Nuclear Power, Fuel Cycle and Nuclear Science

over **650** **on-line training** and **education courses** hosted on **CLP4NET**

33 **coordinated research projects**

4 **Nuclear Knowledge Management** Schools

6 **Nuclear Energy Management** Schools

33 **Integrated Nuclear Infrastructure Training activities**

INPRO **international collaborative projects**

15 **completed**

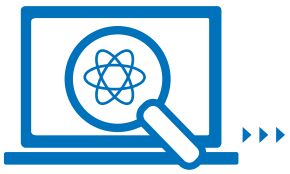
5 **ongoing**

39 **publications**

2019

Internet Reactor Laboratory

4 host institutions



9 guest institutions

18 professional networks

8 missions

5 IAEA-designated International Centres based on Research Reactors

in **5** countries

181 consultancy meetings

2 conferences

74 technical meetings

Nuclear Power

Objective

To support Member States with existing nuclear power plants to enhance performance and ensure safe, secure, efficient and reliable long term operation, including development of human resource capability, leadership and management systems. To assist 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 NESs [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

The Agency continued to support Member States interested in or embarking on new nuclear power programmes by providing assistance in line with the Milestones Approach documented in *Milestones in the Development of a National Infrastructure for Nuclear Power* (IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1)). In 2019, 28 Member States were actively considering, planning or embarking on a nuclear power programme (Fig. 1).

The Agency conducted an Integrated Nuclear Infrastructure Review (INIR) Phase 2 mission to Egypt and an INIR Phase 1 follow-up mission to Ghana. The INIR evaluation methodology was tested in Bulgaria to evaluate its use for an expanding nuclear power programme. At the end of 2019, the number of INIR and INIR follow-up missions conducted since 2009 reached 29 missions to 21 Member States.

In 2019, the Agency met with eight Member States to develop or update their Integrated Work Plans and Country Nuclear Infrastructure Profiles.

Nuclear power infrastructure competence building (Fig. 2) included Integrated Nuclear Infrastructure Training (INIT). The Agency conducted 33 interregional training activities in 9 Member States to increase awareness and understanding of the Milestones Approach. Practical training was provided to around 500 participants from 42 Member States.

"The Agency conducted 33 interregional training activities in 9 Member States to increase awareness and understanding of the Milestones Approach."

The Agency conducted six expert missions to five embarking Member States to assist and advise key organizations on the development of leadership, management systems and improved nuclear organizational culture in line with the Agency's safety standards. Six Member States received training on the Nuclear Power Human Resources modelling tool and support in developing their national human resource plans.

The annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure was held in Vienna for Member States to share good practices and lessons learned in establishing the infrastructure required for a safe and sustainable nuclear power programme. Meeting participants also discussed ways of financing and contracting for new nuclear power plants as well as infrastructure development for small and medium sized or modular reactors (SMRs).

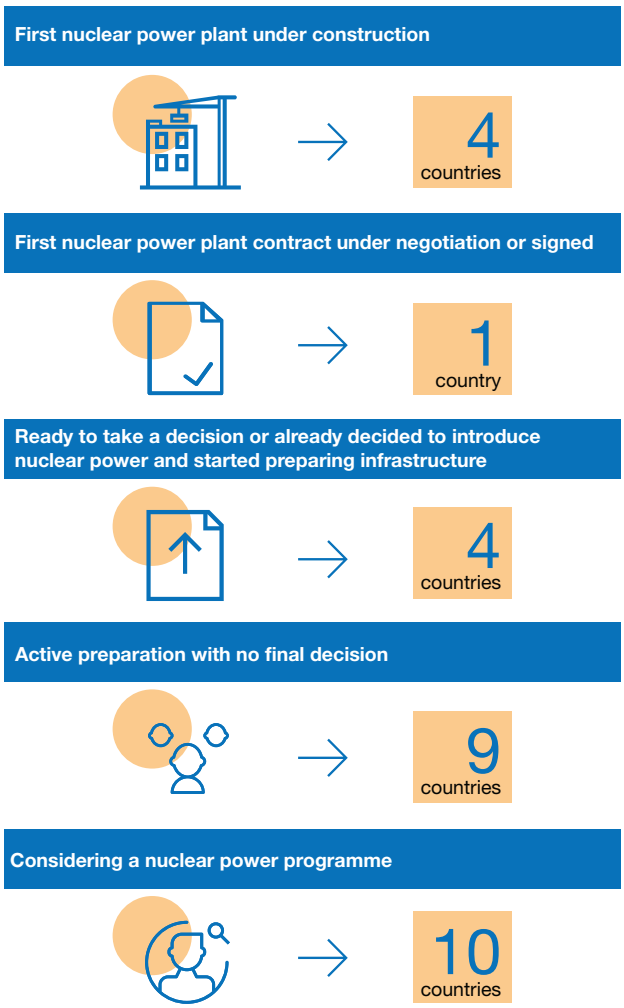


FIG. 1. Number of Member States considering or embarking on a nuclear power programme according to official statements (as of 31 December 2019).

