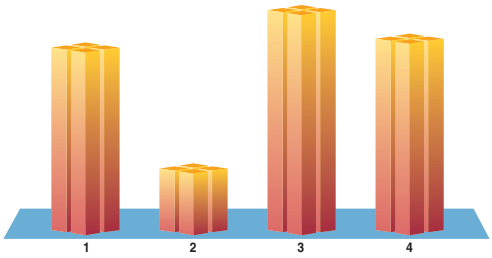
Nuclear Science

Objective

To increase Member State capabilities in the development and application of nuclear science as a tool for their economic development.

Regular budget expenditure: $7 390 084
Extrabudgetary programme expenditure (not included in chart): $21 518



1. Nuclear and Atomic Data: $2 055 189
2. Research Reactors: $682 231
3. Nuclear Research Facilities and Instrumentation: $2 482 871
4. Maintenance of Knowledge in Nuclear Science and Technology: $2 169 793

Key Issues and Highlights

- User retrievals from the Agency's nuclear data web site grew by 32%.
- The Agency initiated a CRP on 'Improvement of the Standard Cross-sections for Light Elements', which will have a major impact on nuclear applications libraries.
- The Agency organized the 19th Fusion Energy Conference, which was held in Lyon, France. In addition, under Agency auspices the parties to the International Thermonuclear Experimental Reactor (ITER) finalized the Co-ordinated Technical Activities. They have requested continued Agency participation during the next phase, the ITER Transitional Arrangements.
- Within the framework of a tripartite initiative of the Agency, the Russian Federation and the USA, the first pilot shipment of Russian origin research reactor fuel from Uzbekistan to the Russian Federation, was negotiated and prepared. Shipment will take place in 2003.
- The Agency convened a major meeting on managing nuclear knowledge to identify priorities, and a subsequent General Conference resolution called for a greater Agency focus on: nuclear knowledge management; workforce ageing and data and knowledge retention; and assistance to Member States in preserving nuclear education and training.

Nuclear and Atomic Data

All nuclear technologies depend on atomic and nuclear data to provide accurate descriptions and quantitative understanding of the underlying processes employed for both energy and non-energy applications. The Agency co-ordinates a number of international networks and conducts in-house studies to help establish and maintain an extensive range of data libraries. In this regard, use of the Agency's nuclear data web server (*http://www-nds.iaea.org*) grew by 32% in 2002 due to regular updates and the addition of new data libraries developed through CRPs. Figure 1 shows these increased queries, across all geographical regions. Table I also shows a significant increase in requests for CD-ROMs.

Significant progress was made in 2002 on a new version of the primary nuclear reaction database that

Table I. **User Requests for Nuclear Data, 2000–2002**

Requests	2000	2001	2002
Internet retrievals from the main Agency nuclear databases	9642	12 894	20 773
Access through the Internet to other Agency files and information	11 472	16 153	18 135
Information on CD-ROMs	648	883	1108
Off-line retrievals	2557	2231	2548

