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Resumption of Nuclear instead of even more Wind Power

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Abstract

On April 15, 2023, Germany took its last three commercial nuclear power plants off the grid. Only thirteen years before then, in 2010, 17 reactors had supplied about one third of the German electricity consumption. Since then, Germany has expanded wind and solar electricity production capacity far beyond need, but its availability remains as low as 25 % for wind and 13 % for solar power. Installed weather-dependent electricity production capacity already exceeds 200 GW, while peak demand has declined to 80 to 85 GW. Renewable droughts during dark-winter or hot-summer periods without wind, negative prices and rising imports show that surplus capacity does not mean reliable supply. In addition, the grid-expansion and system costs dominate the bill, not the turbine prices; household electricity charges have roughly tripled since 2000 and German industrial electricity prices are now among the highest in world, more than double compared to China or the USA. Nevertheless, German power-sector CO₂ intensity remains at the ten-fold of that of France, which gets about 70 % of its electricity from its own nuclear plants. Former German nuclear power plant managers and the Radiant Energy Group judge that about 12 GW of existing nuclear power plants could return to the grid in three to six years for some €18 billion. Resumption of nuclear power is therefore the shorter route to lower system costs, fewer imports and lower emissions than even more mandated wind-power expansion.

Keywords: Nuclear energy; Germany; energy transition; wind power; photovoltaics; system costs; grid stability; reactivation

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1. Introduction

This article summarizes the presentation given on 26 June 2026 at the 17th International EIKE Climate and Energy Conference (IKEK-17) in Halle (Saale). The political basis is the AfD federal election manifesto of 2025, which states that existing nuclear power plants (NPP) should be returned to service as quickly as possible [1]. The technical basis is that electric generation must equal the load in every second, whereas weather-dependent fluctuating electricity production capacity based upon wind and sunlight has surpassed twice the maximum German demand while base-load production capacity has been taken off the grid too quickly.

In 2010, 17 reactors were still operating: six boiling-water and eleven pressurized-water units. In the North these were Brunsbüttel, Brokdorf, Krümmel, Unterweser, Grohnde and Emsland; in the South Biblis A and B, Grafenrheinfeld, Philippsburg 1 and 2, Neckarwestheim 1 and 2, Gundremmingen B and C, and Isar 1 and 2 [2]. For about three decades they supplied roughly one third of the German electricity. On April 15, 2023, Germany took its last three commercial NPPs off the grid. All German NPPs are currently being dismantled.

2. Installed capacity, utilization and land take

A comparison compiled by Hofmann-Reinecke for 2024, using data from the Federal Statistical Office and related series, shows the gap between nameplate capacity and annual output. German wind farms, with a capacity of 63.5 GW, generated 24.5 per cent of their nameplate

capacity; Spanish wind farms, with a capacity of 30.8 GW, generated 22.5 per cent. German photovoltaic installations, with a capacity of 81.5 GW, generated 10.4 per cent; Spanish photovoltaic installations, with a capacity of 33.2 GW, generated 15.3 per cent [3].

Energy-Charts, which draw on the market master data register, recorded around 80 GW of wind power (69 GW onshore, 10 GW offshore) and 120 GW of photovoltaic power at the beginning of March 2026, making a total of around 200 GW [4]. Germany's peak load stands at around 80 to 85 GW. Periods of surplus generation are therefore structural in nature.

Nevertheless, the Renewable Energy Sources Act (EEG) and the Offshore Wind Energy Act set targets for 2040 of 400 GW of photovoltaic capacity, 55 GW of offshore wind energy and 160 GW of onshore wind energy – totaling 615 GW – whilst assuming the same peak load [5, 6]. The BDEW's 'Spotlight' report from June 2026 records an installed capacity of 118 GW of photovoltaics, 10 GW of offshore wind energy and 68 GW of onshore wind energy at the end of 2025 [7].

