NEA
NUCLEAR ENERGY AGENCY

New Horizons for Nuclear Energy:

Opportunities and Challenges

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The Nuclear Energy Agency

34 countries seeking excellence in nuclear safety, technology, and policy

- The premier international platform for cooperation in nuclear technology, policy, regulation, research, and education
- 34 member countries plus strategic partners (e.g., China and India)
- 8 standing committees and more than 80 working parties and expert groups
- 20 joint undertakings
- Global relationships with industry and universities

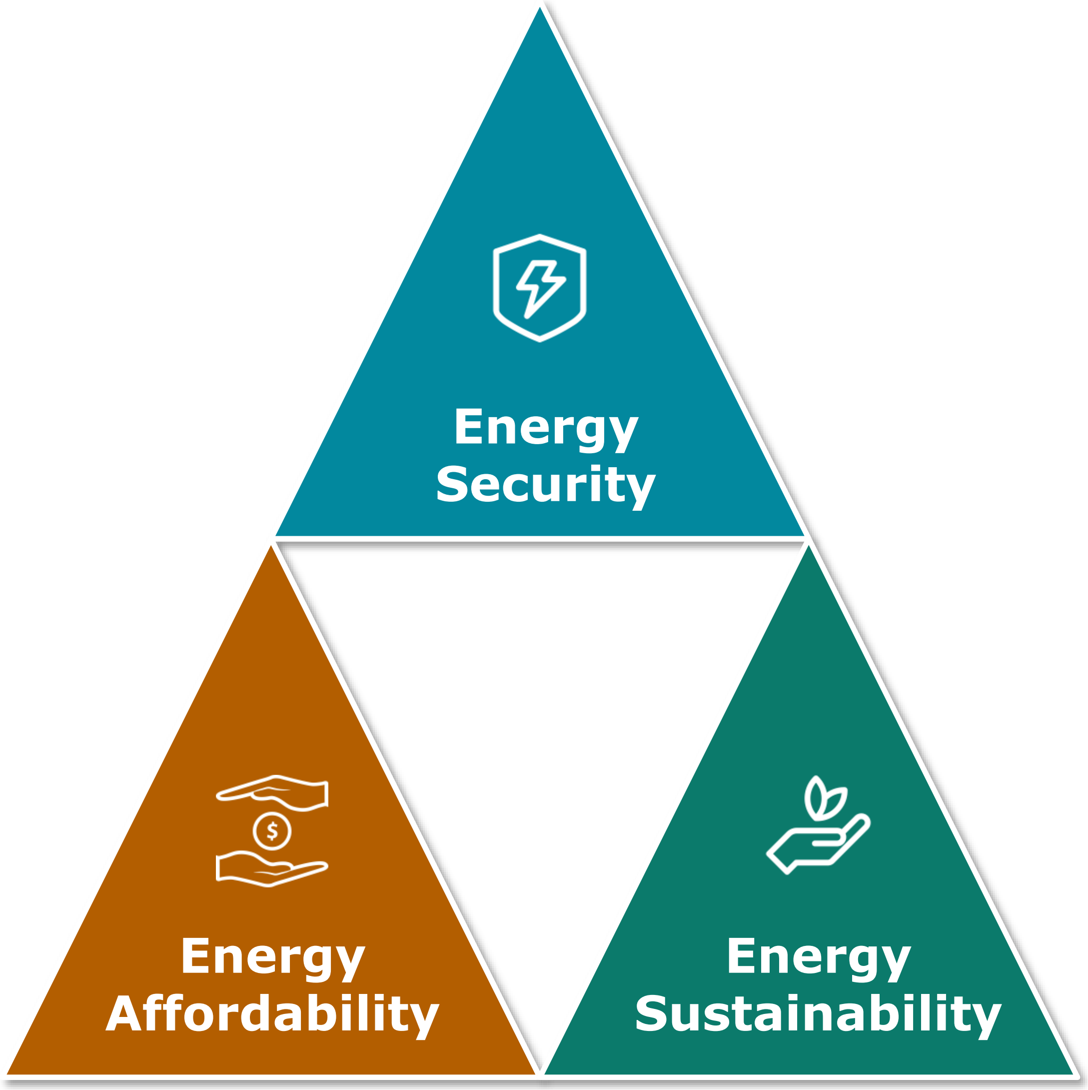
Argentina	Australia	Austria	Belgium
Bulgaria	Canada	Czech Republic	Denmark
Finland	France	Germany	Greece
Hungary	Iceland	Ireland	Italy
Japan	Korea	Luxembourg	Mexico
Netherlands	Norway	Poland	Portugal
Romania	Russia*	Slovak Republic	Slovenia
Spain	Sweden	Switzerland	Turkey
United Kingdom	United States		

**Suspended*

NEA countries operate approximately 80% of the world's installed nuclear capacity

