

Global perspectives on nuclear energy development



King Lee
Director Harmony Programme

SIEW RoundTable
28 October 2022

We are the voice of the global nuclear industry

188
members

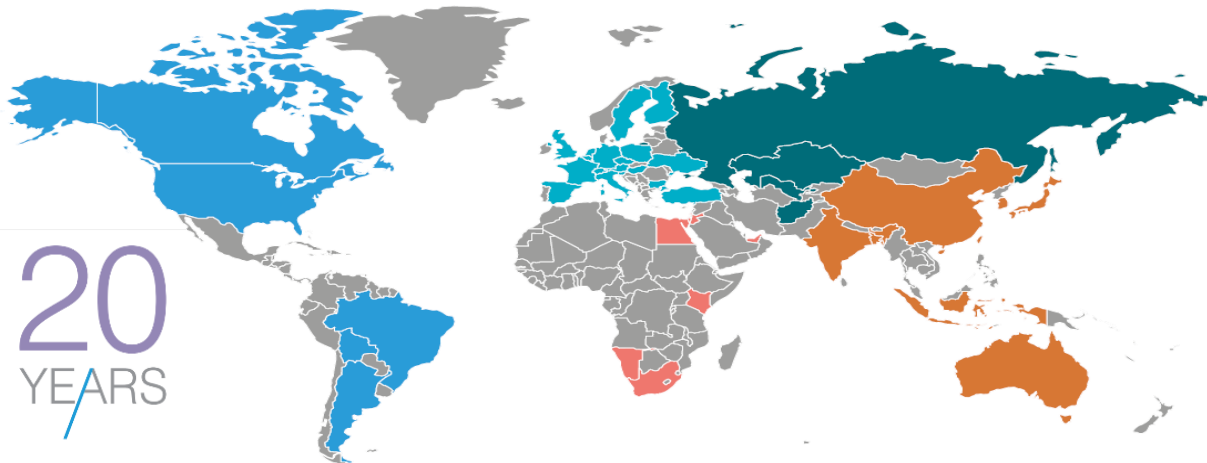
45
countries

Europe | 62 members

Austria, Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, Italy, Luxembourg, Netherlands, Poland, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom

Russia and Central Asia | 14 members

Afghanistan, Kazakhstan, Russia, Uzbekistan



WORLD NUCLEAR
ASSOCIATION

20
YEARS

Americas | 45 members

Argentina, Bolivia, Brazil, Canada, USA

Africa and Middle East | 10 members

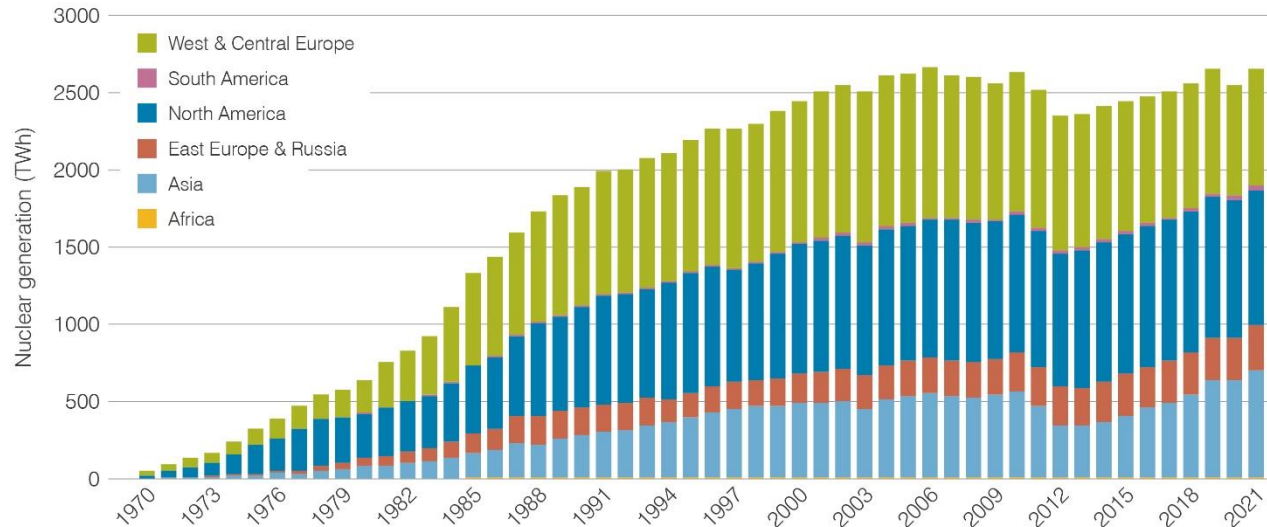
Egypt, Israel, Jordan, Kenya, Namibia, South Africa, United Arab Emirates