The federal law requires the federal states to designate approximately 2 per cent of their territory for onshore wind energy. Baden-Württemberg was allocated 1.8 per cent for wind energy and 0.2 per cent for ground-mounted photovoltaic installations. Commercial and industrial areas already account for around 2.5 per cent of the state's territory. By the end of 2023, only 0.5 per cent of this area had been designated for wind energy [8].

New installations of photovoltaic systems totaled 17.6 GW in 2024 and are estimated at 17.7 GW for 2025. Plug-in balcony systems contributed 0.4 GW in 2024 and 0.5 GW in 2025. Ground-mounted systems alone accounted for 8.4 GW in 2025 [7]. Private rooftop systems remain very popular with households. The photovoltaic systems mandated in public buildings place a triple burden on the taxpayer: he has to pay at the time of purchase, during operation and upon subsequent decommissioning.

3. Investment and system costs

Gross investment in the electricity supply sector rose from 12.9 billion euros in 2016 to 21.4 billion euros in 2023 and 31.5 billion euros in 2024, with estimates of 40.8 billion euros for 2025 and forecasts of 44.8 billion euros and 46.6 billion euros for 2026 and 2027 respectively [9]. The lion's share is accounted for by transmission and distribution networks, with a smaller proportion going to power plants. Centralized power plants with a capacity of around 1.4 GW – or up to 1.6 GW in the case of an EPR reactor unit – fed into a grid that became sparser towards the periphery. Decentralized wind and solar power plants reverse this topology and require an additional collection grid, which is enormous and whose construction has merely been started.

A system cost study commissioned by EnBW (Energie Baden-Württemberg) and carried out by Aurora Energy Research estimates the cost of the energy transition up to 2045 at more than three trillion euros [10]. The study assumes a figure of 3.2 trillion euros, which, spread over 20 years, corresponds to around 160 billion euros per year. As German end-user prices are already among the highest in the world [7, 9], further investment expenditure must be covered through additional tariffs or taxation. This approach, without recurring extra-budgetary support, is not financially viable.

4. The phase-out and its operational consequences

The civilian use of nuclear energy began in the 1960s. Today, the World Nuclear Association lists a total of 36 power reactors in Germany as having been permanently decommissioned [11]. Following German reunification in 1998, the Rheinsberg and Greifswald plants in the former German Democratic Republic were decommissioned immediately. The 2001 consensus under Chancellor Schröder, SPD, set the remaining operating lifetimes of all the other German NPPs. Stade and

Obrigheim were taken off the grid in 2005. In 2010, the CDU/FDP government extended the remaining operating lifetimes. Following the Fukushima accident in March 2011, caused by a tsunami in which around 20,000 people lost their lives, the reactors commissioned before 1980, as well as Krümmel, were shut down immediately. The remaining NPPs followed in the years after. Emsland, Neckarwestheim 2 and Isar 2 were the last German NPPs to be taken off the grid on April 15, 2023 [12].

Nuclear energy – From the 2000s to today

- Nuclear phase-out at the beginning of the 2000s under the red-green Chancellor Schröder - nuclear consensus in 2001
- Obrigheim (1969, BW) and Stade (1972, NI, 672 MW) were shut down in 2005
- Extension of the operating time through the 11th amendment to the Atomic Energy Act under Chancellor Merkel in 2010 (CDU-FDP)
- The other nuclear power plants then had to be taken offline one by one.
- The last three nuclear power plants, Emsland, GKN II, and Isar 2, went out of operation on April 15, 2023 (Scholz, SPD-FDP-Greens)



Philippsburg (SWR+DWR, 1979-2019)



*Figure 1: Timeline of the German nuclear phase-out.
Shown are pictures taken by the author.*

The gross generation statistics show that nuclear power's share has fallen over the years from one-third to zero in Germany, as well as an over-all decline in domestic generation [9]. Nowadays, when wind and solar power generation is low, Germany relies on imports, primarily from NPPs in France and Switzerland. In 2025, the physical net import balance from France amounted to around 19.6 TWh, as shown in the conference slides. The French energy mix consists to 69 to 75 per cent of nuclear power.