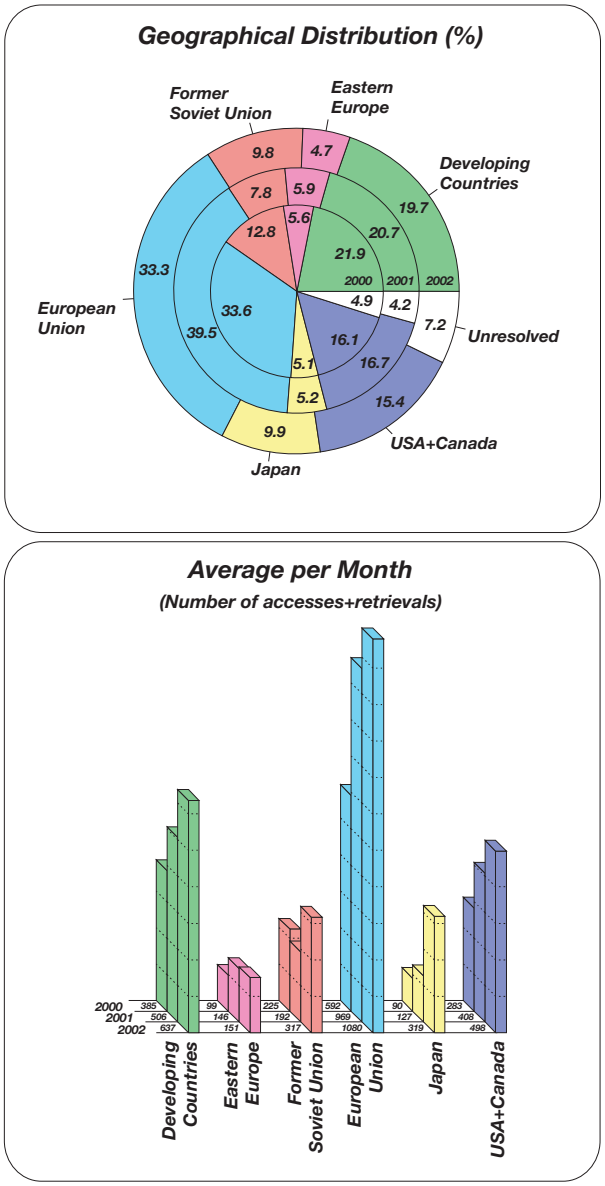


FIG. 1. Web accesses and retrievals for the IAEA–IPEN nuclear data services (IPEN, in Brazil, is the Agency's nuclear data mirror site web server in Latin America).

combines bibliographic (CINDA) and experimental (EXFOR) data. The database will be accessible through the web. The completed work packages include:

- Preparation of EXFOR and all related software;
- Documentation and transfer of administration functions to database managers;
- Creation of important segments of the CINDA database software.

In September the first meeting of a CRP on 'Improvement of the Standard Cross-sections for Light Elements' was held to define the work plan and the benchmarking procedures to be employed. The preparation of these standards data will have a major impact on all applications based data files and recommended procedures. The results from this CRP will be a useful input for the creation of more comprehensive libraries of this type by Member States.

Extensive data evaluations were completed in a CRP on 'X Ray and Gamma Ray Decay Data Standards for Detector Calibration and other Applications'. These new and revised data will improve the accuracy and reliability of nuclear measuring techniques for a wide range of scientific and industrial applications. The final library will be assembled, and documentation completed, by the end of 2003.

Cancer treatment using therapeutic radioisotope based nuclear medicine is becoming increasingly important, requiring evaluated nuclear data for the production of radioisotopes and to determine their decay characteristics. A CRP was initiated in 2002 to generate this information; preparations were made for the first Research Co-ordination Meeting in June 2003.

Nuclear fusion research is advancing at a rapid pace around the world. As part of its work in this area, the Agency convened a Technical Committee Meeting on 'Atomic and Plasma-interaction Data for Fusion Science and Technology' in Jülich, Germany. The main focus was on likely data needs in atomic and plasma-surface interactions and on specific data needs for fusion research.

Future fusion machines (such as ITER) will use the deuterium–tritium reaction and will have strict limits on the amount of tritium that will be allowed to accumulate inside a machine. A CRP on the tritium inventory in fusion reactors was initiated with the aim of quantifying interaction and transport of tritium within fusion reactors. The initial Research Co-ordination Meeting reviewed current data and research needs and formulated a comprehensive work plan.

Research Reactors

Under a regional technical co-operation project on research reactor spent fuel options in Latin America, workshops and training courses were convened in Latin American countries in four areas: (1) characterization of current spent fuel inventories; (2) harmonization within the region of safety rules and regulations for the management and transport of spent fuel; (3) public outreach; and (4) study of all options for the long term management and disposition of spent fuel.

Work began during the year on two new projects. The first involved the preparation of a compendium of purpose-built facilities for research reactors so that designers can take advantage of the operating experience gained over the last 50 years. This experience has shown that the designs of specialized facilities can often be mutually exclusive. The second task concerns the development and qualification of new high density LEU research reactor fuels based on uranium–molybdenum alloys that will allow conversion from HEU to LEU of the highest flux reactors and make available a reprocessing fuel to replace silicide fuel, which has no reprocessing option.

