



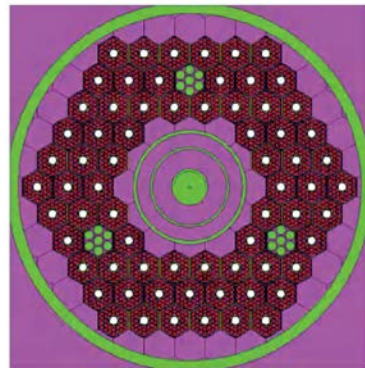
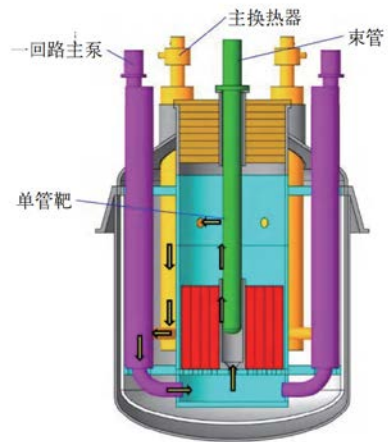
# **LFR update on fuel cycle activities**

Giacomo Grasso (Representative from LFR pSSC)

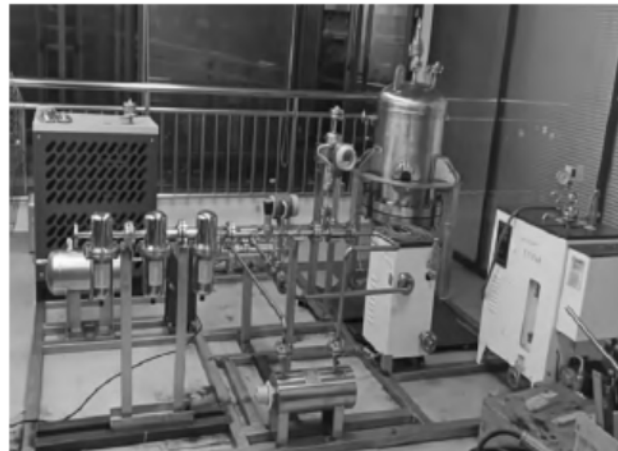
Deep Dive on Fuel Cycles  
April 15 - 2026, Hainan, China

# LFR Technology in China

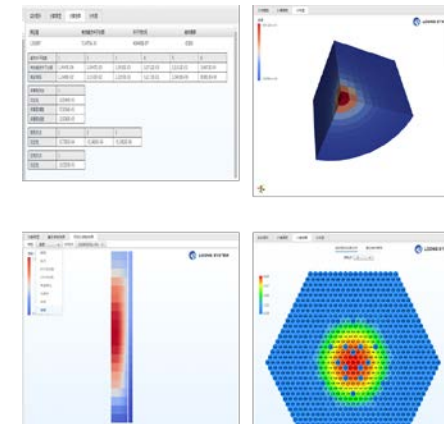
- **CiADS Led by CAS-IMP:** the environmental impact assessment for the first phase of accelerator has been approved in 2022; **The CIAE** undertakes the design and construction of the nuclear island main process systems; tendering for some equipment has been initiated.
- **LFR fundamental research is more active, especially primarily conducted by institutes and universities** (INEST, HFIPS, CAS, IMR, CAS, Xi'an Jiaotong Univ., Lanzhou Univ., Shanghai Jiao Tong Univ., Harbin Engineering Univ. etc. )
- **Nuclear power enterprises (CNNC, CGN, SPIC) were invested to the LFR conceptual design and validation activities in recently years**



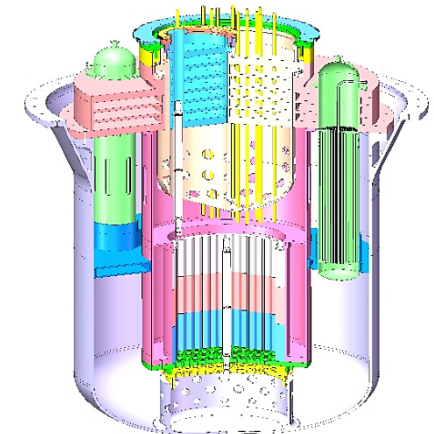
Layout of CiADS reactor and core  
by **CNNC**



Experimental on Migration mechanism of  
LFR radioactive aerosols  
by **CGN**



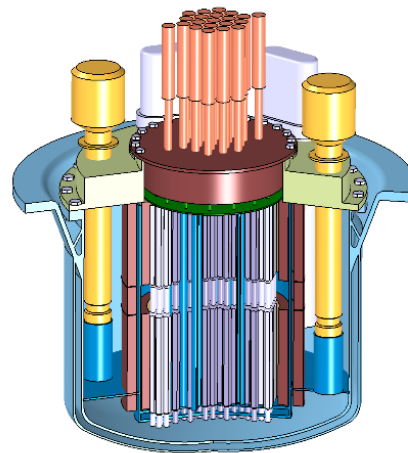
SARAX code for LFR  
by **Xi'an Jiaotong Univ.**



