

Nuclear Power

Objective

To assist Member States considering the introduction of nuclear power programmes in planning and building their national nuclear infrastructures. To provide integrated support to Member States with existing nuclear power programmes and to those planning new nuclear build in order to help improve operating performance and safe long term operation through the implementation of good practices and innovative approaches, and lessons learned from the Fukushima Daiichi accident. To provide collaborative frameworks for operators of water cooled reactors to benefit from advances in technology, and for Member States to facilitate effective development of fast reactors and gas cooled reactors and to expand the safe use of non-electric applications.

Launching Nuclear Power Programmes

In 2015, around thirty Member States were actively considering or planning a nuclear power programme (Table 1). The Agency continued to support these embarking countries, mainly through technical cooperation projects, in areas such as establishing the appropriate legal and regulatory framework, strengthening coordination among national institutions, drafting and reviewing human resource development plans, and developing radioactive waste management policies and strategies. Through focused interregional, regional and national workshops, training courses and fellowships, it provided staff of nuclear power development projects, regulatory bodies and technical support organizations substantive training in various infrastructure issues. More than 15 events took place in 2015 focused on increasing Member State awareness and understanding of the ‘Milestones’ approach and key infrastructure issues such as management, human resource development, the legal and regulatory framework, and funding and financing. Stakeholder involvement continued to be an important area of focus for countries at all stages of nuclear infrastructure development. The Agency facilitated expert missions related to stakeholder involvement in Egypt, Indonesia, Kenya, Saudi Arabia and Viet Nam, as well as workshops in Finland and Japan.

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TABLE 1. Number of Member States considering or planning a nuclear power programme, according to their official statements (as of 2015)

First nuclear power plant started construction/under construction	2
First nuclear power plant ordered	1
Decided to introduce nuclear power and started preparing the appropriate infrastructure	7
Active preparation for a possible nuclear power programme with no final decision	7
Considering nuclear power programme	10

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To better coordinate assistance to newcomer countries, the Agency consolidated coordination mechanisms such as Country Nuclear Infrastructure Profiles and Integrated Work Plans (IWPs). Taking into account the recommendations of Agency missions and the results of technical cooperation projects, the Country Nuclear Infrastructure Profiles and IWPs of several countries were updated in 2015, in consultation with the Member States concerned.

The Agency’s Integrated Nuclear Infrastructure Review (INIR) missions continued to be in high demand in 2015. These missions provide Governments and nuclear programme stakeholders with an overall, integrated view of the status of all 19 infrastructure issues of the ‘Milestones’ approach to introducing a nuclear power programme. INIR recommendations enable Member States to determine which infrastructure areas require further development to meet programme needs and schedule requirements. In 2015, an analysis of past INIR mission recommendations and suggestions was published in *Integrated Nuclear Infrastructure Review (INIR) Missions: The First Six Years* (IAEA-TECDOC-1779). The publication analyses the outcomes of the reviews and derives a picture of the challenges faced by countries hosting INIR missions and the approaches they have developed to address them. Also during the year, steps were taken to finalize the concept for INIR Phase 3 missions, as called for in the IAEA Action Plan on Nuclear Safety and several General Conference resolutions.

In the United Arab Emirates (UAE), construction continued on the country’s first nuclear power plant, at Barakah; the first of the plant’s four units is expected to be operational by 2017, and the final unit, by 2020. The Agency conducted three safety and security related review missions to the UAE in 2015. Construction continued on both units of Belarus’s first nuclear power plant (Fig. 1). Commissioning of the units is planned for 2018 and 2020. The Agency organized several expert missions during the year to advise stakeholders on developing a regulatory framework and ensuring that the required human resources are available. In introducing nuclear power, Turkey is using a build–own–operate contracting approach. In 2015, Turkey’s IWP was updated to ensure that Agency assistance and services that support nuclear power infrastructure development are applied effectively, in terms of timing and content, to support the development of the country’s nuclear power infrastructure.



FIG. 1. Construction of Units 1 and 2 of the Ostrovets nuclear power plant in Belarus. (Photograph courtesy of the Directorate for Nuclear Power Plant Construction, Belarus.)

