Lead-cooled Fast Reactors: an opportunity for closing the fuel cycle
newcleo was incorporated in September 2021 and since then raised €400 million, and is running a capital raise of up to €1 billion.

The company has more than 450 employees across Europe, has completed 3 acquisitions and has several partnerships.
REACTOR TECHNOLOGY: GEN-IV LEAD-COOLED FAST REACTORS

Fast reactors allow a more efficient use of fuel, and lead’s intrinsic characteristics, together with our design provisions, enhance safety and reduce costs.

DESIGN: SMALL MODULAR REACTORS

Designed to be manufactured at a plant and transported to a site for installation, economies of scale → economies of series.

FUEL: MIXED OXIDE

newcleo is investing in MOX fuel manufacturing, using plutonium and depleted uranium from the current nuclear industry and allowing multi-recycling.

AS-200
200 MWe terrestrial module

TL-30
30 MWe battery, also for maritime
Learning from the past: the LFRs advantages

**Similar concepts**
Liquid-metal fast reactors, same fuel, thermal-hydraulics and mechanical aspects, can be burners or self-breeders

**More promising in terms of cost and safety**
- Lead doesn’t react with air or water in an intense way like sodium, hence no intermediate loop needed and DHR systems can be simplified
- No shielding assemblies needed thanks to lead properties
- Favourable neutronics allow large pitch-to-diameter ratio, reducing pressure losses (despite the much higher density), enhancing natural circulation hence the safety performance
- Combined with the high boiling temperature, LFRs have an advantage in coping with severe accident initiators like ULOF, ULOHS, TLOP

<table>
<thead>
<tr>
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<th>Sodium</th>
<th>Lead</th>
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<tbody>
<tr>
<td><strong>Density [g/cm³]</strong></td>
<td>0.847</td>
<td>10.48</td>
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<tr>
<td><strong>Melting temperature [K]</strong></td>
<td>371</td>
<td>601</td>
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<tr>
<td><strong>Boiling temperature [K]</strong></td>
<td>1156</td>
<td>2023</td>
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**Lead challenges**
- High density impacts on seismic performance, need for a short vessel
- Erosion concerns limit coolant velocities
- Enhanced material are being studied to withstand corrosion at high temperature

Technical solutions can be identified to maximise compactness and density of the primary system, up to 4x more than SPX1
Thermal fission reactors use a very small portion of the extracted uranium: an average 1GWe LWR uses every year 200t of mined uranium of which only 1t is fissioned (Fission Products), the rest today goes to “waste”.

Today:

- **CONVENTIONAL REACTORS**
  - Mineral extraction and conversion
  - Natural Uranium
  - Enrichment
  - Low Enriched Uranium
  - Depleted Uranium
  - Thermal Nuclear reactor
  - Fission Fragments
  - Plutonium/Minor Actinides
  - Disposal

The future: newcleo SOLUTION

- MOX factory/reprocessing
- Fission Fragments
- LFR reactor
- Disposal
- Long-lived waste
- Multiple times

Fast Reactors and fuel reprocessing can extract energy from existing material and at the same time reduce radiotoxicity of residual waste to dispose: Fission Products return to value of the natural uranium ores after ~250 years.

High-level waste has become an expensive liability.

All artificial radioactivity created by reactors is virtually gone.
**Precursor**

10 MW electrically heated/non-nuclear facility with turbogenerator

It reproduces scaled or full-scale components of the LFR-AS-30

**LFR-AS-30**

30 MWe nuclear module with core outlet at 430/440° (later 530°), using MOX as fuel

Demonstrator and test reactor

**LFR-AS-200**

200 MWe nuclear SMR, for stand-alone or multi-module configuration, using MOX as fuel

First-Of-A-Kind (FOAK) reactor

**LFR-TL-30**

30 MWe mini nuclear reactor for industrial and maritime applications

Working as a nuclear battery, with infrequent refuelling (10y +)
**ENEAA-Brasimone non-nuclear experimental facilities**

- **CAPSULE**  
  Operational in February 2024  
  Facility to test various kinds of steel, bare and coated, in stagnant lead under oxygen-controlled concentration, essentially between $10^{-8} - 10^{-6}$ wt.%; temperatures span between 450 - 750 °C.

- **CORE 200 kW**  
  Operational in March 2024  
  Loop-type facility to test various kinds of steel, bare and coated, in fluent lead under oxygen-controlled concentration, essentially between $10^{-8}$ and $10^{-6}$ wt.%; temperature in the corrosion test section 650 °C and velocity 1 m/s; in the erosion test section the temperature is 520 °C and the velocity 10 m/s.
  It will also be used to test the effectiveness of cold traps and mechanical filters.

- **OTHELLO 2 MW**  
  Operational in 2025  
  Loop-type facility with a Fuel Pin Bundle Simulator and a mock-up of newcleo Steam Generator with three full length tubes. It will be used to test a Fuel Pin Bundle Simulator to validate thermal-hydraulic computer codes, to appreciate the consequences of partial inter-pins obstructions.
  Also, to test the behaviour, both lead side and water/steam side, of the Steam Generator.

- **PRECURSOR 10 MW**  
  Operational in 2026  
  Pool-type integral test facility with an electrical resistors bundle, and three Steam Generators at a thermal reduced scale, and the associated turbine-generator set. It will be used to test the global behavior of the plant in stationary and transient mode, the inlet of lead flow both in hot and cold plenum and of possible stagnant zones, the effectiveness of the DHR system, test various mechanisms as the control rods.

- **MANUT**  
  Conceptual phase  
  It is a "cold" facility to test the fuel hanging and handling systems as well as the rotating plugs operation during refueling campaign. This facility is just at a first conceptual draft.

**Partnership signed in March 2022**: ENEA unique global know-how and newcleo 25-30 engineers and EUR50+ million for about 10 years. Renovation works started in June 2022.
Increasing numbers of partners and suppliers
Developing next generation of nuclear talent, supporting knowledge sharing, promoting diversity
Thank you

Stefano BUONO

newcleo

Futurable Energy