Offshore Floating LFR  
by **Lanzhou Univ.**

# LFR Technology in China

- **CLEAR series LFR developed by International Academy of Neutron Science (IANS)**
  - ✓ **CLEAR-M**: Small modular transportable reactor with 10MWe
  - ✓ **CLEAR-200**: Small modular LFR with 200MWth
  - ✓ **CLEAR-A**: 1GeV/10mA proton accelerate coupled with 100 MW<sub>th</sub> LFR
- **Validation platform for CLEAR**
  - ✓ **NIRVANA**: Verification Platforms were built to support LFR engineering verification
  - ✓ **CLEAR-M0**: pool-type integration verification facility, >5MWth, **started commissioning and core outlet temp. reaches 550°C**



CLEAR-200



NIRVANA

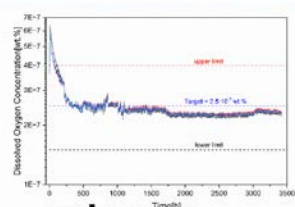




# LFR Technology in Europe

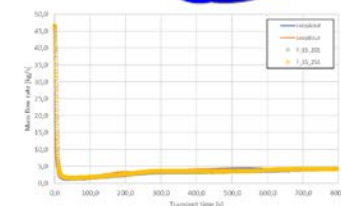
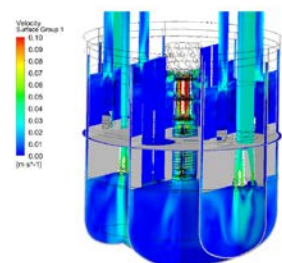


sck cen



sck cen

PATRICIA



## LESTO LEad fast reactor Safety design and TOols

EURATOM2027: Safety of advanced and innovative nuclear designs

Duration: 4 years (until October 2028)

EU contribution: ~ 4 M€

SNETP Label

Main Objectives:

- Integration of LFR technology with renewable energy sources (RES) and life cycle of LFR reactor fuels
- Post-accident long-term management and decay heat removal
- Coolant purification, oxygen detection and control for a pool-type configuration, release and transport of fission products
- Corrosion protection in Pb at high temperatures (up to 650°C), flow-induced erosion and fretting phenomena
- Building up of a representative database for LFR pool thermal-hydraulic for V&V of numerical approaches (STH, CFD, multiscale approach) for large pools both in steady state and transient conditions



Funded by the European Union

This project has received funding from Horizon Europe - Euratom programme under grant agreement No 101166337. Project coordinator: ENEA (main contact: Simone Gianfelici - simone.gianfelici@enea.it)

## Key results

### Fuel element system

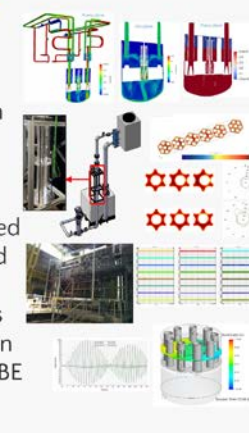
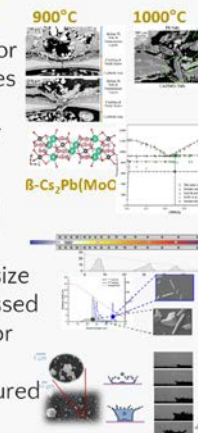
- Phase equilibria for main radionuclides in JOG-Pb/LBE
- Kinetics of high-T JOG-clad-Pb

### Containment system

- Aerosol particle size distribution assessed
- Aerosol and vapor transport and deposition measured

### Reactor coolant system

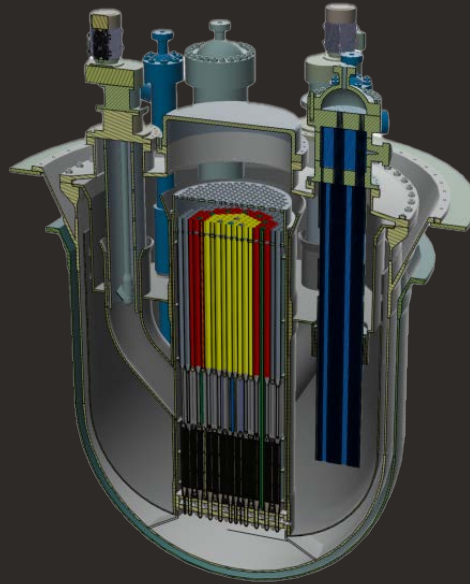
- Mesh validated for asymmetric flow
- Turbulence fields in deformed bundles captured
- Vibration modes & frequencies assessed for bundle (FIV) and pool (sloshing)
- Ultra-sonic sensors tested on calibration block exposed to LBE