Several countries introducing nuclear power advanced in developing their infrastructure in 2015. Bangladesh established the Rooppur Nuclear Power Plant Company to operate the country's first nuclear power plant and started negotiations on state credit and on the general engineering and construction contract. Egypt conducted site evaluation activities and signed an agreement for the construction of a nuclear power plant with four units on the Dabaa site. Jordan signed contracts to perform a water supply study and site supervisory activities, and the Jordan Nuclear Power Company was established in October. Kazakhstan officially requested an INIR mission, scheduled to take place in 2016. An INIR mission concluded that Nigeria had made progress in the development of its nuclear infrastructure and made recommendations for further actions. The Agency and Nigeria developed a four year IWP to ensure that future support is tailored to those recommendations and addresses all nuclear power infrastructure issues in a balanced and prioritized manner. Poland, through its national technical cooperation programme, implemented activities on waste management strategy, developing industrial capabilities and technology transfer, site characterization, and site licensing, as planned in its IWP. It also held a national workshop on financing issues, in Warsaw, to discuss the investment framework. Viet Nam announced that the start of construction of its first nuclear power plant had been rescheduled for 2020–2022, in line with a reassessment of the time needed to build the necessary nuclear power infrastructure.

Ghana, Kenya, Malaysia, Morocco, Saudi Arabia and Sudan are actively preparing to take an informed decision on whether to introduce nuclear power into their energy mix; their focus is on conducting the necessary studies and preparing a comprehensive report. The Agency provided a variety of support during the year, including INIR missions to Kenya and Morocco that recognized the progress made and made recommendations for further actions. The Agency conducted advisory missions to Saudi Arabia and Malaysia supporting the development of self-evaluation reports. Its review of Ghana's draft nuclear power programme policy and road map, and training in the INIR self-evaluation methodology resulted in modifications to the work plan for that country's new technical cooperation project for nuclear power infrastructure development.

The Agency focused in particular on Africa in 2015. At the Third Conference on Energy and Nuclear Power in Africa, held in Kenya in April, representatives of 35 African Member States discussed the need to undertake sustainable energy planning, and many expressed an interest in nuclear power. Following the conference, Niger organized the first meeting of the West African Integrated Nuclear Power Group to study the possibility of creating a regional nuclear power programme. All requests for INIR missions in 2015 came from African countries; namely, Kenya, Morocco and Nigeria. At a Technical Meeting held in Vienna in July, representatives of ten African countries agreed to form the African Network for Enhancing Nuclear Power Programme Development (ANENP). During the 59th regular session of the Agency's General Conference, participants in a side event entitled 'Africa's Energy Needs and the Potential Role of Nuclear Power' highlighted the Agency's important role as a forum for newcomer countries and countries operating nuclear power plants to share knowledge and experience.

The Agency published an updated version of *Milestones in the Development of a National Infrastructure for Nuclear Power* (IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1)) in July. The new version takes into account feedback on implementation of the 'Milestones' approach in Member States and is expected to enhance and expand Agency guidance for embarking countries.

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Operating Nuclear Power Plants

At the Fifth Nuclear Operating Organization Cooperation Forum, held during the 59th regular session of the General Conference in September, industry executives from

Canada, Finland, Japan and the Republic of Korea, and from the Electric Power Research Institute, World Association of Nuclear Operators and NUGENIA (Nuclear Generation II and III Association) discussed the top challenges for the nuclear power industry in the next decade. The more than 75 participants agreed that new strategies and tools, and organizational resilience were needed to address challenges resulting from changing nuclear, environmental and financial policies, coupled with evolving energy markets and portfolios that include renewable sources.

New Publication on Plant Life Management Models

When nuclear power plants reach the end of their nominal design life, they undergo a special safety review and an ageing assessment of their essential structures, systems and components before their licence to operate is validated or renewed for terms beyond the original service period. In 2015, the Agency issued *Plant Life Management Models for Long Term Operation of Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-3.18), which highlights the licensing practices of several Member States regarding long term operation. The publication supports nuclear power plant owners and operators planning an extension of plant operation beyond design life, and provides information on the necessary mechanisms for implementing ageing management in plants constructed with long term operation in mind.

