Joint IAEA-ICTP Workshop on Reactor Physics, Thermal Hydraulics and Plant Design Engineering of Small Modular Reactors (SMR4212)

Advances in Nuclear Power Technology Development and their Non-Electric Applications: Status in Member States and IAEA Programmatic Activities

Frederik Reitsma

Section Head

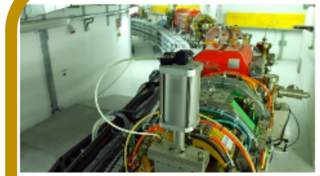
Nuclear Power Technology Development

13 April 2026

Division of Nuclear Power

Nuclear Power Engineering Section

The Section supports countries operating nuclear power plants or expanding their existing programmes to improve engineering, performance, management systems, human resource management, stakeholder involvement and technical infrastructure. It shares best engineering practices and innovations consistent with the global objectives of nuclear safety, security and non-proliferation. Read more →



Nuclear Power Technology Development Section

Fostering information exchange and collaborative research and development for advanced nuclear reactor technologies, this Section provides information to the IAEA's Member States on technology status and development trends for advanced reactor systems and their applications. Read more →

Nuclear Infrastructure Development Section

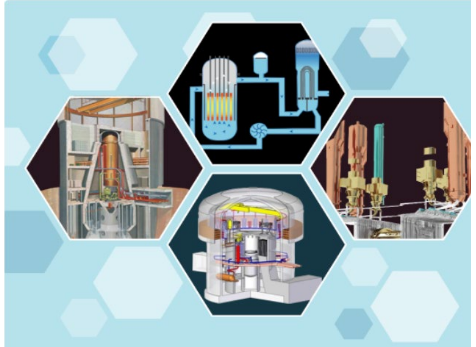
This Section is responsible for coordinating IAEA assistance to Member States considering or embarking on nuclear power programmes. It supports capacity-building, conducts review missions and offers guidelines, standards and workshops on developing the infrastructure for a safe, secure and sustainable nuclear power programme. Read more →

International Project on Innovative Nuclear Reactors and Fuel Cycles Section

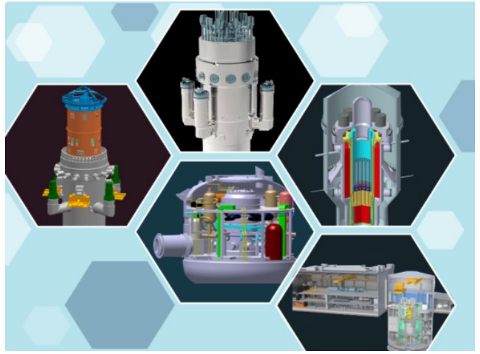
The Section coordinates the activities of the membership-based International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) to increase international cooperation on global nuclear energy sustainability, long term strategies and institutional and technical innovations for nuclear energy development and deployment. Read more →

Nuclear Power Technology Development Section

Fostering information exchange and collaborative research and development for advanced nuclear reactor technologies, this Section provides information to the IAEA’s Member States on technology status and development trends for advanced reactor systems and their applications.

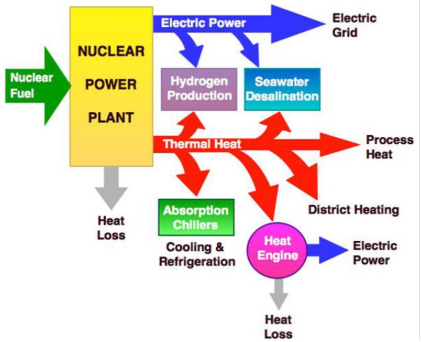


Advanced Water-Cooled Reactors



SMRs

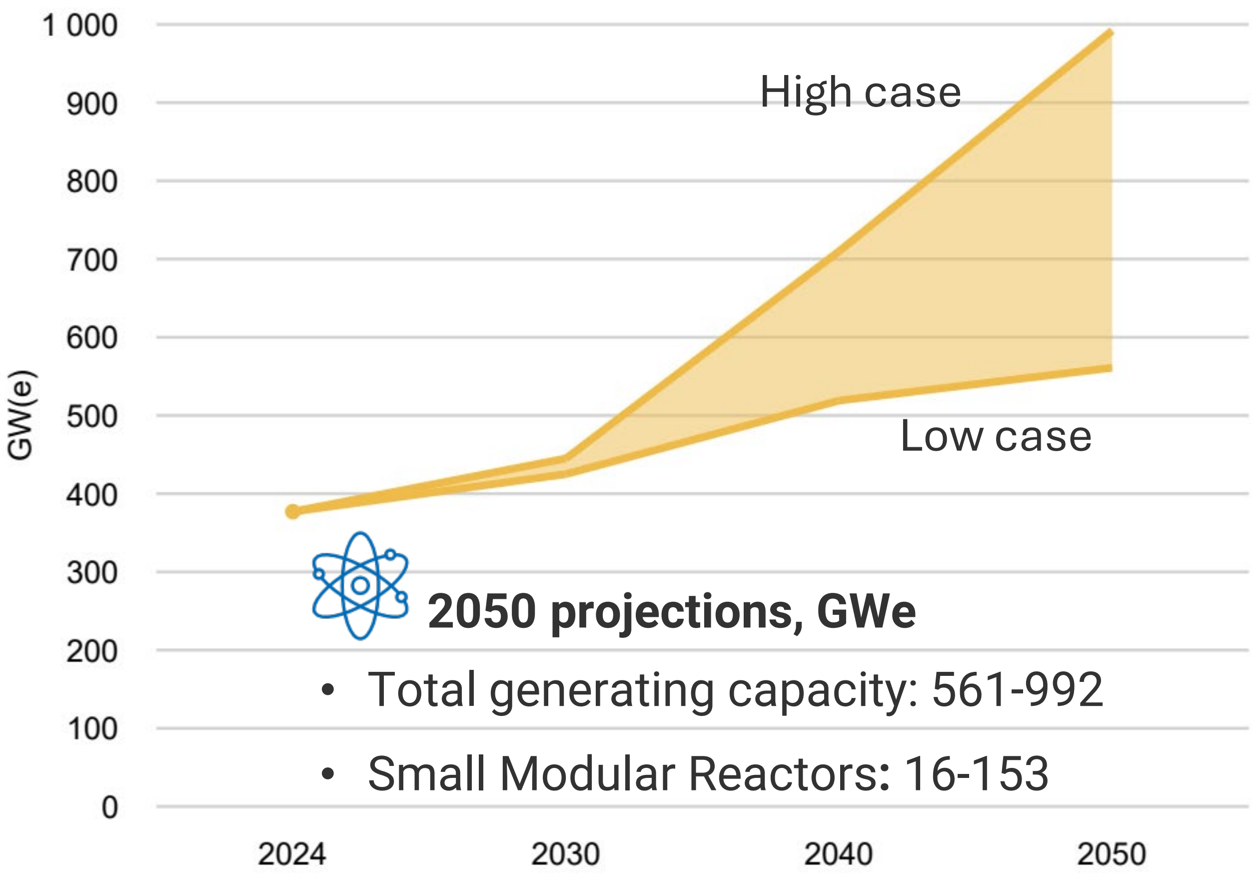
Advanced Technology for Fast Reactors



Non-Electric Applications

Fusion Technology

World Nuclear Electrical Generating Capacity

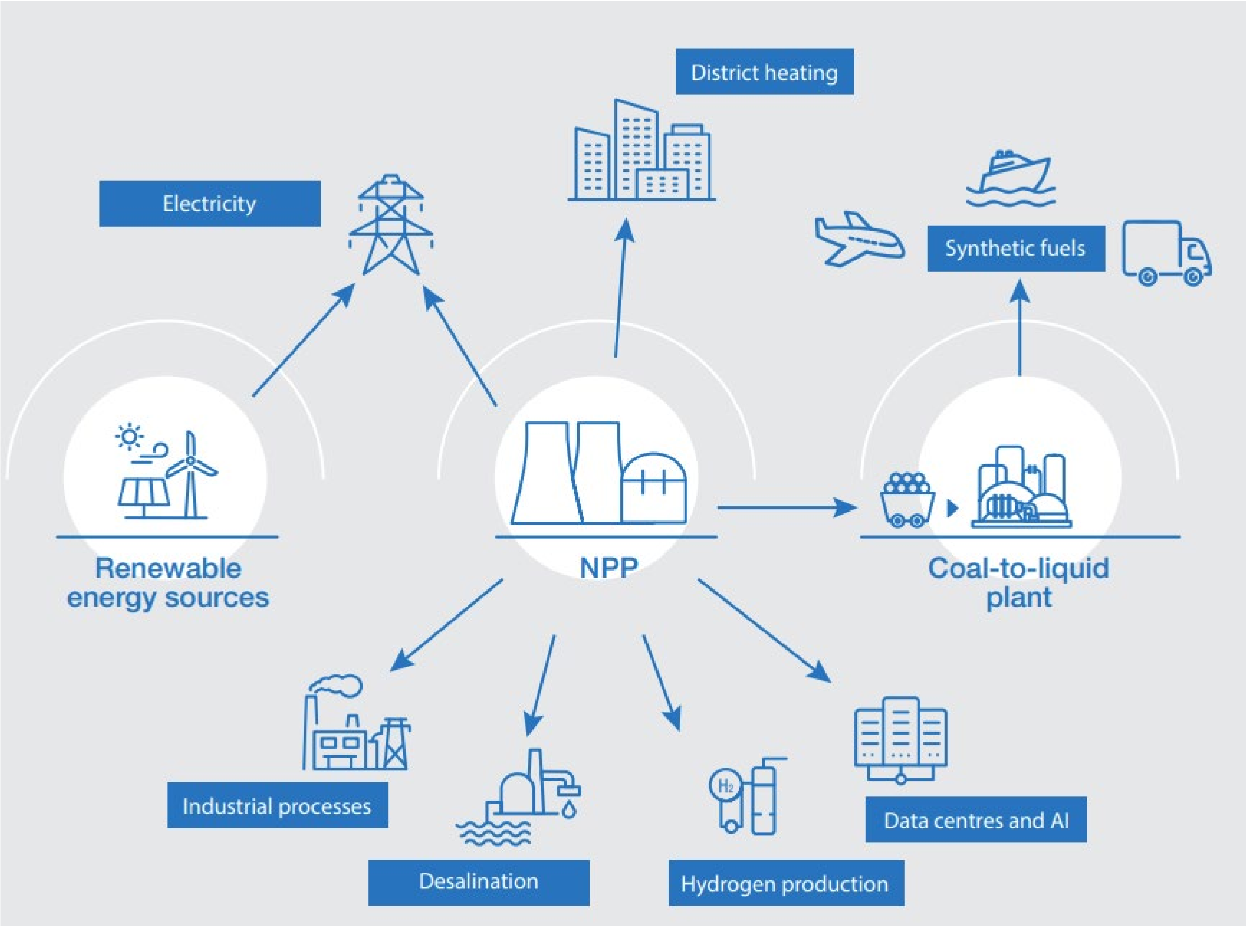


2050 projections, GWe

- Total generating capacity: 561-992
- Small Modular Reactors: 16-153

IAEA Energy, Electricity and Nuclear Power Estimates for the Period up to 2050, RDS-1 2025 Edition

Nuclear energy decarbonizing large industrial hubs



Source: https://www-pub.iaea.org/MTCD/Publications/PDF/p15898-25-02856E_PAT-013_web.pdf

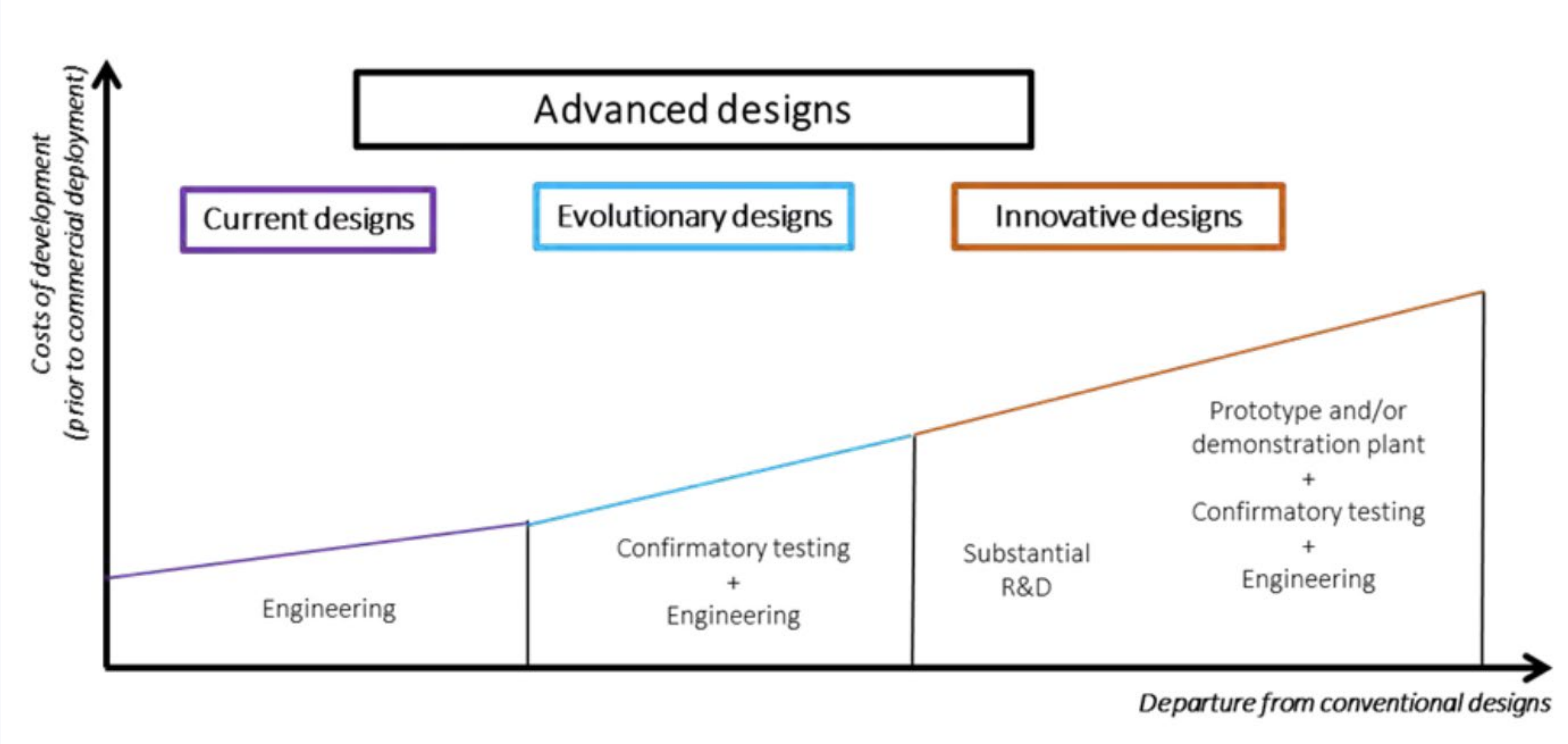
IAEA

International Developments on Advanced Reactor Technolgy

Advanced Reactors: Evolutionary and Innovative

- **Evolutionary Designs** - an advanced design that achieves improvements over current designs throughsmall to moderate modifications, with a strong emphasis on maintaining proven design elements to minimize technological risks.

