ADVANCED CONCEPTS FOR WASTE MANAGEMENT AND NUCLEAR ENERGY PRODUCTION IN THE EURATOM FIFTH FRAMEWORK PROGRAMME

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ABSTRACT

This paper summarises the objectives of the research projects on Partitioning and Transmutation (P&T) of long-lived radionuclides in nuclear waste and advanced systems for nuclear energy production in the key action on nuclear fission of the EURATOM Fifth Framework Programme (FP5) (1998-2002). As these FP5 projects cover the main aspects of P&T, they should provide a basis for evaluating the practicability, on an industrial scale, of P&T for reducing the amount of long lived radionuclides to be disposed of. Concerning advanced concepts, a cluster of projects is addressing the key technical issues to be solved before implementing High Temperature Reactors (HTRs) commercially for energy production. Finally, the European Commission's proposal for a New Framework Programme (2002-2006) is briefly outlined.

Keywords: chemical separation, transmutation, waste, advanced concepts for power generation

1 - INTRODUCTION

The Fifth Framework Programme (FP5) (1998-2002) of the European Atomic Energy Community (EURATOM) has two specific programmes on nuclear energy, one for indirect research and training actions managed by the Research Directorate General (DG) and the other for direct actions performed by the Joint Research Centre of the European Commission (EC). The strategic goal of the first one, "Research and training programme in the field of nuclear energy", is to help exploit the full potential of nuclear energy in a sustainable manner, by making current technologies even safer and more economical and by exploring promising new concepts [1]. This programme includes a key action on controlled thermonuclear fusion, a key action on nuclear fission, research and technological development (RTD) activities of a generic nature on radiological sciences, support for research infrastructure, training and accompanying measures. The key action on nuclear fission and the RTD activities of a generic nature are being implemented through indirect actions, i.e. research co-sponsored and managed by DG Research of the EC, but carried out by external public and private organisations as multi-partner projects. The total budget available for these indirect actions during FP5 is 191 millions €.

The key action on nuclear fission comprises four areas: (i) operational safety of existing installations; (ii) safety of the fuel cycle; (iii) safety and efficiency of future systems and (iv) radiation protection. In the safety of the fuel cycle, waste and spent fuel management and disposal, and partitioning and transmutation are the two larger activities, as compared to the decommissioning of nuclear installations. Safety and efficiency of future systems covers two sub-areas: (i) innovative or revisited reactor concepts and (ii) innovative fuels and fuel cycles.

The implementation of the key action on nuclear fission is made through targeted calls for proposals with fixed deadlines. Two calls have been made, one in March 1999 and another one in October 2000. A final call will be made in October 2001. Following the calls for proposals made in 1999, about 140 proposals covering all areas of the key action and of the generic research have been accepted for a total funding of around 110 million €. Most of the projects have already started in 2000. The October 2000 call resulted in the selection of about 75 proposals for another 50 million €. The new research contracts are being negotiated and the projects are expected to start in the Autumn of 2001. All information concerning the nuclear fission programme is available on the CORDIS website (www.cordis.lu/fp5-euratom).

This paper gives a general overview of the projects selected for funding by the EC in the field of advanced concepts for waste management and nuclear energy production in the EURATOM FP5. First, the research projects related to Partitioning and Transmutation (P&T) of long-lived radionuclides in nuclear waste are summarised after a brief outline of the goals of P&T. Then, a presentation is given of the projects on future systems based on nuclear fission for energy production (new and revisited reactor concepts) and other applications (e.g. desalination). Finally, the main goals and the content of the proposal made by the EC for a New Framework Programme (2002-2006) in February 2001 are briefly summarised.

2 - PARTITIONING AND TRANSMUTATION (P&T)

2.1 – Goals of P&T and the organisation of R&D

Spent fuel and high level waste contain a large number of radionuclides from short-lived to long-lived ones, requiring geological disposal for very long time periods. The long-lived radionuclides are mainly the actinides and some fission products. Partitioning and Transmutation aims at reducing the inventories of long-lived radionuclides in radioactive waste by transmuting them into radionuclides with a shorter lifetime [2].

