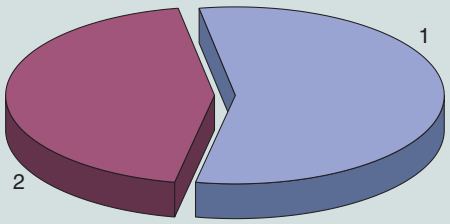
The Agency's Programme in 2001: Technology

NUCLEAR POWER

PROGRAMME OBJECTIVE

To assist Member States, at their request, in planning and implementing programmes for the utilization of nuclear power, as well as to support them in achieving improved safety, reliability and economic cost effectiveness of their nuclear power plants by promoting advanced engineering and technology, training, quality assurance and infrastructure modernization.

Regular budget expenditure: $4 124 557
Extrabudgetary programme expenditure (not included in chart): $589 175



1. Nuclear Power Planning, Implementation and Performance: $2 298 347
2. Nuclear Power Reactor Technology Development: $1 826 210

KEY ISSUES AND HIGHLIGHTS

- Publications were issued on quality assurance standards, risk management, managing change in nuclear utilities, economic performance indicators, personnel training and evaluating outside contractors.
- Updated versions of Agency databases and the Power Reactor Information System (PRIS) were released to Member States. In addition, a third module on steam generators was added to the Agency's database on nuclear power plant life management.
- A major international seminar was convened in Cairo to review innovative small to medium sized reactor (SMR) designs.
- CRPs on seismic features and thermal-hydraulic codes for metal cooled reactors were completed, and a new CRP was started on the economics of selected nuclear desalination projects.
- The first full year of the extrabudgetary International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) was completed.

NUCLEAR POWER PLANNING, IMPLEMENTATION AND PERFORMANCE

Global electricity demand is projected to more than triple in the next 50 years. Figure 1 shows the increase in the global energy availability factor in the last decade. Individual plant availability increased in many cases by some 30 percentage points. From 1990 to 2000, global energy availability increased from 73% to over 82% — the equivalent of adding 28 GW(e) of new generating capacity. The data for 2001 indicate that a new record was again set. Currently, the energy availability factors at the most successful nuclear power plants are well above the 2000 average of 82%. However, for most of the world's nuclear plants there is still much room for improvement.

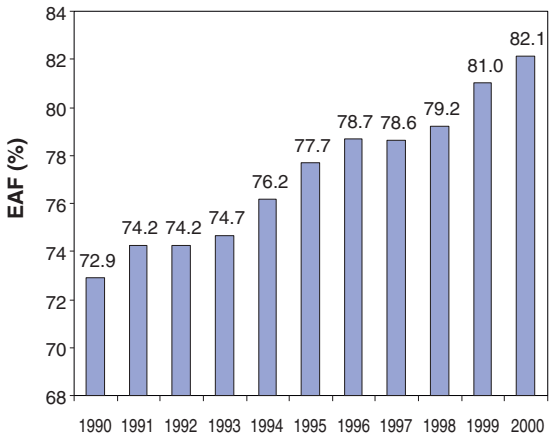


FIG. 1. Global average energy availability factor (EAF).

The Agency assists Member States in planning and implementing nuclear power projects and managing the performance and service life of nuclear power plants. The Agency used 'Internet Virtual Office' to facilitate collaboration and the dissemination of information to experts in Member States involved in projects.

Contractor personnel provide many essential services to nuclear utilities and individual nuclear power plants during planned outages, for refuelling, for major upgrade projects, for specialized maintenance and for routine non-nuclear services such as security, administrative support, facility management, buildings maintenance and catering. An issue of great importance with respect to contractor personnel is that of ensuring, in a cost effective manner, that they are competent and qualified to perform the assigned tasks. A technical document on *Assuring the Competence of Nuclear Power Plant Contractor Personnel* (IAEA-TECDOC-1232) assists utility and nuclear power plant managers, and other relevant organizations, in identifying the required technical and professional competence of contractor personnel, and includes specific tools for contractor assessment and evaluation.

A technical report comparing the ISO-9901:2000 quality standards and the Agency's 50-C/SG-Q safety codes was completed. Prepared in response to numerous requests and a high level of interest in Member States, this publication is a follow-on to *Quality Assurance Standards: Comparison between IAEA 50-C/SG-Q and ISO-9001:1994*, which was jointly developed in 2001 with FORATOM. Both publications assist Member States in developing quality assurance policies and programmes and are considered especially useful to the utility/supplier interface in the nuclear industry. The current quality standard ISO-9001:1994 is in force until December 2003, when it will be replaced by the revised ISO-9001:2000 that was published in December 2000.

