

# Nuclear Power, Fuel Cycle and Nuclear Science



**1521**

online training and education courses hosted on **CLP4NET**



**24**

active coordinated research projects within the Department of Nuclear Energy



around  
**400**  
events



over **2 million**

International Nuclear Information System users  
nearly **3 million** unique searches  
over **4.7 million** page views



**24**  
databases

**25**  
modelling tools and simulators



**14**

active Collaborating Centres within the Department of Nuclear Energy

# 2022



## Internet Reactor Laboratory

**4** host institutions

**11** guest institutions



**31**

peer review missions



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

in **6** countries



**29**

publications issued in 2022



## Participants in IAEA schools

**501** Nuclear Energy Management School

**392** Nuclear Knowledge Management School

**24** Regional Research Reactor School

# Nuclear Power

## Objective

*To support Member States with existing 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 NESs [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.*

## Launching Nuclear Power Programmes

In 2022, the number of Member States considering, planning or implementing a new nuclear power programme remained at 26. 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.

Twelve Integrated Work Plan meetings were held to identify priority areas for Agency support for newcomer countries. The Agency conducted 13 training courses and workshops within the Integrated Nuclear Infrastructure Training programme and 21 workshops, consultancy meetings and expert missions in support of national nuclear power infrastructure development.



*Participants in the Interregional Training Course on Nuclear Power Infrastructure Development, held in November 2022 in Japan, during a visit to the Hamaoka NPP Training Centre.*

Together with the World Association of Nuclear Operators, the Agency hosted a side event on “Cooperation with Other International Organizations: Assistance to Embarking and Expanding Countries” during its 66th General Conference. The annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure continued to be a valuable forum for Member States to discuss challenges and issues in developing infrastructure for the introduction or expansion of nuclear power.

At the 13th meeting of the Technical Working Group on Nuclear Power Infrastructure, its members noted the significant growth in interest in nuclear power, the expectations from Member States, and the activities associated with new Agency initiatives, including the Nuclear Harmonization and Standardization Initiative and the IAEA Platform on Small Modular Reactors and their Applications.

The Agency signed a Memorandum of Understanding with the Arab Atomic Energy Agency to promote peaceful uses of nuclear energy and enhance nuclear power programme infrastructure, nuclear safety and security.

## Operating Nuclear Power Plants and Expanding Nuclear Power Programmes

The second Global Forum for Nuclear Innovation explored opportunities to accelerate innovation for the continued safe and reliable operation of the global fleet of operating nuclear power plants (NPPs).

The publication *Sustaining Operational Excellence at Nuclear Power Plants: Principles and Challenges* (IAEA Nuclear Energy Series No. NR-G-3.1) provides owners/operators with strategic responses to current business challenges and effective measures to sustain nuclear power’s uniquely high performance levels.

The publication *Management of Ageing and Obsolescence of Instrumentation and Control Systems and Equipment in Nuclear Power Plants and Related Facilities Through Modernization* (IAEA Nuclear Energy Series No. NR-T-3.34) assists Member States in developing strategies to address ageing and obsolescence issues for instrumentation and control systems, and conveys details and experience concerning modernization considerations.

The publication *Introduction to Systems Engineering for the Instrumentation and Control of Nuclear Facilities* (IAEA Nuclear Energy Series No. NR-T-2.14) assists Member States in understanding the philosophy and methodologies of systems engineering and provides guiding principles for its application to nuclear facility instrumentation and control.

## Human Resource Development and Management and Stakeholder Engagement Support

The publication *Human Resource Management for New Nuclear Power Programmes* (IAEA Nuclear Energy Series No. NG-T-3.10 (Rev. 1)) provides Member States with a structured approach to developing an effective human resource management strategy and the infrastructure needed to support the workforce across the key organizations in accordance with the nature and scope of a national programme.

The Agency modernized and updated the Nuclear Energy Capacity Building Hub site, hosted on the IAEA CONNECT platform, to provide Member States with online technical information to further sustain ongoing nuclear power projects.

