MSR activities in France

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MSR workshop at PSI 10/12/2025

Content

1. Context

Non-PWRs developments – why ?

Closure of the fuel cycle

- **France remains committed to the closed fuel cycle policy**
  - One through Pu recycling is currently implemented in ORANO plant and EDF PWR
  - An intermediate step : Pu multi-recycling in PWR (development program in France)
  - Ultimate, long term objective remains the complete closure of the fuel cycle in order to stop natural Uranium importation -> with fast neutron reactors in the reactors fleet
- **Regarding fast neutron reactors**
  - SFR is the reference technology : further developments are considered before industrial deployment (economy and safety improvements)
  - Other technologies are considered for exploratory studies -> MSR (Molten Salt Reactor)

Optimization of waste management (MA transmutation)

New drivers : heat production for energy intensive industries and flexibility

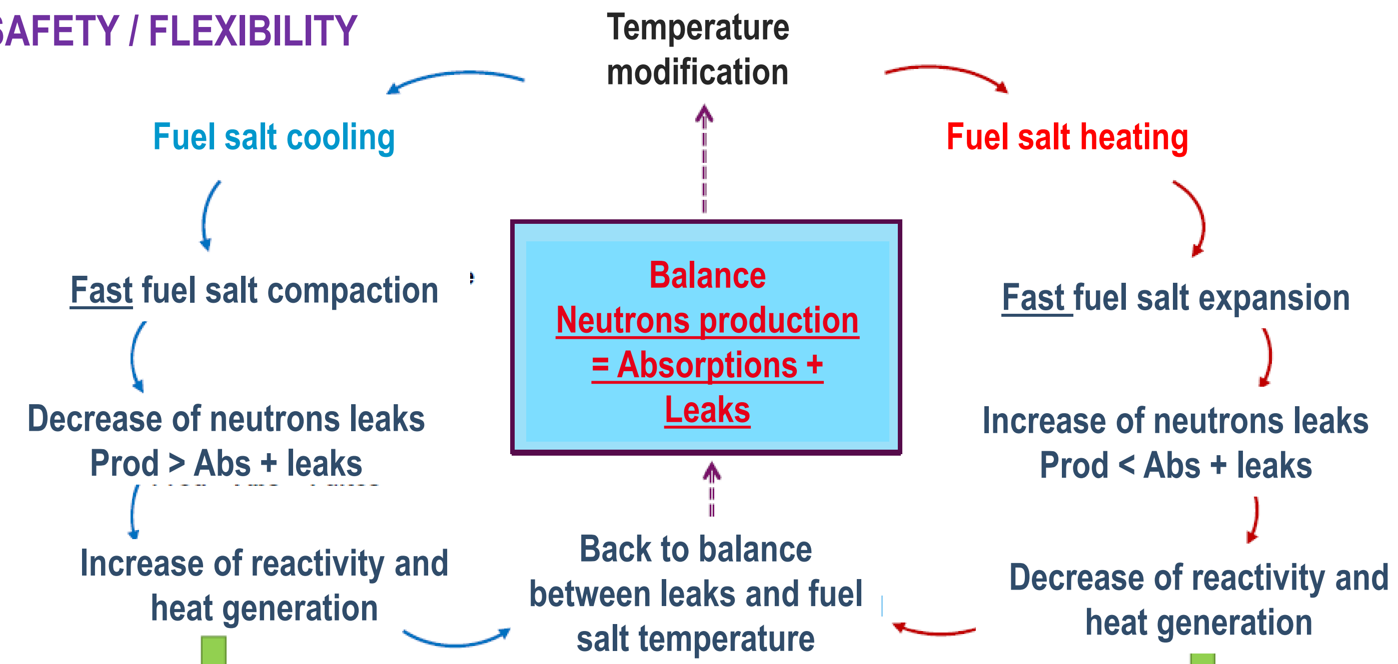
- Industrial needs : large amount of decarbonized electricity + heat in subsitutation to natural gaz or fossil fuels
- new opportunities in particular for small and medium size reactors collocated with industrial heat applications

-> New industrial actors

Specificities of MSRs

Homeostatic equilibrium

SAFETY / FLEXIBILITY



Reactive piloting by the secondary pumps: increase in pumps speed >> power increase
Load following

Intrinsic safety
Limited heating even in case of strong reactivity insertions

Interest for transmutation

- Salt irradiation time is not limited by the irradiation of the internal structures of the core (e.g. clads)
- No degradation of the safety parameters with the introduction of minor actinides
- *Reduction of cooling time with pyro-metallurgical treatment*

High température

MSR have very interesting *potential* advantages in the French context in "fast neutrons" configuration
BUT many obstacles to overcome

Needs for R&D

Potential advantages	**Technological breakthrough**
Nuclear material management - Possible use of U235 or Pu (chloride salt) - Efficient Pu use - Transmutation of Am, Cm… **Intrinsic safety** - No energetic accidental scenarios - Largely negative reactivity feedbacks - No pressure - Possibility of relocating the fuel salt to manage criticality **Flexibility** - Load following in an energy mix with intermittent renewable energies (+ high T°C uses) - µ-reactor, SMR, high power reactors - burner, breeder, isogenerator	**Salt chemistry** - Few physico-chemical data on salts - Evolving composition/salt properties as a result of irradiation - Actinides and fission products solubility, precipitation, vaporization … questions of salt homogeneity, nominal and accidental conditions (O2 entry ..) **Materials** - Corrosive medium - High temperature ("cold" T°C > 500 °C) - Irradiation (the vessel is the first barrier) **Operation and safety** - Safety approach to be built - Management of leaks, fission products, radiation protection - Operating/maintenance procedures **Technologies to be developed** (instrumentation, purification, exchangers...) **Salts fabrication processes to be developed** **Gas and salt treatment processes to be developed** (including pyro metallurgy)

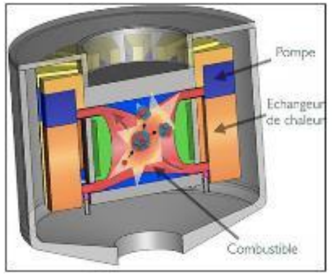
A "popular" concept among investors, potential for acceptance, a disruptive concept, expected gains on investment costs

R&D programs to characterize feasibility by objectively identifying advantages and obstacles
Technology development programs

2. R&D projects

R&D projects on MSRs in France

- **Fast MSFR studies at CNRS**
  - Fluoride MSFR in the Th/U233 fuel cycle
  - Chloride MSFR in the U/Pu fuel cycle
  - RAPTOr burner versions



CONCEPT MSFR DU CNRS

- **The ARAMIS project (2020-2022)**
  - Study of a plutonium burner MSR (ARAMIS-P)
  - CEA/ORANO bilateral program
  - Low-power units in the context of a fuel reprocessing plant (targeted capacity of ~ 100 kg/year/unit)
  - Feasibility studies / Prioritization of R&D locks and 1st experimental program (synthesis salt / corrosion)

- **The ISAC project (2022-2026)** :
  - Feasibility study for an americium burner MSR (ARAMIS-A)
  - National plan for nuclear waste management framework
  - Evaluation of the gain on the inventory of waste to be stored
  - 5 Partners: CEA, CNRS, EDF, FRAMATOME, ORANO

- **The MOSARWASTE project (2023-2027)** :
  - Molten Salt Reactors Waste Management, complementary to the ISAC project
  - Focuses on HL waste - cycle of matter & waste of a MSR, ways to manage the subsequent HL waste
  - Partners: CEA, CNRS, ORANO

The ISAC project

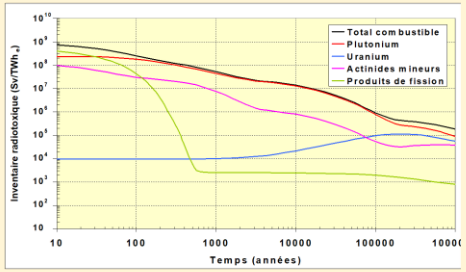
Why is there interest in transmutation ?

