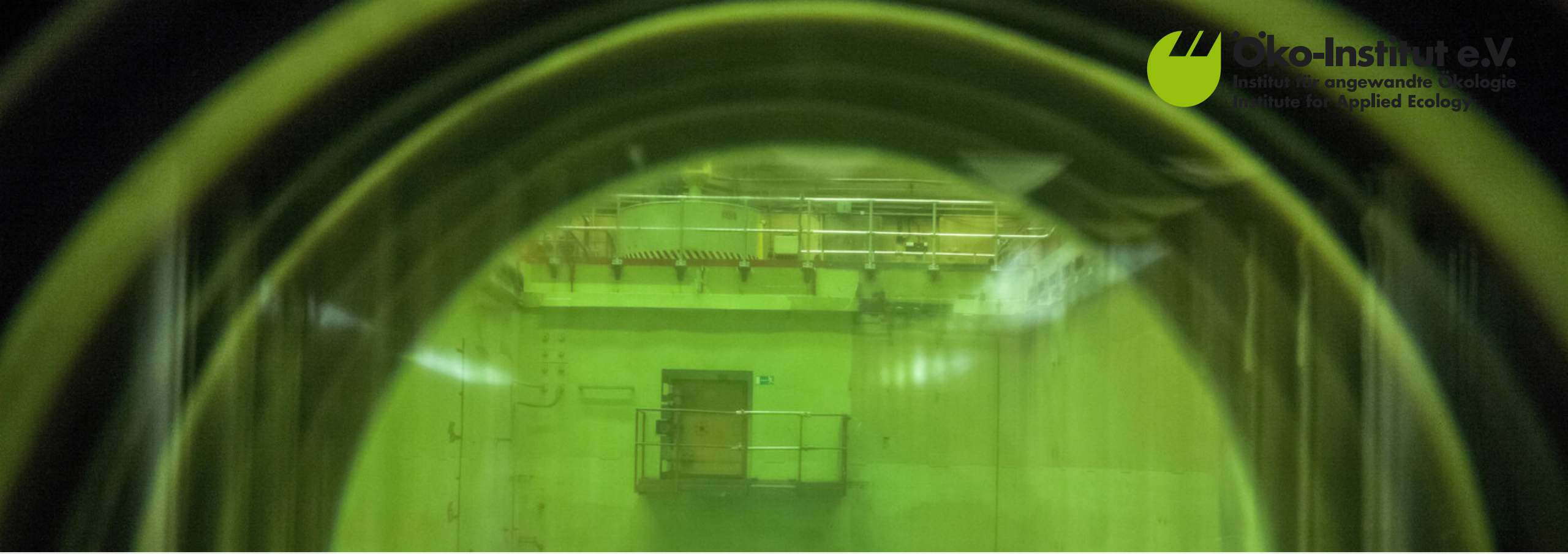

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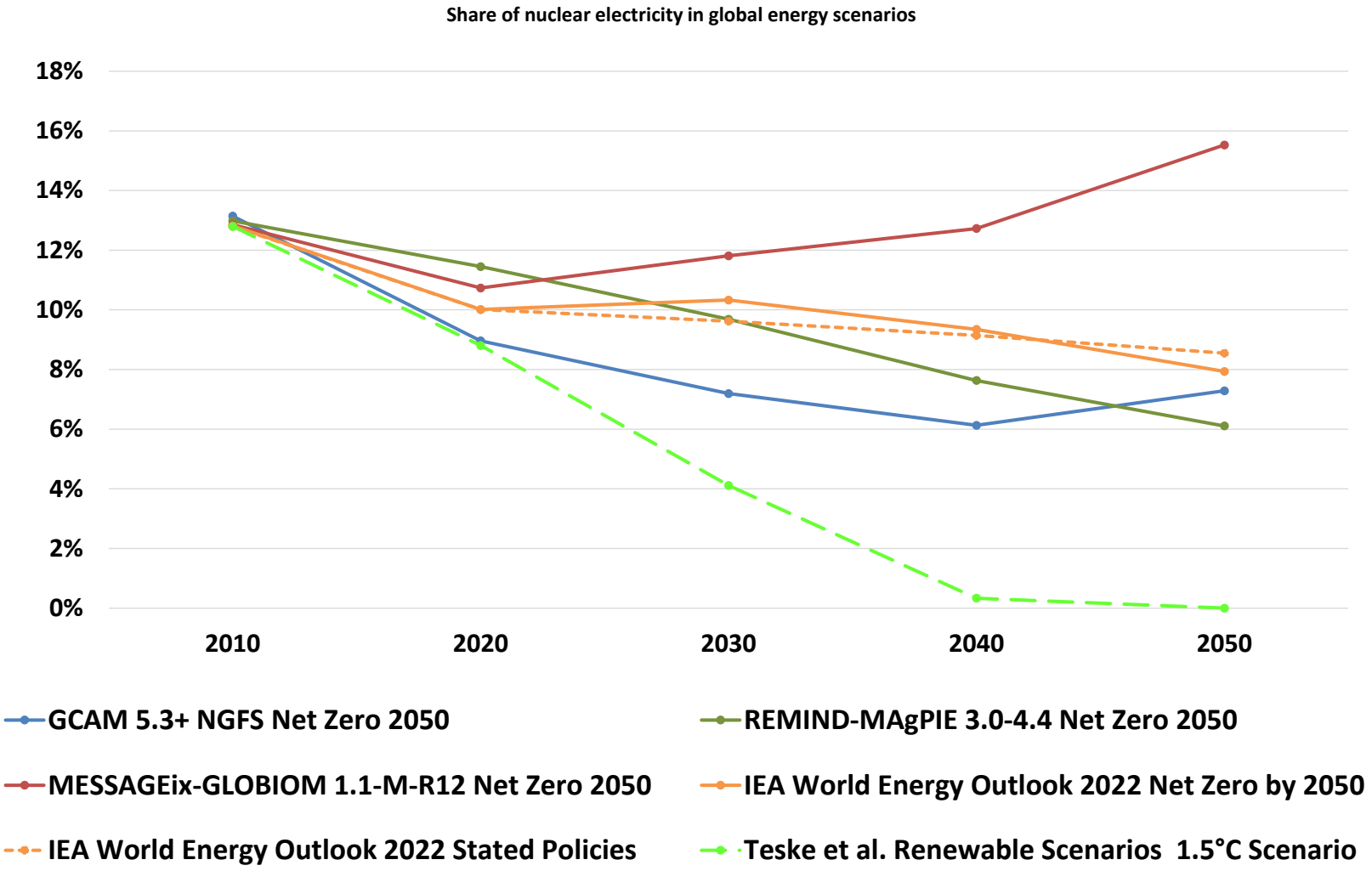
