

EXPLORING SPENT SALT TREATMENT OPTIONS BASED ON LA HAGUE HYDROMETALLURGICAL PROCESSES

**Joint IAEA-NEA-EC/JRC Workshop on the Taxonomy and Related Terminology of Fuel Cycles for
Molten Salt Reactors, Vienna, 3-7 November 2025**

I. Morlaes, E. Capelli, O. Drouvot, B. Morel

© ORANO 2025 - All rights reserved



orano

CONTENT



- 1 **Context and interest in MSR**
- 2 **La Hague Hydrometallurgical Process and Industrial Experience**
- 3 **MSR Fuel Cycle Scenarios based on La Hague Processes**
 - **Front-End side**
 - **Back-End side**

A proven expertise in the NUCLEAR FUEL CYCLE

A major player in the nuclear fuel cycle, Orano transforms nuclear materials to offer its customers high value-added products and services.

Its industrial platforms are recognized for their cutting-edge technologies and processes.

In the top 3

worldwide in its
core activities

€5.9 Bn

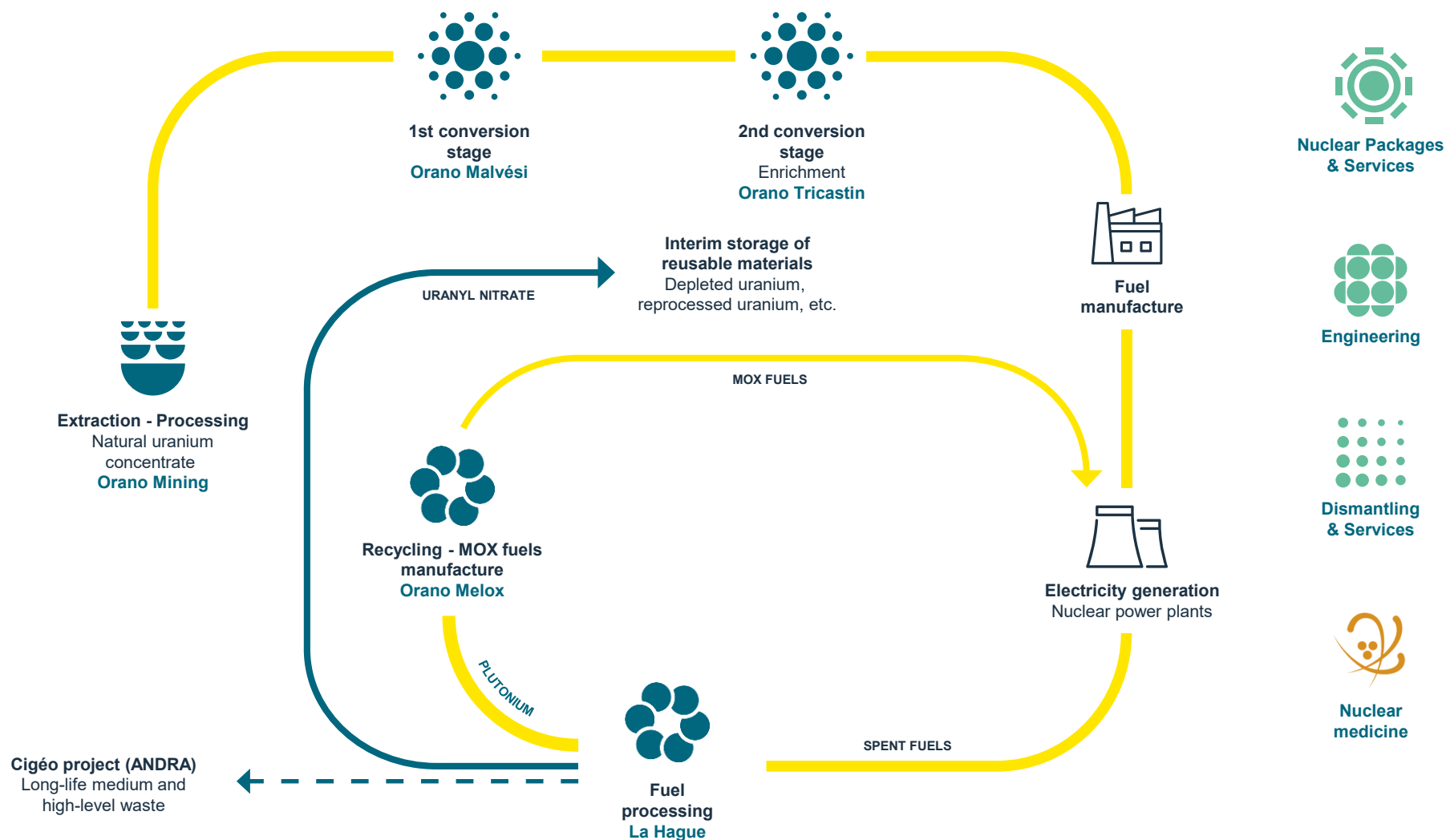
in revenue (2024)

