NETZ
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NDP compact

Network Development Plan Electricity 2037
with Outlook 2045, Version 2025, second draft

Imprint

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Summary of NDP 2037/2045 (2025)

The four German transmission system operators (TSOs) 50Hertz, Amprion, TenneT Germany and TransnetBW with control area responsibility plan, build and operate power grids at the extra-high voltage level, including the necessary infrastructure. In addition to onshore and subsea power lines, this includes substations, switchgear and innovative types of facilities required to support further expansion of volatile generation from wind power and photovoltaics. The Network Development Plan Electricity is the central planning tool for assessing future transmission requirements and proposing suitable infrastructure measures to meet these requirements.

The NDP 2037/2045 (2023) marks the first time the TSOs have focused on 2045 as the target year for achieving climate neutrality in Germany. In this plan, the requirements for a carbon-neutral grid were presented using three scenarios for the respective target horizons of 2037 and 2045 and backed by actionable measures. As part of the scenario development, the TSOs engaged in intensive dialogue with the operators of the gas grid infrastructure. They also collected comprehensive data on the future energy requirements of potential large-scale consumers.

The second draft of the NDP 2037/2045 (2025) is now available and builds on this analysis. It is based on the scenario framework approved by the BNetzA and considers the grid expansion requirements for the coming years and decades set against the economic, technical and (geo)political developments. This scenario was recalculated, analysed and re-evaluated.

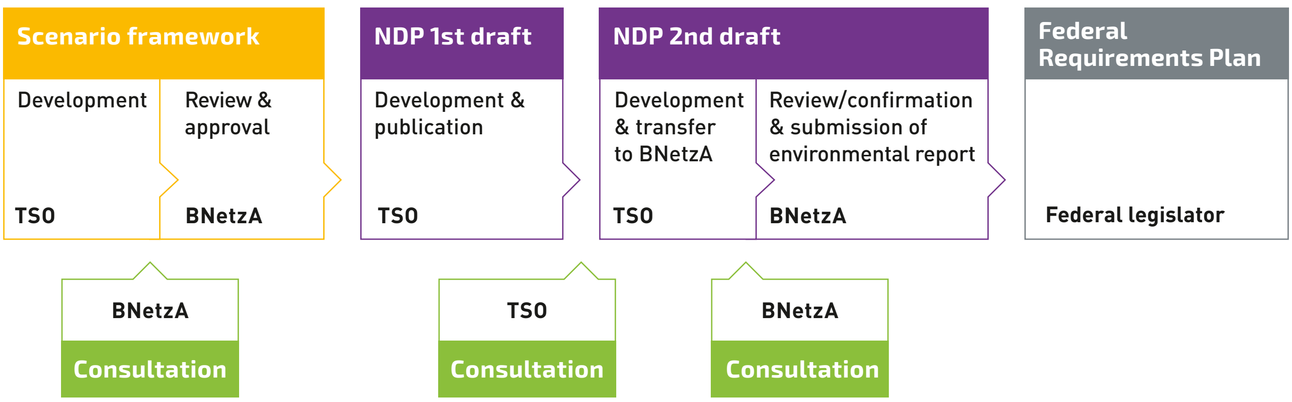
The first draft of the NDP 2037/2045 (2025) was published on 10 December 2025 and was open for public consultation until 14 January 2026. In accordance with Section 12b(3) sentence 1 of the Energy Industry Act (EnWG), interested parties were able to submit comments during this period, thereby providing valuable input for preparation of the second draft.

Assumptions regarding power consumption and the expansion of renewable energy revised downwards

This NDP examines three scenario pathways through which climate neutrality can be achieved by 2045. Scenarios A, B and C are considered for the target years 2037 and 2045 respectively. This second draft contains scenarios A, B and C for both years. The range of scenarios has been significantly expanded compared to the NDP 2037/2045 (2023). Among other reasons, this change was made because the actual trend in current power consumption deviates significantly from previous forecasts, which may have long-term implications for grid expansion requirements and the overall structure of the power supply. This concerns developments in industrial power consumption, the slower-than-expected uptake of electric mobility compared to political targets and expectations, as well as the electrification of heating through heat pumps.

For the first time, the TSOs will present an additional scenario for the year 2037, known as Scenario A 2037+. It is expected to be published as a special report following the second draft of the NDP, likely in April 2026.

Figure 1: The process from the scenario framework to the Federal Requirements Plan



Source: Transmission system operators

This supplementary scenario factors in an additional 14 GW of installed capacity in the onshore wind sector compared to Scenario A 2037. In total, the NDP 2037/2045 (2025) thus quantifies the necessary grid developments across seven different scenarios. To increase planning reliability, a 2032 trend scenario is also included in the second draft.

Among other things, it is used to determine the medium-term requirement for reactive power compensation systems to maintain voltage. It also serves as the basis for the 2027 System Stability Report.

Table 1: Overview of the scenario key figures

Energy source	Reference year 2024	A 2037	B 2037	C 2037	A 2045	B 2045	C 2045
Installed capacity in GW							
Thermal power plants	75.8	48.2	64.2	64.2	62.5	83.5	83.5
Pumped storage	9.9	12.0	12.0	12.0	12.0	12.0	12.0
Total conventional generation	**85.7**	**60.2**	**76.2**	**76.2**	**74.5**	**95.5**	**95.5**
Onshore wind	63.5	126.6*	158.2	158.2	143.5	160.0	176.0
Offshore wind	9.2	50.0	56.0	56.0	60.0	70.0	70.0
Photovoltaics	99.8	270.0	345.4	379.9	315.0	400.0	440.0
Biomass	9.1	5.0	5.0	5.0	3.0	3.0	3.0
Hydropower	4.6	4.6	4.6	4.6	4.6	4.6	4.6
other renewable generation	0.9	1.0	1.0	1.0	1.0	1.0	1.0
Total renewable generation	**187.1**	**457.2**	**570.2**	**604.7**	**527.1**	**638.6**	**694.6**
Total generation	**272.8**	**517.4**	**646.4**	**680.9**	**601.6**	**734.1**	**790.1**
Power consumption in TWh							
Net power consumption	**464.4**	**774.8**	**956.7**	**994.2**	**868.7**	**1,101.8**	**1,195.1**
Drivers of sector coupling							
Electromobility in millions	2.4	27.8	33.6	37.8	36.8	44.5	44.9
Power-to-Heat in GW	0.8	9.5	25.3	22.2	16.4	26.1	23.3
Heat pumps in millions	2.0	7.7	8.7	9.5	11.3	13.3	14.0
Electrolysis in GW	0.2	20.0	42.0	42.0	31.6	58.5	70.0
Further storage and demand-side flexibilities in GW							
Small-scale battery storage	9.9	46.7	59.5	65.3	59.7	73.7	80.9
Large-scale battery storage	1.7	41.1	67.6	94.1	41.1	67.6	94.1
DSM (industry and commerce, trade and services)	1.4	4.6	7.7	8.7	8.4	12.9	14.5

* The Federal Network Agency (BNetzA) has additionally approved an onshore wind power capacity of 140.5 GW for this scenario. The analyses relating to this will be published at the end of April 2026.

Source: Federal Network Agency

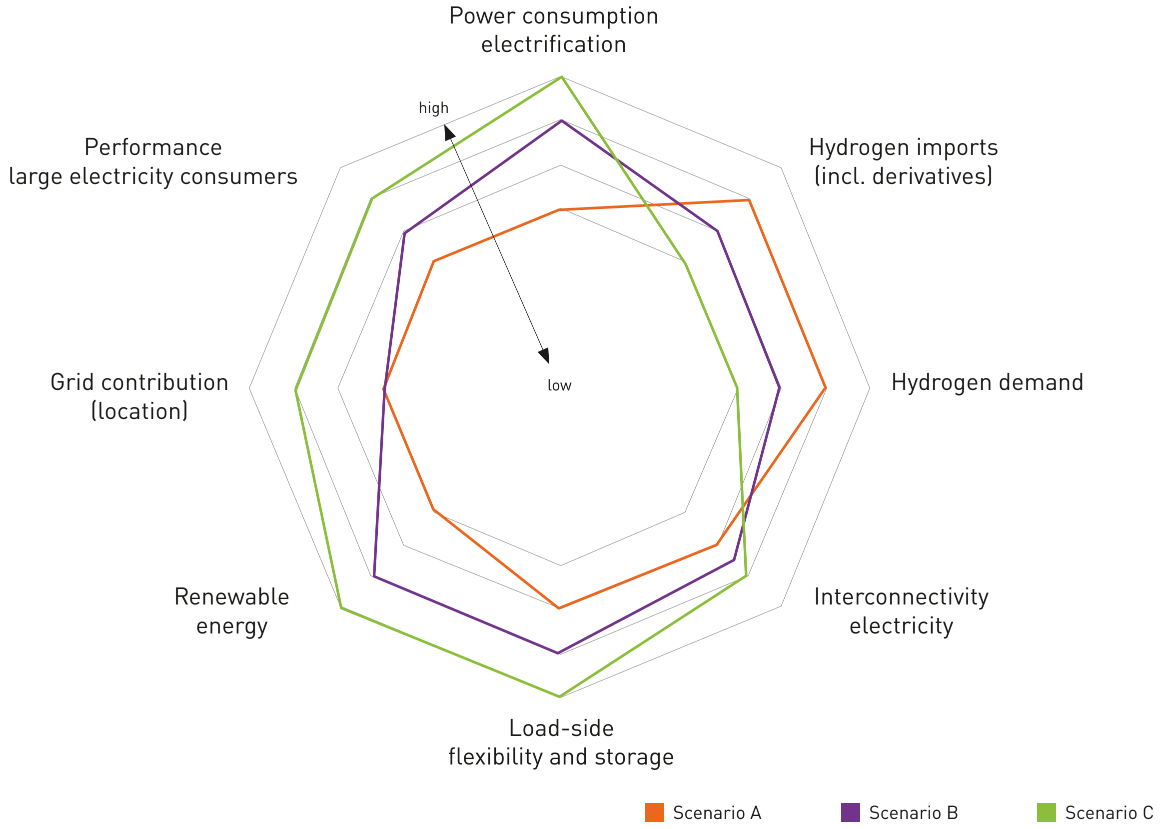
The three currently selected scenario paths differ primarily in the level of electrification, the associated power consumption, the role of hydrogen, as well as the expansion of renewable energy. Scenario A describes low electrification, high hydrogen imports and delayed expansion paths for renewable energy. Scenario B follows the statutory expansion paths for renewable energy and is closely aligned with the system development strategy. By contrast, scenario C is based on high power consumption and extensive electricity production capacity.