Scientific view on the role of nuclear energy in the energy transition

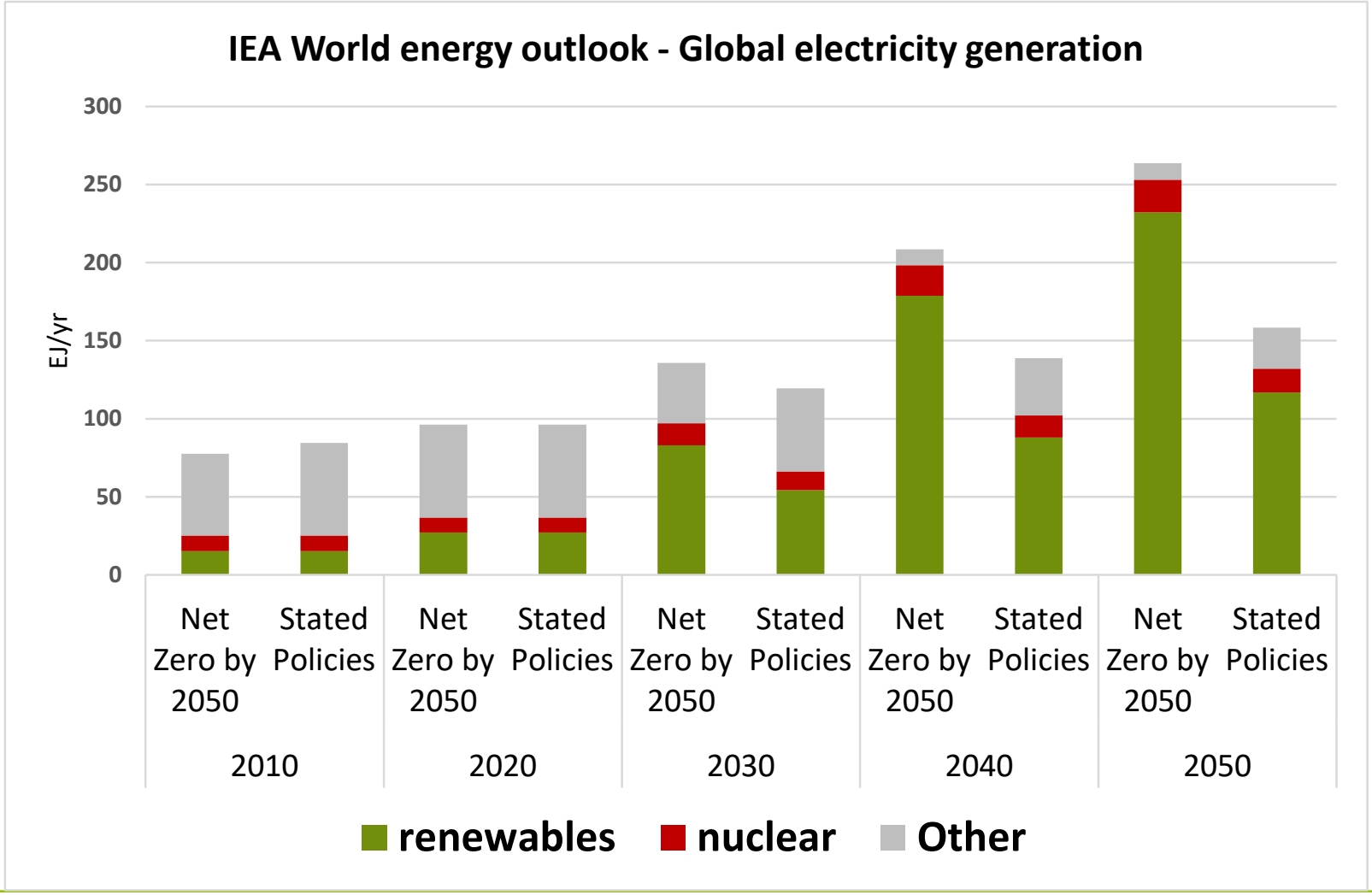
Anke Herold | Europe Calling | 20.04.2023