Asia-Pacific | 52 members

Australia, Bangladesh, China mainland and Taiwan, India, Indonesia, Japan, Singapore, South Korea

Major reactor vendors - nuclear utility companies - uranium mining, conversion, enrichment, and fuel fabrication companies - nuclear engineering, construction and waste management companies – R&D organizations - transport, law, insurance and finance service companies

Nuclear energy increased in 2021



Global electricity production

2653 TWh (+100 TWh)

Global average capacity factor

82.4% (+ 2.1%)

Operable reactors



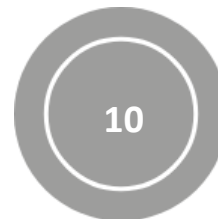
Capacity: 396 GWe (-1GWe)
6 reactors grid connected in 2021

Reactors under construction



10 construction starts (8.9 GWe) in 2021

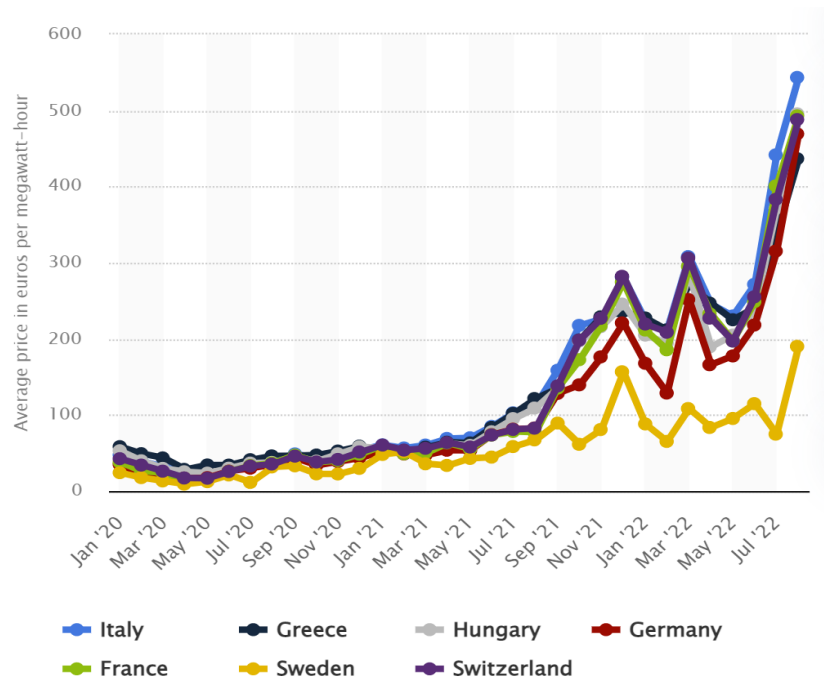
Reactors shutdown



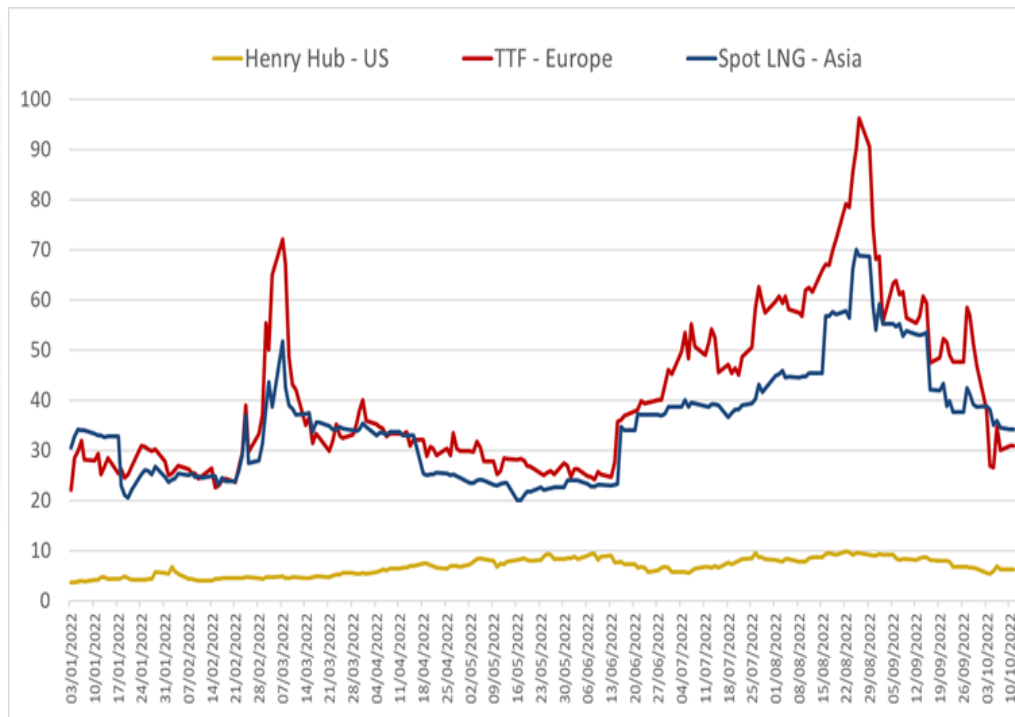
Capacity: 8.7 GWe

Energy has taken a front row seat in global geopolitics

Average monthly electricity wholesale prices selected countries in the European Union (Euros/MWh)



International daily spot gas prices in 2022 (\$/MBtu)



Energy crises - nuclear power provides reliable, clean and affordable energy



United Nations

UN News

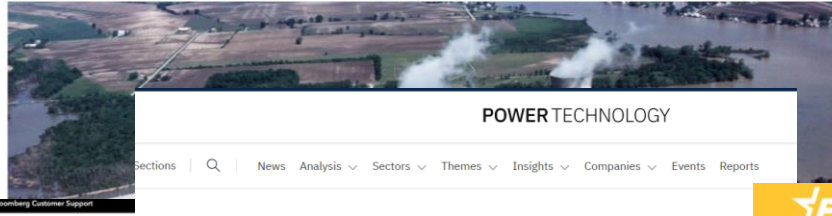
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Global climate objectives fall short without nuclear power in the mix: UNECE



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UK aims to source 25% of power from nuclear plants by 2050

UK Prime Minister Boris Johnson met with leaders from the nuclear

English

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GERMANY

Energy crisis: Germany's Scholz extends nuclear power plants' lifespan in 'snub' to Greens

By Euronews with AFP • Updated: 18/10/2022



Forbes

ENERGY

The Inflation Reduction Act Will Spawn Nuclear Energy's Growth

Ken Silverstein Senior Contributor @
I write about the global energy business.

Aug 22, 2022, 08:45am EDT

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France to build up to 14 new nuclear reactors by 2050

By Davide Basso | EURACTIV.fr

11 Feb 2022



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SECTORS > POWER | 20 December 2021

Weekly data: China's nuclear pipeline as big as the rest of the world's combined

China has a massive 228 nuclear reactors in development, according to GlobalData. If completed, these will have a capacity larger than Germany's entire power grid.

