AGENZIA NAZIONALE
PER LE NUOVE TECNOLOGIE, L'ENERGIA
E LO SVILUPPO ECONOMICO SOSTENIBILE

IGD-TP 4th Exchange Forum

WG3: New Waste Type, in collaboration with SNETP

Long-term Behavior of Waste Forms from Gen IV Reactors towards Geological Disposal

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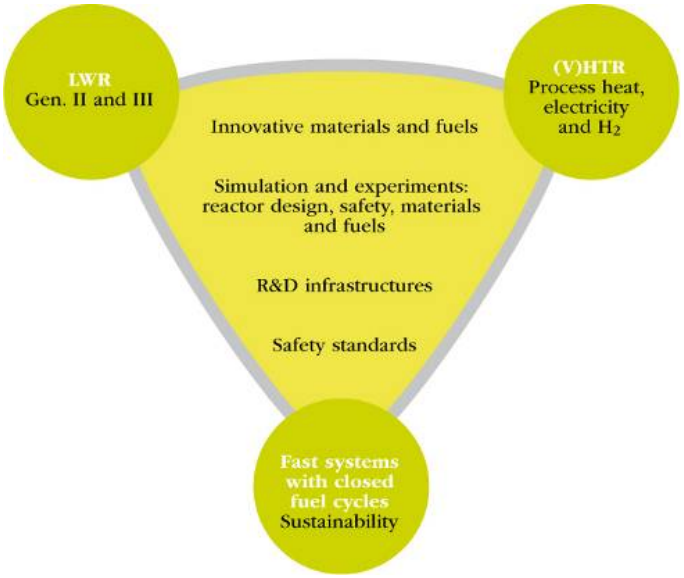
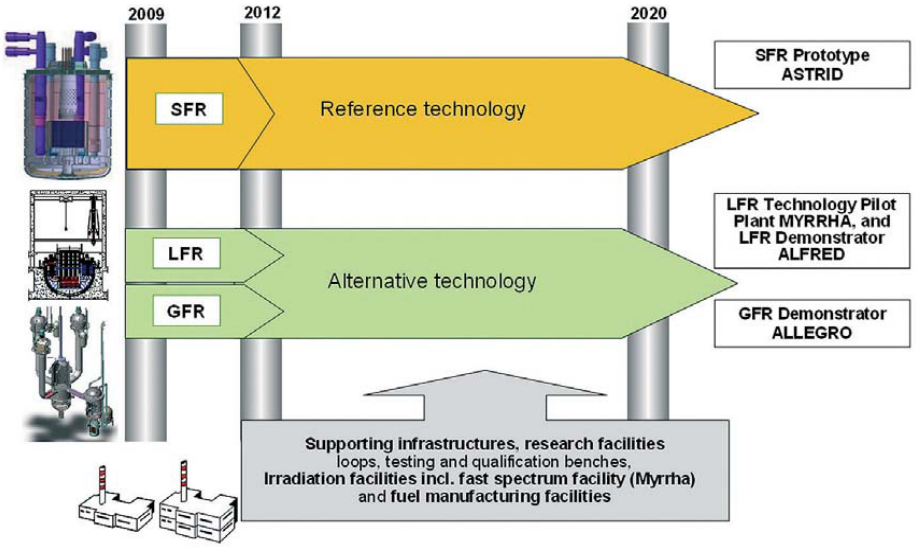
Prague, October 29-30, 2013

