

World Status of Fast Reactors and IAEA E&T Resources on Innovative Nuclear Energy Systems

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IAEA Interregional Workshop on Aspects of
Modelling and Simulation in Gen-IV Type
SMR Developments, 03-07 November 2025,
Moscow



Fast Reactors: World Status and IAEA Resources

- Fast Reactors: World Status
 - in Operation
 - under Construction
 - in Development
 - IAEA Advanced Reactors Information System (ARIS)
- IAEA Educational and Training Resources for Innovative SMRs
 - Joint ICTP-IAEA Workshops
 - IAEA ONCORE Initiative: Open-Source Nuclear Codes for Reactor Analysis
 - Webinars
 - FR26 International Conference on Fast Reactors and Related Fuel Cycles

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Fast Reactors in Operation & under Commissioning

Country	Name	Coolant	Fuel	Purpose	Power (th/e) MW	Year (Op.)	Status
Russia	BOR-60	sodium	UO ₂	experimental	60/10	1969	operating
	BN-600	sodium	UO ₂	prototype	1470/600	1980	operating
	BN-800	sodium	UO ₂ /MOX	commercial	2100/880	2015	operating
China	CEFR	sodium	UO ₂	experimental	65/20	2011	operating
	CFR600-1	sodium	UO ₂ /MOX	prototype	1500/650	2023	operating
India	FBTR	sodium	UO ₂	experimental	40/13	1985	operating
	PFBR	sodium	UO ₂	prototype	1250/500	2026	commissioning
Japan	JOYO	sodium	UO ₂ /MOX	experimental	100/--	1978	lic renew (2026)



BN-600, Russia, 1980

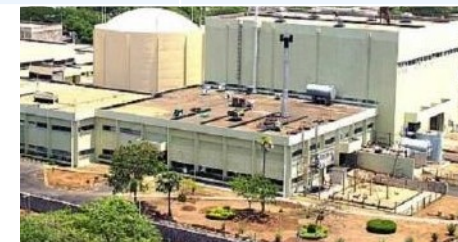
IAEA WS on Gen-IV Type SMRs: FR Status
Vladimir Kriventsev, 4 Nov 2025, Moscow



BN-800
Russia, 2015



CEFR, 20 MW(e)
China, 2011



FBTR, 13 MW(e)
India, 1985



PFBR, 500 MW(e)
India, 2024

BN-600 (since 1980)



Parameter	Value
Thermal power, MW	1470
Electric power, MW	600
Number of heat removal loops	3
Primary circuit configuration	Pool
Steam generator design	Once-through, sectional-modular
Maximum neutron flux density, $n \cdot cm^{-2} \cdot s^{-1}$	$6.5 \cdot 10^{15}$
Fuel	UO ₂
Max. fuel burn-up, % h. a.	11.1
Inlet/outlet core coolant temperature, °C	377/550
Inlet/outlet SG coolant temperature, °C	518/328
Inlet/outlet SG water/steam temperature, °C	241/507
Live steam pressure, MPa	13.2
Design lifetime, year	30 (extended to 45) 60

BN-800 (since 2015)



Parameter	Value
Thermal power, MW	2100
Electric power, MW	880
Number of heat removal loops	3
Configuration of the primary circuit	Pool
Steam generator design	Once-through, sectional-modular
Maximum neutron flux density, $n \cdot cm^{-2} \cdot s^{-1}$	$8.8 \cdot 10^{15}$
Fuel	UO ₂ -PuO ₂
Max. fuel burn-up, % h. a.	9.9
Inlet/outlet core coolant temperature, °C	354/547
Inlet/outlet SG coolant temperature, °C	505/309
Inlet/outlet SG water/steam temperature, °C	210/490
Live steam pressure, MPa	13.7
Design lifetime, year	40

PFBR: Prototype Fast Breeder Reactor (India)



Power : 1250 MW_t
(500 MW_e)

Primary circuit : Pool Type

Reactor coolant : Sodium

Number of PSP : 2

Number of IHX : 4

Number of sec loops : 2

Number of SG per loop : 4

Containment building : RCC rectangular shape

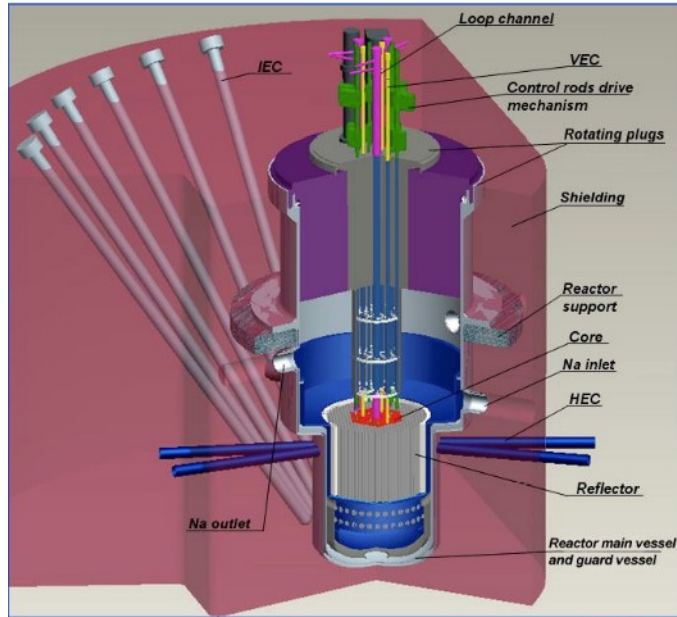
Design Life : 40 Years

As presented by Mr Uppala at TWG-FR Meeting in June 2025

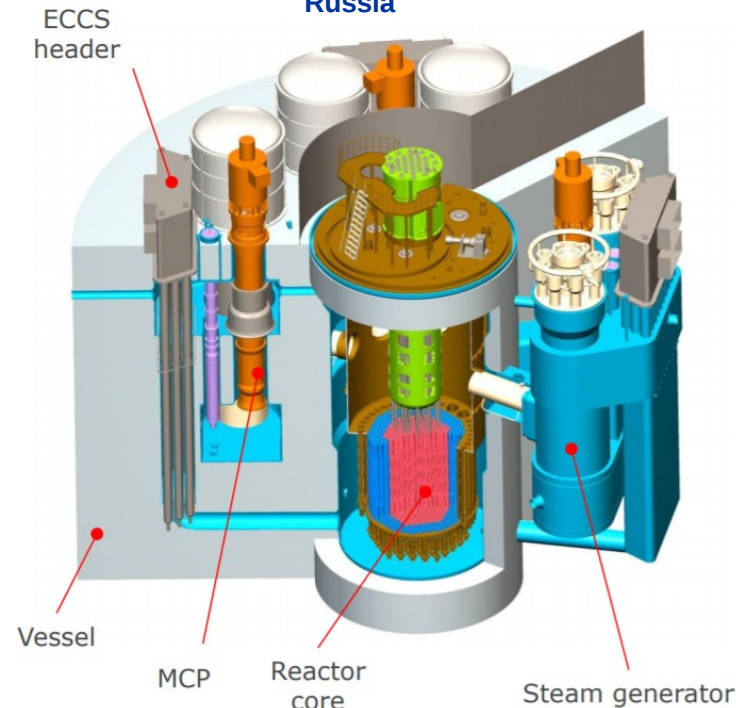
Fast Reactors under Construction

Country	Name	Coolant	Fuel	Purpose	Power, MW(th/e)	Year (Op.)	Status
Russia	MBIR	sodium	MOX	experimental	150/50	~2028	construction
	BREST-OD-300	lead	PuN/UN	demonstrator	700/300	~2026	construction
China	CFR600-2	sodium	UO ₂ /MOX	prototype	1500/650	~2028	construction

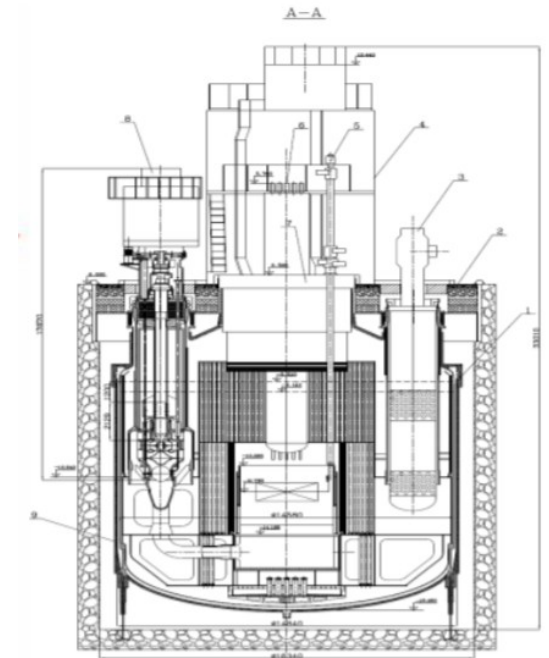
MBIR, Russia



BREST-OD-300
Russia



CFR600, China



Status of MBIR

CURRENT STATUS OF CONSTRUCTION



MBIR construction site (2024)



CONSTRUCTION

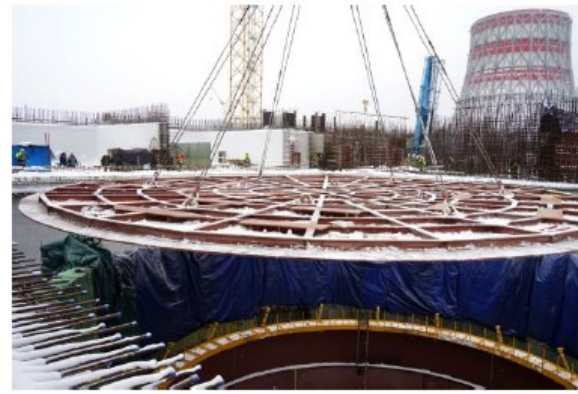


MBIR construction site (2024)

