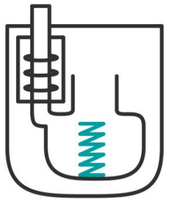
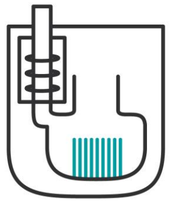
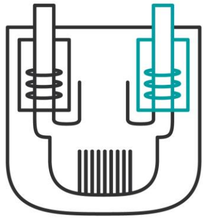
newcleo's R&D programme

04 June 2024 – Università degli Studi di Palermo

newcleo's plan-to-market







MOX

AS-30

AS-200

2026

2030

2031

2033

R&D and Precursor

Several R&D facilities, and a **10 MW** non-nuclear facility with turbo-generator

MOX production

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

LFR-AS-30

30 MWe nuclear irradiation reactor with core outlet at 430/440° (later 530°)

LFR-AS-200

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

Design, manufacturing and operation in progress

Basic Design and pre-licensing in progress:
technical meetings with ASN and IRSN started in mid-2023

Conceptual design in progress

R&D is at the core of *new*cleo's DNA

In parallel to engineering activities, *new*cleo's R&D programme is progressing fast: findings are key in the completion of the reactors' design and licensing processes.

UNDERSTANDING

CHARACTERISATION

QUALIFICATION

VALIDATION

ASSESSMENT

OPERATION AND SAFETY

DEMONSTRATION

- **Structural materials and coatings**
- **Fuel and fuel integrity**
- **Primary coolant behaviour and chemistry**
- **Core integrity**
- **Primary system integrity**
- **Instrumentation and Control (I&C)**
- **Reactor physics / neutronics**
- **Components handling systems**
- **In-Service Inspection (ISI) and repair**
- **Balance of plant**
- **Plant operation and accident response**

SIMULATION AND EXPERIMENTAL CAMPAIGNS

Close technological partnership with **ENEA** and notable contributions from *new*cleo's **SRS** and **FUCINA ITALIA**

Collaborations with labs and universities

Ongoing conversations with specialised companies

Large investments: **EUR100+ millions allocated**

ENEA-Brasimone non-nuclear experimental facilities and lab

CAPSULE
operational since December 2023

STAGNANT LEAD TESTING under controlled oxygen content at **400 - 750 °C**

CORE
200 kW
operational since April 2024

FLOWING LEAD TESTING under controlled oxygen content **w/cold trap** and **mechanical filters**. Corrosion test section at **1 m/s up to 650°C** and erosion test section at **10 m/s up to 520°C**

OTHELLO
2 MW
operational in 2025

LOOP FACILITY simulating a **FUEL PIN BUNDLE + STEAM GENERATOR PROTO**

PRECURSOR
10 MW
operational in 2026

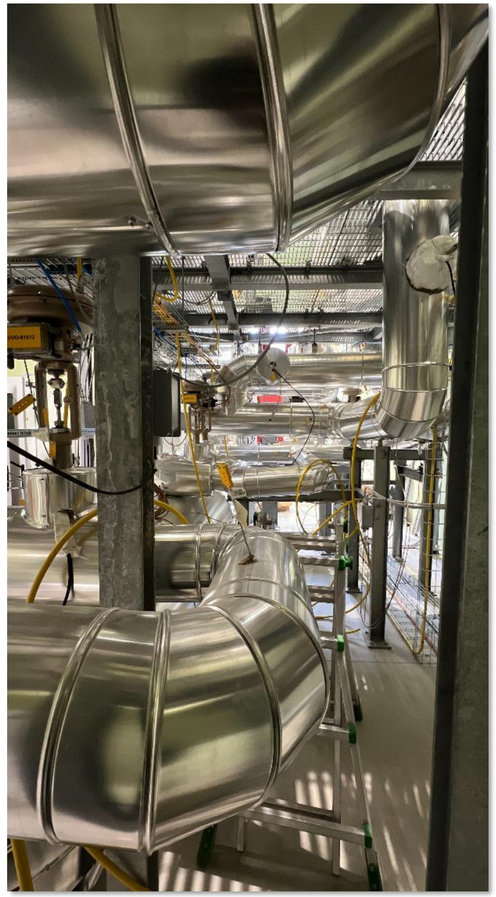
POOL TYPE INTEGRAL TEST FACILITY with electrical resistors, DHR, CRs and 3 SGs + turbine