Due to the expected increase in electrification, gross power consumption (2024: 518 TWh/year)[1] will rise to between 866 and 1,087 TWh/year in the target year 2037 and to between 989 and 1,294 TWh/year in the target year 2045. Compared with the 2037/2045 NDP from 2023, all scenarios display a downwardly revised forecast. This revision is particularly pronounced in the A scenarios, amounting to around 50 TWh/year in 2037 and around 120 TWh/year in 2045.

To meet the rising electricity demand, the installed capacity of solar and wind power plants will be significantly expanded. Compared to the current expansion level, a three- to four-fold increase in installed capacity is expected (see Table 2). By contrast, little change is expected in the generation capacity of run-of-river and storage hydroelectric power stations. A decline in generation capacity is anticipated for biomass plants. The share of renewable energy in gross power consumption will rise to over 90% in both target years. In all scenarios, Germany remains a net electricity importer with rising net imports. This is driven by growing demand, high costs of electricity production from hydrogen power plants and growing offshore wind feed-in from other European countries.

1 See: 'Energy Supply 2024 – Annual Report (updated version)'.

Figure 2: Schematic diagram illustrating the classification of scenario paths



Source: Transmission system operators

Table 2: Comparison of installed renewable energy capacity

Installed capacity in GW	Stock (Reference year 2024)	Target year 2037 (NDP 2037/2045 (2023))	Target year 2037 (NDP 2037/2045 (2025))	Target year 2045 (NDP 2037/2045 (2023))	Target year 2045 (NDP 2037/2045 (2025))
Photovoltaics	99.3	345.4	270.0–379.9	400.0–445.0	315.0–440.0
Offshore wind energy	9.2	50.5–58.5	50.0–54.7	70.0	59.2–70.2
Onshore wind energy	63.5	158.2–161.6	126.4–158.0	160.0–180.0	143.3–175.8
Total	**172.0**	**563.1–574.5**	**446.4–592.6**	**630.0–695.0**	**517.5–686.0**

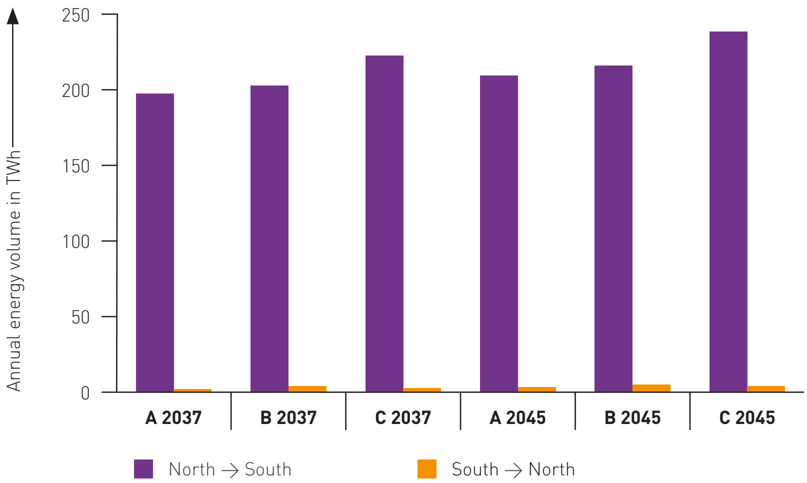
Source: Federal Association of the German Energy and Water Industries (BDEW), transmission system operators

Current planning data and information of potential sites are used to determine the future regional distribution of renewable energy generation facilities. In the onshore wind energy sector, the bulk of generation capacity will continue to be based in northern Germany, although significant expansion is also expected in the southern regions. A regional divide is emerging in the photovoltaic sector: whilst rooftop photovoltaics are being expanded in western and southern Germany as well as in conurbations, ground-mounted installations dominate in the north, in the eastern federal states and in Bavaria. The high feed-in of wind energy, both onshore and offshore, in northern Germany continues to strongly determine domestic transmission requirements, with predominant load flows in a north-south direction and only small annual energy volumes flowing in a south-north direction.

High thermal power plant capacities – but low feed-in

With regard to controllable power plant capacities, hydrogen as an energy carrier will play a key role on the path to climate neutrality. In all scenarios, hydrogen power plants are planned to cover peak loads. In Scenario A 2037, which assumes the lowest power consumption, the power plant portfolio is predominantly hydrogen-powered and supplemented by fossil gas power plants with CO_2 capture via Carbon Capture and Storage (CCS). For domestic hydrogen production via electrolysis, this scenario assumes a production of 36.7 TWh, with a demand of 53.5 TWh for electricity production in power plants. In all scenarios, hydrogen demand is predominantly met through imports rather than domestic production. In electricity-intensive Scenario C, the domestic share is higher. By 2045, a strong ramp-up is expected in domestic production and hydrogen demand for electricity production. Hydrogen is required on a significant scale for the decarbonisation of industry and the heating sector.

Figure 3: Annual energy volume of the domestic transport task in Germany



Source: Transmission system operators

A capacity of 58.8 to 73.9 GW (2037) and 74.6 to 95.4 GW (2045) is assumed for the conventional thermal power plant portfolio. In the target year 2037, this still includes gas power stations using fossil natural gas as fuel with an installed capacity of between 13.9 and 15.2 GW. However, these power plants cover less than 5% of annual power consumption, as they function solely as peak-load power stations to fill power generation gaps.

European integration leads to increased transmission volumes

Due to its central location in Europe and the corresponding trade flows with neighbouring electricity bidding zones, Germany is closely integrated into the European internal electricity market. To reflect these relationships and integrate them into German grid planning, this NDP is largely based on the final report on the European Network Development Plan, the 'TYNDP 2024 Scenarios Report'. This report was jointly prepared by the European electricity and gas transmission system operators and published in January 2025.

A scenario from this Ten-Year Network Development Plan (TYNDP) approved by the BNetzA is integrated into the analyses of the German NDP in accordance with Section 12b(1), sentence 6 of the Energy Industry Act (EnWG) to represent the European external grid. This ensures close integration between national and European planning processes. For the present NDP, the BNetzA has confirmed the 'National Trends+' scenario as the international scenario. This scenario accounts for the national energy plans of European countries whilst also meeting European climate protection targets.

Data from the European Resource Adequacy Assessment 2024 is used to model trading capacities between market areas. Net imports of electricity from abroad in scenarios A and B range between 25 and 73 TWh, covering around 3 to 7% of gross power consumption in Germany. At 91 TWh, net imports in scenario C 2045 are the highest. Denmark, the United Kingdom, the Netherlands, Estonia, Norway and France will be the most important source countries.

This draft NDP analyses and presents interconnector projects to and from Germany that contribute to the integration of the European energy market and the achievement of climate targets in a TYNDP 2024 scenario. Some of these interconnectors have been identified as hybrid interconnectors (incorporating offshore wind farms) within the framework of the Offshore TSO Collaboration (OTC) for the northern European seas (North Sea, Irish Sea, Celtic Sea) and the Baltic Offshore Grid Initiative (BOGI) for the Baltic Sea region. The integration of these interconnectors results in significantly higher transmission requirements for the German transmission grid compared to the previous NDP.

Bearing these interconnectors in mind, meticulous attention was paid to ensure consistent coordination with the TYNDP 2024 and current project developments. Consequently, only four interconnector projects were assessed in the TOOT procedure that had been approved within the scenario framework.

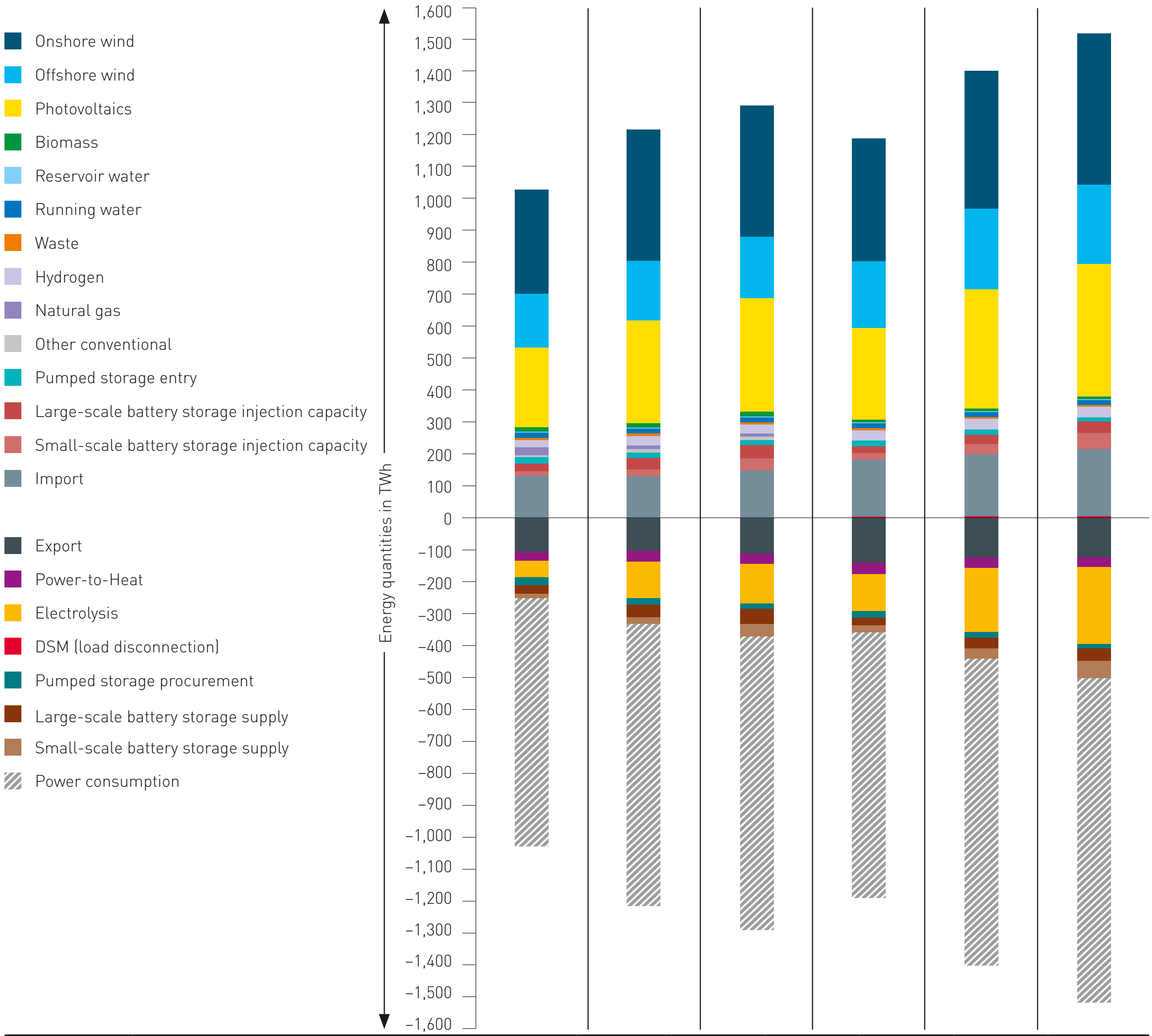
The growing importance of large-scale battery storage

The very high number of grid connection applications for large-scale battery storage, as well as the increasing role of storage in general within the energy system, is also reflected in this draft of the NDP. All battery storage projects that have already been granted grid connection approval and are at an advanced development stage are fully taken into account. Projects that are still in the planning phase are only reflected proportionally, at 25 to 50% of their capacity, depending on the scenario. Against this backdrop and based on the approved scenario framework, the total capacity of large-scale battery storage for the period between 2037 and 2045 is 41 to 94 GW. This represents a significant increase compared to the assumptions in the NDP 2037/2045 (2023). Unlike in the previous NDP, the current NDP does not show any further significant growth in flexibility by 2045. The calculation is based on the approved scenario framework. Furthermore, the importance of small-scale battery storage systems and flexible consumers will also increase considerably. Operating these storage systems will be significantly impacted by the daily generation pattern of photovoltaic systems.

