

10 years after Fukushima: consequences of the nuclear phase-out for the energy transition?

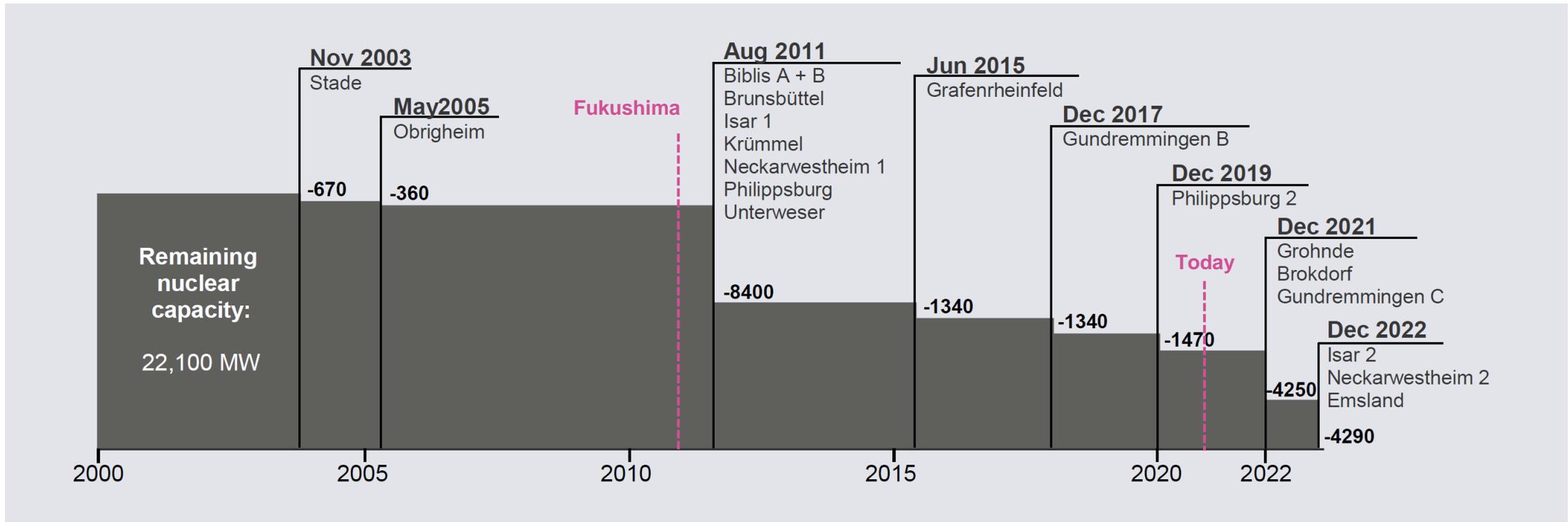
Answers to 10 common questions

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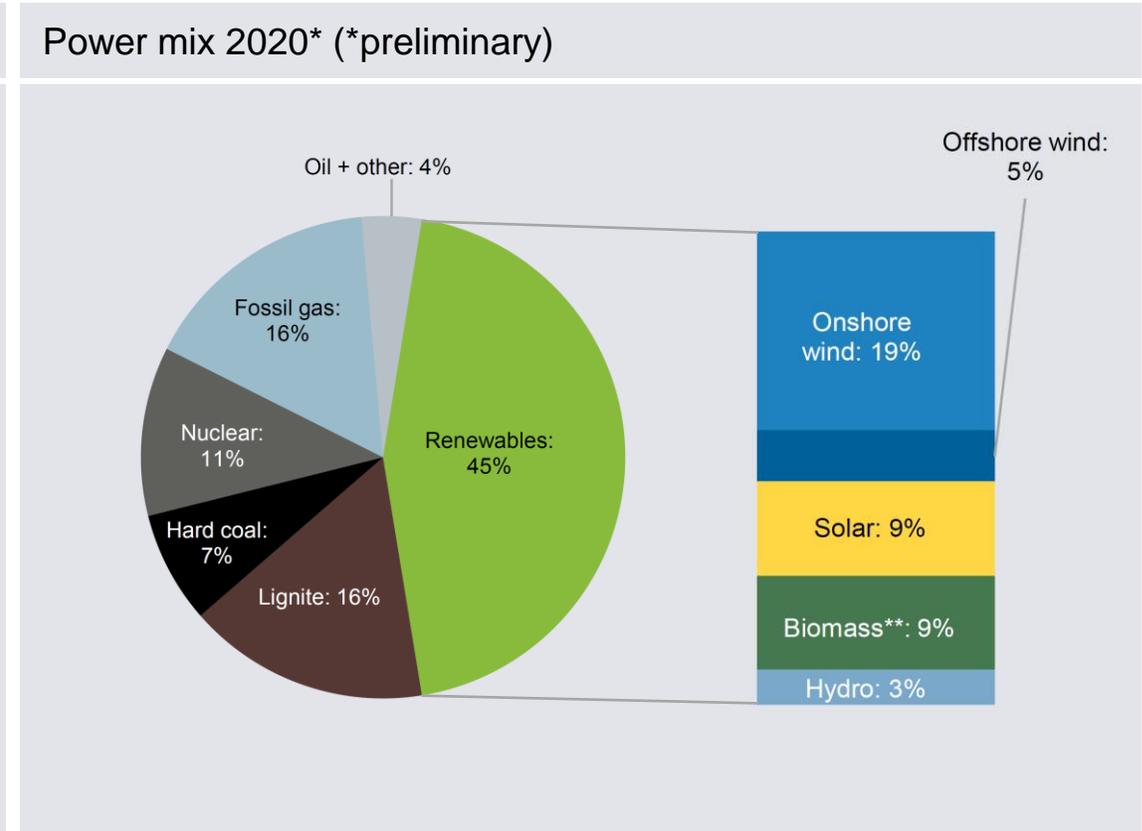
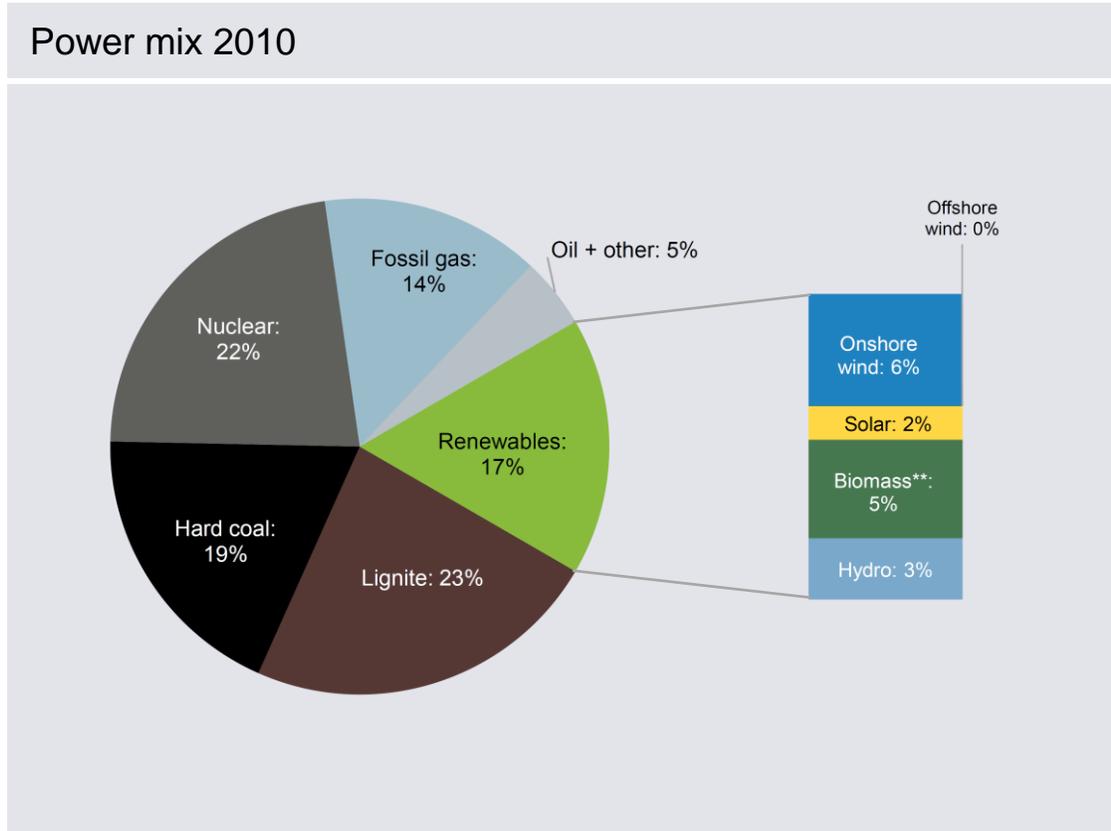
Starting point: After the meltdown in Fukushima, the nuclear phase-out of 2000 was reactivated - since then, 11 nuclear power plants have been shut down, 6 will follow until the end of 2022

Decommissioning of nuclear power plants agreed as part of the nuclear phase-out 2000 - 2022



Own depiction based on Energytransition.org

(1) How has the share of nuclear power changed since 2011? Nuclear in the electricity mix halved from 22% to 11%, while the share of renewables increased from 17% to 45%.

