DE LA RECHERCHE À L'INDUSTRIE

From fuel to fuel: Dissolution, Partitioning and fuel manufacturing

ASGARD, SACSESS, GENIORS

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INTRODUCTION

THE 3 PROJECTS

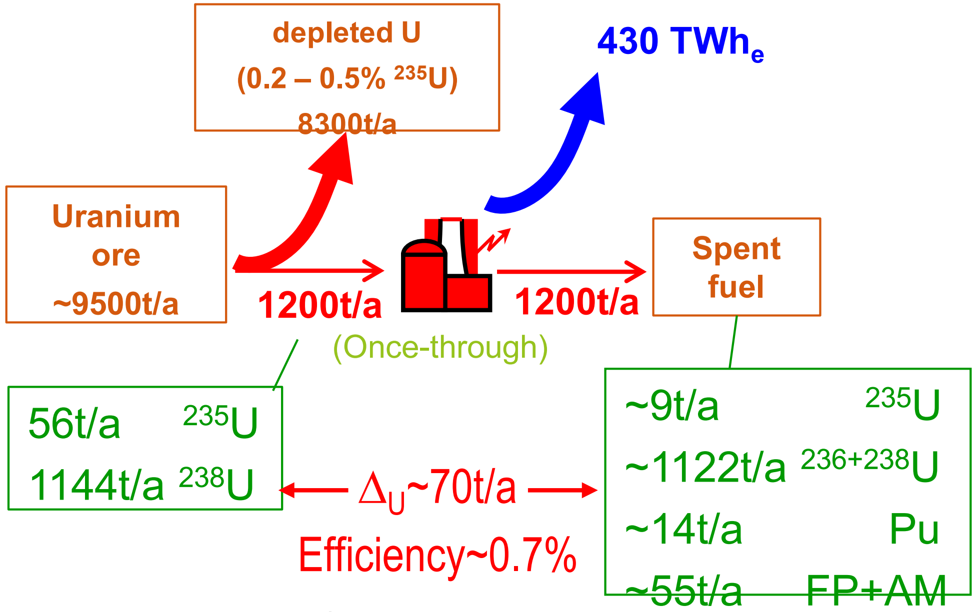
EDUCATION AND TRAINING

INTRODUCTION

Nuclear Energy Today – open fuel cycle

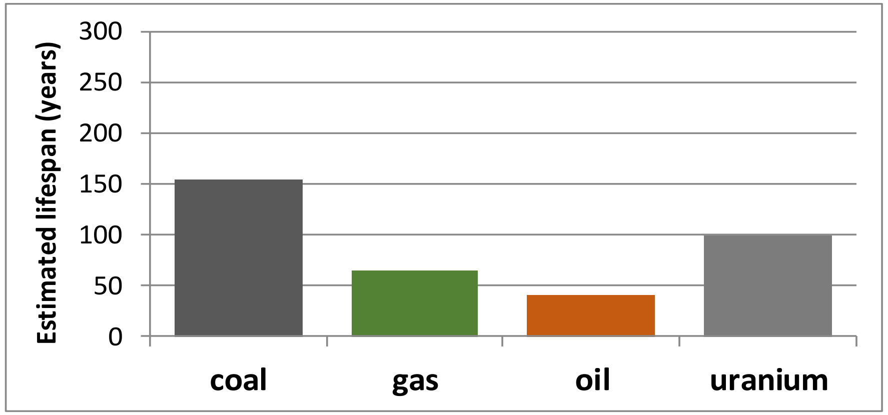
Does not preserve natural resource

- Natural U is a limited resource
  - Although present everywhere, U-ores of reasonable economic interest are limited (260$/kg U)
  - Minimum lifespan ~135 years *(with current consumption 56kt/y)*
  - Need for preserving U-resource



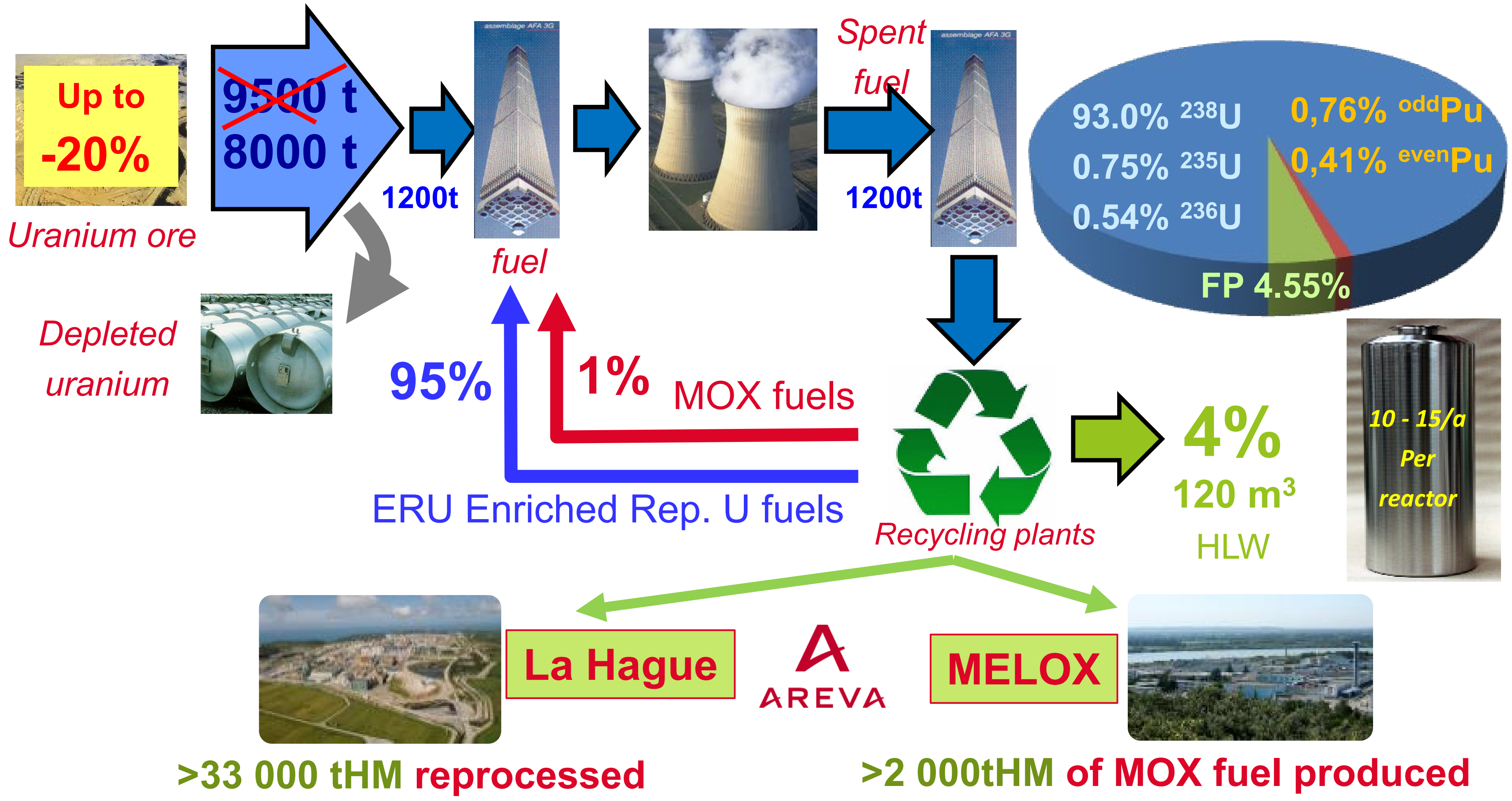
Rough estimates derived from French Fuel cycle assuming no recycling

- Global efficiency is currently very low: ~0.7%
  - ~70t from the initial ~9500t Uore



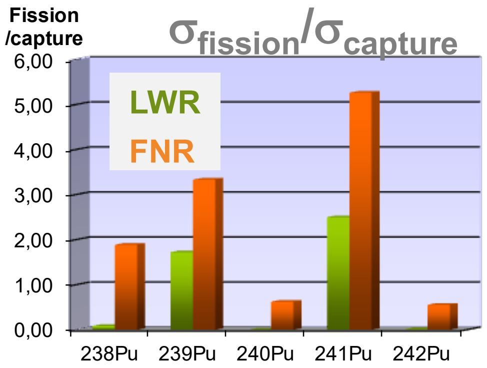
- **Need for improving U-efficiency**

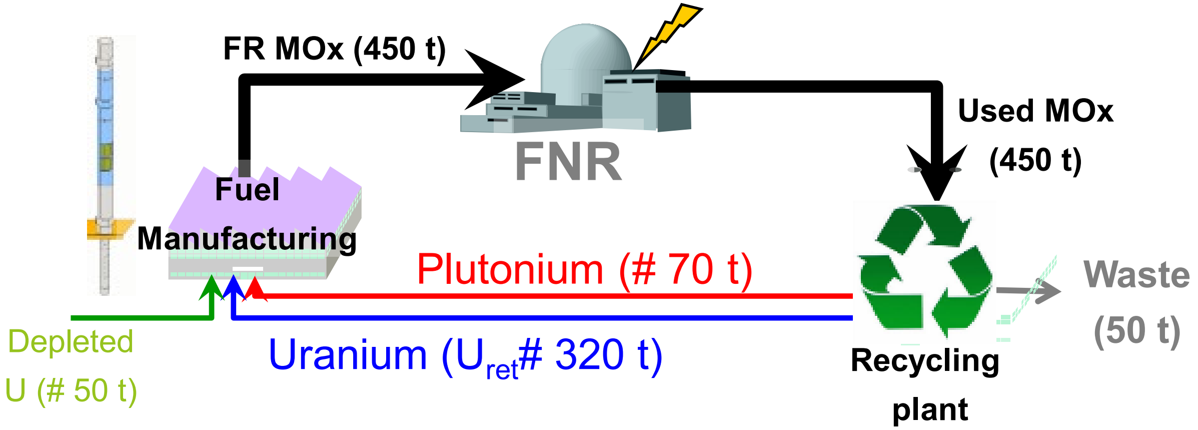
Nuclear Energy Today – Once through fuel cycle (French fuel cycle)



- 15 to 20% of French electricity yearly supplied by recycled materials
- ~1500t uranium ore yearly preserved
- No significant SNF interim storage ⇔ risk reduced

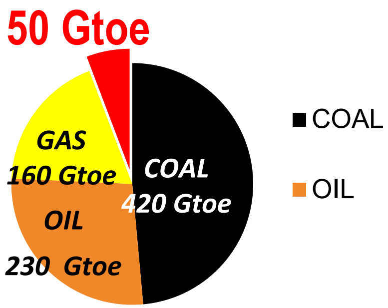
GEN4 systems with fast neutrons





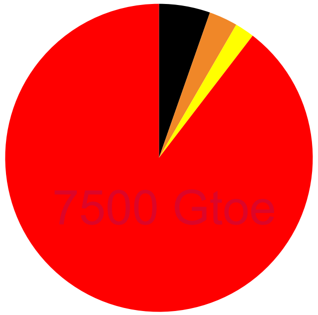
1GWe ~ 150t U_{nat}/y

With thermal reactors



U=6% world energy potential

With fast neutron reactors

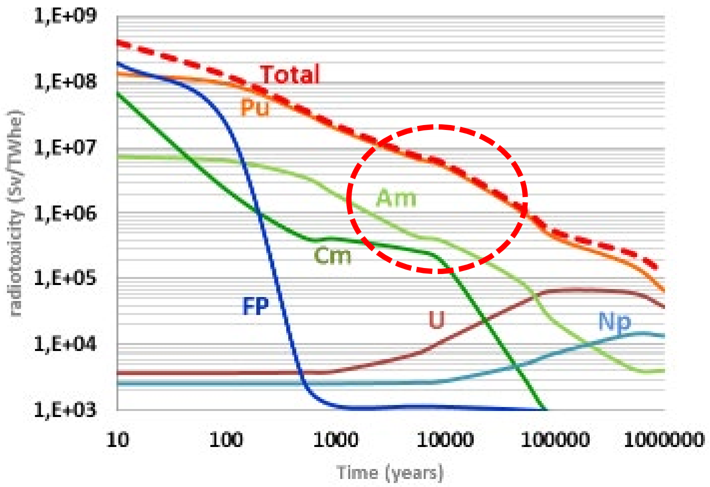


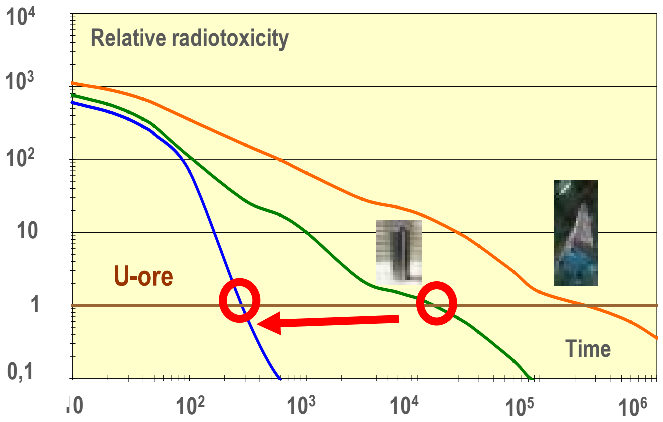
U=90% world energy potential

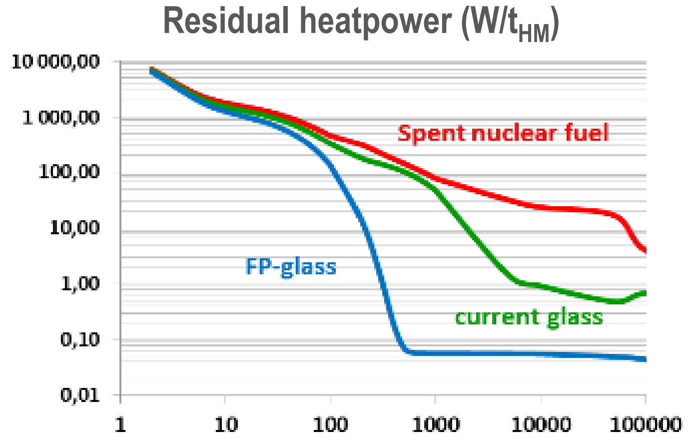
1GWe ~ 1t U_{nat}/y

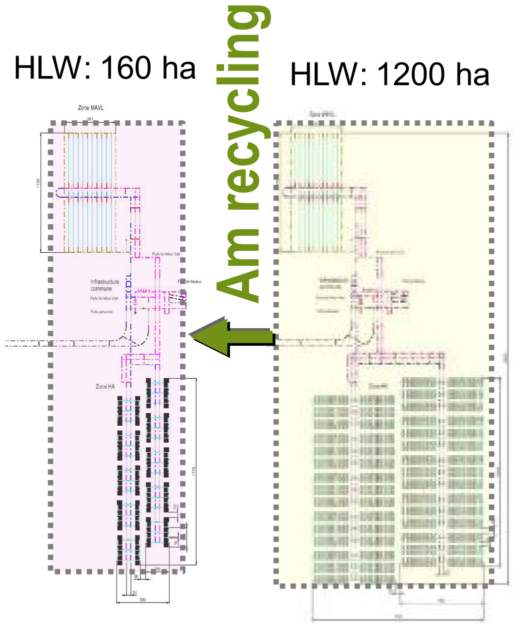
Very significant improvement of natural uranium efficiency

Recycling the minor actinides (transmutation): a potential contribution for decreasing the waste burden