Share of nuclear electricity generation in total electricity production in global net-zero energy scenarios



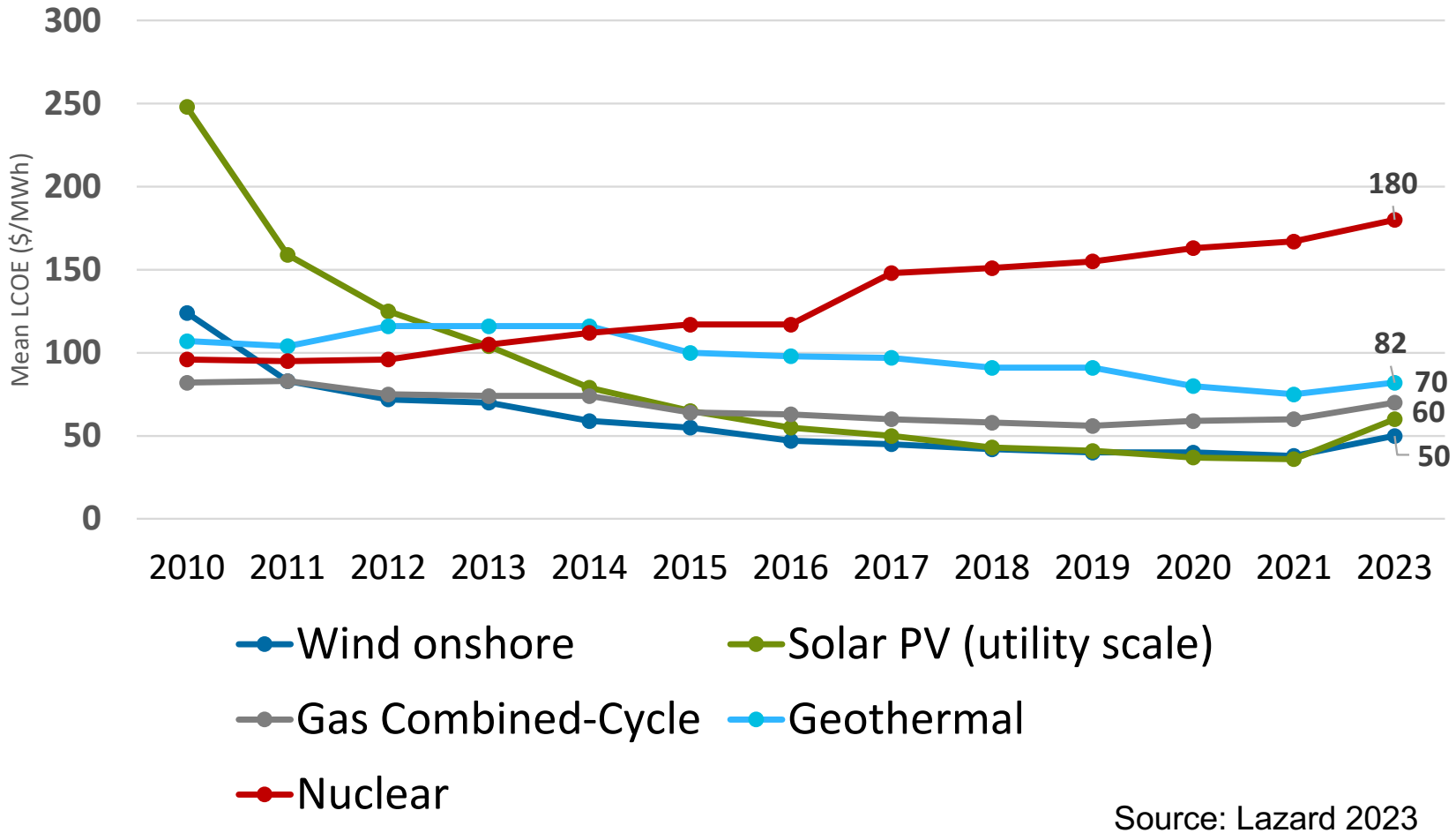
- Share of nuclear electricity in total electricity declining in most scenarios
- Existing nuclear policies & programmes of governments do not match ambition of additional nuclear construction in net-zero scenarios like IEA Net Zero by 2050