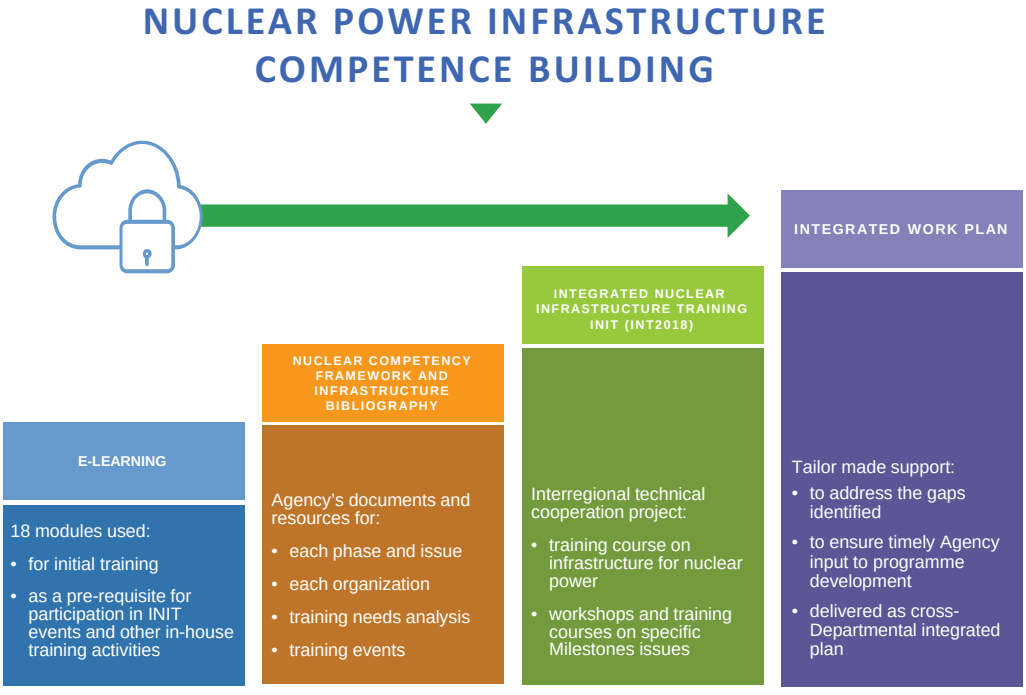


FIG. 2. Overview of the systematic approach to nuclear power infrastructure competence building finalized in 2019.

Operating Nuclear Power Plants and Expanding Nuclear Power Programmes

At the end of 2019, over 66% of the world's 443 operating nuclear power reactors had been in operation for longer than 30 years. At the biannual meeting of the Technical Working Group on Life Management of Nuclear Power Plants, held in Vienna, experts considered relevant operation, maintenance and technical challenges facing the international nuclear power community and identified activities that could assist in overcoming them. This included collaboration for sustained viability of nuclear reactor vessels and internals; for the development of equipment reliability programmes; and for the collection of data on environmental qualification for electrical and instrument and control equipment for beyond the initial design lifetime.

Participants in a Technical Meeting on Challenges in New Build Projects in Countries with Nuclear Power Programmes, held in Vienna, identified potential difficulties in four key areas: the interface between the new project and the country's existing nuclear power programme; the supply chain; project management; and stakeholder involvement.

Recent Agency activities, tools and publications to support Member States were identified at the Technical Meeting on Stakeholder Involvement and Communication for New and Expanding Nuclear Power Programmes. The meeting, held in Vienna, underlined the importance of involving stakeholders at all stages of the development of a nuclear power programme as a crucial element in the decision making process.

The Agency published *Managing Counterfeit and Fraudulent Items in the Nuclear Industry* (IAEA Nuclear Energy Series No. NP-T-3.26) to assist Member State organizations in preventing, detecting and addressing counterfeit and fraudulent items on an ongoing basis. The Agency also issued *A Methodology to Evaluate the Effectiveness of Training in Nuclear Facilities* (IAEA-TECDOC-1893), which provides a set of training standards and conditions that can be used by any nuclear facility to objectively evaluate the quality of its training.

To increase the capacity of Member States in supply chain management, on-line resources such as toolkits were made available and training courses were conducted, including a Pilot Training Course on Nuclear Supply Chain Management and Procurement attended by 30 participants from 26 Member States.