Milestones e-Learning Modules

The Agency developed two new e-learning modules based on the ‘Milestones’ approach, bringing to 13 the number of modules available on the Agency’s web site (Fig. 2). Over 40 participants from 28 Member States presented their feedback on using the modules at a Technical Meeting on education and training using e-learning tools, held in Vienna in March. Participants affirmed the usefulness and appropriateness of the content, and made recommendations for improvements.

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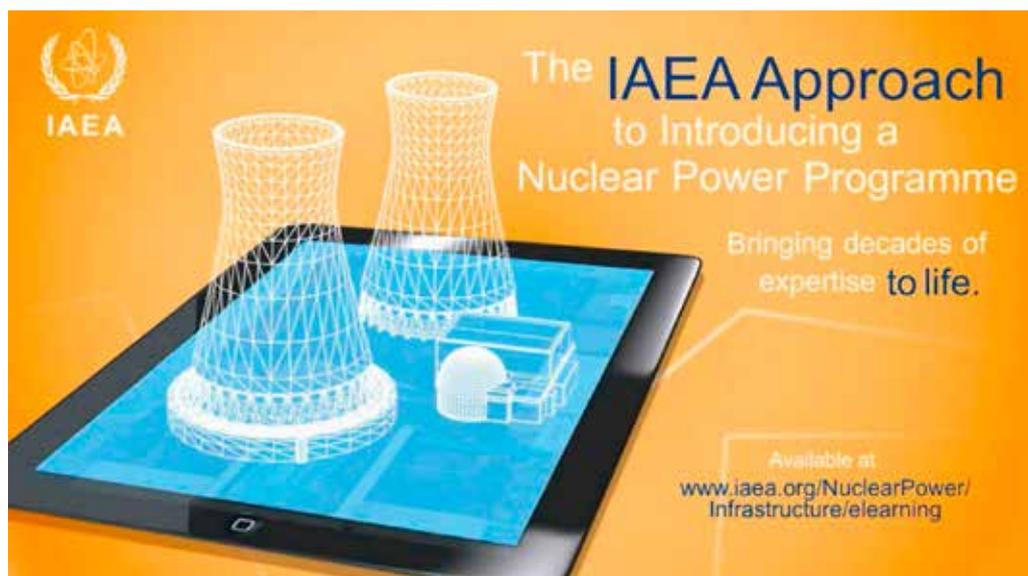


FIG. 2. The Agency’s ‘Milestones’ approach to introducing a nuclear power programme is featured in 13 interactive e-learning modules available on the Agency’s web site.

Capacity Building and Management Support

Throughout the year, the Agency held a number of Technical Meetings and workshops to provide training in areas such as communication, management systems, the nuclear supply chain and industrial safety. Recognizing that responsible, sustainable nuclear power programmes require a commitment to open and transparent communication, the Agency organized a Technical Meeting on best practices in media and public communication for nuclear power programmes. Hosted by Fukui Prefecture, Japan, in October, the meeting was attended by more than 50 participants from 23 countries, both newcomer countries and countries with established nuclear power programmes. The participants focused on sharing experience, good practices and lessons learned, and on exploring how to enhance competencies and better respond to stakeholders' needs.

The joint IAEA–FORATOM Management System Workshop, held in June in Gloucester, United Kingdom, focused on leadership and management for safety in a challenging environment. Over 100 participants from 28 Member States discussed how safety can be enhanced through leadership and management, thinking beyond the rules and managing risks. They also shared practical examples of managing safety.

Member States showed considerable interest in topics related to the supply chain in 2015. Three workshops on bid evaluation and contracting for nuclear power plants, held through the technical cooperation programme, assisted Bangladesh, Malaysia and Viet Nam in establishing adequate processes for procurement.