Role of renewables and nuclear in IEA World Energy Outlook scenarios



2050:
Share of nuclear: 8-10%
Share of renewables: 75-88%

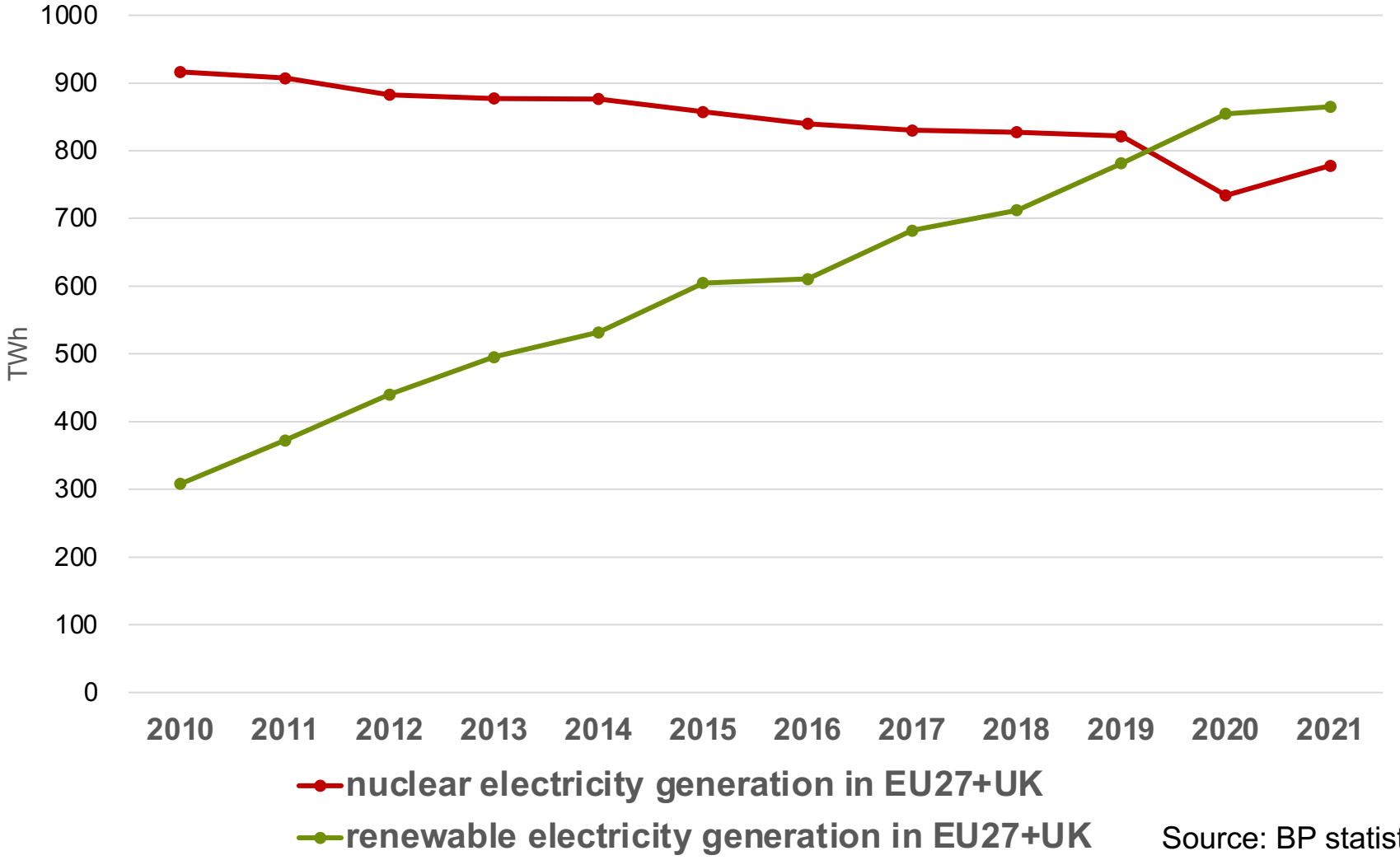
Cost development of renewable and nuclear electricity generation



