Nuclear Power

Objective

To enhance the capability of interested Member States considering launching nuclear power programmes to plan and build the necessary infrastructure. To enhance the capability of interested Member States with existing nuclear power programmes to improve nuclear power plant operating performance, life cycle management including decommissioning, human performance, quality assurance and technical infrastructure, through good practices and innovative approaches consistent with global objectives on non-proliferation, nuclear safety and security. To enhance the capacity of Member States to develop evolutionary and innovative nuclear technology for electricity generation, for actinide utilization and transmutation and for non-electric applications, consistent with sustainability goals.

Launching Nuclear Power Programmes

Nuclear power remains an important option to increase electricity production for countries with growing energy requirements. Although a few countries have delayed decisions to start nuclear power programmes, significant steps were taken in 2012 by several countries planning to introduce nuclear power. In July, the United Arab Emirates (UAE) became the first country in 27 years to start the construction of a first nuclear power plant (Barakah-1), when the Emirates Nuclear Energy Corporation (ENEC) poured the first concrete after receiving a construction licence from the Federal Authority for Nuclear Regulation (Fig. 1). Belarus and Turkey, which had previously signed contracts, continued their preparation for licensing construction in 2012. Table 1 compares Member States at different stages of decision making and planning for nuclear power at the end of 2011 and 2012, according to their official statements.

FIG. 1. Construction at Barakah-1 in the UAE (photograph courtesy of ENEC).

Table 1. Number of Member States at different stages of decision making and planning for nuclear power in 2011 and 2012

	2011	2012
First nuclear power plant started construction	0	1
First nuclear power plant ordered	3	2
Decided and started preparing infrastructure	6	6
Active preparation with no final decision	6	6
Considering a nuclear power programme	14	13

The Agency continued to cooperate with States that have taken a decision on starting a nuclear power programme ('newcomer' countries) and that are actively building infrastructure. As an example, during the General Conference, the Member State delegations of all advanced newcomers met with Agency experts on nuclear infrastructure development.

Integrated Nuclear Infrastructure Review (INIR) missions were conducted in Belarus, Jordan and Vietnam in 2012. An updated INIR evaluation methodology was used for the first time in December 2012 during the mission to Vietnam. To better assist Member States in completing Phase 3 of the 'Milestones' approach[1] — i.e. activities to commission a first nuclear power plant — the concept for INIR missions to Member States at this phase was developed.

[1] For further information on the phases, see INTERNATIONAL ATOMIC ENERGY AGENCY, *Milestones in the Development of a National Infrastructure for Nuclear Power*, IAEA Nuclear Energy Series No. NG- G-3.1, IAEA, Vienna (2007).

Engineering Support for Operation, Maintenance and Plant Life Management

There is continuing interest around the world in the long term operation of existing plants. The Agency organized the third International Conference on Nuclear Power Plant Life Management, held in Salt Lake City, USA, in May. Over 350 participants representing 38 Member States and 3 international organizations attended the conference. Among the issues discussed were ways to safely and efficiently extend the life of many of the world's operating nuclear power plants, as well as ways for existing reactors to effectively deal with the increased expectations for safety in a 'post-Fukushima world'.

At the second meeting of the Nuclear Operating Organizations Forum in September, more than 70 delegates and other participants from Member States met to share operating experience and management strategies to help strengthen the effectiveness of operating organizations. The important role of operating organizations and other stakeholders in the development of safe and sustainable nuclear power plants was recognized and recommendations were made to increase the Agency's interactions and strengthen its cooperation with nuclear power plant operators and other stakeholders in the nuclear industry.

"There is continuing interest around the world in the long term operation of existing plants."

The instrumentation and control (I&C) system of a nuclear power plant serves as its 'central nervous system', ensuring efficient and safe power production. An Independent Engineering Review of I&C Systems mission was conducted at the All-Russia Scientific Research Institute for Nuclear Power Plant Operation, Russian Federation, in December to review the computerized process control system of the AES-2006 nuclear power plant. The mission concluded that extensive engineering work of high quality had been performed to develop the advanced I&C system and that, in general, the reviewed areas met the requirements of the relevant sections of IAEA Safety Standards Series No. NS-G-1.3, *Instrumentation and Control Systems Important to Safety in Nuclear Power Plants*.