Strategic Policy Context

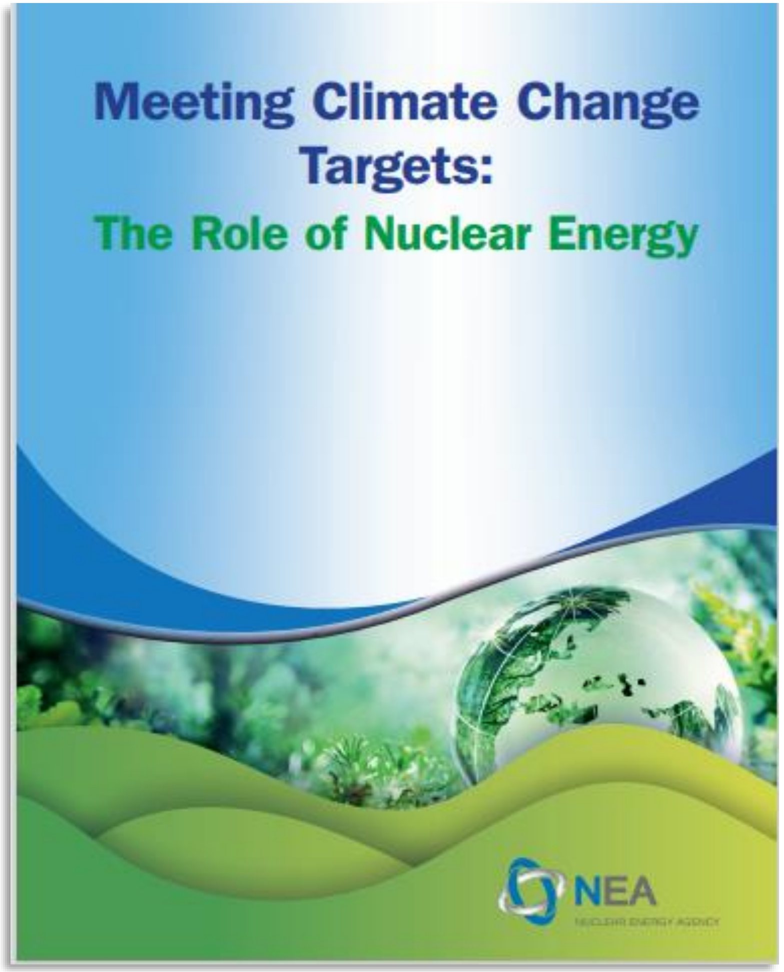
Strategic Energy Policy Context:
The Energy Trilemma

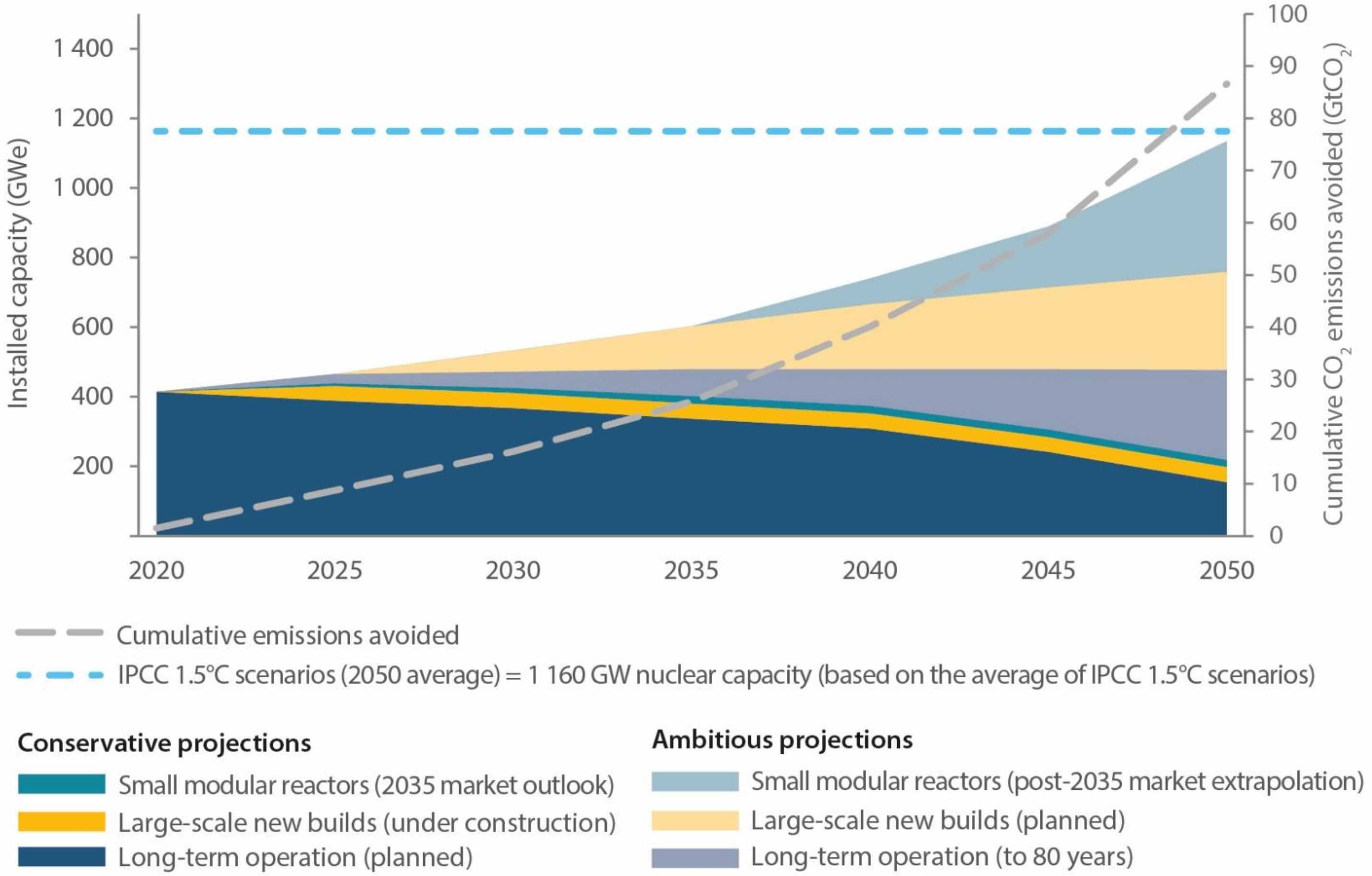


There are <u>no</u> magic solutions to the Energy Trilemma.

National conditions, available natural resources and policy preferences will continue to shape energy policy decisions.

