

**WORLD NUCLEAR  
ASSOCIATION**

# **Nuclear and Renewables: Integrated Energy Systems**

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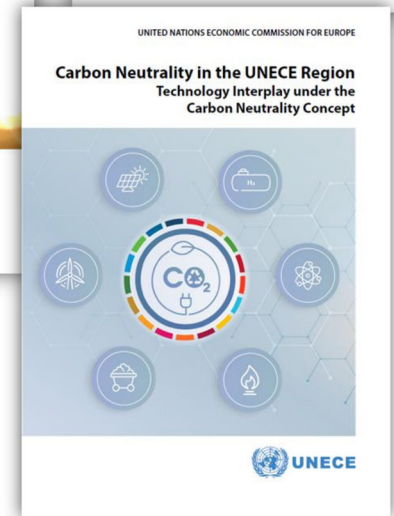
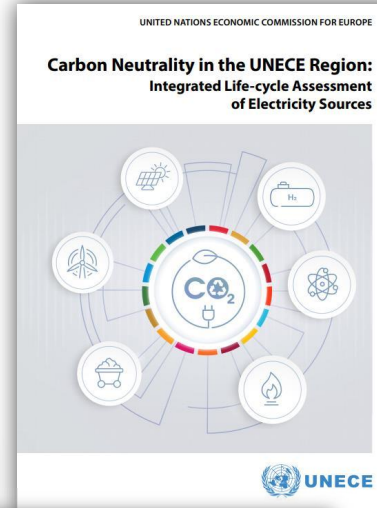
11-12 September 2023

# ■ ■ UNECE Carbon Neutrality Project

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



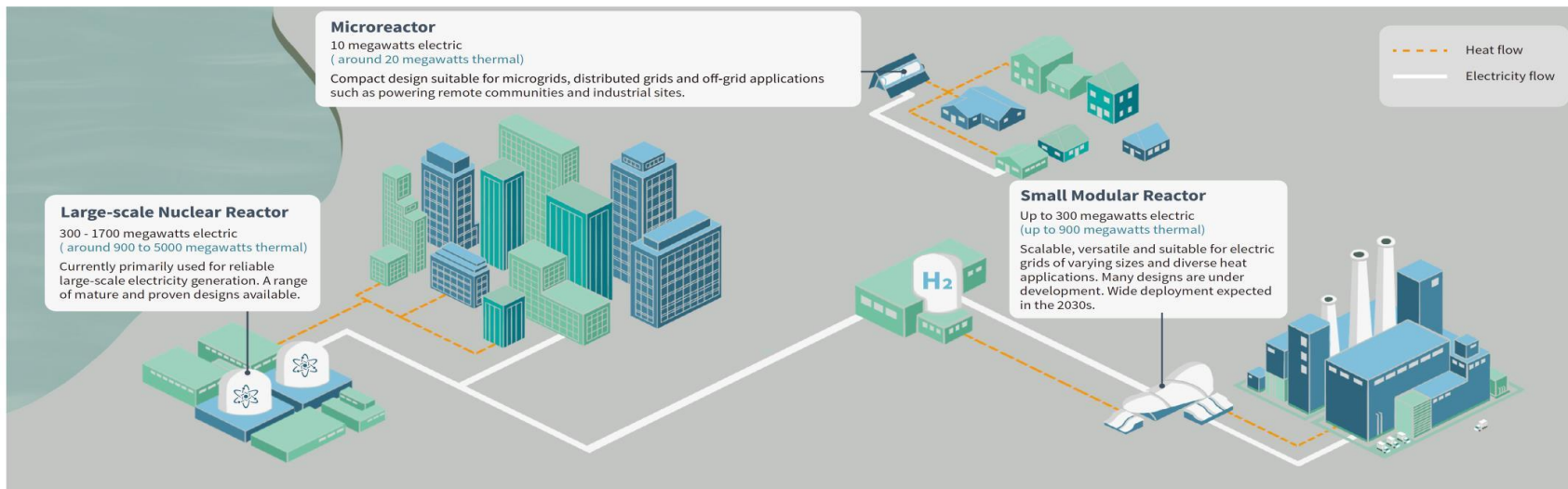
<https://carbonneutrality.unece.org/>



# UNECE Nuclear Power Brief

## 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 process:

- 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 instil confidence and facilitate the wider application of nuclear power to decarbonise electricity and energy intensive industries