SNETP pillars and IV Generation Technologies

SNETP
Sustainable Nuclear Energy Technology Platform

NUGENIA



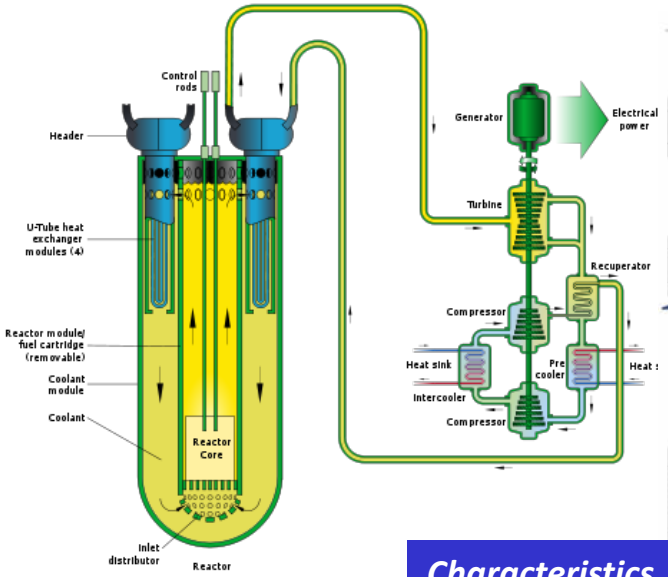


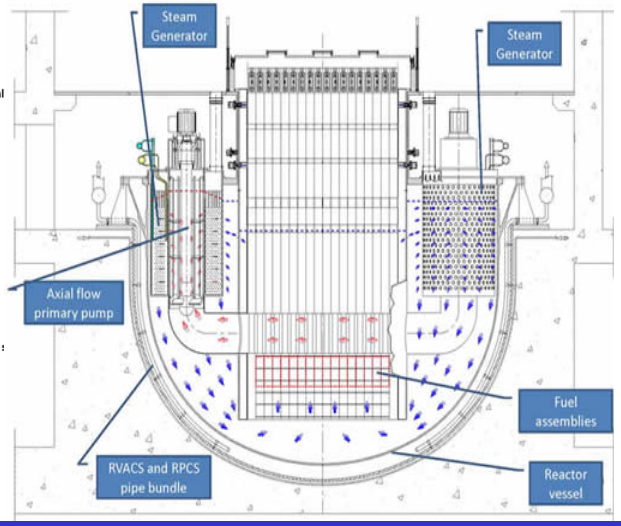
ESNII

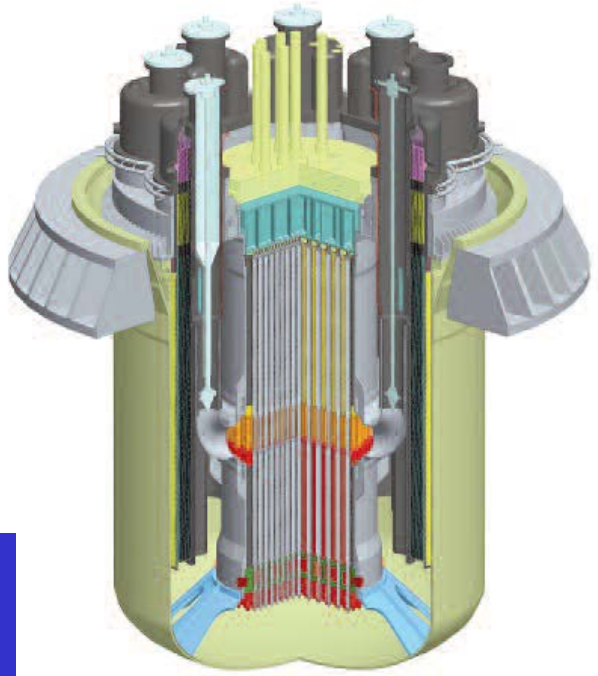
LFR – Lead Fast Reactor Demostrator - ALFRED

Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

AnsaldoNucleare







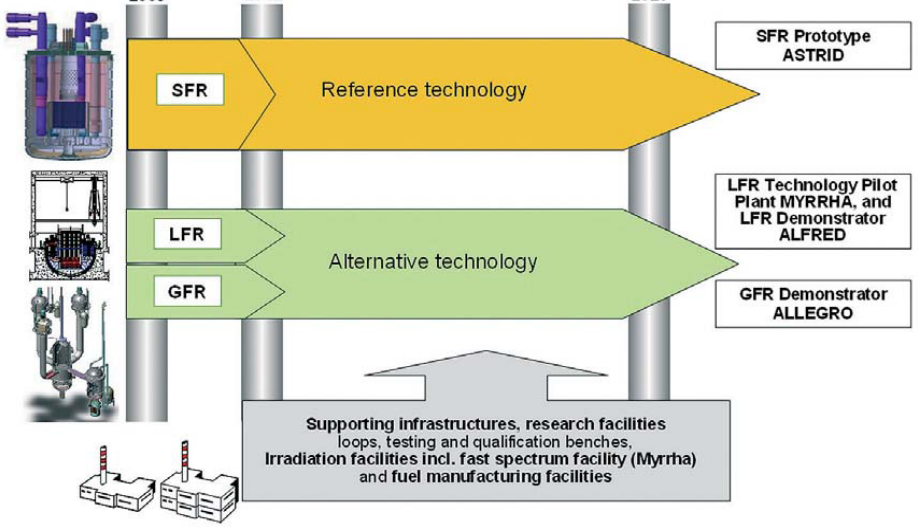
Characteristics

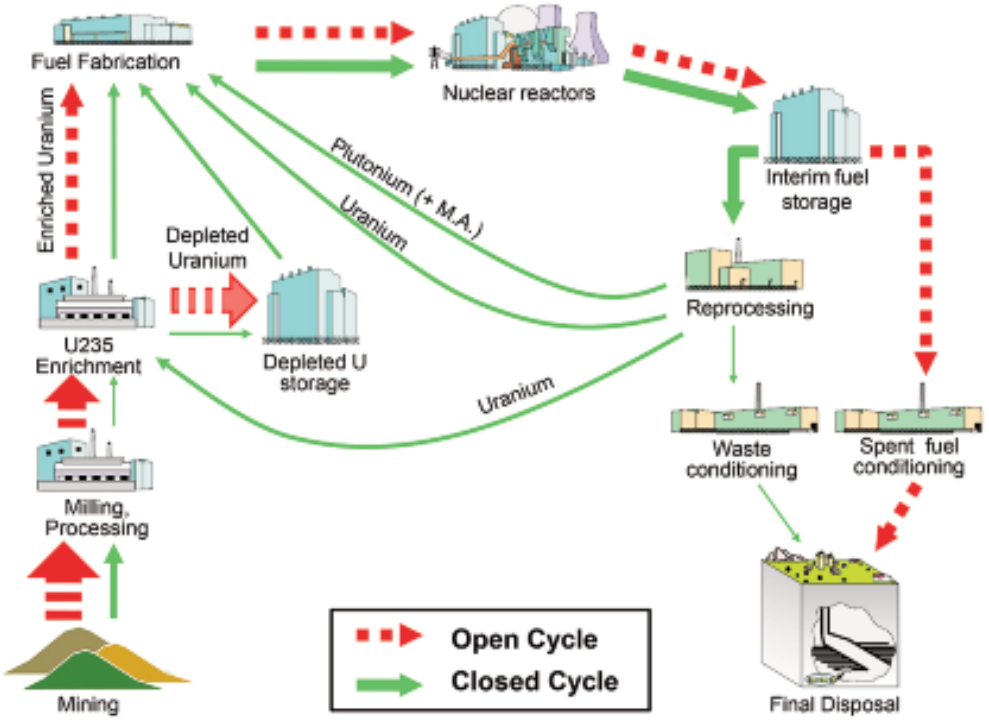
- ***Pb or Pb/Bi coolant***
- ***550 ° C to 800 ° C outlet temperature***
- ***Fast Spectrum***
- ***Multi-TRU recycle***
- ***50–1200 MWe***
- ***15–30 year core life***