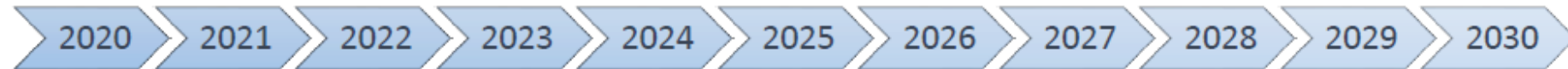
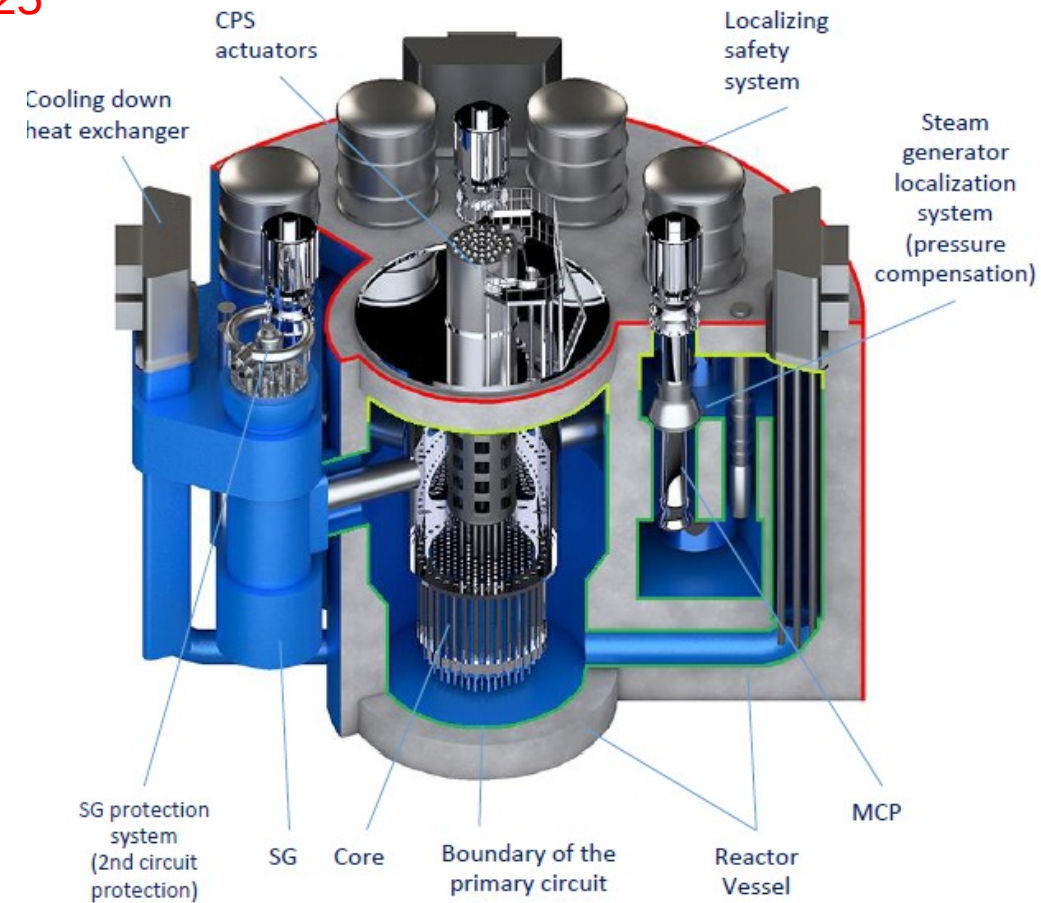
Status of BREST-OD-300

Construction status at PDEC site (December 2023)

Mounting of the BREST-OD-300 reactor began



The lower tier of the enclosing structure was immersed in the reactor shaft (December 2023)



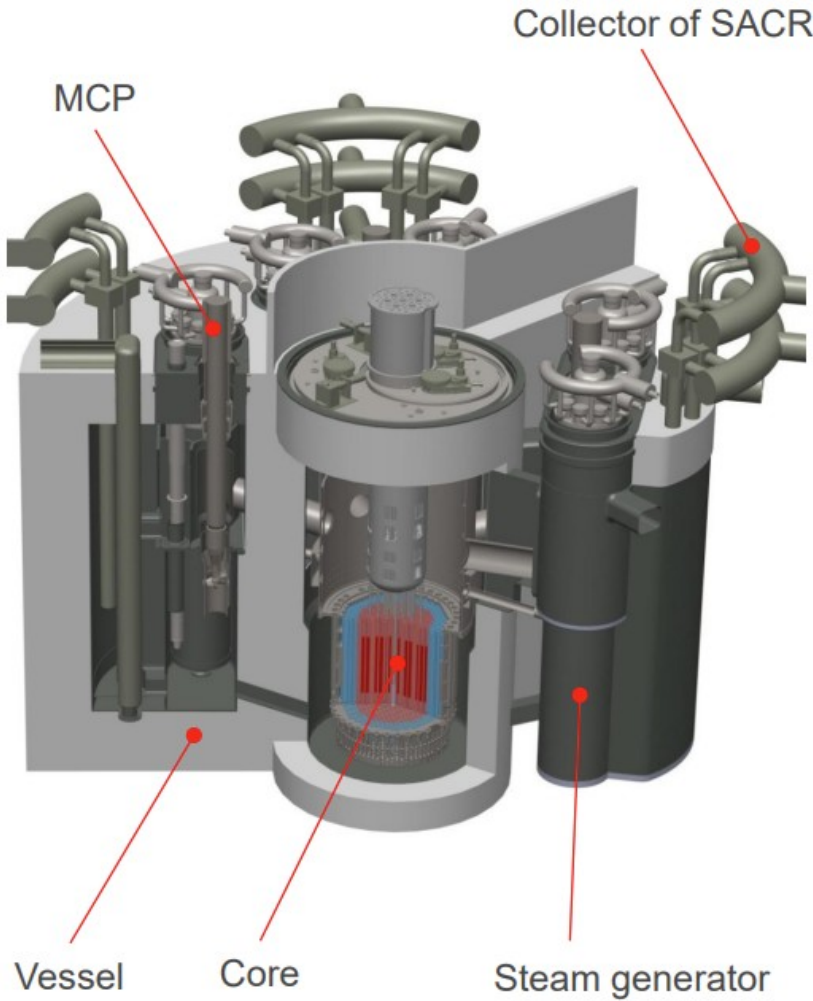
Construction and commissioning of the
Fuel (re-) fabrication module

Equipment manufacturing, construction of the nuclear power plant with the
BREST-OD-300 lead-cooled fast reactor

Construction and commissioning of the
Reprocessing module

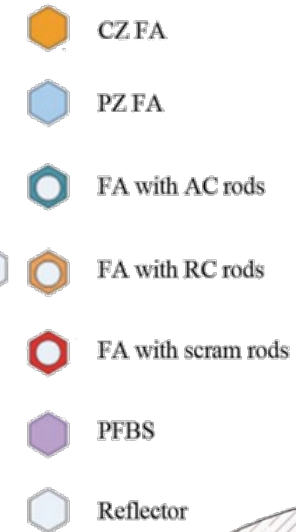
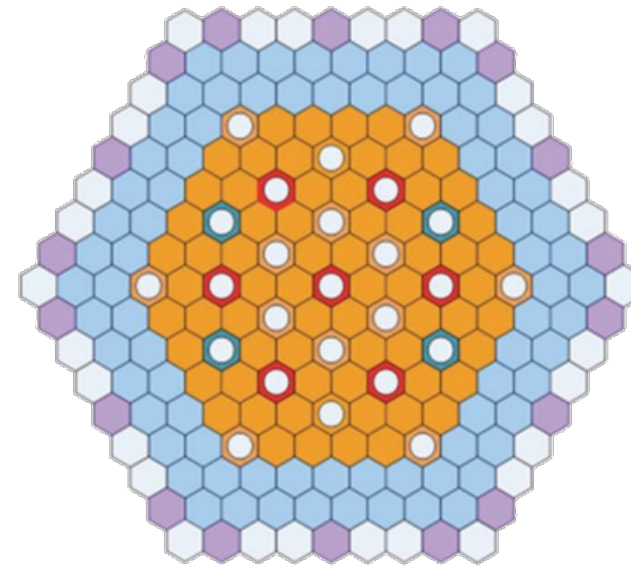
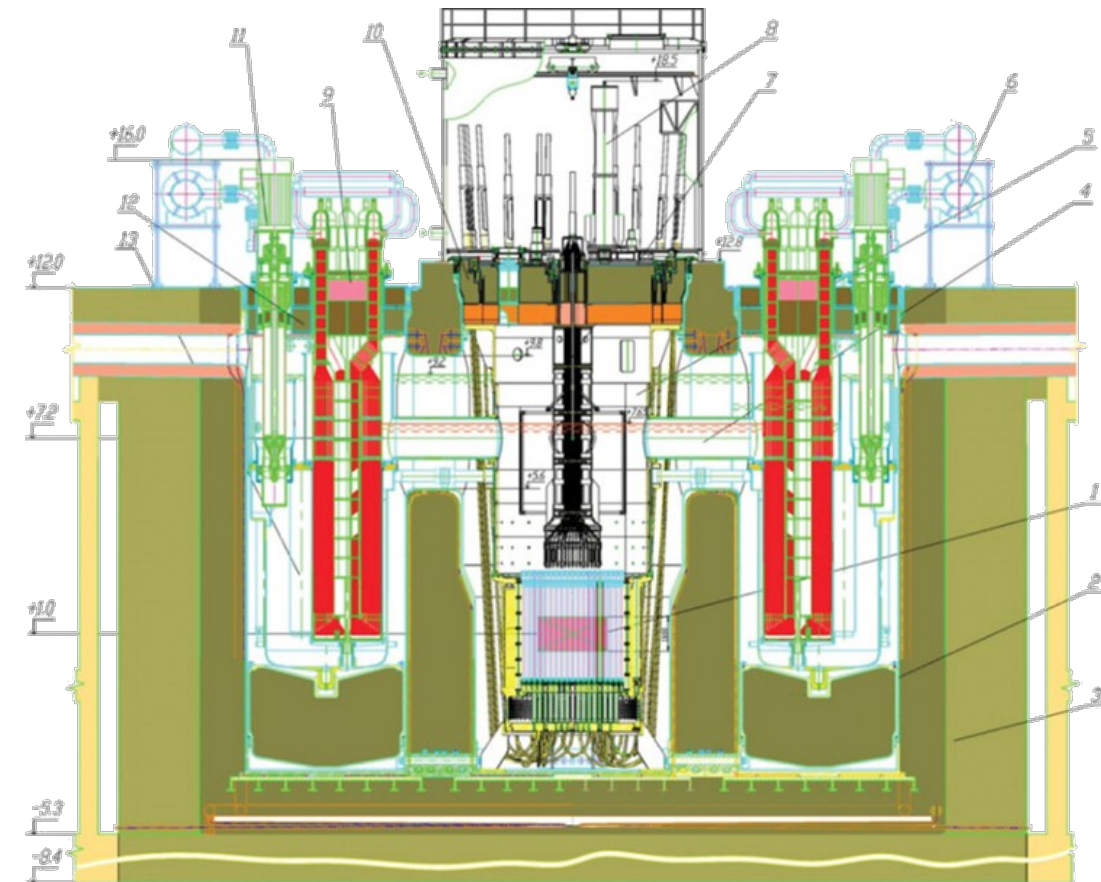
BREST 300