If successfully achieved, P&T will produce waste with a shorter lifetime. However, as the efficiency of P&T is not 100%, some long-lived radionuclides will remain in the waste, which will have to be disposed of in a deep geological repository. P&T is still at the research and development (R&D) stage. Nevertheless, it is generally accepted that the techniques used to implement P&T could alleviate the problems linked to waste disposal.

The interest for P&T in the EU is reflected in the increase of funding in this area over the EURATOM Framework Programmes, 4.8, 5.8 and almost 28 million € for the Third, Fourth and Fifth Framework Programmes respectively.

In the EURATOM Fourth Framework Programme (1994-1998), progress has been made in the development of aqueous processes for partitioning (chemical separation) of minor actinides from liquid high-level waste. In addition, P&T strategy studies concluded that the feasibility of sub-critical reactors coupled to accelerators, the so-called accelerator-driven systems (ADS), should be more thoroughly investigated for transmutation of nuclear waste [3].

The objective of the research work carried out under FP5 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 two major aims of this work are: (i) to develop efficient processes for the chemical separation of long-lived radionuclides from liquid high-level waste and (ii) to gather all scientific and technical data necessary to carry out a detailed engineering design of an ADS demonstrator in the next Framework Programme.

The organisation of the FP5 research projects in the field of P&T is shown in Figure 1. The projects are subdivided into four groups (or clusters): (i) partitioning, (ii) basic studies on transmutation, (iii) technological support for transmutation and (iv) fuel for transmutation. The preliminary design studies for an ADS demonstrator are mainly linked to the three clusters on transmutation. Finally, all FP5 P&T projects are part of a network. The R&D projects on P&T are briefly presented in the following sections.

2.2 – Cluster on partitioning (PARTITION)

The cluster on partitioning includes three projects, **PYROREP, PARTNEW** and **CALIXPART**. **PYROREP** aims at assessing flow sheets for pyrometallurgical processing of spent fuels and targets. Two methods, salt/metal extraction and electrorefining, will investigate the possibility of separating actinides from lanthanides. Materials compatible with corrosive media at high temperature will be selected and tested. It is worth noting that one of the partner of this project is CRIEPI, the research organisation of the Japanese utilities.

The two other projects are dealing with the development of solvent extraction processes of minor actinides (americium and curium) from the acidic high level liquid waste (HLLW) issuing the reprocessing of spent nuclear fuel. In **PARTNEW**, the minor actinides are extracted in two steps. They are first co-extracted with the lanthanides from HLLW (DIAMEX processes), then separated from the lanthanides (SANEX processes). Basic studies will be performed for both steps, in particular synthesis of new selective ligands and experimental investigation and modelling of their extraction properties. The radiolytic and hydrolytic degradation of the solvents will be also studied and the processes will be tested with genuine HLLW.

The **CALIXPART** project is dealing with the synthesis of more innovative extractants. Functionalized organic compounds, such as calixarenes, will be synthesised with the aim of achieving the direct extraction of minor actinides from HLLW. The extracting capabilities of the new selective compounds will be studied together with their stability under irradiation. The structures of the extracted species will be investigated by nuclear magnetic resonance (NMR) spectroscopy and X-ray diffraction to provide an input to the molecular modelling studies carried out to explain the complexation data.

2.3 – Cluster on basic studies on transmutation (BASTRA)

Three projects are grouped in the cluster on basic studies on transmutation: **MUSE, HINDAS** and **n-TOF-ND-ADS**. The **MUSE** project aims to provide validated analytical tools for sub-critical neutronics including recommended methods, data and a reference calculation tool for ADS study. The experiments will be carried out by coupling a pulsed neutron generator to the MASURCA facility loaded with different fast neutron multiplying sub-critical configurations. The configurations will have MOX fuel with various coolants (sodium, lead and gas). Cross-comparison of codes and data is foreseen. Experimental reactivity control techniques, related to sub-critical operation, will be developed. Argonne National Laboratory (ANL) is also participating in the **MUSE** project.

Two other projects deal with nuclear data, one at medium and high energy (**HINDAS**), and the other encompassing the lower energy in resonance regions (**n-TOF-ND-ADS**).

