Status of Lead-cooled Fast Reactor activities in GEN-IV Countries/Entities

Mariano TARANTINO
Co-Chair pSCC GIF LFR

GIF Industry Forum, Toronto, Canada
3-7 October 2022
TS06 - Gen-IV Demos: LFR Technical Session

Aim of the Seminar

Among the promising reactor technologies considered by the Generation IV International Forum (GIF), the Lead-cooled Fast Reactor (LFR) was identified as a technology with great potential to meet needs for both remote sites and central power stations, fulfilling the four main goals of GIF in terms of sustainability, safety, economics and proliferation resistance.

In the technology evaluations of the Generation IV Technology Roadmap, the LFR system was top-ranked in sustainability because a closed fuel cycle can be more easily achieved, and in proliferation resistance and physical protection. It was also assessed as good in safety and economics. Safety was considered to be enhanced by the choice of a relatively inert coolant.

This session aims to highlight the main recent collaborative achievements of the GIF LFR and briefly lists the main ongoing LFR developments in the world.

The most mature LFR designs represent the focus of this session, with the associated development activities demonstrating their high level of technical readiness

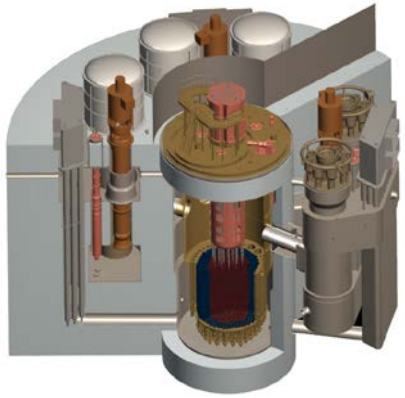
BREST-OD-300

Elimination of NPPs accidents requiring population evacuation or resettlement

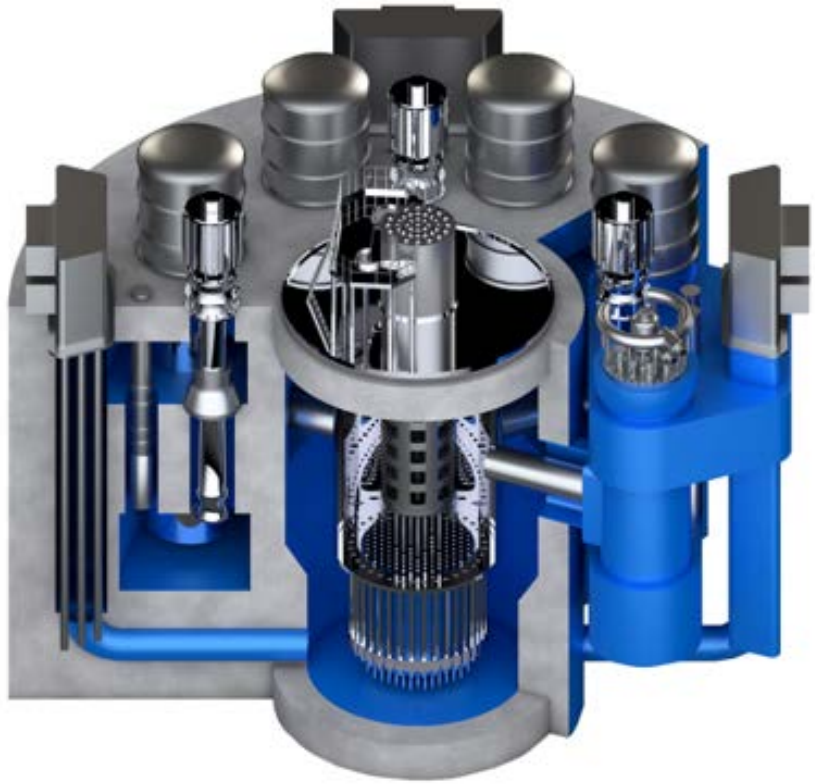
Closed NFC to fully exploit the energy potential of uranium feedstock – use of VVER Pu for starting loading

Consistent approach to radiation-equivalent disposal of radwaste – at the operating stage after development of fuel with MA

BREST-OD-300



Commercial reactor



Technological enhancement to non-proliferation regime no blanket, no Pu extraction during SNF reprocessing, on-site NFC, no uranium enrichment required