2022 NEA Publication: Global installed nuclear capacity needs to triple by 2050 for Net Zero





https://www.oecd-nea.org/jcms/pl_69396/meeting-climate-change-targets-the-role-of-nuclear-energy

COP28 Ministerial Declaration on Tripling Nuclear Energy by 2050

- 25 nations committing to tripling nuclear energy by 2050

- Referenced NEA analysis that demonstrates the need to triple nuclear energy and a pathway to achieve this target

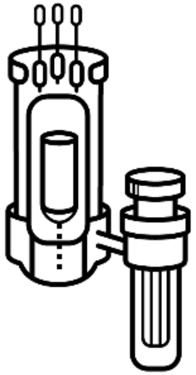
- Emphasis on the role of Multinational Development Banks (MDBs) and International Developmental Finance Institutions (IFIs)

The role of nuclear in future energy systems

The Full Potential of Nuclear Energy to Contribute to Emissions Reductions

Long Term Operation

Large Generation III Reactors

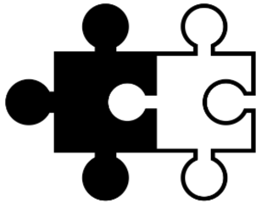


Small Modular Reactors

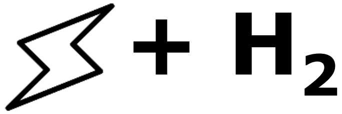
Non-Electrical applications

Complementary nuclear technologies and applications

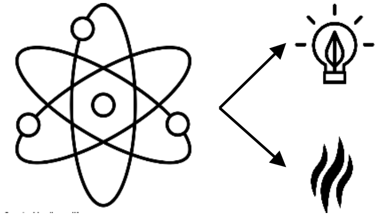
Future Energy Systems & the Role of Nuclear Energy



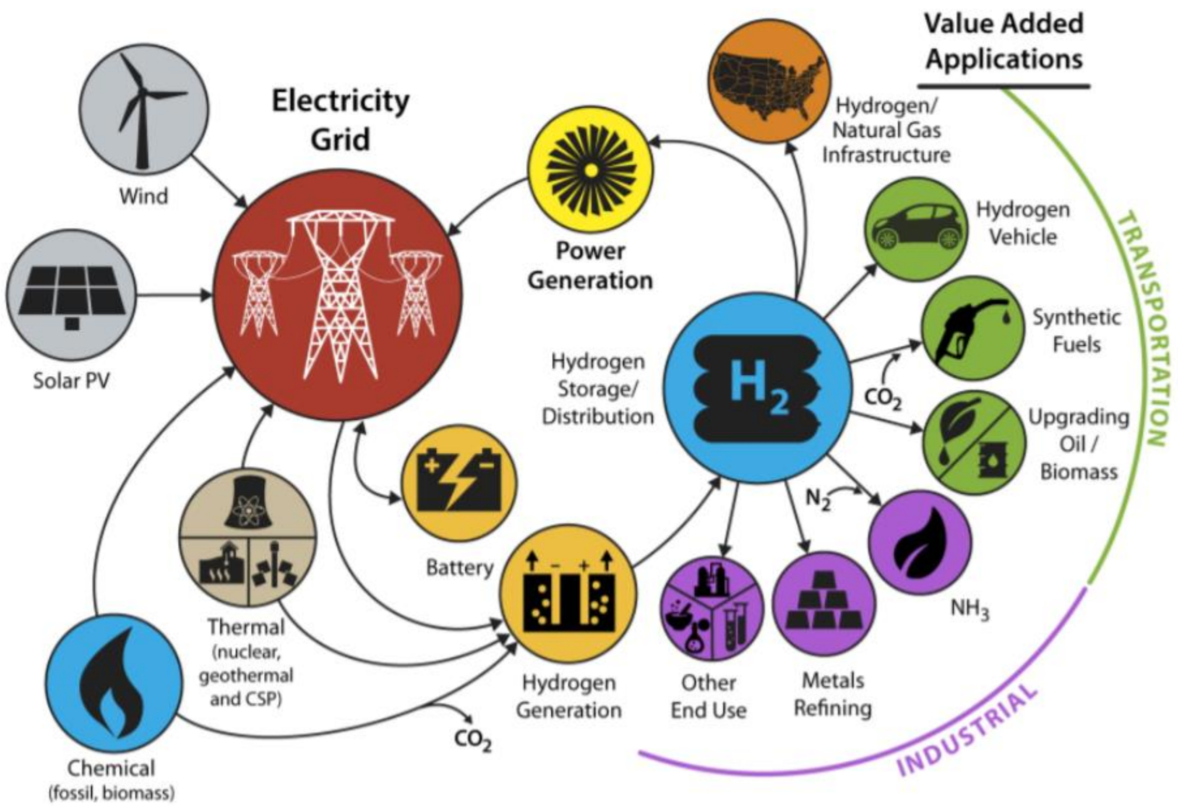
There is **no silver bullet**, all available clean technologies have to contribute to decarbonization



Electricity and clean-hydrogen is the new energy paradigm



As a **reliable source of clean electricity and high heat**, nuclear is a key pillar of future energy systems



Credit: US Department of Energy, Idaho National Lab

Even in very high renewable scenarios, there are hard to abate sectors where SMRs can play an important role

Coal replacement for on-grid power

- More than 2 TWe of coal power plants in operation that will have to be phased-out to meet Net Zero objectives
- Larger SMRs (200-300 MWe) are designed primarily for on-grid power generation and is well-suited to coal power plant replacement

Diesel replacement for off-grid mining

- Smaller SMRs could create an alternative to diesel generation in remote communities and at resource extraction sites
- SMRs could be used to provide power as well as heat for various purposes such as district heating or mine-shaft heating

Merchant Shipping

SMRs could provide a non-emitting alternative for marine merchant shipping propulsion

- SMRs for marine merchant shipping could yield significant emissions reductions as shipping remains a very hard-to-abate industrial sector

Heat & hydrogen

- <u>Fossil cogeneration replacement for industries:</u> High-temperature SMRs to unlock non-emitting alternatives for industry
- <u>Fossil replacement for district heating</u> : Most district heating network rely on fossil fuels and lack scalable decarbonization options
- <u>Hydrogen and synthetic fuels:</u> SMRs localization near industrial demand hubs can unlock large-scale production