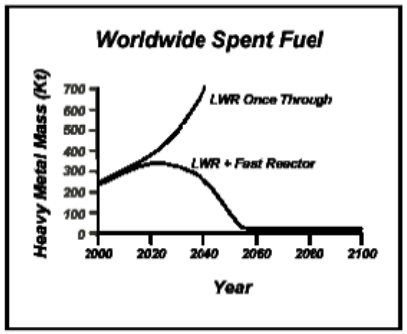
Gen IV reactors spent fuel reprocessing

ESNII prototypes

Fuel reprocessing





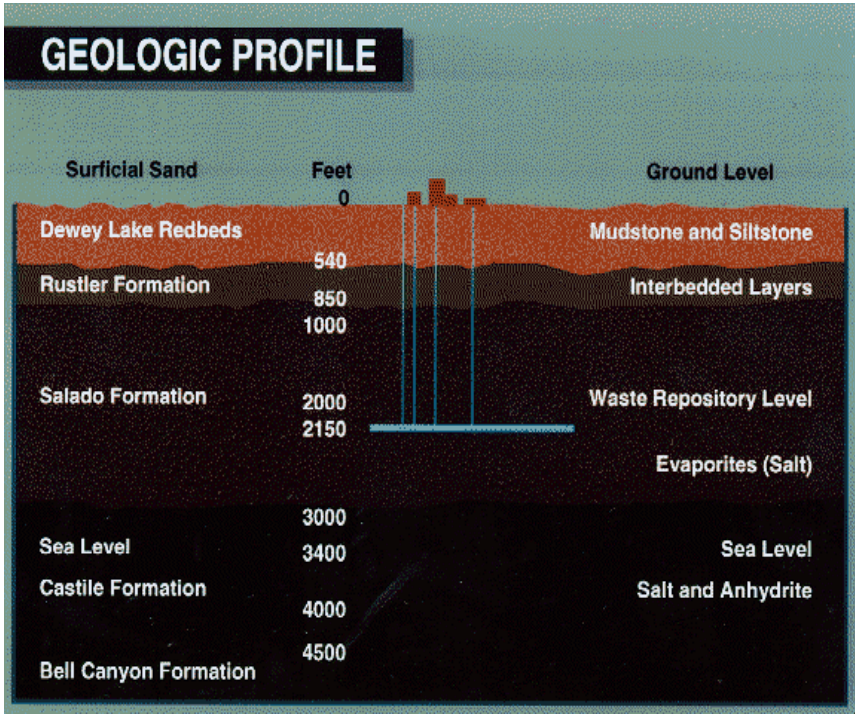


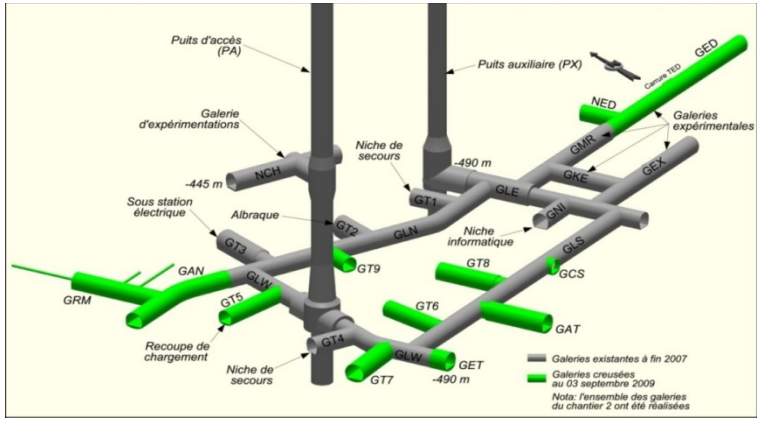
Fuel Cycle Innovations

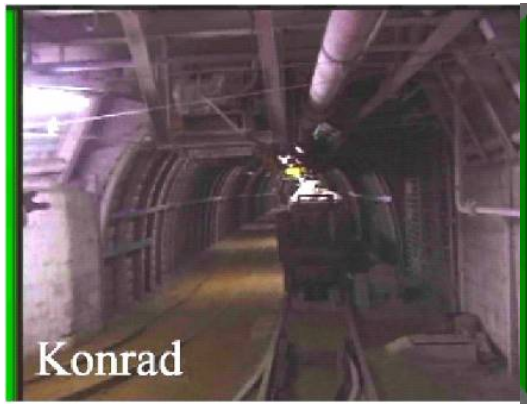
- *Advanced aqueous or pyroprocess recycle technology with intrinsic nonproliferation features*
  - *Produces co-mixed Pu+MA feedstock (no separated Pu)*
  - *Incomplete fission product separation*
- *Fuel Cycle Support Facilities Options*
  - *Co-located*
  - *Regional*
- *Multiple Fuel Options*
  - *Fuel types TRU/U/Oxide, TRU/U/Nitride, TRU/U/Alloy, TRU Alloy, MA Alloy*
  - *Remote refabrication technology depends on fuel type*
    - *Simplified pelletization (oxide, nitride)*
    - *Vibrocompaction (oxide, nitride)*
    - *Injection casting (metal)*