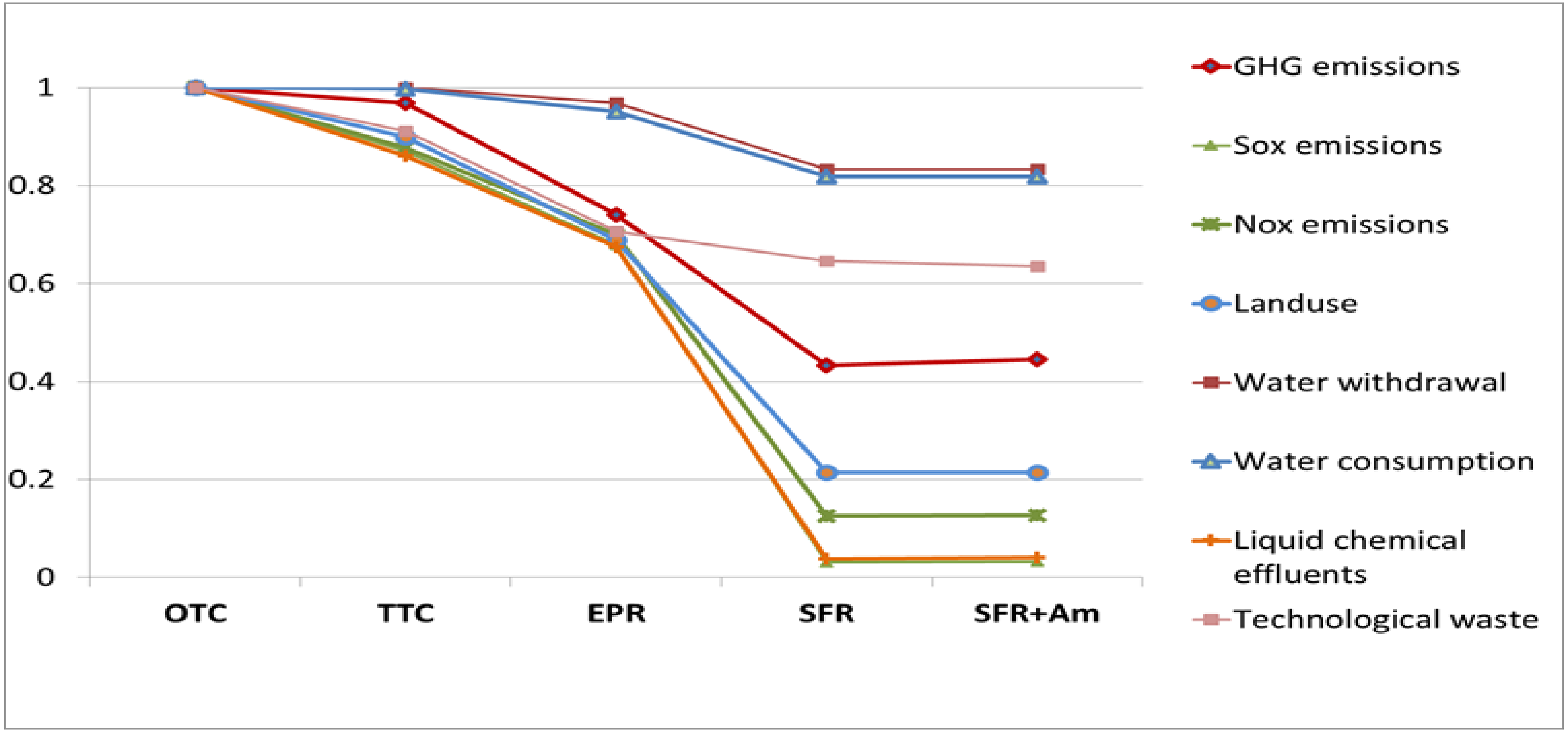






- **Waste toxicity dominated by MA**
  - Recycling MA ⇔ decrease waste lifetime and toxicity
- **Preserve the valuable repository resource**
  - ↘ of the heat load ⇔ ↗ density of the repository
    - With Am recycling, reduction of the repository volume by a factor up to 8
  - Very significant increase of the repository "lifespan"

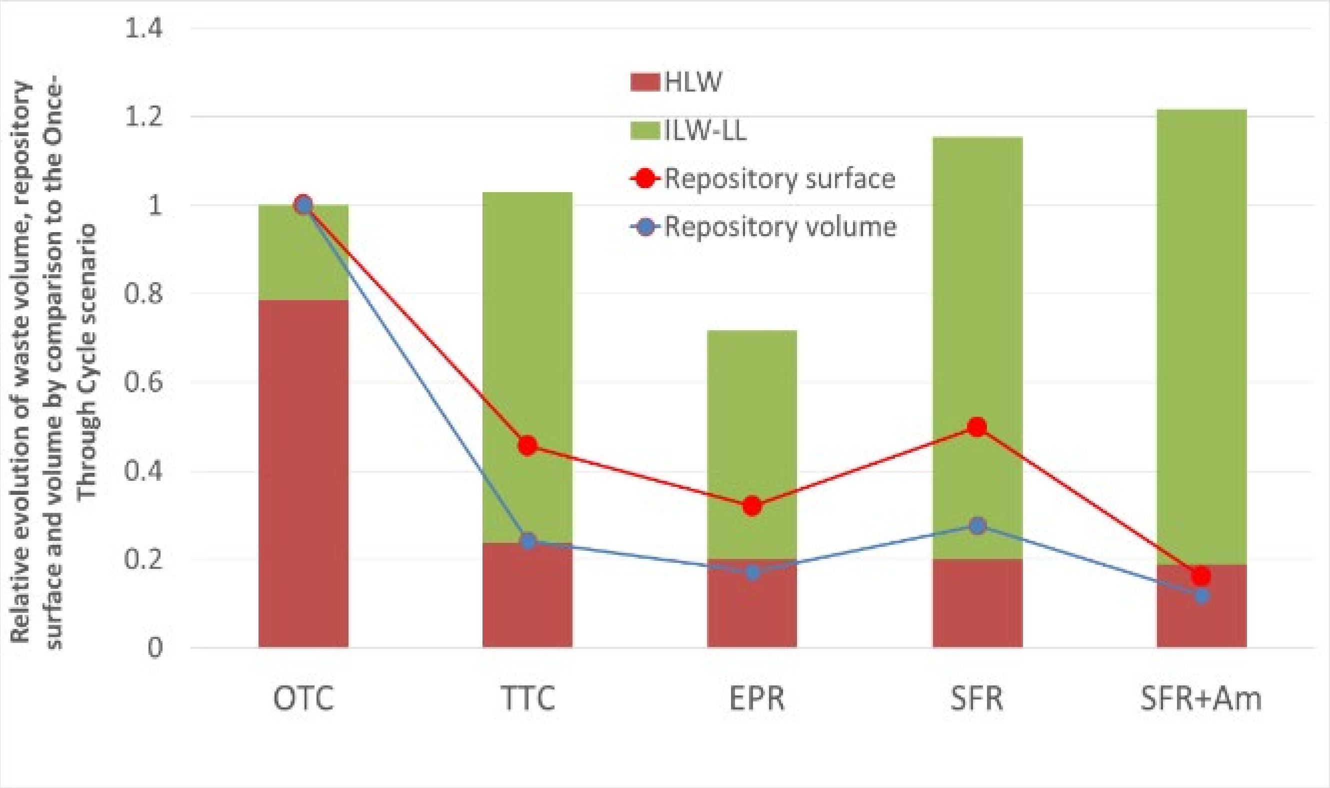
Anticipated beneficial impact of recycling activities



Actinides recycling significantly improve the nuclear energy environmental footprint

Ch. Poinssot, S. Bourg et al., Energy 2014, 6, 199–211
J.Serp, Ch Poinssot, S. Bourg, Energies 2017, 10, 1445.

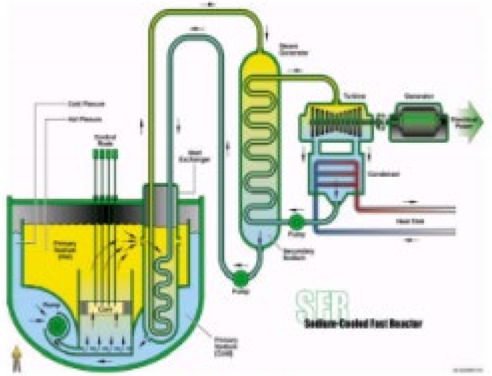
A significant Improvement of the nuclear waste management



Interim storage time:
120 years

- Relative decrease of HLW vs. ILW while total volume of waste ~ constant +/- 20%
- Decrease of thermal power due to Pu-recycling ➔ significant gain for the repository volume
- Decrease of radiotoxicity & lifetime
- Am transmutation: save the repository surface by a factor about 3 compared to SFR

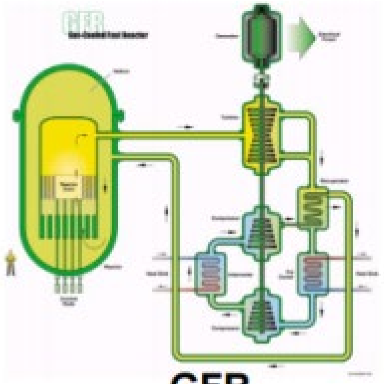
GEN IV Fast Neutron Reactors + ADS in Europe



SFR
Sodium-cooled fast reactor

ASTRID

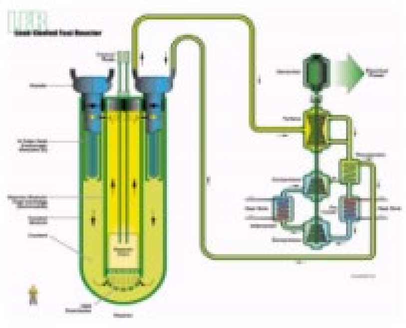
Closed fuel cycle



GFR
Gas-cooled fast reactor

ALLEGRO

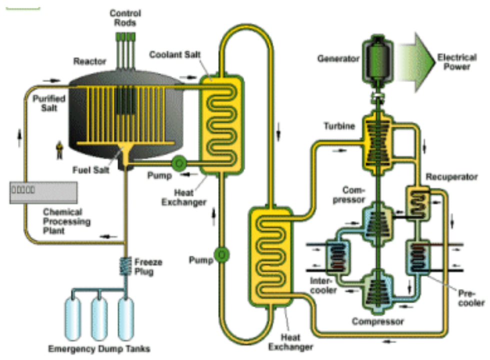
Closed fuel cycle



LFR
Lead-cooled fast reactor

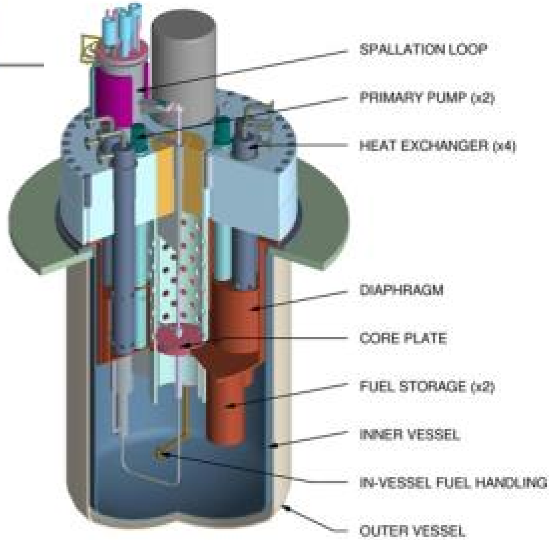
ALFRED

Closed fuel cycle



MSR

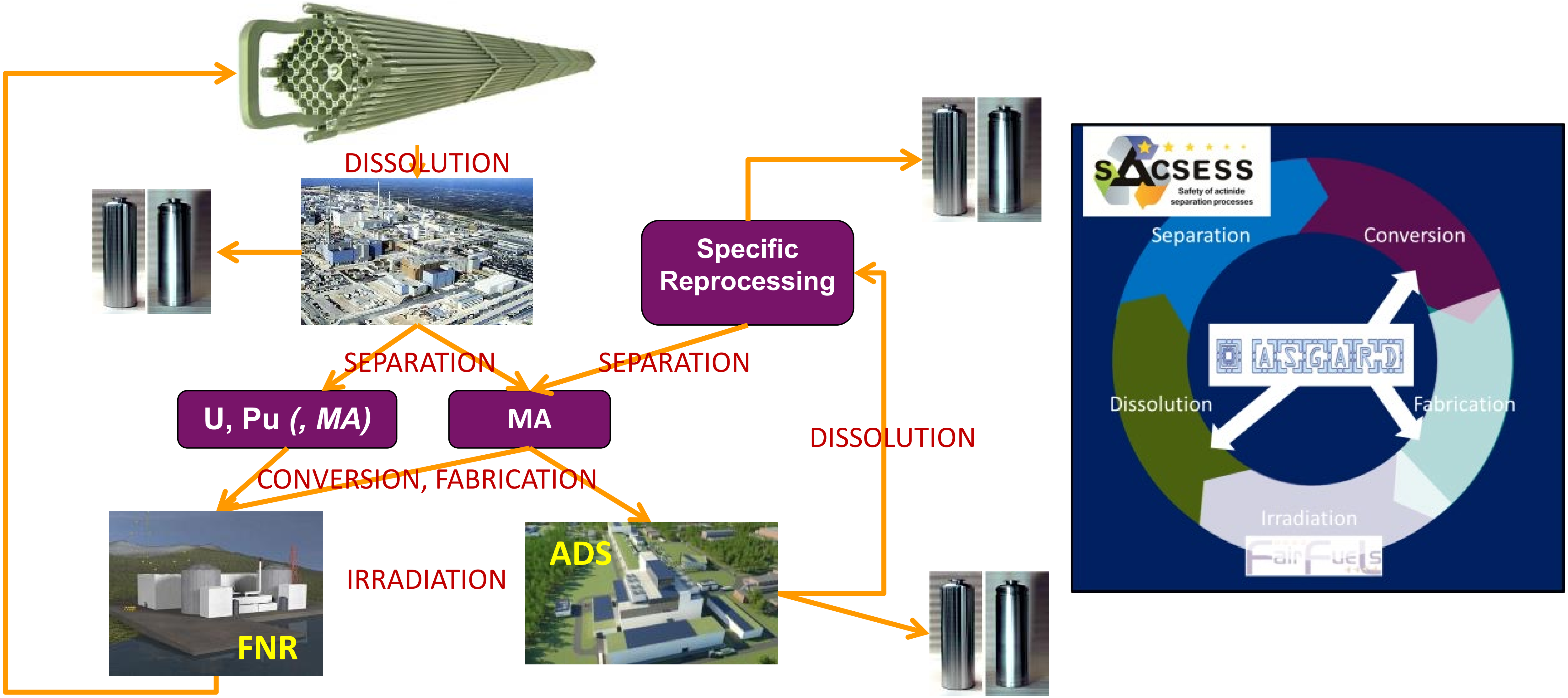
MYRRHA



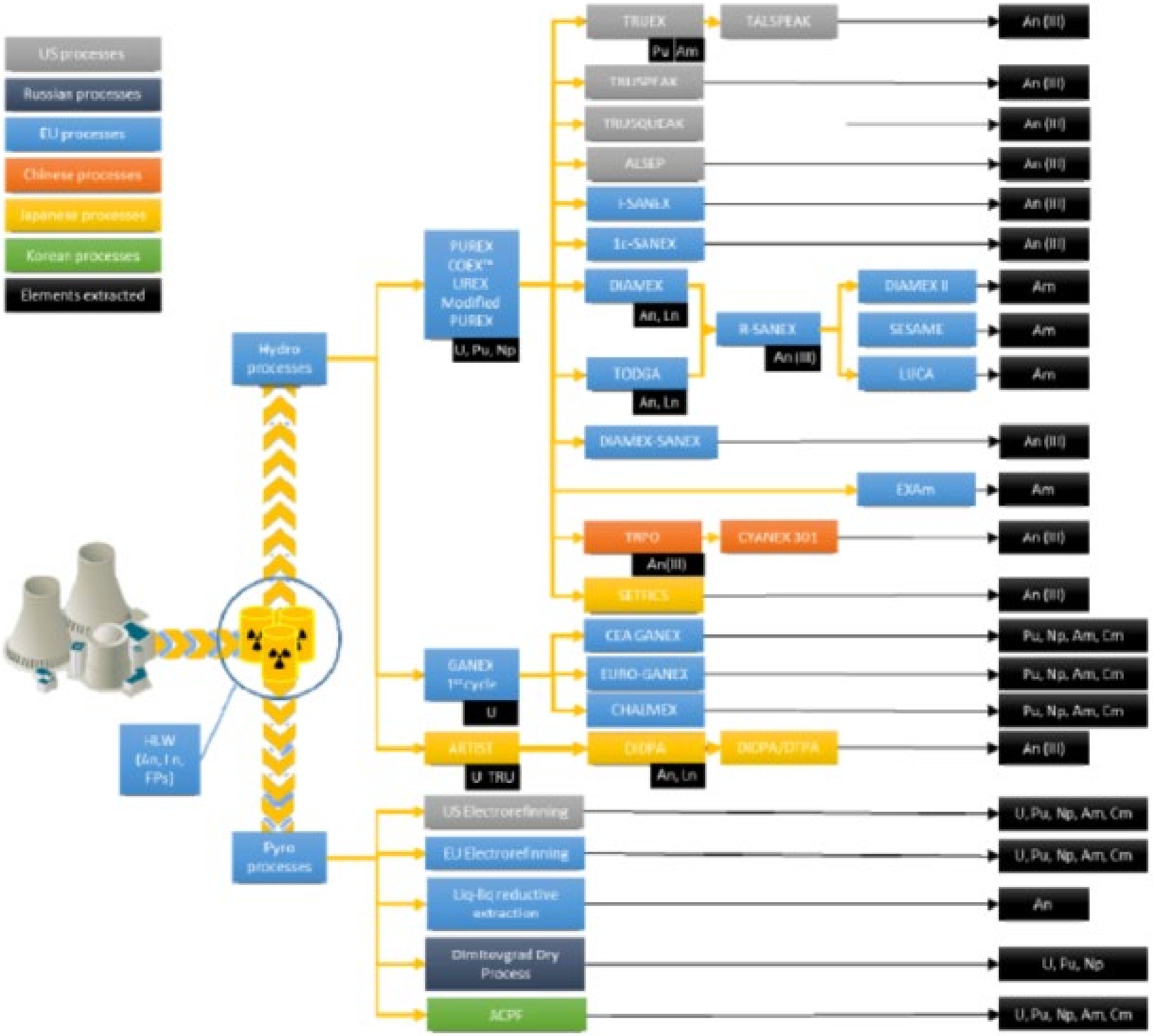
Reference fuel: carbide, nitride…

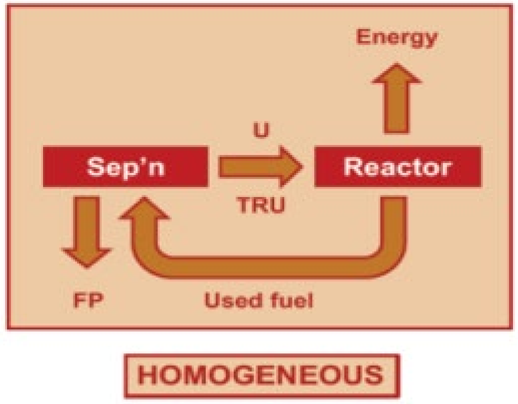
Reference fuel: MOX

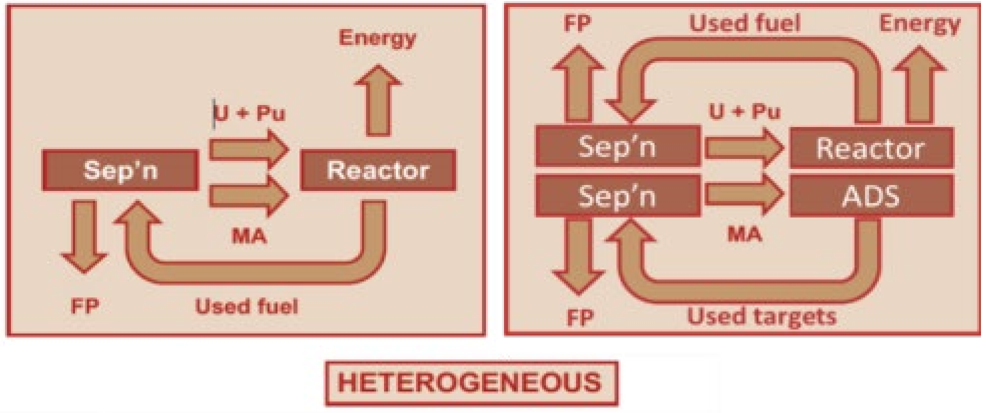
Potential Future Fuel Cycles



Different separation process options developed worldwide for different fuel cycle strategies