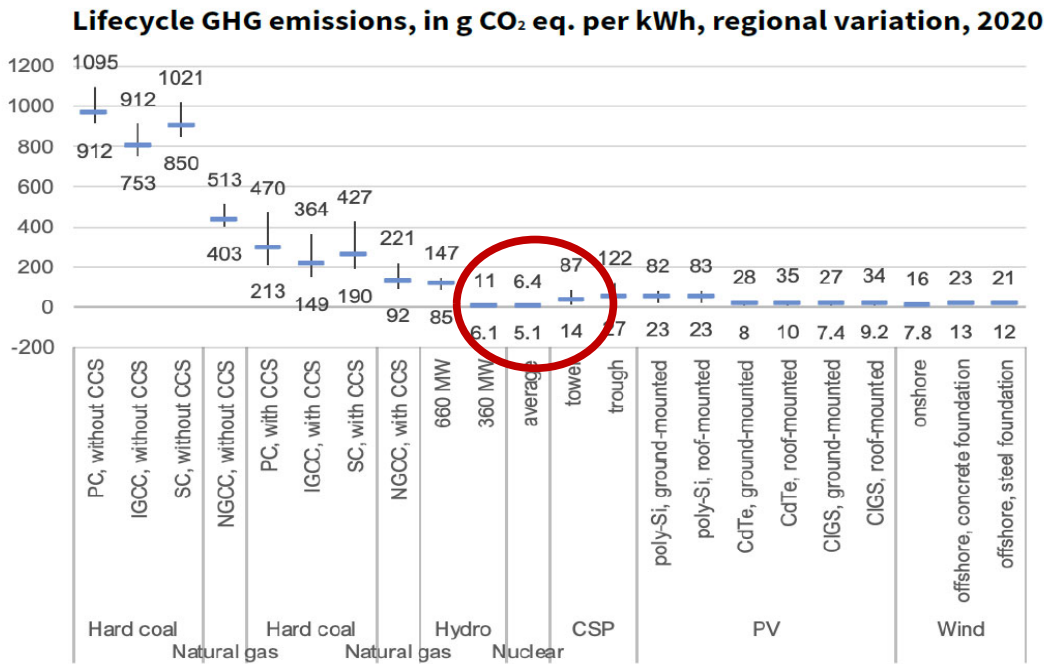
### Incentivising Finance

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

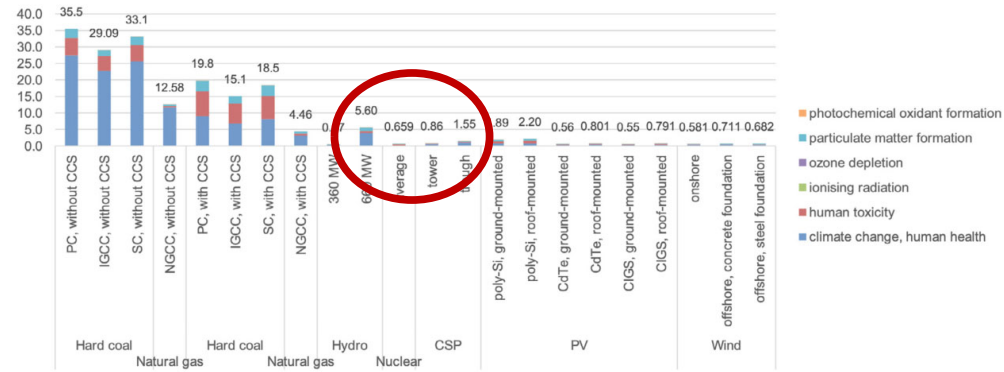
# Life Cycle Assessment – Energy Sources Sustainability

**Figure 50** Life cycle impacts on human health, in points, including climate change.  
 Note on unit: 1 point is equivalent to the impacts (in disability-adjusted life years, DALY) of 1 person (globally) over one year.