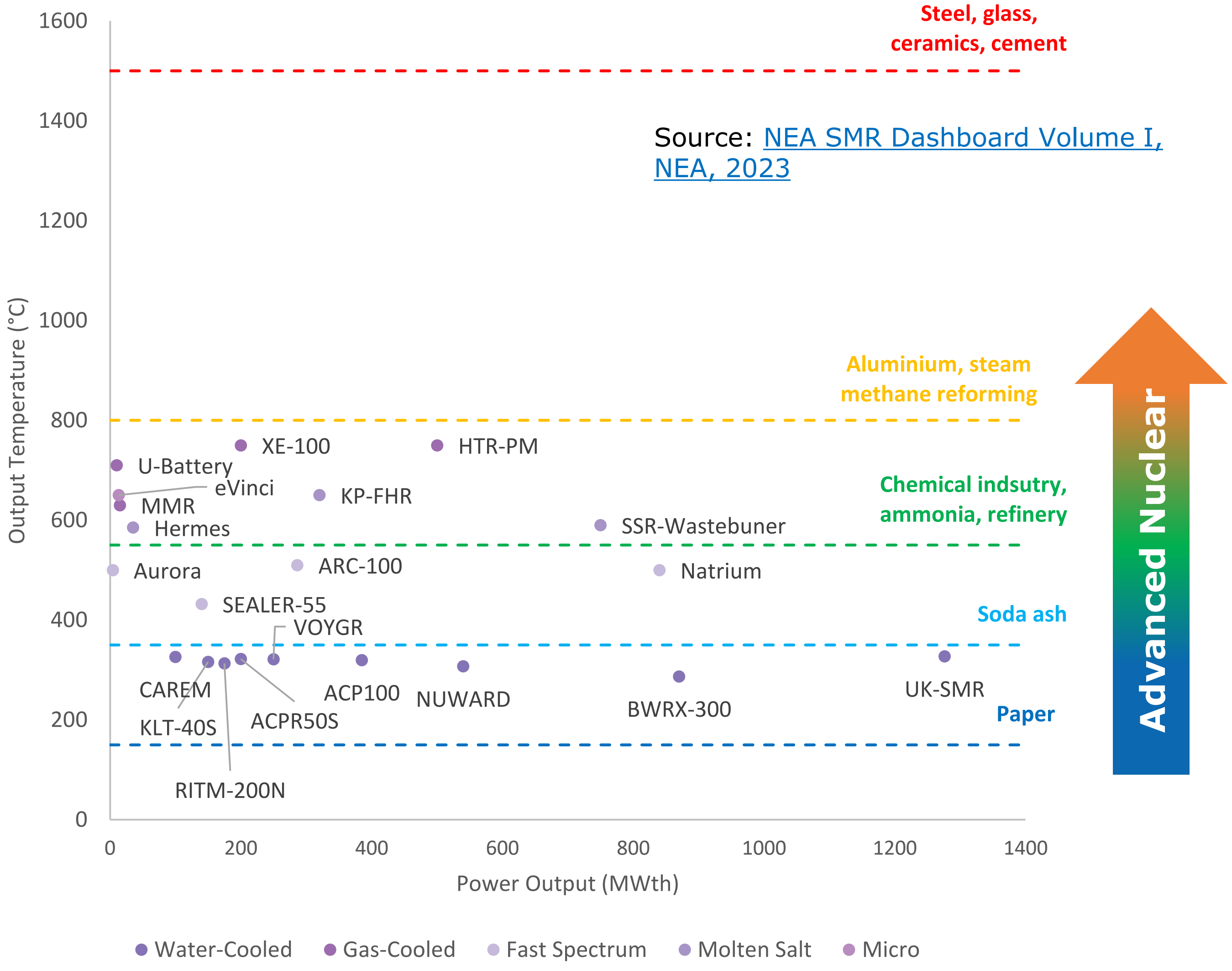
SMRs Are Expected in a Range of Sizes and Temperatures

POWER
- SMRs vary in size from 1 to 300 megawatts electric

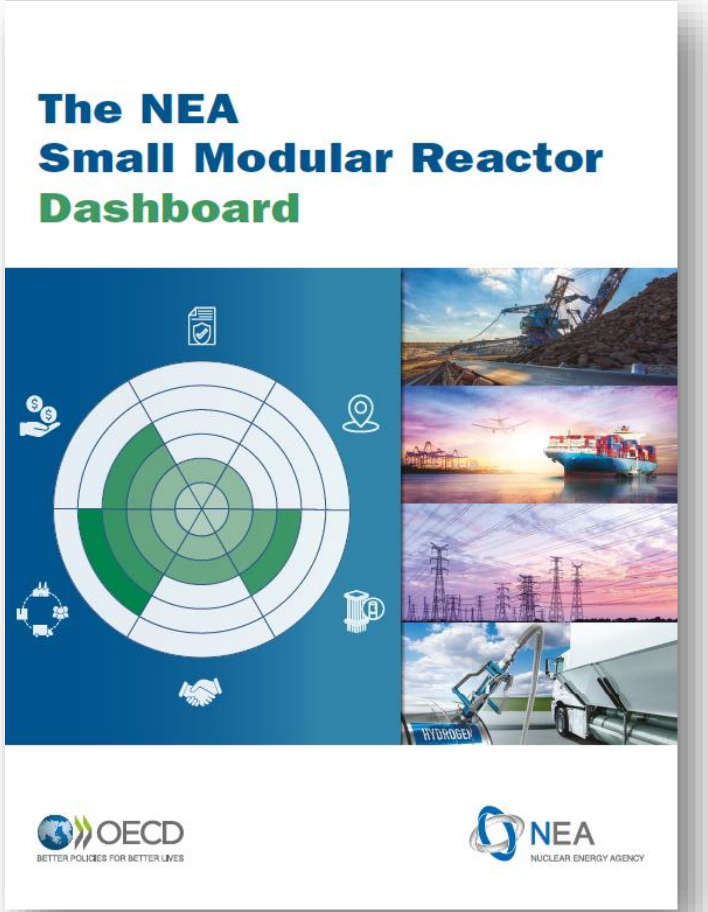
TECHNOLOGY
- Some SMRs are based on Generation III and Light Water reactor technologies
- Other are based on Generation IV and advanced reactor technologies

