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 and planned nuclear power programmes, in a rapidly changing market environment, 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 for the development of evolutionary and innovative nuclear system technology for electricity generation, for actinide utilization and transmutation, and for non-electric applications, consistent with sustainability goals.

Launching Nuclear Power Programmes

Despite the accident at TEPCO's Fukushima Daiichi nuclear power plant (hereinafter the Fukushima Daiichi accident), nuclear power remains an important option not only for countries with existing nuclear programmes, but also for developing countries with growing energy requirements. While some countries indicated that they would defer decisions about introducing nuclear power, others continued with such plans while incorporating emerging lessons from the Fukushima Daiichi accident. Table 1 compares the numbers of Member States at different stages of decision making and planning for nuclear power at year-end in 2010 and 2011, according to their official statements.

Integrated Nuclear Infrastructure Review (INIR) missions were conducted in Bangladesh and the United Arab Emirates in 2011. The INIR process itself was strengthened: an updated brochure on *Guidance on Preparing and Conducting INIR Missions* was published in April, and experts meetings were held to learn lessons from recent missions. Greater emphasis was also placed on preparatory activities, and a meeting in October considered the development of INIR missions to be carried out prior to commissioning, as is called for in the IAEA Action Plan on Nuclear Safety. The Agency began work in 2011 to update the evaluation methodology used in INIR missions.

Table 1. Member States at Different Stages of Decision Making and Planning to Introduce Nuclear Power in 2010 and 2011

	2010	2011
First nuclear power plant under construction	1	0
First nuclear power plant ordered	2	3
Decided and started preparing infrastructure	10	6
Active preparation with no final decision	7	6
Considering nuclear power programme	14	14

Engineering Support for Operation, Maintenance and Plant Life Management

The long term operation of nuclear power plants beyond the timeframe originally anticipated for them requires initiatives in education and training of plant personnel. The Fukushima Daiichi accident has focused additional attention, by both operators and regulators, on design reviews, the validity of a plant's original 'design basis' for extended periods, equipment stocks on-site, and non-safety-related structures, systems and components (SSCs) that are nonetheless important for severe accident management.

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In 2011, the Agency began development of guidelines for approaches and models related to plant life management (PLiM) for long term operation of nuclear power plants and issued two related publications. *Stakeholder Involvement throughout the Life Cycle of Nuclear Facilities* (IAEA Nuclear Energy Series No. NG-T-1.4) offers general guidance and examines the benefits of long term stakeholder involvement in nuclear facilities in terms of enhanced public confidence. *Stress Corrosion Cracking in Light Water Reactors: Good Practices and Lessons Learned* (IAEA Nuclear Energy Series No. NP-T-3.13) provides general descriptions of damage mechanisms associated with different types of stress corrosion cracking that are of concern to SSCs in light water reactors.

At a 'Nuclear Industry Cooperation Forum', held as a side event during the 55th regular session of the General Conference, about 65 representatives from the nuclear industry and the Agency shared operating experience and management strategies to enhance safety and improve performance in the wake of the Fukushima Daiichi accident.

"Cybersecurity received increased attention in 2011, in part owing to the critical role of digital systems in modern nuclear facilities."

To preserve valuable nuclear knowledge and expertise as many experts retire and to consolidate nuclear knowledge for the next generation of nuclear engineers and scientists, the Agency cooperates with the European Union's Joint Research Centre Institute for Energy and Transport (JRC-IET). In 2011, the Agency and JRC-IET began the development of a ten module, web based training course on irradiation embrittlement of WWER reactor pressure vessel material (Fig. 1).

Cybersecurity received increased attention in 2011, in part owing to the critical role of digital systems in modern nuclear facilities. A technical meeting in May on 'Newly Arising Threats in the Cybersecurity of Nuclear Facilities' proposed revisions to international guidance on computer security at nuclear facilities and recommended that the Agency undertake additional reviews of security guidance, start a CRP on the robustness of digital instrumentation and control systems against malicious acts, offer a peer review service on computer security, expand training, establish a 'community of practice' for the field and identify existing best practices in cybersecurity for nuclear facilities. The meeting concluded that while many organizations had worked on cybersecurity, their efforts had emphasized information technology and less work had been done on design requirements, the detection of and recovery from successful attacks, risk assessment, and verification and validation methods.

The successful expansion of a country's nuclear power programme depends on good relationships

FIG. 1. The WWER reactor pressure vessel embrittlement multimedia training course.

among the many parties involved. One way to ensure long term, reliable and sustainable relationships is the establishment of 'strategic partnerships', for example between a nuclear power plant operator and the design authority or vendor for the plant, or between a regulatory body and technical support organizations. In November, a technical meeting on 'Strategic Partnerships for the Expansion of a Nuclear Power Programme' brought together representatives from 15 Member States, who agreed that formalized strategic partnerships could significantly strengthen existing expansion capabilities. The participants also supported the Agency's assistance to Member States for the expansion of nuclear power programmes.

