



Seminario su “Reattori in esercizio e in costruzione per la produzione di energia elettronucleare”

Ordine degli Ingegneri della Provincia di Roma, 11 luglio 2024



**Nuovi programmi nucleari in Europa e nel mondo:
*opportunità per l'industria italiana in vista del
programma nucleare nazionale***

Stefano Monti

Presidente Associazione Italiana Nucleare (AIN) e European Nuclear Society

A very promising landscape for Nuclear (even in EU...)



- **COP28 in Dubai in December 2023:** For the first time ever, nuclear energy included in the First Global Stocktake + declaration on “triple global nuclear capacity by 2050”
- **First Nuclear Energy Summit in Brussels in March 2024**
- **G7 Meetings in Italy** (Ministerial on Energy, Climate and Env. and Final Declaration)
- **EU:** nuclear energy included in:
 - *EU taxonomy (indeed some innovative technologies...)*
 - *Net-Zero Industry Act*
- **Relevant European Nuclear Initiatives:**
 - *Nuclear Alliance (12 EU MSs, all of them with new nuclear programmes: 150 GWe by 2050)*
 - *SMR Industrial Alliance (277 participating organizations throughout Europe)*

Increasing mismatch between declarations on decarbonisation goals and reality

IEA on coal just two days after COP28 (i.e. Dec 2023)



- Global coal demand will set another new record this year
- Coal-fired generation will rise by about 158 TWh, or 1.5% this year
- China and India have intensified efforts to increase coal production
- As a consequence... **Global CO2 emissions will set another new record in 2023 of 36.8 billion tons**

Germany is replacing carbon-free nuclear power capacity with 10 GWe new gas power capacity



EU To Endorse German Plan to Subsidize 10 GW New Gas Power Capacity

By [Charles Kennedy](#) - Jun 07, 2024, 11:30 AM CDT



EU competition regulators have given an informal approval to a German plan to offer state support to new natural gas-fired power capacity of 10 gigawatts (GW) that would help stabilize the grid as Europe's biggest economy is boosting renewables, government and industry sources with knowledge of the talks told [Reuters](#) on Friday.

CHARLES KENNEDY

Charles is a writer for Oilprice.com

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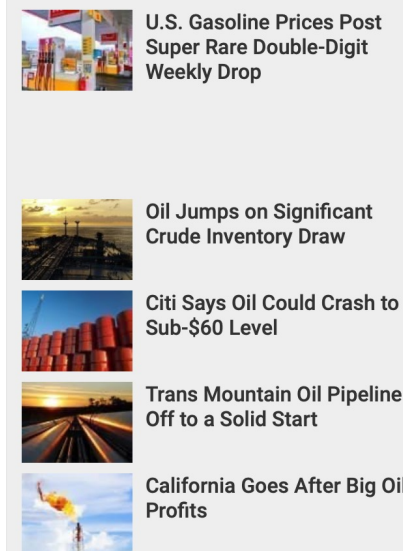
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Oil Jumps on Significant Crude Inventory Draw

Citi Says Oil Could Crash to Sub-\$60 Level

Trans Mountain Oil Pipeline Off to a Solid Start

California Goes After Big Oil Profits





374.7 GWe

The global operating nuclear power capacity from 416 operational nuclear power reactors in 31 countries as of July 2024



23.7 GWe

Capacity added by the connection of new units to the grid and upgrades to existing reactors since beginning of 2022

Resource: IAEA PRIS, July 2024

Nuclear Energy Today



416 NUCLEAR POWER REACTORS
IN OPERATION

374 671 MW_e TOTAL NET INSTALLED
CAPACITY

25 NUCLEAR POWER REACTORS
IN SUSPENDED OPERATION

21 272 MW_e TOTAL NET INSTALLED
CAPACITY

59 NUCLEAR POWER REACTORS
UNDER CONSTRUCTION

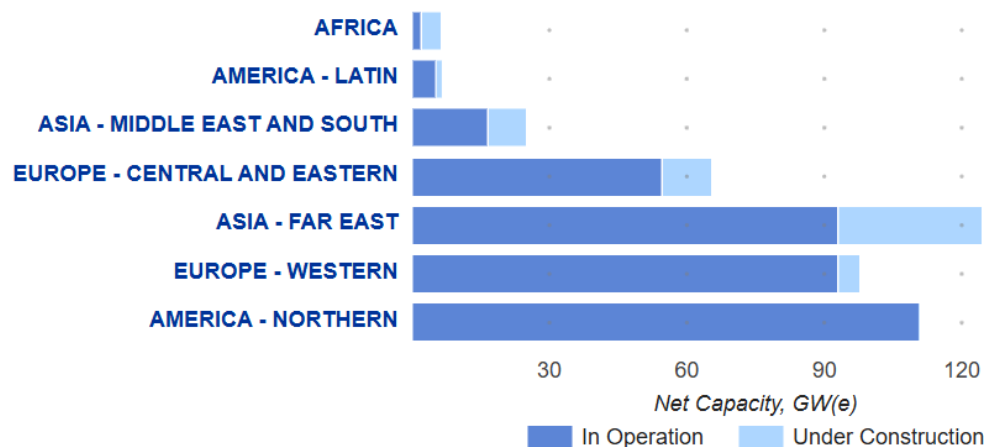
61 637 MW_e TOTAL NET INSTALLED
CAPACITY

