IAEA
International Atomic Energy Agency
Atoms for Peace and Development

SMR: Global Status and IAEA Activities

Forum for Nuclear Cooperation in Asia
Study Panel 2023
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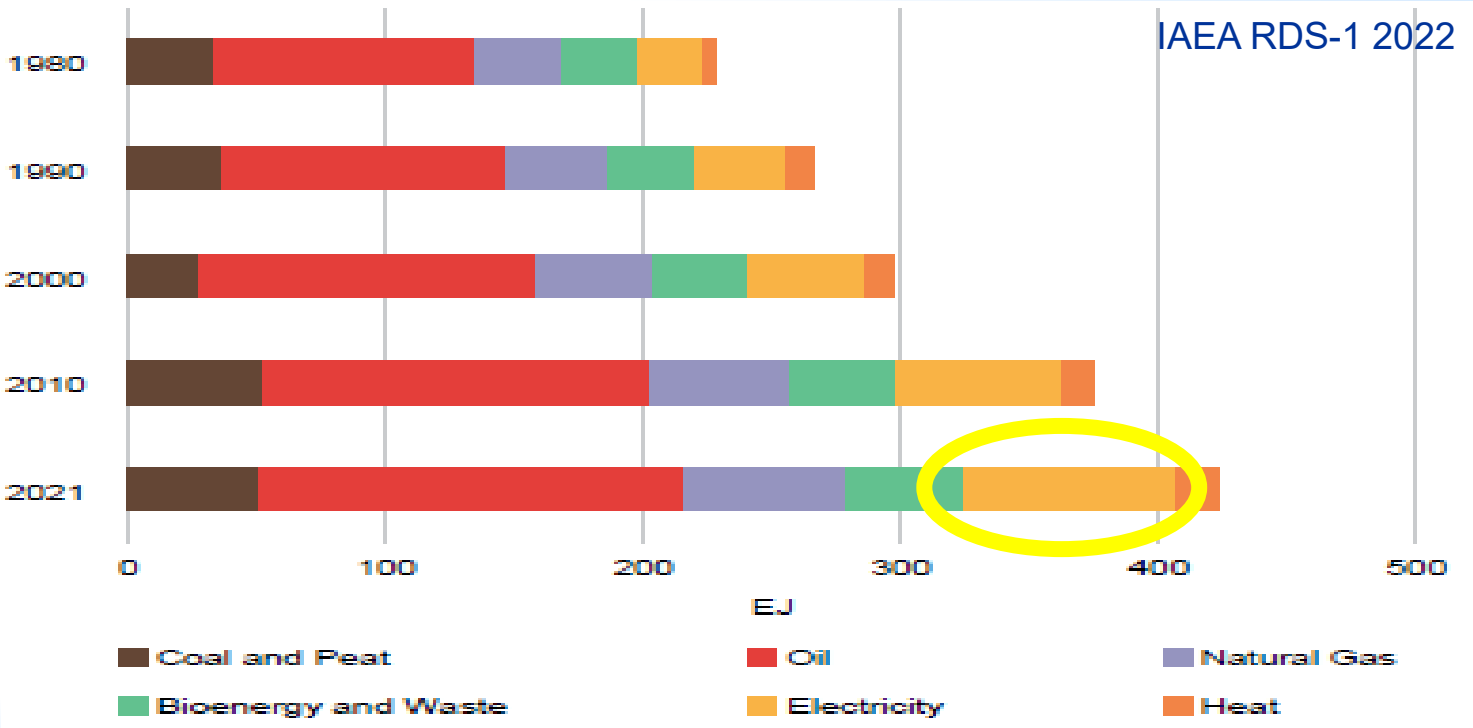
Drivers and Status of Nuclear Power

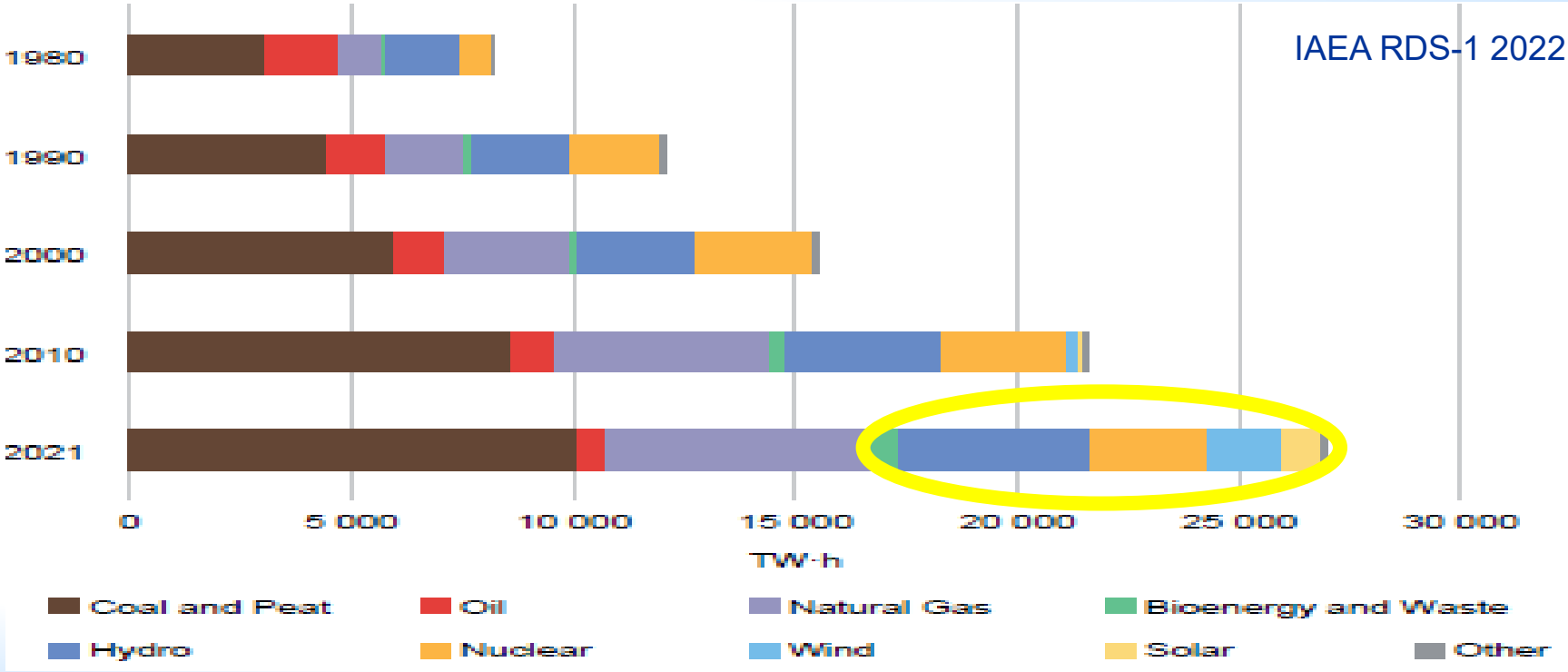
- **Main drivers** for maintaining and expanding the use of nuclear power are **Climate Change Mitigation** and **Energy Security**
- **Status of nuclear power**, 2021
  - 19.5% of final energy consumed was electricity
  - Nuclear power accounted for 9.8% of total electricity production
  - Hydro and Solar/Wind produced 16% and 9%, respectively
  - 32 countries with operating nuclear power plants and about 30 countries interested in nuclear power
- **Innovations** can help nuclear energy meet many of the challenges which are holding back its growth