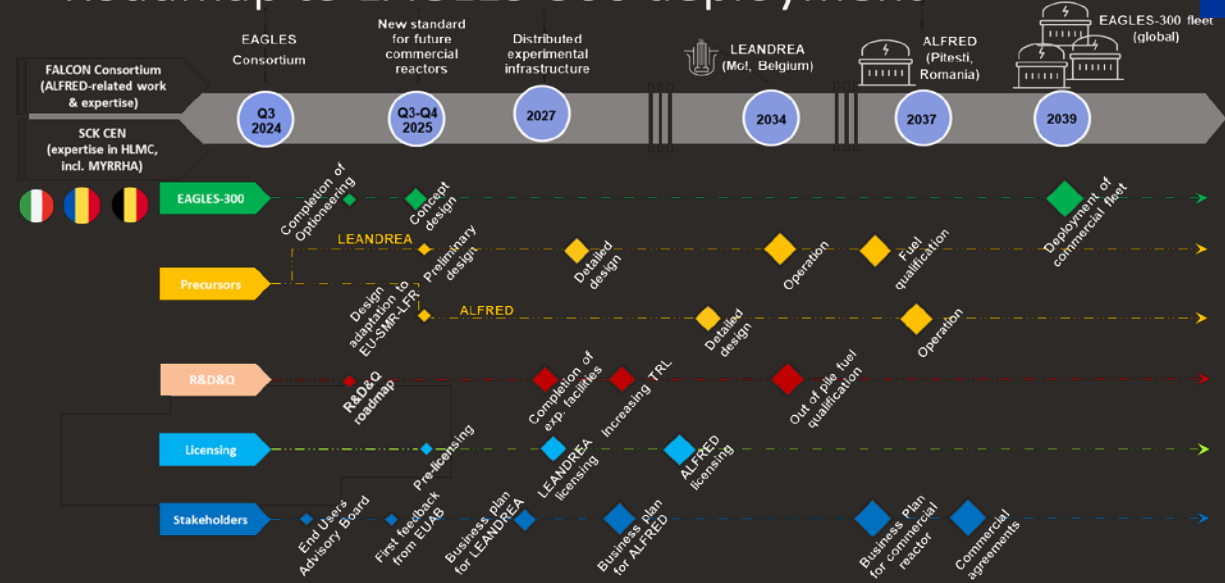
PASCAL

# EAGLES-300

- Competitive economics
  - LCOE looking at future EU energy mix
  - Replacement of fossil fired plants
- Proven passive safety features
  - Enhanced grace time
  - Limitation of EPZ
- Sustainable closed fuel cycle
- High temperature heat
  - 520°C baseline / >600°C prospect
  - Hard-to-abate sectors
- Customers oriented
  - Utilities
  - Industrial districts
- Commercial fleet deployment by 2039



## Roadmap to EAGLES-300 deployment



## Licensing Focus

### Concept

Initial design validation  
R&D&Q roadmap  
Time-to-market driven solutions

### Pre-licensing

Multilateral engagement  
IAEA extra-budgetary project  
BE, RO, IT involved

### Early Permits

Harmonized standards  
LEANDREA as pathfinder  
ALFRED for standardization

### Serial FOAKs

Building on a standardized approach  
Opening to an EU framework  
Exploiting serial effect



LEANDREA pre-licensing application officially started in May 2025, leveraging previous experiences.



In 2017, a preparatory phase to the authorization process of ALFRED was started with CNCAN



ISIN joined the EAGLES international pre-licensing programme in September 2025 as observer

