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 and Expanding Nuclear Power Programmes

Some 60 Member States have expressed interest in the introduction of a nuclear power programme. To strengthen coordination of Agency activities to respond to this interest, an Integrated Nuclear Infrastructure Group (INIG) was established in 2010. Its responsibilities include: the integration of information from various databases for more effective planning and delivery of support activities under technical cooperation projects; training in the use of energy planning tools; legislative assistance; guidance on ensuring beneficial, responsible and sustainable nuclear development; building capabilities, including self-assessment capabilities, among governmental and operating organizations; and the preparation and implementation of education and training materials.

In 2010, the Agency also established the Technical Working Group on Nuclear Power Infrastructure (TWG-NPI), a group of international experts to provide advice to the Agency to support Member States considering or introducing a nuclear programme and to share experience and information on national programmes.

Thailand was the site of the fourth Integrated Nuclear Infrastructure Review (INIR) mission, which benefited from the feedback, experience and lessons learned from the 2009 INIR missions to Indonesia, Jordan and Vietnam.

The Agency organized a workshop on 'Topical Issues on Infrastructure Development: Managing the Development of a National Infrastructure for Nuclear Power', which was attended by 100 representatives from 45 Member States, the European Commission and the World Association of Nuclear Operators. The main outcome was improved understanding of techniques for developing a national strategy for nuclear power and sharing of experience in starting a nuclear power programme. It was also recognized that a strong national strategy forms the basis for many aspects of the infrastructure including workforce planning. Additional workshops were organized in 2010 on common challenges in site selection for nuclear power plants and on industrial involvement and technology transfer for nuclear power plant projects.

"To strengthen coordination of Agency activities … an Integrated Nuclear Infrastructure Group (INIG) was established in 2010."

An interregional training course on leadership and management of nuclear power infrastructure in emerging nuclear power States, organized through the technical cooperation programme, was held in October at the Argonne National Laboratory (ANL) in the USA. The course, organized for a second year jointly by the Agency and the ANL, was attended by 28 participants at the decision making level from 20 Member States from Africa, Asia, Europe and Latin America.

Also through the technical cooperation programme, the Korea Hydro & Nuclear Power Company (KHNP) hosted a two week event to mentor potential future leaders of nuclear power programmes in developing countries. Experienced KHNP managers served as full time mentors to participants, and the KHNP organized site visits to a utility, an engineering company, a training centre, research organizations, an operating nuclear power plant, a construction site, a heavy component manufacturing company, government ministries and the nuclear safety regulatory body.

FIG. 1. Pouring the first concrete at the Sanmen nuclear power project site in China.

At the end of 2010, 24 countries were planning to expand their existing nuclear programmes, and of the 66 reactors under construction, all but one were in countries that are expanding or are planning to expand their existing programmes (Fig. 1). Any increase in the use of nuclear power is expected to occur largely through the expansion of existing nuclear power programmes. In 2010, the Agency therefore initiated new activities on expanding nuclear power programmes to help interested Member States develop the necessary nuclear power infrastructure for expansion and to build the needed expertise in operating organizations.

"At the end of 2010, 24 countries were planning to expand their existing nuclear programmes …"

Engineering Support for Operation, Maintenance and Plant Life Management

A number of Member States have given high priority to the long term operation of nuclear power plants beyond the 30 or 40 years originally anticipated. In 2010, there were 15 technical cooperation projects on strengthening Member State capabilities to improve nuclear power plant performance and service life, a doubling relative to the previous (2007–2008) cycle.

The Agency began two new CRPs in 2010, one on 'Continued Operations beyond 60 Years in Nuclear Power Plants' and the second on the 'Review and Benchmark of Calculation Methods on Piping Wall Thinning Due to Erosion–Corrosion in Nuclear Power Plants'. The objective of the first is to establish a quantitative evaluation method for possible continued operations beyond 50–60 years. The objective of the second is to improve methods for predicting piping wall thinning.

A unified procedure for lifetime assessment of components and piping in WWER nuclear power plants (VERLIFE) for the structural integrity of such plants was completed in 2010. This procedure had been partially developed by the European Union's Joint Research Centre in 2008 and was then completed under the leadership of the Agency. It has been approved for analysing reactor pressure vessels and piping categorized in a particular safety class by licensing authorities in Bulgaria, the Czech Republic, Hungary and Slovakia.

In the area of instrumentation and control (I&C), the Agency introduced a new review service, Independent Engineering Review of I&C Systems (IERICS). Two IERICS missions were conducted in 2010. The first visited the Doosan Heavy Industries & Construction Company Limited in the Republic of Korea to review the prototype of the advanced digital I&C systems designed for APR-1400 nuclear power plants. The second evaluated the digital I&C

systems, based on field programmable gate arrays, used for reactor protection, control and monitoring in Ukrainian nuclear power plants.