## Lifecycle greenhouse gas emission ranges for the assessed technologies

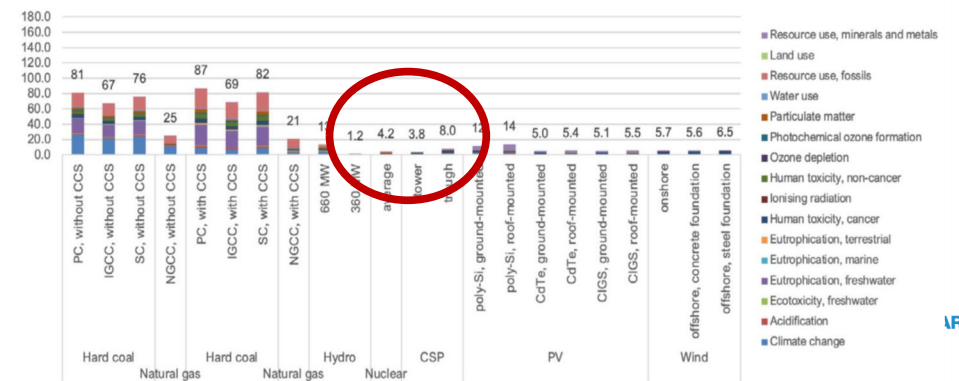


## Life cycle impacts on human health, per MWh, in points



**Figure 53** Normalised, weighted, environmental impacts of the generation of 1 TWh of electricity

## Normalised lifecycle impacts, weighted, of the production of 1 TWh, per technology, Europe, 2020





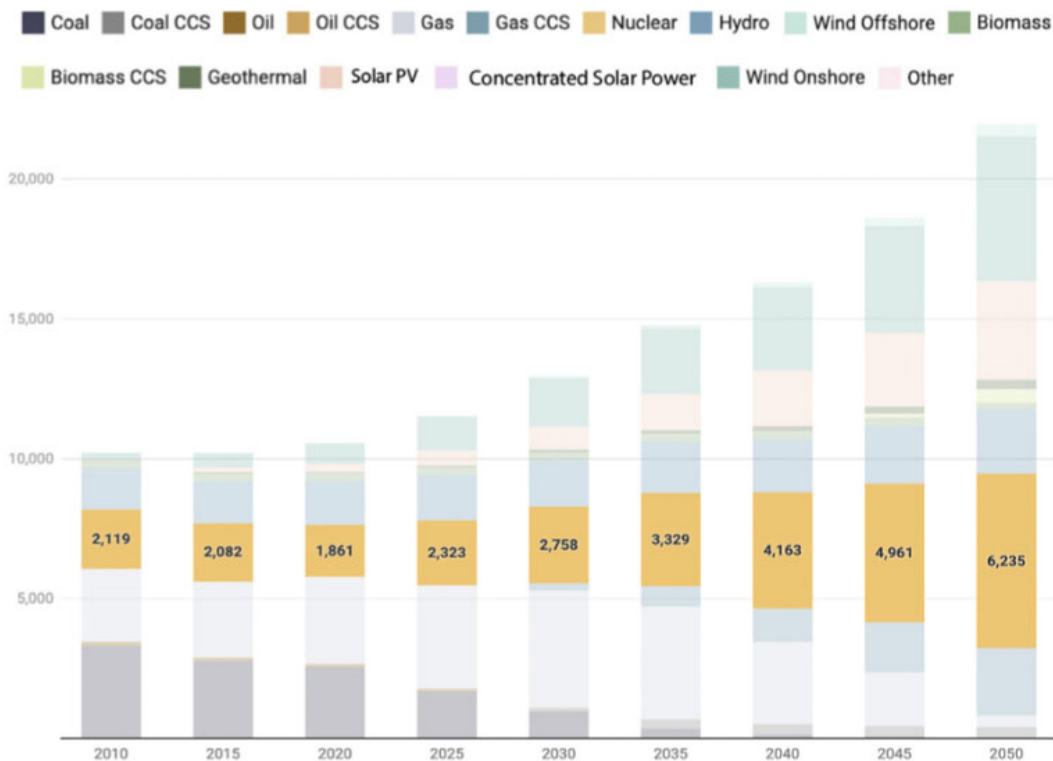
# Carbon Neutrality - Electricity Generation Mix

