



EUROPEAN COMMISSION
RESEARCH DIRECTORATE-GENERAL
ENVIRONMENT DIRECTORATE-GENERAL

European Commission Activities in the fields of:
A: Radioactive Waste Management Policy (DG Environment)
B: Radioactive Waste Management Research (DG Research)

Status Report to the OECD/NEA
Radioactive Waste Management Committee (RWMC)
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The European Commission activities in the field of "*Radioactive Waste Management*"¹ are carried out in two Directorates-General: DG Environment dealing with Radioactive Waste Management Policy, and DG Research dealing with Radioactive Waste Management Research.

The following paper gives an overview about the main activities and achievements.

A. Radioactive Waste Management Policy

In the policy area, a number of activities conducted under the "Plan of Action" for radioactive waste management in the European Union came to fruition.

In September 1999, the Commission adopted a "Recommendation" to the Member States on a "*Classification System for Solid Radioactive Waste*". This recommendation (SEC(1999)1302 final) is that:

- the Member States and their nuclear industry adopt a common classification scheme for national and international communications purposes
- that the scheme should be used for providing information on such wastes to the public, national and international institutions and other interested organisations

The scheme is based on, and is very similar to the one developed by the IAEA. It was developed with the assistance of experts from both Member States and Applicant Countries.

These included the study of *the role of Environmental Impact Assessments in the siting of geological repositories*. This work, that concluded with a successful seminar in April 1999. This showed that EIAs have already played an important part in bringing together the many parties with a legitimate interest in the siting of a repository. It clearly illustrated the need to involve the public – especially in the region around a proposed site

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– from the very earliest stage in the process. The report, which includes a model EIA process for a geological repository, has been published (EUR 19152). This report may form the basis of a formal Communication.

A second seminar, also in April, covered *schemes for financing radioactive waste storage and disposal*. The bulk of the published report (EUR 18185) describes the schemes used by agencies and waste collecting organisations in Member States and also in Canada and the USA. It also examines other financing schemes used for non-radioactive waste forms (for example by the chemical and pharmaceutical industry) and possible consequences of modifications in pricing. It briefly examines the financial advantages of exchange of waste and of “common installations”.

Given the relatively high profile of the problems of *the management of disused sealed sources*, it was not surprising that the workshop held in June to discuss the results of an EC-wide study was very well attended. The “key recommendation” was that “common objectives should be agreed for the regulatory management and disposal of disused sealed sources. These objectives should be implemented in a flexible way through a Common Code of Practice”. The report (EUR 18186 – published a few days ago) includes a number of specific recommendations for consideration both by the EU and individual Member States. Their implementation could result in improvements to regulatory control of sources or disposal arrangements. A formal Communication is being prepared based on this report. Other studies are being undertaken on the management of sealed sources in the Applicant States.

In July, the Commission published a report on *radioactive waste management in the countries of Central and Eastern Europe*. This report (EUR 19154), a more “formal” and updated version of the document produced in 1997, was prepared with the help of experts from all the countries involved. As well as describing the present situation in each of the countries, it identifies a range of existing problems and details some of the international efforts to address these. The work contributes to the Commission’s ongoing assessment and monitoring of nuclear safety in the context of enlargement of the Union.

Even further afield, reports published last year on radioactive waste management in Russia included an evaluation of the radiological impact resulting from injection operations in Tomsk-7 and Krasnoyarsk-26 (EUR 18189) and on the management of sealed radioactive sources produced and sold in the Russian Federation (EUR 18191).

A few days ago, the Commission published a general overview of *the existing and future requirements for decommissioning nuclear facilities in the Czech Republic, Hungary, Poland, Slovakia and Slovenia*. The report (EUR 19155) includes a description of the characteristics and inventory of radioactive waste arising from reactor decommissioning (including an in depth analysis of four selected installations) and a detailed description, country by country, of the basic requirements for decommissioning including the facilities needed for treatment, conditioning, transportation, storage and disposal of the wastes.

Another report published in 1999 covered an *evaluation of the radiological and economic consequences of decommissioning particle accelerators* (EUR 19151). The report covers an inventory of the decommissioning problem of accelerators in the EU, characterisation of three accelerators and their shielding and an estimation of techniques, costs and waste volumes.