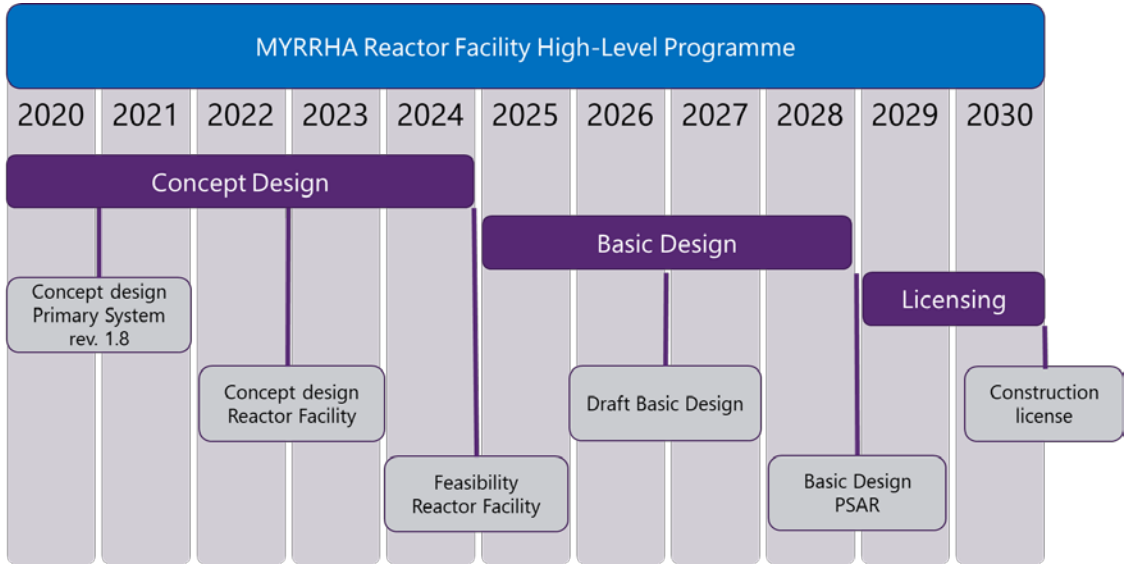
Ensuring competitiveness of nuclear power in comparison with other types of power generation – demonstration of technology potential

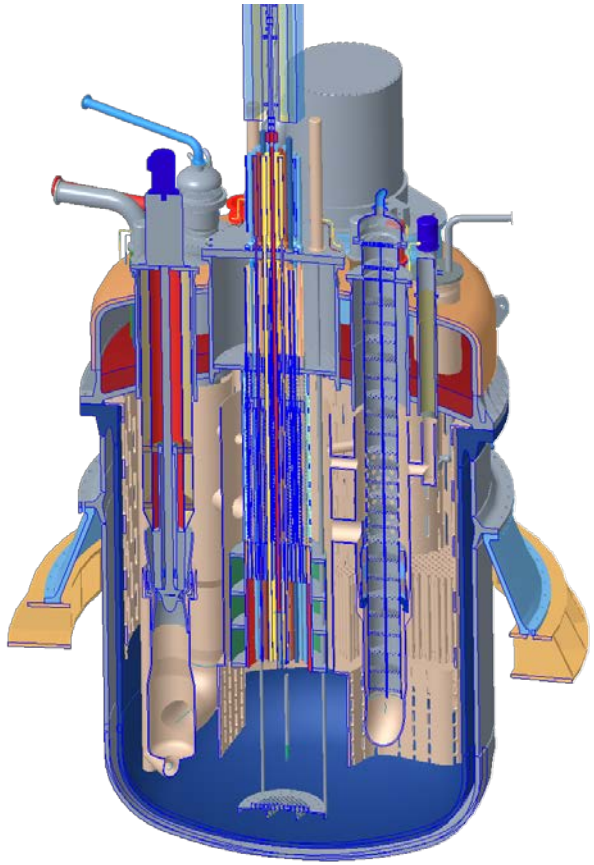
10 Feb 2021: Construction license for BREST-OD-300 issued by Rostechnadzor

June 8 2021: Start of construction (concrete pouring of the foundation slab)