## Carbon Neutrality Innovation Scenario

For the UNECE region by 2050, the amount of generation from renewables increases by 6 folds (60% supply), and nuclear energy triples (~28% supply)

FIGURE 26

Electricity Generation Mix [TWh] Carbon Neutrality Innovation Scenario



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



# UNECE Carbon Neutrality Toolkit

## Key Takeaways



### 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

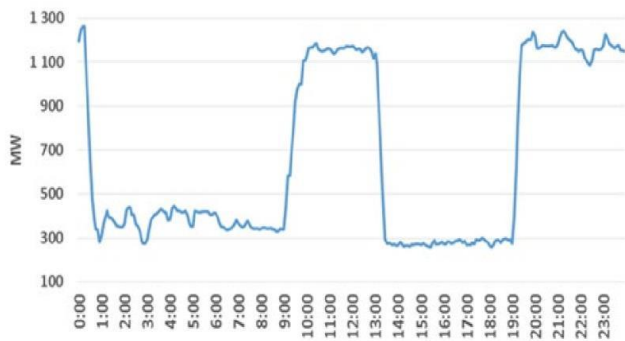


### Innovate

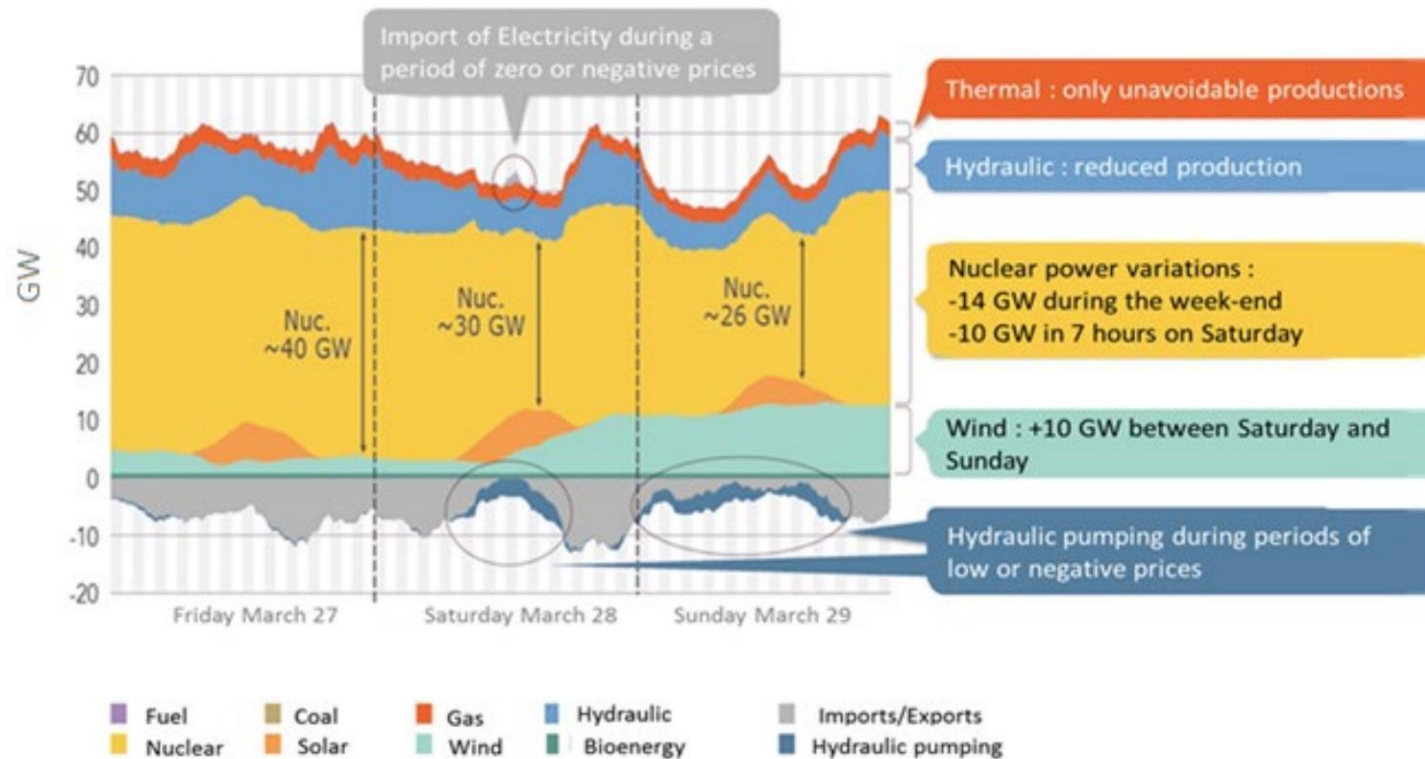
Scale up innovative low- and zero-carbon technologies such as carbon capture, use and storage (CCUS), hydrogen and advanced nuclear power

# Complementarity of Flexible Nuclear and Variable Renewables

**Nuclear Flexibility - Example of power variations over 1 day, Golfech 2 nuclear power plant, 1,300 MW**



France power mix between March 27 and March 29, 2020



Source: National Renewable Energy Laboratory 2020 Flexible Nuclear Energy for Clean Energy Systems

