

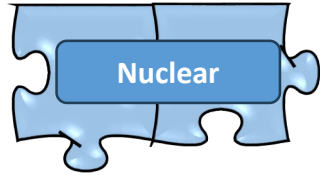
Climate Thursdays webinar, SDU, 04-10-2024

Solution to climate change:

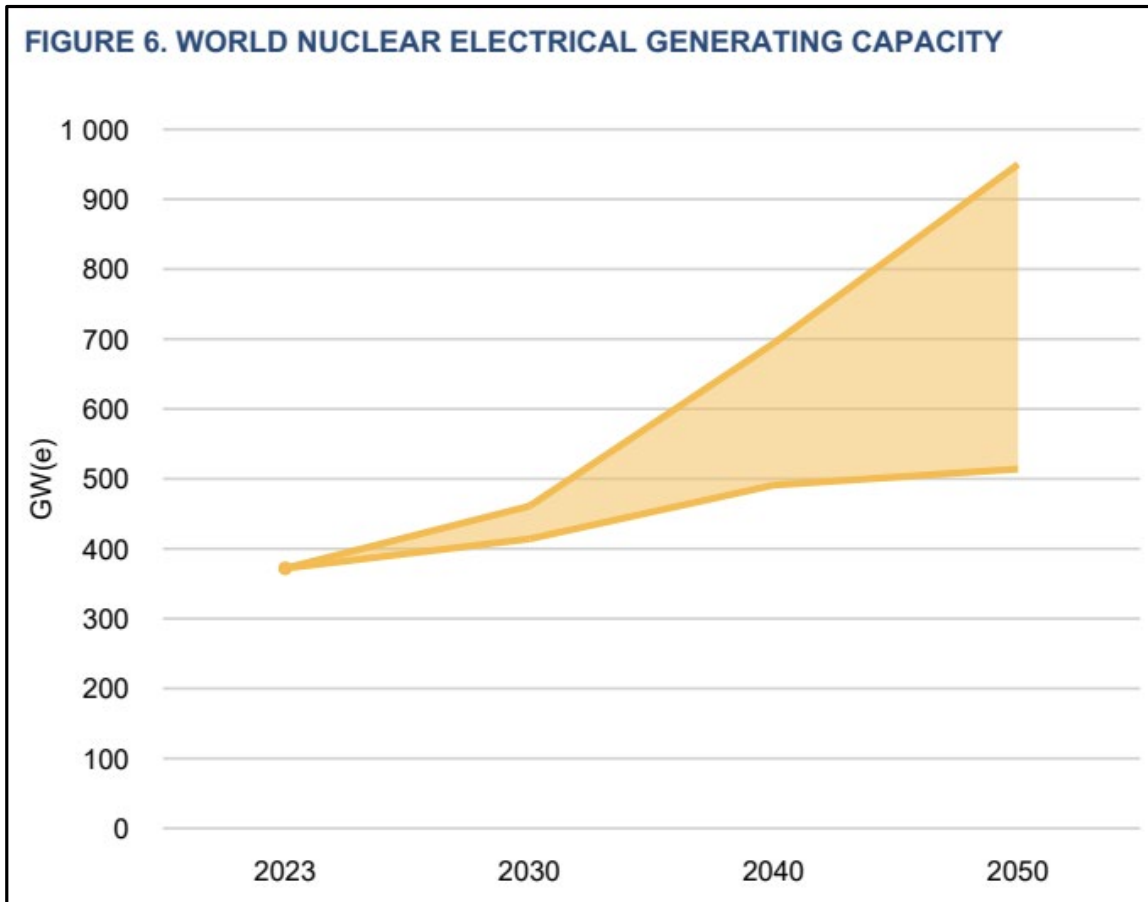
Status and perspectives of nuclear power as part of the Danish energy system?

Bent Lauritzen
Centre for Nuclear Energy Technology
DTU Physics

The role of nuclear in the future energy system



Expected increase in nuclear capacity, with 6 - 24% from SMRs



Source: IAEA 2024 (<https://doi.org/10.61092/iaea.e3qb-hsrr>)



New York Times, 02.12.2023



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POLICY ISSUES COUNTRIES & AREAS BUREAUS & OFFICES ABOUT

Home > Bureau of International Security and Nonproliferation > Remarks & Releases > Declaration to Triple Nuclear Energy

Declaration to Triple Nuclear Energy

OTHER RELEASE

BUREAU OF INTERNATIONAL SECURITY AND NONPROLIFERATION

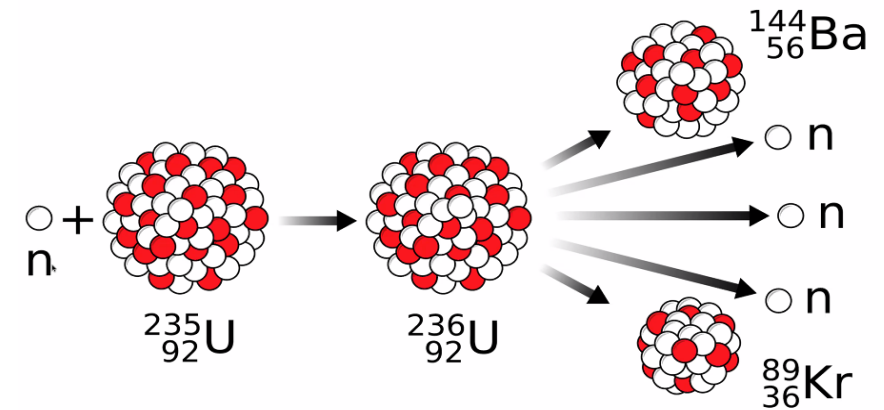
DECEMBER 2, 2023

Outline ...

