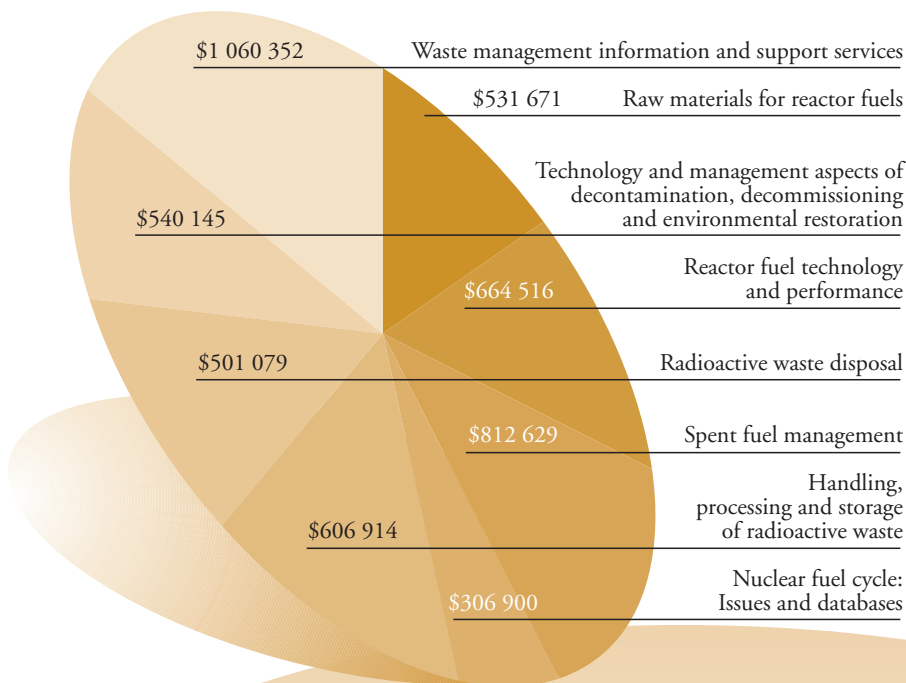


NUCLEAR FUEL CYCLE AND WASTE TECHNOLOGY



Regular budget expenditure:
\$5 024 206

Extrabudgetary programme expenditure (not included in chart):
\$495 245

To assist Member States having or planning to have nuclear fuel cycle activities or needs, either as suppliers for or as operators of power or research reactors and to assist on technology issues concerning the management of radioactive waste of all origins.

Programme objective

The Agency's programme on the nuclear fuel cycle covered four key areas: raw materials for reactor fuels, focusing on uranium supply and demand, and mining and milling; reactor fuel technology and performance, addressing issues on reactor materials and fuel technology; spent fuel management, dealing with spent fuel storage, treatment and transport; and nuclear fuel cycle issues and databases. A symposium on the storage of spent fuel from power reactors was held in Vienna in November. The first meeting of the newly established International Working Group on Nuclear Fuel Cycle Options was also held in Vienna, with special emphasis being given to plutonium issues. The radioactive waste technology programme covered: the handling, processing, storage and disposal of radioactive waste; decontamination and decommissioning of nuclear

installations; environmental restoration; quality assurance aspects of radioactive waste management; waste management planning and infrastructure building; and technology transfer and exchange. The progress of work, including the status of national radioactive waste management programmes, was discussed at the third meeting of the Radioactive Waste Technology Advisory Committee in October.

Raw materials for reactor fuels

A Technical Committee meeting of the Joint OECD/NEA-IAEA Uranium Group was held in

Vienna in October. The primary purpose of the meeting was to prepare the 1999 'Red Book' questionnaire for submission to Member States. The schedule for preparing the 1999 Red Book was set with a target date for publication of March 2000.

A Technical Committee meeting on the impact of new environmental and safety regulations on uranium exploration, mining, milling and waste management was held in Vienna in September. The papers presented at the meeting provided examples of under- and over-regulation, with both situations being undesirable. A general recommendation was that realistic regulations must be developed that apply to a wide range of situations and which allow developing countries to benefit. It was noted that while regulations for reactors may have some application to very high grade mining operations, low grade deposits and by-product recovery operations require different regulations. There is also a need to distinguish between nuclear facilities and uranium/thorium mines, since the levels of risk and the potential for damage were very different. There was a consensus that a strong regulatory framework was important for the credibility of the industry.