BRASIMONE LAB
operational in 2025

Tensile, creep, creep-fatigue, SSRT, fatigue, fracture mechanics in Pb

90 MEUR investment in ENEA Brasimone

CAPSULE module



CORE - portion

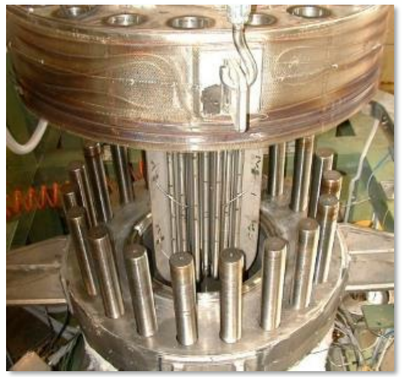
Partnership signed in March 2022: ENEA unique global know-how and *new*cleo 25-30 engineers and EUR50 million for about 10 years. Renovation works started in June 2022

ENEA partnership – facilities

Lead technology for LFRs has been in development for over 20 years in Europe, including at ENEA

CIRCE Large pool (90 tons LBE)

NACIE-UP loop



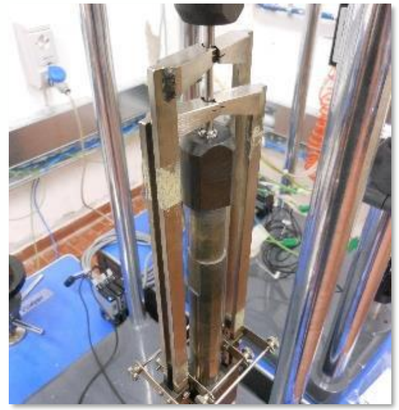
LIFUS-5 Separate Effect facility

RACHELE (Coolant chemistry lab)