We have just concluded a consultation between the various Commission services on the *decommissioning of nuclear installations in the European Union*. This draft Communication to the Member States and the European Parliament includes a proposed "Code of Conduct" and a list of possible future Community actions. We hope that this Communication will be adopted by the Commission before the end of April.

Finally, there has been considerable interest in the preparation of a new "Plan of Action" for radioactive waste management in the European Union. A proposal for a new Plan had been prepared with the assistance of the Commission's Advisory Committee (the "ACPM"). However, this has been blocked until after a final decision on the proposed reorganisation of the nuclear safety activities within the Commission. This decision has now been expected for some time.

The unit "Nuclear Safety, Regulation and Radioactive Waste Management" of DG Environment now has its own web site. This is:

<http://europa.eu.int/comm/environment/nuclear/index.htm>

A number of the reports referenced above can be examined or downloaded through that site.

B. Radioactive Waste Management Research

RESEARCH PROGRAMMES

1 Nuclear Energy (1998-2002)

The 5th EURATOM Framework programme in the field of 'Nuclear Energy' (1998-2002) comprises:

- Two key actions : - Controlled Thermonuclear Fusion and
- Nuclear Fission
- Generic Research on Radiological Sciences and
- Support for Research Infrastructure

The key action '*Nuclear Fission*' aims at enhancing the safety of Europe's nuclear installations, to improve the competitiveness of Europe's industry and to perform a clear move from fundamental research to the problem solving approach to demonstrate the availability of practical solutions to the outstanding scientific and technical problems and public concerns.

The key action comprises four research areas:

- Operational safety of existing installations
- Safety of the fuel cycle
- Safety and efficiency of future systems
- Radiation protection

Research activities within the "*Safety of the fuel cycle*" area aims at developing a sound basis for policy choices on the management and disposal of spent fuel and high-level and long-lived radioactive waste and on decommissioning, and to building a common understanding and consensus on the key issues. Research will focus on:

- Waste and Spent Fuel Management and Disposal
- Partitioning and Transmutation (P&T)
- Decommissioning of Nuclear Installations

The specific objectives within "*Waste and Spent Fuel Management and Disposal*" are to develop methods for comparing different waste management strategies, to demonstrate the technical feasibility of geological disposal and improve the scientific basis for the safety assessment and to establish better methods for achieving public confidence and trust.

The objective of "*P&T*" is to provide a basis for evaluating the practicability, on an industrial scale, of partitioning and transmutation for reducing the amount of long-lived radionuclides to be disposed of.

The objective of "*Decommissioning of Nuclear Installations*" is to establish a network that will improve the competitiveness of Europe's decommissioning industry and contribute towards a common understanding of the key issues.

The total budget available for the "*Safety of the fuel cycle*" area is about 60 M€ for the 5-year period.

Following the deadline for submission of proposals for the '*Nuclear Energy*' programme in October 1999, a total of 36 proposals were selected by the European Commission in the '*Safety of the Fuel Cycle*' area for:

- Waste and spent fuel management and disposal: 23 proposals, proposed funding 19 M€
- Partitioning and Transmutation: 9 proposals, proposed funding 17 M€
- Decommissioning of Nuclear Installations: 4 proposals, proposed funding 1.2 M€

The proposals under negotiation in the sub-area on "**Waste and Spent Fuel Management and Disposal**" are covering research activities devoted to (i) repository technology to test steps in the design, construction and operation of a repository in an URL, demonstration of effective sealing and backfill concepts in URL's and assessing of the disturbance zone of rock mass due to repository construction, (ii) performance assessment of repository systems to further develop PA methodologies and strengthening the scientific input basis for models used in PA calculations and evaluation of safety indicators; (iii) long-term behaviour of repository systems to test and assess the different barriers considering in the multi-barrier concept, (iv) public attitudes and involvement to deal with the evaluation of transparency in decision making and communication process of complex issues such as nuclear waste management with the public and (v) quality checking of waste packages associated with destructive and non-destructive waste assay techniques.