In the field of integrated management of nuclear power plant operations, a new publication — *Risk Management: A Tool for Improving Nuclear Power Plant Performance* (IAEA-TECDOC-1209) — helps operators identify and implement appropriate measures to remain competitive. It provides a structure for risk management, along with examples of how operating organizations are using this tool to help integrate the assessment of safety, operational and economic related risks in a changing environment.

Managing Change in Nuclear Utilities (IAEA-TECDOC-1226) analyses the experience of Member States in adapting nuclear power production to changing market, economic and regulatory environments. It identifies the important factors for maintaining a successful safety conscious, continuous improvement management culture in the midst of change.

Properly managed, changes can enhance nuclear safety, plant reliability and cost competitiveness, from the design stage to decommissioning. The document provides guidance to all levels of management involved in developing and implementing changes within their areas of responsibility.

The use of resources can be optimized by minimizing operations and maintenance (O&M) costs. A new publication, *Developing an Economic Performance International System to Enhance Nuclear Power Plant Competitiveness* (Technical Reports Series No. 406), provides guidance on this subject, using information from the Agency's NEPIS (Nuclear Economic Performance International System) database, which contains cost data provided by utilities from 15 countries. Performance targets and O&M costs are also correlated with the objective of identifying major economic performance indicators.

In the past, much of the focus of formal nuclear power plant training and development programmes has been on technical skills, particularly those of control room operators. The changing market environment in which such plants operate places new emphasis on increased efficiency and operator effectiveness, while still maintaining high levels of safety. A report published in 2001, *A Systematic Approach to Human Performance Improvement in Nuclear Power Plants: Training Solutions* (IAEA-TECDOC-1204), provides guidance on training nuclear power plant personnel in non-technical skills. It also presents an integrated approach that incorporates training as one of several co-ordinated approaches to achieving desired levels of human performance.

Staying with the area of training, the Agency supported an initiative on 'Co-operation among Nuclear Training Centres in the European Region' to improve both the quality and cost effectiveness of training activities in Member States in this region. In April, the Paks Nuclear Power Plant Maintenance Training Centre in Hungary hosted an initial meeting with representatives from 12 Member States. Activities under this initiative will include: development of training centre dossiers and an Internet database of available training tools; as well as collection and sharing of benchmarking information; and exchange of staff.

New releases of Agency databases included a CD-ROM version of PRIS (Fig. 2) incorporating both mapping features and the full database. PRIS data were also released to the public through the Internet *(http://www.iaea.org/programmes/ne/nenp/npes/index.htm)*. The

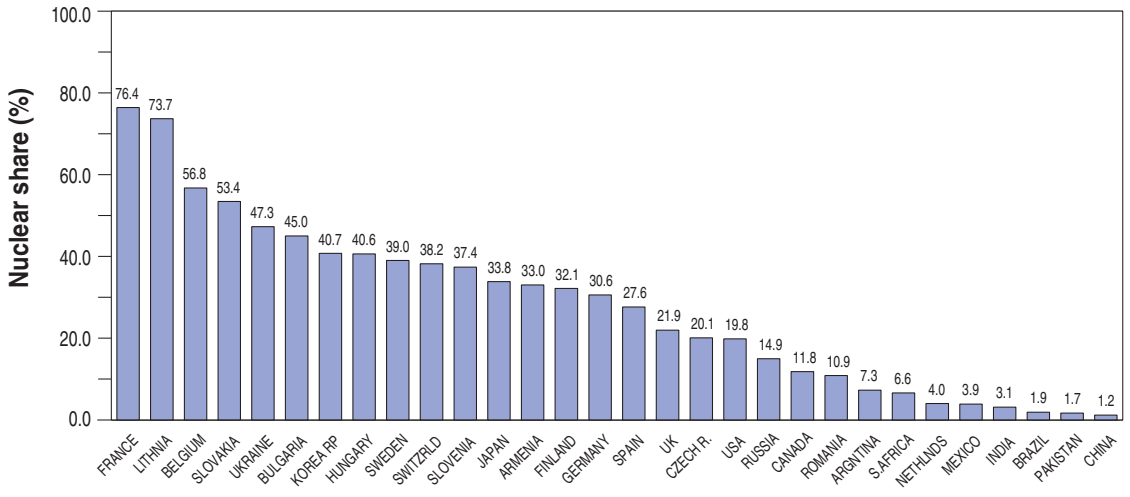


FIG. 2. The percentage of electricity generated by nuclear power in 30 countries in 2000 (based on data from PRIS and Energy, Electricity and Nuclear Power Estimates for the Period up to 2020, *Reference Data Series No. 1, IAEA, Vienna (2001)).*

other two PRIS services to Member States, MicroPRIS and PRIS-PC (the connection to PRIS through the Internet), are currently being distributed to more than 700 users in Member States and international organizations. PRIS contains multiple modules covering different aspects of nuclear power plants, including operating experience and outages, reactor design characteristics, non-electrical applications and decommissioning. Data on delayed nuclear power projects will be added in the near future.