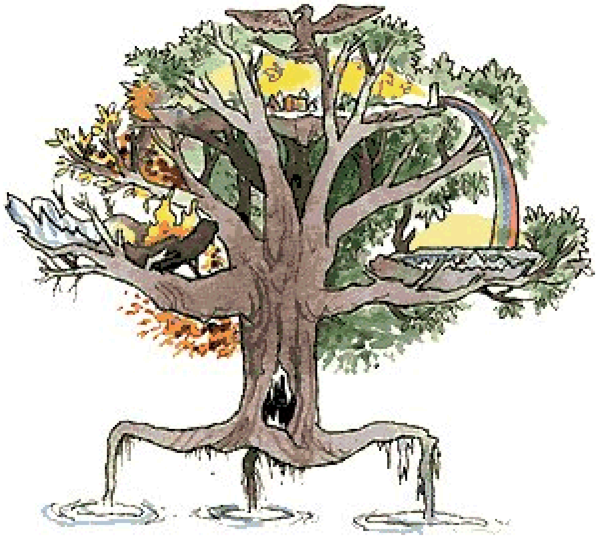
But before, we need to dissolve the fuel, and after, we have to re-manufacture it!

ASGARD

FROM FUEL TO FUEL

NON MOX

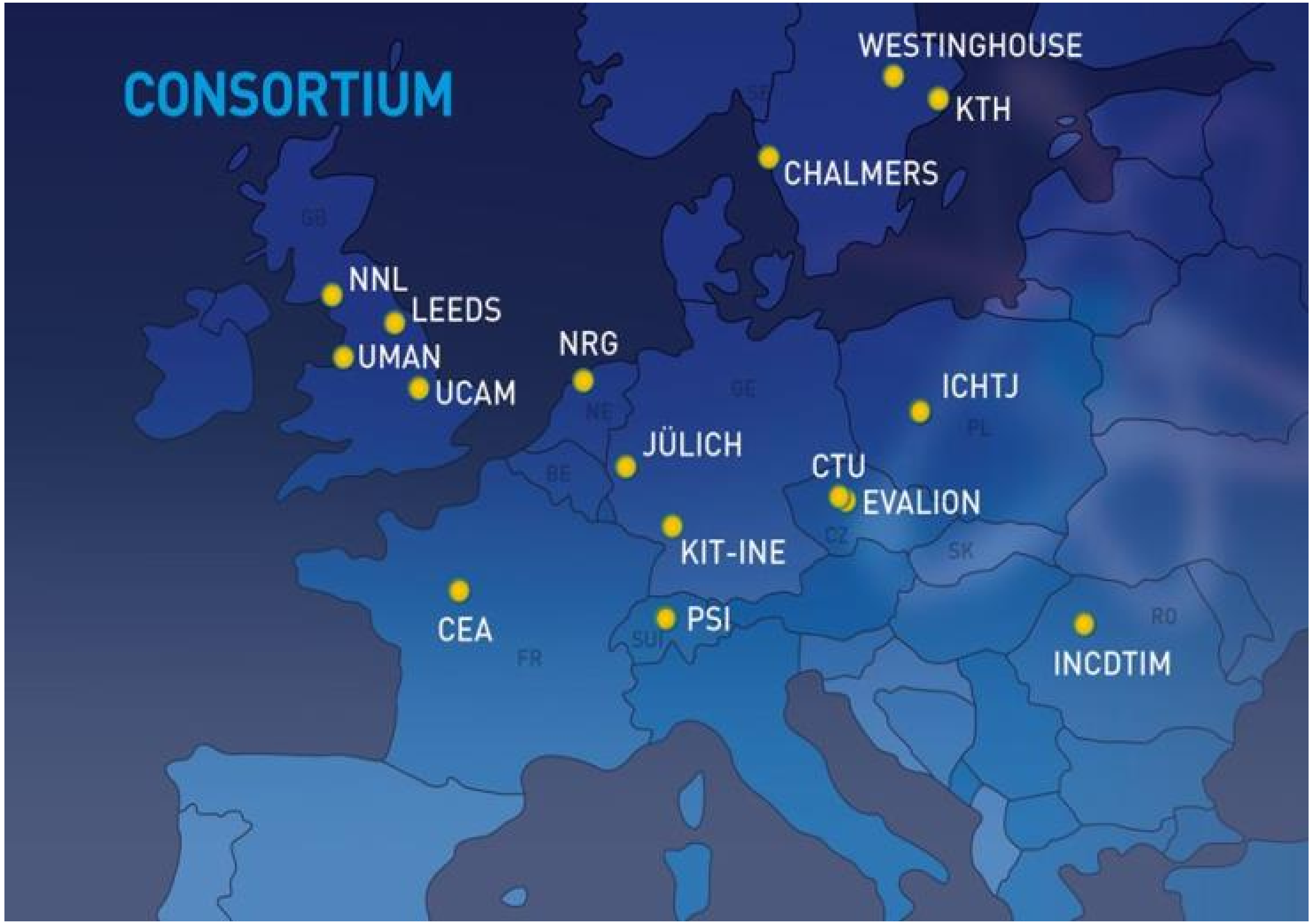
ASGARD



Christian Ekberg, Stephane Bourg, Eva deVisser-Tynova, Andreas Geist, Frodo Klaassen, Teodora Retegan, Mark Sarsfield and Janne Wallenius

Consortium

- Budget: 9365 kEuro (EC 4.9 kEuro)
- Duration: 20120101- 20151231 (4 years)
- Extended to 20150630



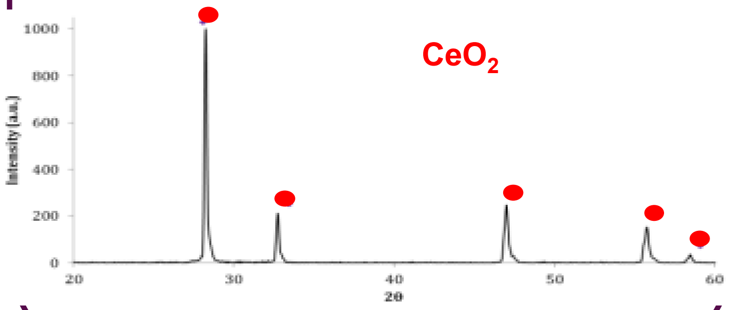
Rationale of ASGARD

- Focus on the behaviour of novel nuclear fuels ranging through production, dissolution, conversion and refabrication
- Novel fuels considered are An (Am) bearing oxides, CERMET (Mo-based), CERCER (Mg based)´, nitrides and carbides
- Provide extensive training and education concerning handling of nuclear material from the whole fuel

CERMET fuels- Dissolution of Mo

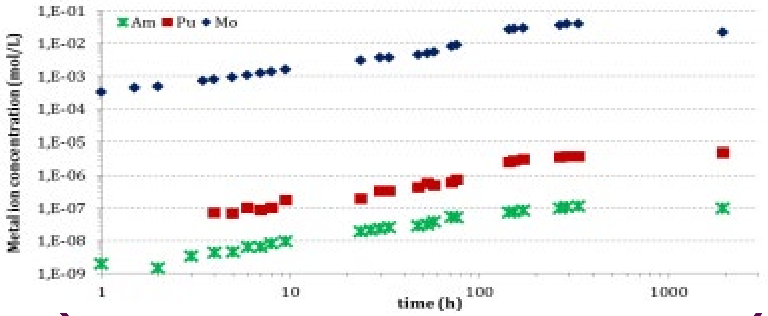
CeO_2/Mo dissolution

- CeO_2 /Mo (60/40wt.%) pellets dissolved in 20 and 100 mL 1 mol/L HNO_3 without or with Fe(III)
- CeO_2 separated from the matrix



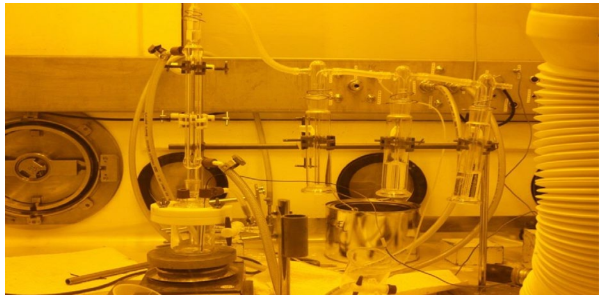
PuO_2/Mo dissolution

- 1 and 3 mol/L HNO_3 and 1 mol/L HNO_3/0.2 mol/L $Fe(NO_3)_3$, RT
- Mo dissolution – faster with Fe (III)
- Pu (Am) dissolution much slower in presence of Fe(III)
- PuO_2 could be separated from Mo matrix



$(Pu_{0.8}Am_{0.2})O_2$/ Mo dissolution

- Irradiated at HFR Petten (HELIOS pin 5)
- 2 steps process:
  - dissolution of Mo -matrix HNO_3 (8 M)
  - dissolution of actinides oxides HF or Ag(II)
- ❑ Samples taken during dissolution for ICP measurements
- ❑ Black residue remained – PuO_2



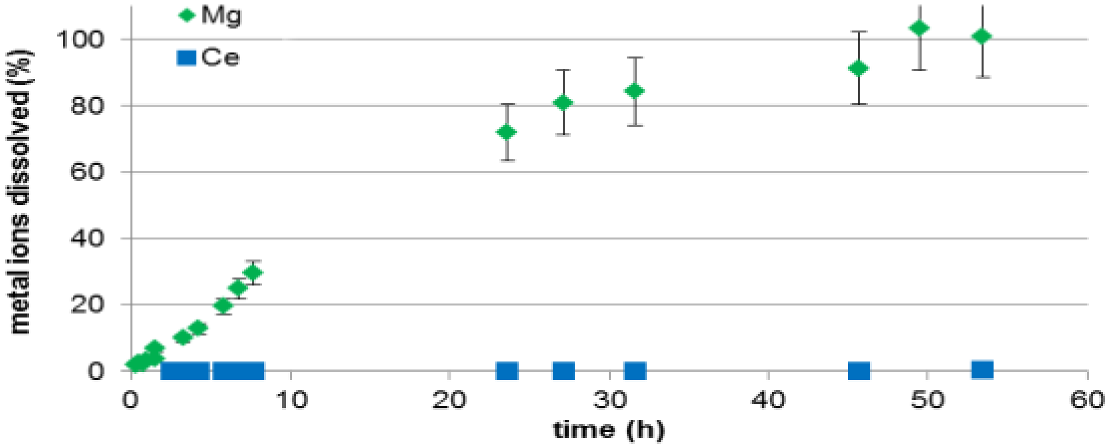
Fresh fuel

Irradiated fuel

CERCER fuels- Dissolution of MgO

- Experiments in 2.5 mol/L HNO_3 at 30 ºC.
- Agitation speed has no effect on dissolution rate, i.e. dissolution rate is surface controlled
- The acid volume has no effect on dissolution rate.
- A two-stage reaction equation for the dissolution of MgO was postulated based on XRD measurements and literature review.
- The dissolution (2 M HNO_3, RT) of MgO/CeO_2 (60/40 wt.%) – MgO completely dissolved, CeO_2 remained as powder

- Actinides can be separated from the magnesia matrix



Conversion from solution to oxide precursors

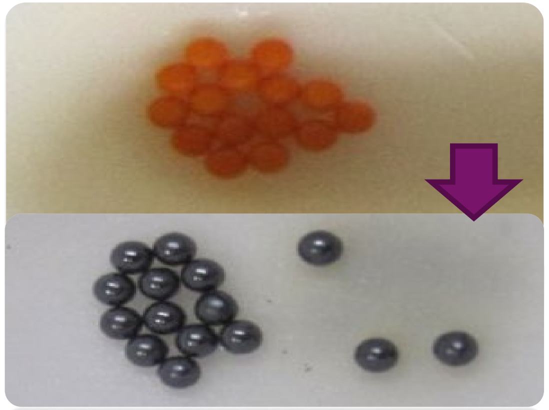
Sol – gel methods

Two methods

- *Internal gelation*
- *Complex Sol-Gel Process*

➢ UO_2/Nd microspheres prepared & characterized

➢ processes studied &optimised



Impregnation of solid matrixes

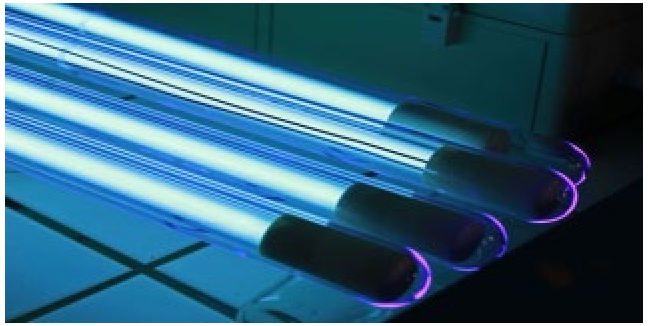
➢ Amberlite IRC-86 and Lewatit TP-207 resins tested for fabrication of UO_2/Nd microspheres

➢ Amberlite IRC-86 successful

Photochemical conversion

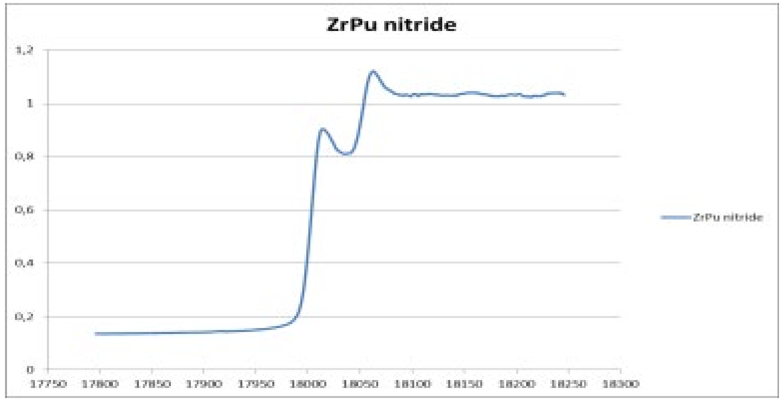
➢ UO_2, ThO_2, ThO_2-UO_2, CeO_2, Eu_2O_3, $(Ce,U)O_2$, Eu_2O_3-UO_2 materials prepared

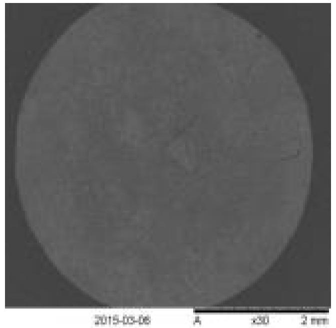
➢ Fuel pellets made



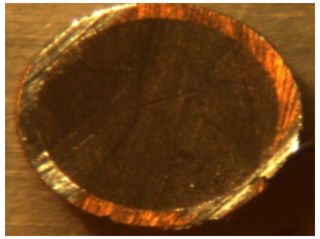
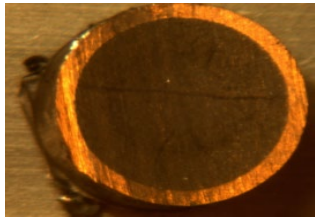
Fabrication of nitrides

