European ADS programme.

Present considered designs & perspectives

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Introduction

The fuel cycle strategy and the fuel cycle back end closure is a national policy in Europe. There are various strategies considered:

- UO₂ in LWR + final disposal,
- UO₂ in LWR + ADS + final disposal,
- UO₂ in LWR + MOX in LWR + ADS + final disposal,
- UO₂ in LWR + MOX in LWR + (dirty MOX + MAs) in FbR + ADS + final disposal

In nearly all scenarios P&T and ADS are given a consideration that leads to a need for a coordinated R&D.

Both critical and sub-critical reactors are potential candidates as dedicated transmutation systems. Nevertheless, critical reactors, heavily loaded with fuel containing large amount of minor actinides (Am and Cm) pose safety problems caused by unfavourable reactivity coefficients and small delayed neutron fraction. With regard to this latter problem, the sub-criticality is particularly favourable and allows a maximum load of minor actinides per unit while operating in a safe manner.

The European Technical Working Group (ETWG) on ADS under the chairmanship of Prof. Carlo Rubbia played a coordinating role at European level for P&T and ADS development as a route for Waste management. The ETWG members concluded in their report of April 2001 that:

- P&T associated to ADS could help the waste management problem;
- There is a need for a first step demonstration of ADS at international level;
- There is a need for a coordinated R&D effort at European level with a strong support from the EC

FP5 ADOPT Thematic Network

As a response to these conclusions, the major European actors from research centers, industries, universities active in the field of P&T and ADS development decided to create a thematic Network called ADOPT for ADvanced Options for P&T. The aim of ADOPT is to coordinate the various projects of the FP5 key-action programme on P&T. Fifteen projects are coordinated under the ADOPT thematic network representing a global European contribution of 28.6 M€ representing about a share of
50% of the total budget. Information on ADOPT can be obtained from http://www3.sckcen.be/adopt/.

PDS-XADS Project
Among the FP5 projects coordinated by ADOPT, there is the PDS-XADS project. PDS-XADS stands for Preliminary engineering Design Studies of the Experimental ADS. Its objectives are:

- to select the most promising technical concepts,
- to address the critical points of the whole ADS system,
- to identify the R&D in support of ADS development,
- to define the safety and licensing issues,
- to preliminary assess the cost of the installation,
- to consolidate the roadmap of the XADS development

Taking into account that fast neutron spectrum is the a priori solution for transmutation purpose, the R&D efforts are focused on liquid metal-cooled ADS and gas-cooled ADS. The preliminary design studies are concentrated mainly on three concepts namely:

- EA-80, a large Pb-Bi cooled XADS (80 MWth core power cooled by liquid Pb-Bi, driven by a 600 MeV * 10 mA proton beam current to be delivered by a LINAC or a cyclotron on a liquid Pb-Bi window or windowless spallation target), proposed by ANSALDO
- GC-XADS, a large Gas cooled XADS (100 MWth core power cooled by He, driven by a 600 MeV * 10 mA proton beam current to be delivered by a LINAC on a liquid Pb-Bi window spallation target), proposed by Framatome ANP
- MYRRHA, a small Pb-Bi cooled XADS (40 MWth core power cooled by liquid Pb-Bi, driven by a 350 MeV * 5 mA proton beam current to be delivered by a cyclotron or a LINAC on a liquid Pb-Bi windowless spallation target), proposed by SCK•CEN.

IP-ADOPT Perspectives
In the FP6, the EC created 2 new instruments for favouring the integration and re-enforcement of the European R&D at large scale, namely:

- Integrated Project (IP):
- Network of Excellence (NoE):

The ADOPT members expressed their wish to re-enforce their activities in the fields of P&T and ADS by creating an integrated project to be called IP-ADOPT.

The aim of this proposal is to mobilise the European scientific and industrial expertise in nuclear fuel reprocessing, nuclear fuel development, nuclear reactor research and engineering design, and high power proton accelerator research and development to provide advanced options for high level waste management leading to the relaxation of the conditions of the waste geological disposal.

The IP-ADOPT project will allow the structuring and the integration of the European activities related to P&T and ADS development as it will:

- avoid the fragmentation of the present P&T and ADS community by focusing the objectives towards a mid-term objective of realising an ADS demo facility
and testing at large scale the economical feasibility of the transmutation of minor actinides in a dedicated core within this test facility;

- offer a stable research environment for this community;
- serve as a trigger for maintaining the national funding in this field at a reasonable level;
- Encourage the realisation of the objective of exploring new technologies that contribute to solving the society problems of waste management and looking to technologies that can be of use for next generation reactors.

The R&D perspectives and needs already proposed by IP-ADOPT are as follows:

- **Partitioning**
  - Development of hydrometallurgical partitioning process, possibly adapted to innovative fuels;
  - Demonstration of the feasibility of a quantitative recovery of actinides by pyrochemical process; possibly with recycling of all actinides together.

- **Advanced Fuels**
  - Development of fuels and targets specifically devoted to transmutation;
  - Better understanding of their behaviour (experimental irradiation and modelling);
  - Fuel safety, licensing and reprocessing aspects.

- **ADS Design**
  - Accelerator development, in particular the qualification of reliability of the prototypical components;
  - Proof of feasibility of both window and windowless spallation targets;
  - Pb-Bi and/or gas cooled sub-critical core design with testing of key components;
  - Establishment of the safety case for ADS;
  - Siting and licensing approach for ADS;
  - Complementary nuclear data measurement and evaluation for achieving a reliable design;

- **Materials & Heavy Liquid Metal Coolant Technology**
  - Promising structural materials qualification under proton and neutron irradiation;
  - Exposure to Pb-Bi through the use of the MEGAPIE-Test, KALLA and CIRCE facilities;
  - Key issues to be addressed are:
    - corrosion due HLM
    - liquid metal embrittlement due to Pb-Bi,
    - embrittlement due to irradiation in a mixed radiation (n,p) field,
    - coating for corrosion or LME mitigation,
    - establishing of engineering characterisation DB
  - Pb-Bi technology as core coolant or target material
    - Thermal-hydraulics data,
    - Modelling and instrumentation of HLM.