Nuclear Power Status and Focus on Small Reactors

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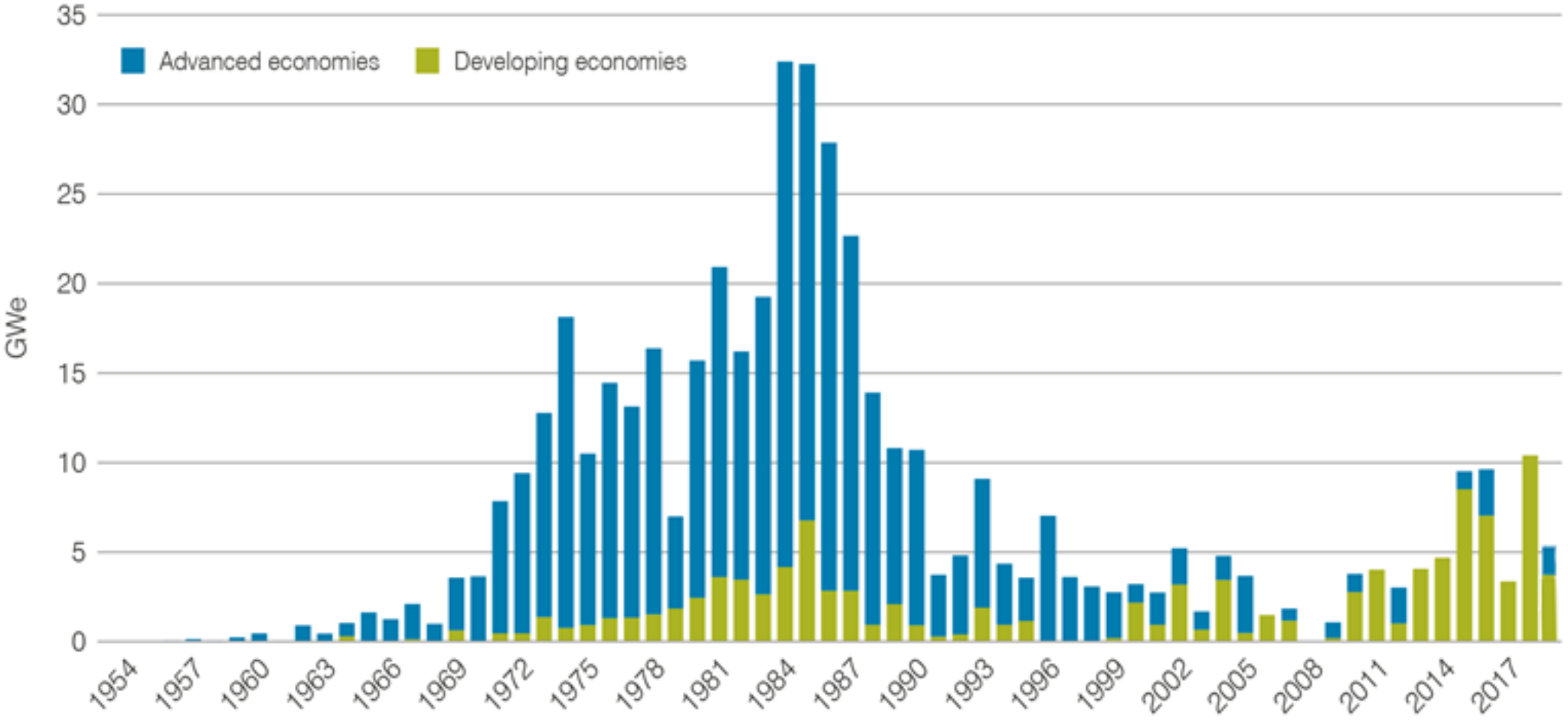
AusIMM North Qld 27 May 2021

Scheduled Start-ups 2021

- China: Fuqing 6 1170 MWe
  - Fangchenggang 3 1150 MWe
  - Fangchenggang 4 1150 MWe
  - Hongyanhe 5 1119 MWe
  - Tianwan 6 1118 MWe
  - Shidaowan HTR 210 MWe
- South Korea: Shin Hanul 1 1400 MWe
- India: Kakrapar 3 700 MWe
  - Kakrapar 4 700 MWe
  - Kalpakkam FBR 500 MWe
- Belarus: Ostrovets 2 1194 MWe
- Finland: Olkiluoto 3 1600 MWe
- Slovakia: Mochovce 3 471 MWe
- USA: Vogtle 3 1250 MWe

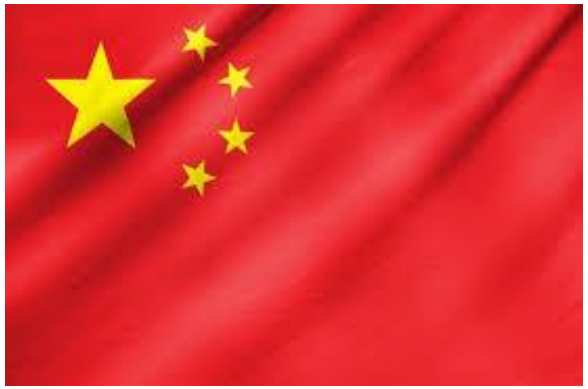
Fuqing 5

Nuclear capacity connected to the grid
Advanced and developing economies



Russia and China

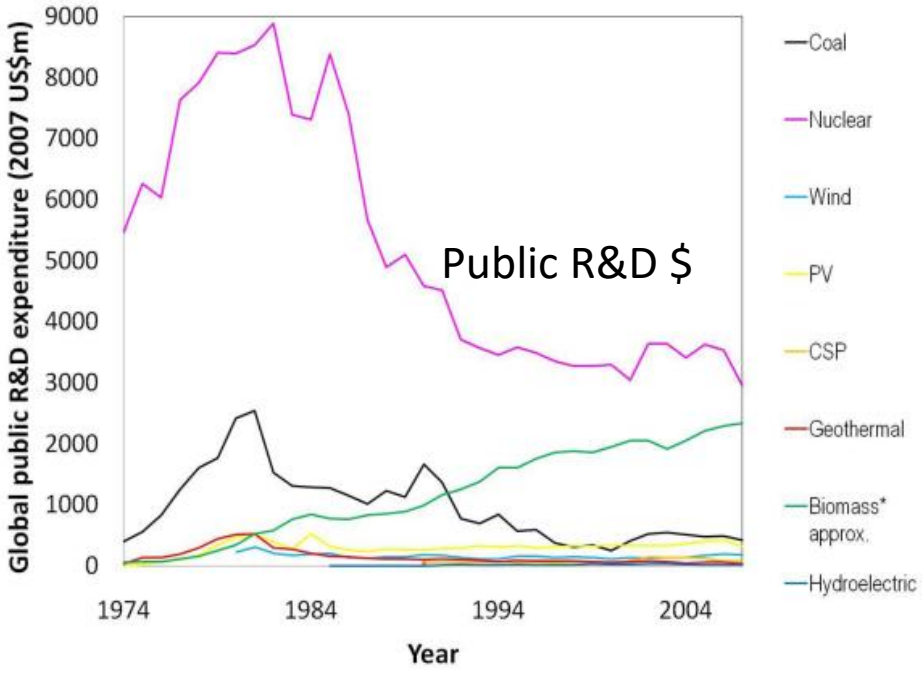
RPV for Rooppur, Bangladesh



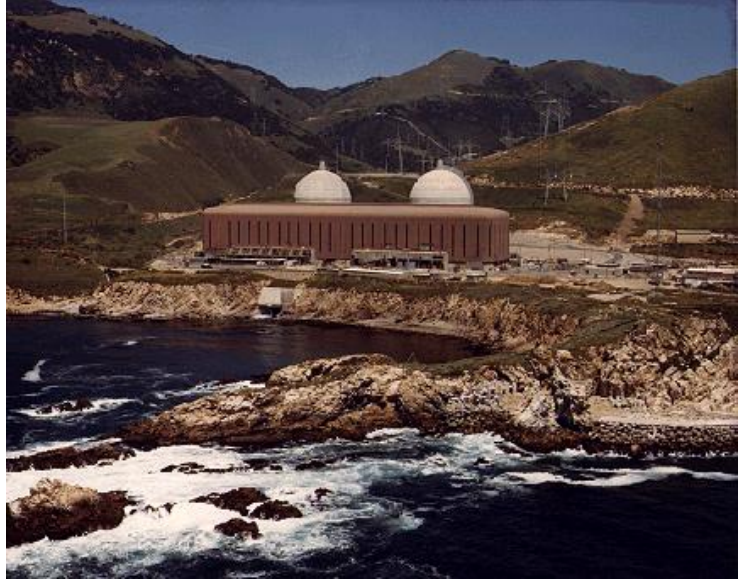
Lingao

Change over 50 years

- Loss of Government support in West
- Lawfare from opponents in West
- Loss of skills in workforce in West
- Degradation of supply chain in West
- Liberalisation of electricity markets in West,
  - no long-term power purchase agreements
- Financing challenge



Today



- USA: Revival of interest by Congress
- USA: Reactor operating licences to 60 then 80 years
- USA: Export financing re-enabled after long hiatus
- UK: strong commitment, but funding hurdles
- Russia: preeminent reactor exporter

Today

- China: huge domestic build program, some exports
- South Korea: built big project in UAE
- Japan: restricted post-Fukushima

Barakah, UAE

Geopolitical drivers

- Russia and China: major role of central bank finance for exports
- Long-term effect: plan, build, operate 60 years, decommission
- The geopolitical importance of nuclear energy makes it a powerful tool for international cooperation.

