

# REPOWER GERMANY

The Case for Repowering Coal and  
Nuclear Sites with Advanced Nuclear

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# REPOWER GERMANY

## The Case for Repowering Coal and Nuclear Sites with Advanced Nuclear Energy May 2026

### 1 EXECUTIVE SUMMARY

Germany—Europe's largest economy—is also its largest coal consumer, its most emissions-intensive industrial power, and the only G7 nation to have closed its entire nuclear fleet. Its industrial electricity prices are roughly double those in the United States and more than 50% above China.<sup>1</sup> Its grid expansion program is estimated to cost EUR 651 billion. The current oil crisis has sharpened these vulnerabilities. Despite impressive renewable deployment, closing nuclear while retaining coal has left Germany more dependent on imported fossil fuels than its climate ambitions require.

**This paper argues that repowering Germany's 28.3 GW coal fleet, three shut-down nuclear sites, and the ~62 GW of utility gas plus industrial and Stadtwerke CHP (~32 GW utility gas; ~10 GW industrial captive; ~20 GW Stadtwerke) with advanced nuclear energy would: eliminate 104 MtCO<sub>2</sub>e of annual emissions (14% of national total); deliver 223 TWh/year of clean electricity from existing grid connections—128 TWh more than coal currently provides; avoid up to EUR 300-400 billion in planned transmission spending; and cut industrial electricity costs towards the \$52-64/MWhe range—competitive with other global producers and below any other clean, firm generation alternative. Combined with continued renewable expansion, this would put Germany on the fastest credible pathway to a fully decarbonized energy system.**

The REPOWER system—Terra Praxis's strategy for modular nuclear delivery—targets capital costs of approximately \$2-3,000/kWe, versus \$8,000-10,000/kWe for conventional nuclear in the West. It achieves this through a technology-agnostic open architecture, Design for Manufacture and Assembly (DfMA), factory-produced "heat box" reactor modules, and product-based licensing ("license once, build many"). Critically, 75% of global energy demand lies outside the power sector—in industry, transport, and heating. Repowered sites can supply not just electricity but process heat, hydrogen, district heating, and power for data centers, unlocking markets that renewables cannot serve alone.

Terra Praxis has two digital tools that make fleet-scale deployment practical. Project Phoenix (U.S. State Department-funded, proven against 13 Ukrainian coal sites) uses a configurator tool developed with Bryden Wood to assess sites and generate optimized conversion designs in days. A separate Gen AI for Licensing tool (built with Microsoft) has demonstrated 92% reductions in permitting timelines. Together, they compress a decade-long process into a five-year deployment cycle—given the right policy support.

Crucially, accelerating the site screening, feasibility, preliminary design, and licensing processes, enables building large project pipelines of derisked projects, these in turn justify the programmatic investments in design, manufacturing, and streamlined delivery that have been shown to radically reduce costs.

The scale of the prize is set by what is left to decarbonize. Germany emitted 649 MtCO<sub>2</sub>e in 2024, down from 1,252 Mt in 1990—a 48% reduction, one of the largest absolute cuts achieved by any large industrial economy (Umweltbundesamt, 2025). The legally binding 2030 target (-65% from 1990) requires cutting another ~210 Mt by decade-end; the 2045 net-zero target requires eliminating the remaining 649 Mt. The categories REPOWER addresses—coal generation, utility gas, and industrial captive heat and CHP—together emit on the order of 250-300 MtCO<sub>2</sub>e/year, roughly 40-45% of Germany's remaining total. A single coal site (Niederaussem) emits ~30 Mt/year at peak; BASF Ludwigshafen's onsite industrial heat and process emissions are ~20 Mt. Repowering is not a marginal contribution to the 2030 and 2045 budgets; it is a direct address of the category that constitutes most of what is left to cut.

<sup>1</sup>IEA, Electricity 2026 — Prices. EU electricity prices for energy-intensive industries averaged roughly double US levels and more than 50% above China and India in 2025.

## 2 GERMANY'S ENERGY CRISIS: THE SCALE OF THE PROBLEM

Europe's largest economy<sup>2</sup> is also its largest coal consumer: 1.55 million TJ of coal supply in 2024, accounting for 23.5% of electricity generation and 15.7% of total energy supply, despite a 56% decline since 2000. Germany ranks first in Europe for coal-related CO<sub>2</sub> emissions at 173 MtCO<sub>2</sub> annually—more than Turkey, Poland, Czechia, and Ukraine combined.<sup>3</sup> All remaining domestic production is lignite—the dirtiest form of coal—while Germany simultaneously imports 932,383 TJ from international markets, making it Europe's second-largest coal importer.

German industrial electricity prices average 18-20 cents/kWh—more than double the US rate of 7-9 cents/kWh and more than 50% above China. BASF has publicly shifted new investment to the US Gulf Coast and China. The Ember "Vision or Division" analysis identified Germany as one of seven EU member states blocking the electricity transition, projecting an emissions intensity of 248 gCO<sub>2</sub>/kWh in 2030—nearly double the EU average target of 150 gCO<sub>2</sub>/kWh.

### 2.1 The Shuttered Nuclear Fleet

Germany's decision to close its nuclear fleet—completed in April 2023 with the shutdown of the final three reactors (Isar 2, Neckarwestheim 2, and Emsland)—removed 4.1 GW of zero-carbon, dispatchable baseload capacity from the grid. Those three plants alone had generated roughly 6% of Germany's electricity in their final full year of operation. The sites remain: land, grid connections, cooling infrastructure, and in many cases the containment structures and turbine halls are intact. These are assets of extraordinary value that the current policy trajectory will allow to degrade into unusable brownfield sites.

Every neighbor is moving in the opposite direction. Poland has committed to build 6-9 GW of nuclear capacity. The Czech Republic is expanding Dukovany. Finland's Olkiluoto 3 is operating. Sweden has lifted restrictions and is planning new build. The Netherlands is preparing for two new reactors. France is committing to a fleet of six EPR2 reactors with options for eight more. Over 30 countries have pledged to triple global nuclear capacity by 2050.<sup>4</sup> Meanwhile, major technology companies—Microsoft, Google, Amazon, Meta—are signing unprecedented nuclear power agreements to supply their data centers with firm, clean electricity. Germany is the only major European industrial economy that closed its nuclear fleet while its energy crisis deepened.