Two workshops on human resources development for nuclear programmes, one held at the national level in Uzbekistan and the second at the interregional level in the Russian Federation, provided participants with an understanding of the levels of human resources and mix of competencies needed in the different phases of developing a nuclear power programme.

The workshop on the development of the technical support organization for Ghana’s nuclear power programme enabled participants to consolidate information on the establishment of external and internal technical support capability.



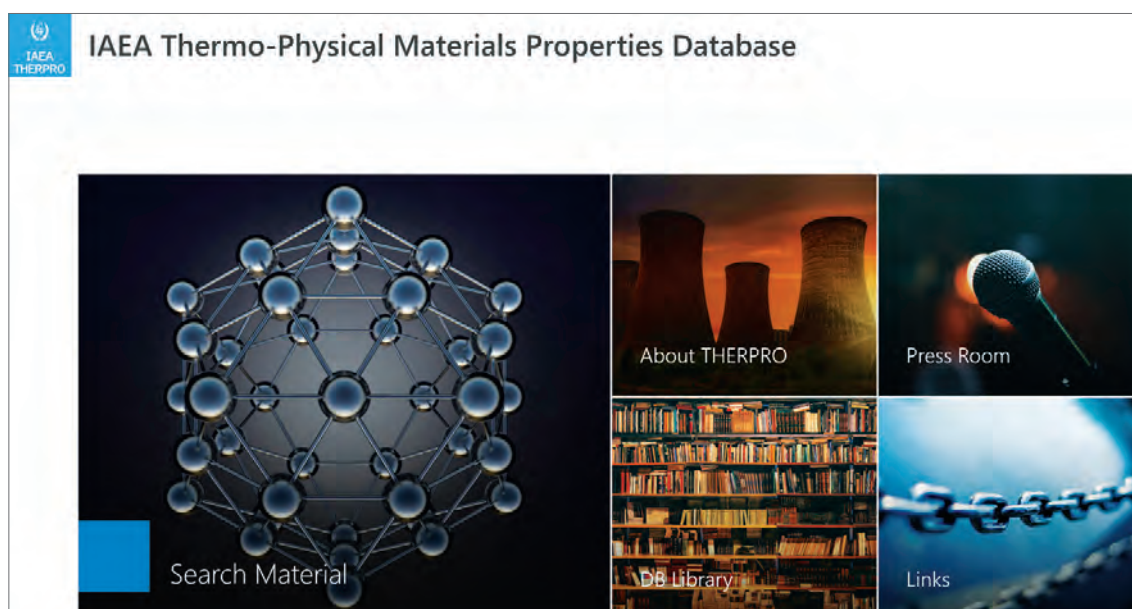
## Nuclear Reactor Technology Development

### *Technology development of advanced water cooled reactors*

A new coordinated research project (CRP) on Technical Evaluation and Optimization of Nuclear-Renewable Hybrid Energy Systems was launched to increase understanding of the role, performance and impact of these systems in meeting current and future energy demands.

The Agency launched a CRP on Advancing Thermal-Hydraulic Models and Predictive Tools for Design and Operation of SCWR Prototypes with the objective of establishing a coherent body of knowledge about fluids at supercritical pressures and/or temperatures needed to prototype supercritical water cooled reactor (SCWR) designs, and of closing gaps in technology areas relevant to design options.

The Agency modernized the Thermo-Physical Materials Properties Database (THERPRO), which provides information about various properties of materials found in the operating fleet of light and heavy water reactors and their advanced designs.



*The THERPRO database is an online comprehensive collection of thermo-physical material properties data. Data relating to more than 11 000 properties of about 1600 materials are compiled in THERPRO.*

The Agency launched a Simulation and Experimental Analyses Network Information System database, which gathers information about Member States' programmes and activities related to the analysis of severe accidents in nuclear reactors.

The Agency updated its publication *Nuclear Reactor Technology Assessment for Near Term Deployment* (IAEA Nuclear Energy Series No. NR-T-1.10 (Rev. 1)), which demonstrates how reactor technology assessment is performed and how it enables decision making in nuclear power planning.