World Final Energy Consumption by Energy Source



19.5% of final energy consumed was electricity in 2021. It is anticipated that the share of electricity will continue to grow.

World Electricity Production by Energy Source



Among low carbon electricity sources, hydro, nuclear, and solar/wind, account for 16%, 9.8% and 9%, respectively.

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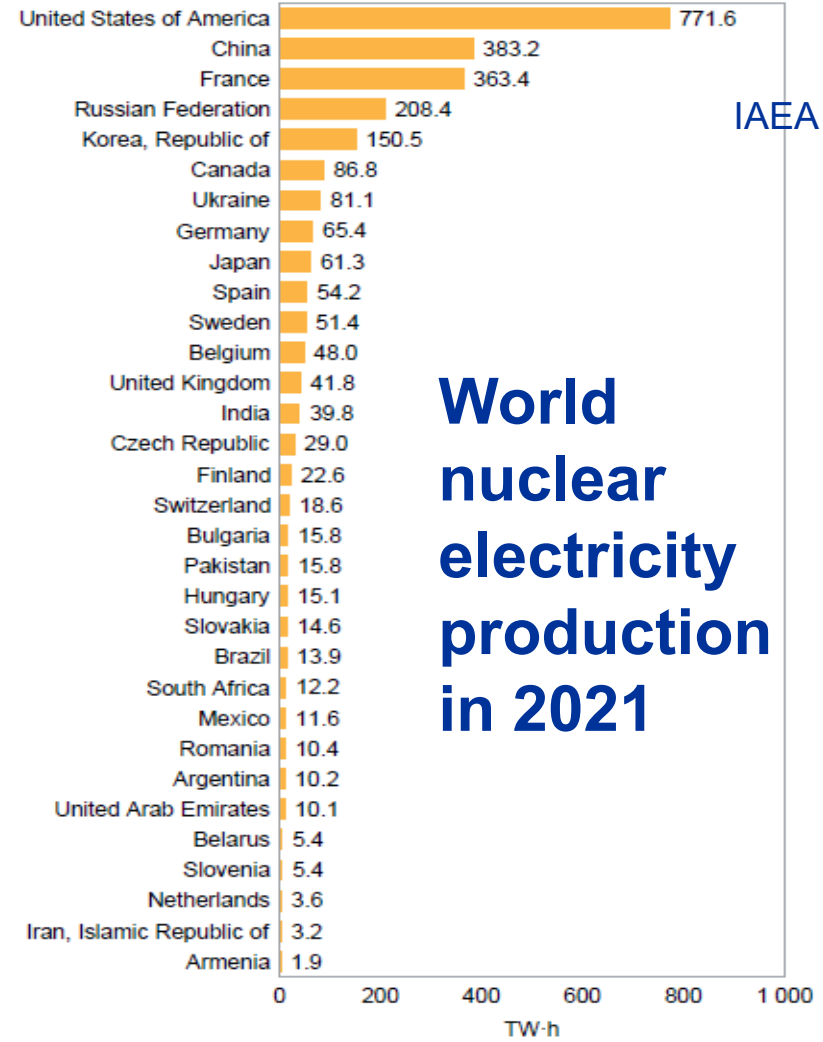
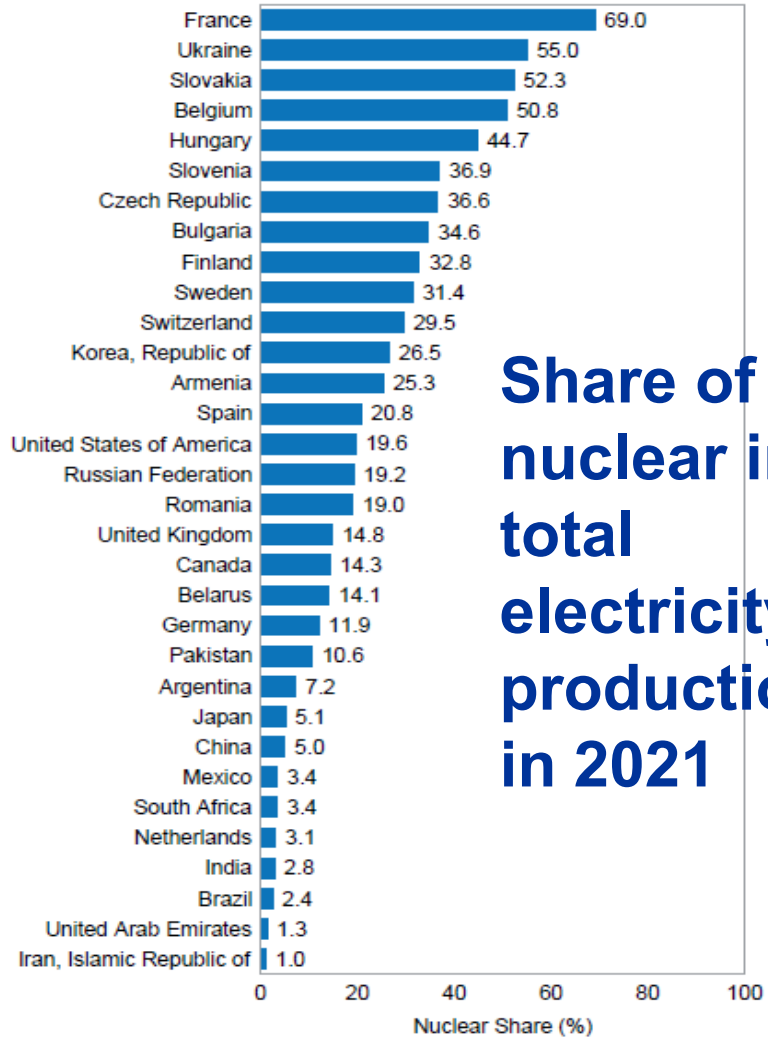


