

The Energy Transition Has a Hiring Problem

11.8-fold 29.7 2031

two answers to two different questions

per cent of new contracts dissolved

workforce binds first, central case

North Rhine-Westphalia's route to climate neutrality is decided in a race between four constraints: people, capital, grid connections and demand. The people constraint is real, but nothing says it binds first.



The Energy Transition Has a Hiring Problem

North Rhine-Westphalia's route to climate neutrality is decided in a race between four constraints: people, capital, grid connections and demand. The people constraint is real, but nothing says it binds first. This report puts all four on one course, names the year each could win, and shows what has to be true for the workforce to be the one that matters.

11.8-fold

two answers to two different questions

29.7%

of new apprenticeship contracts dissolved in 2023

2031

the year the people constraint binds first, on the evidenced central case

CAPABILITY DEMONSTRATED

Bottleneck and interdependency analysis

PUBLISHED

2 September 2026 · version 4.0 · general industry report

A showcase of the Quorum evidence pipeline. This report summarises a small part of a much larger body of research; the scale of that work, and how to commission it, are set out on the closing page.

Prepared by Serinyx GmbH. Every factual statement carries a superscript reference to a verified source list. AI disclosure: researched, drafted and checked by Serinyx's Quorum evidence pipeline under named human sign-off; it should empower human judgement, not replace it. © Serinyx GmbH 2026.

CONTENTS

Sections

01	The skills gap is real; its size is a definition	17 claims
02	The workforce constraint is a pipe, not a headcount	29 claims
03	Which constraint binds first is computable, and the verdict has a location	41 claims
04	The course is set; the rates are yours	4 claims

Also in this report

- Executive summary
- The counterweight: the strongest case against this reading
- How we know, and what we could not establish
- What would change our mind
- About the research corpus
- References, every link verified

Every section header states the number of separately sourced claims that section rests on. Superscript numerals throughout resolve to the reference list, and every value in every figure and table resolves to a source in the same way.

EXECUTIVE SUMMARY

North Rhine-Westphalia has set itself a dated course. The last Rhenish lignite unit closes on 31 March 2030, and the deep-decarbonisation scenarios in the research corpus run to 2045^{40,64,70}. Whether the state can physically deliver that course rests on four constraints: skilled people, capital, grid connections and demand.

This report finds three things. The people constraint is real and measured. Its published size is a choice of definition, not a fact. And nothing in the evidence says it binds first. We put all four constraints on one dated course, name the year each could win, and hand over a model that shows what must be true for the workforce to be the one that matters.

THREE KEY NUMBERS

62,230. The number of advertised qualified-worker positions no registered qualified unemployed person could fill in North Rhine-Westphalia from July 2024 to June 2025. That is 28.0 per cent of all registered openings, the vacancy-arithmetic reading of the gap¹. The wider projection reading, 735,000 by 2030, counts something different and is carried beside it, not averaged in.

2031. The year the workforce rail binds first on the central case, just after the 2030 coal-exit line. It is a banded year, not a point: across the plausible readings of the one rate the evidence cannot supply, it runs from about 2028 to 2037, computed by the report's model.

45 of 100. Of every hundred apprentices who start, the number who reach a job in their trained trade on the model's default Handwerk dissolution rate of 38.5 per cent. On the state's overall dissolution rate of 29.7 per cent the same arithmetic gives 49 to 56. Both meters are evidenced, and the difference is named rather than left for a reader to reconcile^{15,16,62}.

01

The skills gap is real; its size is a definition

RESTS ON 17 SEPARATELY SOURCED CLAIMS

That spread is not a disagreement about the labour market. It is two answers to two different questions.

Germany's most populous state is short of skilled workers by every published measure. How short depends entirely on what the measurer counts. The two best-known counts stand 11.8-fold apart^{1,2}. That spread is not a disagreement about the labour market. It is two answers to two different questions.

The lower pole is vacancy arithmetic. KOFA (Kompetenzzentrum Fachkräftesicherung, the federal skills-monitoring centre at the IW Köln economics institute) publishes a state profile for each federal state. Its reading for North Rhine-Westphalia covers the annual average July 2024 to June 2025. In that window, 62,230 advertised positions for qualified workers could not be filled. That is 28.0 per cent of all registered open positions¹. The measure is called the Fachkräftelücke, the skilled-worker gap. It counts registered vacancies for which no suitably qualified person is arithmetically available among the registered unemployed in the same occupation¹. It is not a count of missing workers. It is a matching failure between two registers. Anything outside those registers is invisible to it by construction. A vacancy never reported to the agency does not exist for this meter. Neither does a job seeker who never registered.

The occupation detail is where the gauge bites. In Bauelektrik, the building electrical trade, 2,889 of 4,249 registered openings were unfillable in the 2024/25 reading. That is 68.0 per cent. Only 32 registered qualified unemployed electricians were available per 100 registered openings¹. That 2,889 is small against the state's 8.25 million employed, but it sits in the single occupation that wires solar roofs, heat pumps and grid connections. Elektrische Betriebstechnik, electrical plant and operations technology, is tighter still. There, 2,769 of 3,729 registered openings were unfillable, 74.3 per cent¹. The mid-tier trades sit near one opening in two. Maschinenbau- und Betriebstechnik reads 47.4 per cent unfillable, Kraftfahrzeugtechnik 46.8 per cent¹. At expert level, meaning roles that require a four-year higher-education qualification, the hardest occupation in the state to fill is construction planning and supervision. It reads 81.0 per cent unfillable, and Informatik stands at 57.0 per cent¹. The national KOFA readings for the same window are higher again. German building electrics read 79.8 per cent unfillable, Elektrotechnik 81.9 per cent and Kraftfahrzeugtechnik 67.6 per cent. A 2023/24 reading put the building trades' national gap at 42,000 unfilled positions³. The state's problem is not a regional oddity. It is a national shortage with a regional address.

The upper pole is a projection. The IHK-Fachkräftereport NRW 2025 was presented on 15 July 2025 by the state's chambers of industry and commerce. It continues a series begun in 2019. It projects the state's skilled-worker gap growing from 447,000 in 2019 to 735,000 in 2030. That is a rise of 64 per cent². The 735,000 is an undercoverage of about 13 per cent of labour demand. Behind it, skilled-labour supply falls from about 6.0 million in 2019 to 4.8 million in 2030. Labour demand falls only slightly, from 6.5 to 5.5 million². Nothing in this gauge counts a job advertisement². It asks how many workers the economy will want in 2030 that demography will not deliver, rather than which registered vacancies cannot be matched today.

Between the poles sit the middle rungs, and they climb in order. The IHK-Fachkräftemonitor NRW 2025 is a separate chamber product, built on the GWS macro-economic model and published in June 2025. It puts the state's unfillable positions at about 290,000 in 2024, rising to up to 610,000 by 2035. The monitor adds up to 40 billion euros of cumulative value creation at risk by 2035, and counts 2.7 million positions to be filled by 2035 once replacement and growth are summed³. A third chamber reading puts more than 400,000 skilled workers as already missing in the state. Its vintage is unstated where the corpus carries it, and it is almost certainly the 2019 base-year figure of the IHK report series re-framed as a current one. So it must never be read as a fourth, independent measurement⁴. Four rungs, one ladder: 62,230, about 290,000, more than 400,000, 735,000 (derived from C-02, C-07, C-08, C-09). Each rung is published and counts something different. A reader who picks one rung and calls it "the gap" has made a choice, not found a fact.

TABLE 1 One shortage, four published readings: the definitional ladder for North Rhine-Westphalia

Gauge and publisher	What it counts	Reading
KOFA Ländersteckbrief NRW (July 2024 to June 2025)	Registered qualified vacancies arithmetically unmatchable to registered qualified unemployed	62,230; 28.0 per cent of registered open positions
IHK-Fachkräftemonitor NRW 2025 (GWS model, June 2025)	Unfillable positions, model-based	About 290,000 (2024), up to 610,000 by 2035
IHK NRW chamber estimate (vintage unstated; likely the 2019 base re-framed)	Current shortfall, method unstated	More than 400,000
IHK-Fachkräftereport NRW 2025 (July 2025)	Projected undercoverage of labour demand in 2030	735,000; about 13 per cent of demand

Sources:^{1, 2, 3, 4}

Why honest counts disagree. The 62,230 is vacancy arithmetic: two registers matched against each other. The 290,000 is a macro-model's reading of positions that cannot be staffed. The 400,000-plus is a projection's base year wearing today's clothes, and the 735,000 is a supply-demand projection out to 2030. Around the ladder orbit other meter families. The Federal Employment Agency's bottleneck analysis classifies 183 occupational categories as shortage occupations nationwide for 2023, 98 of them at skilled-worker level²⁶. The electrical trades association ZVEH counts 96,580 open positions in the German electrical craft in early 2024, up 12.9 per cent year on year, among them 17,170 unfilled apprenticeships⁷. Scraped online postings count 372,500 energy-transition job ads in Germany in 2024¹⁰. Each meter answers its own question, and none is lying. The reader who knows which question was asked can use every one of them.

The trade associations add their own meters and their own disagreements. The SHK sector (Sanitär, Heizung, Klima: plumbing, heating and air-conditioning) is the trade family that installs heat pumps. For it the corpus carries two readings of the current national shortfall: one file carries more than 12,000 missing skilled workers and a second 9,200-plus unfilled positions, which the corpus does not reconcile. The projection reaches 60,000 by 2030, and the public carrier of the series is the sector association ZVSHK⁸. Further out the scenario gauges fork. The SHK shortfall is projected at about 30,000 by 2035 on current trends, rising to 130,000 if energy-transition targets are to be met, a scenario figure the corpus carries and no public source prints. The association's own public readings are 60,000 additional fitters needed by 2030 in a six-million-heat-pump scenario and 24,500 short by 2035^{8,9}. The Öko-Institut estimates the craft workforce needed for a two per cent annual renovation rate at about half again as many as currently exist, roughly 100,000 additional workers in the window, heating and painting trades alone^{8,9}. The 30,000 is the world as it is and the 130,000 is the world as planned.

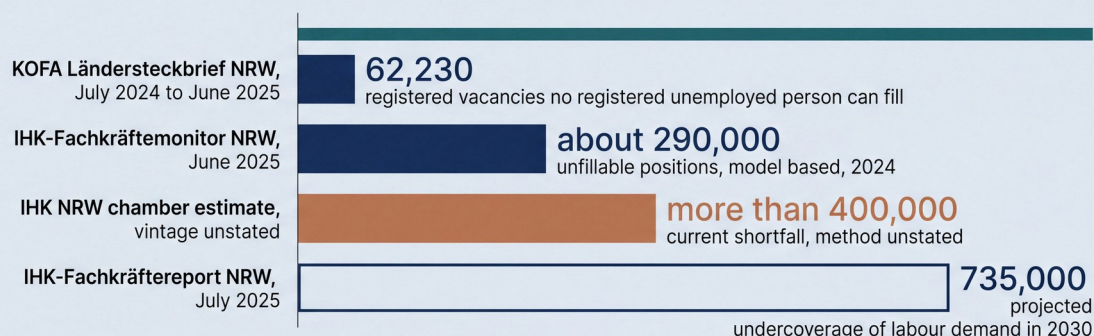
Two more gauges mark the edges of the map. Hydrogen-relevant sectors in Germany lacked about 49,500 qualified workers in 2024, concentrated in electrical plant assembly, operations electronics, mechanical engineering and building electrics¹¹. In construction, 81 per cent of companies report hiring difficulties on a 2025 PwC survey, and the corpus does not state the sample's population or geography, so that caveat ships with the figure¹³.

