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Current status of development in dryPyroelectrochemical technology of spent nuclear fuel reprocessing (3)

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CURRENT STATUS OF DEVELOPMENT IN DRY PYROELECTROCHEMICAL TECHNOLOGY OF SPENT NUCLEAR FUEL REPROCESSING (3)

Flexible conception of spent fuel management

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Possible flows of spent fuel in Russian Fuel Cycle

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- VVER-440, VVER-1000 - U, Pu, MA
- RBMK - U, Pu, MA
- BN-600, BN-800 - U, Pu, MA
- Submarines, test reactors etc. - U, Pu, MA

In case of foreign spent fuel export

- PWR, BWR - U, Pu, MA
- CANDU - U, Pu, MA

To store? To reprocess? To treat?

Basic approaches to SF reprocessing

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- Materials demanding for utilization
  - Reprocessing only in case of using of materials in fuel cycle
  - Excluding of recovery of basic fissile components for stockpiles

Partitioning and recycling instead reprocessing

- All components must be introduced in closed fuel cycle
- Technologies flexibility and modules principle
- Criteria:
  - Minimization of wastes (and storage and disposal costs)
  - Non-proliferation (inherent barriers)

Reprocessing of VVER spent nuclear fuel for recovery of uranium ready for secondary utilization

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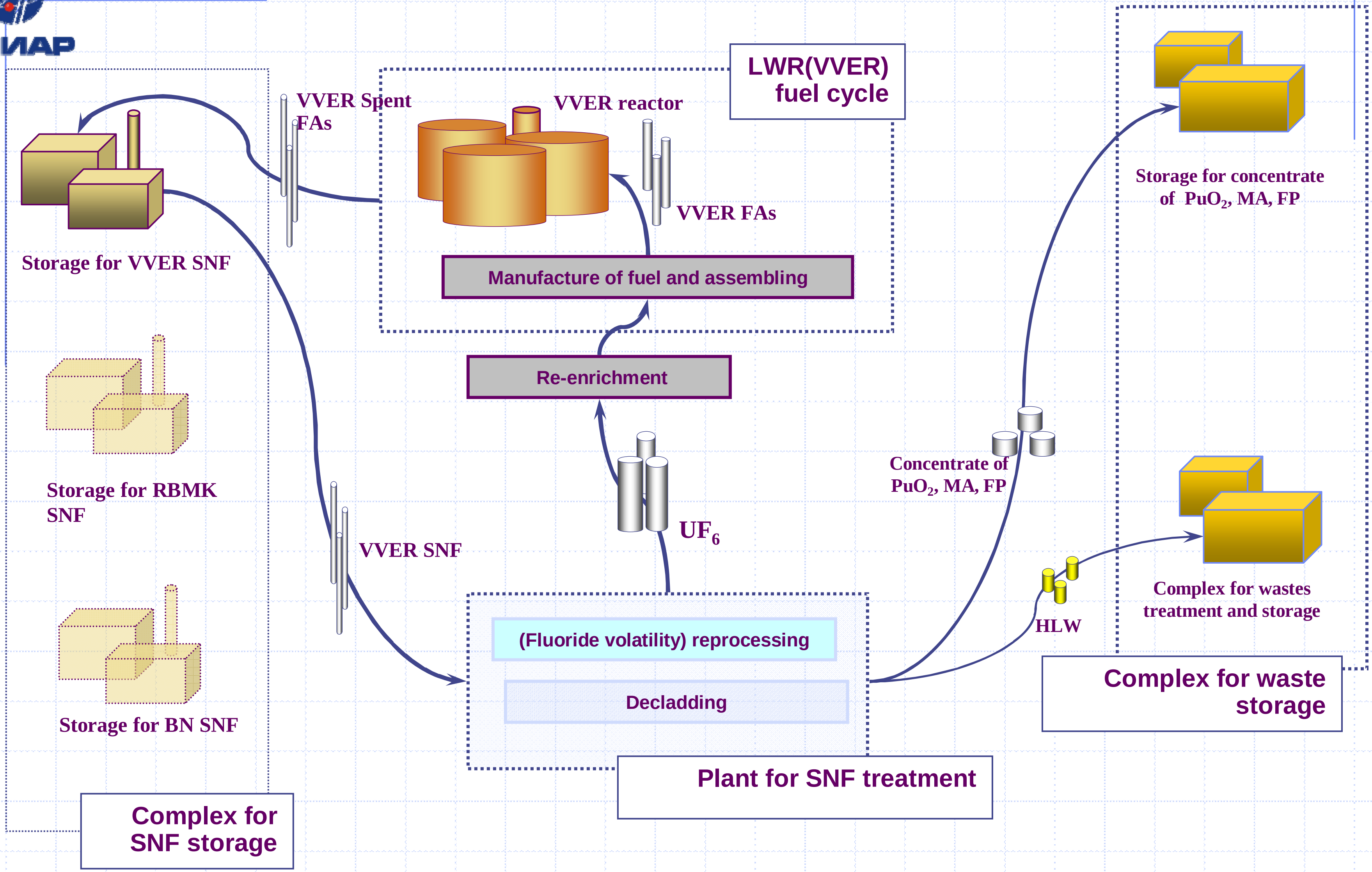
Solved problem: **Uranium resources**

- Usable product – UF_6, enriched on U-235
- Concentrate (ash) Pu+MA+FPs for long storage (for BN closed fuel cycle)
- Wastes – cladding and other materials, FPs

- Reprocessing technologies: only for uranium recovery and purification
- Additional enrichment of uranium
- Storage of Pu+MA concentrate: SNF storage or BN closed cycle
- Other wastes - to disposal

Reprocessing of VVER (LWR) spent nuclear fuel for recovery of uranium ready for secondary utilization



Possible technologies of uranium recovery from VVER SNF

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Requirements

- DF more than 10^6
- Enrichment must be suitable for enrichment plants
- Pu+MA concentrate in form suitable for long storage
- Wastes in form suitable for disposal

Technologies:

- Fluoride Volatility
- Modified PUREX
- REPA – process
- Supercritical extraction in CO_2
- Other new technologies