LECOR Corrosion Loop

HELENA Lead Technology Loop

BIDONE Lead-Pool



Lead Mechanical Laboratory

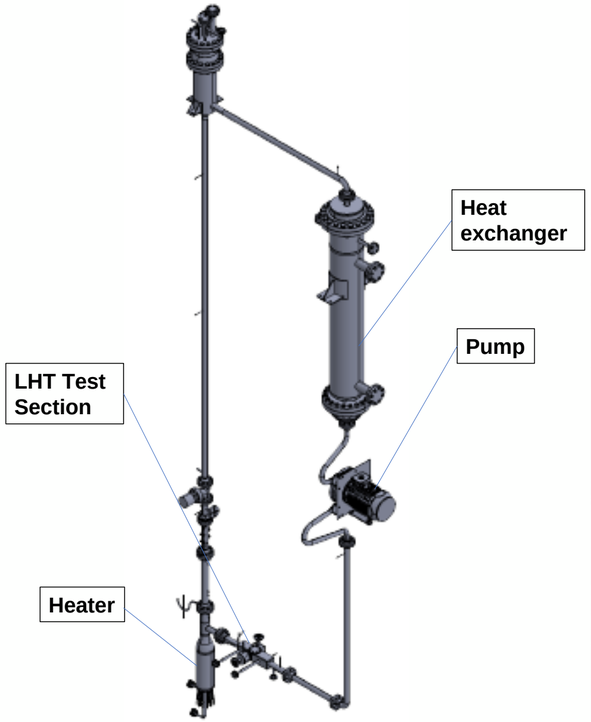
*new*cleo facilities: NACIE-LHT

Refurbishment of ENEA's Brasimone infrastructure

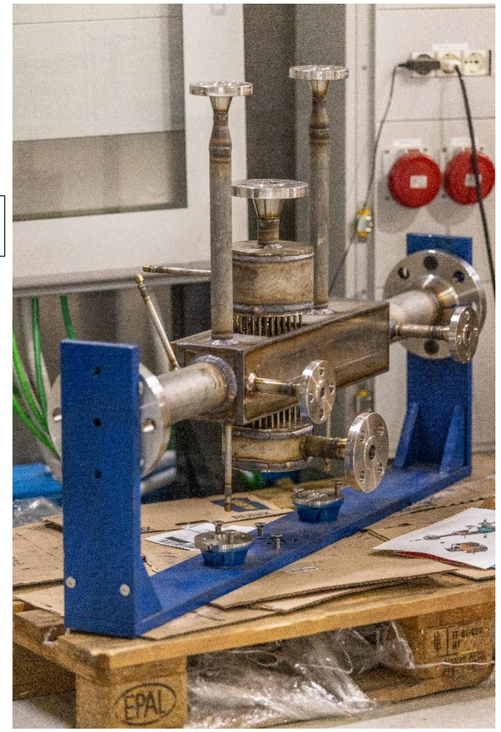
NACIE is an **operational loop** dedicated to thermal-hydraulics, component testing, chemistry control and corrosion protection

The updated configuration of this facility, NACIE-UP (UPgrade), can use both Lead and Lead-Bismuth Eutectic (LBE) as working fluid. It has been designed to work up to 550°C and 10 bar

Main target: preliminary thermal-hydraulic tests on *new*cleo's **steam generator**, to be performed in dedicated test section that will provide **lead-side transverse heat transfer coefficient** data



NACIE, ~8m x ~2m



NACIE-LHT test section

*new*cleo facilities: CIRCE-NEXTRA

Refurbishment of ENEA's Brasimone infrastructure

The main European pool-type facility operating with HLM:

- main vertical vessel of 8.5m height and diameter of 1.2m
- ~70 tons of molten LBE
- includes argon cover gas and recirculation system, LBE heating and cooling systems, auxiliary equipment, storage tank, transfer tank, data acquisition system

CIRCE-NEXTRA is *new*cleo's refurbishment programme devoted to components testing

Pump: to investigate hydraulic performances in a pool-type configuration, vibration dynamics, assessment of mechanical loads, endurance and long-term reliability of mechanical parts (bearing/bushing and impeller)

DHR: focusing on the development of innovative isolation condenser for the closed-loop DHR design option, integrating the campaign of the DCI programme

Steam Generator Tube Rupture: dedicated test sections

CIRCE, test section overview

newcleo facilities: OTHELLO

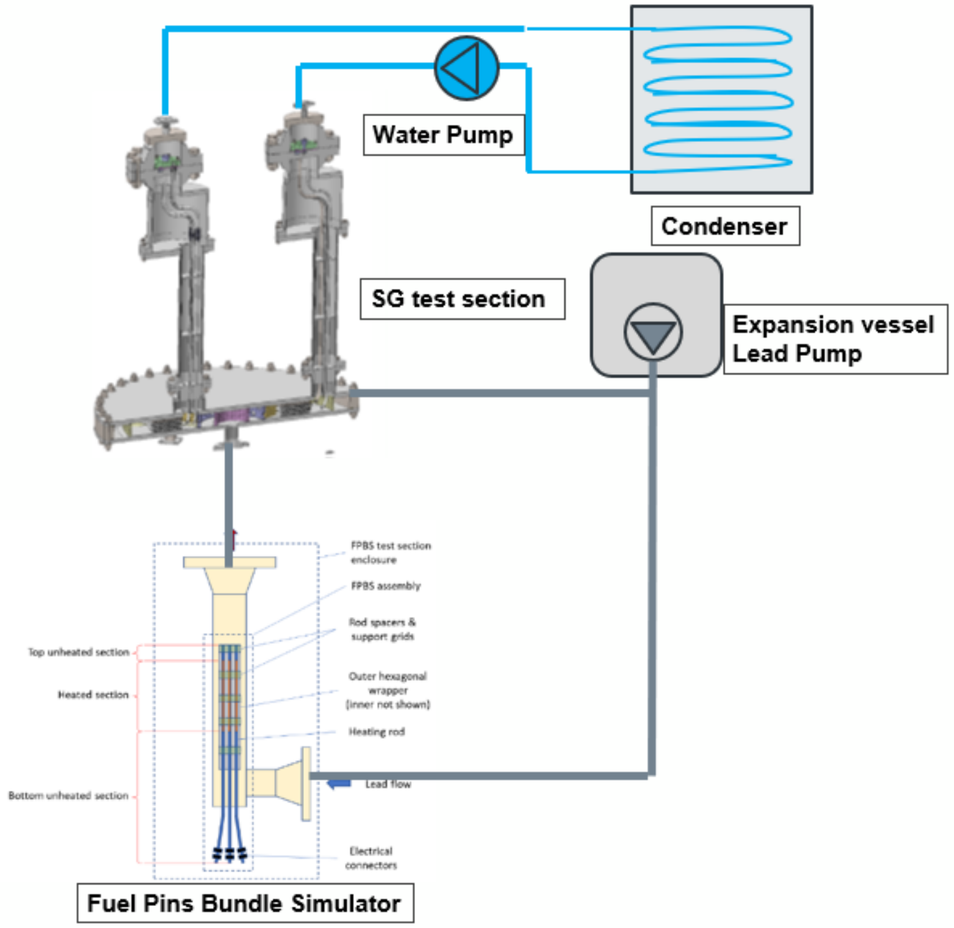
Oxygen controlled Thermal Hydraulic Experimental Lead Loop