Bushehr, Iran

UAE: Preliminary Safety Analysis report – 9000 pages

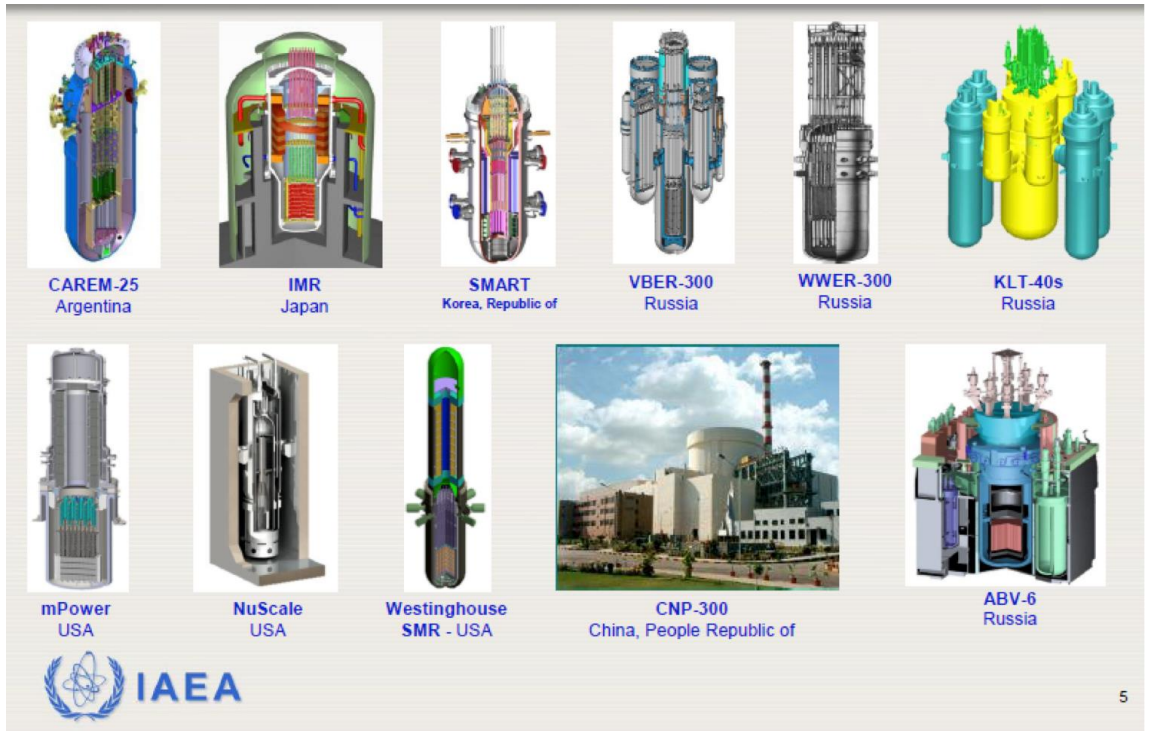
PSAR contents

1. Introduction and General Description of Plant
2. Site Envelope Characteristics
3. Design of Structures, Systems, Components, and Equipment
4. Reactor
5. Reactor Coolant and Connecting Systems
6. Engineered Safety Features
7. Instrumentation and Control
8. Electric Power
9. Auxiliary Systems
10. Steam and Power Conversion System
11. Radioactive Waste Management
12. Radiation Protection
13. Conduct of Operations
14. Initial Test Program
15. Accident Analyses
16. Technical Specifications
17. Management of Safety and Quality Assurance
18. Human Factors Engineering
19. Probabilistic Risk Assessment, Severe Accident, and Aircraft Impact Assessment
20. Physical Protection
21. Safeguards

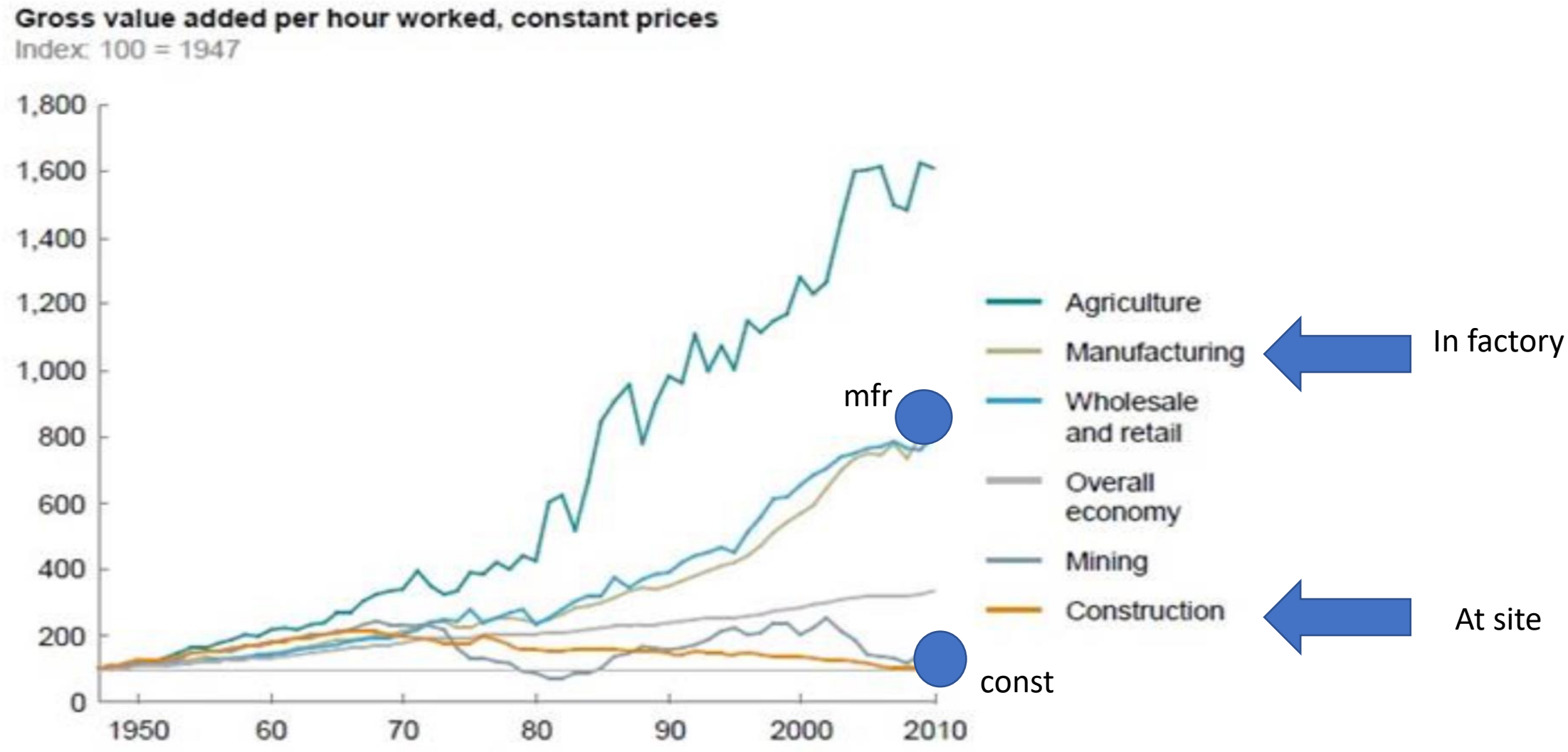
- Supplement 1 – Reference Nuclear Facility Departures and Independent Safety Verification
- Supplement 2 – Safety Issues and Use of Operating Experience

Small reactors, small modular reactors

- Economic drivers, successive build in big plants, eg 6-12 reactors
- Economies of factory build > economies of scale
- Ready replacement of fossil fuel units in established grid
- Load-following ability, so fit in with wind and solar inputs



