LAS/ANS 2024 – Rio de Janeiro, Brazil

Taking Nuclear Energy to "Climate Scale"

How Small Modular Reactors Can Accelerate the Energy Transition to Net Zero

July 2024

Carlos Leipner | Executive Director, LGE Strategic Advisors

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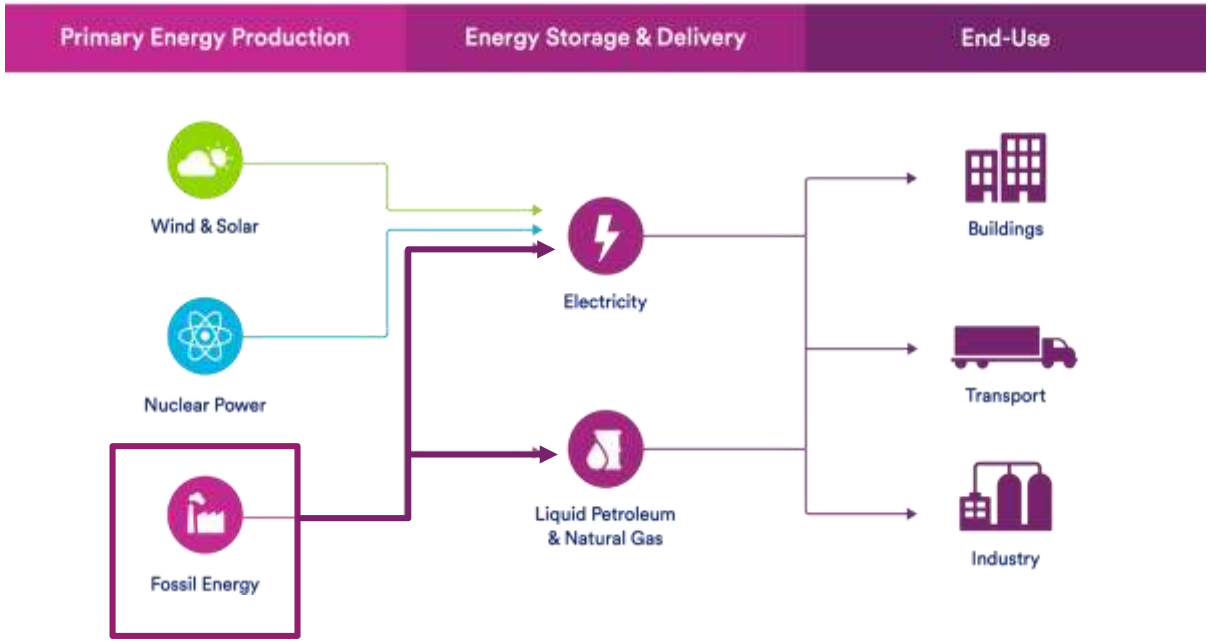
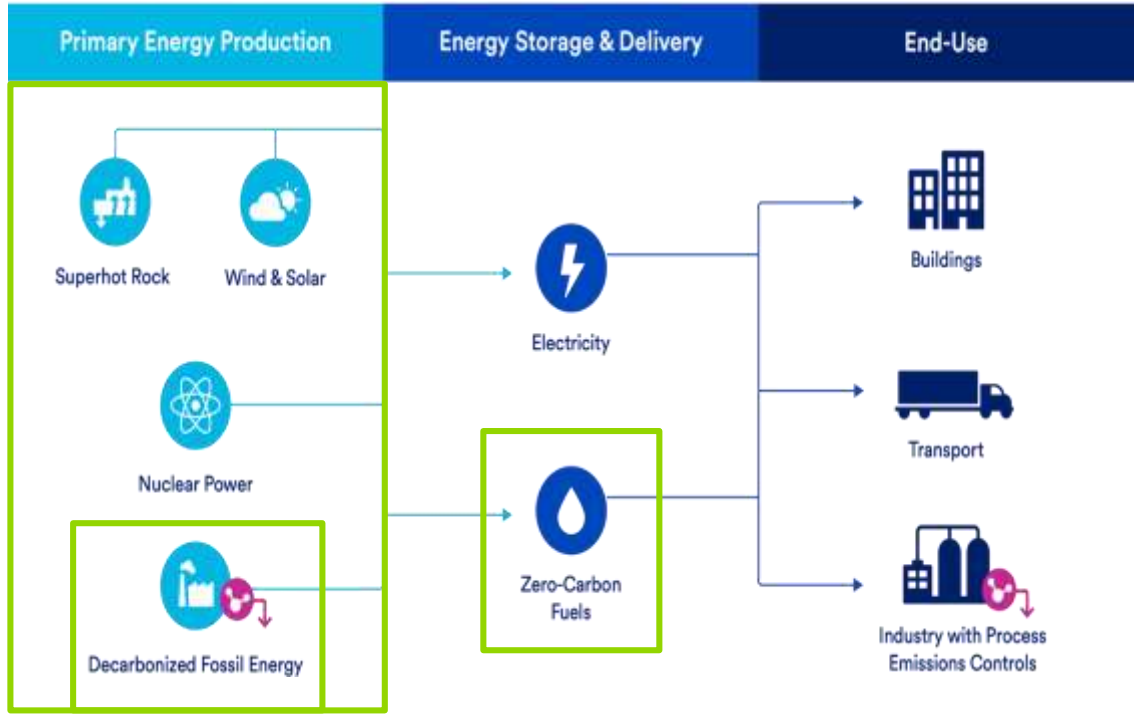
The Energy Transition

