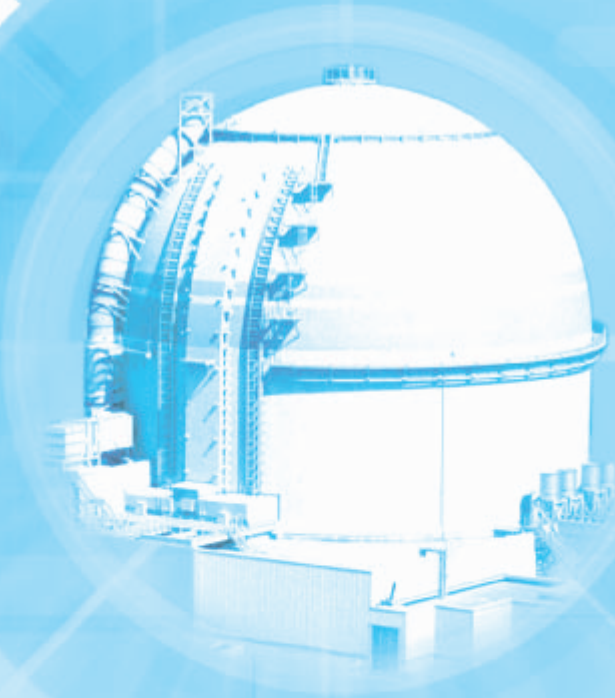


Technology



Nuclear Power

Objective

To increase the capability of interested Member States to implement and maintain competitive and sustainable nuclear power programmes.

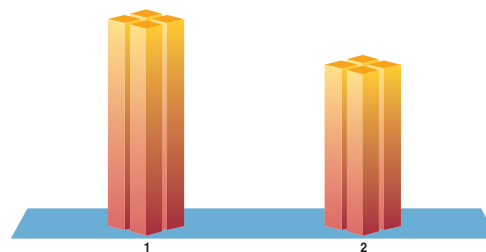
Key Issues and Highlights

- The Agency organized a symposium on nuclear power plant life management to address issues related to licence extension, retirement and decommissioning. As more nuclear power plants approach their original design lifetimes, decisions on such issues are becoming increasingly pressing.
- A new initiative was launched to harmonize the Agency's quality standards with the ISO 9001:2000 international standards.
- Interim results of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) were presented at various international conferences, and were submitted in full in a draft report to the INPRO Steering Committee in December.
- The Agency assisted in convening a conference on nuclear desalination in Marrakesh, and also completed publications on desalination design concepts and on the market potential of this technology. Furthermore, the Power Reactor Information System (PRIS) database was expanded to cover non-electrical applications (i.e. industrial heat, district heating and desalination) and decommissioning.
- Preserving knowledge on fast reactor technology was the objective of a new initiative launched by the Agency.

Engineering and Management Support for Competitive Nuclear Power

Nuclear power plants are ageing around the world. Figure 1 shows that more than a third – 130 plants – have operated for more than 25 years. With ageing, with capital investments fully written off, and with liberalizing electricity markets in many countries, it is increasingly important to know when to extend a

Regular budget expenditure: \$4 128 142
Extrabudgetary programme expenditure
(not included in chart): \$1 198 032



1. Engineering and Management Support for Competitive Nuclear Power: \$2 320 546
2. Nuclear Power Technology Development and Applications: \$1 807 596

plant's operating life, when to choose retirement and decommissioning, how to most cost effectively implement whichever path is chosen and how to get the maximum performance out of a valuable asset in the meantime.

In 2002, the Agency published a technical document on cost drivers for the assessment of nuclear power plant life extension which analyses data on licence extension costs and regulatory approaches in 12 Member States. It is the first international study published on the costs of plant licence extension.

The Agency is also participating in a study on decommissioning strategies and costs, initiated by the OECD/NEA. As a result of the Agency's involvement, ten non-OECD countries are involved in the study, thereby widening its international dimension significantly.