19 915 REACTOR-YEARS OF
OPERATION



Equivalent to the total flight hours obtained by adding 6 years
of all US civil aviation traffic

REGIONAL DISTRIBUTION OF NUCLEAR POWER CAPACITY

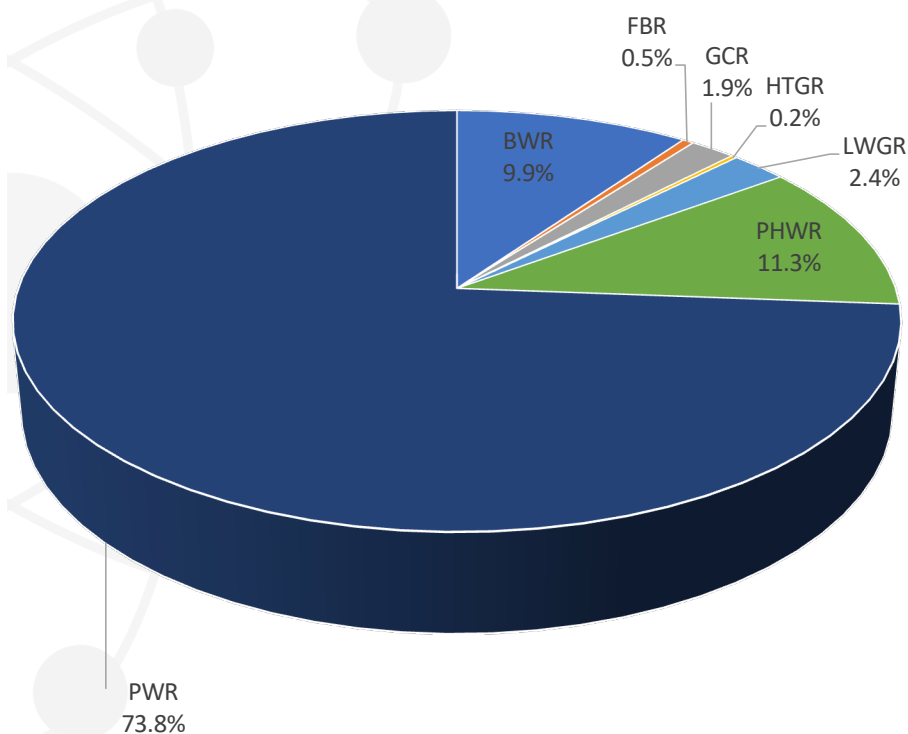


Year 2024

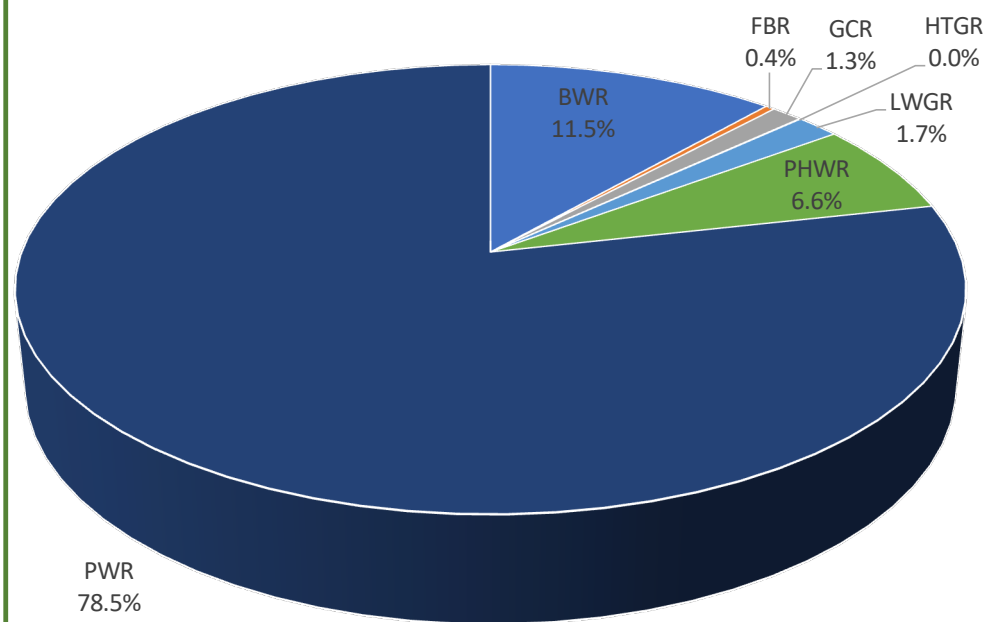
Resource: IAEA PRIS, July 2024

Operational Reactor Types by July 2024

Number of Reactors



Total Net Electrical Capacity



Above charts are generated basing on the IAEA PRIS database (last update on 2024-07-04)

Units Connected to the Grid in 2024 (as of July 2024)



Countries with previous nuclear power operating experience:

- Barakah-4 AP1400 1310 MWe in UAE
- Fangchenggang-4 PWR 1000 MWe in China
- Kakrapar-4 630 PHWR MWe in India
- Vogtle-4 AP1000 1117 MWe in United States

