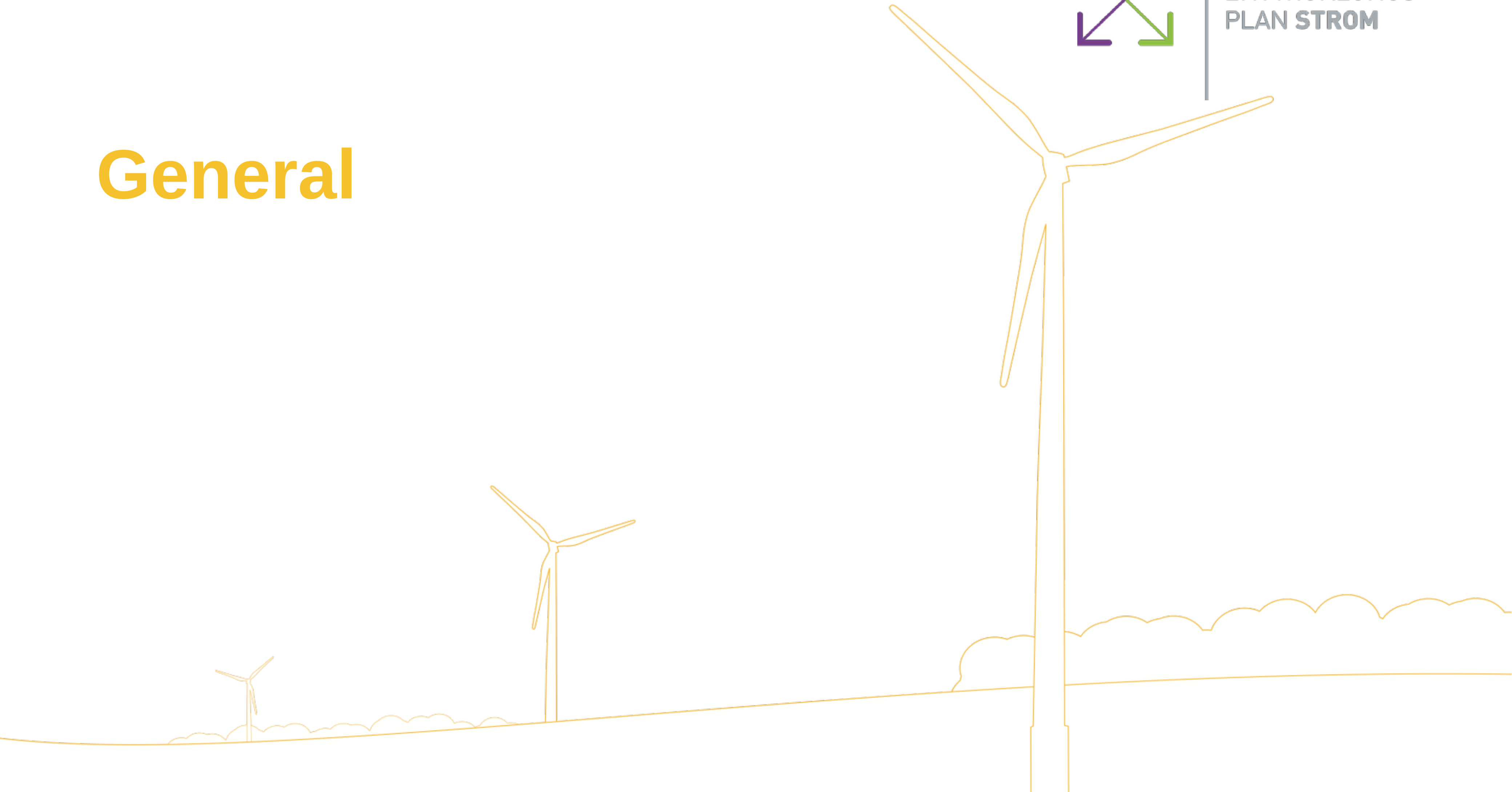
Grid Development Plan 2030 (2017), first draft

General



Grid Development Plan 2030 (2017)

The Grid Development Plan ...

NETZ ENTWICKLUNGS PLAN **STROM**

… 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, increased links between sectors** 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**.

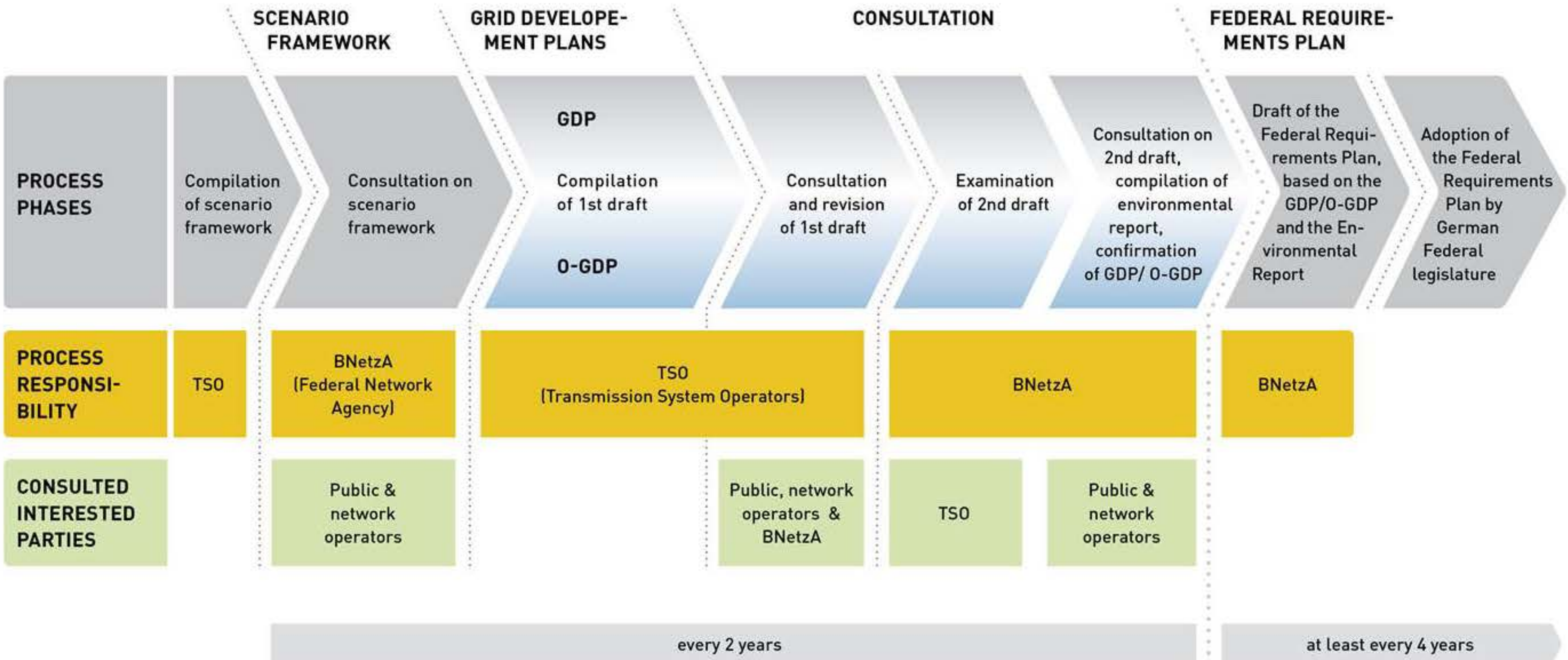
... indicates measures with priority placed on network optimisation over development, which in turn is a higher priority than network expansion.

... 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



Grid Development Plans 2030 (2017)

Timeline – Where we stand.

NETZ ENTWICKLUNGS 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

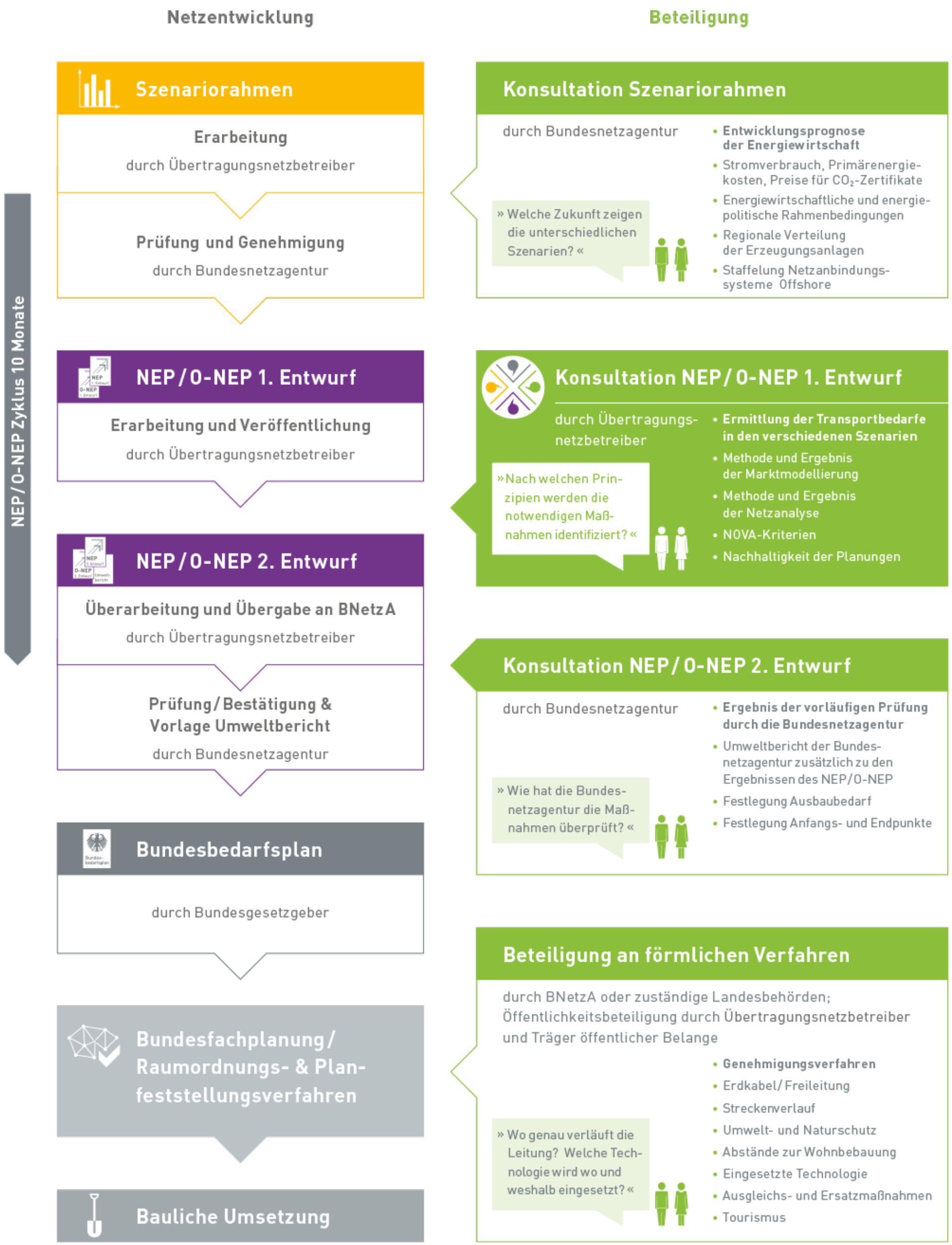
- 30.06.2016 – Approval of the scenario framework (start of 10 month deadline)
- 31.01.2017 – Publication
- 31.01 – 28.02 – Consultation period
- End of April (May 2nd at the latest) – second drafts
- Subsequent review and consultation by the Federal Network Agency
- End of December 2017: approval by the Federal Network Agency (target deadline as per the German Energy Management Act)