The Agency also supports Member States in enhancing the operational safety of existing nuclear power plants. In October and December, Agency experts participated in an international engineering review of reactor pressure vessel material at the Doel-3 and Tihange-2 plants in Belgium (Fig. 2). It was recommended that the licence holder, Electrabel, carry out a confirmatory test programme before the next refuelling outage, as well as an ultrasonic testing inspection, enabling validation of the overall safety case.

The long-standing cooperation of more than 30 years between FORATOM and the Agency in the area of management systems was formalized in March with the signing of a 'Practical Arrangement Agreement'. This agreement is intended to broaden cooperation to cover such areas as energy planning, human resources, and knowledge and waste management.

Human Resource Development

Developing human resources for nuclear power programmes in Member States has specific challenges that require innovative methods and approaches. Mentorship programmes have been established in the

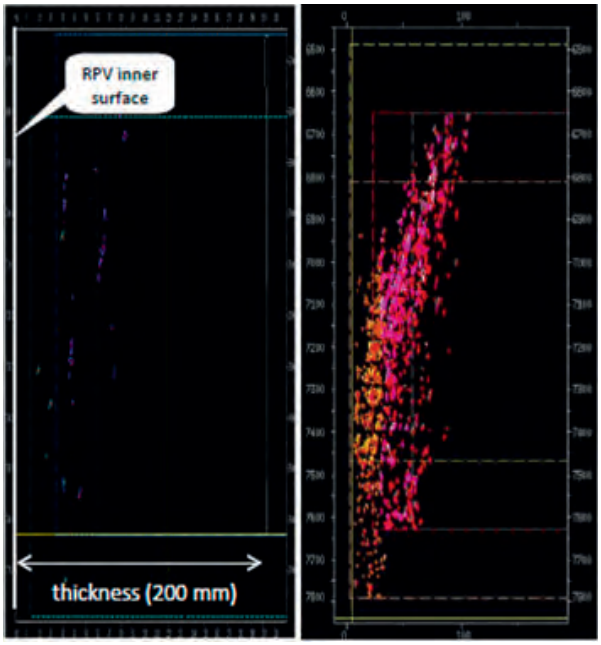

FIG. 2. Typical example of data recorded in the lower core shell of a reactor pressure vessel. The photograph on the left shows an axial section, with indications appearing as colour spots. The photograph on the right shows the accumulation of indications, all detected in a 20° sector of the shell (photograph courtesy of Electrabel).

Asia–Pacific region, in collaboration with experienced countries such as China, Japan and the Republic of Korea, for senior managers and decision makers from countries starting nuclear power programmes. In July, the Agency signed an arrangement with the Korea Electric Power Corporation International Nuclear Graduate School, covering international student recruitment, curriculum development, and seminar and outreach programmes.

One of the Agency's main areas of focus for newcomer States is to help them review the adequacy of their existing national capacity building arrangements and to strengthen them as necessary. A technical meeting in October on 'Capacity Building and Human Resource Development for New and Expanding Nuclear Power Programmes' developed a self-assessment methodology for this purpose, training the 29 participants from 25 Member States.

The Agency's Nuclear Power Human Resources (NPHR) modelling tool supports Member States in analysing their national workforce planning process. Bangladesh, Indonesia, Malaysia, Thailand and Vietnam were trained in the use of this tool, which can be adapted to reflect a country's national needs (Fig. 3).

The increasing cost effectiveness and efficiency of distance learning for training and capacity building in Member States led the Agency to establish a 'Framework Agreement' for the coordinated procurement of e-learning materials. Implementation continued of the 'Milestones' e-learning project to create content for non-experts considering nuclear power. In addition, modules on the 'Milestones' approach for human resource development, stakeholder involvement, project management and construction management were being developed.

In October, the Agency organized a technical meeting focusing, for the first time, on stakeholder involvement in nuclear power. The goal of the meeting, jointly organized with FORATOM, was to exchange information and develop sustainable relationships. The more than 50 participants from 29 countries shared experience, and identified activities and areas that the Agency could support to assist Member States embarking on nuclear power programmes or those with existing programmes.

Nuclear Reactor Technology Development

In the area of advanced water cooled reactors, a course reviewing the science and engineering of supercritical water cooled reactor (SCWR) concepts was held at McMaster University in Mississauga, Canada, in July, under a CRP on 'Heat Transfer Behaviour and Thermo-hydraulics Code Testing for SCWRs'. Sixteen collaborating institutes from nine Member States and two international organizations, including the OECD/NEA, participated in this CRP, which was completed in September. Results included the establishment of a database on heat transfer and pressure drop in supercritical fluid at the OECD/NEA.