2026: First criticality, start of commissioning for BREST-OD-300

MYRRHA



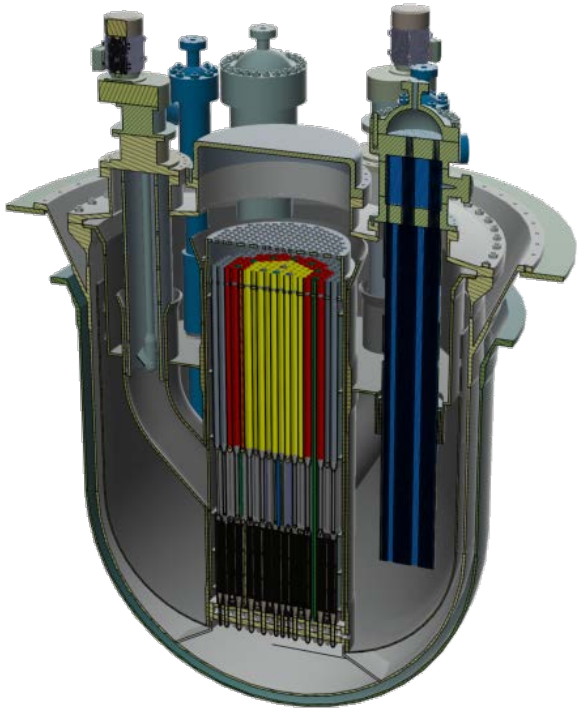


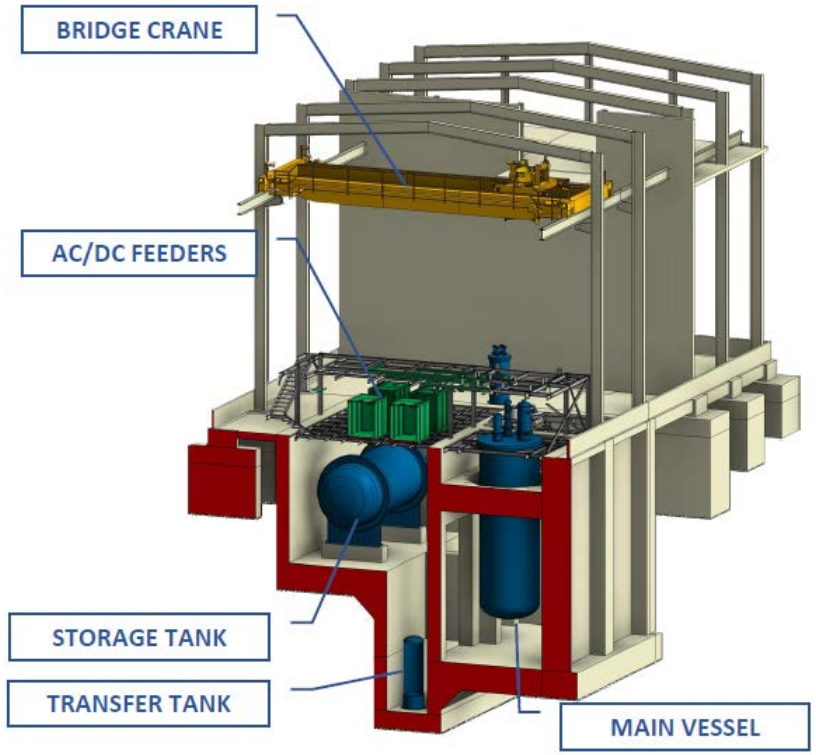
The reactor is scheduled to be commissioned in 2036

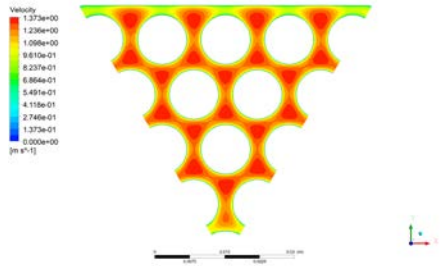
On 7 September 2018 the Belgian Federal Government decided to have the MYRRHA project built on the SCK CEN site in Mol. Based on a total budget of € 1.6 bn, the government committed € 558 m towards the project's phased approach.

In addition, the Belgian government announced the establishment of an international non-profit organization that will be ideally suited to welcome investment from additional participating countries. As MYRRHA fits within the European Union's ESFRI (European Strategic Forum for Research Infrastructure) and SET (European Strategic Energy Technologies) Plan, it is a candidate for European Investment Bank financing.