Units Connected to the Grid in 2023

Countries with previous nuclear power operating experience:

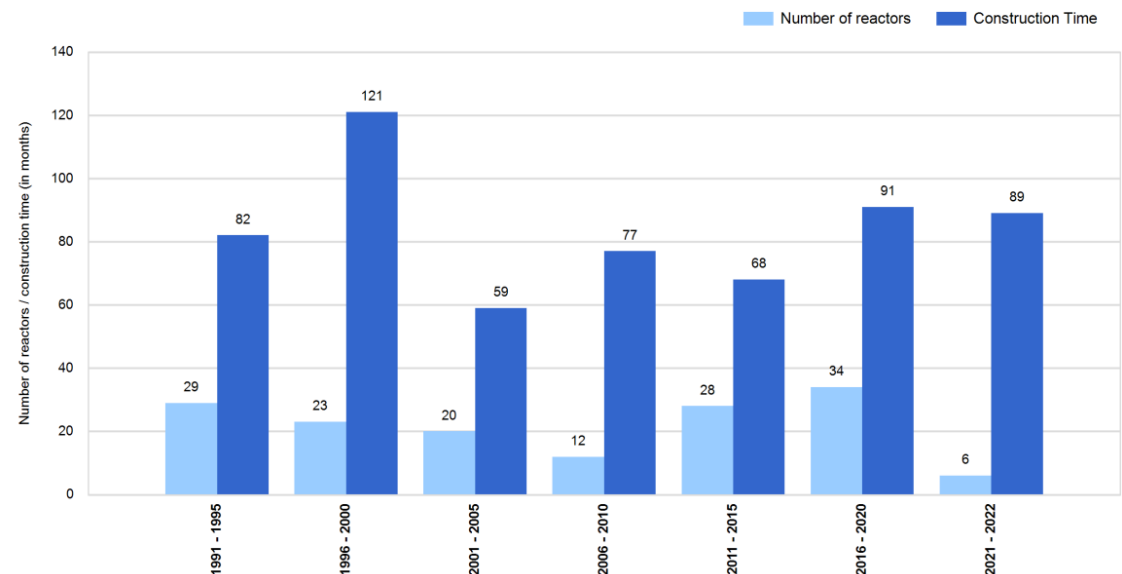
- Belarusian-2 VVER 1100 MWe in Belarus
- Fangchenggang-3 PWR 1000 MWe in China
- Mochovce-3 VVER 440 MWe in Slovakia
- Shin-Hanul-2 AP1400 1340 MWe in Korea, Republic of
- Vogtle-3 AP1000 1117 MWe in United States

Resource: IAEA PRIS, July 2024

New Build Construction

- Today, 59 reactors with over 61.6 GWe capacity are under construction
- Asia continues to dominate the market: 74 reactors with 69.5 GWe capacity connected to the grid from 2005 to July 2024
- So far, in 2024 the construction of two PWRs started in China (Lianjiang-2, 1224 MW(e), Zhangzhou-3 (1129 MW(e)
- In 2023, the construction of Haiyang-4 (1161 MW(e), PWR), Lufeng-6 (1116 MW(e), PWR), Sanmen-4 (1163 MW(e), PWR), and Xudabu-1 (1000 MW(e), PWR) started in China
- In 2022, the construction of seven PWRs (five in China, and one in Turkey) started.

Figure 4. Worldwide median construction time in months (as of 31 Dec. 2022)



Resource: Nuclear Power Reactors in the World, IAEA, 2023

Newcomer countries since 2020

Countries that have connected to the grid their first NPPs:

- United Arab Emirates (Barakah, 5321 MWe, 4 operational units)
- Belarus (Belarusian, 2220 MWe, 2 operational units)