Human Resource Development

Human resource development remained a high priority, particularly for Member States considering launching nuclear power programmes. Two training courses on the topics of leadership and management for countries introducing nuclear power were organized jointly by the Agency and France and the United States of America, respectively. The French course was hosted by the French Alternative Energies and Atomic Energy Commission (CEA) at Saclay, France, in June, and the US course was hosted by Argonne National Laboratories in the USA in November. In October, the Republic of Korea hosted the third mentoring programme to be organized by the Agency and the Korea Hydro & Nuclear Power Company (KHNP), at which future leaders of nuclear power projects in six countries introducing nuclear power were mentored by recently retired KHNP executives.

A technical meeting in November on 'Recruitment, Training and Qualification of Personnel for New Nuclear Power Programmes' provided an opportunity for both newcomers and Member States with established programmes to share experience. Through the technical cooperation programme, workshops on workforce planning and human resource development were organized in Malaysia, Nigeria and Vietnam. The Agency also published *Workforce Planning for New Nuclear Power Programmes* (IAEA Nuclear Energy Series No. NG-T-3.10).

At the 55th regular session of the General Conference, the USA presented the Agency with 'Nuclear Power Human Resources' (NPHR), a software modelling tool that can be adapted for workforce planning for new and expanding nuclear power programmes. The Agency will develop NPHR further to help national decision makers understand the needs of the nuclear power programme for workforce development, based on regulatory frameworks and other factors. NPHR will also potentially help Member States to gather data to contribute to an Agency effort to survey the global human resource requirements of nuclear power programmes, including new programmes.

In parallel, the Agency launched a 'Nuclear Power Industry Workforce Survey' of those Member States with existing nuclear power programmes in an effort to identify the total existing nuclear power programme workforce, as well as the short to medium term human resource requirements of existing programmes. The results of this survey should be available in the first half of 2012.

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In the area of capacity building, and as part of the IAEA Action Plan on Nuclear Safety, the Agency is developing a new self-assessment method to enable Member States with existing nuclear power programmes, as well as those considering such programmes, to review the adequacy of their existing national capacity building arrangements and to identify areas to be strengthened.

Nuclear Reactor Technology Development

At a workshop on 'Technology Assessment of Small and Medium-sized Reactors (SMRs) for Near Term Deployment', held in December, potential buyers and operators of SMRs had the opportunity to learn from reactor designers about the specific design, safety and other features of various SMRs under development (Fig. 2). The workshop participants ranked reactor safety as the most significant consideration, followed by economics, proven technology, plant performance and operability, and constructability.

A new publication, *Construction Technologies for Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-2.5), provides information on conventional and advanced techniques and methods being used in different aspects of the construction phase

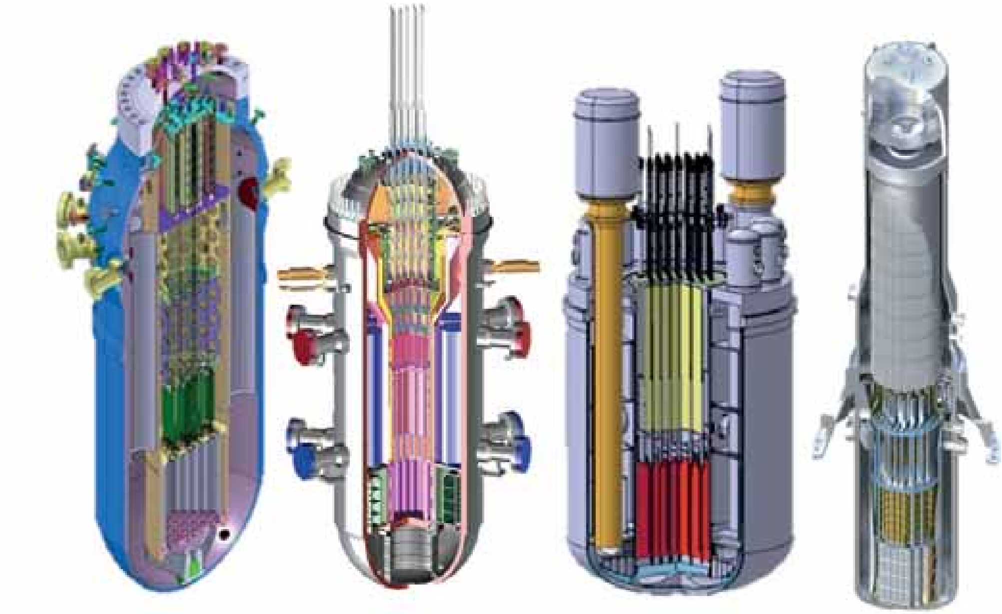

FIG. 2. Examples of SMRs under development (left to right): CAREM from Argentina, SMART from the Republic of Korea, SVBR-100 from the Russian Federation and mPower from the USA.

of projects, in both the nuclear and non-nuclear industries. In addition, workshops were held in Shanghai in June for the Asia region and in Paris in December for Africa and Europe. The workshops presented advances in construction techniques and the advantages and disadvantages of each technique.