The consequence is a discipline, and it is cheap. Every gap figure here arrives with its publisher, year, base and counting rule attached. The two poles are never averaged and neither is promoted above the other. The reader sets the definition, and should. A training plan sized for 62,230 unfillable vacancies looks nothing like an industrial strategy sized for 735,000 missing workers.

EXHIBIT 1

THE DEFINITIONAL LADDER

One question, four published answers,
11.8-fold apart.



The two poles are never averaged.
Each rung is published; each counts something different.

Serinyx Quorum evidence ledger; every plotted value resolves to a verified source.

02

The workforce constraint is a pipe, not a headcount

RESTS ON 29 SEPARATELY SOURCED CLAIMS

The injury is in the composition of the work, not the count.

North Rhine-Westphalia's skilled workforce of 2030 is being decided now, inside a training pipe. That pipe takes three to three and a half years to fill in the key trades, is rationed at the entrance, and loses roughly a third of its contents before the end^{15,65}. The stock of installers in five years is arithmetic, not sentiment: what enters the pipe, less what leaks, less what retires. And the Rhenish coalfield, the region the coal exit was supposed to wound, is gaining jobs. The injury is in the composition of the work, not the count¹⁹⁻²¹.

Start at the entrance. New apprenticeship contracts numbered 106,827 in the 2024 training year (Berufsbildungsjahr, the apprenticeship reporting year), down 1.4 per cent year on year, the second-lowest reading since records began in the 1970s and 8.5 per cent below the 116,772 of 2015^{15,16}. One corpus file behind this report's first reading carried the same 106,827 under a 2023 label, against 109,000 for 2022 and 108,000 for 2021. Put plainly, the corpus put that number in the wrong year; the official IT.NRW series, the state statistics office, dates it to the 2024 training year, with 108,393 for 2023. This report uses the official label, and the mislabel is recorded in the evidence ledger behind it^{15,16}. Even the year's total depends on the meter. The Federal Employment Agency registered 103,731 new contracts to September 2024 against 105,734 registered applicants. The BIBB, the Federal Institute for Vocational Education and Training, survey definition reads about 86,500, 17.8 per cent of the national 486,711^{15,16}.

The market fails at matching, not only at volume. September 2024 closed with 12,393 unfilled apprenticeship spots, up 7.5 per cent, beside 9,660 unplaced applicants, up 27.3 per cent^{15,16}. The year-on-year intake is down only 1.4 per cent, churn rather than collapse; the structural case comes from demography, not this wiggle. A cumulative count of unfilled places gives 51,613 for 2024, though the corpus does not state the counting rule behind it¹⁵. The BIBB 30-September point-in-time survey gives about 19,500 unoccupied positions, 12.4 per cent of all offers and the largest absolute stock of any federal state, 28.1 per cent of the national 69,405¹⁵. Both readings are written down and are almost certainly different universes. Because the rule is unknown, the pair is carried as context rather than used as a load-bearing figure¹⁵.

The entrance itself is rationed. The Angebots-Nachfrage-Relation (ANR, offered apprenticeship places per 100 seekers) stood at 93.7 in 2024 on about 156,800 offered places¹⁵. A reading below 100 means fewer places than seekers, so applicants queue and places are the binding input. Two margins must be kept apart. At the rationed margin, places bind and the pipe is slow; at the mismatched margin, empty places and idle applicants coexist by occupation and region, and information or mobility can clear that in months. This report's model reasons on the rationed margin, the one the training lag governs. The state is one of several large states below the line, not the worst: Niedersachsen reads 93.1, Hessen 96.5, while Bayern at 112.3 and Baden-Württemberg at 108.3 offer more places than seekers, and employers there compete for applicants¹⁵. That shape makes training capacity an evidenced lever rather than a rhetorical one¹⁵. With more seekers than places, the wage signal works through employers' willingness to offer places, not through applicants' willingness to queue¹⁵.

The occupations that matter most are not entering fast enough. Nationally, new electrician contracts fell 3.1 per cent in 2024 to 14,391 and the SHK trades fell 3.2 per cent to 14,280. At chamber level the detail sharpens. HWK Dortmund, a major Ruhr craft chamber, took in 431 contracts in Elektroniker for energy and building technology in 2024, the key building-electrification trade¹⁷, and 443 in Anlagenmechanik for SHK, the heat-pump installation trade¹⁷. Vehicle mechatronics, at 676, was the largest single intake among the transformation trades the chamber lists¹⁷. Across the state's seven craft chambers, 26,076 new contracts were signed in 2024, roughly a quarter of the state's total (derived from C-30 and C-22), and the chamber completion rate stood at 75.8 per cent¹⁸.

Then the pipe leaks, and the leak has a name. The Vertragslösungsquote is the share of new contracts dissolved before completion. In the state it reached 29.7 per cent in 2023, up from 23.4 per cent in 2014¹⁵. In the Handwerk, the craft trades, the 2023 reading is 38.5 per cent, more than one in three craft apprenticeships abandoned and the worst sector reading¹⁶. The two rates share one evidence sentence by corpus construction and are carried as separate rows per the principal's I-11 ruling, one datum per row^{15,16}. Survival to a finished qualification runs at about 70 to 75 per cent on the corpus baseline; a second file reads the same quantity higher, at 75 to 80 per cent, and both are written down rather than averaged⁶². Of those who finish, about 70 to 75 per cent are employed in their trained occupation within three months⁶². Read the pipe through and the completion meter is the dissolution meter seen from the other side. The corpus pairs "about 70 to 75 per cent completed successfully" with "about 25 to 30 per cent dropout or dissolution" in one line, semicolon between. A finished qualification is the same event as surviving the dissolution risk, not a further filter. Reasoning on the overall rate of 29.7 per cent, of every 100 who start, about 70 to 75 finish, and about 70 to 75 per cent of those work in their trained occupation within three months, so about 49 to 56 of the original 100 reach the trade (derived from C-31 and C-33). That yield is what a training budget actually buys. The model defaults to the stricter Handwerk rate of 38.5 per cent, where the same two-leak arithmetic gives about 45 of 100, and the difference is stated here rather than left for the next reader.

The lag is set by regulation, not by effort. Ausbildungsdauer, the regulated training duration, is three and a half years for an electrician, three and a half years for SHK under its 2016 ordinance, and three years for the insulation trades. Refrigerant certification adds two to four weeks, a heat-pump technician needs a further one to two years after the apprenticeship, and solar installer certification takes six to twenty-four months. These shorter lanes top up an existing qualification rather than replace the apprenticeship, and the corpus does not quantify their throughput, so the three-and-a-half-year figure is the apprenticeship lane, stated for the trades where it holds⁶⁵. A cohort signing in autumn 2026 clears the pipe around 2030. The regulated occupation list itself moves slowly: four new environmental-technology occupations took effect on 1 August 2024, covering wastewater, circular economy and waste, pipeline networks and water supply, the first new green Ausbildungsberufe of this cycle¹⁵.

TABLE 2 The pipe at a glance: North Rhine-Westphalia's apprenticeship flows and their rates

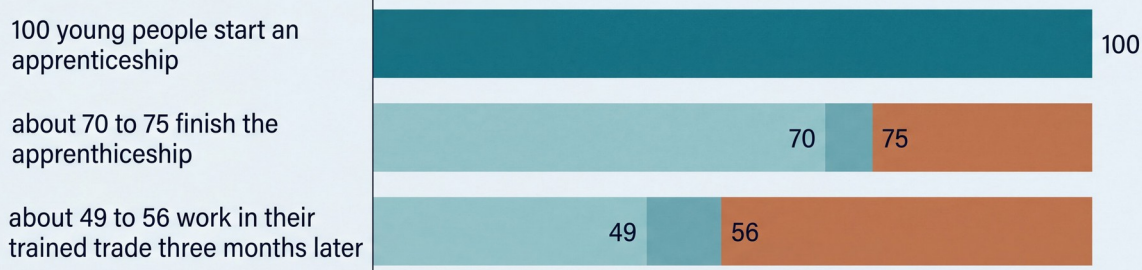
Stage	Reading	Year and basis
New contracts, all occupations	106,827	training year 2024 (down 1.4 per cent; the corpus's alternative 2023 label is a recorded mislabel against IT.NRW)
Offered places per 100 seekers (ANR)	93.7	2024, on about 156,800 offered places
Unfilled spots beside unplaced applicants	12,393 beside 9,660	September 2024, up 7.5 and 27.3 per cent
Dissolution rate, all sectors	29.7 per cent of new contracts	2023, up from 23.4 per cent in 2014
Dissolution rate, craft trades	38.5 per cent of new contracts	2023
Completion and in-trade employment	About 70 to 75 per cent complete; about 70 to 75 per cent of completers in the trade	Corpus baseline; second file reads completion at 75 to 80 per cent

Sources:^{15,16, 15,16, 15, 62, 15, 16,}

EXHIBIT 2

THE WORKFORCE PIPE

Of every 100 who start, about 49 to 56 work in their trained trade.



Intake: 106,827 contracts in 2024, down 1.4 per cent; the lag is 3.5 years, 42 months for the heat-pump trade. Dissolution ended 29.7 per cent of new contracts in 2023, 38.5 per cent in the craft trades. Bars mark two corpus readings, written down, never averaged.

Serinyx Quorum evidence ledger; every plotted value resolves to a verified source.

Now the correction, and it has two halves. The reader's prior says a coalfield in a coal exit sheds jobs. The first half says otherwise. Employment in the Rhenish Revier has grown about one per cent a year since 2020, per the state economics ministry's 2025 regional report, tracked from actual Federal Employment Agency and statistical-office data rather than projection¹⁹⁻²¹. More than 36,000 new social-security jobs were created between 2019 and 2023, the years of the accelerated exit¹⁹⁻²¹. The regional employment index reached about 130, where 2010 equals 100, by 2023, outperforming both the German average and other coal regions¹⁹. The ministry states the conclusion flatly: the coal phase-out "is not leading to a general decline in labour demand"¹⁹. Even the Anrainerkommunen, the municipalities directly adjacent to mines and plants where losses concentrate, have kept pace¹⁹. The first half survives an independent check: a recomputation from agency district tables confirms 36,871 added jobs between mid-2019 and mid-2023, matching the ministry and showing growth front-loaded, with momentum near 0.3 per cent a year since 2023¹⁹⁻²¹.

Scale matters for the second half. Direct lignite employment in the Revier is about 7,500 in mining and plants, against about 870,000 regional jobs and 2.5 million inhabitants, under one per cent of regional employment¹⁹. The RWI institute's multiplier adds about 0.6 supplier jobs per direct job, implying up to 12,000 directly or indirectly dependent²². A wider RWI count, cited in a November 2022 state parliament response, puts lignite-dependent employment at 14,400 in the Revier and 21,500 statewide²³. The two readings count different things and are written down, never averaged. Even at the widest reading the exit touches a workforce the size of a mid-sized town inside a region holding 870,000 jobs.