- Sol-gel beads and pellets of ZrN and (Pu,Zr)N has been manufactured
  - EXAFS show one structure for (Pu, Zr)N
- (Pu,Zr)N pellets sintered in Ar or N2
  - The ones in N_2 has two crystal structures
  - The ones in Ar has one crystal structure
- Problems with carbon content but being solved
- The expected blackberry structure could be avoided and a smooth pellet acheieved



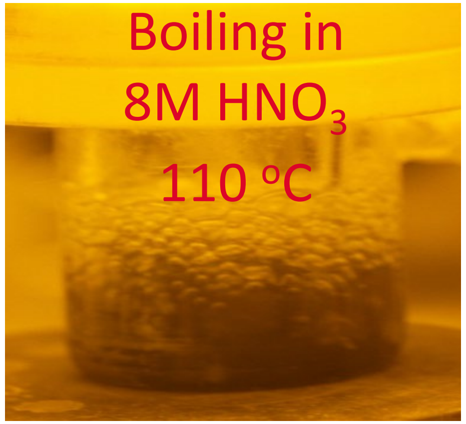


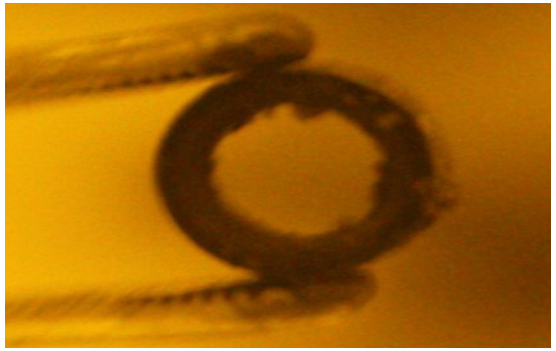
Dissolution of nitrides – Irradiated CONFIRM fuel: (Pu,Zr)N

CONFIRM pin slices (including cladding)

- m ≈ 1.13 -1.27 g
- h ≈ 4.6 – 5.2 mm
- Pu ≈ 400-440 mg





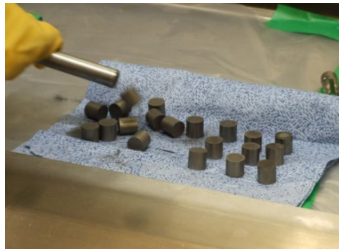
Exp. 1

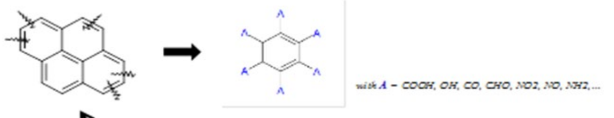
	Exp. 1	Exp. 2	Exp. 3	Exp. 4
Additions	-	1 M HF*	0.8 M HF	250 mg AgO
Boiling time (h)	13	23	6	16
Liquid volume (ml)	100	100	150	100
Undissolved fuel on cladding	YES	**NO** (or little)	**NO**	YES
Solid residue (particles) (Zr cont.)	YES	YES	**NO**	YES
Remaining solid (clad.+fuel) (mg)	547	574	117	716

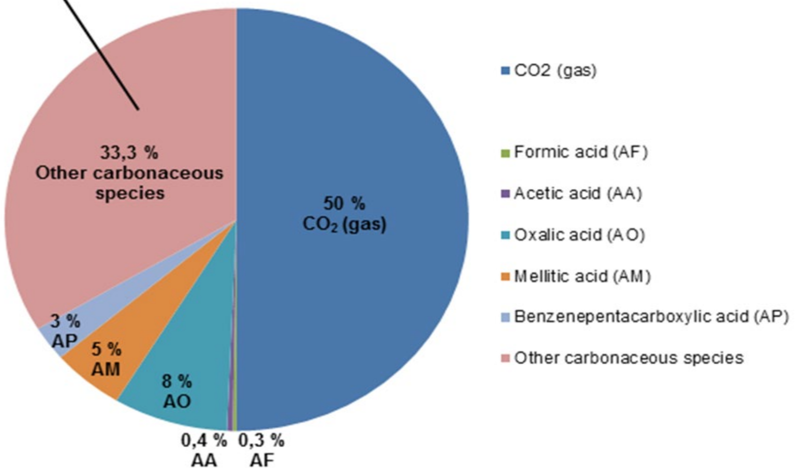
** added after 54h*

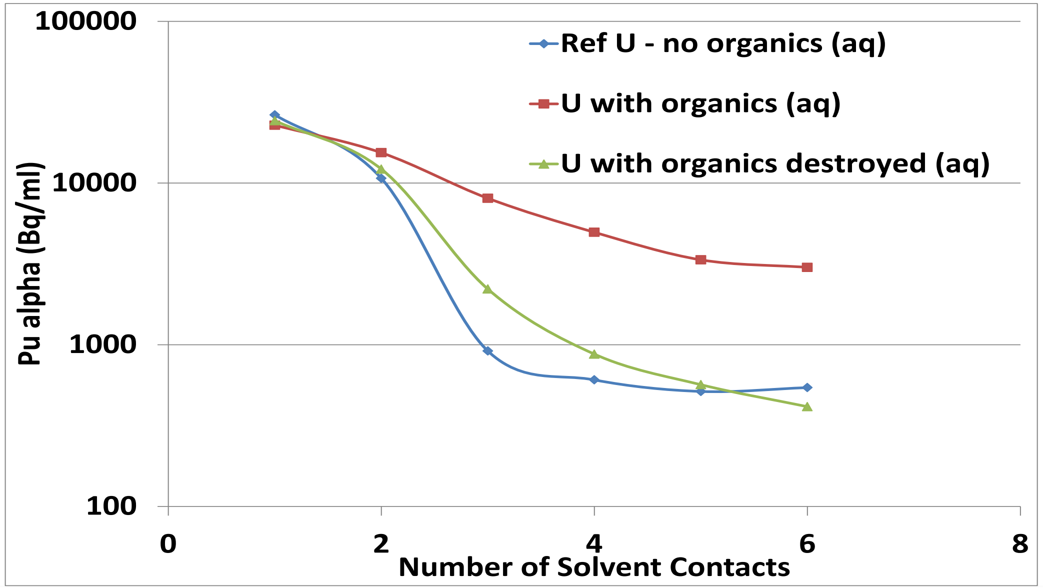
- Pin starts to dissolve from the middle
- HF necessary for complete dissolution

Reprocessing (U,Pu)C – direct dissolution









"Uranium carbide dissolution in nitric acid: organic compounds speciation" S. Legand, C. Bouyer, F. Casanova, D. Lebeau and C. Lamouroux (submitted).

"Dissolution of Uranium Carbide Fuel pellets" M.J. Sarsfield, C.J. Maher, T.L. Griffiths (submitted).