Olkiluoto 3, Finland



- **Why nuclear ?**
- **Nuclear power technology**
 - **sustainability and outlook**
- **Nuclear power in Denmark?**



Why nuclear? (EU Parliament - STOA)

Drivers:

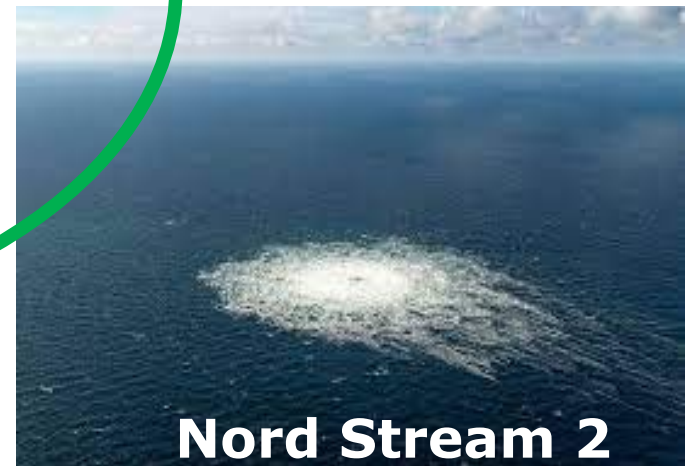
- Clean energy
- Secure energy
- Affordable energy

Need for (electricity):

- Dispatchable energy
- Scalable energy
- Zero carbon



Olkiluoto 3



Nord Stream 2

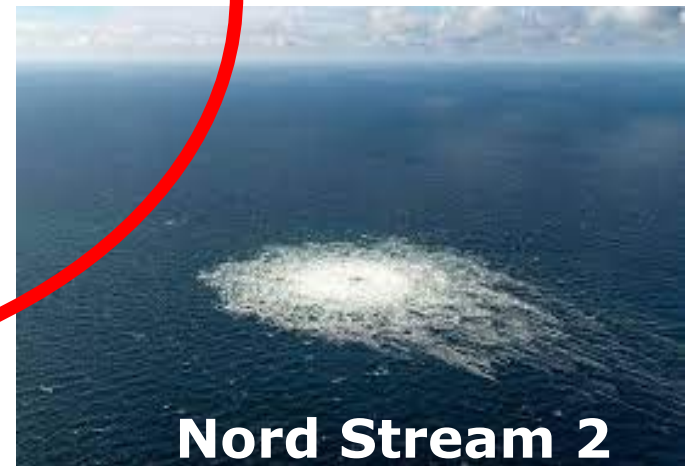
Why nuclear?

Nuclear gives:

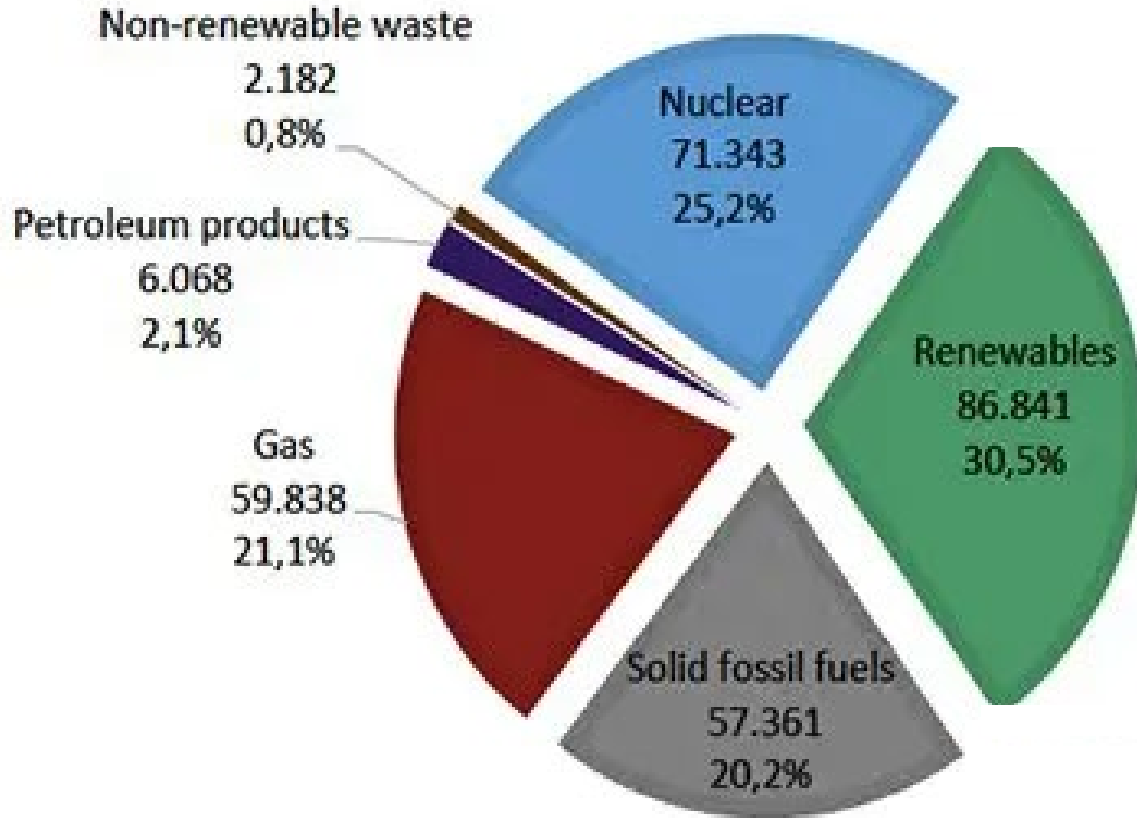
- Clean energy
- Security of supply
- Energy independence

European barriers:

- Public acceptance
- Lack of skills
- High unit costs
- Lack of innovation
- Regulations