The second half is the one the transition feels. The same ministry report that certifies headcount growth flags deteriorating job quality. Newly filled posts are often befristet (fixed-term). Demand grows for Helfer roles, jobs open to workers without a completed qualification, while demand for workers with a completed qualification declines, and shortages concentrate at the Fachkraft level, the skilled worker with a finished qualification¹⁹. Thirty-seven per cent of regional companies report an acute need for further qualification, yet only about 30 per cent know the Teilqualifikation instrument, which lets workers qualify in modular stages, per an agency survey carried by local radio whose sample frame is unstated³⁸. The regional qualification programme states that the gap between unqualified and skilled workers "continues to widen"³⁹. Incomes stretch underneath: the ratio of the ninetieth to the tenth percentile rose from 3.66 to 3.91 between 2014 and 2024, the lower threshold rose from 777 to 1,035 euros and the upper from 2,842 to 4,048, so top incomes pulled away faster. The Gini coefficient, a zero-to-one measure of inequality where zero is perfectly equal, stood at 0.31 in the state in 2023 against 0.30 nationwide⁴². These three programme-carried readings are context for the composition claim, not independent measures of a shortfall.

The recomposition shows across the whole economy. North Rhine-Westphalia's Umweltwirtschaft, the environmental economy, employed about 599,000 in 2023, up 21,600 from 2020, generated 52.8 billion euros of gross value added and has grown 4.3 per cent a year since 2010, faster than the state overall⁴⁰. Nationwide, green-skills apprenticeships rose about 14 per cent between 2013 and 2021 while brown-skills fell about 15 per cent, and Germany held 341,000 green jobs in 2021, up

9.7 per cent⁴¹. Fossil exposure is small and concentrated: about 52,000 workers in the state, 0.63 per cent of the 8.25 million employed, an estimate the corpus flags as such²⁶.

Headcount fine, composition not. Both facts hold, and the same ministry report carries them in one binding¹⁹⁻²¹. That is the answer to the coalfield paradox. The region can gain jobs while the transition runs short of workers, because the jobs it gains are not the jobs the transition needs. A growing count of fixed-term helper posts does not wire a single heat pump, and a pipe rationed at the entrance will not produce the electricians who can^{15,17,19}.

EXHIBIT 3

THE REVIER CORRECTION

Headcount fine, composition not.

THE COUNT IS GROWING

about one per cent employment growth a year since 2020

index 100 in 2010

index about 130 in 2023

0

THE QUALITY IS DETERIORATING

4 ministry signals of deteriorating job quality

- newly filled positions are often fixed-term
- demand grows for helper roles
- demand falls for completed vocational training
- shortages concentrate at the Fachkraft level

The region gained 36,871 jobs from mid-2019 to mid-2023.

Serinyx Quorum evidence ledger; every plotted value resolves to a verified source.

COUNTERWEIGHT, PART ONE: DEMAND AND MONEY CAN BIND BEFORE PEOPLE DO

The strongest case against the workforce verdict is not scepticism about the shortage. It is the record of 2024. German heat-pump demand fell by nearly half that year for reasons no training programme could fix, and recovered by more than half the moment policy steadied²⁷. A constraint that relaxes itself when subsidies stabilise was never the installers. If that year repeats, workforce is not the binding constraint. Demand is.

Read the series, the cleanest natural experiment in the corpus. German heating heat-pump shipments (Absatz: manufacturer shipments, not installations) surged from 154,000 in 2021 to 236,000 in 2022 and a record 356,000 in 2023, driven by the gas crisis and buying ahead of the Gebäudeenergiegesetz, the building energy law²⁷. Sales then collapsed 46 per cent to 193,000 in 2024, a policy-induced shock rather than a structural decline or an installer limit²⁷. Shipments understate true 2024 installations because the trade worked an inventory overhang the manufacturers' association puts at 65,000 to 85,000²⁷. Then recovery: sales reached 299,000 in 2025, up 55 per cent, heat pumps took 47.7 per cent of all heat generators sold, gas boilers fell 33 and oil boilers 74 per cent²⁷. The total heater market shrank about 12 per cent to roughly 627,000, a 15-year low, so heat pumps gained share in a shrinking market, and nearly two million are now installed²⁷.

The state's own numbers must be handled with care because they do not officially exist. NRW heat-pump sales are carried only as estimates scaled from national figures. One dossier assumes a 20 to 22 per cent population share, giving 2024 sales of about 39,000 to 42,000 and a 2025 recovery of 60,000 to 66,000. A newer dossier assumes a 12 to 15 per cent capture share, about half the older assumption. No official state series exists^{27,28}, and both estimates are written down, never averaged. The installed base carries the same warning: an early-2026 estimate puts it at 200,000 to 250,000, a 2024-vintage estimate at 360,000 to 400,000, a penetration of 2.5 to 3 per cent of dwellings^{27,28}.

The subsidy ledger shows the crash was policy-made. KfW, the state development bank, grant approvals for heating rose 34 per cent in 2024 to 151,000, December alone set a record at 37,482, and approvals surged a further 91 per cent in 2025 to about 288,000^{27,28}. The architecture had become the market's central mechanism. As terms stood in early 2026 grants ran at 30

per cent base, bonuses could lift them to a 70 per cent maximum, and the cap sat at 21,000 euros per unit on 30,000 of eligible costs²⁷. Two shocks moved the series: the 2023 law debate before the crash and the 24 February 2026 coalition announcement abolishing the 65 per cent renewable-heating mandate, which re-injected uncertainty even with grants confirmed through 2029. Terms changed again in July 2026 under the successor law, so the architecture carries its vintage^{27,57}.

The demand rail has physics behind it, not only mood. At the 2022 census 68.7 per cent of the state's dwellings heated with gas, against 56 per cent nationally, 14.0 per cent used heating oil, 9.7 per cent district heating and only about 2.7 per cent renewables or heat pumps. The stock behind those shares is 9,256,682 dwellings at end-2024, about 70 per cent built before 1990²⁹. New construction is not the constraint: in homes built after 2020 the heat-pump share already runs 53.7 per cent in the state against 49 nationally, so the constraint is the existing stock²⁹. The renovation rate, the share of stock deep-renovated each year, ran 0.72 per cent over the first three quarters of 2024, about 1.0 per cent annualised, against roughly 4 per cent required for neutrality, a factor-of-four gap³⁰. Some 45 per cent of German building floor area sits in classes F, G or H, 55 per cent for single-family homes³¹.

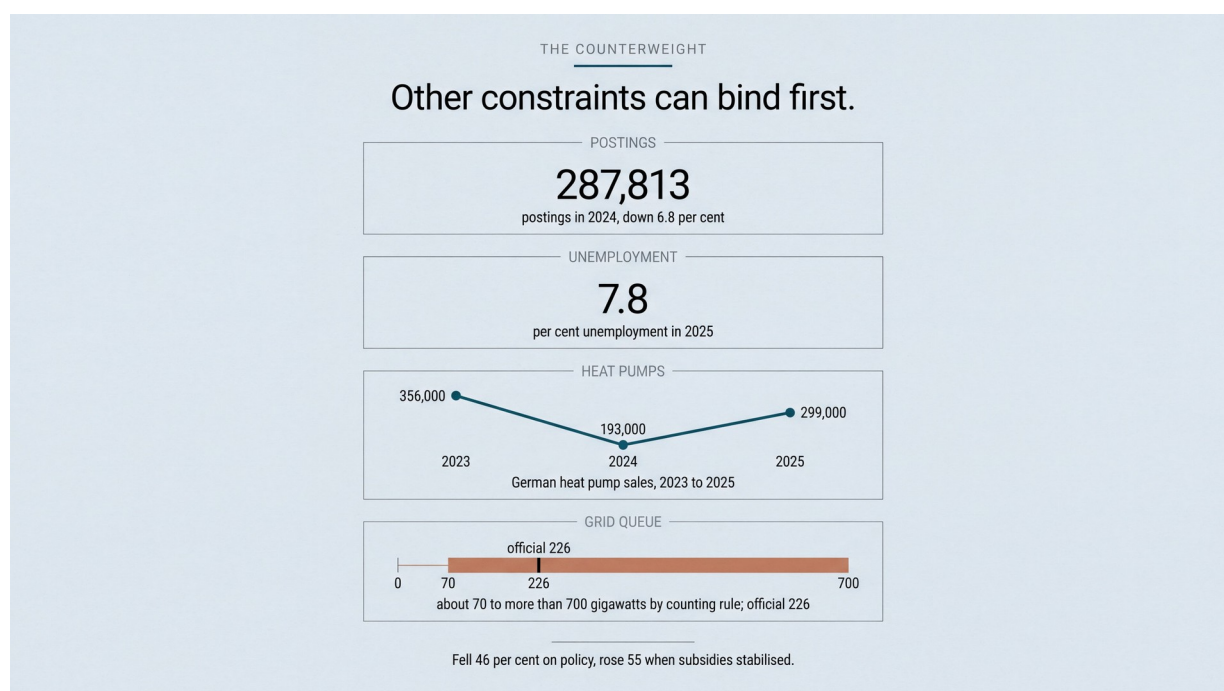
Cost is the demand-side brake the reader can hold. An installed air-source heat pump averaged about 30,000 euros in 2025, down about 4,000 from the 2024 peak, real offers spanned 20,000 to 63,000 in a consumer-centre sample of 160 offers, and German installed costs run roughly double the United Kingdom's about 14,000 there³². Operating costs flip the sign, running about 41 per cent below gas for a typical home³², so the capital expense is what households balk at, not the running cost. Affordability is most unequal at the bottom: the lowest state income class, under 1,300 euros a month, spent 11.4 per cent of income on household energy in 2022 against a 4.8 per cent average, and the federal government puts the share spending over 10 per cent at 13.8 per cent³³.

The grid rail queues behind the same evidence standard. One reading puts about 70 gigawatts waiting for a connection⁶³, another counts more than 500 gigawatts of battery-storage requests, up from about 300 at the start of 2024 against only about 2 gigawatts operating, a requests-to-operating ratio near 250 to one⁶³, and a third describes a backlog above 700 gigawatts whose scope the corpus does not define⁶³. The official reading reconciles the spread: at end-2024 the transmission operators held roughly 650 large-battery requests totalling 226 gigawatts, with distribution-level requests excluded⁶⁴. So the honest summary is a band, not a point^{26,63}. Congestion is real and measured: Germany curtailed 9,374 gigawatt-hours of renewables in 2024 at 2.78 billion euros, 96.5 per cent of clean power still reached consumers, and the distribution share of curtailment rose to 26 per cent from 20⁶⁴. The state sits on the receiving side, its gas plants ramped up by 1,747 gigawatt-hours, the largest positive redispatch of any state, because those plants cover for curtailed power elsewhere. Redispatch is the operator-ordered re-dispatch of generation, ramping plants down ahead of a bottleneck and up behind it, and curtailment concentrates in Schleswig-Holstein and Niedersachsen⁶⁴.