- **Innovative Designs** - an advanced design which incorporates conceptual changes in design approaches or system configuration in comparison with existing practice

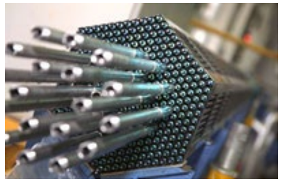


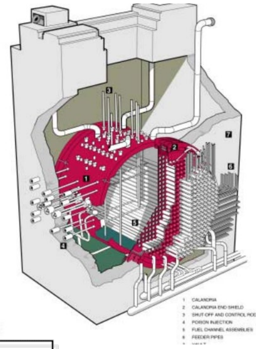
(As defined in IAEA "Terms for Describing Advanced Nuclear Power Plants" NR-T-1.19)

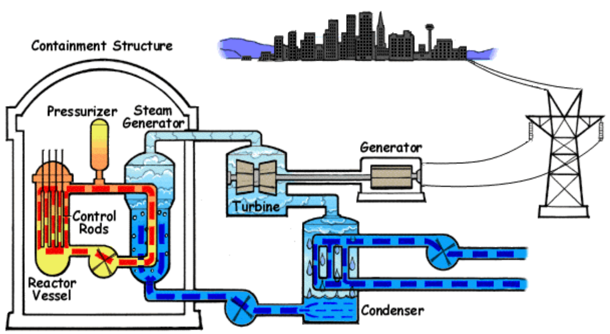
Commercial Reactors (Gen-II and III)

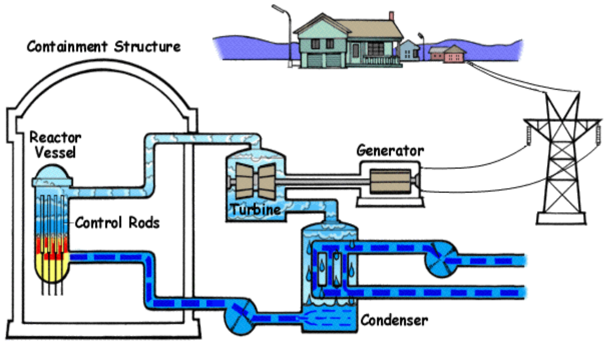
Most Common Technologies

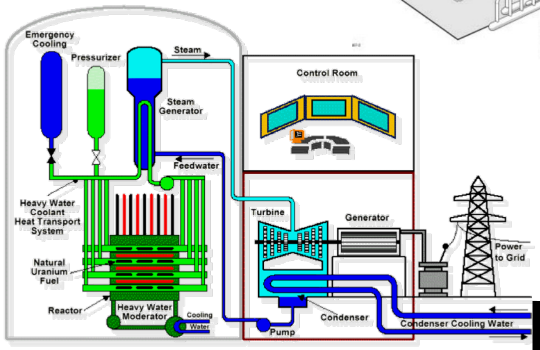
	PWR	BWR	PHWR
- **Moderator & coolant** - **Fuel** - **Operating Pressure** - **Characteristics**	- Light water - Enriched Uranium - ~15MPa (~6-7MPa steam) - Most common NPP technology	- Light water - Enriched Uranium - ~7MPa - Direct cycle: steam from drives from the reactor to the turbines	- Heavy water - Natural Uranium - ~10MPa - Pressure-tube design: pressure tubes within the calandria
- **Examples**	- Westinghouse and Combustion Engineering (USA) - Framatome (AREVA/EDF) (France) - KONVOI (Germany) - VVERs (Russia)	- General Electric BWRs (USA) - ABB Atom BWRs (Sweden) - Toshiba Hitachi BWRs (Japan)	- Bruce, Pickering, CANDU-6 (Canada) - Indian PHWR-220 & 540 MWe (India) - Atucha (Germany/Argentina)





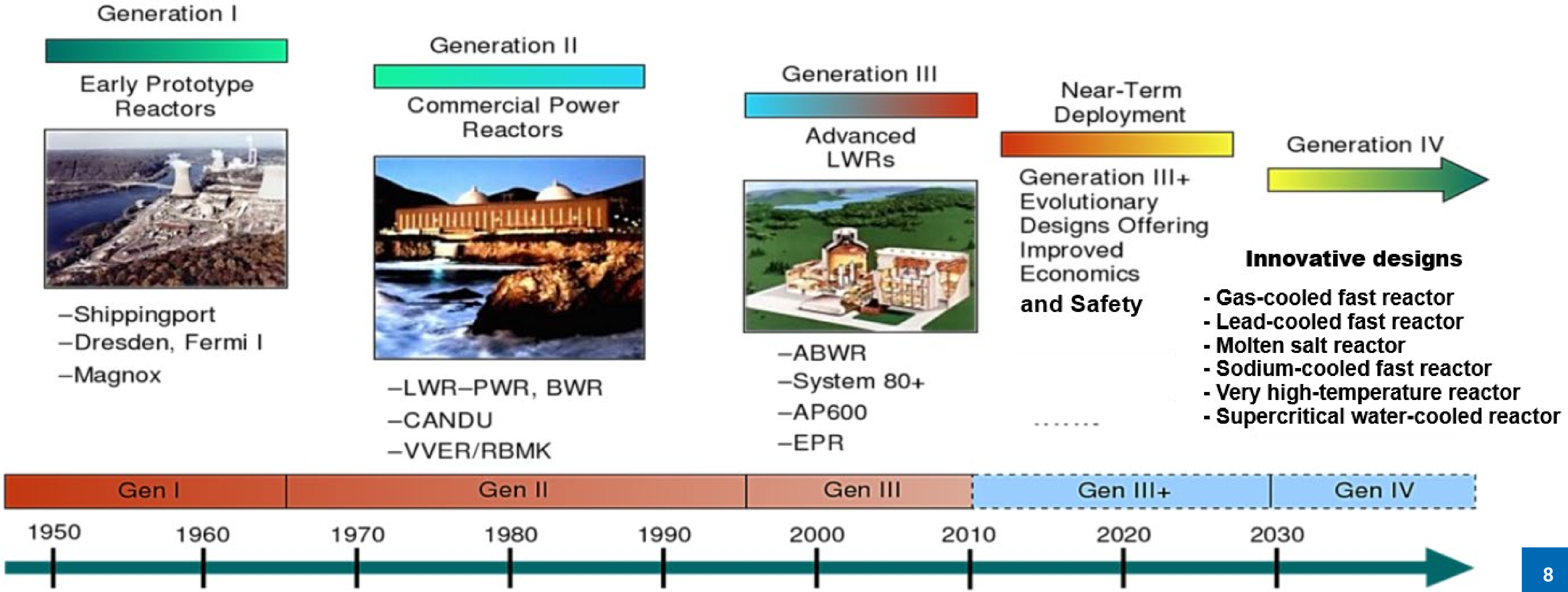






Evolution of Nuclear Power Reactor Technology

Generation IV: Nuclear Energy Systems Deployable no later than 2030 and offering significant advances in sustainability, safety and reliability, and economics



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Advanced Reactors

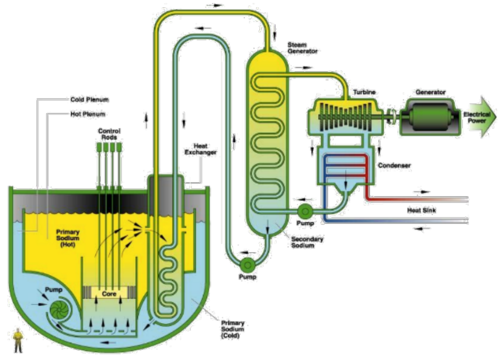
Currently 126 designs, including SMRs and microreactors

Water Cooled Reactors | Gas Cooled Reactors | Fast Reactors | Molten Salt Reactors | Small Modular Reactors | Microreactors

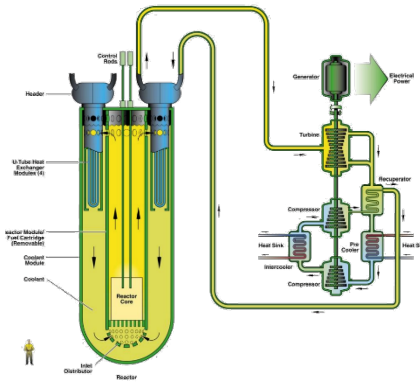
IAEA and GIF Terminology: Innovative Gen-IV Reactors

- **Early Prototypes and Demonstration Plants Gen-I**
- **Current Fleet Gen-II/III**
- **Advanced Nuclear Reactors**
    - *Evolutionary designs*
      Gen-III and Gen-III+
    - *Innovative designs*
      Gen-IV
    - SMRs can be either *evolutionary* or *innovative*
    - *Innovative SMR*
      Advanced Modular Reactor (AMR)
- **ARIS:** IAEA Advanced Reactors Information System: https://aris.iaea.org/

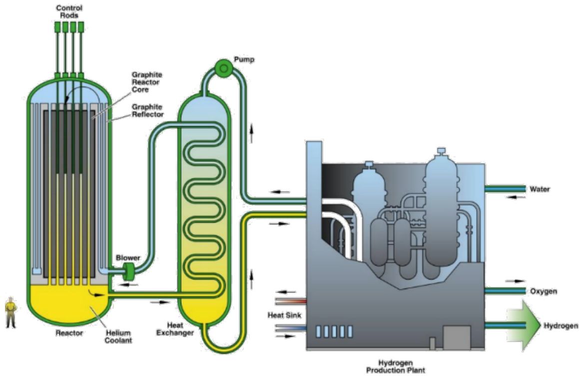
Sodium cooled Fast Reactor (SFR)

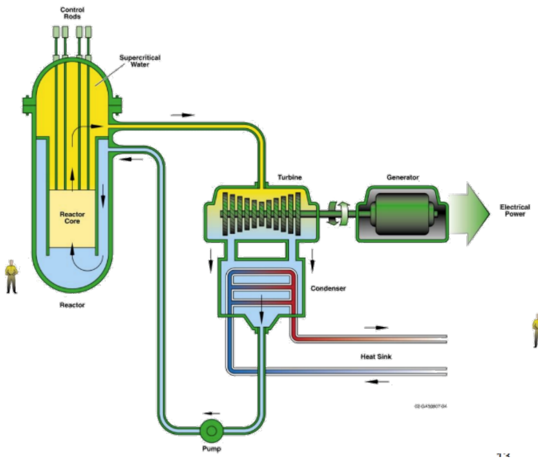


Lead cooled Fast Reactor (LFR)

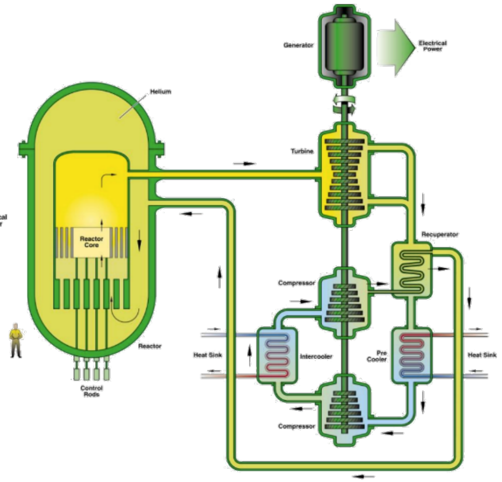


Very-High-Temperature Reactor (VHTR)

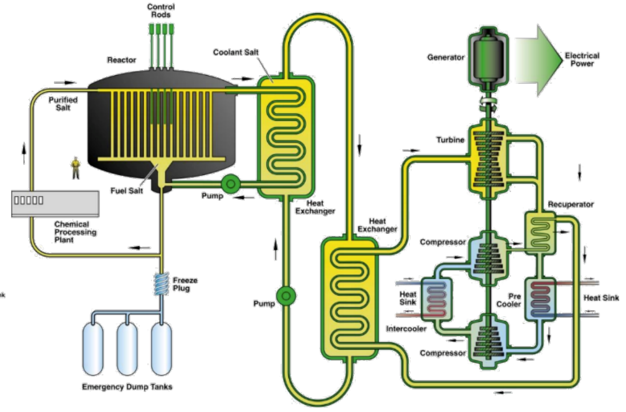




Supercritical Water cooled Reactor (SCWR)



Gas cooled Fast Reactor (GFR)

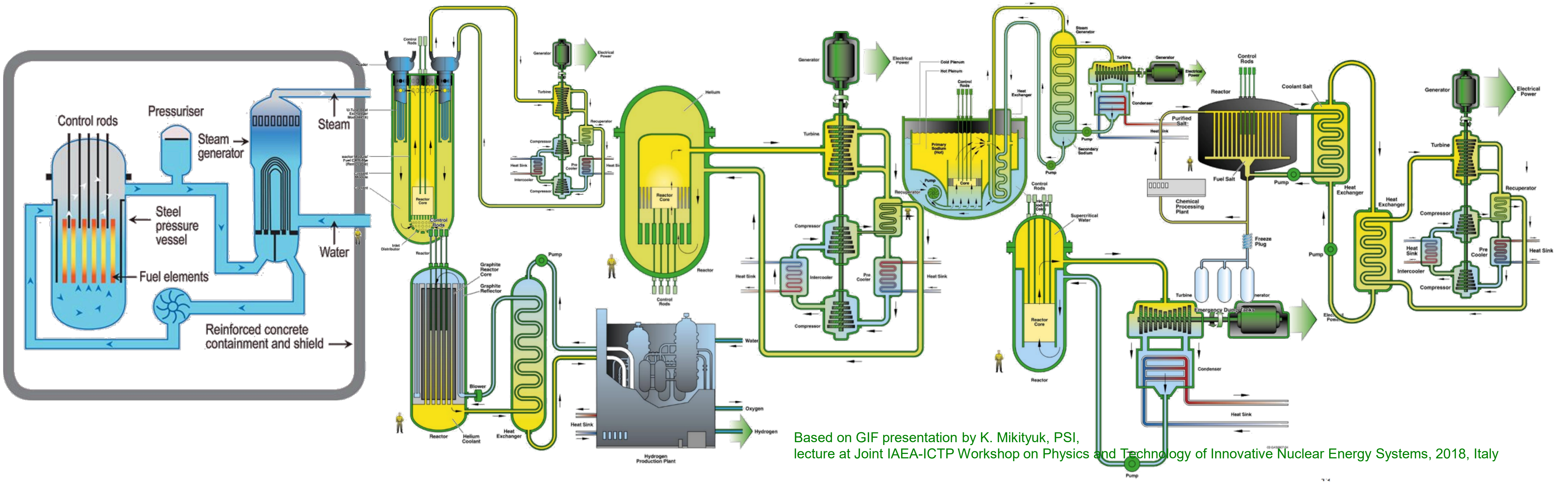


Molten Salt Reactor (MSR)

GIF website: www.gen-4.org

Comparing Innovative Reactor Concepts

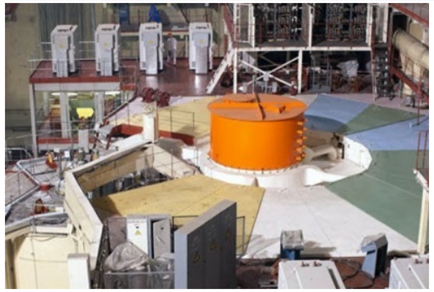
	WCR	SCWR	HTGR	GFR	SFR	LFR	MSR
coolant	H_2O	H_2O	He	He	Na	Pb/LBE	Fluoride/Chloride
outlet T, C	288-329	500	750	750	550	500	800
efficiency, %	35	45	50	50	45	43	48
max P, MPa	17	25	7	7	~0.2	~0.5	~0.2
spectrum	thermal	thermal/fast	thermal	fast	fast	fast	thermal/fast



Based on GIF presentation by K. Mikityuk, PSI,
lecture at Joint IAEA-ICTP Workshop on Physics and Technology of Innovative Nuclear Energy Systems, 2018, Italy

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**	April 2026	Operation
Japan	JOYO	sodium	UO_2/MOX	experimental	**150/--**	1978	lic renew (2024?)