A multipurpose facility operated with pure lead aimed at testing main primary components and support validation of thermal-hydraulic codes

Fuel pin bundle simulator: a full-scale electrically heated fuel pin bundle to address: ring spacers thermal-hydraulics, pressure losses in FAs, FA convective heat transfer in forced circulation and natural circulation, flow blockages and detection. The facility is designed to also accommodate an unheated fuel pin bundle simulator for the study of flow-induced vibrations.

Steam generator test section: featuring a lower number of spiral tubes but full-scale length will be tested in representative conditions to address: heat exchange performance and heat transfer coefficients (primary/secondary sides), flow distribution among tubes, flow-induced vibration, thermo-mechanical behaviour and loads assessments, functional tests in excess-flow / check valves.

Coolant freezing test section: preliminary, limited-scope investigations on lead freezing phenomena



newcleo facilities: DCI

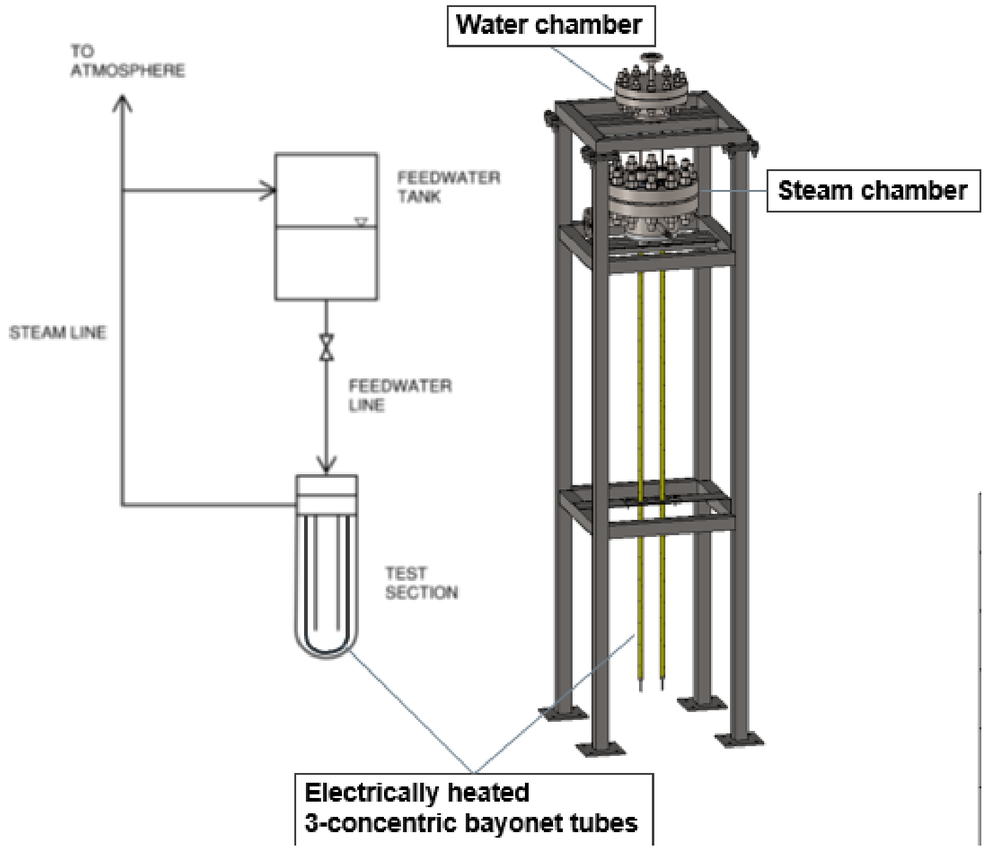
Dip Cooler Instability

An experimental loop to investigate thermal-hydraulic aspects: water flow rate instabilities and start-up.