With respect to the ageing nuclear workforce and the challenge of transferring knowledge to the next generation, the Agency has been carrying out several activities for nuclear power plant personnel. These cover human resources management, defining core competencies that must be maintained for power plant operation and the effectiveness of alternative training programmes. For example, the 'Systematic Approach to Training' (SAT) minimizes competency gaps and continuously provides feedback to enhance nuclear power plant safety and reliability. A technical document was published on the effectiveness of

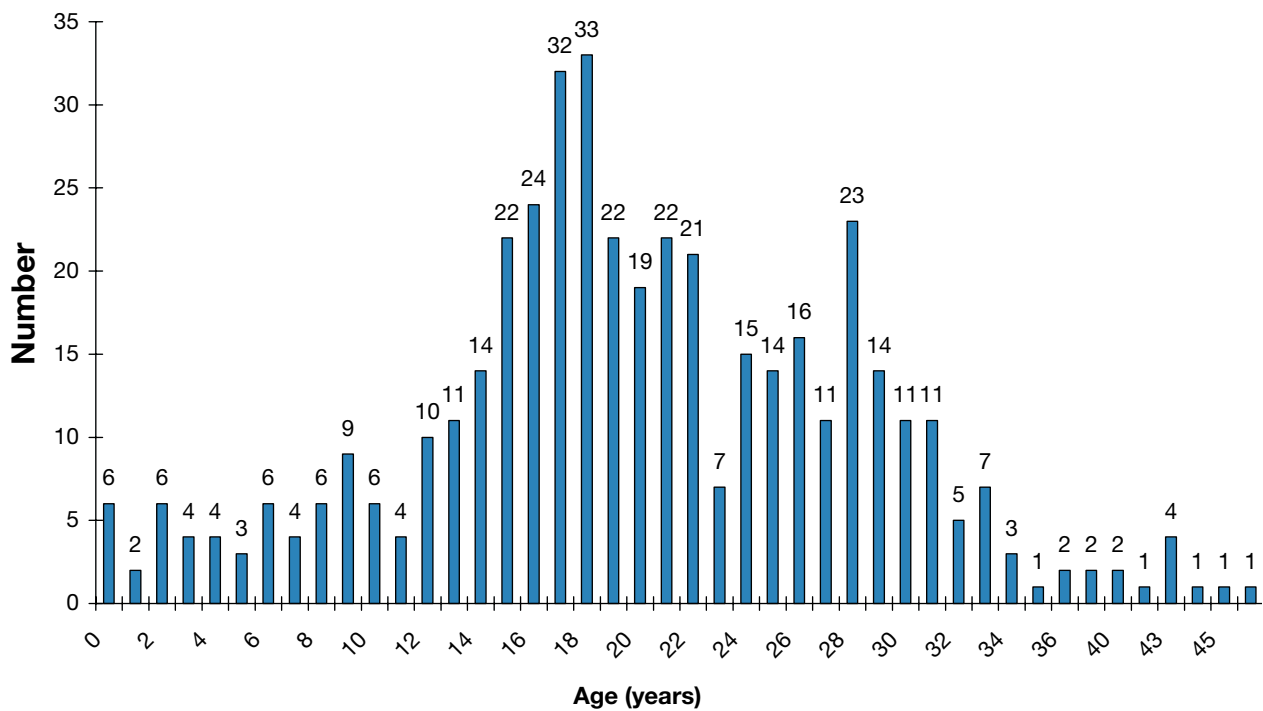


FIG. 1. Number of reactors worldwide by age (as of 31 December 2002).

nuclear power plant personnel training with guidance on evaluating and continuously improving training systems.

The Agency also completed a technical document on the use of control room simulators for nuclear power plant personnel training. While it focuses on training for control room personnel using full scope simulators, it also covers the use of these simulators (full scope or limited) for training other plant personnel. The report is intended to contribute to improved safety by providing new and better methods for training personnel other than operations personnel with simulators.

Modern information technology techniques can improve and enhance the efficiency of application of the SAT process and greatly enhance the retrievability of training information for the staff at nuclear power plants. In this regard, a CRP was completed on information management solutions for SAT applications, summarizing lessons learned and providing guidance for upgrading information management in Member State SAT programmes. The project emphasized computer based information management systems to improve operational efficiency and increase safety performance.