The capital rail rounds out the case. The building-decarbonisation financing gap is estimated at 8 to 18 billion euros a year, against annual need of 20 to 30 billion and about 12 billion of current flows, cumulating to 360 to 810 billion by 2045, shipped as scenario arithmetic rather than a measured gap⁶⁴. For public buildings alone dena, the German Energy Agency, puts need at 120 billion by 2045, and the state holds about 15,000 to 20,000 public buildings⁶⁴. The denominator is strong and softening: nominal state output was 871.9 billion euros in 2024, 20.3 to 20.8 per cent of national product, rank one of sixteen, but it shrank 0.4 per cent in real terms after minus 1.3 per cent in 2023³⁵. Municipal fiscal room is the tightest link. The state carries about 40 per cent of national municipal debt, its municipalities took about 7.3 billion of new debt in 2024 per the official release, the corpus reads 7.7 billion and carries the one-third nationwide share with that reading, and the integrated total reached 70.5 billion, 3,913 per capita³⁶. The Daehre Commission put Germany's transport maintenance gap at 7.2 billion a year for fifteen years, a figure old enough to carry its commission's vintage³⁷.

Now test the verdict, do not assume it. The research corpus records workforce as a binding constraint in every field it studied, which is evidence about the corpus's design as well as the economy⁶¹. Company surveys add independent perception: in the DIHK report 43 per cent of companies report hiring difficulties and only 13 per cent problem-free hiring, a second file carries the same 43 per cent for unfilled apprenticeship posts, and both referents are written down⁴². The KfW-ifo barometer adds 31.6 per cent of construction companies constrained by skills against a 25.8 all-economy reading, and average vacancy duration reached a record 161 days in 2025¹⁴. Against that wall stands one year of sales: demand fell 46 per cent in 2024 after manufacturers shipped a record 356,000 the year before²⁷, and recovered 55 per cent when subsidies steadied²⁷. Where demand can halve and recover on a policy document, the workforce rail cannot be presumed first. It has to earn the position, on a dated course.

EXHIBIT 4



Serinyx Quorum evidence ledger; every plotted value resolves to a verified source.

COUNTERWEIGHT, PART TWO: UNEMPLOYMENT IS HIGH AND THE OPENINGS ARE STILL UNFILLED

North Rhine-Westphalia has the worst unemployment of any western non-city state and one of the weakest new-posting flows in over twenty years, while its skilled openings stay hard to fill^{24,25}. All three hold at once. The paradox dissolves once the labour market is read as two pools that barely touch: one large pool of workers without formal qualifications, one tight pool of workers with them²⁴.

The demand side first, because it is the counterweight's spine. Only 287,813 new positions were registered in 2024, down 6.8 per cent on the 308,747 of 2023 and below even the COVID year 2020 at 327,342. In the agency's own words, not in over twenty years were so few positions registered²⁴. The stock tells the same story on another meter: December 2024 closed with 129,602 registered openings, down 6.7 per cent year on year, the vacancy index stood at 102 and labour demand was at its lowest since 2009 outside COVID²⁴. The stock meter counts only registered vacancies, a minority of all vacancies, so it understates the level while tracking direction²⁴, and the two meters are kept apart though both point down²⁴.

Unemployment is high and rising. The rate averaged 7.8 per cent in 2025, about 783,416 people, the worst since 2015 and 1.5 points above the national 6.3, and the 800,000 mark was breached in August 2025 for the first time since 2010²⁵. The trajectory climbs: 6.8 in 2022, 7.2 in 2023, 7.5 in 2024, 7.8 in 2025²⁵. On the 2024 panel the state ranked eleventh of sixteen: Bayern read 3.7, Baden-Württemberg 4.2, Germany 6.0, the state 7.5 and Bremen worst at 11.1²⁵. The 2024 detail adds 618,638 unemployed, youth unemployment at 7.8 and the long-term share at 38 per cent²⁵. Inside the state the spread is fourfold: the Ruhrgebiet reads about 10.2 per cent in 2025, Gelsenkirchen 14.9 and Coesfeld about 3.5²⁴. The December regional reading gives the same structure in counts: 253,034 in the Ruhrgebiet at 10.1 per cent, 260,135 in the Rheinland at 7.3 and 47,792 in the Münsterland at 5.0²⁴. The shortage map and unemployment map are the same map and do not cancel.

The bridge between the two facts is one December 2024 table, the definitional key to the report. Of the unemployed, 426,830 had no formal qualification, 56.7 per cent of the total, facing only 28,431 helper openings, which makes 1,501 per 100. Meanwhile 200,274 skilled unemployed faced 75,606 skilled openings, 264 per 100, and 78 per cent of openings require vocational training or higher²⁴. The pools are nearly disjoint. KOFA matches qualified to qualified and finds a shortage¹; the raw rate counts both pools and finds slack²⁵. Both are correct, answering different questions about different people^{1,24,25}.

TABLE 3 Two pools, one labour market: the qualification mismatch, December 2024

Pool	Registered unemployed	Openings	Unemployed per 100 openings
Without formal qualification (helper level)	426,830 (56.7 per cent of all unemployed)	28,431	1,501

Pool	Registered unemployed	Openings	Unemployed per 100 openings
Skilled workers	200,274	75,606	264

Sources:²⁴. Basis: Federal Employment Agency regional reading, December 2024; 78 per cent of openings require vocational training or higher.

The transition's own demand held up better than the aggregate. Online energy-transition ads more than doubled between 2019 and 2024, from 173,000 to 372,500, their share of postings from 1.8 to 3.8 per cent, and in the 2024 downturn energy postings fell only 8 per cent against 16 for the whole market¹⁰. The perception meters keep their lights on: about 43 per cent of companies report hiring difficulties¹², construction reads 81 per cent on a survey whose basis the corpus does not state¹³, and about a quarter of companies overall report skills constraints against nearly a third in construction¹⁴.

So the paradox is not a paradox, and it cuts both ways. For the workforce verdict, the skilled pool is tight even at 7.8 per cent unemployment and the slack lives in the other pool^{24,25}. For the counterweight, an economy shedding 6.8 per cent of postings is not one where every constraint binds at once, and if demand stays this weak the workforce rail does not have to bind first²⁴. The mismatch table is the hinge: the constraint binds early, specifically and in named occupations when demand returns, where 264 face 100 openings, not where 1,501 do²⁴. The workforce speed is set inside the skilled pool, and the aggregate rate is the wrong gauge to read it by.

03 Which constraint binds first is computable, and the verdict has a location

RESTS ON 41 SEPARATELY SOURCED CLAIMS

People, capital, grid and demand are not four debates for four meetings. They are four constraints with published readings that can be set on one dated course. The course has two marks: 31 March 2030, when the last Rhenish lignite unit closes⁵⁰, and 2045, the horizon the deep-decarbonisation scenarios run to^{64,70}. Ask the four constraints the same question, which one binds first, and the answer stops being rhetoric. It becomes a year.

The calendar itself is evidence. Under the original 2020 statute the last Rhenish units ran to 31 December 2038; the 4 October 2022 agreement moved the final exit to 31 March 2030, eight years earlier and the earliest in Germany⁵⁰. Affected workers are cushioned by qualification measures, early-retirement options and the Anpassungsgeld, an adjustment allowance anchored in the 2020 statute⁵⁰. Money is not the missing piece on paper: the structural-strengthening law provides up to 14.8 billion for the region through 2038⁵². Delivery runs slower than announcement: as of early 2026, 370 projects sat in the pipeline and the second funding phase begins in early 2027⁵³. The hardest deadline is European: the state holds about 1.9 billion of EU regional and Just Transition money for 2021 to 2027, and 75 per cent of the 683-million Just Transition share must be spent by end-2026⁵⁸. A federal special fund adds 500 billion for infrastructure and neutrality nationwide⁵⁸.

The workforce rail is the one this report has built piece by piece, and its institutions are fixed. Sixteen chambers of industry and commerce and seven craft chambers pass every contract, exam and standard, and the chamber system supervised 175,645 apprentices in 2024^{18,46}. Private capacity exists beside the chambers: one Cologne academy alone reports more than 15,000 training events a year and about 200,000 participants, company self-published figures⁴⁹.

Underneath the pipe, demography drains the reservoir. The replacement ratio is the count of young residents against those nearing exit, and the state's reads 66.2 per cent in 2023: 1,886,098 aged 15 to 24 against 2,850,838 aged 55 to 64, about 66 per 100 nearing exit, sixth of sixteen and above the national 64.7⁴⁷. The entering cohorts are smaller in headcount: the 2031 labour-entry cohort, born 2008, numbers about 150,000 against more than 300,000 in the 1964 cohort, so entrants per retiring cohort have halved². The average employed age rises from 44.9 in 2019 to a projected 47.6 in 2030, about 100,000 more exit than enter each year, and the population is projected to fall 0.4 per cent in total through 2034, with only Düsseldorf growing³. About 2.5 million state workers retire by 2035³.

Ageing shows in the technical occupations, too. Some 22.4 per cent of the state's MINT workforce (science, technology, engineering and mathematics) was 55 or older in the third quarter of 2023; the national figure was 22.3 and the comparable 2012 reading 15.1⁴⁸. Migration is the only tap still filling: Germany's 2023 employment growth came entirely from foreign workers on agency statistics²⁵, while the state leaks about 5,500 net to other states a year, an assumption IT.NRW carries in its projection rather than a measurement^{67,68}. Migration departures earn their own sentence: the corpus records 10,719 non-EU skilled workers leaving Germany in 2023 with no public corroboration, while the official report counts 20,565 employment-purpose departures, 4,430 of them Blue Card holders, an EU skilled-work permit, different readings carried side by side^{67,68}.

The pipe draws unevenly on the two halves of the population. The female apprenticeship share is about 40 per cent overall and 36.4 per cent of 2025 contracts, while among electricians the corpus records 15 to 25 per cent and the public record shows women at only a few per cent of intake⁵⁹. Wages close the workforce loop: a typical apprenticeship pays about 1,209 a month on the 2025 average, 1,185 in this state, a statutory first-year minimum of 724 applies from 2026, and the corpus's older 500-to-800 baseline is not borne out publicly. After completion pay runs 2,000 to 3,500⁶⁶, and for mid-life changers only 60 to 65 per cent earn at or above their prior wage, a gap with no published band carried as a finding⁷⁰. Because places are rationed, this wage signal works through employers' willingness to offer places rather than applicants' willingness to queue¹⁵.

The other three rails carry their own published paces. Capital deploys against evidenced friction and the 8-to-18-billion gap ships as scenario arithmetic⁶⁴, while anchor capex comes in two vintages, about 55 billion globally over 2024 to 2030 against 50 billion by 2030 with 15 billion for Germany, written down not averaged⁵⁹. Grid investment is a wide spread: the corpus scenario reading puts need at 150 to 230 billion by 2045, the bottom of the public range, against 365 to 392 in the operators' 2025 draft, 85-to-123-per-cent growth in the dena study and 651 billion at IMK⁷⁰. The grid clears a queue with an order anchored on the official 226 gigawatts⁶⁶. Amprion is investing about 8 billion in the state over five years across roughly 30 projects, a company statement whose state slice could not be re-verified⁵⁵, the 2-gigawatt A-Nord link is expected in 2027 with about 700 million a year of projected savings under a recorded attribution spread⁶⁶, and the smart-meter quota reached 13.91 per cent at end-2024 against a legal 20 by end-2025⁵⁴. Public sentiment gives demand room: in February 2026, 42 per cent wanted to keep the 2030 exit and only 22 per cent to postpone⁴⁴.