The BREST: key components and technical characteristics

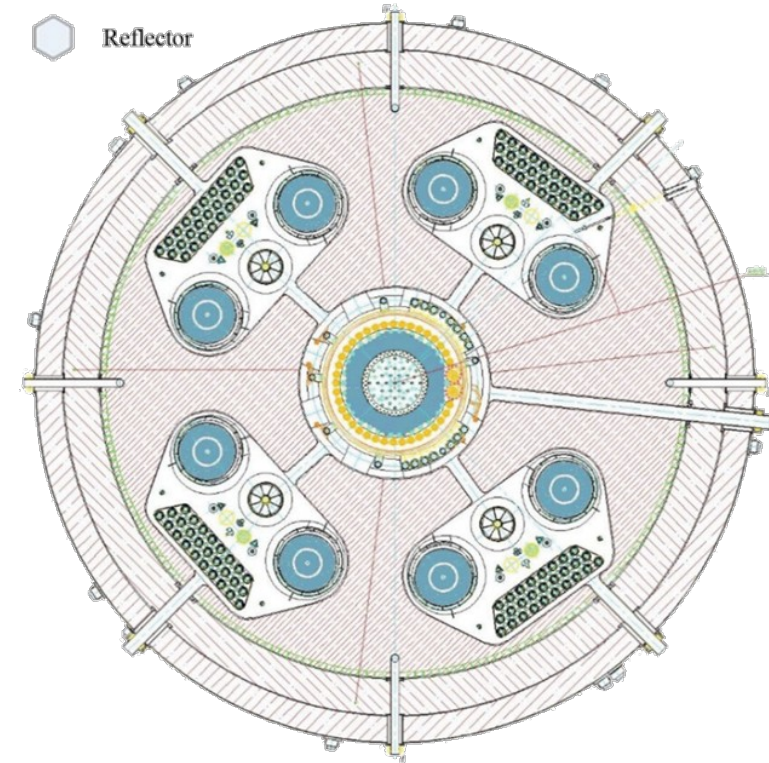


Thermal power, MW	700
Electric power, MW	300
Steam production rate, no less than, t/hour	1480
Coolant of the first contour	Lead
Gas pressure above the lead level: - exceed, MPa - maximal, MPa	0,003-0,008 0,02
Average temperature of the lead coolant on the active zone entry/ exit, °C	420/540
Average temperature of the lead coolant on the steam generator entry/ exit, °C	340/505
Loop number	4
FA number in the active zone	169
Active zone height, mm	1100
Fuel load, t	20,6
Fuel campaign, years	5
Burn-up of unloaded fuel (maximum/ average), % HM.	9,0/5,5

BREST-OD-300

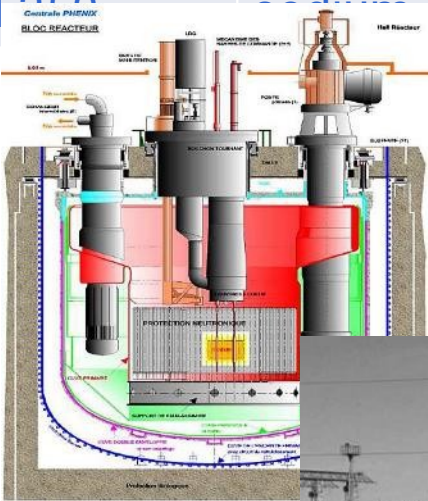
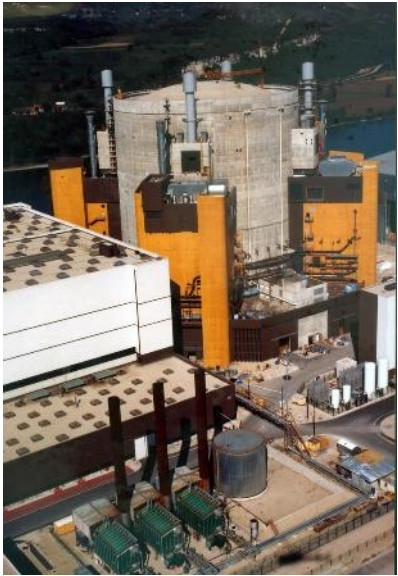


- 1 – core;
- 2 – block of vessels;
- 3 – reactor pit;
- 4 – header pipeline;
- 5 – core basket;
- 6 – cooldown system;
- 7 – instrumentation string;
- 8 – in-pile refueling machine;
- 9 – steam generator;
- 0 – upper plate;
- 11 – reactor coolant pump;
- 12 – SG-MCP block;
- 13 – filter.

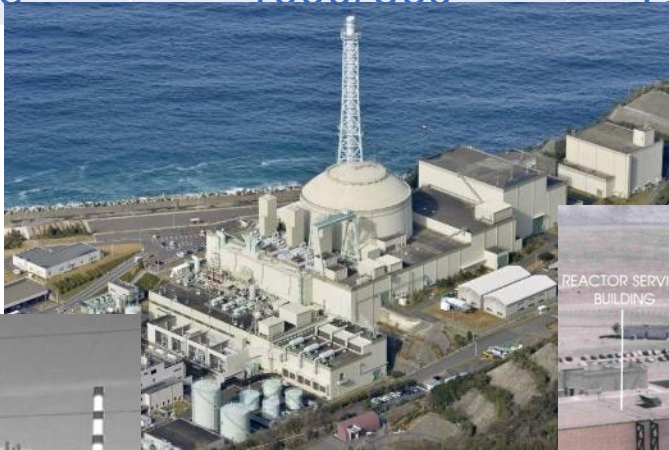


Fast Reactors under Decommissioning

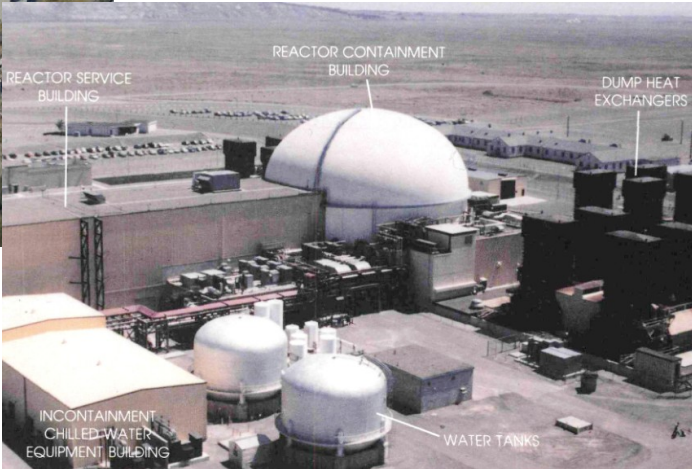
Country	Name	Coolant	Fuel	Purpose	Power, MW(th/e)	Year (Op.)	Status
France	Phenix	sodium	UO ₂	prototype	590/250	1973	decommissioning
	Superphenix	sodium	UO ₂	FOAK	3000/1242	1986	decommissioning
Japan	MONJU	sodium	MOX	prototype	714/280	1994	decommissioning
USA	FFTF	sodium	UO ₂	experimental	400/--	1980	decommissioning
Kazakhstan	BN-350	sodium	UO ₂	prototype	1000/350	1973	decommissioning



BN-350, Kazakhstan



MONJU, Japan



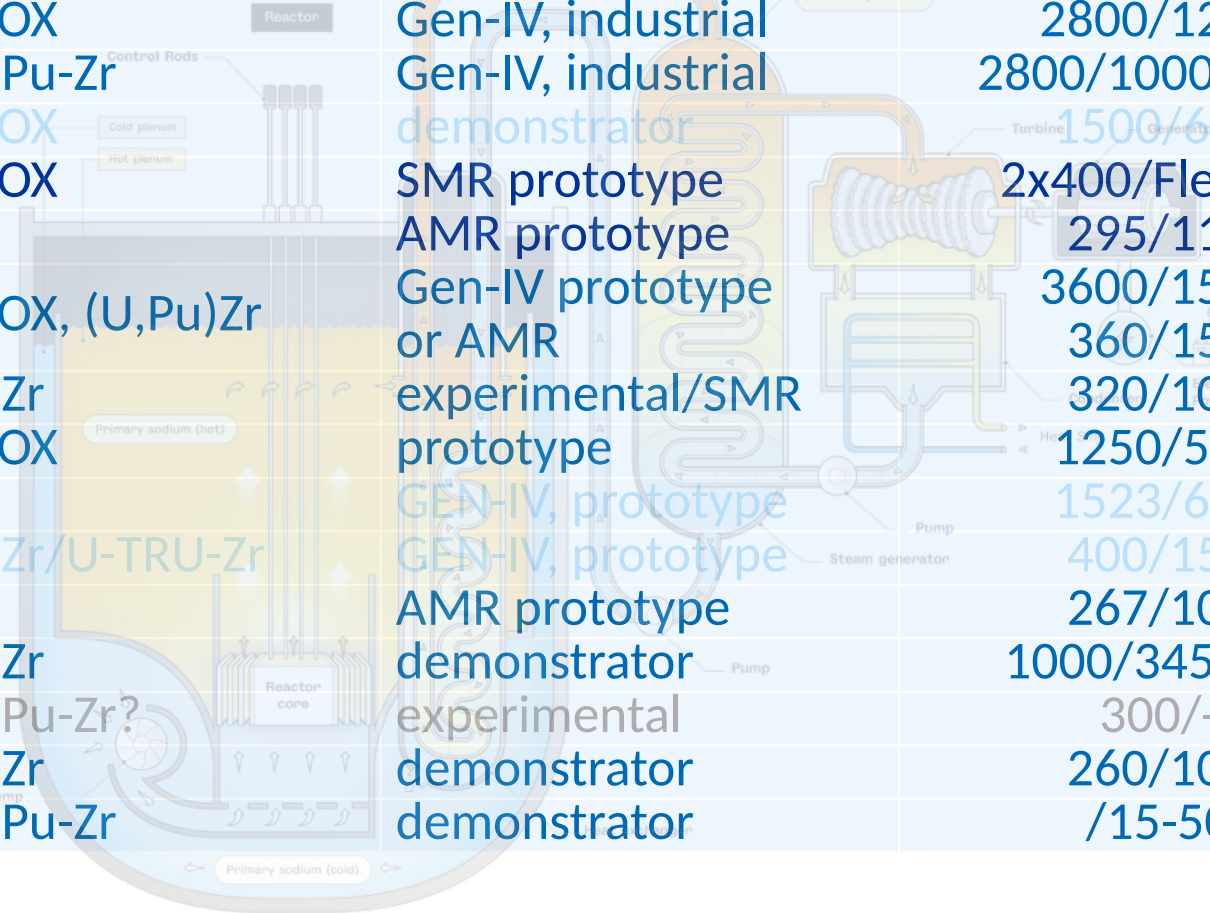
FFTF, USA



Phenix, France

Innovative SFRs under Development and Design

Country	Name	fuel	Purpose	Power (th/e), MW	Status
Russia	BN-1200	PuN/UN/MOX	Gen-IV, industrial	2900/1220	design
China	CFR1200	MOX	Gen-IV, industrial	2800/1200	design
	CiFR1000	U-Pu-Zr	Gen-IV, industrial	2800/1000-1200	design
France	ASTRID	MOX	demonstrator	1500/600	suspended
	HEXANA	MOX	SMR prototype	2x400/Flexible	concept
	OTRERA		AMR prototype	295/110	concept
EU	ESFR	MOX, (U,Pu)Zr	Gen-IV prototype or AMR	3600/1500 360/150	concept
India	PFBR-2	U-Zr	experimental/SMR	320/100	concept
	FBR 1&2	MOX	prototype	1250/500	design
R. of Korea	KALIMER-600		GEN-IV, prototype	1523/600	design
	PGSFR	U-Zr/U-TRU-Zr	GEN-IV, prototype	400/150	suspended
	SALUS-100		AMR prototype	267/100	design
USA	NATRIUM	U-Zr	demonstrator	1000/345-500	design
	VTR	U-Pu-Zr?	experimental	300/-	design
	ARC-100	U-Zr	demonstrator	260/100	Concept
	Oklo	U-Pu-Zr	demonstrator	/15-50	concept