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Europe must support nuclear energy

DISCLAIMER: All opinions in this column reflect the views of the authors

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By Marco Visscher and Myrto Tripathi Dec 3

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Green Climate Politics

South Korea to Build Nuclear Plants to Meet Net-Zero Targets

- Country to lift atomic power generation above 30% by 2030
- Renewables will continue to be deployed at 'reasonable level'

The Enrico Fermi nuclear generating station near Monroe, Michigan, US.

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ENERGY

Nuclear power is key for Japan's energy security and carbon neutrality goals, minister says

PUBLISHED MON, SEP 5 2022-2:14 AM EDT

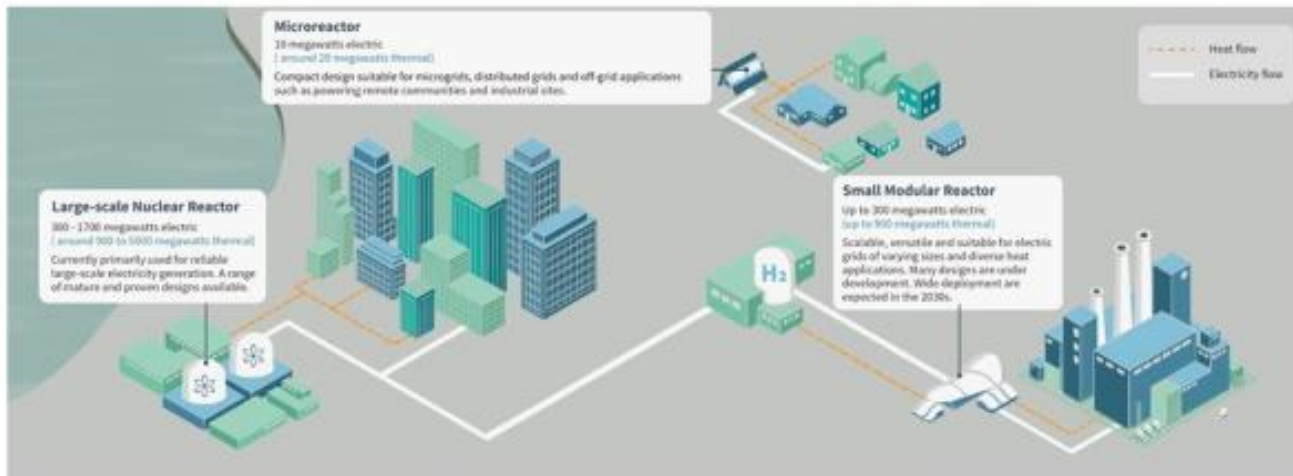
Lee Ying Shan

TV

Nuclear energy offers a great opportunity to decarbonize the entire economy

NUCLEAR POWER

Nuclear power is an important source of low-carbon electricity and heat that contributes to attaining carbon neutrality



ELECTRICITY GENERATION



Nuclear power plants can produce reliable 24/7 electricity or operate flexibly as required. Dispatchable electricity sources are essential for keeping the costs of the overall system low.

HYDROGEN



Nuclear power can be used to produce low-carbon hydrogen via several processes:

- Low-temperature electrolysis - using nuclear electricity
- Steam electrolysis - using nuclear heat and electricity
- Thermochemical process - using nuclear heat at above 600°C

PROCESS HEAT FOR INDUSTRY



High-temperature heat from nuclear plants can be transformative in decarbonising hard-to-abate sectors.

DISTRICT HEATING



Nuclear plants are a proven source of heat for urban district heating that have operated successfully in a number of countries.



