

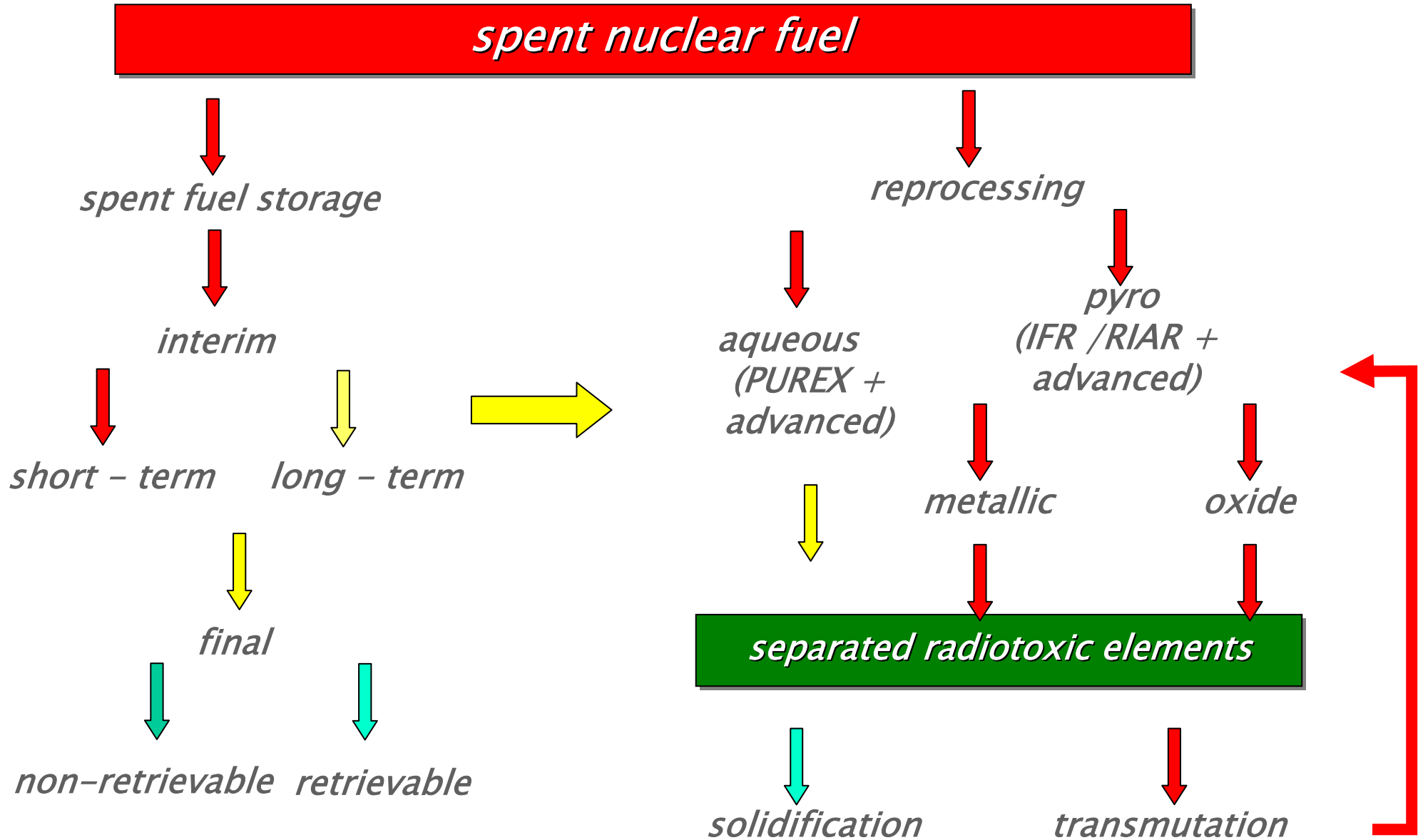
# *European Nuclear Waste Management Options*

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Joint Research Centre (JRC)  
Institute for Transuranium Elements (ITU)**