01

PLUTONIUM

In spent fuel, the main contributor to radiotoxicity is Pu >>> MA >> FPs

➔ The Pu must be properly managed

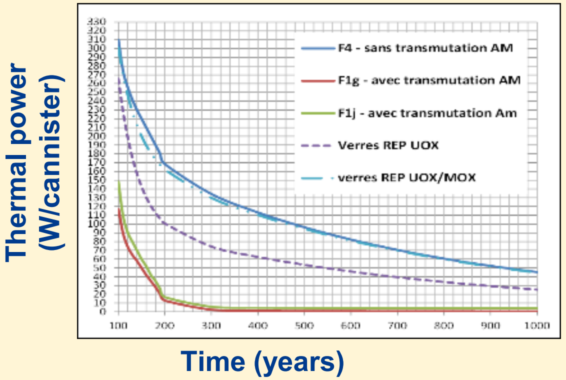


02

STORAGE FOOTPRINT

Cannisters thermal is dimensioning (rock heating)

Am transmutation allows a significant gain



03

FISSION PRODUCTS

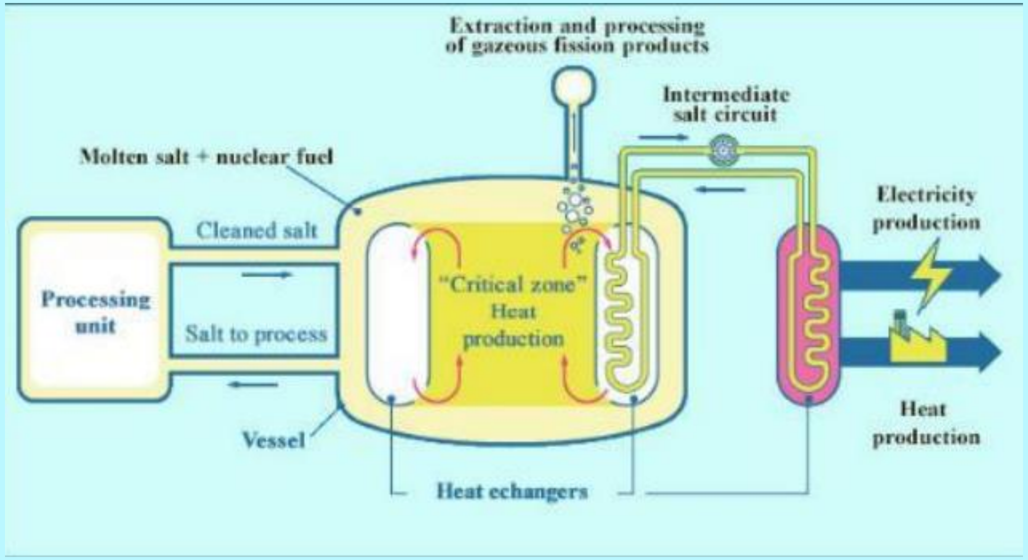
Final waste to be managed, in all cases ; underground repository is the solution

Transmutation of MA (minor actinides) in SFRs (fast neutron reactors with sodium coolant) or ADS (Accelerator Driven systems) has been studied in France in an important way: we know its advantages and limitations

The fast Molten Salt Reactors

Interests for the transmutation of Minor Actinides

- **No manufacture of solid fuel**, ***no transport, no sub-assembly handling***
- **High ratio of the time spent by the fuel in reactor / outside reactor → Efficiency of transmutation**



The ISAC project : expectations by the end of 2026

Strengthen the advantages
Attractive transmutation performances Complete inventory of waste produced (cycle and reactor)
Intrinsic safety
Gain on deep geological repository foot print

Progress on challenges
Credible reactor pre-design (compactness, etc.)
Salts synthesis and treatment processes
Choice of materials and corrosion control strategy
Characterization of the operation and the maintenance of a MSR
Stability of the core power distribution
Salts data acquisition

Concept maturity: TRL 2 at the beginning of the project, TRL 3 at the end

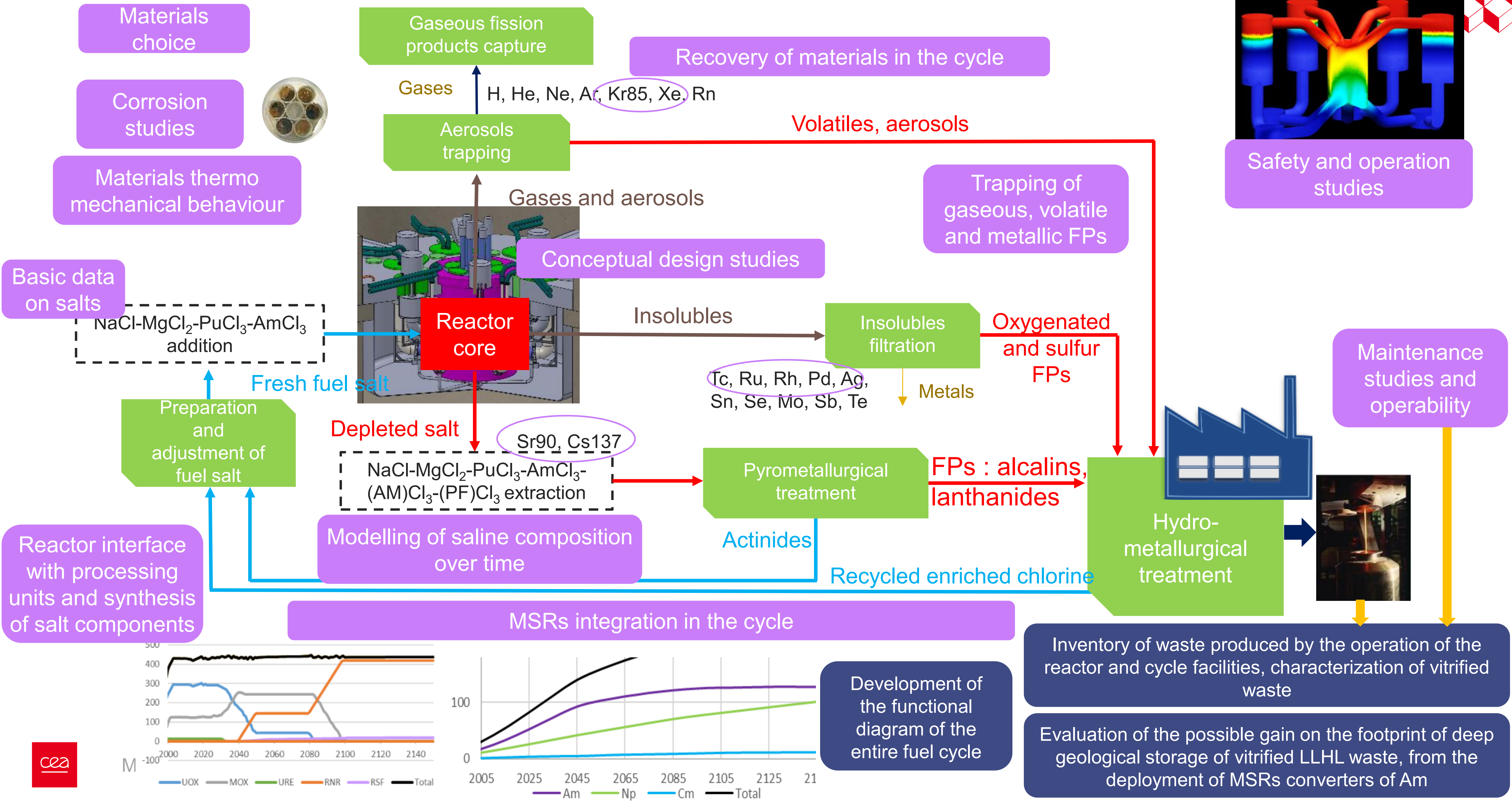
An integrated approach: the reactor + the fuel cycle + a use scenario (cycle closure)

Reactor view : a fast neutrons MSR, Pu+Am chloride salts (300MWth)