€35.9 Bn

in order backlog
(or almost 7 years
of revenue) (2024)

17,500

Employees (2024)



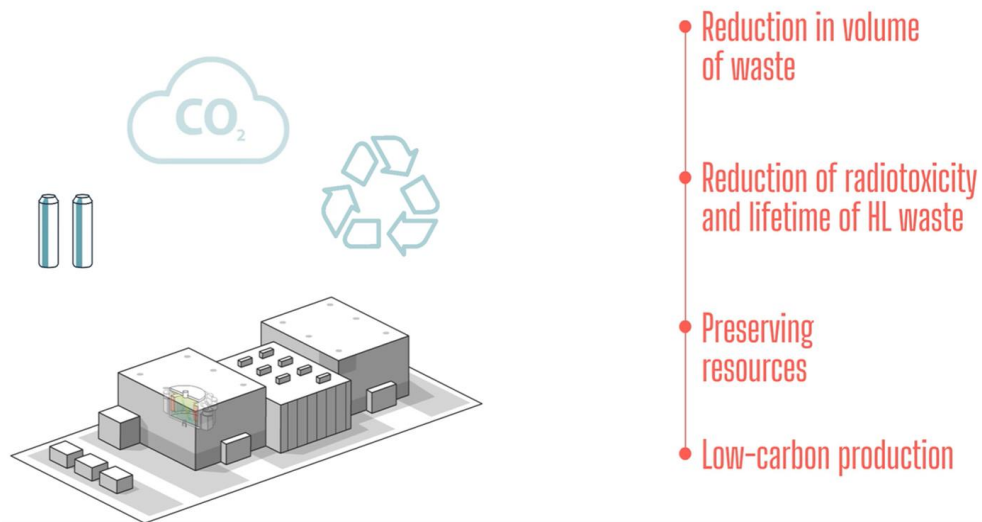
Seizing the potential of MOLTEN SALT REACTORS...

Orano is developing **innovative solutions** that bring value and progress for society's future. Its strategy is to accelerate its innovation cycles and explore new activities to serve its customers in tomorrow's markets, **for a more sustainable future.**



❖ **Although research fields and gaps in knowledge remain extensive, MSR is a promising and rapid evolving technology.**

- From a technological point of view, MSRs show significant advantages in terms of intrinsic safety, simplified fuel fabrication and FP management.
- There is a potential for combining multi-recycling options with chloride MSR, offering an even more integrated and responsible management of spent nuclear fuel and producing valuable isotopes for other applications.
- **Reducing the volume and the radiotoxicity of high-level waste is a strategic issue for the nuclear industry and MSRs can contribute to this objective through MA conversion**