ALFRED







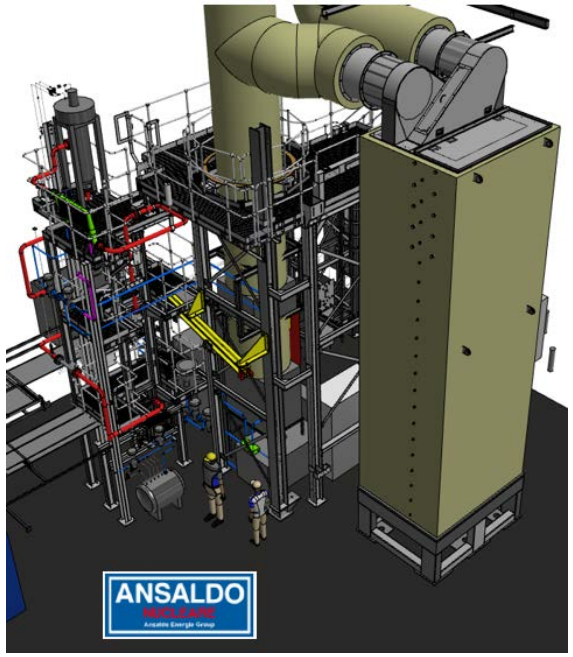
Research Infrastructure: ATHENA (ongoing)

ALFRED, a demonstration reactor, also prototypic of a Lead-based SMR, to bridge the final gap between conducted research and industrial application

Westinghouse LFR

Status:

- *Design*: conceptual design and plant layout near completion
- *Licensing*: pre-licensing meetings with UK Regulators
- *Testing*:
  - 8 test rigs being set up in the UK
  - Others being built/used in the US (at Westinghouse, U. of New Mexico, Virginia Tech and U. of Pittsburgh) and Italy (ENEA)



Department for Business, Energy & Industrial Strategy

Westinghouse

ANSALDO NUCLEARE

ENEA
Italian National Agency for New Technologies, Energy and Sustainable Economic Development