- nuclear 3.6 times more expensive than wind onshore
- nuclear 3 times more expensive than solar PV

- Impacts of US Inflation Reduction Act:
  Nuclear
  US$ 30 billion
  Renewables & batteries:
  US$ 127-265 billion
- US funding support will further reduce renewable costs but not significantly contribute to lower costs for nuclear

Trends in nuclear and renewable electricity generation in EU



Source: BP statistical review of world energy 2022

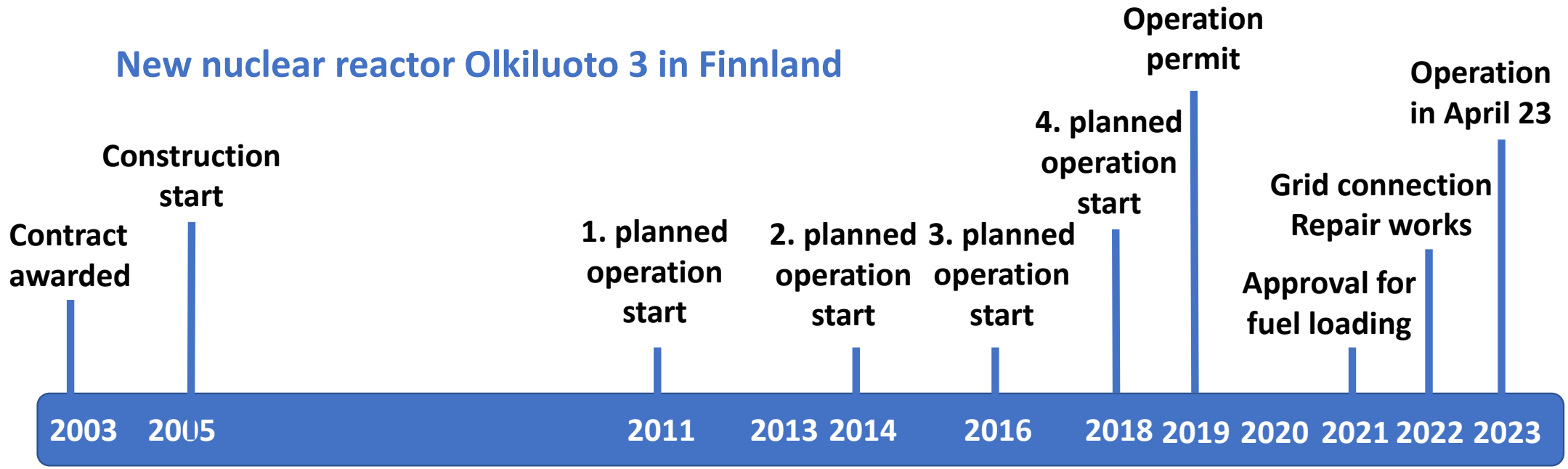
Construction periods of new nuclear plants in EU

