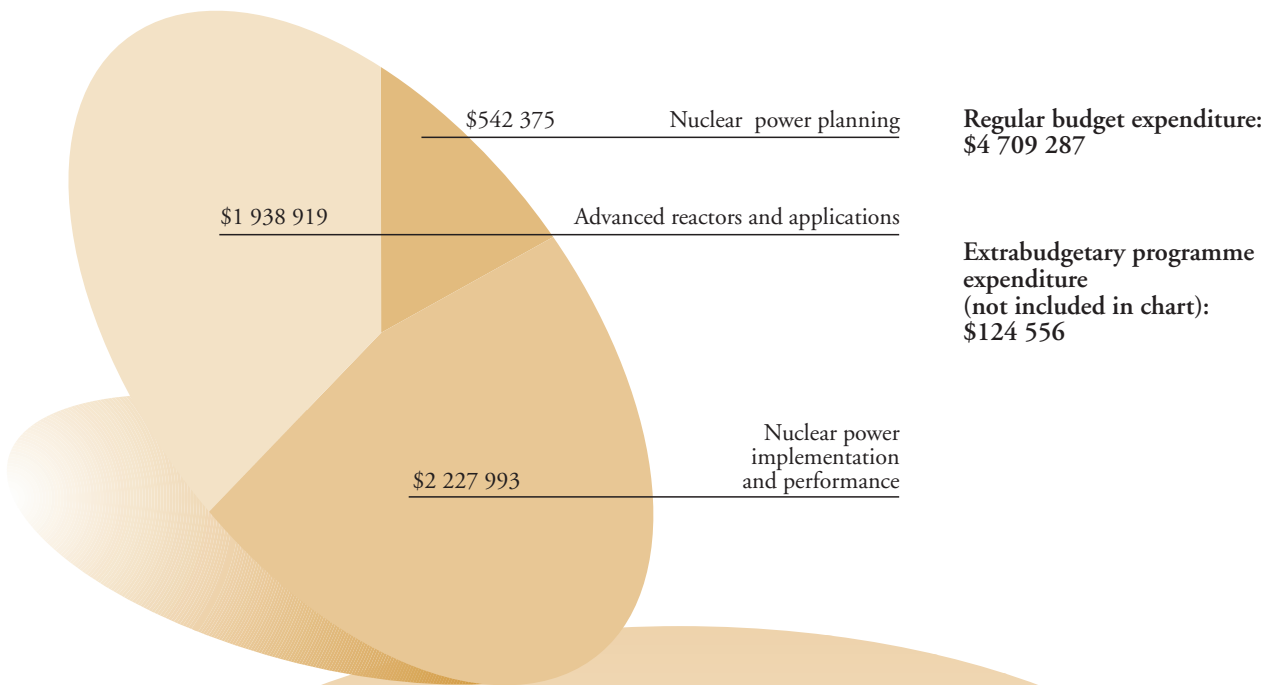


NUCLEAR POWER



To assist Member States to pursue the nuclear power option, through the provision of advice and technology transfer in the fields of: nuclear power programme planning, feasibility studies, bid preparation and evaluation, infrastructure and personnel development; instrumentation and control, project management, operational performance, reliability improvement and life management of nuclear power plants; and the development of advanced reactor designs and non-electric applications.

Programme objective

The nuclear power programme assisted Member States in the planning and implementation of nuclear power projects and in the development of advanced reactor technology. Of special interest to developing Member States was the publication of a report entitled *Choosing the Nuclear Power Option: Factors to be Considered*. An international seminar was held in Mumbai, India, on the potential role and the strategies for deploying nuclear power in developing countries. The message from the seminar was that while an extensive

infrastructure was needed to handle regulation, training, operations and public communication, there was considerable interest in nuclear power in developing countries as part of their future energy strategy. An international symposium was convened in Seoul on the strategic issues, technologies and economic viability of evolutionary water cooled reactors. The information from this meeting will be used to help plan future Agency activities in LWR and HWR development.