Complex demands on the electricity transmission grid

As the number of facilities for generating, storing and increasing the flexibility of electricity production and consumption grows, so too do the demands on the transmission grid and its expansion. With that in mind, it is necessary to scrutinise a wide variety of possible expansion options and identify the pathways that reflect the lowest investment costs for the grid infrastructure as well as the lowest possible congestion management costs.

Figure 4: Comparison of electricity production, electricity demand and imports/exports



Type	in TWh	A 2037	B 2037	C 2037	A 2045	B 2045	C 2045
Generation	Onshore wind	325.8	410.0	411.1	384.4	431.0	473.4
	Offshore wind	168.8	186.7	191.9	208.6	252.9	247.5
	Photovoltaics	249.6	321.8	356.2	287.3	373.2	414.8
	Biomass	15.0	15.0	15.0	9.0	9.0	9.0
	Reservoir water	2.0	2.0	2.0	2.0	2.0	2.0
	Running water	16.1	16.1	16.1	16.1	16.1	16.1
	Waste	8.3	7.1	6.9	6.1	5.8	5.7
	Hydrogen	22.0	29.6	27.9	31.3	32.6	32.1
	Natural gas	23.9	10.8	10.0	0.0	0.0	0.0
	Other conventional	6.3	11.2	10.1	0.5	0.5	0.5
	Pumped storage entry	20.9	18.0	15.4	18.5	15.8	13.2
	Large-scale battery storage injection capacity	24.4	35.6	43.2	21.7	30.5	35.8
	Small-scale battery storage injection capacity	13.4	20.0	36.6	20.1	30.9	50.4
	Import	131.8	131.2	148.9	182.5	199.0	214.8
Consumption	Export	107.1	103.8	112.7	141.0	126.3	123.8
	Power-to-Heat	27.2	33.8	32.5	35.6	31.2	30.8
	Electrolysis	52.4	114.4	123.8	115.7	201.2	241.0
	DSM (load disconnection)	−0.1	−0.1	−0.1	−2.3	−2.9	−3.2
	Pumped storage procurement	24.6	20.6	17.2	21.4	17.7	14.4
	Large-scale battery storage supply	26.5	38.7	47.0	23.6	33.2	38.9
	Small-scale battery storage supply	14.5	21.7	39.8	21.8	33.5	54.8
	Power consumption*	776.1	882.1	918.2	831.2	959.1	1014.8

* In this presentation, power consumption comprises net power consumption including all grid losses without considering power consumption by electrolysis and power-to-heat plants (district heating) as well as demand side management (DSM).

Source: Transmission system operators

This accounts for inflation- and market-driven cost increases in a product and services market that is partly characterised by supply bottlenecks. For the grid analyses in this NDP, a scientifically sound, heuristic methodology was once again employed, which made it possible to explore several thousand combinations of expansion options. This comprehensive review of alternatives for the identified projects and measures did not yield a target grid that would be preferable to the grids presented in the respective scenarios in this NDP.

To meet future challenges and continue the transition to a carbon-neutral energy system, the four TSOs are deploying a wide range of proven and innovative solutions and technologies. This NDP also considers weather-dependent overhead line operation as well as the conversion to high-temperature conductor cables for grid optimisation, which make it possible to increase transmission capacity at relatively low cost without jeopardising system stability.

Significantly differing grid expansion requirements across time horizons

The carbon-neutral grid, which once again serves as the target scenario in this NDP, requires a significant increase in grid enhancement and expansion measures. However, the expansion of the range of scenarios results in a much greater variety of potential measures compared to the NDP 2037/2045 (2023), which can be derived from the respective pathways.

In addition to the measures already enshrined in the Federal Requirements Plan Act, this NDP continues to identify a substantial need for grid expansion measures to reduce existing grid bottlenecks. To achieve an optimised transmission grid, the scenarios examine whether grid expansion or accepting congestion management costs is more economically advantageous. Due to rising prices and market shortages, this trade-off is coming into sharper focus. Consequently, the target grid will be smaller than envisioned in the NDP 2037/2045 (2023). Additionally, there will be a greater need for congestion management after development of the target grid.

Compared to the NDP 2037/2045 (2023), the total scope of measures in the initial grid increases from around 6,900 to around 10,400 km. Of this amount, approximately 5,000 km relates to AC grid upgrades and new construction on new routes. Approximately 5,300 km comprise DC measures, including new construction and interconnectors to neighbouring European countries. This increase in the initial grid stems from the fact that, over the past two years, planning approval procedures for several further projects have been initiated or completed by the relevant state authorities or the Federal Network Agency (BNetzA). As a result, many projects are already in the construction preparation phase or under construction. Completed projects have also been transferred from the initial grid to the existing grid.

Whilst this expansion can reduce congestion in the extra-high voltage grid, it cannot eliminate it to the extent necessary, because the transformation of the electricity production system has gained significant momentum with the continued expansion of renewable energy. Accordingly, in addition to the initial grid (Startnetz), this NDP also identifies further measures leading to a carbon-neutral grid by 2045.

The expansion grid in this NDP varies depending on the respective scenario path. This variation is primarily attributable to the significant expansion of renewable energy in all scenarios, driven by political energy transition and climate protection targets. Compared to the NDP 2037/2045 (2023), changed framework conditions mean that a lower demand for domestic HVDC transmission lines is identified in all scenarios. The changed framework conditions include a later rise in electricity demand, optimised offshore grid expansion planning and balancing of investment costs against savings in congestion management. The fundamentally altered structure of the scenarios means that AC expansion changes, especially between the time horizons of 2037 and 2045 under consideration. This affects the scope of the measures as well as the selection of expansion measures.

In the previous NDP, the BNetzA had confirmed a transmission requirement for five additional HVDC lines (DC40, DC40plus, DC41, DC42 and DC42plus) with predominant load flows in north-south and west-east directions. However, taking the necessary investment costs into consideration, this requirement has decreased significantly in the current NDP. Conversely, in all scenarios, there is a consistent demand for the DC42 HVDC transmission line, which connects Schleswig-Holstein with Baden-Württemberg over a distance of just under 700 km. In all scenarios, except for A 2037, this 2 GW HVDC transmission line is supplemented by another 2 GW line running largely parallel to it, the DC42plus line from Schleswig-Holstein to Bavaria.

For cost-efficiency reasons, both HVDC lines extending beyond the initial grid are supposed to be constructed as overhead lines. In the second draft of the NDP, projects DC43 and DC44 were identified in scenario C 2045.

Although the NDP 2037/2045 (2025) indicates a negative cost-benefit ratio, both projects have a significant impact on reducing bottlenecks. Consequently, these two DC transmission lines are being considered by the TSOs as planning options for future grid development plans. Overall, in Scenario A 2037, the need for network enhancement and expansion is lower than in the previous NDP, even for AC measures. In addition to the initial grid, new construction and grid enhancement measures are required over a length of around 4,200 km. For DC, this amounts to approximately 1,000 km, including around 400 km of AC and DC interconnector links connecting the German transmission grid to other European countries.

In Scenario A 2045, the need for AC and DC expansion measures rises to a length of around 9,500 km, of which approximately 1,700 km relates to interconnectors in AC and DC configurations. Compared with the first draft of the NDP 2037/2045 (2025), the second draft indicates a slightly higher expansion requirement for the AC grid, including in scenarios A and B.

The reason for this is that all TSOs are applying a uniform maximum current limit of 3.6 kA per circuit in the 380 kV AC grid, which is based on a request from the BNetzA. The assumption of a partially lower current-carrying capacity leads to greater bottlenecks and, consequently, to an increased need for grid expansion.

Offshore optimisation reduces the need for expansion at sea and on land

Like the onshore initial grid, the offshore initial grid has been expanded compared to the previous NDP. Several projects are already under way, which means that converter stations, platforms and cables have been ordered by the respective TSOs or are in the approval process. The offshore initial grid for the North Sea and Baltic Sea comprises a total capacity of 24.1 GW and a route length of approximately 4,200 km. Of this total capacity, 22.8 GW is in the North Sea, covering around 3,600 km, and 1.3 GW is in the Baltic Sea, covering approximately 55 km. For comparison: Currently, just under 9.6 GW of offshore capacity is connected to the German transmission grid as part of the existing grid in the North and Baltic Seas.

In the offshore sector, this NDP introduces, for the first time, measures for offshore optimisation of offshore grid connection systems (ONAS), with commissioning scheduled to start in 2035 in the North Sea, focusing on Zones 4 and 5, in order to increase offshore expansion efficiency. In collaboration with Fraunhofer IWES, the TSOs have developed a planning framework that systematically accounts for the negative impact of shadowing effects on the output of wind turbines. Temporary increases in the transmission capacity of the ONAS to up to 2.1 GW were also incorporated in Scenario C. The principle of overbuilding was made mandatory, as the wind farms are only operating at full capacity for a few hours a year.