Three regulators, one file: towards EU harmonization

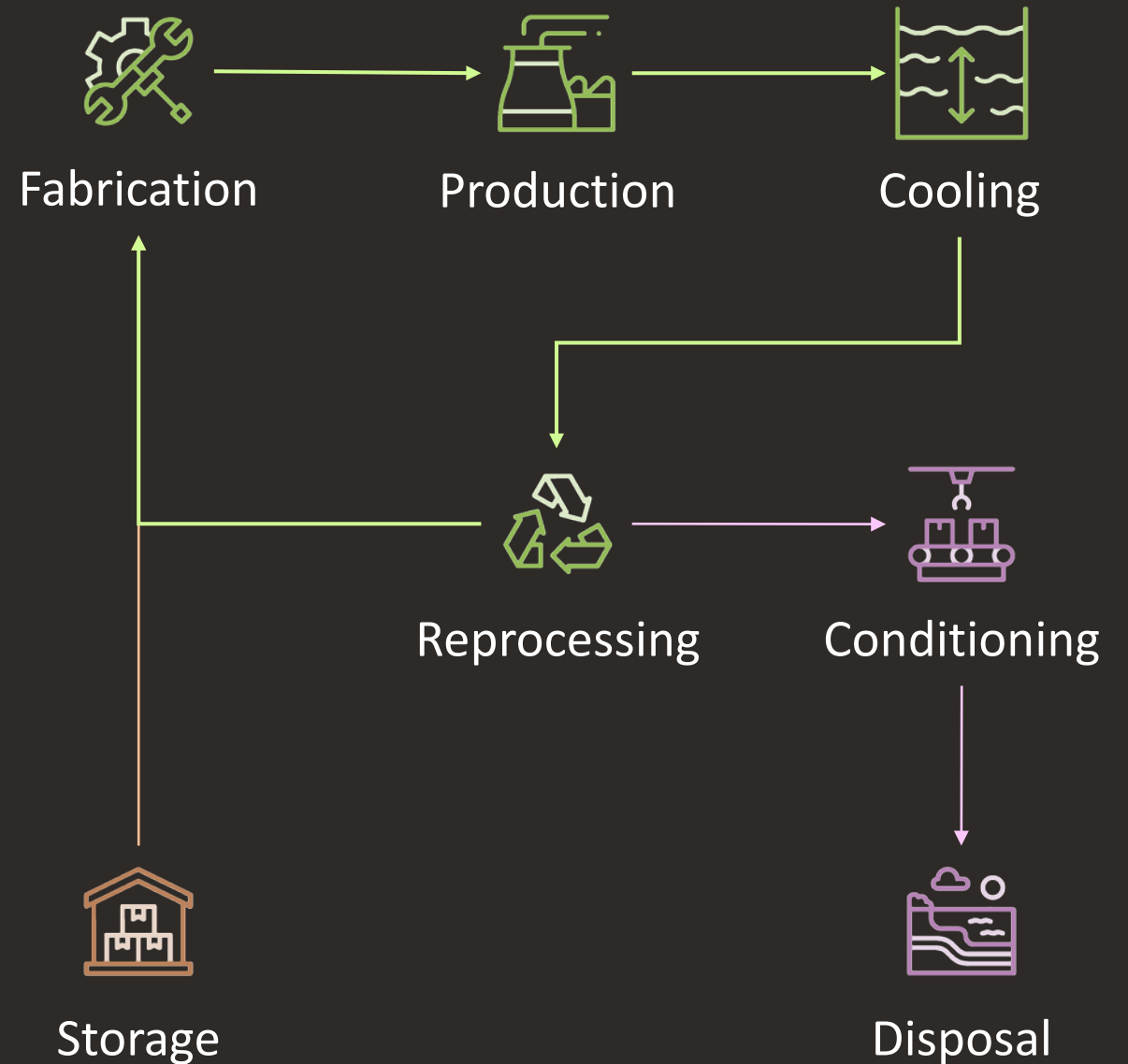


EAGLES and newcleo join forces on LEANDREA

# EAGLES's vision

To deploy a safe and economic lead fast reactor able to cope with the **closure of the fuel cycle**, in a long-term availability strategy.

For this, a reactor is sought, operating around the **iso-breeding point**, for maximum flexibility also within breeding and burning modes, if requested.



# Building blocks in a European joint framework



## Fuel manufacturing:

- the reference option is to support European actions, jointly with other designers, for the establishment of a **common fuel supply chain** for fast reactors;
- as a backup (including for bridging gaps in the shorter-term), a new supply chain can be built **internal to the Consortium**, around the knowledge and expertise of SCK CEN.



## Fuel reprocessing:

- the confirmed long-term strategy of fuel reprocessing in France, with the renewal and extension of the La Hague reprocessing plant, represents the reference solution for a **centralized European hub**.



# A new, innovative player in nuclear energy

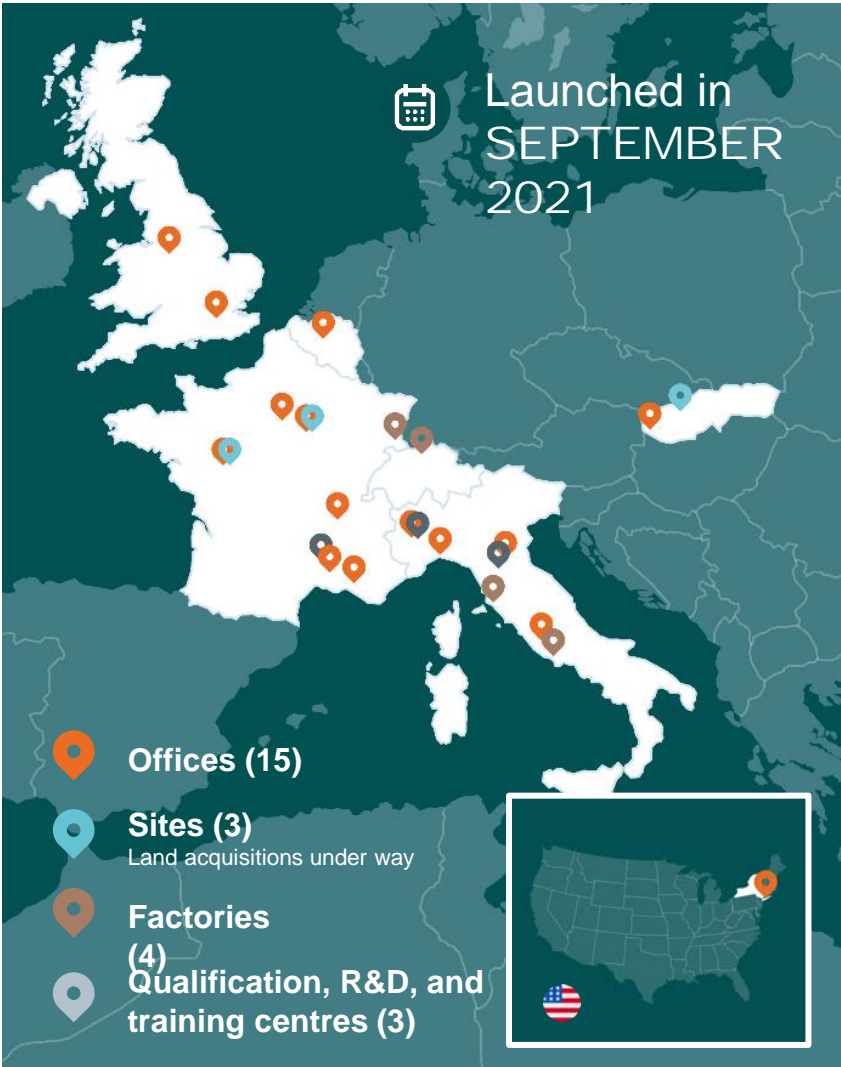
REACTOR DESIGN:  
Small Modular (SMR) +  
Lead-cooled Fast Reactors  
(LFR) = AMR  
newcleo is working to design, build, and  
operate Gen-IV Advanced Modular  
Reactors (AMRs) cooled by liquid lead