A technical document providing guidance on good practices in the management of uranium mining and milling operations was published. Companion guidebooks are being prepared that address such topics as environmental impact assessment, the implementation of environmentally friendly mining and milling methods, and the treatment of effluents and in situ leaching technologies. The purpose of these guides is to promote the best operational practices in those Member States involved in the development of uranium production projects.

Reactor fuel technology and performance

Corrosion of fuel rod cladding materials and primary circuit components remains a serious concern for current water cooled power reactors, especially those being operated at high burnup and thermal rates. In response, the Agency published a technical document that reviewed waterside corrosion of zirconium alloys in nuclear power plants.

The corrosion of fuel and primary circuit components of water cooled power reactors, including in-pile, loop

and autoclave tests, corrosion modelling and mechanisms, and the interrelation between water chemistry parameters and the corrosion rate, was considered at a Technical Committee meeting held in Hluboka nad Vltavou, Czech Republic. The data showed that significant improvements were achieved in the reduction of corrosion and dose rates by replacing the cladding material with one more resistant to corrosion, or by the improvement of water chemistry conditions. However, heavier fuel duties have resulted in the appearance of new corrosion related phenomena, such as sub-cooled boiling and shadow corrosion. Consequently, R&D in this area will continue.

Corrosion of zirconium alloy cladding on the fuel side is the subject of a CRP on stress corrosion cracking. This CRP has been extended for one year to repeat some tests in the experimental matrix which were unsuccessful on the first attempt as the participants were learning to cope with the difficult test procedures.

A CRP on hydrogen and hydride degradation of the zirconium alloys used for fuel cladding and pressure tube material was initiated, with the first Research Co-ordination meeting held in Vienna. The first phase of testing involves a round robin exercise in which the participants will measure delayed hydride cracking rates and hydrogen concentrations, and characterize the microstructures of standard compact tension specimens cut from a CANDU pressure tube.

The behaviour of fuel and control assemblies in current and advanced water reactor designs was considered at two Technical Committee meetings. The first meeting, in Nyköping, Sweden, focused on: fuel chemistry and fission product behaviour; swelling and pellet clad mechanical interaction; cladding failure mechanisms at high burnup; and thermal properties and fuel behaviour in off-normal conditions. A major result of this meeting was an assessment of the relative impact of burnup increase on potential clad failures. The other meeting, held in Vienna, studied control assembly materials currently used in PWRs, BWRs, WWERs and RBMKs, as well as improved replacement materials that could also be used in advanced water reactor designs. The technical discussions focused on the performance of absorber materials, cladding and guide tubes and guide cards in reactors, taking into account issues affecting and limiting the working lifetimes of control assemblies, and hence their economic viability.

The scope of the OECD/NEA-IAEA International Fuel Performance (IFPE) database was extended,

primarily by the inclusion of new data from the Russian Federation. An important application of this database was in fuel performance code improvements carried out by several Eastern European countries with WWER power plants. Specifically, qualification of a version of the TRANSURANUS code for WWER fuel was achieved using the IFPE database.

A technical assistance project in China helped in the establishment of the Centre for Quality Assurance of Nuclear Fuel by procuring a device for tube quality control, and by training staff. Also, Chinese fuel specialists were trained in the use of the IFPE and French CRACO databases.

An expert mission was undertaken to evaluate a technical assistance project in Bulgaria which will provide operators at the Kozloduy nuclear power plant with a fast and effective means to detect fuel rod failures in WWER-1000 assemblies using a visual inspection device in the spent fuel storage pool.

Spent fuel management

A symposium on the storage of spent fuel from power reactors was held in Vienna in November. The meeting provided a forum for: the exchange of information; discussions on the prospects for spent fuel storage, the worldwide situation and the major factors influencing national policies in this field, and identification of the most important directions that national efforts and international co-operation should take. There was consensus that the techniques and procedures currently in use to handle and store spent fuel are safe and meet the stringent safety requirements applicable in different countries. The main conclusion of the symposium was that the primary spent fuel management solution over the next few decades will be interim storage. Consequently, the duration of interim storage will become longer than earlier anticipated and storage facilities will have to be redesigned or adapted to accept spent fuel from advanced fuel cycle practices (i.e. high burnup and mixed oxide (MOX) spent fuel).

