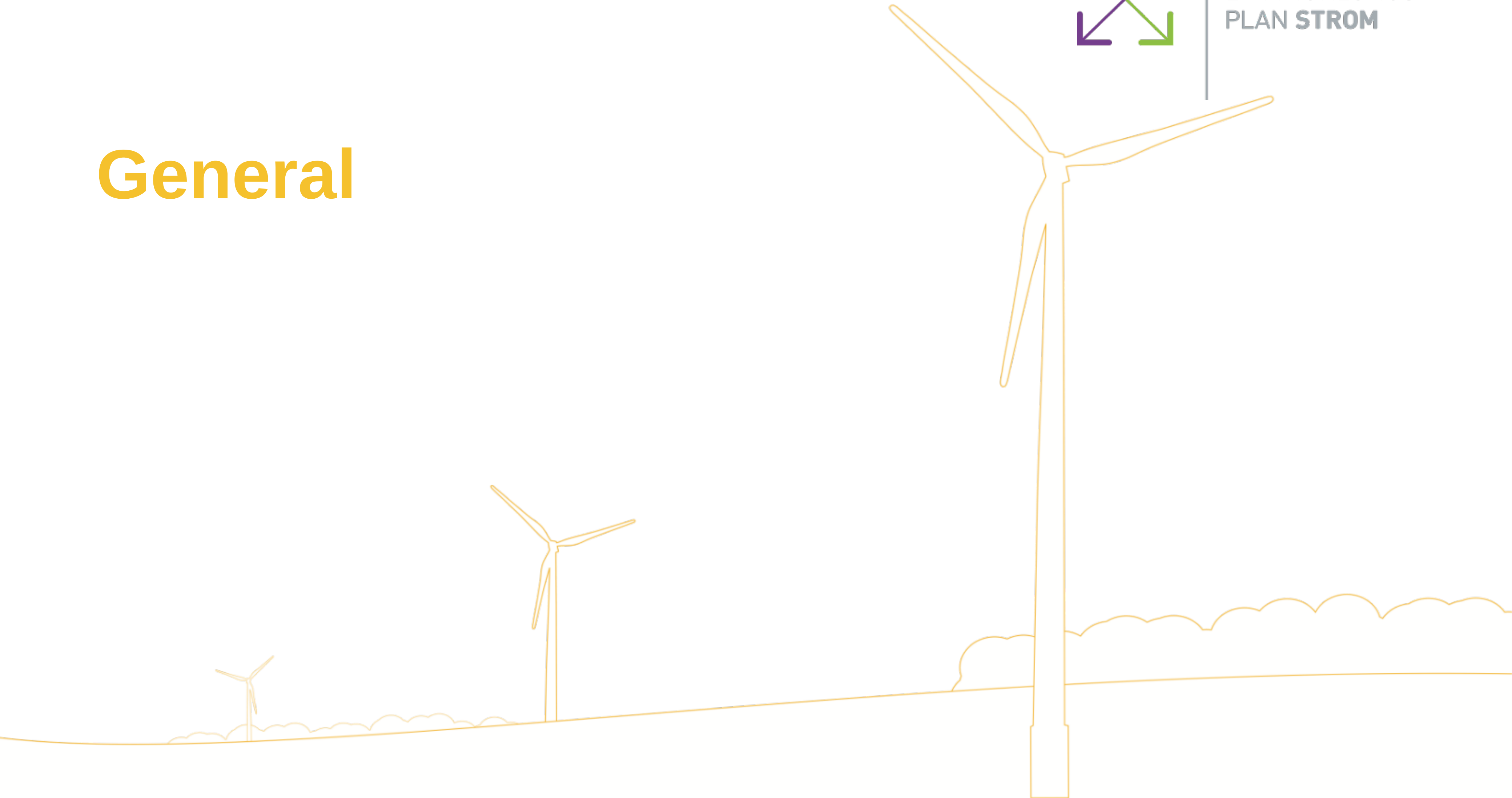
Grid Development Plan 2030 (2017), second draft

General



Grid Development Plan 2030 (2017)

The Grid Development Plan ...

… is the grid development plan for an **onshore transmission network**.

… is closely linked to the **Offshore Grid Development Plan**.

... takes into account the **integration of renewable energy sources,** and the **development of the European energy market**.

... describes measures that satisfy both **legal requirements** and the **underlying scenario framework from the Federal Network Agency**.

... highlights **transmission requirements between start and end points** (two grid nodes) – but **does not show specific line corridors or routes**.

... indicates measures with priority placed on network optimisation over development, which in turn is a higher priority than network expansion (NOVA).

... shows the expansion of the **380 kV alternating current network** and the **high voltage direct current (HVDC) connections** needed in order to meet the north-south transmission requirements.

... does not show or indicate preference for **any potential power station sites** or locations for renewable energy facilities.

Grid Development Plans 2030 (2017)

The GDP process

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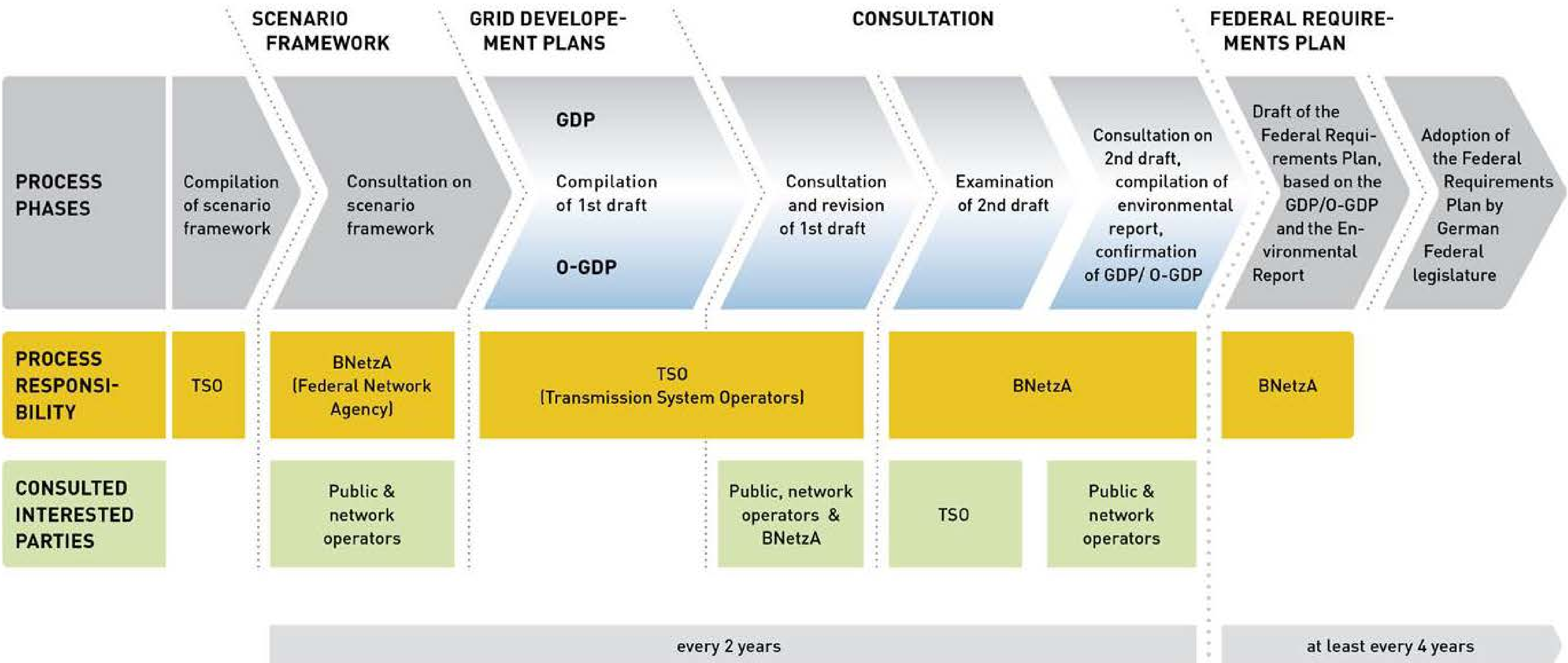

Grid Development Plans 2030 (2017)

Timeline – Where we stand.

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PLAN STROM

GDP and O-GDP 2025

- GDP 2025 – No confirmation due to the recent amendment of the Renewable Energy Act
- O-GDP 2025 – Confirmed

GDP and O-GDP 2030, 2017 version

- 30.06.2016 – Approval of the scenario framework (start of 10 month deadline for TSOs)
- 31.01.2017 – Publication first drafts by TSOs
- 31.01 – 28.02.2017 – Consultation period for the first drafts
- 02.05.2017 – Publication of second drafts by TSOs
- Subsequent review and consultation of second drafts by the Federal Network Agency
- End of December 2017: approval by the Federal Network Agency (target deadline as per the German Energy Management Act)

GDP 2030, 2019 version

- 10.01.2018 – Submission draft for the scenario framework by TSOs

Grid Development Plans 2030 (2017)

Overview of the consultation process

NETZ ENTWICKLUNGS PLAN STROM

NEP / O-NEP Zyklus 10 Monate

Netzentwicklung	Beteiligung
Szenariorahmen Erarbeitung durch Übertragungsnetzbetreiber Prüfung und Genehmigung durch Bundesnetzagentur	**Konsultation Szenariorahmen** durch Bundesnetzagentur » Welche Zukunft zeigen die unterschiedlichen Szenarien? « • **Entwicklungsprognose der Energiewirtschaft** • Stromverbrauch, Primärenergiekosten, Preise für CO_2-Zertifikate • Energiewirtschaftliche und energiepolitische Rahmenbedingungen • Regionale Verteilung der Erzeugungsanlagen • Staffelung Netzanbindungssysteme Offshore
NEP / O-NEP 1. Entwurf Erarbeitung und Veröffentlichung durch Übertragungsnetzbetreiber	**Konsultation NEP / O-NEP 1. Entwurf** durch Übertragungsnetzbetreiber » Nach welchen Prinzipien werden die notwendigen Maßnahmen identifiziert? « • **Ermittlung der Transportbedarfe in den verschiedenen Szenarien** • Methode und Ergebnis der Marktmodellierung • Methode und Ergebnis der Netzanalyse • NOVA-Kriterien • Nachhaltigkeit der Planungen
NEP / O-NEP 2. Entwurf Überarbeitung und Übergabe an BNetzA durch Übertragungsnetzbetreiber Prüfung / Bestätigung & Vorlage Umweltbericht durch Bundesnetzagentur	**Konsultation NEP / O-NEP 2. Entwurf** durch Bundesnetzagentur » Wie hat die Bundesnetzagentur die Maßnahmen überprüft? « • **Ergebnis der vorläufigen Prüfung durch die Bundesnetzagentur** • Umweltbericht der Bundesnetzagentur zusätzlich zu den Ergebnissen des NEP / O-NEP • Festlegung Ausbaubedarf • Festlegung Anfangs- und Endpunkte
Bundesbedarfsplan durch Bundesgesetzgeber	
Bundesfachplanung / Raumordnungs- & Planfeststellungsverfahren	**Beteiligung an förmlichen Verfahren** durch BNetzA oder zuständige Landesbehörden; Öffentlichkeitsbeteiligung durch Übertragungsnetzbetreiber und Träger öffentlicher Belange » Wo genau verläuft die Leitung? Welche Technologie wird wo und weshalb eingesetzt? « • **Genehmigungsverfahren** • Erdkabel / Freileitung • Streckenverlauf • Umwelt- und Naturschutz • Abstände zur Wohnbebauung • Eingesetzte Technologie • Ausgleichs- und Ersatzmaßnahmen • Tourismus
Bauliche Umsetzung	

Grid Development Plans 2030 (2017)

Key changes compared to the GDP 2025

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- Comprehensive depiction of the revised Renewable Energy Act which came into effect at the start of 2017 (**EEG 2017**)
- GDP and O-GDP 2030 incorporate the new Offshore Wind Act (WindSeeG)
- Approval of the scenario framework by the Federal Network Agency dated 30.06.2016:
  - Calculation of **3 + 1 scenarios**: A 2030, B 2030, C 2030 and B 2035
  - In three scenarios German power plants collectively comply with a **CO_2 emission limit**
  - **Peak capping** in all scenarios to a maximum 3% of all facilities' annual energy output on the basis of onshore wind energy and photovoltaic power

    → no dimensioning of the electricity transmission grid for "the last kilowatt hour generated from renewable energy sources"
- New methods for the regionalisation of energy consumption

NETZ ENTWICKLUNGS PLAN STROM

Consultation of the first draft GDP 2030 (2017)

Consultation first drafts GDP and O-GDP 2030 (2017)

Overview

- The first drafts of the GDP and O-GDP 2030 were published on **31.01.2017** with a consultation period from Jan 31 to Feb 28, 2017.
- **2133 statements** were submitted to the TSOs, **2116 concerning the GDP** and **17 concerning the O-GDP.**
- **1916 statements** concerning the GDP 2030 were submitted by **individuals**. **200 statements** were submitted by **institutions.**
- All **electronically submitted statements**, for which approval was given, were published at www.netzentwicklungsplan.de/de/stellungnahmen-nep-o-nep-2030-version-2017 (**506 statements**).
- An individual confirmation or answer to each statement is not given.

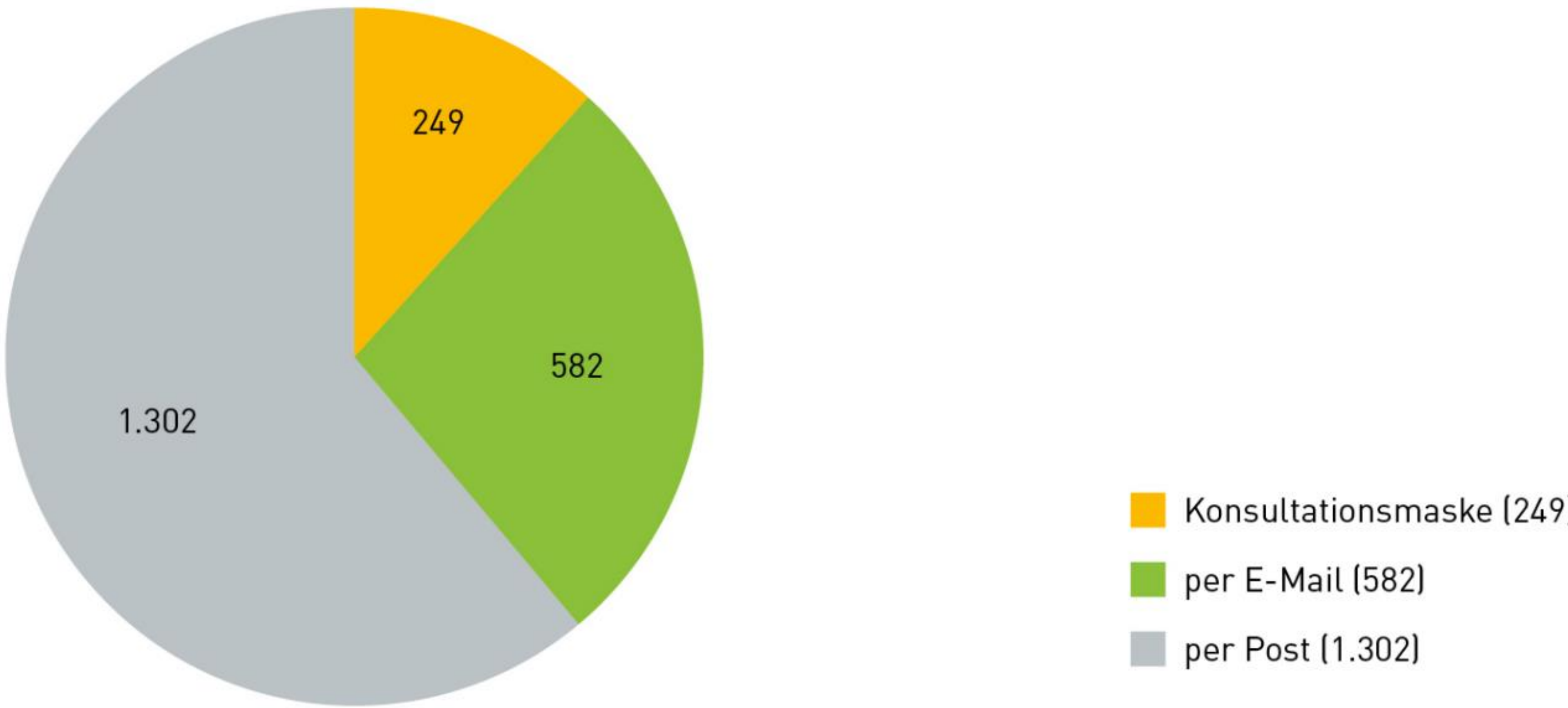
Consultation first drafts GDP and O-GDP 2030 (2017)
Incorporation of consultation statements

NETZ ENTWICKLUNGS PLAN STROM

- The TSOs considered the contents of the submitted statements and revised the first drafts of the GDP and O-GDP on this basis.
- Changes to the first drafts of GDP and O-GDP are marked ***in italics***.
- The consultation statements are discussed in a **consultation-chapter** of the GDP and O-GDP. (GDP: Chapter 6; O-GDP: Chapter 5)
- At the beginning of each chapter **a box with the significant changes** to each chapter of the GDP and O-GDP can be found.

Consultation first drafts GDP and O-GDP 2030 (2017)

Statements by channel of submission



Consultation first draft GDP 2030 (2017)

Statements by type of stakeholder

Absender	Anzahl der Stellungnahmen
Privatpersonen	1.916
Kommunen	97
Bürgerinitiativen	39
Bund/Länder	15
Verbände	16
Umwelt-/Naturschutzverbände	10
Energieunternehmen	10
Unternehmen	7
Sonstige	3
Wissenschaft und Forschung	3

Compared to the GDP 2025 (15.636 statements) the number of consultation submissions for the GDP 2030 declined by 85 %.

The number of statements submitted by individuals, especially concerning the projects **DC5** (SuedOstLink) and **P44/P44mod**, which were the topic of most consultation statements to the GDP 2025 by individuals, decreased significantly.

