

Programme B. NUCLEAR FUEL CYCLE AND MATERIALS TECHNOLOGIES

Rationale: In line with Goal A of the Medium Term Strategy, the general outcome of this programme has been focused on meeting, in a sustainable manner, the different needs and interests of Member States having a stake in the whole or part of the nuclear fuel cycle. There are various issues in this area affecting sustainability, for example incidents caused as a result of facility operation with insufficiently trained or motivated staff, differences in fuel technology standards between Member States operating nuclear power plants of different designs, increasing potential environmental burden caused by some mining/milling operations or storage of large quantities of spent fuel, liabilities associated with retiring facilities and installations, and potential proliferation risks from civil plutonium utilization and associated security concerns. There are political or social issues leading to delays in the deployment of spent fuel repositories resulting in increasing volumes of spent fuel to be stored and a prolongation of interim storage and ever increasing volumes of radioactive residual fuel cycle materials, in particular long lived materials. There is also an increasing number of nuclear power plants which are being taken out, or planned to be taken out, of service in the very near future that have spent fuel storage facilities to be decommissioned. These issues tend to erode public confidence in nuclear power because of the failure to deploy adequate solutions.

Environmental issues (from mining to long term management of residual materials), decommissioning of spent fuel management facilities and proliferation resistance, particularly through innovative technologies, and the long term management of residual materials from the nuclear fuel cycle will receive greater attention in this programme. The programme is designed to address these issues by providing analysis and guidance on good practices, harmonization, improvement and innovation for the major components of the nuclear fuel cycle. Today, the nuclear fuel cycle receives special attention within the United Nations system and other international organizations (e.g. NEA/OECD) in terms of international co-operation for development. The Agency will assist in meeting the development needs, particularly those of developing Member States, several of which only have a very small nuclear power programme, by exchanging information on and promoting internationally accepted safe and reliable practices in the area of the nuclear fuel cycle.

National and international organizations involved in the energy and environmental sectors, fuel cycle services (governmental and private), operators of facilities (from mining, through reactor operation to storage and disposal of waste) and R&D

organizations are the ones with the highest level of interest for the Agency's activities in this area.

Objective: To strengthen the capabilities of interested Member States for policy making, strategic planning, technology development and implementation of safe, reliable, economically efficient, proliferation resistant, environmentally sound and secure nuclear fuel cycle programmes.

Outcome
— Use in interested Member States of the Agency's recommendations, guidance and information leading to enhanced competence to conduct sustainable nuclear fuel cycle activities, including research and development, and to address urgent issues in the nuclear fuel cycle.
Performance Indicators
— Number of Member States using guidance, methods and procedures recommended by the Agency in the areas of nuclear fuel cycle technology and materials management.
— Number of participants/organizations/Member States participating in Agency activities (e.g. technical meetings, CRPs, databases and publications) in the area of the nuclear fuel cycle and materials.

Specific criteria for prioritization:

- Improvement in the management of spent fuel from power reactors.
- Minimization of environmental impacts of nuclear fuel cycle activities.
- Improvement of nuclear fuel performance.
- Catalysing innovation in nuclear fuel cycles.

Subprogramme B.1. Uranium Production Cycle and Environment

Rationale: Uranium is the key element and raw material for sustainable utilization of nuclear energy. Currently, most uranium is produced in Member States without a nuclear power programme and is consumed in Member States having no uranium production. This indicates that planning of both supply and demand of uranium has to be approached from a global perspective and against the current and near future nuclear energy needs. In this respect, the Agency is the only global authoritative forum to provide independent and reliable analysis and information on the status of world uranium production and the projections of uranium requirements in Member States with nuclear power programmes. To ensure that the broadest and most balanced information in this matter is available to Member States the Agency collaborates with the

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OECD/NEA in the collection, analysis and publication of worldwide data on uranium resources, production and demand (the 'Red Book'). This information is used by Member States with uranium production and/or nuclear power for their planning and policy making.