Human Resource Management

The Agency conducted 11 workshops on workforce planning in 2010. It also organized an international conference on 'Human Resource Development for Introducing and Expanding Nuclear Power Programmes,' in Abu Dhabi, United Arab Emirates, in March. At the conference, an initiative was announced by the Agency and eight other organizations to conduct a number of surveys of human resource needs throughout the nuclear power field, and to develop workforce planning tools for countries considering or launching new nuclear power programmes. The Agency will have a lead role in those aspects of the surveys related to operating organizations, regulatory bodies and staffing for new nuclear power programmes.

Nuclear Reactor Technology Development

Member States, both those considering their first nuclear power plant and those with an existing nuclear power programme, are interested in access to up to date information about all available nuclear reactor designs as well as important development trends. In 2010, the Agency introduced the Advanced Reactors Information System (ARIS). ARIS is a web accessible database that provides Member States with comprehensive and balanced information about all advanced reactor designs and concepts (Fig. 2) (*http://aris.iaea.org*).

In the area of water cooled reactors, the Agency produced two publications. *Good Practices in Heavy Water Reactor Operation* (IAEA-TECDOC-1650) identifies regulatory advances, occupational dose reductions, performance improvements, and operational and maintenance cost reductions achieved in heavy water reactor operation. *Advanced Fuel Pellet Materials and Fuel Rod Design for Water Cooled Reactors* (IAEA-TECDOC-1654) reviews the current status of and potential improvements in fuel rod designs for light and heavy water cooled power reactors.

"The Agency conducted 11 workshops on workforce planning in 2010. It also organized an international conference on 'Human Resource Development for Introducing and Expanding Nuclear Power Programmes,' …"

As part of a CRP, the Agency organized a training course on 'Natural Circulation Phenomena and Passive Safety Systems in Advanced Water Cooled Reactors'. The course provided lectures on actual examples of such systems, their theoretical and experimental background, and analytical methods

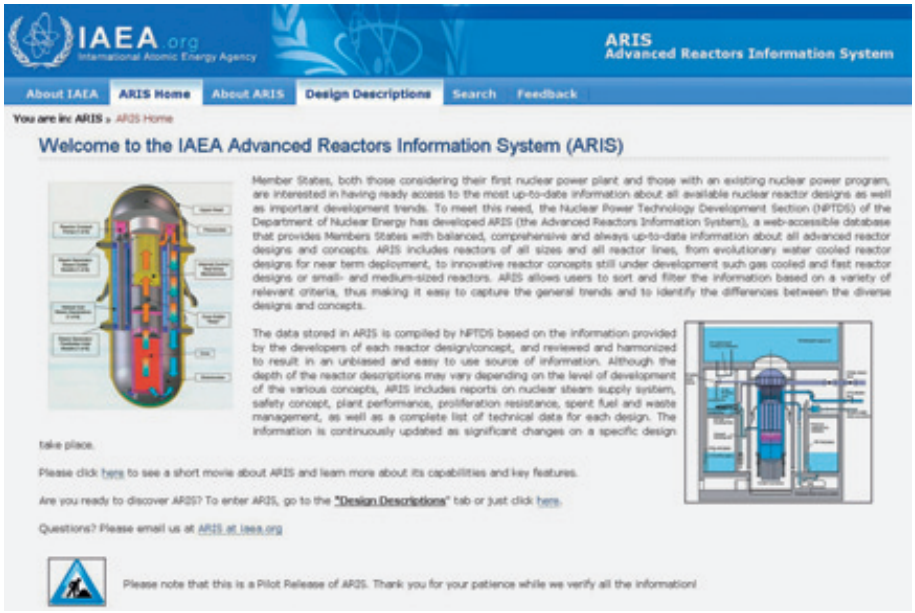

FIG. 2. The home page of the ARIS database.

for natural circulation phenomena in water cooled reactors.

With regard to fast reactors, the Agency organized a workshop — together with experts from Generation IV International Forum (GIF) member countries with fast reactor development programmes, the EC Joint Research Centre and the OECD/NEA — to exchange information on safety related fast reactor operational experience, various national safety approaches for the next generation of sodium cooled fast reactors (SFRs), and ongoing and planned R&D in this field. The workshop developed an improved understanding of safety issues of SFRs based on the comprehensive information contained in over 30 presentations from seven countries.