BN-600
Russia, 1980

BN-800
Russia, 2015

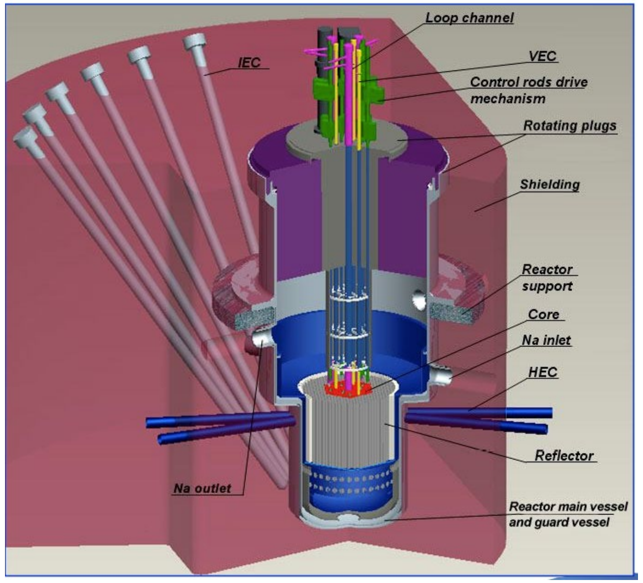
CEFR, 20 MW(e)
China, 2011

FBTR, 13 MW(e)
India, 1985

PFBR, 500 MW(e)
India, 2024

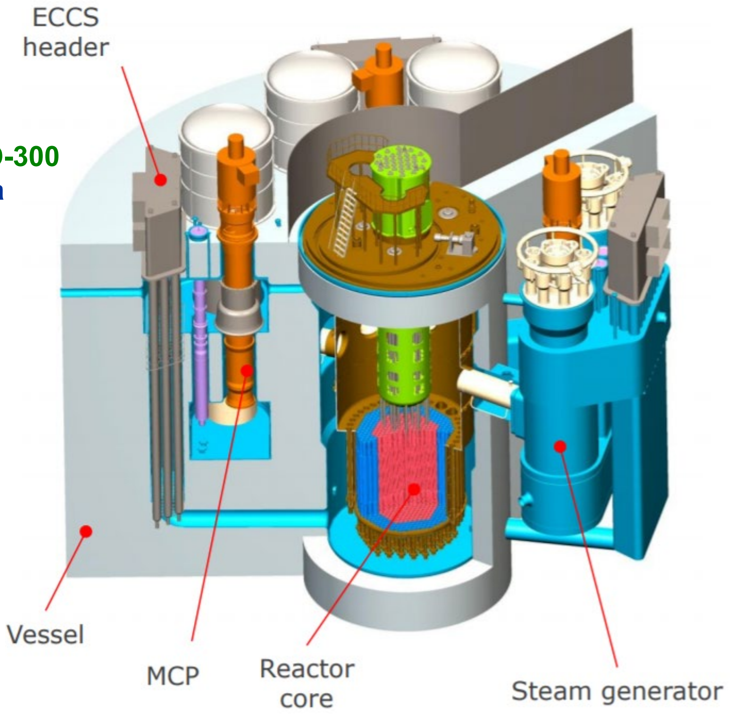
Fast Reactors under Construction

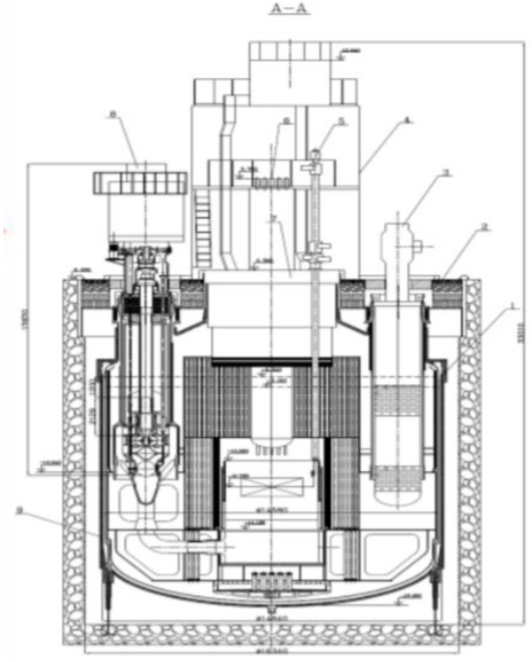
Country	Name	Coolant	Fuel	Purpose	Power, MW(th/e)	Year (Op.)	Status
Russia	MBIR	sodium	MOX	experimental	**150/50**	~2028	construction
	BREST-OD-300	lead	PuN/UN	demonstrator	**700/300**	~2026	construction
China	CFR600-2	sodium	UO_2/MOX	prototype	**1500/650**	~2028	construction



MBIR, Russia

BREST-OD-300 Russia





CFR600, China

Progress with Advanced Reactor Deployment – In the News

INDIA TODAY

India has a nuclear reactor that can make more fuel than it burns. Science explained

India's Prototype Fast Breeder Reactor at Kalpakkam has attained a historic milestone. The 500 MWe reactor, which produces more fuel than it consumes, puts India on course to harness its vast thorium reserves.

Date: 6 April 2026 : 500 MWe pool type sodium-cooled fast breeder reactor (FBR) using MOX fuel

Why it matters

- Marks **India's formal entry into Stage II** of the **three-stage nuclear programme**.
- Enables large-scale **plutonium breeding** and future **thorium utilisation (Stage III)**.
- One of **very few commercial-scale fast reactors worldwide**, and the only new one outside Russia.

The 500 MWe Prototype Fast Breeder Reactor at Kalpakkam in Tamil Nadu, designed and built entirely in India by BHAVINI and IGCAR, attained criticality on 6 April 2026. It is India's most advanced nuclear reactor to date.

Progress with Advanced Reactor Deployment – In the News

The First Advanced Nuclear Reactor in U.S. History Just Got Approved—and Bill Gates Is Behind It The Microsoft co-founder is betting next-generation nuclear reactors can power the AI boom while cutting carbon emissions.

Inc.

Date: 4 March 2026 : 345 MWe sodium-cooled fast reactor + molten-salt energy storage

Why it matters

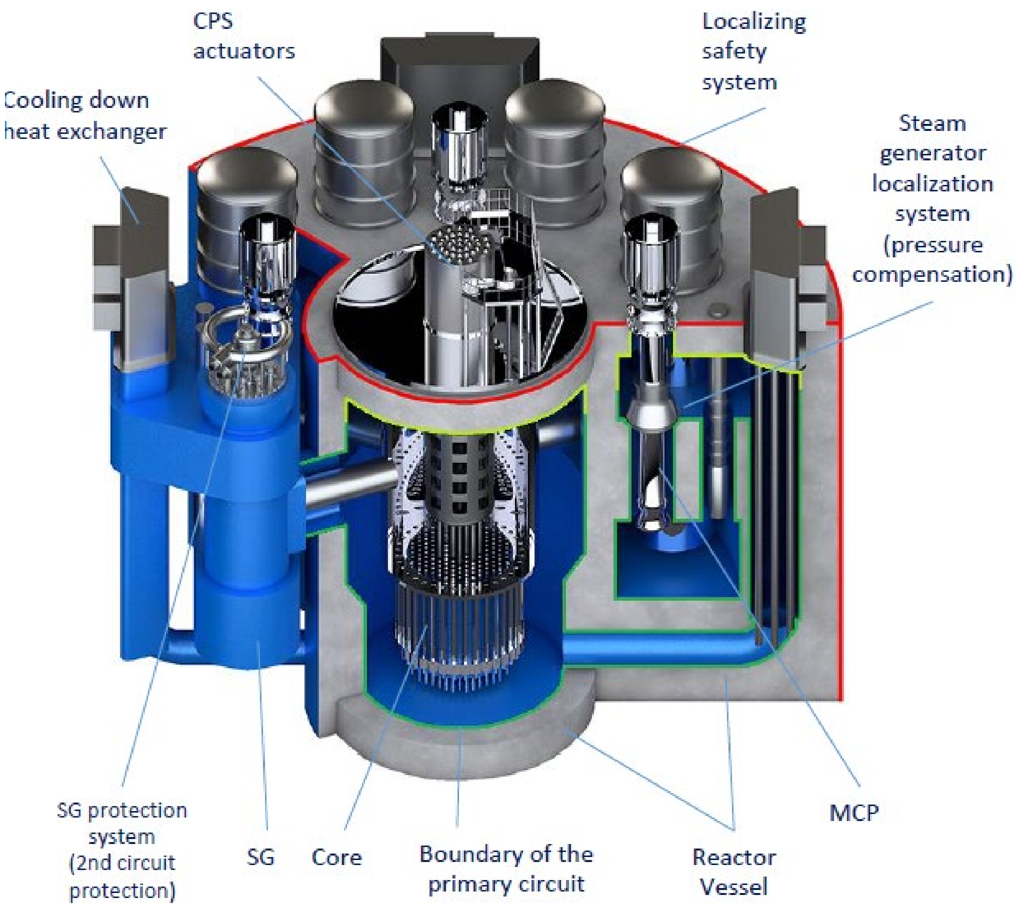
- First NRC construction permit ever issued for a commercial advanced (non-LWR) reactor. - Regulatory breakthrough for Gen-IV systems.
- Designed to support variable loads → ideal for AI/data-centre demand.

As presented by Ms Y. Kyzina at TWG-FR Meeting in June 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)



2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030

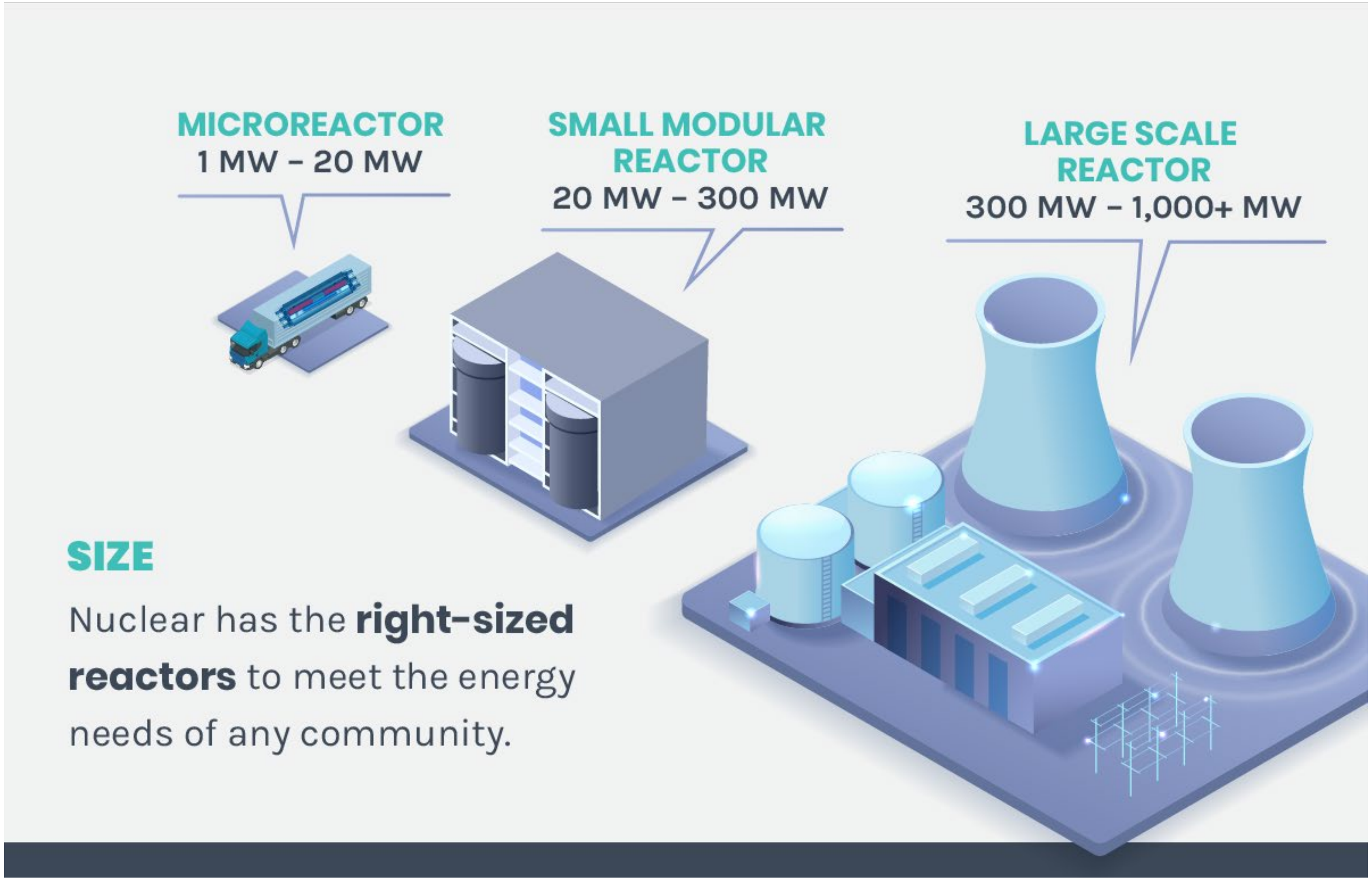
Construction and commissioning of the ***Fuel (re-) fabrication module***

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

Construction and commissioning of the ***Reprocessing module***

Advanced Reactor Technology Information - SMR

SMR – Definition not only by Size



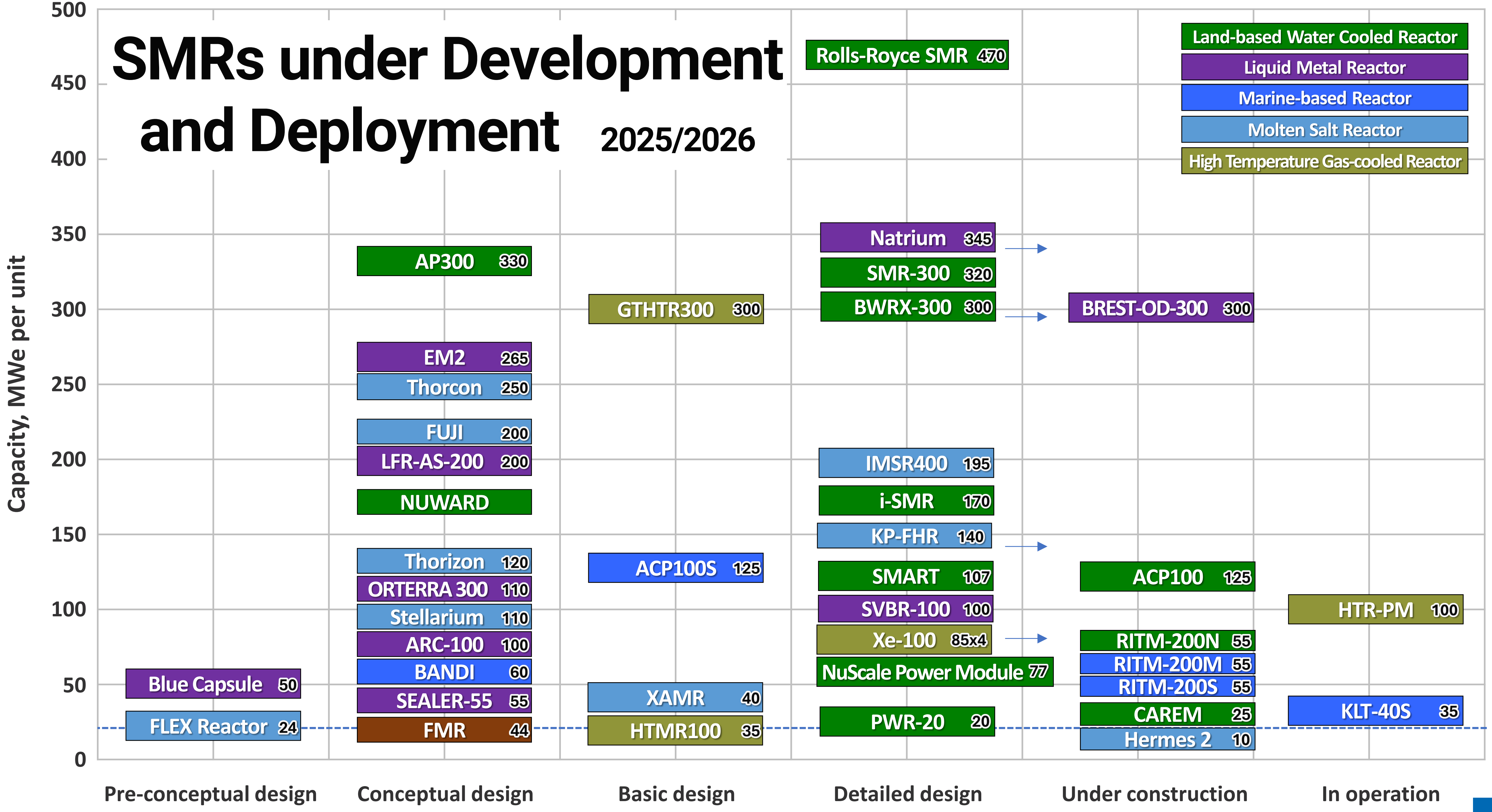
Reality of SMR technology (examples of operating NPP) 1/2

https://fnpp.info/

Russian Federation
2 x KLT-40S reactors (PWR)
70MWe
50 Gcal/h Heat power production
Enrichment: 14,1%
2020, May- Start of commercial operation
3-3.5 yrs operation prior to refuelling
2023, December - refuelled

