Small Modular Reactors (SMR)

Results from the *SMR Dashboard* of the OECD Nuclear Energy Agency (NEA) and some remarks on SMR economics

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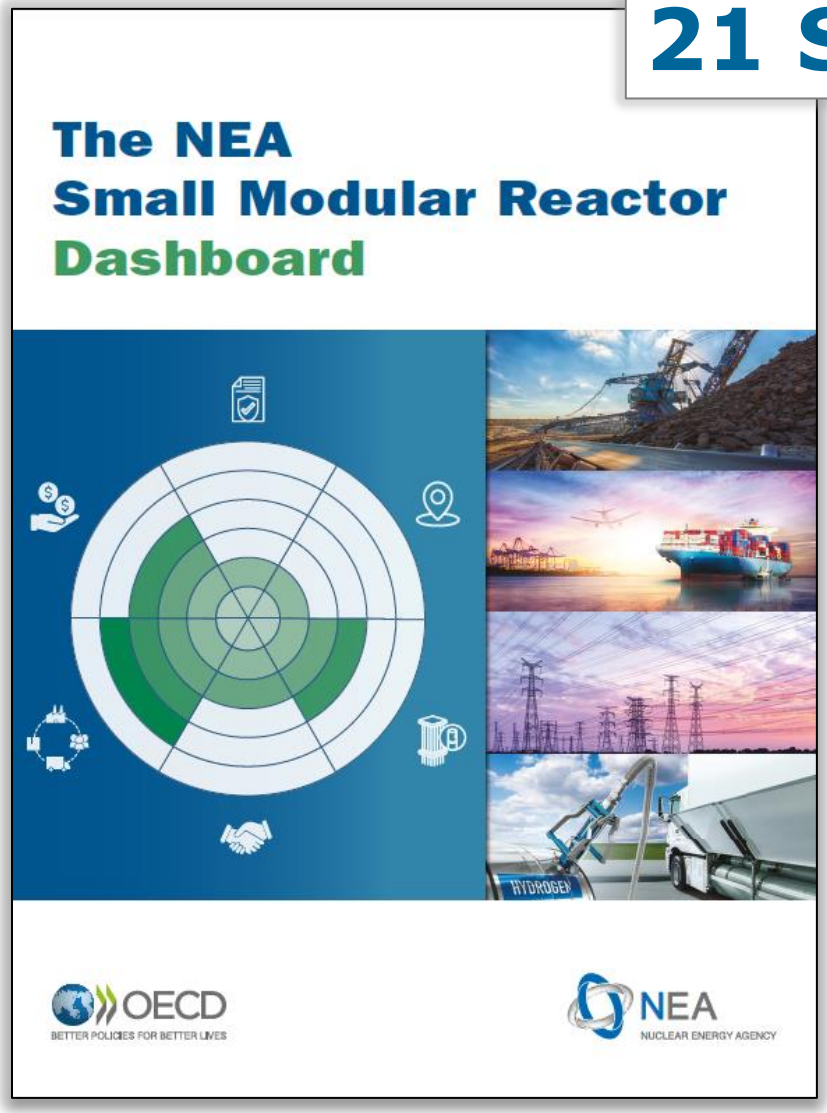
Volume I launched on March 13, 2023

