

# Nuclear Power

## Objective

To enhance the capability of interested Member States to implement competitive and sustainable nuclear power programmes and to develop innovative nuclear technologies for the future.

## Engineering and Management Support for Competitive Nuclear Power

Nuclear electricity production has grown almost continuously since the inception of the nuclear industry. Part of this growth is due to the construction of new nuclear power plants, part is due to the uprating of existing plants and part is due to energy availability improvements at existing plants. Since the beginning of the 1990s, when new construction slowed, energy availability improvements and power uprates have become, at the global level, increasingly important factors in expanding nuclear electricity production. From 1990 through 2004, global nuclear electricity production increased from 1901 to 2619 TW·h. Installed nuclear capacity rose from 327.6 to 366.3 GW(e), due to both new construction and uprates at existing facilities. The global average energy availability factor improved from 71.6 to 83.3%. The relative contributions of the three factors to the additional 718 TW·h produced in 2004 (compared with 1990) are shown in Fig. 1.

The results presented in Fig. 1 are based on comprehensive worldwide data available in PRIS, the Agency's database on power reactors. Work in 2005 focused on making PRIS a more practical tool for nuclear power plant performance analyses by improving the interface between the system and end-

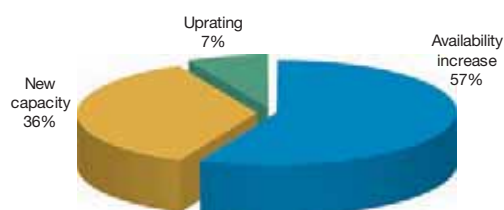


FIG. 1. Contributions to the growth of nuclear electricity production, 1990–2004.

users. This resulted in improved data consistency and completeness and in better applicability of PRIS statistics. External modules containing data from non-electrical applications of power reactors and information from decommissioning processes of shut down reactors were incorporated as an enhancement of PRIS. The extension of PRIS, together with relevant feedback from users, was documented in 2005 in a report entitled *Power Reactor Information System (PRIS) and its Extension to Non-Electrical Applications, Decommissioning and Delayed Project Information*.

Another effort focused on the modification and enhancement of the Capital Cost Database in the Agency's Nuclear Economic Performance Information System (NEPIS), developed jointly with the Electric Utility Cost Group in the USA, and a pilot project to collect data for the current NEPIS reporting cycle. The database was modified and enhanced by adding detailed cost accounts for significant capital projects on a unit basis, by making the definitions of capital cost accounts consistent with the previous NEPIS definitions (where applicable), and by consolidating all capital cost accounts into one module.

The Asia and Pacific region is one of the most dynamic in the world in terms of nuclear power development. In response to Member State needs, national and regional projects in 2005 under the Agency's technical cooperation programme covered energy planning, infrastructure development, design evaluation for new nuclear power plants, and management improvements to ensure the safe and reliable operation of nuclear power plants. One project study focused on the evaluation of nuclear power and other energy options in achieving sustainable energy development. As a result, Pakistan has adopted a long term development plan to build 8800 MW nuclear power plants over the next 25 years. Indonesia has included nuclear power as an energy option in its National Energy Development Plan, with the possible introduction of the first nuclear power plant in the country by 2016.

An important event in 2005 was the convening of an international ministerial conference on 'Nuclear Power for the 21st Century', organized by the Agency in cooperation with the OECD/NEA, and hosted by the Government of France. The Director General, in his opening remarks, focused on nuclear power's improving global outlook and important role in the world's future energy mix.

The conference included sessions on world energy needs and resources, environmental challenges, driving factors for strategies and choices, and issues of governance. Thirty-two ministerial presentations described different national perspectives and policies on the future of nuclear power. The vast majority of participants who attended the conference affirmed that “nuclear power can make a major contribution to meeting energy needs and sustaining the world’s development in the 21st century, for a large number of both developed and developing countries”, and that the “IAEA has an essential role to play in facilitating the development and use of nuclear energy for peaceful purposes, in ensuring compliance with peaceful use undertakings, in assisting States in maintaining high levels of safety and security, in fostering international cooperation and in disseminating to the public information on nuclear energy.”

After the tsunami of December 2004, the Agency organized a special workshop on external flooding hazards at nuclear power plants. Held in Kalpakkam, Tamil Nadu, together with the Indian Atomic Energy Regulatory Board and Nuclear Power Corporation of India Ltd, the workshop focused on the exchange of experience and the collection of technical information arising from the tsunami.