In Baden-Württemberg, gross generation fell from 53,899 GWh in 2022 to 37,147 GWh in 2023 (a reduction of 31 per cent). Nuclear output in this state fell from 11,142 GWh to 1,947 GWh (–82.5 per cent) in 2023; the 2023 figure represents the operation of Neckarwestheim 2 from January to April 15 [13]. The state has since been a structural importer of about one third of its electric power.

The Iberian Peninsula blackout was cited as a warning for the system. At the critical moment, approximately 62 per cent of generation came from photovoltaic sources and 12 per cent from wind, whilst several of Spain's seven nuclear units were offline, as shown on the conference slides. Rotating masses in thermal power plants dampen frequency deviations; photovoltaic inverters did not, at that time, and thereby allowed this enormous black out to happen. Germany got lucky, as it was cushioned by the Ibraheim inertia of the intervening French nuclear fleet.

5. Prices, EEG support, periods of low wind and low sunlight and storage

Monthly bills for a three-person household rose from around €40 in 2000/01 to just under €100 before the 2022 crisis, peaked at around €135 to €140, and remain at over €115 to €120 since then [9]. In a press release from the BMU (Federal Ministry of the Environment) dated July 30, 2004, Federal Environment Minister Jürgen Trittin stated that EEG subsidies would cost the average

household around one euro per month, “as much as a scoop of ice cream”, which corresponds to 480 million euros per year for 40 million households [14]. But even in that year, the federal subsidies amounted already to more than 2000 million euros; and they continued thereafter to rise up to 29 billion euros in 2020. Following the period of high gas and electricity prices after the start of the Russian invasion into the Ukraine, they stood at 18.9 billion euros in 2024; the BDEW’s forecast from June 2026 anticipates 16.3 billion euros for 2025 and 14.3 billion euros for 2026 [7]. However, the general trend in German energy policy gives cause for concern that subsidies may return to the 2020 levels soon.

Photovoltaic full-load hours plummet in January, February, November and December, when demand is at its highest [7]. SMARD records for January 26–29 2026 show low photovoltaic output and a residual share of conventional energy from lignite, hard coal and gas. From the 5th to the 8th of August 2025, solar energy dominated during the day; at night, coal and gas were needed. On the 24th and 25th of June 2026, a summer lull meant that onshore and offshore wind energy was virtually zero at night, pumped-storage reserves were depleted and imports from French and Swiss NPPs were required [15]. The day-ahead price in the DE-LU zone reached €747.10 per MWh or 74.7 cents per kWh [16].

The usable capacity of large electricity storage plants connected to the German grid (6.3 GW and 1 MWh and above) totaled 143.6 GWh at the end of 2025, of which 137.9 GWh corresponded to pumped-storage power plants with a capacity of 6.3 GW. Installed batteries contributed a maximum of 15.9 GW and 25.3 GWh; household batteries alone accounted for around 20 GWh [9]. The Federal Network Agency estimates the capacity of the 28 operational pumped-storage power plants to be at around 6.2 GW and 147 GWh [17]. Combined storage capacities of this magnitude – around 175 GWh – would cover a 40 GW shortfall for only 4.5 hours, if all storage facilities were full; however, the latter is never the case as they form the operational reserves of several separate utilities.

As a result of the addition of wind and solar power to the German grid, the number of hours with a negative day-ahead balance rose from 301 in 2023 (3.4 per cent of the year) to 457 in 2024 (5.2 per cent) and to 576 hours in 2025, which corresponds to around 6.6 per cent or an average of more than 1.5 hours per day [7, 15]. During these hours, Germany needs to pay neighboring countries huge amounts of money to take the German surplus electricity.