A Technical Committee meeting was held in Vienna in September on the technologies and safety aspects of a regional spent fuel storage facility for power and research reactor fuel. Since spent fuel storage is a well established and proven technology, the potential benefits of regional spent fuel storage in terms of the

technical, economic, institutional and ethical/sociopolitical aspects were highlighted. It was emphasized that several issues still needed to be discussed further, notably the institutional and sociopolitical questions involved.

Spent fuel management for WWER/RBMK reactors was the subject of a Technical Committee meeting/workshop held at the Ignalina nuclear power plant in Lithuania. The workshop, part of the Extrabudgetary Programme on the Safety of WWER and RBMK Nuclear Power Plants, with contributions from the Government of Japan, provided an opportunity to exchange information on the drying of sound and defective fuel for dry storage and the detection technologies, classification and handling of such fuel. The major conclusions of this workshop were that fuel not foreseen for reprocessing should be put into dry storage for a long period of time, and that all defective fuel should be moved to dry storage to prevent further corrosion damage.

As a result of work in a CRP on irradiation enhanced degradation of materials in spent fuel storage facilities, a technical document reviewing the durability of spent nuclear fuels and facility components in wet storage was published. The document examines the problem of materials degradation of spent fuel in both power and research reactor wet storage facilities in an attempt to assess their durability. The objective is to assist the operators of wet storage facilities in presenting justifications to the licensing authorities to extend the lifetime of these facilities.

Nuclear fuel cycle: Issues and databases

As a result of the 1997 symposium 'Nuclear Fuel Cycle and Reactor Strategy: Adjusting to New Realities', the International Working Group on Nuclear Fuel Cycle Options (IWG-NFCO) was established to address emerging issues in the nuclear fuel cycle area, particularly the accumulation of spent fuel and separated plutonium from both civil and military uses. At the first meeting of the Group in Vienna in October, the Agency's fuel cycle programme was evaluated.

The services of consultants were used to update the status of separated civil plutonium inventories and make forecasts of future trends. It was concluded that while current inventories conformed to the Plutonium

Management Guidelines (INFCIRC/549), future trends indicated that there was a need for long term storage, and evaluation of the technical and economic impacts.

The Nuclear Fuel Cycle Information System (NFCIS) was upgraded to a modern client/server MS SQL Server database management system. This enhances data sharing and the robustness of the computer application. Methods to improve data collection, update the database and disseminate the information to Member States were identified. NFCIS data will be published in the Reference Data Series and electronically through the Internet. The Nuclear Fuel Cycle Simulation System (VISTA), a newly developed Agency model for calculating and estimating nuclear fuel cycle service requirements, continued to be developed. This system, which will be made available to Member States, will integrate existing data from other Agency databases (such as the Power Reactor Information System and the Energy and Economic Databank) and will serve as an international nuclear fuel cycle reference model. The Nuclear Fuel Cycle Profile was upgraded so as to be accessible through the NFCIS.

Handling, processing and storage of radioactive waste

Most of the world's radioactive waste is generated in a few countries operating nuclear power plants and fuel cycle facilities. While reliable and safe procedures are generally available for the management of such wastes, the management of relatively small amounts of radioactive waste generated from non-fuel-cycle applications represents a significant problem for many Agency Member States. The available infrastructure is either inadequate, or sometimes is completely missing. In view of this, almost half of the Agency's ongoing waste technology tasks are oriented to non-fuel-cycle waste. A technical document covering all aspects of waste management in the production and use of molybdenum-99 was published to assist Member States in solving the problems related to the widespread medical applications of this isotope. Two technical reports on the management of radioactive waste from various nuclear applications were also completed.

The delay in a decision on the final disposal of conditioned radioactive waste, and public opposition to the siting of disposal facilities in some countries, have resulted in great efforts being made to minimize waste

and improve the quality of waste arisings packages for extended interim storage prior to disposal. To meet this challenge, two publications were prepared. One report examined waste minimization issues for the front end of the nuclear fuel cycle, while the other focused on the interim storage of radioactive waste packages.

A new CRP on the chemical durability and performance assessment of spent fuel and HLW forms under simulated repository conditions was initiated. The aim is to promote the exchange of information on research activities and to make available to developing Member States the data obtained in countries that are leaders in this field.

A technical co-operation project, originally intended to assist Armenia in the improvement of waste management techniques at the Medzamor nuclear power plant, has been extended to establish an integrated national waste technology infrastructure meeting modern safety requirements.