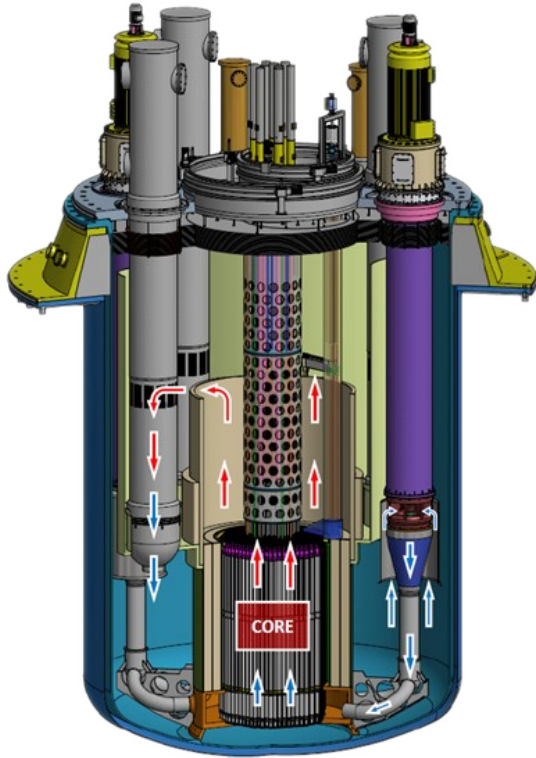
Conceptual design of CiFR1000

CiFR1000 is composed of several fast reactors and one fuel regeneration facility in same plant site. Fuel regeneration facility integrate pyro-processing and metal fuel fabrication line for fuel reprocessing and regeneration.



Parameter	Value
1) Coolant type	Na-Na-H ₂ O
2) Thermal power	2800MWt
3) Electric power	1200MWe
4) Thermal efficiency	>40%
5) Primary loops	4
6) Secondary loops	4
7) Fuel type	Metal Fuel
8) Cladding material	FMC630
9) Breeding ratio	>1.2
10) Maximum fuel burnup	180000MWd/tHM
11) Refueling cycle	>12 months
12) Availability	> 90%
13) Safe Shutdown Earthquake (SSE)	0.3g
14) CDF	$<1 \times 10^{-6}$
15) LERF	$<1 \times 10^{-7}$
16) Design life	60 years
17) Construction cycle	60 months

Sodium cooled Fast SMRs (New Designs)



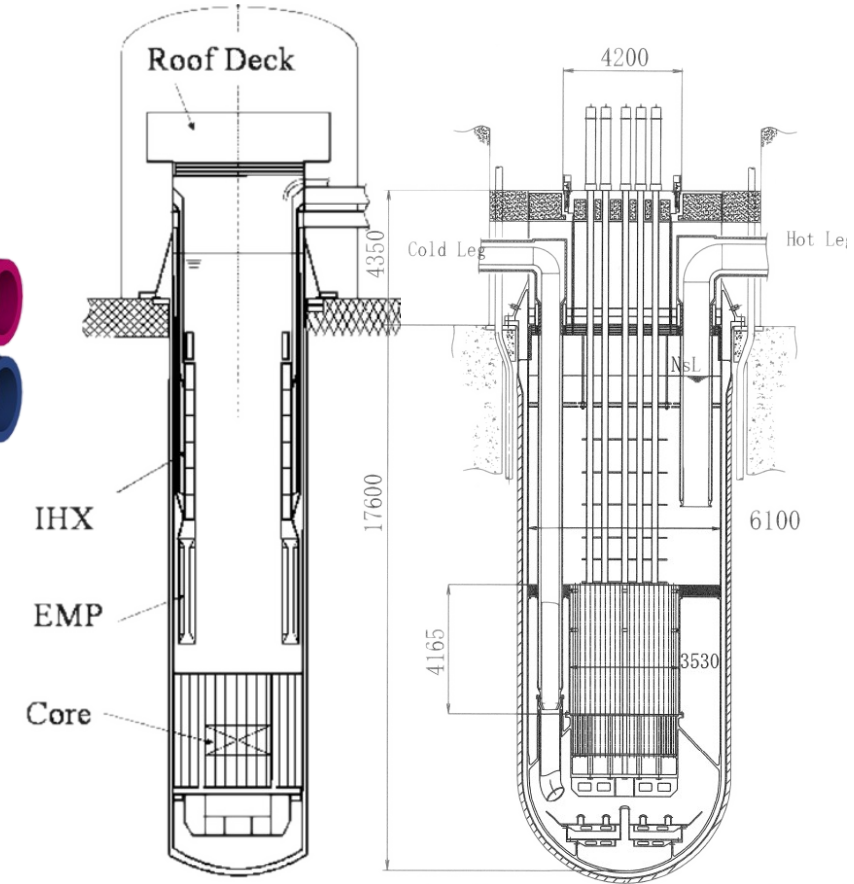
150 MW(e) PGSFR
Rep. of Korea



400 MW(th) HEXANA
France



180MW(th) + 110 MW(e)
OTRERA
France



Reactor Vessel

50 MW(e) SMFR
Japan

300 MW(e) SFR
Japan

HEXANA: Multi-Purpose SFR

HEXANA

2 modules nucléaires
de 400MW thermiques

Puissance constante

Module de stockage
de chaleur

Variation de puissance assurée
par le stockage de la chaleur

Chaleur

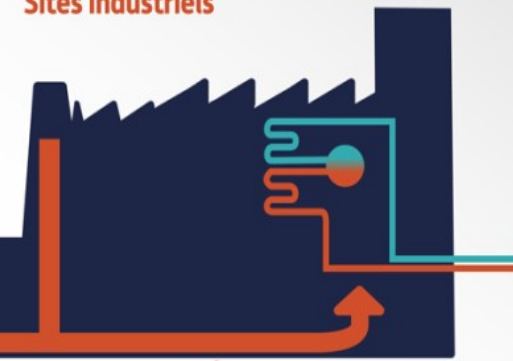
Chaleur

90°C

300°C

500°C

Sites industriels



Production flexible d'électricité

jusqu'à 20% P/min



Applications

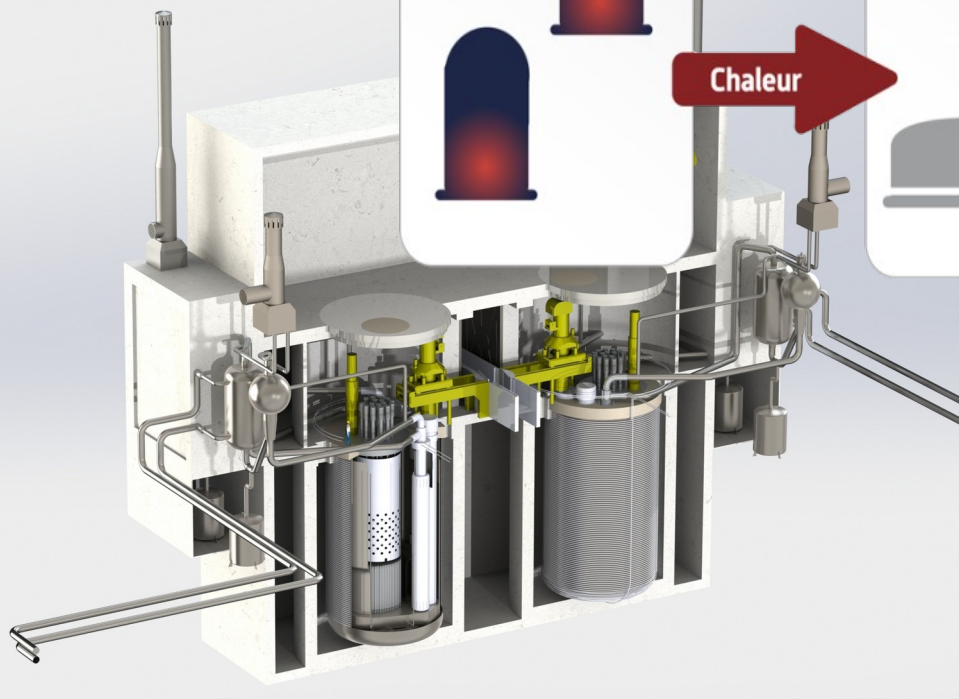
H₂

H₂O

eFuel

CO₂

2x400 MW(th) reactors



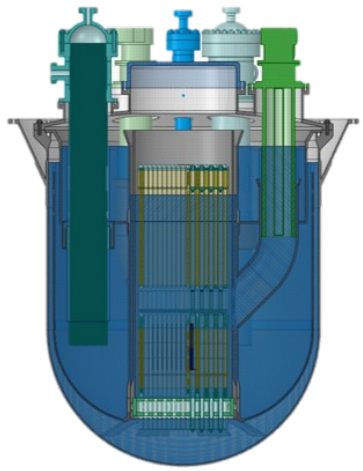
Innovative LFRs under Development and Design



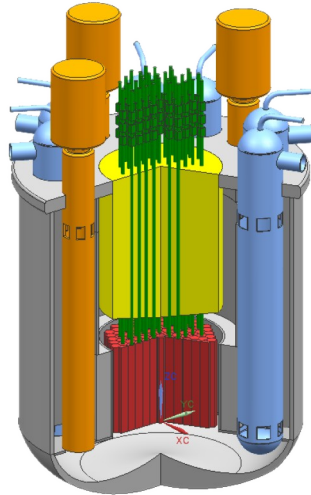
Country	Name	Type	coolant	fuel	Purpose	Power (th/e), MW	Status
Russia	SVBR-100	LFR	LBE	UO ₂	prototype	280/100	design
China	CLFR-300	LFR	LBE/Pb		demonstrator	740/300	concept
	CLEAR-I	LFR	LBE	UO ₂	experimental	10/-	design
	CLEAR-M10d	LFR	Pb	UO ₂	demonstrator	25/10	concept
Belgium	MYRRHA	LFR ADS	LBE	MOX	experimental	100/-	design
Italy + EU	LFR-AS-30/200 (newcleo)	LFR	Pb	MOX	Experimental /prototype	/30 or /200	concept
Romania /Italy + EU	ALFRED	LFR	Pb	MOX	Gen-IV, industrial	300/120	design
EU	EAGLES-300	LFR	Pb	MOX	Gen-IV, demonstrator	900?/350	concept
Sweden	SEALER-55	LFR	Pb	UN	commercial	140/55	design
USA	Westinghouse LFR	LFR	Pb	MOX	demonstrator	950/450	design
USA	SSTAR	LFR	Pb		experimental	45/20	suspended