Carbon Intensive Energy System



Decarbonized Energy System



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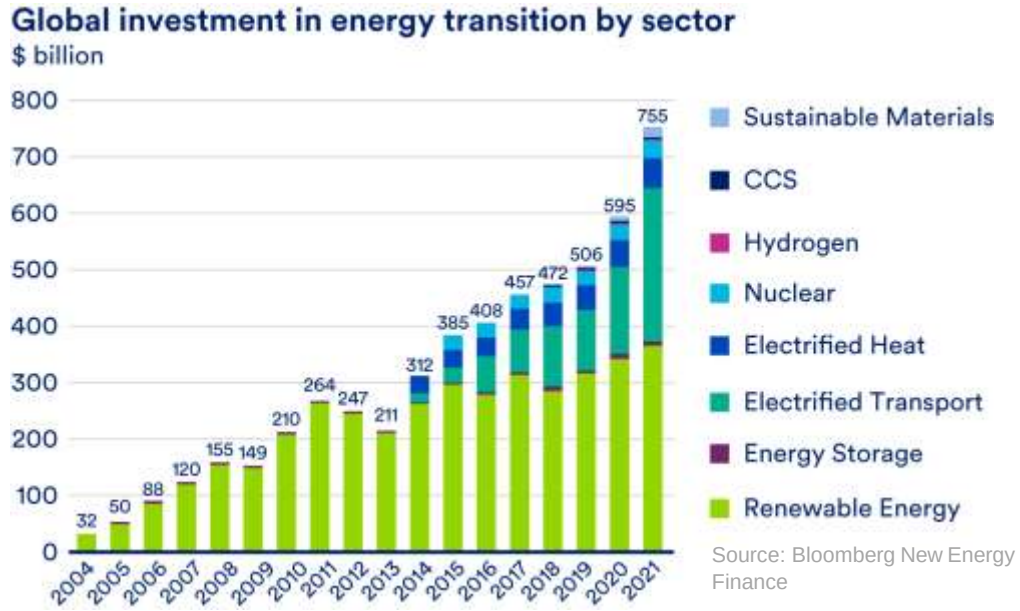
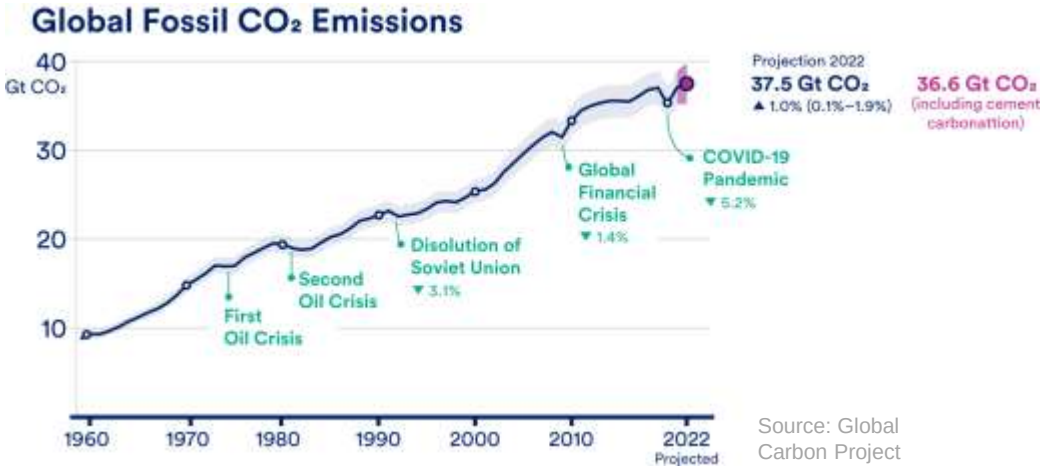
Opening thought

- The world is spending more than $750 Billion per year on clean energy, most of it on EVs and renewables.
- Yet, emissions continue to dramatically rise.
- To gain more quickly on the climate problem, we need more aggressive deployment of zero carbon energy, and nuclear is an essential part of the portfolio.
- But why isn't nuclear growing?