Consultation first draft GDP 2030 (2017)

Main topics GDP

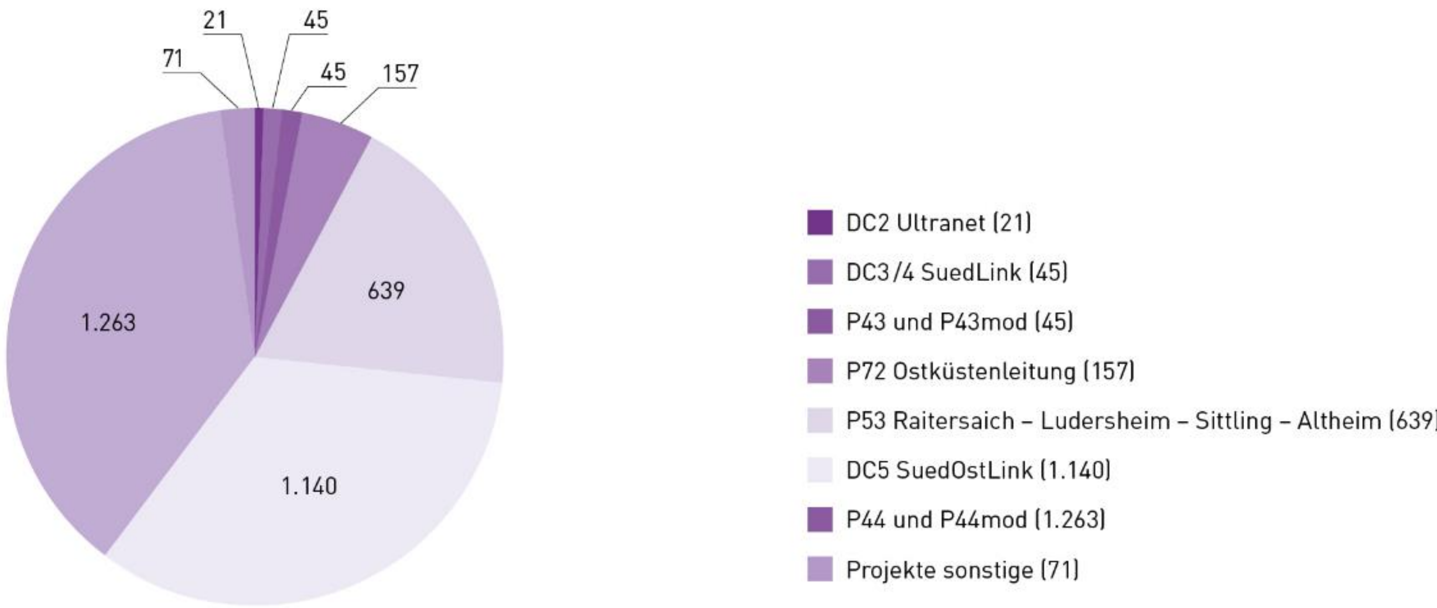
- Main topics of the statements:
  - **Basic questions and doubts** about the **assumptions** of the **scenarios** and the resulting **requirements for grid development**.
  - Critique of the **input parameters** and results of the **market simulation**: Questions concerning the assumptions about installed capacity as well as energy production resulting from the market-simulation.
  - Regional concerns around the grid-node **Grafenrheinfeld** (P44/P44mod, P43/P43mod) as well as the **HVDC-Connection from von Saxony-Anhalt to Bavaria** (DC5; SuedOstLink)
- The statements show the difficulty of addressing concerns at the **appropriate stage of the process**:
  - **Input parameters of the market simulation** (renewable-, and conventional energy production, demand, storage, regionalization, CO_2, EU, …) → **Scenario framework**
  - **Questions and suggestions concerning specific projects → Downstream planning processes.**

Consultation first draft GDP 2030 (2017)

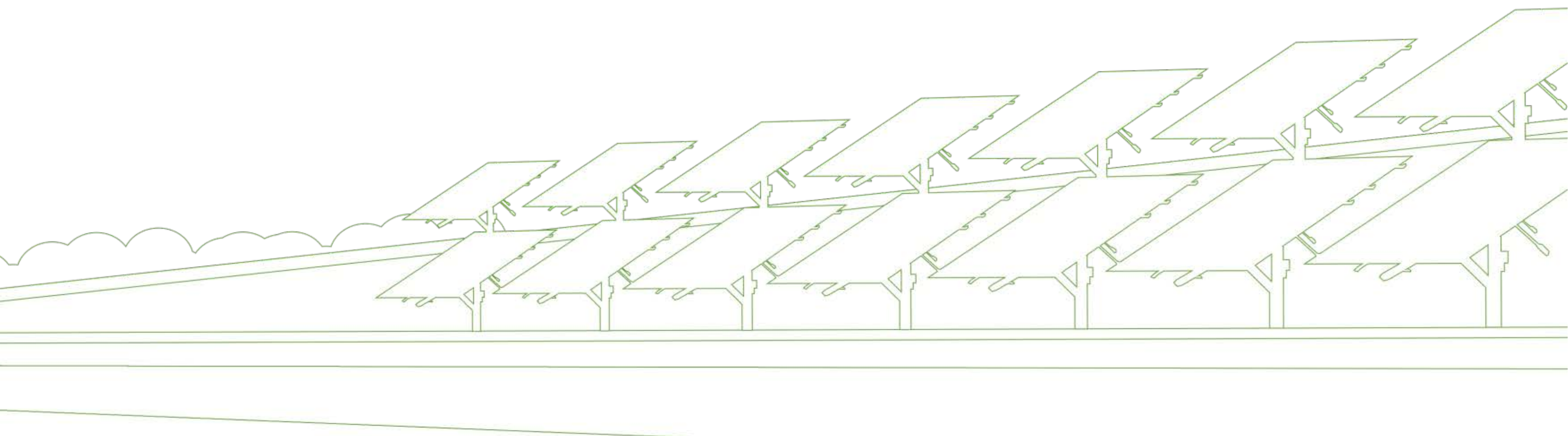
Statements on specific projects

The majority of statements by individuals concern **specific projects**.

The focus of the majority of statements on few specific projects lead to 2000 statements, almost 95% of all statements submitted, concerning projects in the control area of TenneT. Out of those statements, the majority came from **Bavaria**.



Second draft GDP 2030 – key changes



Second draft, GDP 2030 (2017)

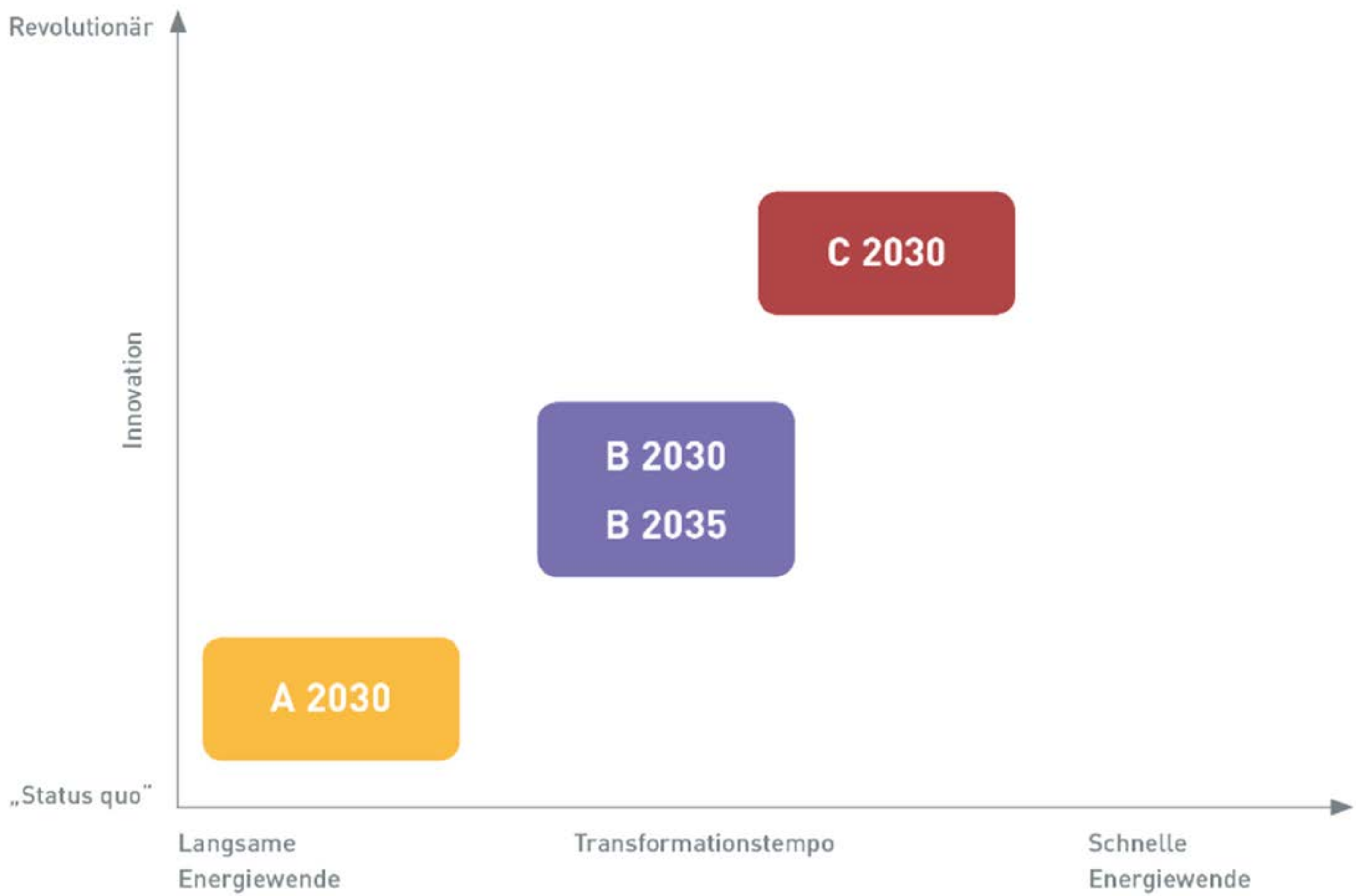
Key changes to the first draft

1. Clarification of the description of import/export and electricity transit → Chapter 3 + 4
2. Supplementation of the argument concerning the Climate Action Plan 2050 → Chapter 3
3. Depiction of FRP-grid overload → Chapter 4.2.3
4. Discussion of alternatives to the offshore grid connection point Cloppenburg → Chapter 4.2.4
5. Measure-specific calculations for the projects P43mod/P44mod as alternatives to P43/P44 („Unbundling of Grafenrheinfeld“) → Chapter 4.2.6, 4.2.7, project descriptions for P43mod/P44mod
6. Explicit display of additional and re-cabling as mildest form of grid empowerment → Chapter 4.2.6 und 4.2.7
7. Depiction of alternative HVDC-Options in scenario B 2035 → Chapter 4.2.6
8. Supplementation of the project descriptions by the project characterisations → Chapter 4.3 and project descriptions

Scenario-framework

Grid Development Plan 2030 (2017)

Classifying the scenarios



Grid Development Plan 2030 (2017)

Overview of all scenarios

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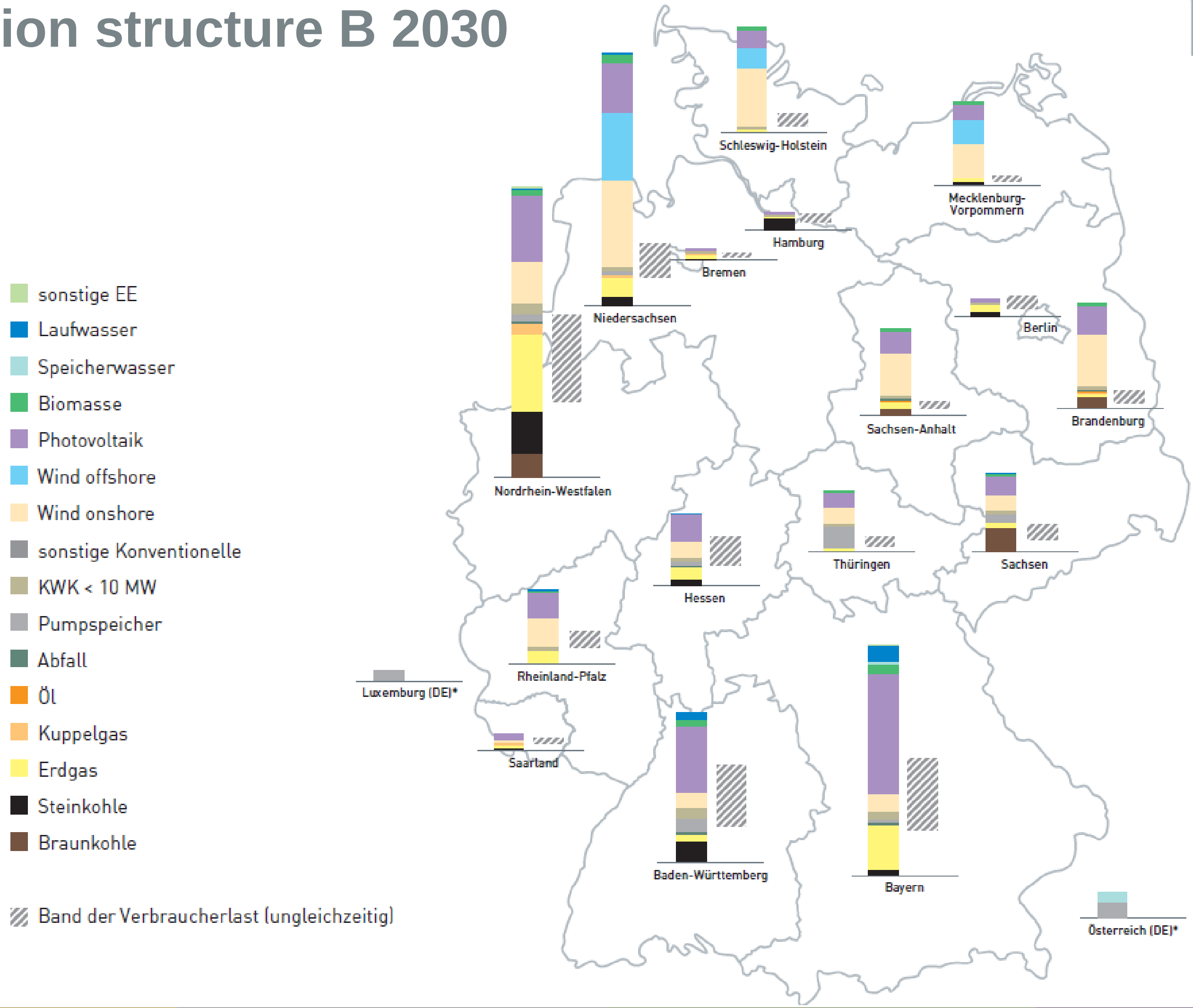
	A 2030	B 2030	B 2035	C 2030
Conventional power stations	High % of coal capacities	(Very) high % of natural gas capacities	Very high % of natural gas capacities	(Very) high % of natural gas capacities
Renewable energy % in total energy consumption	50.6 % (within the EEG corridor)	52.2 % (within the EEG corridor)	57.4 % (within the EEG corridor)	53.4 % (above the EEG corridor)
Net energy consumption	517 TWh	547 TWh	547 TWh	577 TWh
Level of **links between sectors**	Low	Medium	Medium	High
Amount of **flexibility options** and **storage**	Low	High	Very high	Very high
Collective power plant **emission limit**	None	165 M t CO_2	137 M t CO_2	165 M t CO_2

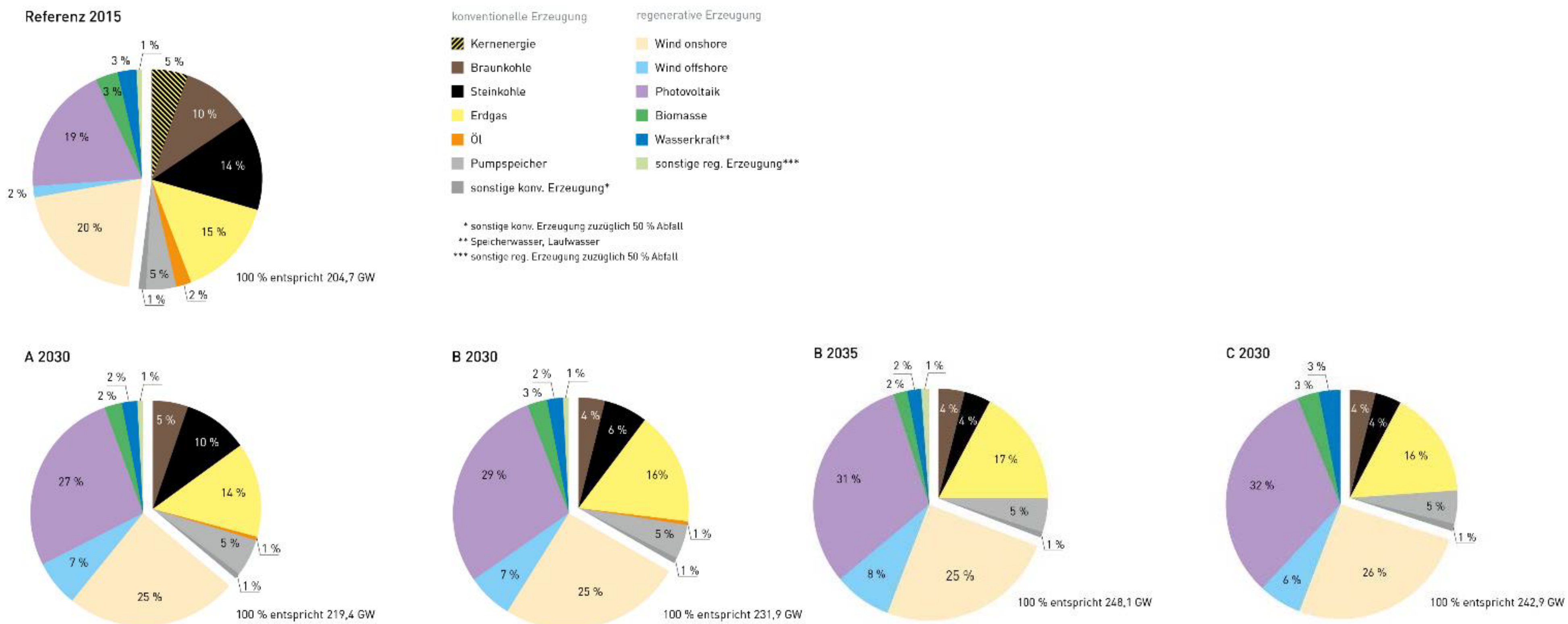
Grid Development Plan 2030 (2017)

Scenario framework; generation and consumption structure B 2030



Grid Development Plan 2030 (2017)

Overview of the distribution of installed capacity per energy source in the four scenarios of the GDP 2030



Grid Development Plan 2030 (2017)

Results of renewable energy peak capping

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- Provides for the capping of peaks in supply from onshore wind energy and photovoltaic power
- Avoids dimensioning the grid for the “last kWh generated from renewable energy”
- Peak capping as a theoretical approach (developed for downstream voltage levels); differentiation from real grid operation processes
- Supply from wind energy sources is reduced for around 3,000 hours per year and for 750 hours from photovoltaic sources. Overlap effects are observed in around 250 hours.
- Maximum supply reduction of 5.5 GW for onshore wind energy and 14.5 GW for photovoltaic energy
- Regional differences, incl. North-South divide for wind energy

Reduced feed-in amounts for onshore wind and photovoltaic

Angaben in TWh	Eingesenkte Einspeisemenge Windenergie onshore	Eingesenkte Einspeisemenge Photovoltaik
A 2030	2,1	0,7
B 2030	2,2	0,8
B2035	2,2	0,9
C 2030	2,3	0,9

Grid Development Plan 2030 (2017)