10

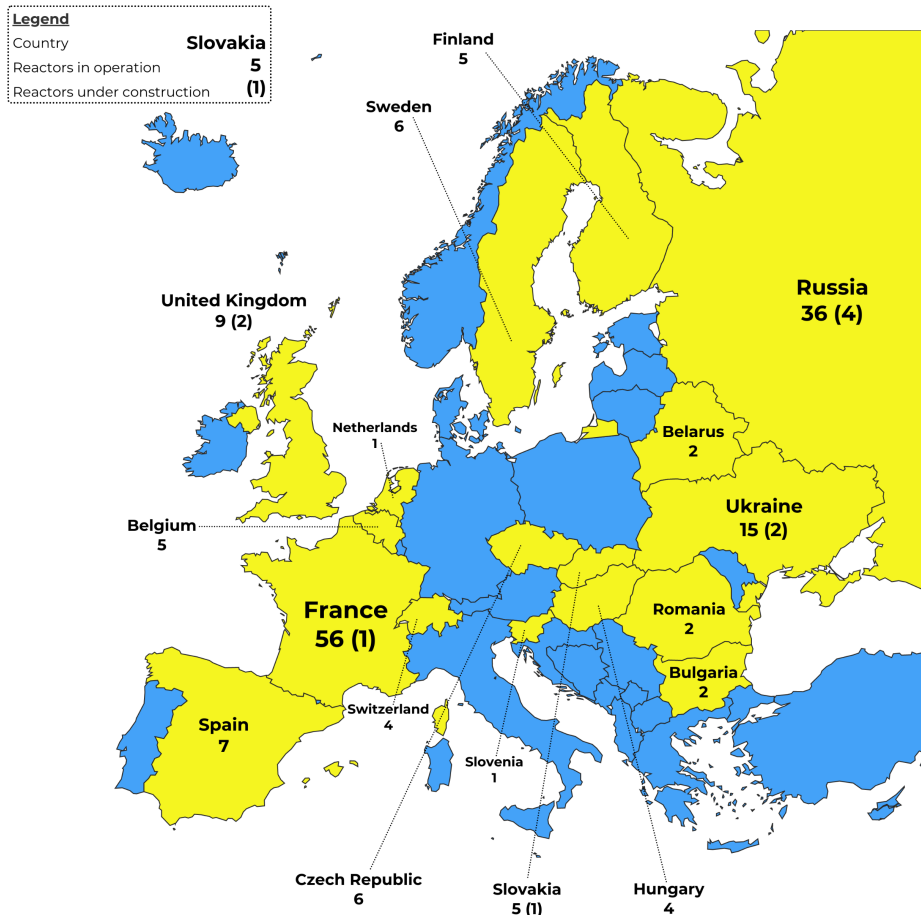
post-decision-making phase

Countries that have made a decision and are building the infrastructure or have signed a contract and are preparing for or started construction

 Bangladesh	 Nigeria
 Egypt	 Poland
 Ghana	 Saudi Arabia
 Jordan	 Türkiye
 Kenya	 Uzbekistan

- Turkey (Akkuyu, 4456 MWe, 4 units under construction)
- Bangladesh (Rooppur, 2160 MWe, 2 units under construction)
- Egypt (El Dabaa, 4400 MWe, 4 units under construction)

Nuclear Power Units in Europe



- Today, 167 reactors are operating in Europe, with a total capacity of 147.8 GWe.
- 10 reactors are currently under construction, plus 4 in Turkey
- The world's Top 9 nuclear shares in power production are all in Europe. In the first positions, France (64.8%), Slovakia (61%), Hungary (48.8%) and Finland (42%).

New-build dynamics for EDF Group in Europe

- EPR in operation and programs or projects under development
- Prospects with bid submission
- Structured discussions about potential projects

The Netherlands 
 Potential of 2 EPR in a first time
 Potential **NUWARD SMR** program to be considered in a second phase

United Kingdom 
 2 EPR under construction (HPC project)
 2 EPR under development (SZC project)
 Potential **NUWARD SMR** program

France 
 1 EPR under commissioning
 6 EPR under development + 8 EPR in option
 First of a kind SMR program with **NUWARD SMR** under development

Sweden 
 Potential of 2 EPR1200
 Potential **NUWARD SMR** program

Finland 
 1 EPR in commercial operation
 Potential of EPRs and **NUWARD SMR** program

Poland 
 Preliminary offer for up to 6 EPR and a potential **NUWARD SMR** program

Czech Republic 
 Bid for 4 EPR1200
 Potential **NUWARD SMR** program

Slovakia 
 Potential of 1 EPR1200 and a **NUWARD SMR** program

Slovenia 
 Potential of 1 EPR / EPR1200 or 2 EPR1200 program
 Discussion on SMR

Italy 
 Potential of 2 **NUWARD SMR**

Courtesy I2EN

Other announced realizations in EU

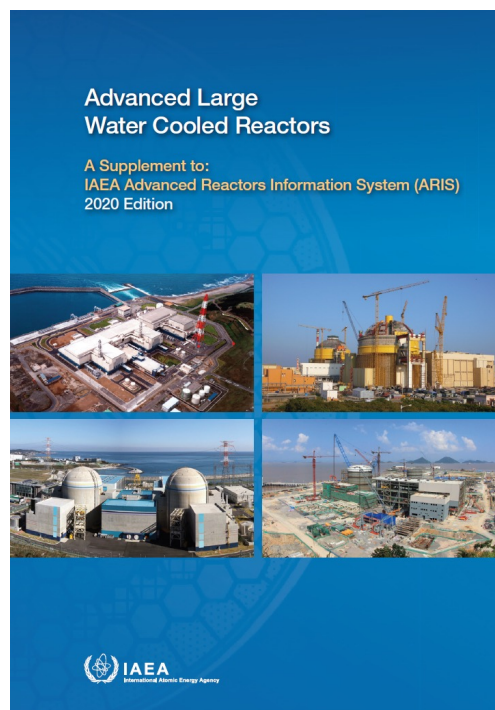


EU Country	Reactor type and #	Comments
Bulgaria	2 x AP1000	Firm commitment
Czech Republic	1 + 3x optional, EPR1200 (see prev. slide) or APR1400	Final decision by 2024 Some interest in Neward
Hungary	2x VVER 1200	Under construction
Netherland	2x (likely) o 4x (low probability) Gen III+ 1000-1650MW	EPR2 is an option (see prev slide). Interest in Neward
Polonia	3x AP1000 confirmed 2x or 4x APR1400 (<i>private partnership</i> , low probability)	SMR-HTGR possible additional option
Romania	2x CANDU + SMR Nuscale	Site for LFR-ALFRED offered
Slovakia	1x VVER V-213 - Mochovce-4	Under construction
Slovenia	1x large LWR	Unknown technology
Sweden	Other LWRs additionally to EPR1200 (see previous slide)	SMR technology to be decided