FUEL MANUFACTURING:  
Mixed Uranium Plutonium  
Oxide (MOX)  
MOX and Fast Reactors allow the multi-  
recycling of nuclear waste into new fuel  
with no new mining for generations

INTRINSICALLY SAFE power production

COMPETITIVE energy cost

CIRCULAR nuclear waste recycling



- ↑ €645 million of private funds  
~€70 million revenues in 2024
- ✓ French first **licensing stage completed** for the reactor in **Chinon** and the fuel production facility in **Nogent**
- » Selected by **France 2030** and the **European Industrial Alliance on SMRs**

900+  
EMPLOYEES  
GLOBALLY

30+  
YEARS of  
leadership  
in Lead  
Technology

25  
PATENTS

Highly specialised EPCM capabilities

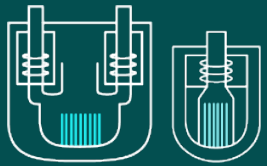
FUCINA ITALIA  
A newcleo company

S.R.S.  
A newcleo company

RUTSCHI  
A newcleo company



# A long-term vision centred on safety, costs and sustainability



Reactor technology:  
AMR: SMR + Gen-IV LFR

## LEAD-COOLED

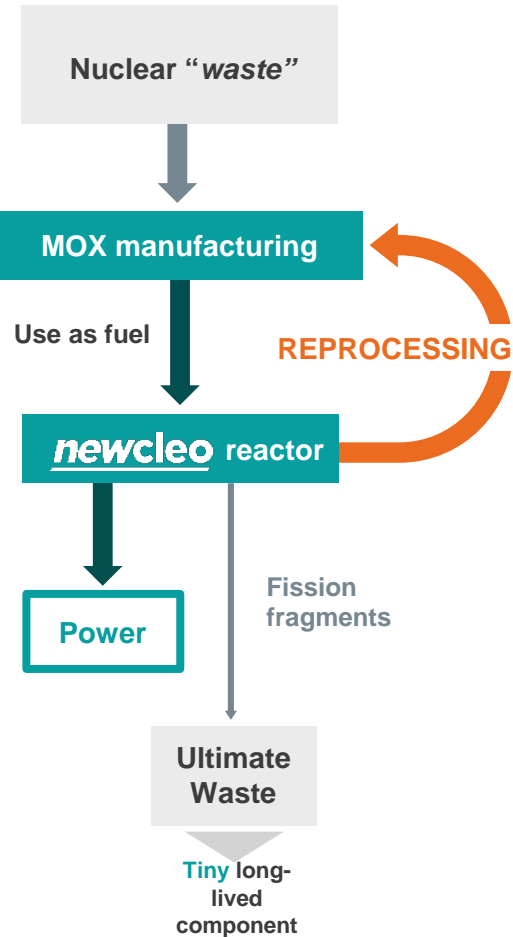
High temperature | Compact and simple | Intrinsic safety

## FAST NEUTRON SPECTRUM

Low production of nuclear waste | Able to recycle reprocessed spent fuel

## SMALL MODULAR REACTOR

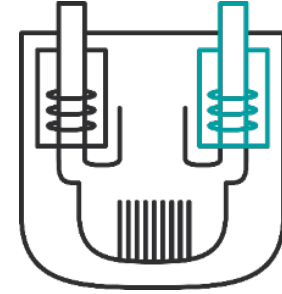
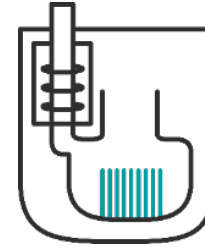
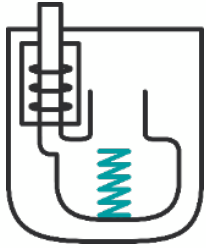
Faster construction | Site flexibility and industrial heat production | Further economies from series and modularisation



Fuel: MOX

- MOX is made of reprocessed spent fuel. A clean solution to the issue of costly and **long-lasting nuclear waste disposal**, but also a protection against future high, oscillating Uranium costs and availability
- The **long-term strategy** will eliminate the need to mine new uranium, enable **energy independence**, and reduce the volume headed to geological repository
- Spent fuel will be **reprocessed** multiple times. The unavoidable waste is less than **1t of fission fragments** (radioactive for 250y) from one year's generation by a 1GWe of *newcleo* LFRs vs. **200t** of nuclear waste from conventional reactors (radioactive for 250,000y)

# newcleo's plan-to-market



## R&D and Precursor

2026

Several R&D and qualification facilities, and a **10 MW non-nuclear reactor** with turbo-generator (Precursor) built in ENEA-Brasimone