Finland: Olkiluato 3 duration of 20 years

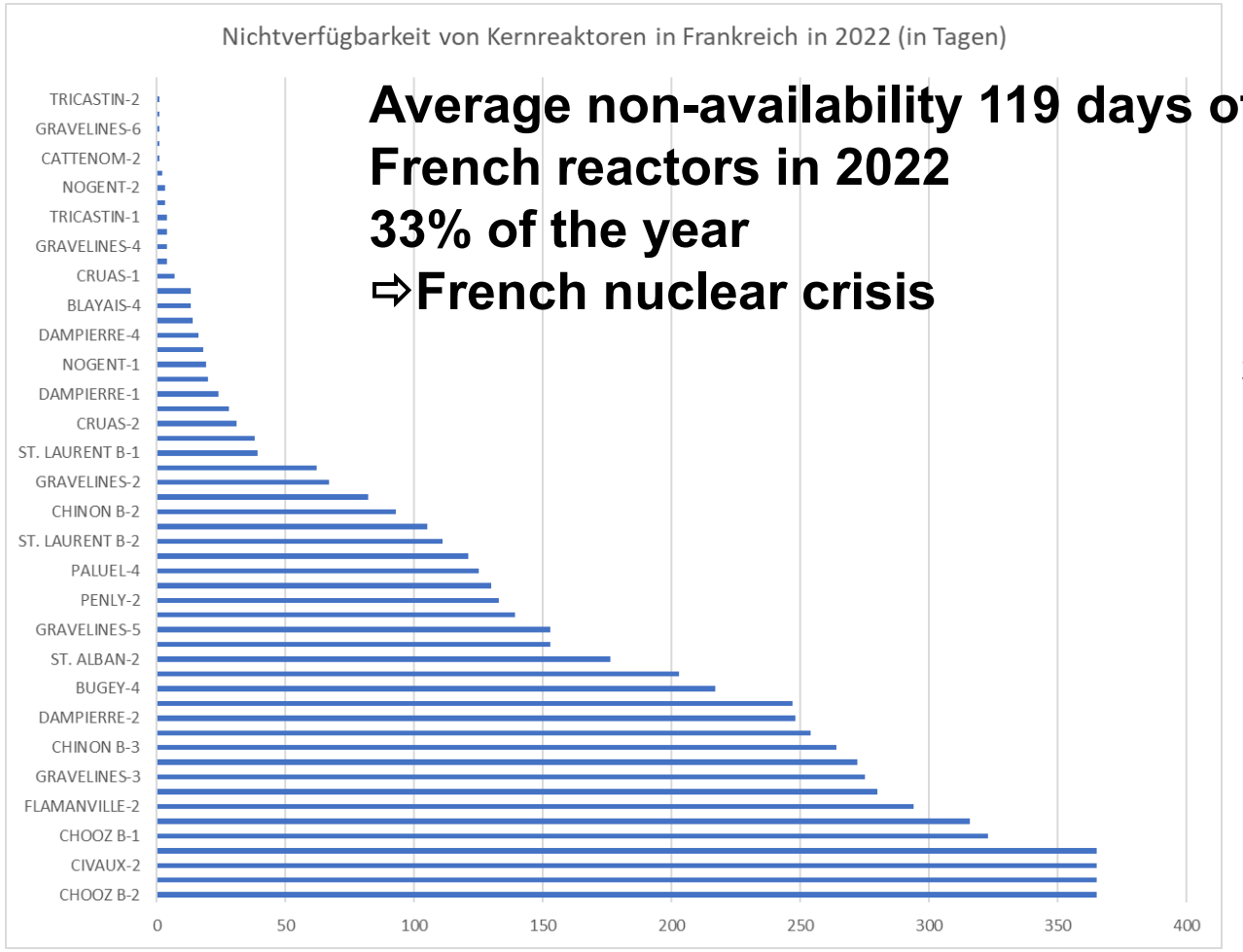
UK: Hinkley Point C approval in 2013, planned operation start in 2023, currently delayed to 2028
⇨minimum 15 years?

France: Flamanville 3 decision in 2005, operation not yet started, planned for mid-2023 ⇨18 years?

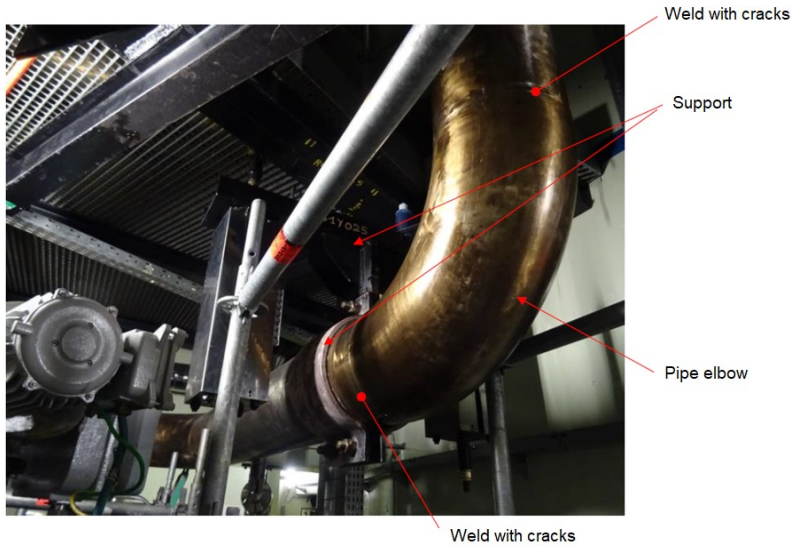
US: Vogtle-3 and 4: 2008 contract awarded, planned operation 2017/2018, one unit started operation in April 2023, 2nd unit planned for end of 2023 ⇨15 years



Non-availability of reactors in France in 2022



Average non-availability 119 days of French reactors in 2022
33% of the year
⇨French nuclear crisis