Source: Bloomberg New Energy Finance



Source: Global Carbon Project

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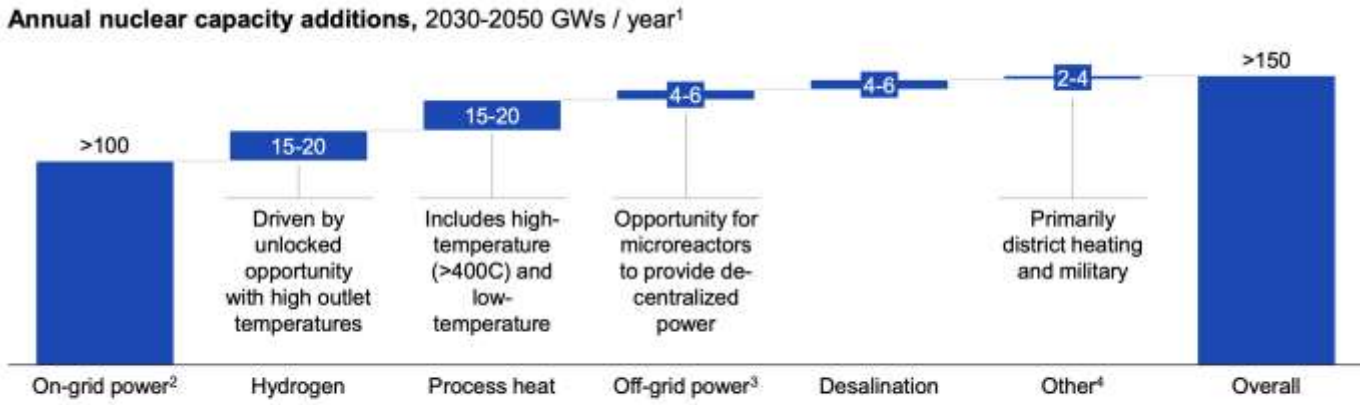
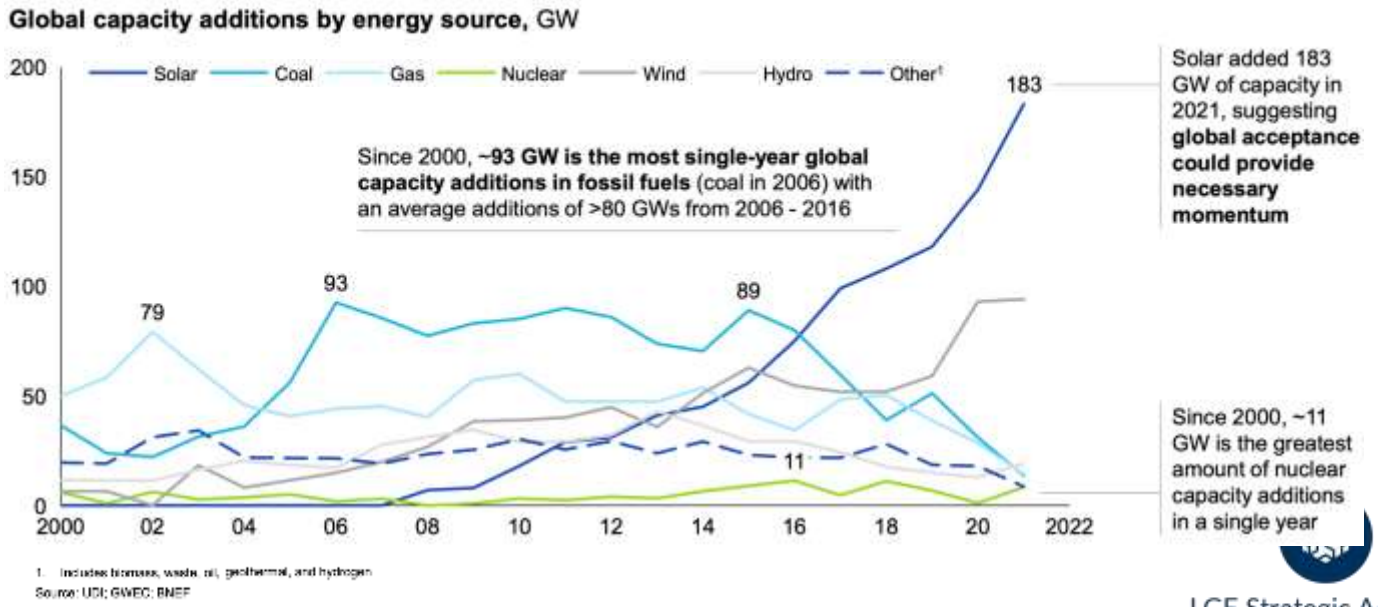
Nuclear deployment at 100+ GW year* is needed, more than 10X recent history

* For reference, 1 GW = 1 large reactor. Only 390 GW of nuclear energy reactors are installed today.

- **Top right:** Annual nuclear capacity additions needed to manage carbon emissions from electricity and other fuels
- **Bottom right:** Actual recent build rates for nuclear and other energy sources





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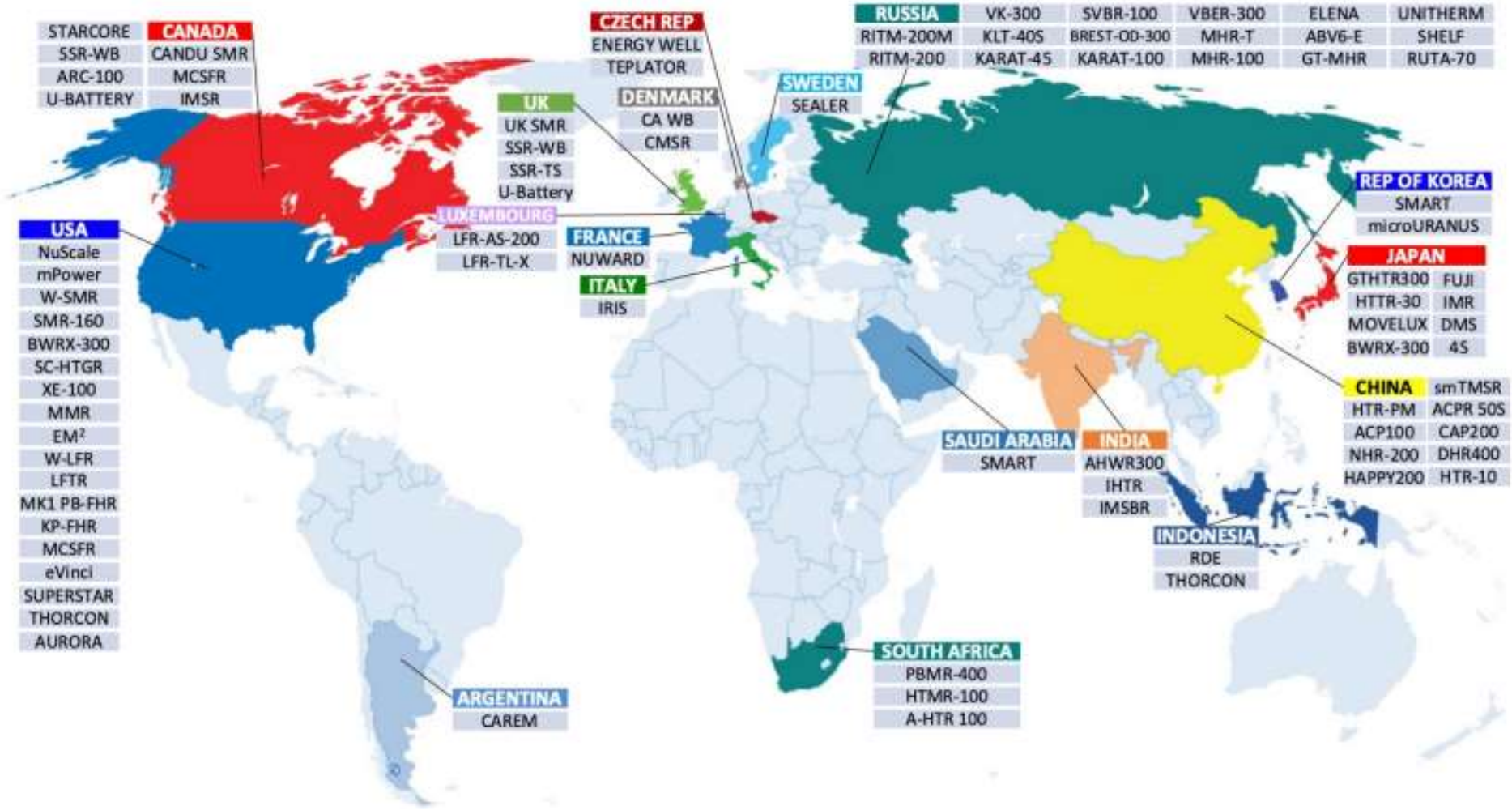
Source: McKinsey and Company analysis for CATF