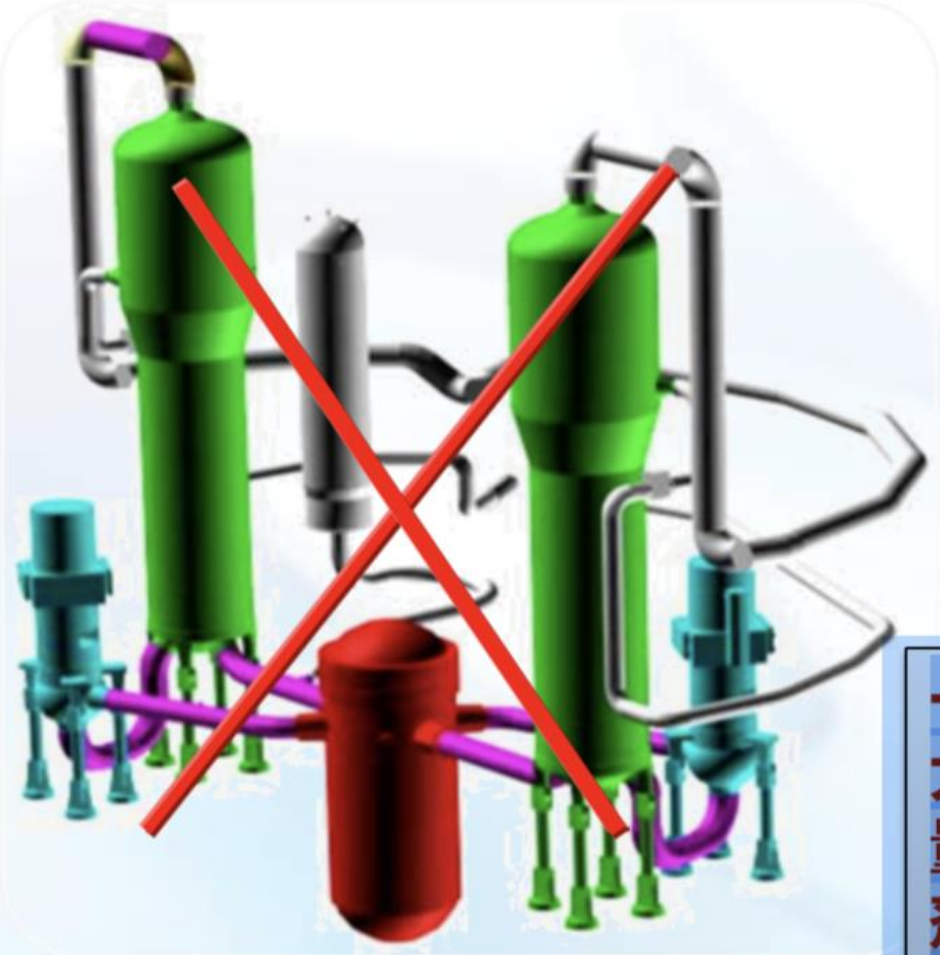
Also: process heat to 800°C



Construction labor productivity has decreased in the West

MIT

In China: compare 1200 MWe with 125 MWe



传统压水堆回路系统

传统　　革新

一体化反应堆设计，大大减少了主回路管道数量，简化了反应堆冷却剂系统结构，消除了大LOCA事故，提高了反应堆固有安全特性。

ACP100

一体化反应堆模块

5.5 m diameter
10 m high
256 tonnes

In China

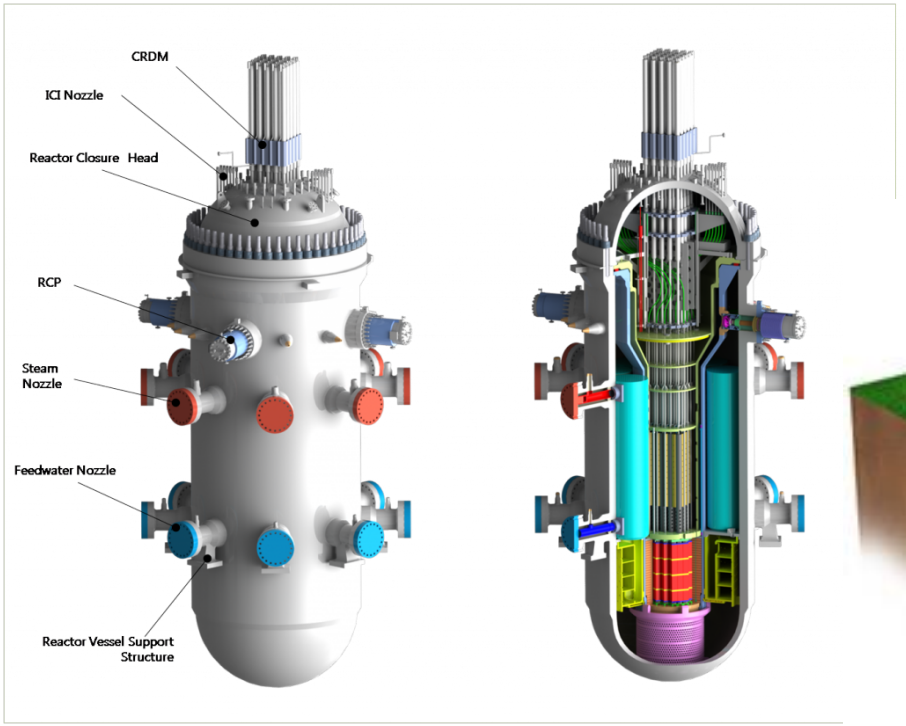
Steam Generator 24 meters high, 800 tons