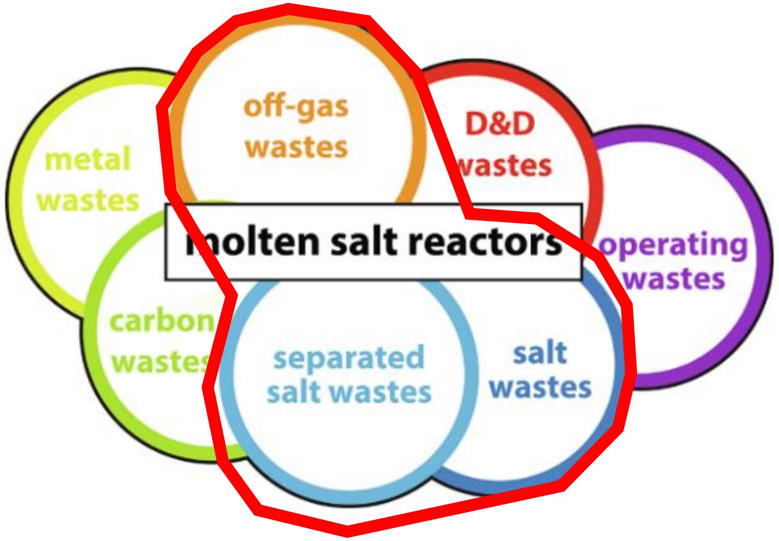
Cycle and scenario view : MSRs are complementary to PWRs and SFRs -> a small number (?) of MSRs specifically providing the americium conversion function

Preliminary Am conversion objective : 50kg/TWh

The ISAC project : a systemic approach



The MOSARWASTE project - Context and aim

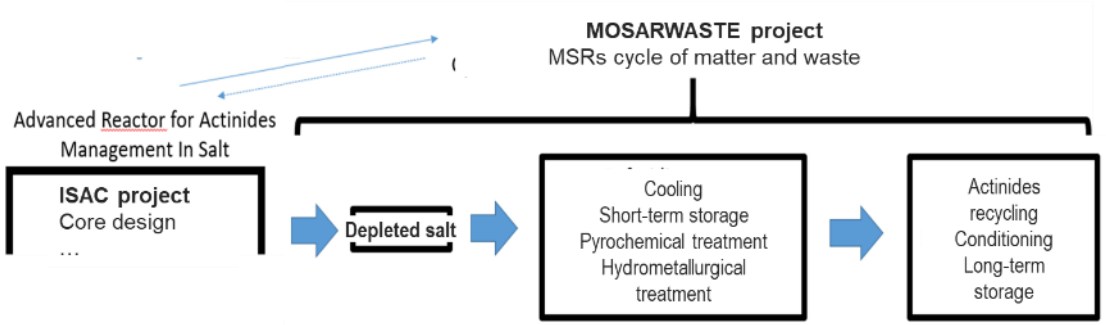


Scope of the MOSARWASTE project

In the context of a sustainable nuclear energy and a public acceptance: considering the reactor design at the same time than the waste management!

What about the cycle of matter and the waste management arising from MSR?

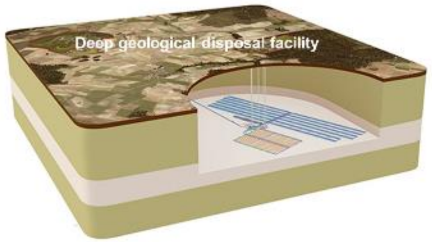
- Various types of effluents & waste produced from operating a MSR
- Studies based on ARAMIS-type reactor (ISAC project)



MOSARWASTE focuses on HL waste

- To establish the cycle of matter & waste of a MSR based on its operating modes.
- To identify the way to manage the subsequent HL waste

Vitrification



The MOSARWASTE project – Content and organization

WP1. Project Coordination (leader = CEA)

CNRS coordination

WP6. MSR with fluoride salt vs chloride salt
State of the art
What about the cycle of matter (salt reprocessing, final waste…)

CEA coordination

WP3. Management of "final waste"
Is vitrification possible with some upgrading?
What about alternative matrices?

WP4. Storage of HL waste arising from chloride type MSR
For salt cooling because of short-lived radionuclides
Which kind of material adapted for their conditioning for this period of time?

WP5. What about geological disposal of this type of waste?
Specificities of this(ese) new waste package(s)?

ORANO group coordination

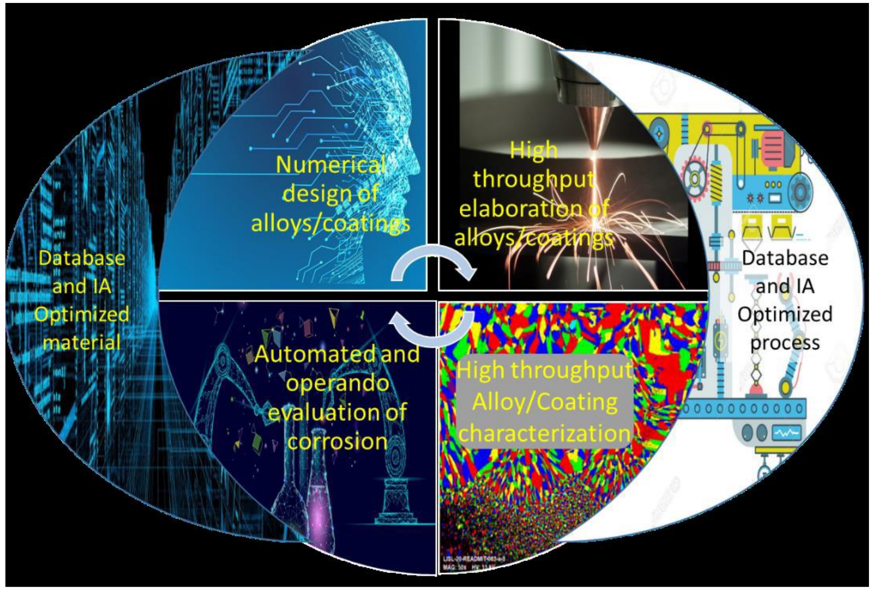
WP2. Knowledge Management
Which isotopes are produced in the salt during the reactor life?
What are the reprocessing routes for the salt?
What are the "final waste" to take into account?

Other national projects

The PORTHOS project (2022-2025) dedicated to the development of processes for the fabrication, purification and conditioning of $ThCl_4$ (leader : ORANO, partners: CNRS…)

The A-DREAM project (2022-2026) : Accelerated Development of corrosion REsistAnt Materials (leader : CEA, partners : CNRS, universities)
Generic approach to accelerate the discovery of corrosion resistant materials and coatings in harsh environments -> molten salt LiCl-KCl in eutectic proportion.

- ✓ digital design of materials/coatings
- ✓ synthesis of these materials at high speed
- ✓ implementation of accelerated corrosion tests



High capacity furnace (CEA-Saclay)

European projects

horizon europe

ENDURANCE

The ENDURANCE project (2024-2028) for the technological development of MSRs in Europe (leader :POLIMI, partners : CEA, CNRS, FRAMATOME, IRSN, start-ups)

MIMOSA

The MIMOSA project 2022-2026) on the multi-recycling of spent fuels, and the integration of molten salt reactors into existing and future energy systems (leader: ORANO – partners: CNRS, EDF...)

CONNECT NM

European partnership dedicated to advancing research, development, and innovation in the field of nuclear materials
2 proposals regarding MSR materials

GIF

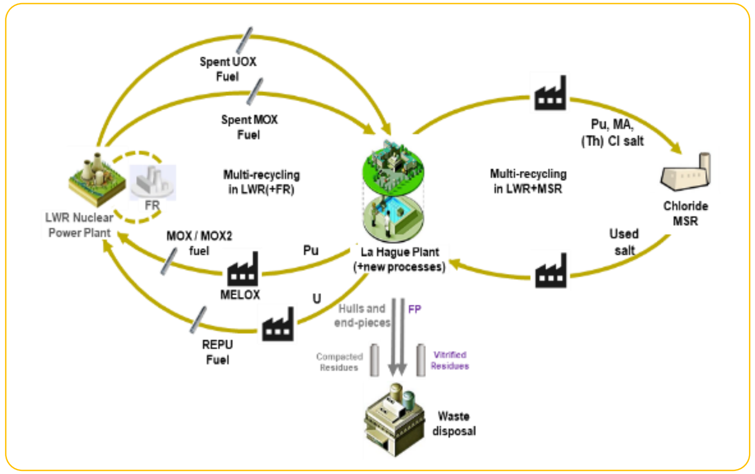
France is signatory of the MSR pSSC and RSWG

Technical progress – Focus on MIMOSA (European project – 2022-2026)