Concepts in development >100



Ref: IAEA 2024

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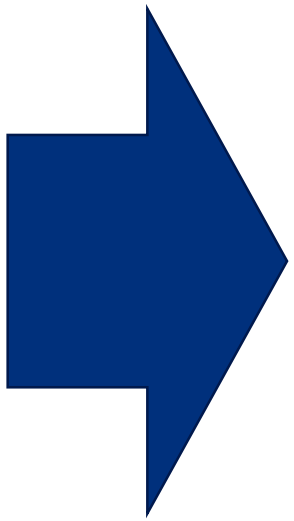
The Nuclear Technology Buffet

- **At least 12 million "reasonable" combinations**
- **~900 combinations have been explored to some extent**
- **~40 *combinations* in active development today**

Ref. S. Qvist

Advanced Nuclear Characteristics

- Inherently safe
- Higher temperatures
- Flexible output
- Simple modular construction
- Smaller unit size
- Fuel recycling



Cheaper power
&/or Easier to finance

More markets &
Greater acceptance

Other products
(than electricity)

Ref: Staffan Qvist 2024

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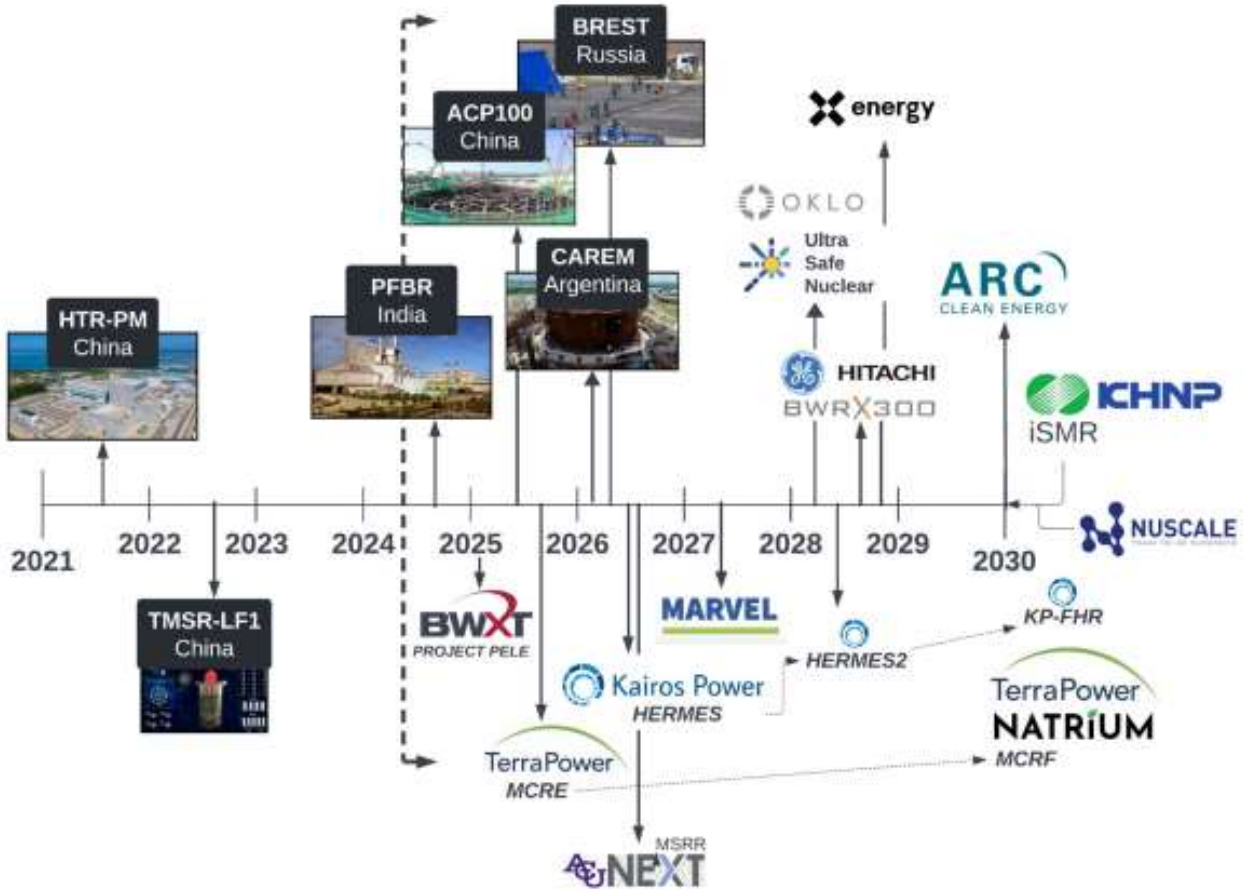
Advanced Nuclear Timeline – Example of ~30 concepts