Some inputs carry their own warnings. The hydrogen jobs potential, up to 130,000, appears under three horizons, none stated, by 2040 and by 2045, so the horizon must be fixed before use⁵⁰. The corpus holds no published output-per-head figure, installations per installer per year, which makes that rate a reader input with no evidenced default, stated so the reader sets it knowingly. History supplies a precedent rather than a parameter: Ruhr hard-coal work fell from about 500,000 in 1957 to about 4,500 in 2016, and ending subsidies in 2018 cost an estimated 12 billion more than an earlier exit⁴³. The eastern comparator shows composition risk rather than collapse: one operator fell from 2,150 in 2007 to 1,300 in 2024, and demographic decline may mask some effects⁴⁵.

TABLE 4 Four rails, one course: what sets each rail's speed, and the evidence behind it

Rail	What sets the pace	Key published readings
Workforce pipe	Intake, duration, dissolution, retirements, wage feedback on offered places	106,827 contracts (2024); 3.5-year electrician pipe; 29.7 and 38.5 per cent dissolution (2023); about 2.5 million retirements by 2035
Capital	Financing flows, municipal room, anchor capex, fund deadlines	Gap 8 to 18 billion a year (scenario); municipal debt 70.5 billion; 75 per cent of EU transition money due by end-2026
Grid queue	Queue clearance, transmission build, congestion	Official 226 gigawatts in about 650 requests (end-2024); band about 70 to 700-plus by rule; 9,374 gigawatt-hours curtailed (2024)
Demand	Subsidy design, policy stability, building stock, sentiment	Heat pumps 356,000 to 193,000 to 299,000 (2023 to 2025); 68.7 per cent of dwellings on gas; 42 per cent for keeping the 2030 exit

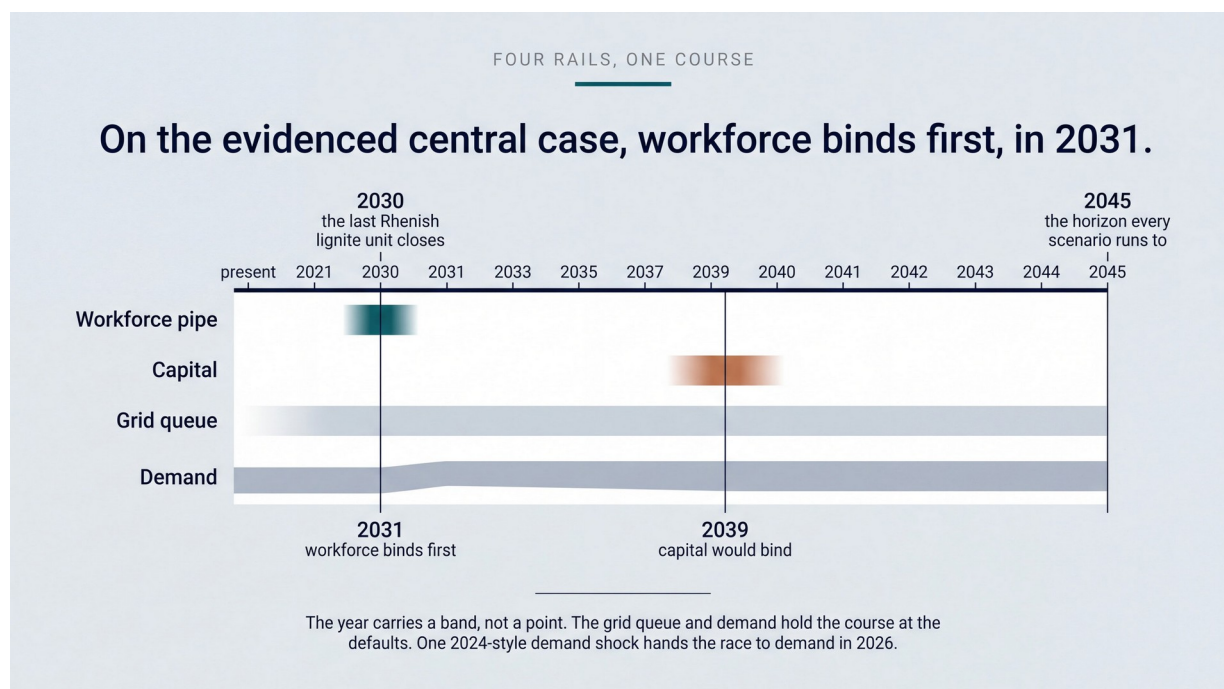
Sources:^{15,16,15,16,63,63,26,27,27,29,64,36,44,65,3,54,58,}

Read the four rails together and the verdict changes shape. It is not "workforce is binding" or "workforce is not". It is three things: which rail binds first, in which year, and under what conditions the ordering changes. On the central case the workforce rail binds first in 2031, just after the 2030 coal-exit line. Capital would bind in 2039, and grid and demand hold the course at the defaults (computed over C-21, C-33, C-34, C-53, C-54, C-64, C-81 and C-87).

The year is a band, not a point. The decisive output-per-installer rate has no evidenced default, and across its plausible readings the workforce year runs from about 2028 to 2037, with the other levers moving it by roughly a year. The ordering is evidence, not fate. Three conditional scenarios change the winner: one 2024-style demand shock hands the race to demand in 2026²⁷, a stuck queue hands it to the grid in 2026⁶³, and a deep capital squeeze hands it to capital in 2027⁶⁴, each declared in the model with its inputs.

Two disciplines govern every verdict. First, positions carry uncertainty as bands, never single lines. The grid rail's central value is a national figure standing in for a state figure, the weakest of the four, so the model sets it not to bind at the defaults, and that exclusion rule is printed here inside the verdict rather than left in a note. Second, the winner is never reported without the conditions under which the order changes. A race has a winner and a projection has a band, and confusing the two is how banded evidence gets read as fate.

EXHIBIT 5



Serinyx Quorum evidence ledger; every plotted value resolves to a verified source.

04 The course is set; the rates are yours

RESTS ON 4 SEPARATELY SOURCED CLAIMS

The model handed over is the argument made runnable. Four rails run on one dated course with the 2030 coal exit marked on it. The workforce pipe is fed by intake and drained by dissolution and retirement, so it fills three and a half years late. Capital deploys against fiscal friction and hard deadlines, the grid queue clears in a visible order, and demand moves with installations and policy documents.

The reader sets the rates. Apprenticeship intake is set by year and named occupation^{15,16}, because electricians and heating fitters are different pipes. The dissolution rates, overall and craft, are set because a third of the pipe is not a detail^{15,16}, and the wage feedback on offered places runs through employers rather than applicants¹⁵. Retirement profiles, output per head, the pace of capital, the order and clearance of the queue, and the demand trajectory under stable and unstable regimes are all reader-set. Each rate carries this report's published evidence with publisher, year and counting rule. Where evidence is a band the model takes a band, and where the corpus is silent, as on installations per installer, the rate is the reader's own and labelled as such.

The reader reads two first-class outputs: which constraint binds first, and the year it binds, with the other rails carried as bands around the winner and the change-conditions always underneath. A 2024-style demand collapse hands the race to demand, a stuck queue to the grid, a capital rail slowed by debt and missed deadlines to money, and an intake raised far enough with dissolution lowered far enough hands it to nobody, because in that world the pipe delivers the 2030 path whole.

That last computation is the practical one. How much must intake rise and how far must dissolution fall for the 2030 path to be physically deliverable? A reader can now answer in contracts per year, not adjectives. The choice between funding training capacity or projects first is no longer a posture but a comparison of two dated courses, conditional on the definitions the reader has set. The reader leaves holding that comparison.

HOW WE KNOW

This report showcases bottleneck and interdependency analysis. Every claim below traces to a mapped row in a register built for this report, and every rival rail is weighed on the same evidence standard.

The collection sits inside an NRW energy-transition corpus. This pass read the labour, capital, grid and demand files and produced four evidence tables: the published gap gauges^{1,2 to 14}, the training-pipe and coalfield readings^{15,16 to 24}, the

rival-rail evidence²⁰²¹, and dated calendar events thereafter. Conflicting readings were kept as named disagreements, never averaged, and where a value rested on a secondary citation the original was named.

The mechanics were deliberately conservative. Where two files disagreed both rows were kept and flagged, and where no figure existed the gap was marked rather than guessed, so the numbers are a floor, not a polished mean. A later audit may tighten them without needing to invent them.

The evidence cut-off is 12 September 2026. What this report could not establish: an output-per-installer figure, a confirmed absence; NRW's own grid queue and heat-pump sales, carried as national proxies; and the size of the wage and demand-response feedback, whose direction but not magnitude the record supports. These are carried as limits, not smoothed over.

WHAT WOULD CHANGE OUR MIND

Three watchable observations would overturn the workforce-first reading.

1. A sustained demand recovery without a skills bite. If heat-pump sales return to and hold their 2023 level while installer output keeps pace, the workforce rail is not binding. Watch the KfW approvals and Federal Employment Agency vacancy series, which move first.
2. A state grid queue that clears on schedule. If an official NRW connection series replaces the national proxy and clears without a 2026 pile-up, the grid-exclusion rule no longer holds and the rail re-enters on measured data. Watch the Bundesnetzagentur and Amprion network reports.
3. A fast-lane throughput that beats the pipe. If reskilling academies or certification lanes demonstrably convert existing workers at scale, the three-and-a-half-year lag no longer dates the 2030 stock. Watch the chamber and guild completion statistics that record those lanes.

SMALL PRINT

This report is an independent analytical showcase, prepared with automated assistance under named human editorial direction. It is not investment advice, a legal opinion, or a forecast of a specific labour-market outcome.

Copyright 2026 Serinyx GmbH. All rights reserved. Figures and dates are as stated to the evidence cut-off of 12 September 2026.

Corrections: if a factual error is found, it is corrected in a numbered revision with the change noted in the log.

ABOUT THE RESEARCH CORPUS

This report is a summary of a much larger evidence base. The figures below state the size of the research corpus synthesised here, measured on the working corpus at build time.

Full study corpus	1,917 files, about 4.3 GB, more than 4.5 million words of working research text (markdown and text files; documents and spreadsheets additional)
Distilled into this report	109 individually sourced claims
Independently referenced	73 references; 46 with live verified public links
Checked independently of drafting	four external reviews, none by the drafters; the world model checked adversarially with standing to block
Signed off	the Serinyx principal (date recorded at sign-off)

Corpus word counts cover machine-readable text files; total sizes include datasets and rendered assets. Sources marked adjudicated were independently verified in the source study before this report used them.

THIS IS A SHOWCASE

One word per 565 corpus words.

7,962

words in this report

more than
4.5 million

words in its corpus

109

sourced claims it rests on

Four reviews checked it; none composed it.

45 of 73 references carry live-verified links; 8 more via publisher index.

Commissioned work is that study, run on your question.

THIS IS A SHOWCASE

About one word in five hundred and sixty-five of the corpus's working research text.