Peak capping of onshore wind energy per state

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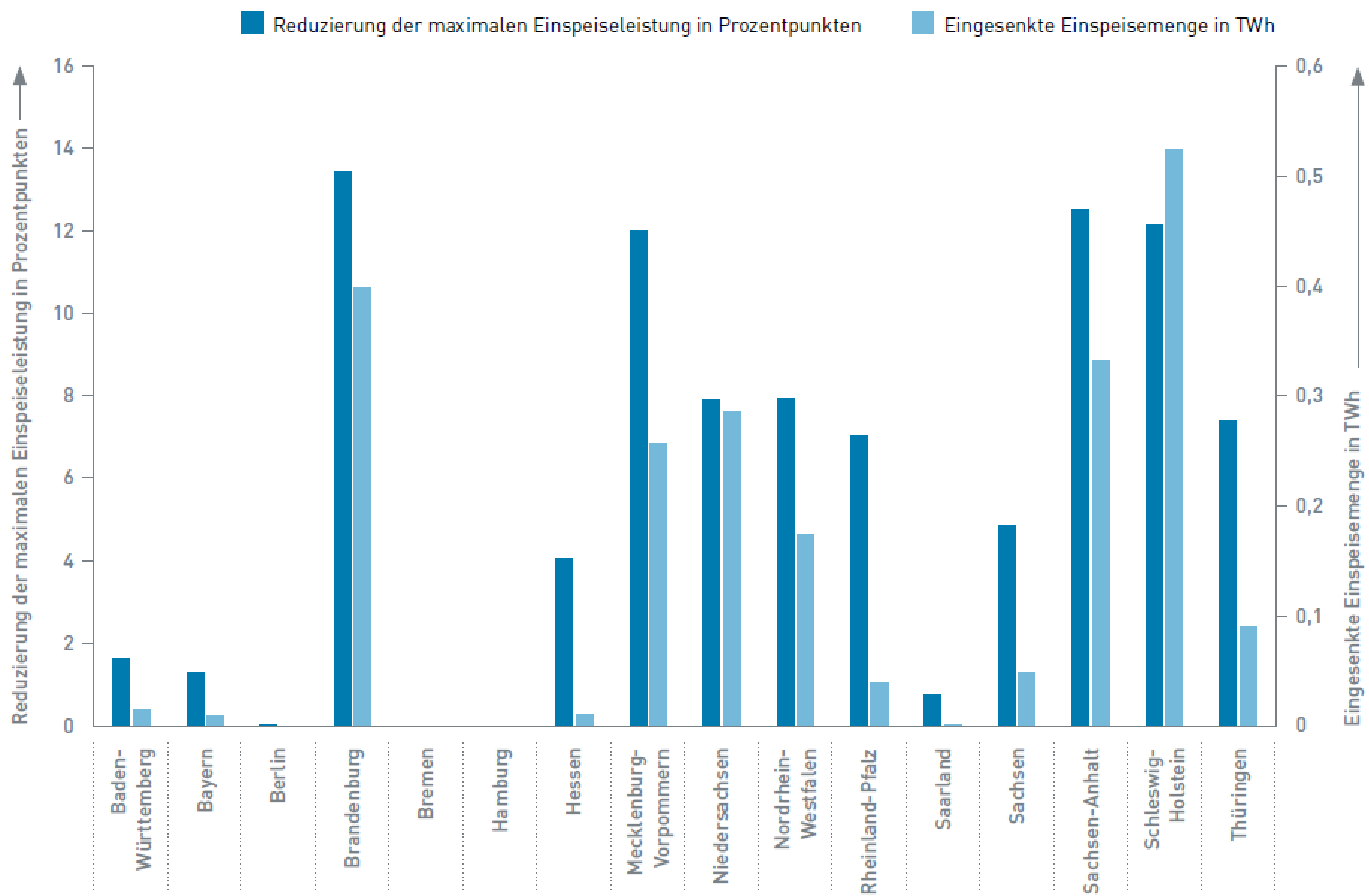
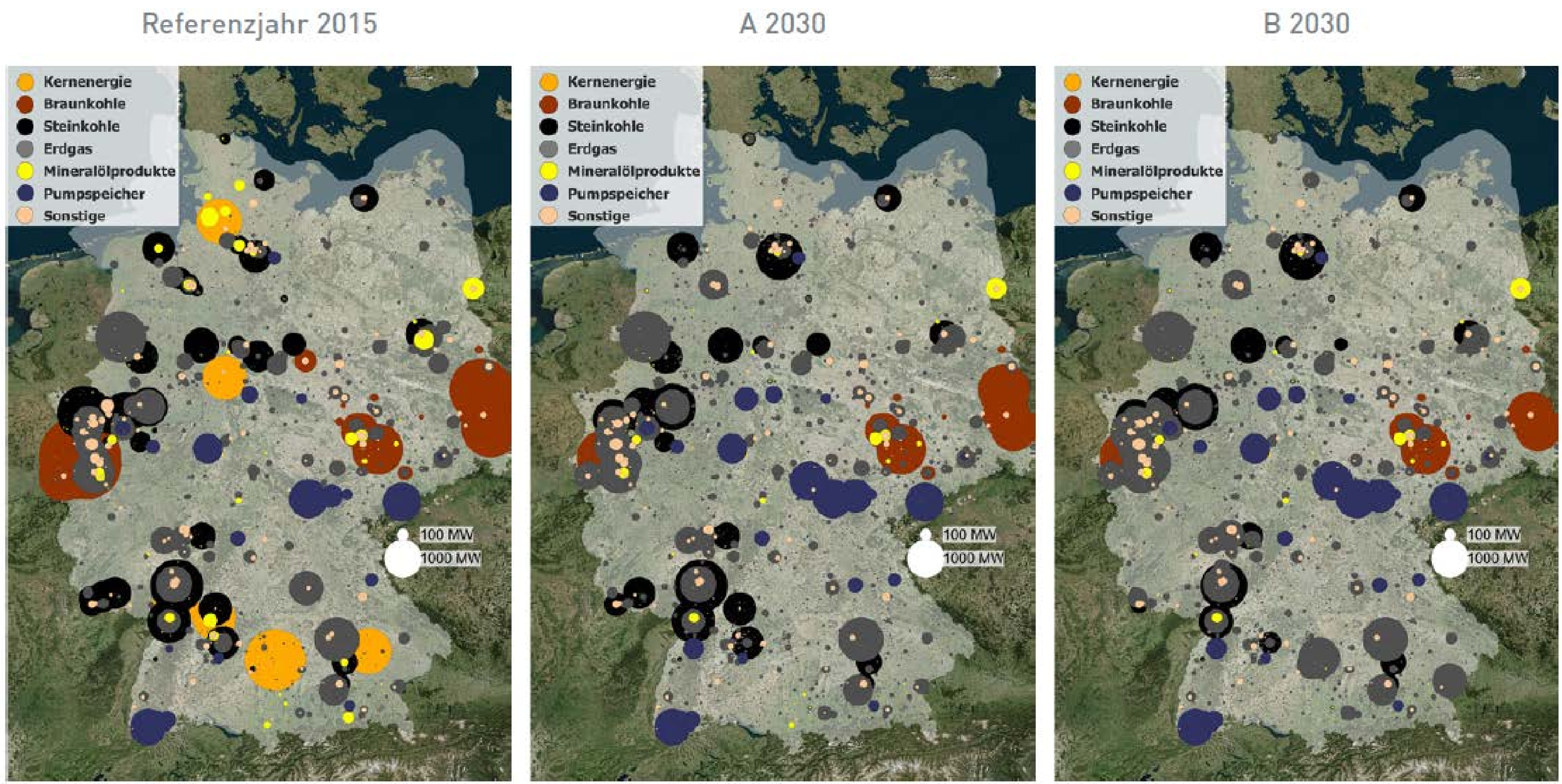


Grid Development Plan 2030 (2017)

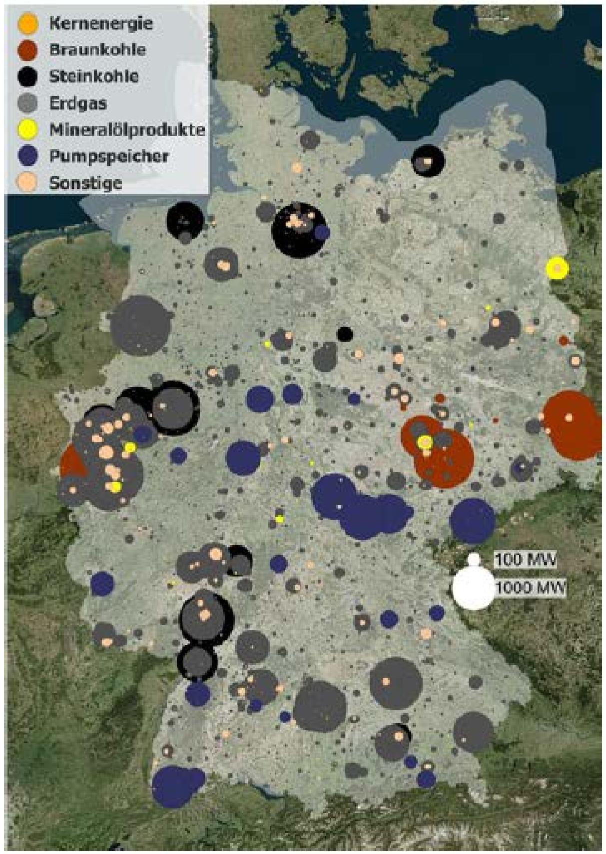
Development of conventional generation capacity



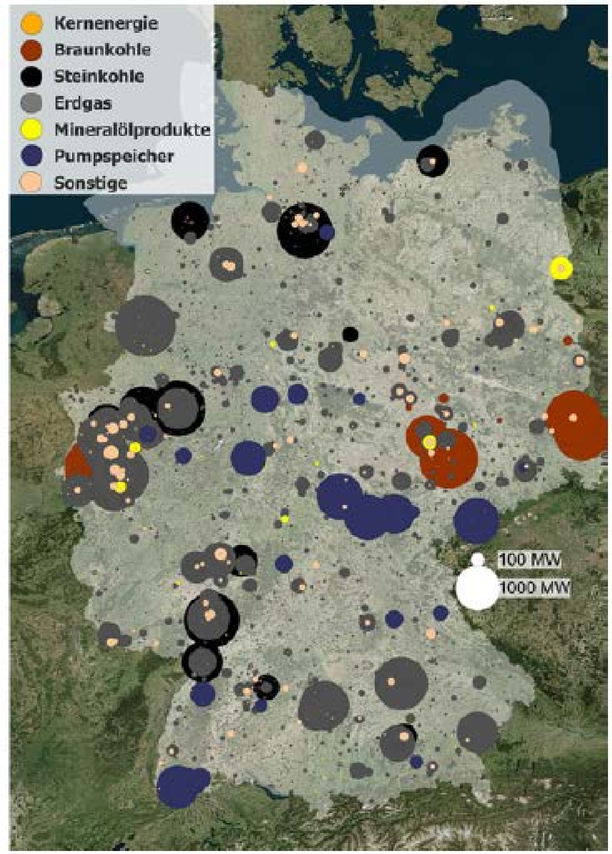
Grid Development Plan 2030 (2017)

Development of conventional generation capacity

B 2035

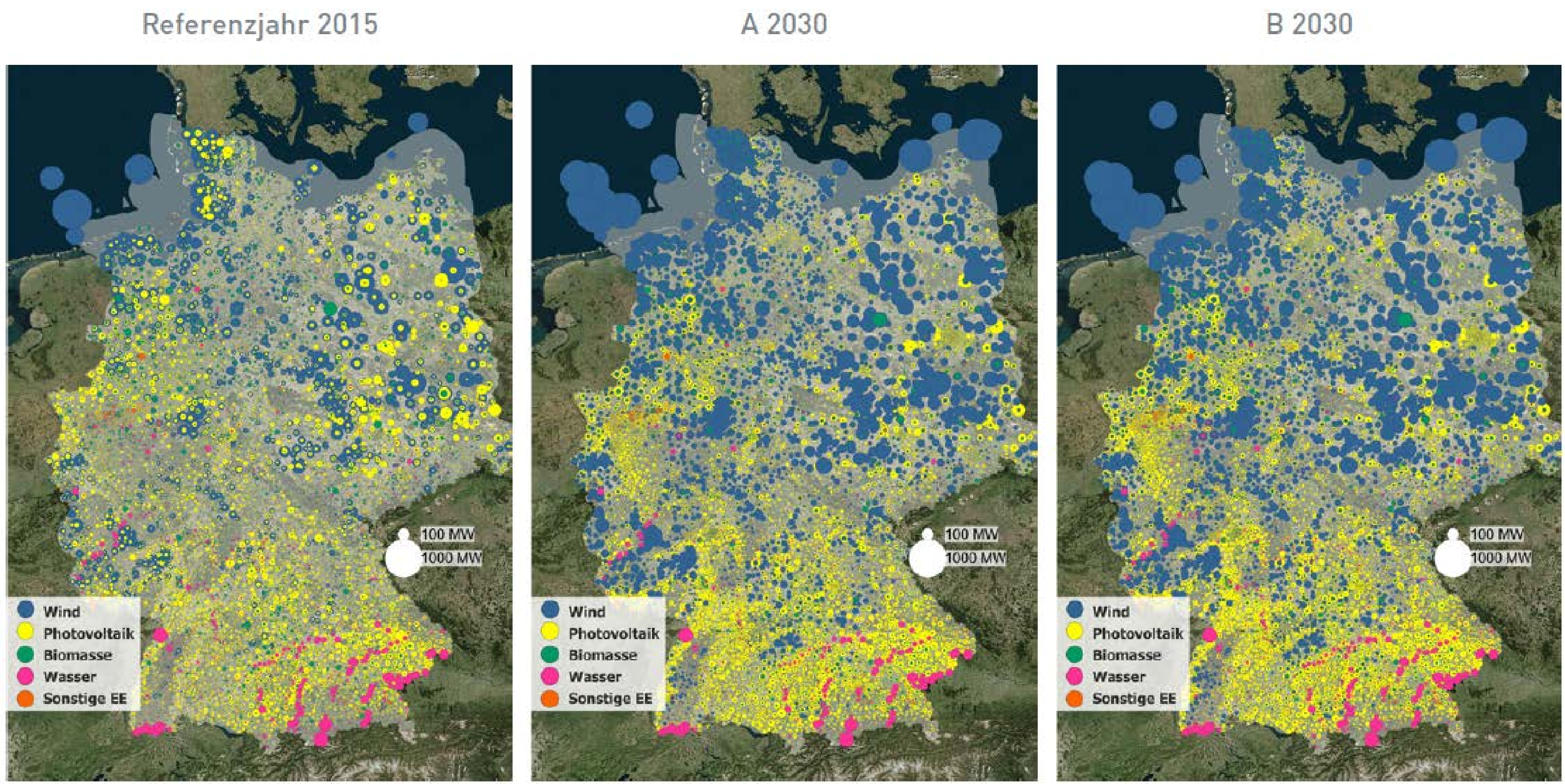


C 2030



Grid Development Plan 2030 (2017)

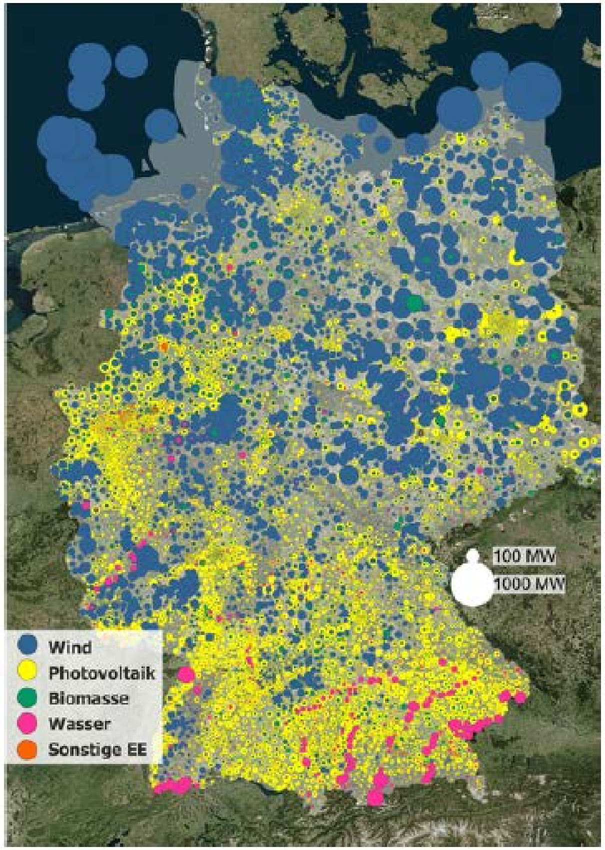
Development of renewable energy generation capacity



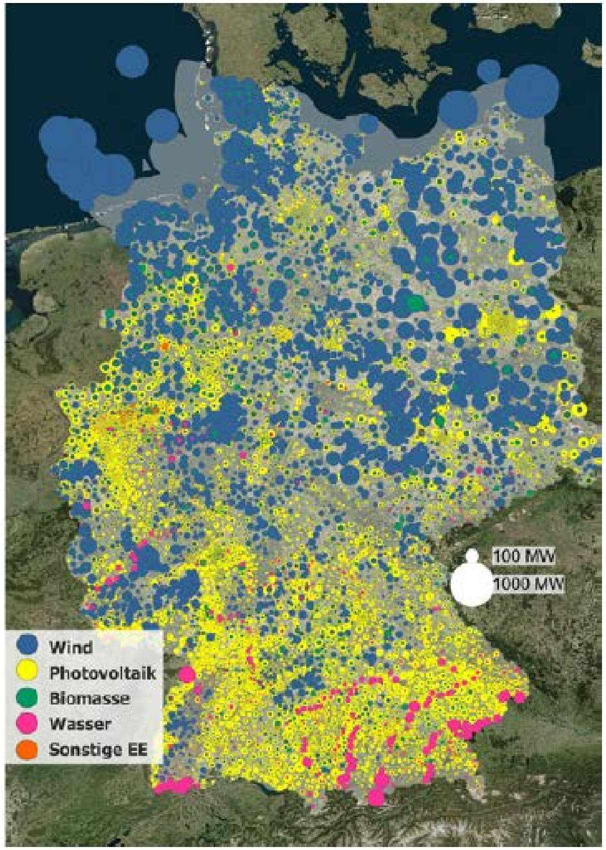
Grid Development Plan 2030 (2017)

Development of renewable energy generation capacity

B 2035



C 2030



Grid Development Plan 2030 (2017)

Scenario framework – results of modelling regional energy demands

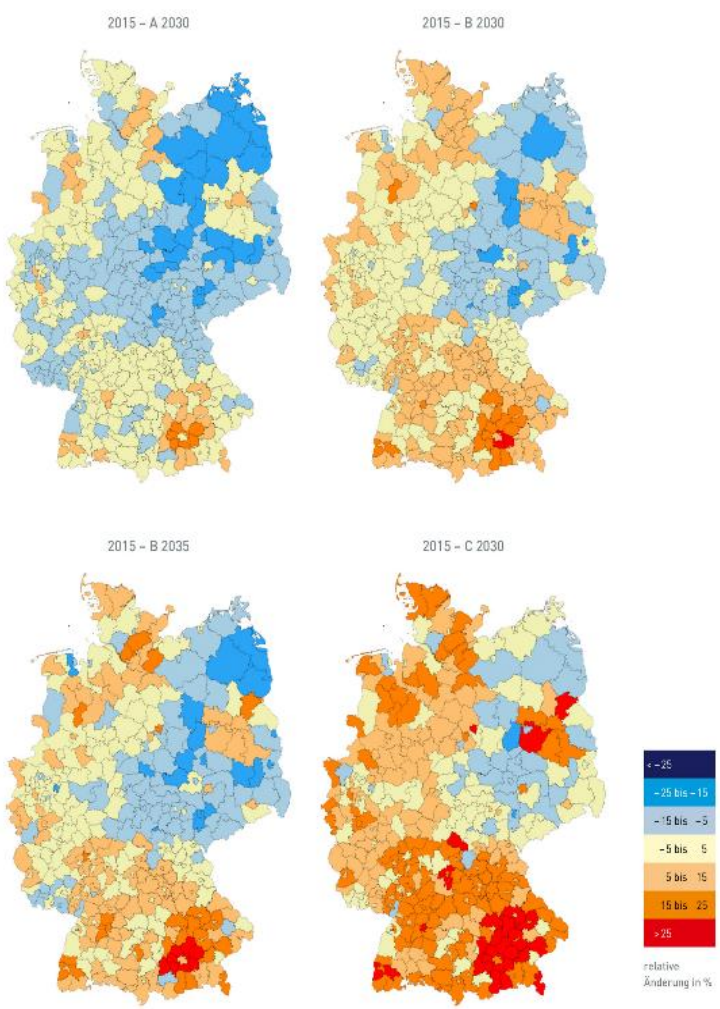
NETZ ENTWICKLUNGS PLAN STROM

- Urban regions and neighbouring conurbations show higher energy demands and increases in respective annual peak loads
- Majority of districts in the states of former East Germany and more rural areas show falling energy demands
- Scenario C 2030: overall there is a clear rise in the net energy demand as a result of the rapid increase in electric modes of transport as well as the widespread use of heat pumps
- Scenario C 2030: greatest regional changes in terms of demand structure – distinct shift in key demand areas in the south with falling demand in predominantly rural or more peripheral regions.
- The main drivers of regional energy demand are the assumed development of regional structural parameters such as population development or the market penetration of electromobility and heat pumps at a regional level

Grid Development Plan 2030 (2017)

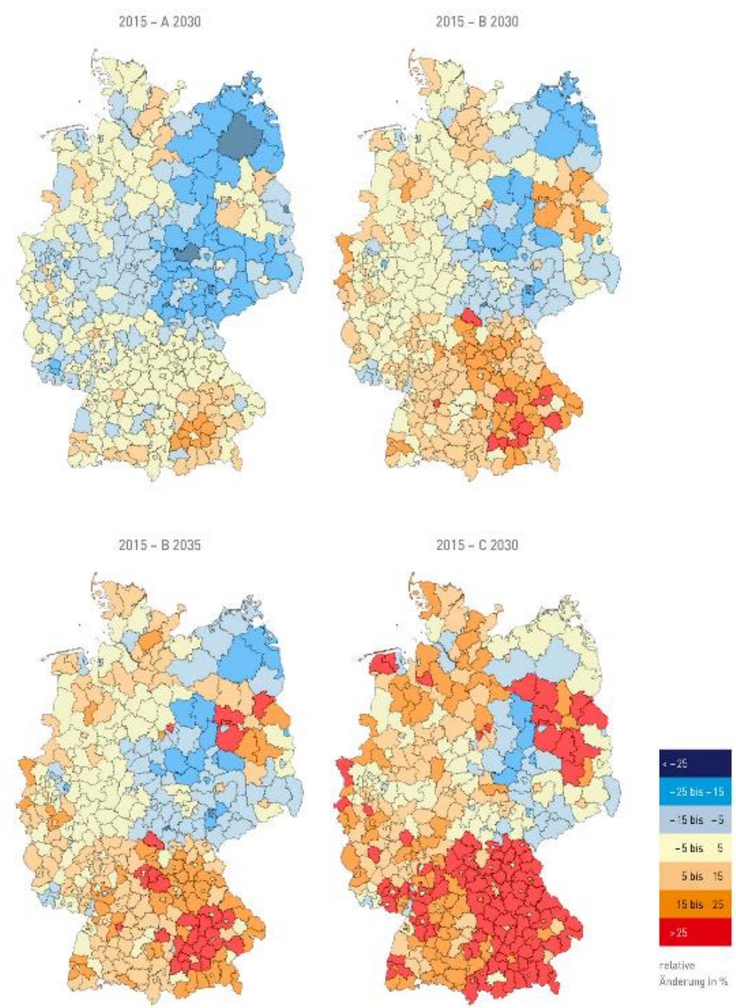
Scenario framework – results of modelling regional energy demands