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In the area of small and medium sized reactors, Agency activities focused on addressing cross-cutting technology and institutional issues in the light of the accident at the Fukushima Daiichi nuclear power plant. A booklet on the *Status of Small and Medium-sized Reactor Designs*, a supplement to the Agency's Advanced Reactors Information System, was published in September, providing information on advanced reactor designs and concepts.

Gas cooled reactor activities in 2012 concentrated on closing technology development gaps by providing a platform for information exchange and international collaboration. A publication on *Advances in High Temperature Gas Cooled Reactor Fuel Technology* (IAEA-TECDOC-CD-1674) was published in 2012 summarizing the results of a CRP on 'Advances

FIG. 3. Training course on the Agency's NPHR model.

in HTGR Fuel Technology'. Efforts to preserve knowledge in this area led to the development of a training course on HTGR technology in October in Beijing, which was attended by 35 scientists and engineers from ten States.

The co-generation option for nuclear power plants (i.e. electricity and water production) is becoming more suitable for many countries, as was recognized in a technical meeting on 'Advances in Seawater Desalination Using Nuclear Power'. In addition, a new tool on water management in nuclear power plants, the 'Water Management Program' (WAMP), was released in November. WAMP provides a quick reference for the estimation of water requirements and helps in the evaluation of water needs during the siting evaluation and selection process of nuclear power plants, especially for newcomer countries.

"A two track revision of the INPRO methodology and an expansion of NESA to enable a comparison of nuclear energy systems with innovative technologies were also under way in 2012."

Enhancing Global Nuclear Energy Sustainability through Innovation

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) supports Member States in developing and deploying sustainable nuclear energy systems. In 2012, three States joined INPRO: Malaysia, Romania and Vietnam. This brought the number of members to 38[2].

In 2012, a nuclear energy system assessment (NESA) using the INPRO methodology was completed for Belarus, confirming in general the long term sustainability of the nuclear energy system planned for that country. Two more NESAs were under way, in Indonesia (Fig. 4) and Ukraine.

A two track revision of the INPRO methodology, based on feedback from concluded assessments, and an expansion of NESA to enable a comparison of nuclear energy systems with innovative technologies were also under way in 2012.

A number of reports on the results of completed collaborative projects, such as GAINS (Global Architecture of Innovative Nuclear Energy Systems Based on Thermal and Fast Reactors Including a Closed Fuel Cycle), were published. These include the *Role of Thorium to Supplement Fuel Cycles in Future Nuclear Energy Systems* (IAEA Nuclear Energy Series No. NF-T-2.4), *Proliferation Resistance: Acquisition/Diversion Pathway Analysis (PRADA)* (IAEA-TECDOC-1684) and *Assessment of Nuclear Energy Systems based on a Closed Nuclear Fuel Cycle with Fast Reactors* (IAEA-TECDOC-1639/Rev. 1).

Strategic discussions between nuclear technology holders, users and other stakeholders were promoted through the fourth and fifth INPRO Dialogue Forums, the former on 'Drivers and Impediments for Regional Cooperation on the Way to Sustainable Nuclear Energy Systems', held in July, and the latter on 'Long-term Prospects for Nuclear Energy in the Post-Fukushima Era', held in August. At the fourth Dialogue Forum, collaboration among States was confirmed as a necessary condition for making a transition to future sustainable nuclear energy systems (Fig. 5).

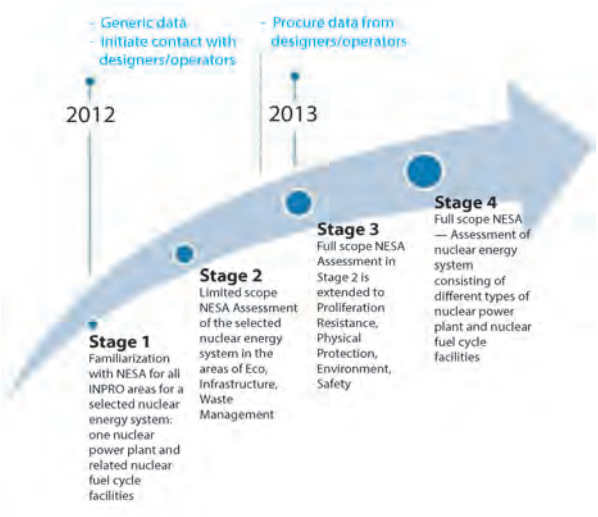

FIG. 4. A graded approach for the NESA for Indonesia.