This report runs to 7,962 body words. The research corpus it distils holds more than 4.5 million words of working research text, across North Rhine-Westphalia's state labour reports, chamber statistics, ministry publications and market research on the transition. The ratio is about one word in five hundred and sixty-five, and the report rests on 109 individually sourced claims and 73 references, 53 of them verified against public sources (45 fetched live and 8 verified through the publisher's index) on 12 September 2026.

What you have read here is a showcase. It demonstrates a handful of capabilities on a topic chosen to be legible in twenty minutes. A commissioned engagement is not a longer version of this document; it is the study underneath it, run on your question, with sign-off on the brief and a full audit trail.

For a full piece of research or advisory work, contact Lorenz at lorenz@serinyx.com.

REFERENCES

Every link below was fetched and verified on 2 September 2026. Sources that cannot be publicly linked are listed without a URL and say so. No placeholder or reconstructed links are used.

- KOFA (Kompetenzzentrum Fachkräftesicherung, at IW Köln).** Ländersteckbrief Nordrhein-Westfalen, Jahresdurchschnitt 2024/2025 (July 2024 to June 2025): Fachkräftelücke 62,230, 28.0 per cent of all registered open positions; Bauelektrik 2,889 of 4,249 unfillable (68.0 per cent); Elektrische Betriebstechnik 2,769 of 3,729 (74.3 per cent); Bauplanung/-überwachung at expert level 81.0 per cent (2025). <https://www.kofa.de/media/Publikationen/Laendersteckbriefe/Nordrhein-Westfalen.pdf>
- IHK NRW (rheinische IHKs).** IHK-Fachkräftereport NRW 2025 (presented 15 July 2025, continuing the 2019 series): skilled-worker gap grows from 447,000 (2019) to 735,000 (2030), ~13 per cent undercoverage of labour demand; skilled-labour supply 6.0M to 4.8M vs demand 6.5M to 5.5M; 183 BA bottleneck occupations (98 Fachkraft, 54 Spezialist, 31 Experte); birth cohorts over 300,000 (1964) vs ~150,000 (2008) (2025-07-15). https://rp-online.de/nrw/panorama/ihk-fachkraeftereport-in-nrw-fehlen-735000-fachkraefte-und-zwar-in-diesen-branchen_aid-131146665
- IHK Düsseldorf (ihk magazin, for the IHK-Fachkräftemonitor NRW).** IHK-Fachkräftemonitor NRW 2025 (GWS macro-model, published 30 June 2025): ~290,000 unfillable positions (2024) rising to up to 610,000 (2035); up to €40 billion cumulative value creation at risk by 2035; 2.7 million positions to be filled by 2035; ~2.5 million employees retiring by 2035 (2025-06-30). <https://www.ihkmagazin.de/fachkraefteengpaesse-daempfen-wachstum-ihk-fachkraeftemonitor-nrw-zeigt-aktuellen-handlungsbedarf/>
- IHK NRW.** Masterplan page (Höhere Berufsbildung): '447.000 Fachkräfte fehlen aktuell in NRW' and '735.000 Fachkräfte werden 2030 in NRW fehlen' (2026 (accessed 2026-09-12)). <https://www.ihk-nrw.de/hauptnavigation/unsere-schwerpunkte/bildung/masterplan>
- KOFA (Kompetenzzentrum Fachkräftesicherung).** KOFA Kompakt Jahresrückblick series (national gauge): the 2024 edition carries Bauelektrik 18,343 of 22,972 (79.8 per cent) and Elektrotechnik 14,218 of 17,352 (81.9 per cent); the 2025 edition shows Bauelektrik 16,270 of 21,510 (75.6 per cent) and a national Fachkräftelücke of 369,516 (-24.1 per cent vs 487,029) (2025-2026 editions). https://www.kofa.de/media/Publikationen/KOFA_Kompakt/KOFA_Kompakt_Jahresrueckblick_2025.pdf
- Bundesagentur für Arbeit.** BA Fachkraefteengpassanalyse 2024 (Nuernberg, May 2025), public copy: states the 2023 edition classified 183 bottleneck occupations (98 skilled-worker, 54 specialist, 31 expert); 2024 fell to 163 (2023 edition (2024)). https://www.vbw-bayern.de/Redaktion/Frei-zugaengliche-Medien/Abteilungen-GS/Bildung/2025/Downloads/2024_BA-FK-Engpassanalyse.pdf
- ZVEH (Zentralverband der Deutschen Elektro- und Informationstechnischen Handwerke).** Fachkräftebedarf in den E-Handwerken (29 January 2024): 96,580 open positions in the electrical craft in early 2024 (2023: 85,525), across apprenticeships, journeyman and master positions (2024-01-29). <https://www.zveh.de/news/detailansicht/e-handwerke-bedarf-an-hoehere-qualifizierten-fachkraefte-steigt-1.html>
- ZVSHK (Zentralverband Sanitär Heizung Klima).** Fachkräftebedarf im SHK-Handwerk (Wärmekonferenz, 23 March 2022, and ZVSHK scenario computations): ~60,000 additional fitters needed by 2030 for the six-million-heat-pump target; ~24,500 short by 2035 on the climate-neutral path; ~30 per cent of today's workforce retiring within ten years (2022-03-24). <https://www.zvshk.de/presse/medien-center/pressemitteilungen/heizungsbranche-mit-loesungsstrategien-fu%C3%88r-klimaschutz-und-versorgungssicherheit>
- Öko-Institut.** Bremst Handwerker mangel die Energiewende aus? (April 2018): achieving a 2 per cent annual building renovation rate requires ~50 per cent more craft workers than currently exist, ~100,000 additional workers in window-building, heating installation and painting/plastering trades (2018-04-25). <https://www.oeko.de/news/pressemitteilungen/bremst-handwerker-mangel-die-energiewende-aus/>
- Bertelsmann Stiftung (study by Institut der deutschen Wirtschaft).** Die Energiewende als Jobmotor (Gutachten, 6 March 2025): online job ads for energy-transition work 173,000 (2019) to 372,500 (2024); share of all postings 1.8 to 3.8 per cent; 2024 downturn -8 per cent vs -16 per cent overall (2025-03-06). <https://www.iwkoeln.de/studien/jan-buechel-jan-felix-engler-armin-mertens-malte-kueper-eine-analyse-von-online-stellenanzeigen-in-deutschland.html>
- IW Köln.** Fachkräftemangel: Nadelöhr für den Wasserstoffhochlauf? (IW-Report, 26 February 2025): hydrogen-relevant sectors lacked ~49,500 qualified workers in 2024; key shortage occupations Elektroanlagenmontage, Elektroniker Betriebstechnik, Maschinenbau-/Betriebstechnik and Bauelektrik (2025-02-26). <https://www.iwkoeln.de/studien/paula-risius-jurek-tiedemann-malte-kueper-regina-flake-nadeloe-hr-fuer-den-wasserstoffhochlauf.html>
- DIHK.** DIHK-Fachkräftereport 2024/2025 (December 2024, ~23,000 companies): 43 per cent report open positions they cannot fill and only 13 per cent report problem-free hiring; construction 53 per cent, civil engineering 61 per cent (2024-12). [no publicly verifiable link; cited from the research corpus]
- PwC Deutschland.** Bauindustrie unter Druck (PwC-Studie 2025 zur deutschen Bauindustrie): 81 per cent of construction companies struggle with the skilled-worker shortage; 85 per cent under cost pressure; 69 per cent with revenue losses and postponed projects (2025-02-19). <https://www.pwc.de/de/risk-regulatory/risk/capital-projects-and-infrastructure/bauindustrie-unter-druck.html>
- KfW-ifo (Fachkräftebarometer, KfW Research).** KfW-ifo-Fachkräftebarometer Oktober 2025 (press release 19 November 2025): 31.6 per cent of construction (Bauhauptgewerbe) companies report production constraints from skills shortages; average vacancy duration at a record 161 days; all-economy reading 25.8 per cent (2025-11-19). https://www.kfw.de/%C3%9Cber-die-KfW/Newsroom/Aktuelles/Pressemitteilungen-Details_870912.html
- BIBB (Bundesinstitut für Berufsbildung).** Datenreport / Berufsbildungsbericht series: national new apprenticeship contracts 486,700 (2024, -0.5 per cent); 69,400 unfilled places and 70,400 unplaced applicants at 30 September 2024; Vertragslösungsquote 29.7 per cent (2023 and again 2024); four new Umwelttechnologie/in apprenticeship occupations effective 1 August 2024 (2025-2026). [no publicly verifiable link; cited from the research corpus]
- IT.NRW (Statistisches Landesamt, Berufsbildungsstatistik).** Berufsbildungsjahr 2024 (release 19 December 2024): 106,827 new dual apprenticeship contracts in NRW, -1.4 per cent (2023: 108,393; -8.5 per cent vs 116,772 in 2015); Vertragslösungsquote Handwerk 38.5 per cent (2023, release 184/24) (2024-12-19). <https://www.it.nrw/nrw-14-prozent-weniger-neue-azubis-im-berufsbildungsjahr-2024-127053>
- HWK Dortmund.** Ausbildungsbilanz HWK Dortmund 2024: 431 new contracts Elektroniker/in für Energie- und Gebäudetechnik; 443 Anlagenmechaniker/in für SHK; 676 Kraftfahrzeugmechatroniker/in (chamber total 3,664, +0.5 per cent) (2025). [no publicly verifiable link; cited from the research corpus]