SACSESS

IMPROVING THE SAFETY OF SPENT FUEL REPROCESSING

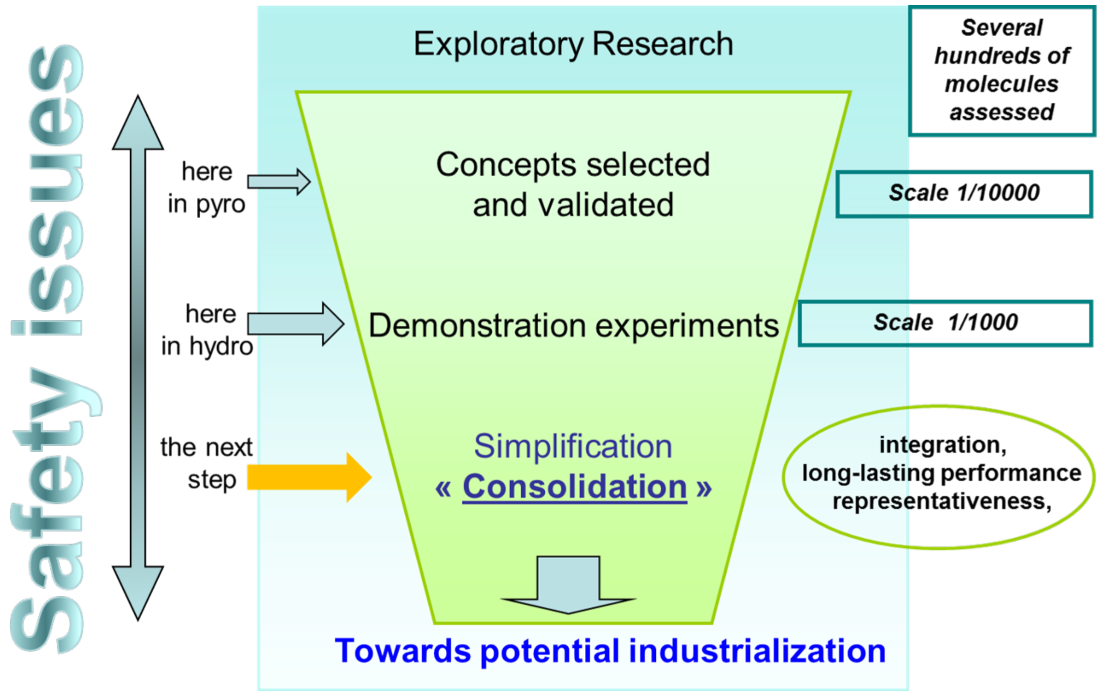
SACSESS, 2013-2016

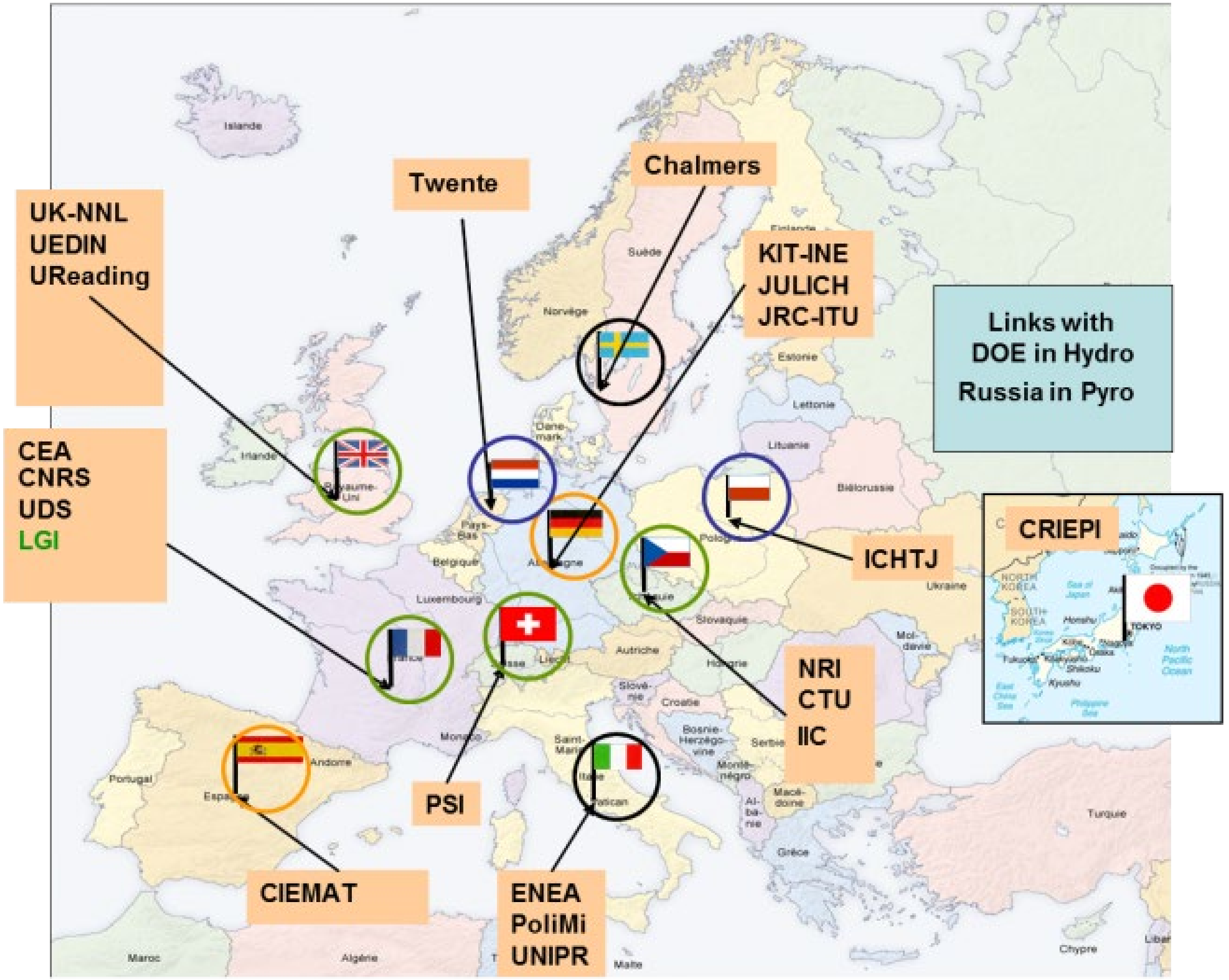
26 Partners

2013-2015

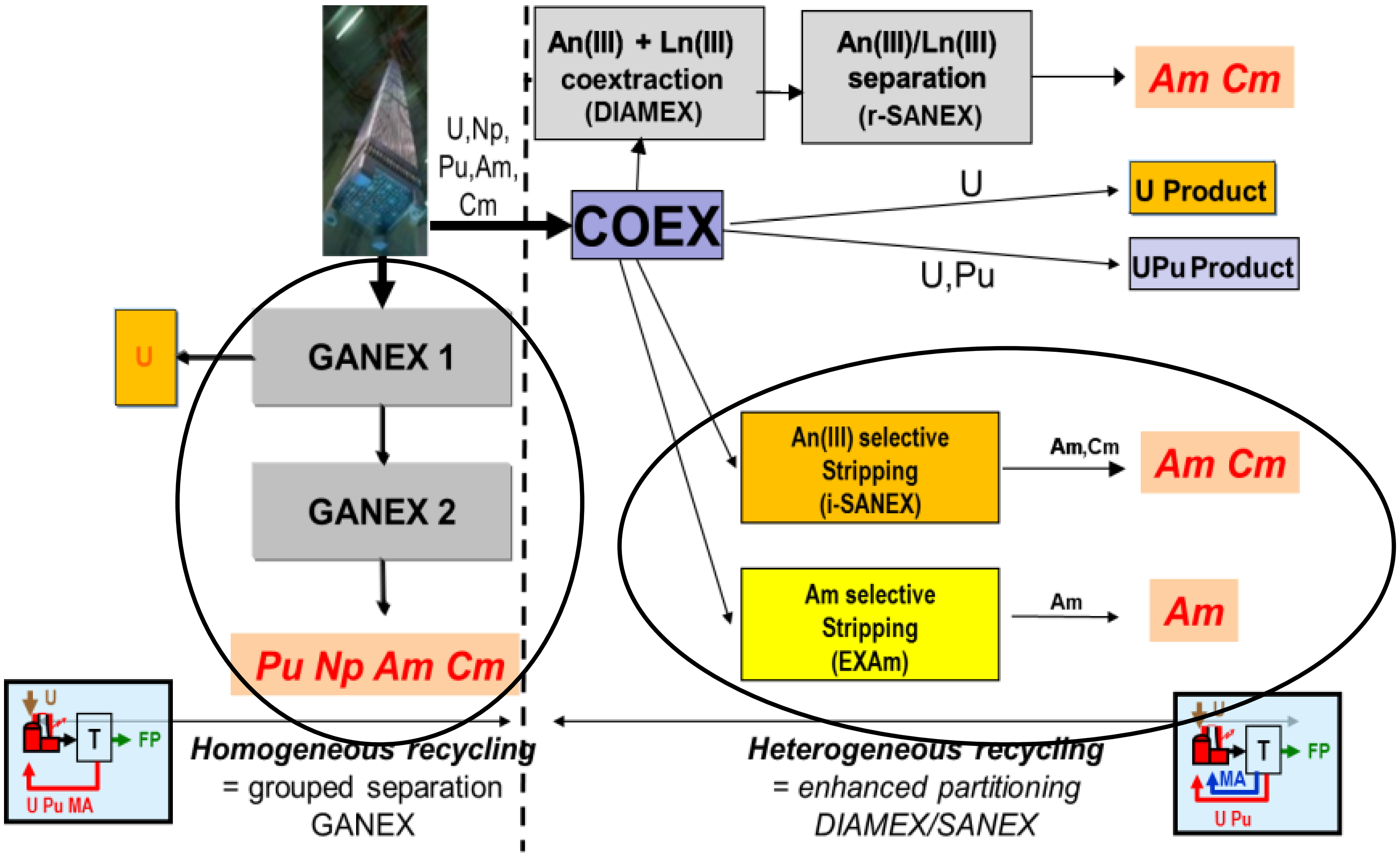
Budget 10,5 M€

Grant 5,55 M€

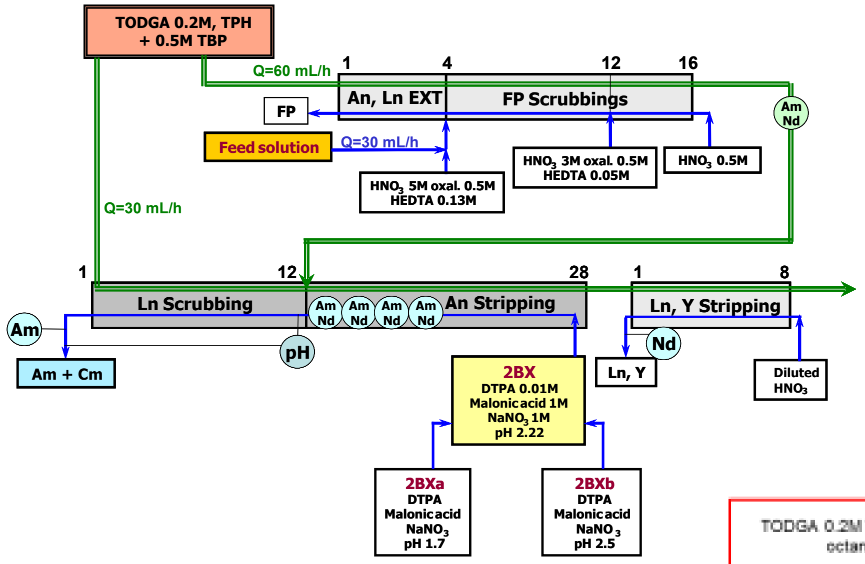




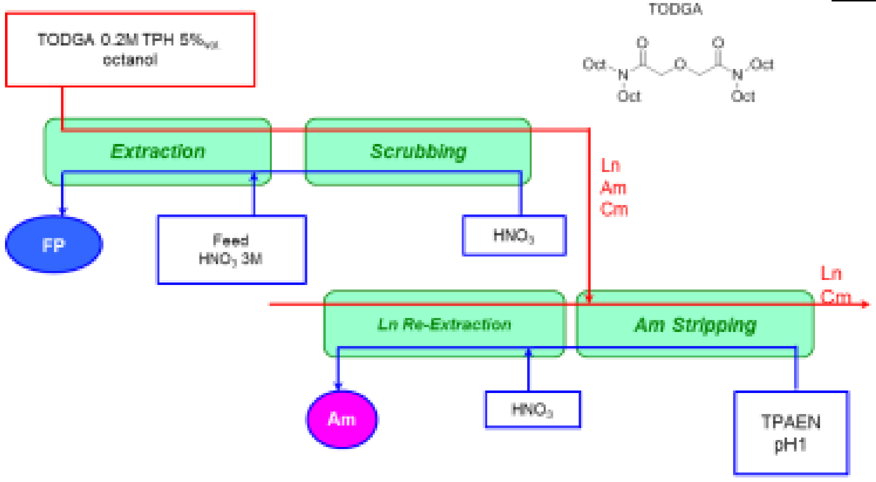
Reference aqueous separation process routes in Europe



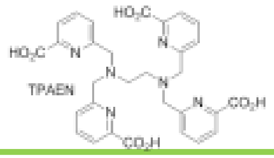
The SACSESS reference process flowsheets

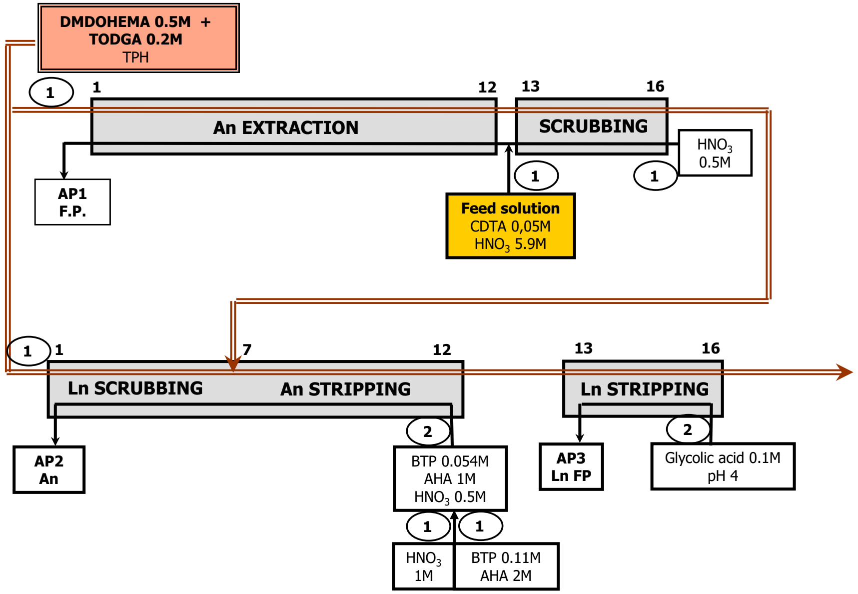


i-SANEX

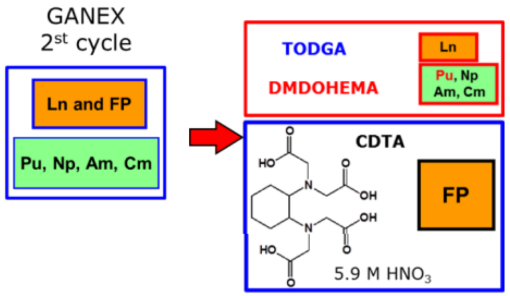


EURO-EXAM





EURO-GANEX



CEA DEN · SACSESS Safety of actinide separation processes

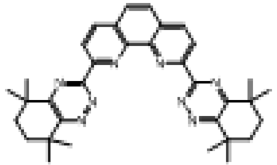
Progress on radiolytic stability studies

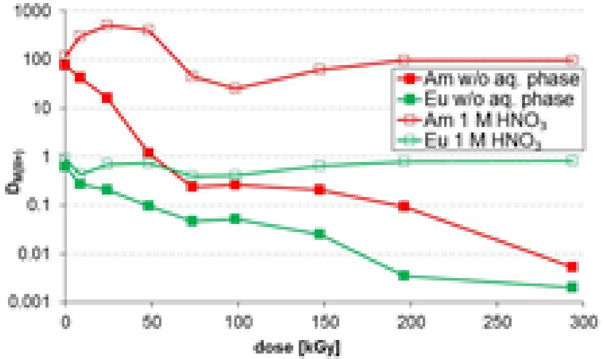
Liquid-liquid extraction ($CyMe_4BTPhen$)

comparison to HPLC-DAD results

JÜLICH FORSCHUNGSZENTRUM

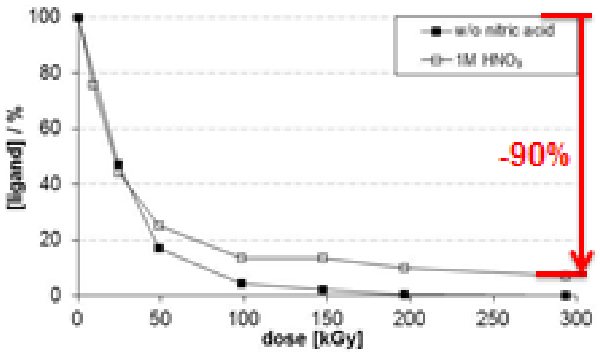
UACh





Org.: Irrad. 10 mmol/L $CyMe_4BTPhen$ in 1-octanol
Aq.: fresh 1.0 mol/L HNO_3 + $^{241}Am/^{152}Eu$ tracer

- Decreasing D-values with increasing dose
- HPLC-DAD shows destruction of molecule
- Nitric acid while irradiation stabilizes D-values
- 90% reduction of ligand concentration detected by HPLC-DAD
  ⇒ due to 1:2 complex, D-value should drop down ~ two orders of magnitude



6

New built species during radiolysis, able to extract An/Ln ⇒ mass spectroscopy

Loading capacity of degraded organic GANEX solvent

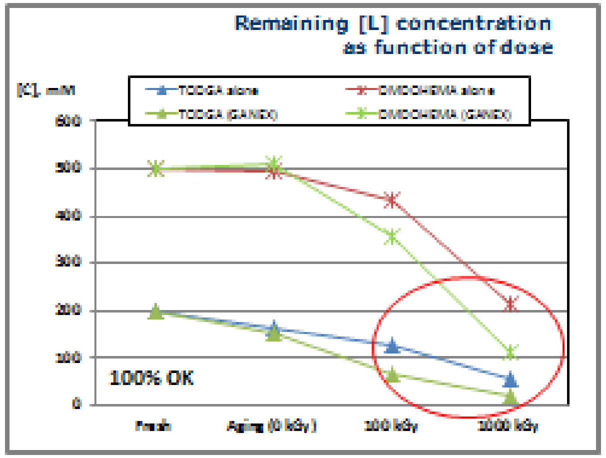
Ciemat

Euro-GANEX

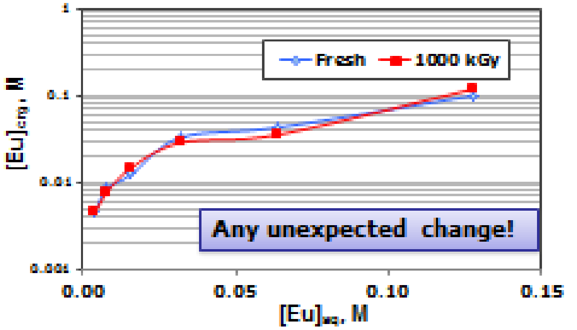
- ✓ 0.2 mol/L TODGA
- ✓ 0.5 mol/L DMDOHEMA
- ✓ In kerosene (OK)

Loading capacity studies are needed!!!

- *More than 50% degradation of both extracting agents.*



- Ln(III) loading capacity after irradiation (1000 KGy, 1.5 kGy/h).

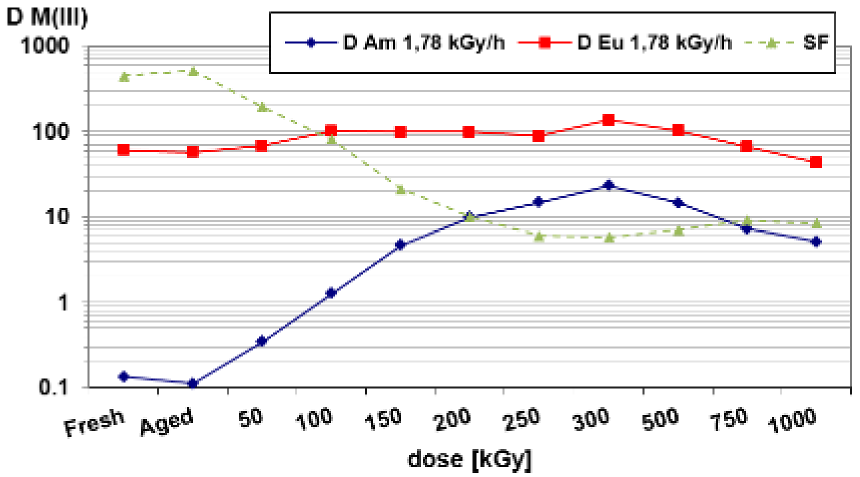


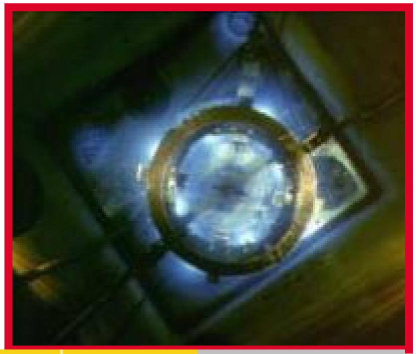
Organic Solution: 0.2 M TODGA + 0.5M DMDOHEMA in OK.
Aqueous solution: [HNO_3] = 4 mol/L and Eu(III) concentrations from 0.004 M to 0.128 M, spiked with ^{152}Eu (1000 Bq/mL).

CIEMAT – 2nd year SACESS Project Meeting, 20-21 April, Warsaw

SO3-Ph-BTP Stability: importance of dynamic tests – more loops are needed!

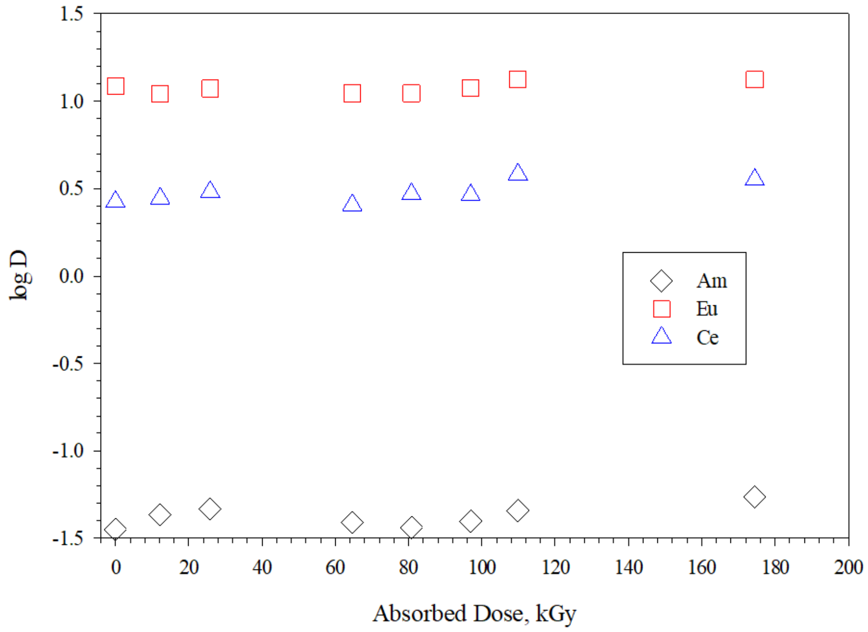
Static tests



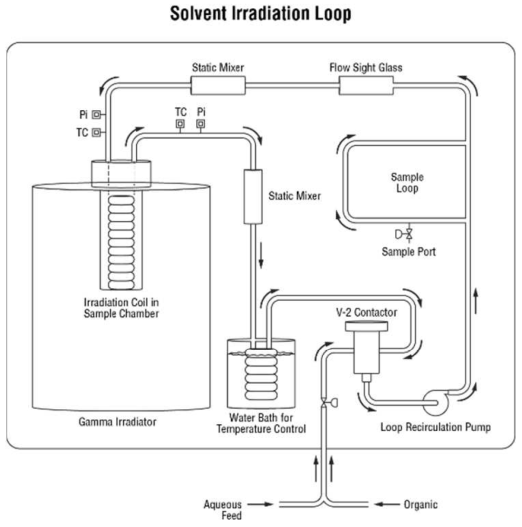


- Closed cap
- Aqueous phase irradiated
- Extraction

Dynamic tests



- Aerated
- Aqueous & organic phases irradiated in contact



GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

D. Peterman, *251st ACS Meeting, 2016*

U.S. DEPARTMENT OF ENERGY

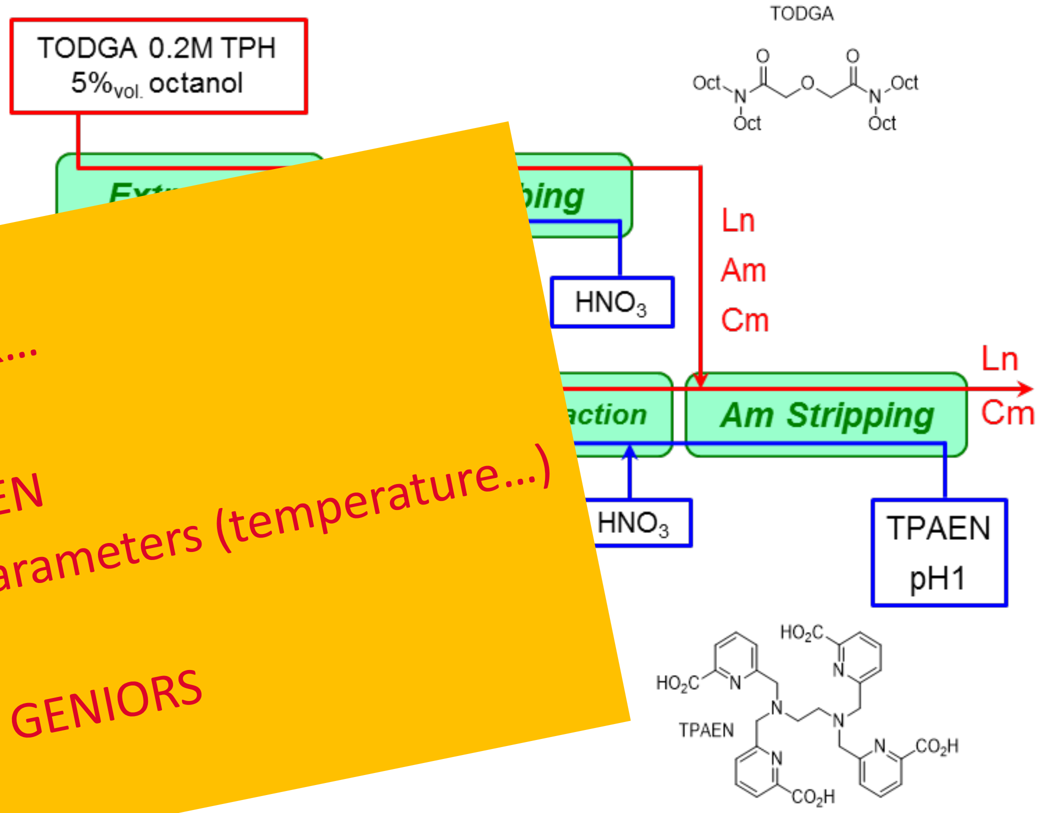
EURO-EXAM: a new process flowsheet

- TODGA + TPAEN ➔ stripping of Am selectively from Cm AND light Ln
- SF(Cm/Am) and (La/Am) ➚ with TPAEN conc.
- TPAEN concentration can be increased up to 2.5 mM
- Am stripping slow but ➚ with te
- Light Ln / Am separa
  concentrations of Ln