Management with plutonium after reprocessing of VVER & PWR SNF

Solved problem: **Excluding of pure plutonium**

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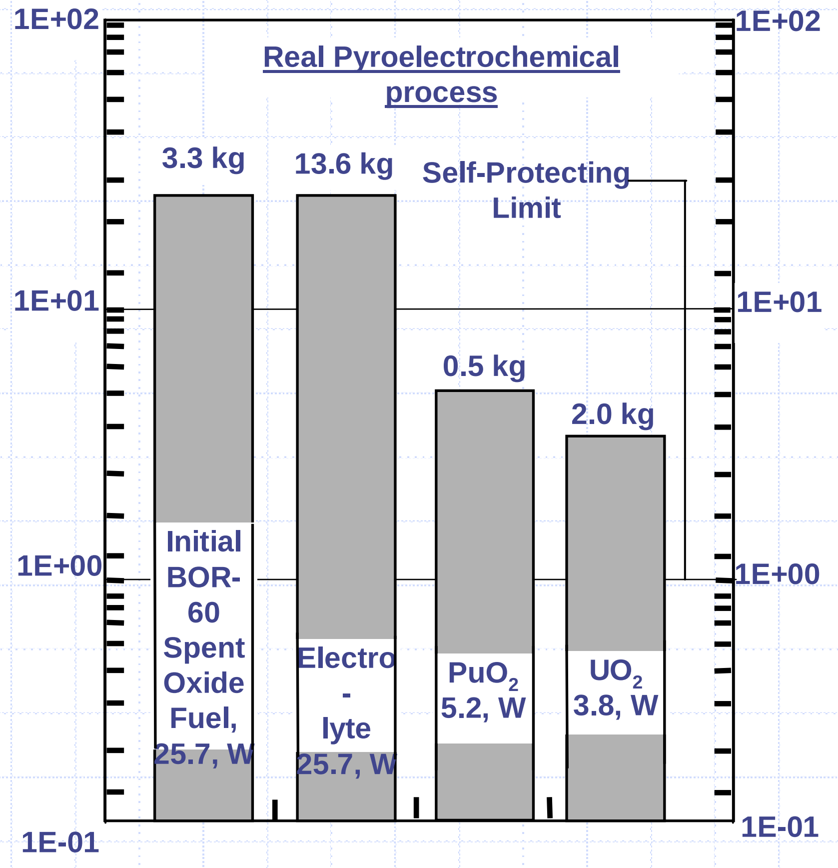
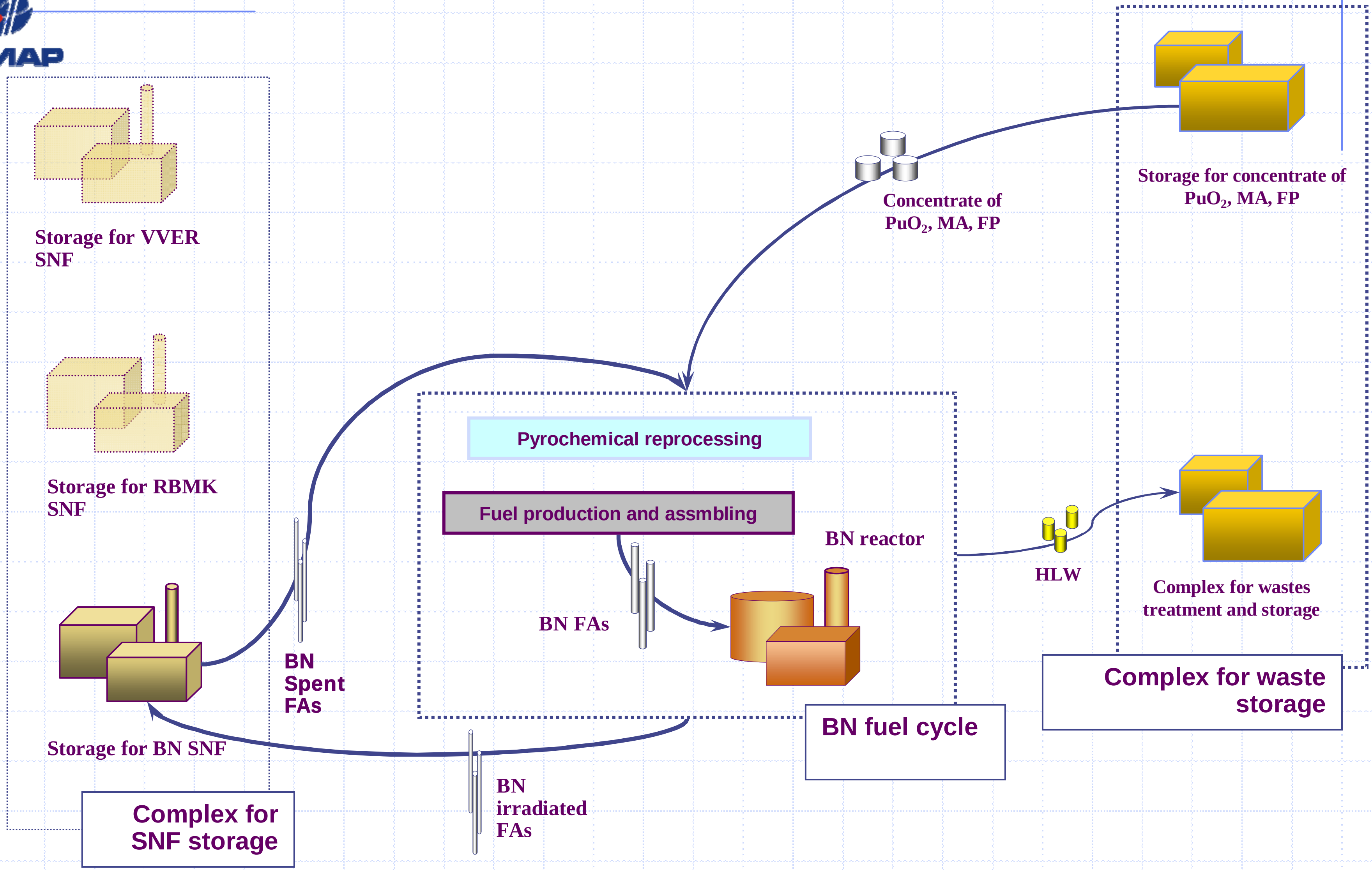
For utilization of Pu in Fast reactors:

- High DF no necessary
- Additional treatment in closed cycle of Fast reactor
- Possibility of recycle of other TRU (*Np, Am, Cm*)



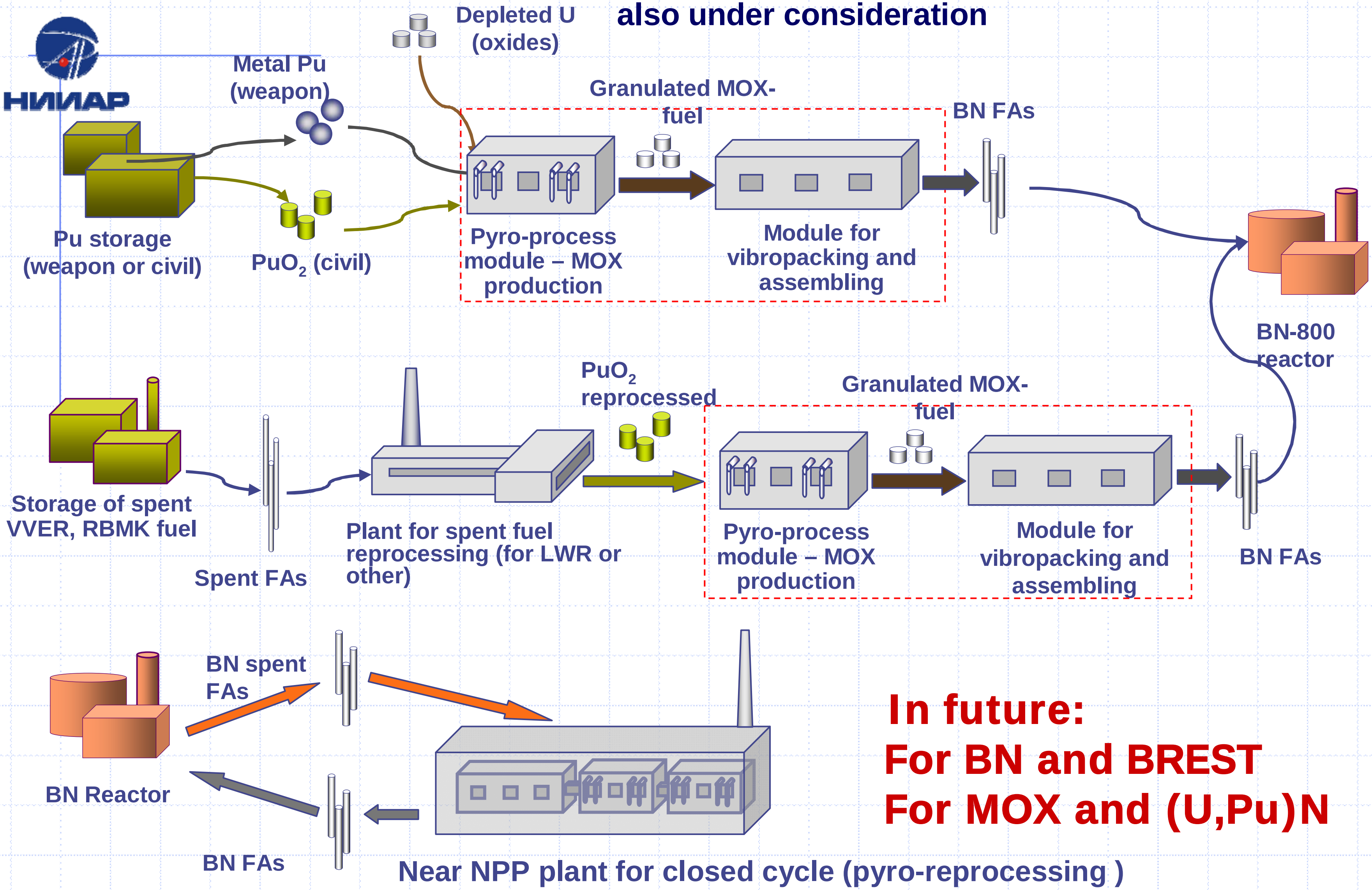
Self-Protection of BOR-60 spent Fuel Reprocessing by Gamma Radiation .

Management with plutonium after reprocessing of LWR SNF



Implementation prospects for BN-800 (BN-1600)

Combination of pyroprocess and vibropacking technology are proposed for creation of BN-type MOX fuel productions and recycling in different scenarios. Similar combination for pellet MOX is also under consideration



Reduction of stored spent fuel volume

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Technological approaches:

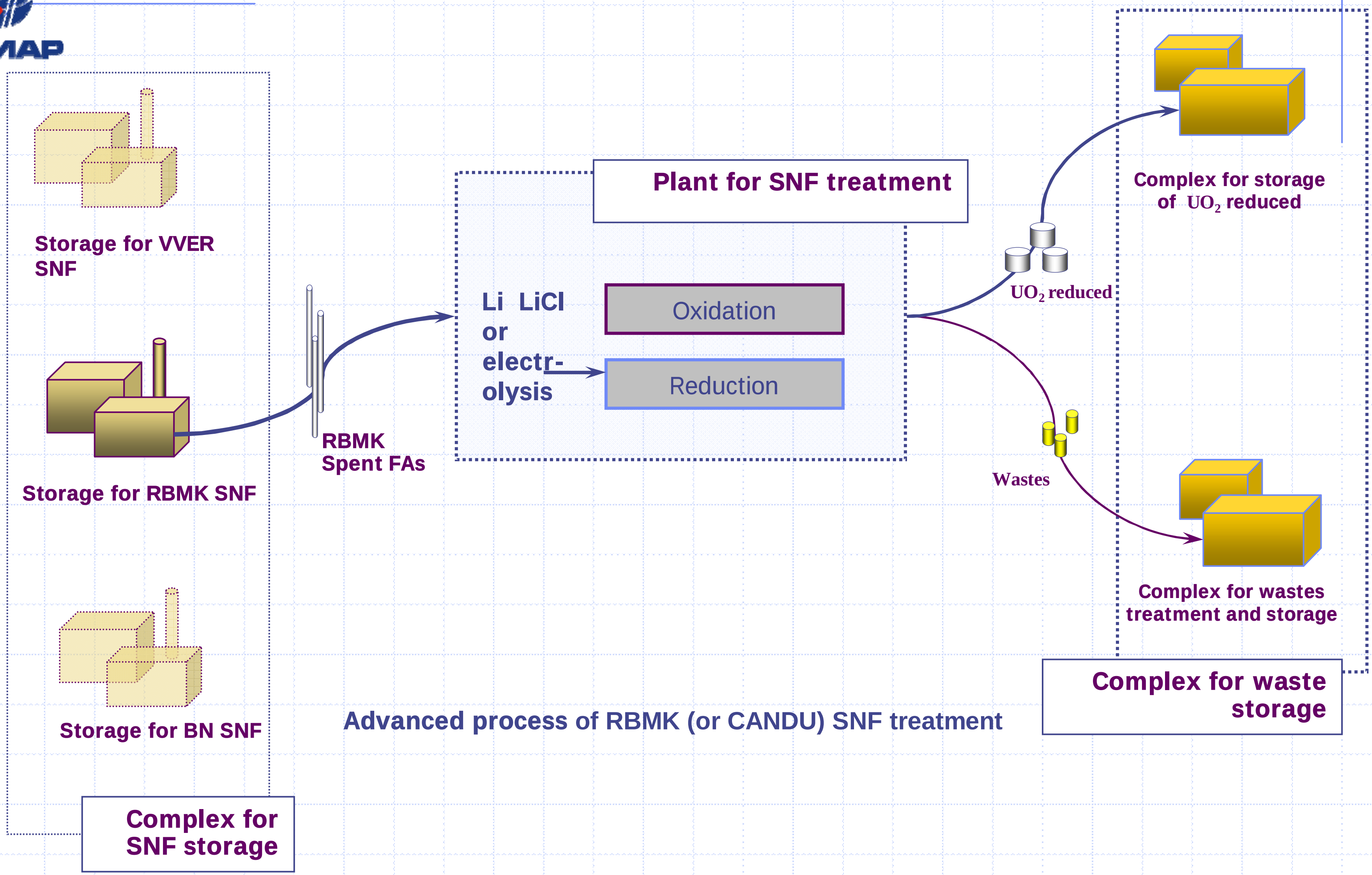
- Decladding, oxidation and metallization of SNF with followed packing

Fraction of spent fuel:

- Cs+Sr
- U+Pu+MA+FP *(in metallic form)*
- Gaseous FPs
- Cladding and other materials

- The tests on metallization of VVER SNF were carried out in pilot scale facility
- The technological conditions of reduction of oxide uranium fuel worked out for reduction rate no less than 96 %
- Obtained results on decontamination of SNF from Cs-137 and Sr-90 confirm perspectivity of process for the purposes of advanced SNF storage