Courtesy ESN

Current Large Advanced WCRs for Immediate Deployment

Canada	
EC6	740 MWe
ACR1000	1165 MWe
China	
HPR1000	1000 MWe
CAP1400	1400 MWe
France	
EPR	1630 MWe
EPR1200	1200 MWe
Japan	
ABWR	1315 MWe
APWR	1700 MWe

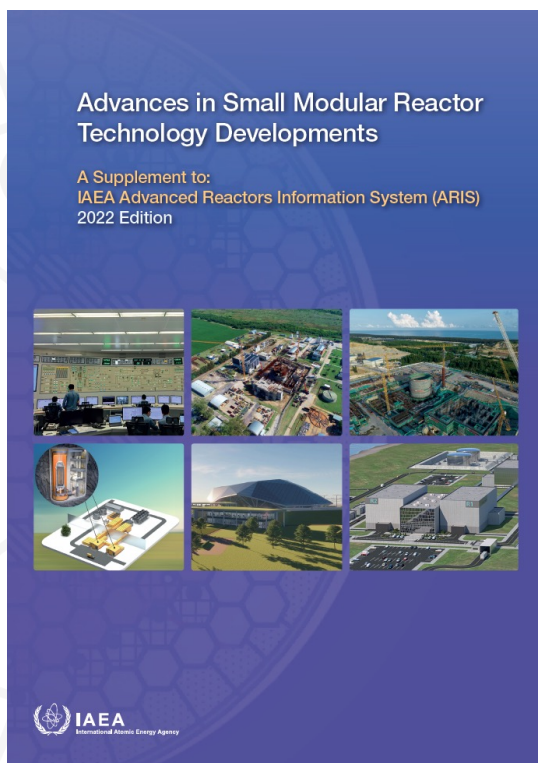


Republic of Korea	
APR1400	1416 MWe
OPR1000	993 MWe

Russian Federation	
VVER-1000	917 MWe
VVER-1200	1114 MWe
VVER-TOI	1175 MWe

United States of America	
ABWR	1315 MWe
AP1000	1117 MWe
ESBWR	1520 MWe

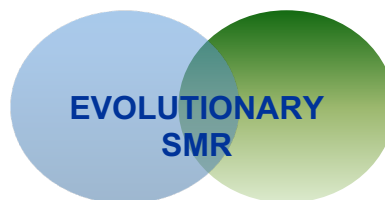
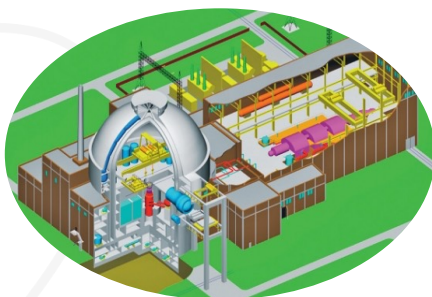
IAEA ARIS SMR Booklet 2022



IAEA SMR Booklet, 2022 Edition	
Number of reactor designs:	83
Member states involved:	18
Reactor types	1.1. Water-cooled Land Based – 25 1.2. Water-cooled Marine Based – 8 2. High temperature Gas-cooled – 17 , including 3 HTGR-type test reactors 3. Liquid Metal-cooled Fast Neutron Spectrum – 8 4. Molten Salt – 13 5. Microreactors – 12
Distinguishing features	• Annexes on economics, non-electric applications, experiments for design validation, fuel cycle and waste management • Insightful annexes with various charts and tables
Status	Finished, submitted for publication.
Downloadable version	Coming soon.

The 2022 IAEA SMR ARIS Booklet is a biennial publication as a supplement to the IAEA Advanced Reactor Information System (ARIS) Database. It provides a brief yet comprehensive design description of 83 different reactor designs. The 2022 version is an updated version of the 2020 booklet. It includes 11 more designs and a more comprehensive set of annexes.

Advanced Reactors



CAREM, HTR-PM, KLT-40S, ACP100,
NuScale, SMART, BREST-OD-300



**EVOLUTIONARY/
CURRENT
ADVANCED**

ABWR, ACR-1000, AP1000, APWR, ATMEA1,
EPR, ESBWR, WWER 1200, CAP1400,
APR1400, HPR1000...

**INNOVATIVE
SMRs + others**

LFR, GFR, SFR, SCWR, VHTR, MSR, ADS

SMR – Deployment Horizon by 2030

SMRs at advanced stage:

- 2 in commercial operation (China, Russia)
- 3 under construction (Argentina, China, Russia)
- 1 received SDA from U.S. NRC



HTR-PM first unit connected to grid on 20 Dec. 2021, commercial operation expected in **2022**



CAREM-25 construction halted in 2019, then restarted in 2019, expected to start **operation in 2025**



KLT-40S connected to the grid in Dec. 2019, started **commercial operation** at the end of **May 2020**