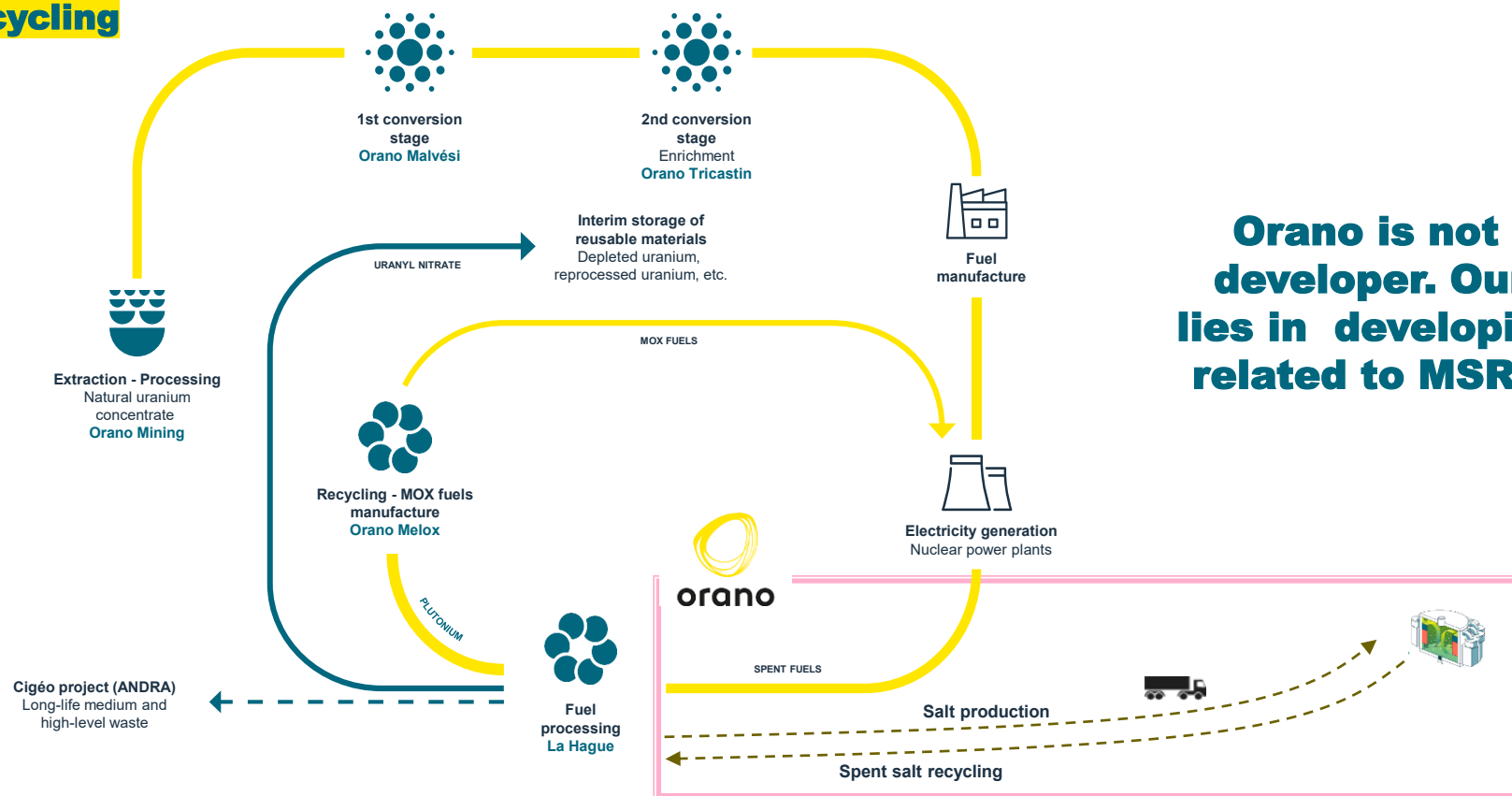
- **Operation in Pu or Pu+MA cycle, i.e., without Uranium** → harder neutronic spectrum and maximized consumption of Pu/MA
- **No fabrication of solid fuel** (complex at industrial scale with MA)
- **No cladding limitation to burn up**, so the actinides remain in the core until they fission and are thus totally "burned"
- **No degradation by MA of counter-reaction factors** → possibility to increase the MA content in the core (vs. LMFR with solid fuels)

... and evaluating the impact of Fast chloride MSR on the current and future nuclear fuel cycle

✓ Since 2019, Orano has been actively exploring the potential of **fast chloride MSR** actinide converters to enhance the value of the current Spent Nuclear Fuel reprocessing solutions proposed by the La Hague plant...