The test section is a mock-up of the dip coolers, fed by a water tank positioned several meters above. In the test section, the two bayonet tubes are equipped with electrical heaters that provide uniform outer wall temperature. From the water collector, the water flows downward inside the inner tube and comes out vaporising in the annular chamber between the inner and intermediate tube. Helium fills the annulus between the intermediate and outer tube

The system is designed to enable tests in different conditions:

- pressure values
- operating temperature
- flow rates
- open- and closed-loop configurations



newcleo facilities: PRECURSOR

The main areas covered are:

- Integral thermal-hydraulic performance in stationary conditions, normal startup/shutdown and accidental scenarios (coolant mixing, transition from forced to natural circulation with possible thermal stratification, oscillation and surface and sloshing)
- BOP transients/instability and interactions with the Primary System;
- Core-system thermal-hydraulics;
- SG thermal-hydraulic performance in normal and transient conditions;
- Primary pumps behaviour;
- DHR operation assessment;
- Filling and draining system, coolant and cover gas auxiliary systems.

It will also serve plant accident response: set-points for safety system actuation, transient Figure of Merits, accident response procedures, validation of thermal-hydraulic codes. The accident matrix to be investigated will encompass scenarios such as partial/total loss of primary flow, loss of DHR systems during shutdown states (normal/accidental shutdowns), loss of off-site power, turbine trip, loss of feedwater, loss of preheaters.

POOL-TYPE

10 MWth

NON-NUCLEAR

COUPLED WITH THE BOP

STATIONARY AND TRANSIENT CONDITIONS

PLANT ACCIDENT RESPONSE

*new*cleo facilities: MANUT (Dry/in-Lead)

for Fuel / Component Handling and Control rod actuation

MANUT will validate design choices on fuel assemblies (mechanical aspects), fuel handling operation and equipment, and primary system's components handling.

The main areas of interest related to fuel handling are:

- Fuel assembly mechanical design and functional tests on handling procedure and equipment;
- Rotating Plug System, which allow the connection between the Fuel Handling Machine and the reactor while maintaining primary confinement function;
- Fuel Handling Machine

Dry tests at the beginning, followed by tests in lead that will be carried out in close collaboration with ENEA.

A similar approach is envisaged for tests on component handling procedures and related components (counter flange / handling flask mechanism and leak tightness).

Testing activities are also foreseen on *new*cleo's control rods mechanisms

*new*cleo's R&D programme summary

To broaden and complement this programme, **further collaborations** with nuclear companies, universities, laboratories and institutes **are being established and actively pursued by *new*cleo** to leverage existing infrastructure and accelerate R&D programmes

LFR Technical Domain / Experimental Facility	CORE1 & CORE2	CAPSULE	LEAD/CHEM LAB (BRA)	MAT LAB (TO)	MANUT in-lead	MANUT dry	EFESTO	NACIE-LHT	DCI	CIRCE-NEXTRA	OTHELLO	PRECURSOR
Structural materials and coatings	■	■	■	■								
Core, fuel and control/shutdown rods					■	■					■	
Coolant chemistry and auxiliary systems	■	■									■	■
Primary system integrity and component studies							■	■	■	■	■	■
Fuel and component handling					■	■						
Plant operation & accident response												■
Balance of plant integrity studies												■

The current planning of most R&D infrastructures foresees the completion of exp. campaigns within 2026 -> **submission of the DAC file (French Safety Authority Licensing Dossier file) for the construction of LFR-AS-30/200 reactors** for low temperature operations.