Design, manufacturing and operation in progress

## MOX production

2030

**FR-MOX production facility**, starting from available (separated) material in France

Basic Design in progress  
Licensing in progress for both facilities

## LFR-AS-30

2031

**30 MWe** nuclear irradiation reactor with core outlet at 440°C and later 530°C in France

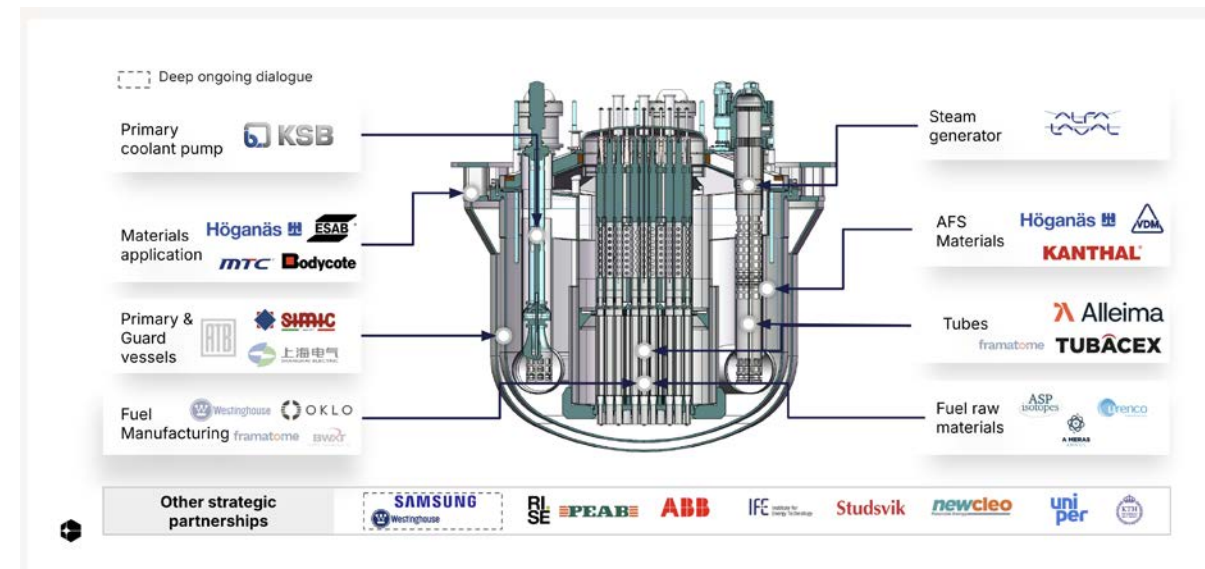
## LFR-AS-200

2033

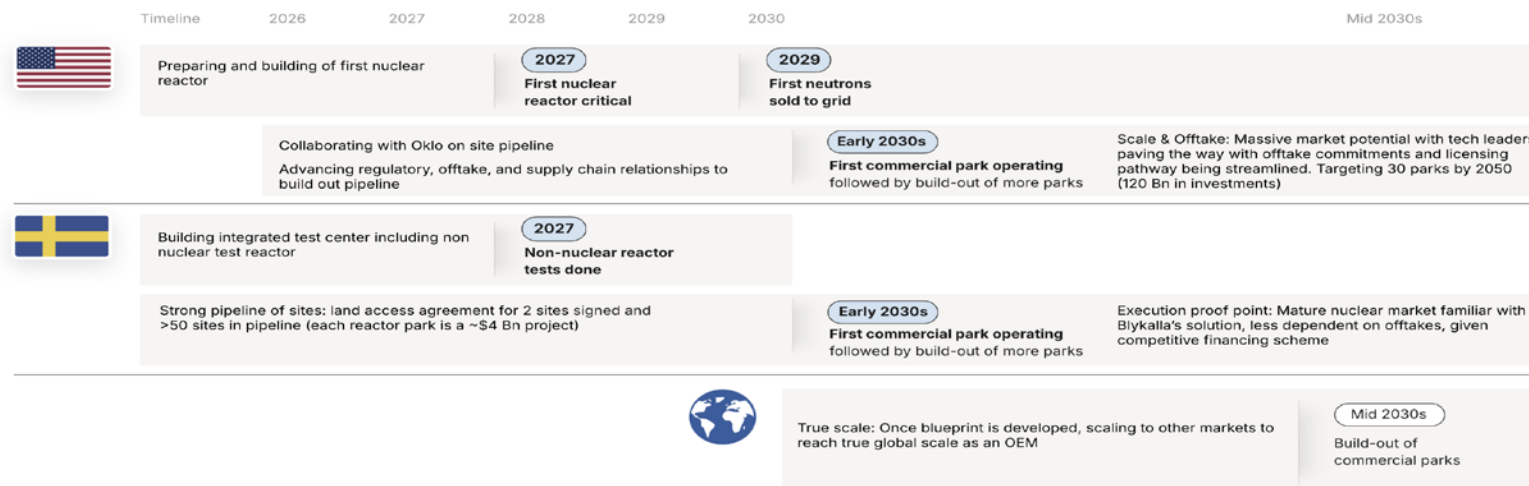
**200 MWe FOAK**, also for non-electrical uses (e.g. cogeneration and chemicals production)