... via assessment of potential services related to salts throughout the entire nuclear fuel cycle.

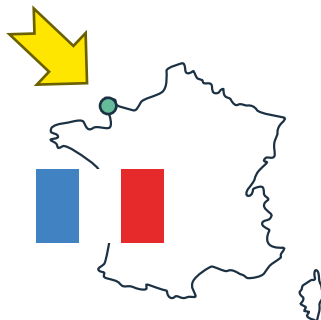
- **Salt production**
- **Spent salt recycling**
- Logistics



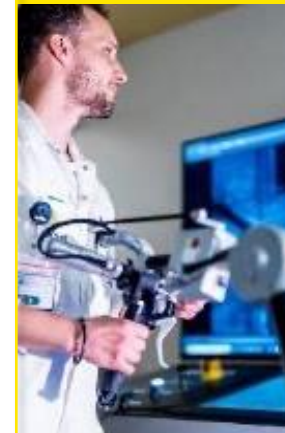
Orano is not a reactor developer. Our ambition lies in developing services related to MSR fuel cycle.

La Hague Hydrometallurgical Process

Decades of Industrial Experience



Orano La Hague



The La Hague site **processes nuclear fuels to recover and recycle energy materials** and produce new low-carbon electricity.

Orano's recycling activities

Generate over **10%** of nuclear electricity in France

55+ years of industrial experience

- ✓ **~41,000 tHM** of French and Foreign SNF reprocessed in La Hague over the past 55+ years
- ✓ French processing-recycling **strategy confirmed** by the Nuclear Policy Council in 2024

Launch of two key strategic projects

- ❖ **Sustainability and resilience program extending the life of the existing La Hague and Melox plants beyond 2040.**
- ❖ **Renewal of the fuel reprocessing plant and the MOx fuel manufacturing plant at La Hague site : a unique set of industrial assets operating through to 2120.**