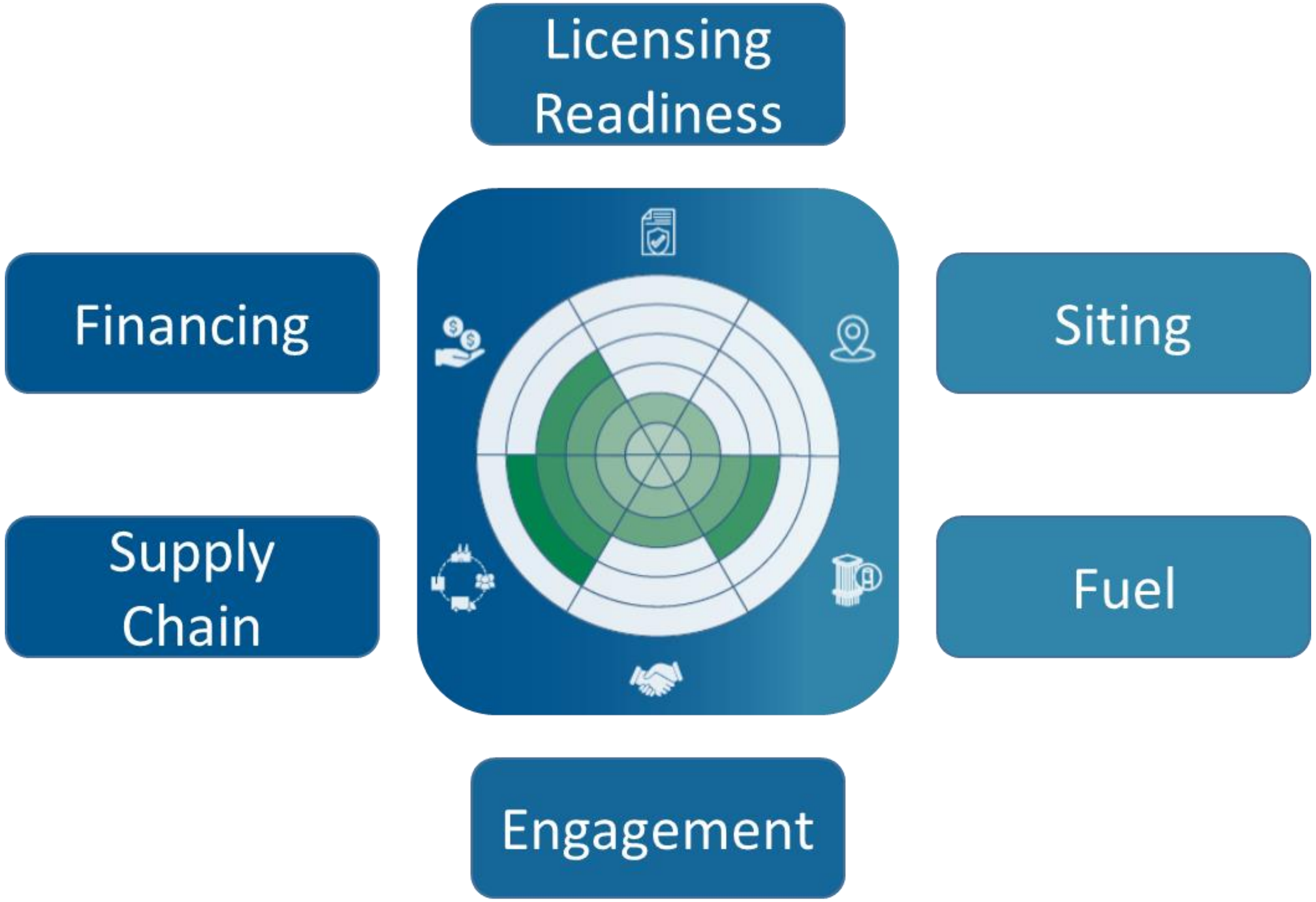
TEMPERATURE
- From 285°C to 850°C in the near-term and up to or over 1,000°C in the future

FUEL CYCLE
- Some SMRs are based on a once-through fuel cycle
- Other seek to close the fuel cycle by recycling waste streams to produce new useful fuel and minimize waste streams requiring long-term management and disposal