World nuclear electricity production in 2021

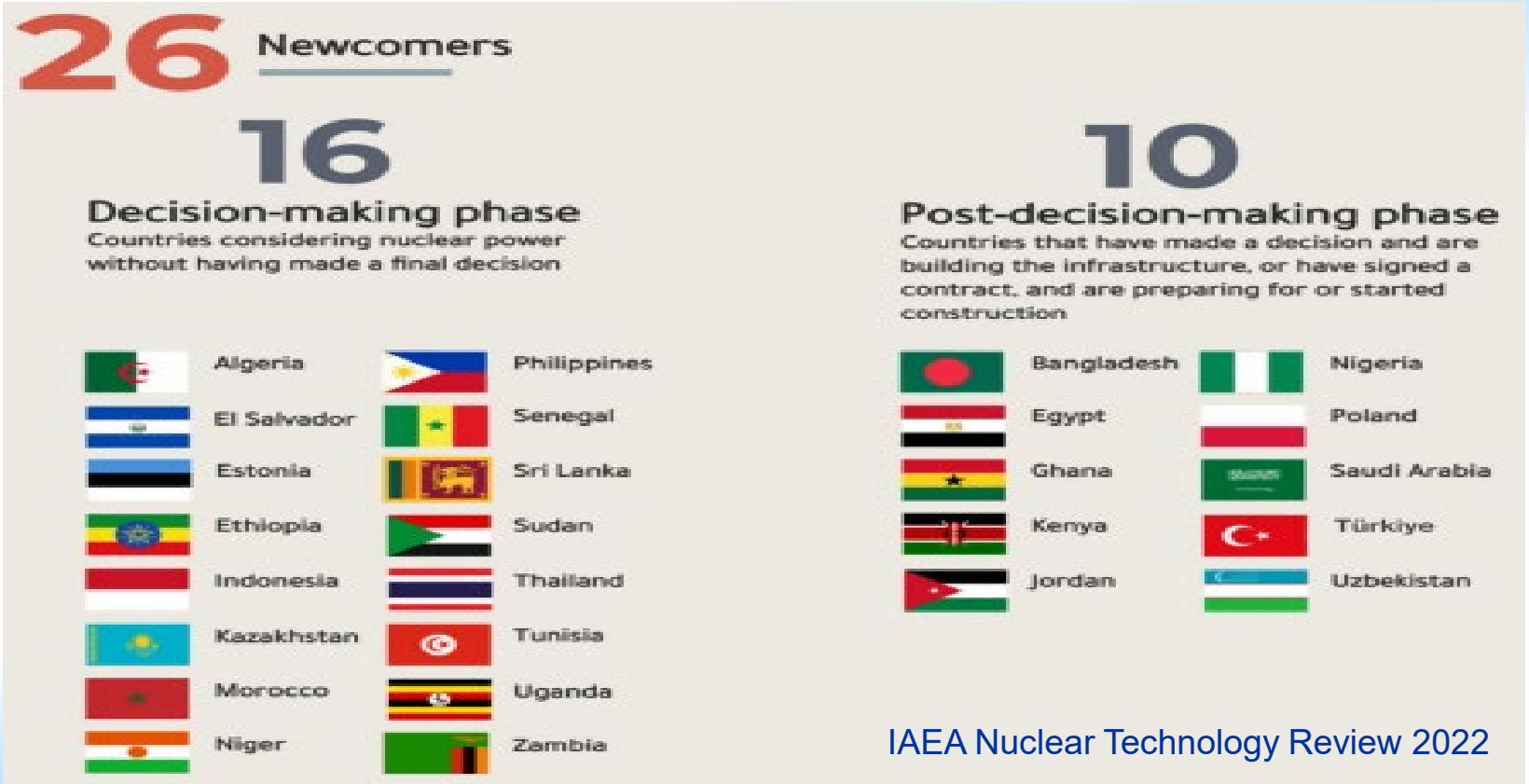
Note: The nuclear electricity production in Taiwan, China, was 26.8 TW·h.