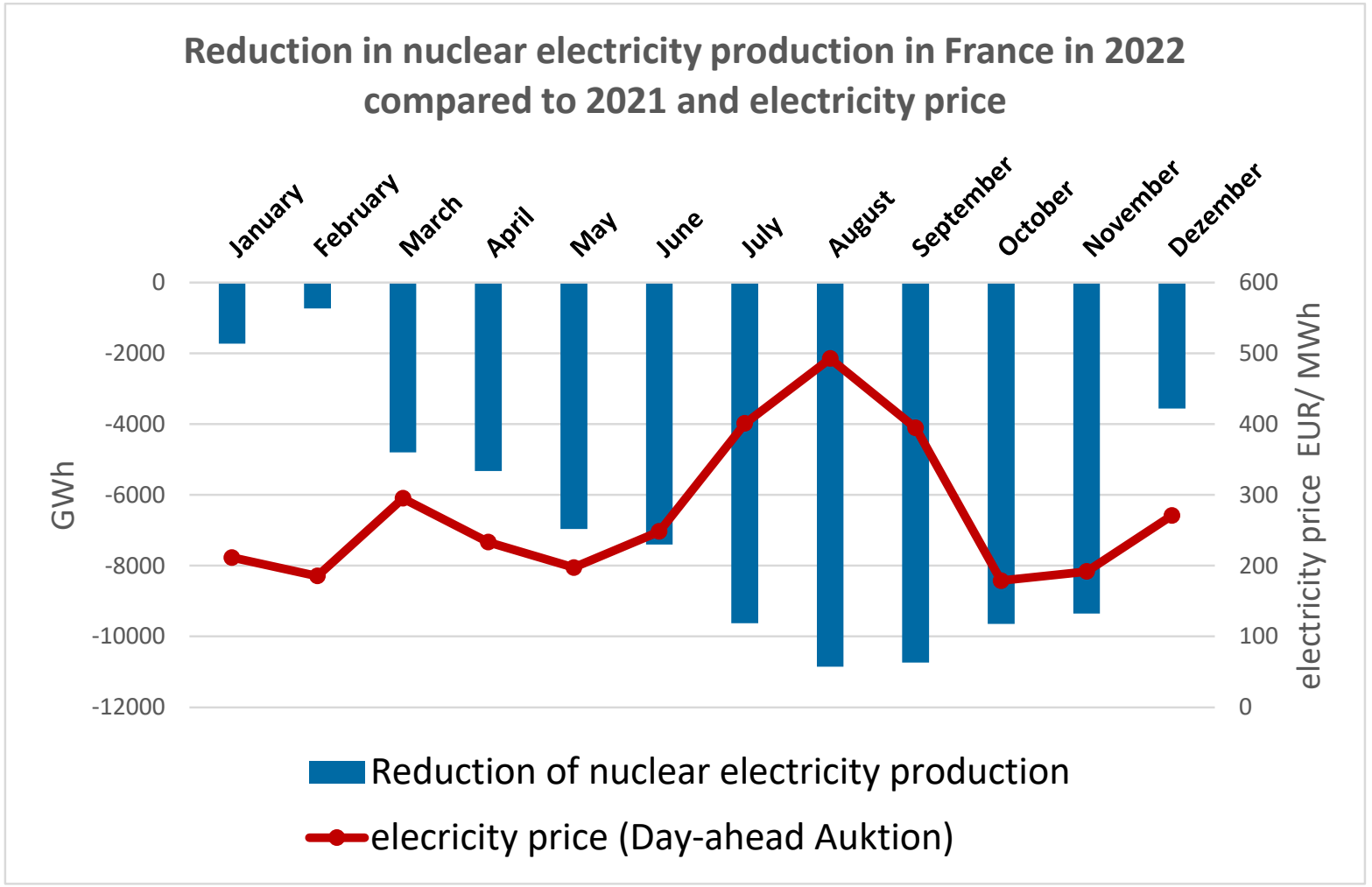
32 out of 56 nuclear reactors shut down

- 16 of the newest reactors due to corrosion and cracks in pipes of the main cooling circuit
- Remaining reactors due to planned maintenance works
- In summer due to draught & heat conditions

Average non-availability in previous years

- 2021: 103 days per reactor
- 2020:115 days per reactor
- 2019: 96 days per reactor

Nuclear production gap in France contributed to very high electricity prices in Europe in 2022