GDP 2030, 2019 version

- 10.01.2018 – Submission of TSO draft for the scenario framework

Grid Development Plans 2030 (2017)

Overview of the consultation process



NETZ ENTWICKLUNGS PLAN STROM

Grid Development Plans 2030 (2017)

Key changes compared to the GDP 2025

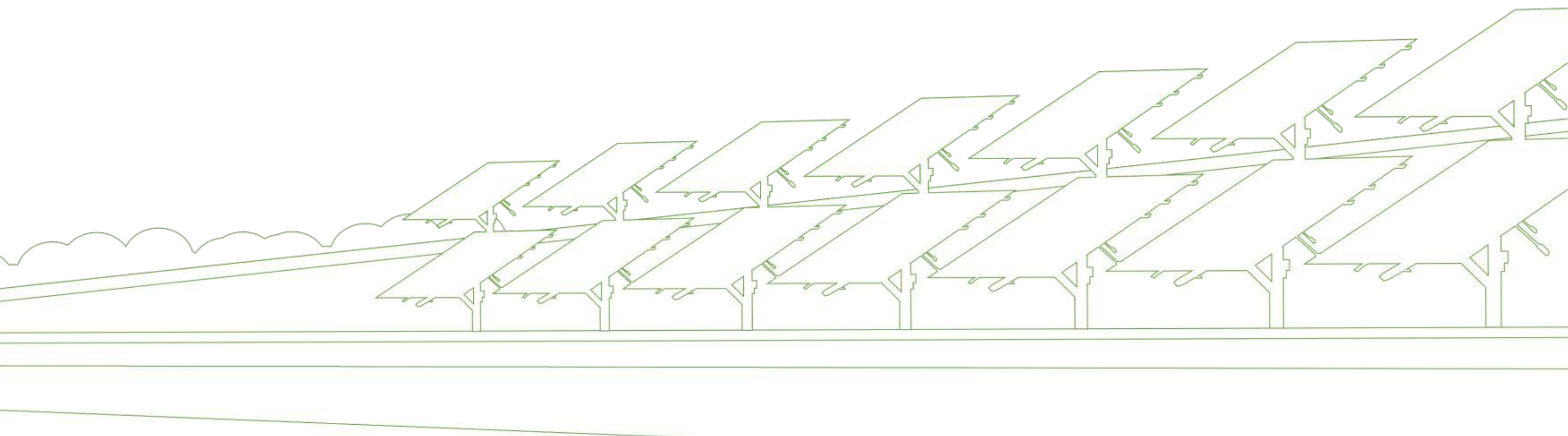
NETZ ENTWICKLUNGS PLAN STROM

- Comprehensive depiction of the revised Renewable Energy Act which came into effect at the start of 2017 (**EEG 2017**) → Expansion of onshore wind power is slowed down
- **Areas of grid expansion** have not been taken into account
- O-GDP 2030 incorporates the new Offshore Wind Act, which took effect in early 2017
- Approval of the scenario framework by the Federal Network Agency dated 30.06.2016:
  - Calculation of **four scenarios** with flexible target horizon:
    A 2030, B 2030, C 2030 and B 2035
  - In the scenarios B 2030, C 2030 and B 2035, German power plants must collectively comply with a CO_2 emission limit as a secondary condition to the market simulation
  - 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 network for "the last kilowatt hour generated from renewable energy sources"
- New methods for the regionalisation of energy consumption

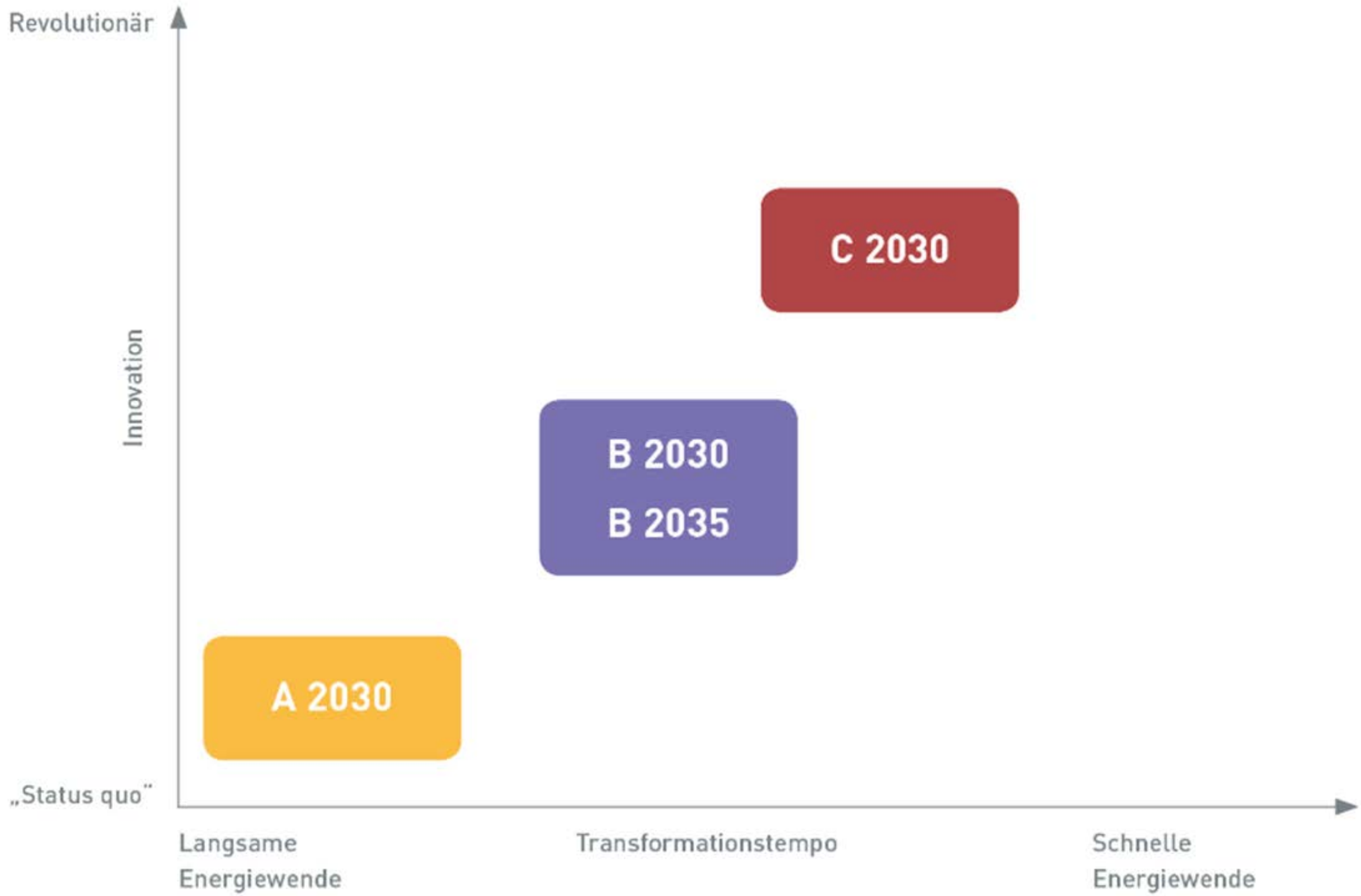
NETZ ENTWICKLUNGS PLAN STROM

Grid Development Plan 2030 (2017)
Scenario framework



Grid Development Plan 2030 (2017)

Classifying the scenarios



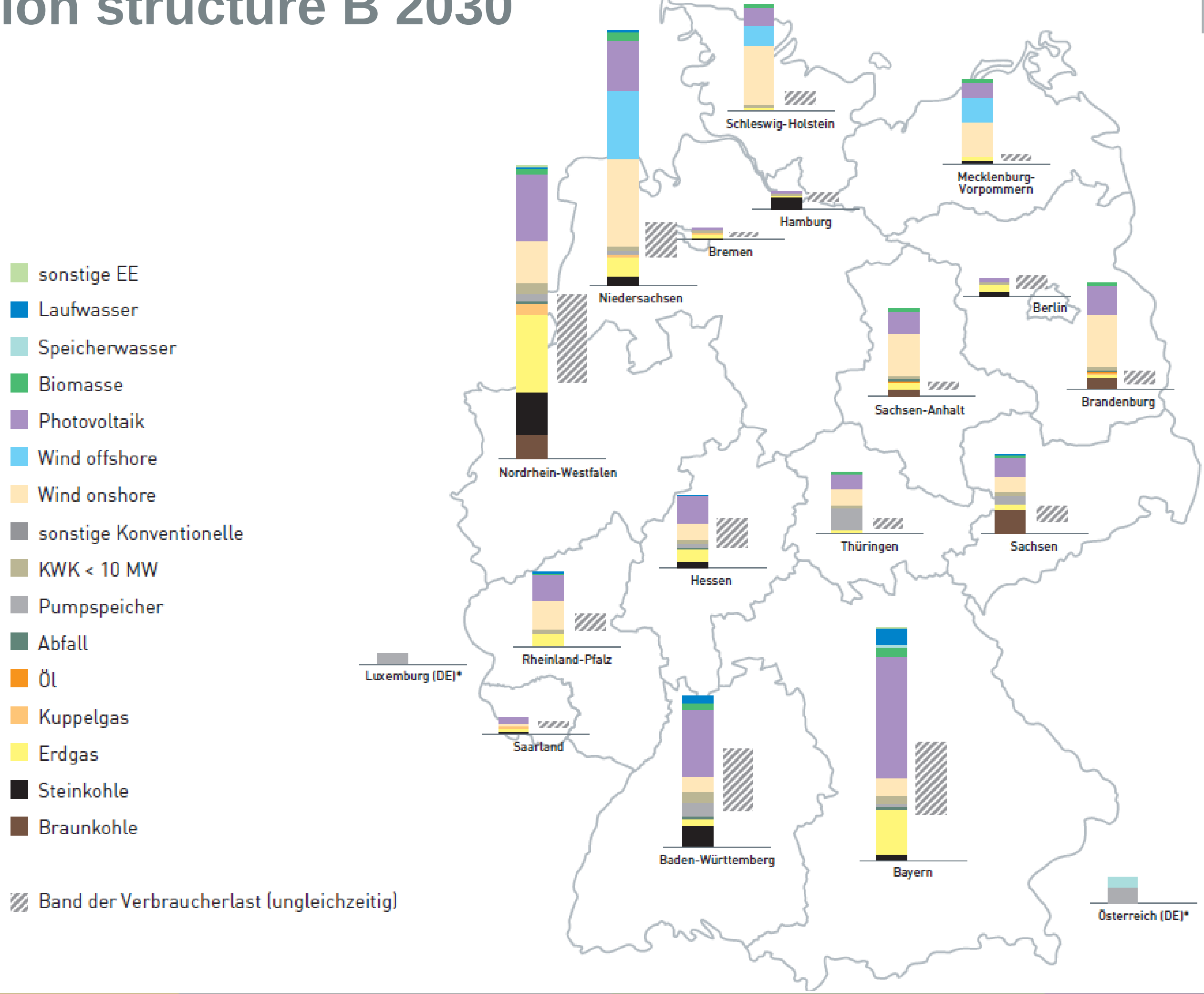
Grid Development Plan 2030 (2017)