With regard to "Research infrastructure", one project will constitute a forum for pooling and assessing experiences from various URL's, in particular concerning backfilling and sealing systems.

In the sub-area "**Partitioning and Transmutation**", nine proposals are under negotiation. Three proposals are dealing with experimental work on chemical separation of actinides from high-level waste by hydro-metallurgical and pyro-chemical processes. The technological support to transmutation by ADS will be addressed by three projects to investigate nitride fuel irradiation, neutron/proton irradiation damage of a spallation target and to assess the use of lead alloys as a spallation target and a coolant for ADS.

Basic studies of transmutation are covered by one project addressing experimental neutronic studies of sub-critical configurations and two projects on nuclear data required for transmutation and ADS engineering design. Studies on the thorium cycle will be pursued with a main emphasis on thorium-plutonium fuel irradiation in an additional project and nuclear data as part of the project on nuclear data for transmutation.

Under the "**Decommissioning of Nuclear Installations**", the Thematic Network on Decommissioning (TND) and the continuation of a common decommissioning data base (EC DB NET-2) shall provide the basis for a co-operation and a transfer of knowledge between research institutions, industry and decommissioning projects within the EU including the associated countries.

The remaining budget foreseen for the calls to be made in the second half of 2000 and 2001 available for projects in the area "*Safety of the fuel cycle*" is about 22 M€.

2 Nuclear Fission Safety (1994-1998)

The programme on '*Nuclear Fission Safety*', which includes research on '*reactor safety*', '*radioactive waste management and disposal and decommissioning*' as well as '*radiation protection*' covers in total about 125 projects with an overall budget of 170.5 M€ and will be finalised this year.

In the area of "*Radioactive waste management and disposal*", including research work on "*Partitioning and Transmutation*" (P&T) and "*Decommissioning of nuclear installations*", the Commission is involved in about 60 projects with a financial contribution of about 47 M€ [1]. The topics covered are:

- Safety Aspects of Waste Disposal
- Field Experiments in Underground Research Facilities
- Research on Basic Phenomena
- Partitioning and Transmutation
- Decommissioning of Nuclear Installations

Main results of these research topics have been among others, presented and discussed at the 5th European Community Conference on "*Radioactive Waste Management and Disposal and Decommissioning: EURADWASTE'99*", held from 15 to 18 November 1999 in Luxembourg [2].

Some conclusions of the conference, drawn from the two panel discussions on "*Radioactive Waste Management in Europe: Challenges and ways forward*" and "*Research for disposal: between demonstration and implementation*" are:

- Postponing decisions to dispose of radioactive waste in deep underground repositories and indefinite surface storage of these wastes would impose great burdens on the organisation of society over very long time-scales while phased deep geological disposal is possible.
- Implementation of P&T would only make sense if it were associated to the continued use of nuclear fission energy beyond the operation of the present generation of nuclear power plants.
- Research should not be brought to an end in areas where there are still major conflicting views among the scientific community.
- It is recommended to demonstrate the feasibility of implementation of disposal concepts in Underground Research Laboratories, this backed up by a continuous

support of fundamental research in order to create the conditions for a better perception by the public and decision makers of the need to find solutions for all types of radioactive wastes.

ACHIEVEMENTS UNDER THE "NUCLEAR FISSION SAFETY" PROGRAMME

1 Radioactive Waste Management and Disposal

1.1 Safety Aspects of Waste Disposal

"*Disposal of spent fuel*" has been investigated through the research project on "*Spent Fuel Performance Assessment*" (SPA), which identified differences in the methodological approach and models used and discussed them. Progress was made in various fields involved in the study, namely with regard to the various "*source term models*" adopted by the participants, engineered barrier behaviour, possible effects of an Excavation Damage Zone (EDZ), radionuclide transport in the far-field (clay, crystalline rocks and salt formation) through an update in data review and modelling capability, scenario and biosphere definition, deterministic and probabilistic calculation methods.