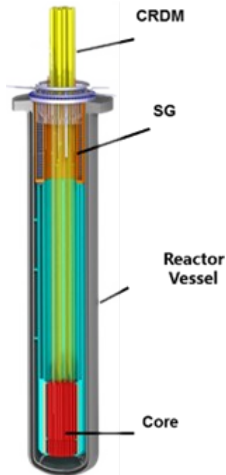
Heavy Liquid Metal cooled Fast Reactors



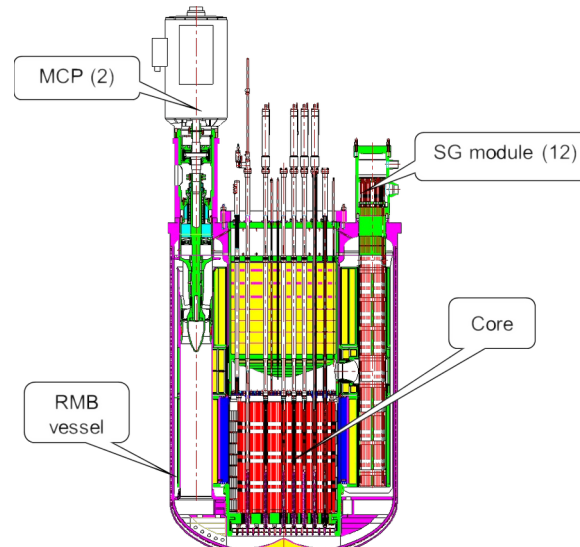
ALFRED
125-250 MW(e)
EU



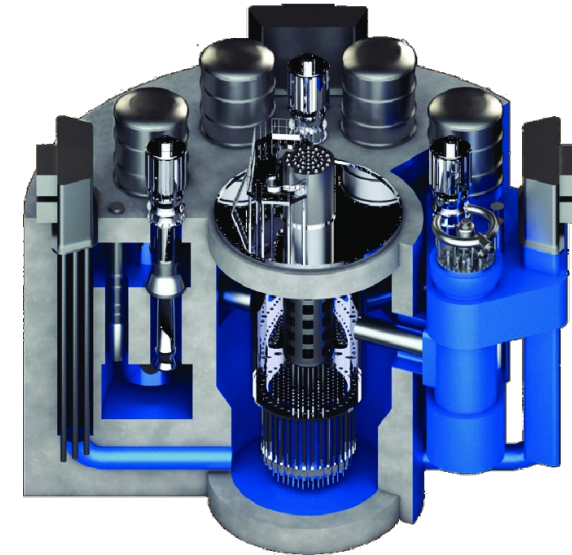
CLFR-300
China



14 MW(e) CLEAR-M10d
China



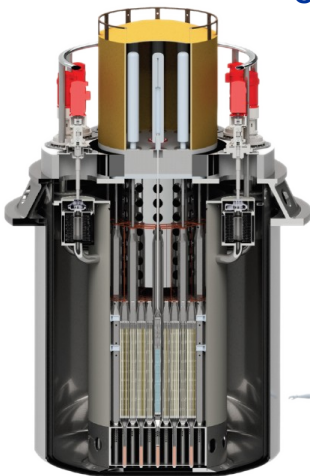
CB&P-100 (LBE)
Russia



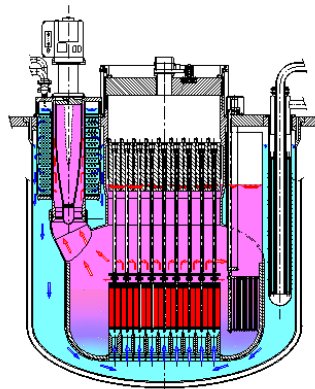
BREST-OD-300
Russia



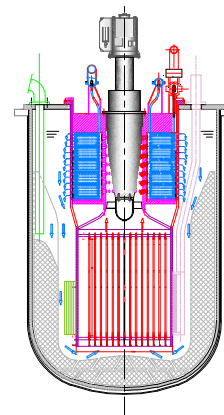
3-10 MW(e) SEALER
Sweden



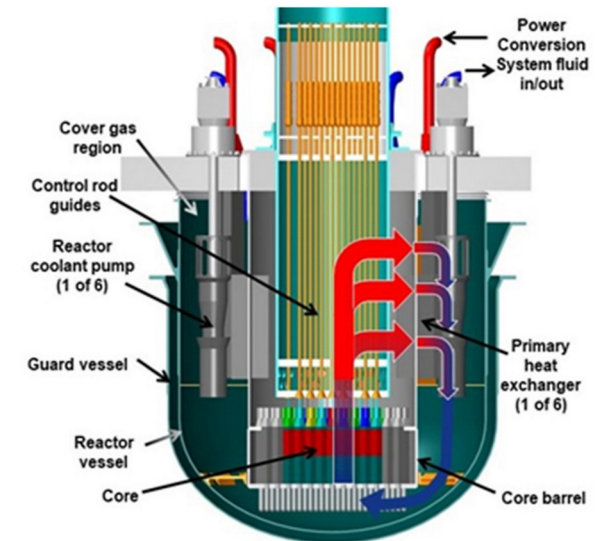
55 MW(e) SEALER
Sweden



LFR-AS-200 MW(e)
newcleo, Italy



Transportable LFR-TL-5 MW(e)
newcleo, Italy



Westinghouse LFR 450 MW(e)
WEC, USA

Joint Romania-Italy- Belgium EU-SMR-LFR

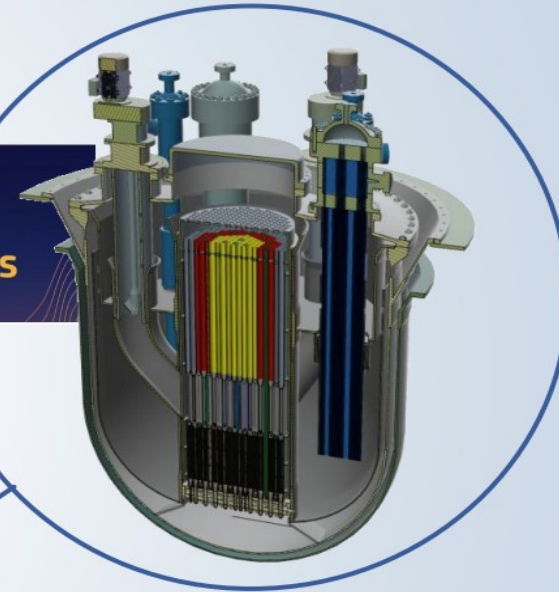
International collaborations

Collaboration agreement for accelerating the development of LFR technology



EU-SMR-LFR (re-branding EAGLE-300)

European Industrial Alliance on **SMALL MODULAR REACTORS**



Reference design

Simplified, robust, modular

Candidate sites

Mol-Belgium and Pitesti-Romania

Shared roadmap

Jointly owned IP

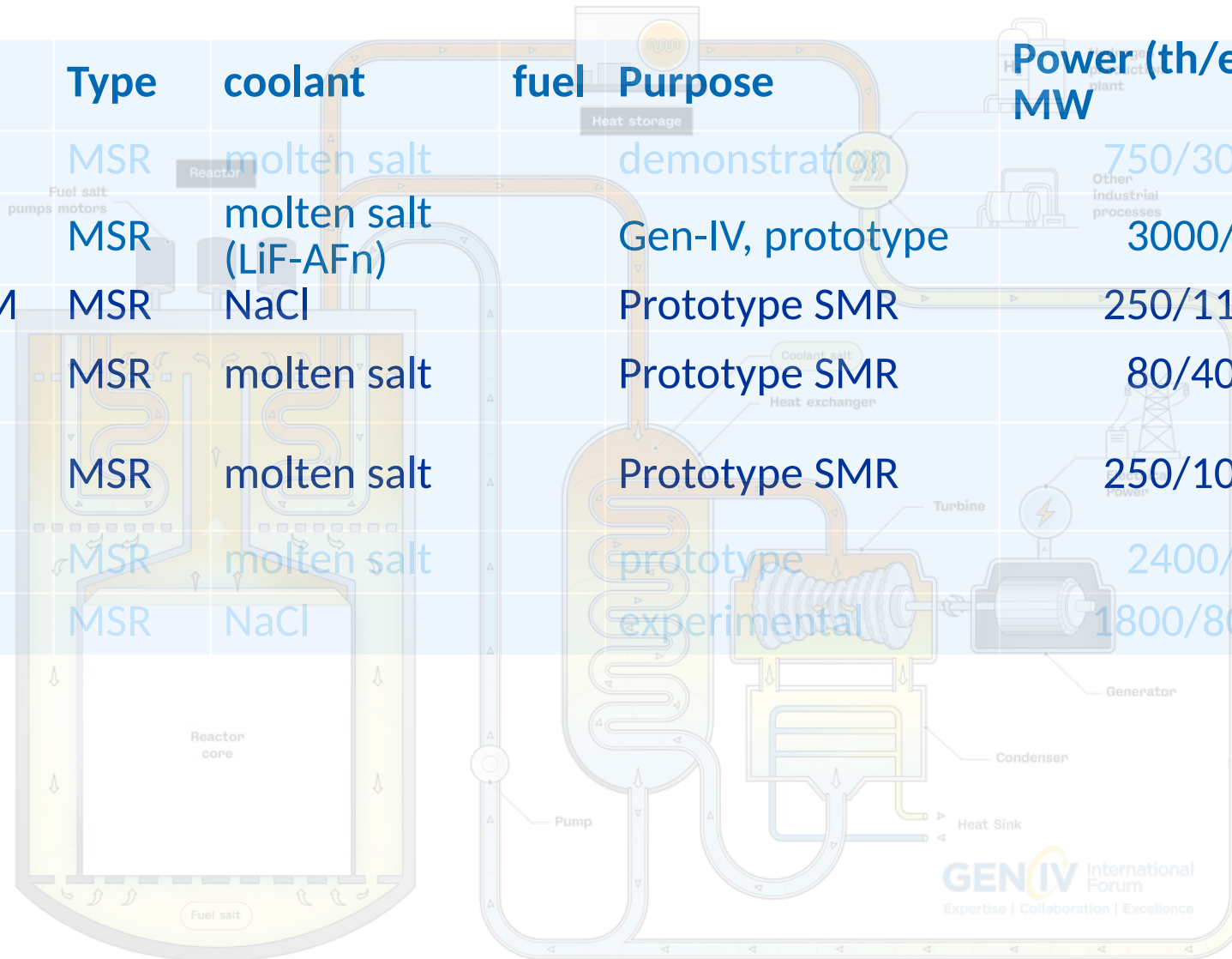
- Competitive economics
- Proven passive safety features
- Sustainable closed fuel cycle
- High temperature heat
- Commercial fleet deployment by 2040



Eagles Consortium - a newly established alliance which goal is to develop and commercialize EAGLES-300, a next-generation lead-cooled Small Modular Reactor (SMR).