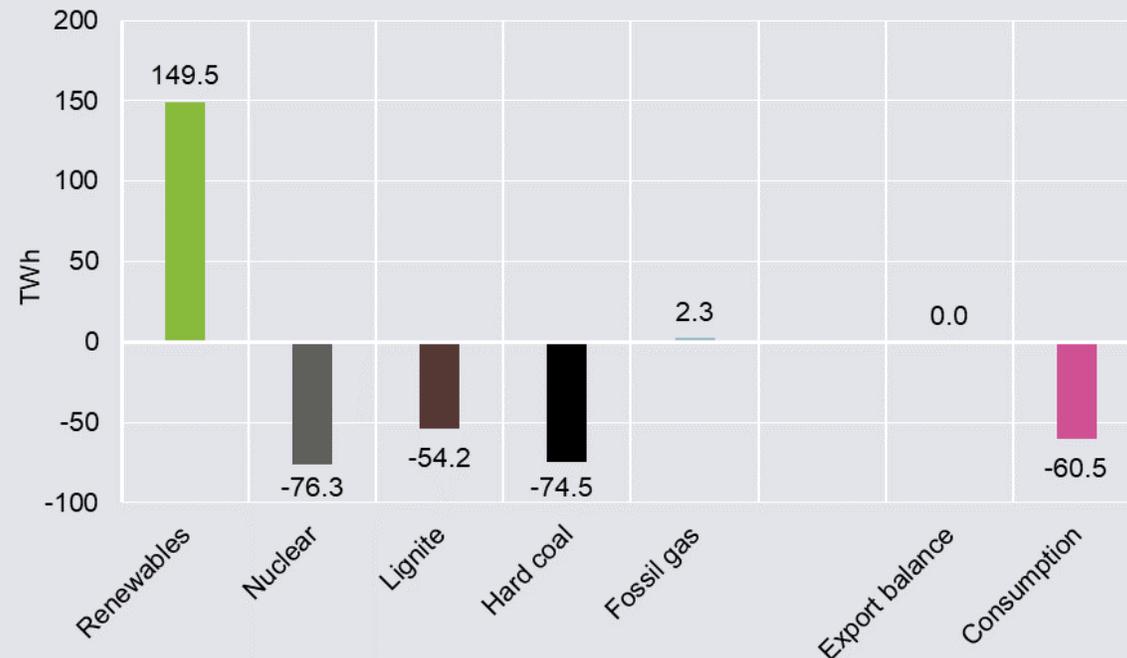


Agora Energiewende (2021)

Agora Energiewende (2021), **incl. biowaste from households

(2) Did the nuclear phase-out create an electricity shortfall? The growth in renewables outstripped the drop in nuclear power - by almost double.

Development of electricity generation and consumption 2020 vs. 2010



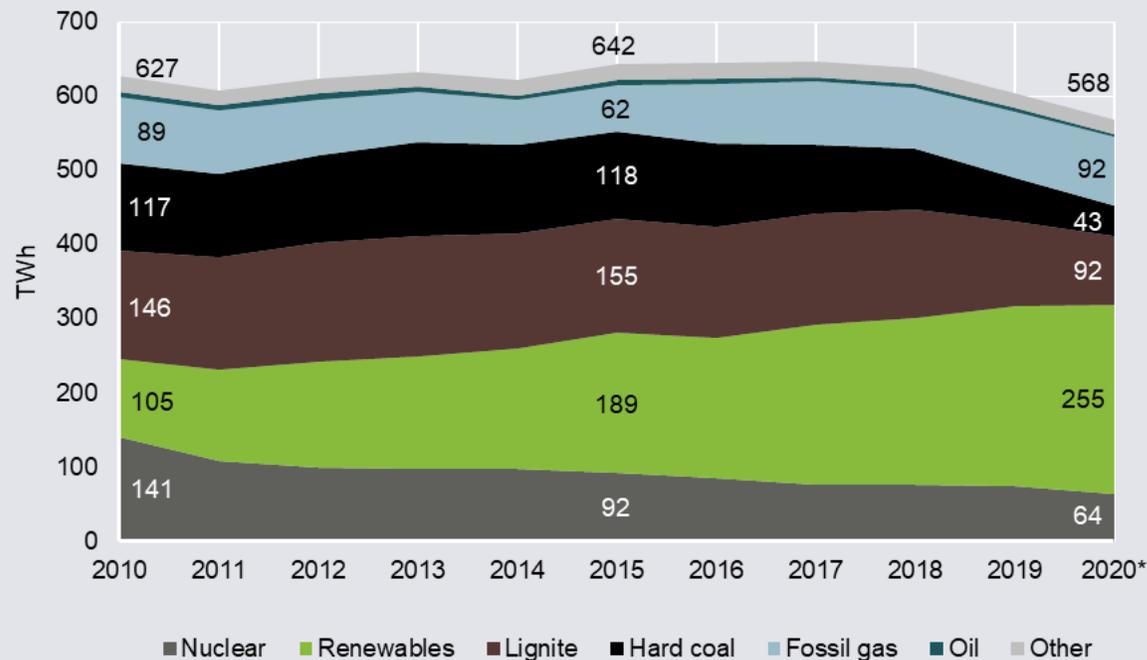
AG Energiebilanzen, *preliminary

- There has been no "electricity shortfall" (as was feared when nuclear power was phased out), nor have there been higher gas imports to replace it.
- Since 2010, electricity generation from nuclear power plants has fallen by 76 TWh, while generation from renewables has risen by 150 TWh - in this respect, the nuclear phase-out has been compensated for by renewables two-fold.
- Electricity production from natural gas in 2020 is almost exactly at the 2010 level, while coal has fallen significantly in recent years.
- The significant drop in electricity consumption in 2020 is mainly due to corona - higher electricity consumption is expected again in 2021.

(3) What is the timeline for the nuclear phase-out?

So far, it is only about half complete, with 2 important stages still to come at the end of 2021 and 2022