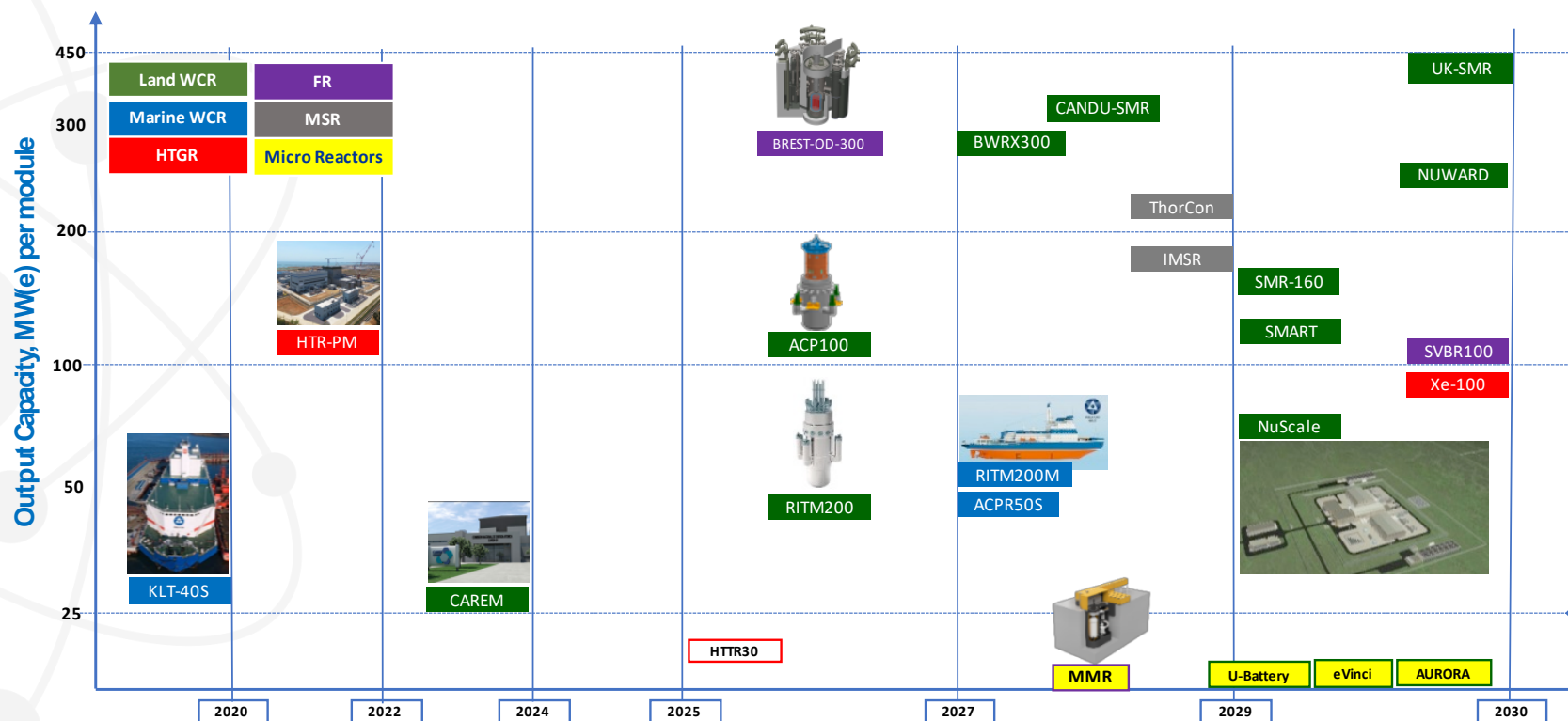
ACP100 construction officially started on 13 July 2021, at Changjiang NPP in Hainan province, scheduled commercial operation by the end of **2026**



RITM-200N preparatory work started in 2024 at Ust-Kuyga in Yakutia province, scheduled commercial operation by the end of **2028**

Courtesy IAEA

SMR – Deployment Horizon by 2030



Fast Reactors in Operation & under Commissioning

Country	Name	Coolant	Purpose	Power (th/e) MW	Year (Op.)	Status
Russia	BOR-60	sodium	experimental	60/10	1969	operating
	BN-600	sodium	prototype	1470/600	1980	operating
	BN-800	sodium	commercial	2100/880	2015	operating
China	CEFR	sodium	prototype	65/20	2011	operating
India	FBTR	sodium	experimental	40/13	1985	operating
	PFBR	sodium	prototype	1250/500	(Est.) 2025	commissioning
Japan	JOYO	sodium	experimental	150/--	1978	license renew