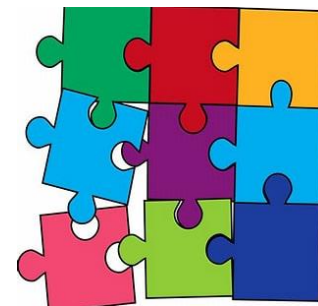


CPN, Feb. 26, 2024

MSR Fuel Cycle Scenarios

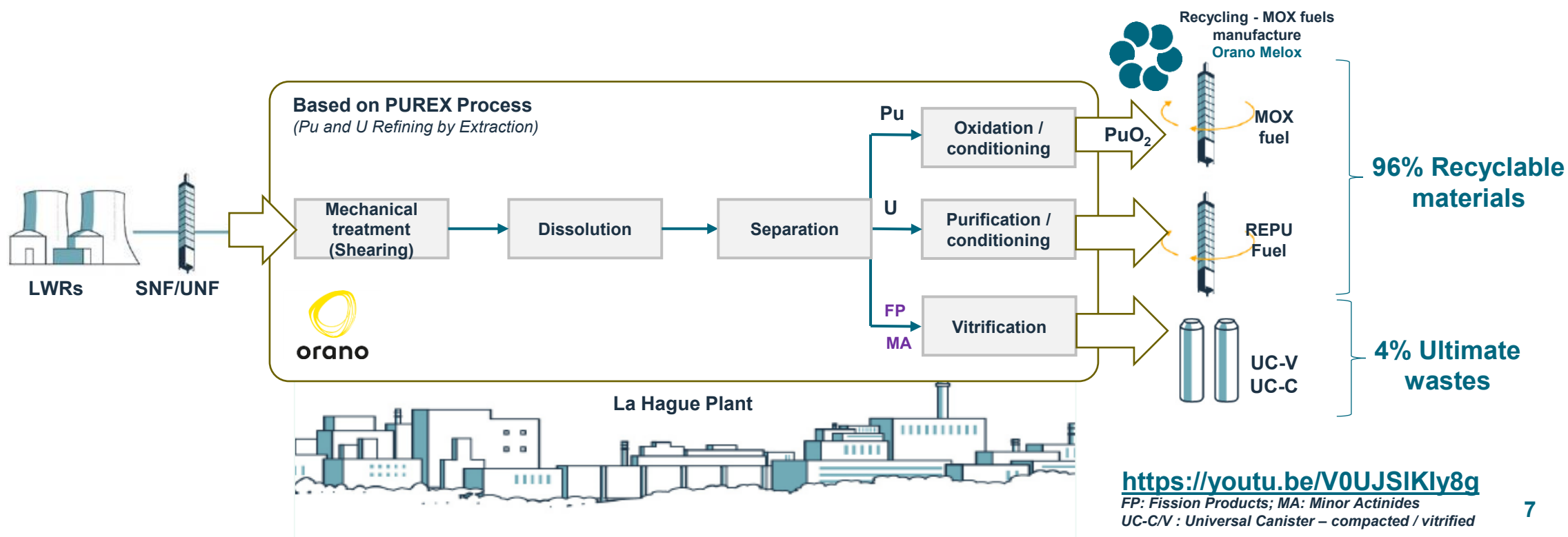
based on La Hague Processes

Leveraging synergies between MSR technology and La Hague plant can help build an industrial and **risk-optimized molten salt fuel cycle**