A third module on steam generators has been added to the Agency's Nuclear Power Plant Life Management database. This module will make it easier to monitor and analyse the state of steam generators in different countries on the basis of information acquired during their accumulated operating years. Such results are important for steam generator life optimization, and are helpful in the scheduling of timely decisions on necessary repairs and replacements.

Requests from developing Member States for technical co-operation missions are given high priority and influence significantly the content and structure of the Agency's programme in nuclear power. In addition, direct outputs of the regular programme (e.g. standards, CRP results, documents, reports and databases) are used in planning, designing and implementing technical co-operation projects. Wherever possible, activities within regular and technical co-operation projects are implemented jointly to take advantage of synergies and have a greater impact in recipient Member States. In 2001, support was provided to a range of technical co-operation projects in such areas as:

— Engineering aspects of life management of nuclear power plants;
— Planning and management of the first/new nuclear power project;
— Integrated approaches to improving operations management;
— Planning, management and implementation of nuclear power plant decommissioning;
— Personnel training and qualification.

A total of 135 people received training through training courses, 535 through workshops and technical meetings, 9 through fellowships and 19 through scientific visits.

NUCLEAR POWER REACTOR TECHNOLOGY DEVELOPMENT

In addition to support for continuous performance improvements in current nuclear power plant facilities and projects, the Agency also provides support for R&D on new and modified designs that promise lower costs, better performance, a higher level of safety and greater proliferation resistance (Box 1).

Global interest in modular high temperature gas cooled reactors (HTGRs) continues, driven by their promising safety and economic features. The Agency's 'Knowledge Base' web site on HTGR technology *(http://www.iaea.org/inis/aws/htgr)* continued to draw global attention as a source of information and publications. The following achievements were recorded in 2001:

— The Chinese HTR-10 reactor underwent operational tests;
— The Japanese HTTR reached 30 MW(th) of full power;
— Design studies were carried out on the proposed Pebble Bed Modular Reactor project in South Africa, with a planned upgrade of power from 268 to 302 MW(th);
— Studies were carried out in the Russian Federation on the proposed international plutonium burning GT-MHR design project;
— The European High Temperature Reactor Technology Network was actively engaged in co-ordinated research related to HTGRs within the 5th EURATOM framework programme. In the USA, HTGR concepts and technology are being examined as a possible future design candidate for the 'Generation IV technology roadmap' and 'Nuclear Energy Research Initiative' projects.

The Agency's Technical Working Groups on Advanced Technologies for Light Water Reactors (TWG-LWR) and Heavy Water Reactors (TWG-HWR) focused on technology developments to improve the economic competitiveness of water cooled reactors while meeting stringent safety objectives. In this connection, investigations

aimed at optimizing the technology, safety and the economics of water cooled reactors were carried out jointly with the OECD/NEA, the European Commission, industrial organizations and government agencies. One conclusion was that in order to achieve the largest possible cost reductions for nuclear plants, proven means for reducing costs must be fully utilized, and new approaches should be developed and implemented.

Building on its expertise in water cooled reactor designs, the Agency also sponsors the development of nuclear reactor simulators, which operate on PCs and simulate the responses of medium and large sized water cooled reactor types (e.g. BWRs, PWRs and HWRs) under operating and accident conditions. The Agency's simulator workshops have now become an annual event at the International Centre for Theoretical Physics (ICTP) in Trieste. During 2001, a new 1360 MW(e) BWR simulator was developed and demonstrated at the ICTP workshop. Updated versions of the PCTRAN PWR and the WWER-1000 simulators were also made available.

In the field of metal cooled reactors, one area of concern is thin walled and flexible reactor components that operate at low pressure but could be seriously affected by earthquakes. Responding to this concern, the Agency recently completed a CRP on the verification of analysis methods for predicting seismically isolated nuclear structures, and harmonization and validation of analysis methods for fast reactor thermal-hydraulic codes and relations using experimental data. Another CRP seeks to validate, verify and improve methodologies and computer codes used for the calculation of reactivity coefficients in liquid metal fast reactors.

Lead and lead–bismuth cooled systems offer an alternative to sodium, provided the high corrosion activity and other long term material compatibility problems are solved. In response to Member State requests, the Agency has been conducting information exchange activities in