- « *The MIMOSA project will devise and demonstrate a* ***risk-cost optimized integrated multi-recycling strategy of plutonium and uranium*** *combining multi-recycling options in LWRs with recycling Pu and other transuranics today considered as waste, in Cl MSRs using existing European infrastructures such as the Orano reprocessing plant in La Hague*»

- Main focus on : **Scenarii studies and key aspects of feasibility and performance, e.g., salt properties, salt evolution under irradiation, corrosion, salt treatment and recycling technologies**

- **Status (nov. 2025):**
  - On-going iterations on scenarii studies with MSRs in the EU
  - Pure salt synthesis done at JRC for **$PuCl3$** and TU-Delft for **$ThCl4$** for further experiments
  - Property measurements (T_{melt}, density,…) finished on a ternary salt (NaCl-MgCl2-PuCl3)
  - Chloride salt irradiation experiment in LR-0 reactor in the Czech Republic
  - Corrosion tests on-going for metallic and **SiC** material in chloride salt (static, dynamic) with $NdCl_3$ as a simulant of $PuCl_3$; construction of a corrosion / irradiation test bench
  - Development of unitary blocks of a pyrochemical process for chloride salt reprocessing
  - Compatibility assessment of chloride salt reprocessing with La Hague processes
  - Construction of a device to extract by flotation the solid fission products from the salt
  - Final event of MIMOSA during EUROMOST'26 : 26-29 May, 2026



https://www.mimosa-euratom.eu/mimosa-newsletter-n2/

orano, TUDelft, CVŘ Research Centre Řež, EDF, NRG, cnrs, DIFFER, THORIZON, JRC, NUCLEAR 21, ARTTIC

MIMOSA

3. Experimental facilities

CEA Marcoule - ATALANTE : synthesis of actinide chlorides, cycle studies, chemistry and electrochemistry studies of molten salts with actinides

G1 – ZIP Chimène

Pyrochemistry on non radioactive materials :

- Glove boxes under Ar
- Furnaces, TDA-TGA, Potentiostats

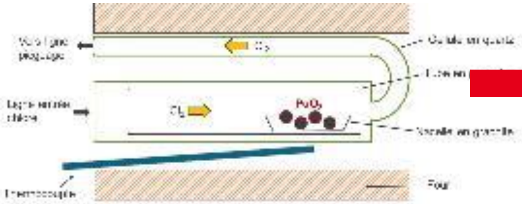
ATALANTE – L8

Pyrochemistry on radioactive materials :

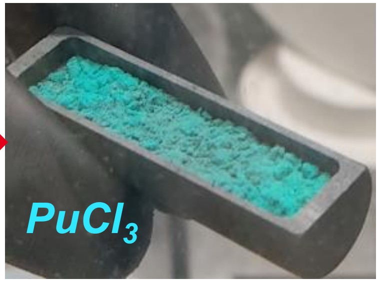
- Furnaces, Potentiostats
- Glove boxes with HCl/Cl_2 input,
- Glove boxes under N_2
- Spectrometer α, spectrophotometer

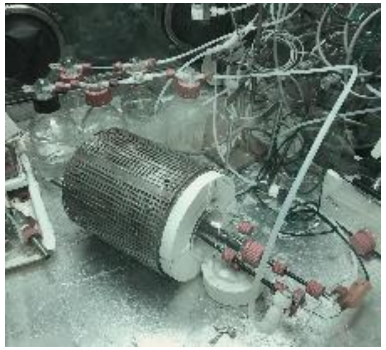
Synthesis of actinide chlorides and cycle studies

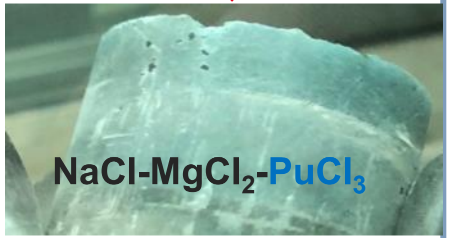
Carbochlorination line



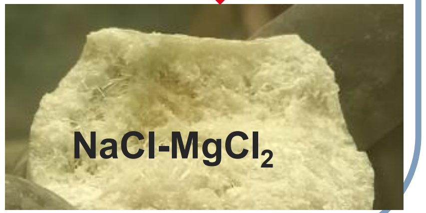
$$PuO_2 + 1,5Cl_{2(g)} + C = PuCl_3 + CO_2$$