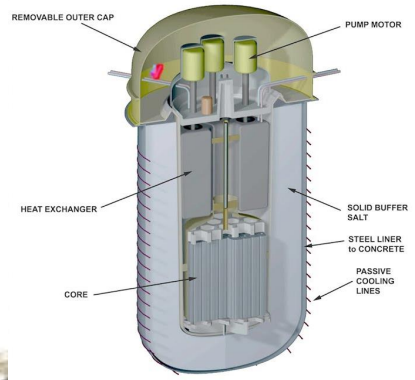
ACP100: 125 MWe

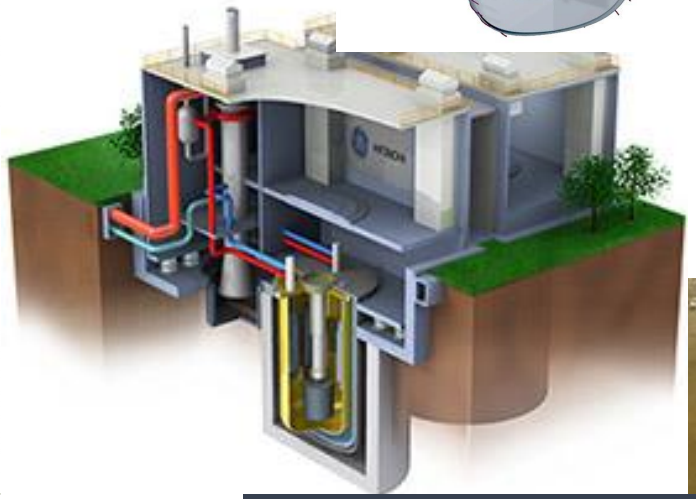
Under construction
Changjiang, Hainan

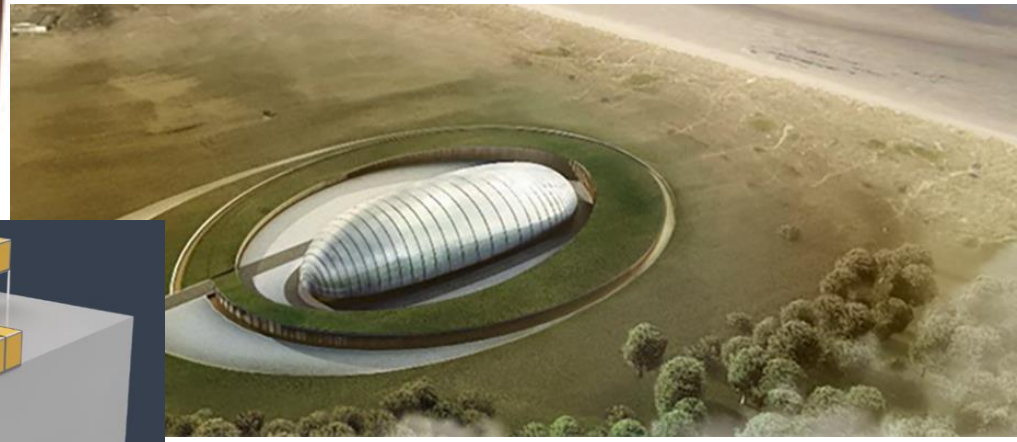
5.5 m diameter
10 m high
256 tonnes

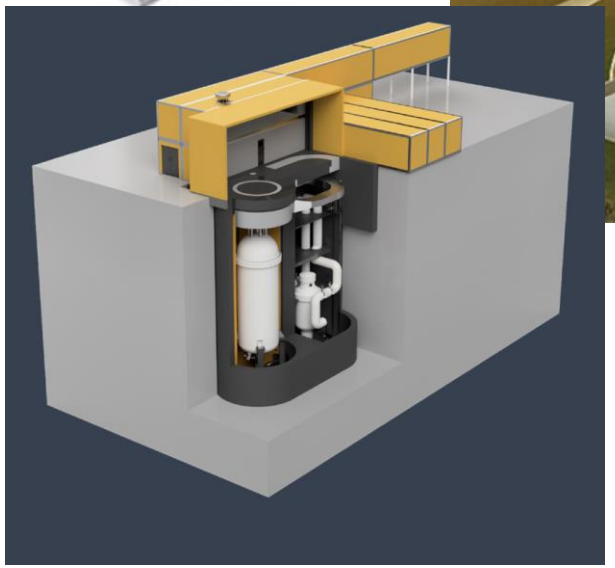
Nine small reactors





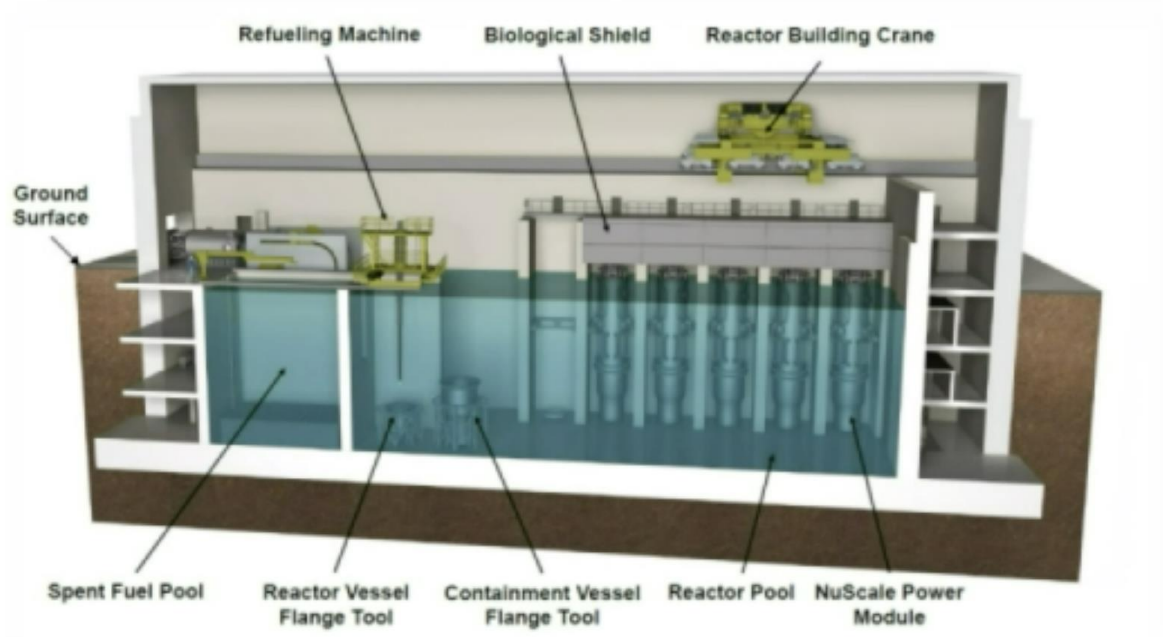




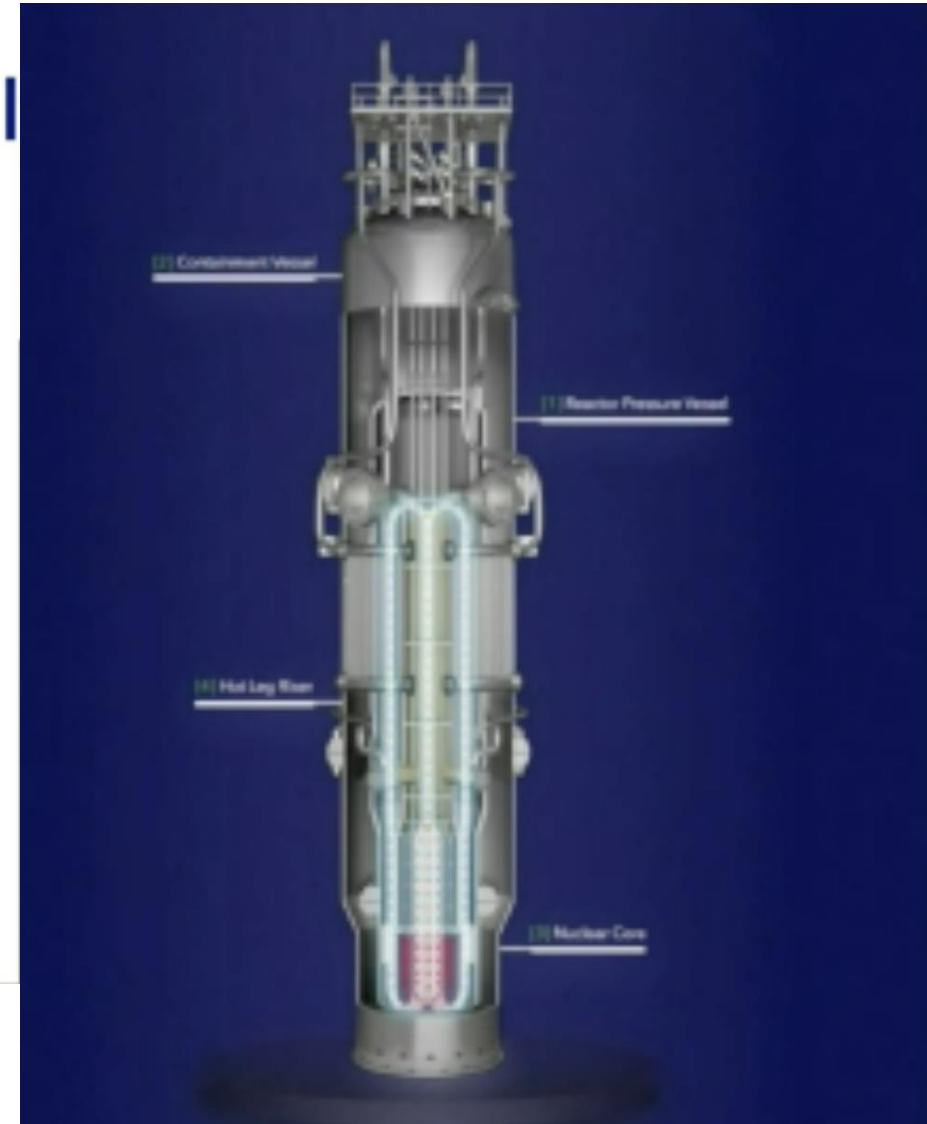


NuScale: 60 MWe

Reactor Building Houses NuScale Power Modules™, Spent Fuel Pool, and Reactor Pool