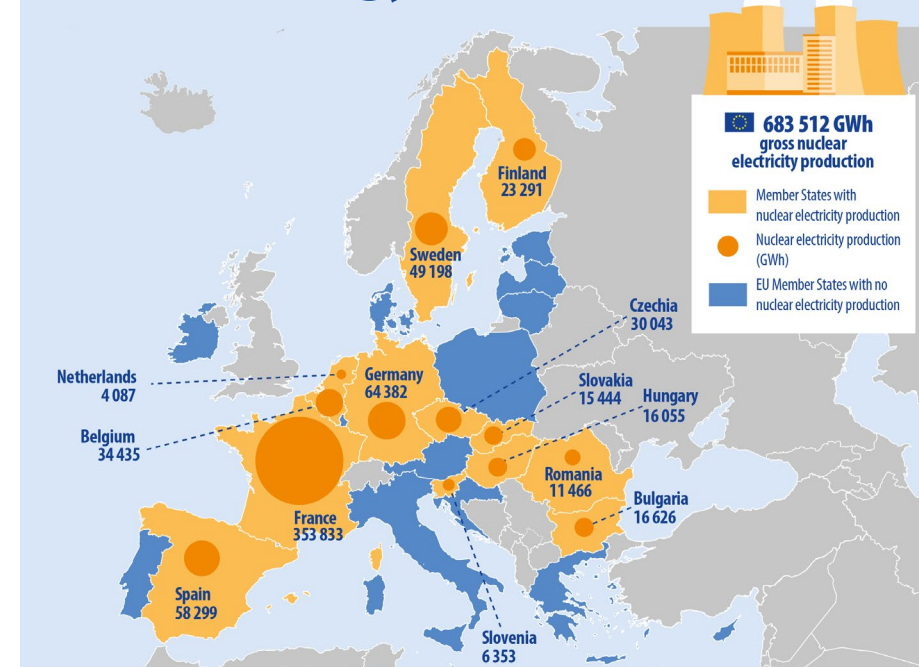


Electricity generation by source, EU



Source: Eurostat, 2017, 2020

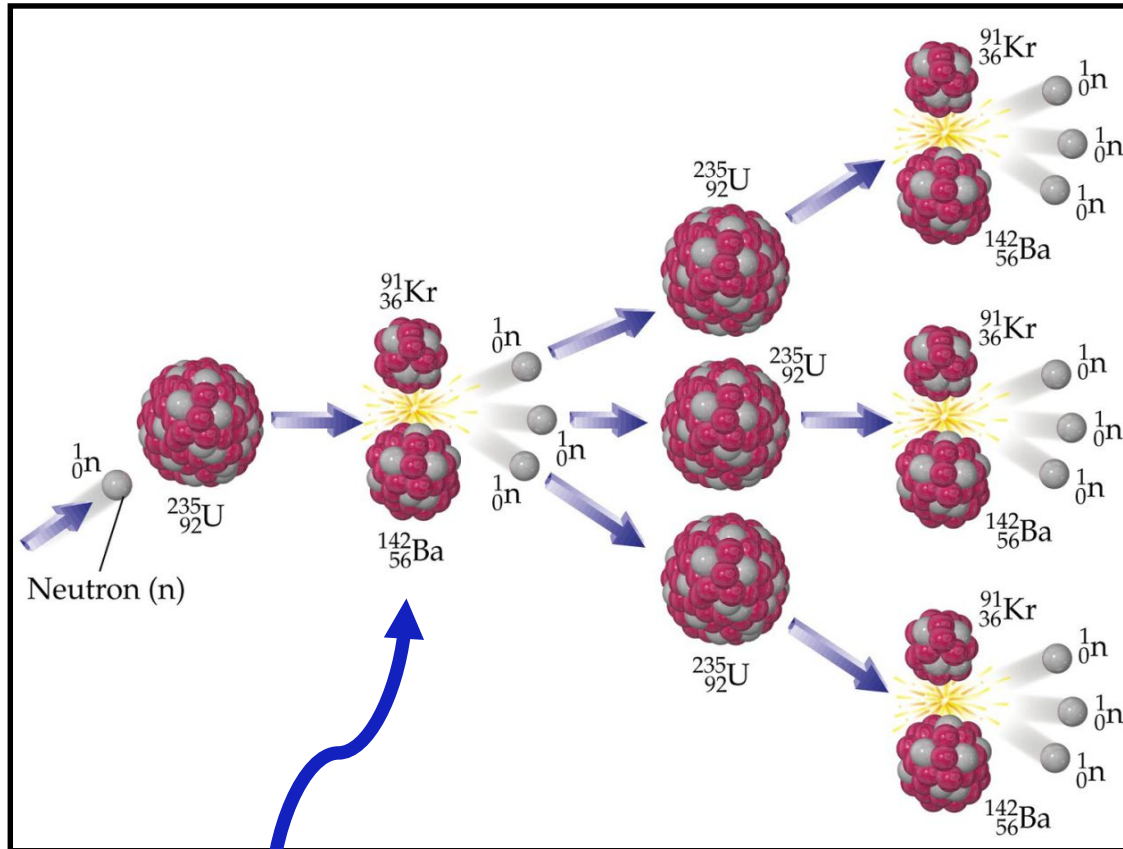
Nuclear energy in the EU, 2020



Nuclear and renewables have at least to double in order to replace fossil fuels

Nuclear power technology

Nuclear energy from splitting uranium

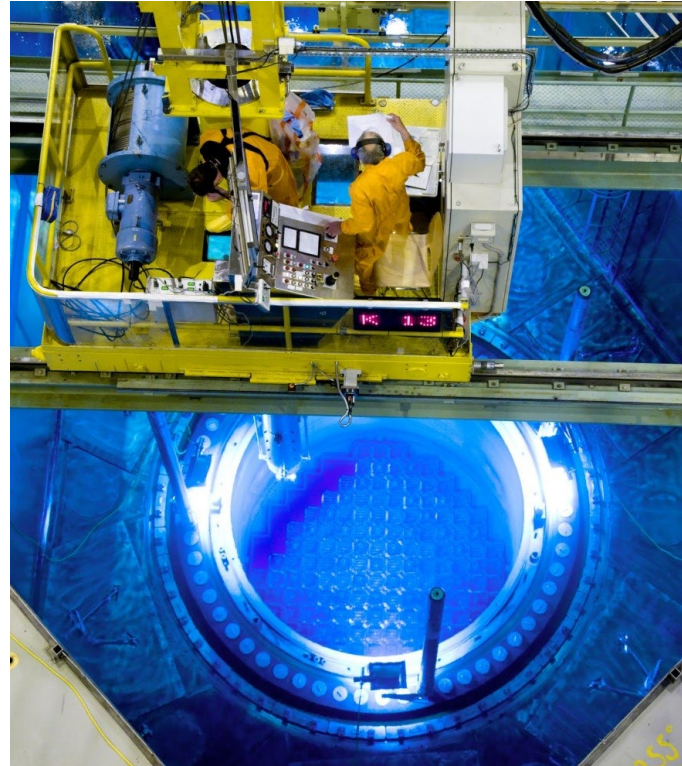


Radioactive fission products

Nuclear power characteristics:

- (Extremely) high energy density
- Abundant energy supply
- Radioactive fission products
- Cooling required at all times

Light Water Reactor (LWR)