New e-learning modules on advanced technologies and severe accidents were translated into several languages.

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

A new CRP on Technologies Enhancing the Competitiveness and Early Deployment of Small Modular Reactors was launched to identify and enhance understanding of the families of enabling technologies with the potential to either reduce the construction cost and schedule or better suit users' needs, thus facilitating and favouring their early deployment.

### *IAEA Platform on Small Modular Reactors and their Applications*

Small modular reactors and their applications have the potential to make an important contribution to achieving global climate goals and energy supply security. There are more than 80 designs under development in 18 countries, according to the Advanced Reactors Information System.

The Agency supports Member States towards the safe and secure deployment of small modular reactors, which can enhance energy security while helping to achieve global climate goals. To this end, the Agency has launched two interconnected mechanisms: the IAEA Platform on Small Modular Reactors and their Applications and the Nuclear Harmonization and Standardization Initiative (NHSI).

Serving as the focal point for the Agency's activities in the field of small modular reactors and their applications, the Platform provides coordinated support and expertise from across the entire Agency, encompassing all aspects relevant to the development, deployment and oversight of small modular reactors. The Platform is designed to facilitate cooperation and collaboration among Member States and other stakeholders, supporting the safe and secure deployment of small modular reactors worldwide. It supports Member States in the early deployment of small modular reactors, including in accelerating their technology development and demonstration, enhancing their readiness level, and analysing the competitiveness of small modular reactors with respect to other clean energy technologies.

The medium-term strategy through 2029 for small modular reactors and their applications was developed to provide strategic direction and a road map for relevant activities. High-level work is under way to implement this strategy. The small modular reactors web portal has been established for sharing information on such reactors and their applications among all interested stakeholders and for coordinating all Agency activities in the areas of technology, safety, security and safeguards.

The Agency started providing assistance to the Brazilian Association for the Development of Nuclear Activities with regard to building an energy system model to evaluate the introduction of small modular reactors into electricity systems. A workshop on desalination was held and preparations started for an expert mission on using small modular reactors for electricity generation and nuclear desalination, for the Jordan Atomic Energy Commission (see related case study).



*The Director General visits CAREM-25, Argentina's first prototype small modular reactor, currently under construction, October 2022. (Photograph courtesy of I. Dambrauskas/CAREM)*

To address the growing interest in floating NPPs, the Agency started analysing potential issues in deploying this type of small modular reactor. A symposium on this topic is planned.

### ***Nuclear Harmonization and Standardization Initiative***

After the NHSI kick-off meeting (see p. 6 of the Overview chapter), the Agency invited industry representatives to send expressions of interest in participating in each of the four topical working groups in the industry track. Other industry stakeholders also joined subsequently. In addition, as three of the four topics had already been launched, Member States had had earlier opportunities to nominate representatives.

The groups made use of existing Agency mechanisms (consultancy or technical meetings, CRPs etc.), with nominated Technical Officers. Additional resources were sought via extrabudgetary contributions. Each topical working group had different schedules and activities in 2022, mainly focused on establishing and defining their scope and schedule.

The first working group is discussing the content of a high-level Agency publication that will harmonize existing user requirements as defined by three utility associations, and which is also intended to be a learning tool for non-nuclear utilities/users. The second working group's objective is to create a database enabling high-level comparisons in eight domains of codes and standards such as quality management, engineering and design (in collaboration with the World Nuclear Association's Cooperation in Reactor Design Evaluation and Licensing group), manufacturing, qualification, oversight and acceptance. The third group's focus is to establish global cooperation and resource-sharing for experiments and code validation between entities operating experimental facilities, technology holders and technical support organizations, in collaboration with the OECD/NEA. The fourth working group is working on developing a publication aimed at providing forward-looking scenarios that could accelerate the deployment of small and medium sized or modular reactors and microreactors in technology-recipient countries.

Two interface meetings took place involving industry representatives and the regulatory track to discuss and determine industry participation in the three working groups in the regulatory track.

Regular communication with external stakeholders from both tracks on progress under NHSI is planned through interface informational calls.