## 3 THE TRANSMISSION TRAP: €651 BILLION AND RISING

Germany's current energy strategy depends on a €651 billion expansion of electricity transmission—moving wind power from the north to industrial centers in the south. A study by the Institute for Macroeconomics and Economic Research (IMK) and the University of Mannheim, published in December 2024, found that the total cost of grid expansion could reach €651 billion by 2045. This comprises approximately €328 billion for the transmission grid and €323 billion for the distribution grid. The consulting firm ef.Ruhr estimated an even higher figure of €732 billion.<sup>5</sup>

These are not theoretical costs. They are passed to consumers through grid fees, which have already risen by over 25% since 2021. In 2023, Germany invested approximately €15 billion in grid projects; the IMK study indicates this must roughly double to €34 billion annually.

<sup>2</sup>Germany remains the largest economy in Europe and the third largest globally, with GDP of EUR 4.47 trillion in 2025 (KPMG/Langit Eastern, 2026).

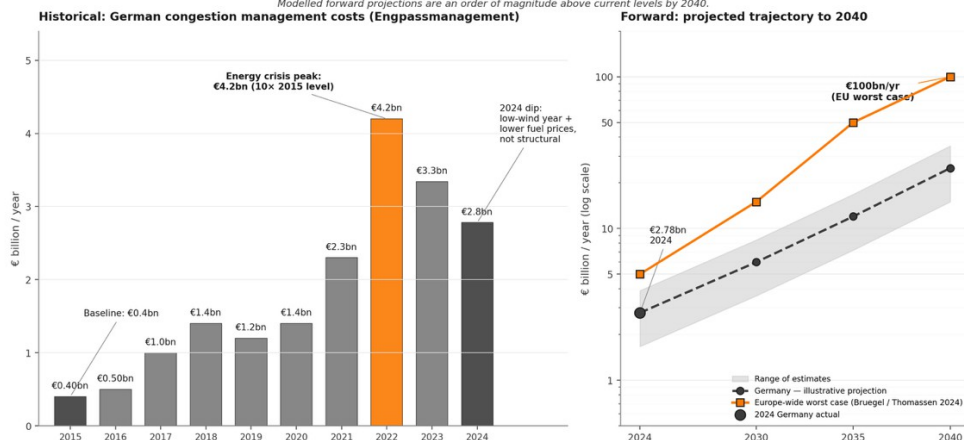
<sup>3</sup>IEA, Germany – Countries & Regions, 2024 data.

<sup>4</sup>Declaration to Triple Nuclear Energy by 2050, launched at COP28 (December 2023), endorsed by over 30 countries including the US, UK, France, Japan, South Korea, Canada, and UAE. Reaffirmed at COP29 (November 2024).

<sup>5</sup>Institute for Macroeconomics and Economic Research (IMK) and University of Mannheim, December 2024. The consulting firm ef.Ruhr estimated total costs at €732 billion.

### The cost of the existing strategy is rising.

Congestion management cost in Germany rose seven-fold from 2015 to its 2022 peak. The 2024 dip is fuel-price- and weather-driven, not structural. Modelled forward projections are an order of magnitude above current levels by 2040.



Adjacent grid costs not shown above: • NEP 2037/2045: €360-650bn grid investment required by 2045 • SuedLink: original €3bn → €10bn budget (3.3x escalation since first plan) • €6.5bn federal subsidy to grid fees in 2026 to absorb part of the increase from customers



Source: BNetzA Monitoringbericht and quarterly Netzengpassmanagement reports; SMARD; NEP 2037/2045 (2025) draft; Bruegel 'Upgrading Europe's electricity grid' (2024); Clean Energy Wire.

### 3.1 Why Transmission Is the Binding Constraint

Transmission is the single most important constraint on energy project development. Without available grid capacity, developers will not invest. Building transmission typically takes longer than building power plants, requires approvals across multiple jurisdictions, and faces persistent public opposition. As Terra Praxis has documented, transmission dedicated to wind and solar costs approximately 2x per TWh for wind and 4x for grid-scale solar, compared to conventional dispatchable generation.<sup>6</sup>

Grid expansion has become a major stumbling block for the Energiewende. Projects have been long delayed by local opposition—particularly the major north–south corridors (SuedLink, SuedOstLink). Germany initially prioritized underground cables to overcome public resistance, but the Federal Network Agency (BNetzA) now estimates that switching to overhead lines would save approximately €35 billion by 2045. Even this change faces opposition from state governments in Lower Saxony and North Rhine-Westphalia.<sup>7</sup>

The alternative is to place clean generation capacity where the grid connections already exist. Section 4 sets out how this works.

## 4 SINKS TO SOURCES: THE REPOWERING OPPORTUNITY

The EU has roughly 100 GW of coal capacity still operating, with at least 34 GW committed to close by 2030. Add Türkiye's 22 GW and the Western Balkans' 8 GW, and the wider European figure approaches 130 GW. Germany and Poland together account for roughly three-quarters of EU coal generation.<sup>8</sup>

Each of these sites has what a greenfield project would spend years acquiring: land zoned for industrial energy, high-voltage grid connections, cooling water, existing permits, skilled workforces, and communities whose economic base depends on the plant. Once decommissioned past the point of reuse—switchyards dismantled, workforces dispersed—that advantage is gone permanently.

<sup>6</sup>Terra Praxis, "Risks to the Energy Transition," August 2023.

<sup>7</sup>Clean Energy Wire, "Germany plans switch from underground to overhead power lines to cut costs," April 2026.

<sup>8</sup>Terra Praxis, Europe's Coal Fleet, Ready to Repower, May 2026.

The repowering model transforms these sites from "energy sinks" consuming fuel and emitting carbon into "energy sources": clean generation assets providing electricity, industrial process heat, hydrogen, and district heating. Germany's coal sites are concentrated in the industrial heartlands—North Rhine-Westphalia, Saxony, Brandenburg, Lower Saxony—exactly where demand is highest. The three closed nuclear sites (Isar 2, Neckarwestheim 2, Emsland) add further high-value locations.