Overview of all scenarios

	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
3% peak capping onshore wind/solar	Yes	Yes	Yes	Yes
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

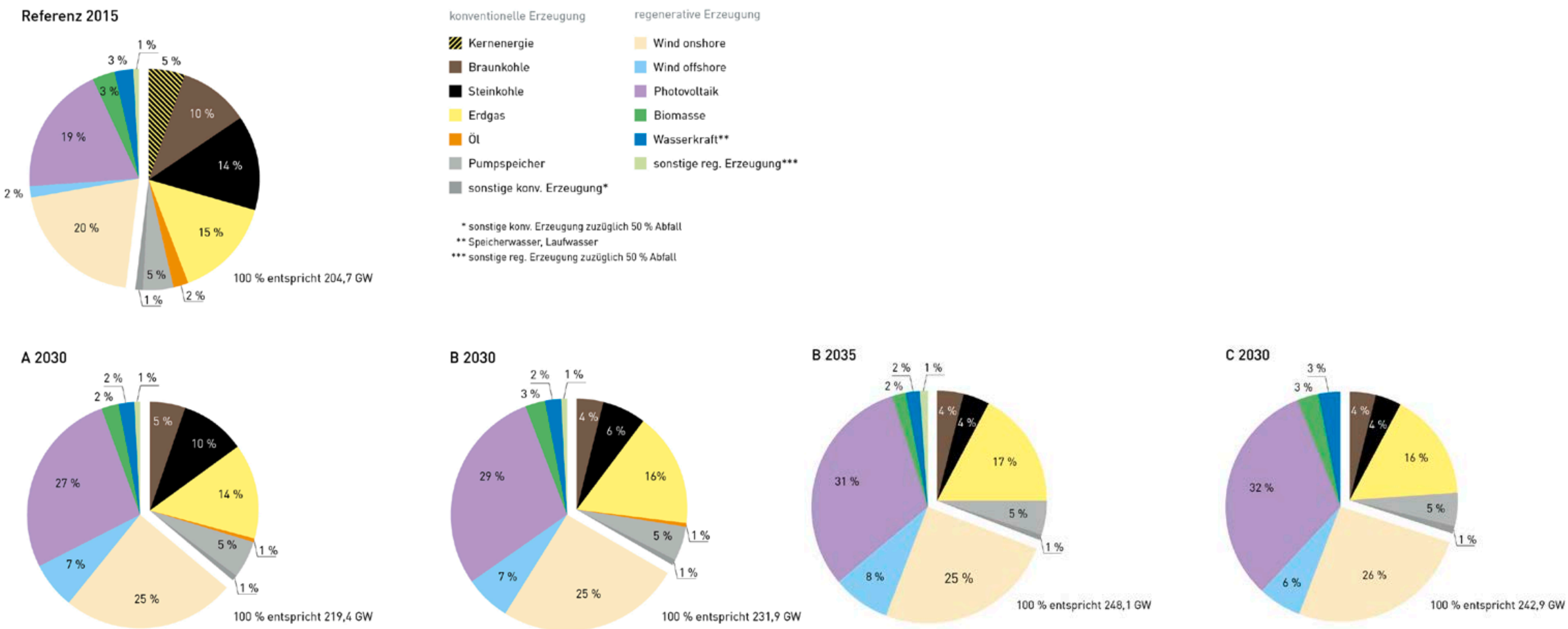
Grid Development Plan 2030 (2017)

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

NETZ ENTWICKLUNGS PLAN STROM

- 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 network 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

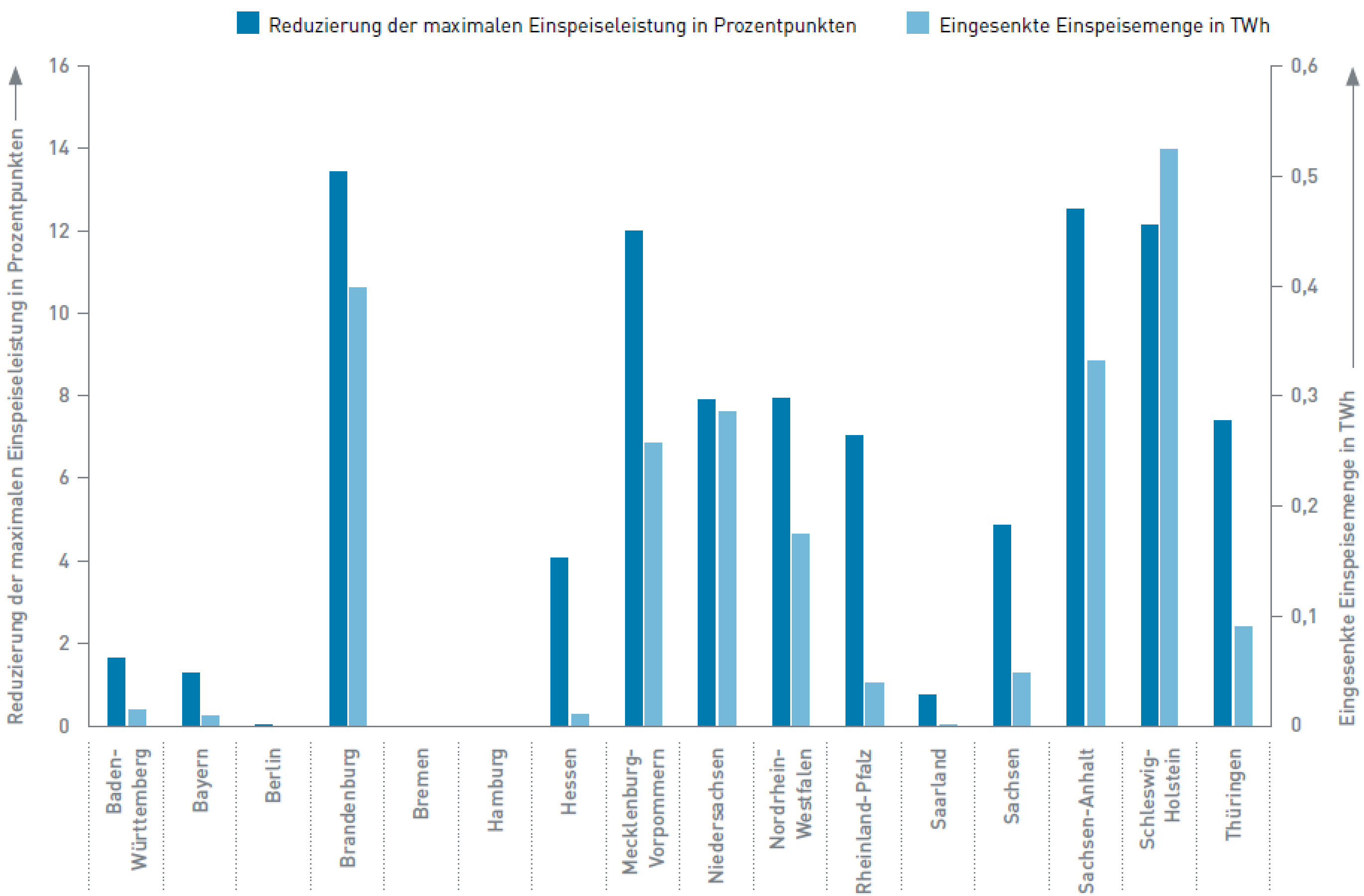
Reduced feed-in amounts for onshore wind and photovoltaic

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

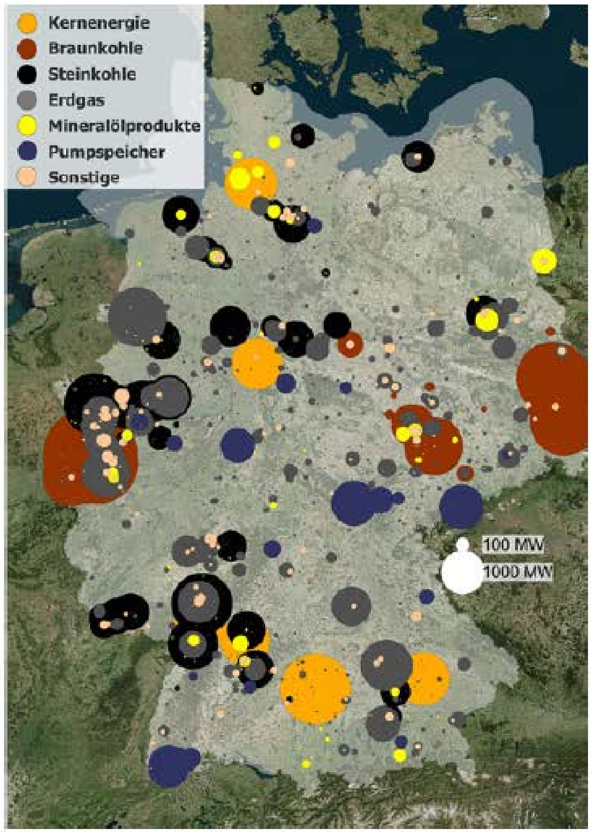
NETZ ENTWICKLUNGS PLAN STROM



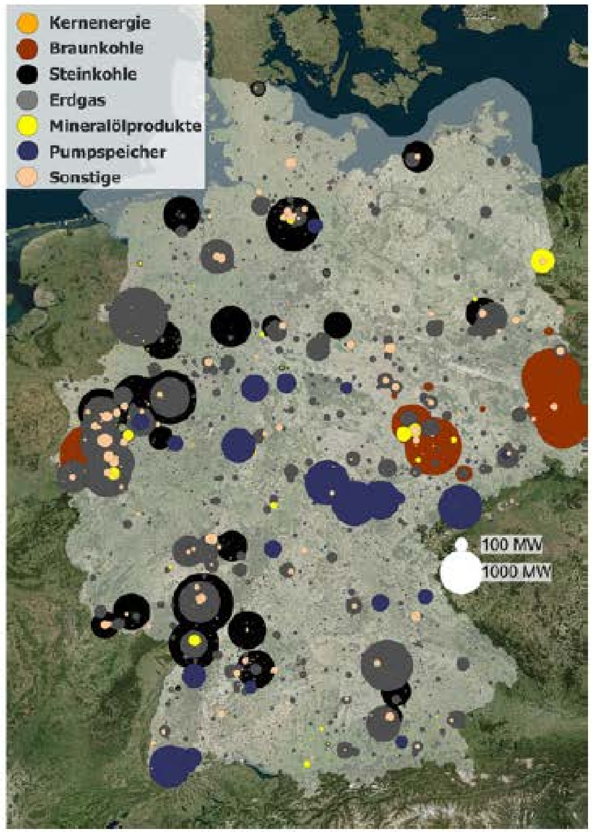
Grid Development Plan 2030 (2017)