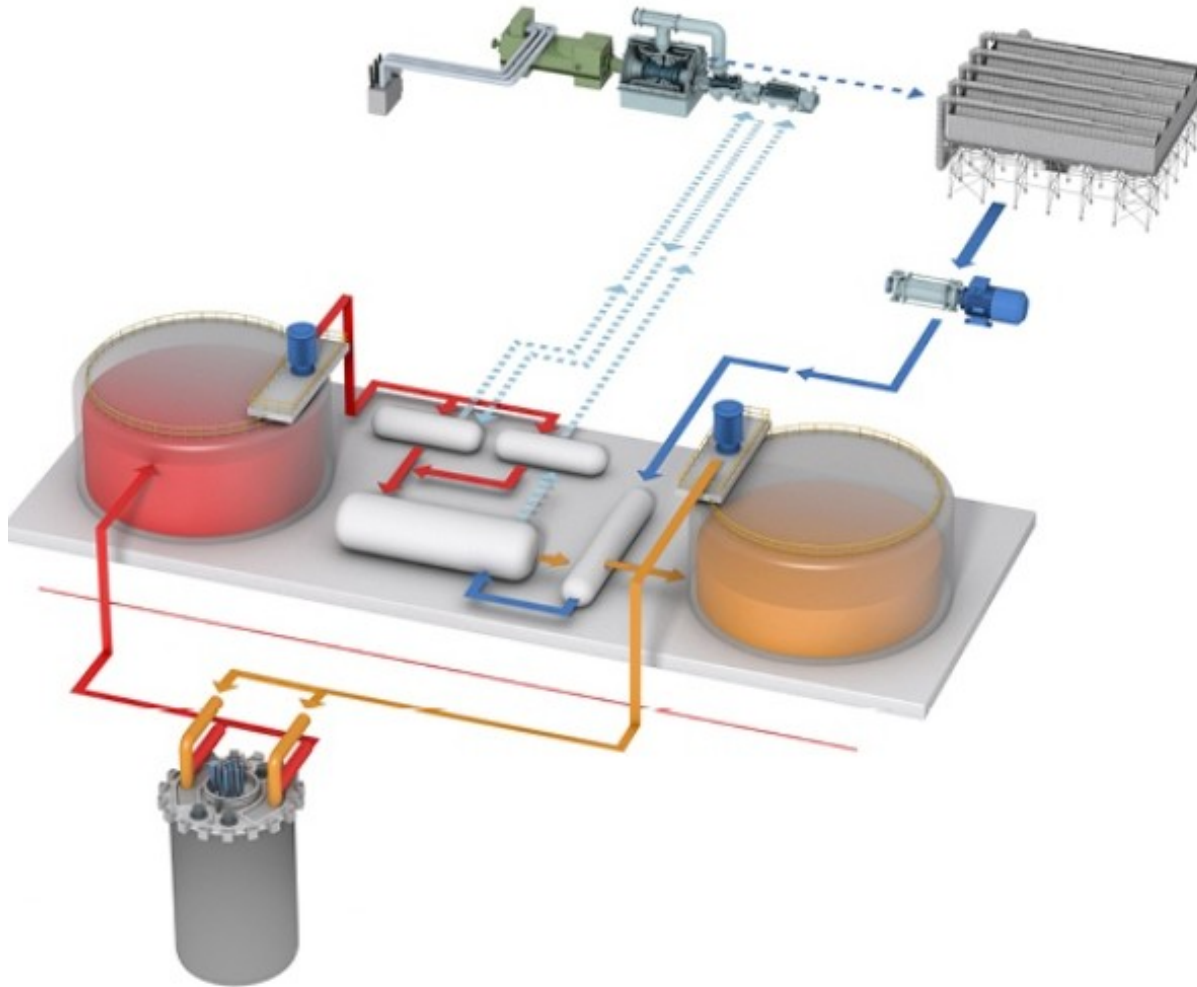
Gen-IV MSR under Development and Design

Country	Name	Type	coolant	fuel	Purpose	Power (th/e), MW	Status
Canada	SSR-W	MSR	molten salt		demonstration	750/300	demo
France	MSFR	MSR	molten salt (LiF-AFn)		Gen-IV, prototype	3000/	concept
	STELLARIUM	MSR	NaCl		Prototype SMR	250/110	concept
	XS(A)MR (Naarea)	MSR	molten salt		Prototype SMR	80/40	concept
Netherlands /EU	Thorison	MSR	molten salt		Prototype SMR	250/100	concept
Russia	MOSART	MSR	molten salt		prototype	2400/	concept
USA	MCFR	MSR	NaCl		experimental	1800/800	design



NATRIUM: SFR with Molten Salt Storage System

Designed by Terrapower

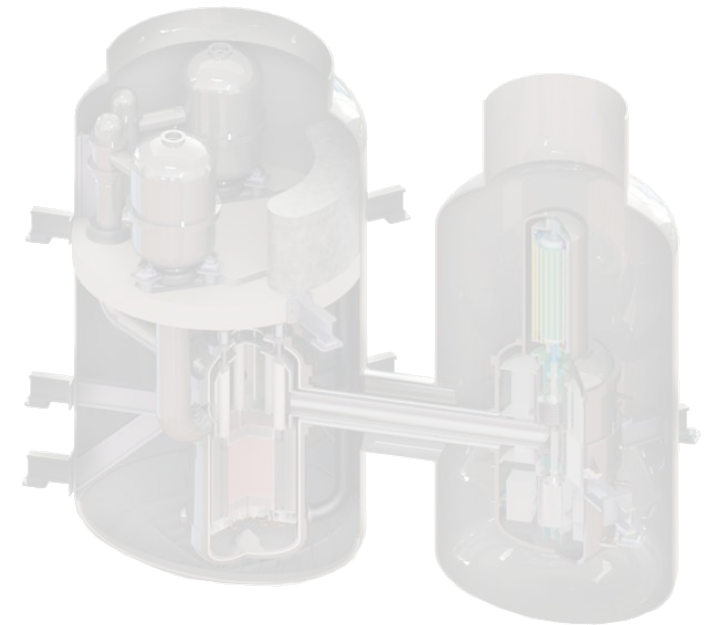
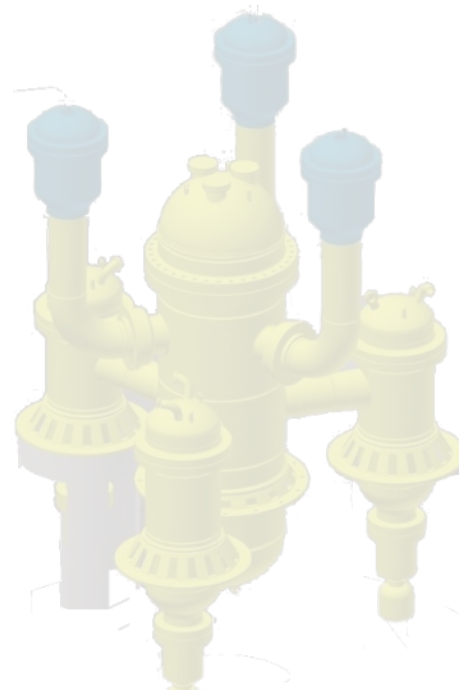
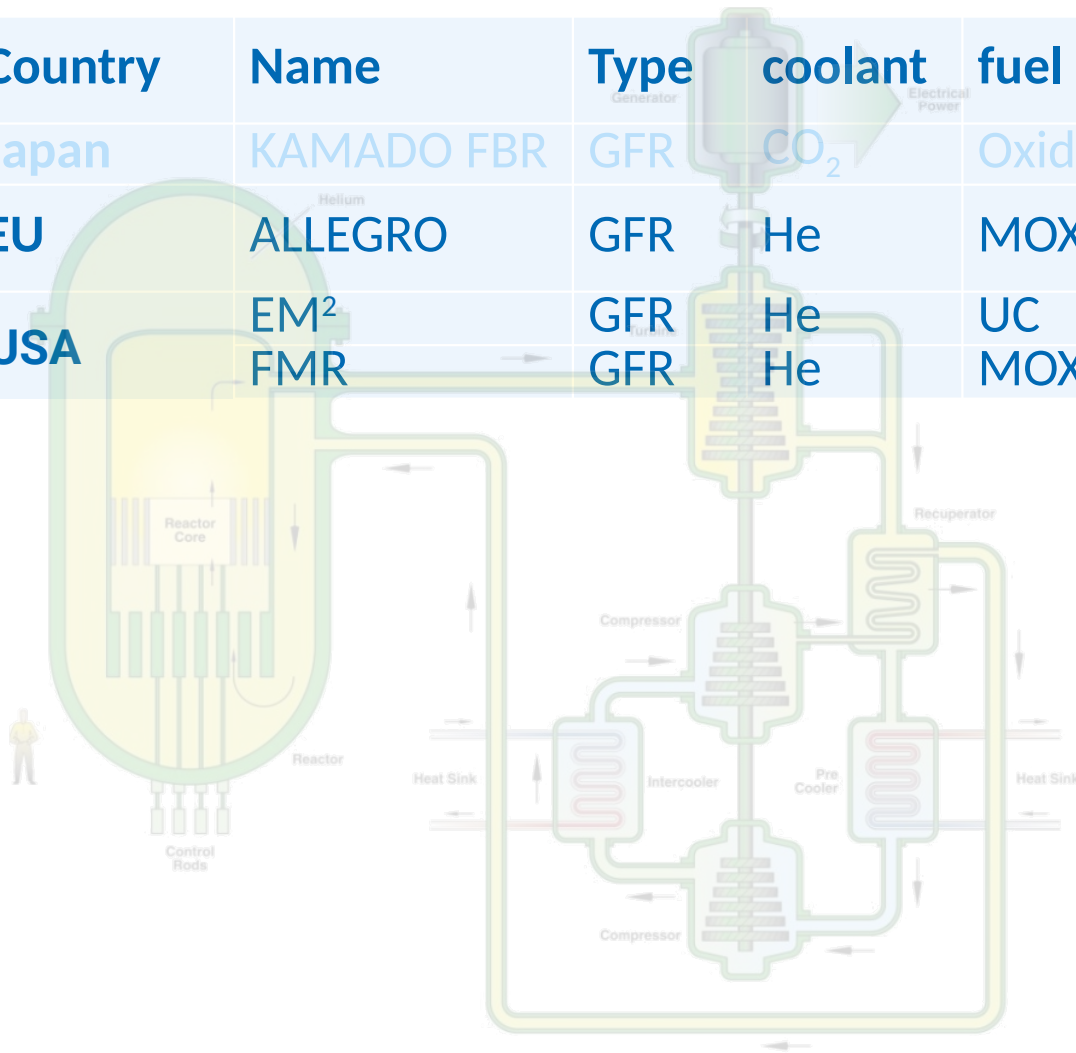