Raising Awareness

Recognise that nuclear power is a source of low-carbon energy and heat that can help decarbonise energy systems



Promoting Acceptance

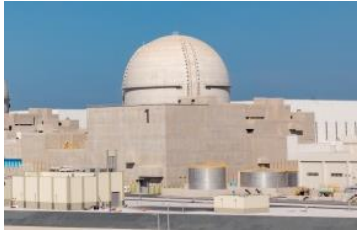
Develop policies that build confidence and facilitate the wider application of nuclear power to decarbonise electricity and energy intensive industries



Incentivising Finance

Develop financing frameworks that build confidence and incentivise affordable public and private investment in support of new nuclear power projects

Lots of excitement about new nuclear projects, large and small



Barakah 1 & 2 - UAE
APR-1400
In operation



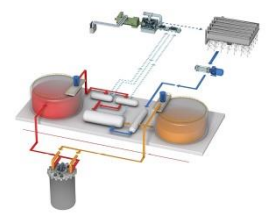
Haiyang- China
AP1000
In Operation



Rooppur 1&2- Bangladesh
VVER-1200
Under Construction



Akademik Lomonosov
KLT-40S - Russia
In operation



Natrium, US
345 MWe SFR
MS storage
Under Development



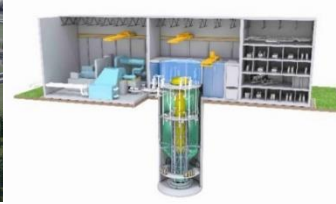
NuScale, US
77 MWe PWR
Design Licensed



HTR-PM, China
2x110 MWe HTGR
In Operation



Terrestrial, Canada, US, UK
190 MWe IMSR
Under Development

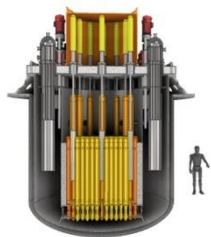


BWRX300, US
300 MWe BWR
Under Review



Aurora/Oklo, US
1.5 MWe Heatpipe FNR
Under Review

Funding for demonstration Swedish lead-cooled SMR



A Uniper Sweden and LeadCold JV has received funding in support of the construction of a demonstration LeadCold SEALER (Swedish Advanced Lead Reactor).

The SEALER design is claimed to generate 3-10 MWe over a 10-30 year period without refueling.

Moltex SMR clears first phase of regulatory review



The Canadian Nuclear Safety Commission has completed the first phase of the VDR for Moltex Energy's 300 MWe Stable Salt Reactor - Wasteburner (SSR-W 300).

The SSR-W is a molten salt reactor that uses nuclear waste as fuel. The company aims to deploy its first reactor at the Point Lepreau site in New Brunswick by the early 2030s.

Assystem to cooperate with Naarea on micro- reactor



French Assystem has signed an agreement with newly-created French micro-reactor developer Naarea to build its ultra-compact eXtra Small Modular Reactor (XSMR).

Naarea says it expects to produce the first units of XSMR 1 to 40 MW molten salt reactor by 2030.

Empresarios Agrupados contracted for first ThorCon reactor

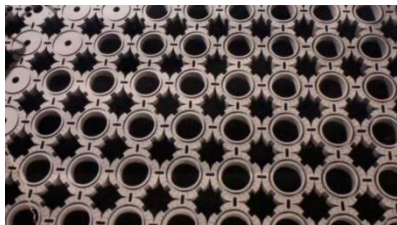


Spanish engineering firm Empresarios Agrupados (EA) has been named as architect engineer for the 500 MWe floating ThorCon molten salt reactor (TMSR-500) to be deployed in Indonesia.

According to ThorCon, only 24 months will be required from the start of construction before each plant will be capable of sending electricity to the grid

High Temperature Reactors

UK selects HTGR for advanced reactor demonstration



The UK will build a high-temperature gas reactor (HTGR) as the centrepiece of its Advanced Modular Reactor Research, Development & Demonstration Programme.

The goal is to have a demonstration unit in operation "by the early 2030s, at the latest

Doosan to assess manufacturability of Xe-100



Doosan will support the development of the reactor by performing a study for its optimum design in terms of manufacturability.

The Xe-100 is an 80 MWe (scalable to a 320 MWe four-pack) high-temperature gas-cooled (HTGR) reactor.

Demonstration HTR-PM connected to grid



The demonstration High Temperature Gas-Cooled Reactor - Pebble-bed Module at the Shidaowan site in Shandong province of China was connected to the grid at the end of 2021.