Decrease of spent nuclear fuel volume intended for long-term storage



Advanced process of RBMK (or CANDU) SNF treatment

Replacement of part of stored SNF by uranium with FPs

Problem of Pu isotopic composition degradation

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Technological approach

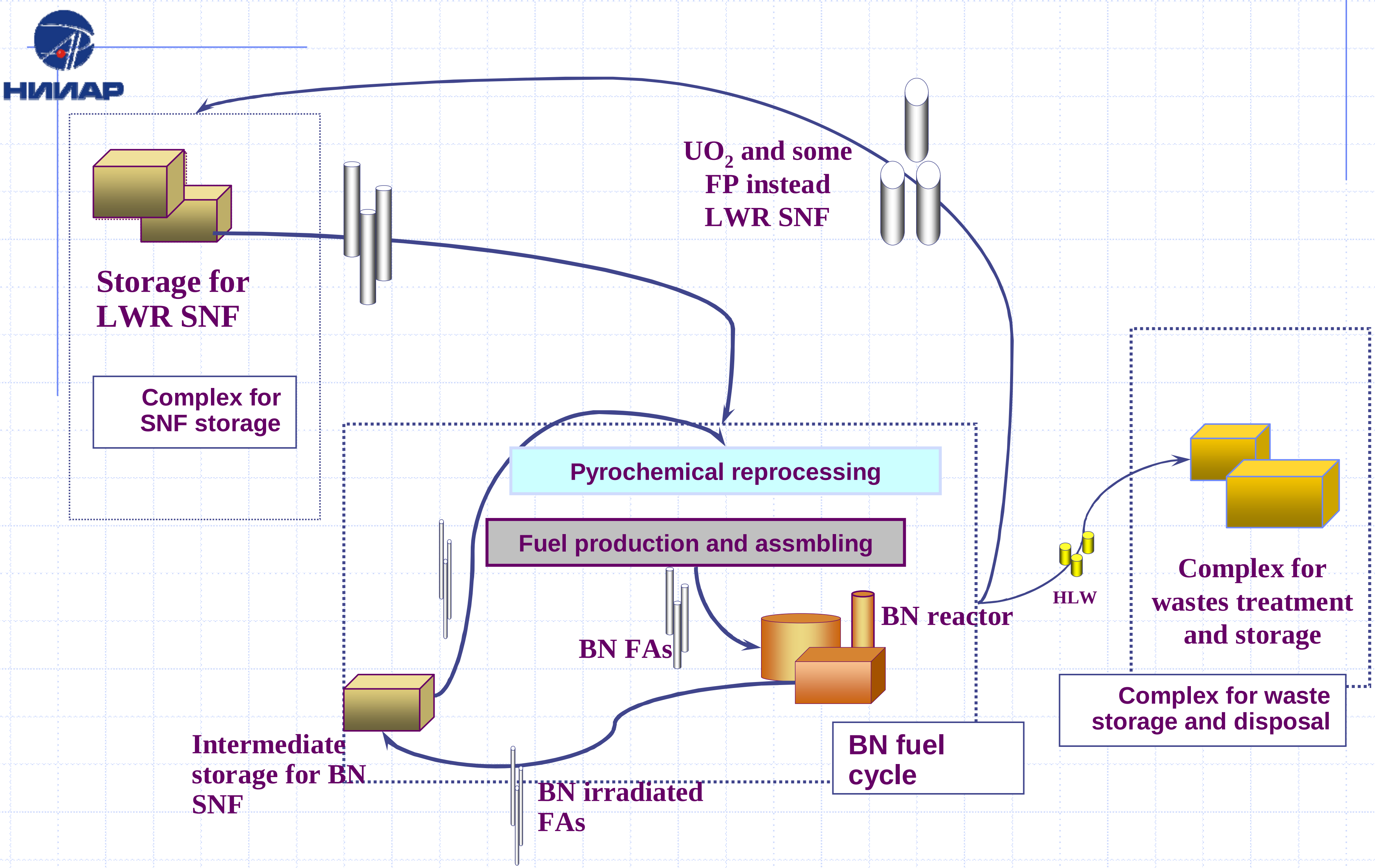
MOX-fuel for fast reactors, as example

- Reprocessing of MOX-fuel in closed cycle of fast reactors only for recovery of PuO_2+MA for recycle
- UO_2 is recovered in crystal form with inclusion of FPs for storages instead of SNF
- Fuel pins production from mechanical mixture of granulated PuO_2+MA with RBMK SNF

Options:

- RBMK SNF is introduce on reprocessing stage
- Similar technological flow–sheet could be for nitride fuel: metallic uranium recovered with FPs or as alloy with Pb, Zn, Sn

Combined fuel cycle of FBR with utilization of LWR SNF and replacement of LWR SNF by UO_2 after reprocessing



Incineration of long lived minor-actinides (one of way)

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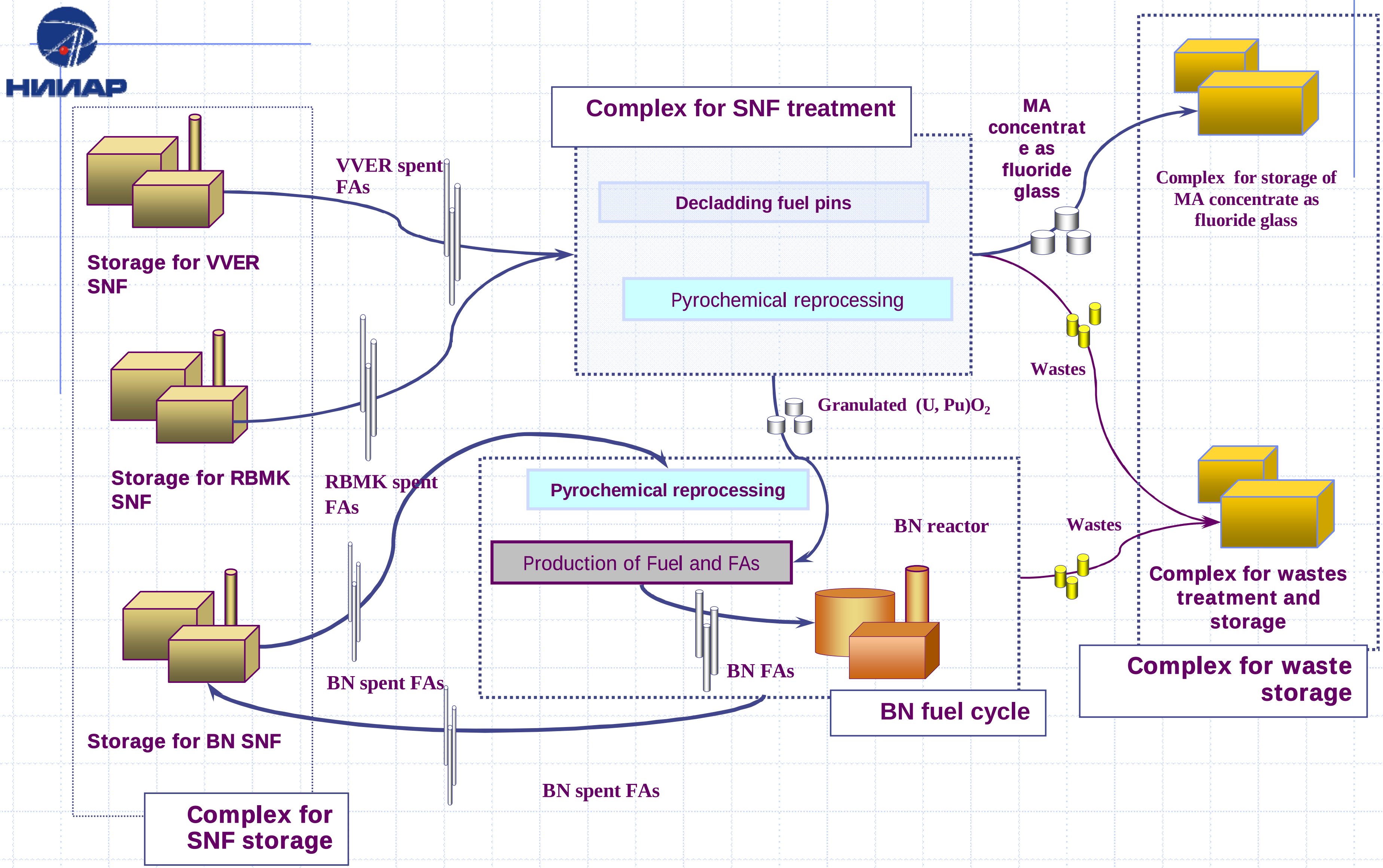
- Transmutation of minor-actinides (Np, Am, Cm) not yet expediently from economic point of view