18. **Handwerkskammer zu Köln (reporting the all-NRW HWK total).** Jahresbilanz Ausbildungsmarkt 2023/2024 (30 October 2024): all seven NRW Handwerkskammern together 26,076 new apprenticeship contracts to 30 September 2024 (+0.62 per cent); ~126,000 nationally in the craft system (2024-10-30). <https://www.hwk-koeln.de/artikel/jahresbilanz-stabiles-plus-an-neuen-ausbildungsvertraegen-32%2C0%2C2986.html>
19. **MWIK (NRW Ministry of Economic Affairs, Industry, Climate Protection and Energy).** Bericht zur Arbeitsmarktentwicklung 2025 im Rheinischen Revier (structural-programme evaluation; VDI TZ, RWI, PRAC Bergs): the Revier has ~2.5 million inhabitants and ~870,000 jobs, with ~7,500 workers in mining and power plants; employment index 2010=100 tracked 2010-2023 (2026-01 (Bericht 2025)). https://www.wirtschaft.nrw/system/files/media/document/file/2026_01_13_bericht_zur_arbeitsmarktentwicklung_2025.pdf
20. **Bundesagentur für Arbeit, Statistik.** Gemeindedaten, sozialversicherungspflichtig Beschäftigte am Arbeitsort, seven Revier districts, 30 June values 2019-2025: 832,505 (2019) to 869,376 (2023) = +36,871; 832,016 (2020) to 869,376 (2023) = +4.5 per cent; 875,253 (2025) (2019-2025 releases). [no publicly verifiable link; cited from the research corpus]
21. **BBSR (Bundesinstitut für Bau-, Stadt- und Raumforschung).** Reviere im Blick: Das Rheinische Revier - employment up 19 per cent 2013-2023 (Germany +17 per cent); strongest growth Heinsberg +27 per cent, Mönchengladbach +20 per cent; ~7,000 lignite workers remaining; 2023 output ~48 million tonnes (2025 (accessed 2026-09-12)). https://www.bbsr.bund.de/BBSR/DE/forschung/kohleregionen/reviere-im-blick/_node.html
22. **RWI (Leibniz-Institut für Wirtschaftsforschung; Evaluierungsbericht for MWIK, carried by the Zukunftsagentur Rheinisches Revier).** Strukturförderung im Rheinischen Revier wirkt - Erster Evaluierungsbericht (MWIK press release, 12 November 2025): ~12,000 lignite-dependent jobs including supplier industry (end 2023); +4.5 per cent employment growth since 2020 (state +4.4 per cent); unemployment 6.7 per cent (state 7.2 per cent) (2025-11-12). <https://www.rheinisches-revier.de/service/neuigkeiten/detail/strukturfoerderung-im-rheinischen-revier-wirkt-erster-evaluierungsbericht-vorgelegt>
23. **Landtag NRW (Drucksache, November 2022 response, citing RWI calculations).** State parliament response of November 2022: direct, indirect and induced lignite-dependent employment 14,400 (Rheinisches Revier) and 21,500 (NRW); advancing the exit from 2038 to 2030 puts 4,400 Revier jobs (6,600 NRW) at risk earlier; lignite value creation €1.2 billion (2022) (2022-11). [no publicly verifiable link; cited from the research corpus]
24. **Bundesagentur für Arbeit, Regionaldirektion NRW.** Press release 3 January 2025 (NRW labour market, December 2024): 287,813 new postings in 2024 (-6.8 per cent; 2023: 308,747; 2020: 327,342), fewest in over twenty years; 129,602 open positions (-6.7 per cent, -9,326); BA-Stellenindex NRW 102 points; qualification mismatch 264:100 skilled vs 1,501:100 helper; regions Ruhrgebiet 253,034 (10.1 per cent), Rheinland 260,135 (7.3 per cent), Münsterland 47,792 (5.0 per cent) (2025-01-03). <https://www.arbeitsagentur.de/vor-ort/rd-nrw/presse/2025-2-nrw-arbeitsmarkt-arbeitslosigkeit-steigt-im-dezember-konjunktuelle-entwicklung-belastet-den-arbeitsmarkt>
25. **Bundesagentur für Arbeit, Statistik (NRW and Länder series).** NRW unemployment series: 7.5 per cent and 618,638 unemployed (2024 annual average, rank 11 of 16; Bayern 3.7, Baden-Württemberg 4.2, Germany 6.0, Bremen 11.1); 7.8 per cent (2025, ~783,000, worst since 2015; Germany 6.3); branch and nationality employment series (2025-2026). [no publicly verifiable link; cited from the research corpus]
26. **Bundesnetzagentur.** Stromspeicher thematic page: at end-2024 the transmission system operators held ~650 connection requests for large battery storage totalling 226 GW; distribution-level requests uncounted; MaStR (15 October 2025): ~2.4 GW / 3.2 GWh operating, ~5.0 GW / 10.4 GWh planned (2025 (page updated 2025-12-10)). <https://www.bundesnetzagentur.de/DE/Fachthemen/ElektrizitaetundGas/Speicher/artikel.html>
27. **BWP (Bundesverband Wärmepumpe) and BDH.** Absatzzahlen (BWP/BDH Absatzstatistik): heating heat pumps 154,000 (2021), 236,000 (2022), 356,000 (2023), 193,000 (2024, -46 per cent), 299,000 (2025, +55 per cent, nearly half of all heat generators sold); over 151,000 subsidy approvals in 2024; installed stock ~1.9 million (2026-01 (2025 release)). <https://www.waermepumpe.de/presse/zahlen-daten/absatzzahlen/>
28. **KfW.** BEG Heizungsförderung approvals 2025 (KfW programme 458; figures per the federal economics ministry): ~288,000 heat-pump approvals within ~330,000 approved heating applications in 2025 (87 per cent heat-pump share; 2024: ~192,000) (2026-01). [no publicly verifiable link; cited from the research corpus]
29. **IT.NRW (Statistisches Landesamt).** Zensus 2022 heating structure, NRW (release 6 August 2024): 68.7 per cent of dwellings gas-heated at the 15 May 2022 reference date (56 per cent nationally), 14.0 per cent heating oil, 9.7 per cent district heating; 9,132,252 dwellings (2022); Gebäude- und Wohnungsbestand series: 9,256,682 dwellings (31 December 2024) (2024-08-06). <https://www.it.nrw/zensus-2022-rund-zwei-drittel-aller-wohnungen-nrw-nutzten-gas-als-heizenergie-126652>
30. **BuVEG (Bundesverband energieeffiziente Gebäudehülle; study by B+L Marktdaten).** Sanierungsquote series: 0.72 per cent (Q1-Q3 2024), 0.61 per cent projected Q4, 0.69 per cent full-year 2024 (2023: 0.70; 2022: 0.88); 2025: 0.67 per cent, a new low; facade 0.46-0.5 per cent; ~2 per cent needed for the 2030 climate targets (2026-02-02 (2025 release)). <https://buveg.de/pressemeldungen/sanierungsquote-2025-talfahrt-fuer-energetische-gebaeudesanierung-geht-weiter/>
31. **dena (Deutsche Energie-Agentur).** dena-Gebäudereport 2024 (November 2023), referenced in Agora Energiewende JAHRESWENDE 2024: 45 per cent of German building floor area in energy performance classes F/G/H; 55 per cent of single-family homes in those classes (2023-11). [no publicly verifiable link; cited from the research corpus]
32. **Verbraucherzentrale.** Heat-pump market check (sample of 160 market offers): installed air-source heat pump in a single-family home averaging ~€30,000 (2025, ~€4,000 below the 2024 peak); offers spanning €20,000-63,000; German installed costs roughly double the UK's (~€14,000) (2025). [no publicly verifiable link; cited from the research corpus]
33. **IT.NRW (household energy expenditure, EVS 2022; with the federal government's share reading).** Household energy expenditure 2022 (published January 2024): the lowest income class (under €1,300/month) spends 11.4 per cent of income on household energy vs 4.8 per cent on average; NRW energy prices +39.7 per cent (2022); federal reading: 13.8 per cent of households spend over 10 per cent on energy (2024-01). [no publicly verifiable link; cited from the research corpus]
34. **dena (Deutsche Energie-Agentur).** Fit für 2045 (Teil 2): Investitionsbedarf für die Transformation öffentlicher Nichtwohngebäude (9 September 2024): €120 billion additional investment needed by 2045, ~€6 billion per year; €45 billion energy-cost savings by 2045; amortisation ~20 years (2024-09-09). <https://www.dena.de/infocenter/dena-veroeffentlicht-studie-fit-fuer-2045-teil-2/>
35. **Statistische Ämter der Länder (VGRdL) / IT.NRW.** NRW gross domestic product series: €871.9 billion nominal (2024), rank 1 of 16 states, 20.3-20.8 per cent of national output; -0.4 per cent real (2024) after -1.3 per cent (2023); industrial turnover €385 billion; 2025 nominal reading €909.4 billion (2025). [no publicly verifiable link; cited from the research corpus]