BN-600
Russia, 1980



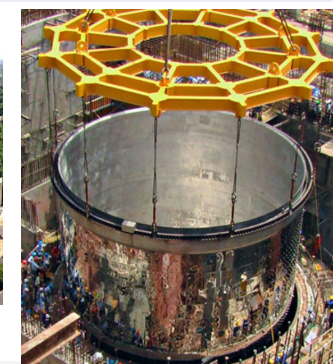
BN-800
Russia, 2015



CEFR, 20 MW(e)
China, 2011



FBTR, 13 MW(e)
India, 1985

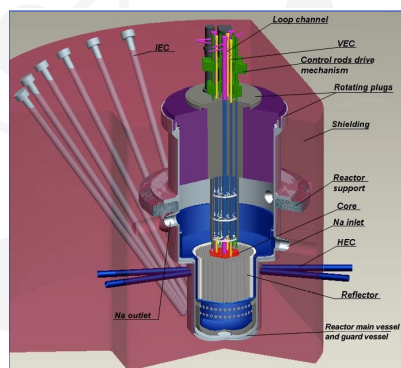


PFBR, 500 MW(e)
India, 2022

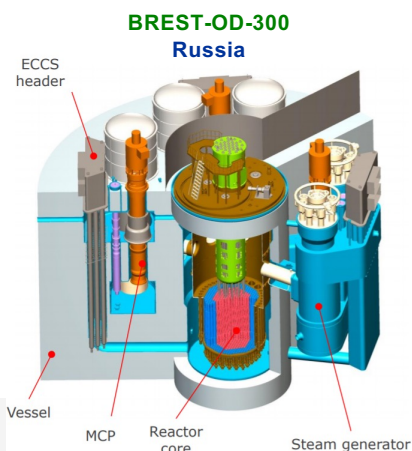
Courtesy IAEA

Fast Reactors under Construction and Decommissioning

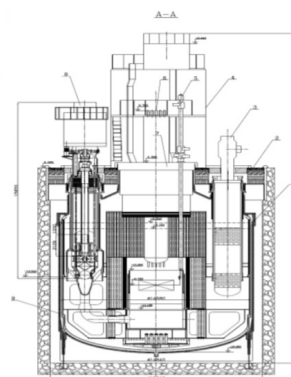
Country	Name	Coolant	Purpose	Power (th/e) MW	Year (Op.)	Status
Russia	MBIR	sodium	experimental	150/50	~2028	construction
	BREST-OD-300	lead	demonstrator	700/300	~2026	construction
China	CFR600 x2	sodium	prototype	1500/600	~2026	construction (2 units)
Japan	MONJU	sodium	prototype	714/280	1994	decommissioning
USA	FFTF	sodium	experimental	400/--	1980	decommissioning



MBIR, Russia



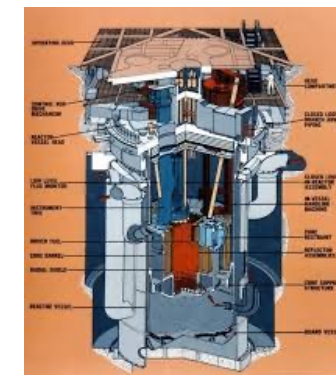
BREST-OD-300
Russia



CFR600, China



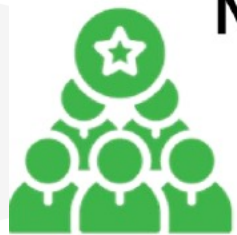
MONJU, Japan



FFTF, USA

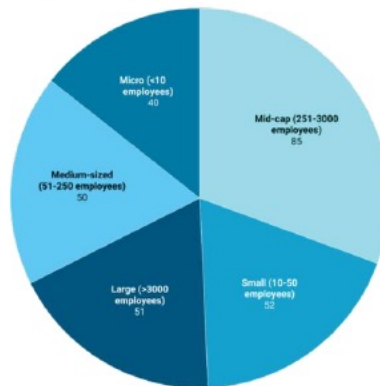
Courtesy IAEA

European IA on SMRs/AMRs



Members

277



5 Technologies



LW-SMR, AMR



Courtesy



European IA on SMRs – TWGs



TWG1: Industrial Applications

Chair: N.Regia (CEFIC)
Vice Chair: A.Georgescu (Eurometaux)

TWG2: Technology and R&D&I

Chair: P.Baeten (SCK-CEN)
Vice Chair: M.Pasquet (Framatome)

TWG3: Supply Chain

Chair: V. Ramany (EDF)
Vice Chair: M.Tacconelli (Walter Tosto)

TWG4: Skills

Chair: M.E. Ricotti (POLIMI, CIRTEN)
Vice chair: O. Bard (GIFEN).

June 2024
October 2024



TWG5: Public Engagement

Chair: M. Martell (GMF)
Vice Chair: TBD

TWG6: Nuclear Safety & Safeguard

Chair: O.Kymäläinen (FORTUM)
Vice Chair: R.Urjan (Nuclearelectrica)

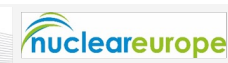
TWG7: Fuel cycle & waste management

Chair: H.Baars (URENCO)
Vice Chair: T.Louvet (ORANO)

TWG8: Financing

Chair: M.Jedlička (ČEZ)
Vice Chair: C.Töpfer (Vattenfall)

Courtesy



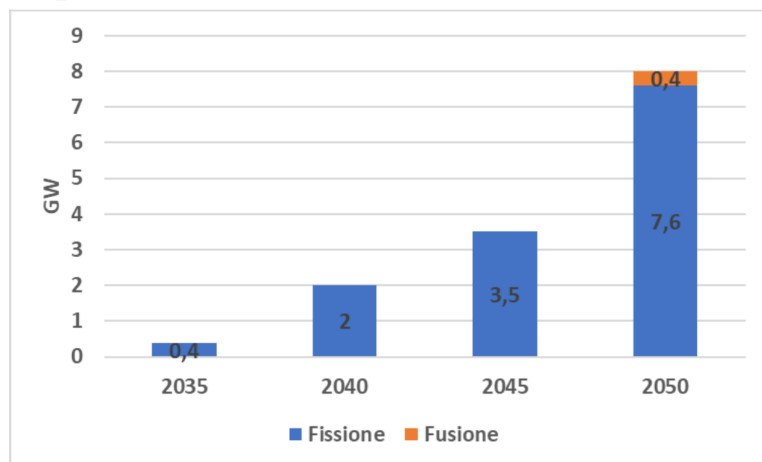
E l'Italia ?