<http://www.jrc.ec.europa.eu>

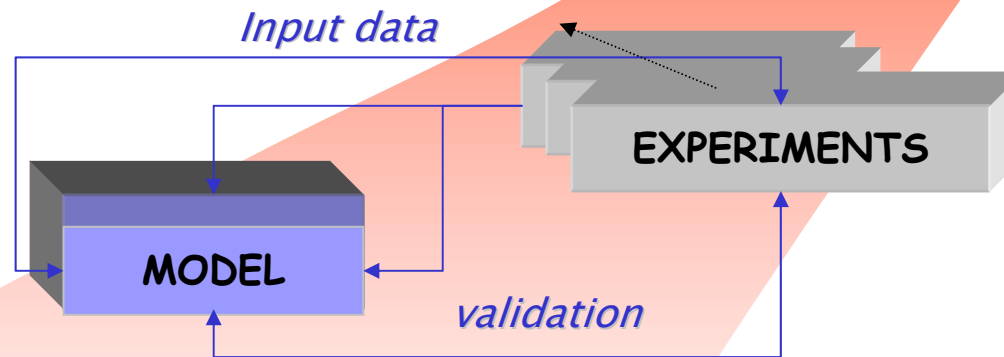
<http://itu.jrc.ec.europa.eu>



### Strategy

*public acceptance of spent fuel (waste) repository depends on reliable assessment therefore assessment procedures (models) need reliable source-term data under realistic conditions (redox, genuine fuel)*

*investigate key processes affecting the barrier performance of the near-field environment*



*quantitative assessment of the long-term behaviour of the overall near-field system*

*European programs:*

*Spent fuel Stability SFS* 

*Near Field*  

*MICADO RECOSSY*



## ***NF–PRO: Near–Field PROCesses***

*Investigate key processes affecting the long–term barrier performance of the near–field system*

*CHALMERS UNIVERSITY OF TECHNOLOGY ,SVENSK KAERNBRAENSLEHANTERING AB, STUDEVIK NUCLEAR AB, UPPSALA UNIVERSITY, Physics Department*

## ***MICADO: Model uncertainty for the mechanism of dissolution of spent fuel in a nuclear waste repository***

*assess the uncertainties in models describing the dissolution mechanism of spent nuclear fuel in a repository for geological time periods*

*STUDEVIK NUCLEAR AB, SWEDISH NUCLEAR POWER INSPECTORATE  
SVENSK KAERNBRAENSLEHANTERING AB  
ROYAL INSTITUTE OF TECHNOLOGY*

## ***RECOSY Redox Phenomena Controlling Systems***

*Assess redox conditions of disposal relevant systems*

*CHALMERS UNIVERSITY OF TECHNOLOGY  
SVENSK KAERNBRAENSLEHANTERING AB*

### *Finnish and Swedish concepts for spent fuel disposal based on copper canisters with inner iron-cast*



- *water intrusion causes corrosion of the iron insert*
- *equilibrium hydrogen pressure: several hundred atmospheres are supposed to determine the redox conditions for several 10,000 years in the repository*
- *laboratory experiments in ITU show that spent fuel corrosion rate is reduced by  $> 1000$  times in the presence of hydrogen*
- *mechanisms involved under investigation*



***significant impact on Performance Assessment of European fuel repositories***

*IE–ITU action: Waste Package and Systems for Transport, Storage and Disposal of High–level Nuclear Waste and Spent Fuel*  
**SAFEWASTE**

*to address critical issues relating to the integrity of waste packages and the long–term performance of systems for storage and disposal of HLW and SNF.*