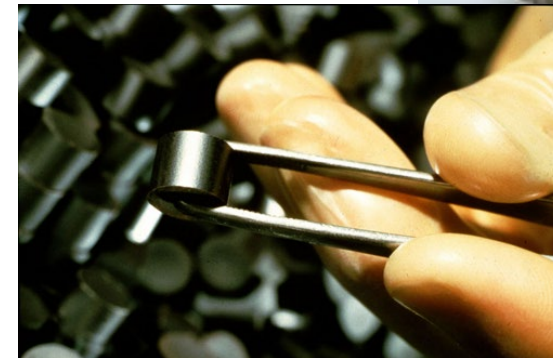
Refuelling a reactor.
Photo: Vattenfall



Ringhals NPP

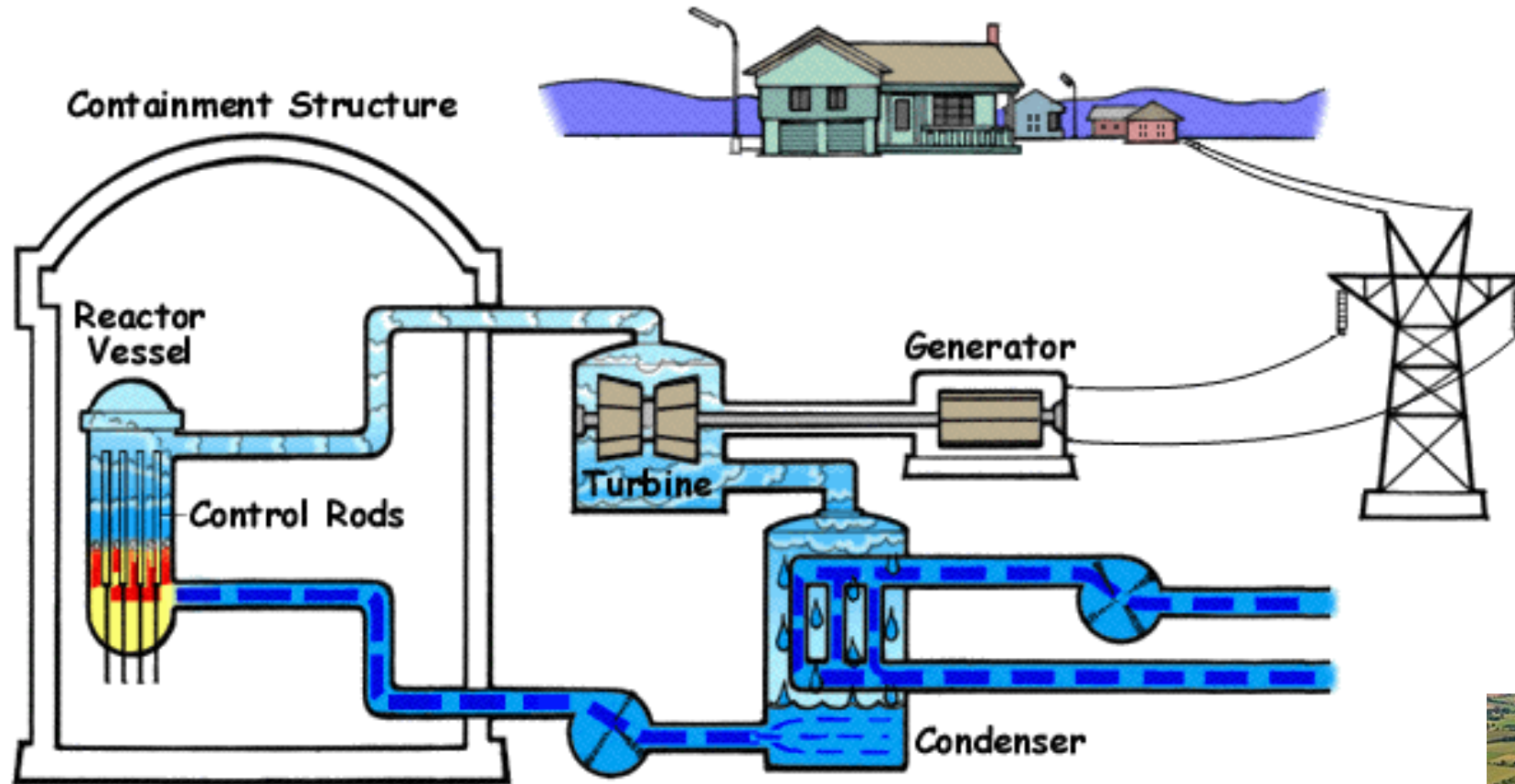


Uranium ore



UO₂ fuel pellet

Boiling Water Reactor - BWR



Nuclear power

– sustainability and outlook

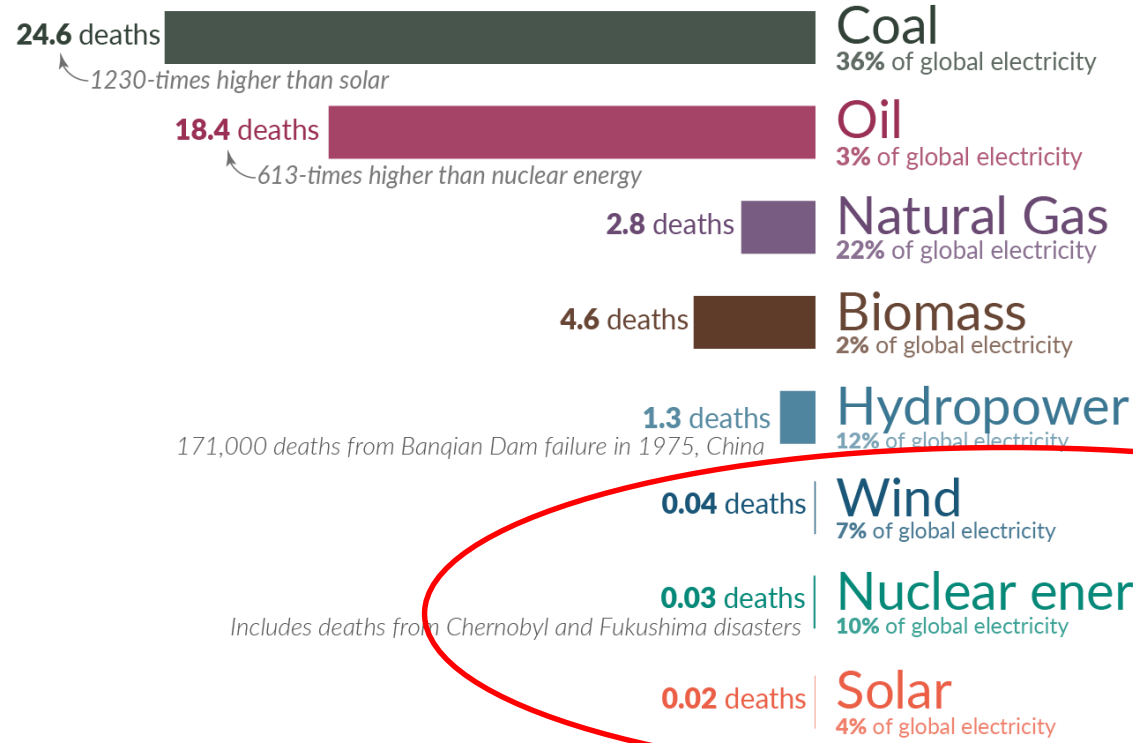
Provision of clean and safe energy

What are the **safest** and **cleanest** sources of energy?