A Technical Meeting on industrial safety at nuclear facilities, held in Fuqing, China, in November, enabled 22 participants from 11 Member States to share their experience and practices in this area, and to provide feedback on a draft Agency guidance document on the subject. Meeting participants noted that identifying and tracking near miss events and all instances of time lost due to accidents and injuries remained a challenge in many Member States.

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Support for Accident Monitoring Systems for Nuclear Power Plants

In February, the Agency issued *Accident Monitoring Systems for Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-3.16), covering all relevant aspects of accident monitoring in nuclear power plants. The report addresses issues such as accident management and accident monitoring strategies; selection of plant parameters for monitoring plant status; and establishment of performance, design, qualification, display and quality assurance criteria for designated instrumentation.

Development and Implementation of a Process Based Management System

Implementing a process based management system can be challenging for organizations accustomed to traditional, non-integrated, non-process based management systems. In this regard, in 2015 the Agency published *Development and Implementation of a Process Based Management System* (IAEA Nuclear Energy Series No. NG-T-1.3). The publication provides practical guidance to nuclear organizations planning to implement a management system in compliance with the requirements established in *The Management System for Facilities and Activities* (IAEA Safety Standards Series No. GS-R-3), as well as to nuclear organizations in embarking countries.

Nuclear Power Technology Development

In February, in the framework of the IAEA Action Plan on Nuclear Safety, the Agency hosted an International Experts Meeting on Strengthening Research and Development Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant. Over 150 experts from 35 Member States and 5 international organizations discussed post-Fukushima research and development strategies, measures to protect nuclear power plants against external and internal events, technologies to prevent and mitigate severe accidents, severe accident analysis, emergency preparedness and response, and post-accident recovery. The Agency followed up the meeting by holding a Technical Meeting on Severe Accident Mitigation through Improvements in Filtered Containment Venting for Water Cooled Reactors, in August, and a Training Meeting on Post-Fukushima Research and Development Strategies and Priorities, in December. During 2015, the Agency developed a training toolkit designed to support capacity building in Member States that are embarking on a severe accident management programme.

A workshop held in Vienna in September, with 34 participants from 23 Member States, was aimed at assisting embarking countries in evaluating available nuclear power technologies against their own country specific environments, site requirements and energy needs. Courses on understanding the physics and technology of advanced reactors using PC based simulators were held in Chile, Jordan, the Republic of Korea and the United States of America, which together drew 157 participants from over 20 Member States. Also in 2015, the Agency launched a new activity aimed at studying the integration of nuclear power with renewables and smart grids. A booklet entitled *Advanced Large Water Cooled Reactors*, based on the Agency's Advanced Reactors Information System (ARIS) database, was published in September.

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In response to growing interest in the development of small modular reactors for both electricity generation and non-electric applications, the Agency held a side event at the General Conference in September and a Technical Meeting in Vienna in October highlighting design, safety, regulation and operational aspects of small modular reactors to promote sustainable nuclear power technology for near term deployment. At a Technical Meeting on the Economic Analysis of High Temperature Gas Cooled Reactors and Small and Medium Sized Reactors, held in Vienna in August, 17 participants from 14 Member States and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA) identified the need for technology developers and economists to cooperate closely in order to ensure more accurate economic analyses of advanced small reactor designs.

In the area of fast reactors, the Agency's activities in 2015 were focused largely on safety related issues. The Agency continued its work with the Generation IV International Forum on developing safety design criteria for and guidelines on innovative sodium cooled fast reactors. A Technical Meeting on Passive Shutdown Systems for Liquid Metal-cooled Fast Reactors (LMFR), held in Vienna in October, was attended by 20 experts from 12 Member States. In May, the Agency hosted the 48th annual Meeting of the Technical Working Group on Fast Reactors, in Obninsk, Russian Federation. Discussions among the 22 participants from 17 Member States and the European Commission included proposals for Technical Meetings, coordinated research projects (CRPs) and studies to be implemented in forthcoming programme and budget cycles. The new Fast Reactor Knowledge Preservation Portal went live at the end of the year, enabling Member States with a fast reactor programme to share both publicly available and protected data and documentation on fast neutron systems, and to retrieve information on recent and ongoing CRPs and other studies. In 2015, the Agency issued two publications on fast reactors: *Fast Reactors and Related Fuel Cycles: Safe Technologies and Sustainable Scenarios* and *Status of Accelerator Driven Systems Research and Technology Development* (IAEA-TECDOC-1766).