The aim of a tripartite initiative of the Agency, the Russian Federation and the USA is the management and disposition in the Russian Federation of Russian origin research reactor fuel currently at facilities abroad. A meeting was convened to consider preliminary plans for fuel shipments, and the first pilot shipment of Russian origin fuel — from Tashkent, Uzbekistan, to Mayak in the Russian Federation — was negotiated and prepared. Shipment will take place in 2003, with the plan being to develop a programme for shipments from other participating countries. Successful implementation of this programme will alleviate safety concerns about corroded spent fuel at several facilities, while reducing proliferation risks associated with the remaining inventories of Russian origin HEU fuels.

A new CRP on 'Corrosion of Research Reactor Aluminium-clad Spent Fuel in Water' was initiated. It involves research in eight countries to obtain a better understanding of localized corrosion affecting aluminium based fuel cladding, and of water chemistry conditions that minimize such corrosion.

In a CRP on small angle neutron scattering (SANS), collaboration between laboratories in developing and developed countries resulted in the development of specialized detectors, monochromators and beam converging systems. These new components will help in the development of better SANS devices for materials investigations.

Financial constraints, ageing of facilities and lack of trained staff have hampered the operation and effective utilization of research reactors. A strategic plan is thus an essential tool in justifying the resources required for operation and management control of all relevant activities. To assist Member States in developing such plans, the Agency organized a workshop on 'Strategic Planning for Research Reactors' under a technical co-operation project for the Asian region. The main objective was to provide guidance to managers in preparing a strategic plan for their facilities. The importance of SWOT (strength–weakness–opportunities–threats) analysis as a management tool was stressed and a 'typical' strategic plan was presented for demonstration. The workshop's success was such that this activity will now be extended to other regions.

Nuclear Research Facilities and Instrumentation

In the field of fusion energy, the Agency organized the 19th Fusion Energy Conference, in Lyon, France. Significant advances were reported on the magnetic as well as inertial confinement of plasma for energy production. In magnetic confinement, the bulk of the work reported was on tokamak systems, but the physics and technology of more compact systems like stellarators and reversed field pinches have made significant progress, indicating their potential for the future. The technical details of four sites offered for ITER were presented at the conference.

In nuclear fusion research, spherical tokamaks, spheromaks and field reversed configurations are forerunners of potentially less expensive and more compact fusion reactors. The Agency convened a Research Co-ordination Meeting to review the status of research and chart directions for future work. The final report provides a road map for enhancing the potential of compact toroid plasmas for fusion power. To help foster co-operation and joint experiments between developed and developing countries, the Agency also sponsored workshops at ICTP on plasma diagnostics and industrial applications.

Under Agency auspices, the parties to ITER, i.e. Canada, the European Union, Japan and the Russian Federation, finalized the Co-ordinated Technical Activities, completing the engineering design of a 500 MW device. Four sites have been offered for ITER, and technical evaluations of these sites are nearing completion. The ITER parties have requested continued Agency participation during the next phase, the ITER Transitional Arrangements.

Nuclear techniques can contribute significantly to the development of new and modified materials relevant to information technology, energy management, environmental protection and human health. In 2002, an Agency advisory group reviewed current trends in ion beam applications. The group recommended greater networking between scientists from developed

and developing countries because R&D requires both ion beam facilities and a range of analytical techniques for materials characterization.

The Agency published the final report for a CRP on developing and characterizing semiconductor material by ion beams. It presents important results on diamonds, prepared by chemical vapour deposition, as radiation detectors in a high radiation environment, gallium arsenide for manufacturing devices working at high temperatures and high power, and lithium niobate for optical wave guides.

In a review of 12 software packages from different vendors for ion beam analysis, validation methods were identified to test accuracy, estimate errors and quantify differences between the programs. The review also revealed a continuing need for more data evaluation and model development. In another project, commonly available gamma ray analysis programs for routine low level and environmental sample analysis were compared. The comparison identified needed improvements in most of the software packages and the complementary software required for others.

To better define the thermal history of sedimentary basins in Algeria, and to estimate hydrocarbon reserves, the Agency helped the Centre for the Development of Nuclear Techniques and the National Geological and Mining Research Organization to establish a fission track dating laboratory. In Croatia, the Agency helped set up an electrostatic ion beam accelerator for ion beam analysis and materials modification.