Tracking Deployment Progress: *The NEA SMR Dashboard*



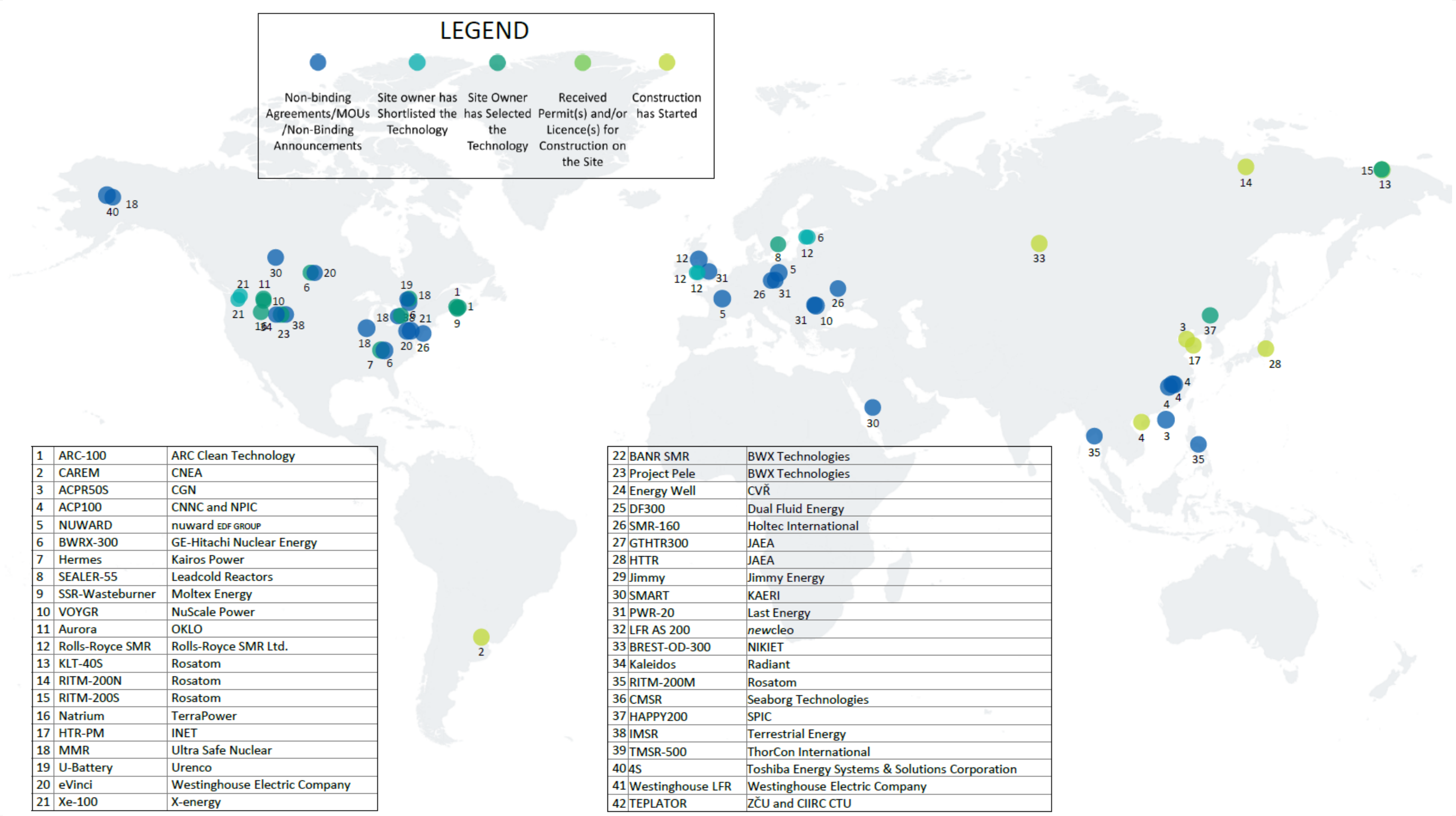


Links:
Volume I: [NEA SMR Dashboard Volume I, NEA, 2023]
Volume II: [NEA SMR Dashboard Volume II, NEA, 2023]

SMR Sites around the World

Source: NEA SMR Dashboard Volume I, NEA, 2023

SMR sites around the world



1	ARC-100	ARC Clean Technology
2	CAREM	CNEA
3	ACPR50S	CGN
4	ACP100	CNNC and NPIC
5	NUWARD	nuward EDF GROUP
6	BWRX-300	GE-Hitachi Nuclear Energy
7	Hermes	Kairos Power
8	SEALER-55	Leadcold Reactors
9	SSR-Wasteburner	Moltex Energy
10	VOYGR	NuScale Power
11	Aurora	OKLO
12	Rolls-Royce SMR	Rolls-Royce SMR Ltd.
13	KLT-40S	Rosatom
14	RITM-200N	Rosatom
15	RITM-200S	Rosatom
16	Natrium	TerraPower
17	HTR-PM	INET
18	MMR	Ultra Safe Nuclear
19	U-Battery	Urenco
20	eVinci	Westinghouse Electric Company
21	Xe-100	X-energy

22	BANR SMR	BWX Technologies
23	Project Pele	BWX Technologies
24	Energy Well	CVŘ
25	DF300	Dual Fluid Energy
26	SMR-160	Holtec International
27	GTHTR300	JAEA
28	HTTR	JAEA
29	Jimmy	Jimmy Energy
30	SMART	KAERI
31	PWR-20	Last Energy
32	LFR AS 200	*newcleo*
33	BREST-OD-300	NIKIET
34	Kaleidos	Radiant
35	RITM-200M	Rosatom
36	CMSR	Seaborg Technologies
37	HAPPY200	SPIC
38	IMSR	Terrestrial Energy
39	TMSR-500	ThorCon International
40	4S	Toshiba Energy Systems & Solutions Corporation
41	Westinghouse LFR	Westinghouse Electric Company
42	TEPLATOR	ZČU and CIIRC CTU

Nuclear Reimagined

Credit: ThirdWay

Policy frameworks to support nuclear deployment

Nuclear Energy Faces Many Challenges

Systems thinking	A systems approach is required to understand the full costs of electricity provision, and to ensure that markets value desired outcomes: low carbon baseload, dispatchability, and reliability.
	The nuclear sector must move quickly to demonstrate and deploy near-term and medium-term innovations including advanced and small modular reactors, as well as nuclear hybrid energy systems to produce heat, electricity, synthetic fuels and meet other needs.
Speed & Scale	Rapid build-out of new nuclear power is possible, but requires a clear vision and plan.
	Historical and recent experience shows that under the right policy frameworks and with a robust programmatic approach, nuclear power can achieve rapid delivery times.
Building and maintaining public trust	Building trust is central to building public confidence and requires sustained investments in open and transparent engagement.
	A common mistake is to assume that public confidence is primarily a communication issue. Science communication is essential but does not substitute for meaningful two-way engagement.
Understanding the role of Governments	Governments have a role to play in all capital intensive infrastructure projects – including nuclear energy projects.
	The role of governments can include direct funding, but also enabling policy frameworks that allow an efficient allocation of risks to allow nuclear energy projects to compete on their merits on equal footing with other non-emitting energy projects.