Environmental protection is of particular importance in the uranium production cycle. It is subject to a growing number of international conventions such as the Convention on Environmental Impact Assessment in a Transboundary Context, which entered into force in 1997, and other conventions signed by several Agency Member States but yet to enter into force (e.g. Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters and the Convention on the Protection of the Environment through Criminal Law).

The Agency will document and provide guidance on best practices in the planning, operation and closure of uranium production facilities, from the perspective of changing environmental regulations in mining facilities in general and growing environmental concerns in uranium mining in particular. This is of particular importance for Member States which are developing uranium resources but do not have adequate regulatory and technological infrastructures.

Objective: To improve the capability of interested Member States to take informed policy decisions and plan strategies associated with uranium production or uranium requirements, to make use of preventive measures to reduce impacts from uranium mining and milling on the environment through guidance and transfer of information on current status and perspectives.

Outcomes
<ul style="list-style-type: none"> — Use in Member States of the information provided by the Agency on uranium resources, supply and demand in their assessment and planning of future uranium production and/or procurement. — Consideration and/or use in Member States of information and guidance provided by the Agency on best practices in uranium mining from the point of view of mitigating the environmental impact of such activities.
Performance Indicators
<ul style="list-style-type: none"> — Number of Member States contributing to and using Agency analysis of uranium supply and demand. — Number of Member States following guidance on best practices associated with the mitigation of environmental impacts as provided in Agency publications, services and meetings.

Programme changes and trends: Underlying this subprogramme, more reliable and better defined information on supply and demand of uranium is indispensable for Member States' policy making and strategy planning, particularly in the scenarios for potential increased use of nuclear power in the decades to come. Since environmental protection

during the operation and closure of mining and milling facilities is becoming increasingly important for uranium producing Member States, the periodic worldwide report on "Uranium Resources, Production and Demand" (the 'Red Book') to be published in 2004 will focus on world uranium production and environmental issues. A symposium on "Uranium Production and Raw Materials for Nuclear Fuel Cycle – Supply and Demand, Environment, Economy and Energy Security" is planned in 2005 and will address comprehensively the major issues on uranium production.

Resource changes and trends: The proposed resources for the Subprogramme B.1 amount to \$428 000 in 2004, reflecting a decrease in the budget of \$2 000, or 0.5% compared with 2003, and an increase of \$31 000, or 7.2% in 2005 over 2004. This increase reflects the greater efforts in addressing the environmental issues associated with mining and milling of uranium.

Financial resources (2003 prices)

B.1	2003	2004	2005
Reg. budg.	430 000	428 000	459 000

Recurrent Project B.1.01: Assessing uranium resources and projecting supply and demand

Main outputs: The following documents will be produced: publication in 2004 of "Red Book 2003", providing the latest quantitatively and qualitatively analysed global information on uranium resources, together with the projections of supply and demand; the "Red Book 2005" will also be ready in draft form.

Ranking: 1 ex aequo

Project B.1.02: Promoting best practices in uranium production to support sustainability and minimize environmental impacts

Main outputs: The project will result in two technical documents: guidebook (2004) on environmental impact assessment of in situ leach (ISL) mining, providing a reference for uranium mining operators, developers and environmental agencies on the major issues to be considered in this field; and global mapping of the geochemical background of uranium deposits for use by international organizations and environmental organizations in Member States, setting a threshold for various comparisons of natural conditions and impact of mining operations. The proceedings of the symposium on uranium production and raw materials for the nuclear fuel cycle (2005) will be issued and will provide information on the latest views, plans and experience in support of the sustainability of the raw fuel cycle materials and the fuel cycle.

Unfunded activities/means of implementation: CRP on the use of in situ leach (ISL) mining method from deeper levels to support sustainability and minimize environmental impacts.