The objective of the **HINDAS** project is to collect most of the nuclear data necessary for ADS application. This will be achieved by basic cross section measurements at different European facilities, nuclear model simulations and data evaluations in the 20-200 MeV energy region and beyond. Iron, lead and uranium have been chosen to have a representative coverage of the periodic table, of the different reaction mechanisms and, in the case of iron and lead, of the various materials used for ADS.

The **n-TOF-ND-ADS** project aims at the production, evaluation and dissemination of neutron cross sections for most of the radioisotopes (actinides and long-lived fission products) considered for transmutation in the energy range from 1 eV up to 250 MeV. The project is starting with the design and development of high performance detectors and fast data acquisition systems. Measurements will be carried out at the TOF facility at CERN, at the GELINA facility in Geel and using other neutron sources located at different EU laboratories. Finally, an integrated software environment will be developed at CERN for the storage, retrieval and processing of nuclear data in various formats.

2.4 – Cluster on technological support for transmutation (TESTRA)

The cluster on technological support for transmutation has three projects: **SPIRE, TECLA** and **MEGAPIE**. The **SPIRE** project addresses the irradiation effects on an ADS spallation target. The effects of spallation products on the mechanical properties and microstructure of selected structural steels (e.g. martensitic steels) will be investigated by ion beam irradiation and neutron irradiation in reactors (HFR in Petten, BR2 in Mol and BOR 60 in Dimitrovgrad). Finally, data representative of mixed proton/neutron irradiation will be obtained from the analysis of the SINQ spallation target at the Paul Scherrer Institute (PSI) in Villigen.

The objective of **TECLA** is to assess the use of lead alloys both as a spallation target and as a coolant for an ADS. Three main topics are addressed: corrosion of structural materials by lead alloys, protection of structural materials and physico-chemistry and technology of liquid lead alloys. A preliminary assessment of the combined effects of proton/neutron irradiation and liquid metal corrosion will be done. Thermal-hydraulic experiments will be carried out together with numerical computational tool development.

The **MEGAPIE** project has the aim of developing and validating expertise for the design and operation of a heavy liquid metal (Pb-Bi) spallation target producing a high neutron flux. It is planned to be coupled to the proton beam of the cyclotron accelerator (≈ 1 MW power) in PSI in Villigen in 2004. The project will provide a comprehensive database from several experiments testing a single component of the target, such as the beam window, the heat exchanger, the corrosion control system and from a full-scale thermalhydraulic simulation experiment. The safety and reliability aspects will be assessed for the whole system. An outlook on the extrapolation and applicability of the results of the MEGAPIE project for an ADS spallation target will be given.

2.5 – Cluster on fuel for transmutation (FUETRA)

Fuel issues for ADS are addressed in three projects: **CONFIRM, THORIUM CYCLE** and **FUTURE**. In the **CONFIRM** project, computer simulation of uranium free nitride fuel irradiation up to about 20% burn-up will be made to optimise pin and pellet designs. Other computations will be performed especially concerning the safety evaluation of nitride fuel. Plutonium zirconium nitride [(Pu, Zr)N] and americium zirconium nitride pellets will be fabricated and their thermal conductivity and stability at high temperature will be measured. (Pu, Zr)N pins of optimised design will be fabricated and irradiated in the Studsvik reactor at high linear power (≈ 70 kW/m) with a target burn-up of about 10%.

The objective of the project **THORIUM CYCLE** is to investigate the irradiation behaviour of thorium/plutonium (Th/Pu) fuel at high burn-up and to perform full core calculations for thorium-based fuel with a view to supplying key data related to plutonium and minor actinide burning. Two irradiation experiments will be carried out: (i) four targets of oxide fuel (Th/Pu, uranium/plutonium, uranium and thorium) will be fabricated, irradiated in HFR in Petten and characterised after irradiation; (ii) one Th/Pu oxide target will be also irradiated in KWO Obrigheim.