Table 1. The Transmission Cost Comparison

| Metric                     | Current Grid Expansion Plan      | Repowering at Existing Sites             |
|----------------------------|----------------------------------|--|
| Transmission grid cost     | EUR 328 billion                  | Near-zero (existing connections)         |
| Distribution grid cost     | EUR 323 billion                  | EUR 50-100 billion (local upgrades only) |
| Annual investment required | EUR 34 billion/year              | EUR 8-12 billion/year                    |
| Timeline to completion     | 2045 (if no further delays)      | 5-8 years per site from decision         |
| Public opposition risk     | High (new corridors, land use)   | Low (existing industrial sites)          |
| Grid fee impact            | +130% increase projected by 2045 | Stable or declining                      |

#### 4.1 The Capacity Factor Dividend

Germany's coal fleet currently operates at remarkably low-capacity factors. In 2024, the fleet of approximately 28.3 GW generated roughly 95 TWh of net electricity (71.1 TWh from lignite and 24.2 TWh from hard coal)—implying an average capacity factor of just 38%. These plants are running barely a third of the time, yet they occupy grid connections sized for their full rated capacity.<sup>9</sup>

Nuclear plants routinely achieve capacity factors of 90% or higher. If Germany's 28.3 GW of coal capacity were replaced like-for-like with advanced nuclear reactors at 90% capacity factor, the same grid connections would deliver 223 TWh/year—128 TWh more than coal currently provides. That additional 128 TWh equals one-quarter of Germany's total electricity consumption, delivered at existing grid nodes with zero new transmission, at the baseload reliability that energy-intensive industry requires. The investments Germany has made in flexible consumption, would enable efficient utilization of these high-capacity factor clean resources.

#### 4.2 The Carbon Dividend

Germany's coal fleet emitted 104 MtCO<sub>2</sub>e in 2024 (80.7 Mt lignite, 23.3 Mt hard coal)—72% of total power sector emissions of 143.9 MtCO<sub>2</sub>e. Replacing it with zero-carbon nuclear eliminates these 104 MtCO<sub>2</sub>e directly—14% of Germany's total national emissions. The additional 128 TWh of clean electricity would also displace gas generation, cutting a further 20-30 MtCO<sub>2</sub>e/year. Total annual reduction: 125-135 MtCO<sub>2</sub>e, nearly eliminating the power sector's carbon footprint. No other single infrastructure decision offers a comparable emissions reduction.

#### 4.3 Beyond Electricity: Industrial Heat, Hydrogen, and Data Centers

Seventy-five per cent of global energy demand lies outside the power sector—in industry, transport, and heating.<sup>10</sup> Current decarbonization strategy focuses almost entirely on electrification. Repowered nuclear sites can supply high-temperature process heat (above 300 degrees C for some advanced reactor designs), hydrogen via high-temperature steam electrolysis at roughly \$2300/tonne (versus \$4900/tonne from natural gas in January 2025), district heating, and co-located power for data centers—which consumed 4.4% of global electricity in

<sup>9</sup>Fraunhofer ISE, German Net Power Generation 2024; The Coal Hub, Germany's power emissions fell 11% in 2024. Authors' capacity factor calculation from these sources.

<sup>10</sup>IEA (2024), World Energy Outlook; EPRI (2021), Rethinking Deployment Scenarios for Advanced Reactors. 75% of global energy demand is outside the power sector (industry, transport, heating).

2024 and are projected to reach 8% by 2030. These markets represent a EUR 0.5-1.5 trillion European opportunity.<sup>11</sup>

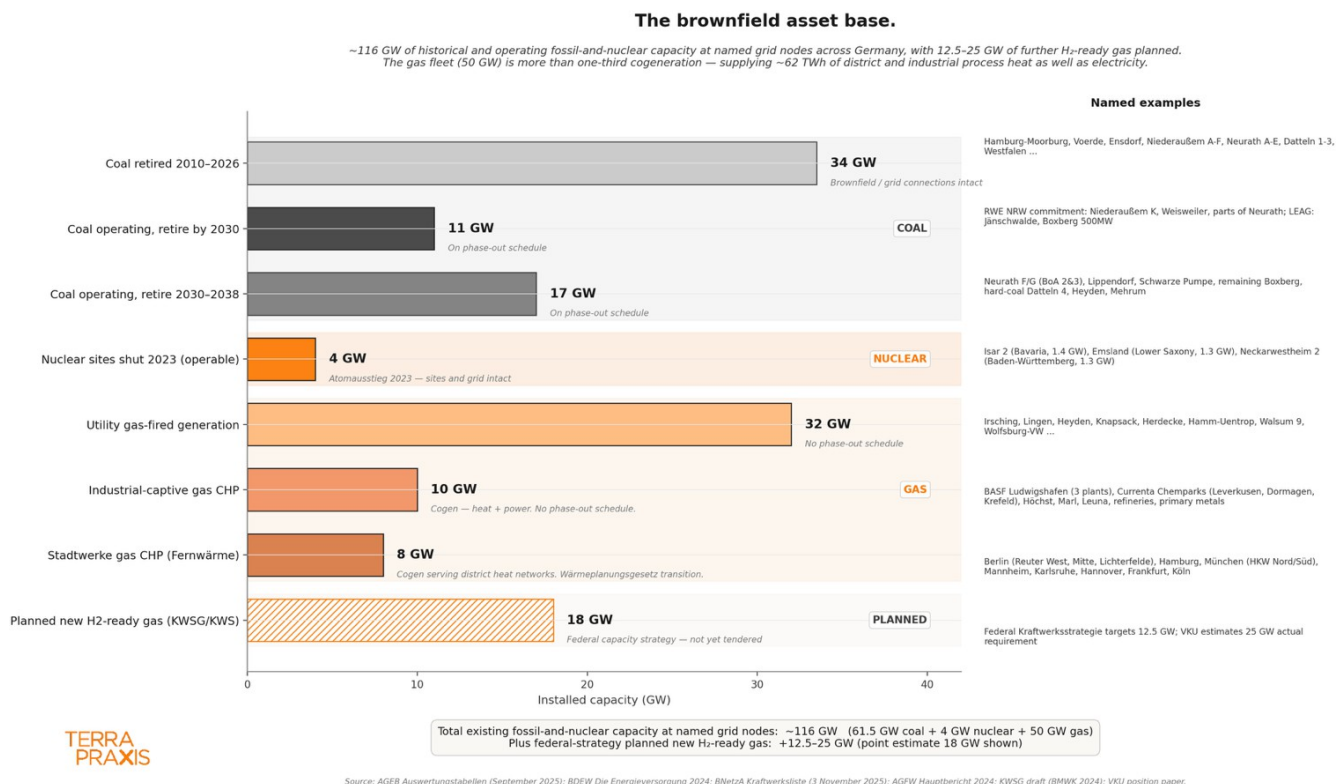
#### 4.4 The Industrial and Security Dividends

Germany's precision engineering and heavy manufacturing energy requirements are well-suited to fleet-scale nuclear deployment. The 700 GW global industrial SMR opportunity means Germany could build a nuclear manufacturing export industry, not just deploy reactors domestically but manufacture components for European and global fleets. A coal-to-nuclear conversion also retains the skilled workforce, turbine operators, electricians, safety engineers, that would otherwise be lost. These communities get a future, not a managed decline.