### ***Fast reactors***

Participants in the Technical Meeting on Open-source Tools supported a new project on Open-source Nuclear Codes for Reactor Analysis and the Agency conducted several workshops and webinars on neutronics codes, thermal hydraulics codes and system codes for reactor analysis.

The Technical Meeting on State-of-the-art Thermal Hydraulics of Fast Reactors resulted in the preparation of a monograph on experimental and numerical achievements in the field in the 21st century.

Two CRPs — on neutronics benchmark analysis of China Experimental Fast Reactor startup tests and on benchmark analysis of a test performed at the Fast Flux Test Facility in the United States of America — were completed, resulting in the validation of simulation tools and enhancement of models used for simulation of reactor neutronics, thermal hydraulics and coupled multiphysics.

### ***Nuclear fusion technology development for future energy production***

Participants in the Technical Meeting on Synergies Between Nuclear Fusion Technology Developments and Advanced Nuclear Fission Technologies discussed how the accumulated experience in developing, designing, constructing, operating and decommissioning nuclear power reactors and plants can help evolving fusion technology.

### ***Non-electric applications of nuclear power***

The Agency initiated a new CRP on the Role of Nuclear Cogeneration within the Context of Sustainable Development, which will assess various nuclear cogeneration applications and will explore why and how countries could consider nuclear cogeneration in their portfolio of options to address climate challenges.

The Technical Meeting on Developing a Road Map for the Commercial Deployment of Nuclear Hydrogen Production explored ways to provide a useful management tool for evaluating, planning and strategizing the development of nuclear hydrogen projects.

The Technical Meeting on the Planning and Implementation of Nuclear Cogeneration Projects allowed Member States to exchange information on existing and planned nuclear cogeneration projects and to assess the latest developments in nuclear cogeneration worldwide.

At the eighth meeting of the Technical Working Group on Nuclear Desalination, members reviewed their national activities on nuclear desalination and integrated water management and provided recommendations to the Agency on plans for future activities in the area of nuclear desalination.