The **FUTURE** project aims at studying the feasibility of irradiation of innovative actinide-based oxide fuels for transmutation. These fuels contain compounds of the type $(Pu, Am)O_2$, $(Th, Pu, Am)O_2$ and $(Pu, Am, Zr)O_2$ homogeneously. These compounds will be synthesised and characterised (their thermal and chemical properties will be investigated at different temperatures). Fabrication processes will be tested. Modelling codes will be developed to assess the fuel performance, bearing in mind the large helium release and the degraded thermal properties. The safety performance of the fuel forms under normal, transient and accident conditions will be modelled with existing codes in the case of ADS.

2.6 – Preliminary design studies

Preliminary design studies of an European experimental ADS, **PDS-XADS**, are aiming at selecting the most promising technical concepts, at addressing the critical points of the whole system (i.e. accelerator, spallation target unit, reactor housing the sub-critical core), at identifying research and development in support, at defining the safety and licensing issues, at making a preliminary assessment of the cost of the installation, and finally at consolidating the road mapping for its development. Two types of accelerator will be investigated: cyclotron and linac. For the spallation target unit, two main options are considered depending whether or not the target liquid heavy metal is separated from the accelerator by a physical barrier (window). Three concepts for the sub-critical core will be studied: a small core of about 20 – 40 MW cooled by lead – bismuth eutectic (LBE), a larger core of approximately 80 MW cooled by LBE and a gas-cooled core.

2.7 - Networking

A thematic network on ADvanced Options for Partitioning and Transmutation, **ADOPT**, is intended to co-ordinate the FP5 R&D activities on P&T. The partners of ADOPT are European research organisations and industries, either co-ordinating the FP5 projects described above or having a significant role in these projects. The objectives of the ADOPT network are to suggest actions suited to promote consistency between FP5 projects and national programmes, to review the overall results, to identify the gaps, to give rise to future research proposals and to maintain relations with international organisations and countries outside the EU involved in P&T and ADS development.

2.8 - ADS related research activities in the framework of the International Science and Technology Centre (ISTC)

A Contact Expert Group (CEG) on ADS related ISTC projects has been created in January 1998. Its main objectives are to review proposals in this field and to give recommendations for their funding to the ISTC Governing Board, to monitor the funded projects and to promote the possibilities of future or joint research projects through the ISTC. Five topics have been identified for the ADS related projects: (i) accelerator technology, (ii) basic nuclear and material data and neutronics of ADS, (iii) targets and materials, (iv) fuels related to ADS and (v) aqueous separation chemistry. Because the funding parties primarily respond to local scientific/political interests and pressure, it was decided in January 2000 to reorganise the CEG into "local" CEGs (EU, Japan, Korea and USA) with some inter-co-ordination between them. This inter-co-ordination should foster exchange of information between ISTC projects in the same field, even if they are supported by different funding parties.

The EU CEG is helping in the development of co-operation between ISTC and FP5 EU funded projects. In fact, collaboration has already started between EU scientists and CIS research teams both in the preparation of ISTC proposals and in the follow-up of projects in some specific areas. Links between ISTC and FP5 EU funded projects are being established in the areas of basic studies on transmutation and aqueous processes for partitioning.

3 - SAFETY AND EFFICIENCY OF FUTURE SYSTEMS

The objective of the area "safety and efficiency of future systems" is to investigate and evaluate new or revisited concepts (both reactors and alternative fuel cycles) for nuclear energy that offer potential longer term benefits in terms of cost, safety, waste management, use of fissile material, less risk of diversion and sustainability. In the medium-term increasing competitiveness is the main priority, whereas in the long-term the main priority is to develop a sustainable energy system. Two sub-areas are covered, namely *"Innovative or revisited reactor concepts"* and *"Innovative fuels and fuel cycles"*.

The majority of the FP5 research projects selected for funding deals with reactor concepts except one, which is related to the sub-area of fuels and fuel cycles. This project, **THORIUM CYCLE**, has been grouped in the FUETRA cluster for convenience (see Section 2.5). Concerning the new or revisited reactors, the nine research projects related to High Temperature Reactors (HTR) are grouped in a cluster. They address the main technical issues to be solved before using the HTRs at the industrial scale to produce energy: fuel technology, fuel cycles, waste, reactor physics, materials, components, systems, safety approach and licensing issues. Four other projects are assessing the sate of the art and R&D needs of other reactor concepts and of other applications of nuclear energy, such as High Performance Light Water Reactors, Gas-cooled Fast Reactors, Molten Salt Reactors and Sea Water Desalination. Finally, a thematic network is addressing the competitiveness and sustainability of nuclear energy in the European Union. These research projects are outlined below.