NUSCALE

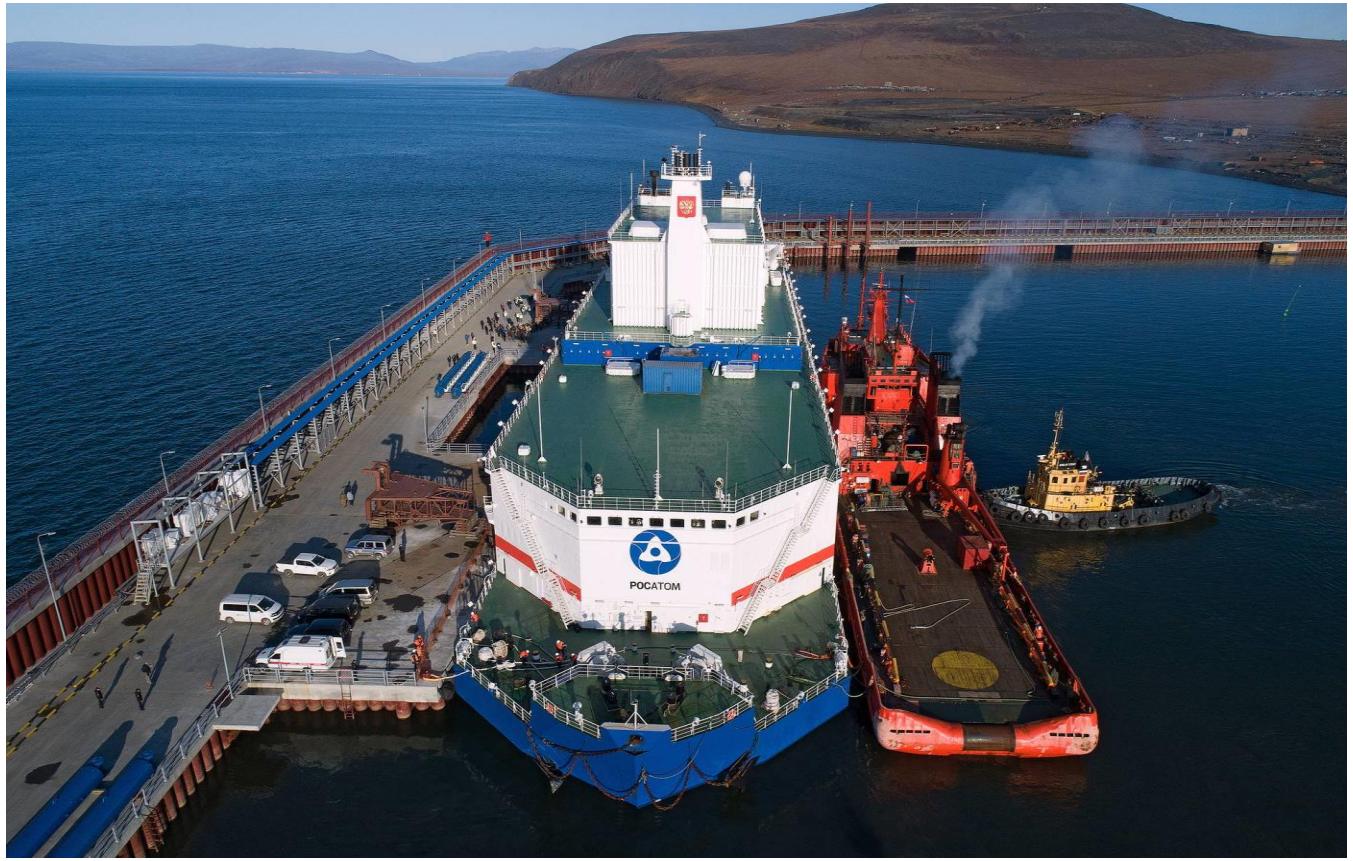


12-unt power plant planned for Idaho

RITM-200M: 50 MWe

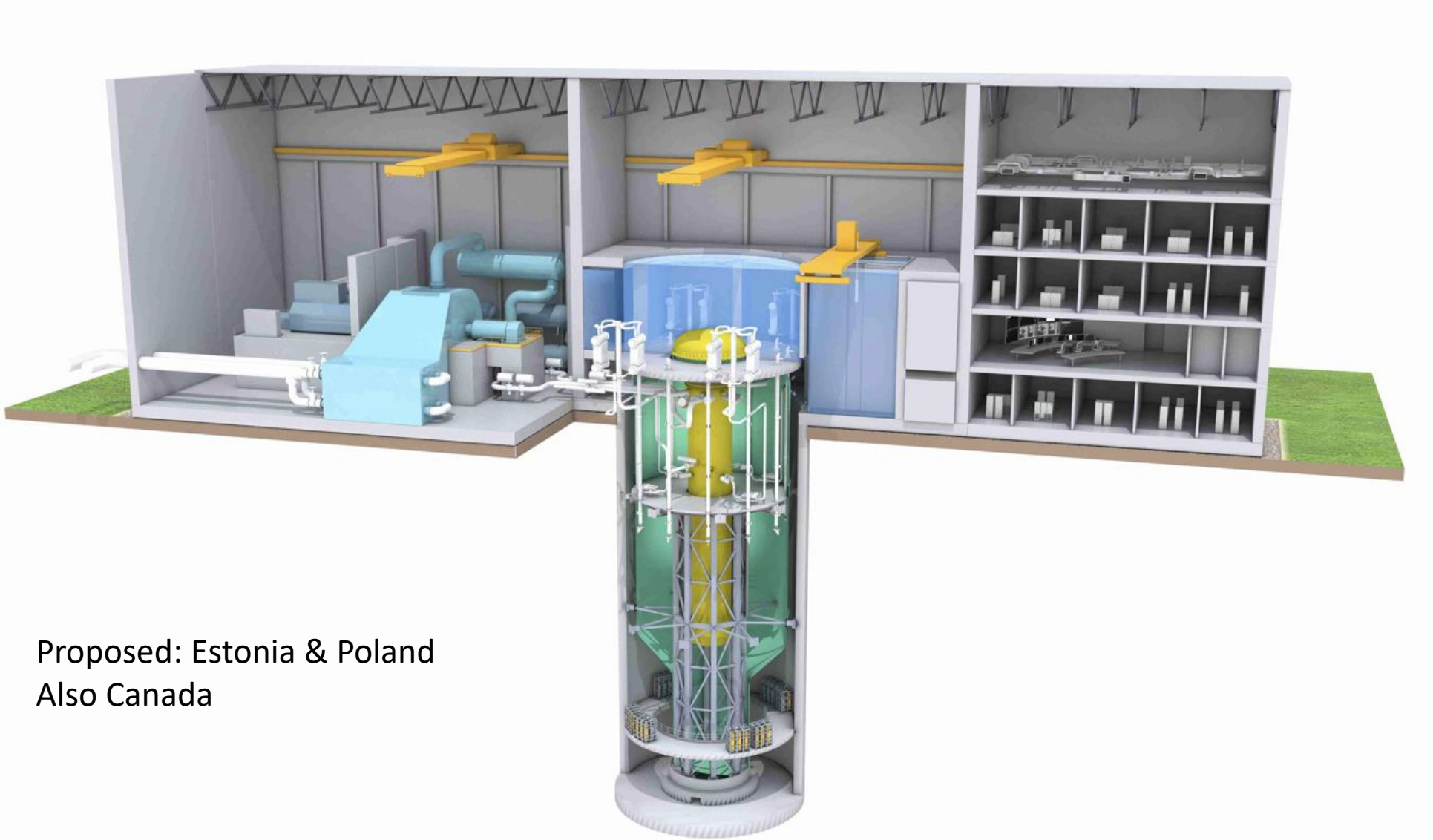
Icebreaker
Power plant
now operating

Floating NPP, Pevek, Siberia – 2 x 35 MWe reactors



Operating from 2019

BWRX: 300 MWe

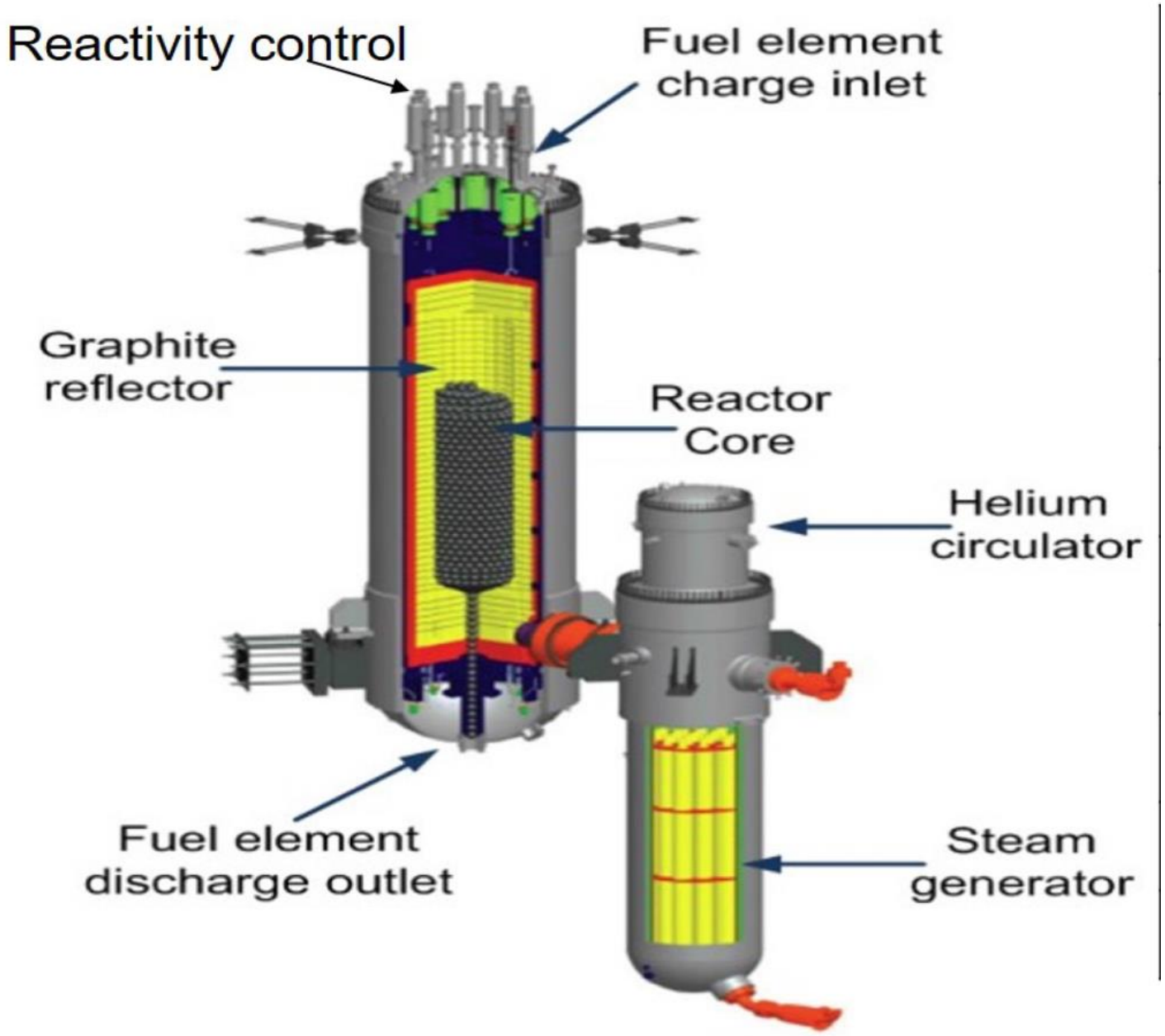


Proposed: Estonia & Poland
Also Canada

HTR-PM: 2x105 MWe

Due on line later in 2021

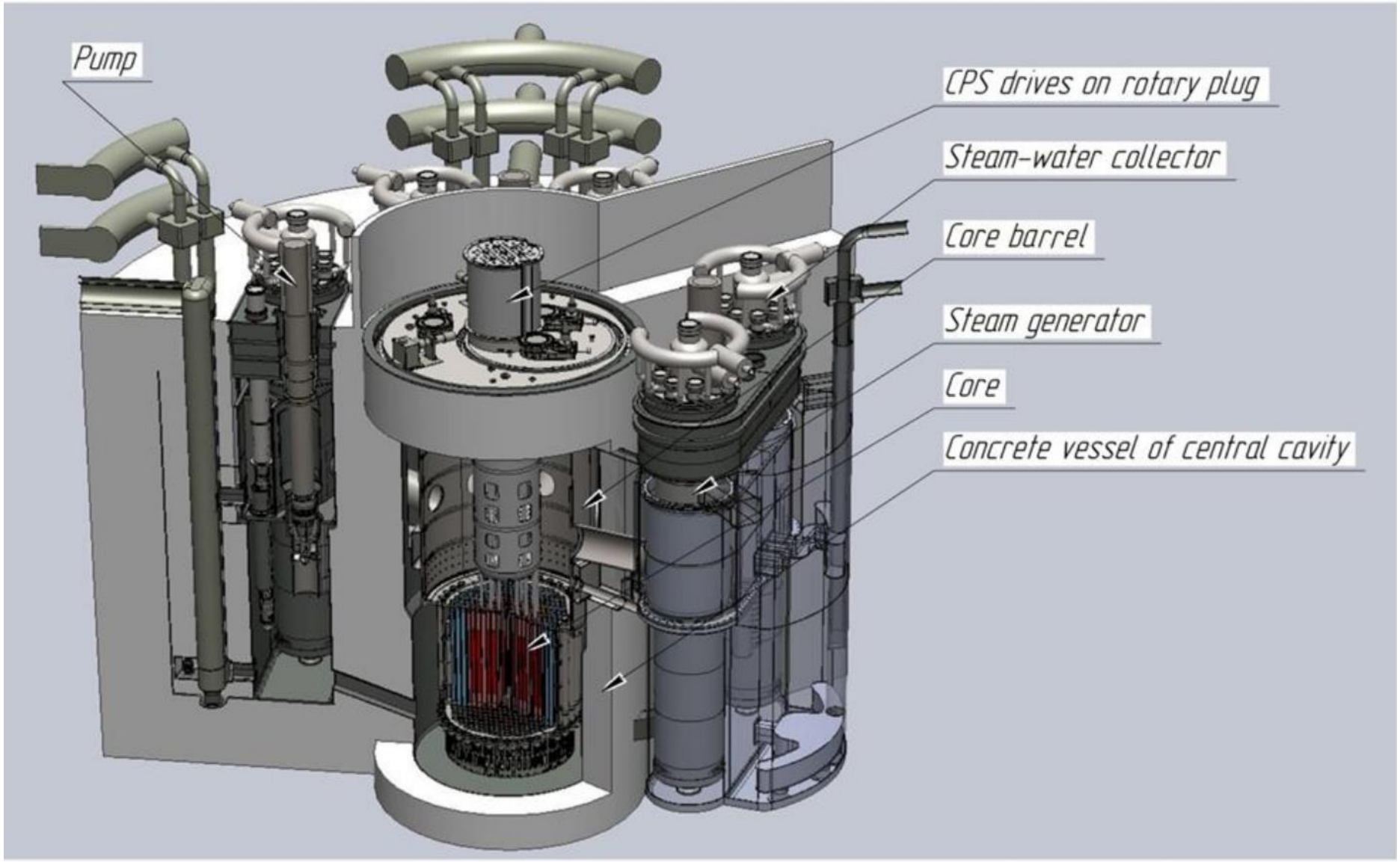
Shidaowan, Shandong



HTR-PM