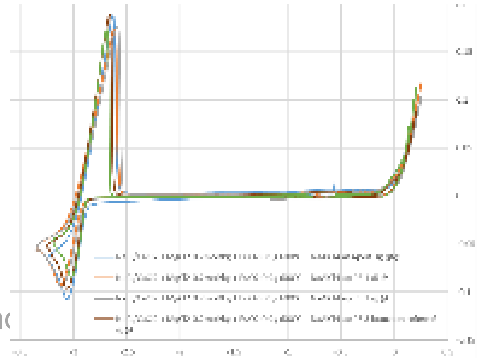


Recovery of 99.5% of Pu contained in NaCl-MgCl2-PuCl3 by pyrometallurgy

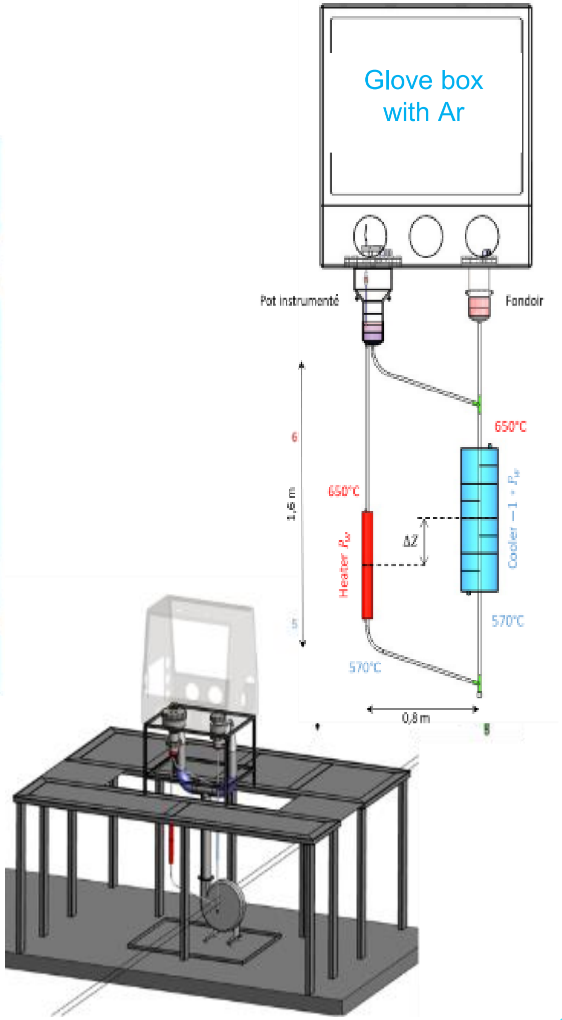


99.9% chloride recovery from a NaCl-MgCl2-CeCl3 salt by hydrometallurgy

Electrochemistry studies of molten salts with actinides



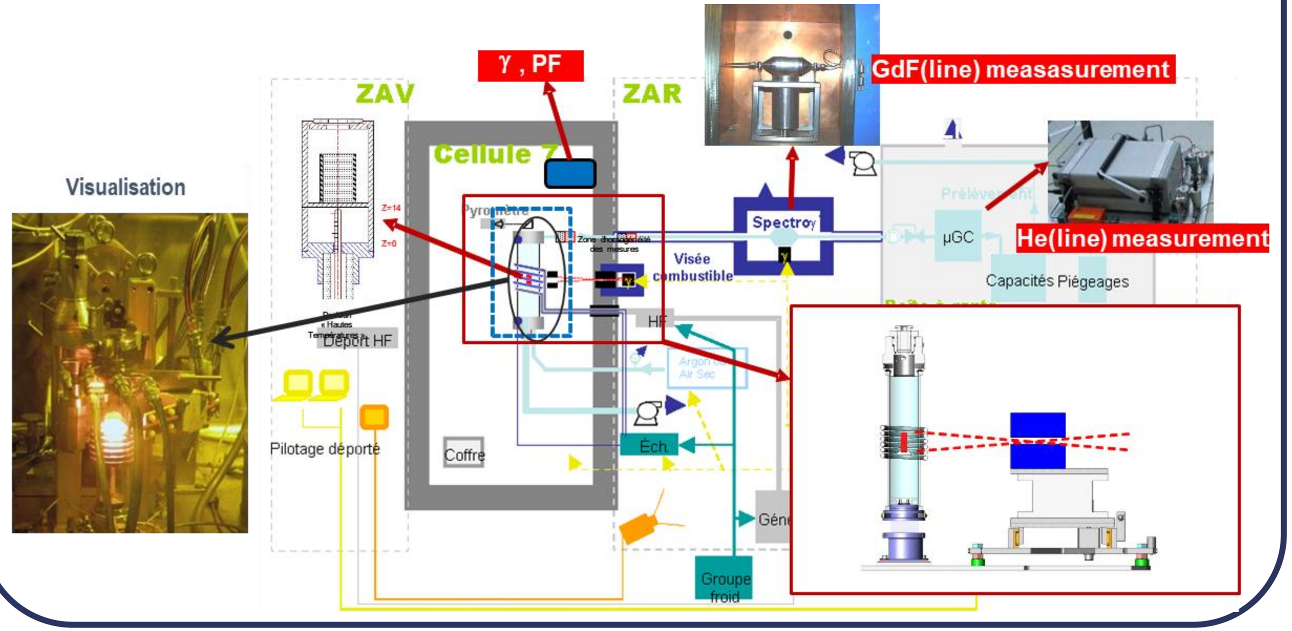
CEA Cadarache – BACCHUS : small loops in natural convection for corrosion studies and chemestry control



Anisothermal system

CEA Cadarache - MERARG : complex salt properties

- Measurement of melting points according to salt composition
- Behaviour of fission products and actinides as a function of temperature (release rate)
- Evolution of salt composition (temperature)

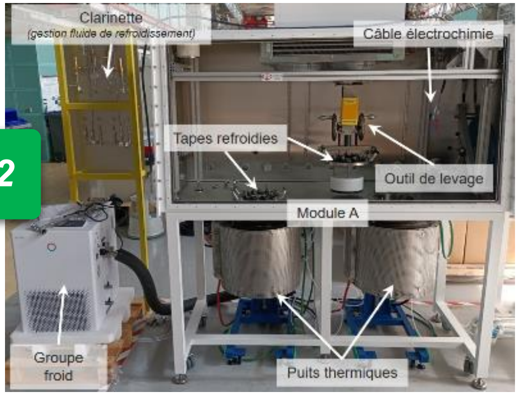


CEA Saclay – MESCAL : glove boxes for corrosion studies / materials screening

MESCAL 1

salts : NaCl-MgCl2, NaCl-CeCl3, NaCl-MgCl2-CeCl3,…

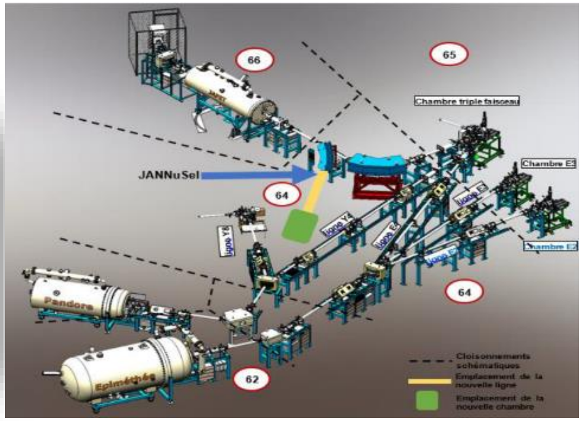
MESCAL 2



MESCAL 2 : Glove box – long time corrosion test
MESCAL Dyn : controlled hydrodynamic corrosion studies
MESCAL Thermo : thermophysical data measurements

CEA Saclay – DAMCO furnace

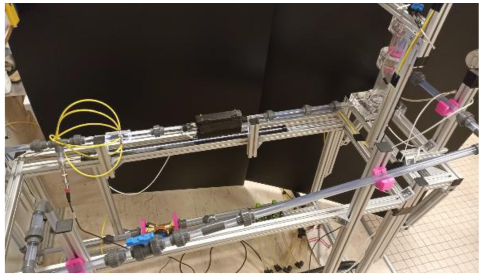
CEA Saclay – JANNUSel : study of the corrosion/irradiation combined effects



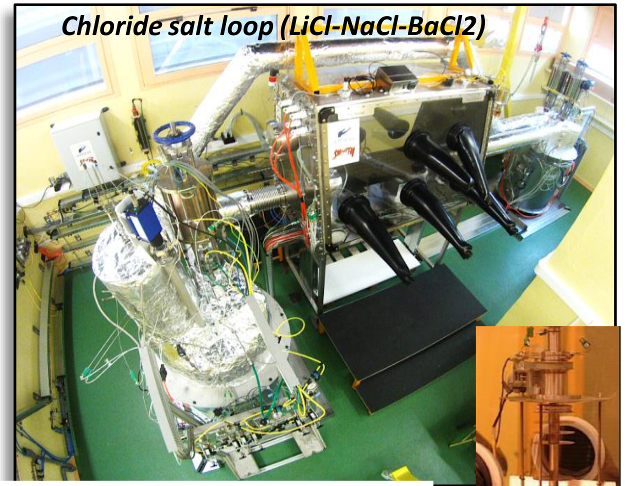
- Protons (4 MeV) beam line on JANNuS
- The irradiation chamber contains molten chlorides at high temperature - the thin sample is the entrance window of the chamber

CNRS Grenoble – SWAT loop : thermo hydraulic studies, two-phase flows, operability

Water 2 phase flow loop



Chloride salt loop (LiCl-NaCl-BaCl2)



LPSC GRENOBLE | MODANE Plateforme **FEST**
Fluids Experiments and Simulations in Temperature

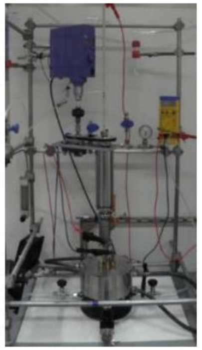
Université d'ORLÉANS

Cemhti

SORBONNE UNIVERSITÉ

PHENIX

CNRS Toulouse – Corrosion test



INP TOULOUSE

UNIVERSITÉ TOULOUSE III PAUL SABATIER

LABORATOIRE DE GÉNIE CHIMIQUE TOULOUSE • UMR 5503

CNRS Orsay – Molten salt chemistry: Fission products chemistry, pyrochemical treatment, synthesis and purification of salts, corrosion

XRD

Experimental measurement device

Gas installation

TGA

Inert Glove Box

ICP

université PARIS-SACLAY

Laboratoire de Physique des 2 Infinis Irène Joliot-Curie

CNRS-Lille – Coupled effects : mechanical constraints and molten salt exposure

Université de Lille

UMET Unité Matériaux Et Transformations

centralelille

INRAE

cea

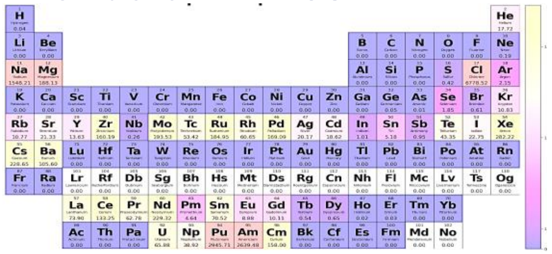
4. Simulation codes

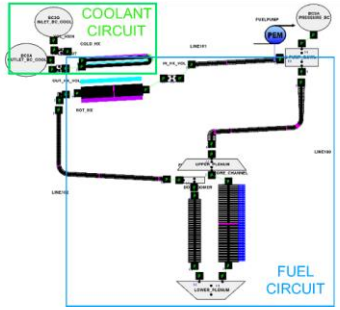
Simulation codes at CEA for MSRs

- Fuel evolution/management code: **MOSARELA** (MOlten SAlt REactor Life-cycle Assessment) - developed specifically for MSRs
  - Generates material balance sheets for all reactor units (core, cover gas,...) according to their history (power, fissile/fertile salt supply, removal of irradiated salt, gas discharged...) over the operating time.
  - Set of convenient procedures for MSR design studies
  - Transport equation solved by a Monte-Carlo code (TRIPOLI-4, SERPENT2, Open MC…), burnup equation solved with an in-house evolution solver or by coupling with MENDEL (CEA depletion code)