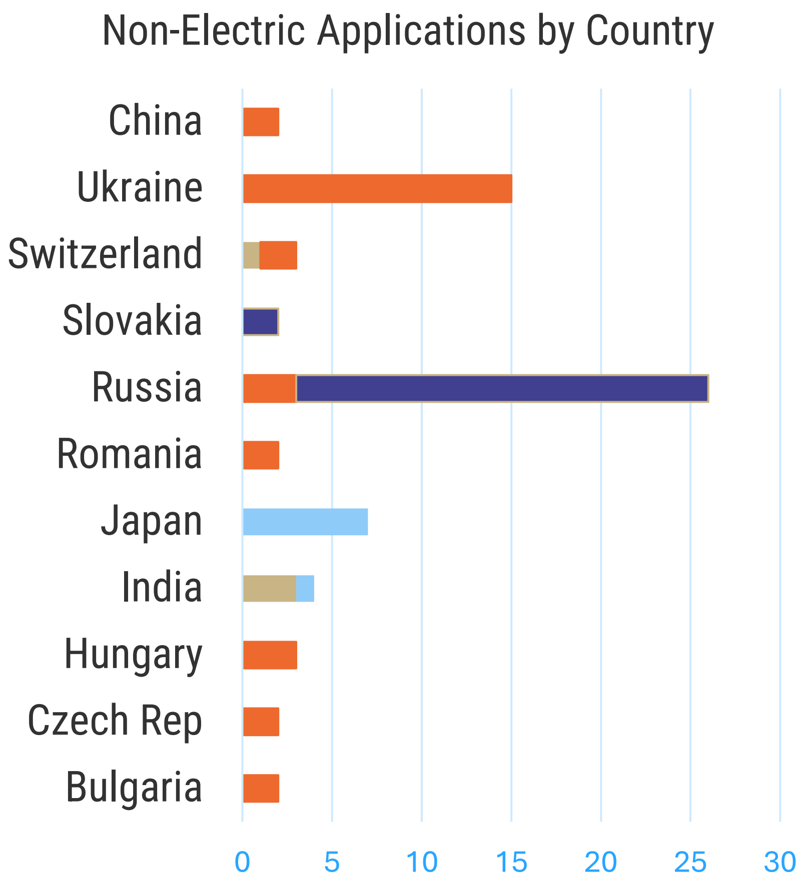
https://www.world-nuclear-news.org/Articles/HTR-PM-heating-project-commissioned

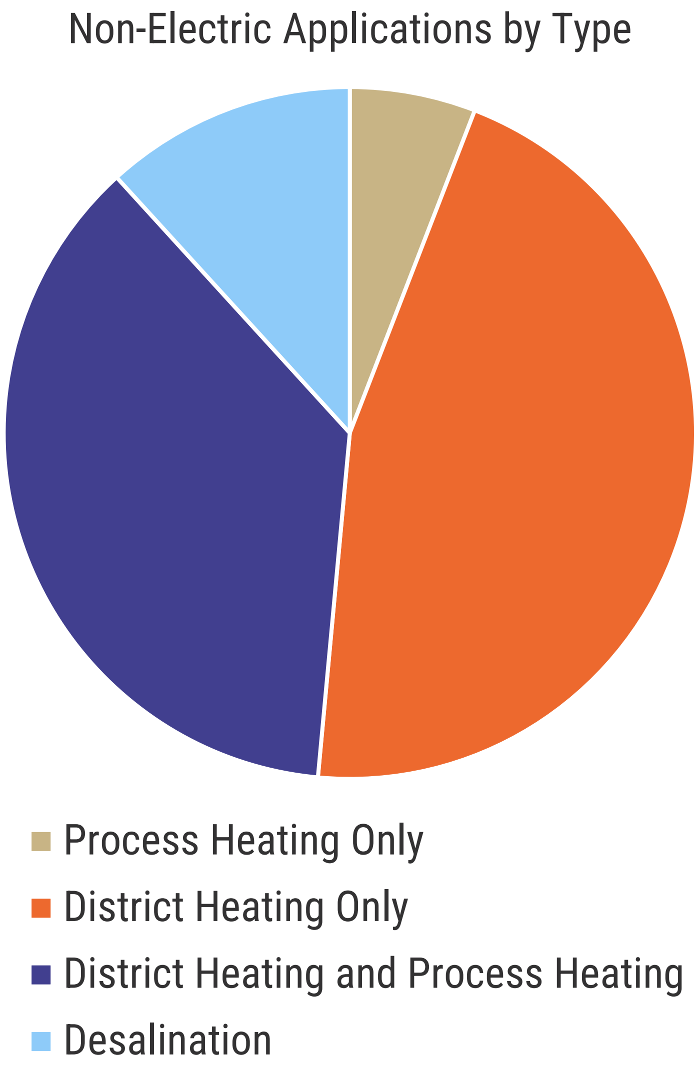
China
2 x 200 MW units
210 MWe
245,000 spherical fuel elements ('pebbles’),
each 60 mm in diameter and containing
7 g of fuel enriched to 8.5%
2023, December- Start of commercial operation
Refuelling on-ine


SMRs under Development and Deployment 2025/2026
Capacity, MWe per unit
500
450
400
350
300
250
200
150
100
50
0
Pre-conceptual design
Conceptual design
Basic design
Detailed design
Under construction
In operation
Land-based Water Cooled Reactor
Liquid Metal Reactor
Marine-based Reactor
Molten Salt Reactor
High Temperature Gas-cooled Reactor
Blue Capsule 50
FLEX Reactor 24
AP300 330
EM2 265
Thorcon 250
FUJI 200
LFR-AS-200 200
NUWARD
Thorizon 120
ORTERRA 300 110
Stellarium 110
ARC-100 100
BANDI 60
SEALER-55 55
FMR 44
GTHTR300 300
ACP100S 125
XAMR 40
HTMR100 35
Rolls-Royce SMR 470
Natrium 345
SMR-300 320
BWRX-300 300
IMSR400 195
i-SMR 170
KP-FHR 140
SMART 107
SVBR-100 100
Xe-100 85x4
NuScale Power Module 77
PWR-20 20
BREST-OD-300 300
ACP100 125
RITM-200N 55
RITM-200M 55
RITM-200S 55
CAREM 25
Hermes 2 10
HTR-PM 100
KLT-40S 35

Nuclear for the decarbonization of heating

- District heating with nuclear energy is not new
  - From few MWt for smaller cities to possibly hundred of MW for large cities.
  - Practiced extensively in Member States: it is the most common use currently of nuclear heat.





SMRs for district heating and cooling

Two SMRs have been used so far for district heating

- **Akademik Lomonosov** (Russian Federation)
  - From 2020 it has generated more than 300 MWh thermal for the local district heating network at the Pevek mooring base.
- **HTR-PM** (China)
  - District heating pilot project commissioned in March 2024 at Shidao Bay
  - Heat used for about 190,000 square meters of heating space, saving 3700 tons of coal each heating season.

- IAEA is planning the following events:
  - Technical Meeting on **powering data centres and cooling with SMRs,** 28-30 September 2026.
  - Technical Meeting on the status of cogeneration projects in MS, 16-19 Nov 2026.

Tech Giants' Interest in advanced SMRs

Tech Giants' Interest: Both Google and Amazon have entered agreements with companies developing SMRs to meet their energy needs

world nuclear news

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Google and Kairos Power team up for SMR deployments

Tuesday, 15 October 2024

Google has agreed to purchase energy from small modular reactors under a deal that will support the first commercial deployment of Kairos Power's reactor by 2030 and a fleet totalling 500 MW of capacity by 2035.

world nuclear news

Amazon invests in X-energy, unveils SMR project plans

Wednesday, 16 October 2024

Amazon has announced it has taken a stake in advanced nuclear reactor developer X-energy, with the goal of deploying up to 5 GW of its small modular reactors in the USA by 2039.

Google and Amazon Make Major Inroads with SMRs to Bring Nuclear Energy to Data Centers. Top hyperscalers' agreements and investments in Kairos Power and X-energy small modular reactors could move these companies' technologies to the forefront of SMR design.

District heating news

Plans for SMR plant on Svalbard progress

Thursday, 14 August 2025

wnn world nuclear news

An assessment programme has been submitted to the Governor of Svalbard for the construction of a small modular reactor power plant on the Norwegian Arctic archipelago, marking the first formal step towards building the facility.

(Image: Norsk Kjernekraft)

In June this year, Swedish lead-cooled SMR technology developer Blykalla and Norwegian nuclear project developer Norsk Kjernekraft announced the launched of a joint project company, Svalbard Kjernekraft AS.

Longyearbyen - the administrative centre of the Svalbard archipelago - was powered by coal until 2023. Since the closure of the coal plant, temporary diesel systems have been installed, resulting in higher costs and reduced reliability. Blykalla and Norsk Kjernekraft aim to build a compact SMR that connects to the existing electricity and district heating grid, effectively replacing the old coal infrastructure.

Pilot non-nuclear SMR plant to be built in Finnish coal-fired plant

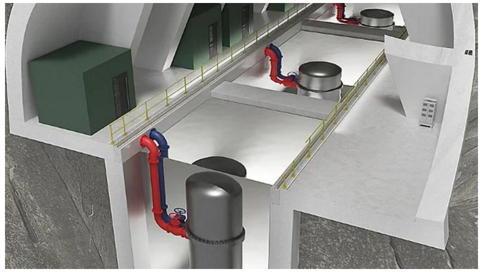
Tuesday, 6 May 2025

wnn world nuclear news

Finnish small modular reactor developer Steady Energy is to build a non-nuclear pilot facility at the decommissioned Salmisaari B coal power station in central Helsinki to demonstrate the maturity and safety of its LDR-50 reactor for district heating.

(Image: Steady Energy)

Steady Energy



August 8, 2025

New Study Confirms Feasibility of SMRs for Urban District Heating – LDR-50 Shown as Profitable Solution

District heating / cooling in the news

world nuclear news

Home · Energy & Environment · New Nuclear · Regulation & Safety · Nuclear Policies · Corporate · Uranium

District heat scheme planned for Mochovce plant

Monday, 20 January 2025

Slovenské elektrárne has outlined details of a scheme to deliver heat for the town of Tlmače from the Mochovce nuclear power plant.

(Image: Slovenské elektrárne)

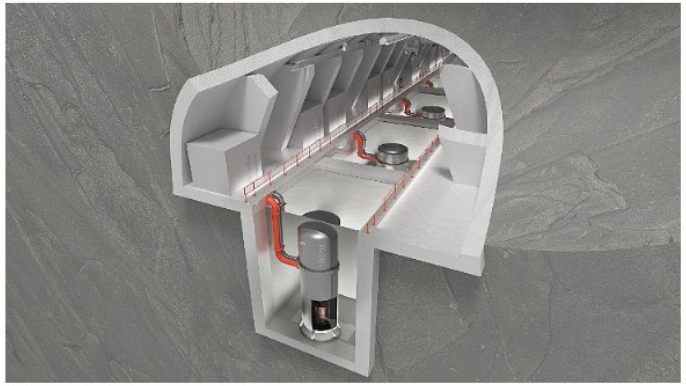
Slovenské elektrárne's Bohunice nuclear power plant has had municipal heating schemes operating since 1987.

Fortum to help develop Finnish SMR for district heating

Monday, 3 March 2025

world nuclear news

Fortum has agreed to support the development of Finnish technology company Steady Energy's district heating nuclear reactor with its simulation expertise. The goal is to create a comprehensive digital twin for Steady Energy's LDR-50 reactor using Apros software.

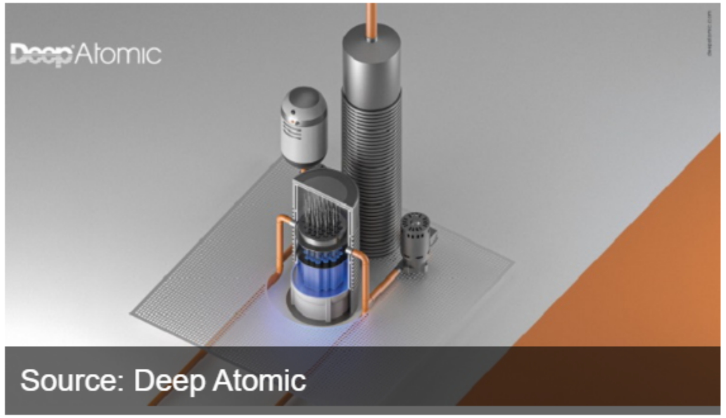


A multiple LDR-50 unit plant (Image: Steady Energy)

Apros, the result of decades of development work by Fortum and Finland's state-owned VTT Technical Research Centre, is an advanced software product for modelling and dynamic simulation of power plants, energy systems and industrial processes. Apros products and services have been sold in more than 30 countries around the world to a wide range of users: EPC project suppliers, equipment manufacturers, energy companies, engineering firms, research institutes and universities.

Powering data centers with SMRs

S. Himmelstein | November 06, 2024



A small modular reactor (SMR) has been designed by Switzerland-based Deep Atomic specifically to provide power and cooling to data centers.