A Concerted Action on "*The retrievability of long-lived radioactive waste in deep underground repositories*" in which experts from nine European countries collaborated in reviewing the current understanding and different views of retrievability led (i) to an overview of how the different countries are considering the issue, (ii) to establish an interpretation and working definition of the retrievability concept, (iii) to a methodology allowing the assessment of how retrievability varies between different disposal concepts and (iv) to identify implications on repository design and technology, safety, socio-political, monitoring and safeguards aspects.

1.2 Field Experiments in Underground Research Laboratories

Large field experiments were carried out in three URL's: in the HADES facility in Boom clay at Mol (B), in the Asse salt mine (D) and in the Grimsel Felslabor in crystalline rock (CH), respectively.

These experiments mainly contributed to:

- Repository construction to investigate the "*Excavation Disturbance Zone*" (EDZ), due to mechanical excavation of a gallery in the Boom clay at Mol and to test the predictive capacity of hydro-mechanical computer models (CLIPLEX project)
- Backfilling and sealing of waste emplacement holes, galleries and shafts investigated through:
 - the RESEAL project, carried out in the HADES-URL, demonstrates the effective sealing of a shaft with a high-density pellet/powder mixture;
 - the FEBEX project investigated the suitability of highly compacted bentonite blocks for the backfilling of waste emplacement galleries and demonstrated the successful fabrication, handling and emplacement of the blocks in the Grimsel Felslabor;
 - the BAMBUS project, performed in the Asse salt mine, investigated the behaviour of crushed salt in both the gallery (TSDE) and the borehole emplacement concept, which gave a large amount of data on the performance of

backfill and host rock under conditions almost equal to those to be expected in a repository;

- Behaviour of repository components, i.e. the waste matrix, the canister and over-pack materials, the buffer material and the argillaceous host rock under the influence of heat and radiation, has been the objective of the project CERBERUS, performed in the HADES-URL.

The large field experiments performed in Underground Research Laboratories have contributed to demonstrate the technical feasibility of backfilling and sealing emplacement holes and galleries and have extended the technical and scientific database necessary for the safety case. The experimental data obtained under as near as possible to representative disposal conditions, has permitted to increase confidence in the predicting capabilities of models.

International co-operation and partnerships in research projects carried out in the URL's and the exchange of information were stimulated via the establishment by the European Commission of a CLub of Underground Storage, TEsting and Research facilities (CLUSTER – URL's) in which, apart from the above-mentioned three URL's, the Äspö HRL (S) and the Tournemire research facility in hard clay in Southern France were also represented. CLUSTER-URL meetings and two workshops were held respectively in Alden-Biesen (B) in December 1997 [3] and in Brussels in November 1998. At the last workshop, the Yucca Mountain project (USA) and the Mt. Terri Tunnel project (CH) were presented as well. Moreover, representatives from EU applicant countries planning to build an URL were participating.

1.3 Research on Basic Phenomena

Under this research topic, a number of international projects has been supported, which have contributed considerably to extend the scientific knowledge and data base on some important processes and parameters to characterise in qualitative and quantitative terms – where possible – the engineered barrier (waste matrix, canister, overpack, buffer/backfill), geo-mechanical behaviour of natural clay and bentonite, gas generation and migration and radionuclide transport/retardation processes to assess the confinement (near-field/far-field) properties of the multi-barrier components.

The investigations of the behaviour of the engineered barrier components lead to some important achievements with regard to:

- Improved modelling of dissolution behaviour of vitrified HLW glass as basis to develop a source-term model used in PA calculations
- Quantification of rates of spent fuel matrix dissolution under various laboratory conditions (groundwater composition, redox conditions, etc.)
- More reliable database for modelling corrosion behaviour of metal containers (e.g. Ti 99.8 Pd, TStE 355 carbon steel)
- Improved reliability in the experimental data base on the behaviour of bentonites and crushed salt as backfill and sealing materials for boreholes and galleries
- Increased confidence in modelling the THM behaviour of argillaceous buffer/backfill materials.

The theoretical studies, laboratory and field experiments as well as natural system (analogue) investigations at various sites contributed further to an improved understanding of some of the process occurring in various geological environments

(fractured and porous media) and provided also a solid database for application in PA calculations.