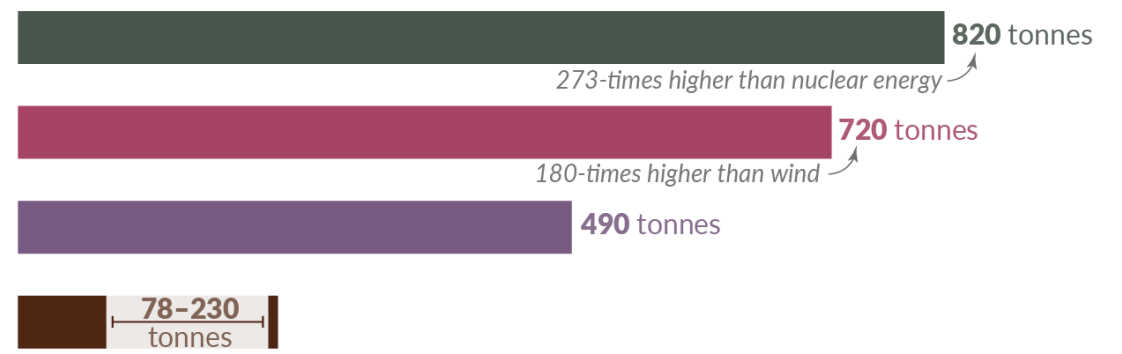
Death rate from accidents and air pollution

Measured as deaths per terawatt-hour of electricity production.
1 terawatt-hour is the annual electricity consumption of 150,000 people in the EU.

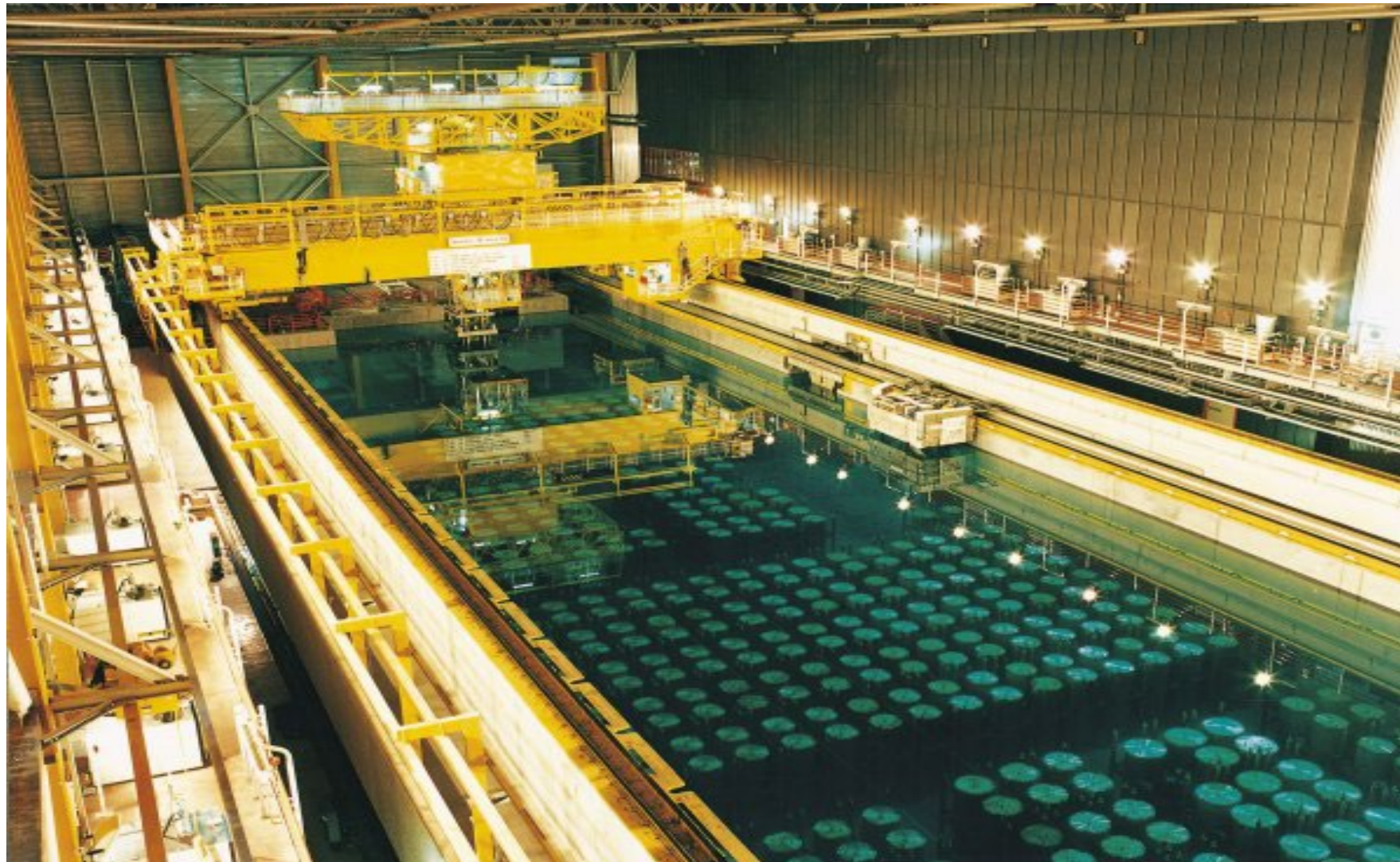


Greenhouse gas emissions

Measured in emissions of CO₂-equivalents per gigawatt-hour of electricity over the lifecycle of the power plant.
1 gigawatt-hour is the annual electricity consumption of 150 people in the EU.