Gross electricity generation by energy source 2010-2020

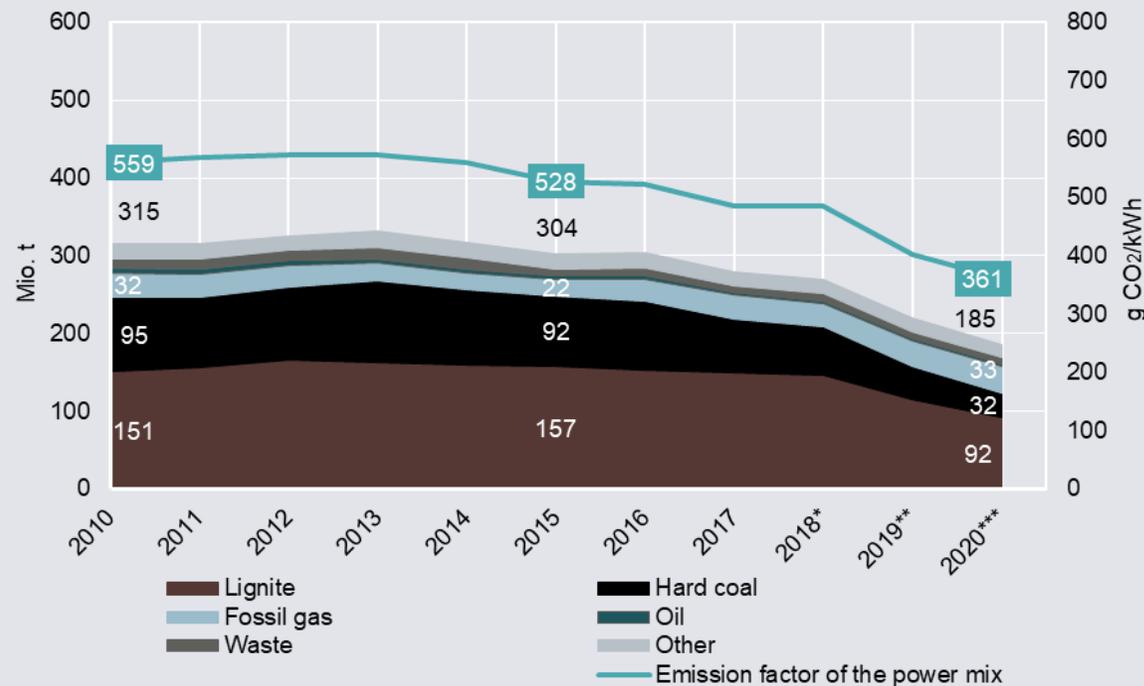


- Due to the shutdown of 8 nuclear power plants in 2011, nuclear power electricity volumes dropped significantly by 40 TWh (from 141 to 100 TWh) from 2010 to 2012, and by about the same amount again in the 8 years thereafter. By 2020, renewables had grown twice as fast.
- As of 31 Dec 2021 and 31 Dec 2022, significant amounts of nuclear power will again be taken off the grid, totaling 64 TWh.
- In order for renewables to be able to replace these lost nuclear power volumes in a carbon-free manner, more renewables must be built quickly, especially since electricity consumption is expected to rise again after the corona crisis.

AG Energiebilanzen, *preliminary

(4) Has the nuclear phase-out increased carbon emissions? Emissions remained relatively high until 2015; since then, they have fallen due to renewables and higher CO2 prices

CO2 emissions of the electricity sector 2010-2020

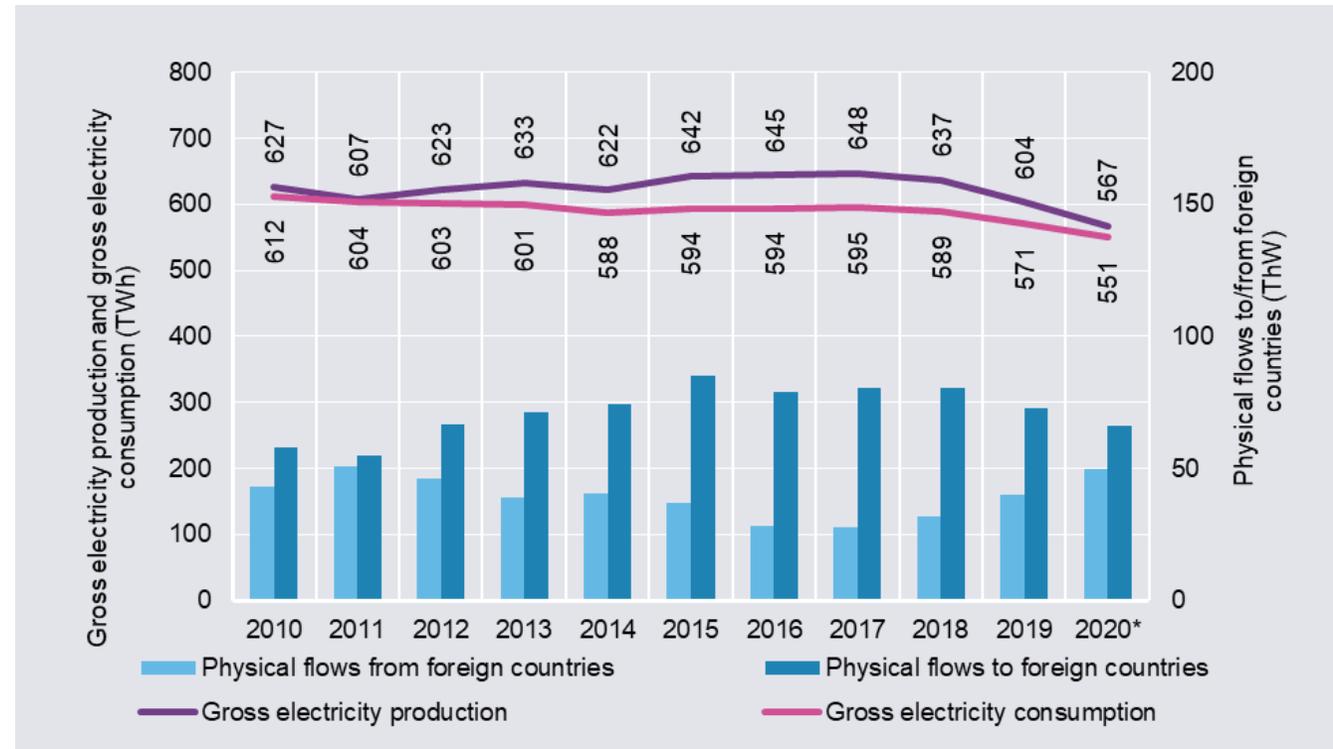


- Contrary to fears in 2011, the nuclear phase-out has not led to rising carbon emissions in the power sector.
- However, carbon emissions hardly fell before 2015 - renewables compensated for the nuclear phase-out, and coal emissions have only fallen significantly since CO2 prices began to rise appreciably.
- If nuclear power plants had remained online in 2011 *and* renewables had been further expanded at the same time, coal-fired power generation and thus CO2 emissions would have fallen more quickly earlier.
- However, it is highly questionable whether renewables would have grown so quickly without the nuclear phase-out.