The energy security case is equally direct. Germany imports coal (932,383 TJ in 2024) and gas (partially replacing Russian supply with US and Qatari LNG), leaving it structurally exposed to price shocks, as the current oil crisis demonstrates. Nuclear fuel is energy-dense (a single load runs 18-24 months), sourced from allied nations (Canada, Australia, France), and storable on-site for years. Repowering converts import dependence into domestic energy sovereignty.

#### 4.5 Beyond Power Plants: Repowering Industrial Sites

The 28.3 GW coal fleet is the most visible brownfield opportunity, but it is not the largest. Three further fleets are addressable: ~32 GW of utility gas-fired generation, which produced 56.9 TWh in 2024 and emitted 20.1 MtCO<sub>2</sub>e (Bundesnetzagentur, Montel Analytics); ~10 GW of industrial-captive CHP at chemical, steel, refinery, and primary-metals sites; and ~20 GW of district-heating CHP operated by Stadtwerke (BDEW). None of these ~62 GW of fossil-gas capacity is on a scheduled phase-out path, and the Wärmeplanungsgesetz now requires every Fernwärme network to decarbonize—putting the Stadtwerke fleet under a binding deadline of its own. Chemparks, refineries, primary steel, primary aluminum, and district-heating nodes are concentrated, grid-connected, water-served sites that need both electricity and high-temperature process heat at the same location—exactly what advanced nuclear can deliver and what wires alone cannot.



The scale at single sites is decisive. BASF Ludwigshafen occupies 10 km<sup>2</sup> and consumes 6 TWh of electricity and 20 Mt of steam annually; full electrification of its processes would roughly triple that electricity demand. ArcelorMittal (Bremen, Eisenhüttenstadt), ThyssenKrupp (Duisburg), and BASF itself have all publicly signaled

<sup>11</sup>Urenco—LucidCatalyst, "The 700 GW Industrial SMR Opportunity," 2025.

relocation or curtailment as energy costs widen the gap with the US and China. Repowering at industrial brownfields addresses both—keeping the demand, and the tax base, in Germany.

## 5 THE DIGITAL ACCELERATORS: PROJECT PHOENIX AND GEN AI FOR LICENSING

### 5.1 Project Phoenix: Fleet-Scale Site Assessment

Terra Praxis' Project Phoenix, funded by the U.S. Department of State, assesses coal plant sites and generates optimized nuclear conversion designs in days rather than the 12-18 months a conventional feasibility study requires. At its core is the REPOWER Configurator, developed with Bryden Wood, which embeds the rules of the open architecture into a comprehensive library of qualified components. It evaluates thousands of possible site configurations - reactor type, heat box count, layout, infrastructure reuse, grid integration—and identifies optimal solutions for each site, automatically generating cost estimates, timelines, and a complete digital thread for regulatory review.

Over 2024-2025, Terra Praxis built and tested the platform against 13 Ukrainian coal sites (24 GW fleet), with Ukraine's Ministry of Energy and Energoatom as partners. Ukraine's coal fleet was operating at just 10-17% capacity factor. Terra Praxis analysis showed that repowering the 24.2 GW fleet at 95% capacity factor would increase the country's electricity generation by over 170%, from 103 TWh to 201.5 TWh. The end-to-end workflow was demonstrated in December 2025.

### 5.2 Generative AI for Licensing: Built with Microsoft

Where REPOWER tools assess sites, the Gen AI for Licensing tool (developed with Microsoft) accelerates the regulatory pathway. It has demonstrated 92% reductions in permitting timelines by processing regulatory frameworks in multiple languages, mapping requirements across jurisdictions, and generating licensing documentation. Agentic capabilities—including the "Virtual NRC in the loop" concept, where AI agents simulate regulatory review—allow developers to test licensing strategies before engaging regulators.

The platform is being demonstrated at the Munich retreat by Microsoft's Conor Kelly and Henning Kilset, with Terra Praxis, NVIDIA, Everstar, and Aalo Atomics building on the foundational capabilities.

### 5.3 Ready for European Fleets

Both platforms are ready for European deployment. The REPOWER tools can screen Germany's coal and nuclear sites in weeks; the Gen AI tool can be applied to European regulatory frameworks immediately. Germany, Poland, the Czech Republic—each fleet can be assessed and advanced through the licensing pathway within months.