Share of nuclear in total electricity production in 2021

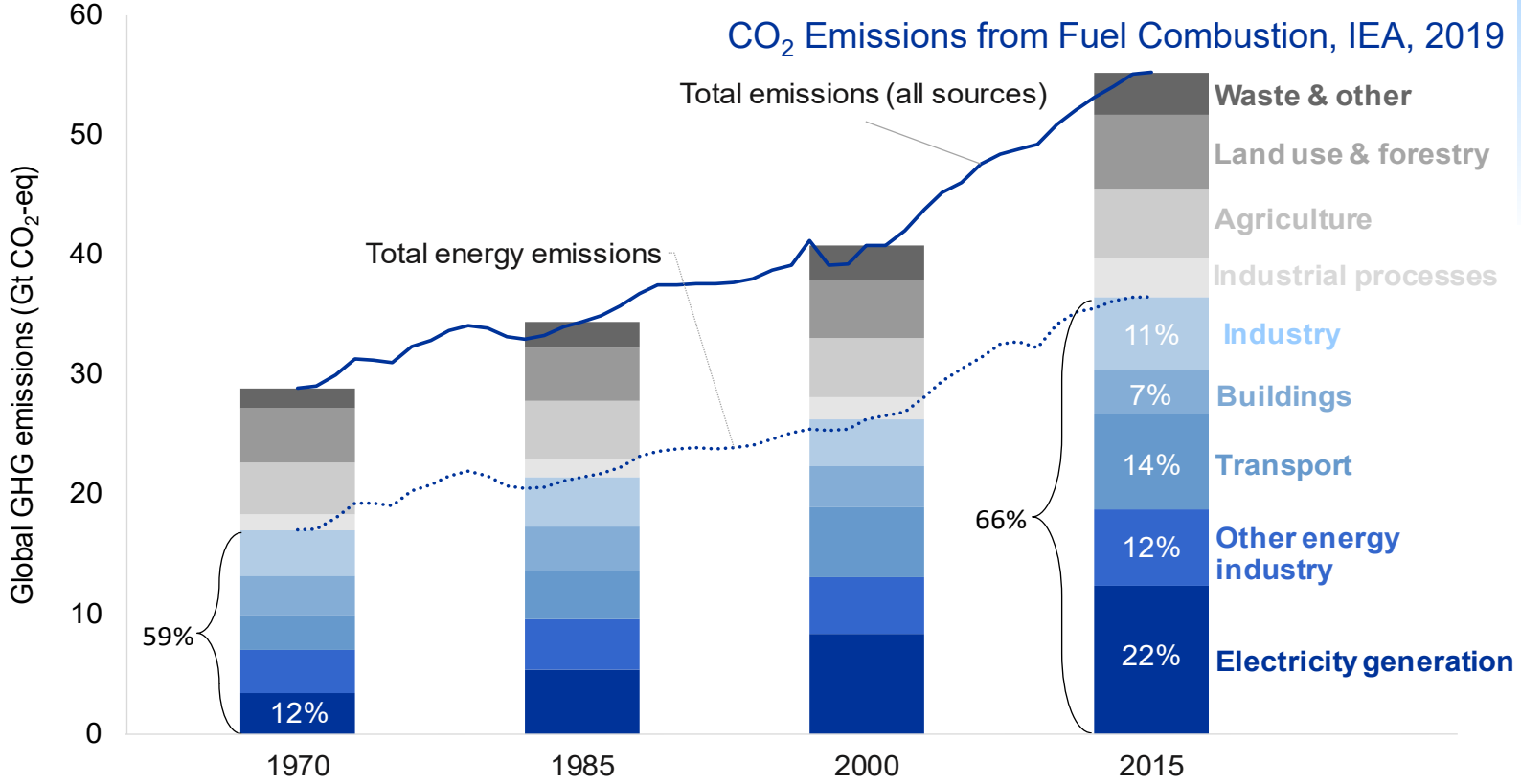
Note: The share of nuclear in the total electricity production of Taiwan, China, was 9.5%.

New Nuclear Power Programmes



IAEA Nuclear Technology Review 2022

Global GHG emissions from all sources



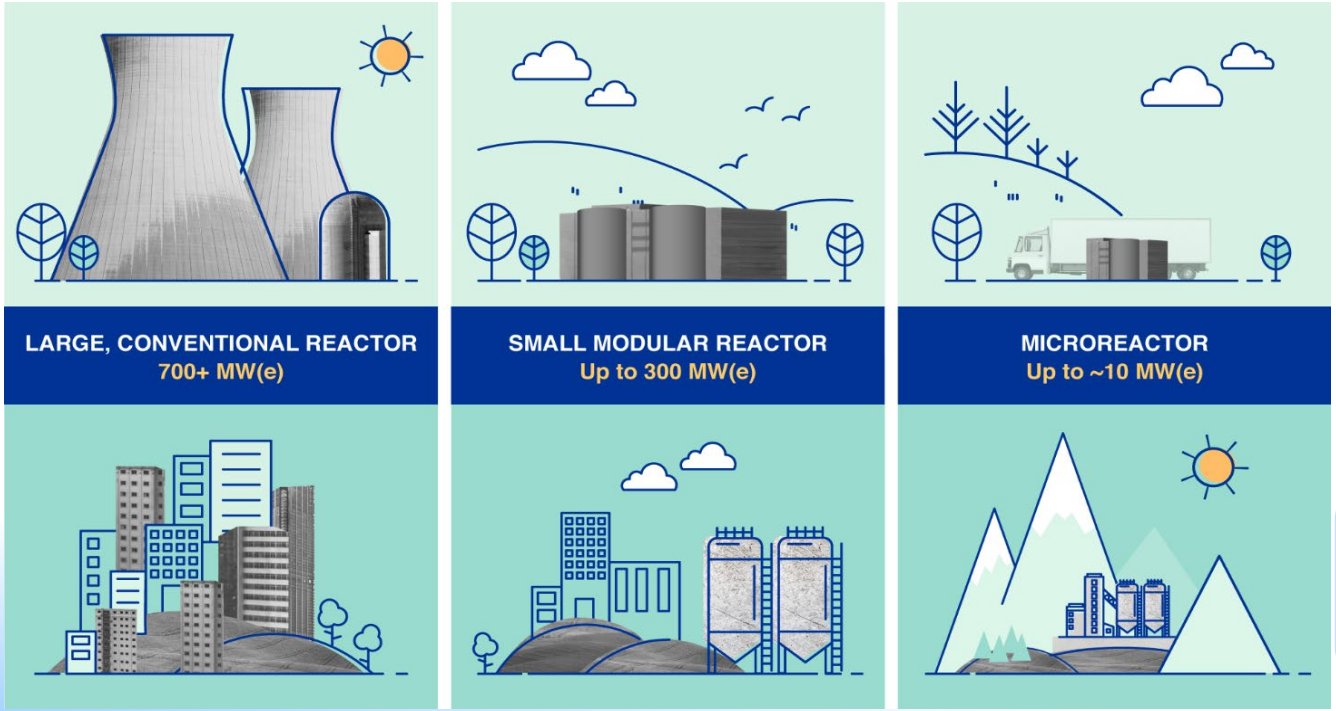
66% of CO_2 emissions are from energy sectors. Emissions from all sectors should be reduced for net zero.

Nuclear Innovation

- **Nuclear Innovation is key to expanded role in the clean energy system**
  - **SMRs**, Gen IV Energy Systems
  - Non-electric Applications
  - Integrated Energy Systems
- **Technical innovations should be developed, demonstrated and deployed in a timely manner** to secure opportunities of contribution to net zero emissions and energy security

Small Modular Reactors

Advanced Reactors that produce typically up to 300 MWe, built in factories and transported as Modules to sites for Installation as demand arises.