Quantified Carbon

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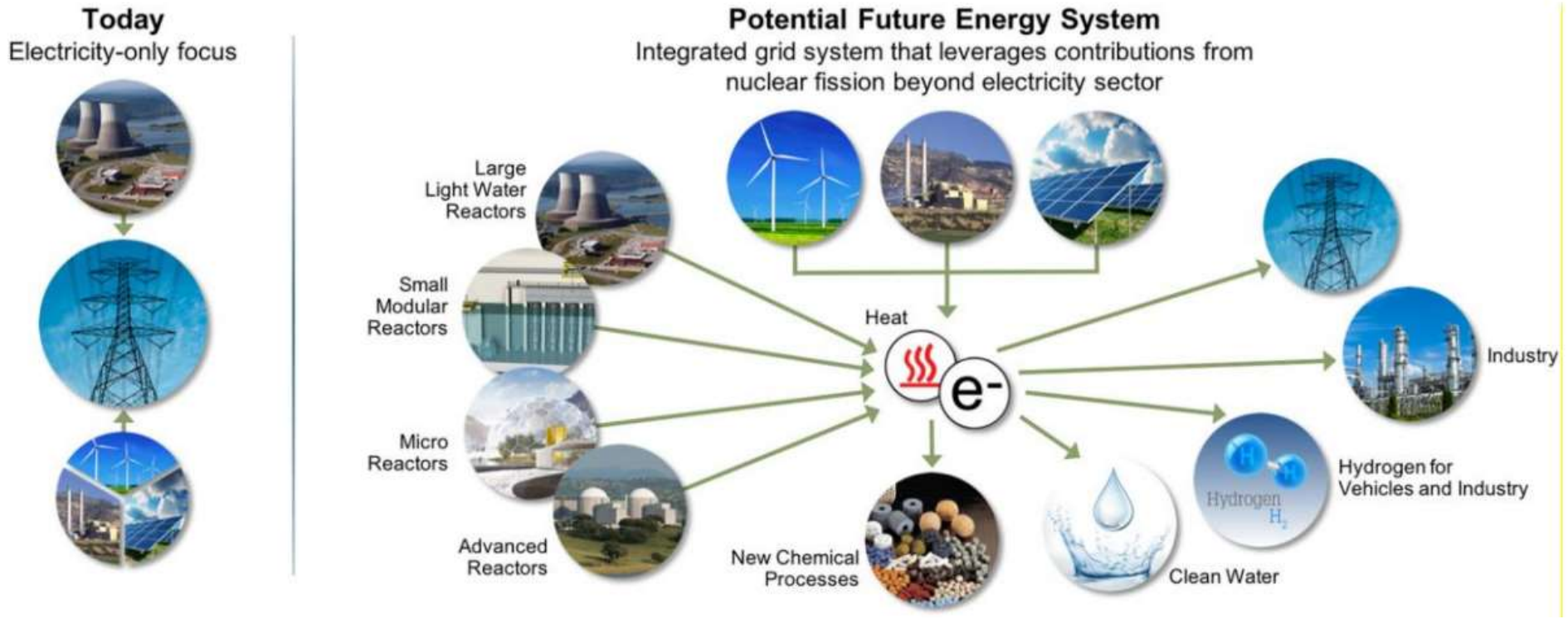
Ref: Staffan Qvist 2024

Broadening the Applications of Nuclear Power



Ref: GenIV IF-NEANH

- A large demand for nuclear energy for industrial applications is expected to grow rapidly on account of steadily increasing energy consumption, the finite availability of fossil fuels and the increased sensitivity to the environmental impacts of fossil fuel combustion.

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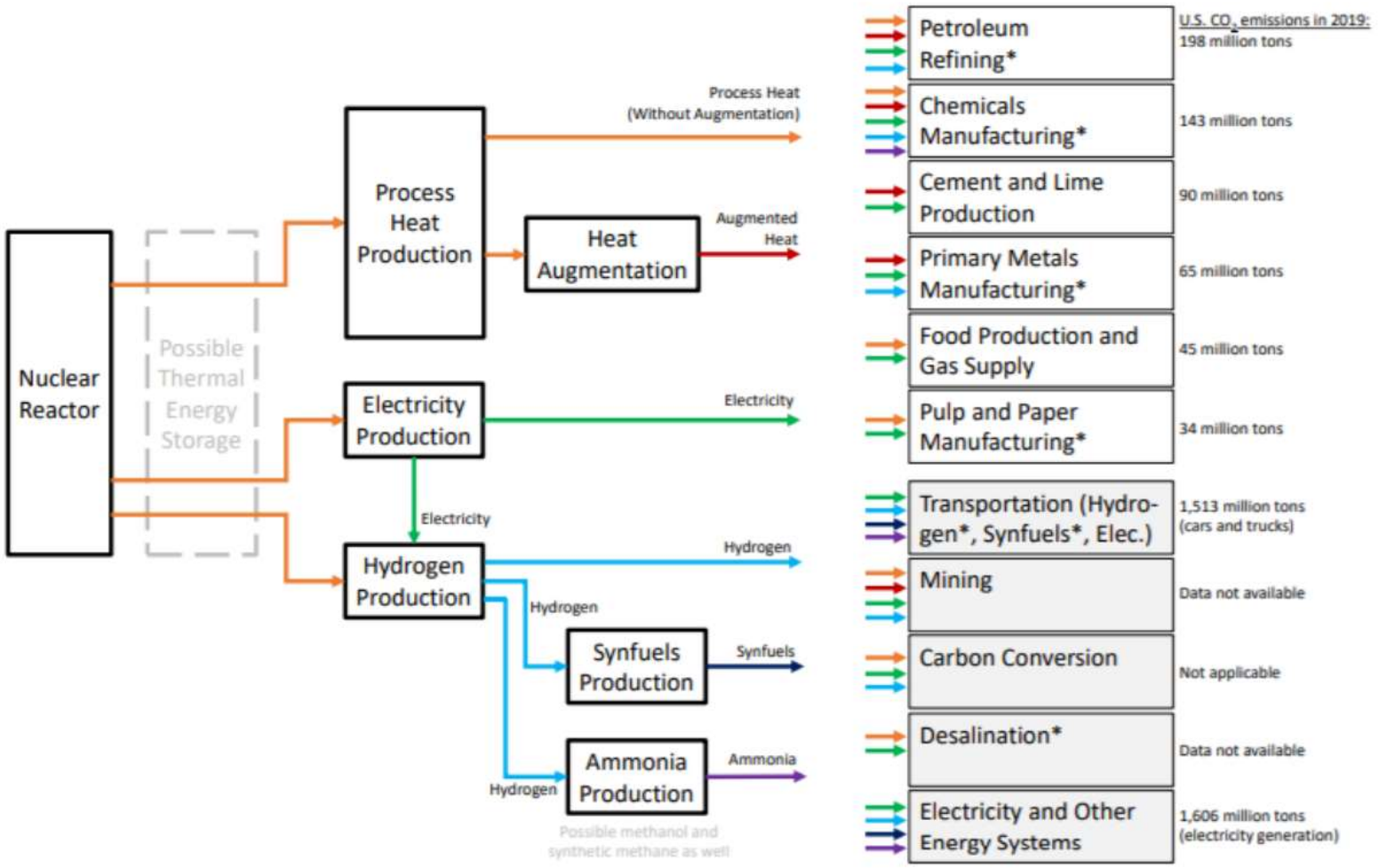
Broadening the Applications of Nuclear Power