The Agency's Laboratories at Seibersdorf provided technical support for activities related to the use and maintenance of nuclear instrumentation in Member States. Key efforts included:

- Characterizing materials by using accelerator based techniques in support of quantification procedures for the X ray fluorescence (XRF) analysis of biological and environmental samples;
- Improving the sample positioning system at the Agency's beam line in Zagreb, Croatia;
- Characterizing depleted uranium particles using microfluorescence;
- Evaluating software for XRF analysis;
- Developing a precise relocation procedure for radioactive microparticles;
- Developing a fundamental parameter method (including software) for XRF analysis with simultaneous excitation by iron-55 and cadmium-109 radioisotope sources;
- Installing and testing a new XRF spectrometer to meet system requirements for quality assurance and quality control;
- Assessing major interference effects in the XRF analysis of air particulates;
- Developing an instrument for recording environmental parameters with a global positioning system capability.

Maintenance of Knowledge in Nuclear Science and Technology

The use of nuclear technology relies heavily on the accumulation of knowledge — both technical information in documents and databases and knowledge in people, e.g. scientists, engineers and technicians. Recent trends emphasize the need for better nuclear knowledge management. The main reasons are that the nuclear workforce is ageing, and fewer young people are studying in nuclear fields at the university level. Indeed, a growing number of universities have given up nuclear education programmes altogether (Fig. 2).

In June, the Agency convened a meeting on managing nuclear knowledge, with the participation of experts from academia, industry and government. The meeting identified six priorities:

- Integration of existing nuclear data and information bases (in the Agency and in Member States) in the form of an easily accessible 'Nuclear Knowledge Portal';
- Promotion of the networking of institutions for nuclear education and training in Member States in co-ordination with existing activities;
- Development of guidance documents on the preservation of nuclear knowledge;

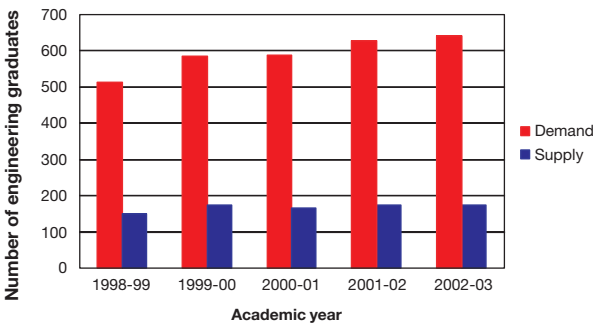


FIG. 2. Gap projected by the Nuclear Engineering Department Heads Organization between the near term supply and demand of nuclear graduates in the USA.

- Implementation of targeted 'preservation of knowledge' projects;
- Design and implementation of outreach activities that improve the general knowledge in society of the benefits of nuclear science and technology;
- Assistance in the development of curricula for internationally accepted higher university degrees on nuclear technology, e.g. by networking universities.

In September, the Agency's General Conference approved a resolution calling on the Agency to: increase the attention given to nuclear knowledge management activities; increase awareness of these activities; assist Member States in preserving nuclear education and training; promote networking; and identify ways to address the problems of workforce ageing and data and knowledge retention. In parallel, the Agency launched a new web site to disseminate information on its activities (*http://www.iaea.org/km/*), as well as two pilot projects — one on fast reactors and another on gas cooled reactors (GCRs).

Despite more than 40 years of R&D around the world on fast reactors, work in this area is currently confined to China, India, Japan, the Republic of Korea and the Russian Federation. Moreover, information is in danger of being lost even in these Member States as both the workforce and key facilities age. The Agency launched a new initiative on fast reactor technology knowledge preservation that seeks to establish a comprehensive international inventory of data and knowledge that could form the basis for fast reactor development 20–40 years from now. A web site *(http://www.iaea.org/inis/aws/fnss/index.html)* in sup-port of this initiative, and a parallel, web accessible, database on R&D programmes related to accelerator driven systems, continue to draw steadily increasing attention as sources of information and publications.

In the case of GCRs, knowledge has been accumulating for over half a century. The archives of milestone projects, such as DRAGON in the UK and AVR in Germany, contain valuable information for supporting current high temperature gas cooled reactor (HTGR) projects and future technology developments. Under this project, the Agency began building a knowledge base on HTGRs incorporating publicly available technical information.