Table 3: Overview of the scenarios incorporated into the grid modelling

Offshore optimisations	Scenario A	Scenario B	Scenario C
Average overbuilding	Ø 15% (2,300 MW)		Ø 9.5% (2,300 MW)
Transmission capacity	2,000 MW		2,100 MW
Installed generation capacity	23,023 MW	30,008 MW	27,687 MW
Base figures for 2037 capacity/ Energy yield	50.0 GW/ 165.0 TWh	56.0 GW/ 184.8 TWh	56.0 GW/ 184.8 TWh
ONAS expansion by 2037 based on the Area Development Plan FEP 2025	3	5	5
Total offshore wind farm power/ **transmitted energy quantity/** curtailed energy volume	50.0 GW/ **172.8 TWh/** 2.3 TWh	54.7 GW*/ **190.0 TWh/** 3.6 TWh	54.7 GW*/ **194.8 TWh/** 2.6 TWh
Base figures for 2045 capacity (plus decommissioning)/ Energy yield	60.0 GW (+7.7 GW)/ 204.0 TWh	70.0 GW (+3.7 GW)/ 238.0 TWh	70.0 GW (+3.7 GW)/ 238.0 TWh
ONAS expansion by 2045 based on the Area Development Plan FEP 2025	10	13	12
Total offshore wind farm power/ **transmitted energy quantity/** curtailed energy volume	59.2 GW*/ **214.0 TWh/** 5.3 TWh	70.2 GW **256.6 TWh/** 8.0 TWh	67.9 GW*/ **250.2 TWh/** 4.9 TWh
ONAS savings compared to confirmed NDP 2037/2045 (2023)	7	4	5

* Although there is a deviation from the base figures specified in the scenario framework, the amount of transmitted energy increases as a result of the offshore optimisation measures.

Source: Transmission system operators

In accordance with the approval of the scenario framework, the statutory expansion target of at least 70 GW of installed capacity for offshore wind energy in the North Sea and Baltic Sea was supplemented by offshore optimisation with a target energy yield of 238 TWh. Optimised site layouts and targeted positioning of wind turbines lead to a significant reduction in shadowing effects. This increases the full-load hours of the offshore wind farms under consideration to an average of 3,900 hours.

Consequently, the ONAS connecting pipeline and the required length of transmission lines at sea and on land are reduced. This revised approach is based on forecast electricity production, not on installed capacity. It leads to a significant reduction in the requirement for 17 offshore grid connection systems by 2045, as identified in the NDP 2037/2045 (2023). With installed offshore wind capacity reduced to 60 GW, the requirement is reduced by seven ONAS in Scenario A 2045; by four in Scenario B 2045; and by five ONAS in Scenario C.

In Scenario A 2045, an installed offshore capacity of 59.2 GW is assumed, which is connected to the transmission grid via ten ONAS in the expansion grid. In Scenario B 2045, the installed capacity of the offshore wind farms is approximately 70 GW. The generated electricity production is fed into the grid via 13 ONAS, four fewer than in the previous NDP. In Scenario C 2045, the installed offshore wind farm capacity totals around 68 GW. In addition to the four ONAS saved in Scenario B 2045, one additional ONAS is reduced here. Another innovation involves a temporary increase in transmission capacity. Although scenarios A and C fall short of the 70 GW cap stipulated in the WindSeeG (Offshore Wind Power Act) by 2045, a greater volume of electricity can be utilised on an ongoing basis through site optimisation, higher utilisation rates and the construction of additional facilities.

Route kilometres and investments

In total, new transmission lines with a length of around 33,000 km will be required by 2045. For onshore and offshore projects, the following requirements arise regarding line lengths and investment costs for scenarios A, B and C (see Table 4). In addition to the costs for offshore measures that are already in the approval or implementation phase (initial grid) amounting to €60.8 billion, the total investment requirement for offshore grid expansion is between €96.4 and €109.4 billion by 2037 and between €149.2 and €167.2 billion by 2045.

For onshore projects, in addition to the approximately €114.9 billion in investment costs from the initial grid, the total investment requirement comes to between €184.3 and €196.2 billion by 2037 and between €215.6 and €231.7 billion by 2045. The total costs for expansion of the initial and additional grids will therefore amount to roughly €365 to €392 billion by 2045.

More options for the transition to climate neutrality

The path to climate neutrality by 2045 is becoming increasingly challenging amidst an increasingly complex economic and political environment. Furthermore, rising price and market shortages have led to significant cost increases. The total costs for the confirmed NDP 2037/2045 (2023) grid would rise from around €323 billion at the time of its implementation to approximately €440 billion today (see the report on energy transition monitoring by BET/ewi commissioned by the BMWE in September 2025).

By examining various options and measures, the NDP endeavours to find the right solutions to tackle the complexity of the requirements and the problem of rising investment costs. It identifies the common ground between the various pathways to climate neutrality to facilitate making well-founded and progressive policy decisions regarding the expansion of the electricity transmission grid.

Amongst other things, the NDP takes account of the changed external conditions and requirements by:

- presenting a wide range of options through its expanded range of scenarios, paving the way for a carbon-neutral grid.
- subjecting individual projects to a cost-benefit analysis, whilst ensuring that congestion management requirements are maintained at a level that continues to guarantee grid security.
- reducing the need for particularly capital-intensive domestic HVDC configurations to the absolute minimum.
- assuming the costs for new onshore HVDC lines to be based on overhead lines rather than underground cables.
- presenting a robust long-term perspective for individual grid expansion projects targeting the carbon-neutral grid by 2045 and thus the possibility of more cost-efficient phasing and smoothing of the implementation.

- advancing the offshore grid interconnection.
- basing its calculations on the principle of overbuilding for offshore grid connections, thereby shifting the paradigm from a capacity-based to a generation-based approach to facilitate more efficient utilisation of grid connections.
- factoring in flexibility potentials for reducing grid expansion, arising from storage technologies, amongst other things.
- basing it on lower domestic hydrogen production, which is more electricity- and cost-intensive.
- prioritising integrated system planning for grid-connected energy sources: electricity, gas and hydrogen.
- reducing the total investment costs for Scenario A by just under €80 billion to €364 billion, and for Scenarios B and C by around €50 billion to approximately €392 billion and €390 billion respectively.
- taking measures into consideration that were already confirmed in the previous NDP or identified for the first time in this NDP. Individual measures relevant to grid expansion prove to be robust in the long term. They enable a phased approach to grid expansion leading up to 2045 and result in different expansion scopes between the time horizons of 2037 and 2045. Measures that were already confirmed for 2037 in the previous NDP and are now reported for 2045 continue to be regarded as prospective projects for future grid expansion.

Achieving climate neutrality is only possible with the participation of the public and citizens. The NDP is therefore not merely a tool for determining the need for new power lines, substations and equipment, but also makes a significant contribution to transparency in the implementation of the energy transition. It is a strategic roadmap for the continuous development of our energy system. The measures proposed therein equally serve climate protection and a secure electricity supply.

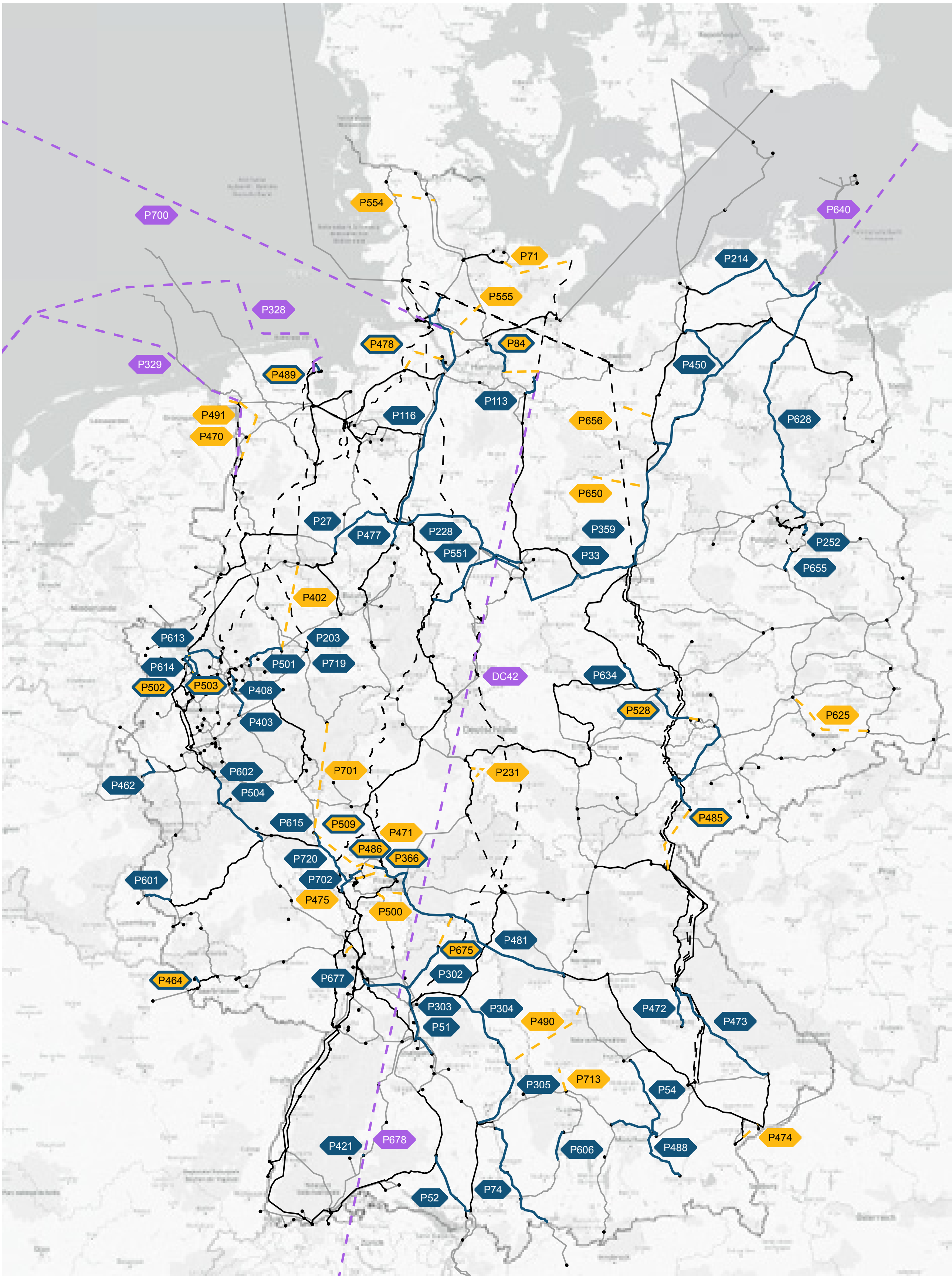
Table 4: Route kilometres and investments for the expansions in scenarios A, B, C 2037 and A, B, C 2045