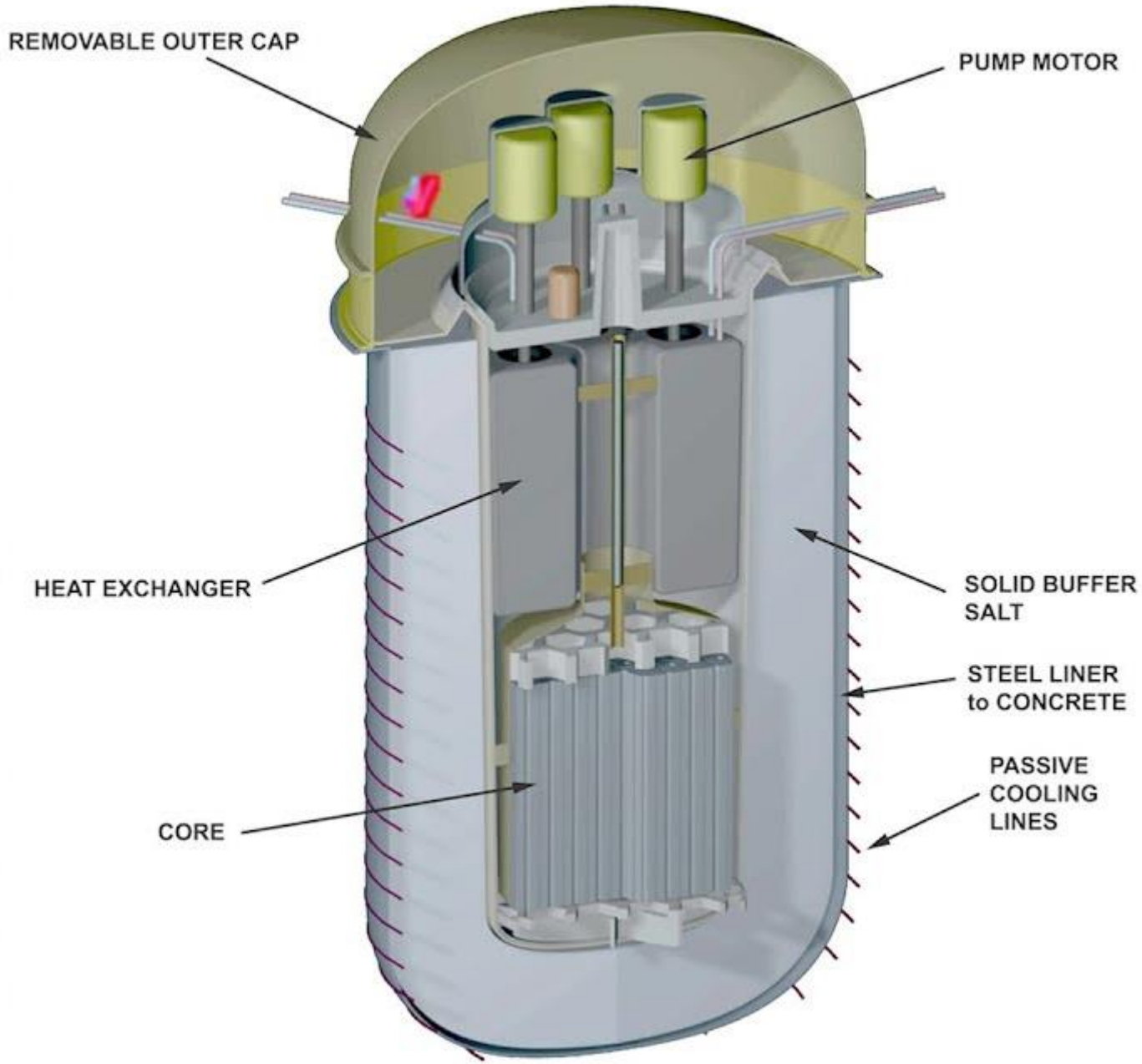

科技重大专项—华能石岛湾核电厂高温气冷堆示范工程压力容器胜利出厂
发展绿色电力 奉献洁洁能源
全球首台HTR-PM压力容器
华能石岛湾高温气冷堆示范工程

BREST: 300 MWe



Construction start 2021?
At Seversk

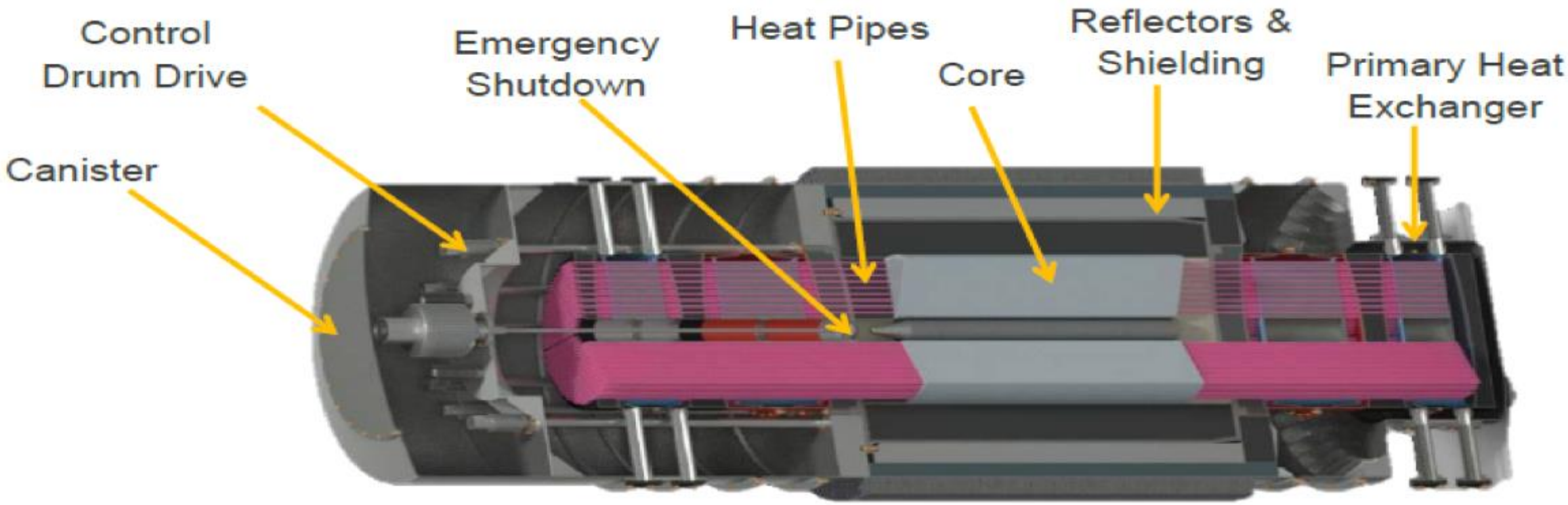
IMSR: 190 MWe


REMOVABLE OUTER CAP
PUMP MOTOR
HEAT EXCHANGER
SOLID BUFFER SALT
STEEL LINER to CONCRETE
PASSIVE COOLING LINES
CORE

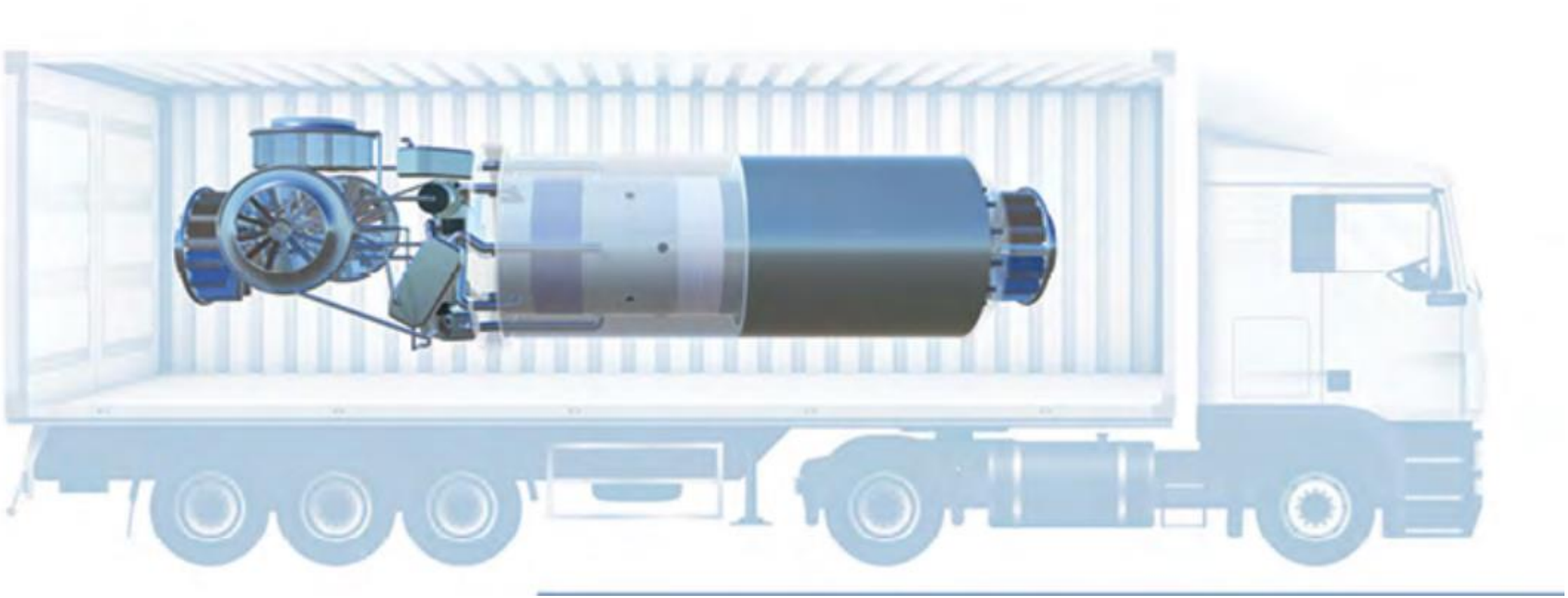
MMR: 10 MWe

Ten of these
with solar PV and wind
Are proposed for a
remote defence base
to produce 1 TWh/yr
@ 10c/kWh