  Solutions:

  2) Re-e

  3) Temp



A lot of issues to fix…

Purity of TPAEN

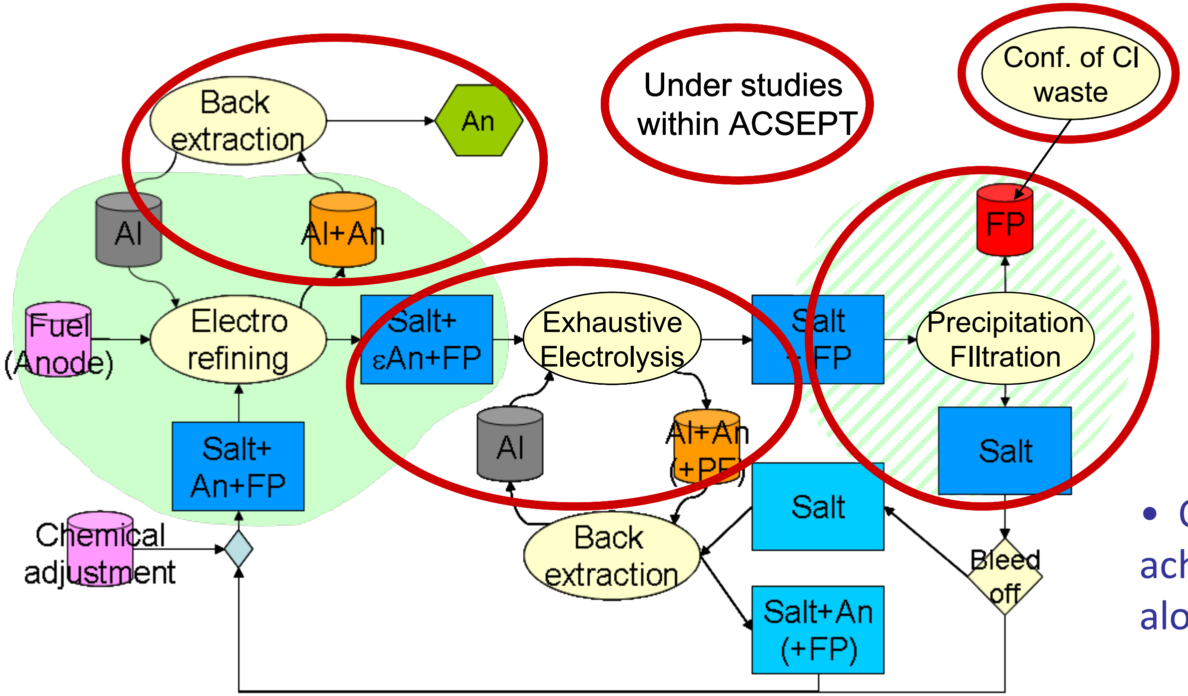
Solubility of TPAEN

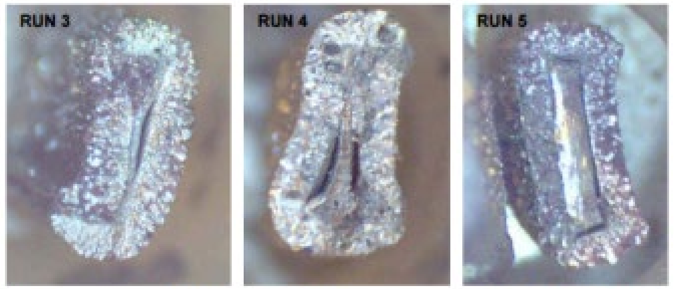
Process maybe too sensitive to some parameters (temperature…)

To be improved! ➔ GENIORS

- Experiments with macro … high complexation capacity of TPAEN
- Additional data acquisitio … Jülich) to develop a thermodynamical model (CEA)
- Spiked test at Jülich in April and June 2016

Electrorefining of irradiated METAPHIX Fuel on aluminium cathode





Optical microscopy photographs of the transverse cuts of the Al cathodes after galvanostatic runs 1 - 5

•Based on the IFR concept (USA), the process is centere the selective electrorefining of A solid aluminium cathode in molten chloride

- Quantitative recovery not achievable by electrorefining alone
- exhaustive electrolysis step and salt recycling under studi
- Actinide back-extraction from Aluminium is deeply studied

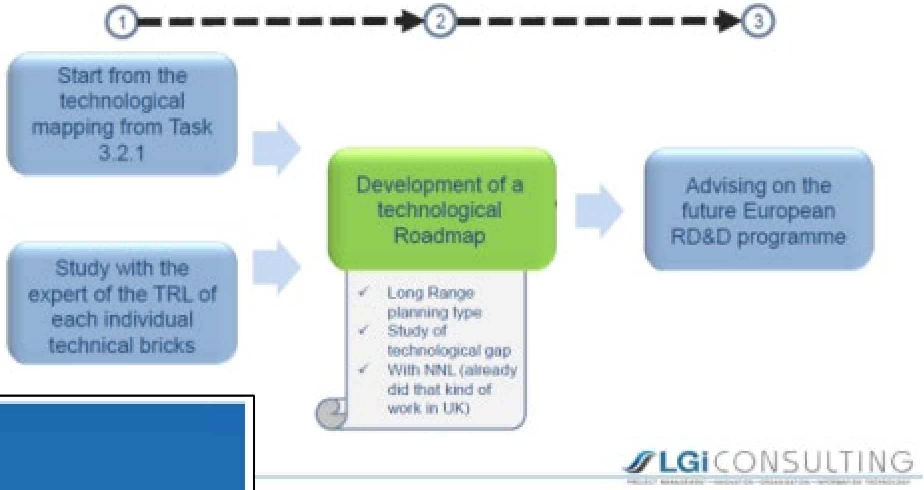
Table 7 Relative content of An and Ln in the deposits from runs 8-11

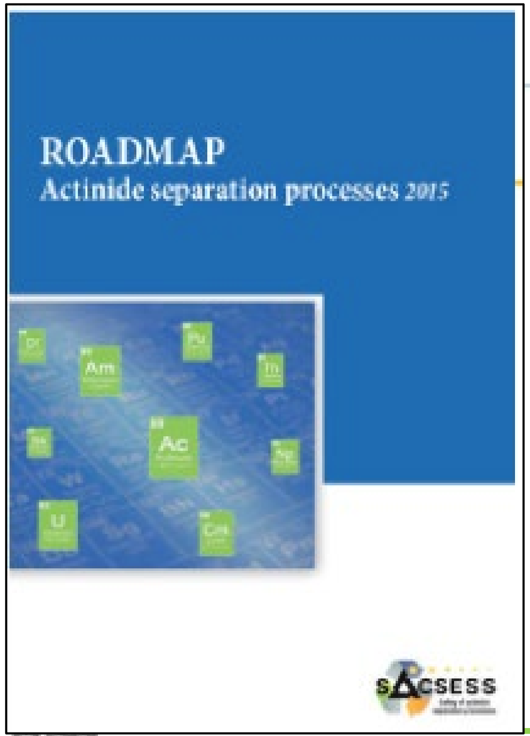
run	8	9	10	11
U	70.86	80.20	74.08	79.74
Np	1.05	0.75	0.87	0.71
Pu	28.02	18.99	24.97	19.48
Am	0.06	0.05	0.07	0.06
Cm	0.01	0.01	0.01	0.01
sum An	99.99	100.00	99.99	100.00
sum Ln	0.01	0.00	0.01	0.00

Table 6 Separation factors normalised to U for potentiostatic runs 8-11

run	8	9	10	11
potential	-1.26 V vs. Ag/AgCl			
U	1	1	1	1
Np	2.45	3.85	2.95	3.86
Pu	4.67	7.79	5.30	7.32
Am	17.3	25.3	14.8	20.5
Cm	60.4	83.2	47.3	61.4
La	1879	9294	5109	7432
Ce	3620	6612	4356	6525
Pr	1141	2800	1799	2917
Nd	1820	4008	2152	3610
Pm	1649	3394	1632	2409
Sm	2242	3008	1730	3718
Eu	2427	2903	1495	3623
Gd	2234	2932	1501	2564
Tb	2183	3071	1303	2124
Dy	2572	3191	1666	2104
Y	2145	2641	1666	2610

System studies





Status	4/4	4/6	1/3	3/8	2/6	0/5	0/5	0/1	1/4	0/1	0/1
Steps or studies needed	All step together U stripping U scrubbing U extraction	All step together An stripping 2 Ln stripping An stripping 1 TRU scrubbing TRU extract	Filter & buffer tank Flowsheet equipe-ment Piping & valves	SO_3-Ph-BTP DMDOHEMA TOGDA in OK Hydrazine DEHIBA in OK Fuel feed AHA CDTA Nitric acid	Pu & mA product Spent solvent 2nd cycle U product Spent solvent 1st cycle Ln product FP raffinate	DEHIBA Hydrazine CDTA DMDOHEMA TOGDA in OK HNO_3/ SO_3-Ph-BTP/ AHA	DEHIBA Hydrazine CDTA DMDOHEMA TOGDA in OK HNO_3/ SO_3-Ph-BTP/ AHA	Temperature range of operation	Pu & mA selfheating FP selfheating Cooling system U selfheating	Hydrogen génération	Long term effect of solvent on materiel
Type of studies or steps	GANEX 1st cycle	GANEX 2nd cycle	Technological needs	Safety and stability studies needed	Radiotoxicity studies needed	Concentration range studies needed	Flow range studies needed	Temperature range studies needed	Thermodynaic behaviour studies needed	Flammability and explosion studies needed	Long term studies needed

EURO-GANEX in a lab

EURO-GANEX in a pilot facility

Joly, P.; Boo, E. *SACSESS roadmap — actinide separation processes*; 2015.

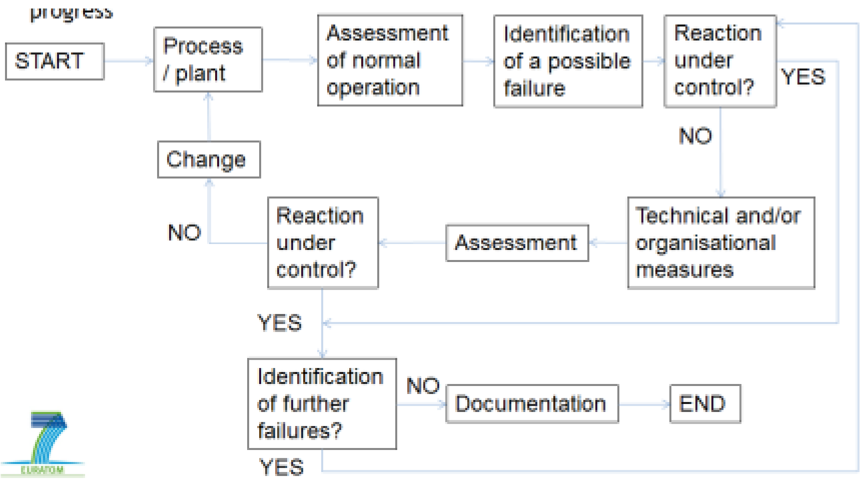
www.sacsess.eu

Global Safety

- Perform safety analyses on hydro and pyro processes to determine weaknesses in their safety and drive experimental programmes of the future to optimise against these issues
- Do this by developing tools that use tools and techniques from the partner nations
- Deploy them with the help of experts in aqueous and pyro reprocessing

<u>The methodology is now established, based on HAZOP approach (April 2014)</u>

<u>Safety case studies were performed in a dedicated workshop (Sept. 2014 & Sept. 2015)</u>



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GENIORS

FROM FUEL TO FUEL
MOX FOR GEN IV

H2020 - GENIORS

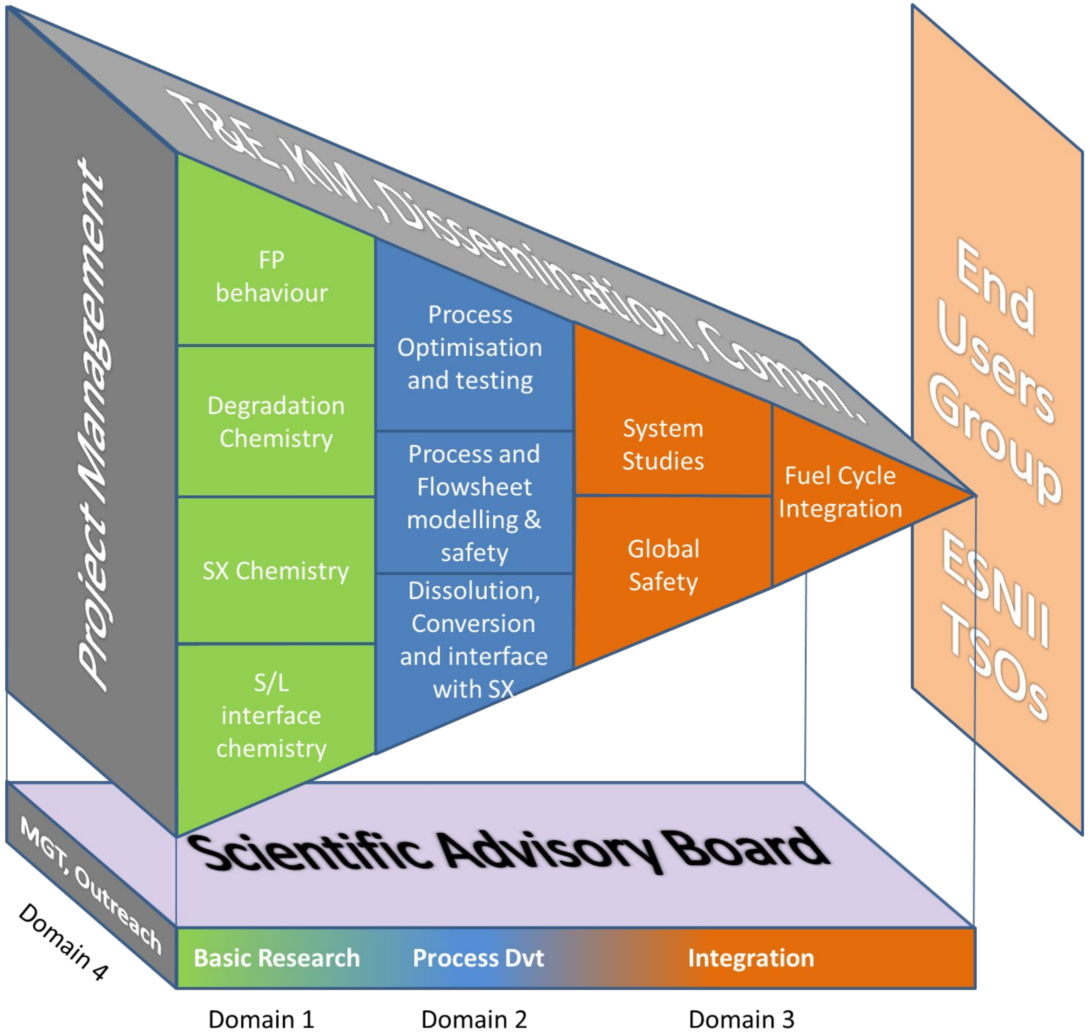
GEN IV Integrated Oxide fuels recycling strategies