The Agency's activities in the area of high temperature (gas cooled) reactors in 2015 supported near term deployment through evaluations of technology readiness, safety requirements, economics and sustainability aspects. At the Technical Meeting on Re-evaluation of Maximum Operating Temperatures and Accident Conditions for High Temperature Reactor Fuel and Structural Materials, held at the Agency's Headquarters in January, participants concluded that reactor deployment with coolant outlet temperatures of up to 850°C is already possible. At the June meeting of the CRP on Modular High Temperature Gas Cooled Reactor Safety Design, held in Vienna, participants adopted two approaches to establishing safety design criteria that take the unique design and safety characteristics of such reactors into account. The Training Course on High Temperature Gas Cooled Reactor Technology hosted by Indonesia in October attracted more than 40 participants from 17 Member States. The course addressed the technological features of modular high temperature gas cooled reactor (HTGR) designs, the impact of their inherent safety characteristics and the safety assessment of advanced HTGR concepts. The Agency launched a new initiative to preserve the high temperature reactor knowledge developed over many decades at the Jülich Research Centre as part of a larger knowledge preservation effort, similar to the one already in place for fast reactors.

In view of the renewed interest in cogeneration of electricity and process heat for non-electric applications using nuclear energy, the Agency organized several activities relating to seawater desalination, hydrogen production and industrial applications. It also continued to upgrade the related tools and toolkits developed to help decision makers evaluate the feasibility of such applications. In 2015, the Agency published *New Technologies for Seawater Desalination Using Nuclear Energy* (IAEA-TECDOC-1753) and organized three major Technical Meetings on the topic, in Vienna, Istanbul and Mumbai, attracting 41 participants from 18 Member States and the OECD/NEA. Also during the year, the Agency organized a consultants meeting to draft a generic guidance report on nuclear cogeneration, held in Vienna. The report will define all aspects of a study of the technical and economic feasibility of using nuclear energy for seawater desalination, both alone and for cogeneration options.

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Enhancing Global Nuclear Energy Sustainability through Innovation

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) aims at ensuring that nuclear energy is available to contribute to meeting the energy needs of the twenty-first century in a sustainable manner. With Thailand joining in 2015, INPRO's membership grew to 41. During the year, Nuclear Energy System Assessments were under way in Indonesia, Romania and Ukraine to support strategic, long range nuclear energy planning. A preparatory meeting was held in the Russian Federation to begin limited scope assessments of specific sodium cooled fast reactor designs using the INPRO methodology.

Two joint consultancies were held in Vienna in May and in September–October with sodium cooled fast reactor design authorities from China, India and the Russian Federation, covering sustainability assessments of reactor safety and economics using the INPRO methodology. A Training Course on Nuclear Energy System Modelling and Assessment Using the INPRO Methodology, held in November in Kuala Lumpur, Malaysia, attracted 29 participants from nine Member States. Three Technical Meetings held in Vienna in November and December, with 36 participants from 16 Member States and the OECD/NEA, focused on INPRO collaborative projects on nuclear fuel and fuel cycle analysis of future nuclear energy systems, key indicators for innovative nuclear energy systems, and waste from innovative types of reactors and fuel cycles. Interactive WebEx based lectures on modelling of nuclear energy systems and assessments using the INPRO methodology were delivered to several universities and research institutions in Member States.

The Tenth INPRO Dialogue Forum, held in Vienna in May, addressed cooperative approaches to the back end of the nuclear fuel cycle and included discussions of drivers of these approaches as well as legal, institutional and financial impediments. The Eleventh INPRO Dialogue Forum, held in Vienna in October, considered the development of road maps for a transition to globally sustainable nuclear energy systems. These two Forums attracted 87 experts from 31 Member States.