FRAZER-NASH CONSULTANCY

Jacobs

NATIONAL NUCLEAR LABORATORY

NUCLEAR AMRC

PRIFYSGOL BANGOR UNIVERSITY

MANCHESTER 1824

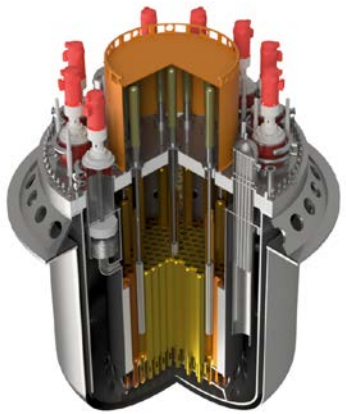
VPE
VACUUM PROCESS ENGINEERING


Courtesy of SRS, Servizi di Ricerche e Sviluppo

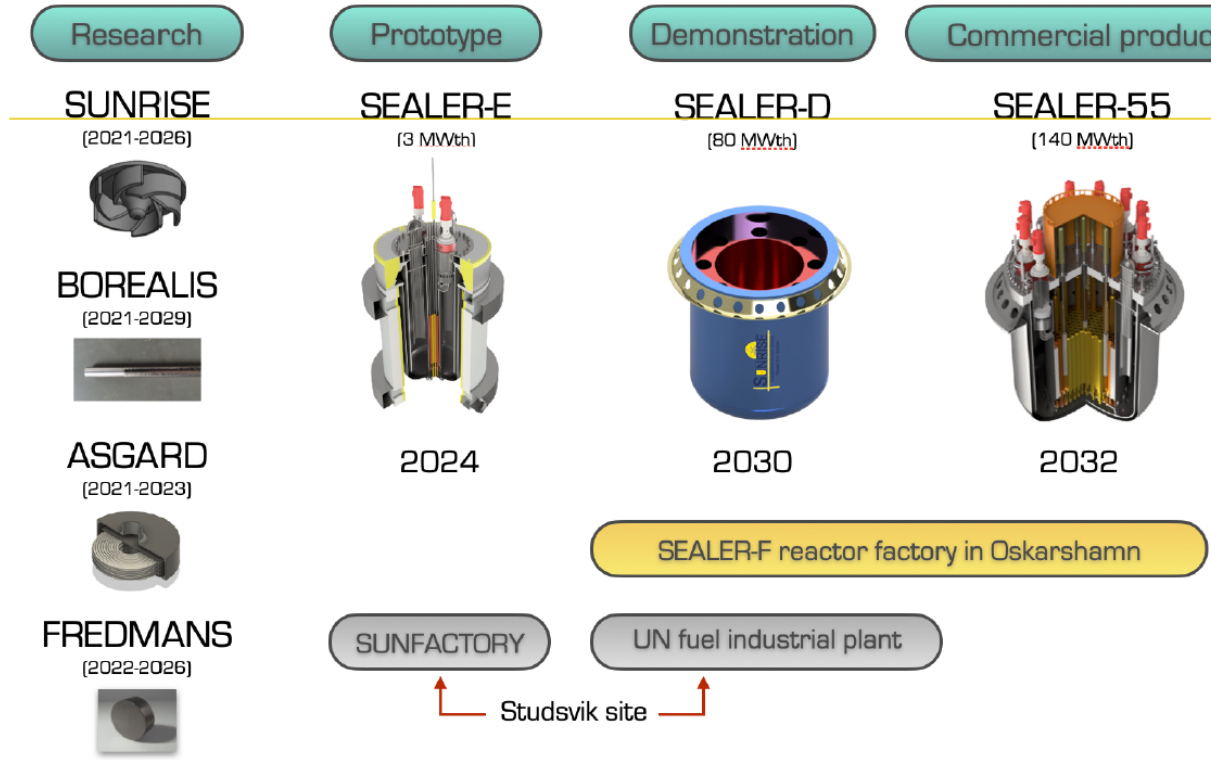

Courtesy of SRS, Servizi di Ricerche e Sviluppo

LeadCold

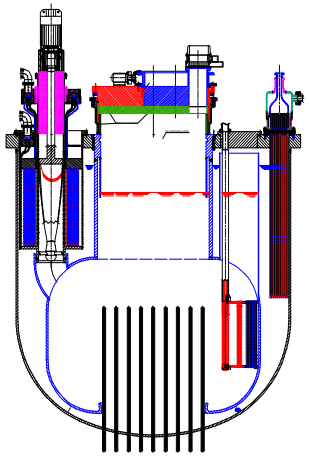
- 55 MWe lead-cooled reactor for commercial power production.
- Design by LeadCold, with support from NRG
- Fuel: $U^{15}N$ and $(U,Hf)^{15}N$ with 12% enrichment of ^{235}U
- Core life: 25 EFPY (6.3% average burn-up)
- Peak damage dose: 120 dpa
- Reactivity swing < 300 pcm
- Vessel diameter x height = 4.8 x 5.5 m
- Time from order to operation: 24 months.

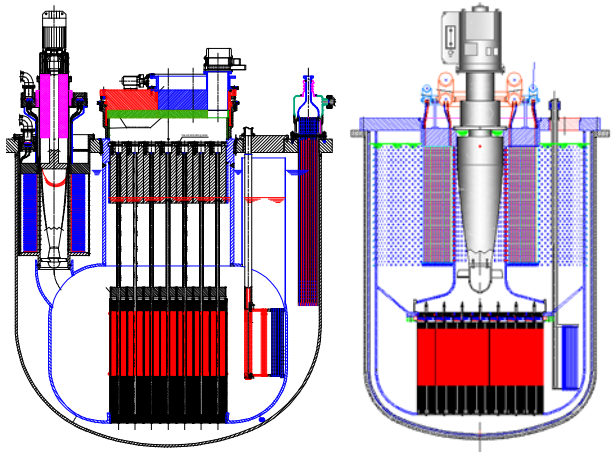


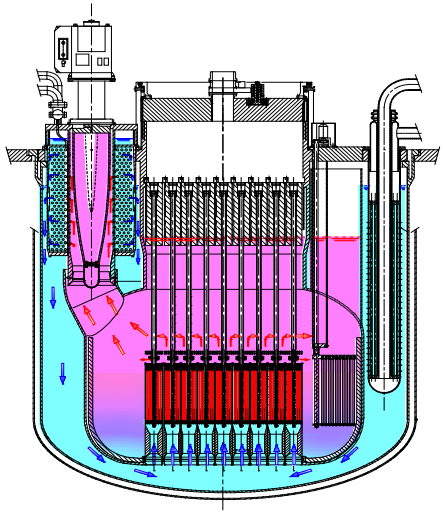
SEALER-55 program

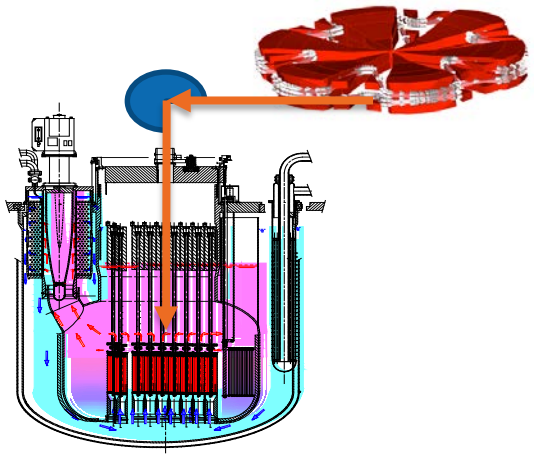


*new*cleo's LFR-SMRs









5 years

7/10 years

10/12 years

Long term

Precursor

Electrically heated facility **10MWth**, with turbogenerator.