The Agency continues to facilitate technology development and improvements in the area of high temperature gas cooled reactors (HTGRs) to achieve the successful demonstration of HTGRs by Member States. Two CRPs related to advances in HTGR technology development were completed in 2010, one on 'Evaluation of High Temperature Gas Cooled Reactor Performance: Benchmark Analysis Related to the HTR-10, HTTR, PBMR 400, GT-MHR and the ASTRA Critical Facility' and another on 'Advances in HTGR Fuel Technology'. The first demonstrated the capabilities of the current generation of computational tools used for HTGR analysis and recommended areas for further development. These computer codes are capable of accurately predicting the transient experimental results from the Chinese HTR-10 reactor. The second CRP examined the use of current knowledge in coated fuel particle manufacturing processes by using different characterization techniques to investigate fuel quality at different manufacturing stages. The irradiation of the fuel and subsequent post-irradiation examination resulted in very low fission product releases, thereby demonstrating the high quality of coated particle fuel manufacturing technologies in existence today.

"The report identified the advantages of these reactors, such as the absence of refuelling equipment, stored fresh fuel or stored spent fuel at the sites of such reactors."

In the area of small and medium sized reactors, a CRP on 'Small Reactors without On-site Refuelling' was completed and its final report published as *Small Reactors without On-site Refuelling: Neutronic Characteristics, Emergency Planning and Development Scenarios* (IAEA-TECDOC-1652). The report identified the advantages of these reactors, such as the absence of refuelling equipment, stored fresh fuel or stored spent fuel at the sites of such reactors. It also developed a method to calculate emergency planning zones for such reactors, with risks comparable with those for large reactors. The report further identified experiments to reduce discrepancies in the results of neutron depletion codes used for fuel design.

The Agency offers the Hydrogen Economic Evaluation Program (HEEP), which can be used to compare nuclear and fossil energy sources as options for hydrogen production, as well as nuclear energy for hydrogen production alone versus nuclear energy for co-generation of hydrogen and electricity. In 2010, the Agency released an improved version of HEEP featuring easier installation, increased flexibility to override default values, an improved help manual and the elimination of software bugs. And *Environmental Impact Assessment of Nuclear Desalination* (IAEA-TECDOC-1642) was published, which assembles operating experience from existing nuclear desalination demonstration projects to estimate the environmental impacts of commercial scale nuclear powered desalination and compares them with those of desalination powered by fossil fuels.

INPRO

The Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) was established to ensure that sustainable nuclear energy is available to meet the energy needs of the 21st century. INPRO brings together technology holders and users so that they can consider what national and international actions are necessary to achieve innovations in nuclear reactors and fuel cycles. In 2010, the Agency marked the 10th anniversary of INPRO's founding in a technical session during the IAEA's 54th General Conference in September (Fig. 3). The session was attended by more than 50 Member States and highlighted achievements in understanding nuclear energy sustainability, long range nuclear energy planning, and promoting technical and institutional innovations.

FIG. 3. Director General Yukiya Amano addressing the technical session at the 54th General Conference to mark the tenth anniversary of INPRO's establishment.

Poland joined INPRO in 2010, bringing total membership to 32[1].

The Agency established the INPRO Dialogue Forum on Nuclear Energy Innovations in 2010. Two meetings were held. The first addressed socioeconomic and macroeconomic factors of nuclear energy deployment, proven technologies in innovative nuclear power systems and safety approaches for these systems. The second dealt with institutional challenges associated with multilateral approaches to sustainable nuclear power deployment.

The Agency completed an *Assessment of Nuclear Energy Systems Based on a Closed Nuclear Fuel Cycle with Fast Reactors* (IAEA-TECDOC-1639). The report identified: the benefits of multilateral approaches for countries with high growth and limited accumulations of spent fuel, and thus correspondingly limited amounts of plutonium; the likely reduction of environmental and waste impacts; the likely proliferation resistance benefits assuming advanced reprocessing not involving plutonium separation; and the design modifications needed to bring costs down to those of thermal reactors and fossil fuelled power plants. It proposed four follow-on collaborative projects for INPRO members, all of which are currently under way. Finally, Kazakhstan initiated a new national nuclear energy system assessment. This involves training provided by international and Agency experts on how to use the INPRO Methodology for nuclear energy system planning.

"The Agency established the INPRO Dialogue Forum on Nuclear Energy Innovations in 2010."

[1] Other members of INPRO are Algeria, Argentina, Armenia, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, the Czech Republic, France, Germany, India, Indonesia, Italy, Japan, Kazakhstan, the Republic of Korea, Morocco, Netherlands, Pakistan, the Russian Federation, Slovakia, South Africa, Spain, Switzerland, Turkey, Ukraine, the United States of America and the European Commission.