Development of conventional generation capacity

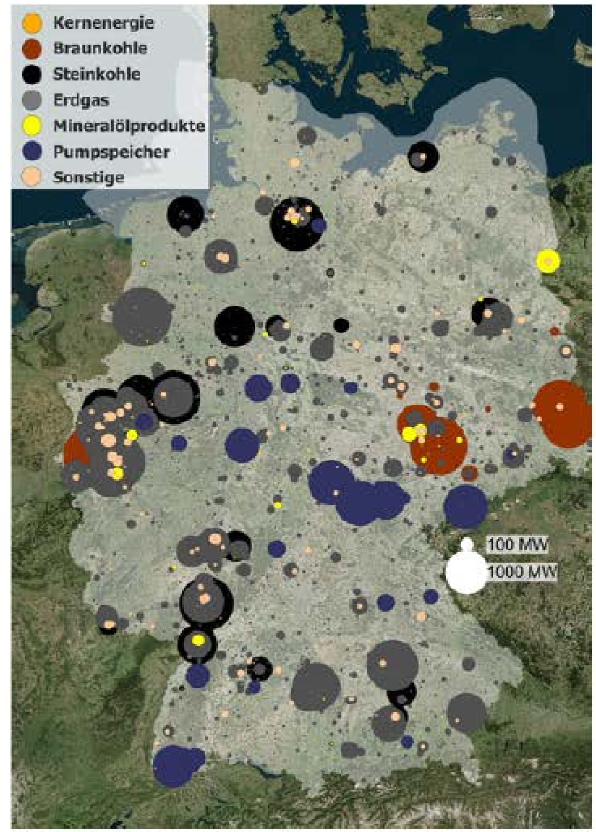
Referenzjahr 2015



A 2030



B 2030

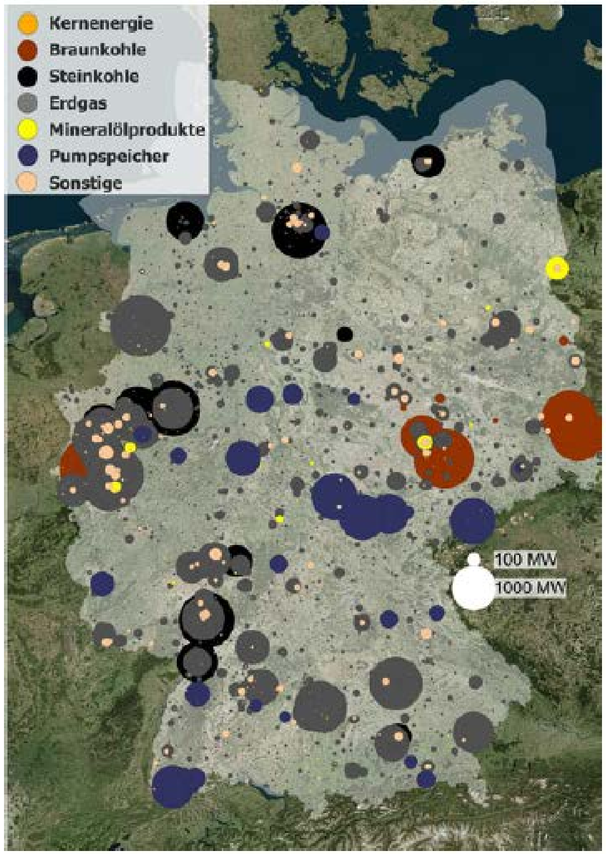


Grid Development Plan 2030 (2017)

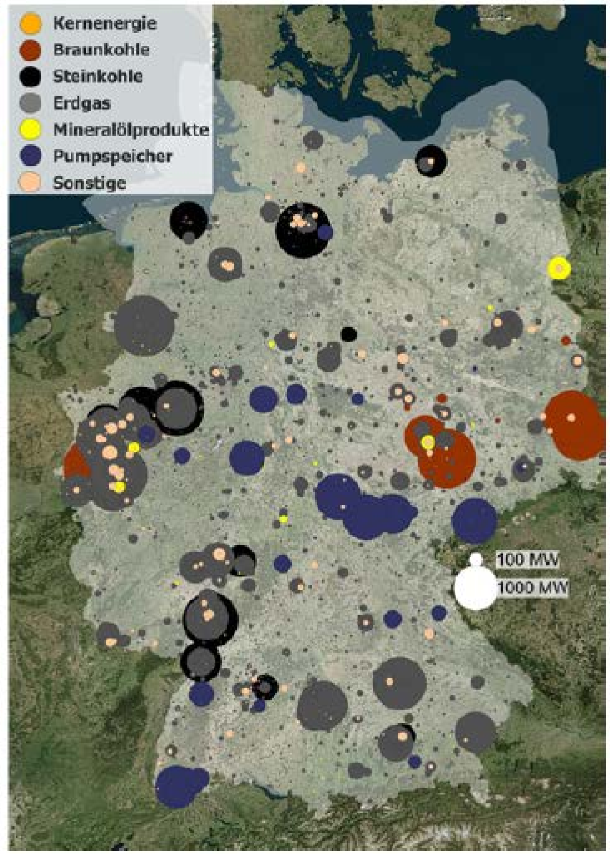
Development of conventional generation capacity

NETZ ENTWICKLUNGS PLAN STROM

B 2035

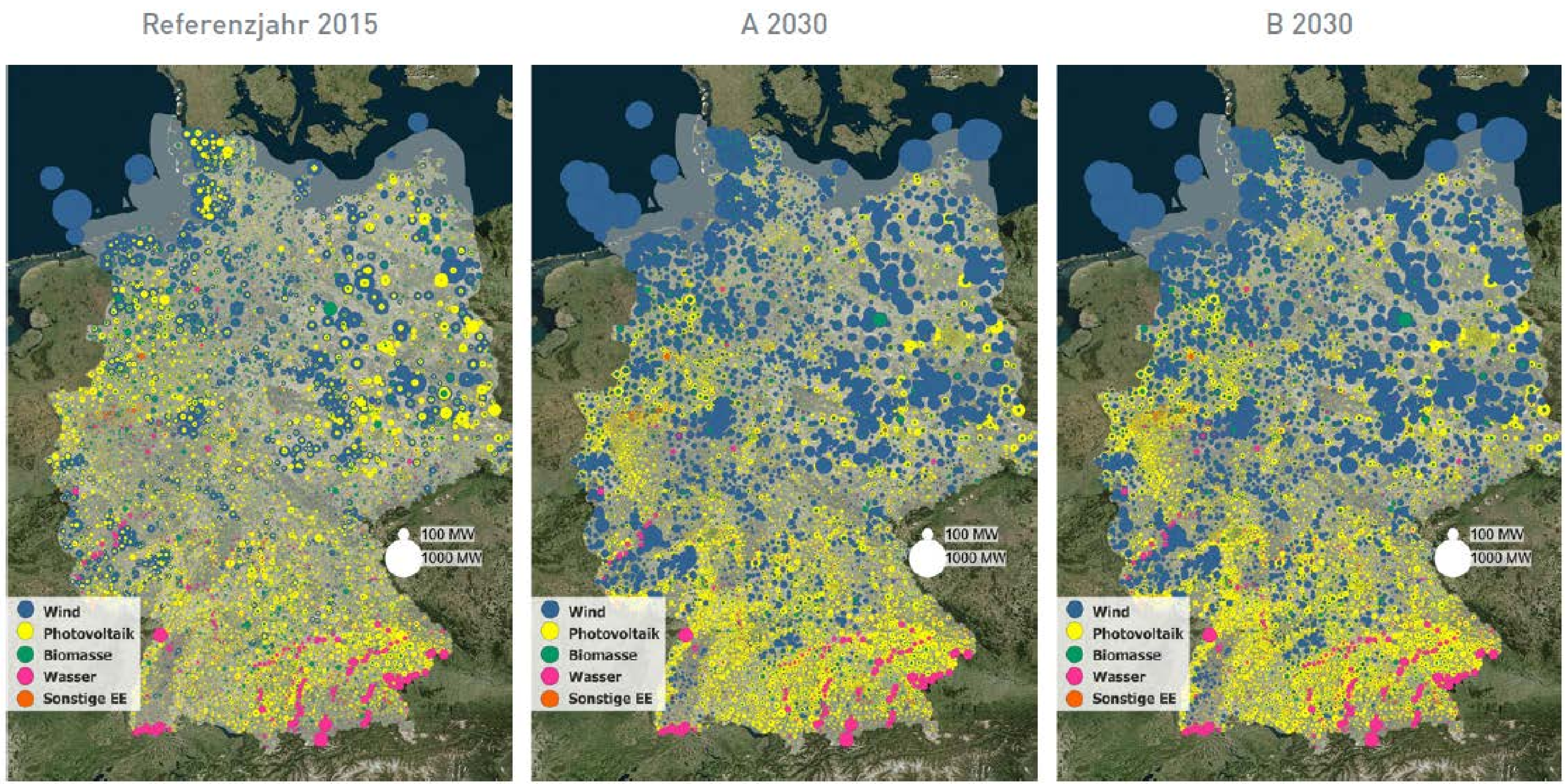


C 2030



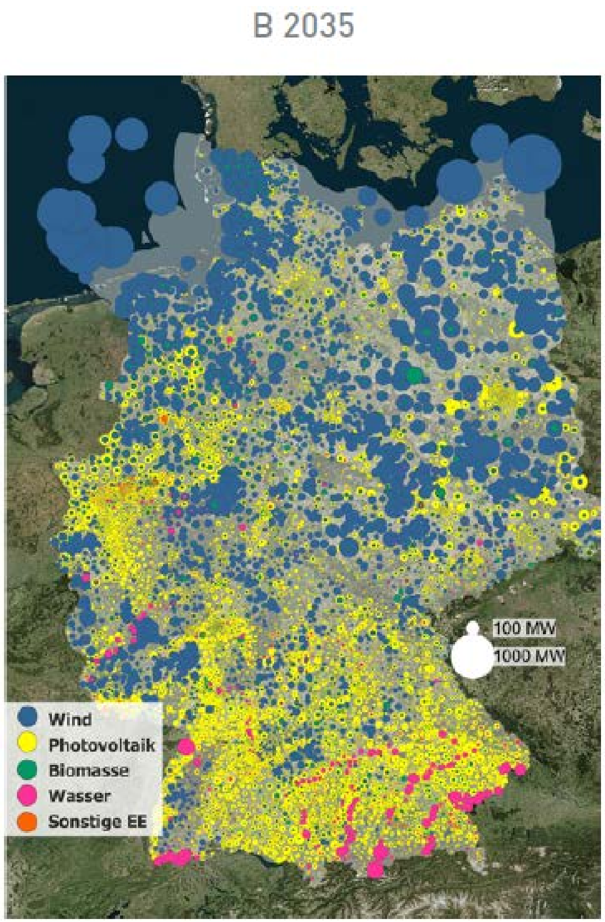
Grid Development Plan 2030 (2017)