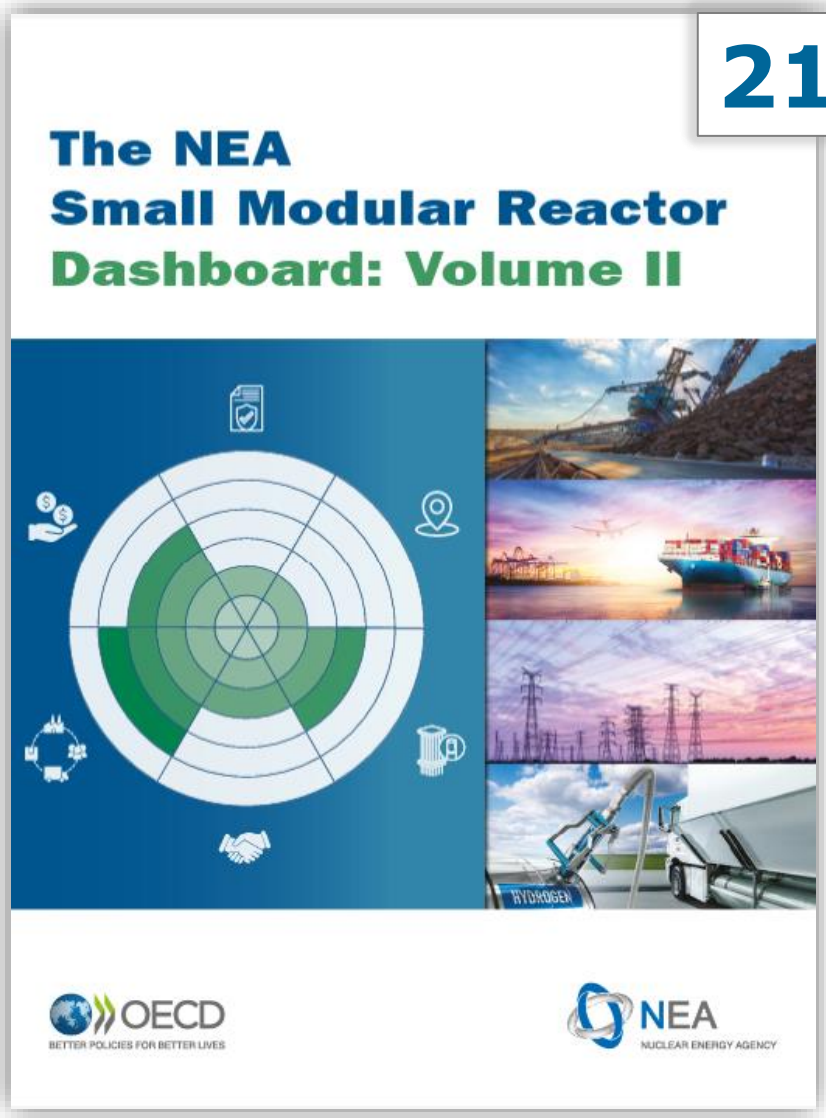


21 SMRs

arc CLEAN TECHNOLOGY · CAREM25 · 中广核 CGN · 中核集团 CNNC · HITACHI · INET · Kairos Power · LeadCold · moltex clean energy · OKLO · NATRIUM · NUSCALE Power for all humankind · nuward · ROSATOM · ROLLS ROYCE SMR · UBATTERY Local Modular Energy · ULTRA SAFE NUCLEAR · Westinghouse · X energy

The logos represented were preferentially sourced from the websites dedicated to the SMR or the design organisation associated with the SMR. Minor modifications were applied related to sizing and colouring

Volume II launched on July 20, 2023



21 SMRs

BWXT BWX Technologies, Inc.

SPIC

Dual Fluid

Jimmy

HOLTEC INTERNATIONAL

newcleo Futurable Energy

CVŘ Centrum výzkumu Řež

RADIANT

SEABORG

ROSATOM

ZÁPADOČESKÁ UNIVERZITA V PLZNI

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

TERRESTRIAL ENERGY

KAERI Korea Atomic Energy Research Institute

LAST ENERGY

Westinghouse

JAEA Japan Atomic Energy Agency

ThorCon

TOSHIBA

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HTR-PM

★ Active in multiple jurisdictions or countries.

Design organisation	INET
Thermal Power (MWth)	500
Outlet Temperature (°C)	750
Spectrum (thermal/fast)	Thermal
Fuel type	TRISO pebble
Fuel (LEU/HALEU/HEU)	HALEU

Licensing

Siting

Financing

Supply chain

Engagement

Fuel

Assessment of HTR-PM's progress to deployment

Licensing

The HTR-PM reactor is fully licensed. It is operating and connected to the electrical grid.

Siting

The HTR-PM is connected to the electrical grid as Shidaowan Nuclear Power Plant in Shandong province.

Financing

The First-of-a-Kind (FOAK) HTR-PM is operating and has been fully financed.

Supply chain

The HTR-PM is owned by a consortium composed of China Huanend, China Nuclear Engineering Corporation and Tsinghua University's Institute of Nuclear and New Energy Technology. China National Nuclear Corporation (CNNC) collaborated with the consortium to provide Engineering, Procurement and Construction (EPC) services, to manufacture fuel elements and for the construction. Up to 93.4% of the equipment was manufactured domestically.