UBA 2020 (*preliminary, **estimate UBA), ***calculation by Agora Energiewende

(5) Has Germany imported more (nuclear) electricity? After 2011, Germany became an electricity exporting country; in recent years, the balance has become more even again

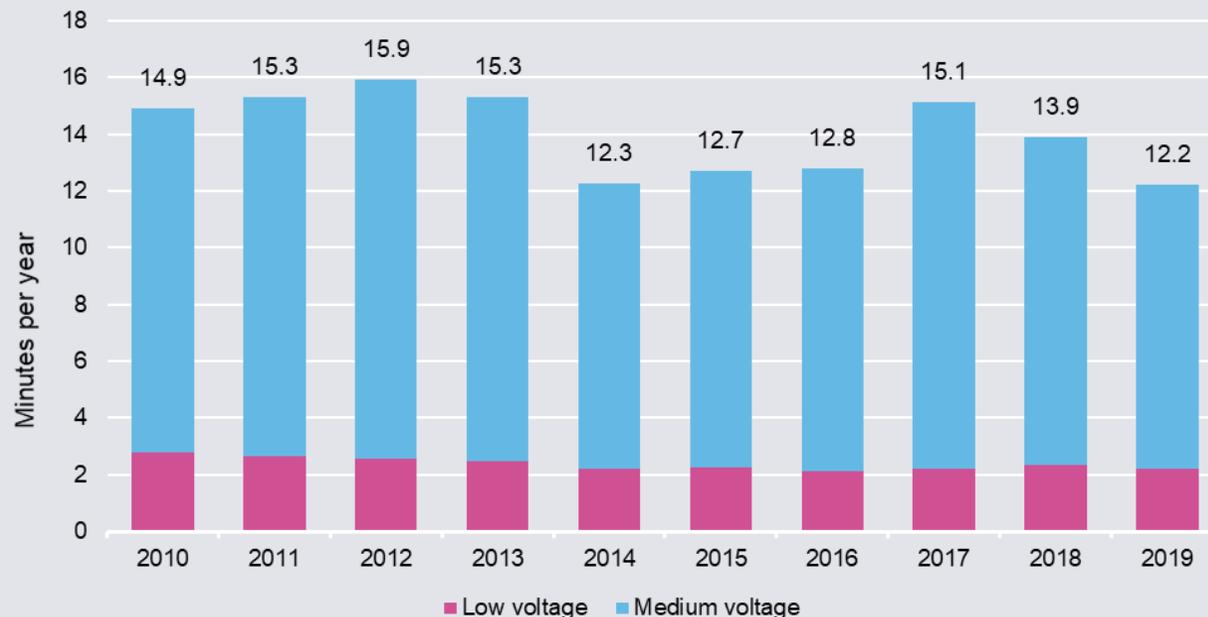
Electricity generation, consumption, and electricity load flows to/from abroad



- Contrary to frequently heard claims, Germany has not become an electricity importer as a result of the nuclear phase-out; on the contrary, electricity exports increased steadily after 2011.
- In electricity trade with France in particular, Germany has always been a net exporter in recent years.
- The reason was that the growth in renewables in Germany combined with low CO₂ prices ensured that German coal-fired power was increasingly exported to neighboring countries in the period 2011-2017.
- Since the CO₂ prices in EU emissions trading have been rising and the expansion of renewables is also increasing in neighboring countries, German exports are falling again.

(6) Has the security of electricity supply suffered? **Power outage times are very low by international standards and have fallen further since 2011.**