Applied Thermal Engineering, volume 247, pages 123042

Economic optimization and thermodynamic analysis of a novel nuclear district cooling system

Weiqi Liu Liu Weiqi[1], Weiqi Liu[1], Quanbin Zhao[1], Z. M. Sun[2], Zhi-Yong Sun[2], Xingmin Liu[2], Gen Li[3], Gen Li[3], JunJie Yan[1], Jinshi Wang[1]

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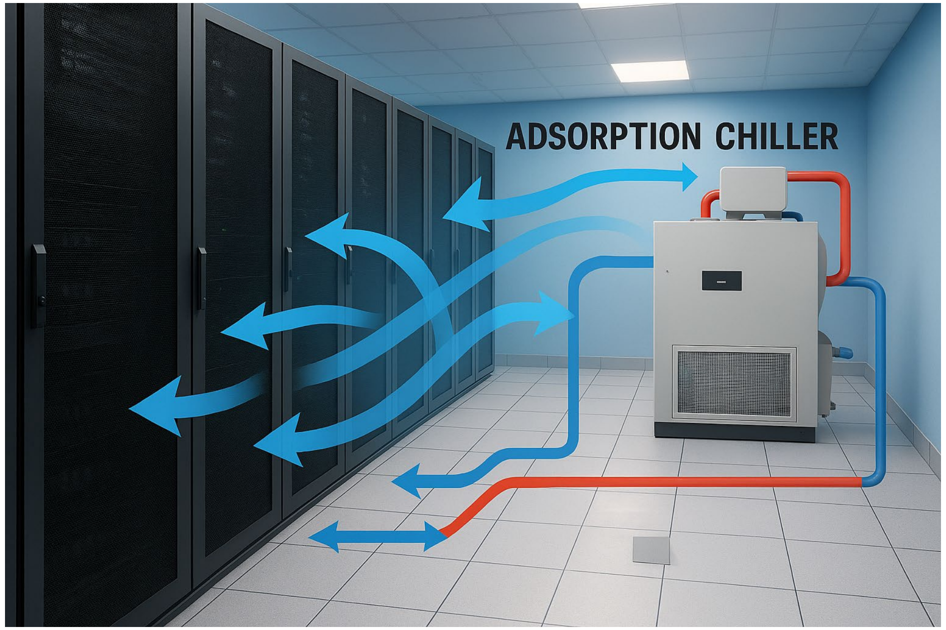
Nuclear energy for cooling AI data centres

- AI data centres require large amount of cooling, roughly matching the IT load:
  - typically, in the tens of MW electrical, up to more than 100 MW for large data centers, >1 GW in the future.
- AI data centres are densely packed and need active cooling – conventional air cooling may not be sufficient for more advanced and dense data centres.
- Nuclear energy, and SMRs, can facilitate data centres cooling
  - Existing access to cooling infrastructure: cooling towers and water usage rights needed by both, nuclear and data centres.
  - Nuclear waste heat can drive adsorption/absorption chillers to provide efficient cooling for data centres.
  - Data centres with advanced cooling will have a competitive advantage, allowing higher workloads.
  - Using nuclear waste heat for cooling will increase the overall efficiency of the combined systems and increase sustainability.



China: Xuwei Cogeneration Plant

China National Nuclear Power: The Phase I project of the Xuwei Nuclear Heating and Power Plant in Jiangsu has been approved by the State Council for nuclear energy.

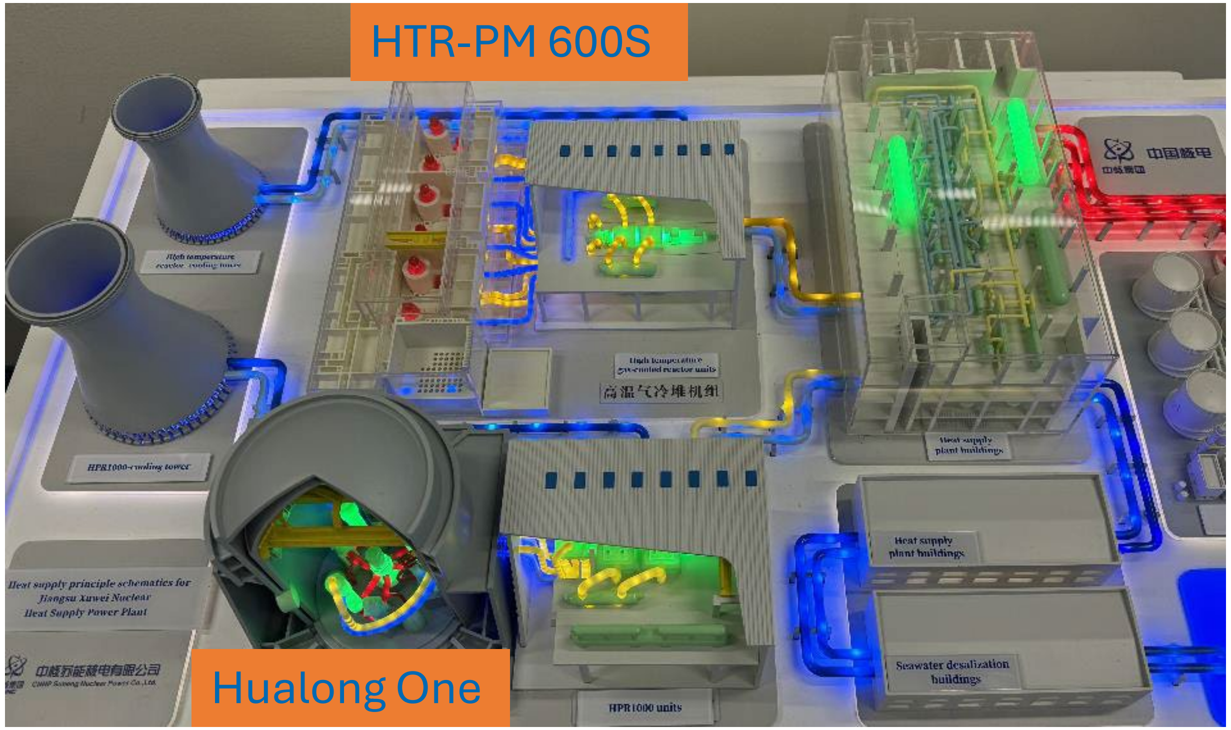
Breakings · Aug 19 14:01

文/A

SH China National Nuclear Power +1.36%

China National Nuclear Power announced that its subsidiary, China Nuclear Su Power Nuclear Power Co., Ltd., as the owner unit, is responsible for the investment, construction, and operation management of the Phase I project of the Xuwei Nuclear Heating and Power Plant in Jiangsu. The project plans to build two Hualong One pressurized water reactor nuclear power generators and one set of high-temperature gas-cooled reactor nuclear power generators, with a

The project will be equipped with a steam heat exchange station, where primary steam from the PWR units first heat demineralized water to produce saturated steam, which is then superheated by HTGR primary steam.



2x Hualong One (FCD expected Aug2025)
+ HTR-PM 600S (FCD Feb 2026) with 6x250MWt units

Steam supply: 4082 t/h
460°C at 4.9MPa
340°C at 3.8 and 2.8 MPa

Generation capacity: 1653 MWe

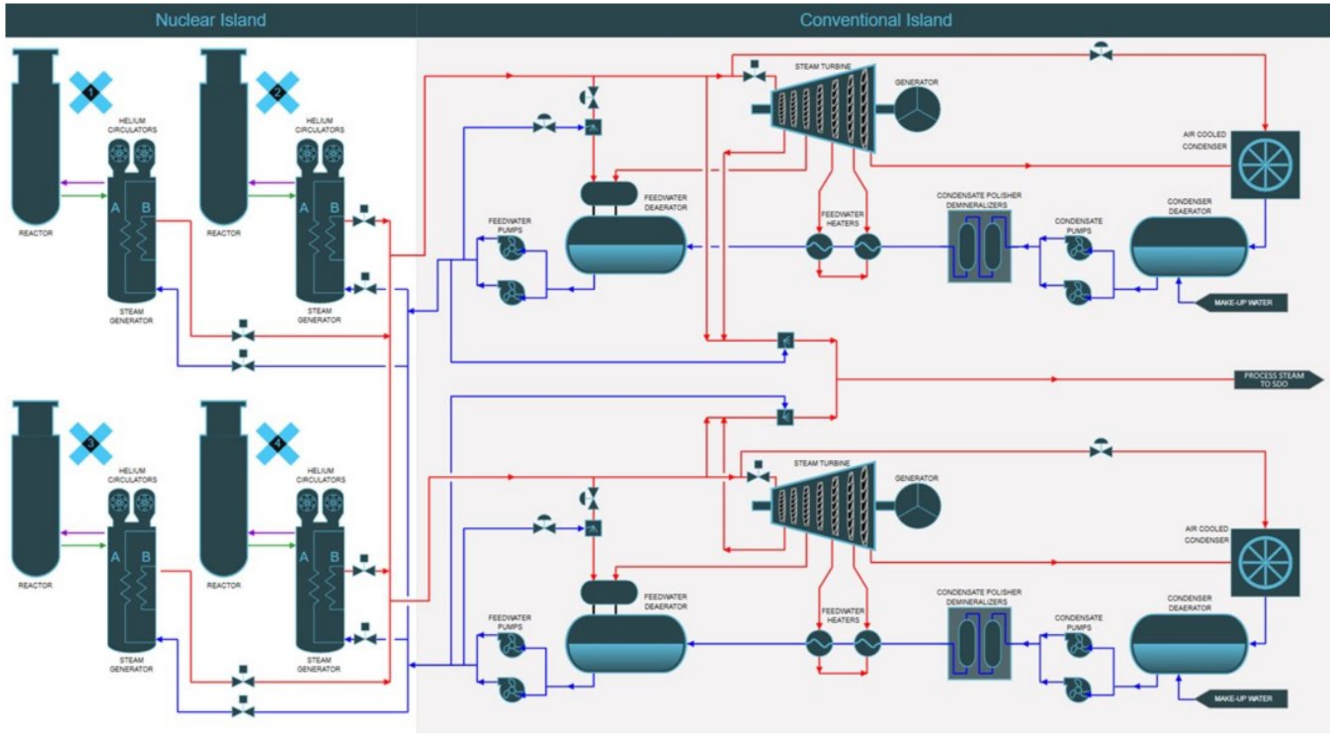
Serving the Lianyungang Petrochemical park

Steam supply ~ Oct 2030

USA: Dow and X-energy Industrial Heat

Four Xe-100 pebble-bed HTGR SMRs (200 MWt each) to replace Dow's gas-fired cogeneration facility at their Seadrift, Texas site. The SMRs will provide heat and electricity to the facility. Circulating helium transfers heat to a single steam generator designed to produce high-grade, superheated steam at 565°C. When operating at 100 percent turbine bypass mode, with maximum steam flow sent to the SDO facility, each Xe-100 reactor can generate 601,000 lb/hr (75.57 kg/s) of steam.

Project Status: Construction Permit Application submitted to the country's nuclear regulator.



IAEA

IAEA Activities on Advanced Reactor Technology Development

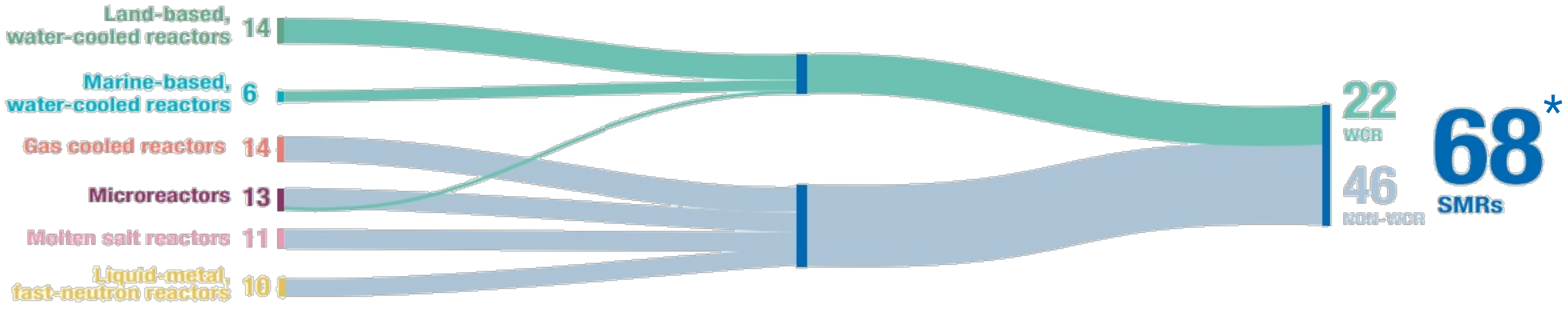
IAEA SMR Platform & ARIS SMR Catalogue

The Platform on Small Modular Reactors and their Applications:

- Established in 2021 to share information and coordinate SMRs activities across the Agency
- Mechanism by which the IAEA responds to requests from Member States to offer expertise from across the entire Agency, for development, deployment, and oversight of SMRs
- Provides latest IAEA news, events, and publications on SMRs
- **SMR Schools** have been launched to raise awareness about key aspects of SMR development and deployment

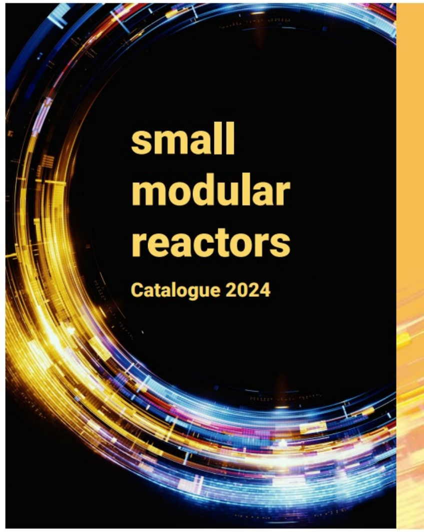
Advances in SMR Developments 2024:

- Available for download from this link: https://aris.iaea.org/publications/SMR_catalogue_2024.pdf
- Published biannually since 2012. Provides a concise overview of the latest status of SMR designs
- The content is provided by the responsible developer and is reproduced with permission



* : The 3rd edition of the catalogue lists 71 designs, with 1 new land-based water-cooled reactor, 1 new molten salt and 1 new microreactor.