  EDF code : **PYMS** (Python Molten Salt Studies with Serpent) for reference isotopic calculation

Salt composition evolution simulation with MOSARELA



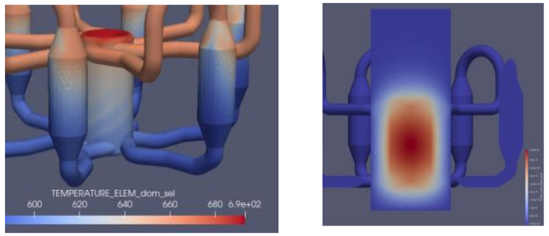


CATHARE3 model of the MSRE

- Standalone thermal hydraulics system code : **CATHARE3** - existing code / adaptation of the point kinetics model – Transport of DNPs and DHPs in the fuel circuit

  EDF code : **PANDAS**
  CNRS code : **LiCore**

- Fast integrated code for N/TH simulations: **TRUST-NK** - developed specifically for MSRs
  - Core-level neutronics solver (multi-groups diffusion and Spn model of transport)
  - Can be coupled internally with any existing thermohydraulic model based on the CEA TRUST platform



TRUS-NK results : T°C field and flux in ARAMIS

- For validation, very few data are available (mainly ARE and MSRE) - no coverage of the fast-spectrum chloride molten salt pool type reactor -> **new experiments are needed**
- **Needs of reliable physical properties of the salts**

Simulation codes at CEA for MSRs

- Reference coupling between neutronics and thermal-hydraulics : **APOLLO3/TrioCFD** – existing codes

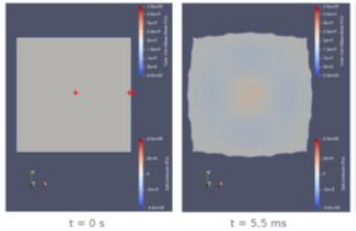
  APOLLO3® : CEA deterministic code for core physics analysis (transport model)
  TrioCFD : CEA CFD code

  Framatome : coupling of the thermohydraulic code **StarCCM+** and the neutronic code **TFM**
  CNRS : coupling of the thermohydraulic code **OpenFOAM** and the neutronic code **TFM**

- Coupling for fast (explosive) transients: **APOLLO3/Europlexus** – existing codes, development of the coupling scheme

  Neutronics / compressible-thermalhydraulics / structural-mechanics coupling tool to simulate fast prompt supercritical excursions in fluid-fuel systems with correct density reactivity feedback and deformation of the structures (ex : the vessel)

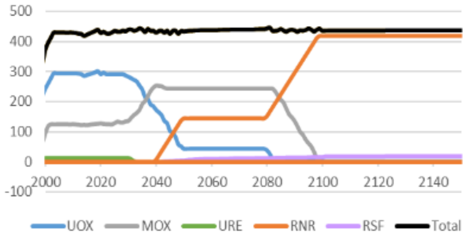
  Europlexus : simulation software dedicated to the analysis of fast transient phenomena involving structures and fluids in interaction



Toy Model AP3/EPX

- Scenarios code : **COSI** – existing code, significant developments for MSRs

  Simulates nuclear reactor fleets and the associated fuel cycle facilities over several decades for scenario studies analyzing the consequences of the choices made over reactor fleet dimensions and nature, fuel types, and the different fuel cycle facility features (plants, interim storage, geological storage, etc.).
  It processes all the fuel cycle isotopic material flows (natural U, depleted U, reprocessed U, Pu, minor actinides, fission products, etc.)



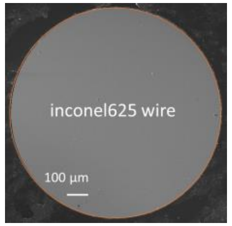
  EDF code : **TIRELIRE-STRATEGIE**
  Framatome code : **COSAC**
  CNRS code : **ISF**

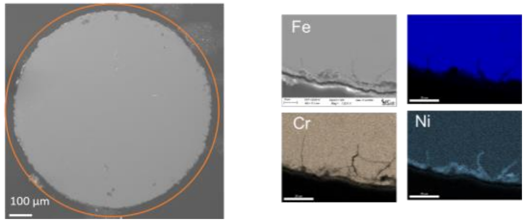
5. CNRS activities

CNRS IJCLab activities

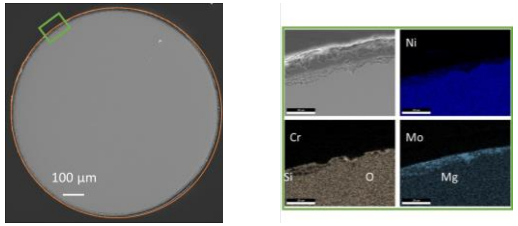
By applying a double approach, thermodynamic calculations and experimental studies, several research studies are developed:

- Synthesis and purification of chloride salts
- Chemistry of chloride molten salts
- Chemistry of fission products in molten salts
- Corrosion studies (Corrosion mitigation by controlling the salt chemistry)
- Pyrochemical treatment

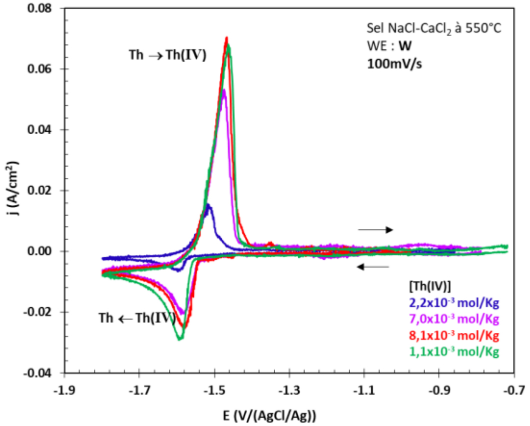




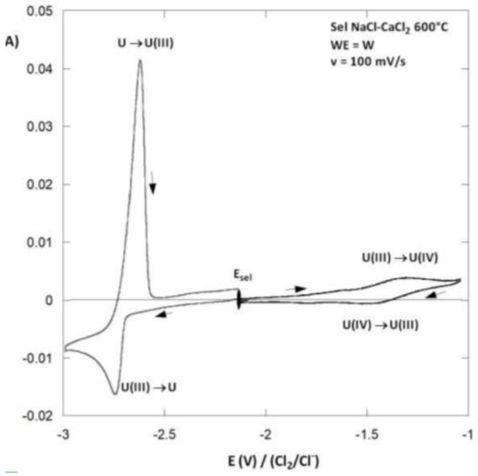
without redox control



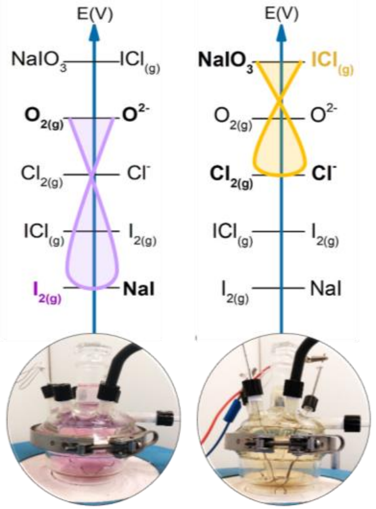
with redox control



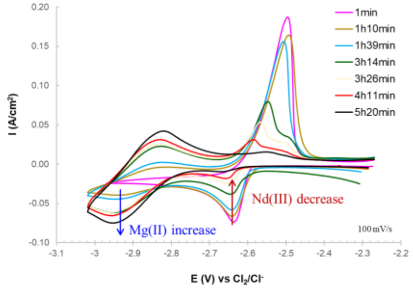
Redox behavior of $ThCl_4$
in chloride molten salts