System Average Interruption Duration Index (SAIDI) for Germany

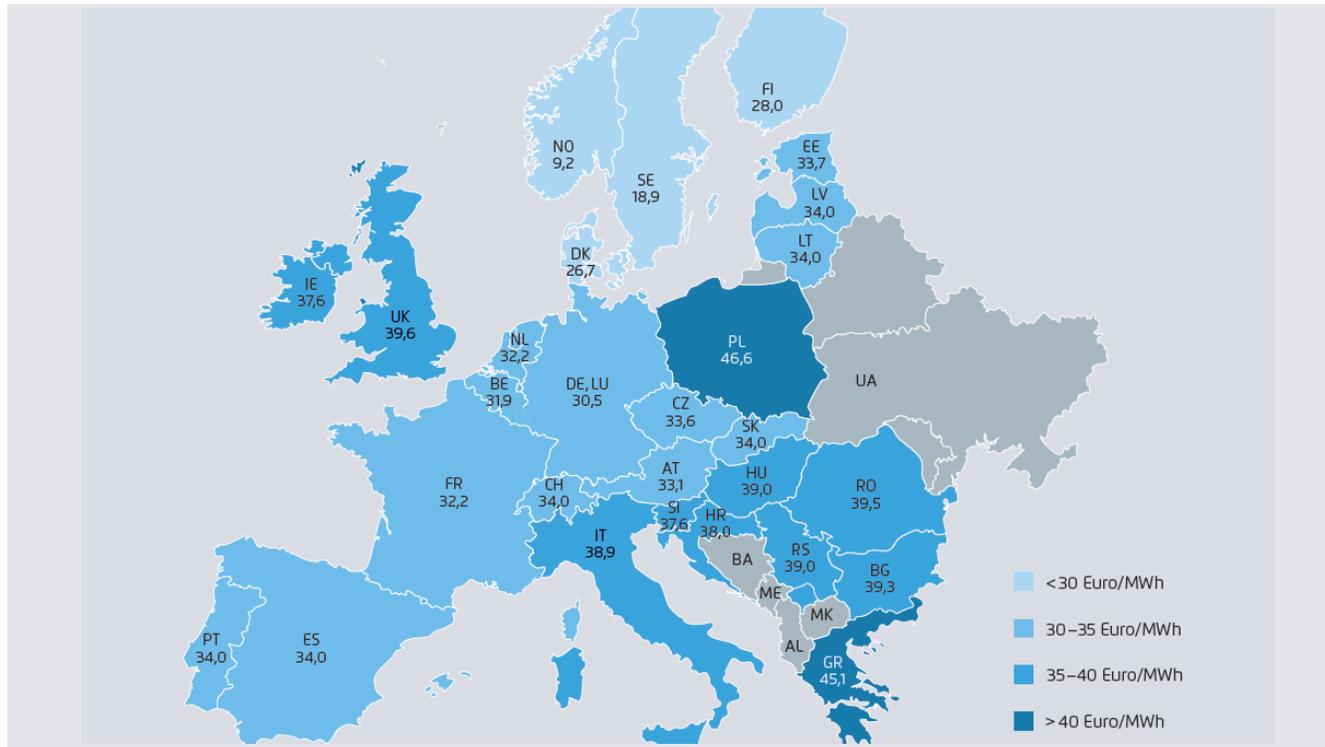


Bundesnetzagentur (2020)

- One fear often voiced in the context of the nuclear phase-out was that the level of security of supply would decline.
- In fact, power outage times in Germany have been falling continuously since data began to be published in 2006 and are best-of-class in an international comparison.
- The average interruption duration per consumer was 12.2 minutes in 2019. This is the lowest outage duration to date since data collection began.
- According to the Federal Network Agency, the energy transition and the increasing share of decentralized generation capacity are not having a negative impact on the quality of power supply in Germany.

(7) Have wholesale electricity prices risen as a result of the nuclear phase-out? Germany regularly has the lowest wholesale electricity prices in Europe after Scandinavia

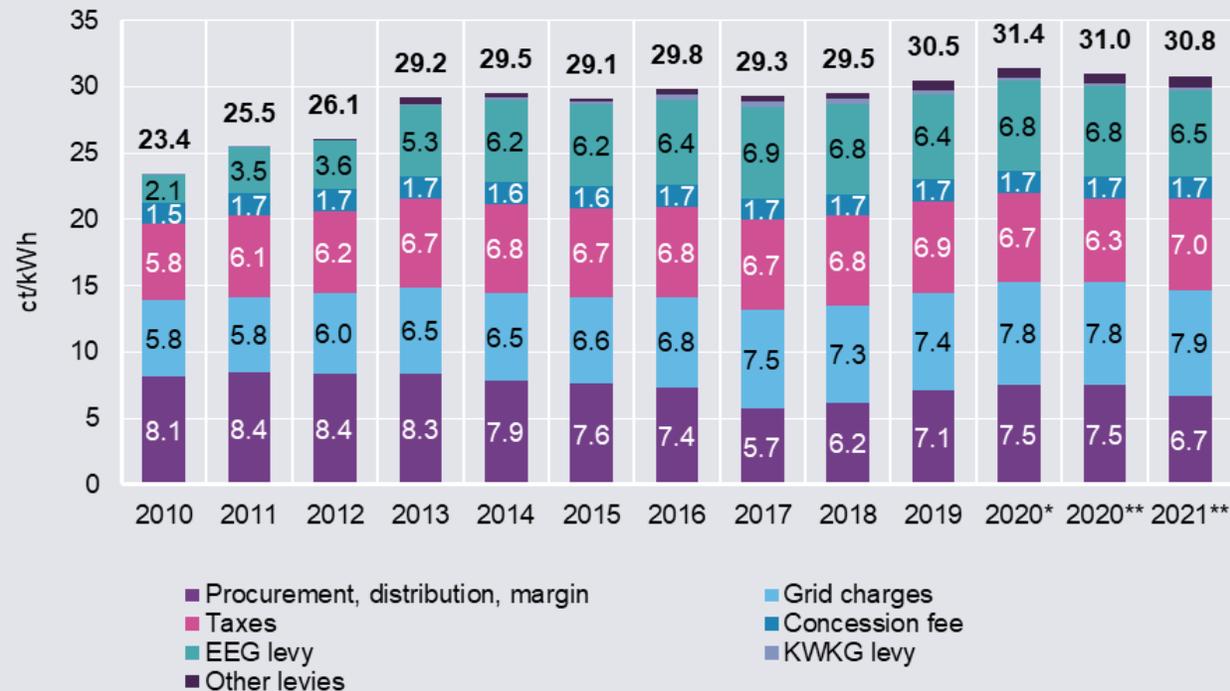
Exchange electricity prices in Europe 2020 (day ahead)



- One fear often voiced in the wake of the nuclear phase-out was rising electricity prices.
- However, electricity is very cheap on the exchange due to the high share of renewables in Germany. Only the Scandinavian countries with their high shares of hydropower have even lower electricity prices.
- In recent years, the electricity exchange price in Germany has always been lower than in France, the country with the most nuclear power plants.
- Industrial processes in the energy-intensive basic materials industry, which are largely exempt from taxes, levies and surcharges, therefore enjoy relatively favorable electricity prices in Germany.