Abbildung 7: Veränderung der Nettostromnachfrage je Landkreis



Quelle: Übertragungsnetzbetreiber

Abbildung 8: Veränderung der zeitungleichen Jahreshöchstlasten je Landkreis



Quelle: Übertragungsnetzbetreiber

Grid Development Plan 2030 (2017)

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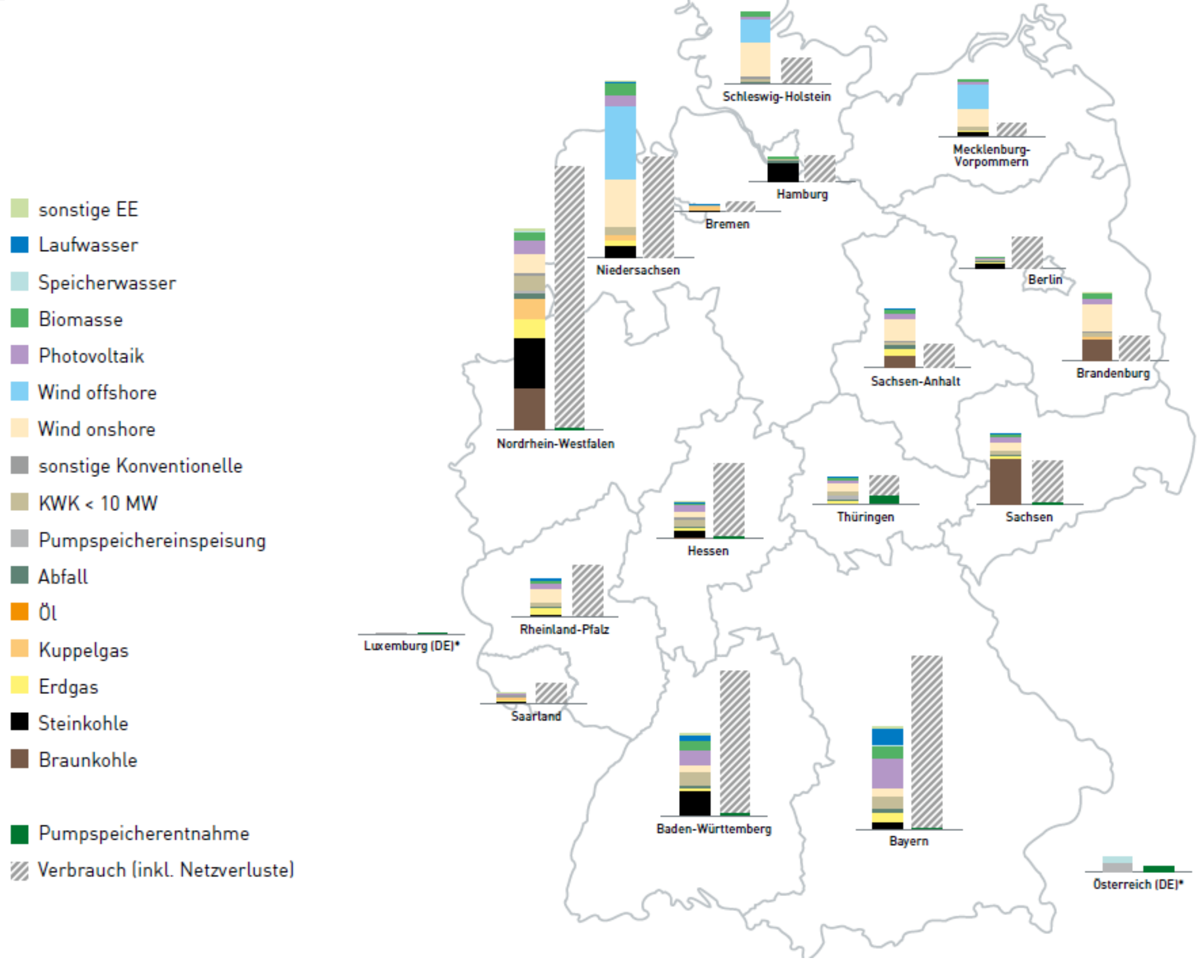
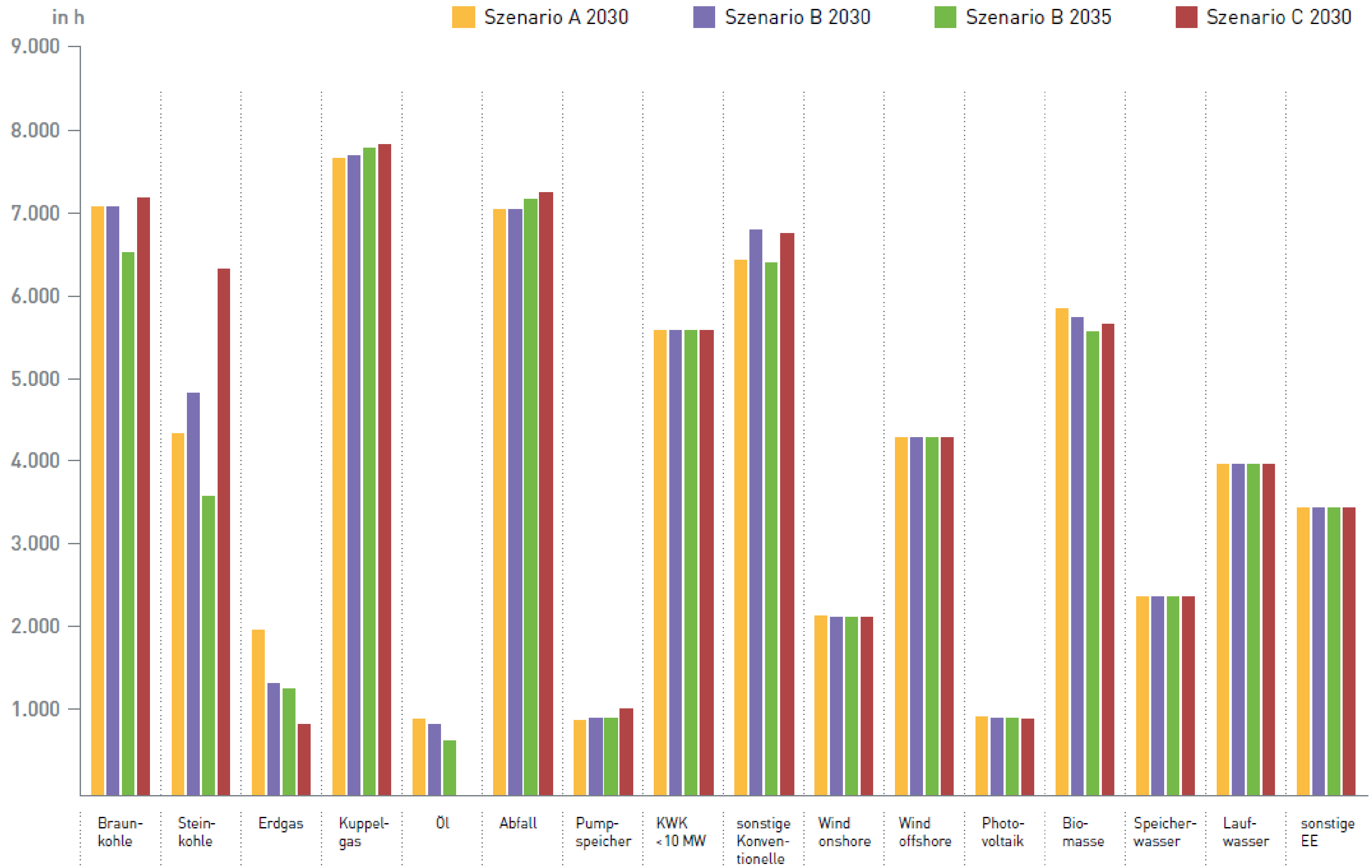
B 2030 – Energy supply and demand balance (per state); North-South divide



Grid Development Plan 2030 (2017)

Full load hours of conventional power stations



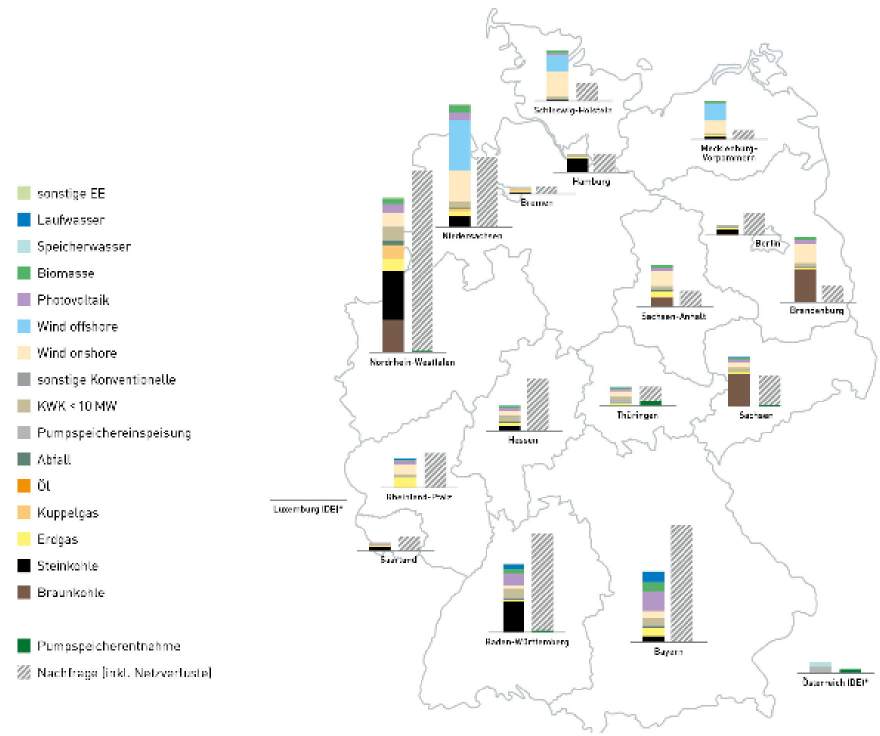
Grid Development Plan 2030 (2017)

Energy supply and demand balance at a state level

Scenario A 2030

A 2030 (Angaben in TWh)	Braun-kohle	Stein-kohle	Erdgas	Kuppel-gas	Öl	Abfall	Pump-speicher-einspeisung	KWK < 10 MW	sonstige Konven-tionelle	Wind onshore	Wind offshore	Photo-voltaik	Bio-masse	Speicher-wasser	Lauf-wasser	sonstige EE	Nachfrage (inkl. Netz-verluste)	Pump-speicher-entnahme
Baden-Württemberg	0,0	22,9	1,2	0,0	0,2	0,7	1,0	6,5	0,0	2,7	0,0	8,7	3,5	0,0	3,5	0,1	72,4	1,1
Bayern	0,0	4,1	6,2	0,0	0,0	1,5	0,2	6,2	0,0	4,8	0,0	15,3	6,4	0,1	7,9	0,2	87,5	0,2
Berlin	0,7	3,2	1,3	0,0	0,0	0,3	0,0	1,2	0,0	0,1	0,0	0,2	0,2	0,0	0,0	0,0	16,1	0,0
Brandenburg	24,6	0,0	0,5	0,8	0,2	0,8	0,0	2,0	0,2	14,2	0,0	3,4	2,1	0,0	0,0	0,1	12,1	0,0
Bremen	0,0	0,7	0,7	1,3	0,0	0,6	0,0	0,4	0,0	0,4	0,0	0,1	0,1	0,0	0,1	0,0	5,2	0,0
Hamburg	0,0	10,3	0,5	0,0	0,1	0,2	0,0	1,7	0,0	0,1	0,0	0,1	0,2	0,0	0,0	0,0	13,5	0,0
Hessen	0,3	3,0	2,7	0,0	0,0	0,7	0,2	3,6	0,2	3,7	0,0	2,8	1,2	0,1	0,1	0,1	38,2	0,3
Mecklenburg-Vorpommern	0,0	1,9	1,2	0,0	0,0	0,1	0,0	1,0	0,0	9,4	12,3	0,9	1,4	0,0	0,0	0,0	6,6	0,0
Niedersachsen	0,0	7,7	4,0	2,3	0,0	0,5	0,0	4,6	0,0	23,3	38,0	5,1	6,1	0,0	0,1	0,1	52,0	0,0
Nordrhein-Westfalen	24,0	37,0	8,8	10,3	0,2	3,5	0,5	8,9	0,5	10,8	0,0	6,8	3,6	0,1	0,4	0,7	135,5	0,6
Rheinland-Pfalz	0,0	0,0	7,1	0,0	0,0	0,7	0,0	1,9	0,0	7,5	0,0	2,9	0,8	0,0	0,9	0,0	25,7	0,0
Saarland	0,0	2,9	0,1	0,6	0,0	0,2	0,0	0,4	0,3	0,9	0,0	0,7	0,1	0,0	0,0	0,1	10,1	0,0
Sachsen	24,1	0,0	1,7	0,0	0,0	0,1	0,4	2,9	0,0	3,9	0,0	2,1	1,5	0,0	0,2	0,0	22,3	0,5
Sachsen-Anhalt	7,5	0,0	4,1	0,0	0,1	1,3	0,0	2,1	0,2	11,6	0,0	2,7	2,0	0,0	0,1	0,0	12,0	0,0
Schleswig-Holstein	0,0	0,5	0,2	0,0	0,0	0,2	0,0	1,8	0,4	19,1	11,3	2,0	1,9	0,0	0,0	0,0	13,2	0,0
Thüringen	0,0	0,0	1,8	0,0	0,0	0,1	3,2	1,8	0,0	4,0	0,0	1,8	1,2	0,0	0,1	0,0	10,5	3,8
Österreich (DE)*	0,0	0,0	0,0	0,0	0,0	0,0	4,8	0,0	0,0	0,0	0,0	0,0	0,0	3,2	0,0	0,0	0,0	2,9
Luxemburg (DE)*	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4
Summe**	**81,0**	**94,3**	**42,1**	**15,2**	**0,8**	**11,7**	**10,6**	**47,2**	**1,8**	**116,5**	**61,6**	**55,6**	**32,3**	**3,5**	**13,4**	**1,5**	**533,1**	**9,9**

* Erzeugungsanlagen im Ausland mit Einspeisung in das deutsche Übertragungsnetz
** Bei der Aufsummierung der Einzelwerte können sich Rundungsabweichungen ergeben.



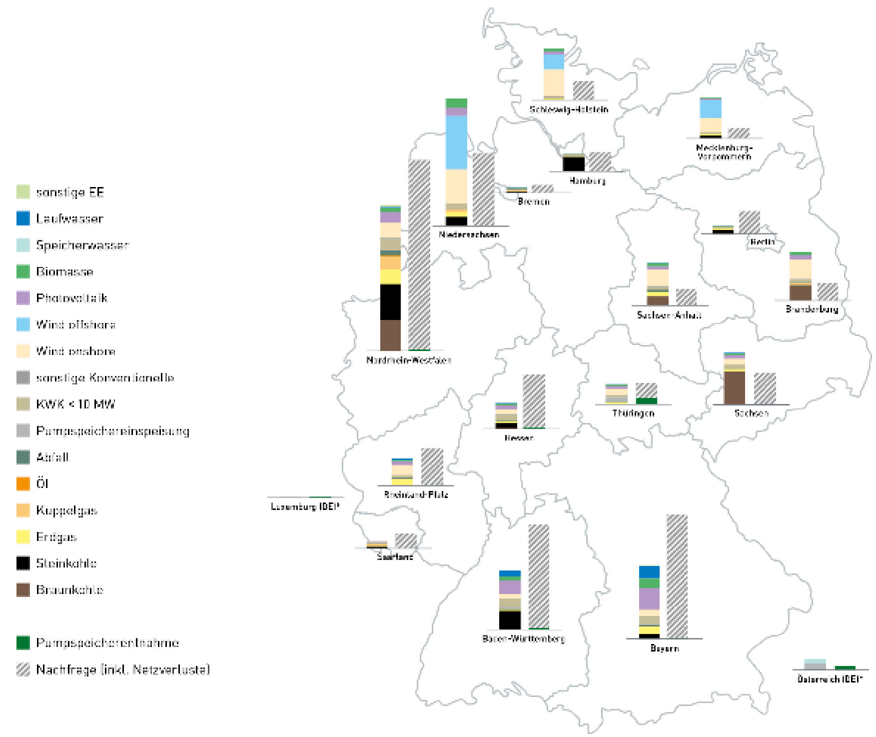
Grid Development Plan 2030 (2017)

Energy supply and demand balance at a state level

Scenario B 2030

B 2030 (Angaben in TWh)	Braun-kohle	Stein-kohle	Erdgas	Kuppel-gas	Öl	Abfall	Pump-speicher-einspeisung	KWK < 10 MW	sonstige Konven-tionelle	Wind onshore	Wind offshore	Photo-voltaik	Bio-masse	Speicher-wasser	Lauf-wasser	sonstige EE	Nachfrage (inkl. Netz-verluste)	Pump-speicher-entnahme
Baden-Württemberg	0,0	13,6	1,2	0,0	0,0	0,7	1,1	6,5	0,0	3,4	0,0	9,5	3,9	0,0	4,2	0,1	77,3	1,1
Bayern	0,0	3,8	5,5	0,0	0,0	1,5	0,2	6,2	0,0	4,8	0,0	16,3	7,1	0,1	9,6	0,2	93,8	0,2
Berlin	0,0	2,7	0,9	0,0	0,0	0,2	0,0	1,2	0,0	0,1	0,0	0,3	0,2	0,0	0,0	0,0	16,5	0,0
Brandenburg	11,5	0,0	0,4	0,8	0,1	0,8	0,0	2,0	0,2	14,9	0,0	3,6	2,3	0,0	0,0	0,1	12,9	0,0
Bremen	0,0	0,6	0,0	1,3	0,0	0,6	0,0	0,4	0,0	0,5	0,0	0,1	0,1	0,0	0,1	0,0	5,5	0,0
Hamburg	0,0	10,3	0,1	0,0	0,1	0,2	0,0	1,7	0,0	0,1	0,0	0,1	0,3	0,0	0,0	0,0	13,9	0,0
Hessen	0,2	3,4	2,1	0,0	0,0	0,8	0,2	3,6	0,2	4,0	0,0	3,1	1,4	0,1	0,3	0,1	40,2	0,3
Mecklenburg-Vorpommern	0,0	2,2	1,1	0,0	0,0	0,1	0,0	1,0	0,0	10,8	13,3	1,0	1,5	0,0	0,0	0,0	7,0	0,0
Niedersachsen	0,0	6,5	3,3	2,2	0,0	0,5	0,0	4,6	0,0	25,6	40,2	5,7	6,8	0,0	0,3	0,1	54,9	0,0
Nordrhein-Westfalen	23,2	26,9	10,7	10,3	0,3	3,5	0,5	8,9	0,4	11,4	0,0	7,7	4,0	0,1	0,7	0,7	142,7	0,7
Rheinland-Pfalz	0,0	0,1	4,5	0,0	0,0	0,7	0,0	1,9	0,0	7,8	0,0	3,3	0,9	0,0	1,0	0,0	27,4	0,0
Saarland	0,0	1,3	0,9	0,7	0,0	0,2	0,0	0,4	0,3	0,9	0,0	0,7	0,1	0,0	0,0	0,1	10,7	0,0
Sachsen	24,8	0,0	1,7	0,0	0,0	0,1	0,4	2,9	0,0	4,3	0,0	2,4	1,6	0,0	0,4	0,0	23,3	0,6
Sachsen-Anhalt	6,6	0,0	3,7	0,0	0,2	1,3	0,0	2,1	0,3	12,5	0,0	2,9	2,3	0,0	0,1	0,0	12,6	0,0
Schleswig-Holstein	0,0	0,2	0,4	0,0	0,0	0,2	0,0	1,8	0,4	19,7	11,3	2,2	2,2	0,0	0,0	0,0	13,9	0,0
Thüringen	0,0	0,0	1,5	0,0	0,0	0,1	3,3	1,8	0,0	4,6	0,0	1,9	1,3	0,0	0,1	0,0	11,1	4,1
Österreich (DE)*	0,0	0,0	0,0	0,0	0,0	0,0	4,8	0,0	0,0	0,0	0,0	0,0	0,0	3,2	0,0	0,0	0,0	3,0
Luxemburg (DE)*	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4
Summe**	**66,4**	**71,4**	**38,2**	**15,3**	**0,7**	**11,7**	**11,0**	**47,2**	**1,7**	**125,3**	**64,8**	**60,9**	**35,7**	**3,5**	**16,7**	**1,5**	**563,8**	**10,4**

* Erzeugungsanlagen im Ausland mit Einspeisung in das deutsche Übertragungsnetz
** Bei der Aufsummierung der Einzelwerte können sich Rundungsabweichungen ergeben.