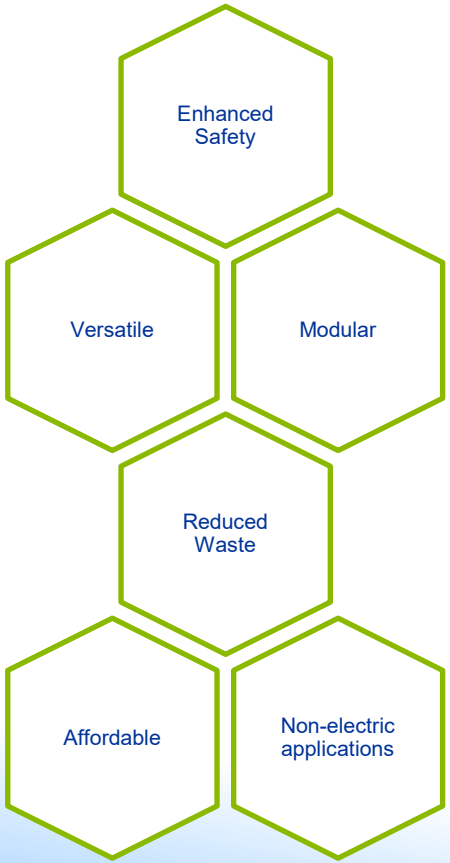


Small: in size, compared to traditional reactors.

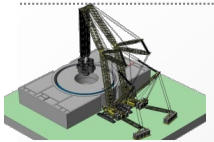
Modular: factory-manufactured, installed onsite.

Reactor: energy generation via nuclear fission.

Key Attributes of SMRs

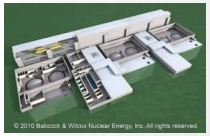


Economic
- Lower Upfront capital cost
- Economy of serial production



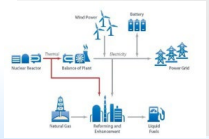
Modularization
- Multi-module
- Modular Construction

Flexible Application
- Remote regions
- Small grids



Smaller footprint
- Reduced Emergency planning zone

Replacement for aging fossil-fired plants



Potential Hybrid Energy System

Better Affordability

Shorter construction time

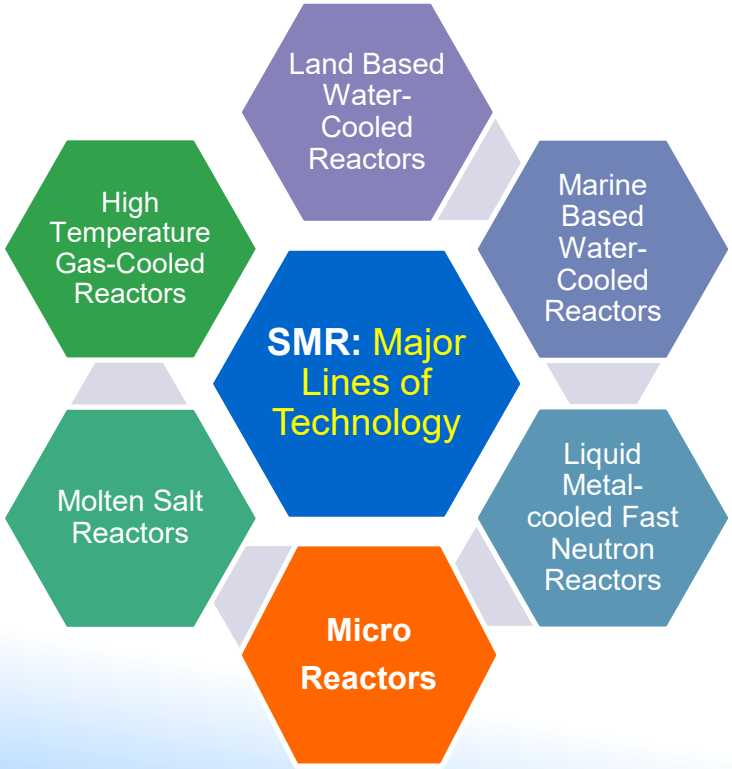
Wider range of Users

Site flexibility

Reduced CO_2 production

Integration with Renewables

Categorization of Technologies



SMR for Non-Electric Applications

Very high temperature reactors

Gas-cooled fast reactors

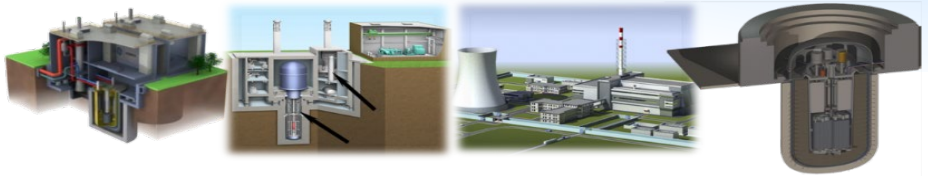
Molten Salt reactors

Supercritical water-cooled reactors

Sodium-cooled fast reactors

Liquid metal cooled reactors

Water cooled reactors



100 200 300 400 500 600 700 800 900 1000 1100 1200

(°C)