Opportunità per sistema italiano su progetti all'estero



- Grande potenzialità per l'industria sistemistica e manifatturiera di acquisire commesse per:
 - ✓ Life extension (60% parco nucleare europeo)
 - ✓ Nuovi reattori WCR di grande taglia (+ 50 GWe al 2050)
 - ✓ FOAK di SMR e AMR
 - ✓ Fusione
- ✓ Circa 50 organizzazioni italiane partecipano a SMR-IA, anche con ruoli di coordinamento
- Buon posizionamento su R&S per SMR-LWR, AMR (LFR, MR), fusione

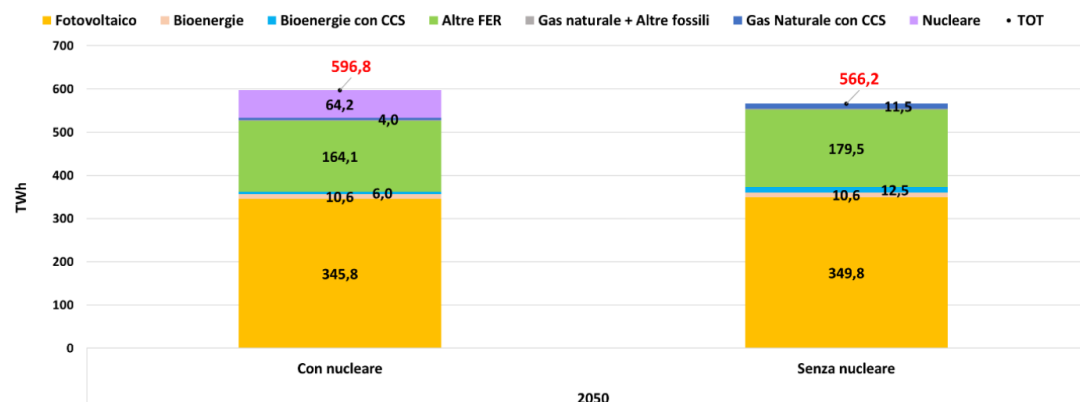
Realizzazioni in Italia: Nuovo PNIEC 2024



Solo reattori in via di sviluppo: SMR, AMR, MR, Fusione

“Con nucleare (circa 11% della domanda elettrica al 2050) si raggiunge l’obiettivo “Net Zero” ad un costo stimato di circa 17 miliardi di € inferiore al costo dello scenario senza nucleare”

Figura 8 – Produzione nazionale di energia elettrica al 2050 negli scenari con e senza nucleare.



NB: entrambi gli scenari al 2050 sono caratterizzati da una capacità installata di circa 245 GW di fotovoltaico e circa 51 GW di eolico

Dilemma italiano

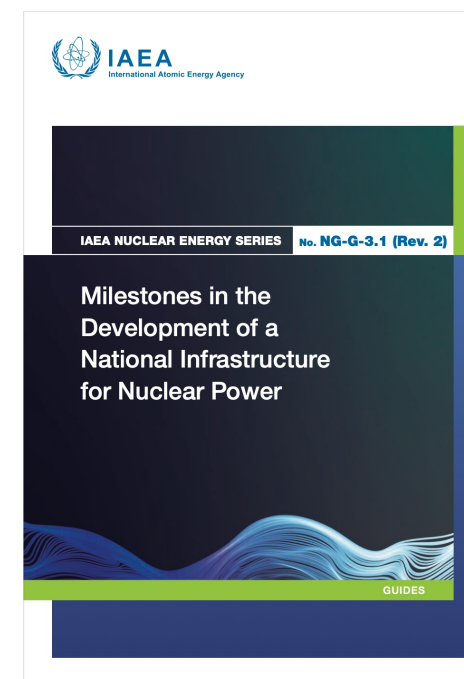
- Solo ricerca e sviluppo o anche deployment industriale?
(ultimo kWh elettronucleare prodotto in Italia nel 1990)
- Se ANCHE deployment industriale.... Necessità di partire quanto prima su:
 - ✓ *Cabina di regia (NEPIO)*
 - ✓ *Adeguamento infrastrutture di base (v. prossima slide)*
 - ✓ *Accordi bilaterali e internazionali*
 - ✓ *Reactor Technology Assessment*
- ✓ Auspicabile un consorzio industriale fra produttori di energia, fornitori di tecnologie, end-users

IAEA Milestone Approach: 19 Infrastructure Issues



Infrastructure elements that should exist in the country to create an enabling environment leading to a successful nuclear programme and mitigating the project risks

Whatever is the NPP !!!





Hotei-san: “focus on the moon and not on the finger pointing to the moon...”



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Presidente

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