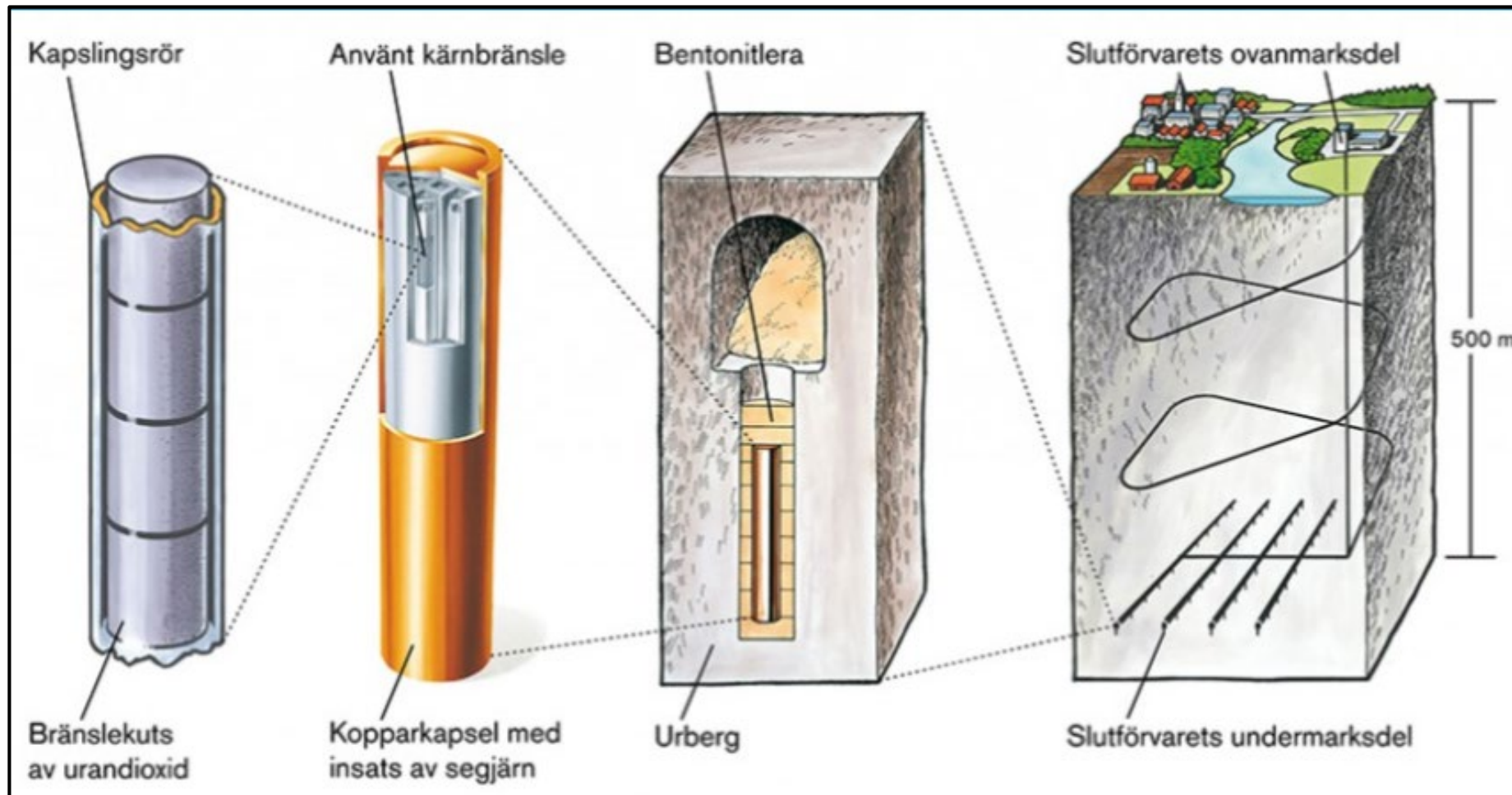


Radioactive waste management



Storage pond for used fuel at Sellafield, UK

SKB: Kärnbränsleförvaret



Source: SKB 2022: [Vår metod - SKB](#)

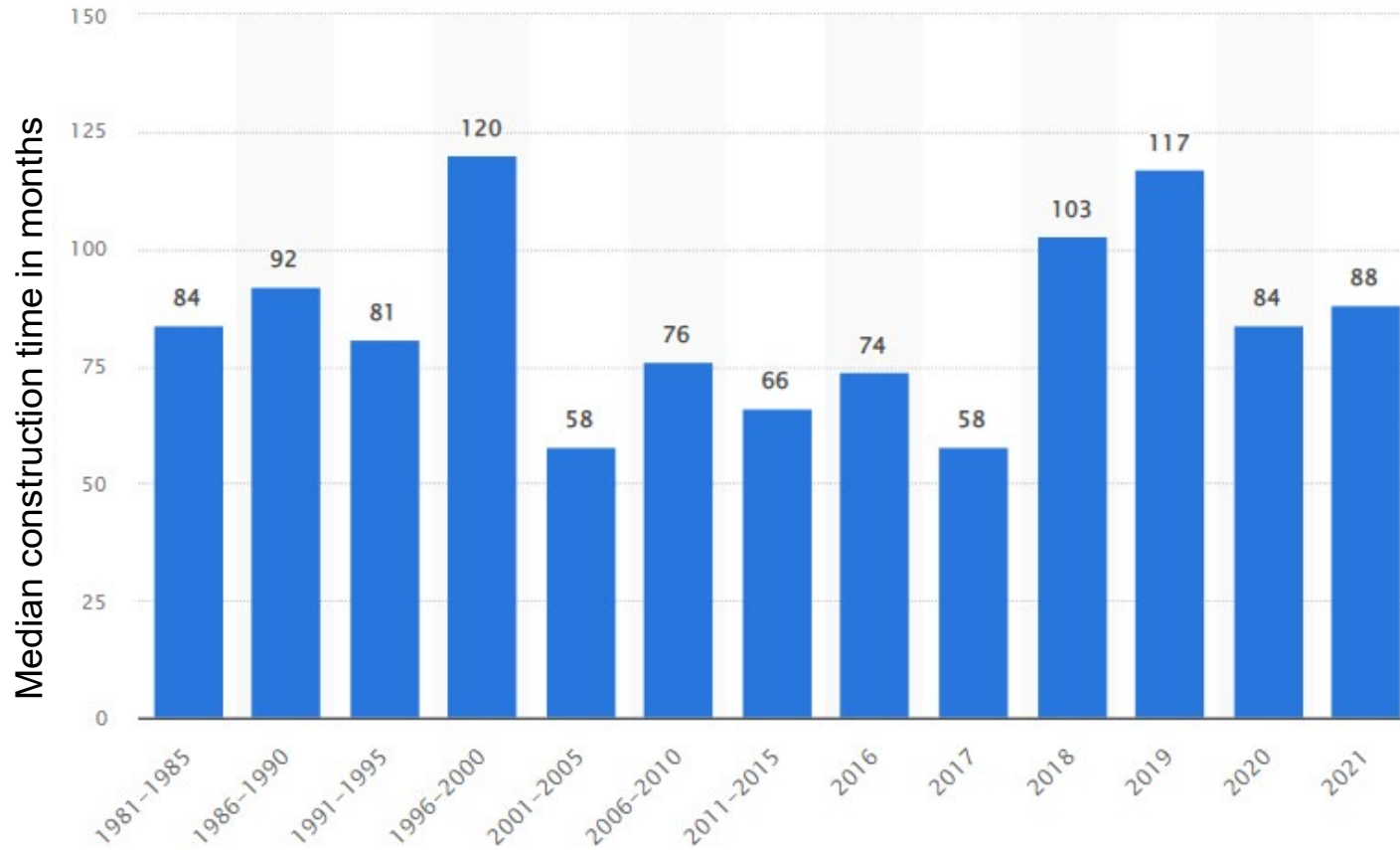
Costs of electricity production, with and without nuclear