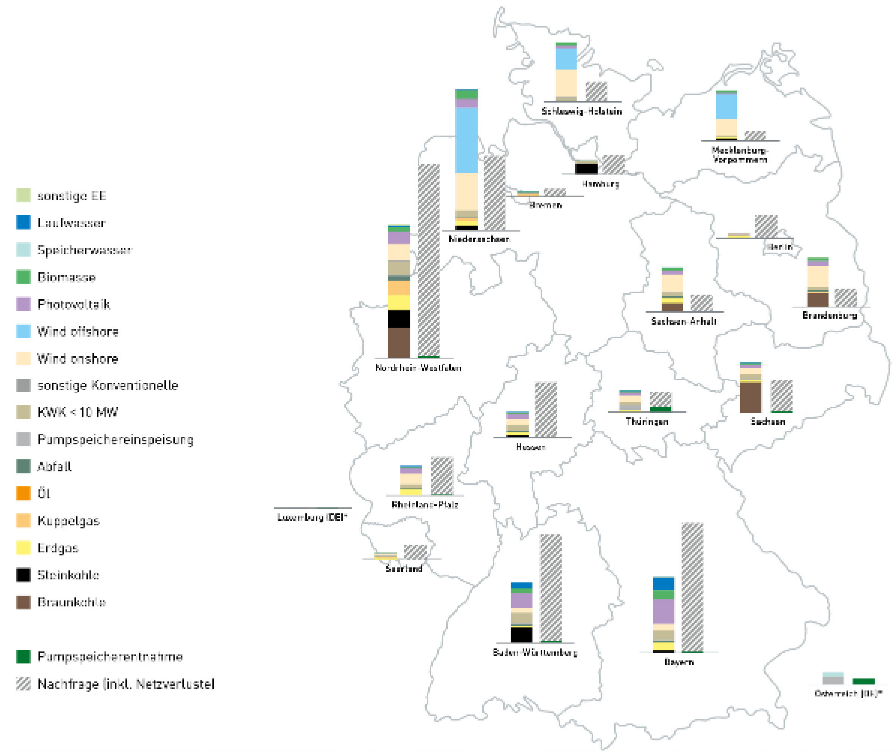
Grid Development Plan 2030 (2017)

Energy supply and demand balance at a state level

Scenario B 2035

B 2035 (Angaben in TWh)	Braun-kohle	Stein-kohle	Erdgas	Kuppel-gas	Öl	Abfall	Pump-speicher-einspeisung	KWK < 10 MW	sonstige Konven-tionelle	Wind onshore	Wind offshore	Photo-voltaik	Bio-masse	Speicher-wasser	Lauf-wasser	sonstige EE	Nachfrage (inkl. Netz-verlusten)	Pump-speicher-entnahme
Baden-Württemberg	0,0	11,1	1,1	0,0	0,0	0,7	1,1	7,6	0,0	3,8	0,0	10,8	3,6	0,0	4,2	0,1	78,2	1,2
Bayern	0,0	1,4	5,7	0,0	0,0	1,5	0,4	7,3	0,0	4,8	0,0	18,0	6,6	0,1	9,6	0,2	94,7	0,5
Berlin	0,0	0,0	1,3	0,0	0,0	0,3	0,0	1,5	0,0	0,1	0,0	0,4	0,2	0,0	0,0	0,0	16,6	0,0
Brandenburg	9,8	0,0	0,4	0,8	0,0	0,9	0,0	2,3	0,2	15,3	0,0	3,9	2,2	0,0	0,0	0,1	13,0	0,0
Bremen	0,0	0,0	0,0	1,3	0,0	0,7	0,0	0,5	0,0	0,5	0,0	0,1	0,1	0,0	0,1	0,0	5,4	0,0
Hamburg	0,0	7,3	0,1	0,0	0,0	0,2	0,0	1,9	0,0	0,1	0,0	0,2	0,2	0,0	0,0	0,0	13,8	0,0
Hessen	0,0	1,4	2,1	0,0	0,0	0,8	0,2	4,3	0,2	4,3	0,0	3,7	1,3	0,1	0,3	0,1	40,1	0,3
Mecklenburg-Vorpommern	0,0	1,3	1,1	0,0	0,0	0,1	0,0	1,2	0,0	11,8	18,5	1,1	1,4	0,0	0,0	0,0	6,9	0,0
Niedersachsen	0,0	3,3	3,2	2,3	0,0	0,5	0,0	5,5	0,0	27,2	48,1	6,6	6,4	0,0	0,3	0,1	54,6	0,0
Nordrhein-Westfalen	21,8	13,2	11,0	10,5	0,2	3,6	0,5	10,5	0,4	11,9	0,0	9,1	3,7	0,1	0,7	0,7	142,2	0,6
Rheinland-Pfalz	0,0	0,0	4,6	0,0	0,0	0,7	0,3	2,2	0,0	8,0	0,0	3,8	0,8	0,0	1,0	0,0	27,4	0,4
Saarland	0,0	0,0	1,0	0,7	0,0	0,2	0,0	0,5	0,3	0,9	0,0	0,9	0,1	0,0	0,0	0,1	10,5	0,0
Sachsen	22,3	0,0	1,9	0,0	0,0	0,1	0,4	3,4	0,0	4,5	0,0	2,7	1,5	0,0	0,4	0,0	23,2	0,5
Sachsen-Anhalt	6,3	0,0	3,6	0,0	0,1	1,4	0,0	2,5	0,2	13,1	0,0	3,2	2,1	0,0	0,1	0,0	12,3	0,0
Schleswig-Holstein	0,0	0,0	0,5	0,0	0,0	0,2	0,0	2,1	0,3	20,2	15,3	2,5	2,0	0,0	0,0	0,0	14,0	0,0
Thüringen	0,0	0,0	1,6	0,0	0,0	0,1	3,0	2,2	0,0	5,1	0,0	2,2	1,2	0,0	0,1	0,0	10,9	3,7
Österreich (DE)*	0,0	0,0	0,0	0,0	0,0	0,0	5,6	0,0	0,0	0,0	0,0	0,0	0,0	3,2	0,0	0,0	0,0	3,9
Luxemburg (DE)*	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4
Summe**	**60,1**	**39,0**	**39,3**	**15,5**	**0,3**	**11,9**	**11,9**	**55,6**	**1,5**	**131,6**	**82,0**	**69,1**	**33,5**	**3,5**	**16,7**	**1,5**	**563,6**	**12,0**

* Erzeugungsanlagen im Ausland mit Einspeisung in das deutsche Übertragungsnetz
** Bei der Aufsummierung der Einzelwerte können sich Rundungsabweichungen ergeben.



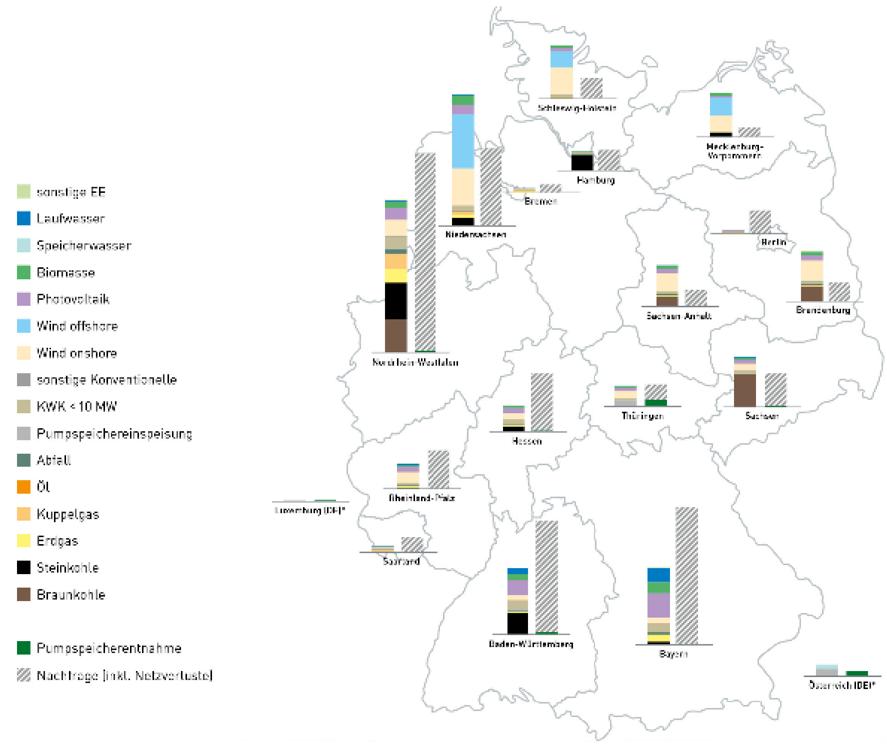
Grid Development Plan 2030 (2017)

Energy supply and demand balance at a state level

Scenario C 2030

C 2030 (Angaben in TWh)	Braun-kohle	Stein-kohle	Erdgas	Kuppel-gas	Öl	Abfall	Pump-speicher-einspeisung	KWK < 10 MW	sonstige Konven-tionelle	Wind onshore	Wind offshore	Photo-voltaik	Bio-masse	Speicher-wasser	Lauf-wasser	sonstige EE	Nachfrage (inkl. Netz-verluste)	Pump-speicher-entnahme
Baden-Württemberg	0,0	16,4	0,5	0,0	0,0	0,7	1,3	6,5	0,0	3,9	0,0	11,0	4,3	0,0	4,8	0,1	82,8	1,5
Bayern	0,0	1,7	5,4	0,0	0,0	1,6	0,3	6,2	0,0	4,8	0,0	18,1	7,9	0,1	10,7	0,2	101,2	0,3
Berlin	0,0	0,0	0,4	0,0	0,0	0,3	0,0	1,2	0,0	0,1	0,0	0,4	0,2	0,0	0,0	0,0	17,4	0,0
Brandenburg	11,0	0,0	0,1	0,8	0,0	0,9	0,0	2,0	0,2	15,4	0,0	4,0	2,6	0,0	0,0	0,1	14,0	0,0
Bremen	0,0	0,0	0,2	1,1	0,0	0,7	0,0	0,4	0,0	0,5	0,0	0,1	0,1	0,0	0,1	0,0	5,6	0,0
Hamburg	0,0	11,2	0,2	0,0	0,0	0,2	0,0	1,7	0,0	0,1	0,0	0,2	0,3	0,0	0,0	0,0	14,8	0,0
Hessen	0,0	3,2	0,9	0,0	0,0	0,8	0,3	3,6	0,2	4,3	0,0	3,8	1,5	0,1	0,4	0,1	42,9	0,4
Mecklenburg-Vorpommern	0,0	2,9	0,2	0,0	0,0	0,1	0,0	1,0	0,0	12,0	13,3	1,2	1,7	0,0	0,0	0,0	7,4	0,0
Niedersachsen	0,0	5,5	2,4	2,2	0,0	0,5	0,0	4,6	0,0	27,5	40,2	6,7	7,5	0,0	0,3	0,1	57,2	0,1
Nordrhein-Westfalen	24,1	27,5	10,3	10,8	0,0	3,6	0,6	8,9	0,4	12,0	0,0	9,2	4,4	0,1	0,8	0,7	147,0	0,8
Rheinland-Pfalz	0,0	0,1	1,4	0,0	0,0	0,7	0,0	1,9	0,0	8,0	0,0	3,8	1,0	0,0	1,0	0,0	28,5	0,0
Saarland	0,0	0,0	0,6	0,7	0,0	0,2	0,0	0,4	0,3	0,9	0,0	0,9	0,1	0,0	0,1	0,1	11,0	0,0
Sachsen	23,7	0,0	0,2	0,0	0,0	0,1	0,6	2,9	0,0	4,6	0,0	2,7	1,8	0,0	0,5	0,0	24,0	0,7
Sachsen-Anhalt	7,4	0,0	0,6	0,0	0,0	1,3	0,0	2,1	0,2	13,2	0,0	3,2	2,5	0,0	0,1	0,0	12,7	0,0
Schleswig-Holstein	0,0	0,1	0,4	0,0	0,0	0,2	0,0	1,8	0,4	20,3	11,3	2,5	2,4	0,0	0,0	0,0	14,7	0,0
Thüringen	0,0	0,0	0,4	0,0	0,0	0,1	3,6	1,8	0,0	5,2	0,0	2,2	1,4	0,0	0,2	0,0	11,6	4,4
Österreich (DE)*	0,0	0,0	0,0	0,0	0,0	0,0	5,0	0,0	0,0	0,0	0,0	0,0	0,0	3,2	0,0	0,0	0,0	3,3
Luxemburg (DE)*	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6
Summe**	**66,2**	**68,6**	**24,2**	**15,6**	**0,0**	**12,0**	**12,3**	**47,2**	**1,6**	**132,6**	**64,8**	**69,9**	**39,8**	**3,5**	**19,0**	**1,5**	**592,9**	**12,1**

* Erzeugungsanlagen im Ausland mit Einspeisung in das deutsche Übertragungsnetz
** Bei der Aufsummierung der Einzelwerte können sich Rundungsabweichungen ergeben.



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Market simulation

Grid Development Plan 2030 (2017)

Key findings from the market simulation

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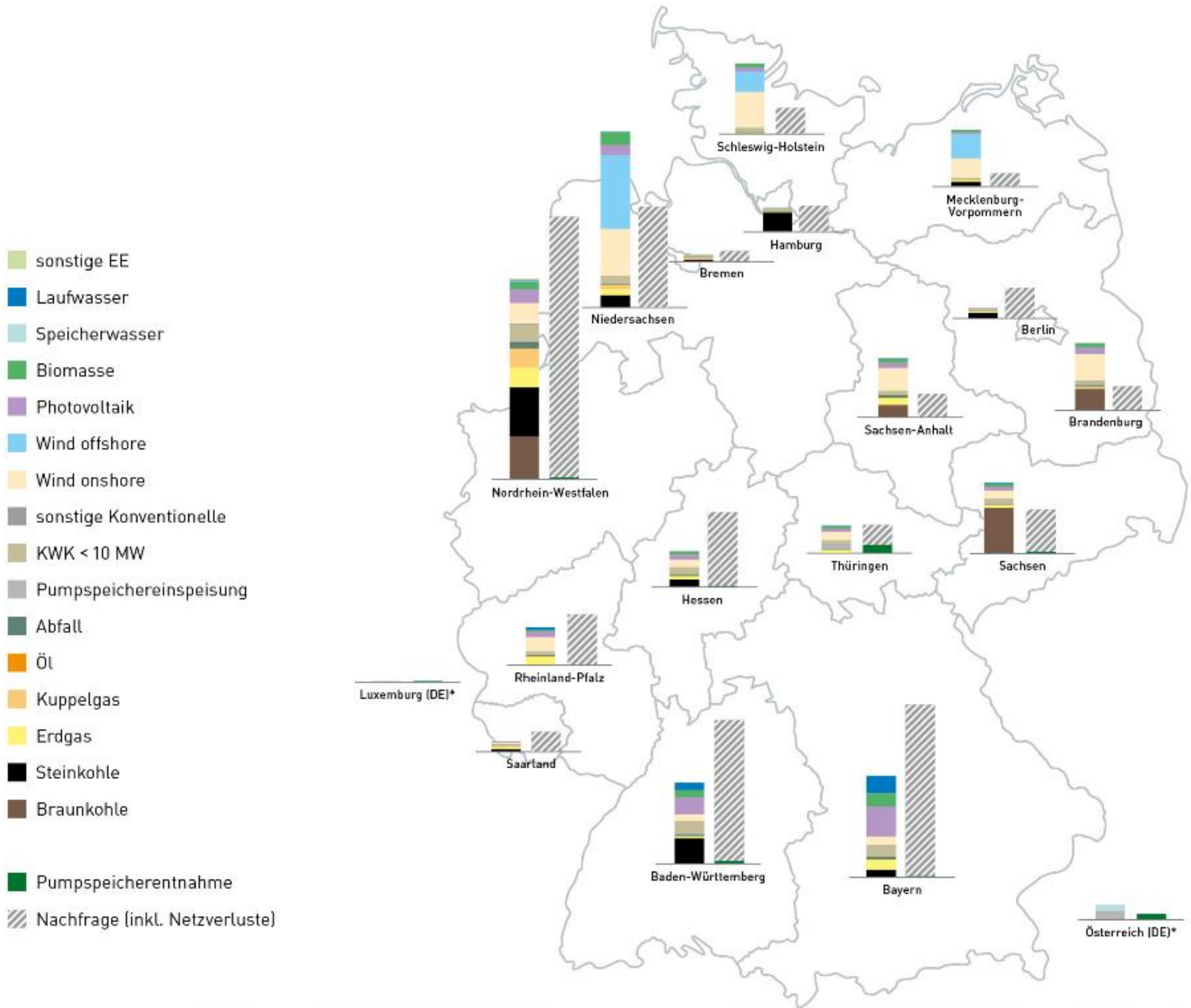
The market simulations for the GDP 2030 illustrate just how far the **transformation of the energy sector** has come in terms of the integration of renewable energy sources.

- Clear **energy generation gap within Germany:** excess generation in Northern Germany, generation deficit in Southern Germany
- Increase in the **importance of renewable energy sources –** wind energy has the largest share of the energy mix
- Expansion of renewable sources of energy and the **central integration of Germany in the single European energy market** are the key drivers behind the task of handling German energy transmission
- **Attainment of political objectives** to a large extent

Grid Development Plan 2030 (2017)

Energy balance B2030: North/South Divide



Supply surplus in northern Germany:

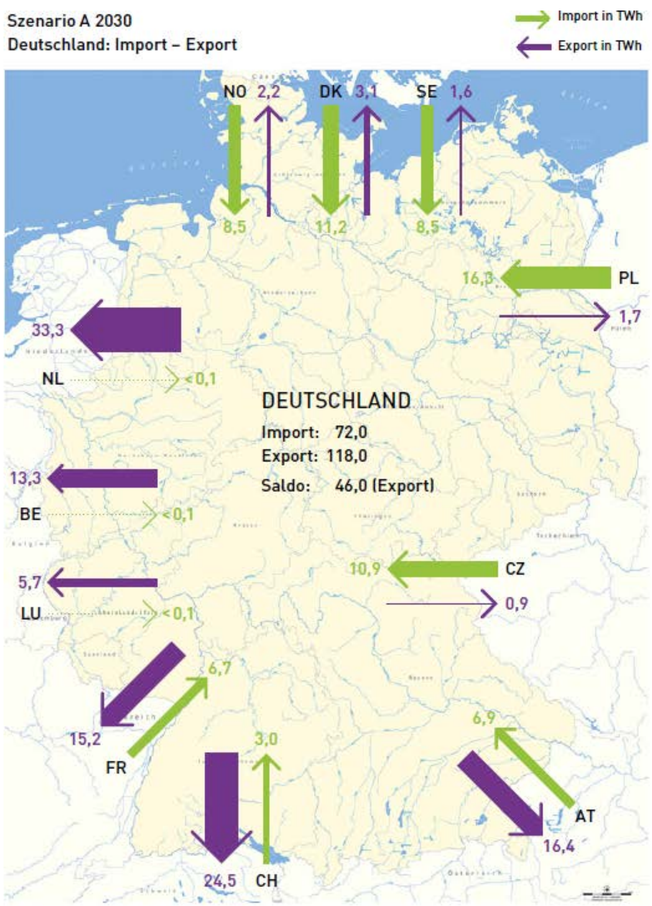
Supply in northern- and east-German states is almost double the local demand.