System Costs = Plant-level Costs + Grid-level Costs

PLANT-LEVEL

Generation Costs

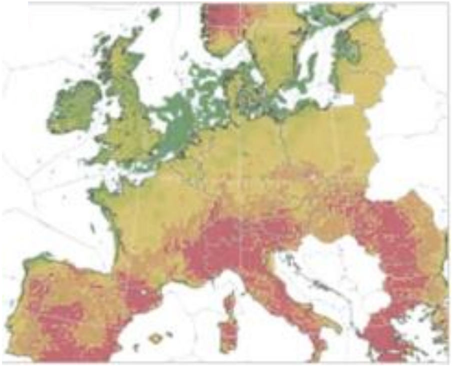
Levelized Cost of Electricity

+

GRID-LEVEL

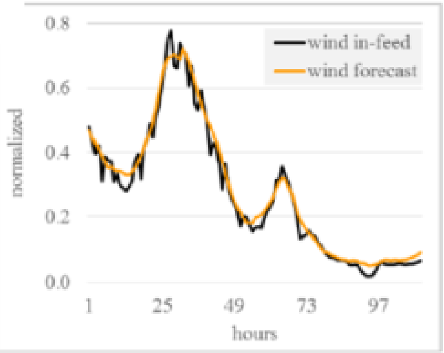
Connection, Transmission and Distribution Costs