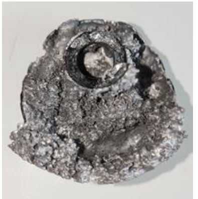


Redox behavior of UCl_3
in chloride molten salts

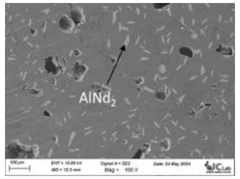


Redox properties of I
In chloride molten salts





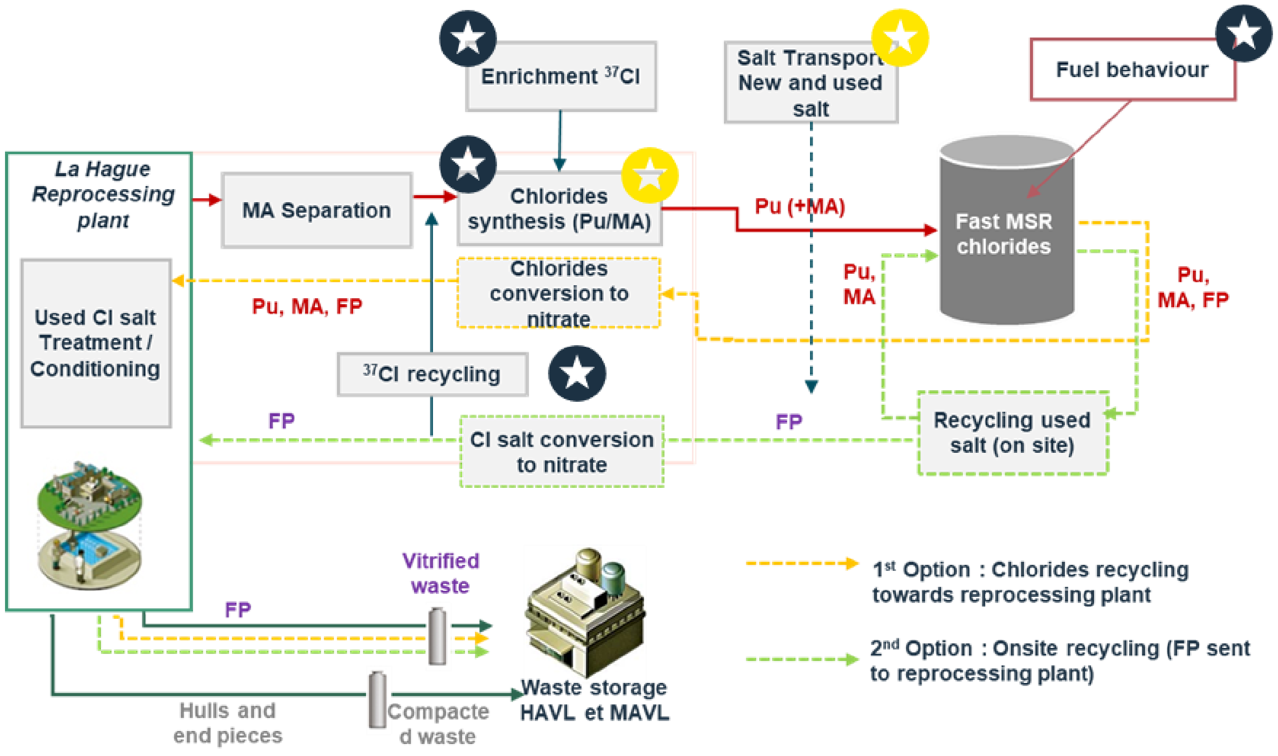
Al-Mg alloy after RE



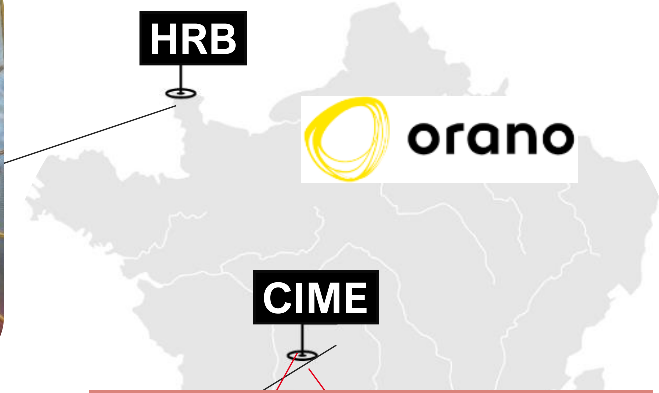
Reductive extraction of Nd(III) in NaCl-$CaCl_2$
at 600°C with Al-Mg liquid alloy
(efficiency 93%)

6. Orano activities

Orano's R&D focus and experimental capabilities



Gas treatment pilot



A pilot facility bridging lab and industry. Capabilities for MSR include salt synthesis, chlorine gas management, dedicated analytical labs, and operation of chloride salt experimental loops.

Molten Salt Lab

But also:

Engagement with multiple R&D centers and university partners to complement and enhance internal capabilities.

Salt production facility

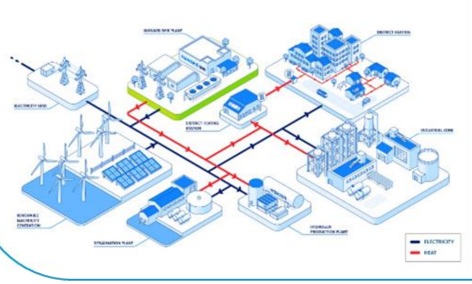
Corrosion test loop

7. Industrial projects in France

SMR and AMR projects in France

SMR

nuward — Subsidiary of **EDF**



- Simple, modular and prefabricated product
- Thermal output of 1,150 MWth, convertible into up to 400 MWe and 115 MWth,
- Supplies competitive, stable, low-carbon electricity and heat,
- Addresses the technical, economic and environmental challenges of industrial clusters, data centres and high-energy consumers,
- Controlled fuel cycle with 96% recycling of spent fuel and a 25% reduction in natural uranium extraction.

https://www.nuward.com/en/about-nuward

archeos

- Low pressure PWR providing from 20 to 50 MW of heat up to 150°C.
- Fast deployment: use of already proven technological bricks
- Commercial targets: agri-food, industry and collectivities

CEA R&D project -> industrial projet in 2025

GOUVERNEMENT — FRANCE 2030 — bpifrance

CALOGENA

- LWR
- Power : 30 MWth
- Application: heat distribution for cities

AMR

otrera

- SFR
- Power : 180 MWth / 110 MWe
- Applications : industrial heat and electricity

CEASpin Off

HEXANA

- SFR
- Power : 400 MWth / 150 MWe
- Applications : industrial heat and electricity

CEASpin Off

BLUE CAPSULE

- Hybrid reactor (HTR cooled by Na)
- Power : 150 MWth / 50 MWe
- Applications : industrial heat and electricity

CEASpin Off

Jimmy

- HTR
- Power : 15 MWth
- Applications : industrial heat

newcleo — Futurable Energy

- Lead Fast Reactor
- Power : 90 or 500 MWth et 30 ou 200 MWe
- Applications : electricity, heat, radio-isotopes

naarea

- **Fast MSR – chloride salt**
- Power : 80 MWth / 40 MWe
- Applications : industrial heat and electricity

STELLARIA

- **Fast MSR – chloride salt**
- Power : 400 MWth / 250 MWe
- Applications : industrial heat and electricity

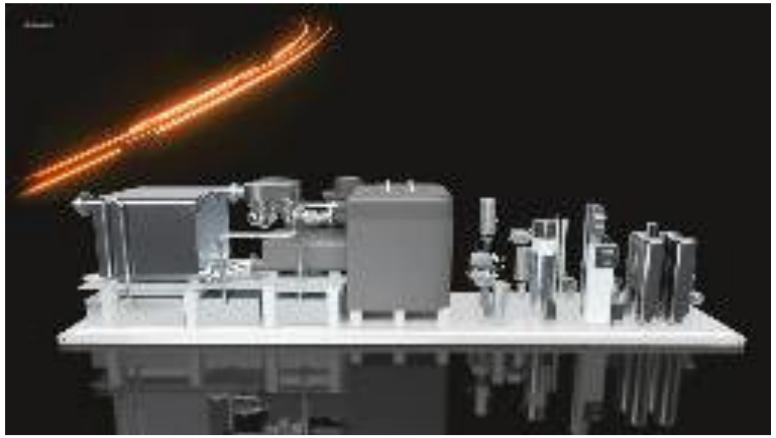
CEASpin Off

THORIZON

- **Fast MSR – chloride salt**
- Power : 250 MWth / 110 MWe
- Applications : industrial heat and electricity