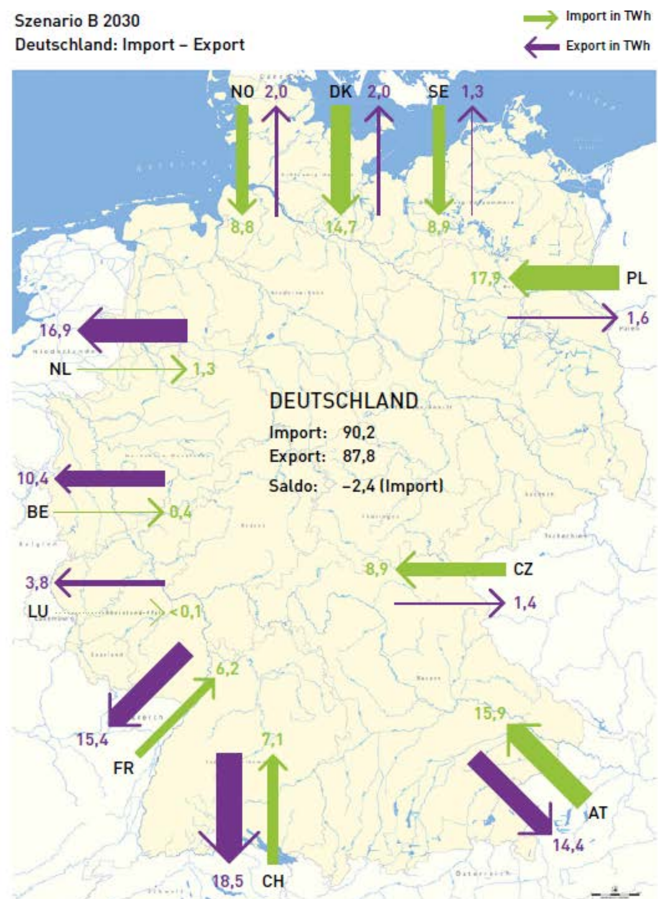
Supply deficit in southern Germany:

Between a quarter and half of energy demand in southern states is satisfied by imports from other states or countries.

Grid Development Plan 2030 (2017)

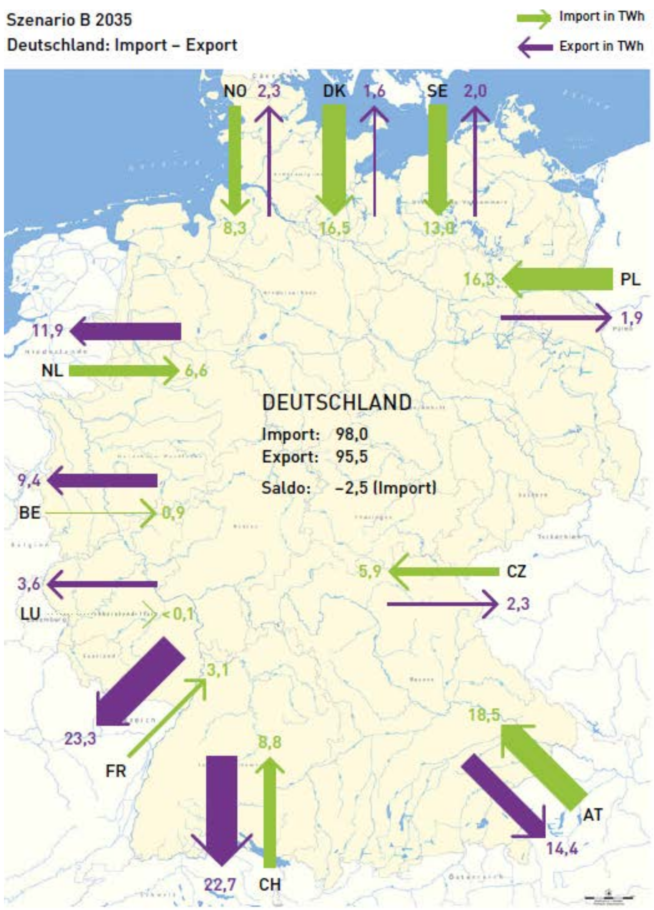
Trade exchanges: net power exporter in A 2030 / equal trade balance in B 2030

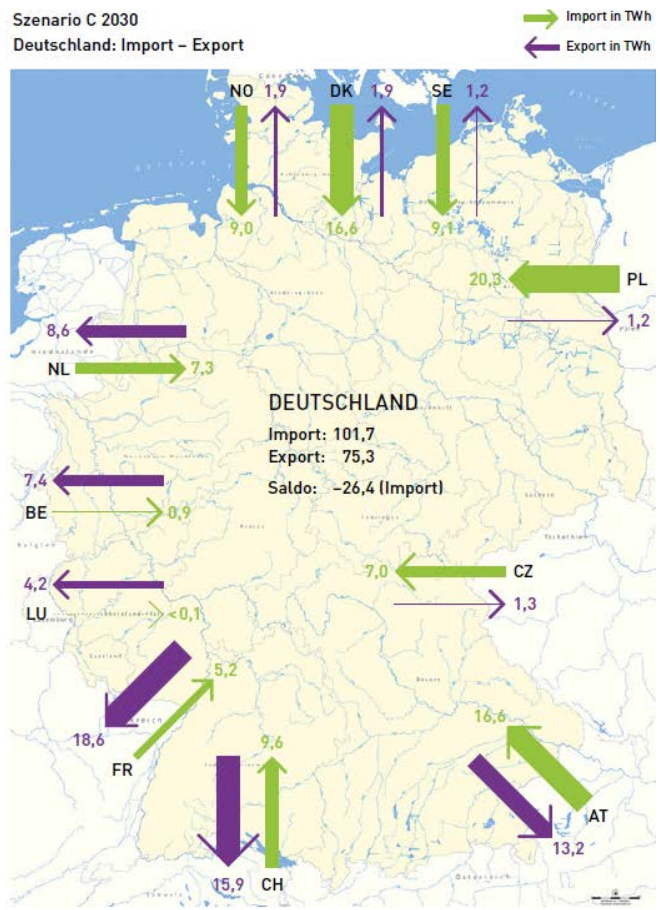




Grid Development Plan 2030 (2017)

Trade exchanges: equal trade balance in B 2035 / net power importer in C 2030





Grid Development Plan 2030 (2017)

Market simulation

- The transformation of the energy sector is very advanced in terms of integrating renewable sources of energy.
- Growing importance of renewable energy; in all scenarios, **wind energy (on and offshore) is the source with the largest share** in the energy mix.
- A **large gap in terms of power generation within Germany** shows in all scenarios, with **surplus generation in Northern Germany** and a **generation deficit in the South**. In the southern German states, between a quarter and half of annual energy demand is covered by domestic and foreign imports. In contrast, energy generation in the northern and eastern federal states is more than double the local demand.
- Key **drivers behind the task of handling energy transmissions within Germany** are the continuing expansion of renewable sources of energy as well as the strong and central integration of Germany in the single European Single Market.
- The auxiliary condition included in the market modelling, which limits CO_2 emissions, could lead to a change in the trade balance, such that Germany would shift from being a net exporter to becoming a net importer of power.

Grid Development Plan 2030 (2017)

Market simulation

- Restricting power station operation due to emission limits in the scenario framework is only necessary in Scenarios B 2030 and B 2035.
- By using a cost-optimised approach to operation in Scenario C 2030, the size and composition of conventional power plants in Germany is sufficient to comply with the scenario framework's CO2 limits.
- Due to the decline in thermal generation capacity and the increase in volatile energy supply from renewable energy, the **amount of power that can be ensured at any one time** ("guaranteed generation capacity") will fall by the year 2030 or 2035 respectively. It is therefore likely that the importance of imports for the security of the German power supply will increase.
- Attainment of political objectives to a large extent.
- Passed by the federal cabinet in November, the **German Climate Action Plan 2050** has not yet been used as a basis for the specifications of the scenario framework. The results of the GDP 2030 show several steps towards a continuing reduction of CO_2 levels. In their proposal for the scenario framework, the transmission system operators have presented a diverse range of elements and models, aimed at further de-carbonisation, which could be used in later GDP procedures.

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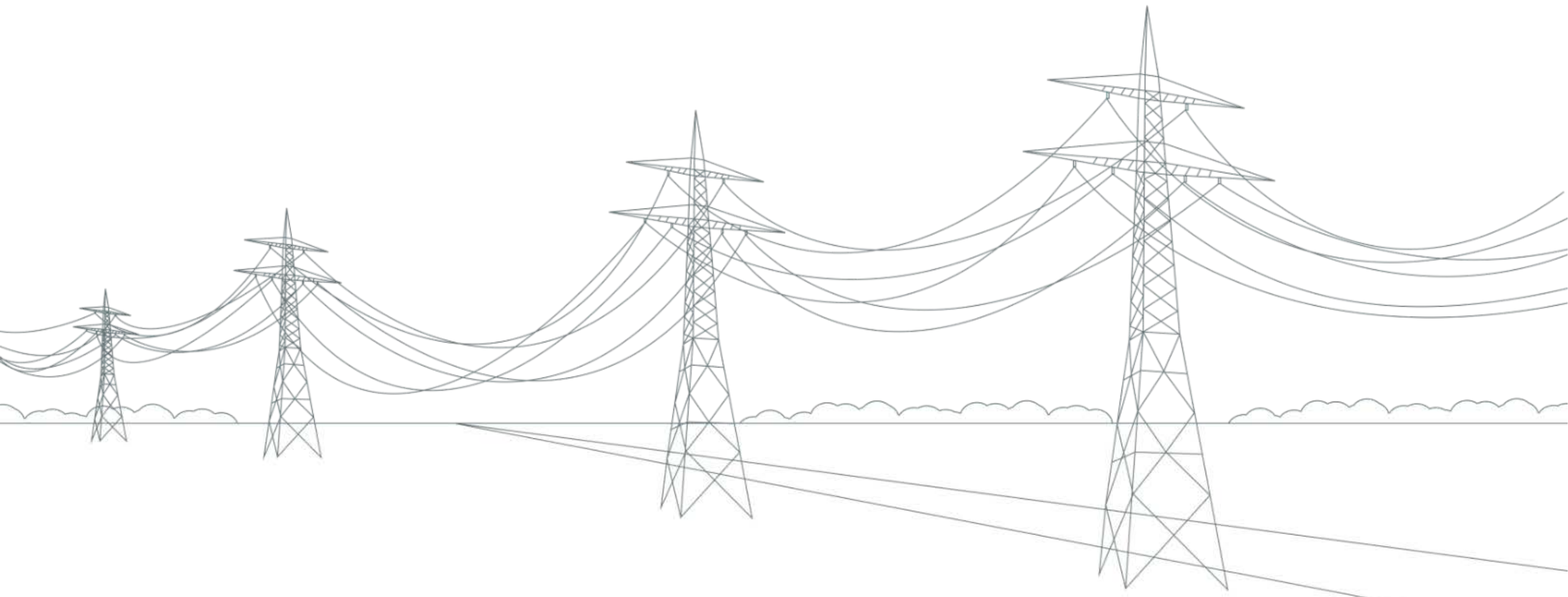
Results GDP 2030 (2017)
Grid analyses



Grid Development Plan 2030 (2017)

Methodology of the GDP 2030

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- The fundamental decision made by the TSOs in the GDP 2012 in favour of a combination of developing the AC power grid and new DC projects is still the basis of the GDP 2030
- Scenarios using the target year 2030 focus on developing the AC grid in combination with point measures to control power flow (no DC grid extension beyond that in FRP 2015)

BASIS
Starting grid = Power Grid Expansion Act + AC

Level 1
GDP 2014
FRP 2015
AC + DC

Level 2
GDP 2030
AC

Level 3
Long-term Scenario B 2035
AC + DC

Grid Development Plan 2030 (2017)

Key results of the network analyses (I)

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- As in the GDP 2025, the measures of the Federal Requirements Plan 2015 prove **robust to changed framework conditions**.
- All scenarios (incl. B 2035) illustrate the **necessity of all measures from the Federal Requirements Plan (FRP) 2015**.
- At the same time, the **combined use of direct and alternating current technology** for ensuring a reliable supply of energy is once again proven necessary.
- However, the FRP measures for 2030 are not sufficient. **Additional AC grid development measures** are required in combination with point measures to control power flow such as serial compensation facilities, phase-shifting transformers or HVDC direct couplers.
- This is due to the target year shifting five years into the future to 2030, resulting in a clear **increase in electricity generation from offshore wind energy and photovoltaic power**. The development of onshore wind energy is slowed down by the EEG 2017 provisions and approximately remains at GDP 2025-levels.

Grid Development Plan 2030 (2017)

Key results of the network analyses (II)

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- **Scenario B 2035** shows that **focusing on the development of the AC-network** with point measures to control power flow, as in B 2030, **will no longer be sufficient**.
- To insure that the network runs efficiently and meets demands, **it is necessary to build additional DC connections** with a total capacity of 6 GW **in addition to further expansion of the AC grid**.
- The **sustainability** of the solution selected by the TSOs in the GDP 2030 will be **re-examined** in the next Grid Development Plan.
- The GDP 2030 includes measures, the **sustainability** of which **is not yet sufficiently discernible**.
- The TSOs have therefore specifically marked some of the measures that have either been identified for the first time in the GDP 2030 or are in addition to those in the FRP 2015 as being so-called **‘measures not yet worthy of proposal**’.

Starting grid GDP 2030 (2017)

The starting grid comprises:

- actual grid (as of 31.03.2017)
- measures from Power Grid Expansion Act (*Energieleitungsausbaugesetz*)
- measures currently being implemented
- measures that are the result of other obligations – e.g. Regulation on Grid Connection of Power Stations (*Kraftwerks-Netzanschlussverordnung* or *KraftNAV*) or industrial commitments

Recabling of existing lines:	200 km
New AC lines in existing routes:	900 km
New AC lines in new routes	600 km
New DC lines:	200 km
Investment:	EUR 6 billion

Grid Development Plan 2030 (2017)

Overload in the starting grid

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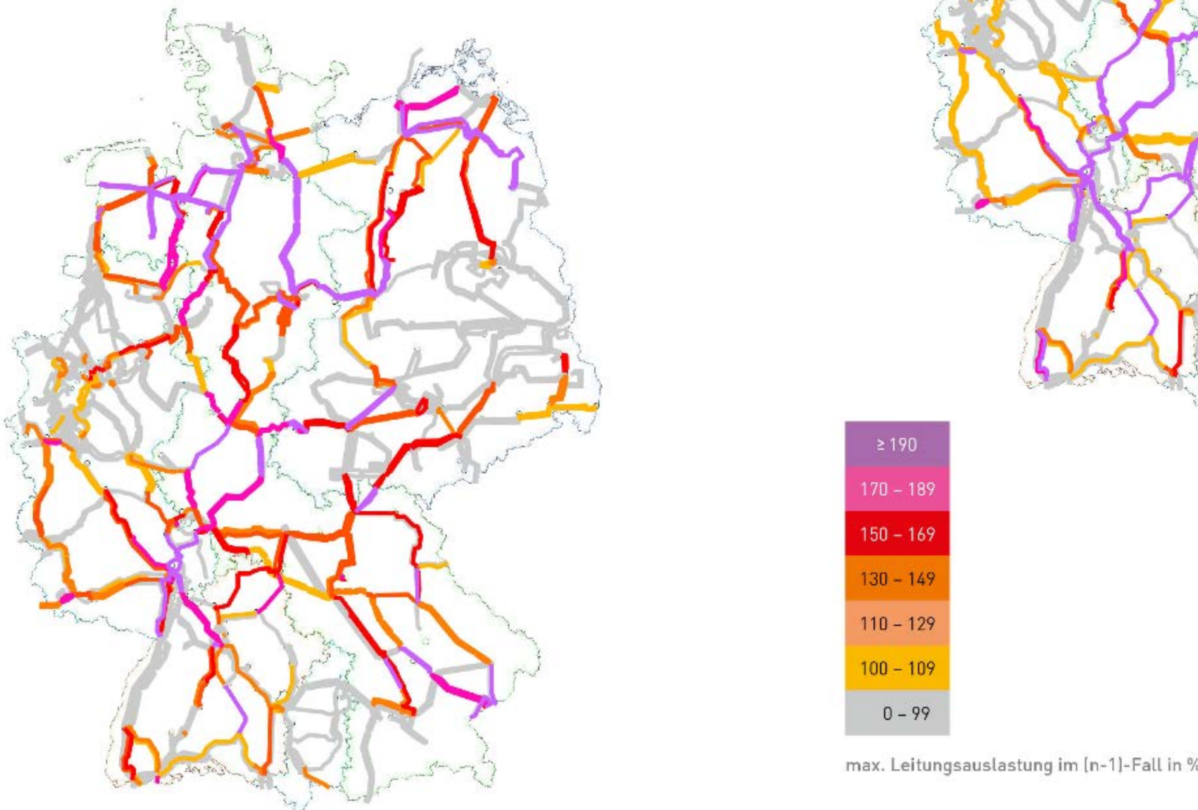
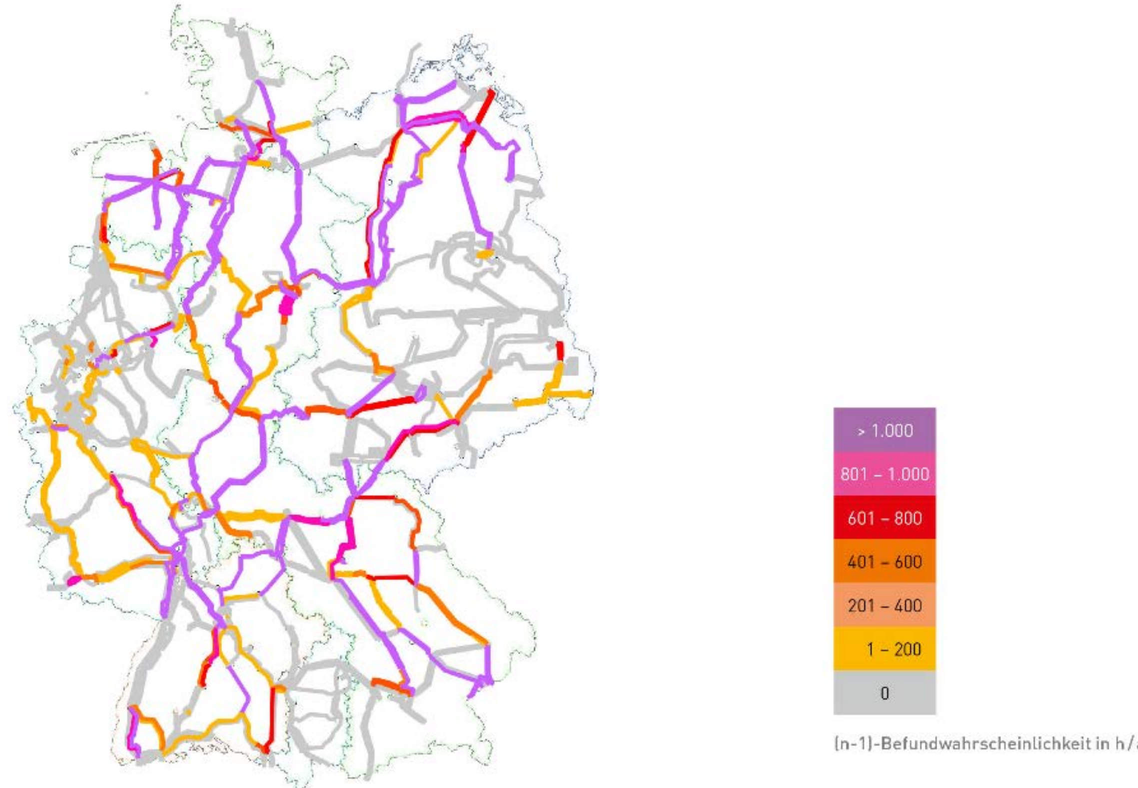
Maximum utilisation of line capacity:
Over 200% in some areas