Costs of delivering electricity from distributed power generation to customers



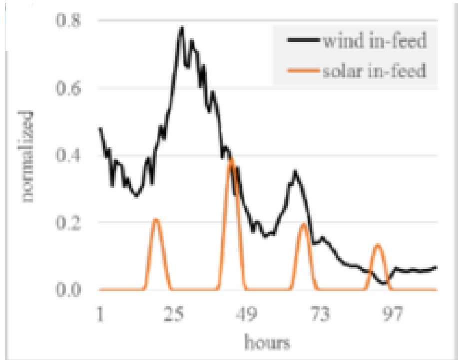
Balancing costs

Grid-level costs imposed by uncertainty in generation



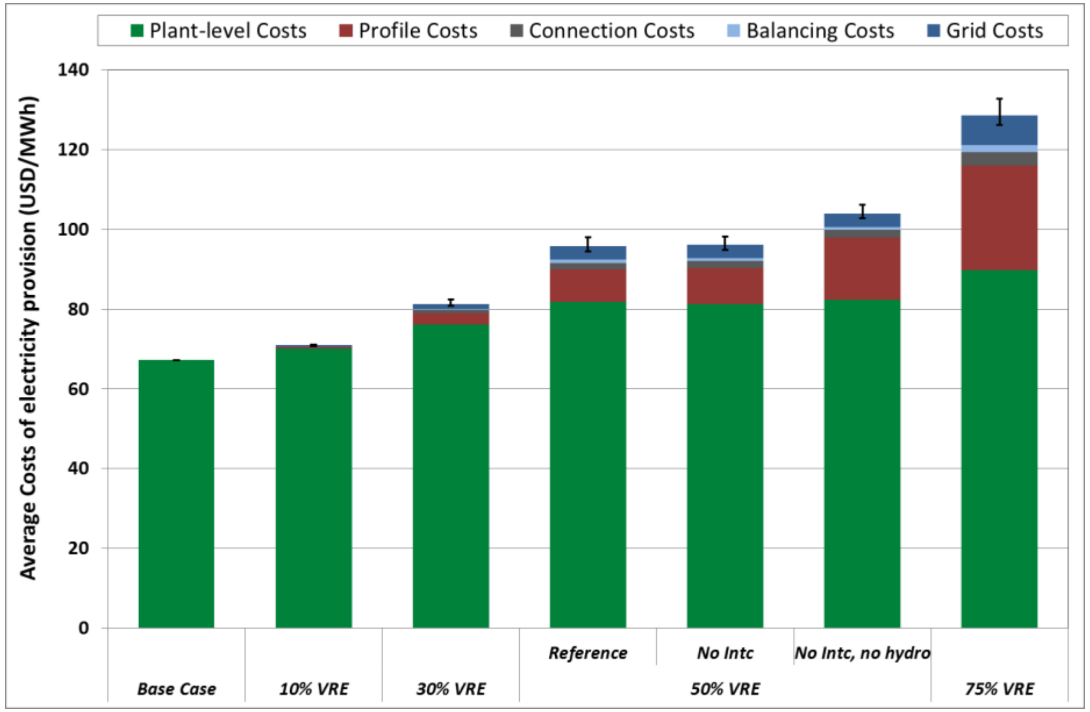
Profile costs

Grid-level costs imposed by Variability or intermittency

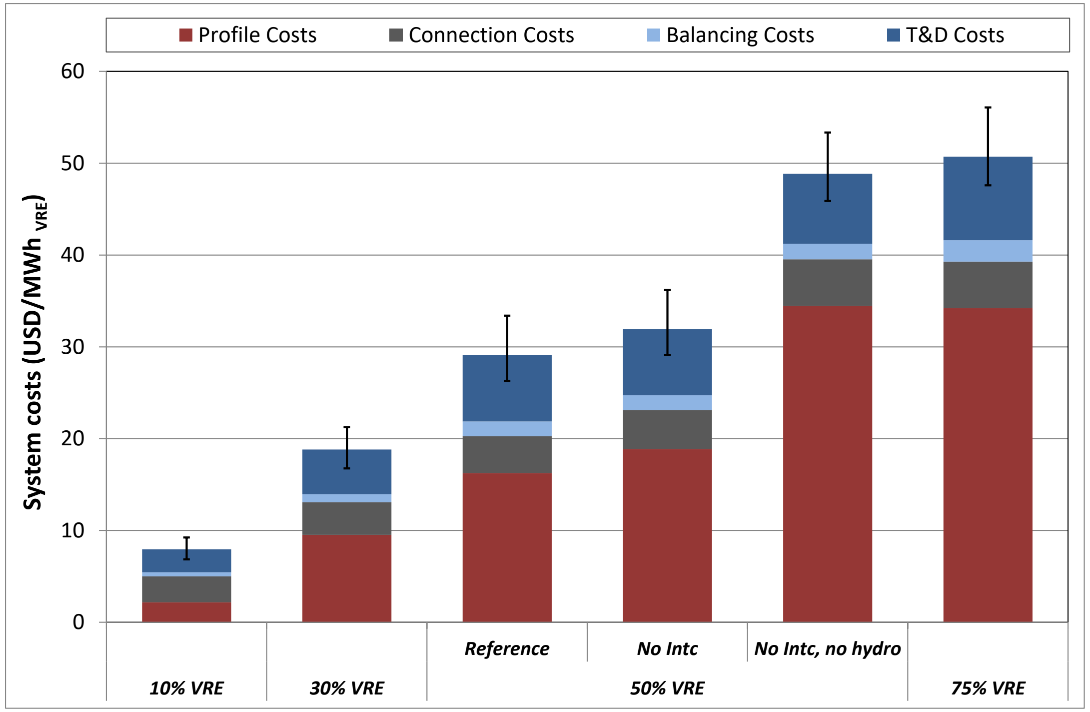


As the share of variable renewables increases, system costs grow quickly

System Costs

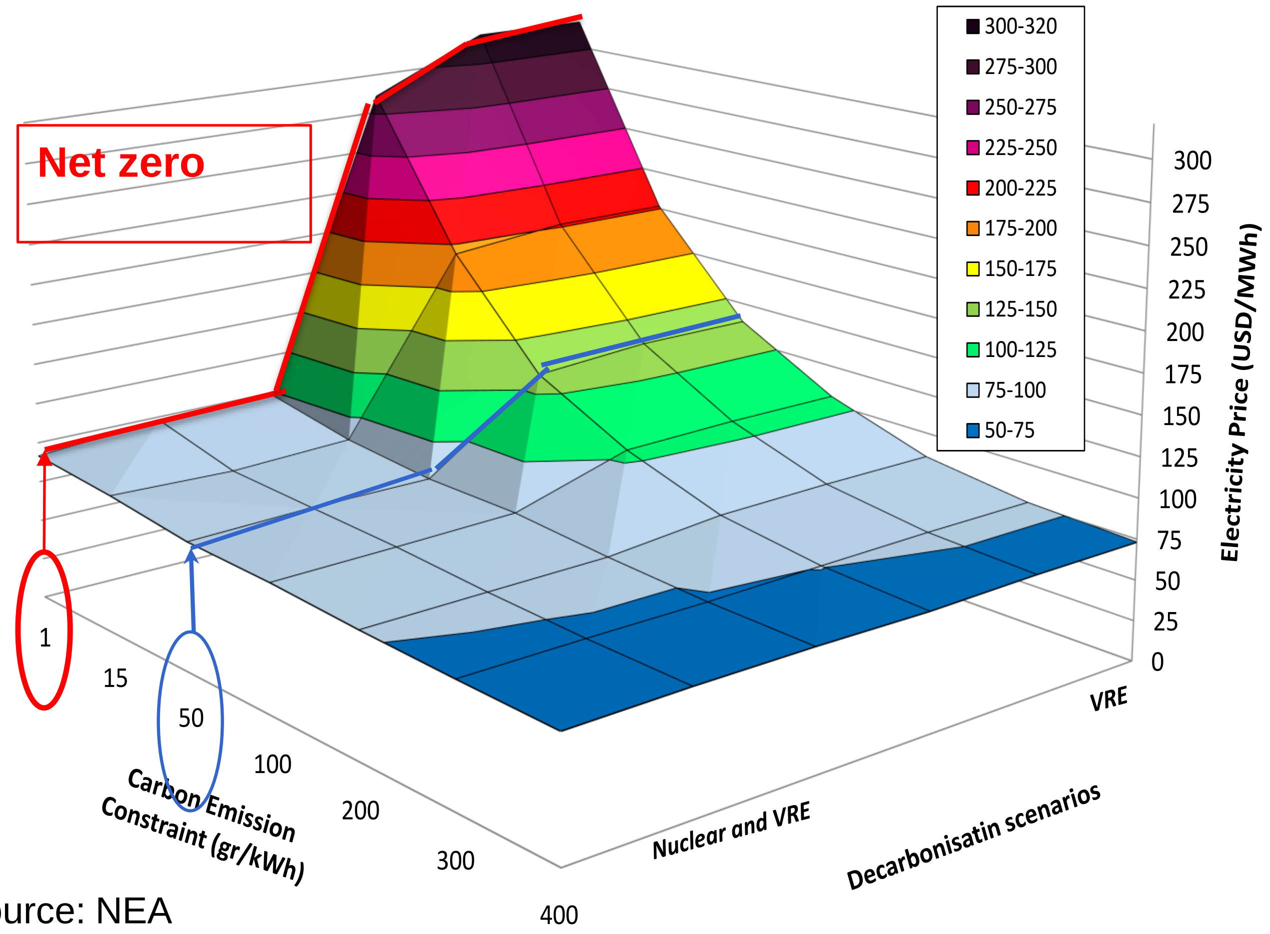


Breakdown of Grid-level Costs



System costs are significant and increase with VRE generation share
Profile costs are the dominant component

System costs depend on carbon constraints and shares of variable renewables



Source: NEA

The cost of electricity increases with the stringency of the carbon constraint, especially in scenarios where only variable renewables are deployed.

Thank you