Expansion grid	Route length in km	Investment volume in EUR billion	Route length in km	Investment volume in EUR billion
	A 2037		A 2045	
Offshore	2,537	35.6	6,558	88.4
Onshore	5,242	69.3	9,512	100.8
Total	**7,779**	**105.0**	**16,070**	**189.2**
	B 2037		B 2045	
Offshore	3,491	48.6	7,979	106.4
Onshore	5,972	73.2	10,497	110.1
Total	**9,463**	**121.8**	**18,476**	**216.5**
	C 2037		C 2045	
Offshore	3,491	48.6	7,332	97.8
Onshore	6,901	81.3	11,116	116.8
Total	**10,392**	**129.9**	**18,448**	**214.6**

Source: Transmission system operators

Overview maps of onshore and offshore grid expansion measures

Figure 5: Overview map of grid expansion measures in Scenario A 2037 (transmission projects only)*

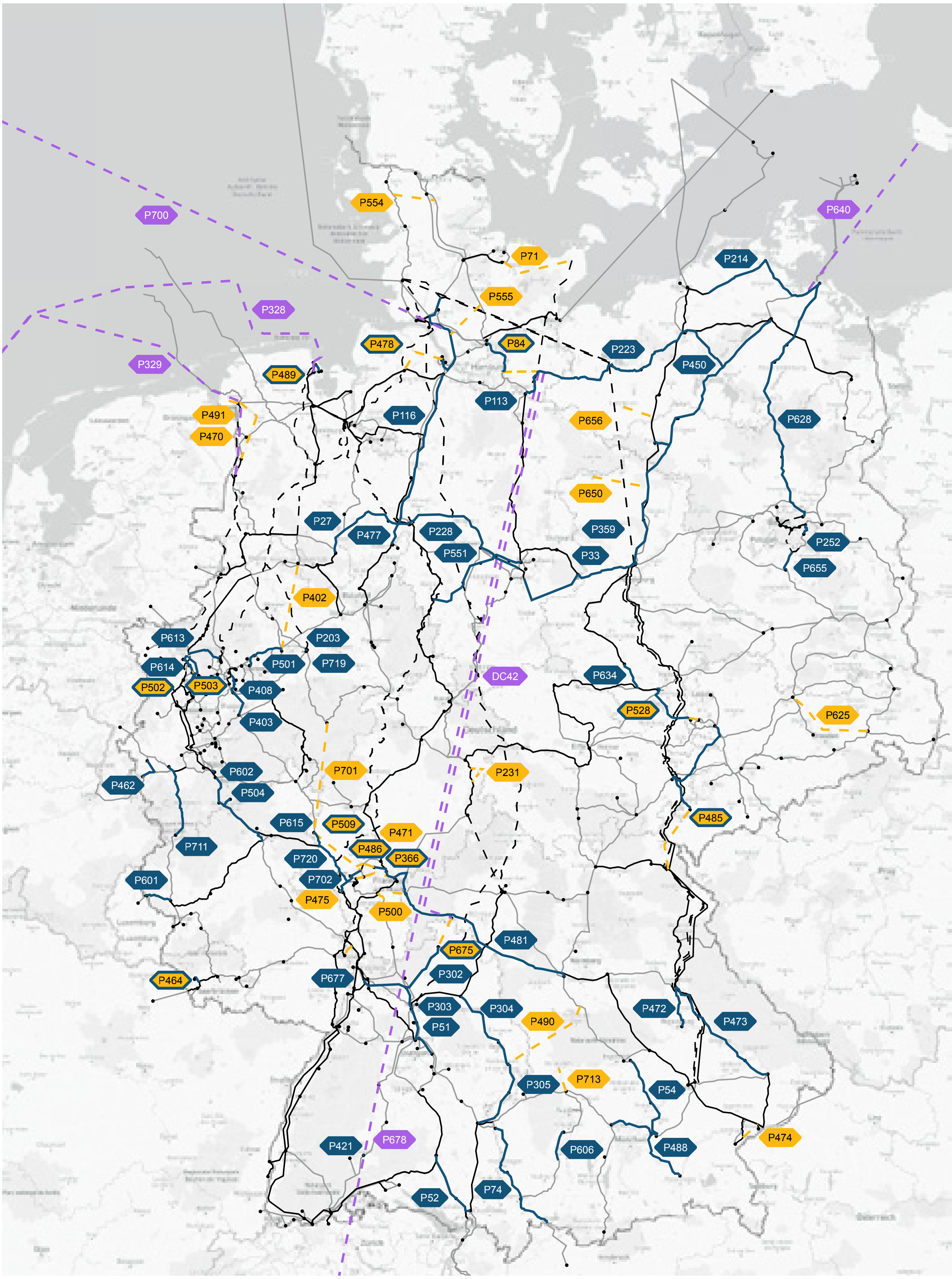


Attachments
Existing grid
Grid enhancement in the initial grid
Grid expansion in the initial grid
AC grid enhancement
DC grid enhancement
AC grid expansion
DC grid expansion
AC grid enhancement
AC grid expansion
AC enhancement and expansion
DC

*The presentation of the new grid expansion projects shows the starting and end points, but no specific routes. They will only be determined in downstream approval procedures.

Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL)

Figure 6: Overview map of grid expansion measures in Scenario B 2037 (transmission projects only)*

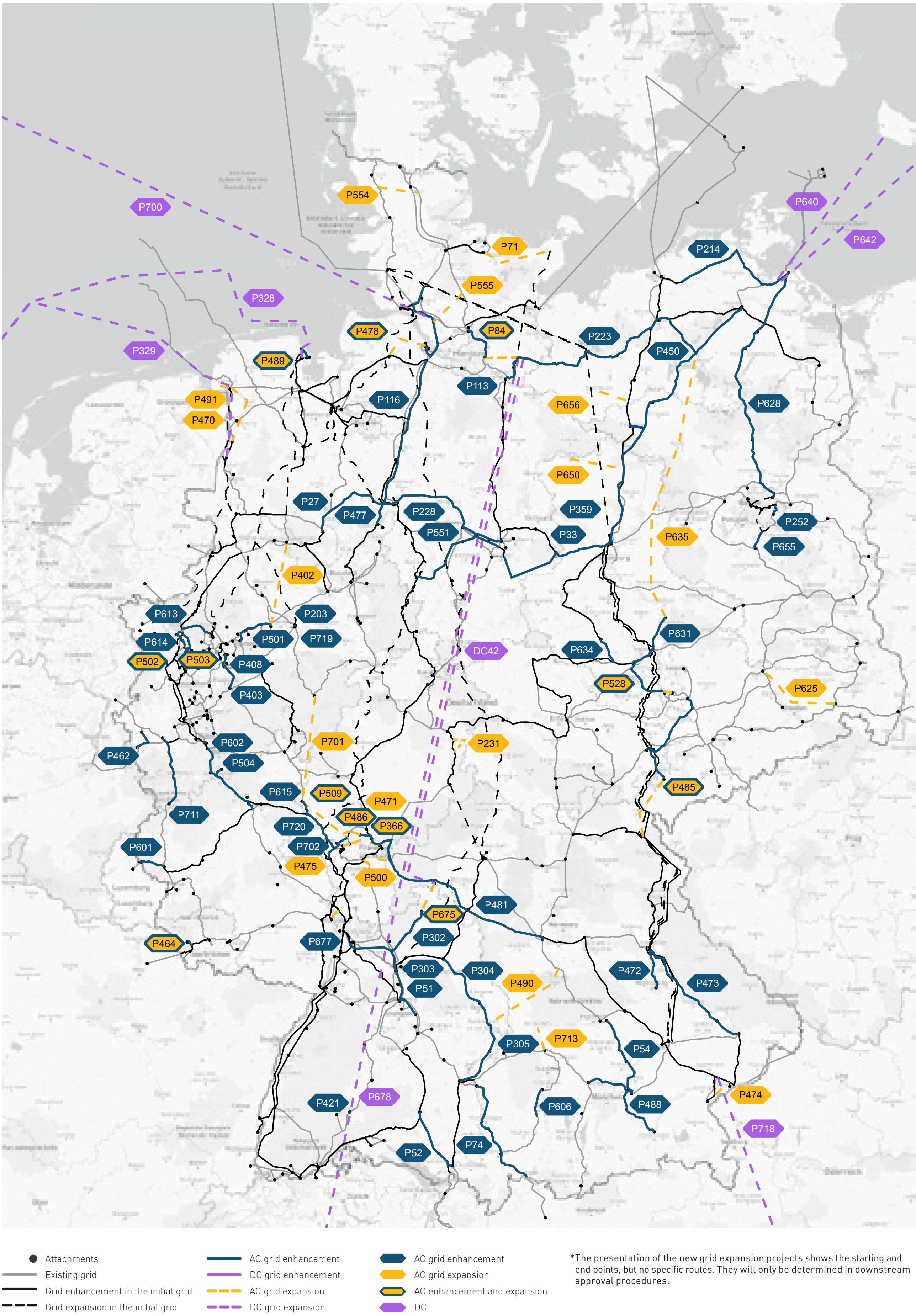


- Attachments
- Existing grid
- Grid enhancement in the initial grid
- Grid expansion in the initial grid
- AC grid enhancement
- DC grid enhancement
- AC grid expansion
- DC grid expansion
- AC grid enhancement
- AC grid expansion
- AC enhancement and expansion
- DC

*The presentation of the new grid expansion projects shows the starting and end points, but no specific routes. They will only be determined in downstream approval procedures.

Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL)

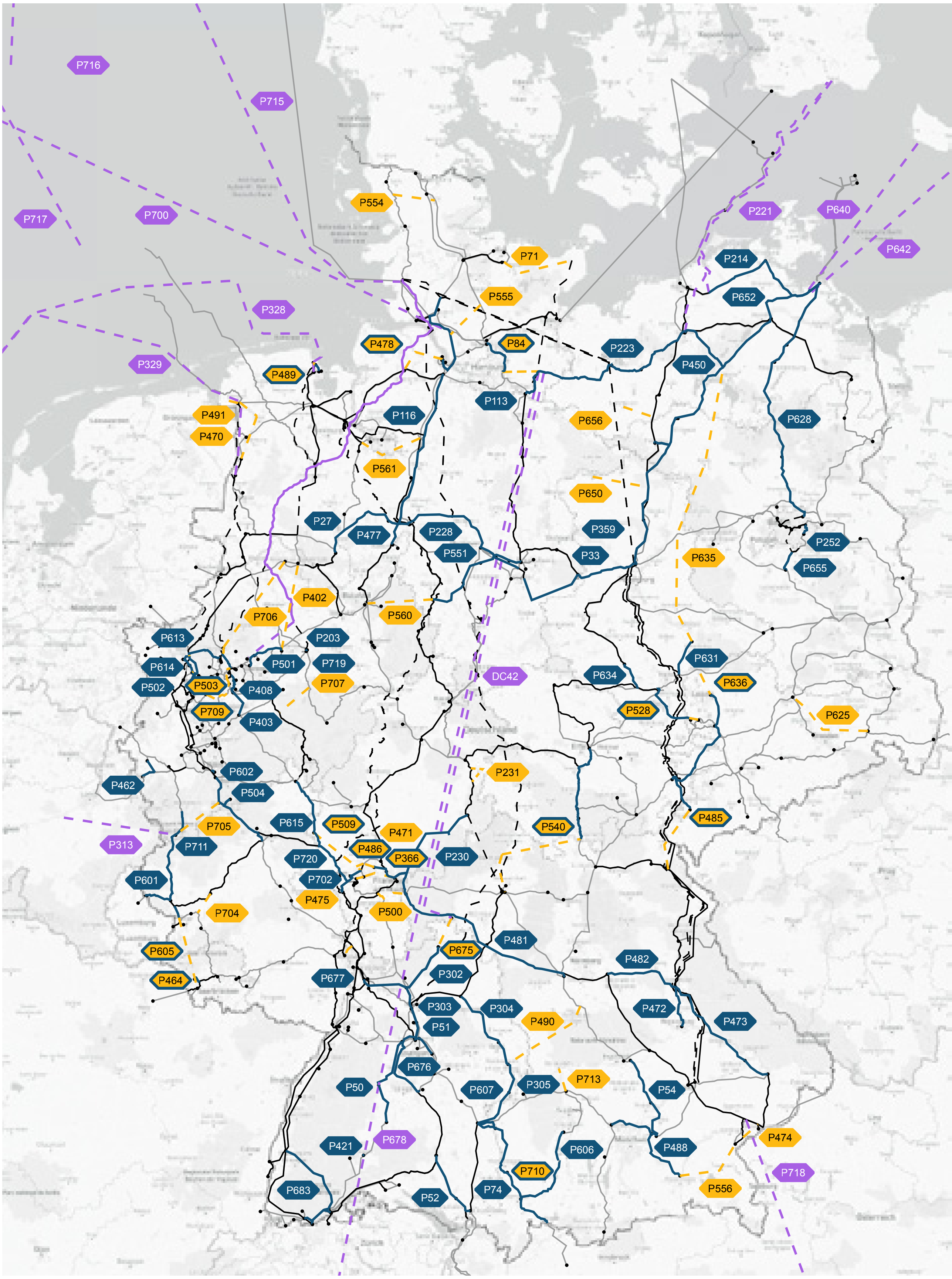
Figure 7: Overview map of grid expansion measures in Scenario C 2037 (transmission projects only)*



*The presentation of the new grid expansion projects shows the starting and end points, but no specific routes. They will only be determined in downstream approval procedures.

Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL)

Figure 8: Overview map of grid expansion measures in Scenario A 2045 (transmission projects only)*

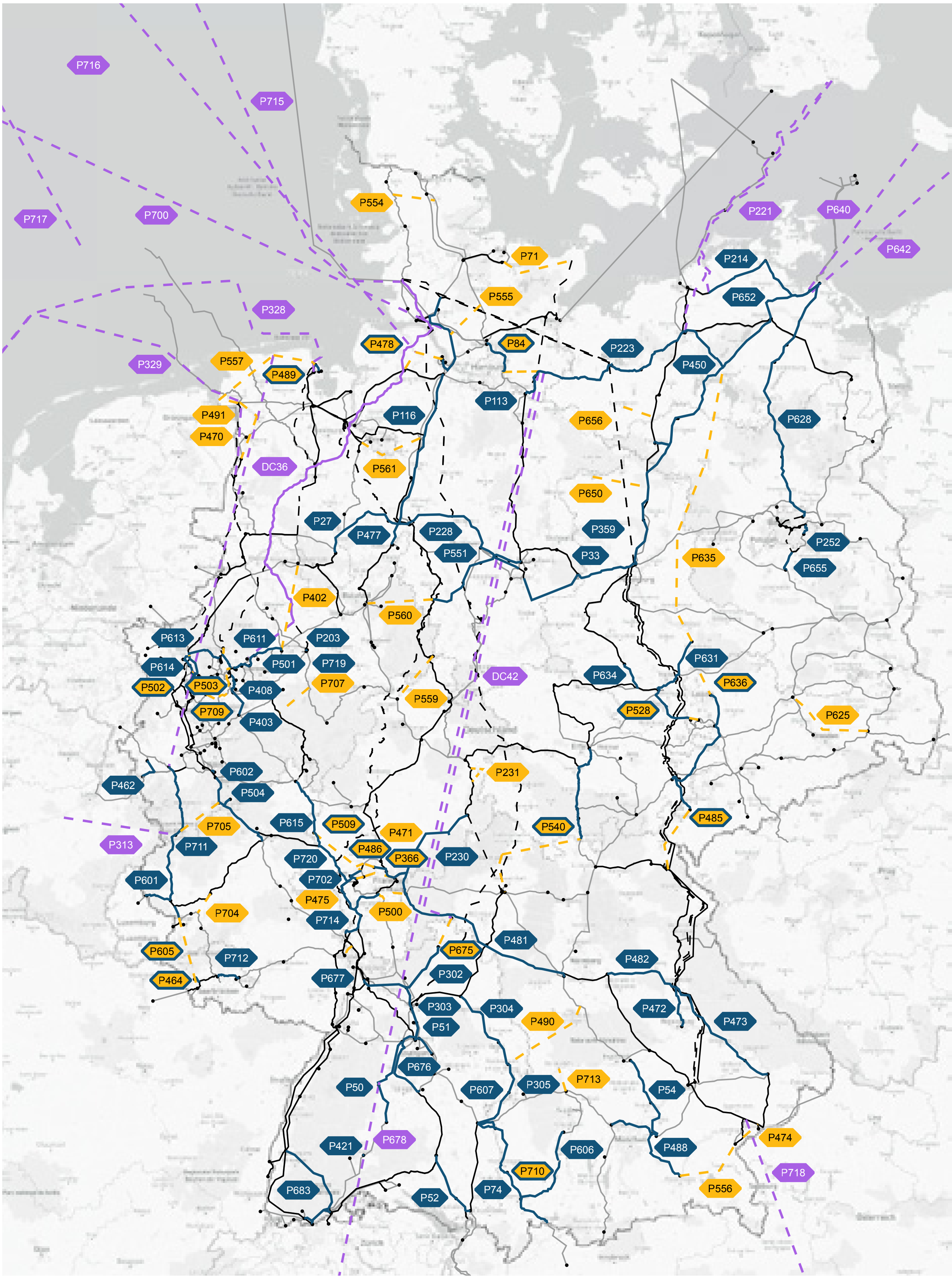


- Attachments
- Existing grid
- Grid enhancement in the initial grid
- Grid expansion in the initial grid
- AC grid enhancement
- DC grid enhancement
- AC grid expansion
- DC grid expansion
- AC grid enhancement
- AC grid expansion
- AC enhancement and expansion
- DC

*The presentation of the new grid expansion projects shows the starting and end points, but no specific routes. They will only be determined in downstream approval procedures.

Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL)

Figure 9: Overview map of grid expansion measures in Scenario B 2045 (transmission projects only)*



Attachments
Existing grid
Grid enhancement in the initial grid
Grid expansion in the initial grid

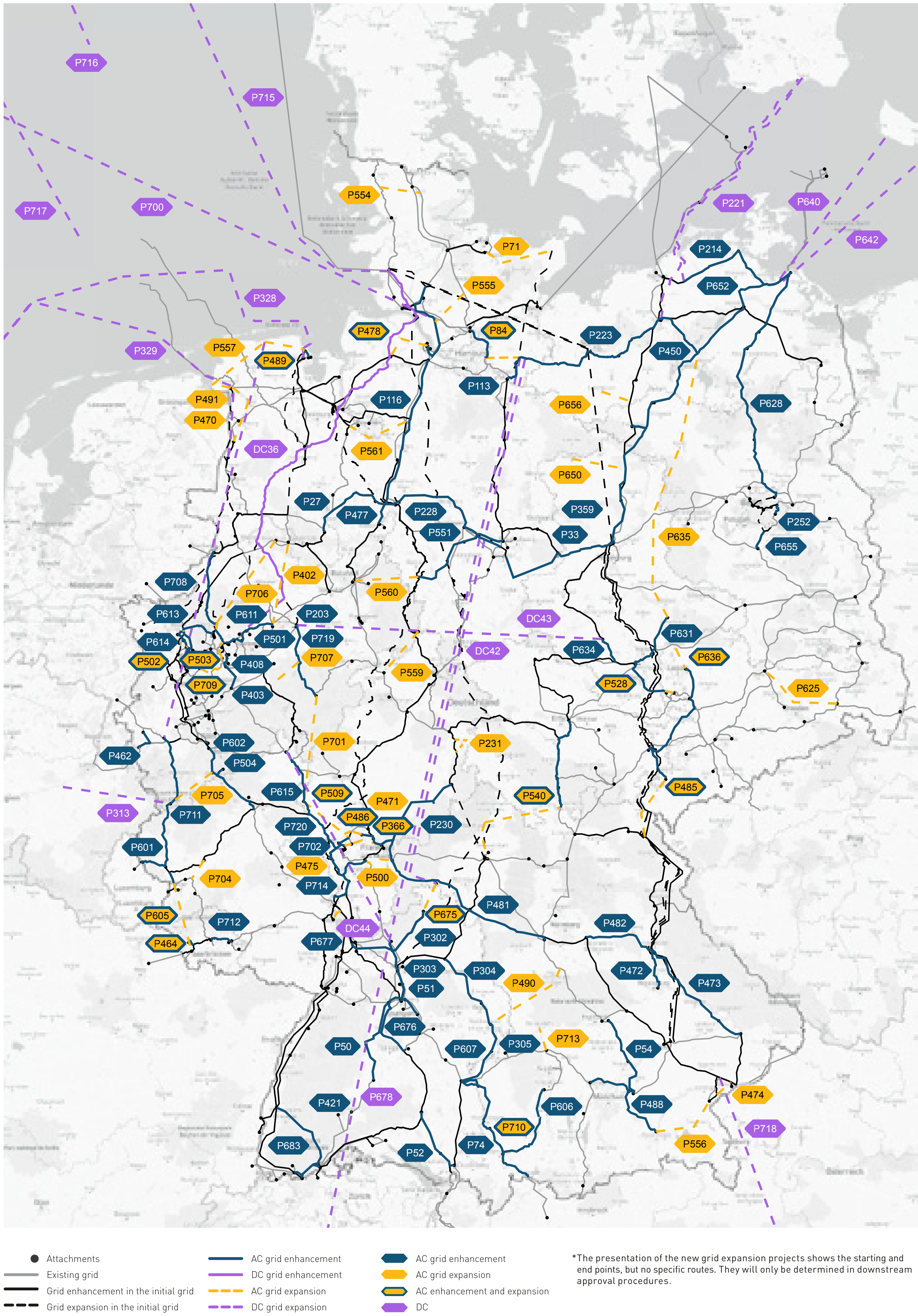
AC grid enhancement
DC grid enhancement
AC grid expansion
DC grid expansion

AC grid enhancement
AC grid expansion
AC enhancement and expansion
DC

*The presentation of the new grid expansion projects shows the starting and end points, but no specific routes. They will only be determined in downstream approval procedures.

Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL)

Figure 10: Overview map of grid expansion measures in Scenario C 2045 (transmission projects only)*

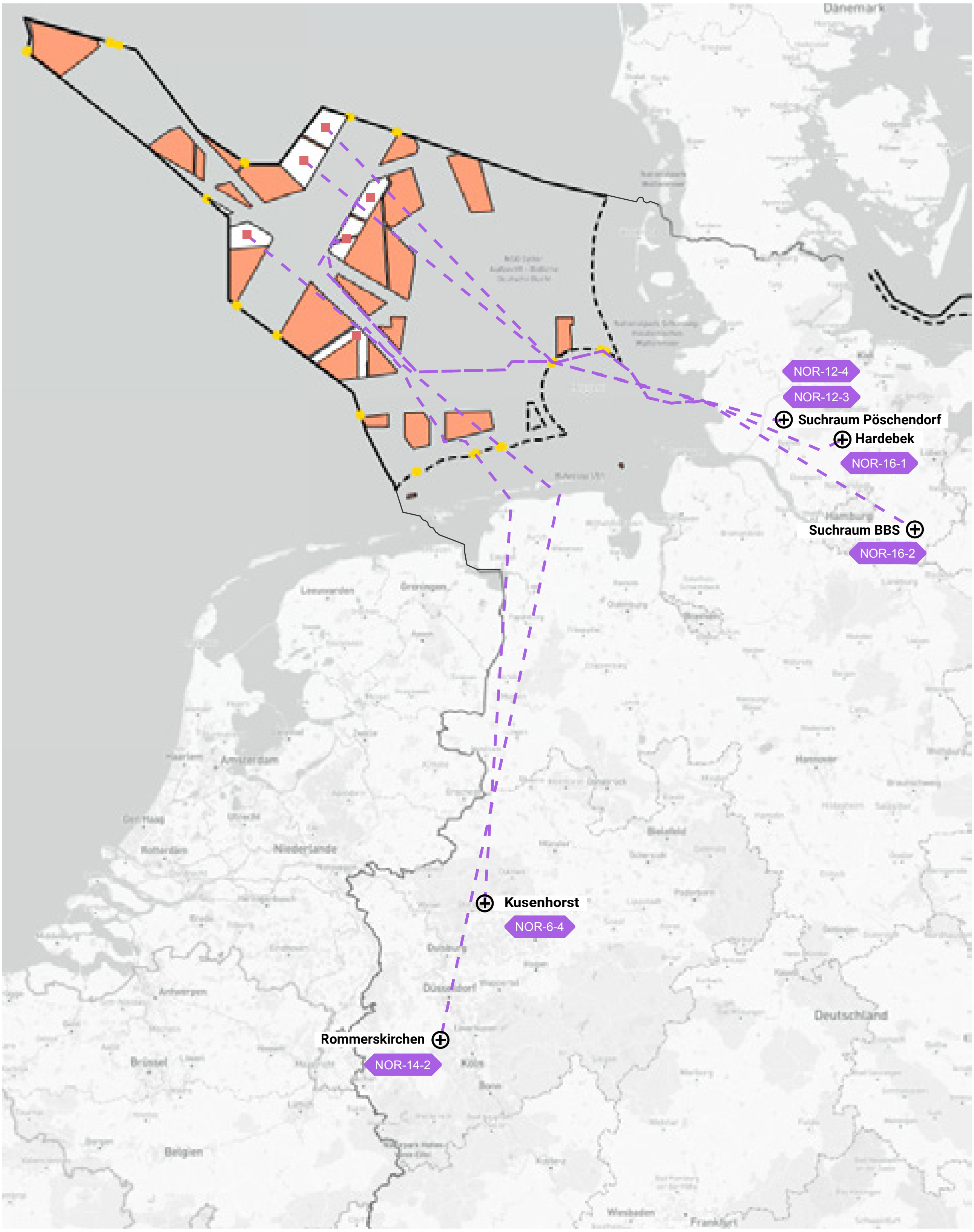


*The presentation of the new grid expansion projects shows the starting and end points, but no specific routes. They will only be determined in downstream approval procedures.

Under the assumptions of the NDP 2037/2045 (2025), the DC43 and DC44 interconnections have a negative cost-benefit ratio. Nevertheless, they are highly effective in reducing bottlenecks. The TSOs therefore identify both HVDC transmission lines as planning options for future NDPs.

Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL)

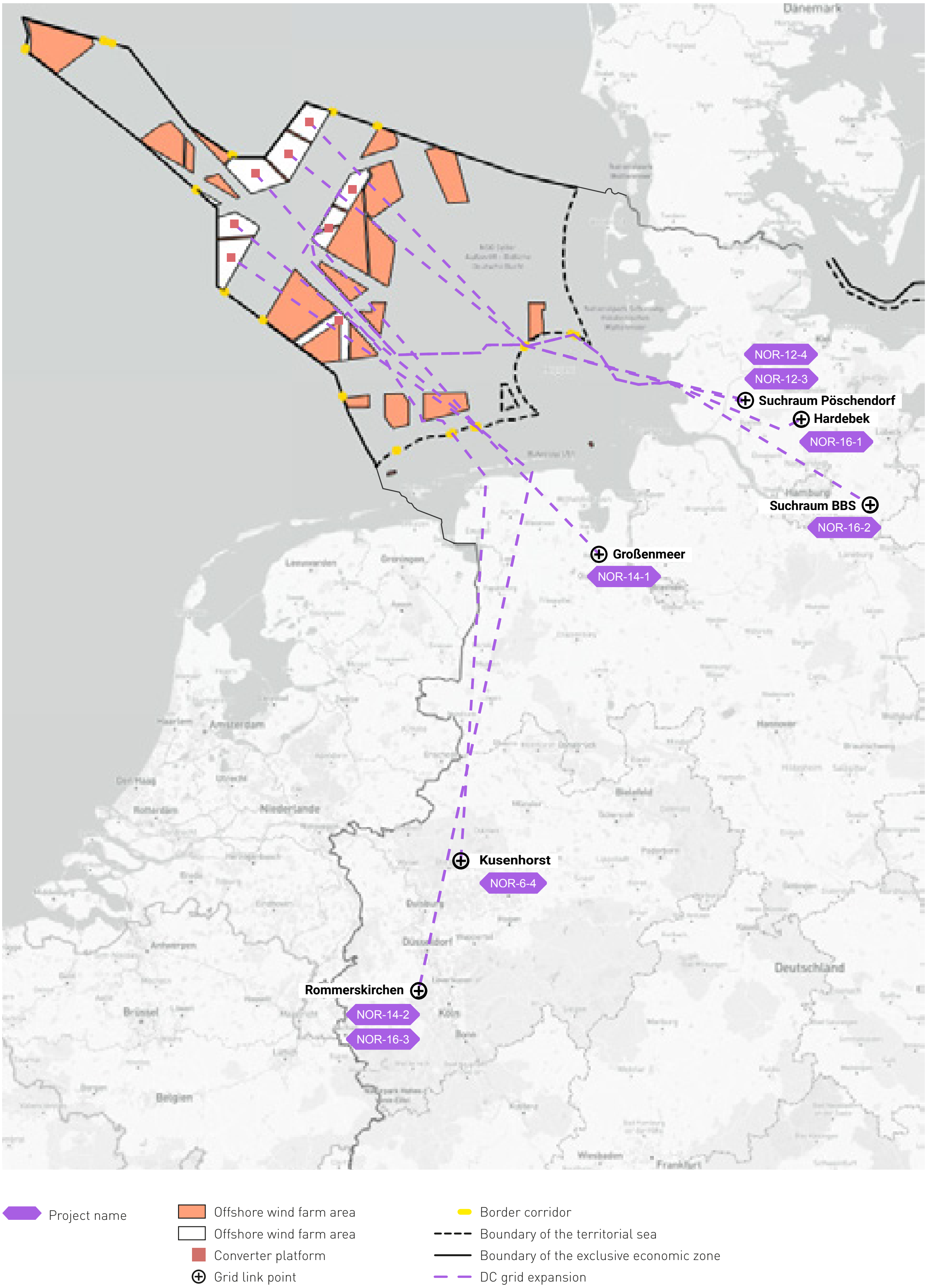
Figure 11: Measures of the North Sea offshore expansion grid in scenario A 2037



Project name
Offshore wind farm area
Offshore wind farm area
Converter platform
Grid link point
Border corridor
Boundary of the territorial sea
Boundary of the exclusive economic zone
DC grid expansion

