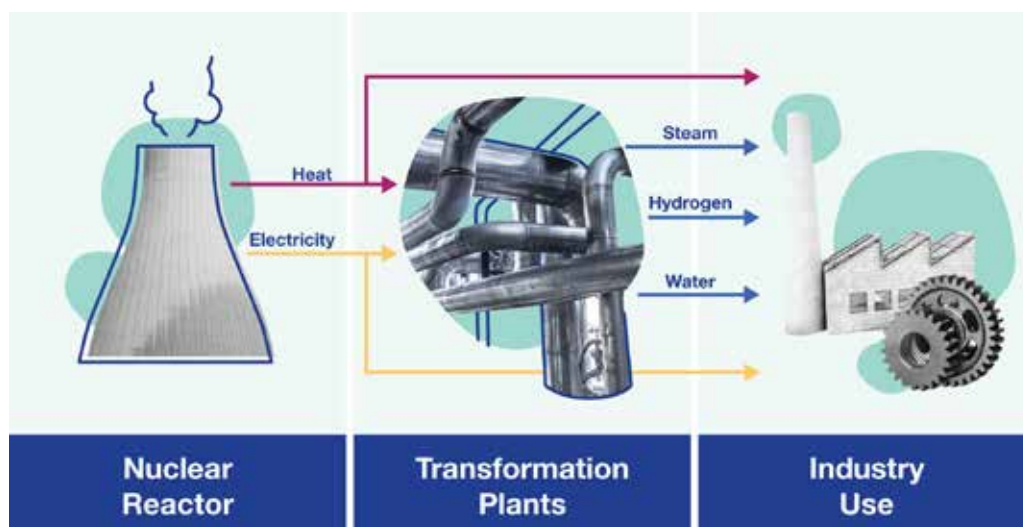
The Agency conducted a Technical Meeting on Potential Schemes for Licensing Nuclear Cogeneration Plants, which explored possible regulatory frameworks for cogeneration projects, safety assessment and safety requirements.

The Technical Meeting on the Role of Nuclear Cogeneration Applications Towards Climate Change Mitigation enabled Member States to exchange information on the



potential for nuclear energy to decarbonize their economies and for nuclear cogeneration to help reach their national climate change commitments.

The side event 'Innovations in the Production and Use of Nuclear Hydrogen for a Clean Energy Transition', held during the 65th regular session of the General Conference, highlighted the role of nuclear energy as a provider of both electricity and heat for clean and reliable hydrogen production, offering insights from existing projects and developments in Canada, the Russian Federation and the United States of America. As part of the Webinar Series on Nuclear Technology Breakthroughs for the 21st Century, the Webinar on Nuclear Heat to Decarbonize the Energy Sector showcased available nuclear technologies to support industrial heat applications and underlined that policy makers, end users, stakeholders and society should consider the nuclear option in their efforts to decarbonize industrial processes.



## Enhancing Global Nuclear Energy Sustainability Through Innovation

The Agency published *Developing Roadmaps to Enhance Nuclear Energy Sustainability: Final Report of the INPRO Collaborative Project ROADMAPS* (IAEA Nuclear Energy Series No. NG-T-3.22), which documents the scope and outputs of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) collaborative project 'Roadmaps for a Transition to Globally Sustainable Nuclear Energy Systems' (ROADMAPS).

The 18th and the 19th INPRO Dialogue Forums allowed participants to explore the importance of partnerships and cooperation for sustainable nuclear development and deployment as well as the role of institutional innovations in enhancing public acceptance of nuclear power.

The Agency organized the IAEA INPRO School on Methodology, Tools and Analysis for Enhanced Nuclear Energy Sustainability in Thailand and the IAEA-STAR-NET Regional School to Train the Trainers on Nuclear Energy System Modelling and Assessment Using the INPRO Methodology, both held virtually due to the COVID-19 pandemic. Participants received training on the use of various INPRO tools to assess, plan and implement sustainable nuclear energy systems.

## CASE STUDY

## Poland Contemplates Nuclear Power as Coal Substitute to Meet Climate Goals

In 2021, when reducing the use of coal was a key theme at the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26), Poland advanced its plans to substitute the most carbon-intensive fossil fuel with nuclear energy. The country continues to work with the Agency on developing infrastructure for a safe, secure and sustainable nuclear power programme.

Poland, which generates approximately 70% of its electricity from coal, has plans to build several nuclear power reactors to greatly reduce its reliance on fossil fuel and to meet climate and energy security goals. Two weeks before the COP26 climate summit in Glasgow, United Kingdom, which coincided with the release of the Agency publication *Nuclear Energy for a Net Zero World*, Director General Rafael Mariano Grossi and Michał Kurtyka, Poland's Minister for Climate and Environment at that time, discussed the country's ambitions for nuclear power.

Speaking as natural gas prices were surging in Europe and other regions of the world, Minister Kurtyka mentioned how the energy crisis would spur more countries to consider nuclear power as part of the solution.

Implementing a nuclear power programme is a complex endeavour — it requires a legislative and regulatory framework and a radioactive waste management plan, as well as broad stakeholder and public support. The Agency supports countries that choose to introduce nuclear power through a range of initiatives, including the Integrated Nuclear Infrastructure Review (INIR) and other peer review services, training and capacity building activities, and advisory services, including for developing relevant management systems

*Poland plans to build several nuclear power reactors to reduce its reliance on fossil fuel and to meet climate and energy security goals. The country currently generates approximately 70% of its electricity from coal.*





for key organizations. The Agency is also tailoring its assistance to countries through Integrated Work Plans (IWP) and responding in a coordinated manner to national needs for an enabling environment for responsible nuclear power deployment.

Poland in recent years has hosted two INIR missions, as well as several other Agency peer review missions.

“Our nuclear programme foresees that between 6 and 9 GWe will be installed by 2043 in terms of nuclear, which means six reactors, and this will play an extremely important role in replacing the existing baseload capacities based on conventional fuels,” Minister Kurtyka said.

Coal and nuclear power plants both produce heat to create steam that drives electricity generating turbines. While coal provides more than a third of global electricity generation, nuclear power is equipped to fill the void resulting from coal plant closures and can provide round-the-clock baseload power in all weather conditions. Baseload power refers to the minimum amount of electric power needed to supply the electrical grid at any given time.

Poland plans to use some of the electricity from its future reactors, as well as from offshore wind farms, to produce clean hydrogen, which can be used to help decarbonize sectors such as industry and transport. The country is also looking into the possibility of deploying high temperature gas cooled reactors, which can improve the efficiency and reduce the cost of producing hydrogen.

In recent years, Poland has hosted an Agency workshop on assessing the environmental impact of nuclear power plants, as well as an IWP review meeting. The country has also taken part in a meeting of the Agency’s Technical Working Group on Gas Cooled Reactors, and has hosted other Agency missions, including an Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation, as well as reviews of its regulatory framework and of the safety of its research reactor.