Basic Design in progress

Ongoing M&A Acquisition programme



## Executing on a dual US-Sweden strategy



Raised \$100m to date of which ~\$50m in Series A2 round co-lead by Oklo





# Summary of ROK Status

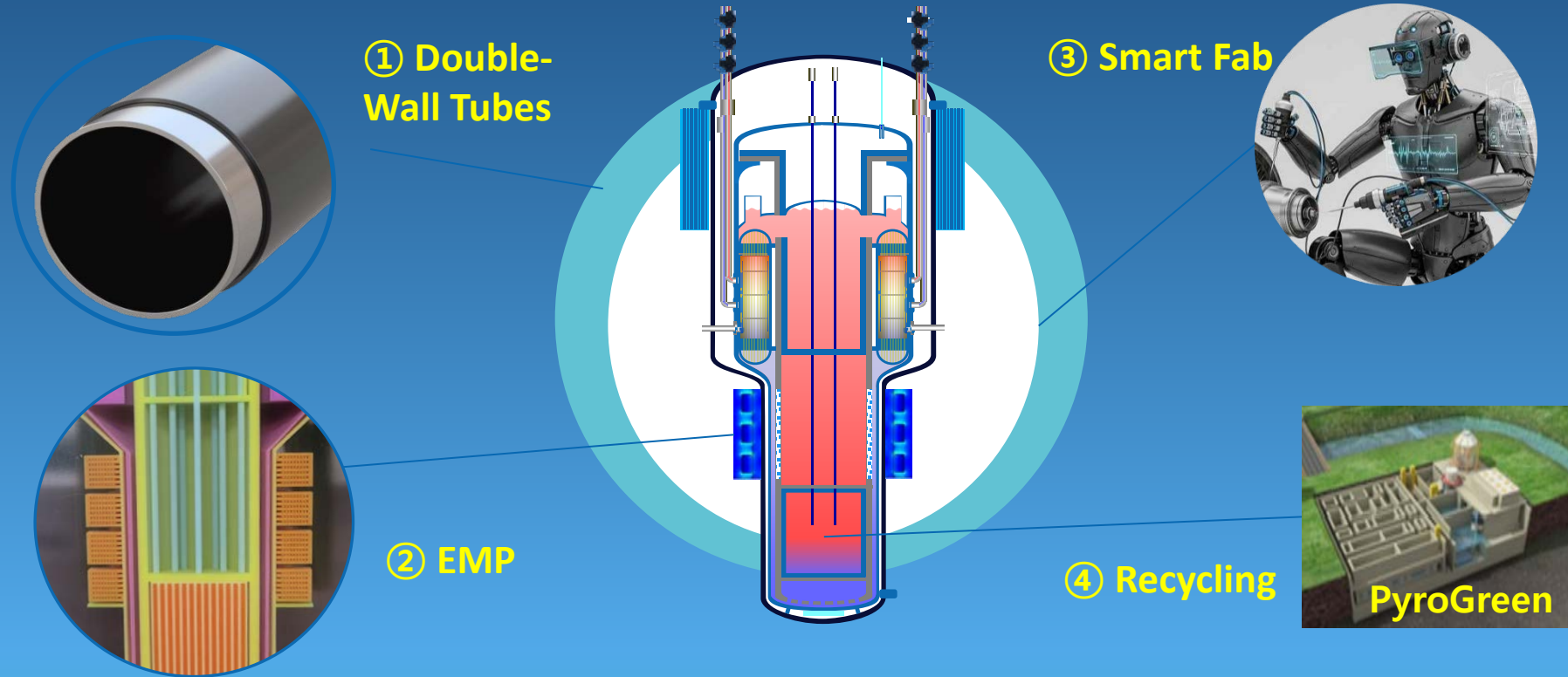
- I. MicroURANUS with 20 ~ 30 MWe rating cooled by Lead-Bismuth Eutectic is being developed for life-of-service without refueling as co-located power supply to autonomous systems.
- II. Development in progress for materials, components and systems including doubled-wall tubes, pumps, smart fab and recycling technology.





## II K-Advanced Reactor Development Program

Freedom Power  
MicroURANUS



- World energy consumption in 2022: 580 million terajoule or 14 Billion TOE = 20,000 GWe-Yr <https://terrapass.com/blog/impact-world-energy-consumption-and-solutions/>
- By 2050, world energy consumption is expected to grow by a factor of two.

# LFR Technology in USA

## Industry Developments

### First American Nuclear Company (FANCO)

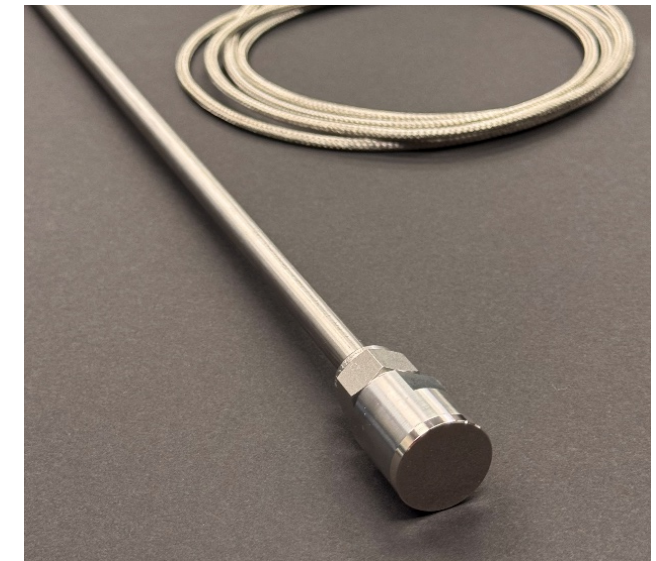
- Formed in 2025
- Development of 100% factory built and tested 240 MWe LBE-cooled loop-type EAGL-1 reactor
- Proprietary Bridge Power™ Solution to start with gas plant, then switch to reactor