New waste form requirements from Gen IV reactors reprocessing to geological disposal

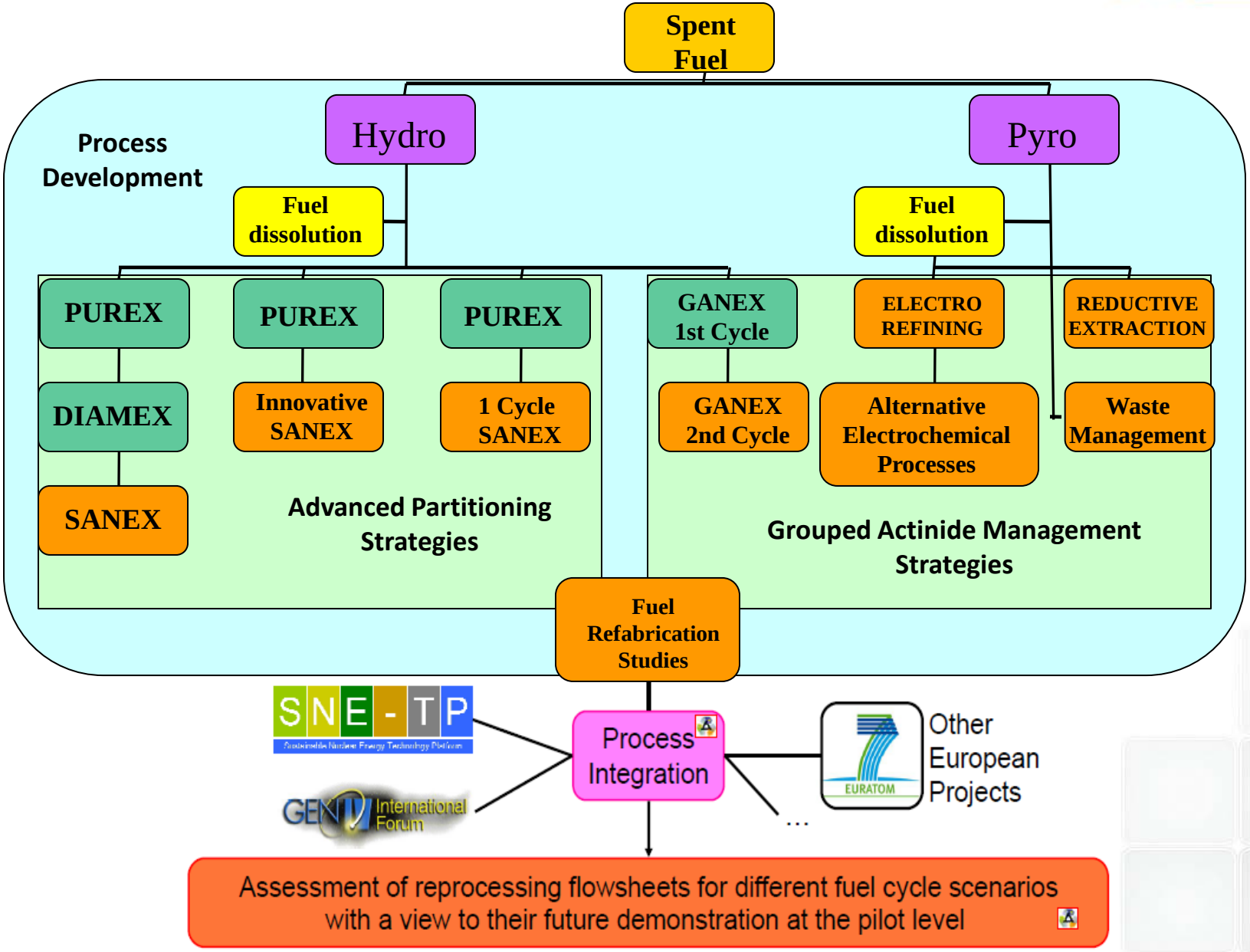
- Burn most of TRU / Minor Actinides
- Reducing FP as much as possible
- Non proliferation of Pu
- Stability of chemical and physical form
- Easy conditioning and storage
- Safe and economic geological disposal
- Average depth around m.500 and not m. 4000







Treatment of spent fuel



WG3: New Waste Type

The main reprocessing methods presently used:

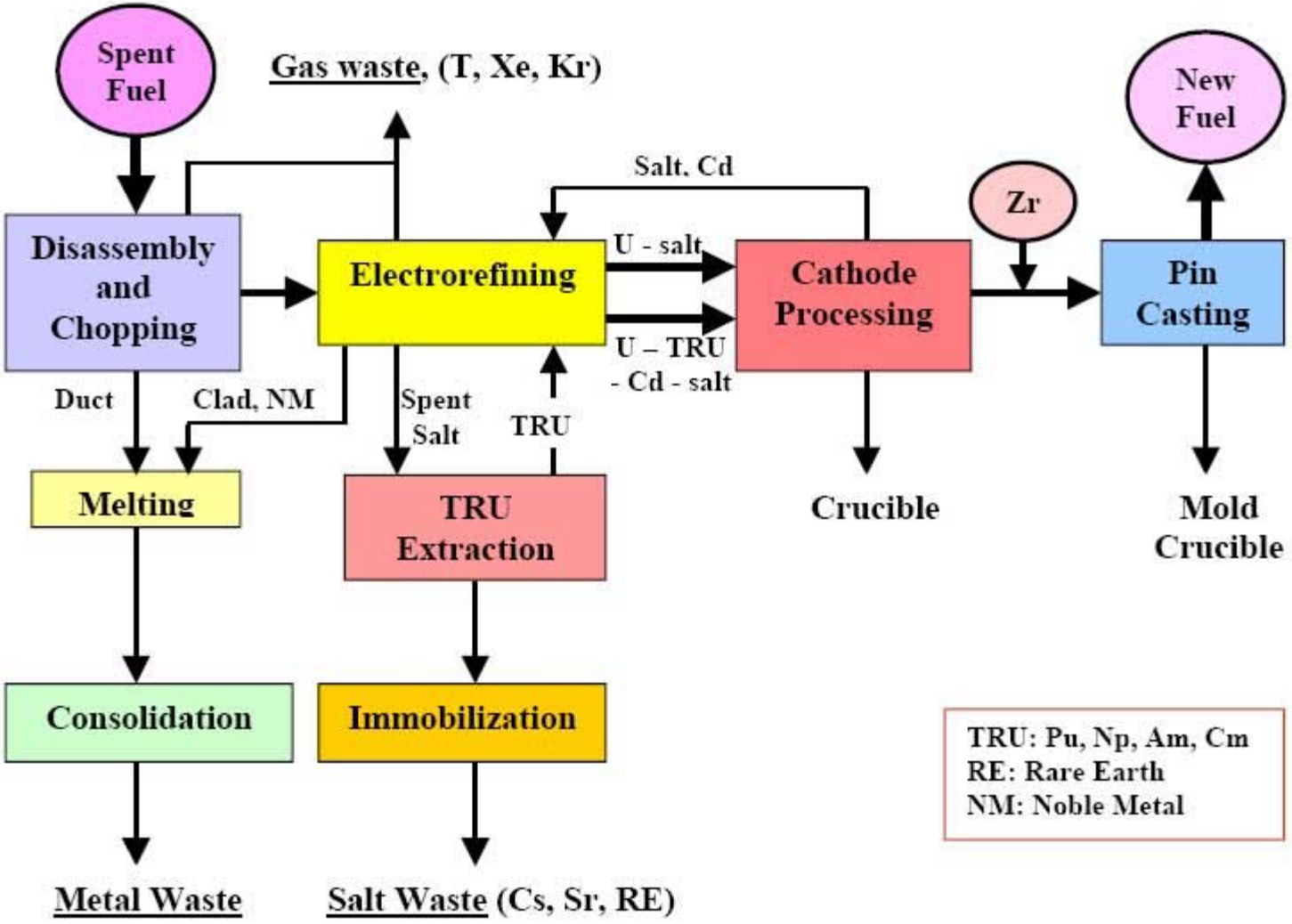
- **Co-extraction**
- **New extraction**
- **Uranium extraction (UREX)**
- **Electrochemical processing**