Westinghouse eVinci: 1.6 MWe



Portable nuclear power plants



Megapower reactor

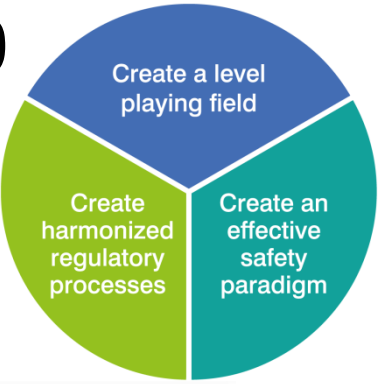
Considerations for SMR deployment

- Government policy leadership
- Selection of standardized design previously licensed in vendor country
- Strong relationship between host and vendor country regulatory bodies
- Common regulatory standards and processes
- Experienced staff and contractors

- Some technology areas more transferable than others:
  - Design and safety assessment
  - Operating organisation and procedures
  - Environmental assessment and siting

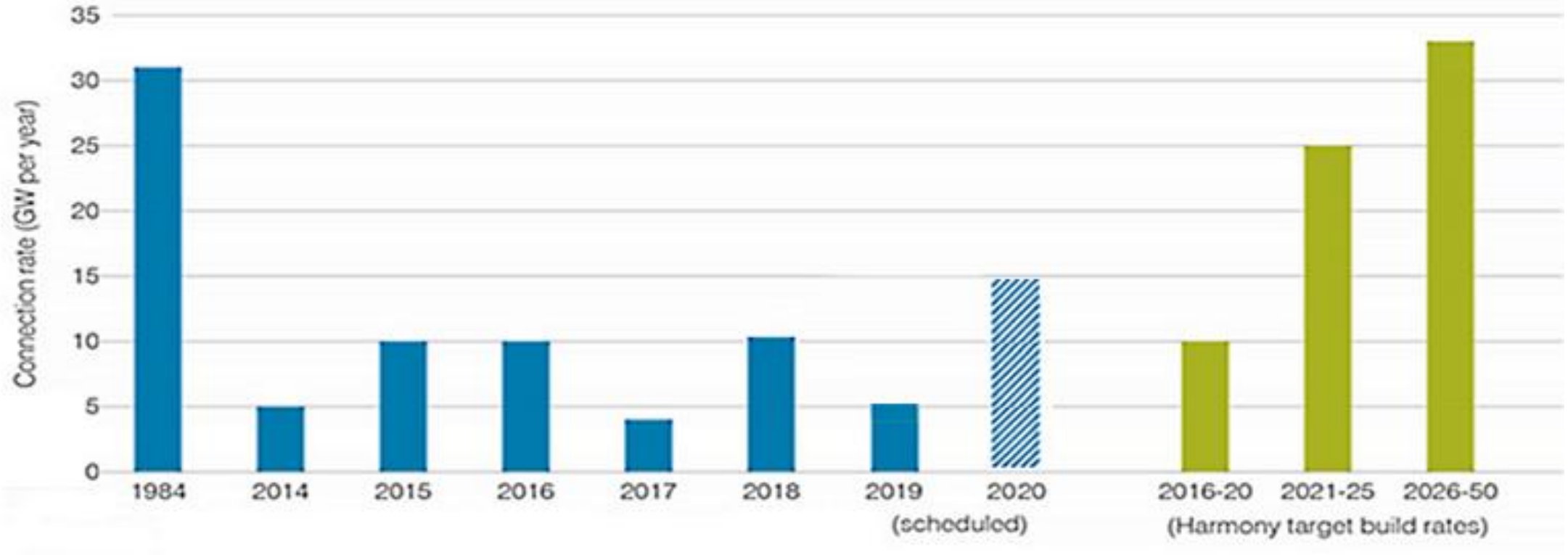
- Host country regulator is ultimately accountable for its decisions