Nuclear Technology Development

Advanced water cooled reactors

A new Agency publication entitled *Classification, Selection and Use of Nuclear Power Plant Simulators for Education and Training* (IAEA-TECDOC-1887) provides information on how to use the Agency's suite of simulators. Another publication, *Nuclear–Renewable Hybrid Energy Systems for Decarbonized Energy Production and Cogeneration* (IAEA-TECDOC-1885), summarizes the findings from a technical meeting on the latest concepts and innovative solutions for addressing the challenges of using a combination of nuclear and renewable energy sources. The Agency also published *Status of Research and Technology Development for Supercritical Water Cooled Reactors* (IAEA-TECDOC-1869).

Seven training courses on advanced water cooled reactor technologies were held; participants received hands-on learning using the Agency's basic principle simulators. Three new Training Course Series publications were issued in support of these courses and the Agency acquired a new basic principle simulator for severe accidents.

SMRs

A Technical Meeting on the Design, Experimental Validation and Operation of SMRs took place in Pakistan. The meeting highlighted the status of SMR technology developments, the

commissioning and operating experience of the four medium sized reactors at Chashma nuclear power plant, and the needs of newcomer countries.

Contributors to the coordinated research project (CRP) entitled 'Development of Approaches, Methodologies and Criteria for Determining the Technical Basis for Emergency Planning Zone for SMR Deployment' reported on different approaches to determining the emergency planning zone and highlighted limitations in the current practices and tools, especially for near field atmospheric dispersion. This information will help to develop methodologies and criteria for determining the technical basis for emergency preparedness and response arrangements for SMRs.

Fast reactors

"the on-line Catalogue of Facilities in Support of Liquid Metal-cooled Fast Neutron Systems….now contains information on some 200 experimental facilities across the world."

Two major studies on benefits and challenges of fast reactors of the SMR type and on structural materials for heavy liquid metal cooled fast reactors were conducted through Agency technical meetings. At the Eighth Joint IAEA–Generation IV International Forum (GIF) Technical Meeting/Workshop on the Safety of Liquid Metal Cooled Fast Reactors, held in Vienna, two GIF reports on safety design guidelines of Generation IV sodium cooled fast reactors were presented for further review.

At a meeting in Vienna, experts updated the on-line Catalogue of Facilities in Support of Liquid Metal-cooled Fast Neutron Systems. The database now contains information on some 200 experimental facilities across the world.

High temperature reactors

The Technical Meeting on the Competitiveness and Early Deployment of SMRs and High Temperature Gas Cooled Reactors (HTGRs) showcased many Member State activities in this area, and in particular novel design and technology enhancements that can increase the competitiveness and attractiveness of SMRs and HTGRs.

The first Joint IAEA–GIF Technical Meeting on the Safety of HTGRs, held in Vienna, presented the outcomes of the four year CRP entitled 'Modular HTGR Safety Design'.

The Joint ICTP–IAEA Workshop on Physics and Technology of Innovative High Temperature Nuclear Energy Systems, held in Trieste, Italy, highlighted the latest technology advancements in HTGRs and molten salt reactors as the basis of non-electric applications such as hydrogen production, including aspects of nuclear energy sustainability.

Non-electric Applications of Nuclear Power

The Agency organized four technical meetings relating to non-electric applications of nuclear energy. The meetings focused on the role of nuclear hydrogen production as part of the whole hydrogen supply chain and life cycle; different aspects of nuclear cogeneration projects; the deployment of nuclear cogeneration using SMRs and HTGRs; and the role of nuclear desalination in the context of climate change mitigation. It also held a Regional Workshop on Non-electric Nuclear Applications: Options, Technology Readiness and Available IAEA Toolkits, in Prague.

A new Agency publication entitled *Guidance on Nuclear Energy Cogeneration* (IAEA Nuclear Energy Series No. NP-T-1.17) introduces the advantages of nuclear cogeneration and addresses issues to be considered for its implementation. The publication also highlights past demonstration projects developed in connection with industrial applications.

Enhancing Global Nuclear Energy Sustainability through Innovation

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) engages in dialogue and outreach through its Dialogue Forums and INPRO schools. In 2019, the INPRO Dialogue Forum on Opportunities and Challenges in SMRs, held in the Republic of Korea, provided a place for experts to interact and discuss cross-cutting issues in nuclear energy systems that include SMRs. Key cross-cutting topics included governmental energy policies in terms of SMRs and nuclear power as a clean energy source, and public and political acceptance of SMRs. In Mexico and the Russian Federation, pilot courses for a new INPRO service (Analysis Support for Enhanced Nuclear Energy Sustainability) trained engineers, scientists and ministry experts in using tools and methods for nuclear energy scenario modelling and systems evaluation.