WG3: New Waste Type

Electrochemical processes

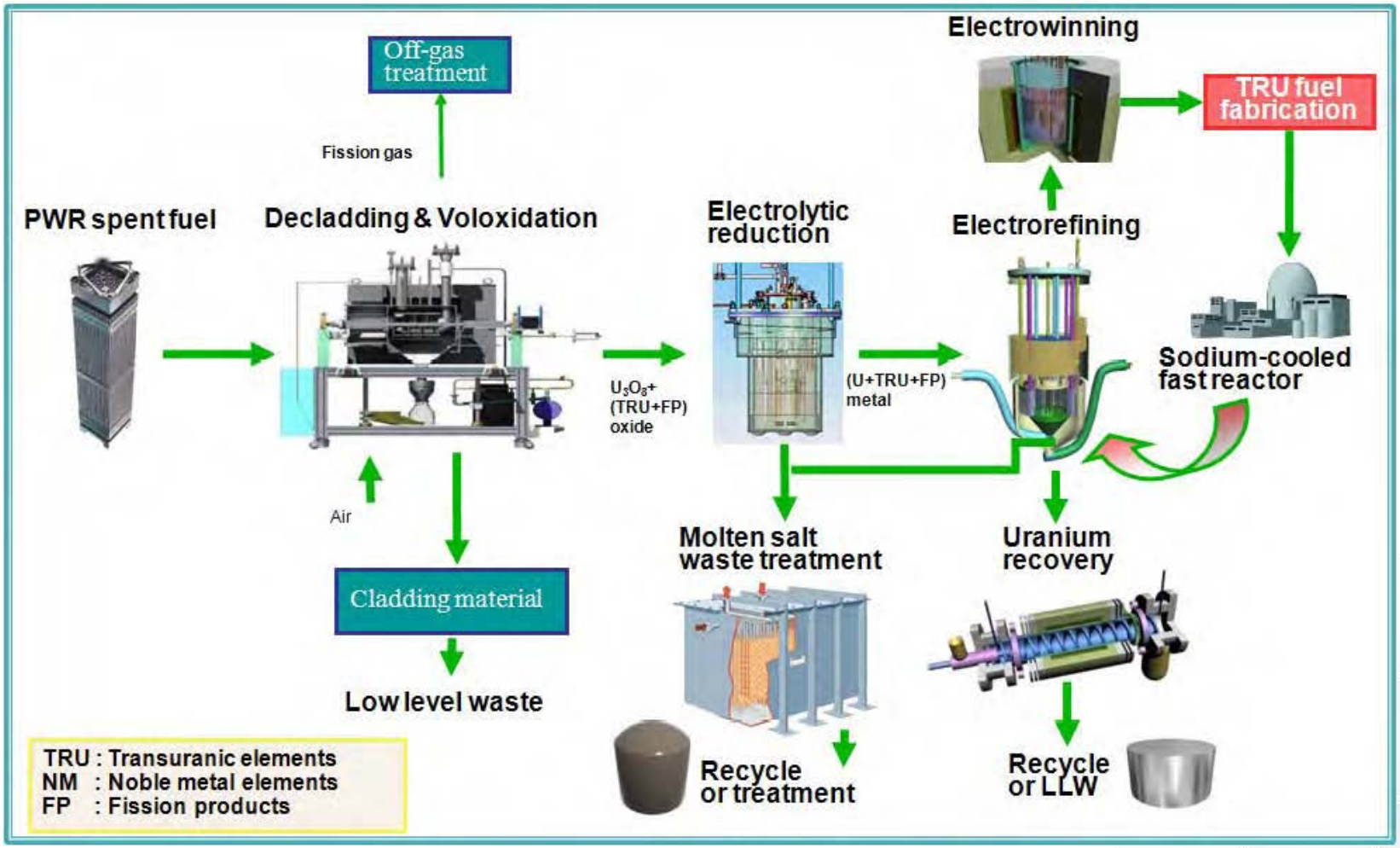
WG3: New Waste Type

Block diagram of the pyrochemical process for metal fuel



WG3: New Waste Type

Schematic illustration of the pyrochemical process for oxide fuel



WG3: New Waste Type

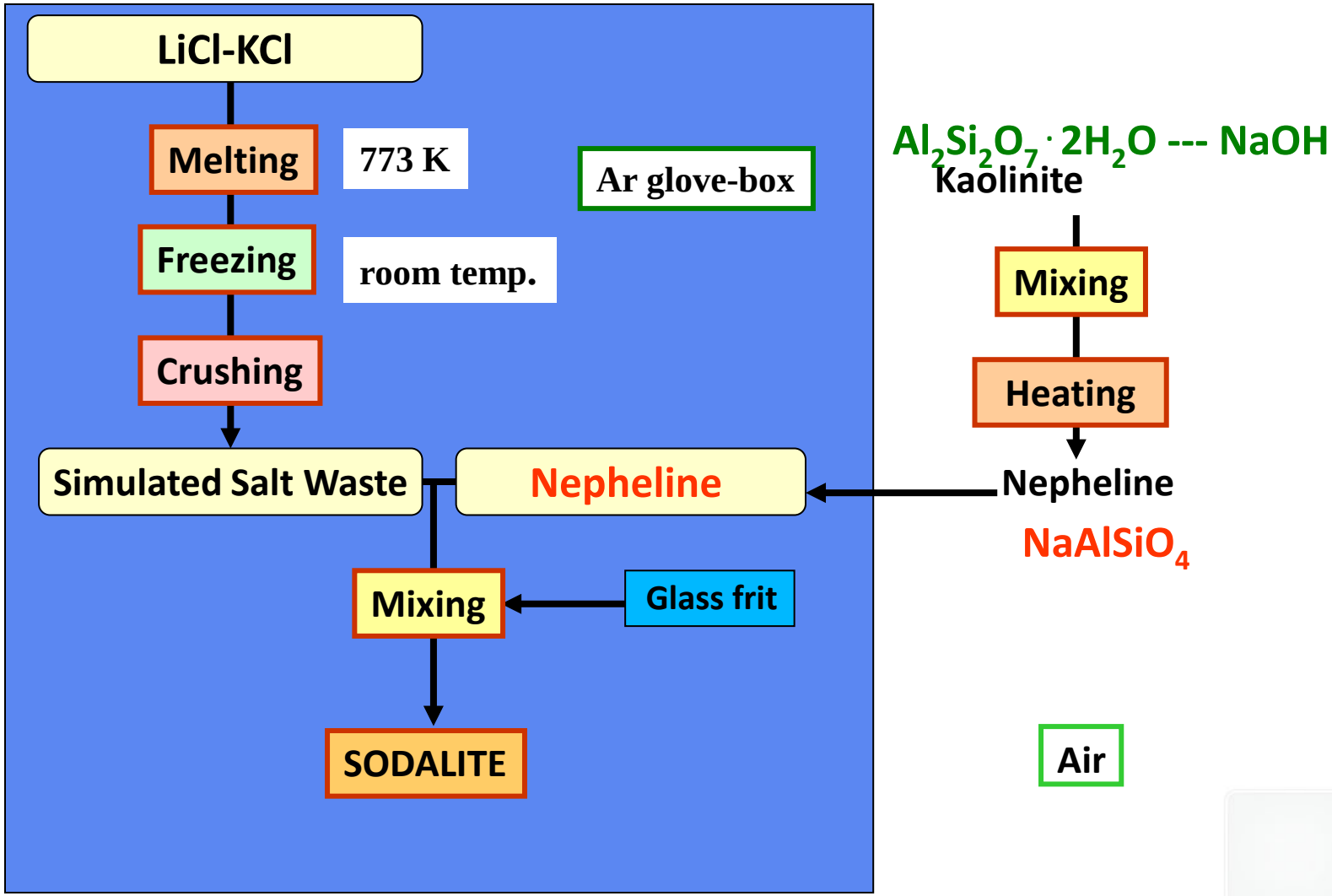
Conditioning of chloride salt wastes from pyroprocesses with different matrices:

SODALITE

SAP

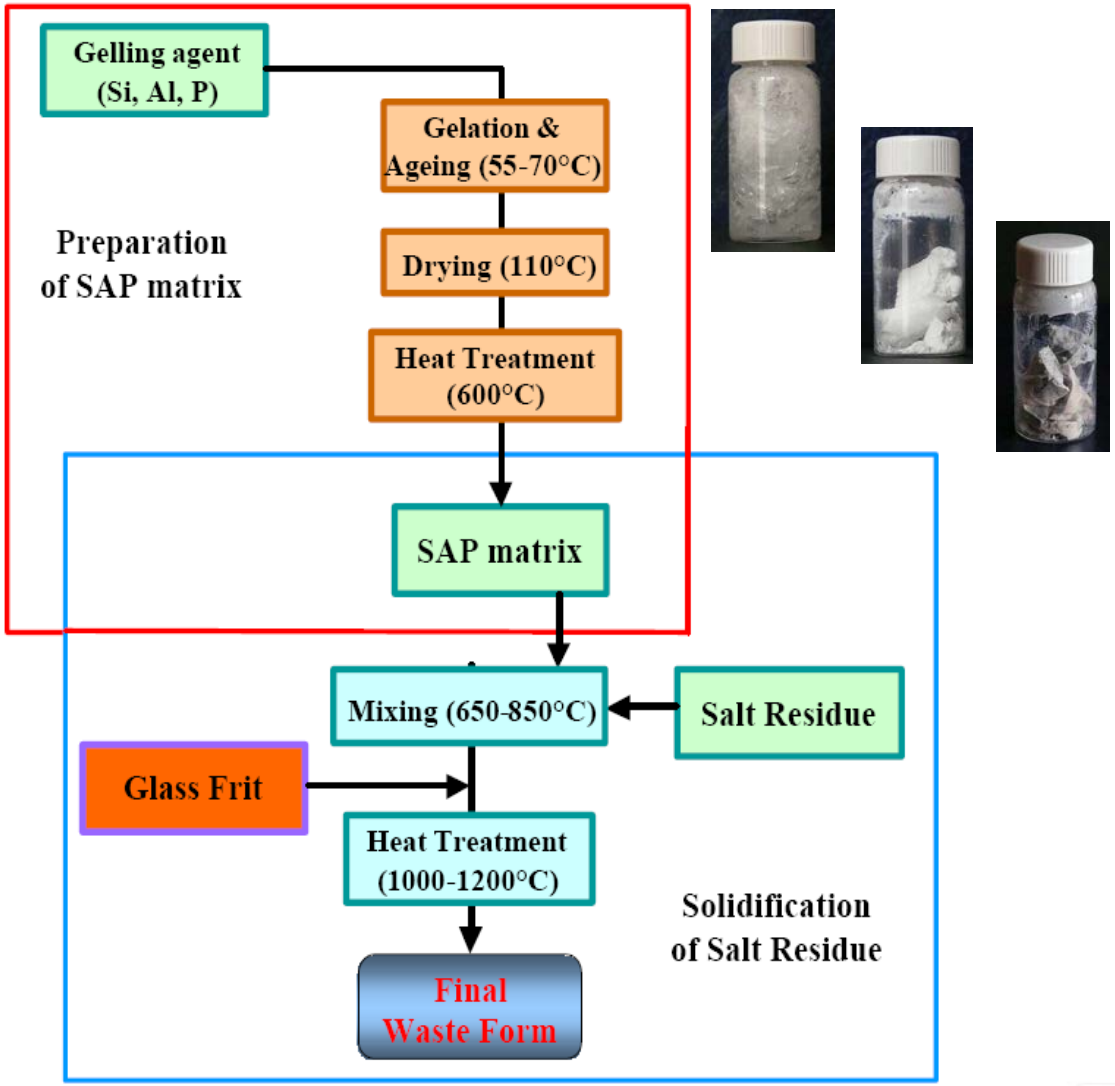
MURATAITE-PYROCHLORE

SODALITE matrix



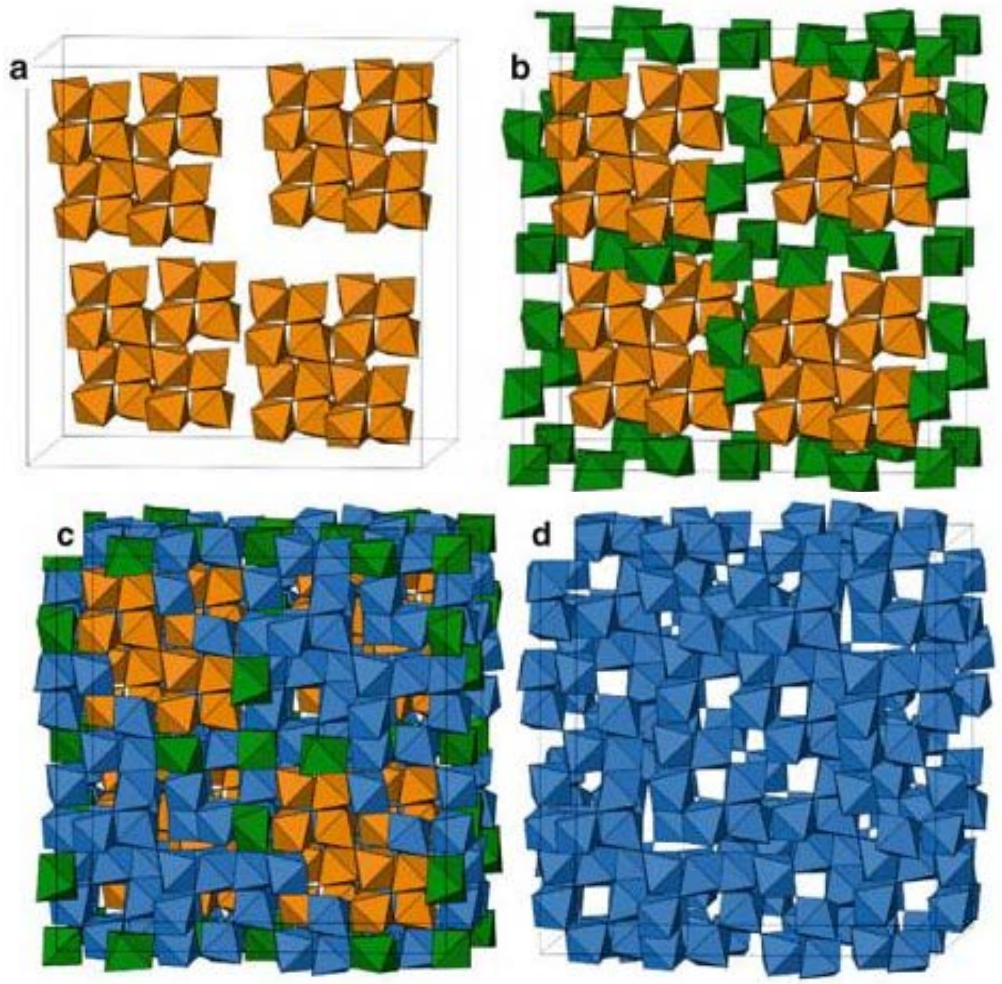
Outline of sodalite synthesis from kaolinite through nepheline

SAP matrix



Outline of SAP synthesis by a conventional sol-gel process

MURATAITE matrix



Octahedral framework in the structure of Mu-5: arrangement of pyrochlore clustera formed by corner sharing of *Ti*1O6 and *Ti*4O6 octahedra (a); linkage of pyrochlore clusters by Ti3O6 octahedra (b); whole framework as combination of linked pyrochlore clusters and murataite-like framework formed by Ti2O6 and Ti5O6 octahedra ©; murataite-like framework (d)

WG3: New Waste Type

Evaluation of long-term behaviour of conditioned salt wastes

- Characterization of the final waste forms
- Static leaching tests up to 150 days
- Assessment of the main parameters which influence fission products release (pH, temperature, contact time)
- Determination of the interactions between host matrix and individual fission elements

WG3: New Waste Type

Characterization of the final waste forms

Density measurements;
Thermogravimetric analysis;
SEM-EDS;
Optical Microscopy;
FTIR;
XRD

WG3: New Waste Type

Static leaching tests up to 150 days

Reference Method