6. CO₂ intensity

Nevertheless, Germany remains responsible for 1.53 per cent of global CO₂ emissions, placing it tenth amongst emitters, behind China with 32.85 per cent and the United States with 13.11 per cent [18], but way ahead of France, for instance. According to Ember’s annual electricity data, the CO₂ intensity of the electricity sector in Germany stood at 344 g CO₂ per kWh in 2024 and at 329.65 g in 2025. France recorded 44 g in 2024 and 41.44 g in 2025, with nuclear energy accounting for around 70 per cent of the electric energy used in France [19]. Annual increases in renewable energy of almost 18 GW in Germany led to only a tiny reduction in German CO₂ output per kWh. This demonstrates that NPPs play a key role in reducing CO₂ emissions as well as securing the energy supply of industrialized nations.

7. Reactivation, the international setting and German options

NPPs provide energy that is not dependent on weather conditions, offer inertia, can follow the load within their design limits and do not require a corresponding phased expansion of the grid.

Poland is preparing the Lubiatowo-Kopalino site for three Westinghouse AP1000 reactors. Following the European Commission’s approval of the state aid in December 2025 [20], groundworks began in August 2026 and the site was handed over to Bechtel; the first concrete for the reactor is scheduled for late 2028 [21]. Italy is currently re-establishing the legal framework for nuclear power generation; the Italian Minister for the Environment is expecting initial electricity

generation to occur between 2033 to 2034 [22, 23]. In Canada, Westinghouse is preparing for construction and has signed supply chain agreements such as the PROMATION memorandum [24]. Belgium suspended decommissioning of its seven reactors in April 2026 [25]. A Radiant Energy Group study had previously judged a restart to be technically feasible [26].

For Germany, the Radiant Energy Group concludes that recommissioning remains technically and economically feasible. The top-priority NPPs for recommissioning – Brokdorf, Emsland, Grohnde, Neckarwestheim 2 and Isar 2 – generate around 7 GW of net capacity and 53.7 TWh per year. According to this analysis, together with a second priority group, around 12 GW could be brought back online in three to five and a half years at a cost of around 18 billion euros, definitely cheaper than the up to 12 GW of new gas-fired power plants planned to be built only for peak loads [27]. Suppliers such as Westinghouse offer the replacement of the key components of the German NPPs, as they have done as part of license extension campaigns in the United States [28]. The prerequisite that is still missing is an amendment to the Atomic Energy Act and a change in licensing practice.

In January 2026, Chancellor Friedrich Merz described the phase-out as a serious strategic error [29]. At Kloster Seeon in January 2026, the CSU backed a return to nuclear power using modern reactors [30]. On 25 June 2026, former German NPP site managers and nuclear engineers, including Horst Kemmeter, Thomas Franke, Sascha Bechtel and Jürgen Haag, wrote in an open letter, that a restart is technically feasible and economically viable, and that they agree with the order of magnitude of the numbers provided by Radiant Energy Group and the German nuclear suppliers' association KernD [31].

The Working Group on Nuclear Power of the AfD fraction therefore calls for the preservation of Isar 2, Neckarwestheim II and Emsland; a review of Brokdorf, Grohnde, Krümmel, Gundremmingen and Philippsburg 2; reform of legislation and licensing procedures; renewed research; the eventual construction of new plants; and the recognition that a solution for a final repository can be found within a finite timeframe.

8. Conclusions

In Germany, installed wind and solar capacity already exceeds peak demand, yet gaps still remain in winter and at night. The existing storage capacity of 175 GWh is not sufficient to bridge even one day without wind or sunshine. Negative prices and import costs reflect the same pattern of surpluses and shortfalls of wind and solar power generation. The CO₂ intensity of the electricity sector has almost remained the same, even though a lot of wind and solar power generation has recently been added to the grid. Based on these findings, a program to bring back into operation around 12 GW of nuclear power over three to five and a half years, with published costs of just under 18 billion euros, is the quickest route back to a reliable, low-carbon electricity supply. Further expansion of wind energy is more expensive and less reliable and therefore not really an alternative.

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