District heating

Seawater desalination

Pulp & paper manufacture

Methanol production

Heavy oil desulfurization

Petroleum refining

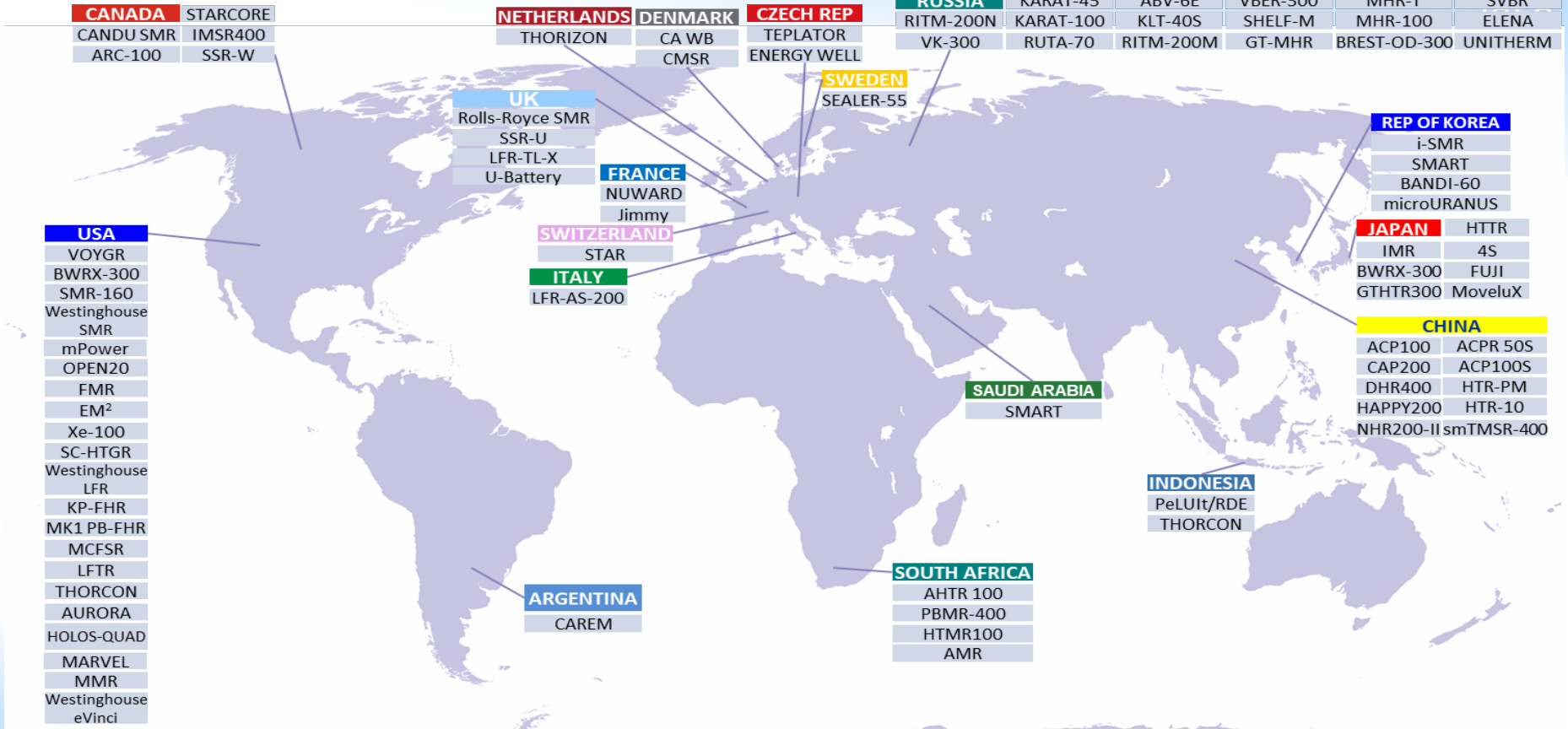
Methane reforming hydrogen production

Thermochemical hydrogen production

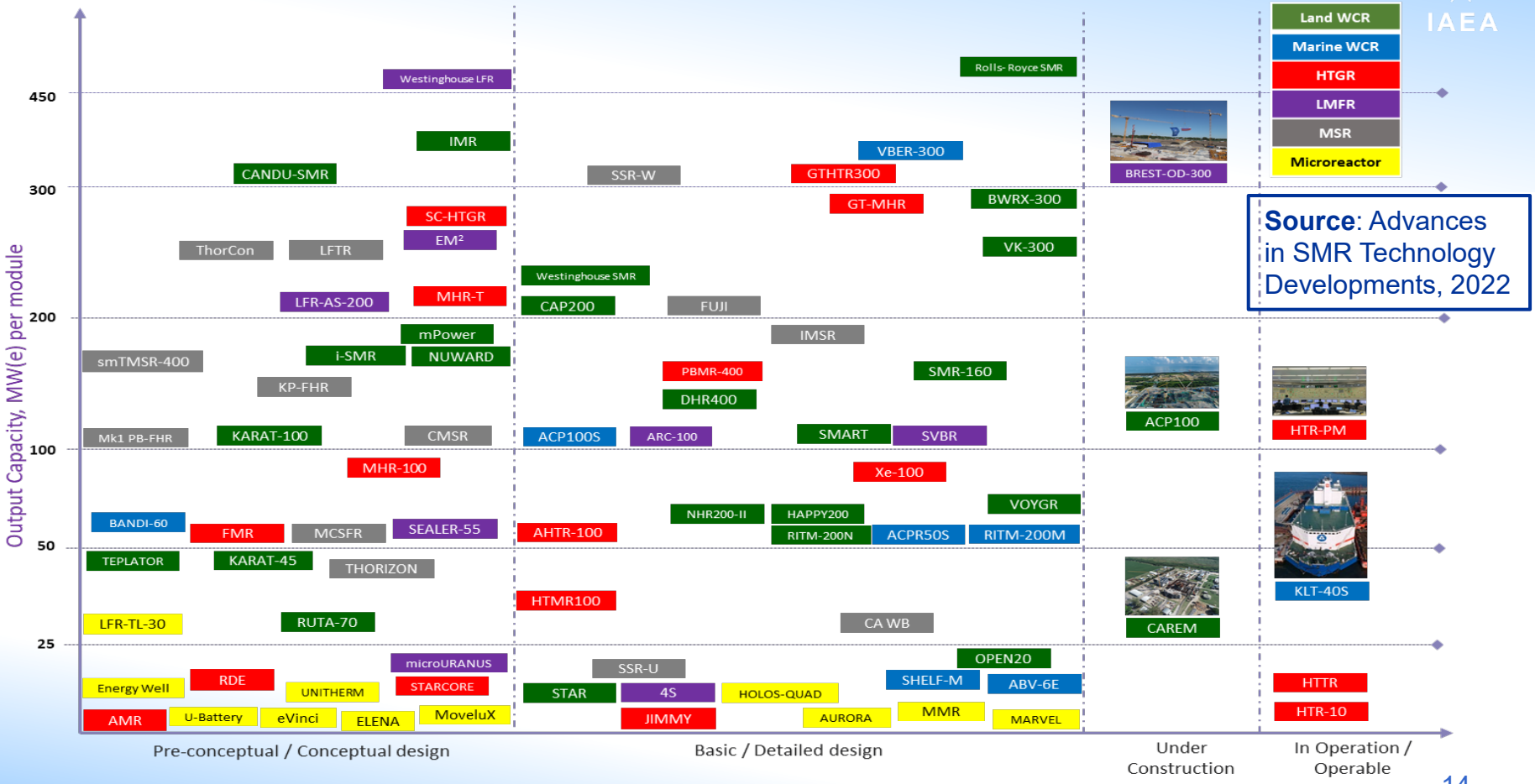
Coal gasification

Blast furnace steel making

Global SMR Technology Development



Stage of Development and Deployment of SMRs

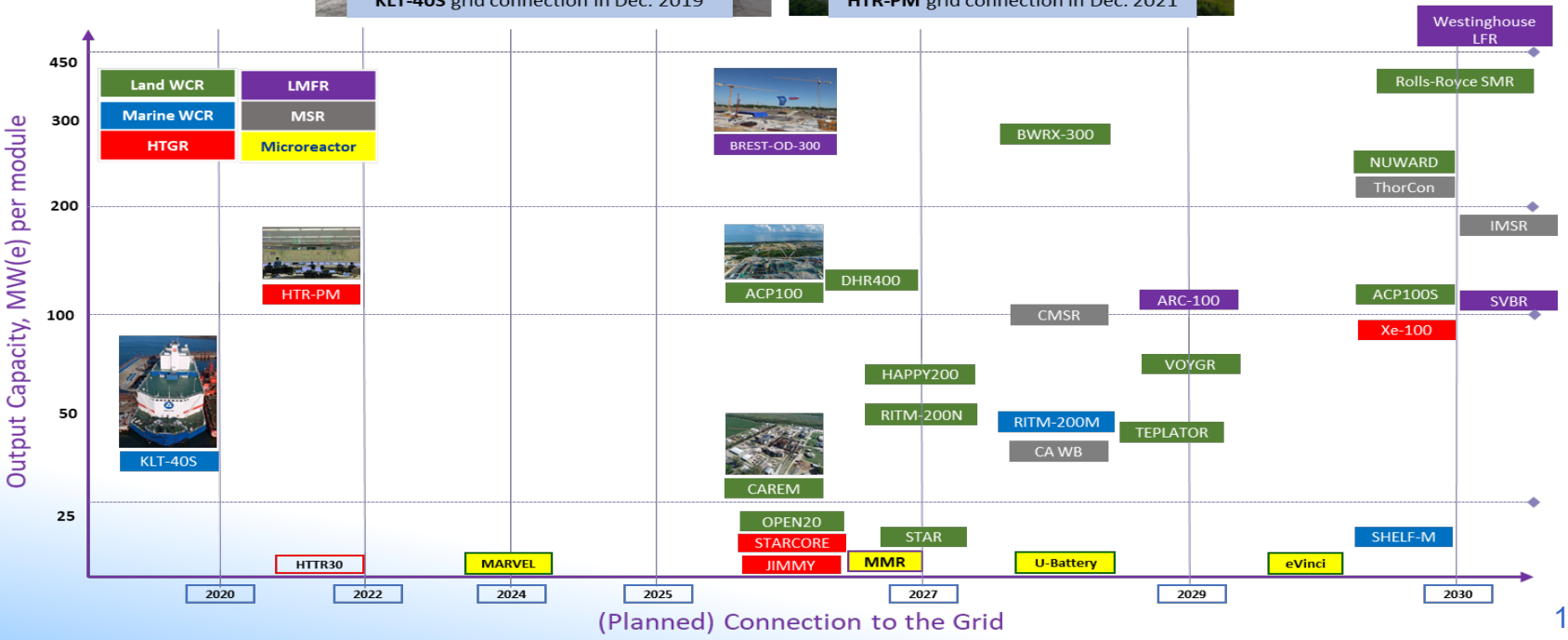


Status and Near-Term Prospect Deployment

The Forerunners: 2 in operation, 3 under construction. More target at deployment by 2030

KLT-40S grid connection in Dec. 2019

HTR-PM grid connection in Dec. 2021



Member States' Progress on SMR Projects

Argentina

CAREM

- ✓ 2013: Construction license
- ✓ 2014: Civil works started
- ○ 2026: Grid connection

Canada

MMR

- ✓ 2019: License to prepare site initial application
- ○ 2027: Site preparation and construction

BWRX-300

- ✓ 2021: Down selected by OPG
- ✓ 2022: OPG submittal of application for construction licence to CNSC for DNNP-1

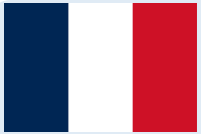