### GuidedWave (FBS, Inc.)

- Advanced High-Temperature Ultrasonic Sensing Arrays for Under-Lead Viewing and NDE
- U.S. Dept. of Energy Phase I SBIR Award
- Tested in water, bismuth, and lead



*EAGL-1 Loop Type Fast Reactor*

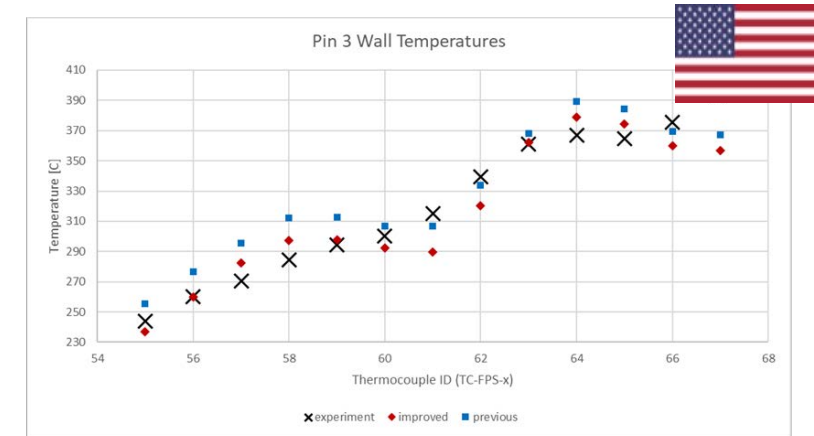


*Single-element prototype ULV sensor with down-rod*

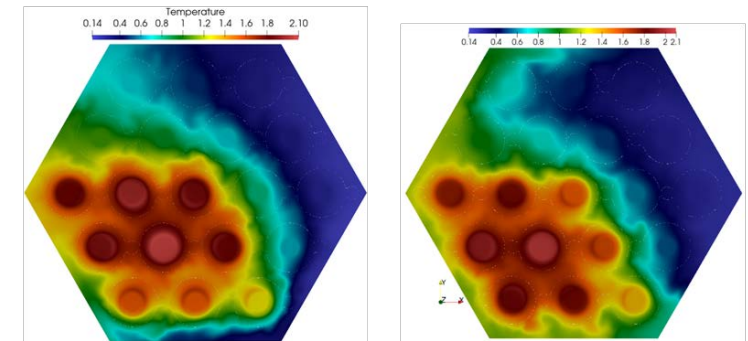
# LFR Technology in USA

## DOE-funded projects

- Participation in **IAEA NACIE Benchmark CRP (ANL)**
  - Fast Reactor Program
  - System-level, subchannel, and CFD codes
  - Simulation of all benchmark tests completed in 2025
- **Liquid Lead Suspended Fuel Subcritical Fission Blanket for Nuclear Waste Transmutation**
  - ARPA-E Nuclear Energy Waste Transmutation Optimized Now (NEWTON) project
  - 2025 – 2028 (3 years)
  - Unique in-core material of fission blanket system brings multiple innovations



Comparison of pin 3 wall temperatures for ADP07-SS2



## Deep dive into LFRs' Fuel Cycles

- All designers acknowledge the unique features of LFRs, notably
  - hard spectrum → for enhanced breeding and reduced equilibrium concentration of minor actinides,
  - wide safety margins → minor actinides loading allowed even beyond equilibrium for transmutation,
  - reduced operational hazards → for practical exploitation of several concepts.
- All such features are leveraged in design to exploit a broad range of fuel cycle options:
  - uranium fueled reactors in once-through,
  - long-life battery-type reactors with centralized reprocessing,
  - uranium-plutonium fueled reactors in closed fuel cycle for resources use optimization,
  - minor-actinides-bearing U-Pu fueled reactors in closed fuel cycle for waste management,
  - lead-suspended fueled targets for deep waste burning.



## Deep dive into LFRs' Fuel Cycles

- Few designs are being (initially) proposed with fuel options, and for deployment in regions, where full-scope capabilities for the rest of the fuel cycle exist.
- In most cases, efforts are needed to establish a complete supply chain for fuel procurement, as well as for spent fuel reprocessing. Among the most remarkable cases:
  - in Europe, initiatives are being started, and intents are conglomerating, for centralized manufacturing services; centralized reprocessing also appears as the reference option, revolving around the French longstanding tradition and expertise;
  - in the USA, discussions are restarting at government level on the possibility for spent fuel reprocessing; some developers are also deploying plans for a new capacity for fuel fabrication (both metallic and oxide);
  - research for non-aqueous reprocessing is also being pursued (e.g., in ROK).