To increase Member State capabilities in the planning and implementation of nuclear power programmes, and in establishing and enhancing national nuclear power infrastructures, the Agency prepared reports on the minimum infrastructure necessary to establish a nuclear power programme, on sharing nuclear power infrastructure, ranging from joint training and research to grid integration, and management issues related to the early closure or licensing renewal of a nuclear power plant. Another publication, on the application to the nuclear industry of human performance improvement principles in organizations, is designed to enhance the capability of Member States to utilize proven practices accumulated, developed and transferred by the Agency for improving personnel performance.

## **Technology Development for Additional Applications and Expanding Nuclear Power**

The Agency’s Technical Working Groups on light water, heavy water, fast and gas cooled reactors bring together experts from developing and

industrialized Member States to identify key areas for the Agency to provide assistance, documentation and training, and to pool R&D resources from national organizations towards agreed common goals. In 2005, the Agency conducted a training course at the Abdus Salam ICTP in Trieste on natural circulation in water cooled nuclear power plants. And research began on a new CRP on heat transfer behaviour and thermal hydraulics code testing for supercritical water cooled reactors. Planning for this CRP is being coordinated with the OECD/NEA and the Generation IV International Forum Supercritical Water Cooled Reactor Steering Committee.

Partitioning and transmutation with multiple recycling of actinides and long lived fission products can reduce the radiotoxic inventory of waste by over two orders of magnitude. This will allow the confinement of the residual waste to reach levels equivalent to natural uranium within a few hundred years. To study this issue, the Agency prepared a publication on the *Implications of Partitioning and Transmutation in Radioactive Waste Management*.

Activities organized by the Agency to advance the development of small and medium sized reactors (SMRs) are focused on addressing the needs of countries with small grids or limited infrastructure. These activities bring together designers and technologists working on the challenge of overcoming the general economies of scale in reactor design to improve the overall economy and safety of smaller plants. In 2005, the Agency issued a publication on innovative SMRs which presents a range of water cooled, gas cooled, liquid metal cooled and non-conventional SMR designs developed worldwide and examines the technology and infrastructure development needs that are common to the various concepts of such reactors.

One trend in the design and technology development of SMRs is that of small reactors without on-site refuelling. These reactors could operate without reloading and shuffling of fuel for between 5 and 30 years, and possibly longer. A CRP on such reactors started in 2005 and will focus on key technologies, including long life cores, inherent and passive safety features and systems, and design and regulatory provisions to reduce or eliminate off-site emergency planning.

SMRs are of particular interest for desalination in many developing Member States. In India, a nuclear desalination demonstration plant in Kalpakkam has used reverse osmosis for desalination for several years and will be using the multi-stage flash process starting in 2006. In this connection, representatives

from over 15 Member States regularly share experience and identify future areas for work in the forum provided by the Agency's International Nuclear Desalination Advisory Group (INDAG).

In 2005, the Agency published a report on the results of a CRP that examined optimal coupling and desalination systems for nine water cooled reactor designs. The overall conclusion was that all of them can provide the input energy required for various desalination processes, i.e. distillation, osmosis and low temperature evaporation.

To assist with economic evaluations of site specific cases involving various types of nuclear reactors and desalination systems, the Agency's Desalination Economic Evaluation Program (DEEP) software was upgraded and the latest version released. This program incorporates improved plant performance and cost models in both the software's thermal and reverse osmosis modules. For the assessment of nuclear powered desalination against alternatives, DEEP adds the ability to evaluate alternatives fuelled by renewable resources, such as biomass, as well as fossil resources. A final new feature is that DEEP can be downloaded directly over the Internet under a licence agreement with the Agency. Eighty copies of the new version are already in use outside the Agency.

## INPRO

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) added two members in 2005 – Ukraine and the USA – bringing the total membership to 24. Tasks in the second part of Phase IB of INPRO, initiated in 2005, includes finalizing the INPRO methodology user's manual, defining and modelling innovative nuclear energy



FIG. 2. Construction work on the fast breeder reactor at Kalpakkam, in India.

system (INS) deployment scenarios, facilitating INS assessments by Member States, and identifying possible frameworks and implementation options for collaborative R&D. The terms of reference for Phase 2, which will begin midway through 2006, foresee that INPRO will continue in three directions: R&D, institutional/infrastructure, and methodology oriented activities.

Over the course of the year, the INPRO user methodology, having been revised on the basis of feedback from a variety of past test projects, was applied in multiple contexts. For example, Argentina applied the INPRO methodology to evaluate the introduction of nuclear power in a system with limited grid capacity, India used it to analyse nuclear systems for hydrogen generation, and China, France, India, the Republic of Korea and the Russian Federation applied INPRO methods in a joint study of a closed fuel cycle using fast reactors. Several States that are members of INPRO have progressed to an advanced stage of development in fast reactor technology (Fig. 2). ■