The Agency has published extensively on quality assurance and quality management (QA/QM) through its Safety Standards, Safety Reports, Technical Reports and Technical Documents. A meeting was convened in 2002 to develop a strategy for harmonizing quality

standards between the Agency and other organizations. Specifically, the Code and Safety Guides Q1–Q14 in IAEA Safety Series No. 50-C/SG-Q, *Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations*, are being harmonized with the ISO 9001:2000 international standards to permit a graded approach for implementation. This initiative, which cuts across the Agency and involves the participation of a broad range of external experts, will bring the Agency to the forefront of international QA/QM applications.

A technical report on nuclear power plant outage optimization strategies was published which provides guidance, as well as experience from current operating plants, for overall optimization through systematic outage planning, preparation, execution and post-outage reviews. Included are recent innovative strategies that have reduced refuelling outages to 8–10 days at some plants — 20 to 30 days if major maintenance work is carried out concurrently (Fig. 2). Careful, performance oriented, monitoring is essential for a high level of safety and reliability. The Agency is therefore outlining a common set of outage performance indicators for use before, during and after outage execution.

A CRP on national approaches to correlate performance targets and operations and maintenance costs emphasizes how economic measures can be used to optimize nuclear power plant performance, including safety performance. The CRP is developing indicators that can guide performance improvements

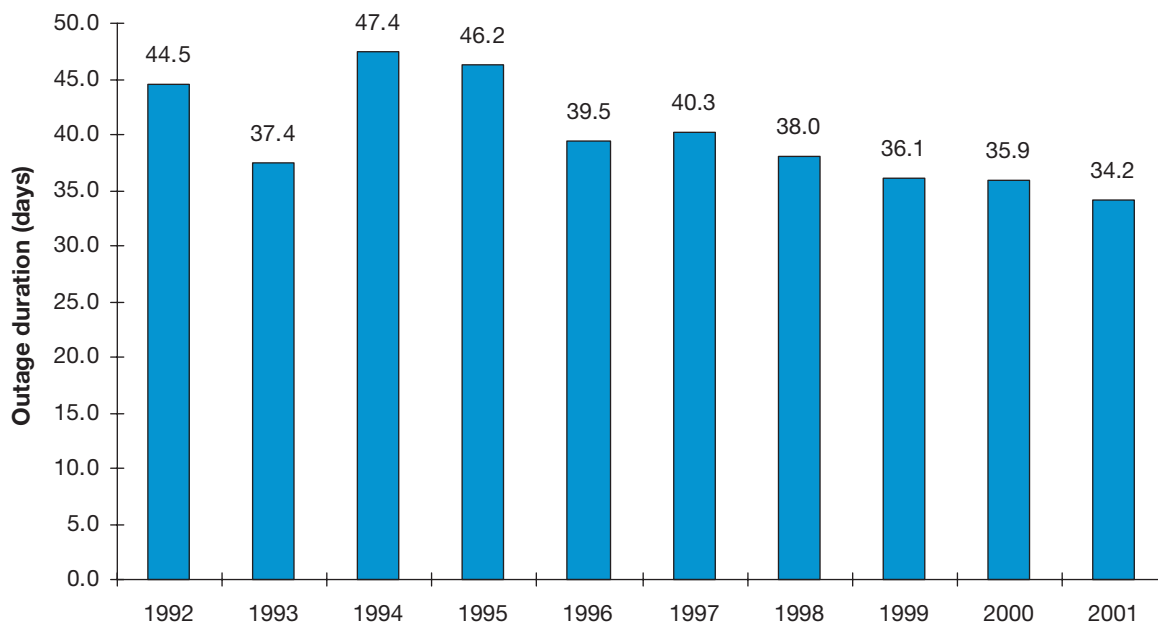


FIG. 2. World average time for planned outages.

within the regulatory, competitive and economic environments of today's plants.

Effective assessments identify when the expense of modernization is offset by the increasing costs of obsolescence, i.e. degraded reliability and availability, increased maintenance and the lack of spare parts, supplier support, functional capabilities and experienced staff. A CRP on the scientific basis and engineering solution for the cost effective assessment of software based instrumentation and control systems resulted in the publication of a document on ways to improve assessment quality and reduce costs.