The plant features two small reactors that drive a single 210 MWe turbine.

U-Battery unveils full-scale SMR mock-up



A full-scale first-of-its kind mock-up of the main vessels has demonstrated how the reactor can be built using modular techniques.

Preparations for installation of the water-cooled inner cladding components have been completed, with installation work expected to continue well into 2022.

US, Japanese firms agree to cooperate on fast reactors



JAEA, MHI and Mitsubishi FBR Systems signed a MoU with TerraPower to cooperate on the development of sodium-cooled fast reactors.

JAEA said Japan aims to accelerate innovations in various nuclear technologies in collaboration with the development of next-generation innovative reactors overseas.

Construction licence issued for Russia's BREST reactor



It will be the world's first experimental demonstration power unit featuring a lead-cooled fast neutron reactor.

The 300 MWe unit will be the main facility of the Pilot Demonstration Energy Complex (PDEC)

Completion of MBIR reactor brought forward



Construction of Russia's multipurpose sodium-cooled fast neutron research reactor was 8% ahead of schedule at the end of 2021 and is now expected to be completed in 2027, one year earlier than previously planned.

The MBIR is a 150 MWt, sodium-cooled fast reactor and will have a design life of up to 50 years.

Newcleo, ENEA to cooperate on advanced reactors



UK innovative reactor developer Newcleo and ENEA sign agreement.

The Italian national agency for new technologies, energy and sustainable economic development – will cooperate on the development of small, lead-cooled fast reactors.

Carbon Neutrality Toolkit

Supporting policymakers to make informed decisions towards the implementation of the 2030 Agenda for Sustainable Development and the Paris Agreement.



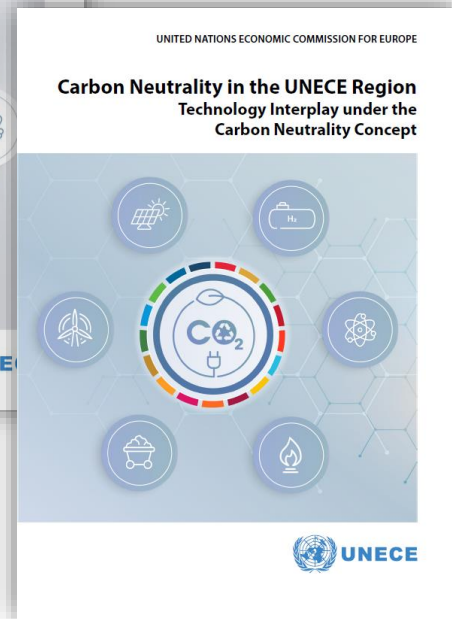
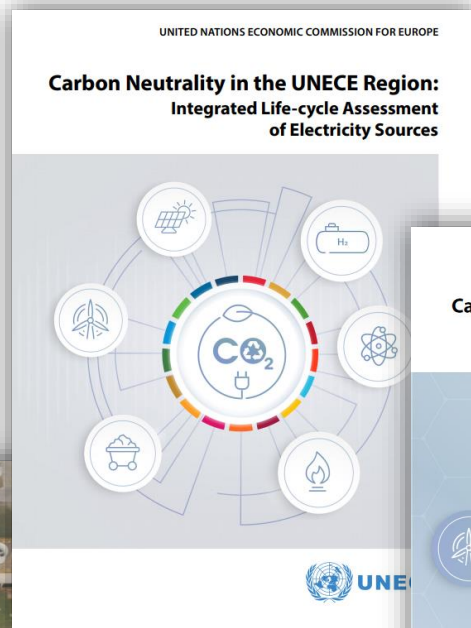
<https://carbonneutrality.unece.org/>

UNECE Carbon Neutrality Project

Carbon Neutral Energy System of the Future
integrated interplay of all low- and zero-carbon technologies.