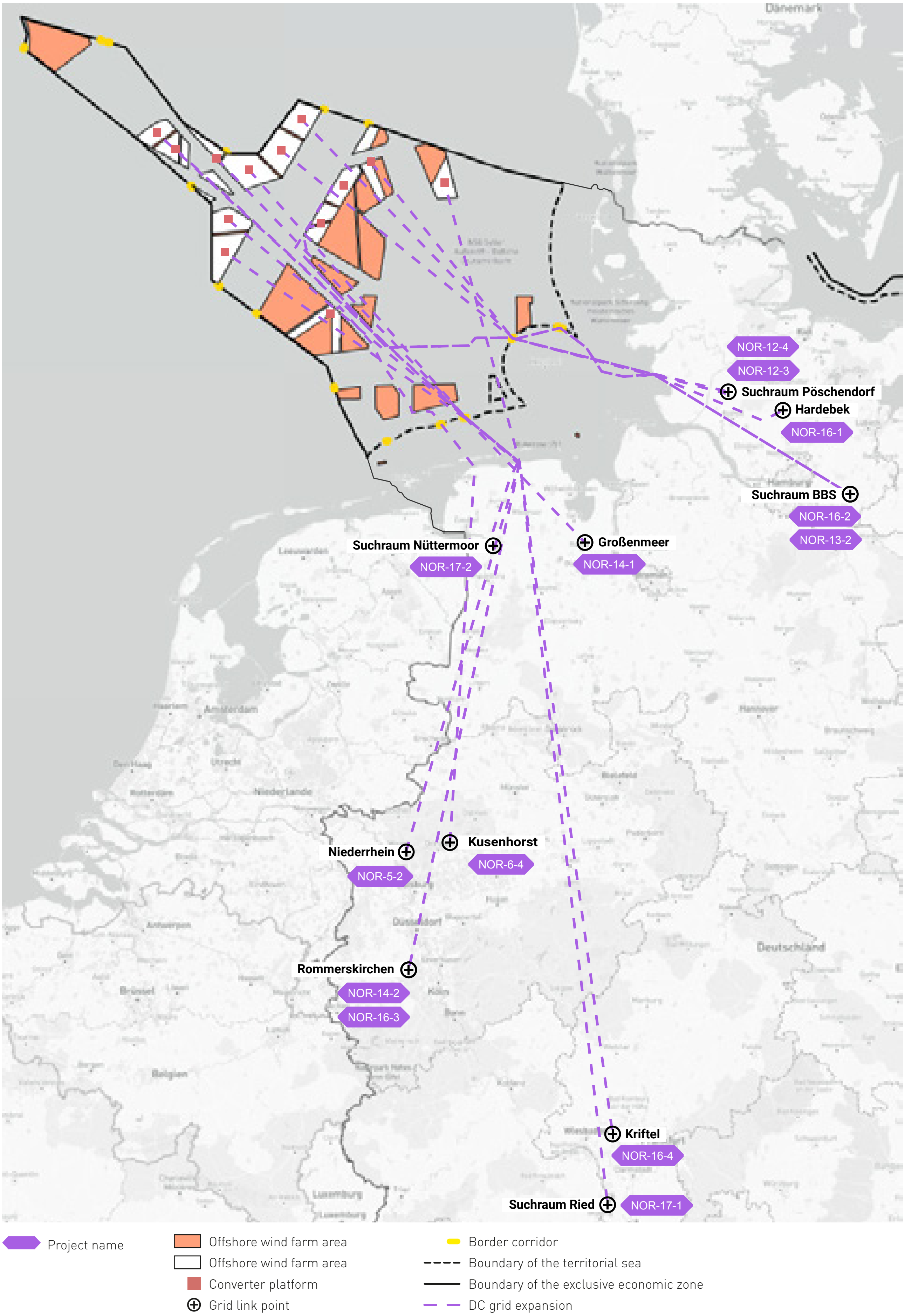
Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL), BSH (© GeoSeaPortal)

Figure 12: Measures of the North Sea offshore expansion grid in scenarios B 2037 and C 2037



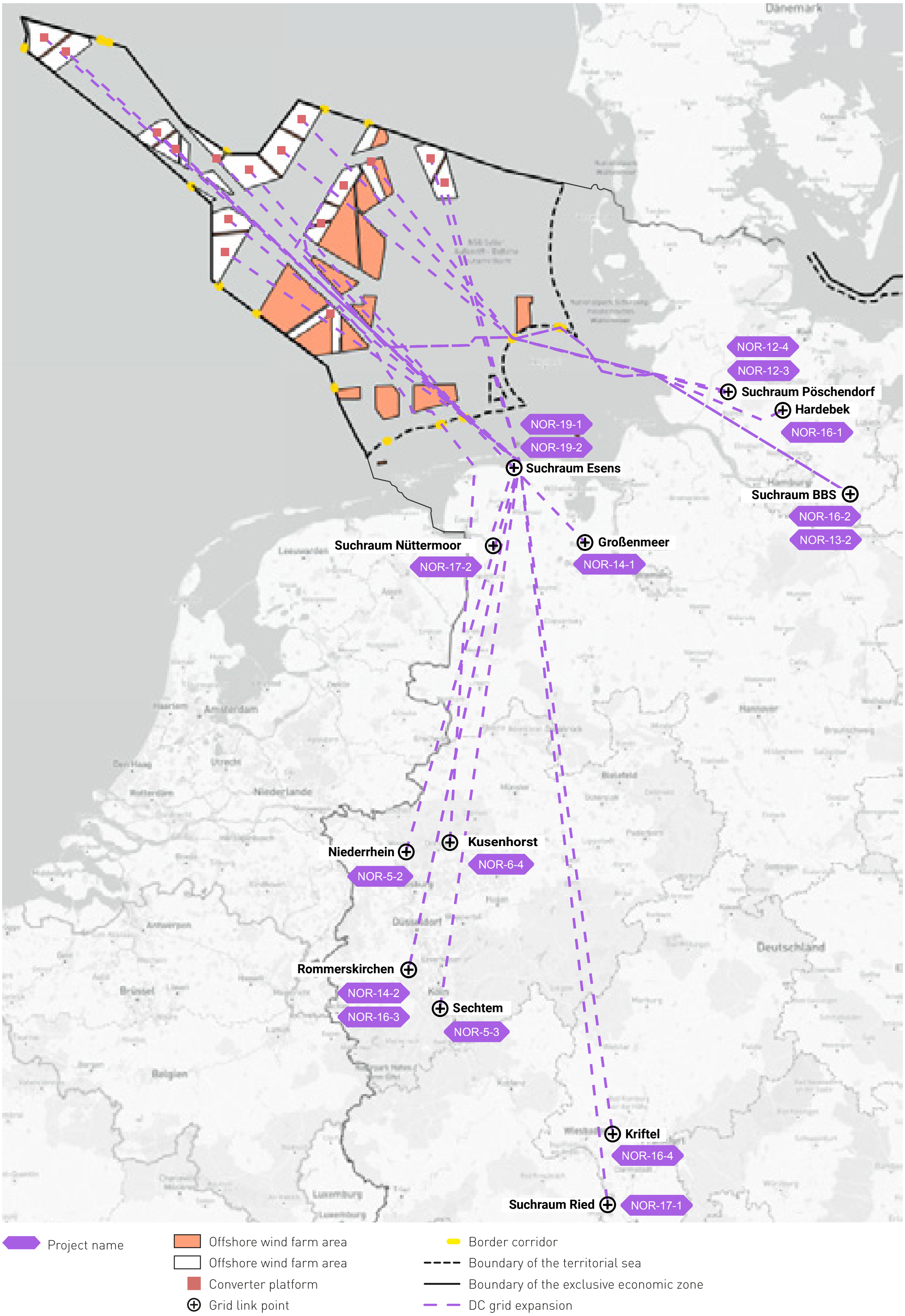
Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL), BSH (© GeoSeaPortal)

Figure 13: Measures of the North Sea offshore expansion grid in scenario A 2045



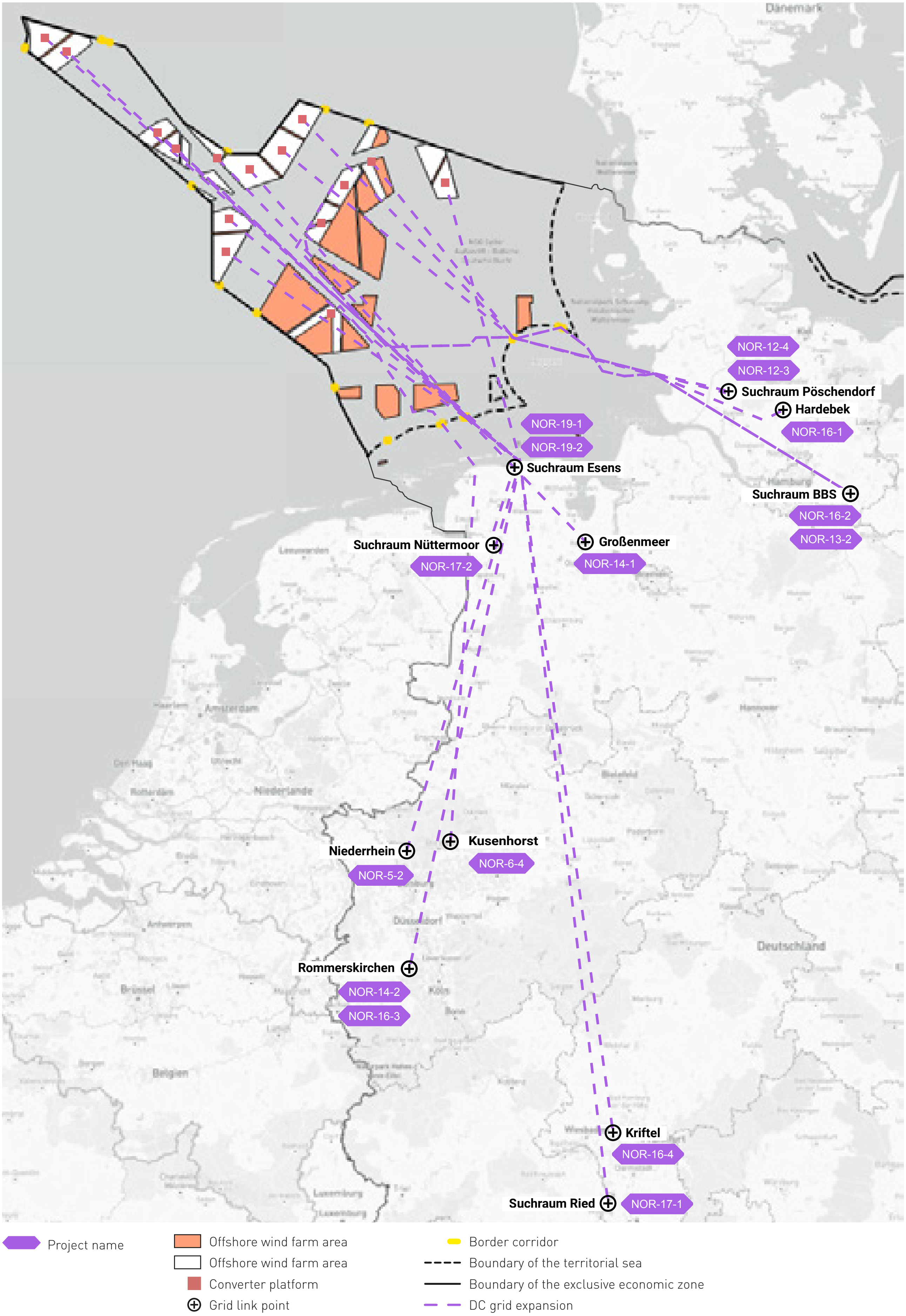
Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL), BSH (© GeoSeaPortal)

Figure 14: Measures of the North Sea offshore expansion grid in scenario B 2045



Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL), BSH (© GeoSeaPortal)

Figure 15: Measures of the North Sea offshore expansion grid in scenario C 2045



Source: Transmission system operators/map basis © Mapbox, © OpenStreetMap (ODbL), BSH (© GeoSeaPortal)