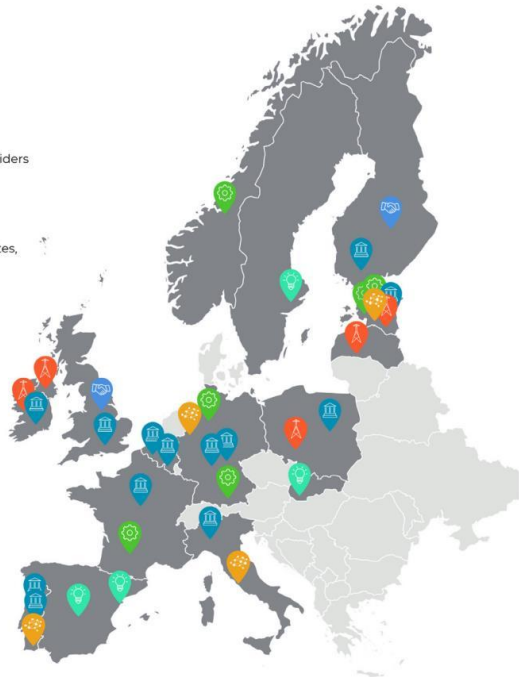


# Low-Carbon Resilient Power System

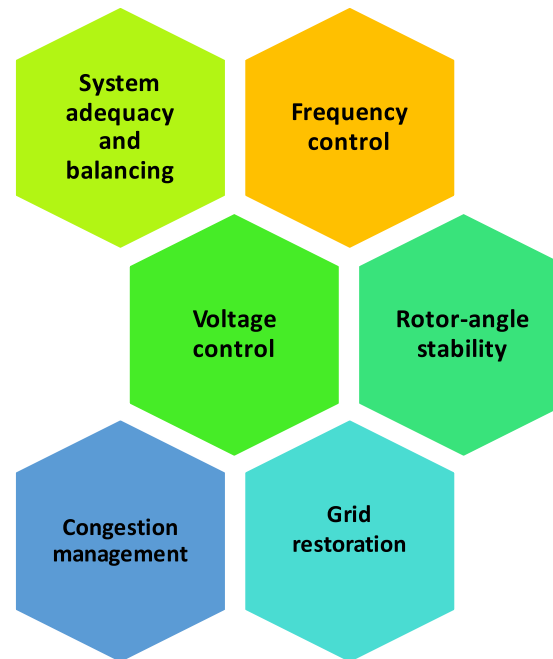


## EU-SysFlex

- TSO
- DSO
- Aggregators
- Technology providers
- Consultants
- Research institutes, universities



## Grid scarcities



### Findings:

As we transition to a European power system with a high share of variable renewables significant technical scarcities in flexibility appear.

Enhanced services will be required from a wide range of technologies in order to mitigate the identified technical scarcities and ensure the required system flexibility.





# Small Modular Reactors and Advanced Reactors – contributing to decarbonization of the entire economy



**Akademik Lomonosov KLT-40S**  
– Russia In operation  