Harmony program: 1000 GW new nuclear capacity by 2050

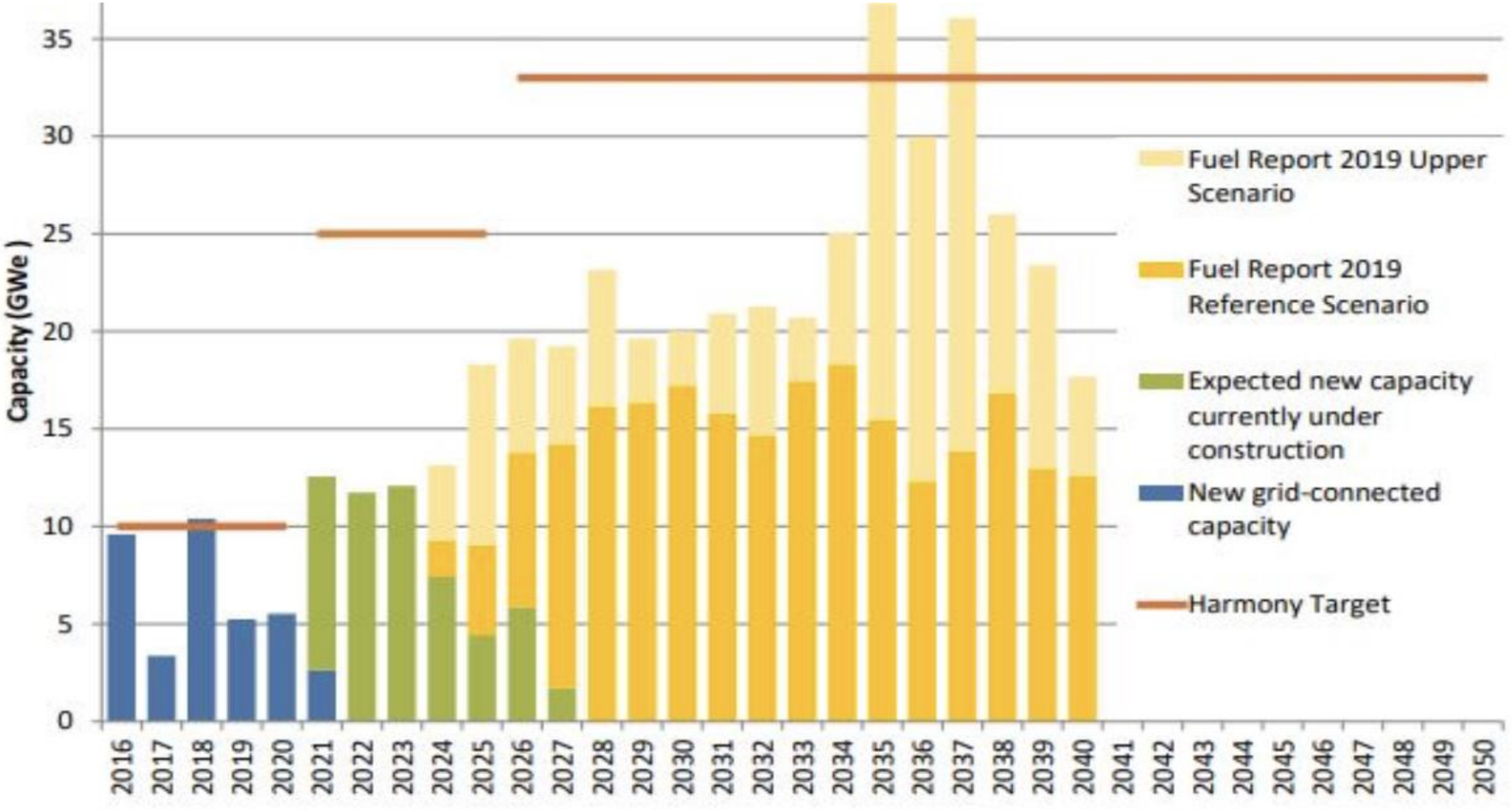


Construction rate doubled from trend of less than 5GW/y to 10GW/y

Then we need to triple from today's level



Expectations well short of need

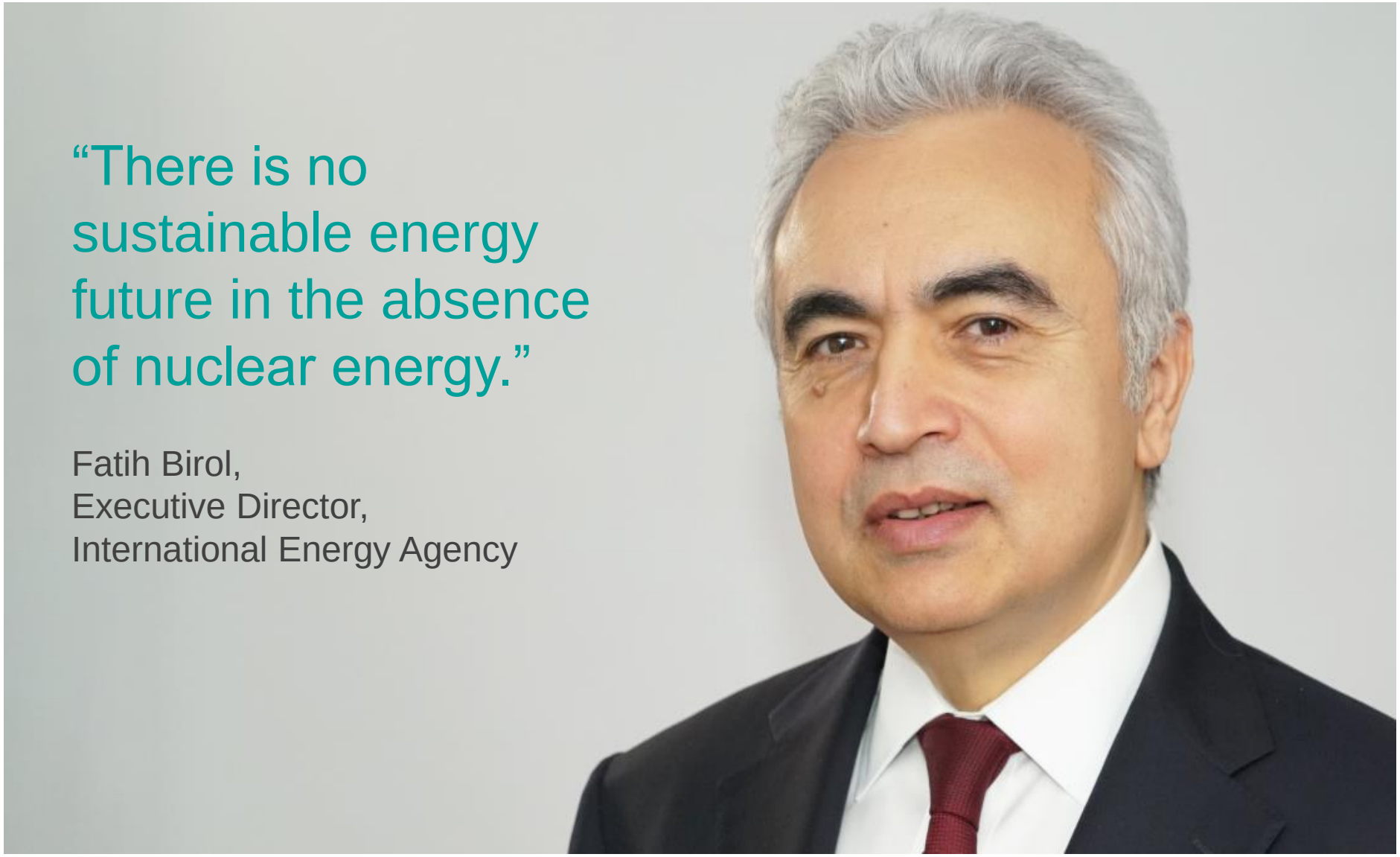


Australia? - 66,500 MWe total, 265 TWh/yr

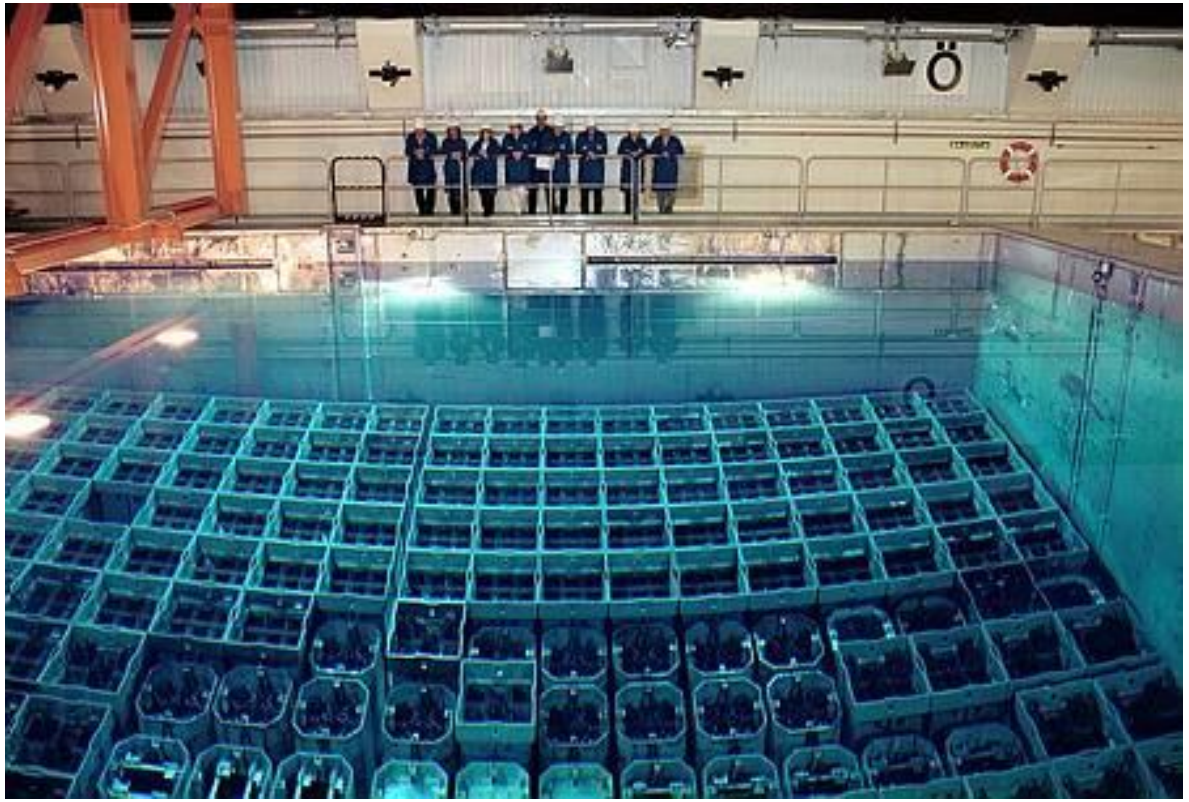
- Long contentment with low-cost coal – now over half of supply
- Nuclear power is illegal!
- Popular support for intermittent renewables – now over 20% of supply
- The cost and impracticality of these at higher levels has yet to be widely understood
- At 50% intermittent renewables supply, the delivered cost will about double
- Questions also of reliability of this delivered power
- Wind capacity factor average 31%, solar PV 12.5% in Australia
- Coal or nuclear is typically over 90% on line, hence reliable

German Energiewende disaster

- Germany's Federal Court of Auditors:
- The shift to renewables has cost at least 160 billion euros in the last five years (to 2019).
- Meanwhile, the expenditures "are in extreme disproportion to the results," Federal Court of Auditors President Kay Scheller said.
- Scheller is even concerned that voters could soon lose all faith in the government because of the massive failure.
- the second part of the Energiewende will be expensive and exhausting – maybe EUR 3.4 trillion by 2050 according to ESYS.


“There is no sustainable energy future in the absence of nuclear energy.”
Fatih Birol,
Executive Director,
International Energy Agency

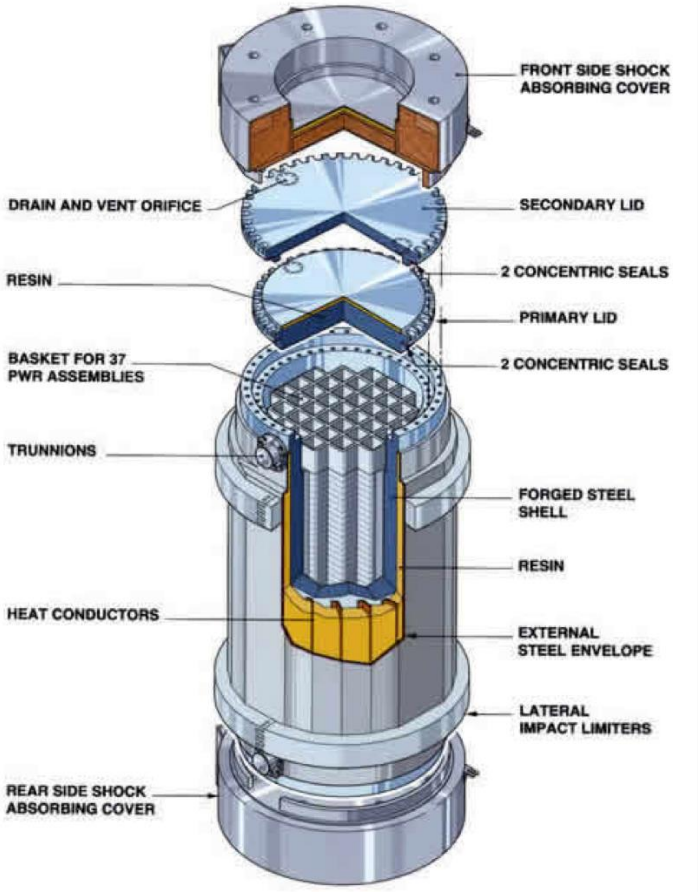
Wastes – storage of high-level wastes



Sweden: CLAB

USA: Connecticut Yankee ISFSI

Transport and disposal of high-level wastes



www.world-nuclear.org

> information library

Safety improvements

Core melt trap for VVER1200 Akkuyu, Turkey
This sits under the reactor pressure vessel

Haiyang AP1000 reactors in China
with emergency cooling water tanks on top