Ref: GenIV IF-NEANH

Currently. ~1% nuclear heat has been used for non-electric applications

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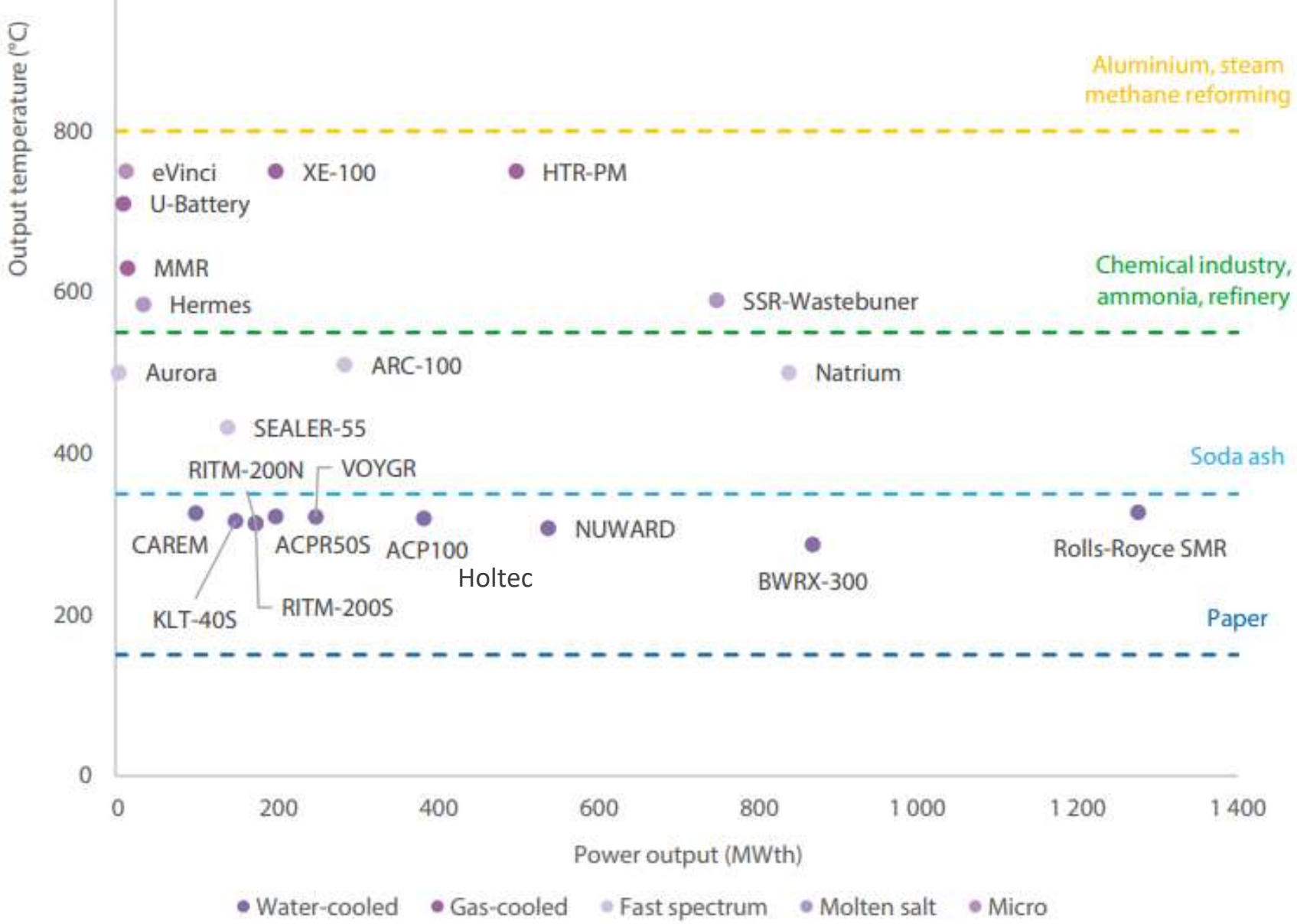
Many SMR/Advanced Reactor Technologies Being Developed Today (>100 projects)



Ref: IAEA 2024

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Nuclear and District heating

- Two Westinghouse-supplied AP-1000 nuclear reactor units have been in commercial operation at the nearby Haiyang nuclear power station since 2018 and 2019.
- Cogeneration via five heat-exchange facilities at Haiyang-1 has replaced 12 coal-fired boilers used to heat households in Haiyang, a coastal city of 200,000 residents reducing CO2 emissions by 180,000 tonnes
- High-pressure steam from the nuclear reactor system is brought to heat exchange facilities and onto the district heating system making use only of high temperatures, but without the transfer of any water.
- A typical nuclear power station produces around 3.4 GW of heat – equivalent to about 100,000 domestic gas boilers – which is used to generate around 1.2 GW of electricity. Currently, around 65% of the energy is lost in the conversion as waste heat.