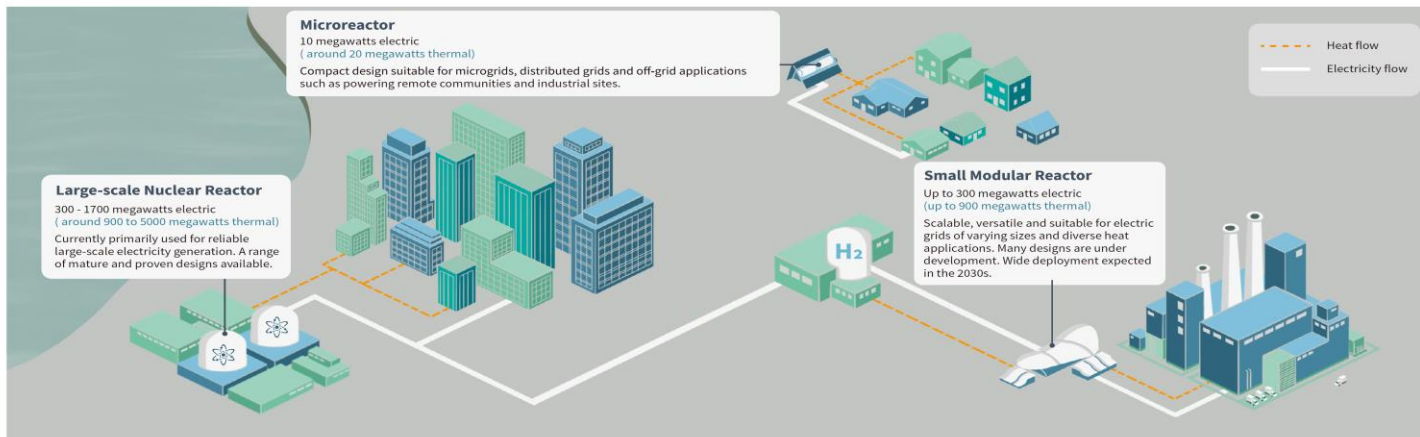
UNECE Carbon Neutrality Toolkit



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UN life cycle assessment publication highlighting the sustainability of nuclear energy compared with other electricity sources.

Greenhouse gas (GHG) emissions

Nuclear power's lifecycle emissions are estimated with the lowest GHG of all technology assessed.

Human health

Nuclear power show low impact on human health

Ecosystems

"Nuclear power show a very low score on the ecosystem damage indicator"

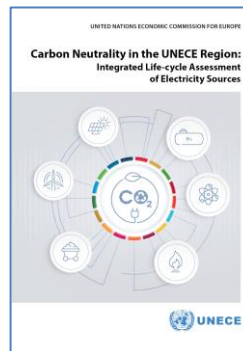
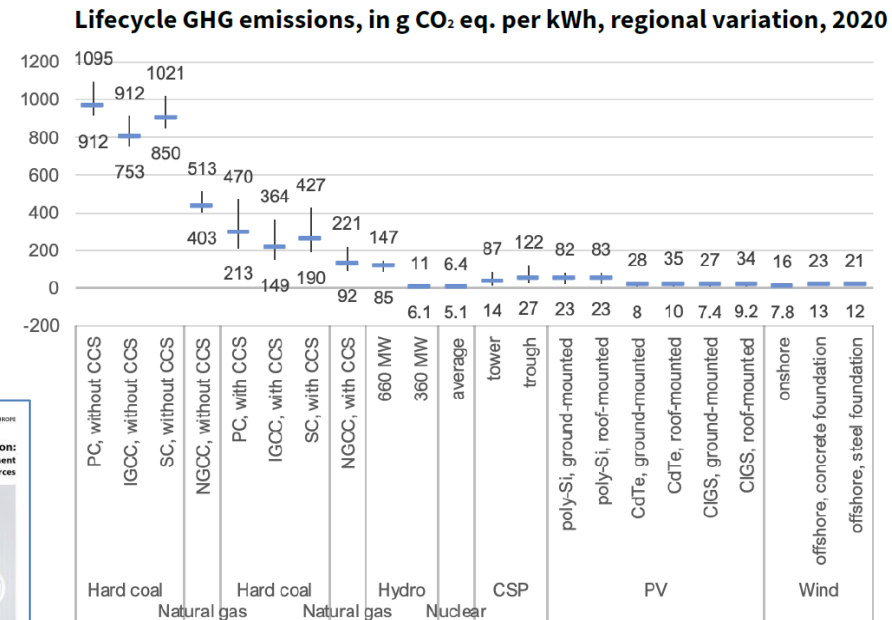