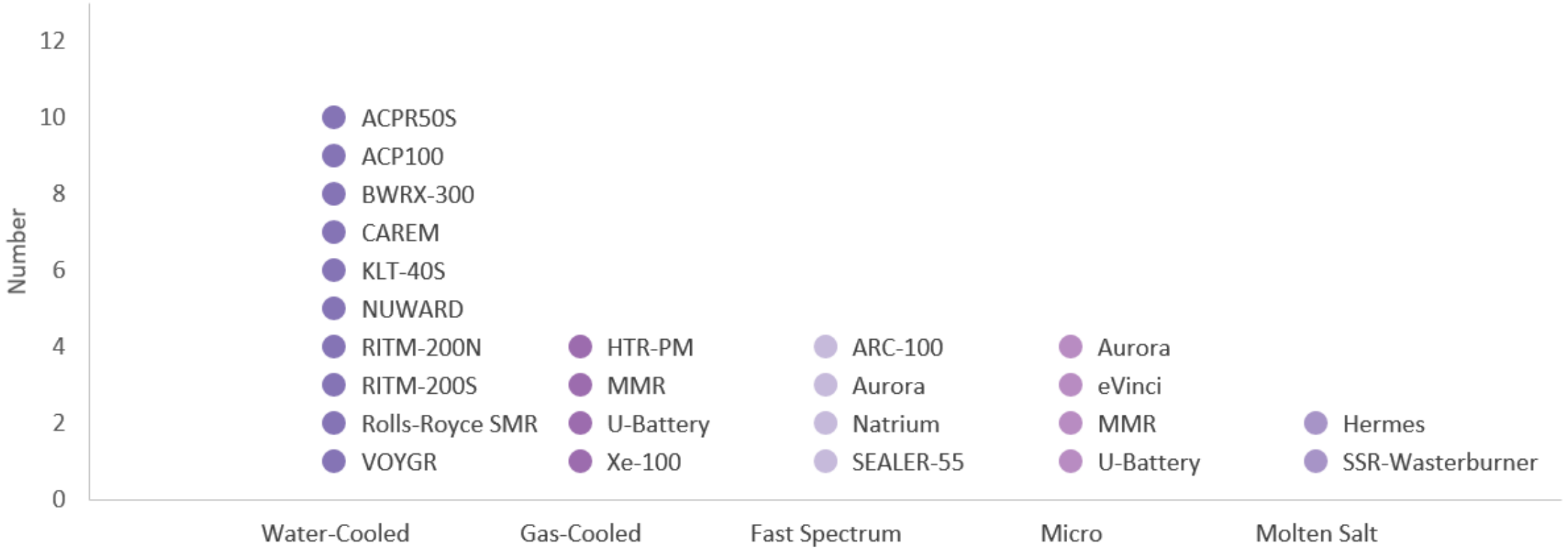
Engagement

The HTR-PM project is owned by a consortium that includes Tsinghua University's Institute of Nuclear and New Energy Technology.