China / City Of Haiyang 'First In Country' To Have District Heating System Powered By Nuclear

By Kamen Kraev
12 November 2021

Nearby station has two Westinghouse-supplied AP-1000 reactor units

The Haiyang nuclear power station in China has two Westinghouse AP1000 plants.

Holtec completes design of HI-HEAT district heating system

18 October 2022

Nuclear and Industrial Applications

- **Dow Inc and X-energy** have agreed to develop and demonstrate the first grid-scale next-generation nuclear reactor for an industrial site in Texas.
- The Seadrift site covers 4700 acres and manufactures more than 4,000,000 pounds (1816 tonnes) of materials per year for use in applications such as food packaging, footwear, wire and cable insulation, solar cell membranes and packaging for pharmaceutical products
- Each Xe-100 high-temperature gas reactor is engineered to operate as a single 80 MW electric unit, optimised as a four-unit plant delivering 320 MWe, on a roughly 30-acre site. The reactor can provide baseload power to an electricity system or support industrial applications with 200 MW thermal output per unit of high pressure, high temperature steam.

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Dow's Seadrift site selected for X-energy SMR project

11 May 2023

Share

Dow has selected its UCC Seadrift Operations manufacturing site in Texas for its proposed advanced small modular reactor (SMR) project with X-Energy Reactor Company. The aim is for the project to be completed by the end of the decade.

How the Xe-100 plant could look (Image: X-energy/Dow)

Dow and X-energy will now prepare and submit a construction permit application to the US Nuclear Regulatory Commission. The aim is for construction work to begin in 2026.

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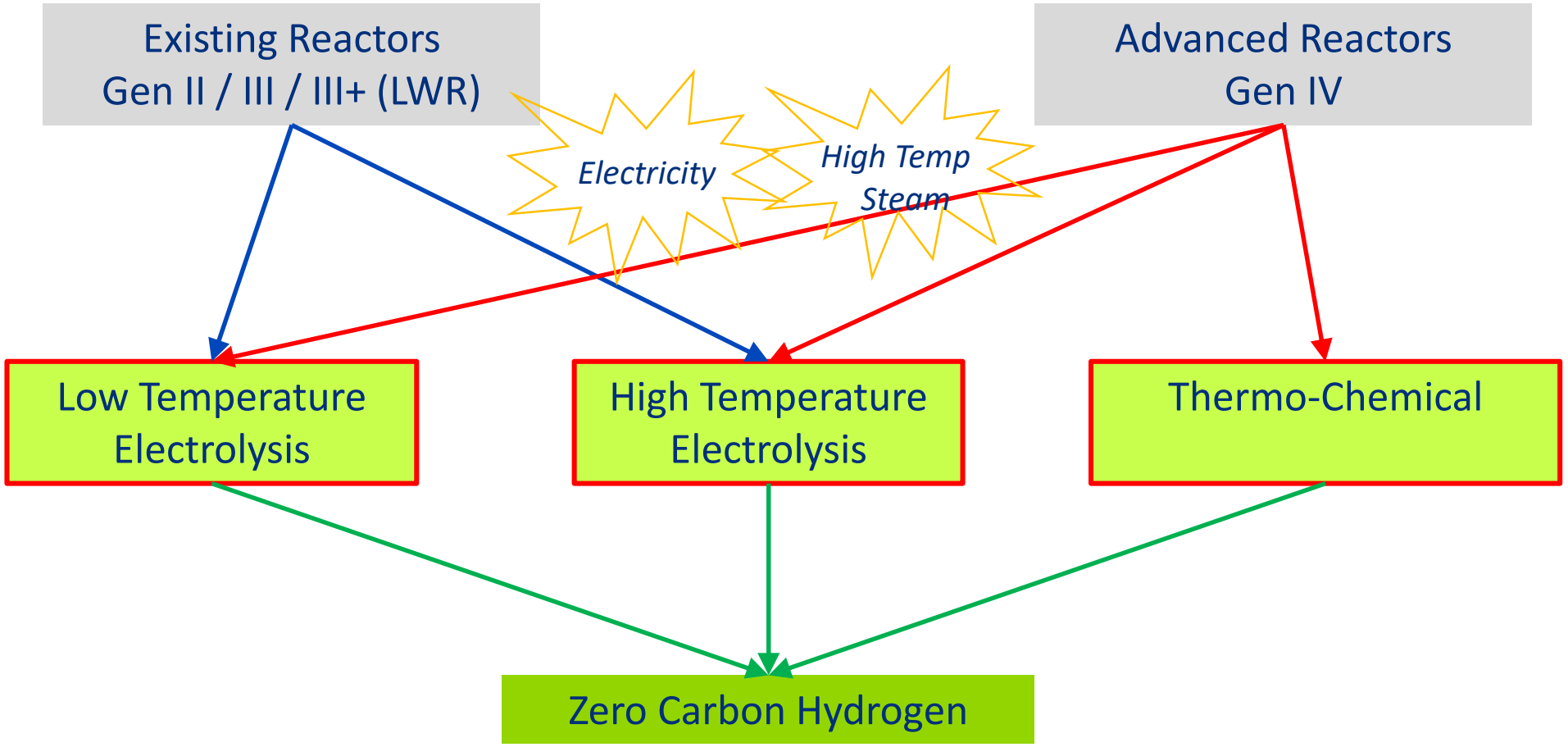
Hydrogen Production via Nuclear Power