China

HTR-PM

- ✓ 2021.12.20: Grid connection
- ✓ 2022: Full power operation

ACP100

- ✓ 2021: FCD at Changjiang site
- ○ 2026: Commercial operation

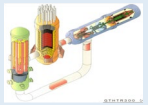


France

NUWARD

- ✓ 2022: Conceptual design completed
- ○ 2023-2026: Basic design
- ○ By 2030: FCD

Japan



GTHTR300

- ✓ 2003: Basic design completed based on the HTTR-30
- ○ 2020s: HTTR-H2 test plant construction and operation
- ○ 2040s: Operation of demonstration plant

Member States' Progress on SMR Projects- Cont'd

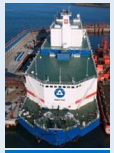
IAEA

Republic of Korea

i-SMR

- 2023: Basic design
- 2028: Standard design approval

Russian Federation



KLT-40S

- ✓ 2019.12: Grid connection in Pevek
- ✓ 2020.5: Started commercial operation, 70 MWe

BREST-OD-300

- ✓ 2021: Start of construction
- 2026: Start of operation of the FOAK pilot demo plant

Sweden

SEALER-55

- ✓ 2022: Electrically heated mock-up funded by the Swedish Energy Agency
- 2024: Electrical mock-up taken into operation
- 2030: Nuclear demonstration unit taken into operation