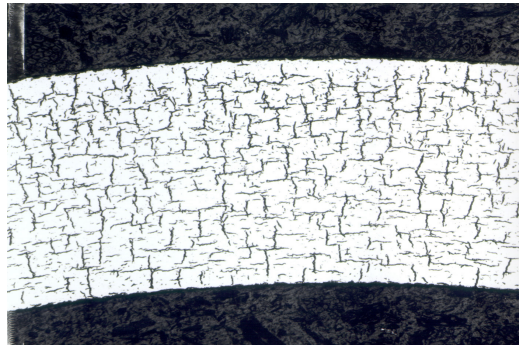
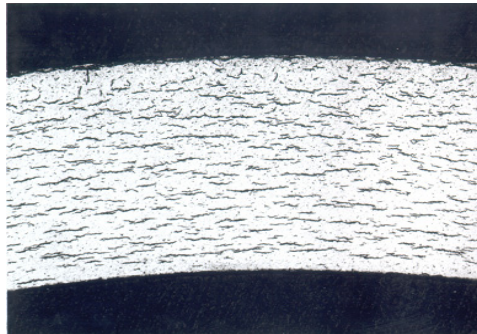
*Customer/users (outside the European Commission):*  
*International organizations (IAEA, OECD/NEA)*  
*Industry (e.g. **SKB**, ANDRA, SKODA, AREVA, GNS, NIREX)*  
*R&D Organizations (e.g. BAM, Helsinki, Univ. Reading Univ., **KTH**)*  
*Regulators (e.g. **SKI**, IRNS, NRC, RWMC)*

*Customer DGs (inside the European Commission)*  
*Research (DG RTD)*  
*Energy and Transport (DG TREN)*

*joint research programme IE – ITU started in 2007 to investigate fuel cladding degradation under long term storage conditions and handling  
controlled radial displacement test for fuel cladding tubes  
specific studies on fuel interactions and effects with cladding.*



*First results presented at ICEM '07*



*SEM pictures showing Zr-hydride orientation in the fuel cladding*

*Application of TRANSURANUS (fuel rod thermomechanical code) and 3D FE codes to the analysis of the stress evolution/failure condition for cladding during storage*

- ✓ *No competition but complementarity between aqueous and pyrochemical techniques*
  - ✓ *Advanced and extended PUREX in the Light Water Reactor (LWR) cycle for separation of all actinides*
    - ✓ *Industrial implementation in progress*
  - ✓ *Pyroreprocessing in the advanced Fast Reactor (FR) cycle for grouped actinide recycling*
    - ✓ *Demonstrated on laboratory scale*
- ✓ *Safeguarding and non-proliferation issue to be developed for both*
  - ✓ *Quite advanced for aqueous technology*
  - ✓ *Considerable development required for dry techniques*

- ✓ *Selective grouped separation of actinides from realistic fuel*
- ✓ *Adherent and compact deposit are obtained on solid Al with a good faradic yield (~ 90%)*
- ✓ *Separation of Minor Actinides (MA) from Ln: the cathodic potential can be chosen in order to collect selectively U, Pu, Am ( $E_c > -1.2V$  vs. Ag/AgCl 1 wt%)*
- ✓ *Efficient An/Ln separation by electrolysis was demonstrated on a gram scale*
- ✓ *separation efficient after 25 electrolyses (> 5g of fuel) of the same salt mixture (more than 6 months of experiments)*

- ✓ *Collaboration Agreement ITU – CTH (Chalmers) on understanding and resolving scientific issues in the field of nuclear chemistry, actinides research, materials research, nuclear fuel development, nuclear safeguard and security and hot cell*
- ✓ *Transuranus Licensing Agreement ITU – KTH Sweden (Royal Institute of Technology) Collaboration for the simulation of advanced fuels with Transuranus*
- ✓ *Collaboration Agreement ITU – SKB, NAGRA, Studsvik (Joint Redox) in the field of spent fuel/waste form corrosion and radionuclides interactions with secondary phases on corroded waste package/iron surface, leading to more effective waste management techniques and strategies*
- ✓ *Third Party Work for CHALMERS fabrication of  $^{233}\text{U}$  doped  $\text{UO}_2$*

## *Two major options for spent fuel management:*

- *direct disposal: Intense collaboration with Sweden*
  - ✓ *Most advanced repository projects in Finland and Sweden*
  - ✓ *European performance assessment projects SFS, NF-PRO, MICADO and RECOSY for FP7*
  - ✓ *Spent fuel corrosion rate significantly decreased (~ 1000 times) due to the presence of H<sub>2</sub> in the repository formed upon canister corrosion*
  
- *advanced reprocessing: collaboration with Chalmers University*
  - ✓ *dirty fuel – clean waste concept for GENIV systems*
  - ✓ *co-recycling of all actinides to minimize the waste*
  - ✓ *European partitioning projects NEWPART, EUROPART and ACSEPT in FP7*