It reproduces scaled or full-scale components of the Mini LFR

Mini LFR-SMR (30 MWe)

Power: **30 MWe**
Core outlet T: 430/440°, later 530°
Fuel: MOX

***new*cleo's present activity is focused on LFR-AS-30**

Small LFR-SMR (200 MWe)

Power: **200 MWe**
Fuel: MOX + MA

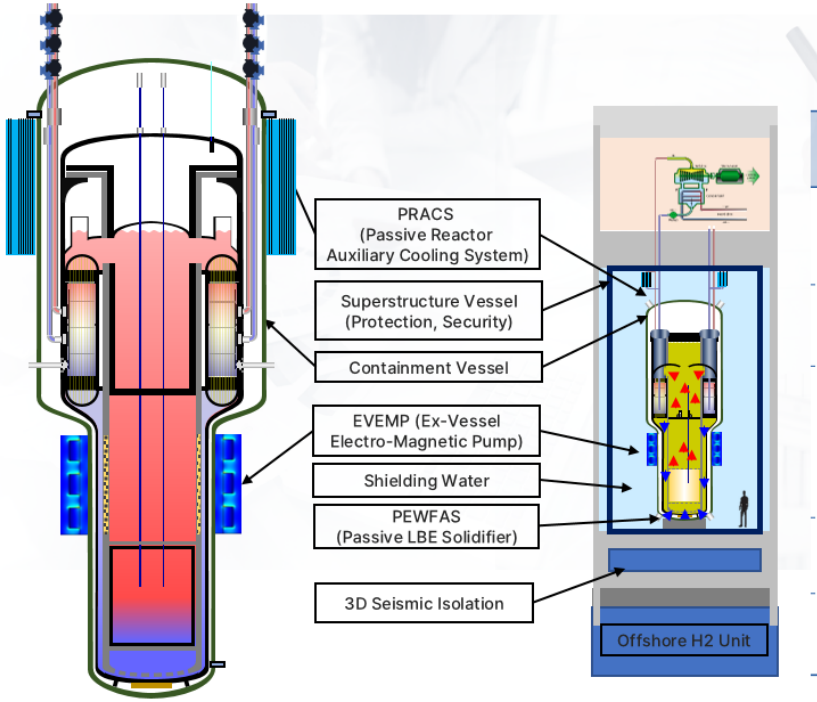
Terrestrial plant to burn existing nuclear waste

ADS LFR-SMR

Power: TBD
Fuel: MOX + MA, U free fuels, Thorium

The future Accelerator-Driven reactor

MicroURANUS's LFR-SMRs



Topic	Solution
Prol.	No Refuel Adv. Materials
Env.	Spent Nuclear Fuel (SNF) Recycle
Acc.	Natural Circulation No Po-210 Freezing ZEPZ
Cont.	SNF Recycle
Econo.	Mass Production Inverted Core

2027

Offshore H_2 Unit

20MWe
Standard Design
Pre-Application
Review

2031/2032

Demonstration

DC & COL
20MWe
Offshore Clean
Hydrogen Plant

2035/2037

Ship Propulsion

Demo System Design
License
Construction
Sea Trials

CLEAR LFR-SMRs

- **The modern energy system plan for China's 14th Five-Year plan has been issued on March 22, 2022:** ***"…actively promote technological development and demonstration applications such as SMR, VTGR, low temperature heating reactor, fast reactor, MSR and offshore floating nuclear power platform"***

- **CLEAR series LFR developed by International Academy of Neutron Science (IANS)**
  - **CLEAR-M: Small modular LFR with 10MWe**
  - **CLEAR-A: 1GeV/10mA proton accelerate coupled with 100 MW_{th} LFR; Ultra-high flux mixed spectrum neutron source: 6×10^{15} n/(cm^2·s)**

- **CLEAR-M0: pool-type integration verification facility, >5MW_{th} , started commissioning in August 2022 and core outlet temp. reaches 550°C**
- **CLEAR-A0: accelerator based subcritical facility, with neutron source yield of 2×10^{14} n/s, started field installation**
- **Other facilities: experimental facilities and devices for engineering verification, 4000 hours' test data**