NAAREA’s XAMR® reactor

naarea



https://aris.iaea.org/publications/SMR_catalogue_2024.pdf

KEY TECHNICAL PARAMETERS	
Reactor type	Homogeneous core loop-type molten salt reactor
Coolant/moderator	Molten salt/None
Thermal/electrical capacity, MW(t)/MW(e)	80 MWth / 40 MWe
Primary circulation	Forced
NSSS Operating Pressure (primary/secondary), MPa	Atmospheric pressure
Refuelling Cycle (months)	38
Approach to safety systems	Redundant passive systems for decay heat removal, static containment and active reactivity control means.
Design life (years)	40

In 2024, creation of the **IMSLab** (Innovation Molten Salt Lab) common laboratory between NAAREA, CNRS and Université Paris-Saclay

https://www.world-nuclear-news.org/articles/naarea-advances-development-of-molten-salt-reactor-fuel

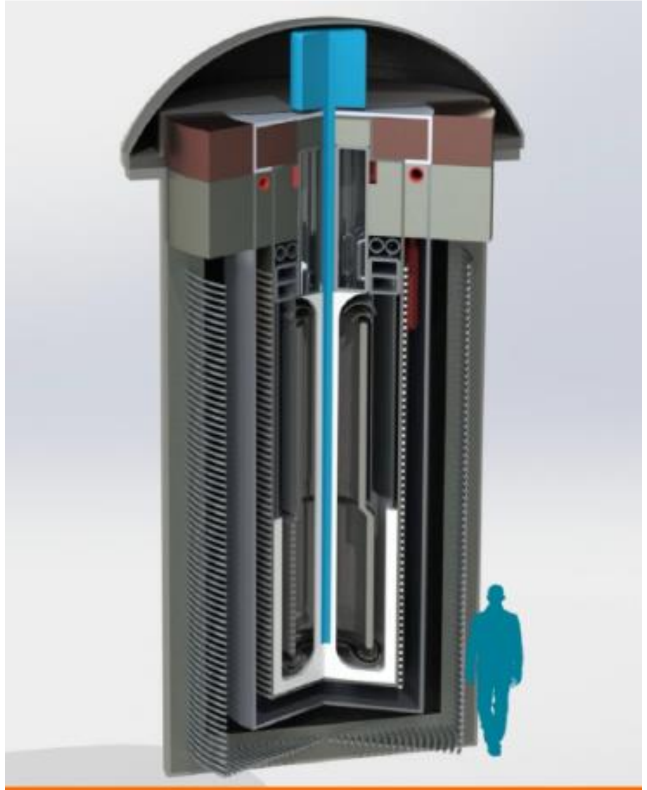
The IMSLab and the JRC (European Joint Research Center) are developing an **innovative proliferation-resistant pyrochemical method of producing NaCl-$PuCl_3$ salt**

https://www.naarea.fr/fr/synthese-du-sel-nacl-pucl3

crédit photo : Lucille PELERIN/REA pour NAAREA

STELLARIA's STELLARIUM reactor

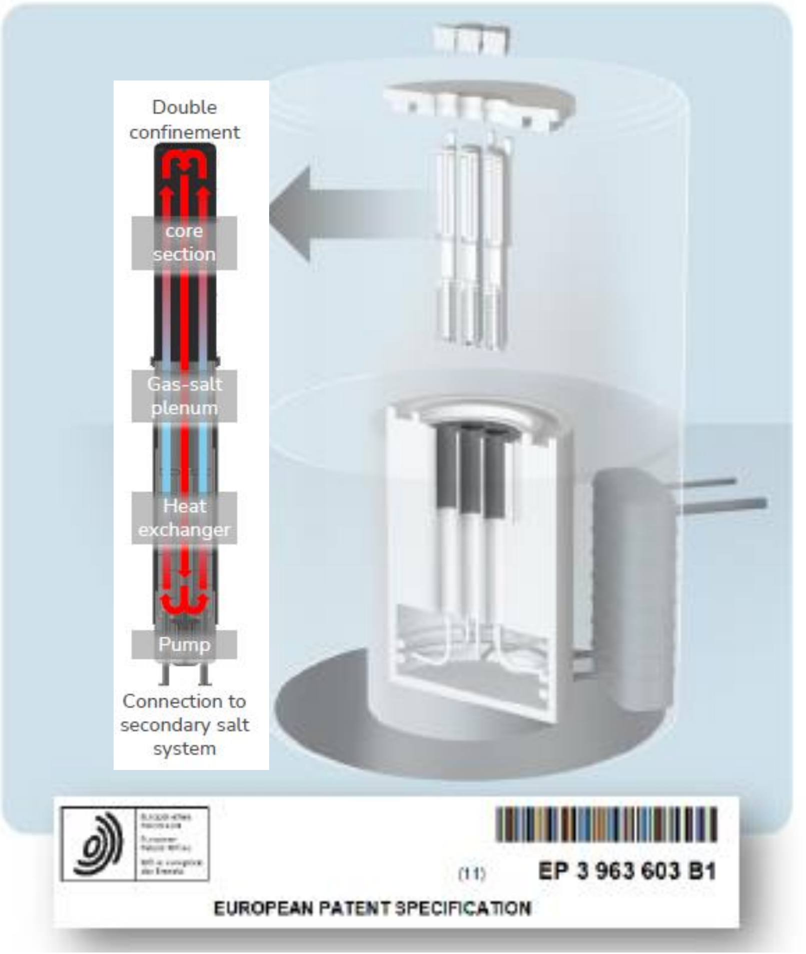
STELLARIA
ENERGY FOR CENTURIES



https://aris.iaea.org/publications/SMR_catalogue_2024.pdf

KEY TECHNICAL PARAMETERS	
Coolant/moderator	Molten salt/None
Thermal/electrical capacity, MW(t)/MW(e)	250 MWth / 110 MWe
Primary circulation	Natural circulation
NSSS Operating Pressure (primary/secondary), MPa	0.13 / 0.4 (hydrostatic) /0.4 (hydrostatic) / 22
Core Inlet/Outlet Coolant Temperature (°C)	550 / 750
Fuel type	Molten Uranium, Plutonium Chloride (optional minor actinides)
Fuel enrichment (%)	< 8% PuCl3 or 16.5% HALEU
Core Discharge Burnup (GWd/ton)	100
Refuelling Cycle (months)	240
Reactivity control	Control rods
Approach to safety systems	Passive and Active.
Design life (years)	60
Distinguishing features	Replacement of vessel every 10 years. In-core closed fuel cycle.

THORIZON's THORIZON ONE reactor



https://aris.iaea.org/publications/SMR_catalogue_2024.pdf

KEY TECHNICAL PARAMETERS	
Reactor type	Modular core fast-spectrum reactor with chloride salt
Coolant/moderator	Chloride salt (no moderator)
Thermal/electrical capacity, MW(t)/MW(e)	250 / 110
Primary circulation	Forced circulation
NSSS Operating Pressure (primary/secondary), MPa	low pressure under all circumstances
Core Inlet/Outlet Coolant Temperature (°C)	500 / 800
Fuel type/assembly array	Fissile-fertile material bearing molten salt in closed containment modules
Refuelling Cycle	5 – 10 years target
Reactivity control	Control rods, burnable poison, core draining, and strong negative temperature feedback
Approach to safety systems	Passive as much as possible
Design life (years)	Full core replacement strategy allows life extension beyond 60
Distinguishing features	Nuclear safe core material replacement strategy, with external core module series production, continuous improvement by module updates, and fuel cycle flexibility

8. Conclusions

Conclusions

- **SFRs are continuously developed and MSRs are studied as a complementary option or a long term alternative**

- **MSRs can be game changers in the nuclear ecosystem because they have strong potential advantages but…**
  - ➢ also many technological challenges (salt chemistry, materials, maintenance...)
  - ➢ The development of R&D is important to help increase the maturity of these systems

- **France is an important player in the field with :**
  - Activities at CNRS since 20 years and CEA since 2020 within a project in collaboration with Orano
  - Significant R&D projects : ISAC, associated with MOSARWASTE involving CEA, CNRS, Orano, EDF and Framatome
  - Experimental facilities at CNRS, CEA and Orano
  - Contributions to European projects : MIMOSA, ENDURANCE
  - 3 industrial projects led by the companies STELLARIA, NAAREA and THORIZON

- **There's an interest for Europe to support a collaborative initiative for R&D on MSRs (fuel cycle and reactor)**

Thank you