Chloride fuel salt cycle

- Soluble in water
- Compatible with La Hague hydrometallurgical processes



Synergies on the Front-End side

Salt production with fissile material recovered from LWR SNF treatment



PuCl₃ production

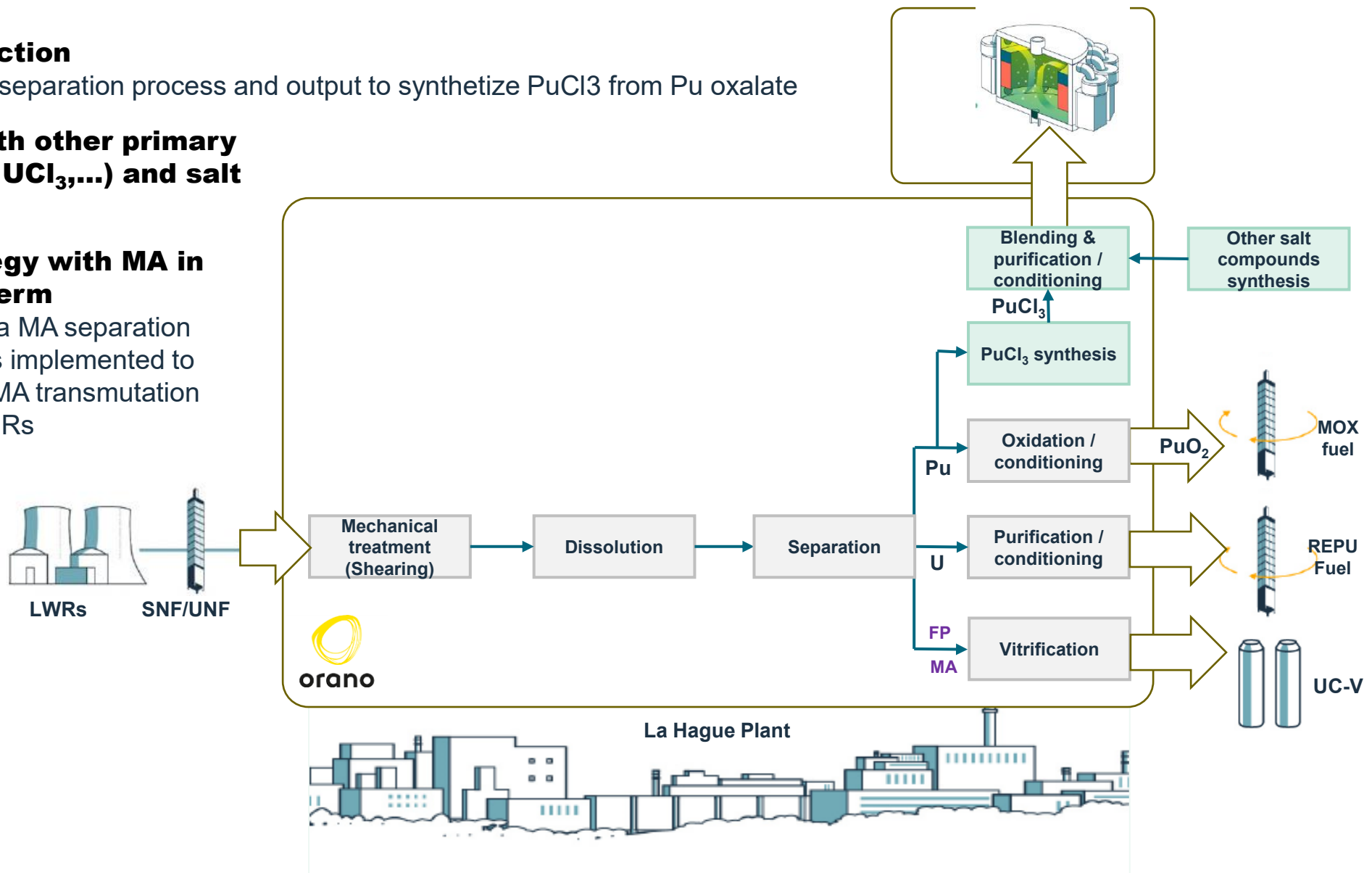
- Using Pu separation process and output to synthesize PuCl₃ from Pu oxalate