Duration: 2002–2008

Ranking: 1 ex aequo

Subprogramme B.2. Nuclear Fuel Performance and Technology

Rationale: Optimized use and reliable behaviour of nuclear fuel and fuel assemblies in the power reactor core are major factors for the sustainability of nuclear energy. Optimized use implies the improvement of the fuel cycle economy and plant availability, which today is achieved by advanced fuel and core designs and more demanding operational strategies (e.g. extended burnup, longer fuel residence time, higher thermal rates), while still satisfying appropriate safety margins.

With regard to fuel reliability, there is an incentive for achieving lower failure rates, greater operational flexibility and operation within appropriate margins for normal, transient and accident conditions. To address this, degradation mechanisms (e.g. radiation induced embrittlement, hydriding, corrosion) and impact on structural and fuel materials, primary coolant technologies, new irradiation and corrosion resistant materials, advanced fuel designs and technologies are being investigated and developed. The Agency is the only independent and non-commercial organization which provides a forum for exchange of experience on technical/scientific and safety aspects of the optimized use and reliability of nuclear fuel and fuel assemblies and which promotes the harmonization of fuel performance related technologies and associated QA/QC. Its work in this area matches with objectives A.2 and A.3 of the Medium Term Strategy, i.e. to achieve more effective use of the current technology (e.g. by using MOX fuel) and to support and facilitate the development of new and emerging technologies to enhance competitiveness, safety and efficiency.

This subprogramme focuses on exchange of information, for example on fuel performance and modelling in normal, transient and accident conditions, and on advanced fuel such as MOX fuel. It also deals with sharing practical experience in fuel related methodologies.

Groups interested in the activities on fuel performance and technology in this subprogramme are fuel designers, research establishments, plant operators and regulatory bodies in industrialized countries and research establishments in countries considering the use of on nuclear power.

Objective: To improve, through transfer of information and sharing experience, the capability of interested Member States to optimize in-pile fuel performance, and to develop advanced technologies for ensuring reliability and economic efficiency in nuclear fuel utilization, while satisfying appropriate safety margins.

Outcomes
<ul style="list-style-type: none"> — Use in interested Member States of information provided by the Agency, and the experience exchanged, for a more quantitative understanding of the mechanisms of in-pile behaviour of fuel, as well as of fuel materials in normal, transient and accident conditions. — Progress in the harmonization of the methodology for design, fabrication and utilization of advanced fuel in Member States with different reactor designs on the basis of information provided by the Agency and the experience exchanged.
Performance Indicators
<ul style="list-style-type: none"> — Number of countries relying on, or considering, advanced technology for improving power reactor core and primary circuit materials performance for enhanced utilization, economics and reliability of the fuel, on the basis of information provided by the Agency. — Number of utilities in interested Member States increasing fuel burnup and fuel residence times based upon information and experience made available by the Agency. — Extent of harmonization of advanced methodologies for water reactor fuel design, fabrication and utilization, in interested Member States, on the basis of information and experience made available by the Agency.

Programme changes and trends: So far, the Agency’s activities on fuel performance and technology has focused on information exchange on the development of fuel and coolant technologies for NPPs. This subprogramme will place in 2004–2005 more emphasis on harmonization of advanced methodologies for fuel design, fabrication and utilization among Member States with different reactor designs. Access to advances in core corrosion monitoring and control, and in validation and verification of national fuel performance codes, will be provided for interested Member States through CRPs on data processing technologies and diagnostics for water chemistry and corrosion control (DAWAC) and fuel modelling at extended burnup (FUMEX-II) respectively.

Resource changes and trends: The proposed resources for Subprogramme B.2 in 2004 remain essentially unchanged compared with 2003. There is, however, a decrease of \$29 000 in 2005 compared with 2004. This decrease is due to consolidation of activities related to improving the performance and quality of regular and advanced nuclear fuels in currently operating nuclear reactors.

Financial resources (2003 prices)

B.2	2003	2004	2005
Reg. budg.	559 000	560 000	531 000

Project B.2.01: Supporting the evaluation and reduction of core and primary circuit materials degradation in nuclear power plants

Main outputs: A technical document and final report of the CRP on hydride induced degradation of the mechanical and physical properties of zirconium based alloys, as well as the final report of another CRP on data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants will be produced.