Radioactive waste disposal

Site selection for the disposal of radioactive waste continues to be a focus of many national programmes. In this connection, a technical report on hydrogeological investigations of geological disposal sites was completed. Since hydrogeological systems are considered in assessment scenarios to offer the most probable pathways in the event of the release of radioactivity from repositories, this report will help in understanding the role played by such investigations in the overall characterization of a site for geological disposal.

The concept of a multinational repository for radioactive waste is under discussion in the waste management community in the light of potential benefits to partner countries from the safety, technical and economic standpoints. However, such a concept involves a number of political and public acceptance issues and therefore its realization requires, as a prerequisite, a consensus among the countries and regions concerned. A report that addresses this issue and provides an assessment of the concept in terms of the factors to be taken into account in the process of consensus building was published. The assessment deals with the basic factors involved in the concept — legal aspects, safety principles, technical issues, cost and liabilities, ownership of waste materials, ethical aspects,

and public acceptance. It also covers the implication of each of these factors in terms of potential benefits and challenges, and the issues that need to be addressed in establishing a multinational repository.

A new CRP was initiated on anthropogenic analogues for use in confidence building with regard to the disposal of high level and long lived radioactive waste. Human made analogues permit comparison of the behaviour of various components of a radioactive waste repository system with the behaviour of similar systems that either occur or occurred in the earth. Migration processes related to ancient artefacts and building materials used in archaeological times, as well as transport and retardation mechanisms in underground nuclear weapon test sites, are the topics for study in this CRP.

Technology and management aspects of decontamination, decommissioning and environmental restoration

Decontamination has traditionally been addressed within the general area of decommissioning. However, advances in the technology have made it clear that the field of decontamination has now reached the stage of being a scientific and technical discipline by itself. In this regard, a CRP that focused on new methods and techniques for the optimization of decontamination for maintenance or decommissioning was completed and a technical document summarizing the results was published. Operating experience, recognition of the lessons, key results in laboratory or pilot scale research, and the validation of mathematical models were some of the achievements of this CRP.

Waste management information and support services

To supplement the *Waste Management Research Abstracts*, an Internet based 'International Research Abstracts Information System' (IRAIS) was put on-line (<http://www.iaea.org/programmes/irais>). IRAIS provides abstract search and retrieval capabilities, as well as automated features to check and validate the abstracts and prepare a finished product for publication.

Progress was made in providing services to Member States in conditioning old radium sources for safe long term storage. The national stocks of radium in Ecuador and Paraguay were conditioned and rendered safe with the assistance of an experienced Brazilian team. This activity has been expanded by the formation of regional teams for conditioning operations in Eastern Europe, Africa and Asia. For example, a South African team carried out an operation in Ghana, while in Bosnia and Herzegovina, radium pigment paint used in a military factory was conditioned in co-operation with the Ruder Bosković Institute of Croatia. Furthermore, teams from China, Pakistan, the Republic of Korea and Peru received training and preparation in conditioning techniques. To improve the quality of radium encapsulation, an automatic welding machine was developed in co-operation with South Africa.

The Sealed Radiation Sources (SRS) Registry, a software package designed for registering and tracking sealed sources (currently in use in over 30 Member States), was upgraded to a Windows version and made available to Member States.

A second demonstration of pre-disposal waste management methods and procedures was organized at the Lo Aguirre Nuclear Research Centre in Santiago, Chile, for participants from Ecuador, Nicaragua and Peru, while a third demonstration was held at the Çekmece Nuclear Research and Training Centre in Istanbul for trainees from Ghana, The Former Yugoslav Republic of Macedonia, Saudi Arabia and Tunisia. A similar demonstration was held for the first time in the East Asia and Pacific region at the Philippine Nuclear Research Institute, Manila, for trainees from Bangladesh, Malaysia, Myanmar and Sri Lanka. Technical and administrative preparations have been completed in Moscow to host a demonstration for the newly independent States and countries from Eastern Europe.

In its capacity as the Secretariat for the Contact Expert Group (CEG) for international co-operation with the Russian Federation in radioactive waste management, the Agency prepared a database that contains information on 175 co-operation projects. At its sixth meeting in Augusta, Georgia, USA, the CEG reached a consensus on "Initial (First Priority) Projects" for international co-operation, while at the seventh meeting in Murmansk, a list of the CEG's "Highest Priority Tasks", prepared on the basis of new material and information presented by the Russian Federation, was approved.