Studie		Estimated cost WITH nuclear are Higher / Equal to / Lower than costs WITHOUT nuclear		
		Higher	Equal to	Lower
1	Pfenninger & Keirstead (2015)		X	
2	Brouwer et al. (2016)		X	X
3	Pattupara & Kannan (2016)			X
4	Buongiorno et al. (2018)			X
5	Sepulveda et al. (2018)			X
6	Cometto et al. (2019)			X
7	Van Zuijlen et al. (2019)		X	X
8	Zappa et al. (2019)		X	X
9	Kerkhoven et al. (2020)	X	X	
10	Kan et al. (2020)		X	X
11	Fattahi et al. (2022)		X	X
12	Scheepers (2022)			X
13	Veenstra et al. (2022)			X



Source: Raad voor de leefomgeving en infrastructuur, 2022

NPP construction time – in the world



Median construction time ~ 7 years

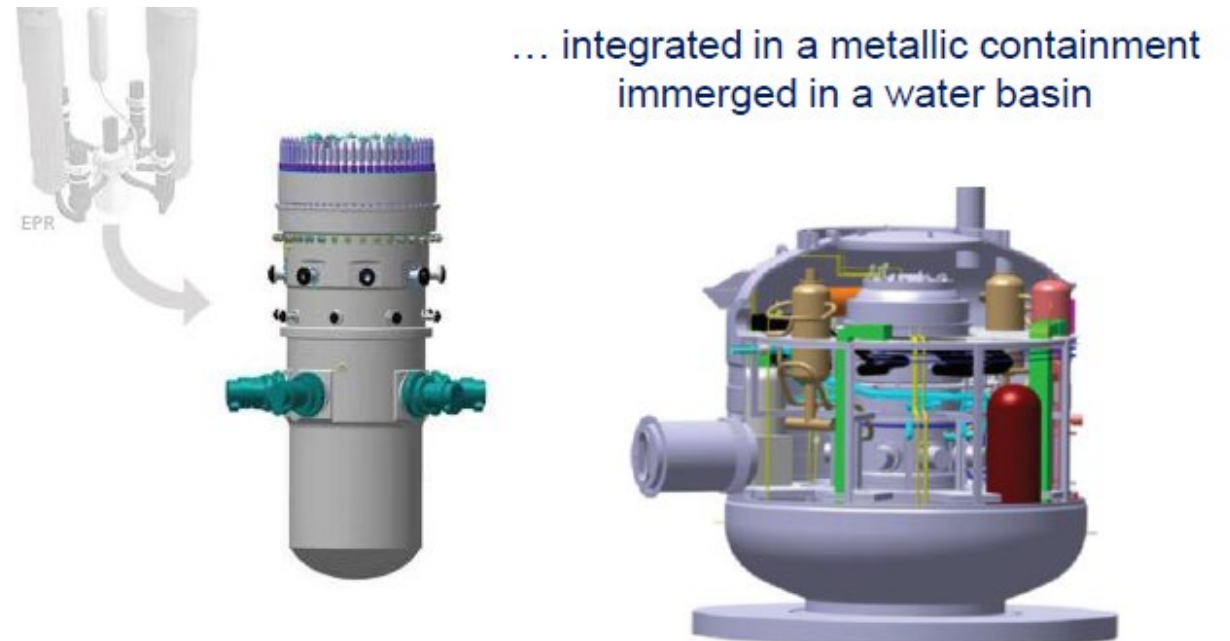
Improved economy

- Modular manufacturing
- Simple and safe designs
- Standardization and series production
- Single design approval

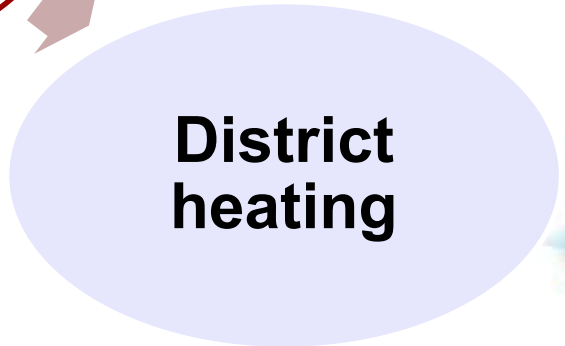
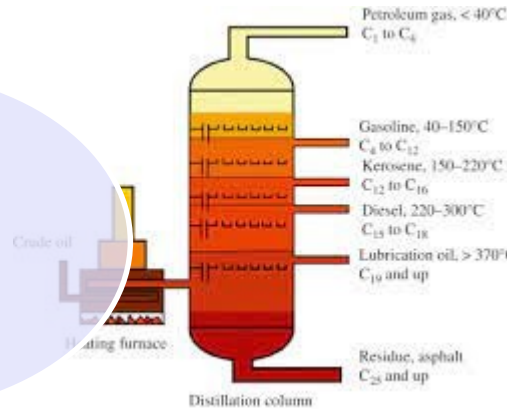
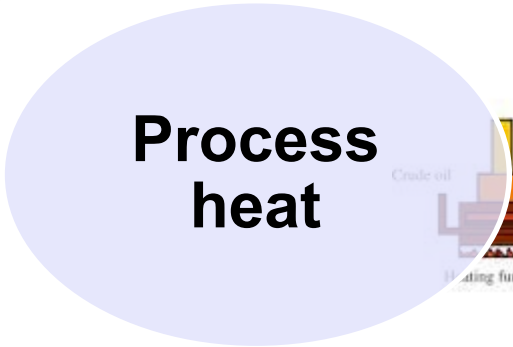
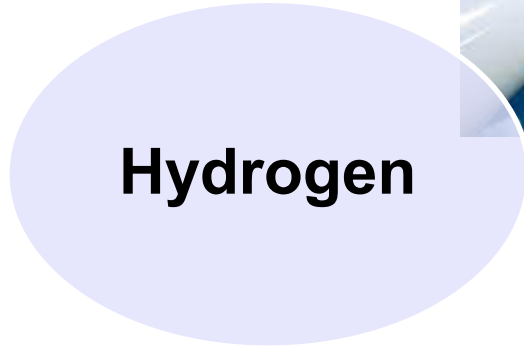
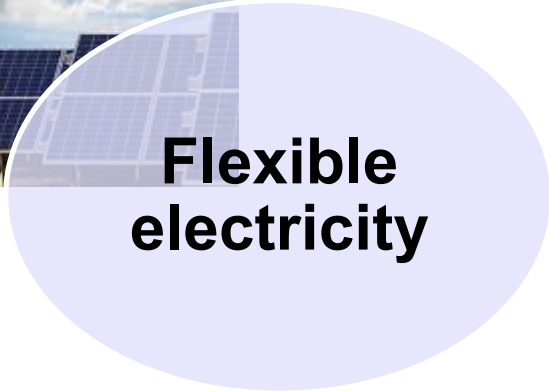
→ Reducing construction times and costs

