A FRENCH PERSPECTIVE ON ADVANCED OPTIONS FOR TRANSMUTATION STRATEGIES

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WASTE MANAGEMENT IN FRANCE

In France, a law (voted in 1991) on Long Lived Waste Management requires :

◊ 15-year research program covering the following 3 areas :

1- Partitioning and transmutation of long-lived radionuclides in nuclear waste.

2- Reversible or irreversible disposal in geological repositories, including the construction of underground laboratories.

3- Conditioning processes and long-term near-surface interim storage.

◊ Annual report by the Government to the French Parliament with support by the French National Evaluation Commission.

◊ Final report and legislative proposal in 2006.

This approach is intended to provide a wide range of scientific and technical solutions that may be combined into open and flexible strategies for the back end of the fuel cycle. The Research and Development work is to be progressively consolidated through successive steps during which its scientific, technical and industrial feasibility will be assessed.

The French government ministries responsible for the program designated the National Radioactive Waste Management Agency (ANDRA) for the leading role in Area 2, and the Commissariat à l'Energie Atomique (CEA) for Areas 1 and 3.

A concerted effort has been undertaken among the parties involved under the terms of the law within the scope of cooperative R & D structures (partnership agreements between the CEA, EDF, FRAMATOME, COGEMA, ANDRA, etc..) and by joint research groups with the participation of ANDRA, the CEA, the CNRS, EDF and French universities : these include PRACTIS (chemical separation), GEDEON (transmutation and hybrid systems), FORPRO (geosciences and disposal) and NOMADE (new conditioning matrices).

The CEA also seeks to continue and strengthen its international cooperation programs in these scientific fields, notably with other European countries, the United States, the Russian Federation and with Japan, including JAERI, JNC, CRIEPI, and Japanese universities.

➢ Research activities related to Area 1 :

- Chemistry of partitioning (mostly acqueous processes, some activity in pyrochemistry).
- Physics of Transmutation in Critical Reactors (with experimental validation programs).
- Fuel and targets (MA and LLFP) development with extensive experimental program and irradiations in reactors.
- Accelerator Driven Systems.

ACCELERATOR DRIVEN SYSTEMS : THE SITUATION IN FRANCE

- The French Ministry for Research (MENRT) has launched in 1997 an initiative to define the possible interest, characteristics, R and D needed and time-scale of a possible demo-experiment (~ 100 MWt).
  This report takes into account the requirements and deadline of the French Law (1991) on Waste Management.

- The report (prepared by CEA, CNRS, EdF, Framatome) has been published at the end of 1998.

- Moreover, a tri-countries initiative (Italy, Spain, France) is underway. A report has been completed in 1998, in order to define the principle characteristics of a demo-experiment ASAP. The report has been prepared by a technical working group, lead by Prof. C. Rubbia.

At the French national level, since 1996, an R and D initiative, "Groupement de Recherche", called GEDEON, is underway, to coordinate the effort of CEA and CNRS, with the participation of EdF and FRAMATOME.

- At CEA, a program on ADS is going on since 1995 (but activities are going on since 1991) in the wider frame of the P/T studies required by the 1991 Law on Waste Management (Area 1).

- Up to now the essential activities have been in the R and D area (spallation physics, nuclear data, subcritical experiments, scenario studies), and the follow-up of the ISTC-559 project (1 MW target in liquid Pb/Bi).

- In 1999, material related activities have started (related to the window and to materials for a liquid metal target), based on previous expertise.

- Also, demo-plant related studies are performed in association with NOVATOME.

- In 1999, the total CEA manpower (including accelerator development) is $\approx$ 80 m.y.

THE SITUATION IN EUROPE

- In the perspective of the 5 th Framework Program for R and D of the European Union, a wide coordination (10 countries, more than 30 laboratories and organisations involved) is underway. Fields for proposed actions :
  - ADS system studies (including critical/subcritical comparison ; accelerator requirements ; demo-plant characteristics including different coolants ; target technology),
  - Materials under irradiation (window, target),
  - Lead alloy technologies (physico-chemical properties, corrosion),
  - Subcritical experiments at zero power,
  - Nuclear data (measurements and evaluation),
  - Pyrochemistry (as a supporting technology for dedicated fuel cycles),
  - Innovative fuels and matrices (e.g. Am targets irradiation).

Some specific points :

- ✧ Motivation for hybrid system development at CEA and in France : Waste management optimisation by advanced options.
- ✧ An example of the role of advanced options for transmutation in a scenario study.
- ✧ A short presentation of the national program GEDEON.
- ✧ Conclusions.

The motivation for hybrid systems development in France : The transmutation of wastes in the frame of the 1991 law on waste management

ADS can find a role in :

a- Energy production (widely discussed by C. Rubbia in the frame of the EA proposal).

b- In the frame of the use of Thorium (as a mean to reduce waste toxicity "at the source").

c- Symbiosis with standard reactors (PWRs with UOX and MOX fuel, possibly Fast Reactors with MOX fuel), in order to manage minor actinides (Np, Am, Cm) and selected Long Lived Fission Products (LLFP) in a separate « stratum » of the fuel cycle. The objective : make deep geological storage more acceptable.

d- Symbiosis with standard reactors (PWRs with UOX fuel), in order to manage Pu, Minor actinides and LLFP (e.g. in phasing-out scenarios).