6/2017 – 5/2021

24 Partners, 11 countries

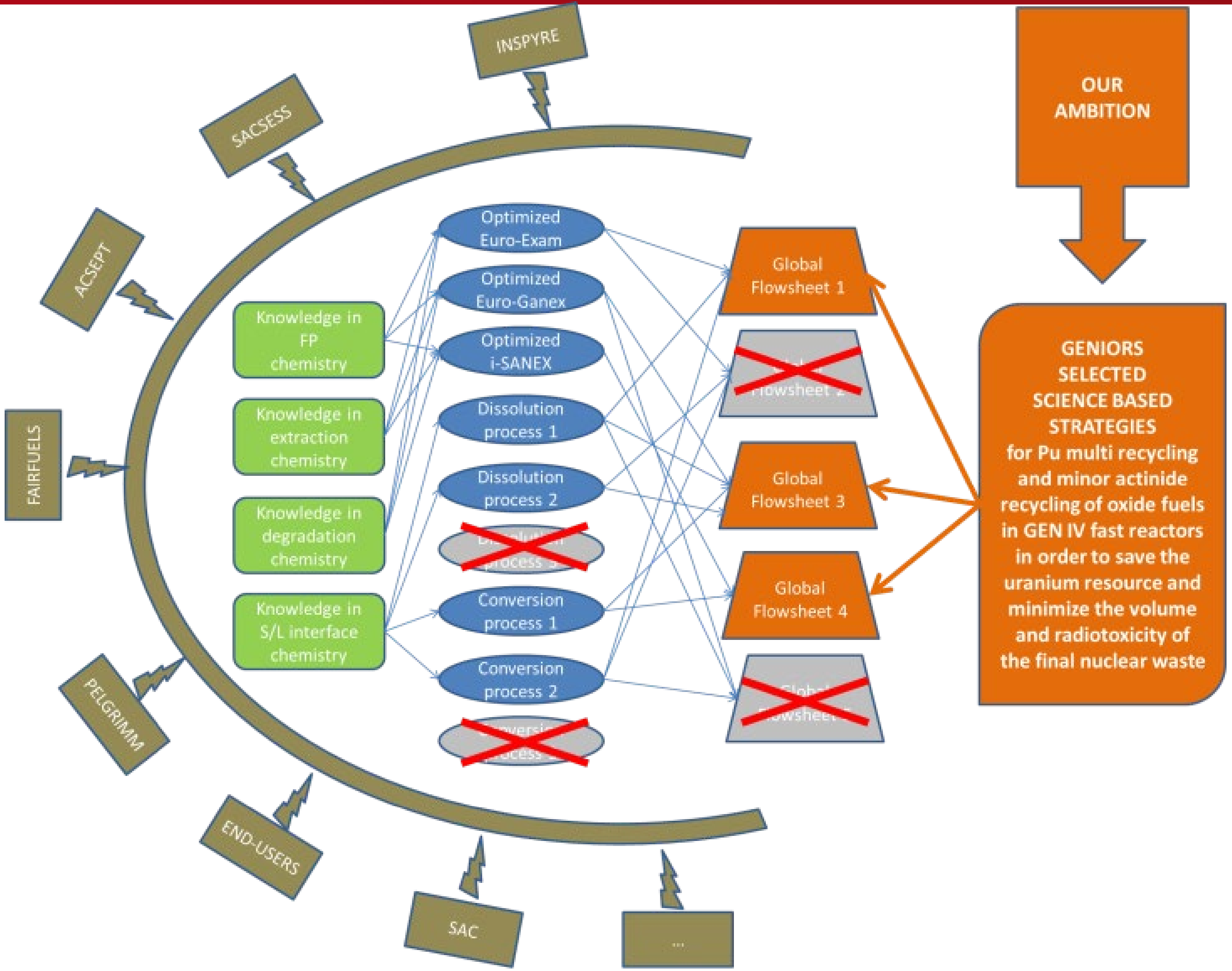
Budget 7,5M€, EU grant 5M€

CEA	JRC-ITU	UEDIN
CHALMERS	JUELICH	UNIMAN
CIEMAT	KIT	UNIPR
CNRS	LGI	ULEEDS
CTU	NNL	UREAD
ICHTJ	POLIMI	ULANC
IIC	SCK-CEN	EDF
IRSN	TWENTE	AREVA



Cooperation agreement with DOE (I-NERI project),

The ambition of GENIORS



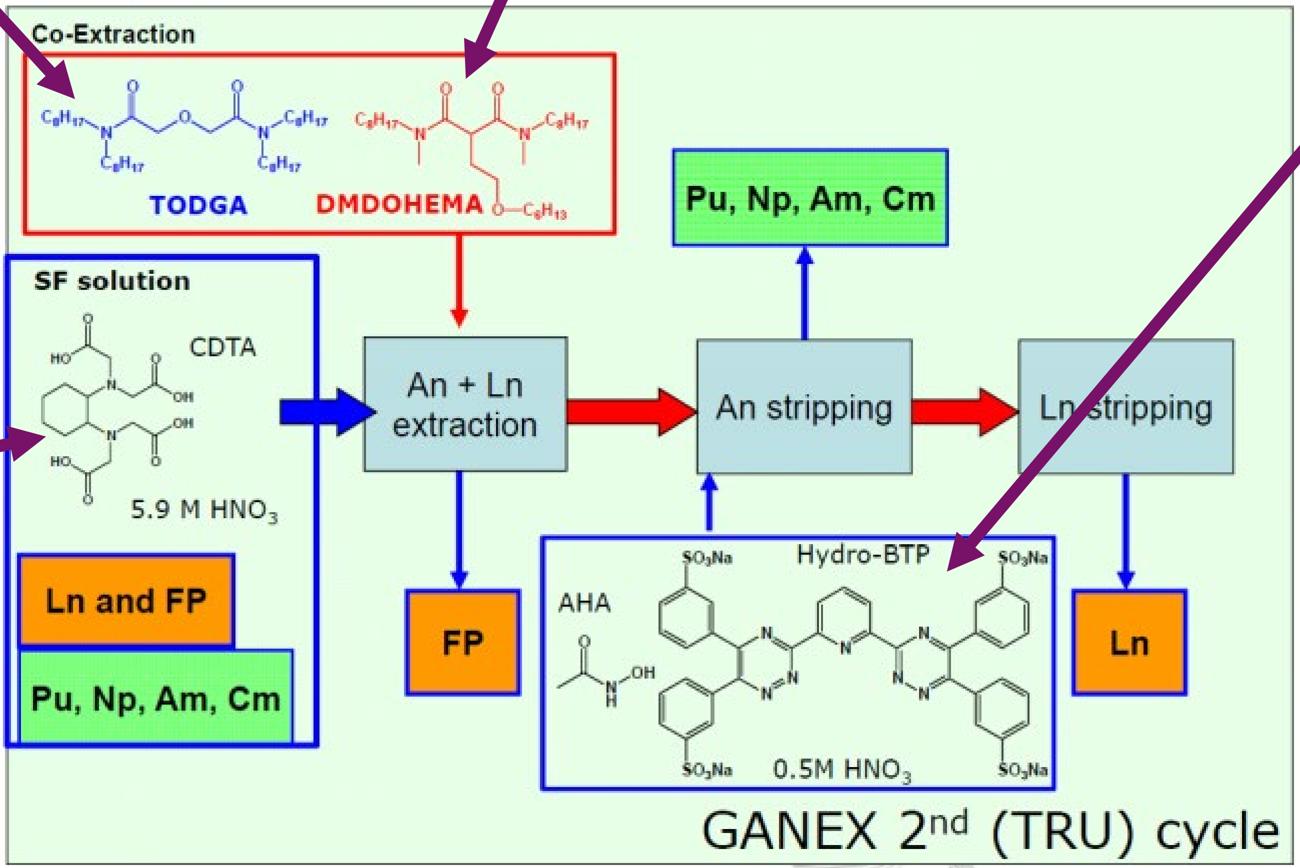
EURO-GANEX

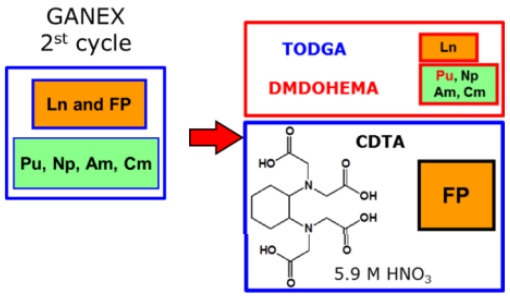
TODGA: Very strong complexation with actinides (III), (IV), (VI) ➔used at low concentration ➔ limited An loading

DMDOHEMA: Phase modifier to avoid 3rd phase formation by TODGA at high acidity and high loading

H-BTP: strip selectively the An from the organic phase – potential issues with S at conversion step

CDTA: Keep FP in the feed solution





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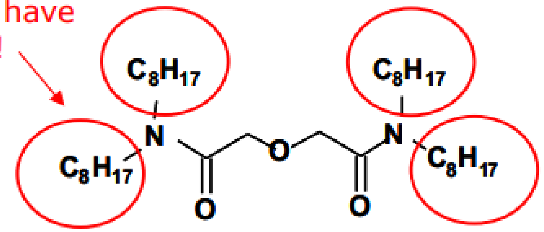
Simplifying EURO-GANEX !
Why not one single molecule at the extraction?

Increase the loading capacity

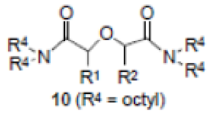
Side chains have an impact !!



- Increased chain length strongly affects the limiting organic concentration.
- A point is reached where the organic phase seems to be stable – with Nd….
- Chain length (number of C) is limited by the increasing viscosity. Especially at high loadings

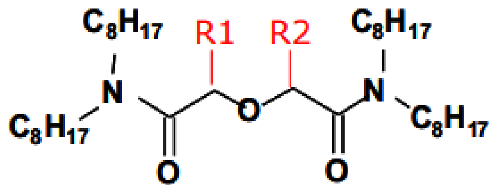
Decrease the complexation strengh

Central groups makes an impact !!

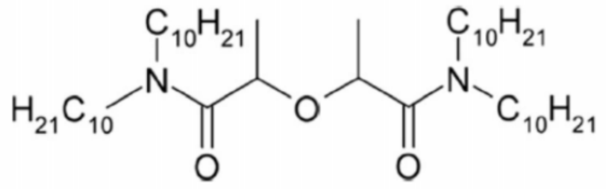


10a = **TWE21**, R1 = Me, R2 = H

10b = **TWE14**, R1 = R2 = Me



- Groups inserted at central carbons exert steric hindrance and thereby affects complexation strength.
- D-values drop orders of magnitude inserting two methyl groups.



mTDDGA !

European Commission

TODGA vs mTDDGA

Parameter	TODGA-GANEX	mTDDGA-GANEX
Organic formulation	TODGA (0.2M) +DMDOHEMA (0.5M) mixture	Only mTDDGA (0.5M)
Diluents	kerosene	n-dodecane
Pu loading limit	~ 20 g/L	32 g/L
3rd phase formation	Yes, at high Pu and acid conc.	No, even at high Pu and acid conc.
Acidity	0.01-3.0 M	0.01-6.0 M
D value for Sr, Mo, Fe	~ 1	~0.1 (10 times lower)

UNIVERSITY OF TWENTE.

mTDDGA could be a promising candidate for a simplified organic formulation for future EURO-GANEX process.

European Commission

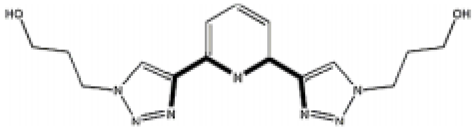
Increased collaboration: round-robin test on irradiation loops GENIORS-DOE

1. An inventory of the description of each loop as well as the current status of operation of each loop
2. An inventory of methods/methodologies of assessing the dose-rate for each loop
3. A definition of a common system to study
4. Aa common source of extractants, diluents and acids must be identified and used by all the partners involved.
5. A rough flowsheet will be provided by Andreas Geist (simplified flowsheet based on the Juelich process), where he will point-out where there is not sufficient data. This flowsheet is supposed to be adapted to each LOOP and reported on the outcome
6. Each Loop will report if the system can be run in the respective facilities
7. Each loop should report an estimate date for starting the test

Replacing the SO3-BTP

STRIPPING SOLVENT FORMULATION
0.08 M PTD in 0.4-0.5 M HNO_3

for ***i*-SANEX** and **EURO-GANEX** processes



Process performances

- Experiments with macro-concentrations of ^{241}Am (1 mM), ^{152}Eu spike, in presence of 0.02M lanthanides for i-SANEX process;

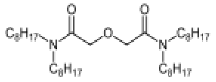
- Experiments with macro-concentrations of ^{241}Am (1 mM) and ^{239}Pu (10 mM), ^{152}Eu spike, in presence of 0.02M lanthanides for EURO-GANEX process;

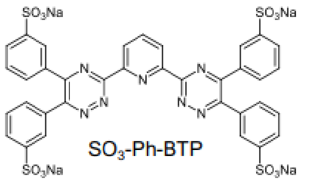
Radiolytic stability studies

to go further in the radiochemical stability of PTD-based extracting system
to confirm the identity of the observed PTD degradation products

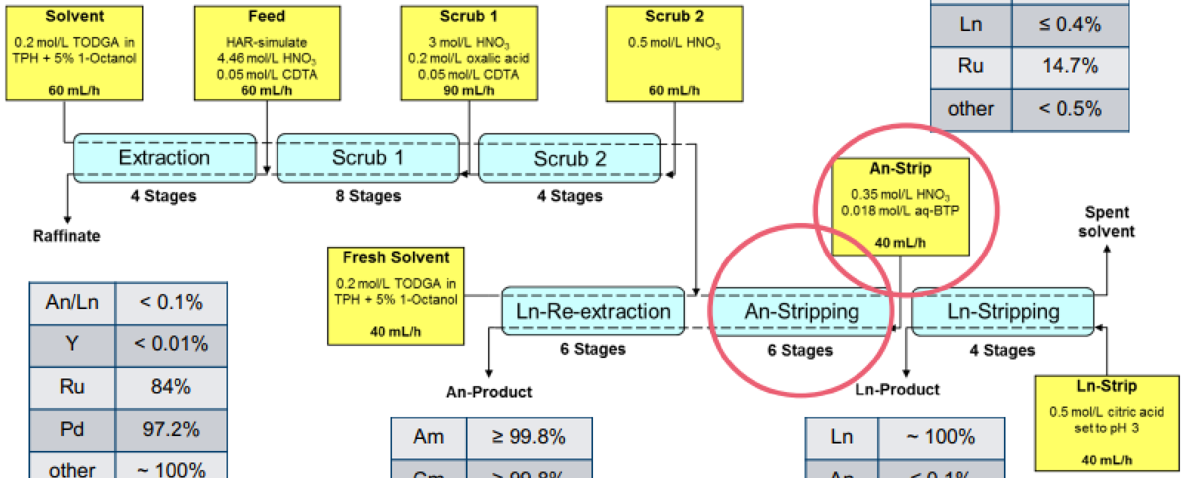
to study the generation of gaseous products from irradiated TODGA-PTD system

Optimizing the i-SANEX process





- No hydrodynamic problems or 3rd phase formation
- Change An-Strip section to make it Am(III) selective



An	≤ 0.1%
Ln	≤ 0.4%
Ru	14.7%
other	< 0.5%

An/Ln	< 0.1%
Y	< 0.01%
Ru	84%
Pd	97.2%
other	~ 100%

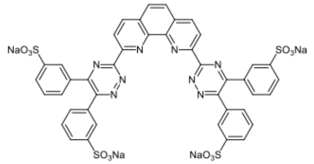
Am	≥ 99.8%
Cm	≥ 99.8%
Ln	≤ 0.1%
other	< 0.4%

Ln	~ 100%
An	≤ 0.1%
Y	~ 99%
Pd	2.8%
other	≤ 0.9%

JÜLICH Forschungszentrum

KIT Karlsruhe Institute of Technology

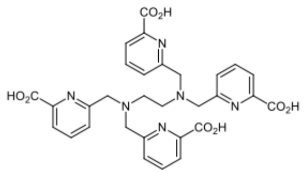
1st alternative: TS-BTPhen[1-2]



- Good Am/Cm selectivity (SF ~ 3.6)
- Good Am/Ln$_{all}$ selectivity
- Difficult synthesis
  - not reliable
  - Not reproducible
- Still interested in the ligand, if synthesis works!