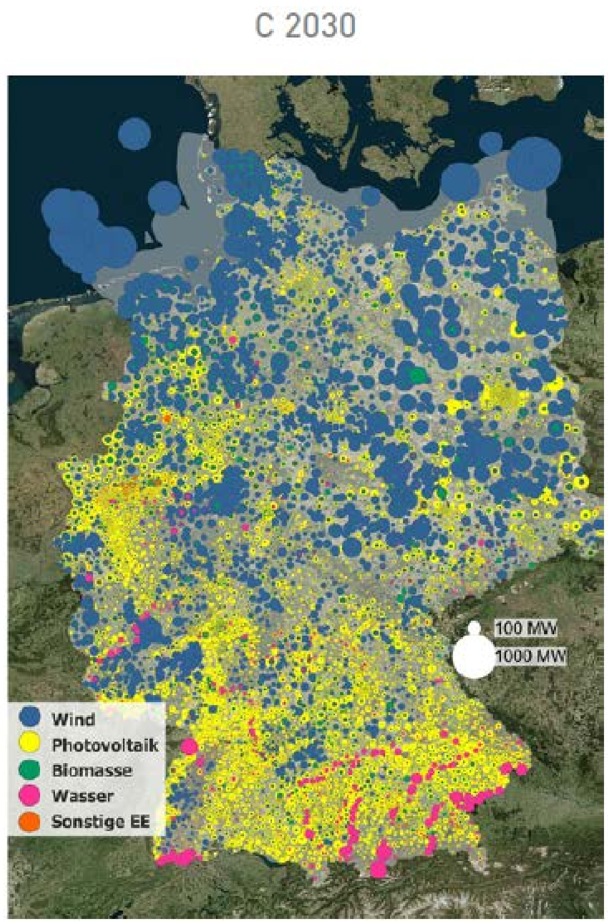
Development of renewable energy generation capacity



Grid Development Plan 2030 (2017)

Development of renewable energy generation capacity





Grid Development Plan 2030 (2017)

Scenario framework – results of modelling regional energy demands

NETZ ENTWICKLUNGS PLAN STROM

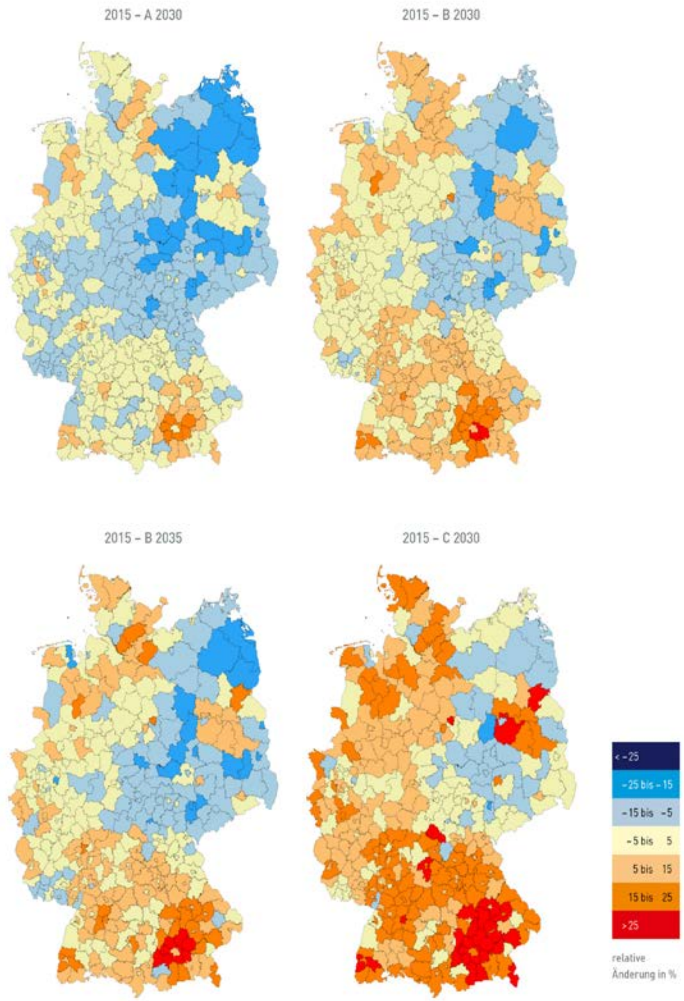
- Urban regions and neighbouring conurbations show higher energy demands and increases in respective annual peak loads
- Majority of districts in the states of former East Germany and more rural areas show falling energy demands
- Scenario C 2030: overall there is a clear rise in the net energy demand 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)

NETZ ENTWICKLUNGS PLAN STROM

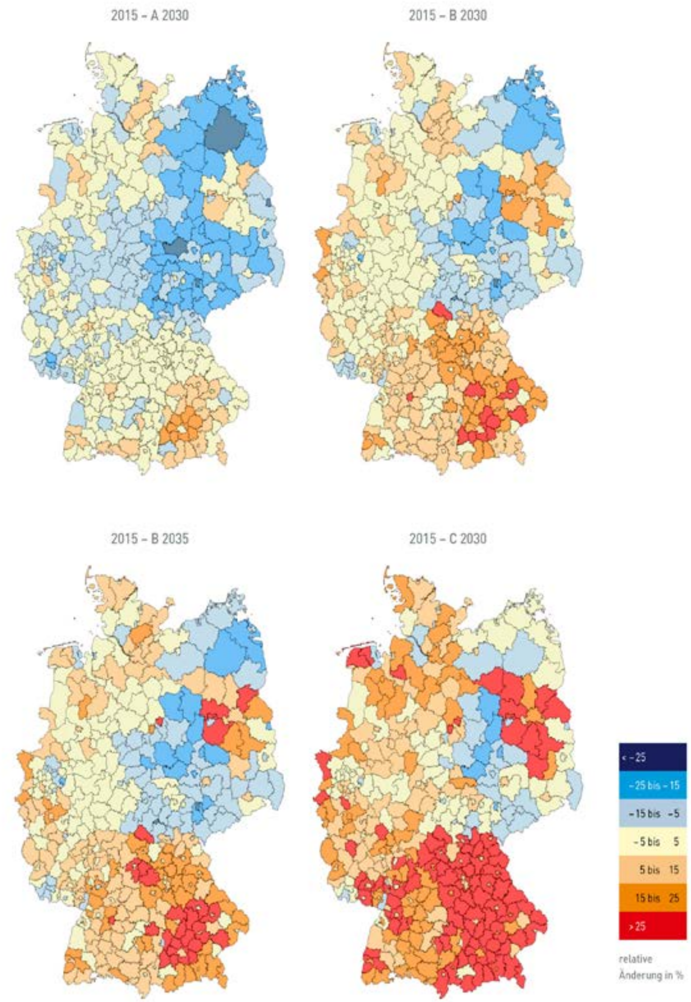
Scenario framework – results of modelling regional energy demands

Abbildung 7: Veränderung der Nettostromnachfrage je Landkreis



Quelle: Übertragungsnetzbetreiber

Abbildung 8: Veränderung der zeitungleichen Jahreshöchstlasten je Landkreis

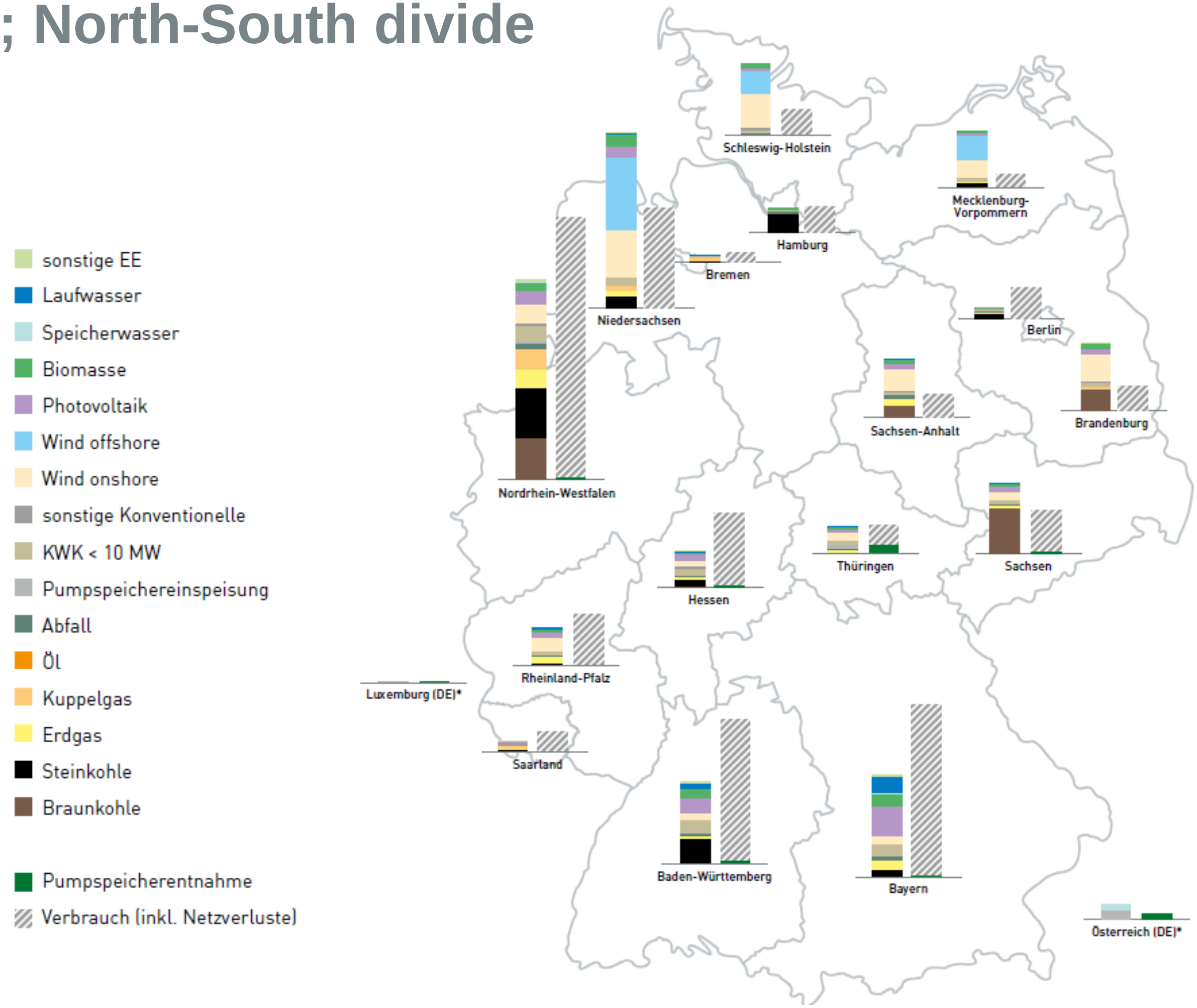


Quelle: Übertragungsnetzbetreiber

Grid Development Plan 2030 (2017)