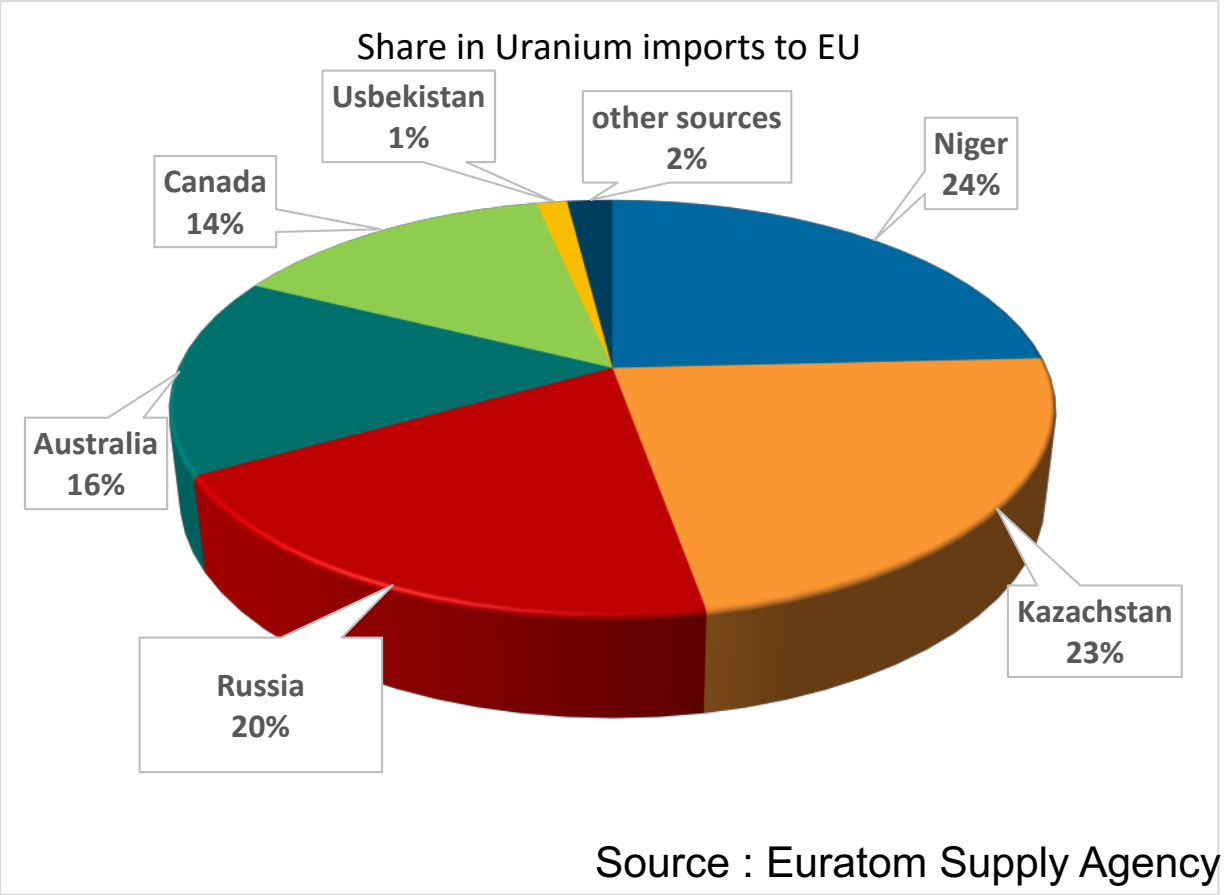


Increased production and export in Germany to France

What to expect for 2023?

- EDF announced to halt 10 reactors due to corrosion in 2023
- At least 10 reactors in 10-year maintenance and safety assessment in 2023
- Problems will continue

Countries of origin of EU‘s uranium imports



Source : Euratom Supply Agency 2022

Kazachstan: Some mines owned by Uranium One which belongs to Rosatom

Uranium conversion:
EU imports 24% from Rosatom

Enriched Uranium:
EU imports 26% from Rosatom

Rosatom only producer of HALEU, highly enriched uranium required for SMR

21 European reactors fully dependent on fuel rods from Rosatom

- 21 European reactors **fully dependent on Russian fuel rods** (WWER-440 reactors)
- Change to Westinghouse production estimated to take 6-10 years, will be more expensive
- Rosatom also provides maintenance and spare parts to Russian reactors
- Other western reactors also use partly fuel rods from Rosatom (not detailed information available)
- In February 2024 Rosatom delivered subtantial parts for French ITER research reactor (electricity supply and security system), 50 additional containers to be delivered this year (News on Rosatom-international website 2023)

	National Share of electricity production that depends 100% on Russian fuel rods
Slowakia	53% of national electricity production
Hungary	45% of national electricity production
Czechia	36% of national electricity production
Bulgaria	35% of national electricity production
Finland	11% of national electricity production (Loviisa)

CO_2 emissions of nuclear plants

Literature sources	GHG emissions gCO_2eq/kWh	Assumed reactor age	Assumed capacity factor
ISA (2006)	58	35 years	85%
Öko-Institut (2009)	33	30 years	Not provided
Sovacool (2008) review	66	20-60 years	85-98%
Lenzen (2008)	65	35 years	85%
Warner and Heath (2012) review	25-30	30-60 years	70-90%
Storm van Leuwen (2017)	117	25 years	100%
Vattenfall (2019)	4	60 years	Not provided
Zhang and Bauer (2018)	9.4	50 years	Not provided
UNECE (2021)	5.5	60 years	95%
Results strongly dependent on assumptions on reactor age and capacity factor Many LCA incomplete coverage		Average age of nuclear reactors: 31 years Mean age of closed reactors: 28 years	

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Thank you for your attention!