Member States are showing substantial interest in better understanding and managing component ageing processes, and in creating nuclear power plant life management strategies well in advance to maximize overall economic benefits within the necessary safety and operational margins. In this regard, the age distribution of reactors shown in Fig. 1 indicates that decisions on licence extension, retirement and decommissioning will become increasingly pressing in the future. Activities focusing on ageing and life management strategies in 2002 included:

- A session entitled 'Nuclear Power – Life Cycle Management' at the Scientific Forum during the Agency's forty-sixth General Conference. The participants emphasized the importance of disseminating experience on licence renewal and decommissioning, providing relevant guidance

and identifying proven practices for safe and economic operation during both decommissioning and licence renewal.

- An Agency symposium in Budapest on nuclear power plant life management. The symposium:
 - emphasized the role of life management programmes in ensuring safe and reliable power plant operation;
 - stressed the importance of integrating the resources needed for plant life management and operation;
 - identified methodological and technological developments for managing ageing processes and understanding degradation mechanisms;
 - facilitated information exchange on national and international policies and life management strategies.
- Development efforts for an international database on nuclear power plant life management.

Agency databases help in analysing nuclear energy's potential for near term expansion and for its long term contribution to sustainable development. In 2002, the updated Power Reactor Information System (PRIS) was distributed on multiple media to more than 700 registered users. Selected components were also made available on the Internet (<http://www.Agency.org/programmes/ne/nenp/npes/index.htm>). PRIS was also expanded to include data on non-electrical applications (industrial heat, district heating and desalination) and decommissioning.

The Agency's technical co-operation programme continues to make a significant contribution to the achievement of the scientific and development objectives of Member States. In 2002, scientific support provided to a range of technical co-operation projects emphasized:

- Infrastructure development and general preparation for a country's first (or new) nuclear power plant, with a particular focus on Africa, Asia and Europe;
- Improved operations management to optimize nuclear power plant performance, service life and decommissioning, with regional projects in Europe, East Asia and Latin America;
- Upgrading of nuclear power plant personnel training and qualification in response to emerging needs;
- Engineering aspects of power plant life management, especially in Europe and Latin America.

Table I shows the number of people who received training through these projects.

Nuclear Power Technology Development and Applications

The final report of a three agency study on innovative nuclear reactor development was published in 2002. A co-operative effort of the OECD's IEA and NEA and the Agency, the study reviewed the potential contribution of representative designs for new innovative fission technologies towards meeting the challenges facing such reactors and suggests areas for collaborative R&D. It emphasizes the need to make better use of the experience to date, to increase the cross-fertilization of ideas among those working on various reactor types, to take greater advantage of

technologies and components developed in other industries, and to increase co-operation in R&D. The study was provided to both the US led Generation IV International Forum and the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO).

The Agency initiated INPRO in 2000 to help ensure that nuclear energy is available to contribute in fulfilling energy needs in the 21st century in a sustainable manner, and to bring together both technology holders and technology users to consider jointly the international and national actions required to achieve desired innovations in nuclear reactors and fuel cycles. During the year, INPRO was engaged in a full range of complex issues covering: the prospects and potential of nuclear power within the next 50 years; user requirements for innovative nuclear energy systems in the areas of economics, sustainability and environment; safety; waste management; and proliferation resistance. The INPRO Steering Committee met twice during the year and made extensive comments on the draft report of Phase 1A of the project. The report provides guidance for the evaluation of innovative nuclear reactors and fuel cycles covering all the issues mentioned above. The Committee will complete its review of the report prior to an Agency conference on innovative technologies for nuclear fuel cycles and nuclear power in June 2003. Interim results from INPRO were presented at conferences in Brazil, China, Croatia, France, India, Japan, the Republic of Korea, the Russian Federation, Spain and the USA.