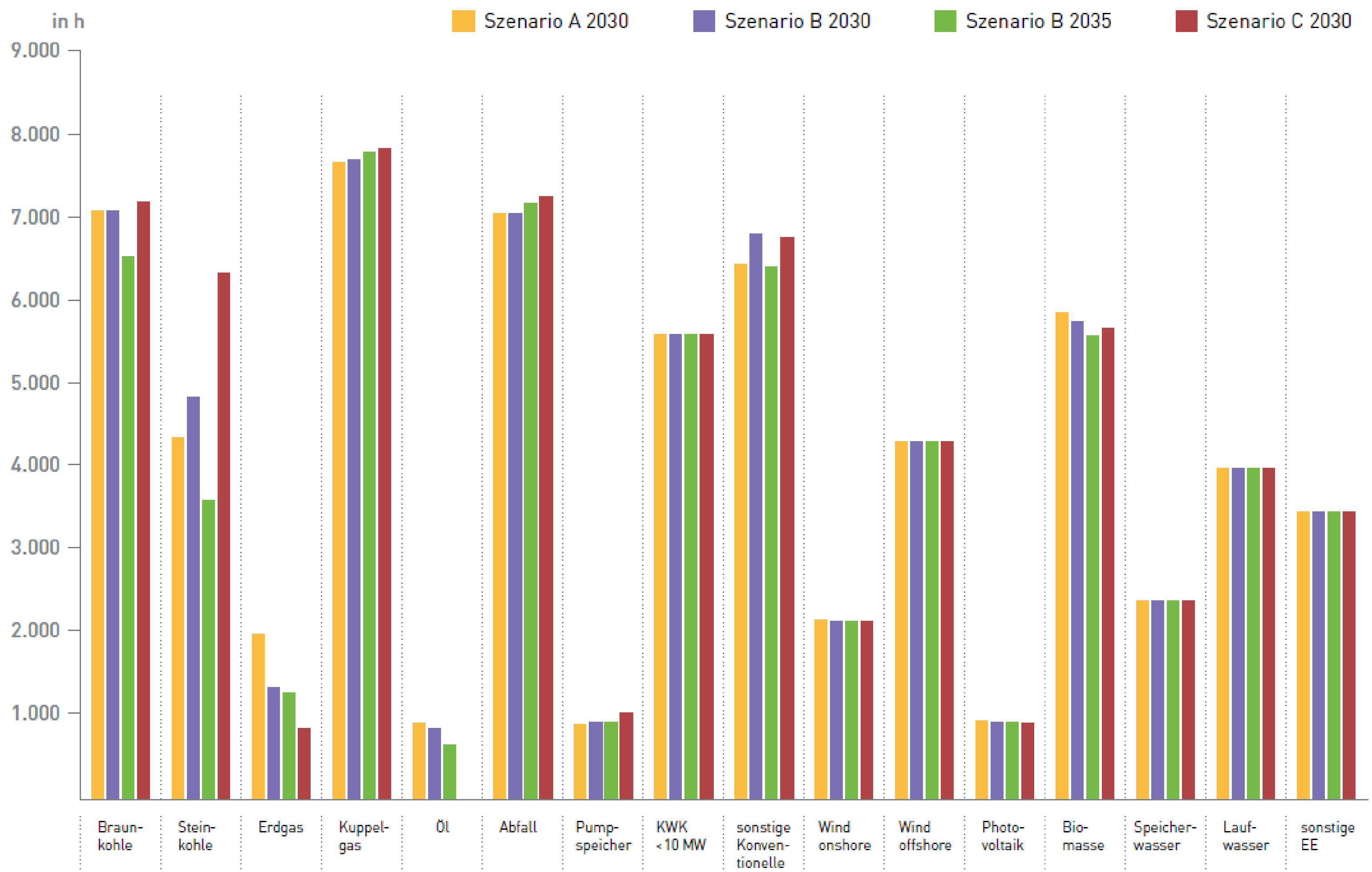
B 2030 – Energy supply and demand balance (per state); North-South divide

NETZ ENTWICKLUNGS PLAN STROM



Grid Development Plan Power 2030 (2017)

Full load hours of conventional power stations

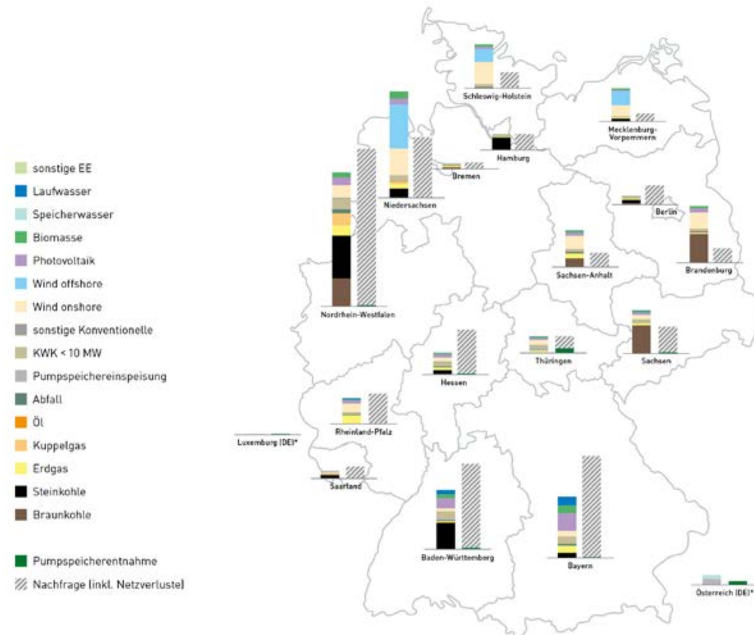


Grid Development Plan 2030 (2017)

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-verlusten)	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.

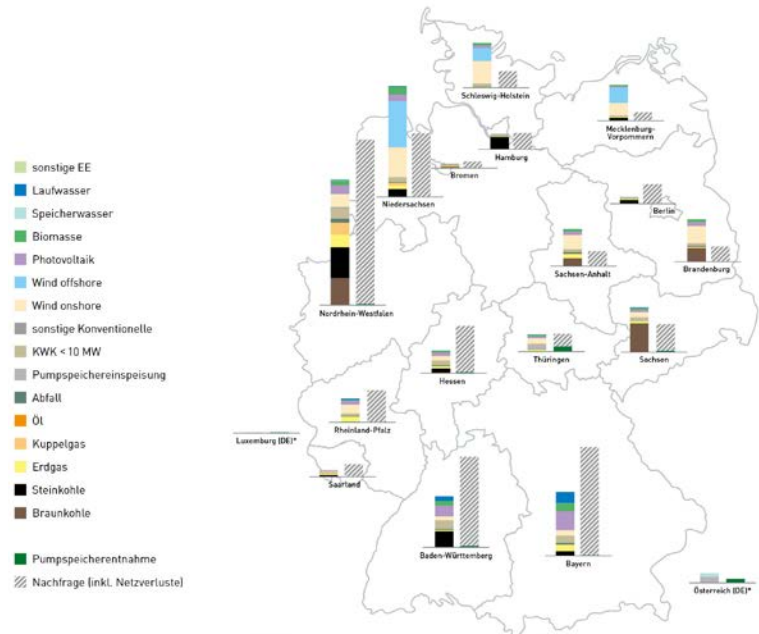


Grid Development Plan 2030 (2017)

Energy supply and demand balance at a state level, Scenario B 2030

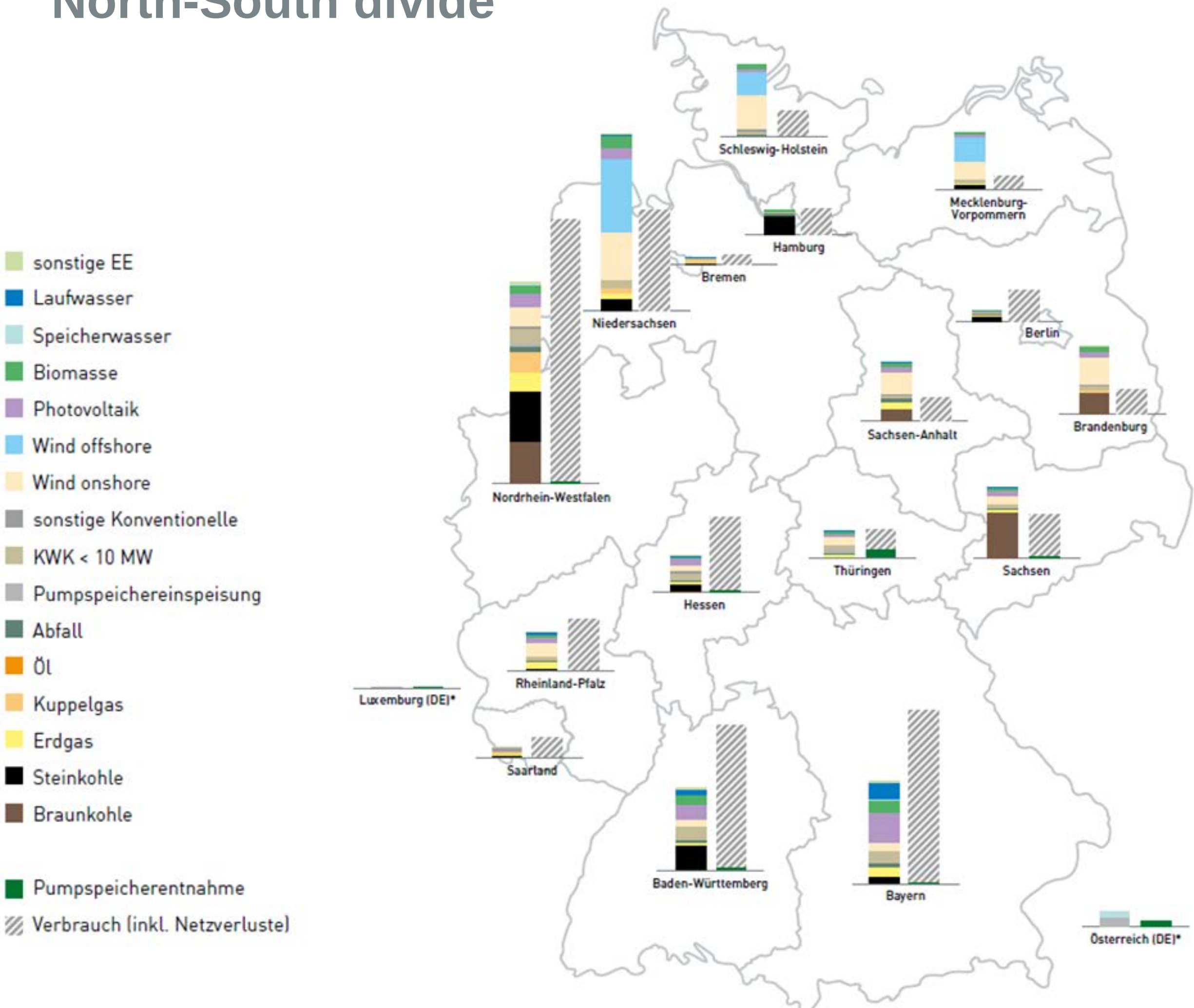
B 2030 (Angaben in TWh)	Braun-kohle	Stein-kohle	Erdgas	Kuppel-gas	Öl	Abfall	Pump-speicher-einspeisung	KWK < 10 MW	sonstige Konven-tionelle	Wind onshore	Wind offshore	Photo-voltaik	Bio-masse	Speicher-wasser	Lauf-wasser	sonstige EE	Nachfrage (inkl. Netz-verlusten)	Pump-speicher-entnahme
Baden-Württemberg	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)

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



Excess energy generation in Northern Germany:

Energy generation in the northern and eastern federal states is more than double the local demand.