## 6 COSTS, FEASIBILITY, AND TIMELINE

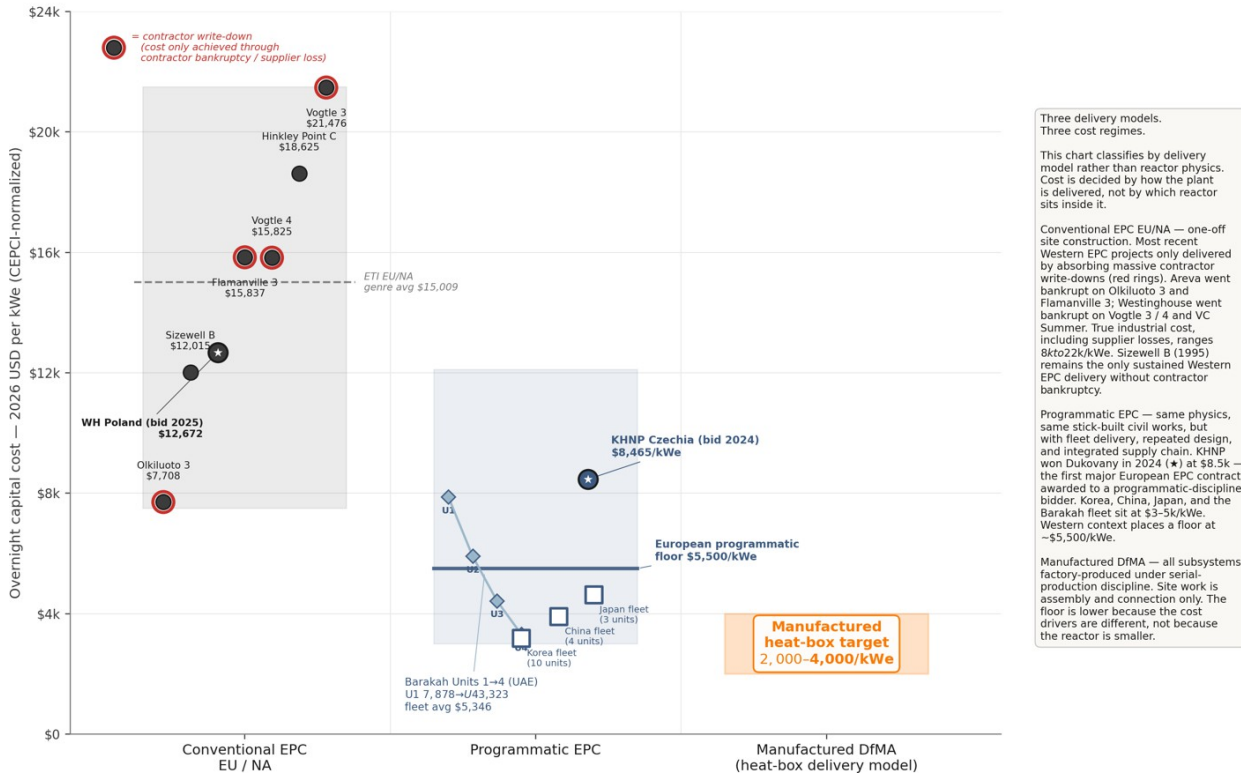
### 6.1 REPOWER Economics: From Artisanal to Industrial

Traditional nuclear construction is delivered as custom-designed, site-specific, labor intensive, one-off megaprojects costing \$8,000-20,000/kWe in the West. The REPOWER delivery system treats nuclear as a standardized industrial product. Detailed cost analysis yields a target repowering capital cost of approximately \$2-4,000/kWe. At these capital costs, the REPOWER system delivers a levelized cost of electricity (LCOE) of \$52-64/MWhe—lower than any other clean, firm, scalable generation alternative including renewables with 24/7 storage, natural gas with carbon capture, and geothermal.<sup>12</sup> This compares to German wholesale prices of EUR 80-100/MWh in 2025, and well below the all-in cost of the renewables-plus-transmission pathway (EUR 100-140/MWh when system integration, balancing, and grid expansion are included).

<sup>12</sup>Terra Praxis analysis using simplified LCOE methodology (NREL). Overnight capital cost range \$1,570-2,180/kWe; financing over 20 years; 7% debt, 12% equity; 70% debt share.

## Nuclear cost is a question of delivery, not physics.

Three delivery models. Three cost regimes. All values in 2026 USD per kWe, normalized via CEPCI.  
 Conventional EPC in Europe and North America has delivered between 8k and 22k/kWe — many only by absorbing contractor write-downs (red rings).  
 Programmatic EPC has been demonstrated at \$3-6k/kWe. Manufactured DfMA delivery sits in a different regime entirely.



Method: All cost figures are overnight capital costs normalized to 2026 USD using the Chemical Engineering Plant Cost Index (CEPCI). True industrial cost includes contractor write-downs absorbed during delivery (red rings): Olkiluoto 3 €1.1bn already includes Areva's €5.5bn loss; Flamanville 3 uses French Court of Auditors construction-cost estimate (€1.9bn, 2020); Vogtle 3 and 4 published costs (\$36.8bn combined, 2024) adjusted upward to include ~\$3.7bn Toshiba parent-company guarantee and additional Westinghouse losses. Recent bids: KHNP Dukovany (Jul 2024); Westinghouse Poland (Dec 2025 EC state-aid approval, €4.2bn); Sizewell B (1995) and Hinkley Point C are not adjusted: no separate contractor bankruptcy.

Source: ETI Nuclear Cost Drivers Project Full Technical Report (2018, Energy Technologies Institute / LucidCatalyst / CleanTech Catalyst); Czech Government / KHNP (Jul 2024); European Commission state-aid approval for Polish nuclear (Dec 2025); TVO; EDF; Georgia Power / Southern Company; ONR; World Nuclear Association; CEPCI annual averages (Chemical Engineering magazine).