IAEA International Atomic Energy Agency



A supplement to:
IAEA Advanced Reactors Information System (ARIS)

Key IAEA Activities on SMR

Technology Development and Deployment
- TWG-SMR
- ARIS Database SMR Catalogue

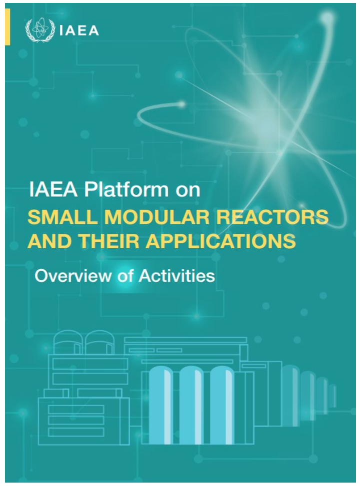
Fuel, Spent Fuel Management, Radioactive Waste and Decommissioning

Approaches to Commissioning and Operation
Issues on the conduct of operation, OLCs and MCR for multi-unit plant

Economics
Economic Appraisal of SMR Projects

Infrastructure Development
- IAEA Milestones Approach applicable to SMR
- New deployment models

IAEA Platform on SMRs and their Applications



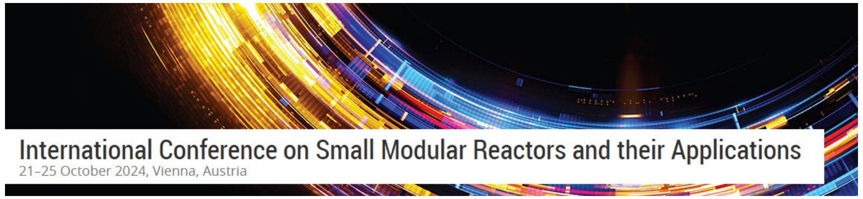
Nuclear Harmonization and Standardization Initiative

Legal Frameworks for safety, security, safeguards and civil liability for nuclear damage

Safety, Security and Regulation
- Applicability of Safety Standards and Security Guides to SMRs
- Emergency Preparedness and Response
- SMR Regulators Forum
- School of Regulating SMRs

Safeguards-by-Design
Facilitation of safeguards inspection early in design stage

Technical Cooperation
Capacity Building

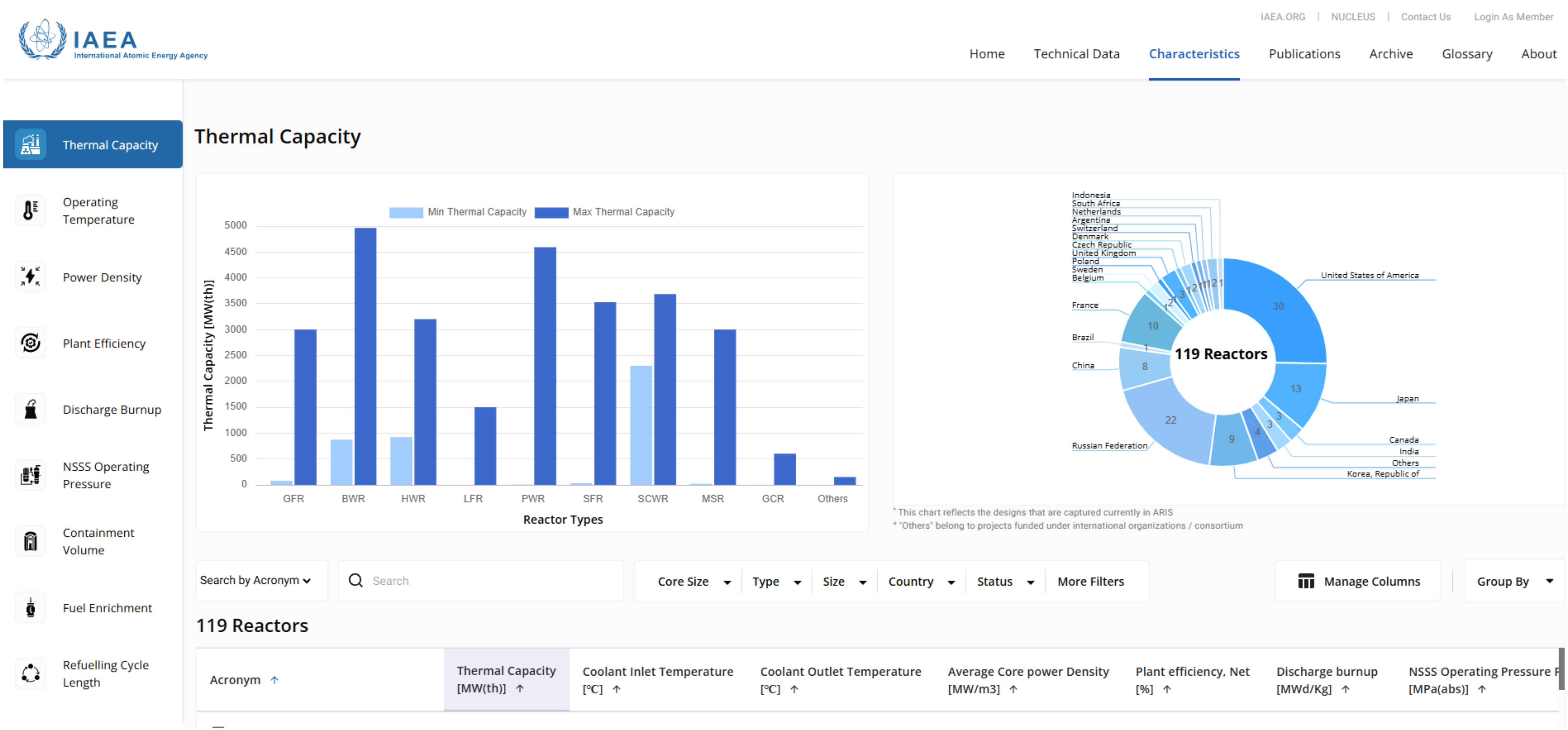


ARIS

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

Designs in ARIS	Design Organizations	Countries
119	> 75	~25

Access online: Advanced Reactor Information System | Aris



ARIS database

The technical information regarding advanced reactor designs is supplied by the relevant design organizations or reactor plant vendors, depending upon the development stage of each design

- *Nuclear steam supply system*
- *Safety concepts*
- *Plant performance*
- *Proliferation resistance*
- *Spent fuel and waste management*
- *List of key technical data*

IAEA Activity on Updating Technology Roadmap for SMR Deployment

1-st CM
26-28 February 2024

TM
19-23 August 2024

SMR-24 Conference
21-25 October 2024

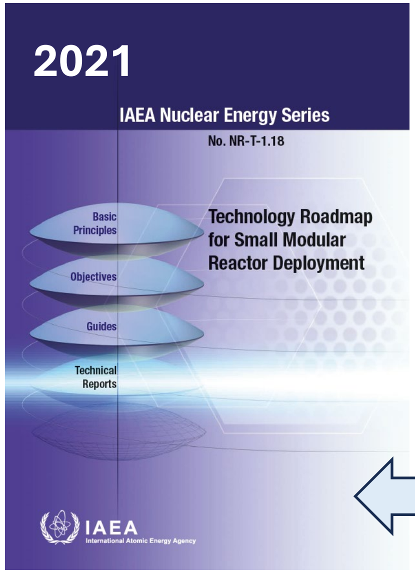
TWG-SMR
09-12 December 2024

2-nd CM
11-14 February 2025

TWG-SMR
08-12 September 2025

3-rd CM
12-14 November 2025

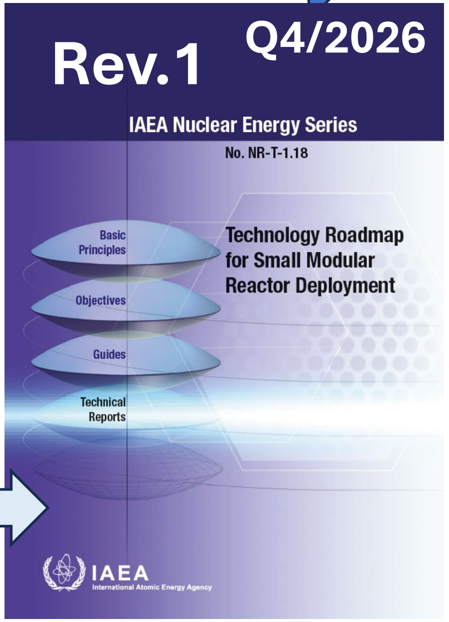
TM
2026



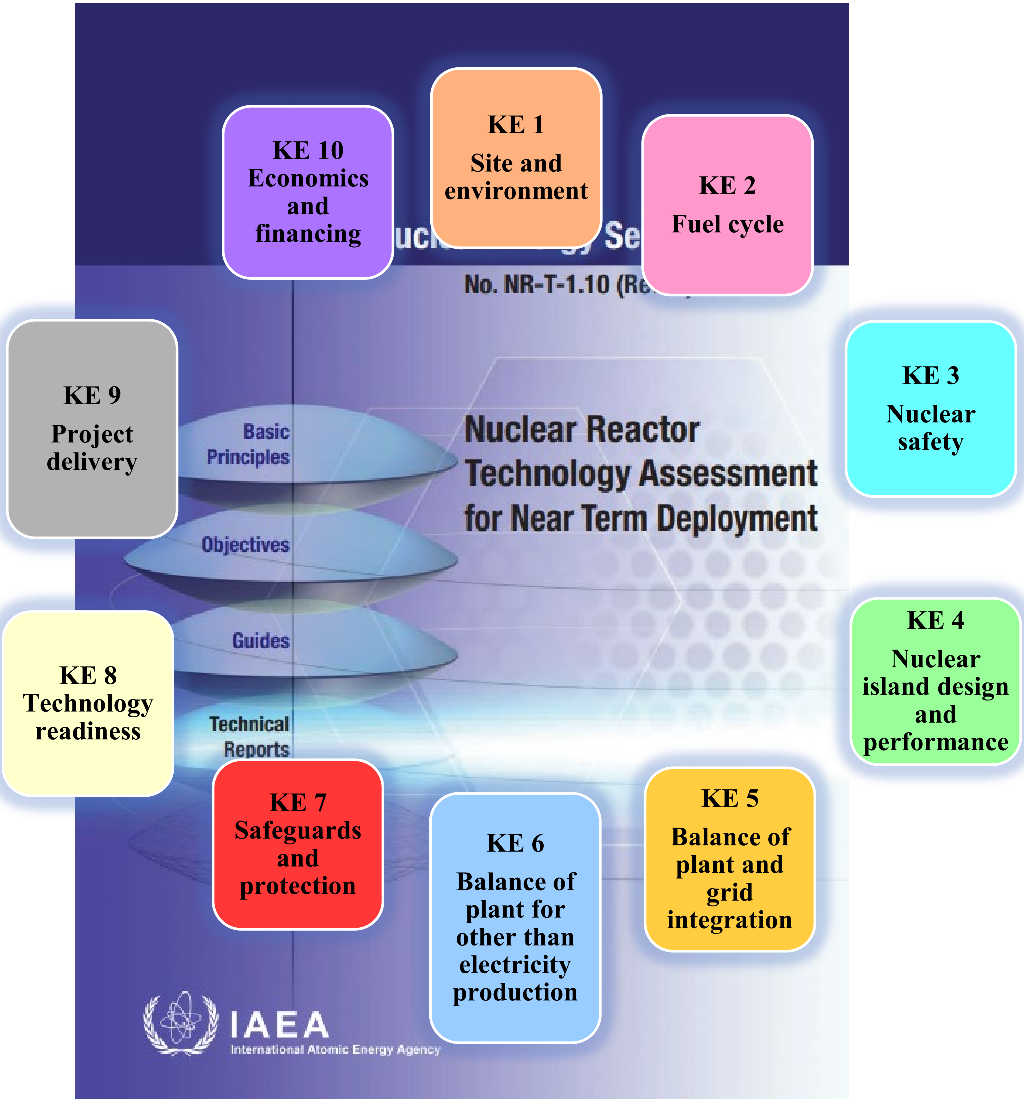
The publication places emphasis on the activities of **owners/operating organizations**, who drive the demand and requirements for reactor designs;

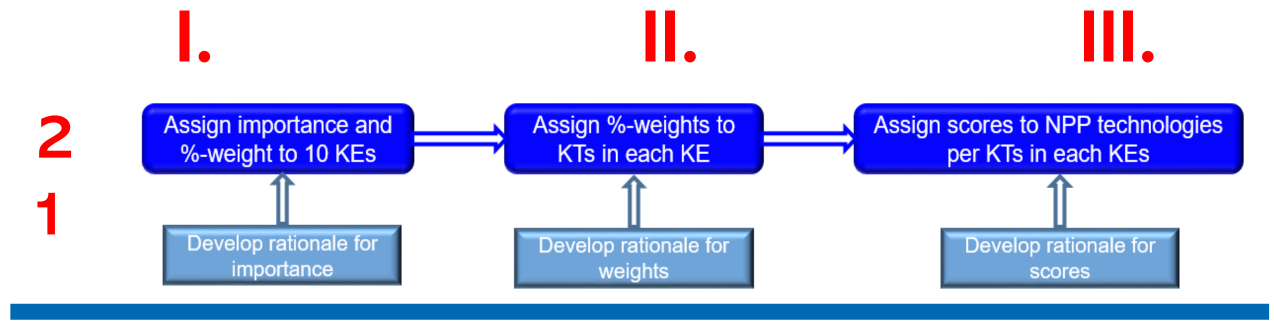
designers, who develop the technologies; and **regulators**, who establish and maintain the regulatory requirements that owners/operating organizations are obliged to meet.

To discuss the status of national nuclear energy programmes from the viewpoints of **designers, utilities, regulators, end-users**; present lessons-learned associated with **transportation associated fuel cycles and supply chain development**; discuss **business and delivery models**, **approaches to funding and financing** to facilitate accelerated deployment of SMRs including **maritime applications**;

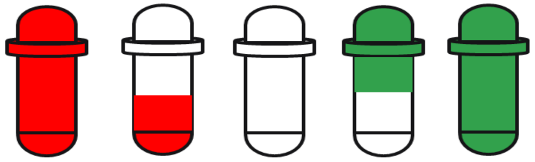


IAEA Methodology for Reactor Technology Assessment





- A key challenge for Member States deploying SMRs is identifying and assessing suitable technologies that align with national objectives. The IAEA launched the **SMR Platform** to coordinate its SMR-related activities and offers tools such as the **RTA methodology**. This event demonstrated SMR assessment using the RTA methodology and the ARIS database.



NPP design satisfies the KEs/KTs to:

Little extent / not acceptable	Lesser than medium extent, but greater than a little extent	Medium extent	Greater than medium extent, but not to a large extent	Large extent
5 – point scoring system				
1	2	3	4	5
9 – point scoring system				
1	3	5	7	9

- Supported by eLearning material, Workbook and TOOLKIT
- Training example: International Workshop on the IAEA Methodology for Reactor Technology Assessment for Near Term Deployment, 28–31 August 2023, Denmark
- **Highlighted at GC 67 (2023) Side Event SMR Platform Activity: Reactor Technology Assessment using ARIS Database.**

Nuclear Harmonization and Standardization Initiative (NHSI)
Overall Objectives

Aim: Facilitate safe and secure deployment of SMRs in maximizing their contribution to reach net zero carbon emissions by 2050

Objective: Enhance harmonization of regulatory approaches and the harmonization and standardization of industrial approaches

Harmonization of Regulatory Approaches Track

- Information Sharing Framework for Regulatory Reviews
- Multinational Pre-Licensing Joint Regulatory Review
- Step-by-step blueprint to establish a global review framework
- Collaborative Reviews and Effective Leveraging
- Security of SMRs Working Group

Harmonization and Standardization of Industrial Approaches Track

- Harmonization of High-Level User Requirements
- Common Approaches on Code and Standards
- Experimental Testing and Validation for Design and Safety Analysis Computer Codes
- Considerations to Facilitate the Accelerated Deployment of SMRs

Network and Toolkits:

Regulatory Cooperation Toolkit*

SMR Regulation and Cooperation Hub*

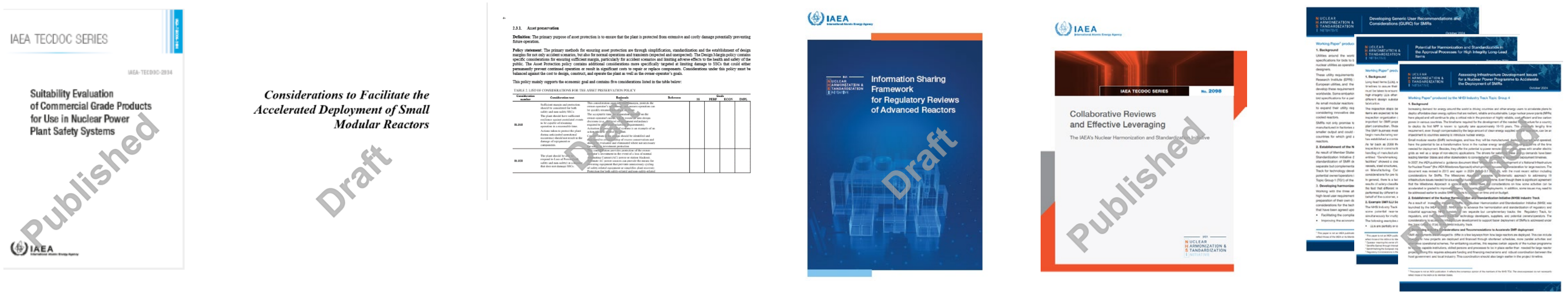
MSCQ Common Approaches to C&S

NEXSHARE Experiments and Code Validation

Good practices for infrastructure development for SMRs Database*

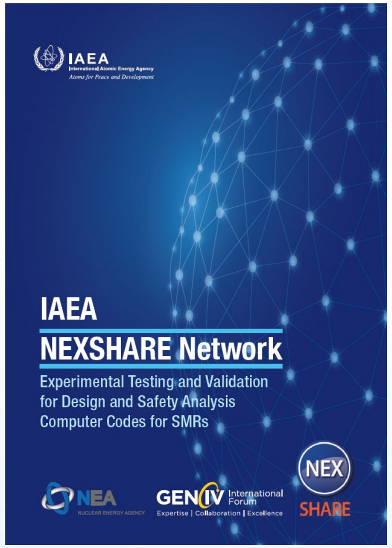
* Under Development

Publications:



NEXSHARE – Introduction

Some SMRs may require modelling capabilities that are beyond the validated boundaries of existing codes or include physical phenomena for which the existing experimental data is insufficient. The significant efforts and resources associated with validation or experimentation constitutes a challenge to a safe and secure timely deployment of SMRs.