3.1 - The HTR cluster

A number of HTRs were developed through the 1960's and 1970's (i.e. Peach Bottom and Fort St Vrain in the US, AVR and THTR in Germany, and Dragon in the UK), but then abandoned. However, this reactor concept has been kept alive due its inherent safety features, its potential for use in high temperature industrial processes and the possibility of using direct cycle gas turbines. It is today the subject of a renewal of interest in Europe as well as in other parts of the world (Japan, China, South Africa, USA, Russia).

The conclusions and recommendations of a project of the EURATOM Fourth Framework Programme, which assessed the HTR key technologies, provided input for the R&D proposals submitted for funding in FP5.

The nine projects of the HTR cluster have a total EC funding of about 8.3 million € [4]. They address the following technical issues:

- **Fuel technology** investigated in the **HTR-F/F1** projects. The objective is to restore (and improve) the capability of fabricating coated fuel particles in Europe. Existing irradiation data will be analysed. Fuel particles, and in particular German pebbles, will be irradiated in HFR in Petten at high burn-up and examined after irradiation. Heat-up tests under normal and accident conditions will be performed in the new KÜFA facility at JRC-ITU in Karlsruhe. A code modelling the thermo-mechanical behaviour of coated fuel particles will be developed and validated. First batches of U- and Pu-bearing kernels and coated particles will be fabricated. Finally, innovative fuels and alternative coating materials will be studied.

- **Reactor physics, waste and fuel cycles** in the **HTR-N/N1** projects. The main aims are to provide numerical nuclear physics tools for the analysis and design of innovative HTR cores, to investigate different fuel cycles that can minimise the generation of long-lived actinides and optimise the Pu-burning capabilities, and to analyse the HTR-specific waste and the disposal behaviour of spent fuel. Existing core physics codes will be validated against tests carried out in HTTR in Japan and in HTR-10 in China. Basic HTR fuel designs (hexagonal block type and pebble-bed) will be studied. HTR specific operational and decommissioning waste streams will be analysed. Corrosion and leaching tests will be performed to model the geo-chemical behaviour of spent fuel dissolution under different conditions.

- **Materials**. The main objective of the **HTR-M/M1** projects is to set up a database for the material properties of the HTR key components, such as the reactor pressure vessel (RPV), high temperature areas (internal structures and turbine) and graphite structures. Activities include: compilation and review of existing data about materials for the above-mentioned components; thermo-mechanical tests on RPV welded joints, irradiated specimens, control rod claddings, and turbine disk and blade materials; oxidation tests at high temperatures on a fuel matrix graphite and on advanced carbon-based materials; and long-term irradiation tests for the graphite components. As the graphites used previously are no longer available, the models describing the graphite behaviour under irradiation will be verified as well as the screening tests of recent graphite properties.

- **Components and systems** investigated in the **HTR-E** project. These are the helium turbine, the recuperator heat exchanger, the active and permanent magnetic bearings, the leak-tightness rotating seal, the sliding parts (tribology) and the helium purification system. The programme contains design studies and also experiments (e.g. magnetic bearing tests at the University of Zittau, thermal-hydraulics test on recuperator heat exchanger at CEA or tribological investigations at Framatome).

- **Safety approach and licensing.** The **HTR-L** project proposes a safety approach for a licensing framework specific to Modular High Temperature Reactors and a classification for the design basis operating conditions and associated acceptance criteria. Special attention is put on the confinement requirements and the rules for system, structure and component classification as well as a component qualification level being compatible with economical targets.

- **Co-ordination**. The co-ordination, the integration and the quality of the work to be performed in the eight HTR related projects are assured by the **HTR-C** project. **HTR-C** will also organise a world-wide technological watch and develop international co-operation, first with China and Japan, which have at present the only research HTRs in operation in the world.