## 6.2 How REPOWER Enables These Costs

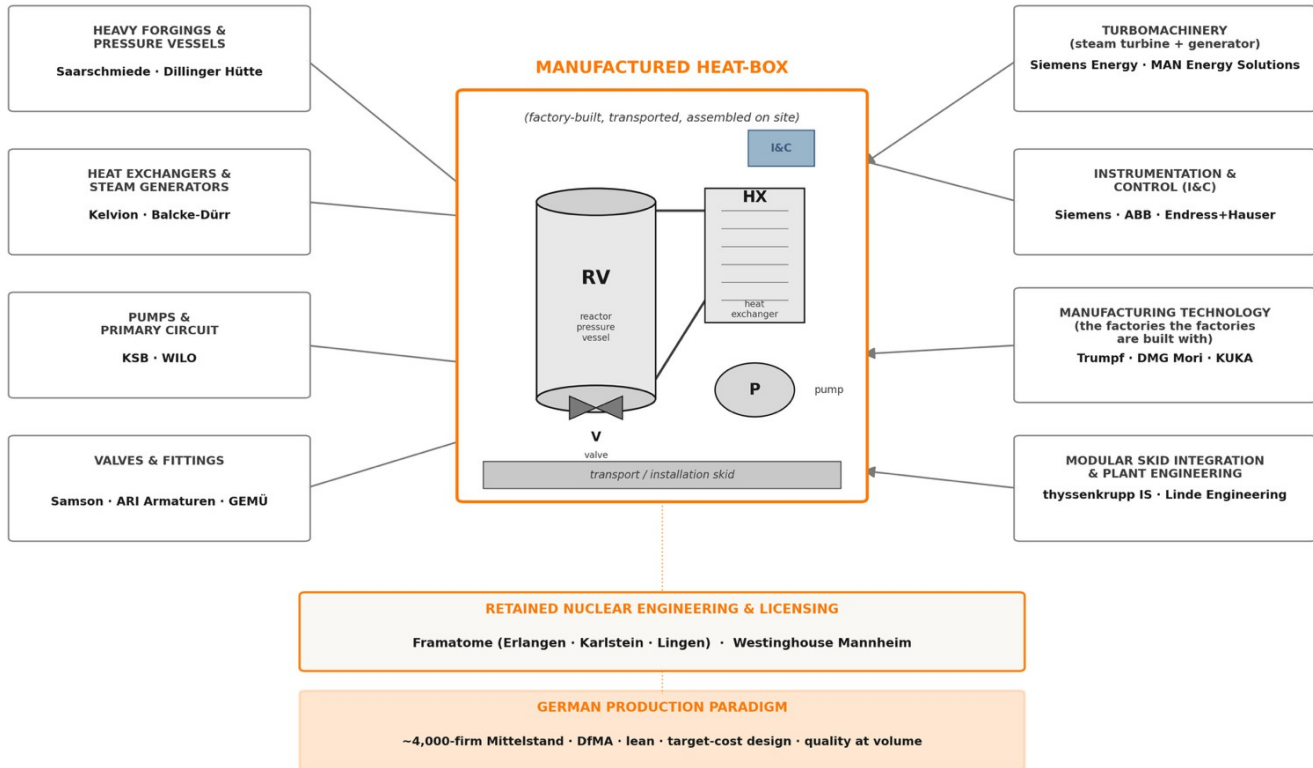
Nuclear today is delivered through a megaproject construction model. This model can achieve attractive costs in intensively planned delivery programs for multiple units as demonstrated in the UAE, Korea, and China, but it has led to very high costs for first of a kind plants delivered as single units, or in pairs.

Redesigning for an open architecture, fully industrialized manufacturing and assembly process, such as applied in automotive design and manufacturing, dramatically reduces the delivered cost. It also enables further cost reduction through cost-down engineering and learning through the manufacturing and assembly process. This further cost reduction comes from applying proven industrial methods that have delivered 30-40% savings in already very competitive industries such as automotive (Volkswagen platform strategy), 60-70% in aviation, and 38% in data center construction.<sup>13</sup> Specifically: open architecture enables the separation of the nuclear and non-nuclear scope, enabling 80%+ of non-nuclear components to be sourced from conventional commercial supply chains; DfMA will enable factory production of "heat box" reactor modules with dramatic cost reduction and schedule compression versus site-built construction.

<sup>13</sup>Open architecture cost reductions: automotive 30-40% (Volkswagen), aviation 60-70%, data centers 38%. See Appendix A, Project Phoenix Prospectus V2.5.

## Every subsystem of a manufactured heat-box already has a German supplier.

A manufactured heat-box decomposes into subsystems that German industry already produces at world-leading scale for power, chemicals, and process industries. The retained nuclear engineering capability — Framatome Erlangen, Westinghouse Mannheim — continued exporting to the rest of Europe after the Atomausstieg.



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Method: Schematic shows representative subsystems of a manufactured heat-box (reactor pressure vessel, primary heat exchanger, primary pump, valves, instrumentation, and transport/installation skid). Named firms are world-leading German suppliers in each subsystem category — illustrative selection from a much larger ecosystem of suppliers and Tier-1/Tier-2 firms. Nuclear engineering capability (Framatome, Westinghouse Mannheim) refers to retained German engineering centres that continue to serve operating European fleets.

Source: Company public disclosures (Framatome, Westinghouse, Siemens Energy, MAN Energy Solutions, KSB, Kelvion, others); VDMA / BDI / VDI industry association data; Open Architecture Nuclear Integration Framework (2023) supplier ecosystem mapping.

### 6.3 Five-Year Deployment Timeline

The target is five years from project decision to operation, against the decade-plus timeline typical of traditional nuclear. This is achieved through: site reuse (eliminating years of land acquisition, environmental assessment, and grid permitting); the Configurator tool (generating optimized designs in days, not years); product-based licensing (pre-approved standardized designs replacing site-by-site review); and DfMA (factory production in parallel with site preparation). At full scale, a nuclear gigafactory producing 70 100MWe heat boxes per year could repower an entire national coal fleet within 10-15 years following an S-curve deployment pattern.

### 6.4 Feasibility Assessment

Table 2. Repowering Feasibility Matrix

| Factor                | Assessment  | Basis   |
|-----------------------|-------------|---|
| Site availability     | High        | Coal closures accelerating; nuclear sites intact            |
| Grid connection value | Very high   | Existing HV connections worth billions                      |
| Technology readiness  | Medium–High | Multiple SMR designs in late-stage development or licensing |

|                         |            |   |
|-------------------------|------------|---|
| Regulatory pathway      | Developing | EU Taxonomy confirmed; mutual recognition emerging                          |
| Political feasibility   | Improving  | Coalition agreement opens door; public opinion shifting                     |
| Economic viability      | Strong     | Below \$2,000/kWe target; €60–70/MWh delivered cost                         |
| Digital tools readiness | Proven     | Phoenix proven in Ukraine; Gen AI for Licensing demonstrated with Microsoft |
| Workforce availability  | High       | Existing coal/nuclear workforces transferable                               |

## 7 DEEPER DECARBONIZATION: WHY GERMANY NEEDS BOTH

### 7.1 The Gaps Renewables Cannot Fill

Germany added 21 GWe of renewable capacity in 2025, bringing the total to approximately 210 GW. Yet net renewable electricity generation fell short of the 346 TWh target. Offshore wind, critical for baseload replacement, added just 0.29 GW, and Germany is now expected to miss its 30 GW offshore target by at least two years.<sup>14</sup> The gap between installed capacity and actual generation reveals the structural challenge: Germany's wind fleet achieved a capacity factor of roughly 22% in 2025 (132 TWh from 68.1 GW onshore + 9.5 GW offshore); solar roughly 8.5% (87 TWh from 116.8 GW installed) (Fraunhofer ISE, "German Public Electricity Generation in 2025," January 2026). No amount of additional wind and solar resolves the need for firm, round-the-clock power during Dunkelflaute periods, nor does it provide the high-temperature industrial process heat that accounts for a large share of Germany's industrial emissions.