[2] The members of INPRO at the end of 2012 were Algeria, Argentina, Armenia, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, Egypt, France, Germany, India, Indonesia, Israel, Italy, Japan, Jordan, Kazakhstan, Republic of Korea, Malaysia, Morocco, Netherlands, Pakistan, Poland, Romania, Russian Federation, Slovakia, South Africa, Spain, Switzerland, Turkey, Ukraine, United States of America, Vietnam and the European Commission.

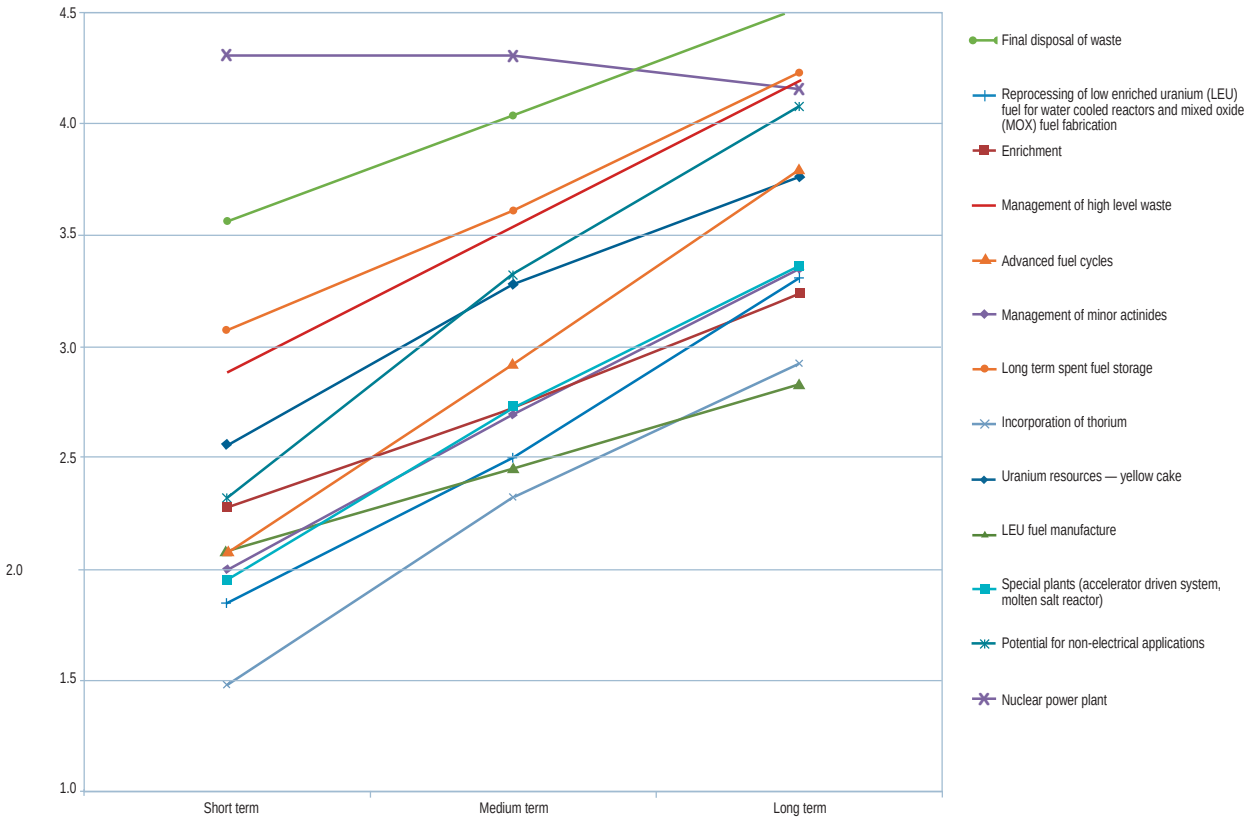

FIG. 5. Importance of collaboration with other States on issues relevant to the transition to sustainable nuclear energy systems.