A European Network on "High Temperature Reactor Technology", **HTR-TN**, has been set up by a multi-partner collaboration agreement between eighteen EU organisations in 2000. The agreement does not involve cash flow between the members and all contributions are made in kind. The EC-sponsored projects described above are the initial core from which **HTR-TN** will depart. The general objective of this network is to co-ordinate and manage the expertise and resources of the participant organisations in developing advanced technologies for modern HTRs, in order to support the design of these reactors.

A Contact Expert Group (CEG) on ISTC projects related to the Gas Turbine Modular Helium Reactor (GT-MHR) has been set up with the same objectives as the CEG on ADS (see Section 2.8). It is hoped that the exchange of information between ISTC and FP5 EU funded projects on HTRs will be greatly improved in the near future.

3.2 - Other reactor concepts and other applications of nuclear energy

The total EC funding for the five projects, which are summarised below, is 2.5 million €.

The overall objective of the **HPLWR** project is to assess the merit and economic feasibility of a high performance LWR operating in thermodynamically supercritical regime (i.e. at a temperature and pressure above the water critical point). This project should also provide a thorough state-of-the-art of this reactor concept, an identification of the main difficulties for its future development, and, if the concept is found to be feasible, recommendations for future R&D programmes. The University of Tokyo is participating actively to this project.

The main objective of the **GCFR** project is to produce a state of the art summary report on gas-cooled fast neutron reactors including: (i) review of earlier work and existing applicable technology, (ii) evaluation of the safety feasibility of the GCFR based on the EUR and the EFR safety requirements, and (iii) integration of GCFR into the overall fuel cycle. In May 2001, the Japan Nuclear Cycle Development Institute (JNC) has joined the project as an observer because of its strong interest in gas-cooled fast neutron reactors.

Molten salt reactors (MSR) present a number of advantages in terms of waste management (high burn-up and on-site reprocessing), system efficiency, use of fissile materials and non-proliferation issues. The objectives of the **MOST** concerted action are to evaluate the knowledge accumulated on MSRs between the 60's and the 80's in the USA, Europe and the former Soviet Union. The best options will be chosen (e.g. salt composition, structural materials), the weak points will be identified and a future R&D programme will be proposed. Oak Ridge National Laboratory (ORNL) is a partner of this project. Tight links are established with a similar ISTC project.

The **EURODESAL** concerted action aims at assessing the technical and economical feasibility of the production of potable or irrigating water through seawater desalination with innovative nuclear reactors (with emphasis on HTRs). The expected outcome is a thorough strategic study built on the available experience. The study should identify the main safety, technological and economic issues related to the coupling of the nuclear and nonnuclear systems. A preliminary economic evaluation should also permit a comparison with fossil and renewable energy sources.

The Michelangelo Network, **MICANET**, has the objective of proposing a R&D strategy to keep the option of nuclear fission energy open in the 21st Century in Europe. Its partners are the main European industrial companies and research organisations involved in nuclear energy. The Network will identify R&D needs and establish roadmaps for developing innovative reactors and fuel cycles. Connections will be established with the FP5 projects on future systems and the possibility of hydrogen production by nuclear energy will be assessed. **MICANET** will also establish an European partnership with the American Generation IV (Gen-IV) initiative by enabling the participation of experts from other Member States than France and the UK, which are already members of Gen-IV, in its working groups and by actively co-operating to its future development.

4 – NEW FRAMEWORK PROGRAMMES FOR RESEARCH AND INNOVATION IN EUROPE (2002 – 2006)

The Commission is aiming at the adoption of the new Framework Programmes (2002-2006) and their specific programmes by both the Council and the European Parliament by June 2002.

In January 2000, the Commission proposed the idea of a "European Research Area" [5]. The intention was to contribute to the creation of better overall working conditions for research in Europe. The starting point was that the situation concerning research in Europe is worrying, given the importance of research and development for future prosperity and competitiveness.

In October 2000, the Commission adopted a communication for the future of research in Europe, which sets out guidelines for implementing the "European Research Area" initiative, and more particularly the Research Framework Programme [6]. It is proposed to change the approach for the next Framework Programme, based on the following principles:

- concentrating on a selected number of priority research areas in which EU action can add the greatest possible value;
- defining the various activities in such a way as to enable them to exert a more structuring effect on research conducted in Europe through a stronger link with national, regional and other European initiatives;
- simplifying and streamlining the implementation arrangements, on the basis of intervention methods and decentralised management procedures.