Energy generation deficit in Southern Germany:

In the southern German states, between a quarter and half of annual energy demands are covered by domestic and foreign imports.

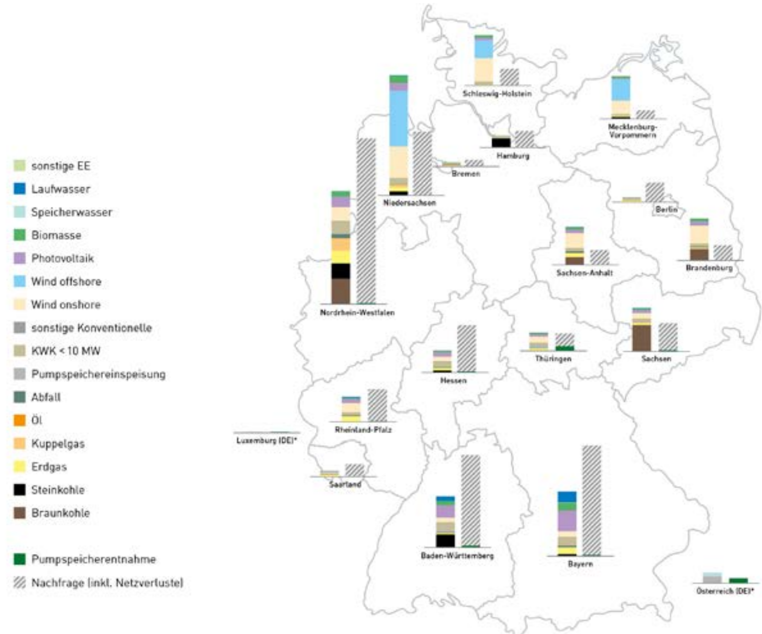
Grid Development Plan 2030 (2017)

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-verluste)	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.

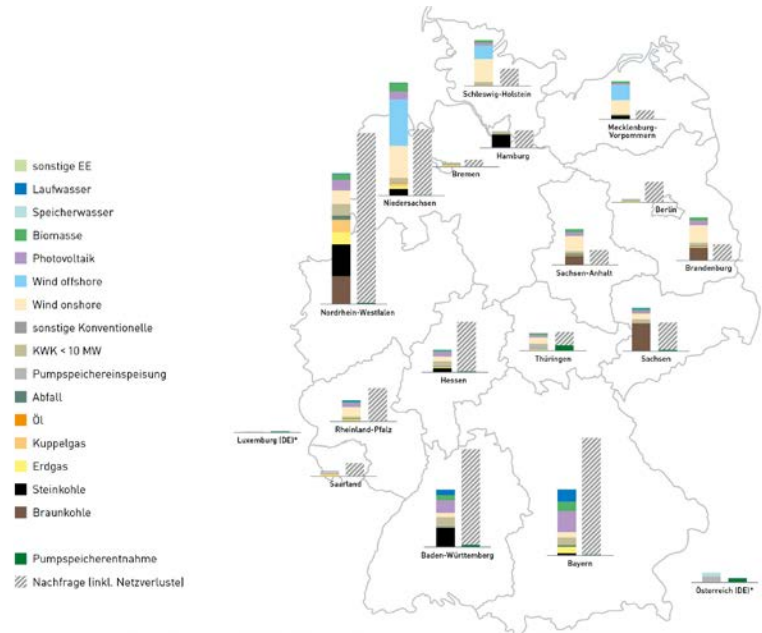


Grid Development Plan 2030 (2017)

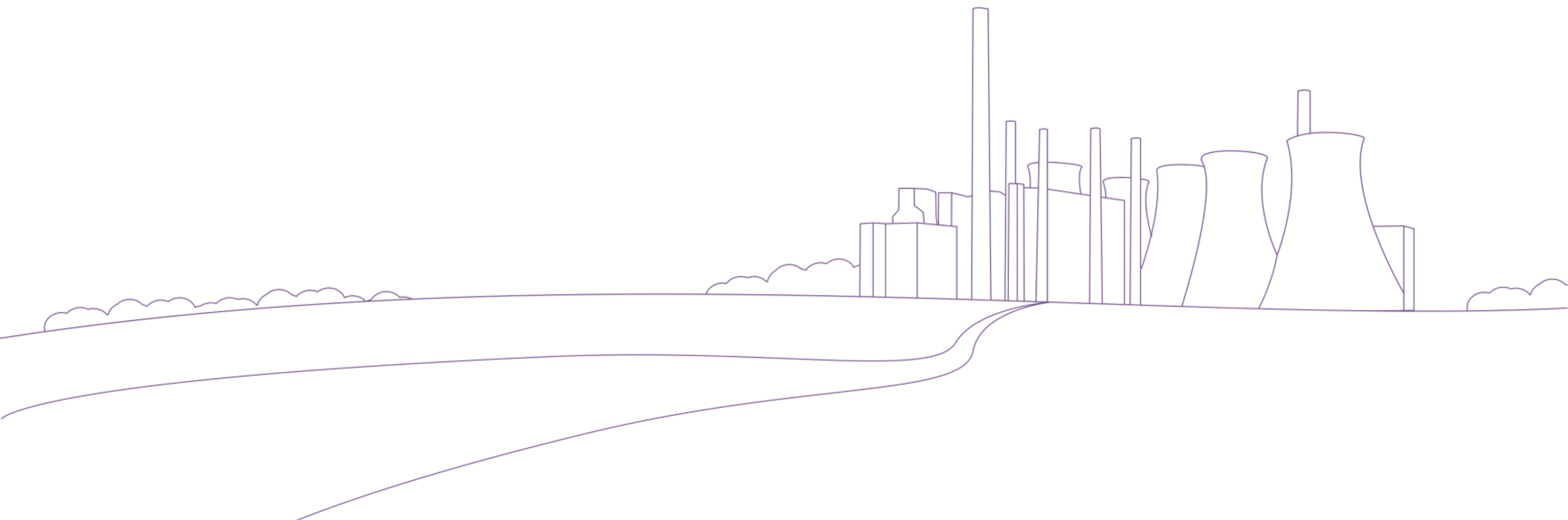
Energy supply and demand balance at a state level, Scenario C 2030

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-verlusten)	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.



Grid Development Plan 2030 (2017)
Market simulation



Grid Development Plan 2030 (2017)

Key findings from the market simulation

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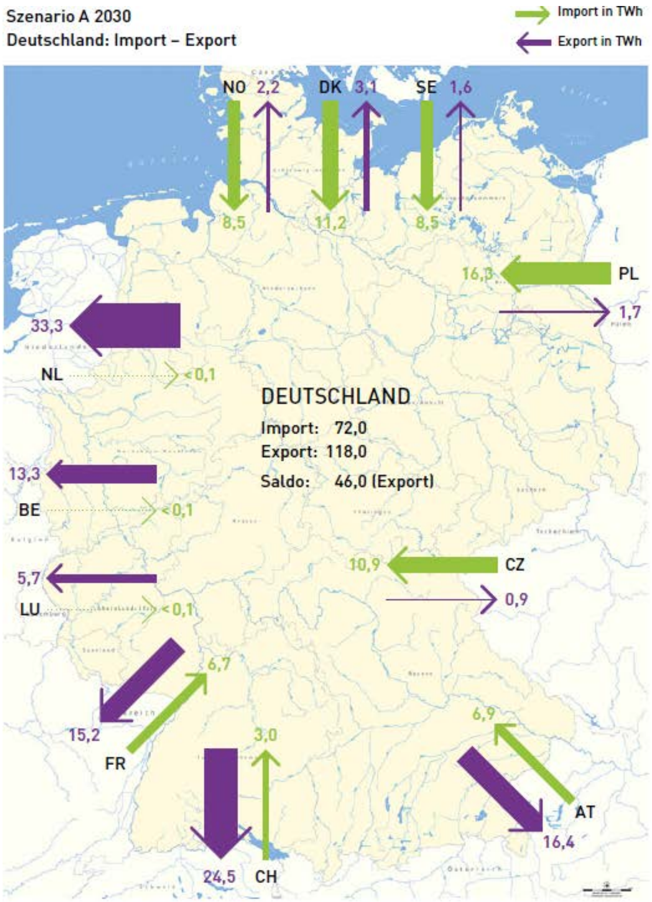
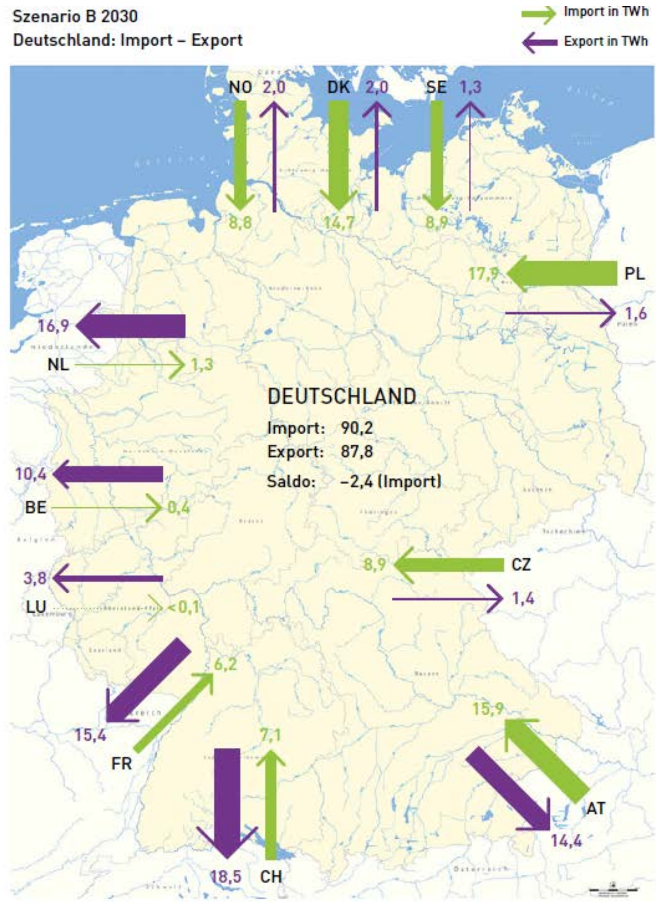
The market simulations for the GDP 2030 illustrate just how far the **transformation of the energy sector** has come in terms of the integration of renewable energy sources.