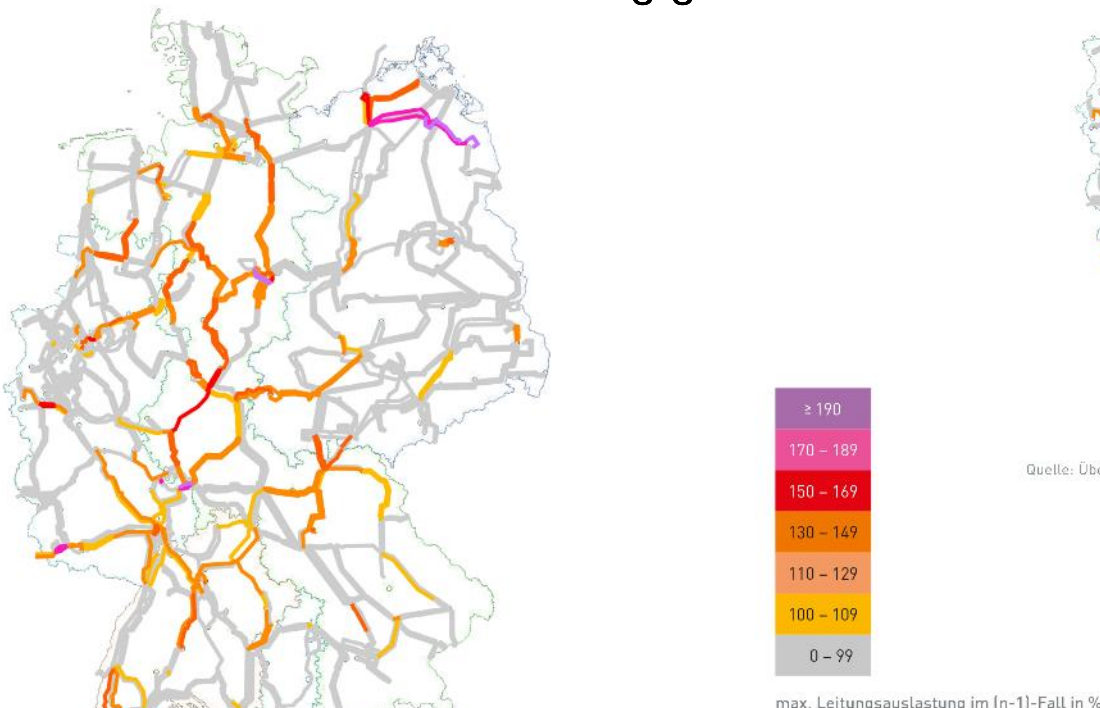
Frequency of overloading:
Over 3,000 hours in some areas

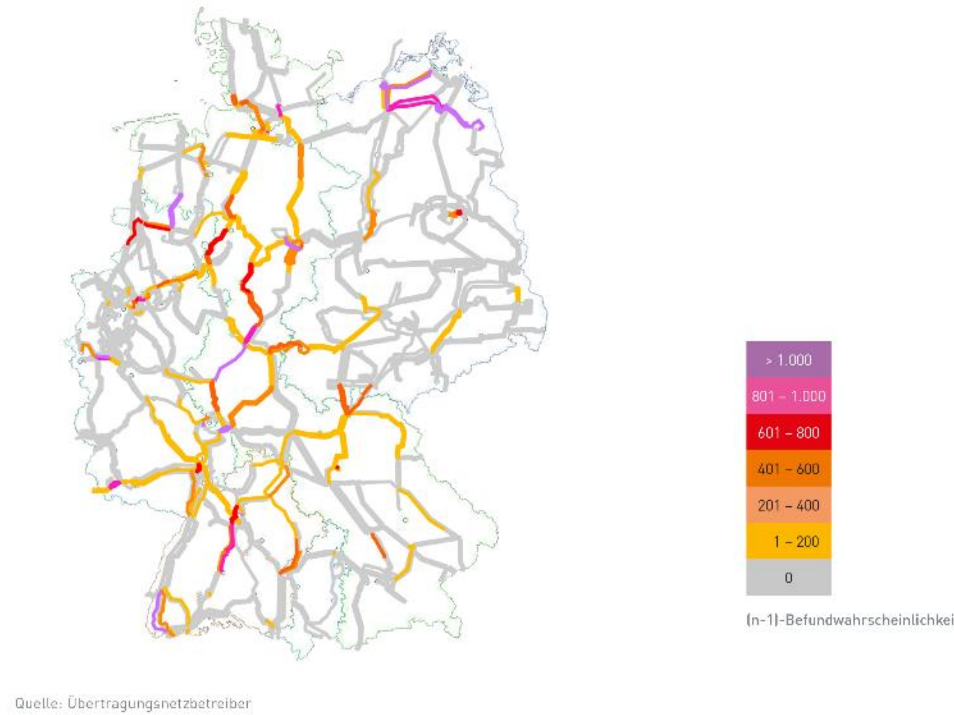
Grid Development Plan 2030 (2017)

Overload in the FRP-Grid

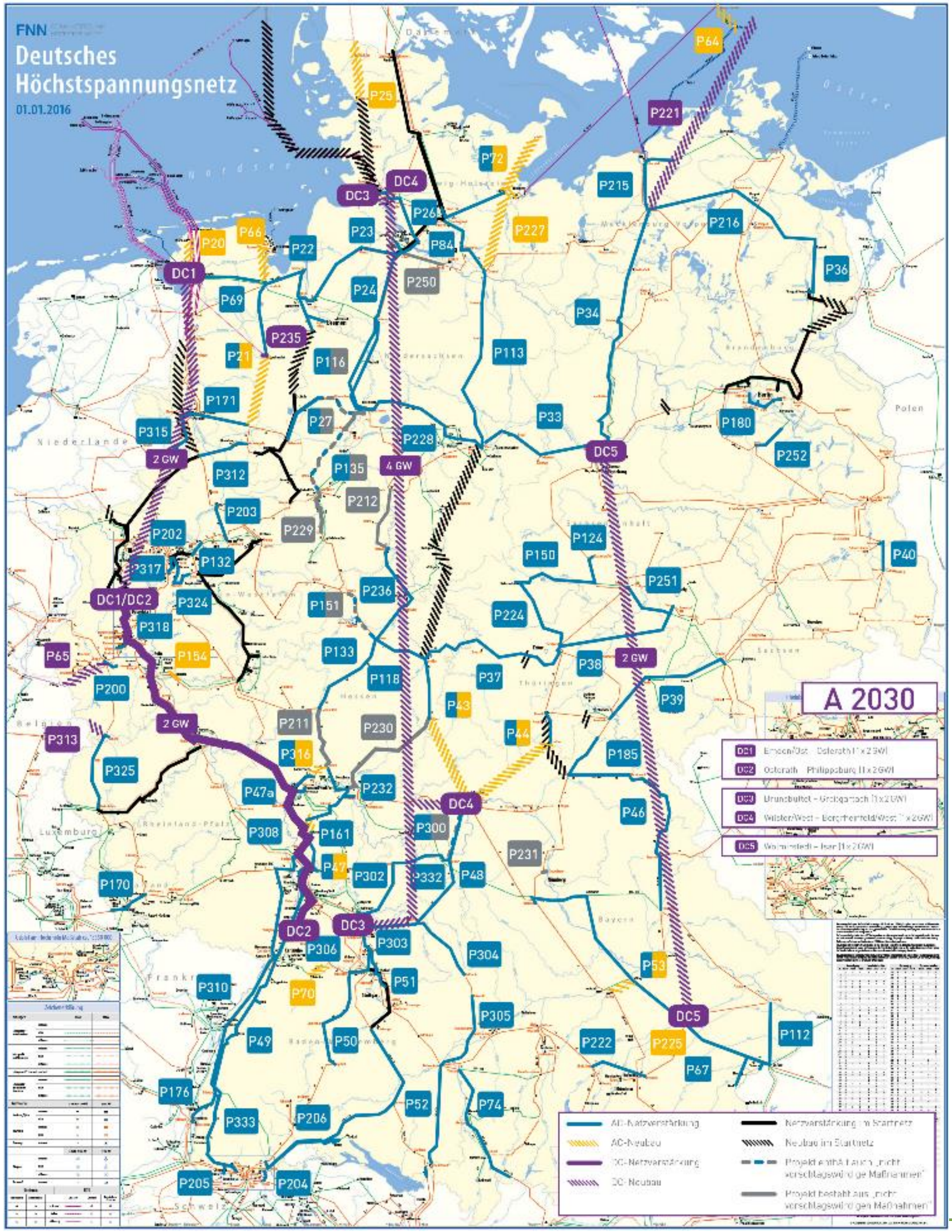
NETZ ENTWICKLUNGS PLAN STROM

Maximum utilisation of line capacity:
Over 200% - as in the starting grid



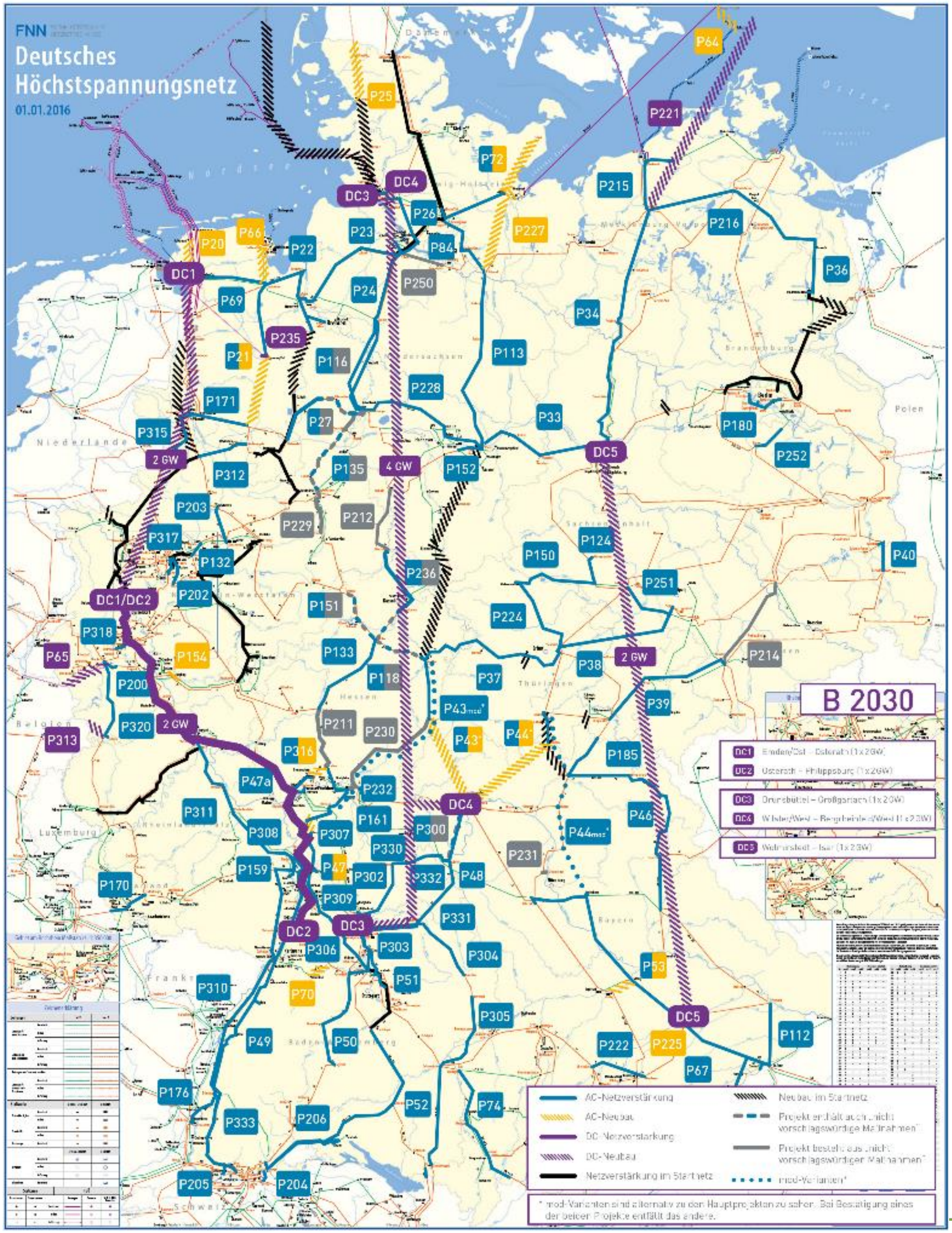


Frequency of overloading:
Over 2,000 hours in some areas



Scenario A 2030 incl. starting grid

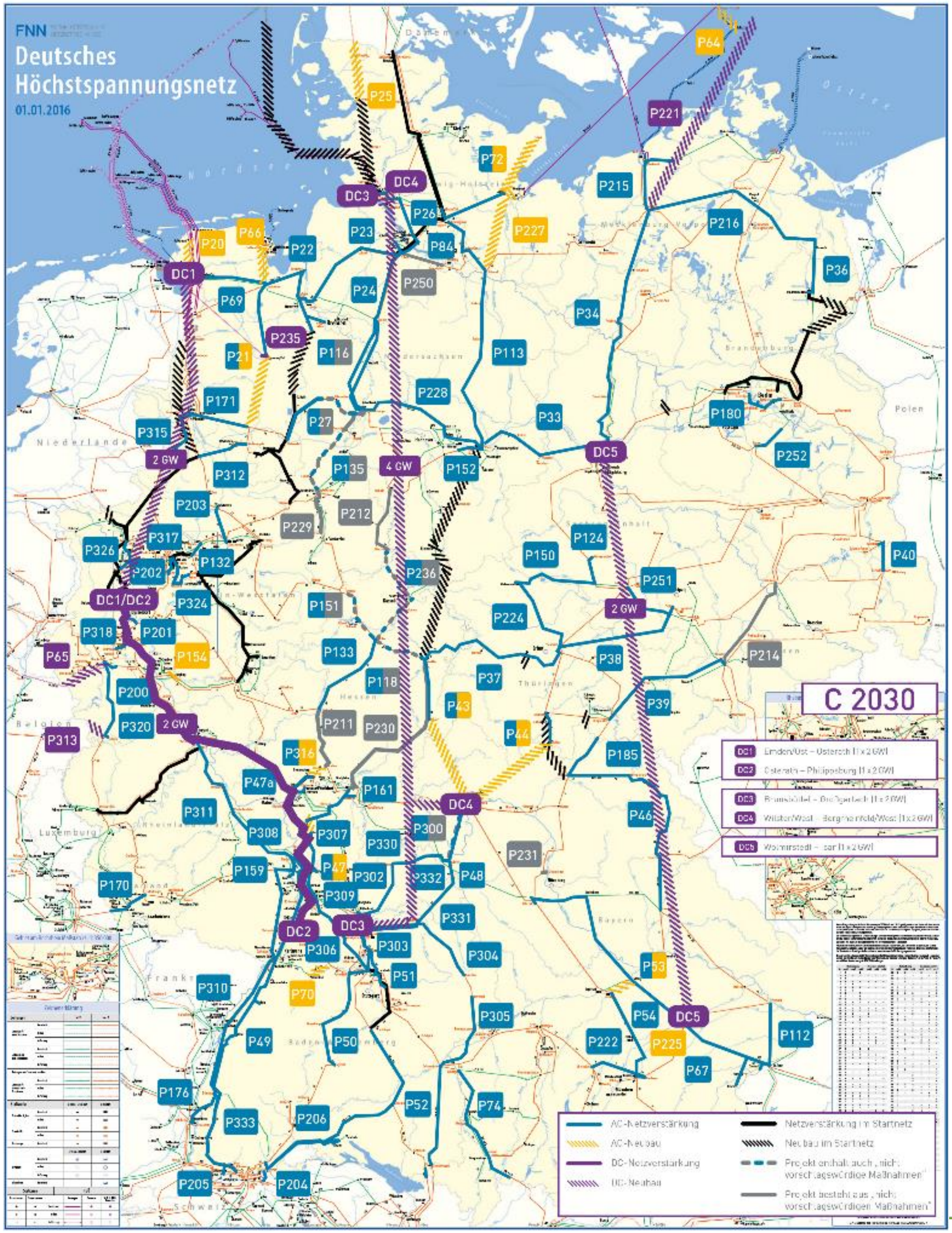
Construction of DC connections in Germany	2,400 km
• Transmission capacity:	8 GW
• Of which interconnectors to Belgium, Norway, Sweden:	330 km
Construction of AC network	1,200 km
DC/AC network development	7,600 km
• Thereof re-cabling	2,900 km
Investment if all DC-lines (except DC2) are built as underground-cables	EUR 32 billion



NETZ ENTWICKLUNGS PLAN STROM

Scenario B 2030 incl. starting grid

Construction of DC connections in Germany	2,400 km
• Transmission capacity:	8 GW
• Of which interconnectors to Belgium, Norway, Sweden:	330 km
Construction of AC network	1,200 km
DC/AC network development	8,200 km
• Thereof re-cabling	2,900 km
Investment if all DC-lines (except DC2) are built as underground-cables.	EUR 33 billion



NETZ ENTWICKLUNGS PLAN STROM

Scenario C 2030 incl. starting grid

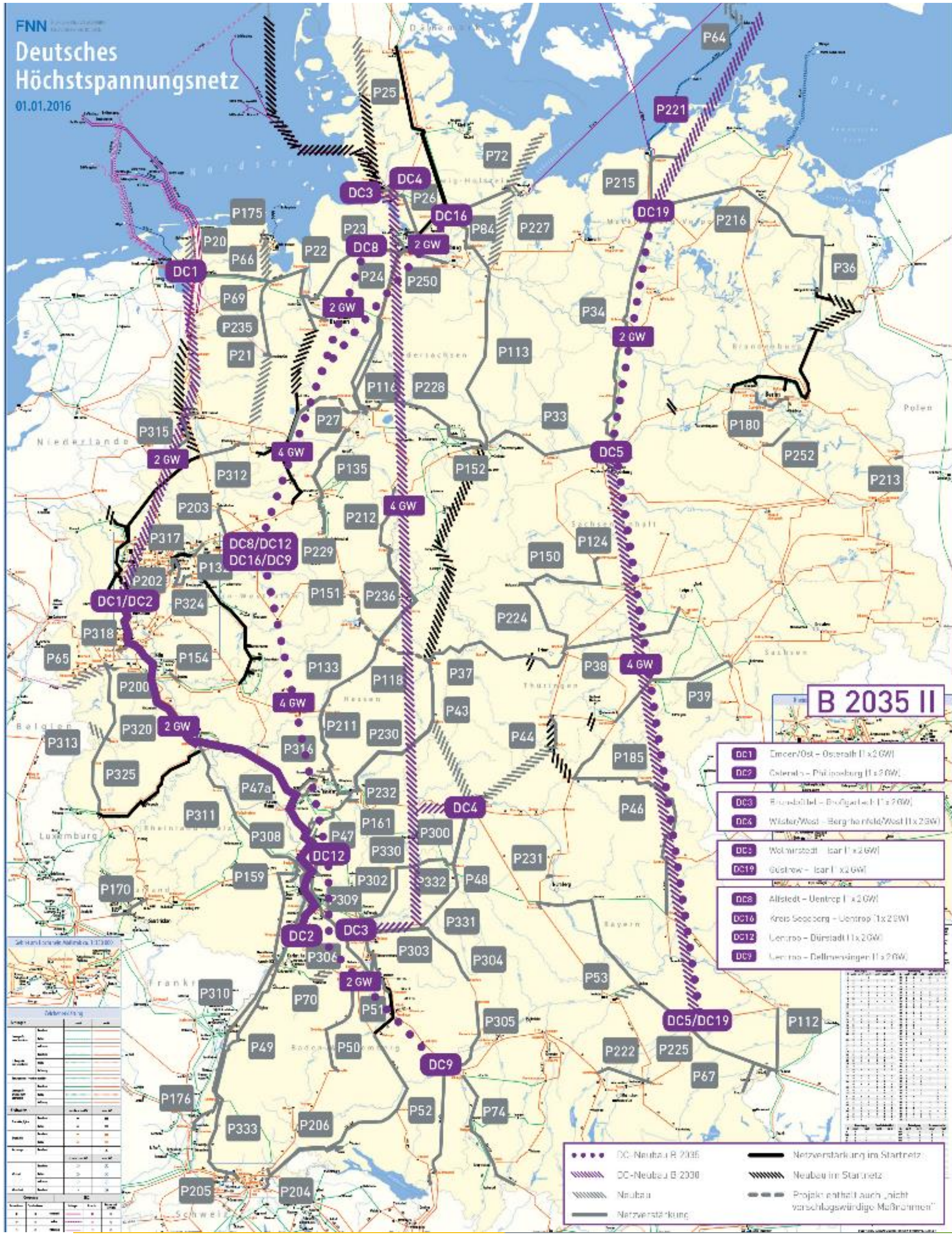
Construction of DC connections in Germany	2,400 km
• Transmission capacity:	8 GW
• Of which interconnectors to Belgium, Norway, Sweden:	330 km
Construction of AC network	1,200 km
DC/AC network development	8,500 km
• Thereof re-cabling	3,400 km
Investment if all DC-lines (except DC2) are built as underground-cables.	EUR 34 billion

NETZ ENTWICKLUNGS PLAN **STROM**

Scenario B 2035: DC-Projects

Option 1

- Increased transmission-demand compared to B 2030
- Development of AC-grid on top of FRP 2017 no longer sufficient.
- In 2035 demand for additional HVDC connection with a capacity of 6 GW
  - DC8/DC12: Alfstedt – Uentrop – Bürstadt with 2 GW over ca. 585 km
  - DC10: Kreis Segeberg – Dellmen-singen with 2 GW over ca. 815 km
  - DC19: Güstrow – Wolmirstedt – Isar with 2 GW over ca. 820 km



NETZ ENTWICKLUNGS PLAN **STROM**

Scenario B 2035: DC-Projects

Option 2

- Increased transmission-demand compared to B 2030
- Development of AC-grid on top of FRP 2017 no longer sufficient.
- In 2035 demand for additional HVDC connection with a capacity of 6 GW
  - DC8/DC12: Alfstedt – Uentrop – Bürstadt with 2 GW over ca. 585 km
  - DC16/DC9: Kreis Segeberg – Uentrop – Dellmensingen with 2 GW over ca. 895 km
  - DC19: Güstrow – Wolmirstedt – Isar with 2 GW over ca. 820 km

Grid Development Plan 2030 (2017)

Demand for grid development and expansion

NETZ
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PLAN **STROM**

Angaben in km	AC-Verstärkung		DC-Verstärkung		AC-Neubau	DC-Neubau	Summe
	Zu-/ Umbeseilung	Neubau in Bestandstrasse	Zu-/ Umbeseilung	Neubau in Bestandstrasse			
Startnetz	*200*	*900*	0	0	600	200	***1.900***
Zubaunetz							
A 2030	*2.400*	*3.700*	*300*	*40*	600	*2.200*	***9.300***
B 2030	*2.800*	*4.000*	*300*	*40*	600	*2.200*	**9.900**
C 2030	*2.900*	*4.200*	*300*	*40*	600	*2.200*	**10.200**
Start- und Zubaunetz							
A 2030	*2.600*	*4.600*	*300*	*40*	1.200	*2.400*	***11.100***
B 2030	*3.000*	*4.900*	*300*	*40*	1.200	*2.400*	***11.800***
C 2030	*3.100*	*5.100*	*300*	*40*	1.200	*2.400*	***12.100***

Hinweis: Abweichungen in den Summen in der Tabelle sind rundungsbedingt.