(8) Has the burden on private households increased? Until 2013, the electricity price for private households rose sharply; since then, it has hovered around 30 ct/kWh.

Retail power prices 2010-2021

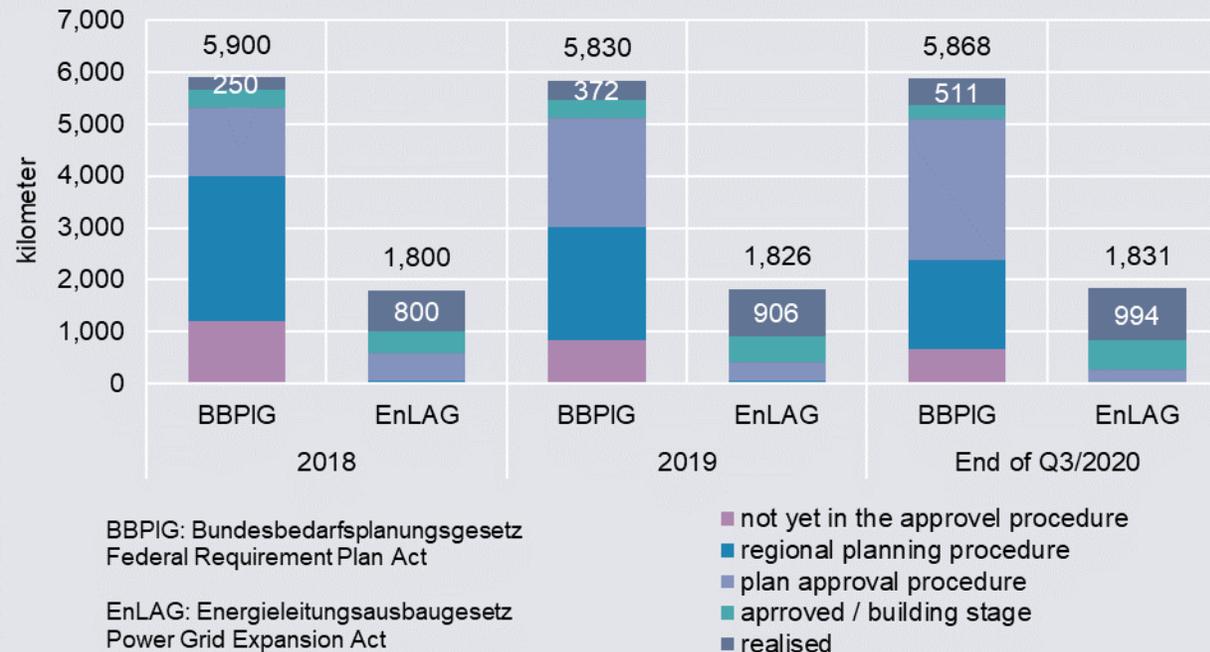


*Half 16 and 19% VAT; **preliminary

- One fear often voiced in the wake of the nuclear phase-out was rising electricity prices for households.
- These have indeed risen since 2010 - but the central reason was the EEG surcharge and not the nuclear phase-out. Due to the promotion of biomass and solar plants, which were still expensive at the time, the surcharge increased from 2 to 6 ct/kWh but has remained essentially constant since 2014.
- Industry and commerce receive numerous exemptions from taxes, levies and surcharges for competitive reasons and therefore pay significantly lower electricity prices than private households.

(9) Did the nuclear phase-out increase the need for grid expansion? Nuclear power was largely replaced by wind power, which has to be transported from the north to the south.

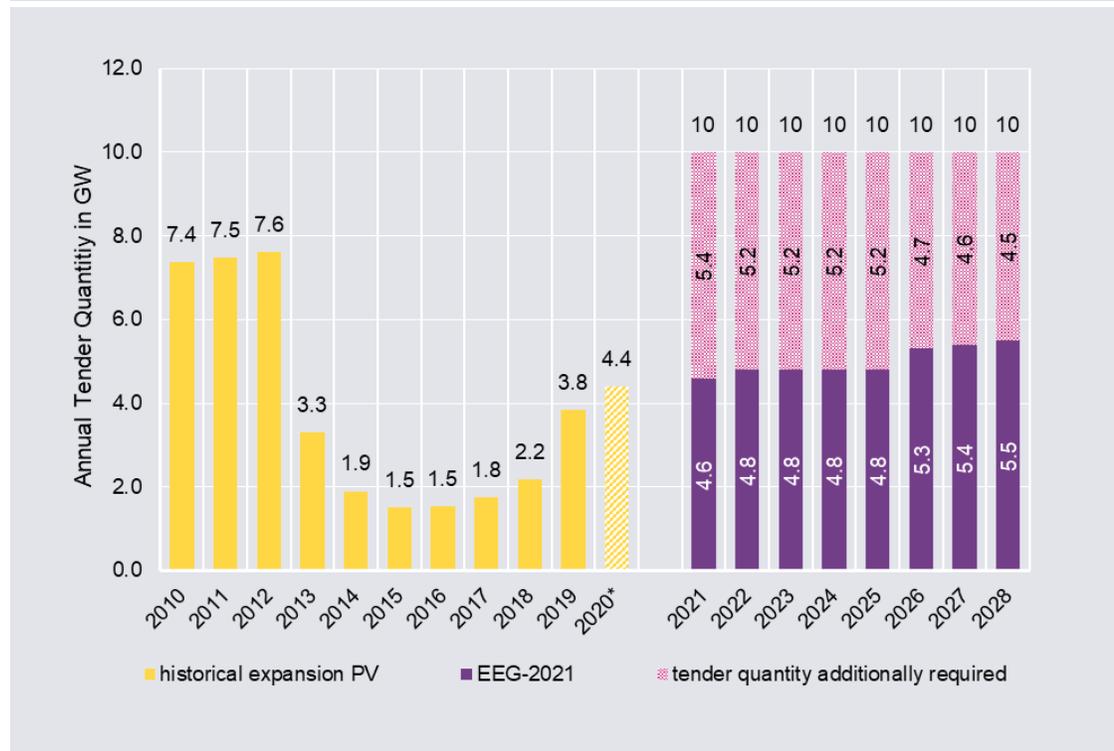
Status of grid expansion in Germany (end of Q3/2020)