(Co- Generation)



**Haiyang- China AP1000**  
In Operation (District Heating)



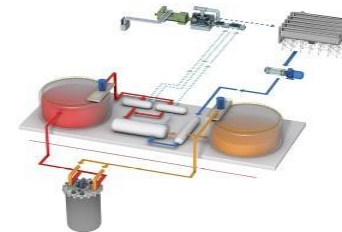
**Aurora/Oklo, US**  
1.5 MWe Heatpipe FNR  
Under Review



**HTR-PM, China, High Temperature Reactor**  
in operation



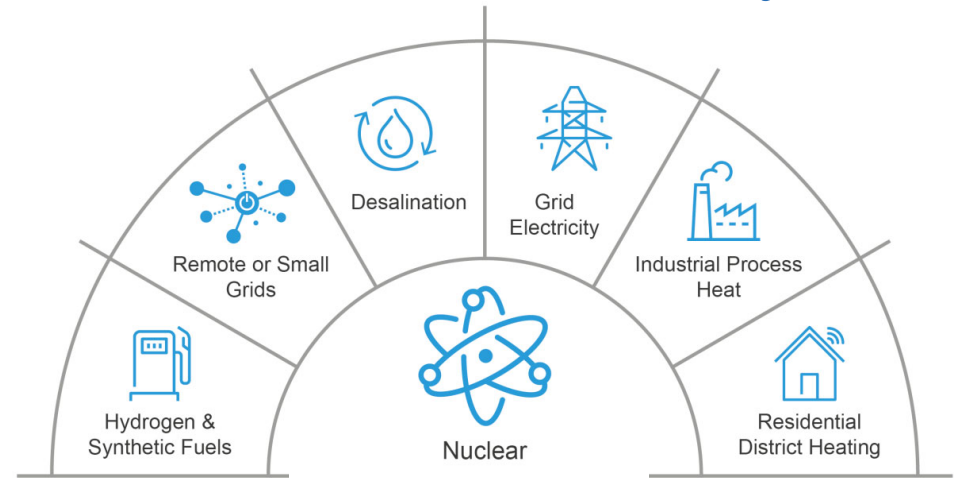
**Nine Mile Point, US,**  
In Operation  
hydrogen generation



**Natrium, US**  
Molten Salt storage,  
Under Development



**GEH BWRX300, US,**  
300 MWe BWR,  
Under Review



**WORLD NUCLEAR**  
ASSOCIATION

Helping the global nuclear industry  
deliver 24/7 clean energy for all

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