Former fossil generation sites repowered with nuclear fill these gaps. At 90% capacity factor, they provide firm baseload that complements variable renewables, reducing the need for gas backup, battery storage, and curtailment. It supplies process heat above 300 degrees C for chemicals, steel, and cement. It powers data centers that require 24/7 guaranteed supply. These are services that renewables, by their nature, cannot provide at the scale and reliability Germany's industrial base demands.

### 7.2 Accelerating the Transition Together

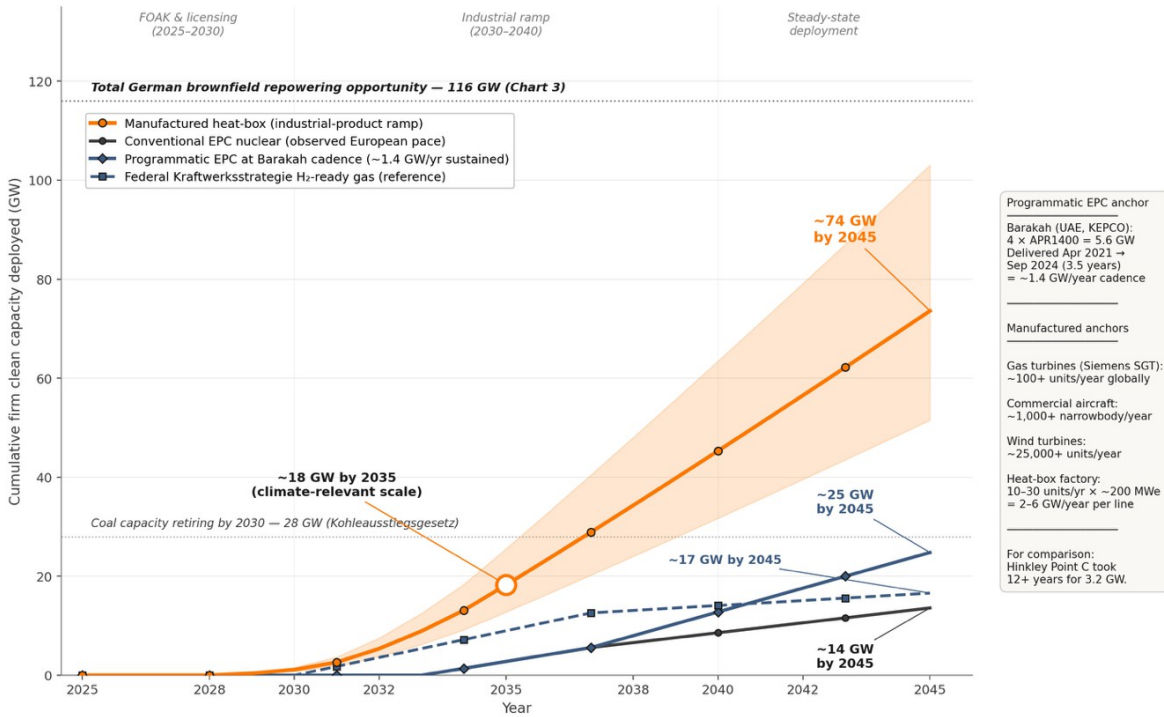
The critical insight is that nuclear repowering makes the renewable transition faster, not slower. By using existing grid connections at coal sites, repowering frees up transmission capacity for renewables elsewhere—reducing the bottleneck that currently constrains wind deployment in the north. The OECD Nuclear Energy Agency has found that grid-level system costs for variable renewables range from \$8-50/MWh, versus just \$1-3/MWh for nuclear.<sup>15</sup> Adding firm nuclear baseload to the grid reduces the total system integration cost of renewables, lowers the storage and backup bill, and cuts overall consumer prices. The IEA's modelling consistently shows that systems combining nuclear with renewables achieve deeper decarbonization at lower total cost than either alone (IEA, "Nuclear Power and Secure Energy Transitions," 2022; IEA, "Nuclear Power in a Clean Energy System," 2019).

<sup>14</sup>Bundesnetzagentur, Growth in renewable energy in 2025; Fraunhofer ISE, German Public Electricity Generation in 2025.

<sup>15</sup>OECD NEA, The Full Costs of Electricity Provision, 2018. Nuclear system costs \$1—3/MWh vs \$8—50/MWh for intermittent renewables.

## Deliverability: closing the German brownfield gap by delivery model.

Germany faces ~116 GW of retiring or aging fossil and nuclear capacity. Four delivery trajectories: only programmatic and manufactured deployment plausibly close meaningful fractions of the gap by 2045. Conventional EPC at observed European pace cannot. Kraftwerksstrategie gas addresses the firming question but not decarbonisation.



Method: Trajectories are illustrative analytical scenarios, not point forecasts. Programmatic EPC line anchored on the Barakah delivery record (KEPCO, UAE): 5.6 GW from 4 x APR1400 delivered Apr 2021 - Sep 2024 (~1.4 GW/yr cadence after ~9 yrs from groundbreaking to first unit). Manufactured ramp assumes FOAK regulatory engagement and factory commissioning 2025-2029, first commercial units 2029-2031, industrial throughput from 2032; shaded band reflects ±30-40% parameter uncertainty. EPC trajectory at observed Western pace (Hinkley Point C, Flamanville 3, Olkiluoto 3, Vogtle 3/4). Gas follows the federal Kraftwerksstrategie / KWStG planned 12.5 GW with possible 25 GW expansion, accounting for tender delays.

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Source: Barakah delivery dates (ENEC / KEPCO / Emirates Water and Electricity Company); EPR1000 build data (TVO, EDF, Georgia Power, ONR); Frontier Economics 'Power Plant Strategy' for BMWK (2025); Kraftwerksstrategie / KWStG draft (BMWK 2024); BNetzA Monitoringbericht; Chart 3 brownfield asset inventory; production-rate references from gas turbine, commercial aviation, and wind turbine industry public data.