Another workshop, on 'Non-electric Applications of Nuclear Energy', hosted by the Nuclear Research Institute Řež in the Czech Republic in October, recognized the need for international collaboration to reduce R&D costs. The importance of a pilot plant for hydrogen production using nuclear energy was also underlined.

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Updated versions of the Desalination Economic Evaluation Program (DEEP 4.0) and the Agency tool kit on nuclear desalination were released, with new features for easier use. The Agency also released a complementary new tool, the Desalination Thermodynamic Optimization Program (DE-TOP), for analysing the thermodynamics of co-generation systems, with an emphasis on water desalination. The Thermo-Physical Materials Properties (THERPRO) database for light and heavy water reactors was upgraded to a new web based system available at *http://www.iaea.org/NuclearPower/THERPRO/* (Fig. 3).

Enhancing Global Nuclear Energy Sustainability through Innovation

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), which supports Member States in developing and deploying sustainable nuclear energy systems, welcomed three new members in 2011: Egypt, Israel and Jordan. This brought the number of members to 35.[1]

In 2011, the INPRO Steering Committee developed the 'INPRO Development Vision 2012–2017' (Fig. 4), with the strategic objective of working towards global nuclear energy system sustainability by modelling and analysing pathways for nuclear energy growth. The pathways include transition to fast reactors and the closing of the nuclear fuel cycle, promoting technical and institutional innovations, and supporting Member States in developing

[1] The members of INPRO at the end of 2011 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, Morocco, Netherlands, Pakistan, Poland, Russian Federation, Slovakia, South Africa, Spain, Switzerland, Turkey, Ukraine, United States of America and the European Commission.

FIG. 3. The THERPRO database clickable map of the periodic table of elements.

national long range nuclear energy strategies that take full advantage of available innovations.

Four Nuclear Energy System Assessments (NESAs) using the INPRO methodology were under way or initiated in 2011 in Belarus, Indonesia, Kazakhstan and Ukraine in support of national long range nuclear energy strategic planning. The NESA Support Package, developed to support a country's assessment, was extended to include sample data and 'e-NESA' software.

The INPRO collaborative project GAINS (Global Architecture of Innovative Nuclear Energy Systems Based on Thermal and Fast Reactors Including a Closed Fuel Cycle) was concluded. It identified and quantified the benefit of transitioning to a globally sustainable nuclear energy system based on fast reactors and closed fuel cycles. A follow-up project, Synergetic Nuclear Energy Regional Group Interactions Evaluated for Sustainability (SYNERGIES), was initiated, with the objective of

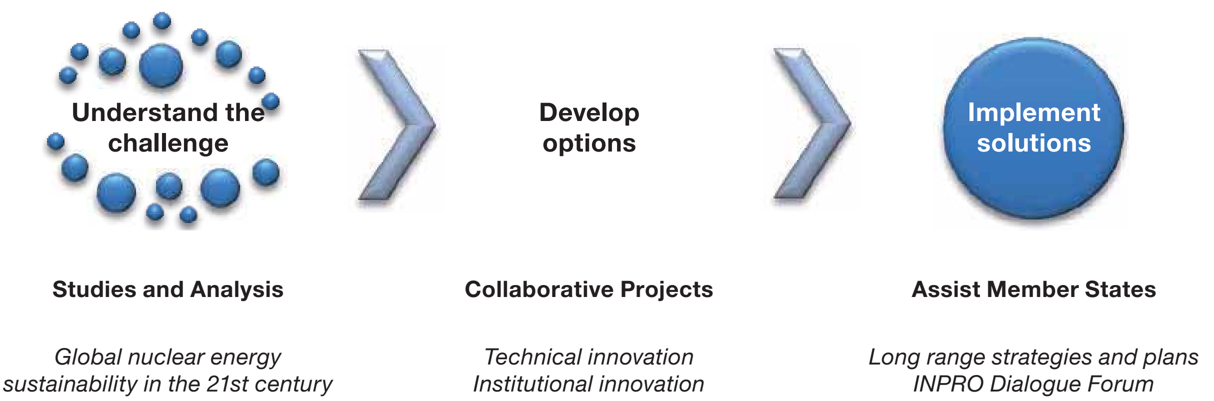

FIG. 4. Global nuclear energy sustainability and INPRO's contribution.

quantifying the benefit of collaboration and synergies among countries during this transition.

The 3rd INPRO Dialogue Forum, which promotes strategic discussions between nuclear technology holders, users and other stakeholders, discussed the development and deployment of small and medium sized reactors (SMRs) and initiated an in-depth survey on common user considerations for SMRs as a follow-up to the publication *Common User Considerations (CUC) by Developing Countries for Future Nuclear Energy Systems* (IAEA Nuclear Energy Series No. NP-T-2.1).