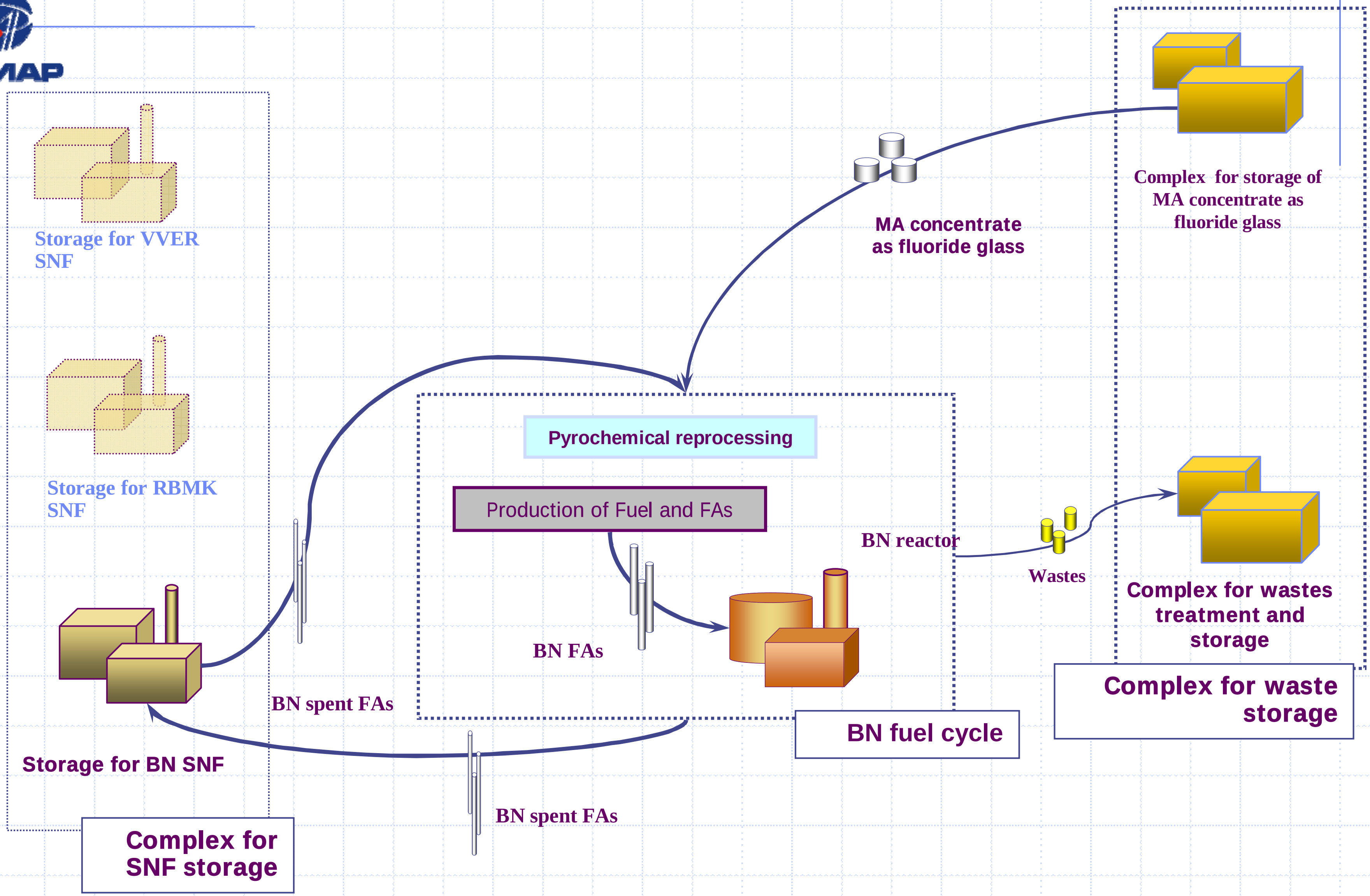
- In the nearest 30...40 years it is possible to be limited only by compaction of minor-actinides for interim storages of SNF, with followed transmutation in special reactor systems, under condition of economic feasibility

- The possible matrix form – fluoride glasses which can be transformed into media for reprocessing later

Long-lived actinides management



Long-lived actinides management (trends)



Conclusions

The mentioned approaches can be realized both within the framework of unit reprocessing complex, and with use of "nuclear islands" concept

- A number of technologies for recycling and treatment of Spent fuel are developed
- Production of recycled fuel after reprocessing could be organized in "non-proliferation" mode
- Flexible technological basis for International SNF Centers is developed
- Nearest and key candidate options is Fast reactor with closed fuel cycle as module for demonstration of technical aspects of actinide utilization in future International Centers for treatment of SNF

- Third generation of partitioning/recycling technologies could be introduced into Fuel Cycle in near future