Many Pathways to Zero Carbon Hydrogen



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Nuclear and Data Centers

- Data centers and data transmission networks are responsible for **1% of energy-related GHG emissions** (330 Mt CO2 equivalent in 2020)
- Estimated global data center electricity consumption in 2022 was 240-340 TWh, or around 1-1.3% of global final electricity demand. This excludes energy used for cryptocurrency mining, which was estimated to be around 110 TWh in 2022, accounting for 0.4% of annual global electricity demand.
- Combined electricity use by Amazon, Microsoft, Google, and Meta more than doubled between 2017 and 2021, rising to around 72 TWh in 2021.
- Google, Microsoft, and Nucor partner for new energy tech PPAs.
    - Focus on accelerating the development of first-of-a-kind and early commercial projects, including advanced nuclear, next-generation geothermal, clean hydrogen, long-duration energy storage (LDES) and others

Global data center electricity use to double by 2026 - IEA report

AI and cryptocurrency workloads are driving up demand

January 26, 2024 By: Matthew Gooding Have your say

Data center electricity usage is set to double by 2026 according to a new report, which blames the rise of power-intensive workloads such as AI and cryptocurrency mining for this growing demand.

The annual electricity report from the International Energy Agency (IEA) says data centers consumed 460TWh in 2022, a figure that could rise to more than 1,000TWh by 2026 in a worst-case scenario.

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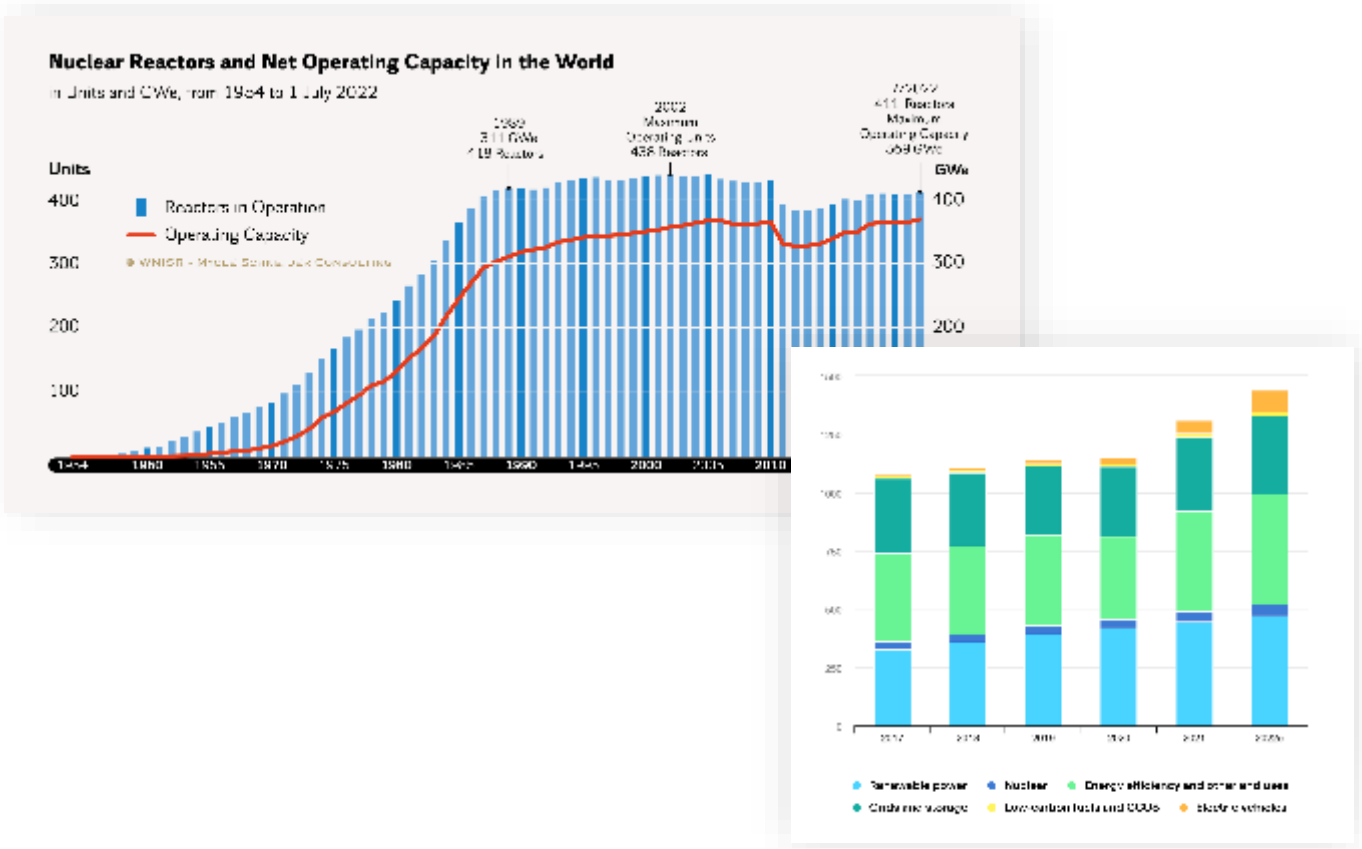
A Global Reset for Nuclear Energy: The Case for Urgency

Global demand for electricity is expected to double or triple by mid-century in most net-zero scenarios to meet human development and climate mitigation requirements

We will also need to fully decarbonize industrial heat and fuels, but **the energy system is not on-trend to meet these objectives**

Nuclear, particularly **SMRs, can be an important option for a decarbonized energy system** that reliably provides clean electricity at all hours and in all seasons, and a potential source of zero carbon heat and fuels.



Source: Bloomberg New Energy Finance

Thank you

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