To promote the continuous improvement of water cooled reactors, the Agency manages technical working groups (TWGs) on advanced technologies for LWRs and HWRs. The TWGs provide a global forum for exchanging information on national programmes, offer advice on Agency activities, and marshal support in Member States for co-operative projects. They played a central role in three Agency reports that were published in 2002:

- *Improving Economics and Safety of Water Cooled Reactors: Proven Means and New Approaches* reviews approaches that have improved economics and safety, and identifies promising new possibilities.
- *Heavy Water Reactors: Status and Projected Development* reviews HWR advanced technology related to fuel cycle flexibility, safety and economics, and development needs over the next two decades.
- *Natural Circulation Data and Methods for Advanced Nuclear Power Plant Design* examines

Table I. Training Activities Focusing on Nuclear Power in 2002

Type of training	No. of people trained
Training courses	92
Workshops/technical meetings	388
Fellowships	40
Scientific visits	22

how safety systems based on natural circulation rather than forced flow — making them independent of active components like pumps and diesel generators — can help make safety systems simpler and potentially more economical, thereby potentially reducing costs for future nuclear power plants. It also describes several new designs that incorporate passive systems based on natural circulation.

On the basis of the report on natural circulation data, planning began in 2002 for a new CRP on natural circulation phenomena, modelling and reliability of passive systems that utilize natural circulation. The CRP will co-ordinate work in industrialized and developing countries on water cooled reactors using passive safety systems, including current advanced LWR designs and future supercritical water reactor designs.

Computer based tools are becoming standard components of training programmes. To assist Member States in nuclear education and training, the Agency sponsors the development of nuclear reactor simulators which operate on personal computers and which simulate responses of a number of reactor types (BWRs, PWRs and HWRs) to operating and accident conditions. These are training tools for university professors on nuclear energy and are also available to individual students, engineers and scientists. Major activities in 2002 included workshops on the application and development of advanced nuclear reactor simulators for educational purposes, and a special session at a workshop on nuclear data and nuclear reactors.

A new CRP, 'Studies on Advanced Reactor Technology Options for Effective Incineration of Radioactive Waste', was begun to help prove the practicality of long lived radioactive waste transmutation. It will provide a comparative assessment of the transient behaviour of advanced transmutation systems and the potential benefits for the back end of the nuclear fuel cycle that can be expected from partitioning and transmutation.

Work related to high temperature gas cooled reactors (HTGRs) focused during the year on: (1) physics and thermal-hydraulic code benchmarking; (2) advances in fuel technology; and (3) the potential for freshwater co-generation. With respect to physics and thermal-hydraulic code benchmarking, a CRP on HTGR performance evaluation completed its comparison and evaluation of participant calculations and prepared the CRP's first technical document for

publication. The publication addresses thermal-hydraulic benchmark problems for the Japanese HTTR and the Chinese HTR-10 gas cooled reactors and compares different modelling approaches used by the various participants. A new CRP was started on advances in fuel technology, and an initial meeting was held on the advantages of HTGRs for desalination as a result of the availability of cost free waste heat. Data and information dissemination was also enhanced through refurbishment of the Agency's HTGR web site (www.iaea.org/htgr). The HTGR knowledge base continued to attract more visitors in 2002, with an average of more than 25 000 hits every month.

The International Nuclear Desalination Advisory Group (INDAG) held its sixth meeting to exchange information on national and interregional progress and to review the Agency's work in this area. In other work, the Agency co-operated with the World Council of Nuclear Workers (WONUC) and the Moroccan Association of Nuclear Engineers (AIGAM) in convening a conference on nuclear desalination in Marrakesh. The conference highlighted technological advances in nuclear desalination, safety, economics and financing in the context of overall global water needs for sustainable development.

The Agency's interregional nuclear desalination project was expanded beyond its ongoing Indonesia–Republic of Korea joint study, with Tunisia embarking on a similar feasibility study with the Commissariat à l'énergie atomique of France, and Pakistan enlisting Agency assistance in launching its own demonstration project. A nuclear desalination unit will be coupled to the KANUPP plant in Karachi, with commissioning planned for 2005. And India started commissioning tests of its demonstration unit at Kalpakkam, while finalizing construction work on the distillation part of the unit.

A new CRP on the economic analysis of nuclear desalination was launched in February. New publications include a report on the status of nuclear desalination plant design concepts, including a review of current experience as well as the status of cogeneration plants and dedicated heat plant concepts. The small and medium type reactors proposed range from water cooled to gas cooled and lead–bismuth designs. The desalination technologies proposed cover the spectrum of multi-stage flash, multi-effect distillation and reverse osmosis designs. Another publication completed during the year addressed the market potential of non-electric applications of nuclear energy.