BOX 1. USING SMALLER PLANTS FOR A WIDER RANGE OF POWER AND NON-POWER APPLICATIONS

Several innovative designs for future nuclear power plants are in the small to medium sized range. These plants can be constructed with factory built structures and components, including complete modular units for rapid installation. They also benefit from economies of *series production*, in contrast to the economies of *scale* sought by larger designs. Small and medium sized reactors (SMRs) may also be easier to finance and may be attractive for countries with small electricity grids or for use in remote locations. Finally, they may be more appropriate for non-electric applications such as district heating, desalination, hydrogen production and oil production from tar sands and heavy crudes. To investigate these various uses, the Agency organized a seminar in Cairo in May on the status and prospects for SMRs, in co-operation with the OECD NEA and the World Nuclear Association (formerly the Uranium Institute). Hosted by the Nuclear Power Plants Authority of Egypt, the seminar looked at innovative SMR concepts with an emphasis on simple and standardized designs, reduced construction times, enhanced safety and reliability and proliferation resistance. Co-generation applications of SMRs such as nuclear seawater desalination and the necessary infrastructure development were also discussed. The major conclusions of the seminar were that with population growth in developing countries greatly increasing the demand for energy and electricity, SMRs were likely to play an important role in these countries. There would also be a continuing global need for different types and sizes of reactors for a range of applications. However, economic competitiveness and public acceptance were seen as the two most critical factors for the growth of nuclear power. There was agreement that the rapid development of commercial SMRs was of great importance as most developing countries would not be willing to wait for two or three decades to increase their electricity capacity. ■

the area of heavy liquid metal coolants for fast reactors. Data on thermophysical and thermal-hydraulic parameters of lead and lead–bismuth eutectic have been collected, reviewed and prepared for documentation, and a comparative assessment was carried out of sodium characteristics.

A new web site *(http://www.iaea.org/inis/aws/fnss)* provides an overview of an Agency project on technology advances in fast reactors and accelerator driven systems for actinide and long lived fission product transmutation. Apart from power production, the rationale for this project stems from public concerns regarding the long term storage of nuclear waste. Fast reactors and accelerator driven systems are being developed in some Member States as a possible response to the challenges of long term waste storage and potential proliferation risks. Through this project, the Agency facilitates information exchange and collaborative R&D, thereby fostering the pooling of resources and expertise. The main objectives of the project are to establish the technical and economic feasibility of new, advanced fast reactor designs, and to provide the basis for hybrid systems technology development activities in Member States.

Starting its second phase of work, the International Nuclear Desalination Advisory Group (INDAG) reviewed recent activities in this area, evaluated the Agency's programme and proposed possible new activities for 2004–2005 to accelerate the deployment of nuclear desalination projects. The first edition of *Newsletter on INDAG*, issued in July, provided information on nuclear desalination activities in several Member States, particularly the demonstration project in Kalpakkam, India.

In October, the National Nuclear Energy Agency of Indonesia and the Korea Atomic Energy Research Institute reached agreement on a joint pre-feasibility study of a nuclear desalination plant in Indonesia under the Agency's interregional technical co-operation programme. A similar agreement was reached between the French Commissariat à l'Energie Atomique and the Tunisian Authority. These important agreements facilitate projects between technology holders and end-users, leading to integrated nuclear desalination systems generating both power and heat.

Other developments in nuclear desalination included:

— Publication of a document on *Safety Aspects of Nuclear Plants Coupled with Seawater Desalination Units* (IAEA-TECDOC-1235);
— Establishment of a web site with information on the technology of nuclear seawater desalination, past and current activities of the Agency, major activities in Member States, sample calculations with the Agency's DEEP software and relevant Agency publications;
— A progress report to the General Conference in September on the Agency's activities in nuclear desalination. Thereafter, in Resolution GC(45)/RES/12, the Conference requested "the Director General to note the high priority given by Member States to the nuclear desalination of seawater and SMR development ... and promote effective international information exchange and co-operation in this area".

A new CRP entitled 'Economic Research on and Assessment of Selected Nuclear Desalination Projects and Case Studies' was launched. Together with an ongoing CRP on the optimization of the coupling of nuclear reactors and desalination systems, this project will facilitate the co-ordination of current and planned national studies on seawater desalination in Member States.

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) — a major extrabudgetary initiative co-ordinated by the Agency — is based on a General Conference resolution in September 2000 that invited all interested Member States, both technology suppliers and users, to consider jointly international and national actions required to achieve desired innovations in nuclear reactors and fuel cycles. In Resolution A/RES/56/94, "Report of the International Atomic Energy Agency", the UN General Assembly emphasized "the unique role that the Agency can play in developing user requirements and in addressing safeguards, safety and environmental questions for innovative reactors and their fuel cycles" and stressed

"the need for international collaboration in the development of innovative nuclear technology". During the year INPRO's Steering Committee approved the project's organizational structure, outline of the proposed report, resources, overall schedule, work plan and tasks. A second meeting in December reviewed initial progress reports and approved continued development of the project. Work also began on user requirements in five areas: economics and resources, safety, environmental impacts, proliferation resistance and "cross-cutting issues", which include infrastructural and industrial requirements, and legal and institutional requirements, as well as education, training and R&D. A sixth task was begun to develop assessment methods and criteria for applying these user requirements to specific innovative nuclear designs.