Quelle: Übertragungsnetzbetreiber

Grid Development Plan 2030 (2017)

Investment costs

NETZ ENTWICKLUNGS PLAN STROM

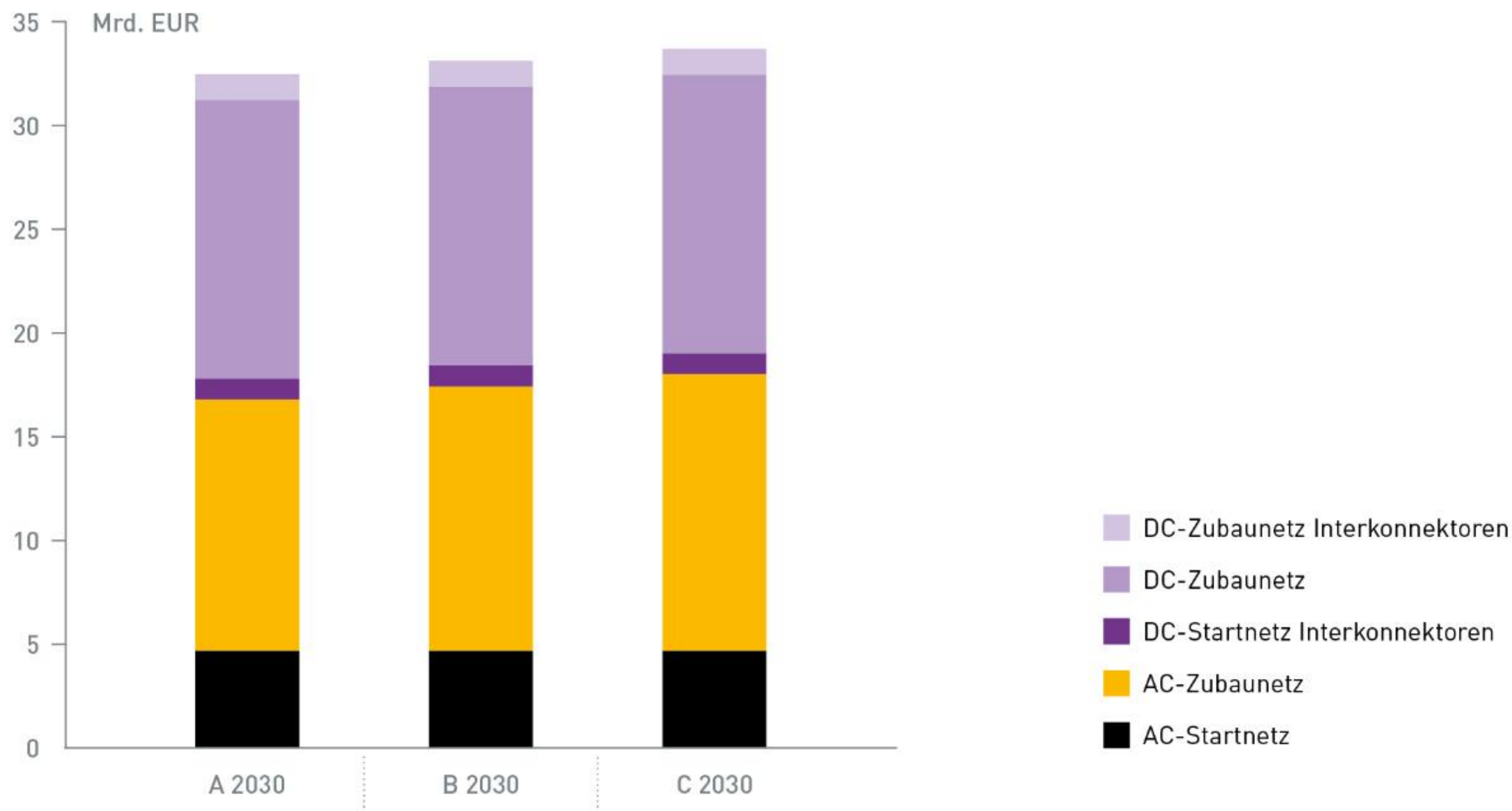
- Calculation of investment costs based on standard costs (provisional!)
- Standard costs for underground DC cables: EUR 4 million/km for 1 x 2 GW, EUR 8 million for 2 x 2 GW
- Volume of investments over ten years totals per scenario:
  - **EUR 32–34 billion** for 100% underground cabling of DC lines (except DC2)
  - **EUR 31–32 billion** for 75% underground cabling of DC lines (except DC2)
  - Includes investment in the **starting grid (approx. EUR 6 billion)**

Angaben in Mrd. EUR (gerundet)	A 2030	B 2030	C 2030
Kabel 100 %	32	33	34
Kabel 75 %	31	32	32

Quelle: Übertragungsnetzbetreiber

Grid Development Plan 2030 (2017)

Investment costs assuming complete underground cabling for DC connections and including DC-interconnectors



Use of underground cables

- In order to calculate the total costs of the HVDC connection lines, a 100% use of underground cabling is assumed for these routes.
  → Alternatively, 75% cabling is assumed, e.g. in order to represent varying specifications in the approval procedure.
- The **additional costs for laying all HVDC connections as underground cables** instead of along overhead lines (EUR 1.5 million/km) are closely linked to the local conditions (e.g. soil quality). In order to estimate costs, expenses of EUR 4 million/km for 1 x 2 GW DC and EUR 8 million/KM for 2 x 2 GW DC are assumed to represent average conditions. These estimations are based on the transmission system operators' initial experiences with AC and DC cables.
- **Underground cabling for AC power lines is possible only for a limited number of pilot projects** which satisfy certain conditions, due to technical and economic efficiency considerations. The final decision about if and where underground cables are to be laid is part of downstream approval procedures. Potential additional costs are therefore <u>not</u> considered in the scope of the GDP.

NETZ ENTWICKLUNGS PLAN STROM

Project characterisation

Grid Development Plan 2030 (2017)

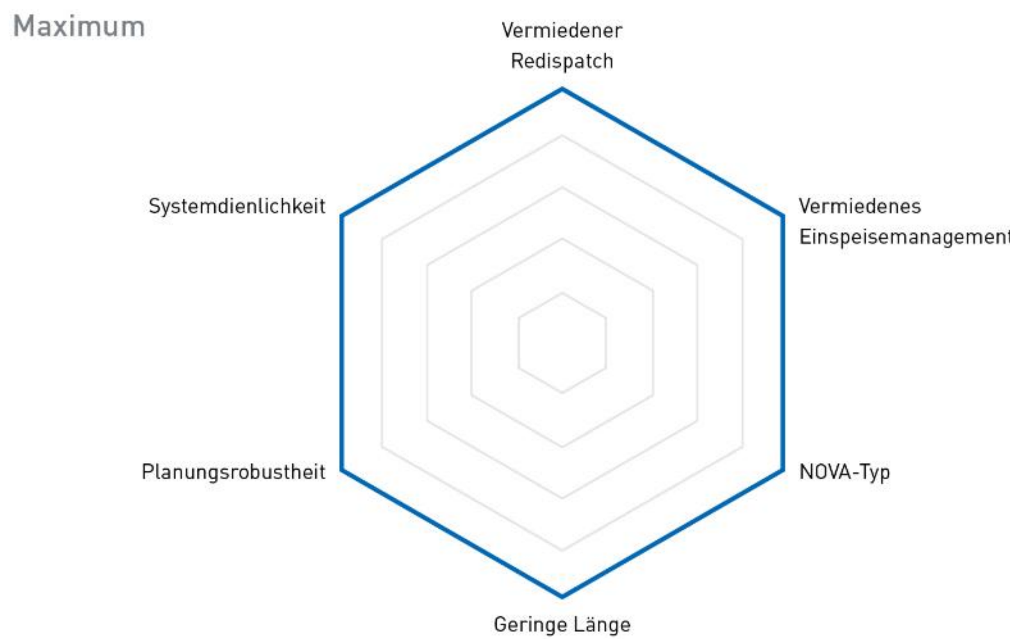
Pilot: Project characterisation

- The TSOs have further developed the evaluation of measures and applied it to the projects of scenario B 2030.
- In the GDP 2030, the projects are described along additional criteria. **This allows for a relative comparison of projects** along the dimensions of the criteria.
- The criteria correspond to different perspectives, for example the amount of avoided redispatch, avoided feed-in management of renewables, relevance for the system, planning-robustness, and the NOVA category.
- The projects in the GDP 2030 are identified via an (n-1) analysis, and are necessary for a grid that meets the demand without congestion.
- The project characterisation characterises the projects, but does **not** demonstrate their necessity.
- The project characterisation was conducted during the consultation-period of the first draft and integrated into the second draft.

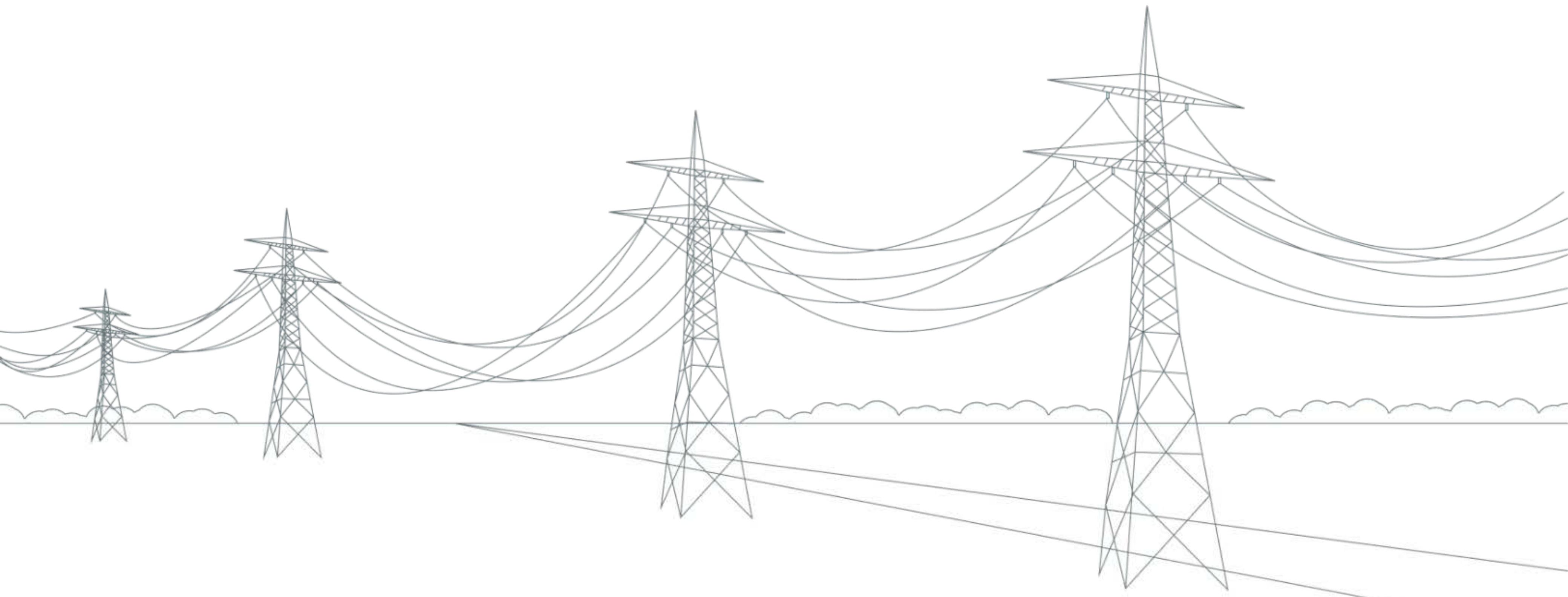
Grid Development Plan 2030 (2017)

Pilot: Project characterisation

- The **results** are depicted in the **project descriptions** as so-called spider graphs.
- The axes are defined to represent **large positive values** in the spider graph.
- An **optimal project** would be at the outer bound of all axes of the spider graph.

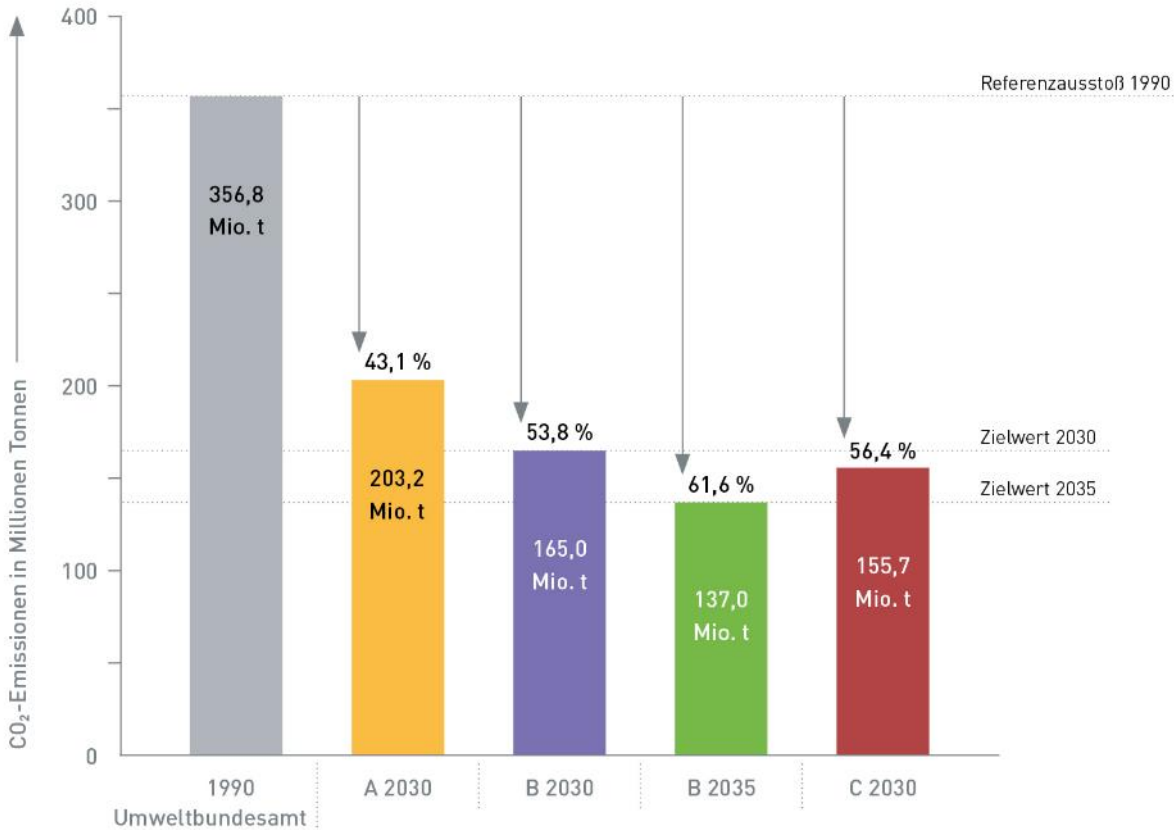


Backup



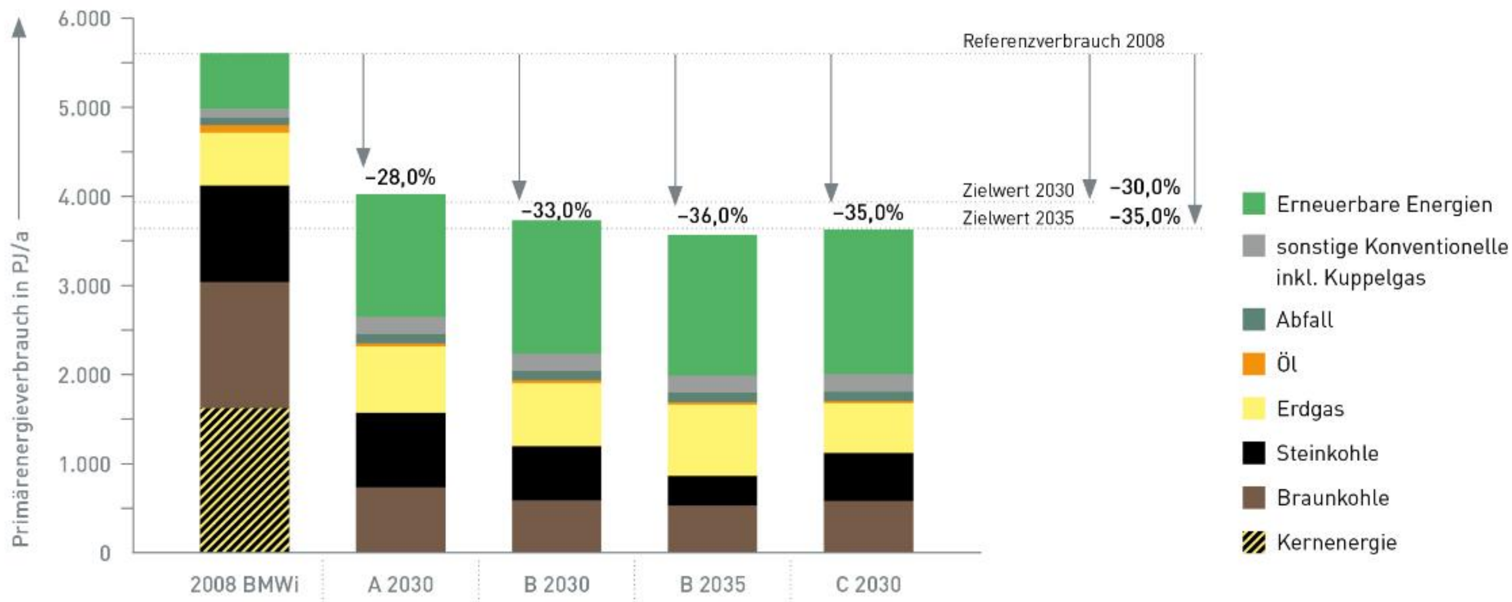
Grid Development Plan 2030 (2017)

CO_2 emissions in German electricity generation in all scenarios of the GDP 2030



Grid Development Plan 2030 (2017)

Primary energy consumption in German electricity generation in all scenarios of the GDP 2030



Grid Development Plan 2030 (2017)

Renewable energy as share of total power consumption