To address these challenges, the IAEA established **NEXSHARE**, a technical forum to facilitate global cooperation and resource sharing for SMRs and advanced reactors experiments and code validation.

The Network was launched in June 2024 under IAEA's **Nuclear Harmonization and Standardization Initiative (NHSI)** and as a collaboration with the NEA, the Gen-IV forum and the European Commission.

- ✓ **Members**: Vendors, Experimental Facilities, TSO, International Organizations.
- ✓ **Steering Committee (SC):** provides strategic guidance and oversight to the Network.
- ✓ **Events**: Workshops and webinars. 2nd NEXSHARE workshop planned 16-20 November 2026 at the NEA.
- ✓ **Web interface / portal**

NEXSHARE's Mission and Objectives:

- **Information Sharing** of Experimental Facilities and Programmes.
- **Enhance utilization** of existing experimental facilities.
- **Resources optimization** for SMR code validation and experiments.
- **Greater confidence** on data and codes used in safety cases.

Types of Simulators

❑ Basic Principle Simulators

- Operate on PC
- Broader audience/an introductory educational & training set of tools
- Configuration suited to classroom and self-learning
- Textbook and manuals
- Provides subsystem training and overall plant training (startup, shut down, malfunctions)

❑ Engineering Simulators

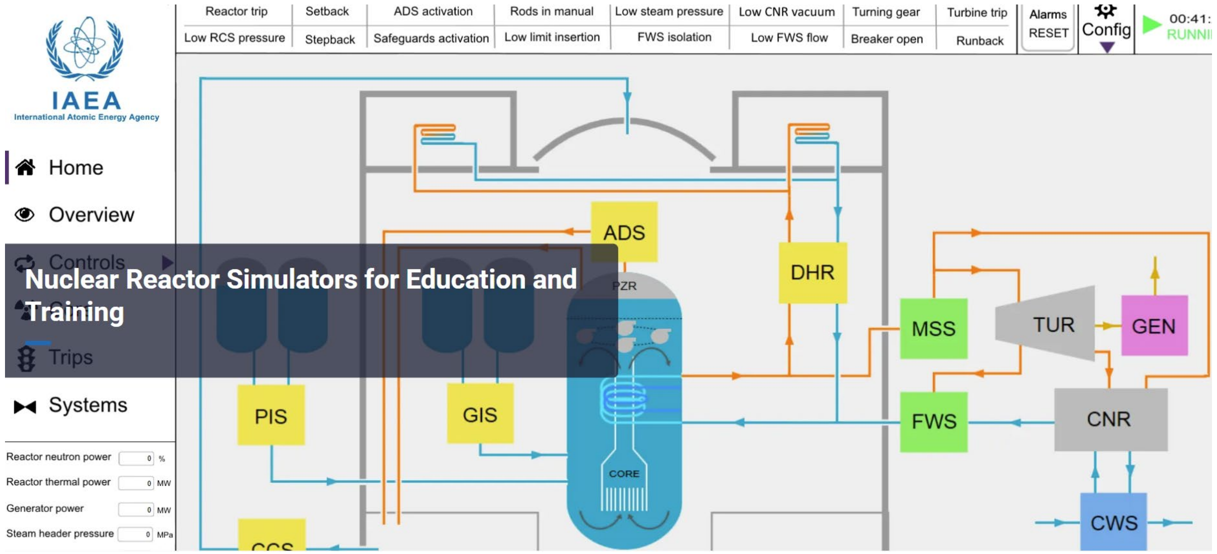
- Nuclear safety improvement
- Calculate and display in real time the physical parameters of NPP

❑ Full Scope Simulators

"A training is conducted in a full-scope simulator at the construction site of the United Arab Emirates's Barakah nuclear power plant in February 2016." (Photo: Louise Potterton/IAEA)

- Indispensable in the licensed training of the NPP control room operators.

Nuclear Reactor Simulators for Education & Training



- Aid in understanding NPP fundamentals.
- The IAEA sponsors training courses and workshops on the topic at the request of Member States.

Pressurized Water Reactor (PWR) Simulators:
Advanced PWR: Two-Loop Large PWR (Korean-OPR 1000)
Russian-type PWR (VVER-1000)
Advanced Passive PWR (AP-600)
Integral Pressurized Water Reactor (SMR)

Boiling Water Reactor (BWRs) Simulators:
Conventional Boiling Water Reactor with Active Safety Systems (BWR)
Advanced BWR with Passive Safety Systems (ESBWR)

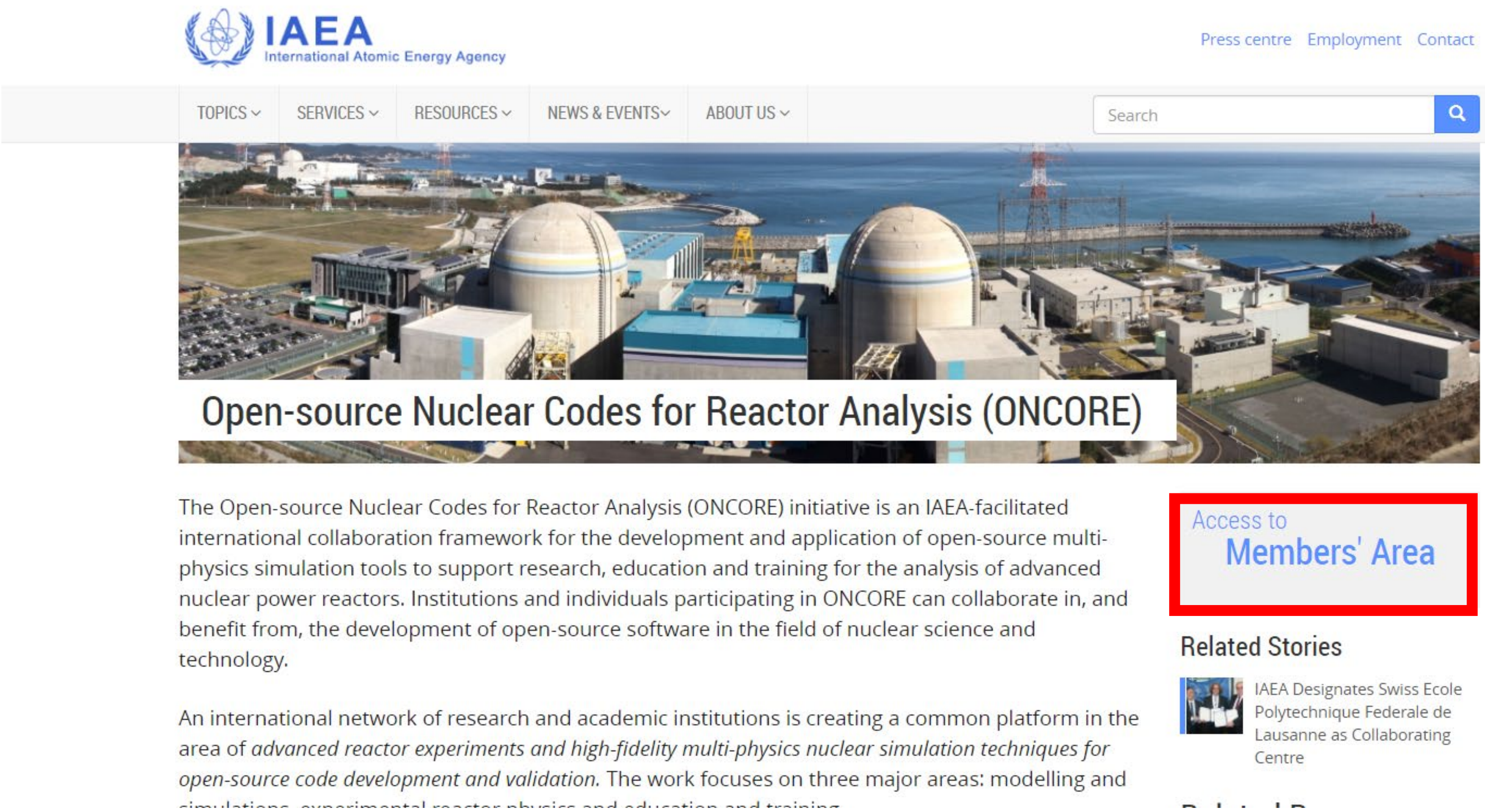
Pressurized Heavy Water Reactor (PHWR):
Conventional Pressurized Heavy Water Reactor (PHWR)
Advanced PHWR (ACR-700)

Part-Task Simulator:
Micro-Physics Nuclear Reactor Simulator

Under Development:
High Temperature Gas Cooled Reactor (HTGR)

Since 1997, NPTDS has built a library of basic education and training simulators available to the Member States for access and use in their development of national nuclear power education and training curricula.

IAEA ONCORE initiative



Technical Meeting on
Development and Application of Open Source Modelling and Simulation Tools for Nuclear Reactors, 20-24 June 2022 Milano, Italy

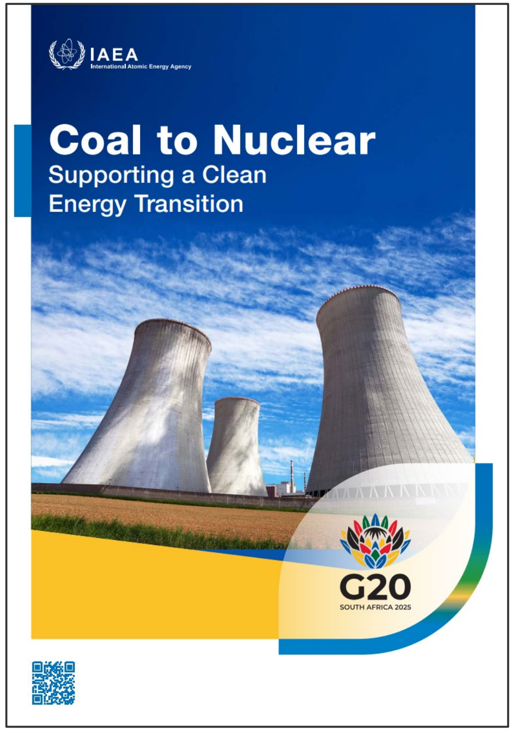
In Publishing
Technical Report Series (TRS)
Development and Application of Open-Source Modelling and Simulation Tools for Nuclear Reactor Analysis

IAEA Webinar Series on Multiphysics Modelling of
Nuclear Reactors using OpenFOAM and its Derivatives

https://www.iaea.org/topics/nuclear-power-reactors/open-source-nuclear-code-for-reactor-analysis-oncore

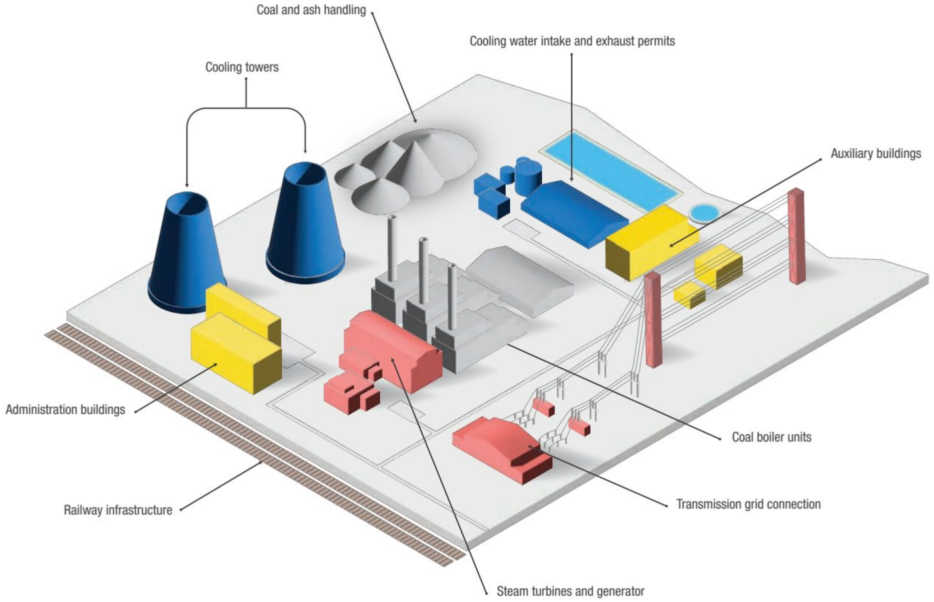
https://nucleus.iaea.org/sites/oncore

Coal to Nuclear transition : Technical Considerations



Site Selection

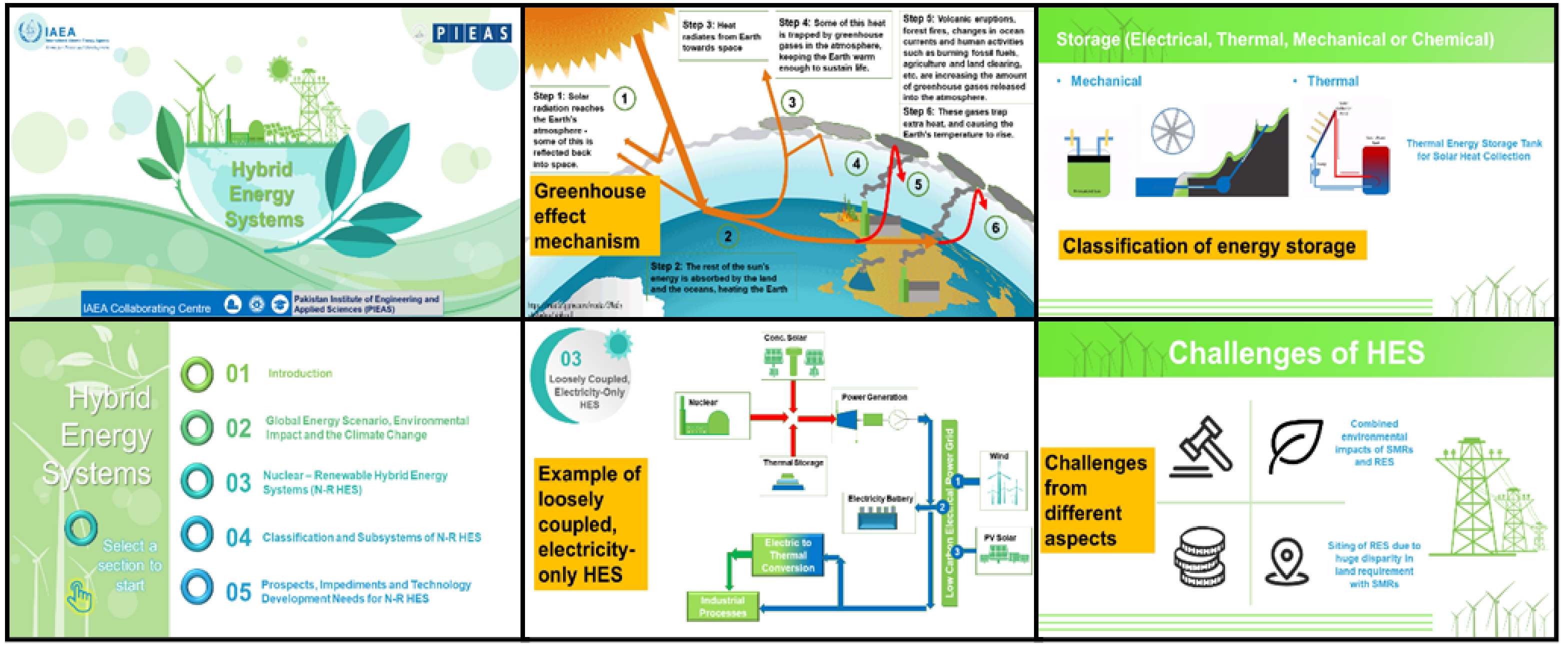
- Size of the site needs to be able to accommodate needed NPP infrastructure
- Location of the site must be suitable for an NPP
    - Nearby population density, industrial plants, natural hazards and other aspects of the site could be suitable for a CPP, but not for an NPP
- Cooling water supply is one of the most important site criteria for a C2N transition
    - Rights and permits to both use and discharge the water are also required
- Decommissioning of the existing CPP can require extensive resources and include environmental issues