Additional material:
AREVA RIAR Feasibility study

Introduction

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RIAR and AREVA

decided to jointly study the feasibility

of a 1000 tHM/y reprocessing plant

based on RIAR's developed dry processes

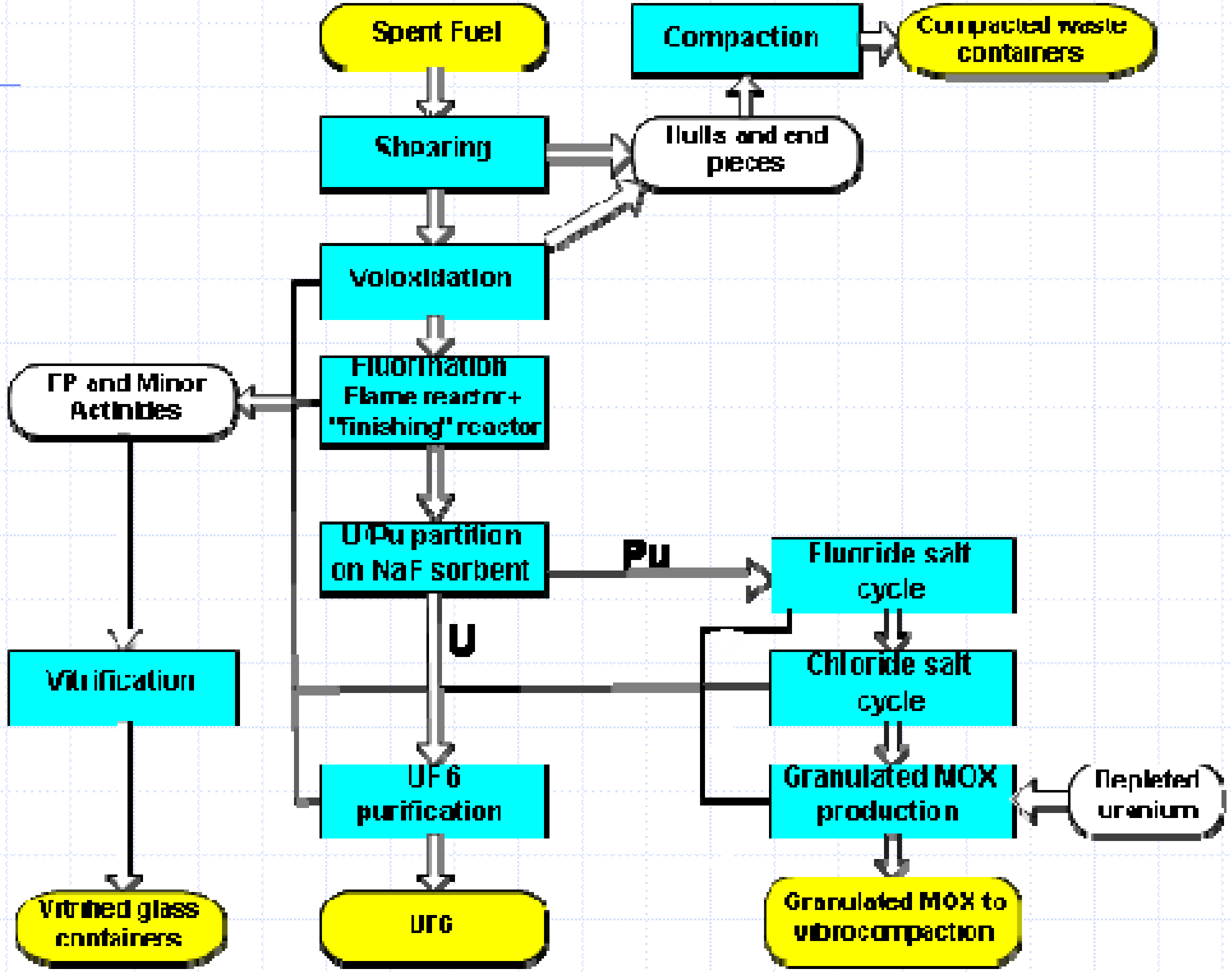
1. Main steps

- May 2004: signature of the contract between AREVA and RIAR
- December 2004: 1st meeting in Dimitrovgrad
- From December 2004 to February 2006, 7 meetings in Russia and one meeting at La Hague were organized. The study was divided into 5 steps:
  - Simplified process diagrams and safety principles (RIAR)
  - Study and analysis of the process diagrams (AREVA)
  - Maintenance principles (AREVA), description of the equipment and more detailed process diagrams (RIAR)
  - Lay-out (AREVA)
  - Cost evaluation (AREVA) and Final Report (RIAR – AREVA)

2. Design bases

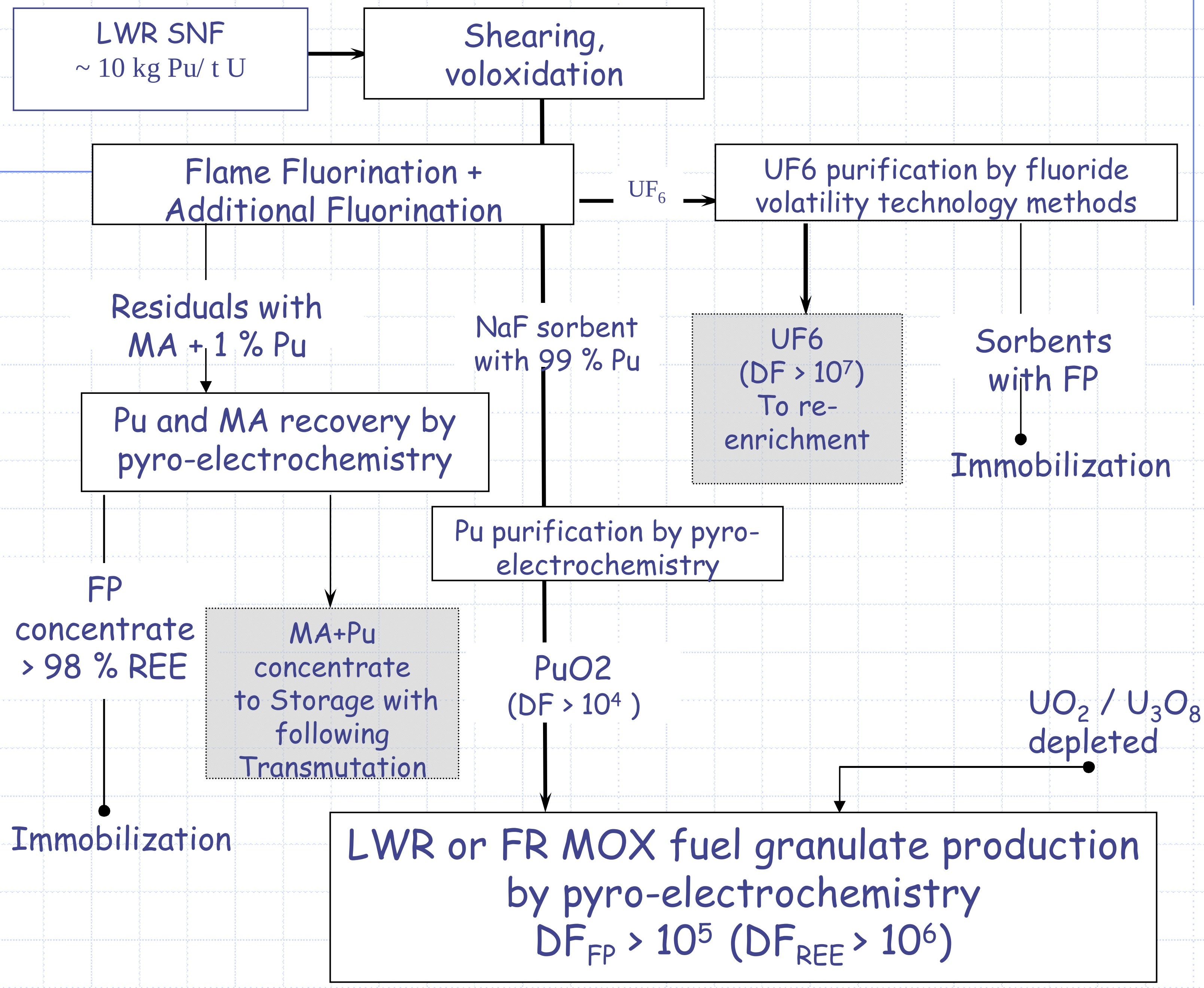
- Inlet:
  - PWR and BWR spent fuel with a burn-up up to 60 GWd/t and an ^{235}U initial enrichment up to 4.5%
- Outlet:
  - Mixed oxide granulates for fast reactors (20% Pu) or PWR reactors (8% Pu), compatible with vibrocompaction
  - Uranium hexafluoride compatible with further uranium enrichment
- No recycling of minor actinides was envisaged for this study
- Standards applied for this study are those generally applied in France and more specifically at La Hague plant when applicable