- Since many nuclear power plants were in southern Germany, the nuclear phase-out leads to a considerable electricity gap in Bavaria and Baden-Württemberg.
- The gap is largely covered by wind power, mainly largely generated in northern Germany and offshore in the North Sea and Baltic Sea. A restructuring of the power grid with additional north-south routes is therefore necessary.
- Of the total of 7,669 kilometers of projects planned under the Federal Requirements Plan Act and the Power Grid Expansion Act, 1,505 kilometers had been completed by the end of the third quarter of 2020. This corresponds to a realization rate of 20 percent.

(10) How will the nuclear phase-out be compensated for in 2021/2022? For renewables to be able to cover the nuclear power volumes that will soon be eliminated, more renewables must be quickly added.

New solar PV 2010-2020 and required levels in 2021 ff



Agora Energiewende (2020)

New onshore wind 2010-2020 and required levels in 2021 ff

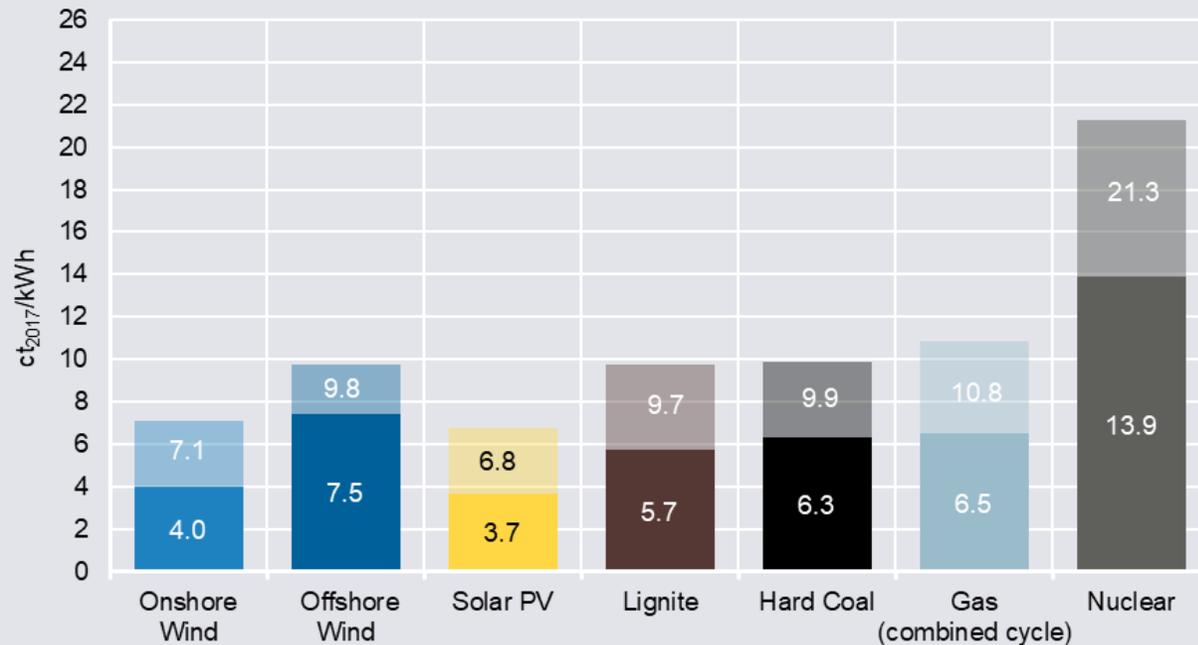


Agora Energiewende (2020)

Outlook: Is there a renaissance of nuclear power?

Nuclear power plants are by far the most expensive technology for generating electricity in the area of new plants

LCOE of individual power generation technologies in Germany 2017



Own calculations based on Prognos and Fichtner (2017), Fraunhofer ISE (2018), Lazard (2020).

- New wind and solar plants are now competitive with conventional power generation technologies - and significantly cheaper than electricity from new nuclear power plants.
- Wind and PV technology costs continue to fall; at favorable locations around the world, wind and solar power can be produced for under 2 cents/kWh, making it by far the cheapest way to produce electricity.
- The cost of fossil power plants depends crucially on the cost of CO₂.
- A renaissance of nuclear energy is therefore not to be expected for cost reasons alone, not to mention the long construction times of 10 to 15 years. The share of nuclear energy in the electricity mix has therefore remained at 10% for years.

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Thanks for your attention

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