345 MW(e) SFR combined with
1GW(th) Energy molten salt-based storage
system

Pick power can boost to 500 MW(e)
Can be used for non-electrical applications
Can work with renewables

Innovative GFRs under Development and Design

Country	Name	Type	coolant	fuel	Purpose	Power (th/e), MW	Status
Japan	KAMADO FBR	GFR	CO ₂	Oxide	demonstrator	3000/1000	Concept
EU	ALLEGRO	GFR	He	MOX	Gen-IV, demonstrator	75/-	design
USA	EM ²	GFR	He	UC	demonstrator	500/265	Concept
	FMR	GFR	He	MOX/UF ₄ / UCO	demonstrator	100/44	Concept

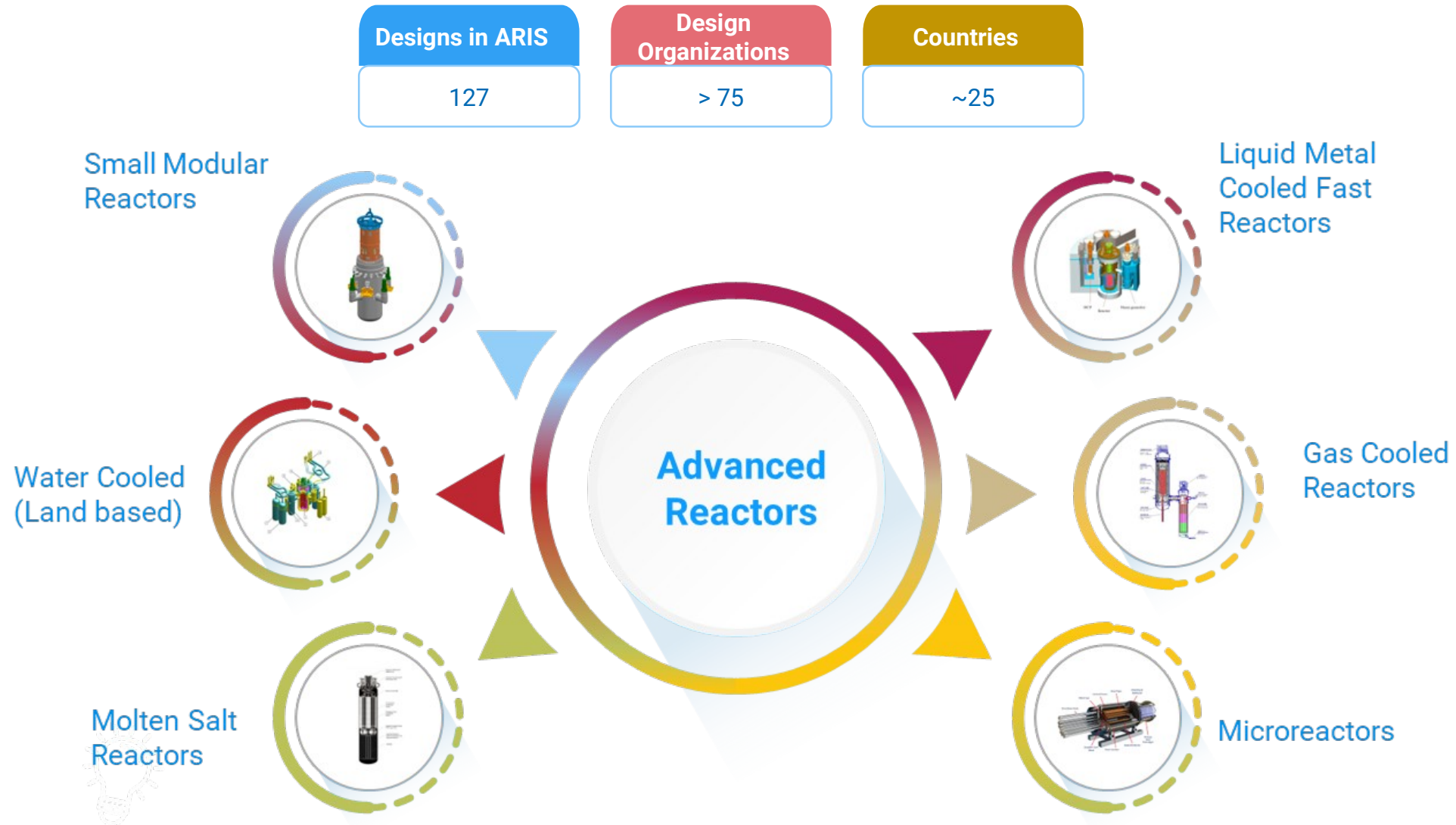


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Advanced Reactors Information System (ARIS)

Web accessible database and a tool for Member States at various stages of nuclear power development, offering standardized, impartial data on reactor designs, including evolutionary and innovative concepts, to support informed reactor technology assessments



[Access online: Advanced Reactor Information System | Aris](#)



Joint ICTP-IAEA Workshops

Physics and Technology of Innovative Nuclear Energy Systems

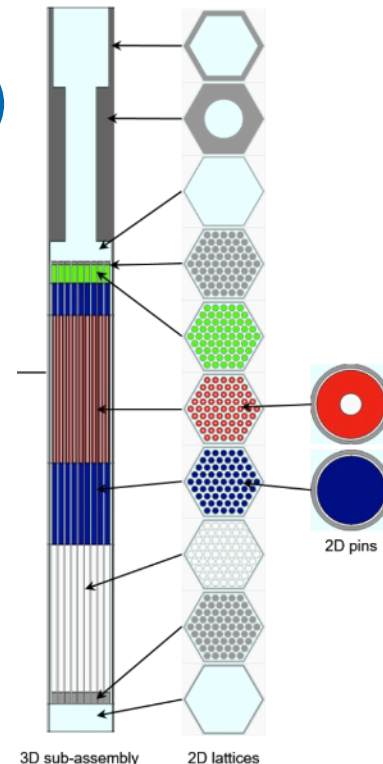
- **In 2016, 2018, 2022 and 2024, in ICPT Trieste, Italy;**
next in July 2026
- *Contributed by NPTDS, INPRO, GIF and external experts*



Open-Source Nuclear Codes for Reactor Analysis (**2023**: IAEA ONCORE Initiative)

- **OpenFOAM** and its derivatives for CFD simulation of multi-physics and multi-scale problems
- **GenFOAM** for core thermal hydraulics, neutron transport and structural mechanics modelling
- **OpenMC** Monte-Carlo neutron transport
- **ARMi** Advanced Reactor Modelling Interface
- 2nd ONCORE Workshop: 22-26 September 2025:

- <https://indico.ictp.it/event/10868>



ONCORE Webinar Series on Multiphysics Modelling of Nuclear Reactors using OpenFOAM

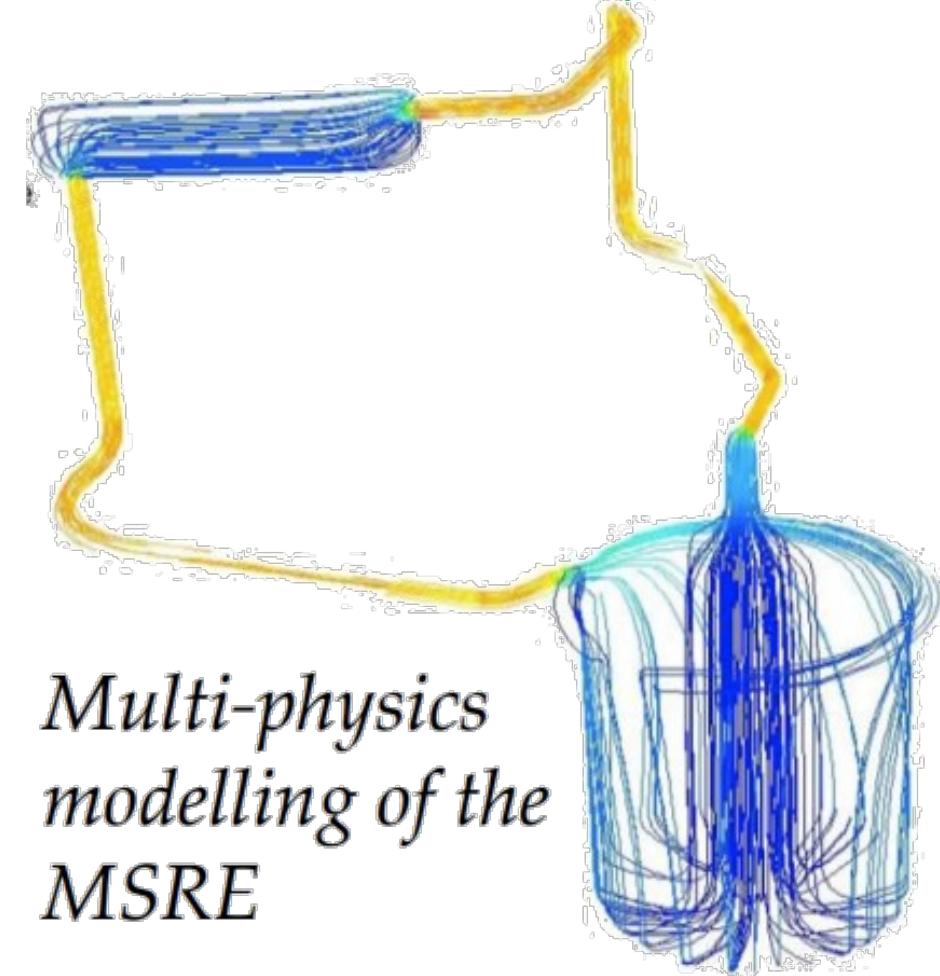
12 lectures in the series covering:

- Overview of using OpenFOAM as a multi-physics library for nuclear reactor analysis
- Brief introduction to the use of finite-volume methodologies
- Basics of Partial Differential Equations (PDEs)
- Problem definition
- Geometry and mesh generation
- Introduction to OpenFOAM's source code and object-oriented programming
- ContainmentFOAM tool for system-scale CFD analysis of containment atmosphere pressurization, H₂/CO mixing and mitigation.
- GeN-Foam tool as multi-physics solver in nuclear reactor design and safety analysis
- OFFBEAT tool, a solver for fuel behavior analysis in nuclear reactors. As a multi-dimensional code, it allows studying the evolution of the fuel in 1-D, 2-D or 3-D, and it can simulate both transient and steady-state conditions.
- GeN-ROM, a data-driven model-order reduction tool for nuclear applications based on GeN-Foam