Unfunded activities/means of implementation: CRP on behaviour of high corrosion resistance Zr alloys and delayed hydride cracking of Zr alloy fuel cladding.

Duration: 2002–2007

Ranking: 6 ex aequo (priority 2)

Project B.2.02: Promoting good fuel performance in operating nuclear power plants

Main outputs: Three reports will be issued: state-of-the-art of water reactor fuel performance and technology; and the others on evaluating factors influencing the structural behaviour of BWR/PHWR/PWR/WWER fuel assemblies; and fuel behaviour modelling at high burnups. These will represent a comprehensive set of information and references allowing fuel designers and plant operators to increase the performance of specific nuclear fuels and fuel assemblies in existing power plants.

Unfunded activities/means of implementation: Preparation of a technical document on the review of fuel failures in water reactors.

Duration: 2002–2006

Ranking: 1 ex aequo

Project B.2.03: Harmonizing fuel qualities and utilizing and promoting advanced technologies for power reactor fuel

Main outputs: A draft report will be prepared on poolside inspection providing information/data on new approaches to fuel rod materials and design, and on recent progress in pool examination techniques. Personnel will be trained as a result of contribution to the technical co-operation projects on fuel quality issues.

Unfunded activities/means of implementation: Preparation of a technical document on advanced water reactor fuels, and the organization of a symposium on characterization and quality control of nuclear fuel.

Duration: 2002–2006

Ranking: 6 ex aequo (priority 2)

Subprogramme B.3. Management of Spent Fuel from Power Reactors

Rationale: The importance of the Agency's involvement in the management of spent fuel from power reactors has been noted on several occasions in meetings of the Board of Governors and is reflected in the Medium Term Strategy. The production of nuclear electricity results in the generation of spent fuel that requires safe, secure and efficient management. Appropriate management of the spent fuel arising is thus a key issue for the steady and sustainable growth of nuclear energy. More than four hundred nuclear power reactors are in operation today and have already accumulated a large amount of spent fuel stored either at or away from the reactor sites.

The majority of Member States have not yet decided about the final solution and destination for the spent fuel arisings and will have to keep them in extended storage until a satisfactory solution is found for their final disposition. Only a limited number of Member States are preparing for final disposal and no repository will be in operation before 2010. In many countries with nuclear power plants, the major current issue in the area of spent fuel management is the need to expand their existing capacities at reactor sites or to provide additional storage space to accommodate upcoming spent fuel arisings. In addition, several Member States are considering taking nuclear power plants out of service in the very near future. Consequently, the associated spent fuel storage facilities would need to be decommissioned in several of these cases.

This subprogramme is intended to play a catalytic role for co-operation among Member States through, inter alia, the collection, evaluation and sharing of information on the current status in spent fuel management and to aid Member States in the planning and implementation of their national programmes for spent fuel management. Target groups include power reactor operators, regulators, designers and waste management organizations in all Member States with power reactors, particularly developing Member States and those in Eastern and Central Europe.

Objective: To improve the capability of interested Member States to plan, develop and implement safe and efficient spent fuel management by the identification and mitigation of the associated problems, using information and guidance provided by the Agency.

Outcome
— Increased use by Member States with nuclear power plants of Agency guidance in the planning or implementation of national programmes for power reactor spent fuel storage and/or management.
Performance Indicator
— Number of Member States using information or guidance provided by the Agency for the planning or implementation of state-of-the-art technologies in spent fuel storage facilities or improving spent fuel storage and management conditions.

Programme changes and trends: The programme associated with these issues has focused so far on the management and technology of interim spent fuel storage. The amount of spent fuel is increasing and the storage duration is being prolonged owing to delays in the opening of repositories. To address these recent issues, this subprogramme emphasizes the development of guidance and information exchange on methods to increase the capacity of existing facilities and extended interim storage.