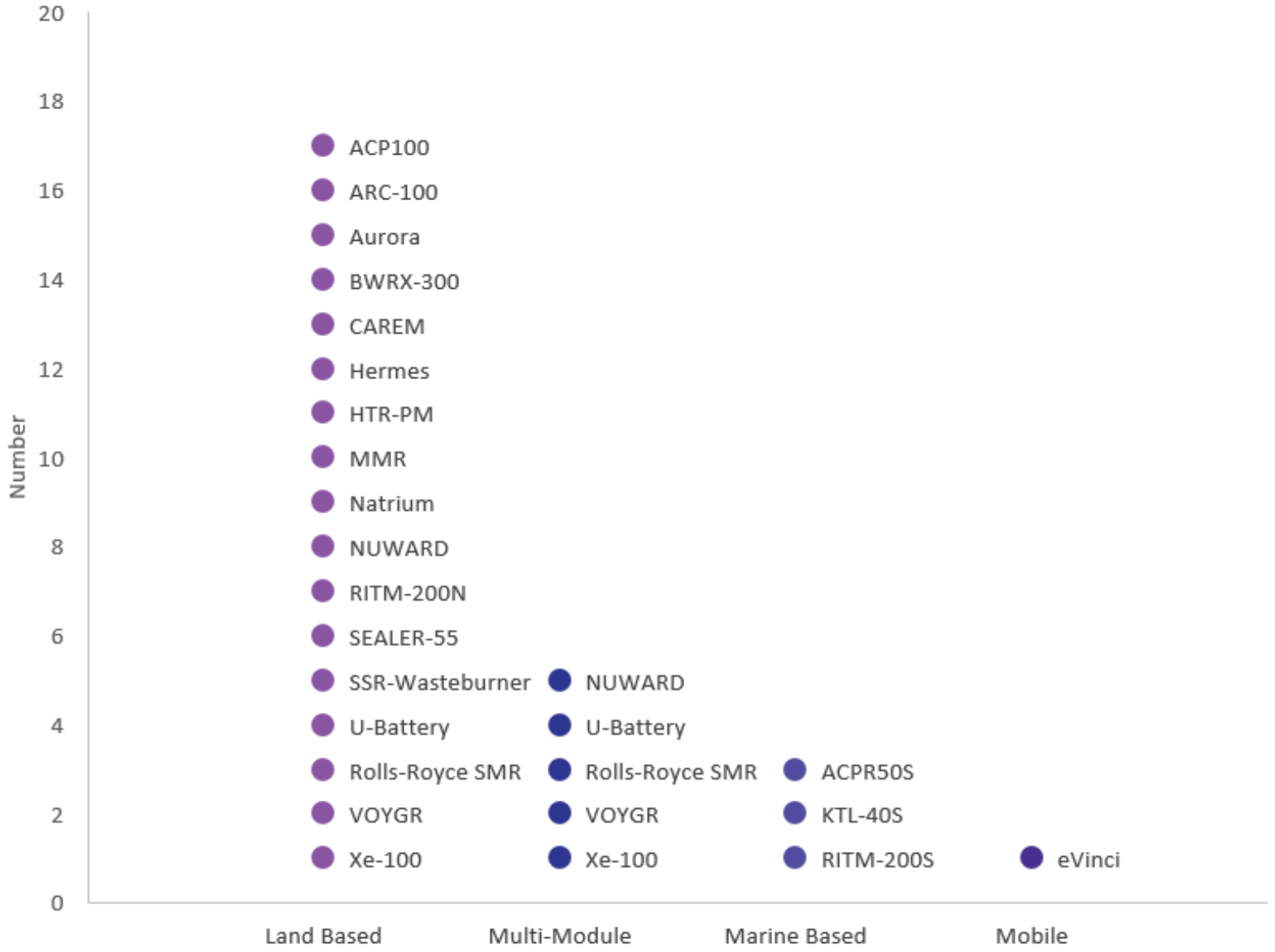
Fuel

HTR-PM fuel is licensed for operation.