In the « transmutation » scenarios (c and d), when compared to the corresponding critical reactor, an ADS has the following features :

- same transmutation rates for actinides (since proportional to the power in the core),
- some extra-neutron availability to transmute LLFP (a neutron consuming process),
- subcriticality can allow to have a core with a very small fraction of delayed neutrons (case of the dedicated cores of scenario c), or a core with a significant reactivity loss/cycle (scenario d), possibly within a deterministic safety approach.

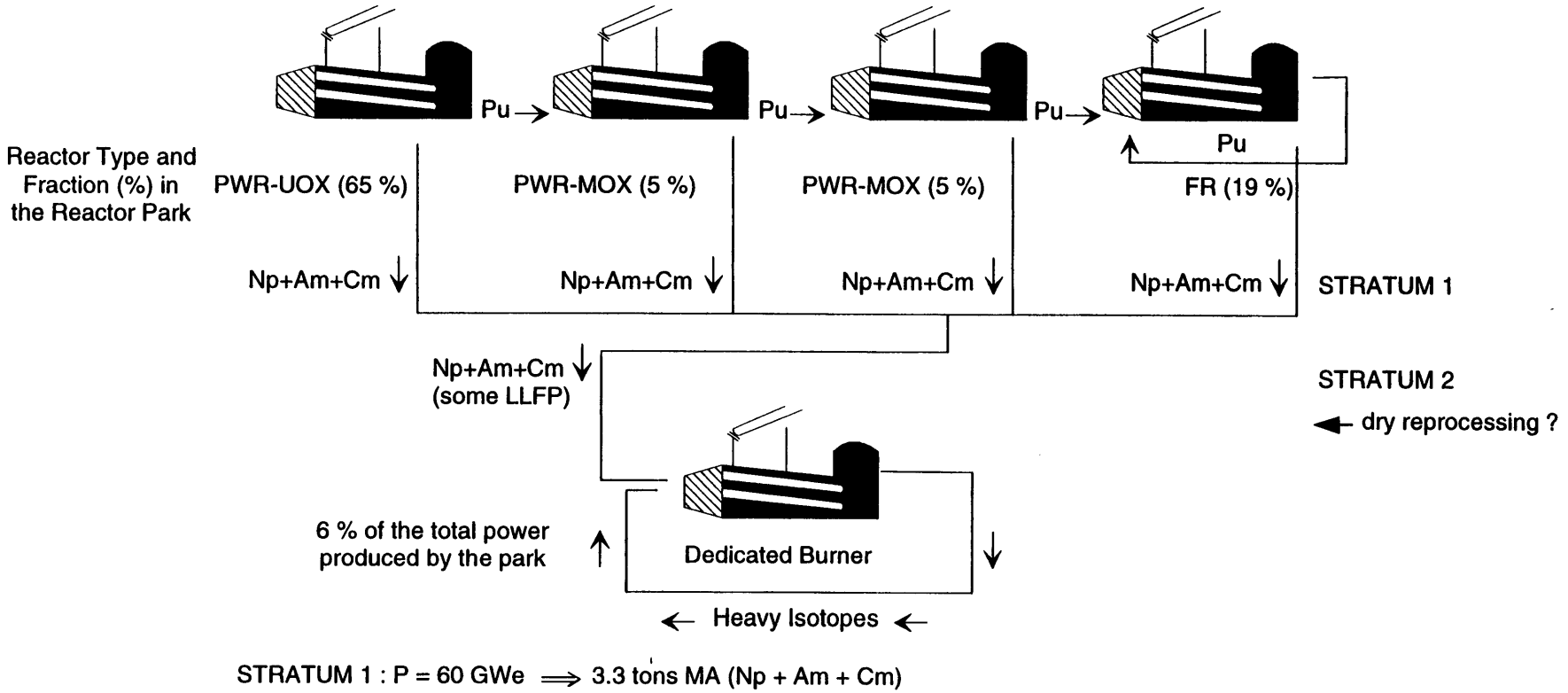
⇒ The transmutation scenarios are at present the major motivation for ADS research.

- However, more studies are still underway to consolidate the motivations for hybrid system development and the motivations for a possible demonstration experiment.

- These studies will be conducted in 1999-2000.

- Scenario studies will play a key role, with the relevant comparisons with the use of critical systems (for transmutation), and detailed evaluations of the impact on fuel cycle.

Scenario « Double strata », with Np, Am and Cm Transmutation



This reactor park allows to reduce waste potential radiotoxicity by a factor of $\boxed{100}$ with respect to a reactor park operated in open cycle and producing the same amount of energy.

The limit is due to the level of losses during reprocessing (here assumed to be 1% for all MA, and 0.1% for U and Pu). If dry reprocessing is used, compact dedicated fuel cycle can be envisaged.

An example of application

Dedicated burner cores can be of two types :

critical or subcritical (ADS).

	Critical	Subcritical (ADS)
Power	130 MWt	130 MWt
Neutron spectrum	fast	fast
Coolant	Pb/Bi	Pb/Bi
Fuel	Pu + MA	Pu + MA
MA burning rate	- 78 kg/TWhe	- 99 kg/TWhe
β_{eff}	~ 170 pcm	-
Target/beam	-	Pb/Bi target - Beam : E_p = 1 GeV - i_p = 1 mA (1.6 mA at EOC)

- If LLFP (I-129, Tc-99) introduced in « moderated flux » S/A at the periphery of the core (LSD concept), the following transmutation rates are obtained :

Tc-99	- 30 kg/TWhe	(both cases, critical or ADS)
I-129	- 18 kg/TWhe	

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