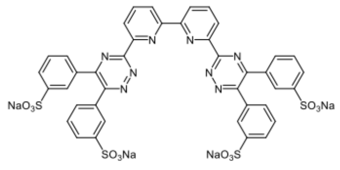
University of Reading

2nd alternative: H_4TPAEN[1-2]



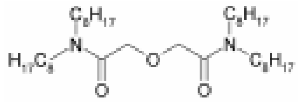
- Good Am/Cm selectivity (SF ~ 4)
- Difficult Am/Ln$_{all}$ selectivity (La/Ce)
- Synthesis okay
- Solubility issues (only low concentrations applicable)
- Chosen for process development and demonstration in SACSESS

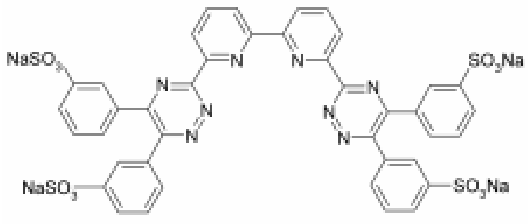
3rd alternative: SO$_3$-Ph-BTBP,

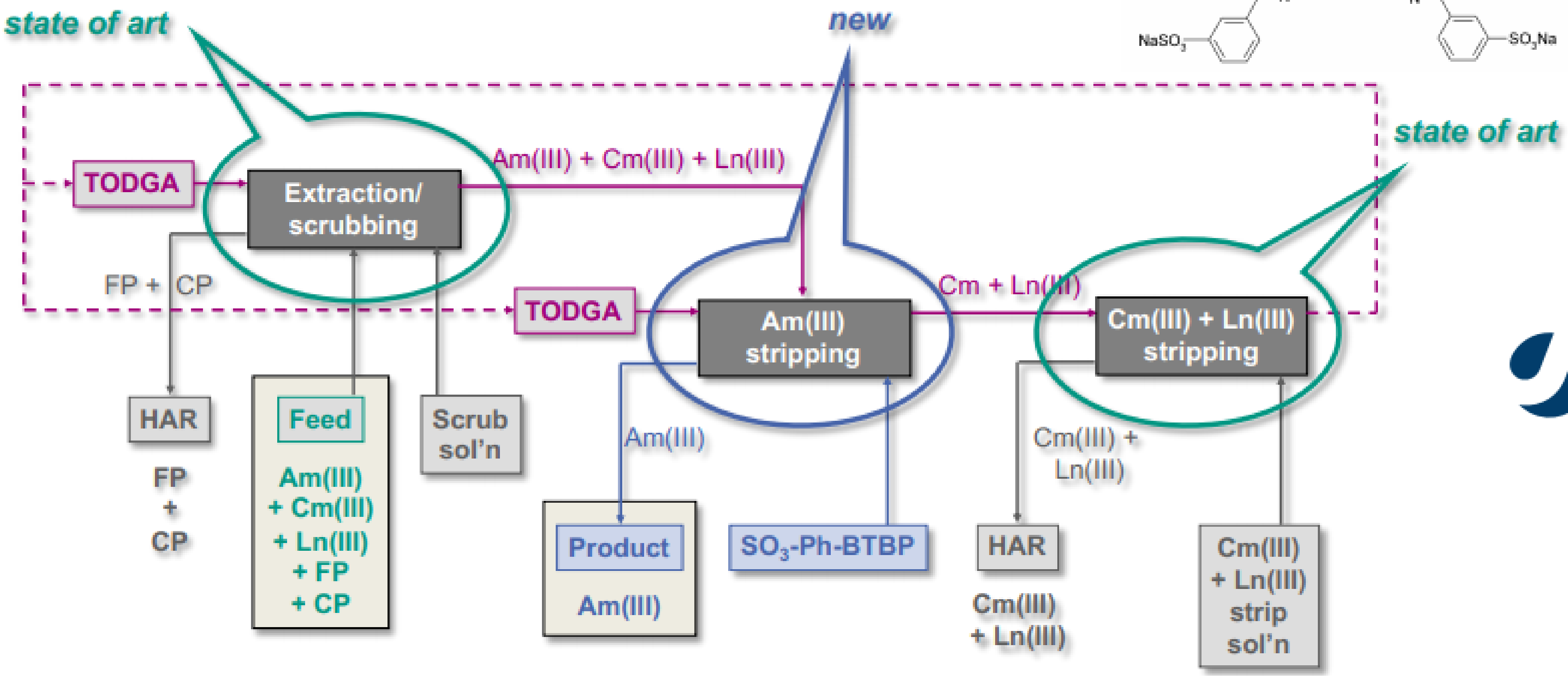


- Medium Am/Cm selectivity (SF ~ 2.5)
- Good Am/Ln$_{light}$ selectivity (La-Gd)
- Synthesis okay
- High solubility
- Chosen for further process development and demonstration in GENIORS

- Am(III) stripping section calculations — $SF_{Cm/Am} \approx 2.6$
  - Collaboration with JÜLICH
  - Work in progress



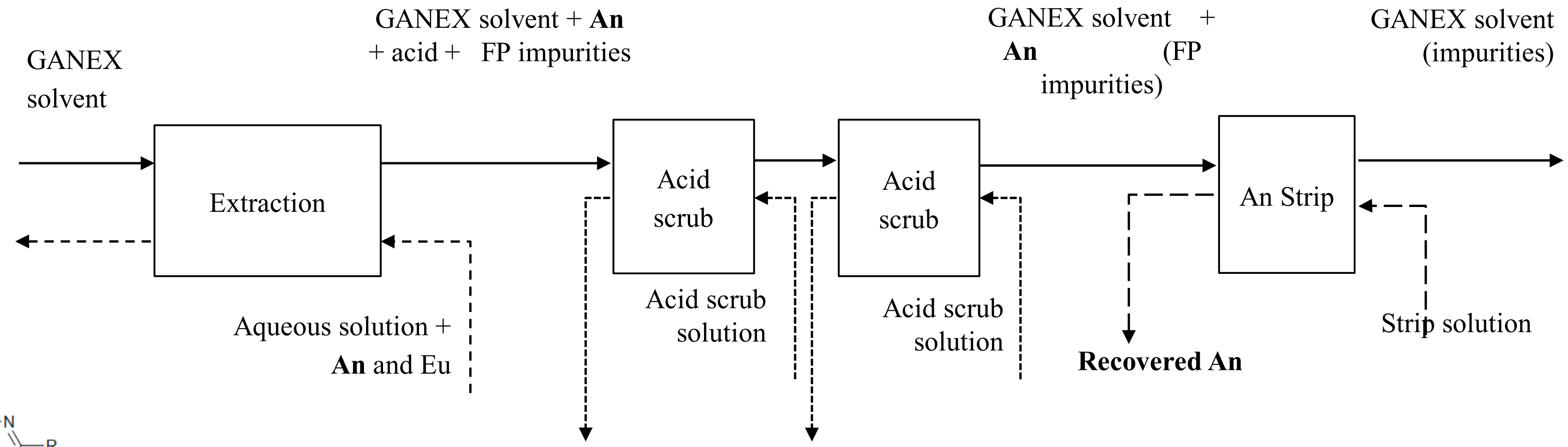


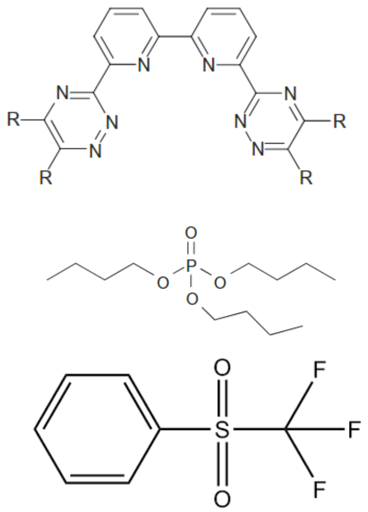


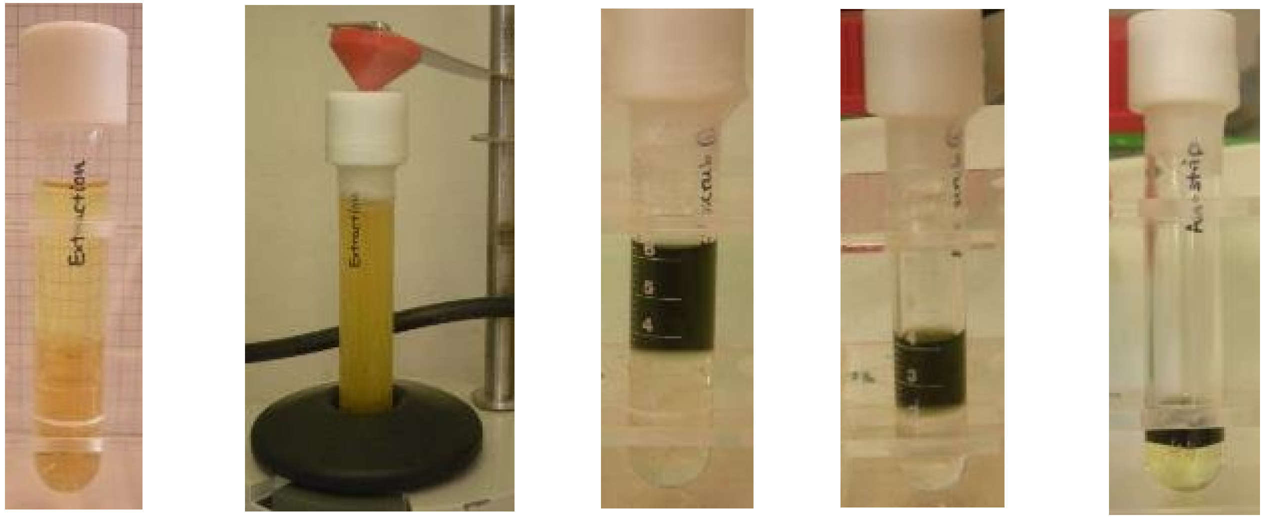
Karlsruhe Institute of Technology

JÜLICH Forschungszentrum

CHALMEX – a potential simpler GANEX option
Batch Process Test (Real Nuclear Waste)



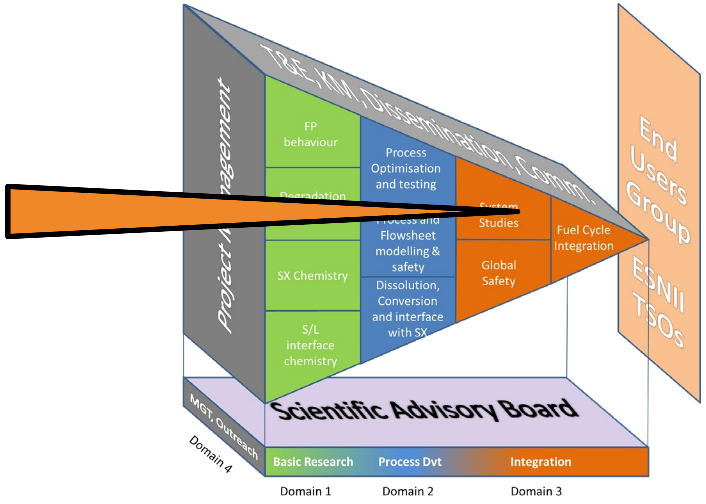


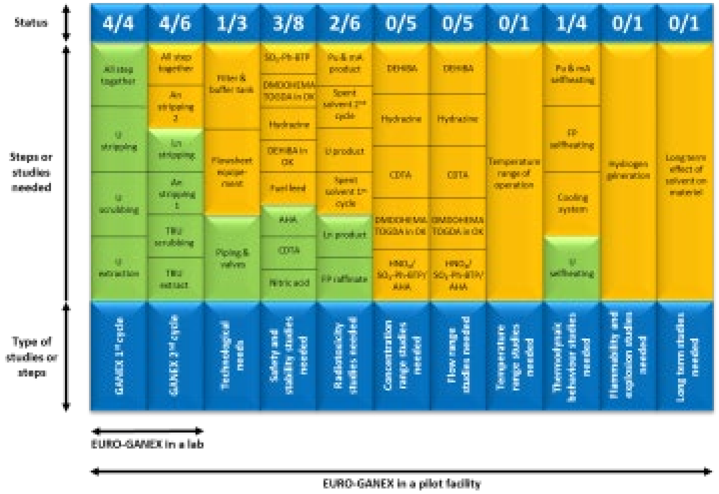


System studies

- Developing processes towards industrialisation studies
- Assessing and illustrating the holistic effects on the nuclear fuel cycle that occur from fundamental changes to the chemistry at the heart of its key processes.

- **Concept Design of a Euro-GANEX Plant**
- **Comparing SX processes for heterogeneous recycling**
- **Process Mapping Studies**
- **“Sim-plant” – engineering simulation of integrated plants**
- **Impact Studies**





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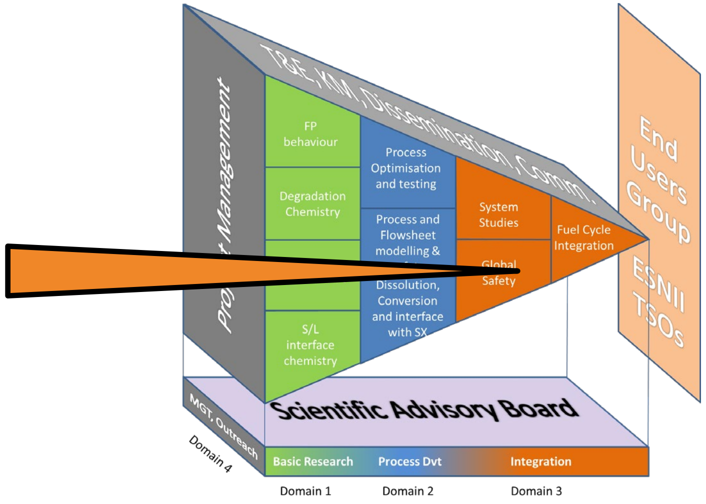
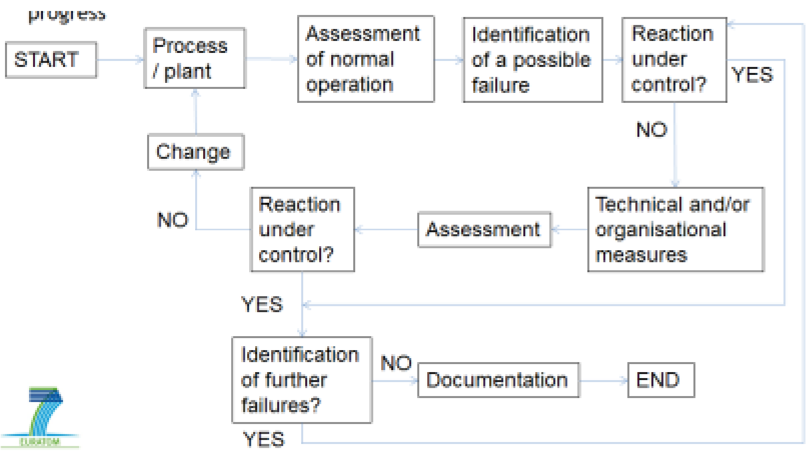
Process safety

- Developing an emerging process towards industrialisation.
- Studying these requirements for both normal and mal-operations across the fuel cycle
  - **Safety Review of a Euro-GANEX plant**
  - **Hazard Analysis and Criticality Studies**
  - **Quantification of Corrosions Risks in EURO-GANEX and EXAm Processes**





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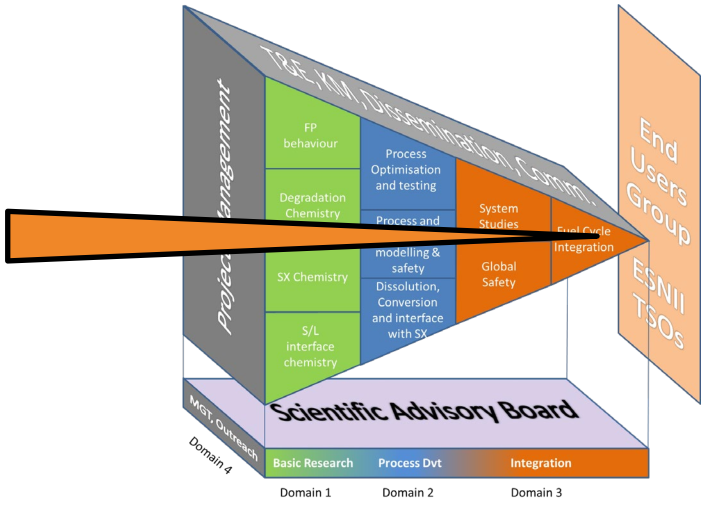
Fuel cycle integration

Integrating the work done in GENIORS in a more global approach by creating synergies with other European and international initiatives and by Involving the stakeholders.

- **Clustering with other European projects and international initiatives** – including collaboration with the
- **Stakeholders/end-users Events**- Two dedicated events will be organised gathering the stakeholders potentially interested by the output of GENIORS will be organised at mid-term and at the end of the project.



SCK•CEN

Joint workshops with DOE

DGA extraction chemistry

Diluent issues

Exchanges with H2020 INSPYRE project on oxide fuel materials

TRAINING

EDUCATION

SACSESS

- Schools
  - **Uranium, Preston (UK) 7-8 April 2014**
  - **Plutonium, Chalmers (SE), 4-8 May 2015**
  - **Modelling, Leeds, June 2016?**
- SACSESS international workshop April 2015
- SACSESS international workshop within Atalante 2016, June 2016
- Student Exchange
- Short students presentations
- Collaboration with DOE: Scientific seminars (Am, kinetics, Radical Behaviour 2015)

ASGARD

- **A winterschool on industrial fuel fabrication**
- **A winterschool on fuel characterisation and isotopic separation (^{15}N)**
- **A summer school on plutonium chemistry together with SACSESS and CINCH**
- **Travel grants for conference participation: 18**
- **Travel and foreign labs training: 4**
- **More than 60 scientific papers**
- **Co-organising an ASGARD session at ATALANTE 2016**
- **Co-organisation of the first ASGARD international workshop at RadChem 2014**

- Co-organising sessions at TopFuels-2015 together with PELGRIMM project
- Several projects in cooperation with the TALISMAN network

The Radical Behaviour Workshop, May 2018, Wûrtzburg

Stakeholders event and topical day on P&T, October 2018, Antwerp

Think-tank on process safety issues, October 2018, Antwerp


TURNING
SPENT NUCLEAR FUEL
INTO A RESOURCE


THANK YOU