International Conference
Nuclear Energy for New Europe 2003
Portorož, Slovenia, September 8-11, 2003
http://www.drustvo-js.si/port2003

Nuclear Waste Problem: Does New Europe Need New Nuclear Energy?

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ABSTRACT

Nuclear Energy for New Europe – what does it mean?

New Europe – it means in first order joined Europe. And it is quite clear that also efforts in nuclear energy must be joined. What can be proposed as a target of joint efforts? Improvement of existing plants, technologies, materials? – Certainly, but it is performed already by designers and industry themselves.

There exists a problem, which each state using nuclear energy faces alone. It is nuclear waste problem. Nowadays nuclear waste problem is not completely solved in any country. It seems reasonable for joining Europe to join efforts in solving this problem.

A satisfactory solution would reduce a risk connected with nuclear waste. In addition to final disposal problem solution it is necessary to reduce total amount of nuclear waste, that means:

- reducing the rates of accumulation of long-lived dangerous radionuclides;
- reducing the existing amounts of these radionuclides by transmutation.

These conditions can be satisfied in reasonable time by burning of minor actinides and, if possible, by transmutation of long-lived fission products.

However we can use this strategy effectively if we will design and construct nuclear energy as a system of which components are united by nuclear fuel cycle as a system-forming factor. The existing structures and approaches may become insufficient for new Europe. Therefore among the initial steps in considering nuclear waste problem must be considering possible promising fuel cycles for European nuclear energy.

So, does new Europe need new nuclear energy? It seems, yes.

1 INTRODUCTION

Stable development of long-term power system seems impossible nowadays without wide-scale nuclear power usage. To make this approach acceptable it is necessary to outline ways for satisfactory solving some important problems including radioactive waste (RAW) management problem. Main sources of RAW generation and accumulation in nuclear fuel cycle (NFC) are:

- U and Th ore extraction from the Earth;
- Nuclear fuel and other nuclides transformation in nuclear reactors (fission, transmutation, activation);
- Irretrievable losses during nuclear fuel fabrication and reprocessing.

The final solution of RAW problem is only final disposal. But to make repository acceptable both from safety and economical point of view it is necessary to reduce

significantly RAW generation and accumulation per unit of generated power. For mentioned RAW sources it means:

- Reducing amount of extracted ore;
- Nuclear reactors operation organization thus to incinerate maximal possible amount of actinides involved to fuel cycle, to transmute more dangerous none-fissile RAW to less dangerous one, to reduce construction materials activation;
- Improvement of nuclear fuel fabrication and reprocessing technologies to reduce irretrievable losses.

Consideration of formulated requirements allows bringing out main system restrictions and pointing out the ways to RAW repository problem solution.

2 WAYS TO REDUCE AMOUNT OF LONG LIVED RAW

2.1 Reducing amounts of extracted nuclear fuel

Using closed U-Pu, U-Th or U-Pu-Th nuclear fuel cycles in multicomponent structure of nuclear power including fast breeder reactors can satisfy this requirement. Natural U and Th can compensate burnt fuel and irretrievable losses.

2.2 Nuclear power structure optimization

Nuclear fuel cycle consists of different types of nuclear reactors, nuclear fuel cycle plants (fabrication, reprocessing, intermediate storage, final repository) and radioactive nuclides processed in them. Nuclear fuel cycle organized these components into nuclear power system having corresponding structure.

To select an appropriate NFC it is necessary to develop nuclear power structure models, perform a comparative analysis and bring out variants with minimal amounts of RAW.

Nowadays in nuclear power two types of solid fuel nuclear reactor are used: with fast and thermal neutron spectra. Generally, optimal structure can include other or new types of reactor.

2.3 Improvement of fabrication and reprocessing technologies

Existing fabrication and reprocessing technologies are not developed to minimize losses and discharges when fuel recycling. It is necessary to consider the ways to improve existing technologies and/or to develop new ones with minimal losses.

2.4 Equilibrium stage of nuclear power development

Nuclear power lifetime can be divided into 3 stages:

Initial stage – energy production grows and structure forms;

Equilibrium stage – energy production and nuclear power structure are stable and only fuel to compensate burning and RAW losses is extracted, and new components are only constructed to replace decommissioned ones with the same type and power;

Final stage – gradual decommission of nuclear power plants and RAW problem final solution.

It is reasonable to expect that equilibrium stage must be much longer then initial and final stages. Therefore the equilibrium stage determines both problem of minimization of RAW generation and accumulation and problem of elimination of all dangerous nuclides and fission products on the final stage. This statement allows us later to consider mainly

equilibrium stages of nuclear power structure. We assume that acceptability of equilibrium stage of nuclear power is an essential condition of long-term nuclear power acceptability. Nuclear power structure modeling for equilibrium stage allows performing NFC optimization to minimize RAW amount.

It is clear that fission products amount is proportional to energy production and cannot be reduced. It is possible only to transmute more dangerous fission products into less dangerous ones, with additional neutron consumption. But problem of fission products is not developed enough to formulate real requirement for fission product transmutation.

On the other hand, minimization of fissile RAW (transuraniums) amount is based on the understanding that transuranium is not a waste but a fuel [1] that was produced by neutrons, consumption, so it must be used for energy production with maximal efficiency. All transuraniums accumulated must return to the fuel cycle, so NFC must be closed for heavy nuclides. In this case neutron balance is improved and amount of transuraniums in fuel cycle decreases and becomes proportional to system power and not to energy production. This amount strongly depends on nuclear power structure and we can manage this structure to optimize neutron balance and amount of radionuclides in system.

However we can use this strategy effectively if we will design and construct nuclear energy as a system of which components are united by nuclear fuel cycle as a system-forming factor. The existing structures and approaches may become insufficient for new Europe. Therefore among the initial steps in considering nuclear waste problem must be considering possible promising fuel cycles for European nuclear energy.

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