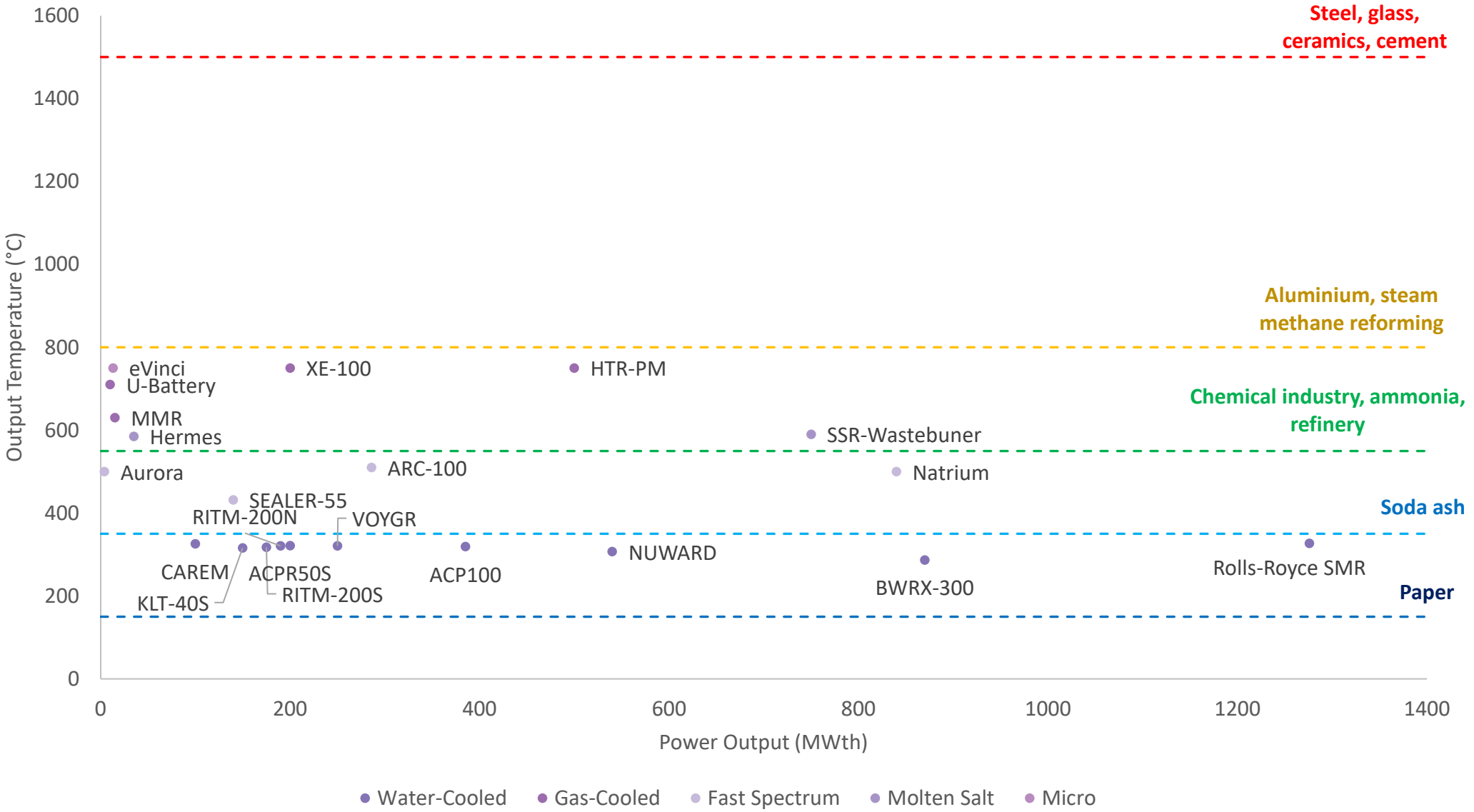
Reactor concepts (Vol I)