Achievements have been obtained with respect to:

- Testing different methodologies and models used in assessing interactive processes of complex natural systems
- Integration of repository performance requirements from an early stage of the investigation (Oklo, Palmottu site)
- Improved understanding of how past evolution of groundwater systems are being developed and evaluated at a number of European study sites (PHYMOL: Mol site, B; EQUIP: Olkiluoto, FIN; Aspö, S; Vienne, F; Sellafield, UK; PAGEPA: Aspö, S; Gorleben, D)
- Improved understanding of the physico-chemical processes and conditions on colloid facilitated RN migration (CARESS, HUMICS, TRANCOM-CLAY)
- Review ongoing thermodynamic database activities (JETDEM) identified issues where the knowledge base is insufficient: aspects of actinide chemistry, redox transformation, sorption processes etc.
- Assessment of *gas generation* from waste packages and *gas migration* through engineered and natural barriers based on laboratory, field experiments and modelling (PEGASUS-cluster) [4]
- State-of-the-art report on the gas issue and its impact on repository performance (in co-operation with OECD-NEA) [5].

Quality Control (QC) and assurance procedures and techniques of nuclear waste packages have contributed to improvement in the accuracy of methods for non-destructive and destructive assay techniques for radioactive waste packages (L/ILW) and to inter-comparison tests contributed to reduce discrepancies in the methods and techniques used, uncertainties in the measurement of nuclide inventory in packages and formulated recommendations for “best practice” in use of assay techniques

2 Partitioning and Transmutation

The research on "*Partitioning and Transmutation*" involves strategy studies, partitioning experimental work and transmutation experiments.

The progress achieved in the field of partitioning of minor actinides by aqueous processes (both experiment and modelling) suggests that it might be possible, in a near future, to develop a process with a single cycle allowing the direct extraction of the minor actinides from the very acidic high level liquid waste.

The conclusions of the P&T strategy studies concerning critical and sub-critical reactors and the results obtained in the transmutation experiments clearly indicate that the ADS have a large potential for the transmutation of nuclear waste, which has to be more thoroughly investigated. In particular, neutronics studies indicate that fast spectrum and liquid lead (or lead/bismuth) cooled, solid fuel ADS have a very large neutron surplus, which should be used for transmutation purposes. In addition, the direct experimental observation of Adiabatic Resonance Crossing demonstrates the possibility of destroying, in a parasitic mode, outside the Energy Amplifier core, large amounts of ⁹⁹Tc or ¹²⁹I at a rate exceeding the production rate.

The thorium cycles were re-assessed as a nuclear waste management option. As compared to the uranium fuel cycle, the waste radiotoxicity is strongly reduced (by about

one order of magnitude) up to 10,000 to 50,000 years of disposal depending on the reactor type and whether the fuel is recycled or not. Thorium-assisted plutonium burning in a LWR is an attractive option with respect to mass reduction of plutonium, which could be about twice that of MOX in a 100 % core loading.

3 Decommissioning of Nuclear Installations

Research on "*Decommissioning of Nuclear Installations*" contributed to further develop selected innovative dismantling techniques, to collect and analyse relevant data from current projects as well as to evaluate decommissioning strategies.

Development and testing of innovative cutting techniques (laser, plasma-arc, water-jet) were achieved, as well as a successful continuation of the co-operation with the four decommissioning pilot projects: WAGR (gas-cooled reactor), KRB-A (BWR), BR3 (PWR) and KGR (VVER), which started already in FP3 (1990-1994), and led to a huge amount of specific data and experience to be used in various decommissioning projects [6].

A common list of standardised decommissioning cost item definitions to ease a world-wide comparability and transferability of data and costs has been created together with the IAEA and the OECD/NEA.

The EC data bases TOOL and COST were implemented and started the collection and processing technical performance data, waste arising, doses and associated costs. Development of strategic and management planning tools for the decision-making and preparation of decommissioning projects has been dealt with in two projects [7].

As the technology in the field of *Decommissioning of Nuclear Installations*, after 20 years of EC-supported research, has achieved an industrial standard, future activities will be concentrating mainly to support "networks" on information exchange, data collection and training activities.

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