Blending with other primary salts (NaCl, UCl₃,...) and salt purification



Same strategy with MA in the longer term

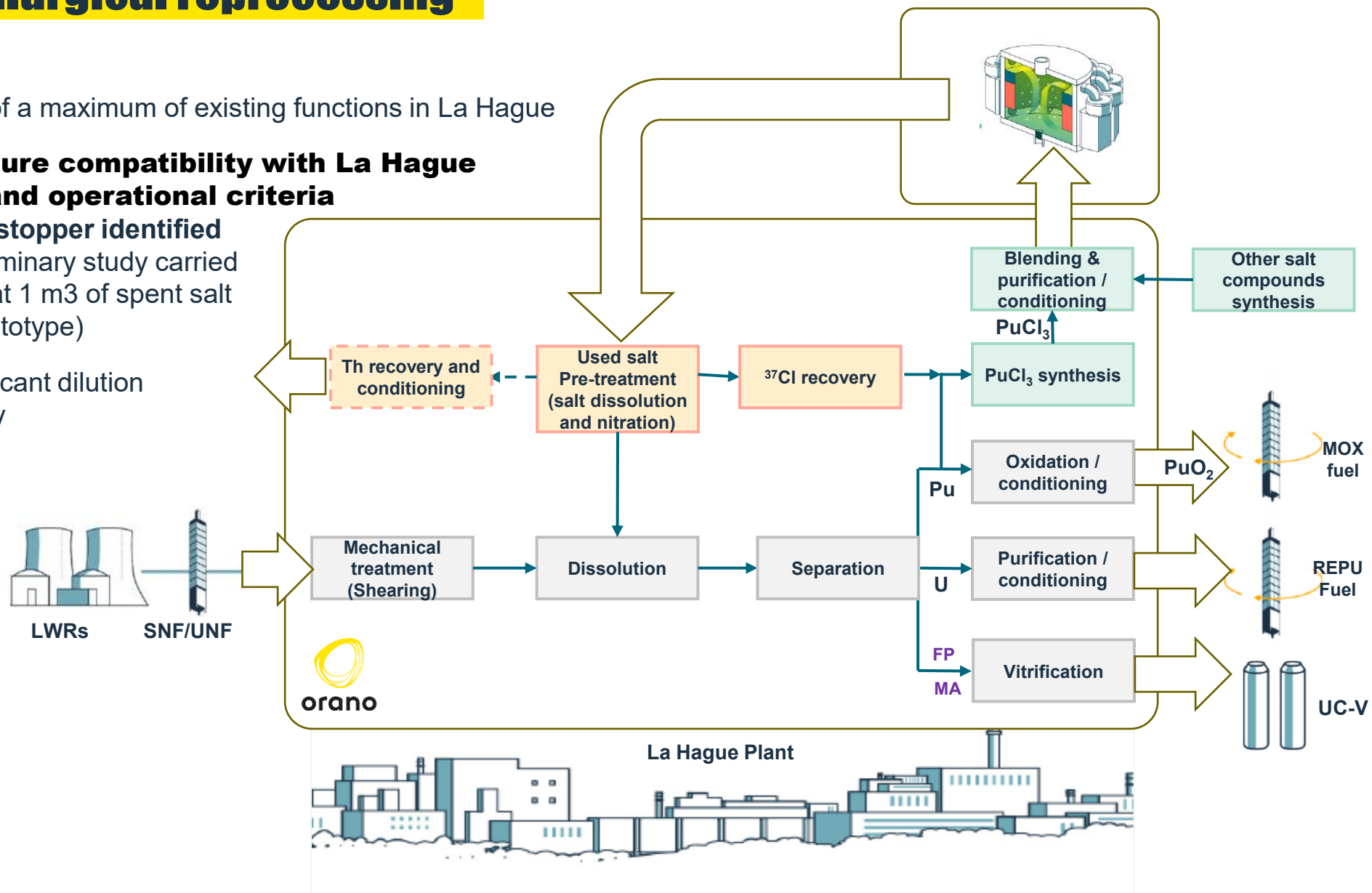
- Provided a MA separation process is implemented to allow for MA transmutation in fast MSR



Synergies on the Back-End side

Hydro-metallurgical reprocessing

- ✓ **Higher TRL**
 - Benefits of a maximum of existing functions in La Hague
- ✓ **Need to ensure compatibility with La Hague processes and operational criteria**
 - No showstopper identified after preliminary study carried out to treat 1 m³ of spent salt (small prototype)
 - But significant dilution necessary