Infrastructure Assessment

- "Repowering" of coal sites generally considers the reuse of existing site infrastructure
- CPP sites include infrastructure and equipment that could be repurposed by NPPs, and reuse of these systems could provide savings on construction costs
- Dependent on several technical and regulatory aspects
- Systems would need to meet the applicable requirements based on each component's safety classification
    - Could require significant regulatory and engineering review
    - May need upgrade and modification

eLearning Module on HES



Hybrid energy systems

- Global energy scenario and the role of Hybrid Energy Systems
- Detailed technical descriptions about the Nuclear and Renewable Hybrid Energy System (N-R HES) with case studies provided
- Review questions with answers

Access: Home | OPEN-LMS (iaea.org)

Part-Task Simulators

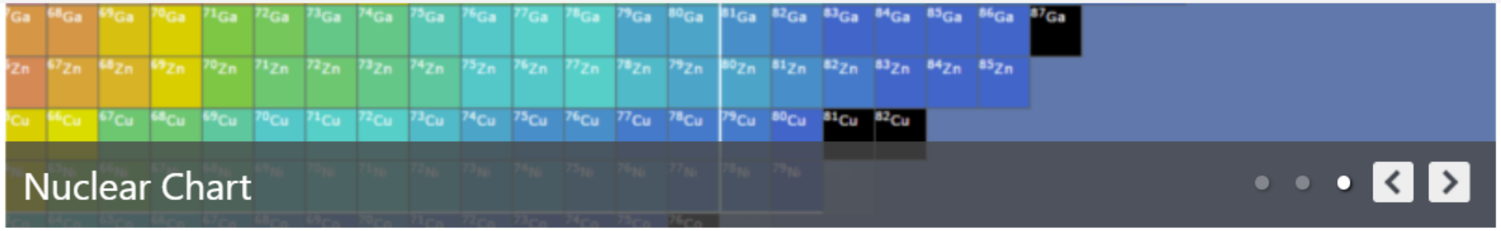
SharePoint

IAEA HOPS

CONNECT Home HOPS Public HOPS Member's Area

Home > HOPS

Send by email



Members Area →

Hub for On-line Nuclear Power Plant Part-Task Simulators (HOPS)

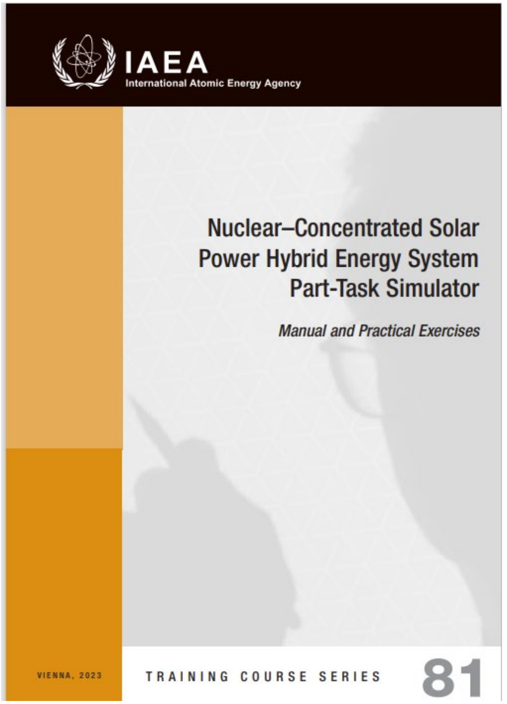
HOPS is established to support the education and training within national nuclear power programmes in the IAEA Member States with on-line graphically interfaced nuclear power plant part-task simulators. In particular HOPS includes:

Not a member yet?

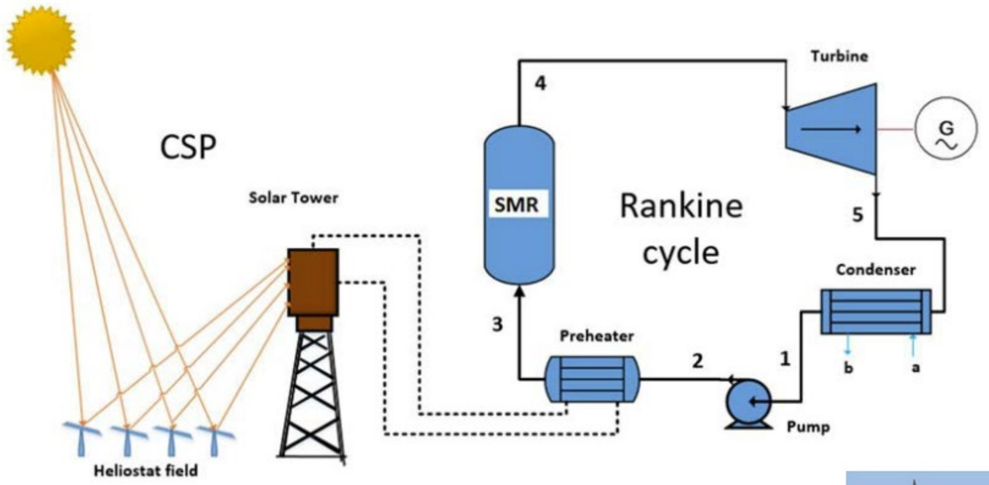
Submit your required details to join and access member area

Join Here →

Nuclear–Concentrated Solar Power Hybrid Energy System Part-Task Simulator



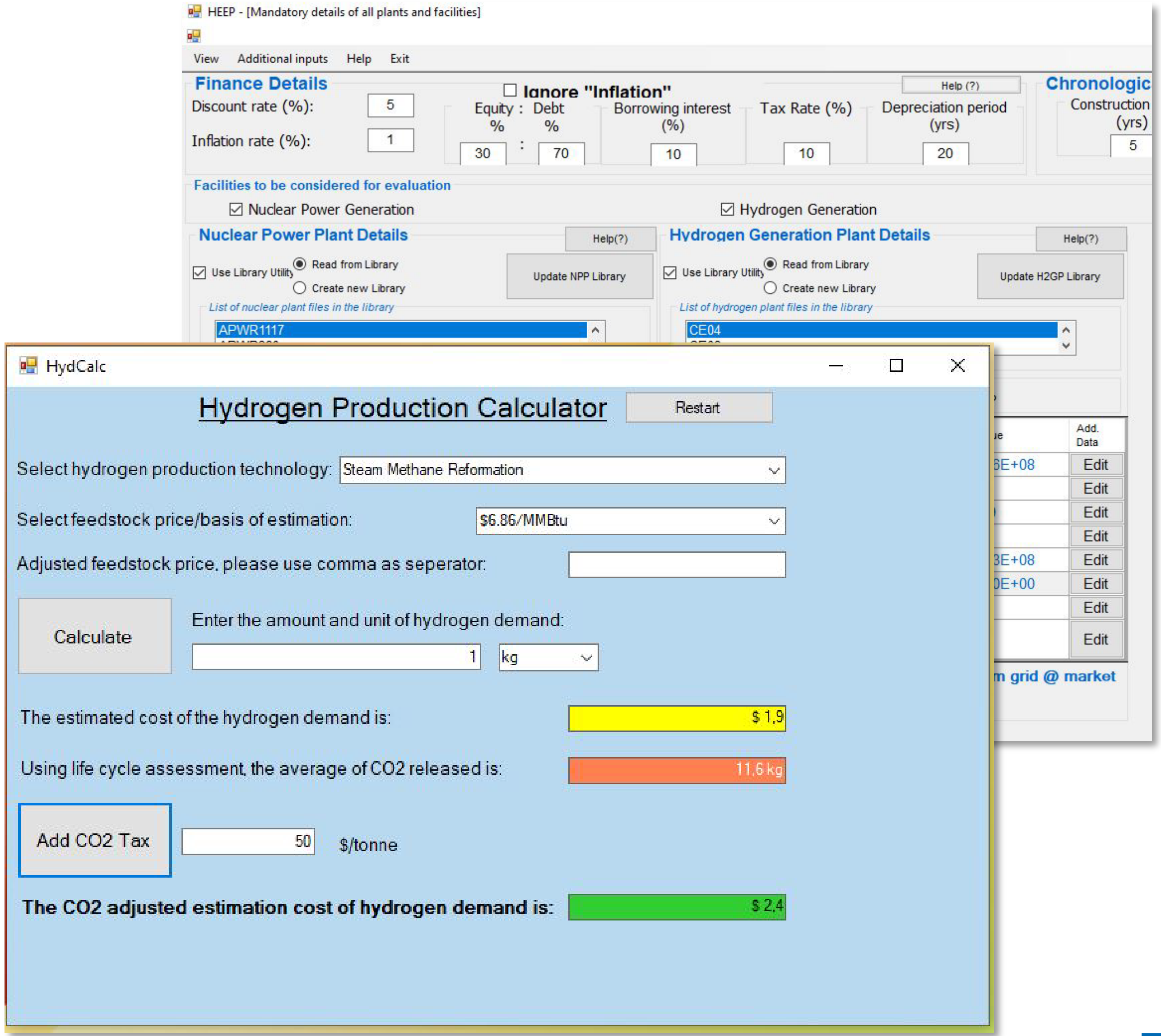
- provides a comprehensive explanation of the nuclear–concentrated solar power hybrid energy system part-task simulator as well as practical exercises to help readers become familiar with its use.



- Provides a detailed description of nuclear-wind HES part-task simulator provided
  - together with the exercises applicable to education and training courses and workshops, or self-learning.
  - Configurations with wind, biomass, hydrogen, etc.

IAEA Hydrogen-Related Tools and Toolkits

- HEEP: Hydrogen Economic Evaluation Program
  - Technoeconomic assessments of hydrogen generation options
  - https://www.iaea.org/sites/default/files/22/01/2021-11-21_setup_heep.zip
- HydCalc: Hydrogen Calculator
  - Hydrogen production cost calculator with nuclear and other technologies
  - https://www.iaea.org/sites/default/files/18/07/hydcalc.zip
- Toolkit on nuclear hydrogen
  - https://www.iaea.org/sites/default/files/20/04/nuchydtoolkit.zip



FUSE Platform

Purpose

Based on feedback from WFEG, member states and the global fusion sector, the IAEA would like to highlight technology development and deployment as we look towards commercial fusion energy.

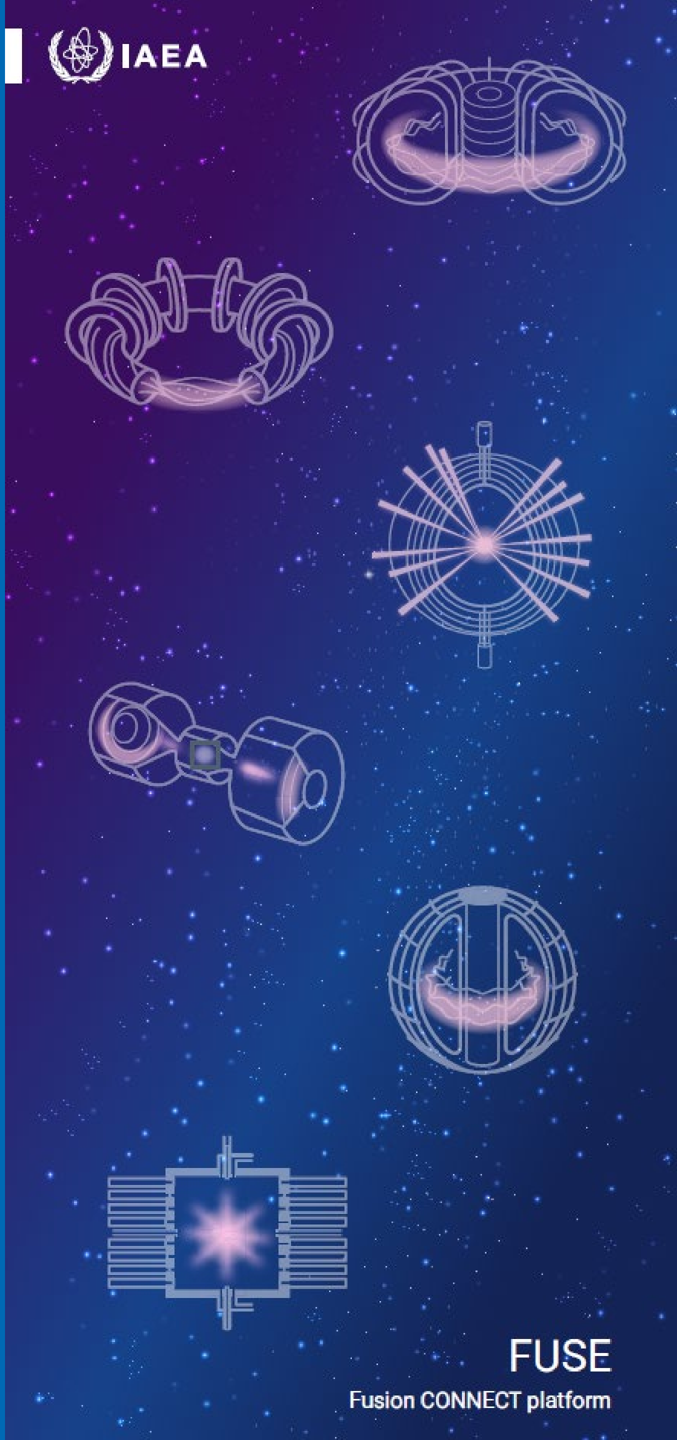
Fusion Technology Module:

- Fusion Organizations
- Fusion Machines
- Fusion Technologies

Links to other IAEA tools and databases including the fusion portal and the fusion data portal

Future – all ongoing technology development and deployment activities, codes and standards, tritium breeding, workforce development, remote handling, etc.

Click banner for link to FUSE



Fusion Organizations (Public and Private) to date

Commonwealth Fusion Systems

RENAISSANCE FUSION

EUROfusion

SHINE

HELION

UK Industrial Fusion Solutions

ZAP ENERGY

iter
china eu india japan korea russia usa

THEA ENERGY

PRANOS
FUSION ENERGY

In development... TYPE ONE ENERGY PACIFIC FUSION OXFORD SIGMA AVALANCHE

IAEA

THANK YOU