Recordings of all lectures available here:

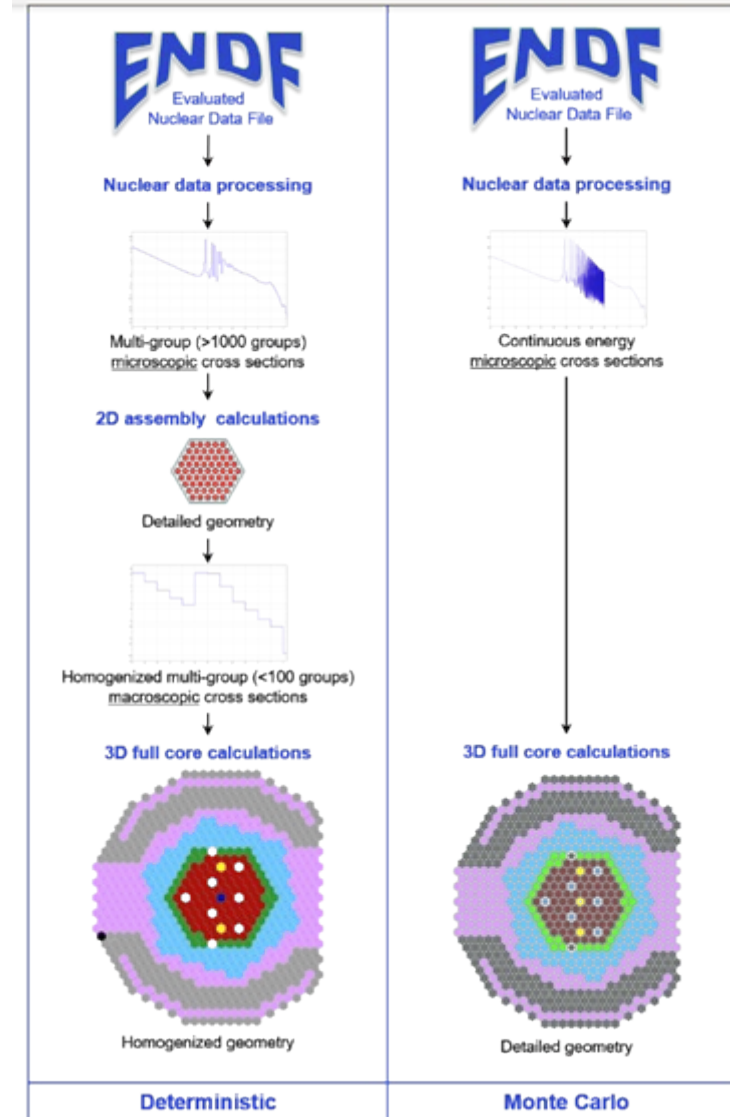
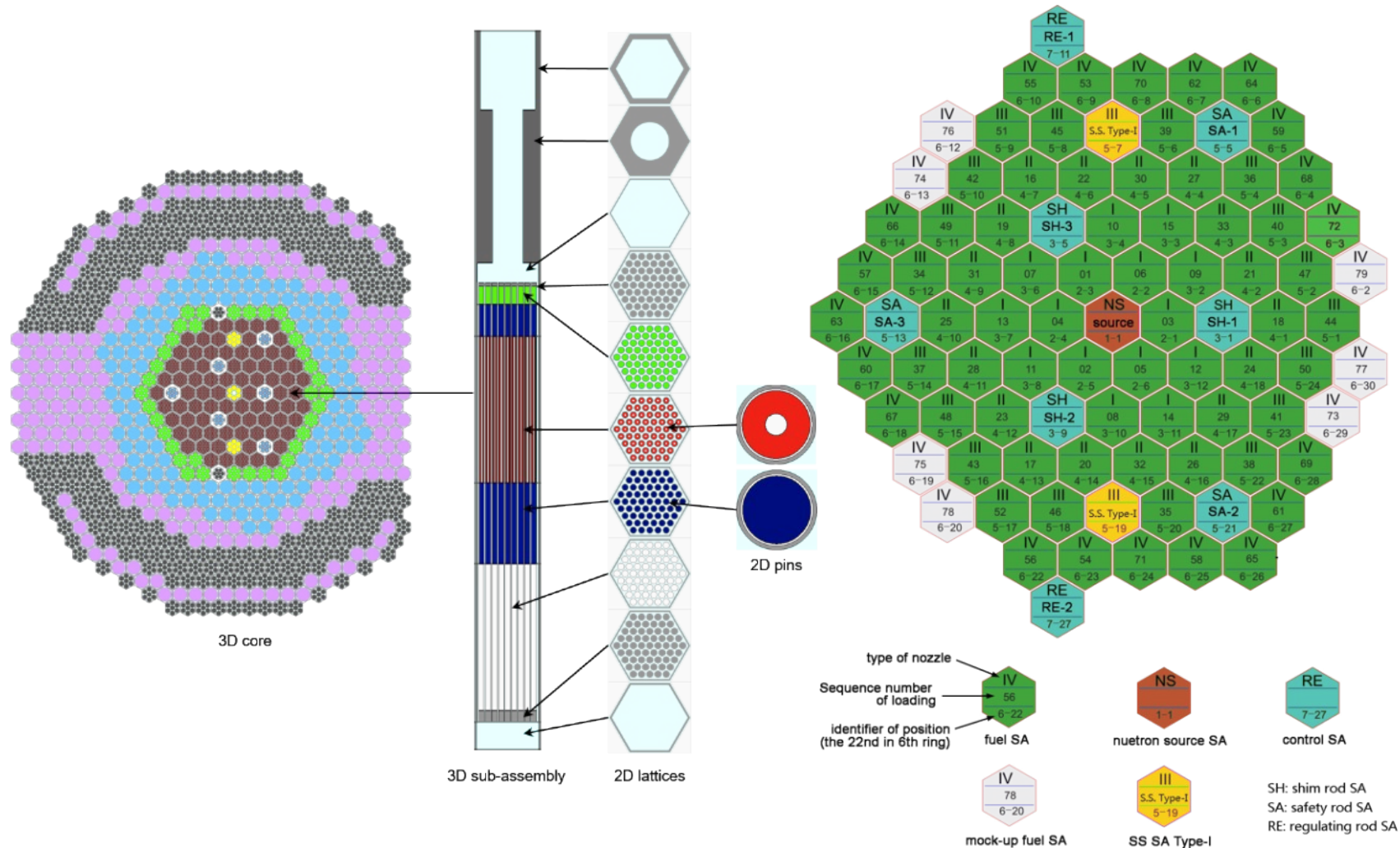
<https://elearning.iaea.org/m2/course/view.php?id=1286>

Molten Salt Reactor Experiment



*Multi-physics
modelling of the
MSRE*

IAEA Training Course Series: Fundamentals of neutronics simulations of a fast reactor based on IAEA's benchmark of CEFR Start-up Tests

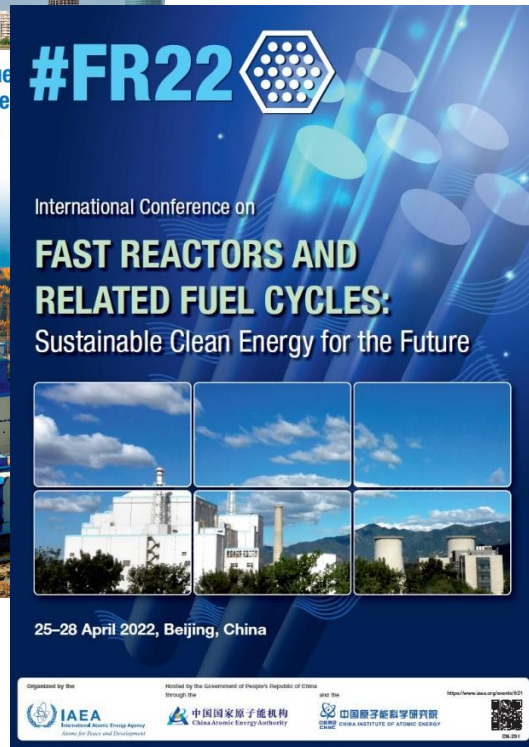


IAEA Conferences on Fast Reactors and Related Fuel Cycles

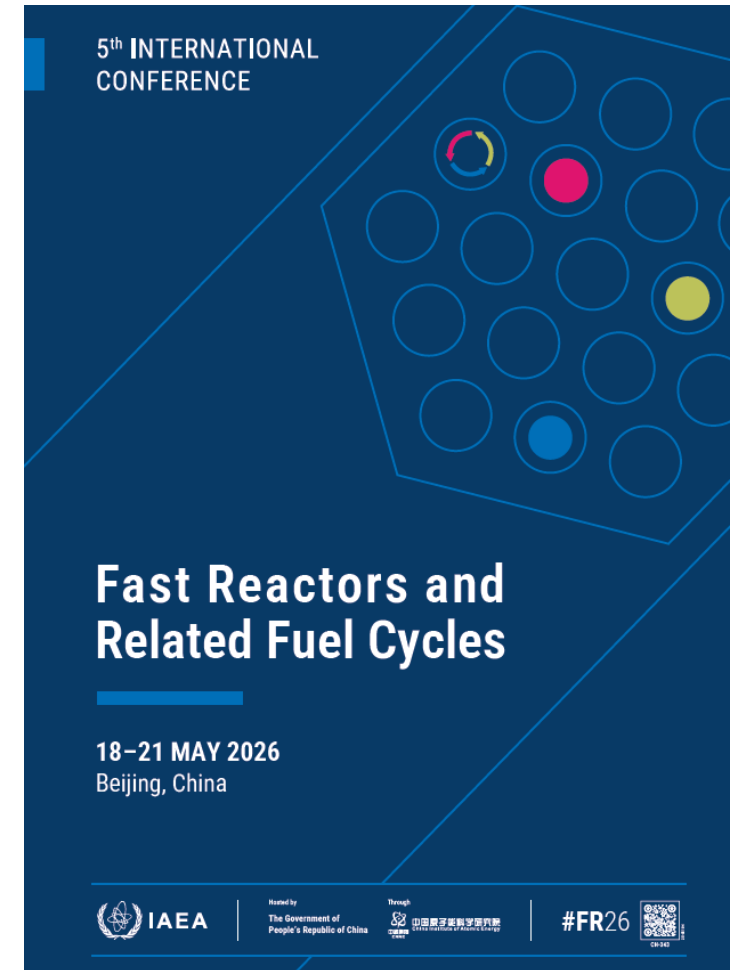


FR22

DG Grossi opens FR22



Mr Bhaduri,
FR22 General Chair



FR26 in Beijing

- Hosted by CIAE
- 18 - 21 May 2026



Atoms for peace and Development...

Thank You!

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