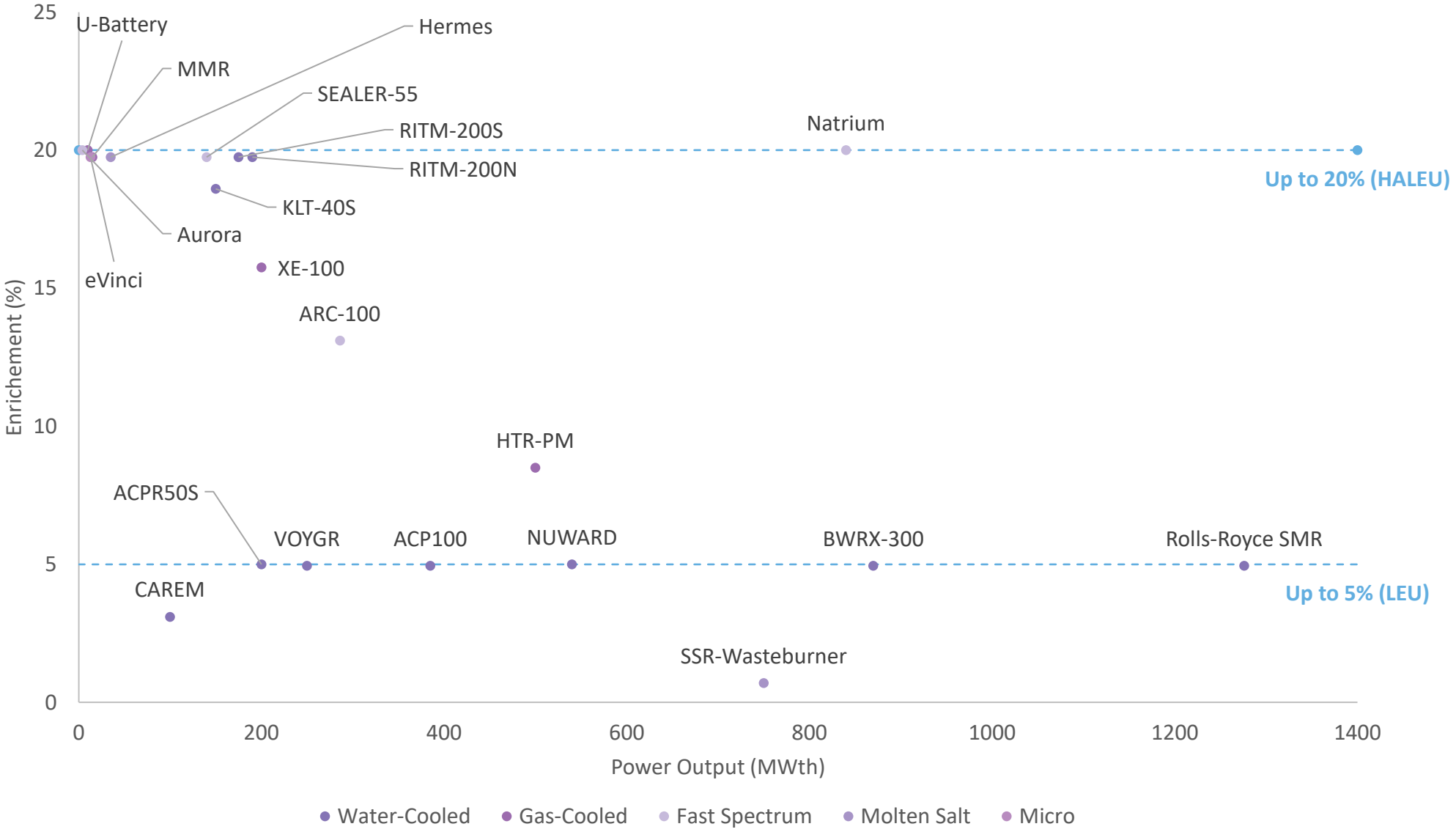
Reactor configurations (Vol I)



Sizes and temperatures (Vol I)



Sizes, temperatures, enrichment requirements (Vol I)



Key learnings

- ✓ Six new indicators by NEA contribute to evidence-based situational awareness
- ✓ Variety of SMR concepts, configurations, applications and markets is an asset and a challenge
- ✓ Russia and China leading on deployment with multiple land and marine-based SMRs already in operation
- ✓ Real and rapid progress towards deployment in North America and Europe
- ✓ Timelines are near-term and accelerating
- ✓ Many business models and financing strategies, public and private financing are unlocking and accelerating
- ✓ Fuel qualification and commercial availability is critical path
- ✓ Readiness of regulators, supply chain, and fuel suppliers may become limiting factors
- ✓ Many developers are focused on first-of-a-kind, the paradigm shift to fleet deployment has not started yet

On the economics and finance of SMRs

- Knowledge limited right now, but will increase quickly, as development of demonstrators begins in earnest; by 2030 we would expect the first demonstrators to be operating;
- SMRs are very diverse, financing and economics will be very different for
  - micro-reactors (<30 MW) for specialised applications in off-grid mining or research stations, industry (high temperature heat) or co-generation;
  - "small" reactors (30 MW < R < 400 MW) for baseload electricity in interconnected systems, possibly for coal replacement;
- For a long time, "large" reactors (>900 MW) were considered economically more advantageous due to increasing returns to scale (IRTS);
- Need to distinguish scaled down versions of existing Gen III designs from Gen IV designs;
- Scaled down Gen III versions promise advantages for supply chain (valves, transport…), factory production and financing (size matters even in trillion USD capital markets);
- SMR development has shown its ability to attract private investment
  - Some developers have proven industrial capabilities (EDF, GE, Hitachi, Rolls Royce, Westinghouse…);
  - Others may be primarily interested in design development;
- Governments, especially US, UK and Canada, view SMR development favorably and provide funds and frameworks. Europe watches with interest.