3. Process description (1)



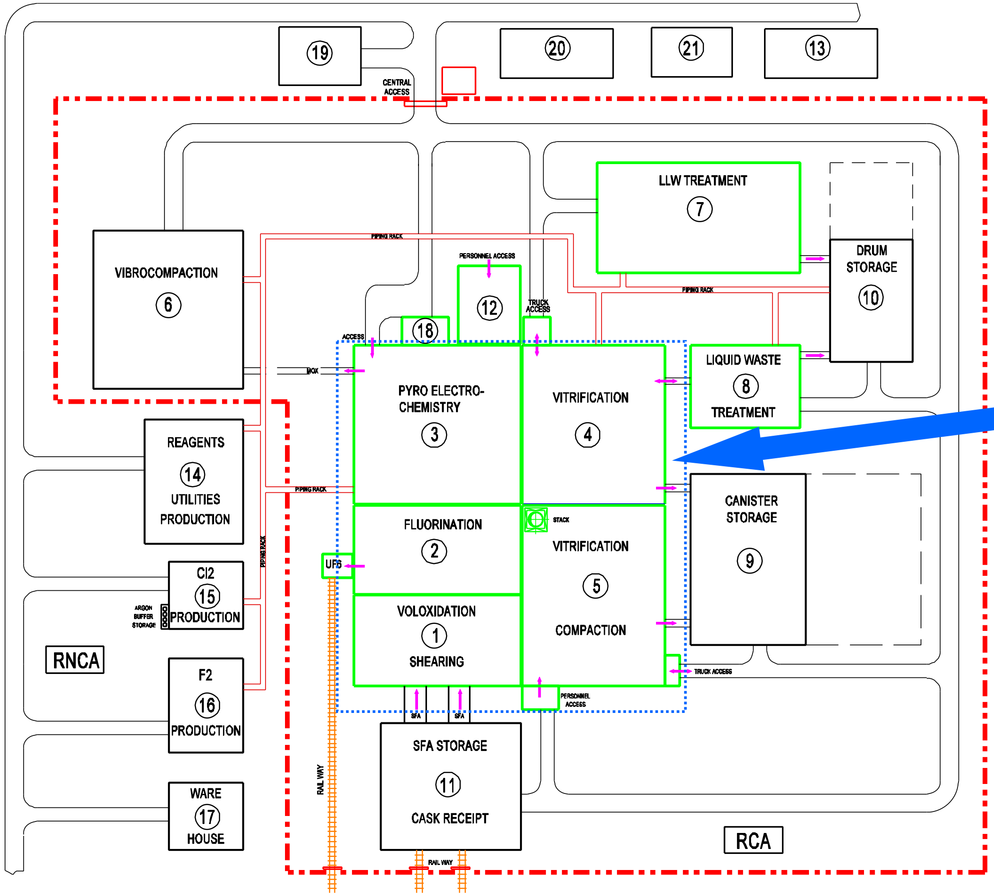
NB: only blue steps were in the scope of the study

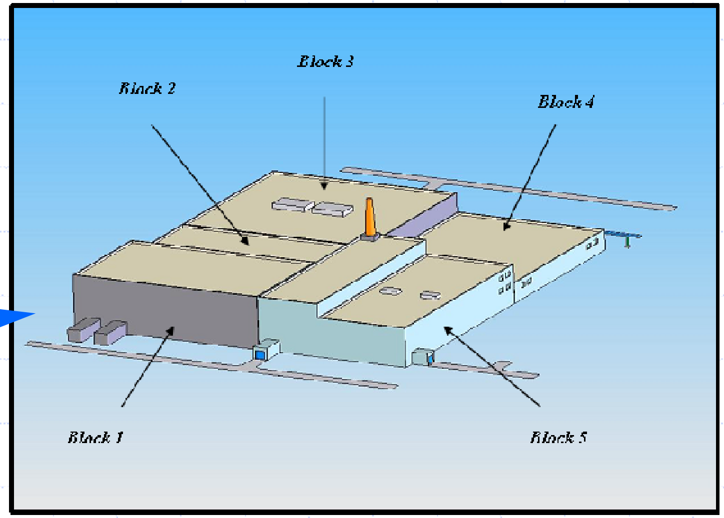
3. Process description (2)



5. Engineering study

- Result of lay-out studies





Single building in five blocks:

- 153 m long;
- 127 m wide;
- 57 m maximum height