### 7.3 Practical Realities: Land, Acceptance, and Scale

In a densely populated country of 357,000 km<sup>2</sup>, the land use dimension matters. Nuclear requires approximately 3.4 km<sup>2</sup> per GW; onshore wind requires 670-930 km<sup>2</sup> per GW; solar requires 116-200 km<sup>2</sup>. Replacing coal's output with nuclear: ~96 km<sup>2</sup> at existing sites. Equivalent output from wind: ~75,000 km<sup>2</sup>.<sup>16</sup> Both pathways face public acceptance challenges—but they are different challenges in different places. Combining nuclear (at existing industrial sites with community support) with renewables (in areas with space and wind resource) distributes the transition across more of the country and more communities, building a broader political coalition for decarbonization.

Table 3. How Nuclear Repowering Complements Renewables

| Dimension           | What Renewables Provide             | What Repowering Adds                                     |
|---------------------|-------------------------------------|--|
| Generation profile  | Variable (11-22% capacity factor)   | Firm baseload (90% capacity factor)                      |
| Grid infrastructure | Requires EUR 651B+ new transmission | Uses existing connections; frees capacity for renewables |
| Industrial heat     | Electricity only                    | Process heat >300C for chemicals, steel, cement          |

<sup>16</sup>Our World in Data, How does the land use of different electricity sources compare?, 2022; NEI, Land Needs for Wind, Solar Dwarf Nuclear Plant's Footprint, 2015.

|                                      |                                 |  |
|--------------------------------------|---------------------------------|--|
| Land use (28 GW equivalent)          | 14,000-75,000 km <sup>2</sup>   | ~96 km <sup>2</sup> at existing sites      |
| System integration cost              | \$8-50/MWh (OECD NEA)           | \$1-3/MWh                                  |
| Dunkelflaute backup                  | Gas plants + storage required   | Provides firm power through all conditions |
| Beyond-electricity markets           | Limited (electrification only)  | Hydrogen, district heating, data centers   |
| CO <sub>2</sub> from coal eliminated | Dependent on phase-out timeline | 104 MtCO <sub>2</sub> e/year from day one  |

## 8 WHY NOW: A CONFLUENCE OF CONDITIONS

Germany faces a systemic risk: the simultaneous convergence of an energy cost crisis, a decarbonization deadline, an industrial competitiveness collapse, and grid infrastructure that cannot be built fast enough. These are not independent problems—they compound each other. High energy prices drive deindustrialization, which erodes the tax base needed to fund grid expansion, which delays the transition, which keeps emissions high. Incremental policy adjustments cannot break this feedback loop. Repowering is the only intervention that addresses all four simultaneously. And there is an unprecedented opening in the market:

First, the regulatory gate is open. The EU Taxonomy classifies nuclear as environmentally sustainable—confirmed by the EU General Court in September 2025—unlocking institutional capital under EU sustainable finance rules.

Second, the economics have shifted. EU ETS carbon prices at c. EUR 75/tonne (and rising) make unabated coal increasingly uneconomic. Germany's deindustrialization crisis has made energy cost competitiveness a top-tier political issue for the first time in a generation.

Third, there is a political opening. Germany's new coalition has signaled willingness to reconsider nuclear. The appointment of Dorothee Bar as Federal Minister for Research, Technology and Space, and a measurable shift in public opinion, create a window that did not exist under the previous government.

Fourth, the oil crisis has made energy sovereignty a live political issue, creating space for arguments that would have been dismissed two years ago.

Fifth, the tools exist. Terra Praxis' REPOWER tools and the Gen AI for Licensing tool are operational today—not concepts, not roadmaps. Fleet-scale site screening can begin in weeks.

## 9 WHAT IS REQUIRED: A PHASED ROADMAP

### 9.1 Months 1-6: Assessment and Legislative Foundation

- Commission Terra Praxis' Project Phoenix tool to screen all 28.3 GW of German coal sites and three closed nuclear sites—the platform can complete fleet-wide assessment within weeks.
- Initiate Atomgesetz amendment to lift the legislative prohibition on nuclear energy.
- Establish a joint federal-state working group on coal-to-nuclear transition, engaging Bavaria, North Rhine-Westphalia, Saxony, and Brandenburg.
- Begin formal engagement with EU partners on mutual recognition of reactor licensing—Germany's participation would be transformative for the European regulatory landscape.

## 9.2 Months 6-18: Regulatory Pathways and First Projects

- Establish an advanced reactor licensing framework—either reformed domestic regulation or mutual recognition of US, Canadian, or EU partner-nation approvals.
- Select 2-3 pilot sites for first coal-to-nuclear conversions and one closed nuclear site for restart assessment.
- Deploy the Gen AI for Licensing tool (built with Microsoft) against German and EU regulatory frameworks to map the licensing pathway.
- Include nuclear energy in Germany's climate and industrial policy frameworks on equal terms with renewables, including access to EU sustainable finance under the Taxonomy.

## 9.3 Months 18-36: Demonstration and Supply Chain

- Commence a first demonstration project—a coal-to-nuclear or nuclear-site-restart that makes the concept tangible for communities and investors.
- Engage German industrial supply chain (precision engineering, heavy manufacturing, modular construction) for REPOWER component production.
- Launch transparent public engagement on costs and trade-offs of the current pathway versus repowering, emphasising jobs, energy bills, and community futures.
- Coordinate with Poland, Czech Republic, and other EU partners on fleet-scale European deployment program.


# 10 CONCLUSION

Repowering Germany's 28.3 GW coal fleet and three closed nuclear sites would eliminate 104 MtCO<sub>2</sub>e/year, deliver 223 TWh of clean electricity (128 TWh more than coal currently provides), avoid up to EUR 300-400 billion in transmission costs, and produce electricity at \$52-64/MWhe—below any other clean, firm alternative. The REPOWER system enabling delivery at \$2-3,000/kWe is 60-80% cheaper than conventional nuclear. The digital tools are proven. The sites are there. The supply chain is ready to mobilize.

What is required is strategic intent. The phased roadmap in Section 9 shows that fleet-wide assessment can begin within weeks. Terra Praxis' Munich REPOWER Retreat brought together the utilities, vendors, governments, and investors who can translate this opportunity into action. The question is whether Germany will act before the assets that make repowering possible are dismantled beyond recovery.



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