Resource changes and trends: The proposed resources for Subprogramme B.3 remain essentially unchanged in 2004 compared with 2003. There is a decrease of \$9 000 in 2005 compared with 2004.

Financial resources (2003 prices)

B.3	2003	2004	2005
Reg. budg.	550 000	548 000	539 000

Project B.3.01: Promoting technologies and strategies for spent fuel management and updating information

Main outputs: The project will result in technical documents on: (a) potential regional concepts for the storage of spent fuel and related technical, economic, institutional aspects, as well as potential benefits and risks associated with such concepts; (b) the optimization of cask/container loading for spent fuel storage in Member States; (c) the operation and maintenance of casks, including options to improve cask operation and maintenance in spent fuel management. A newsletter providing updated global information on spent fuel inventories and management for a larger, interested, technical and energy policy audience will also be available every year.

Unfunded activities/means of implementation: Preparation of an information document on the survey of wet and dry storage.

Duration: 2002–2010

Ranking: 6 ex aequo (priority 2)

Project B.3.02: Providing guidance on good practices for long term storage of spent fuel

Main outputs: The main outputs consist of technical documents on: (a) the requirements, practices and

development in burnup credit application providing a worldwide overview of the use of burnup credit; (b) data requirement and maintenance of records for spent fuel management providing guidance on the data needed, options for and factors involved in the maintenance of records associated with spent fuel management; and (c) the influence of fuel design (in particular for high burnup, MOX fuel and advanced reactor operation) for subsequent spent fuel storage, providing guidance on the preparation and maintenance of data for various technical and institutional issues associated with long term storage.

Unfunded activities/means of implementation: Collection of information on issues such as reprocessing and transportation, connected with spent fuel treatment.

Duration: 2001–2008

Ranking: 1 ex aequo

Subprogramme B.4. Topical Nuclear Fuel Cycle Issues and Information Systems

Rationale: In accordance with the objectives A.2 and A.3 of the Agency's Medium Term Strategy this subprogramme is intended to meet the needs of Member States in addressing nuclear fuel cycle issues and concerns by identifying, assessing and documenting the current status, trends and emerging technologies for various options for the entire nuclear fuel cycle and in obtaining authoritative and factual information on the complex issues involved.

Issues that have an impact on the sustainability of nuclear power, including public perception of sustainability and acceptance for its future development, are: contribution of the fuel cycle to economic competitiveness of nuclear energy, the need for evolutionary, advanced, new or innovative technologies to improve the fuel cycle efficiency and mitigate proliferation, and security and environmental risks from specific processes or materials (such as separated plutonium and chemotoxic materials).

There is very broad and high level of interest in Member States, as well as need within the Agency, to make available and maintain an authoritative and reliable source of information on the status and trends in nuclear fuel cycle policies and programmes, types of fuel cycle activities and facilities around the world and the materials involved. Target groups for the activities in this subprogramme are policy makers, national authorities, fuel cycle service organizations, research establishments and other areas of the Agency.

Objective: To improve the capability of interested Member States to plan and develop new technologies for safe, secure, proliferation resistant and economically efficient nuclear fuel cycles, while

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minimizing waste and environmental impacts, and to address appropriately the issues emerging from nuclear fuel cycle activities, through the use of the information provided by the Agency.

Outcomes
<ul style="list-style-type: none"> — Use in interested Member States of the information provided by the Agency for the development of concepts of proliferation resistance in nuclear fuel cycle systems, facilities and processes. — Use in interested Member States of the information provided by the Agency for the development of advanced and innovative fuel cycle technologies for the mitigation of environmental burden and disposition of nuclear materials and by-products from nuclear fuel cycle activities. — Increased reliability and use of Agency's nuclear fuel cycle information systems.
Performance Indicators
<ul style="list-style-type: none"> — Number of organizations/Member States reflecting the non-proliferation attribute in nuclear fuel cycle systems, facilities and processes based on information provided by the Agency and using Agency information for minimization of environmental impact associated with the back end of the fuel cycle. — Number of experts/organizations/Member States contributing to and making use of databases and models on nuclear fuel cycle developed and made available under the aegis of the Agency.