36. **IT.NRW (Statistisches Landesamt).** Kommunale Verschuldung NRW 2024 (release 4 July 2025): core-budget debt €55.4 billion (+12 per cent); including outsourced municipal units €70.5 billion (+11.6 per cent vs €63.2 billion), €3,913 per capita (2023: €3,483) (2025-07-04). <https://www.it.nrw/nrw-kommunale-verschuldung-2024-gestiegen>
37. **Daehre-Kommission (Kommission 'Zukunft der Verkehrsinfrastrukturfinanzierung' der Verkehrsministerkonferenz).** Final report (December 2012; presented to the Bundestag transport committee 12 February 2014): €7.2 billion per year missing for transport infrastructure maintenance over 15 years (base year 2012), across road, rail and waterways at federal, state and municipal level (2012-12-19). https://www.bundestag.de/webarchiv/textarchiv/2014/49449197_kw07_pa_verkehr-215644
38. **Agentur für Arbeit Brühl (employer survey, carried by Radio Erft).** Employer survey in the Revier (2026 vintage): 37 per cent of companies report acute need for further qualification; only ~30 per cent know the Teilqualifikation instrument (2026). [no publicly verifiable link; cited from the research corpus]
39. **Otto Benecke Stiftung.** Qualifizierungsagenten programme brochure (JTF/ESF/ERDF-funded, 2025): the gap between people with no or insufficient qualifications and skilled workers 'continues to widen' in the Revier (2025). [no publicly verifiable link; cited from the research corpus]
40. **IÖW (Institut für ökologische Wirtschaftsforschung; Umweltwirtschaftsbericht NRW 2024 for MUNV NRW).** Umweltwirtschaftsbericht NRW 2024 (November 2024): ~599,000 employed in NRW's environmental economy (2023), +21,600 vs 2020; gross value added ~€52.8 billion (+€9.2 billion vs 2020); growth 4.3 per cent per year since 2010 (employment +1.4 per cent p.a.) (2024-11). https://www.ioew.de/fileadmin/user_upload/DOKUMENTE/News/Umweltwirtschaftsbericht_NRW_bf_02.pdf
41. **IAB (Institut für Arbeitsmarkt- und Berufsforschung; as cited by Vocatium 2023).** Green-jobs apprenticeship recomposition (IAB data): green-skills apprenticeships +~14 per cent 2013-2021, brown-skills ~15 per cent; 341,000 'green jobs' in Germany (2021, +9.7 per cent vs 2020) (2023). [no publicly verifiable link; cited from the research corpus]
42. **WDR (analysis of NRW income distribution, 2026).** NRW income distribution: 90th/10th-percentile monthly-income ratio 3.66:1 (2014) to 3.91:1 (2024); lower decile threshold €777 to €1,035, upper €2,842 to €4,048; Gini 0.31 (2023) vs 0.30 nationally (2026). [no publicly verifiable link; cited from the research corpus]
43. **Umweltbundesamt.** Analyse des historischen Strukturwandels im Ruhrgebiet (Climate Change 29/2021, published January 2022) and the UBA coal-exit analyses: Ruhr hard-coal employment ~500,000 (1957) to ~4,500 (2016); Entwicklungsprogramm Ruhr DM 17 billion (1968-1971); delayed-exit cost ~€12 billion (2022-01). [no publicly verifiable link; cited from the research corpus]
44. **Infratest dimap (Nordrhein-WestfalenTREND for WDR).** NRW-Trend February 2026 (fieldwork 26-29 January 2026, published 1 February 2026): 42 per cent want to keep the 2030 coal-exit date; 22 per cent favour postponement to 2033; 25 per cent want lignite beyond 2033 (2026-02-01). <https://www.infratest-dimap.de/umfragen-analysen/bundeslaender/nordrhein-westfalen/laendertrend/2026/februar/>
45. **MDR, FR (Frankfurter Rundschau) and IAB Regional.** Mitteldeutsches Revier comparator: Mibrag employment 2,150 (2007) to 1,300 (2024) (MDR, 2025); a district administrator demanding 10,000 replacement industrial jobs (FR, 2026); demographic decline masking employment effects (IAB Regional Sachsen, 2025) (2025-2026). [no publicly verifiable link; cited from the research corpus]
46. **DIHK / IHK NRW.** IHK-Ausbildung in Zahlen (DIHK Ausbildungsstatistik): NRW's IHK system supervised 175,645 apprentices (2024); the NRW institutional grid of 16 IHKs (with 7 HWKs) through which every apprenticeship contract, exam and training standard passes (2025). [no publicly verifiable link; cited from the research corpus]
47. **INSM (Bildungsmonitor 2024) and Statistisches Bundesamt.** NRW demographic replacement ratio 66.2 per cent (2023): 1,886,098 residents aged 15-24 against 2,850,838 aged 55-64 (2024). [no publicly verifiable link; cited from the research corpus]
48. **IW Köln.** MINT-Frühjahrsreport 2024: 22.3 per cent of all MINT workers nationally are 55 or older (2012: 15.1 per cent); NRW 22.4 per cent (Q3 2023); Bayern 19.8 per cent (2024). [no publicly verifiable link; cited from the research corpus]
49. **TÜV Rheinland Akademie.** Company-published training-capacity figures: 15,000+ training events per year, ~200,000 participants per year, 2,500+ trainers (Köln) (2025). [no publicly verifiable link; cited from the research corpus]
50. **KVBG / BMWK / MWIKE (with RWE).** Coal-exit calendar: KVBG (2020) end-date 31 December 2038 for the last Rhenish units (Niederaußem K, Neurath F/BoA 2, Neurath G/BoA 3); the 4 October 2022 BMWK-MWIKERWE agreement, legislated 24 December 2022, moved final exit to 31 March 2030 with no additional compensation; reserve operation 2030-2033 possible with federal cost coverage; Anpassungsgeld anchored in the KVBG (2022-12-24). <https://www.bundesregierung.de/breg-de/aktuelles/kohleausstieg-2030-2139228>
51. **European Commission.** Commission approves €2.6 billion State aid to RWE for early closure of lignite-fired power plants in Germany (11 December 2023; Decision (EU) 2024/2418, SA.53625) (2023-12-11). https://ec.europa.eu/commission/presscorner/detail/en/ip_23_5815
52. **BMWK / MWIKE (Strukturstärkungsgesetz Kohleregionen).** Structural-funds architecture: up to €40 billion nationally through 2038 (€14 billion direct investment grants plus €26 billion federal measures; hard-coal power-plant sites up to €1.09 billion); for the Rhenish Revier more than €14.8 billion from federal, state and local funds to 2038 (phased €5.5 / €4.5 / €4.0 billion) (2020-08-14 (in force; page current 2026)). <https://www.bundeswirtschaftsministerium.de/Redaktion/DE/Artikel/Wirtschaft/kohleausstieg-und-strukturwandel.html>
53. **MWIKER Zukunftagentur Rheinisches Revier.** Delivery status of the Revier funds (wirtschaft.nrw, 2026): 370 projects in the approval pipeline; project sketches for the state component accepted until 31 December 2025; second funding phase begins early 2027; anchor projects fast-tracked by the NRW cabinet (2026). <https://www.wirtschaft.nrw/strukturwandel-im-rheinischen-revier>
54. **Bundesnetzagentur.** Monitoringbericht Energie 2025 (2024 data year): Netzeingpassmanagement volume 30,320 GWh (-12 per cent) and costs ~€2.7-2.9 billion (2023: €3.3 billion); smart-meter Ausstattungsquote in mandatory cases 13.91 per cent at end-2024 against the 20 per cent legal target for end-2025 (largest operators already at 22.1 per cent) (2025-04). [no publicly verifiable link; cited from the research corpus]
55. **Amprion.** Amprion investment programme (company statements via dpa/WiWo, April 2025, and ZfK, April 2026): ~€27.5 billion 2024-2028; €5.4 billion invested 2025; ~€42 billion planned to 2030; the corpus's '€8 billion in NRW over five years across ~30 projects' has no public carrier (2025-2026). <https://www.zfk.de/energie/strom/redispach-kosten-iran-krieg-amprion-netzpaket>
56. **WirtschaftsWoche (dpa).** Energiewende: Stromleitung A-Nord soll Hunderte Millionen Euro einsparen (11 April 2025): Amprion CEO - A-Nord cuts grid-intervention costs by up to €700 million per year from 2027; investment cost ~€3 billion; full commissioning 2027 (2025-04-11). <https://www.wiwo.de/unternehmen/energie/energiewende-stromleitung-a-nord-soll-hunderte-millionen-euro-einsparen/100120866.html>
57. **KfW (BEG Heizungsförderung Wohngebäude, Zuschuss 458).** BEG terms: 30 per cent base grant plus speed, efficiency and income bonuses to a 70 per cent maximum, capped at €21,000 on €30,000 eligible costs per first dwelling unit (terms to 20 July 2026); from 21

July 2026 (GModG): eligible costs €28,000 degressing, speed bonus 16 per cent degressing, efficiency bonus abolished, income bonus re-tiered to 40/30/10 per cent with an 80 per cent cap (2026-07-21).

https://www.kfw.de/%C3%9Cber-die-KfW/Newsroom/Aktuelles/Pressemitteilungen-Details_900928.html

58. **European Commission and Land NRW (EFRE/JTF-Programm NRW 2021-2027).** EFRE/JTF NRW 2021-2027: ~€1.9 billion EU funds (EFRE plus JTF), ~€4.2 billion total programme volume with state co-financing and project shares; JTF ~€683 million for the Rheinisches Revier and the northern Ruhr area, ~€120 million of it via ESF (2021-2027). <https://www.wirtschaft.nrw/europaeischer-fonds-fuer-regionale-entwicklung-efre>
59. **RWE.** Capital Markets Day release (28 November 2023): €55 billion net worldwide investment 2024-2030 in renewables, batteries, flexible generation and hydrogen; green portfolio to more than 65 GW by 2030; coal exit 2030, net zero 2040 (2023-11-28). <https://www.rwe.com/en/press/rwe-ag/2023-11-28-rwe-significantly-increases-investments-in-the-energy-transition/>
60. **MWIK (Wasserstoff Roadmap NRW, presented 9 November 2020).** Wasserstoff NRW: up to 130,000 new jobs from building a hydrogen economy in North Rhine-Westphalia (ministry-commissioned study; roadmap phases to 2025 and 2030; no horizon stated on the ministry page) (2020-11-09). <https://www.wirtschaft.nrw/wasserstoff>
61. **Serinyx.** Serinyx research corpus on the North Rhine-Westphalian transition economy, 2026: cross-field constraint adjudication (workforce availability reported as binding in every field studied) (2026). [internal evidence record of the source study; not a public document]
62. **Serinyx.** Serinyx research corpus on the North Rhine-Westphalian transition economy, 2026: completion-rate adjudication (two corpus readings of the same quantity, 70-75 vs 75-80 per cent, written down not averaged) (2026). [internal evidence record of the source study; not a public document]
63. **Serinyx.** Serinyx research corpus on the North Rhine-Westphalian transition economy, 2026: grid-connection queue readings (about 70 GW, 500-plus GW and 700-plus GW) held as a definitions spread (2026). [internal evidence record of the source study; not a public document]
64. **Serinyx.** Serinyx research corpus on the North Rhine-Westphalian transition economy, 2026: building-decarbonisation financing-gap scenario arithmetic (gap of €8-18 billion per year) (2026). [internal evidence record of the source study; not a public document]
65. **BIBB (Berufesuche; Ausbildungsordnungen).** Regulated training durations: Elektroniker/-in für Energie- und Gebäudetechnik 3.5 years (section 2 of the current Ausbildungsordnung, in force 1 August 2021); Anlagenmechaniker/-in für Sanitär-, Heizungs- und Klimatechnik 3.5 years (42 months, ordinance in force since 2016) (2016-2021). <https://www.bibb.de/dienst/berufesuche/profile/apprenticeship/210715>
66. **BIBB (Tarifliche Ausbildungsvergütungen).** Tarifliche Ausbildungsvergütungen (annual 1 October evaluation): average €1,209 per month across all training years in 2025 (+6.7 per cent) after €1,133 in 2024 (+6.3 per cent); NRW €1,107 (2024) and €1,185 (2025); west German Handwerk €1,091 (2025); statutory minimum €724 in the first year (2026) (2025-10-01). <https://www.bibb.de/de/12209.php>
67. **IT.NRW (Landesbetrieb Information und Technik Nordrhein-Westfalen, Statistisches Landesamt).** Bevölkerungsvorausberechnung NRW 2024 bis 2050/2070 (migration assumptions, support period 2017-2023): net migration balance between NRW and the other Länder minus 5,500 per year from 2024; realised balances minus 4,974 (2024) and minus 4,436 (2023) (2023-2025). <https://statistik.nrw/service/veroeffentlichungen/statistik-kompakt/bevoelkerungsvorausberechnung-fuer-nrw-2024-bis-2050-2070>
68. **BAMF (Bundesamt für Migration und Flüchtlinge).** Migrationsbericht der Bundesregierung 2023 (chapter 4.2.3): 456,200 non-EU nationals left Germany in 2023; 20,565 of them (4.5 per cent) held an employment-purpose residence title at departure, among them 4,430 EU Blue Card holders and 640 self-employed (2025 (reporting year 2023)). https://www.bamf.de/SharedDocs/Anlagen/DE/Forschung/Migrationsberichte/migrationsbericht-2023.pdf?__blob=publicationFile
69. **BIBB (Rangliste der Ausbildungsberufe nach Neuabschlüssen).** Rangliste 2025 (press release 09/2026 of 3 March 2026, survey of 30 September 2025): 475,950 new apprenticeship contracts, 36.4 per cent female overall; Elektroniker third in the men's ranking with 14,082 new contracts; Anlagenmechaniker SHK second with 14,172 (2026-03-03). https://www.bibb.de/de/pressemitteilung_219433.php
70. **Übertragungsnetzbetreiber (50Hertz, Amprion, TenneT, TransnetBW) with Bundesnetzagentur.** Netzentwicklungsplan Strom 2037/2045 (2025), second draft (16 March 2026): calculated investment costs to 2045 of about €365-392 billion across scenarios at transmission level; dena-Verteilnetzstudie II (1 July 2025): distribution-grid investment up 85-123 per cent on 2024 by 2045 (2026-03-16). <https://www.transnetbw.de/de/newsroom/pressemitteilungen/uebertragungsnetzbetreiber-veroeffentlichen-zweiten-entwurf-des-netzentwicklungsplans-strom>
71. **Pexapark (with LevelTen Energy readings carried in trade press).** PPA price readings: Pexapark EURO Composite €52.53/MWh (January 2025), €50.25 (February, -4.3 per cent month on month, Germany among the largest declines), €49.5 (March); Platts-Pexapark standard 10-year German solar PPA €53.17/MWh (16 April 2025, +28 per cent from the 16 February low); LevelTen European solar P25 €63.11/MWh (Q1 2025, +1.3 per cent quarter on quarter) (2025 (Q1 to April)). <https://pexapark.com/in-the-media/>
72. **Serinyx.** No published NRW-level heat pump sales or stock series (2026). [internal evidence record of the source study; not a public document]
73. **Serinyx.** No published band for the share of career changers earning at or above their prior wage after mid-career vocational retraining (2026). [internal evidence record of the source study; not a public document]