Figure 1 Lifecycle greenhouse gas emission ranges for the assessed technologies



Carbon Neutrality through Technology Interplay

The UNECE Carbon Neutrality Toolkit is integrated approach looking at interplay of all low- and zero-carbon technologies.

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

Carbon Neutrality in the UNECE Region Technology Interplay under the Carbon Neutrality Concept



Reference scenario

without dedicated sustainable energy or climate policies.

Carbon Neutrality Scenario

Normative scenario to net zero

Special technology deep dives

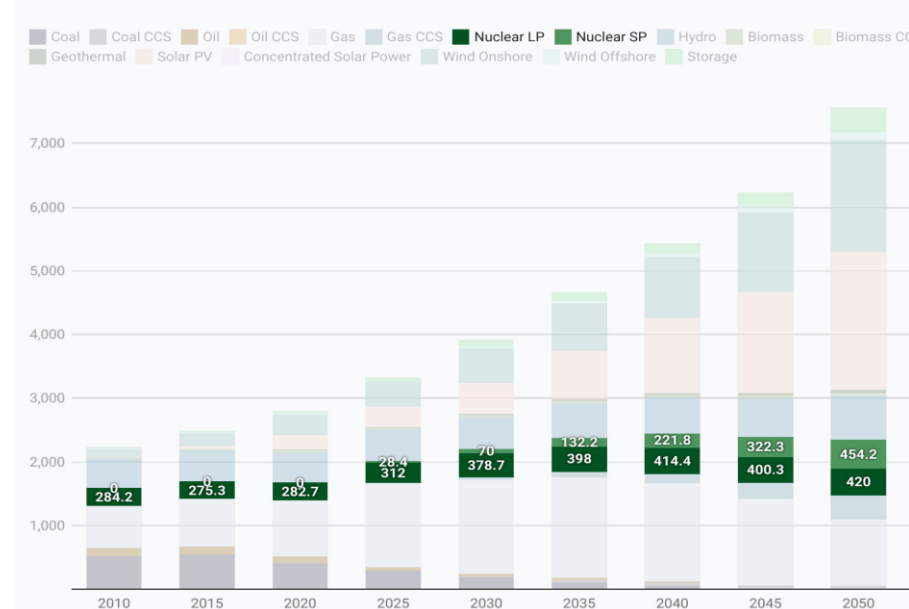
- **Hydrogen**
- **Carbon capture, utilization, and storage (CCUS)**, including direct air capture(DAC)
- **Nuclear energy** –realizing its potential, new application and markets

Carbon Neutrality Innovation Scenario

All three technology deep dives combined: synergies and benefits

For the UNECE region, the amount of generation from nuclear energy triples, with 6235 TWh (~30% supply), with 874 GWe of installed nuclear capacity, of which 450 GWe is projected to be SMRs, by 2050

Electricity Generation Mix [TWh] Carbon Neutrality Innovation Scenario



Key Takeaways – Carbon Neutrality Energy System



Diversify Energy

Diversify primary and final energy supply



Phase-Out Fossil Fuels

Accelerate phase-out of unabated fossil fuels



Electrification

Electrify all sectors through renewable energy and nuclear power



Innovate

Scale up innovative low- and zero-carbon technologies such as carbon capture, use and storage (CCUS), hydrogen and advanced nuclear power

The Harmony programme is a global initiative of the nuclear industry coordinated by World Nuclear Association.

Nuclear energy offers a golden opportunity to build a cleaner, more equitable world, in which everyone has access to clean abundant affordable energy and a high quality of life.

king.lee@world-nuclear.org