Synergies in the Back-End side

Pyro-metallurgical reprocessing



Promising alternative : offer flexibility to be implemented on reactor site

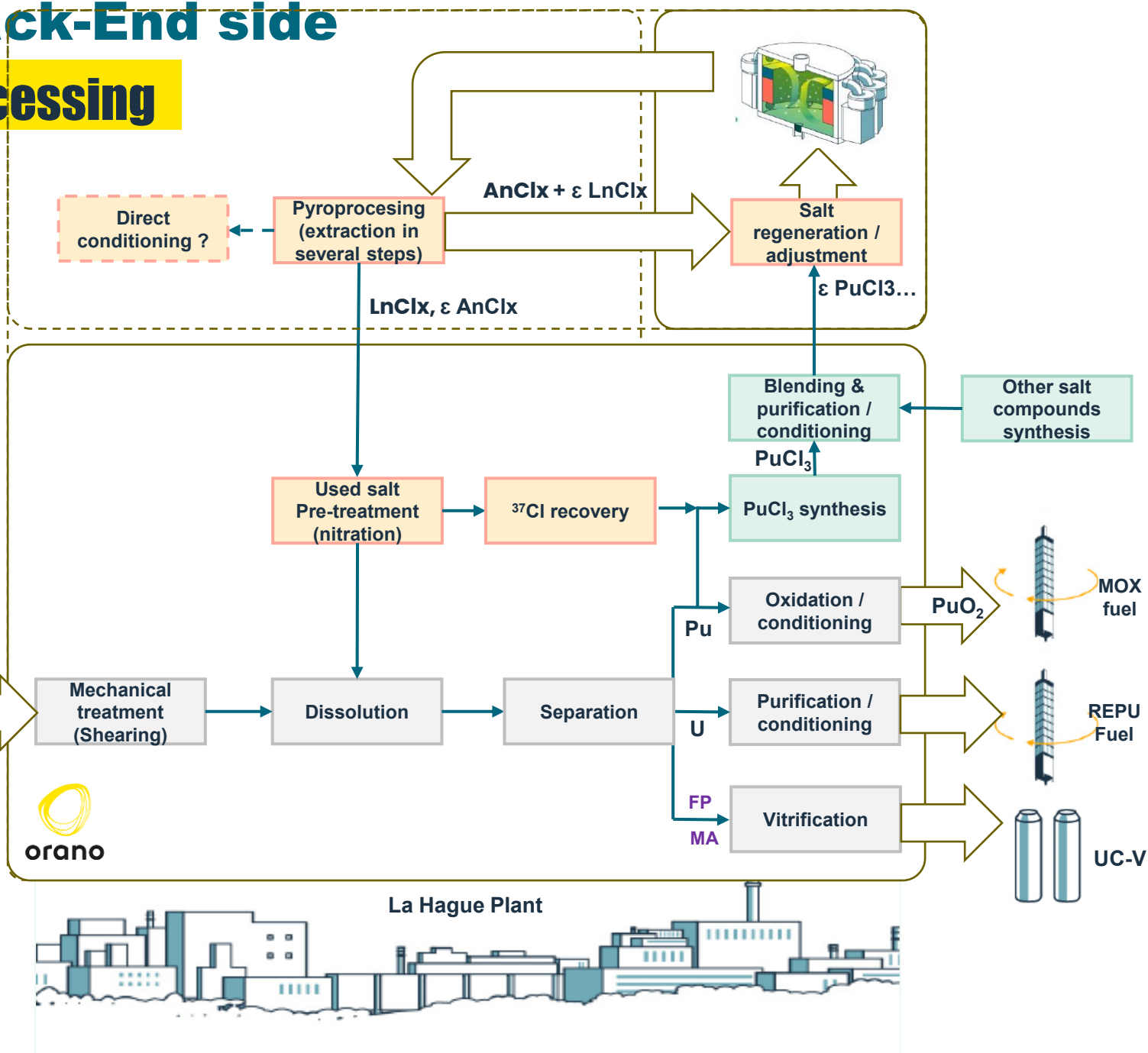
- Actinides directly recycled on site → less volume of spent salt (only waste) to be transported to La Hague
- Minimal cycle time → optimizes valorization of actinides
- Operates at higher temperature → minimizes temporary storage for cooling



Lower TRL

- Need to develop and scale up the most promising processes

Do not completely eliminate the need for remaining waste treatment / hydro-processing



Conclusions



Fuel salt production and the treatment of spent salt are **aligned with Orano's core business** : Orano has been actively exploring the potential of fast CI MSR and performing R&D on the fuel salt cycle since 2019

Chloride salt synthesis (with fissile material recovered from LWR SNF treatment) and spent fuel salt treatment can benefit from **decades of industrial experience** with La Hague SNF reprocessing activities : A key contribution to minimize time to market, risks and investment costs

Preliminary studies and R&D carried out in MIMOSA and ISAC collaborative projects **outline the feasibility and potential industrial implementation** of each of the hydro / pyro processing schemes in synergy with the La Hague plant

Hydrometallurgical treatment is more mature than pyrometallurgical treatment, and could become operational in a nearer future, **offering new perspectives in synergy with La Hague process never explored in the past**

A **MSR fuel cycle taxonomy** should take into account these new potential approaches



orano

Giving nuclear energy its full value