In February 2001, the Commission made proposals for two new EC and EURATOM research Framework Programmes (2002-2006) aimed at contributing towards the creation of the European Research Area for total financial amounts of 16.27 billion € and 1.23 billion € respectively [7].

The EURATOM Framework Programme includes four areas: waste treatment and storage (150 million €), controlled thermonuclear fusion (700 million €), other EURATOM activities (50 million €) and JRC's EURATOM activities (330 million €). Waste treatment and storage will cover R&D work on: (i) long-term disposal in deep geological repositories and (ii) reduction of the impact of waste by developing new concepts of reactors producing less waste and partitioning and transmutation techniques. The other EURATOM activities are: (i) research on radiation protection, more particularly on low levels of exposure; (ii) studies of new and safer processes for the exploitation of nuclear energy; (iii) education and training in nuclear safety and radiation protection.

5 - CONCLUSION

The research projects on advanced concepts for waste management and nuclear energy production in the EURATOM Fifth Framework Programme have already begun. The European research organisations and the nuclear industry are actively participating to these activities. In addition, international co-operation with Japan, Russia and USA has started through various means: direct involvement of some Japanese and American R&D organisations in FP5 research projects, establishment of an European partnership with the American Generation IV initiative and links between FP5 and ISTC EU funded projects.

All the important aspects of partitioning and transmutation are covered by the FP5 research projects presented in this paper: chemical separation of long-lived radionuclides, basic nuclear data and sub-critical neutronics, irradiation and corrosion effects, neutron spallation target, fuel issues and preliminary design studies of an ADS demonstrator. These projects should significantly contribute to fulfilling the objective of the programme, which 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. This challenging field has also the merit of attracting young researchers, which is essential to preserve the expertise in nuclear fission energy.

Concerning future systems, the high temperature reactor (HTR) is raising at present a lot of interest world-wide because of its excellent safety features and its potential for efficient nuclear energy production. This interest is reflected in the cluster of HTR projects in FP5, which should provide a preliminary answer to the problems to be solved and requiring further R&D before deploying these reactors at the industrial scale.

The Commission made proposals for two new EC and EURATOM research Framework Programmes (2002-2006) in February 2001 and is expecting their adoption by June 2002.

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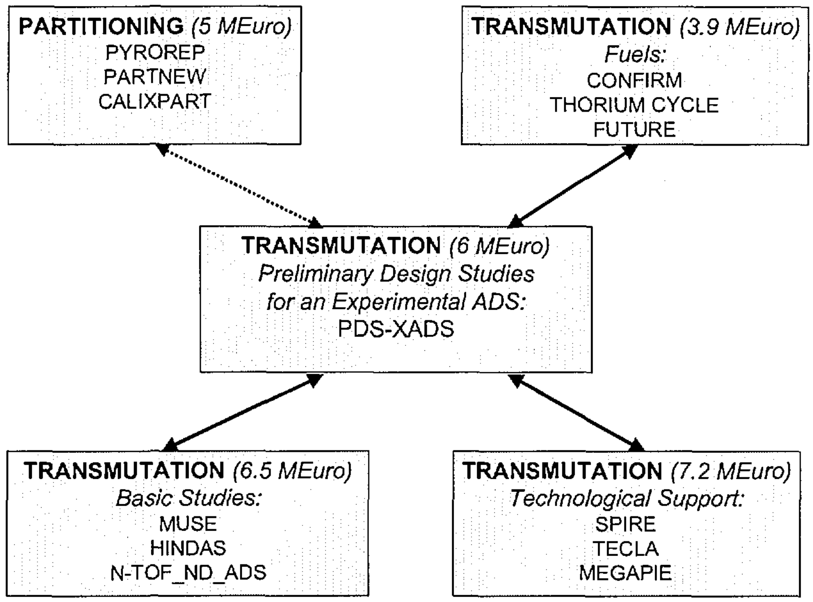

Figure 1: FP5 Projects on Advanced Options for Partitioning and Transmutation