Programme changes and trends: In the previous programmes, proliferation concern was focused mainly on the separated plutonium inventory. In the future, this subprogramme will address proliferation and security concerns throughout the entire nuclear fuel cycle. In addition, technology development and evolution in the nuclear fuel cycle becomes more important for mitigating the environmental burden, enhancing safety and security, and improving economic efficiency and proliferation resistance. Information exchange on proliferation resistance and innovative technologies will be emphasized. A new project is proposed to address management of materials (radioactive and non-radioactive) for different fuel cycle options, looking first into the methods of assessment and analysis, data available and some case studies.

Resource changes and trends: The proposed resources for Subprogramme B.4 amount to \$917 000 in 2004, reflecting a decrease in the budget of \$32 000, or 3.4% compared with 2003. No major change is foreseen for 2005. This decrease results from the discontinuation of a CRP in Project B.4.02.

Financial resources (2003 prices)

B.4	2003	2004	2005
Reg. budg.	949 000	917 000	924 000

Project B.4.01: Facilitating innovative nuclear fuel cycle technologies for sustainability

Main outputs: Technical documents on (a) the entire thorium fuel cycle and thorium fuel, particularly from the technological perspectives associated with the current opinion on the needs for, and attributes of, new reactor/fuel cycle systems, and (b) information on the properties of minor actinide compounds and their processing for the fabrication of nuclear reactor fuels and targets will be produced. Technical meeting documents from workshops on dry and pyro-processing for the treatment of spent fuel, particularly in the context of new fuel cycle concepts will also be made available.

Unfunded activities/means of implementation: Current status and future perspective of liquid metal cooled reactor fuel cycle; innovative fuel for application in future nuclear fuel cycles; and a CRP on HTGR coated particle fuel technology.

Duration: 2002–2008

Ranking: 1 ex aequo

Recurrent Project B.4.02: Promoting solutions of nuclear fuel cycle issues

Main outputs: The project will provide working documents giving views of the Technical Working Group on Nuclear Fuel Cycle Options (TWG-NFCO) on major current issues in the nuclear fuel cycle. Technical documents will be produced on: the technical aspects for improving proliferation resistance of the nuclear fuel cycle; and the current status and future trends of HEU and reprocessed uranium availability and use. Country nuclear fuel cycle profiles will also be provided.

Unfunded activities/means of implementation: Proliferation resistant aspects of transuranium elements as material and technical barriers.

Ranking: 6 ex aequo (priority 2)

Recurrent Project B.4.03: Maintaining and updating nuclear fuel cycle information systems

Main outputs: The project will result in updated databases such as Nuclear Fuel Cycle Information System (NFCIS), Uranium DEPOSIT (UDEPO) and VISTA and accompanying analyses for use by interested persons in Member States, international organizations and other Agency projects. The primary structure of a database on physical and chemical properties of minor actinide compounds will be established for supporting research and development of innovative nuclear fuel cycle technology in Member States.

Unfunded activities/means of implementation: Maintenance of the Nuclear Fuel Cycle Information System (NFCIS).

Ranking: 11 (priority 3)

Project B.4.04: Materials management for different nuclear fuel cycle options

Main outputs: The main outputs of the project will be the reports in relevant fields for the Contact Expert Group (CEG) and participating countries.

Unfunded activities/means of implementation: CRP on analysis of material flows for advanced and innovative reactors and fuel cycles. In addition, the

development of a registry for information on nuclear fuel cycle materials, and preparation of a report on costs of management of materials from nuclear fuel cycle, their environmental impact and mitigation, are partially unfunded.

Duration: 2004–2008

Ranking: 6 ex aequo (priority 2)