UK

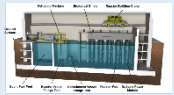
Rolls-Royce SMR

- ✓ 2022: Entered formal regulation
- 2026: Project start of FOAK construction
- 2030: FOAK commercial operation

SSR-U

- Q3-2023: Initial regulatory assessment
- Q4-2023: Preliminary Safety Report completion

USA



VOYGR

- ✓ 2020: Received SDA
- 2023: Design certification
- 2023-2024: Start of construction
- 2029: Operation

Natrium

- 2024: Application for construction permit
- ~2030: Operation of demonstration reactor

Challenges facing Successful Deployment of novel SMR designs

- **Demonstration of Safety and Operating Performance**
- **Secure Deployment:** physical, cyber, transport security
- **Implementation of Safeguards**
- **Demonstration of Economic Competitiveness**
  - Economies of Serial Construction with robust Supply Chain
- **Harmonization of Licensing Framework** for global deployment
- **Electricity market reform** for proper recognition of nuclear energy as clean energy source
- **Robust and predictable financing framework**

IAEA Activities on SMRs

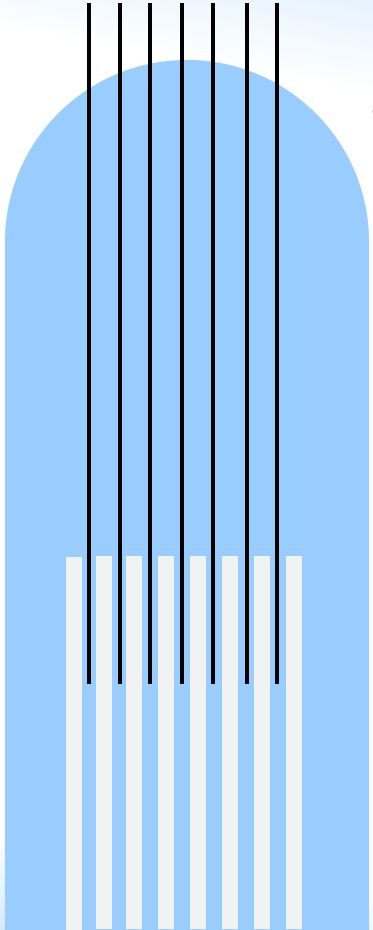
Technology Development and Deployment
- TWG-SMR/GCR
- ARIS Database
- SMR Booklet

Technology Roadmaps
- 'Model' technology roadmaps for specific SMR projects
- Hybrid Energy Systems with SMRs
- Hydrogen production using SMR

Economics
- Economic Appraisal of SMR Projects: Methodologies and Applications

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

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



Fuel, Fuel cycle, Waste Management and Decommissioning

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

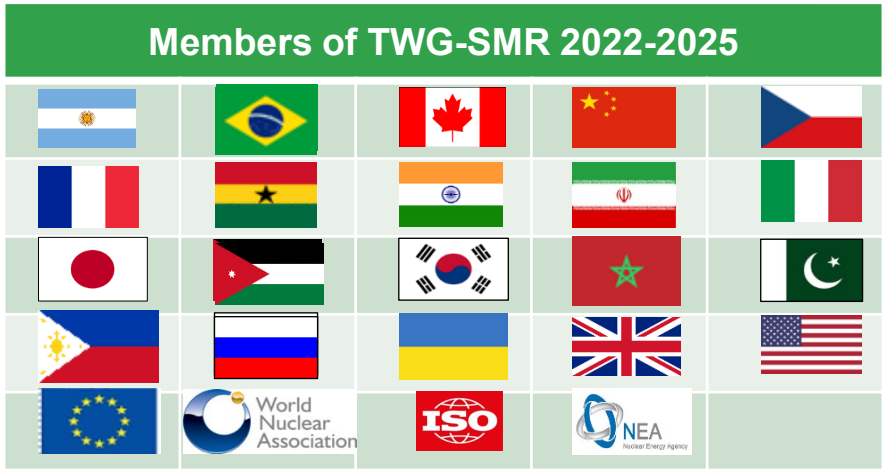
Safety & Security
- SMR Regulators' Forum
- Applicability of the IAEA Safety Standards & Security Guides

Industrial Harmonization and Standardization
- Generic User Requirements
- Industrial Codes & Standards

Reactor Technology Assessment
- Updated Method incorporates SMR

Technical Working Group on SMR

- **Members**: 20 MSs and 4 International Organizations as observers



- **Three technical subgroups**
  - **SG-1:** Update of SMR Technology Roadmap
  - **SG-2:** R&D, Codes & Standards and Preparation for Operation
  - **SG-3:** SMR Technology Deployment for Cogeneration

IAEA SMR Platform

- Serves as **a focal point** for the IAEA's activities on the field of small modular reactors and their applications
- Provides **coordinated support and expertise from across the entire Agency**, encompassing all aspects relevant to the development, early deployment, and oversight of small modular reactors

https://smr.iaea.org

Nuclear Harmonization and Standardization Initiative

Effective Global Deployment of **Safe and Secure** Advanced Nuclear Reactors

Harmonization of Regulatory Approaches Track

- **WG1:** Framework for information exchange
- **WG2**: International pre-licensing regulatory reviews
- **WG3:** Leveraging other regulatory reviews

IAEA as facilitator within and between the tracks

Harmonization and **S**tandardization of Industrial Approaches Track

- **TG1:** Harmonization of high-level user requirements
- **TG2:** Common Approaches to Codes and Standards
- **TG3**: Experimental Testing and Validation for Design and Safety Analysis Computer Codes
- **TG4:** Acceleration of nuclear infrastructure implementation for SMR

Regulators

Governments

Technology Holders

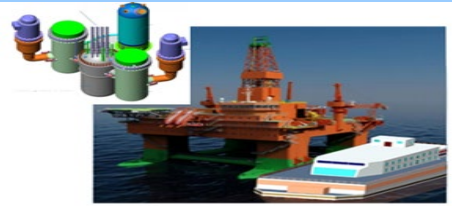
Operators and other end-users

International Organisations and Associations

Upcoming Events

International Symposium on Floating Nuclear Power Plants

14-15 November 2023, Vienna International Centre



International Conference on Small Modular Reactors and their Applications

21-25 October 2024, Vienna International Centre

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Thank you!