### **Enhancing Global Nuclear Energy Sustainability through Innovation**

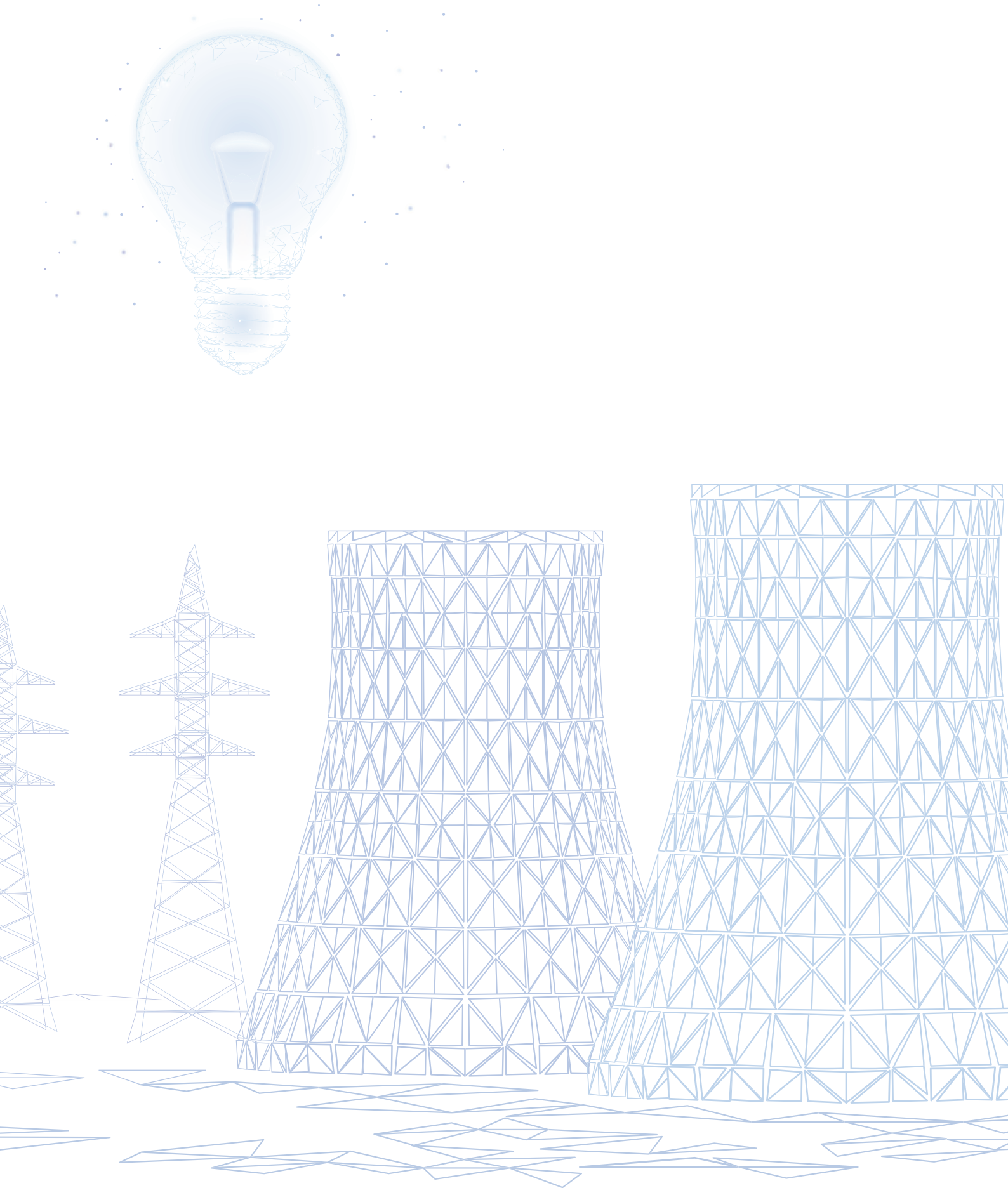
At the 31st Meeting of the INPRO Steering Committee, Uzbekistan was welcomed as a new INPRO member, bringing the membership to 44. INPRO members discussed progress, the initiation of new INPRO collaborative projects, updates to the INPRO Strategic Plan for 2024–2029 and the development and launch of a new INPRO advisory service on strategic planning for the deployment of sustainable nuclear energy systems.

The publication *Case Study on Assessment of Radiological Environmental Impact from Normal Operation* (IAEA-TECDOC-1996) presents examples of different approaches for estimating environmental impact from normal operation of NPPs using case studies from several countries.

The first INPRO school at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, trained participants on the use of the INPRO methodology in assessing and analysing nuclear energy systems for sustainability.







## Agency Advances Support to African Newcomers with INIR Report for Uganda

Agency support to African Member States interested in introducing nuclear power advanced in 2022 as Uganda completed its first Integrated Nuclear Infrastructure Review (INIR).

In May, the Agency delivered the final report of its Phase 1 INIR mission to the Government of Uganda, a country of 43 million people that is looking to diversify an energy mix currently based primarily on hydropower as demand for electricity grows. “The INIR mission concluded that the Government of Uganda is committed to developing the required infrastructure for nuclear power in a coordinated approach with all concerned stakeholders”, said Aline des Cloizeaux, Director of the Agency’s Division of Nuclear Power, in the Ugandan capital Kampala, where she handed over the report to President Yoweri Kaguta Museveni.

“Uganda is developing nuclear power because hydropower alone will not be sufficient to meet national development targets”, said President Museveni, adding that, in addition to electricity generation, nuclear energy would be used for “medical and agricultural purposes”.

The INIR is a holistic peer review that supports Member States in assessing the status of national infrastructure for the introduction and development of a safe, secure and sustainable nuclear power programme. It is based on the IAEA’s Milestones Approach, a comprehensive methodology that systematically guides countries across three phases and 19 different nuclear infrastructure issues towards the introduction of nuclear power. Uganda is among several newcomers in Africa that have hosted INIR missions. Others include Egypt, which is building its first nuclear power plant, Ghana, Kenya, the Niger, Nigeria and the Sudan.