DISTRIBUTION OF AGENCY COMPUTER MODELS

	Number of releases of planning model or package				
	MAED	WASP	VALORAGUA	FINPLAN	ENPEP
Member States	66	95	43	12	54
International organizations	7	12	3	—	6
<i>Totals</i>	73	107	46	12	60

ENPEP: Energy and Power Evaluation Package; FINPLAN: Financial Planning; MAED: Model for Analysis of Energy Demand; VALORAGUA: 'Valor Agua' (value of water); WASP: Wien Automatic System Planning Package.

Nuclear power planning

In 1998, assistance was provided to Belarus, Bulgaria, Croatia, Lithuania, Republic of Moldova and Viet Nam to assess the role of nuclear power in the future expansion of electricity supply systems. There is also a growing interest in developing Member States in utilizing the Agency's technical assistance in planning and implementing their nuclear power programmes. Bangladesh, Egypt and Morocco received such assistance in 1998.

In the related field of the economic assessment of nuclear power plant bid evaluations, development of an improved version of the BIDEVAL software — BIDEVAL-3 — was completed. Distribution will start in early 1999, along with a companion guidebook, *Economic Evaluation of Bids for Nuclear Power Plants*.

An international seminar entitled 'Nuclear Power in Developing Countries: Its Potential Role and Strategies for its Deployment', was organized by the Agency and hosted by the Government of India in Mumbai in October. The purpose of the seminar was to explore the role of nuclear power in meeting the growing demand for electricity in the developing world while conforming to the objectives of sustainable development, and to identify and discuss suitable ways and means for the implementation of nuclear power programmes in developing countries.

Nuclear power implementation and performance

A technical report, *Choosing the Nuclear Power Option: Factors to be Considered*, was published in response to a

need expressed by developing Member States. The publication provides information on the political, governmental, economic, financial, technical and safety related issues associated with planning and implementing a nuclear power programme and highlights the main areas in which policies must be developed, as well as the roles and responsibilities of the government, the plant owner and the national industry.

Thirty Member States contributed to a new publication, entitled *Country Nuclear Power Profiles*, that provides consolidated information on nuclear power infrastructure in these States related to planning, decision making and implementing nuclear power programmes. It is planned to update this document and the associated database to support the Agency's programmatic and technical co-operation activities.

The availability of competent personnel is one of the essential requirements for the safe and reliable operation and maintenance of nuclear power plants. Four technical documents were published in the area of the training and qualification of nuclear power plant personnel. These documents provide information on the experience gained in 26 Member States in the application of programmes based on the systematic approach to training (SAT).

In order to succeed in deregulated energy markets, nuclear power plants in Member States need to reach and maintain a high level of performance, safety and reliability, while at the same time being economically competitive. Some of the best performing nuclear power plants in the world have outstanding safety records, excellent capacity factors and favourable generation costs. These utilities have demonstrated that safety performance and operational excellence are closely related. Technical documents were published describing nuclear power plant organization and

staffing for improved performance and good practices with respect to the development and use of plant procedures. Another technical document, *Evaluating and Improving Nuclear Power Plant Performance*, presenting good practices and the quantitative/qualitative measures of these practices at some of the world's most productive plants, was prepared. Finally, a document on technical support for nuclear power operations was prepared to form the basis of workshops organized in different regions.

Discussions at a meeting in Vienna on the need to improve performance in a competitive environment and the major changes facing the nuclear industry and plant operators in the near future led to the start of work on an international economic performance database in co-operation with the Electric Utility Cost Group in the USA. Designed with the goal of facilitating performance optimization, this database will cover all aspects of economic performance, including activity based costing, operational and maintenance costs and performance indicators.

A technical document on the application of quality assurance/quality management within regulatory bodies was completed. The document provides information for developing systematic approaches to quality within regulatory bodies and contributes to promoting transparency in the performance of regulatory activities. Another completed technical document provides guidance on implementing effective quality assurance programmes applied to safety related software used in nuclear power installations. This document is intended for those responsible for the management and implementation of quality assurance programmes for software, and managers and assessors from suppliers, utilities, technical support organizations and regulatory bodies.