French conceptual design (CEA/EDF)

NUWARD, 170 MW_e PWR



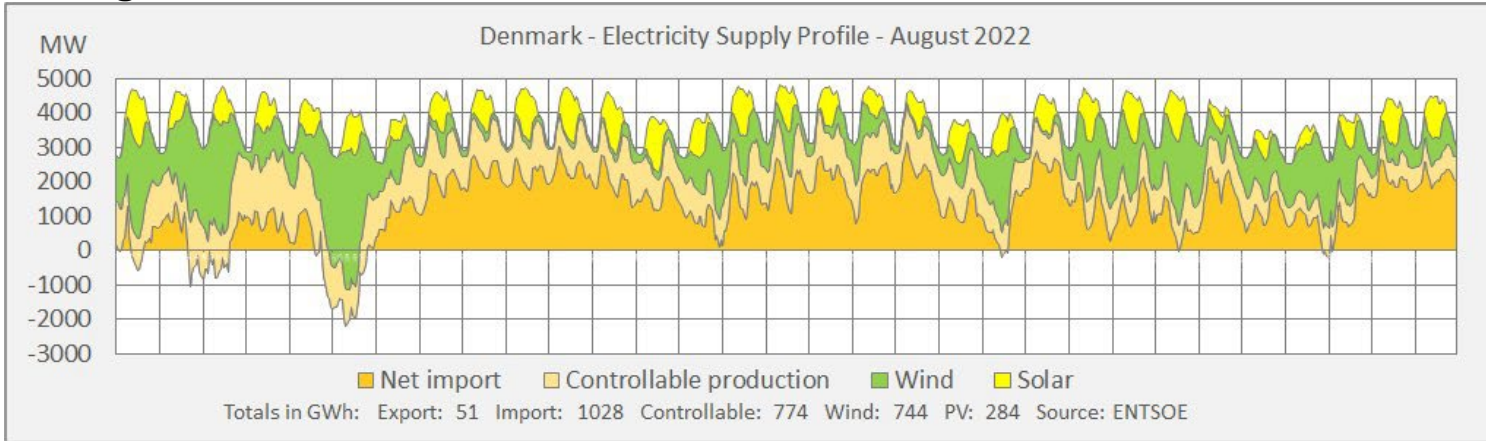
New applications of nuclear energy



Nuclear power in Denmark?

Danish electricity supply

August 2022

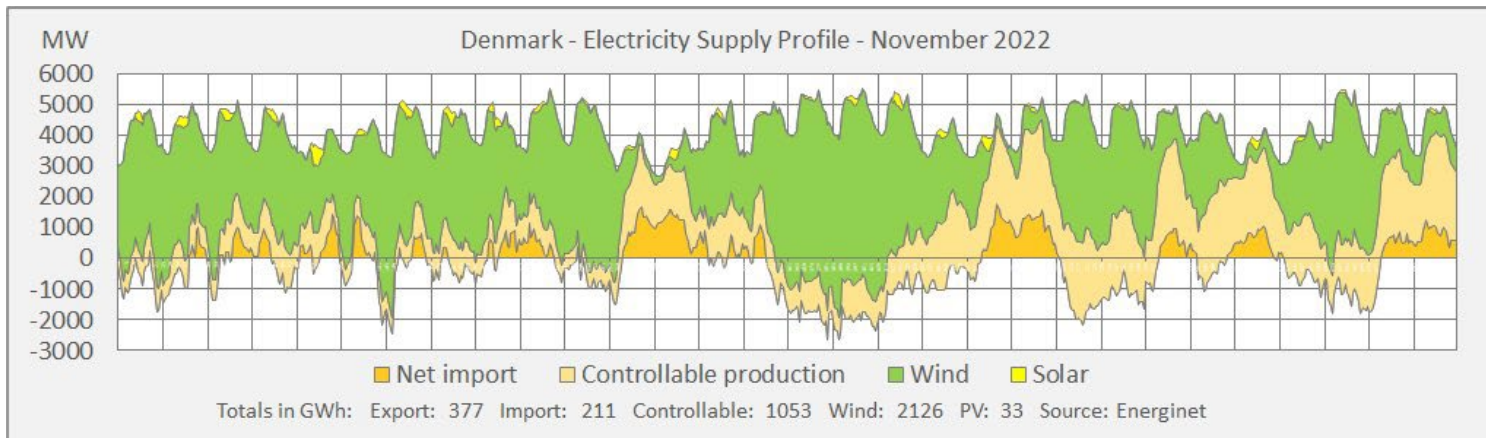


Need to balance weather-dependent wind and solar:

Large scale energy storage:

- Batteries
- Thermal, mechanical
- Chemical (P2X)

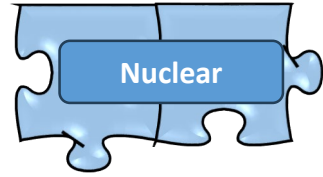
November 2022



Dispatchable production

- Biomass
- Hydropower (import)
- Gas turbines (fossil)
- Nuclear power

The role of nuclear in the future energy system



Benefits

- Security of supply
- Energy autonomy
- Low environ. impact

Perspectives

- New applications
- New technologies
- European industry

Challenges

- Public acceptance
- Radioactive waste
- Lack of skills

Uncertainties

- Decarbonizing ?
- Economy ?



Nord Stream 2



Thank you !