Materials

*new*cleo facilities: Materials R&D infrastructure

*new*cleo's priority is to **validate materials** (structural and coatings) with respect to corrosion, erosion and liquid metal embrittlment in our reactors conditions (high neutron flux, high temperatures, lead)

Starting from lead qualification of the materials listed in RCC-MRx/ ASME, to developing new materials in the long-term

FACILITIES and INFRASTRUCTURES

CAPSULE for corrosion tests in stagnant lead

CORE for corrosion and erosion tests in flowing lead

LEAD/CHEM LAB to evaluate mechanical properties in lead, including slow strain rate tests, creep, long-term creep, creep-fatigue

MATERIAL LAB to validate microstructure and mechanical performance

OTHELLO and ***PRECURSOR*** for post-test analysis of components

CAPSULE module


CORE - portion

newcleo's materials strategy

- In SFR nuclear codes and not operating in Pb → limited R&D needed
- In SFR nuclear codes but operating in Pb → qualification in Pb needed
- Operating in Pb, not in codes → substantial R&D required

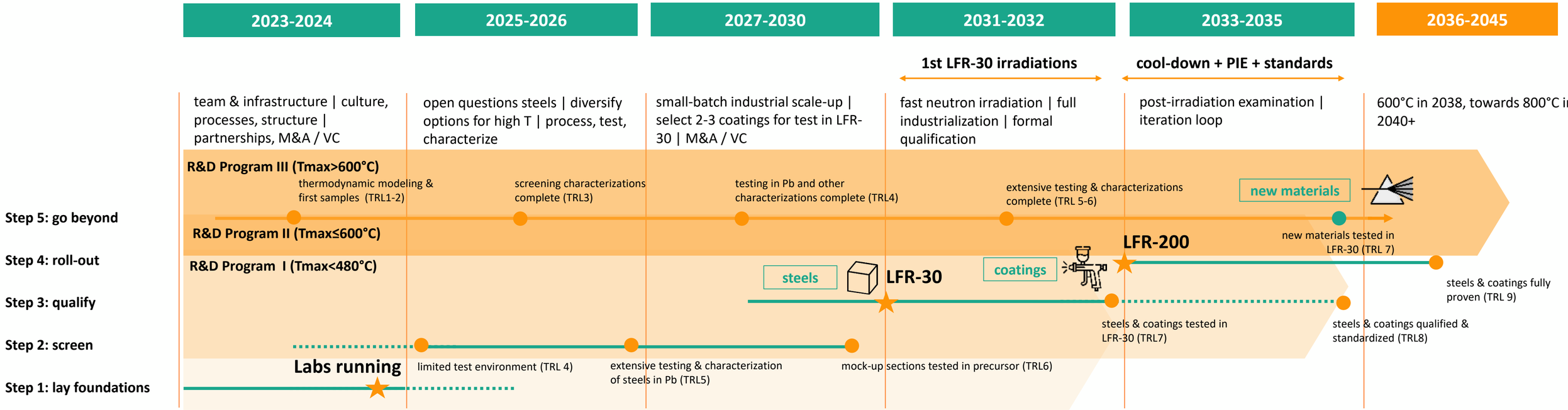
Component	Phase I (≤ 480°C)	Phase II (≤ 600°C)	Phase III (> 600°C)
NOT REPLACEABLE			
1. Roof structure	standard steels		
2. Safety vessel			
3. Reactor vessel	standard steels		
4. Amphora-shaped inner vessel	surface treatments or new material		
REPLACEABLE			
5. Primary pump	surface tr…		
6. Steam generator tubes			
7. Decay heat removal tubes			
8. Other internals			
9. Fuel cladding			
10. Fuel assembly parts			
11. Control rods			

Materials R&D program I

Materials R&D program II

Materials R&D program III

newcleo's materials strategy



Materials and chemistry

Technical units				
	Engineering	Chemistry	Metallurgy	Characterisations
	Corrosion	Mechanics	Surfaces	Microscopy
Sites	Torino	Brasimone	Lyon	Gloucester

ca. 40 MEUR investment in Turin and Brasimone

Collaborationos

cea

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

MINES Saint-Étienne
Une école de l'IMT

EERA JPNM
JOINT PROGRAMME ON NUCLEAR MATERIALS

ENEA

POLITECNICO MILANO 1863

Politecnico di Torino
1859

iit ISTITUTO ITALIANO DI TECNOLOGIA

33 team members and growing
target 60+ in 2027


Thank you