The second module of an Agency database on nuclear power plant life management was completed. Known as the 'International Database on Piping of Nuclear Power Plants', the contents include data on material properties, inspection results and case histories for piping systems in power plants. The software will be made available to all national organizations contributing to the database.

Experience at plants that have introduced upgrades of systems using digital equipment indicates that there is great variability in the costs and problems encountered in implementing, operating and maintaining the upgraded systems. Many of the problems can be traced

to the specifications for the upgrades. A technical document was prepared on specifying requirements for such upgrades using digital instrumentation and control (I&C) to support safe, effective and economic modernization of I&C systems in nuclear power plants. The report presents a methodology for the determination of requirements and the development of specifications and plans needed throughout the life-cycle of digital I&C systems.

There are 43 nuclear power plants in 14 Member States that have experienced construction delays of more than five years as a result of financial, economic and public opinion issues. In response, work was undertaken to assist the managers of delayed nuclear power projects in the identification of problems, exchange experience and develop measures and guidance to maintain readiness for resuming the project implementation schedule when conditions permit. In order to optimize the use of Agency resources and enhance the impact of this guidance, these activities were implemented in conjunction with a regional technical co-operation project on delayed nuclear power plants, involving utilities within Europe. A technical document was prepared providing information and practical examples on the management actions needed to preserve and further develop the capability to restart and complete delayed projects.

Advanced reactors and applications

Small and medium sized reactors (SMRs) are of particular interest for the non-electrical applications of nuclear energy, such as the desalination of sea water and district heating. They are also a suitable option for electricity generation in countries with small electricity grid capacities or for remotely located areas. A technical document providing guidance to developing countries on the preparation of user requirement documents for SMRs and on how to include nuclear desalination requirements was drafted.

The Agency obtained educational simulators (software packages) from Canada and the USA that operate on a personal computer and simulate the responses of a number of reactor types in the SMR range under operating and accident conditions. These simulators are useful in providing insights into the operational characteristics and responses to accident conditions for

generic BWRs, PWRs and PHWRs. They are also used for the training of junior engineers and scientists. Three workshops were held using these simulators, two at the International Centre for Theoretical Physics, in Trieste, and one at the Korea Institute of Nuclear Safety. The first package to be obtained, the Advanced Reactor Simulator, has now been distributed to Member States.

A symposium on 'Evolutionary Water Cooled Reactors: Strategic Issues, Technologies, and Economic Viability' was convened in Seoul, Republic of Korea, in November–December. Organized in co-operation with the OECD Nuclear Energy Agency, the Uranium Institute, the Korean Nuclear Society and the Korea Atomic Industrial Forum, and hosted by the Korea Electric Power Corporation, the symposium reviewed the technology advancements and the readiness of evolutionary water cooled reactors to contribute to near and medium term energy needs. Topics addressed included strategic issues (the global energy outlook, the role of nuclear power in sustainable energy strategies, power generation costs, the financing of nuclear power plant projects, sociopolitical factors, nuclear safety requirements), technological advances (advances in residual heat removal, instrumentation and control, improving prevention and mitigation of severe accidents, development and testing of passive safety systems), and the keys to economic viability (standardization, improved plant management, advances in construction and project management, feedback of experience from utilities into new designs). In addition, reactor design organizations presented the key features of their designs and exhibited models of their products.

A Technical Committee meeting was held in Canada in April on fuel cycle options for LWRs and HWRs. The meeting provided a forum to identify, review and exchange information on international developments in this area. A key conclusion was that the fuel cycle should be evaluated in total, from fuel manufacture to final disposal, and that there is a potential for efficiencies and economic benefits from synergistic fuel cycles in individual countries as well as regionally and globally.