C 1285-02 - Standard Method for Determining Chemical Durability of Nuclear, Hazardous, and Mixed Waste Glasses and Multiphase Glass Ceramics: the Product Consistency Test (PCT)

WG3: New Waste Type

Static leaching tests up to 150 days

Normalized Release

$$NL_i = \frac{c_i}{f_i \cdot (SA/V)}$$

Normalized Release Rate

$$NR_i = \frac{c_i}{f_i \cdot (SA/V) \cdot t}$$

Percentage of release

$$(\Sigma a_i / a_0) \cdot 100$$

WG3: New Waste Type

Assessment of the main parameters which influence fission products release (pH, temperature, contact time)

pH:	**acid; neutral; alkaline**
Temperature:	**23C; 90C**
Contact time:	**1; 3; 7 days**

WG3: New Waste Type

Determination of the interactions between host matrix and individual fission elements

Single fission elements incorporated in the host matrix with characterization of the mineral phases formed:

Alkaline metal: **Cesium**

Alkaline-earth metal: **Strontium**

Rare earth metal: **Neodimium**

WG3: New Waste Type

CONCLUSIONS

The main scope of this proposal is a comparison among these promising matrices for conditioning of chloride salt wastes, with a particular attention to the incorporation mechanisms and to their durability in the long-term, in order to comply with geological disposal

WG3: New Waste Type

Thanks for your attention

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