A CRP on thermohydraulic relationships for advanced water cooled reactors was completed. A technical document which presents a consistent set of relationships for critical heat flux, post dry-out heat transfer and pressure drop is being prepared. A new CRP on the establishment of a thermophysical properties database for

LWRs and HWRs was initiated to foster the exchange of non-proprietary information on reactor materials properties in order to improve design and safety. Another CRP on the intercomparison of pressure tube inspection and diagnostics was started to compare techniques for the characterization of HWR pressure tubes during their service lifetimes.

A technical report, *Design Measures to Facilitate Implementation of Safeguards at Future Water Cooled Reactors*, was published to provide guidelines to designers for minimizing the impact of Agency safeguards on plant operations and ensuring efficient and effective acquisition of safeguards data, to the mutual benefit of the Member State, the plant operator and the Agency. The guidelines incorporate the Agency's experience in establishing and carrying out safeguards at operating nuclear power plants, the development of safeguards techniques and the feedback of experience from plant operators and designers.

Developments in the LMFR area included: start of construction of the small size (60 MW(th), 15 MW(e)) experimental fast power reactor in China; restart of the 250 MW(e) Phénix reactor in France; progress in R&D on the KALIMER 150 MW(e) advanced liquid metal reactor in the Republic of Korea; and the Russian Federation's decision to resume construction of the BN-800 reactor.

A collaborative project between the Agency and the European Commission on a comparison of calculation methods for severe accidents in LMFRs and evaluation of the innovative BN-800 reactor core design was completed. On the basis of analysis results, it was concluded that the proposed sodium layer above the fissile core region is quite efficient in providing an additional inherently activated safety margin for preventing fuel pin failure or local boiling in the domain of operational and severe transients in the design basis.

A CRP on the validation of thermomechanical and thermohydraulic codes and relations for LMFRs was completed and a technical document is being prepared. The document presents a consistent set of relationships for thermohydraulic modelling and thermomechanical assessments.

Two Technical Committee meetings on fast reactor technology were held, one in Obninsk, Russian Federation, in July, and the other in Vienna, in November. Several recommendations were made for reactor and core design improvements. With regard to

LMFR design approaches, the accumulated knowledge on materials, thermohydraulics and mechanical science indicates that a substantial decrease in investment costs, together with a greater assurance that safety margins are effectively maintained, can be derived from reduced emphasis on 'umbrella' transients, compensated for by an accurate analysis of actual transients and operating experience. An accurate account of experience in operating fast reactors, much of which has not been published, should be made available to the States which foresee a need to deploy the technology in the near future.

To foster the exchange of technical information and to preserve the knowledge acquired of LMFR technology, a fast reactor database (FRDB) has been developed. The FRDB contains detailed data on 35 experimental, prototype and commercial LMFRs. Each reactor plant is characterized by about 400 parameters, design data and relevant graphics materials.

A Technical Committee meeting was held to review the specific features and systems of HTGR concepts and their economics. It was concluded that co-ordination of international R&D activities, including dissemination and archiving of information and data, is of primary importance in HTGR development.

The International Nuclear Desalination Advisory Group (INDAG), at its second meeting in June, stressed the need for international co-operation in planning and implementing nuclear desalination demonstration programmes, and recommended that the Agency provide an international forum for the co-ordination and sharing of resources. Following up on this recommendation, an interregional technical co-operation project was established to provide a forum for technology suppliers and prospective end users to discuss the development of integrated nuclear desalination concepts, with the aim of demonstrating the viability of nuclear desalination. In addition, a new CRP on the optimization of the coupling of nuclear reactors and desalination systems was established. This CRP will help to improve the performance and economics of nuclear desalination plants.

Thorium fuel utilization was discussed at an Advisory Group meeting in Vienna in September. One of the conclusions was that a re-examination of this fuel cycle is necessary so that the advantages, problems and possible solutions can be realistically assessed under present conditions. It was recommended that estimates of future requirements for thorium be improved in

relation to its application to fuel cycles, and for corresponding technology development in nuclear power programmes.