- 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)

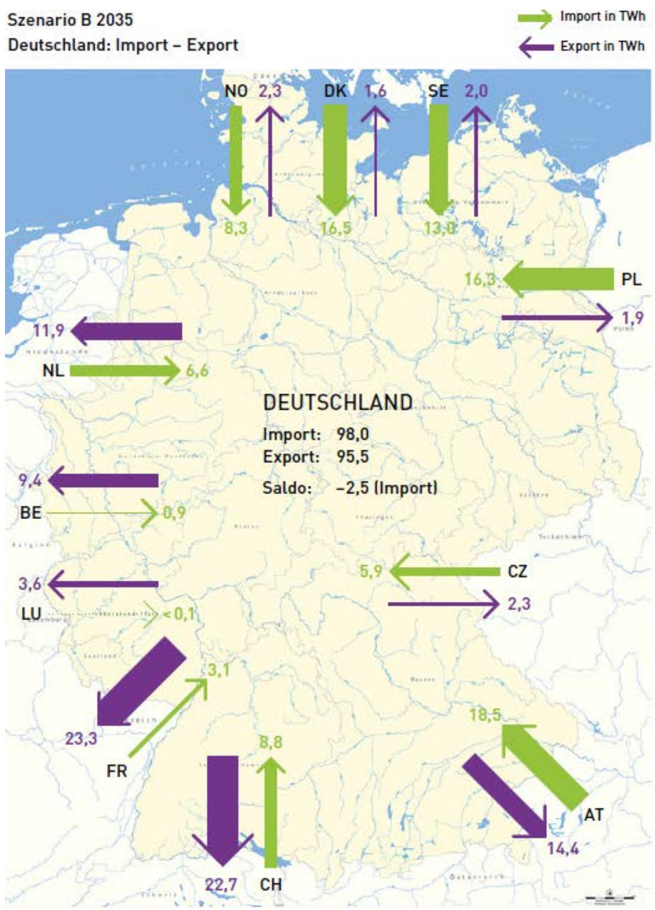
Trade exchanges: net power exporter in A 2030 / equal trade balance in B 2030

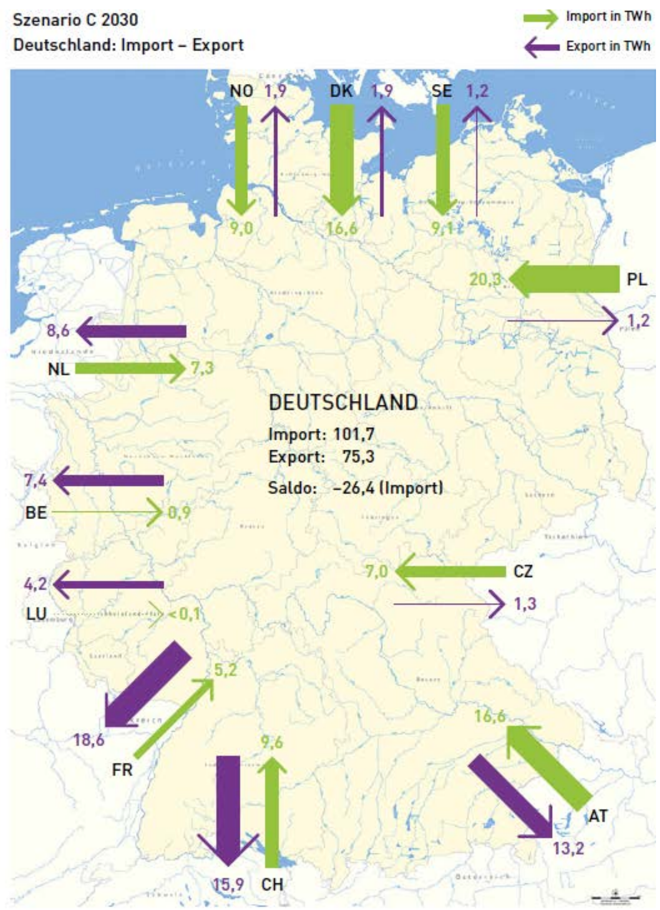




Grid Development Plan 2030 (2017)

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





Grid Development Plan 2030 (2017)

Market simulation

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- 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 Power 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 framewok'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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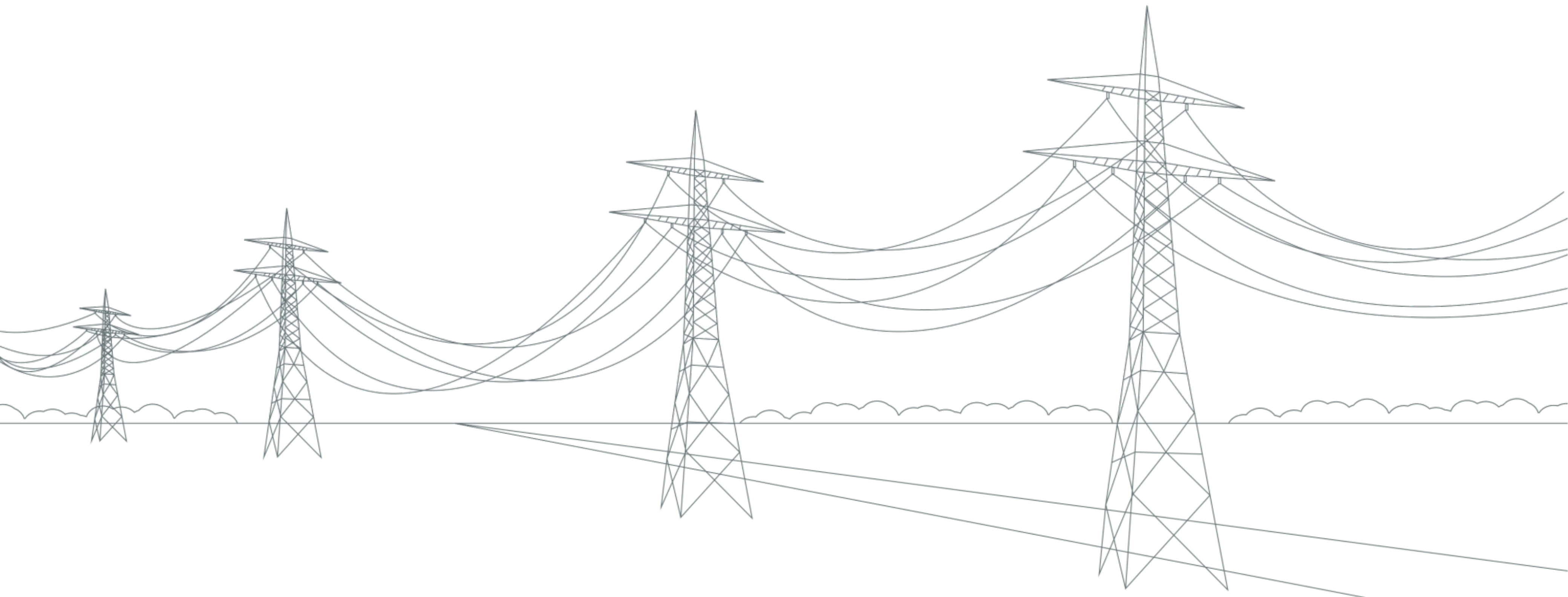
Grid Development Plan 2030 (2017)
Grid analyses



Grid Development Plan 2030 (2017)

Methodology of the GDP 2030

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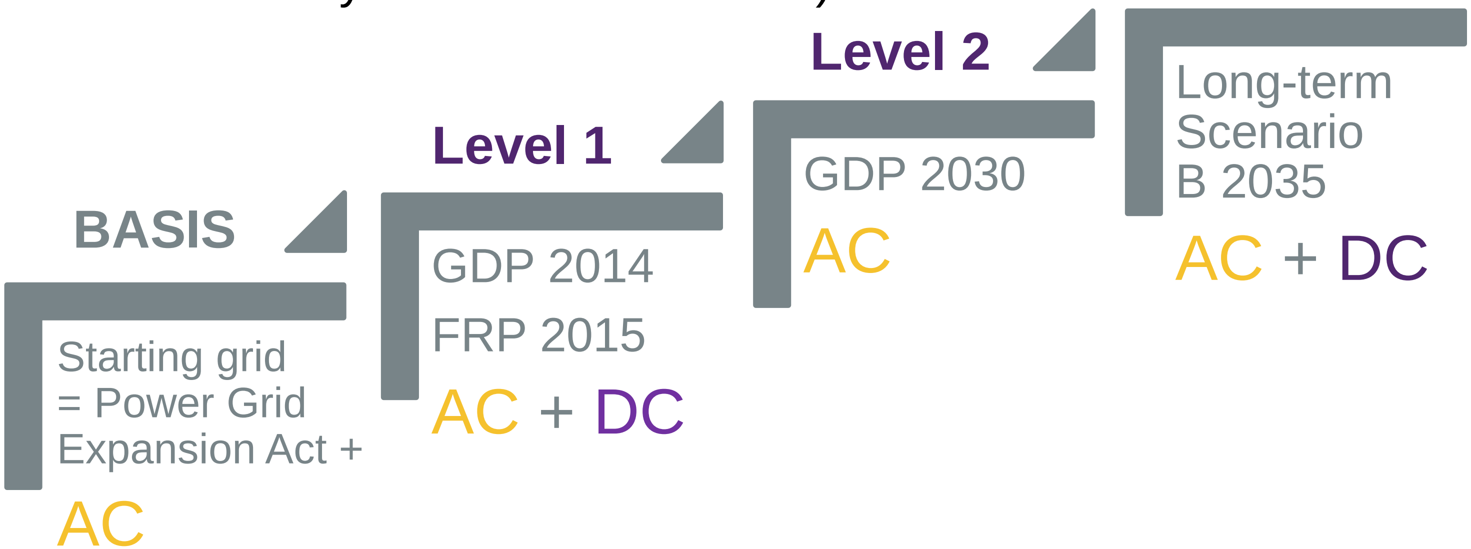
- The fundamental decision made by the TSOs in the GDP 2012 in favour of a combination of developing the AC power network and new DC projects is still the basis of the GDP 2030
- Scenarios using the target year 2030 focus on developing the AC network in combination with point measures to control power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



Grid Development Plan 2030 (2017)

Key results of the network analyses (I)

- 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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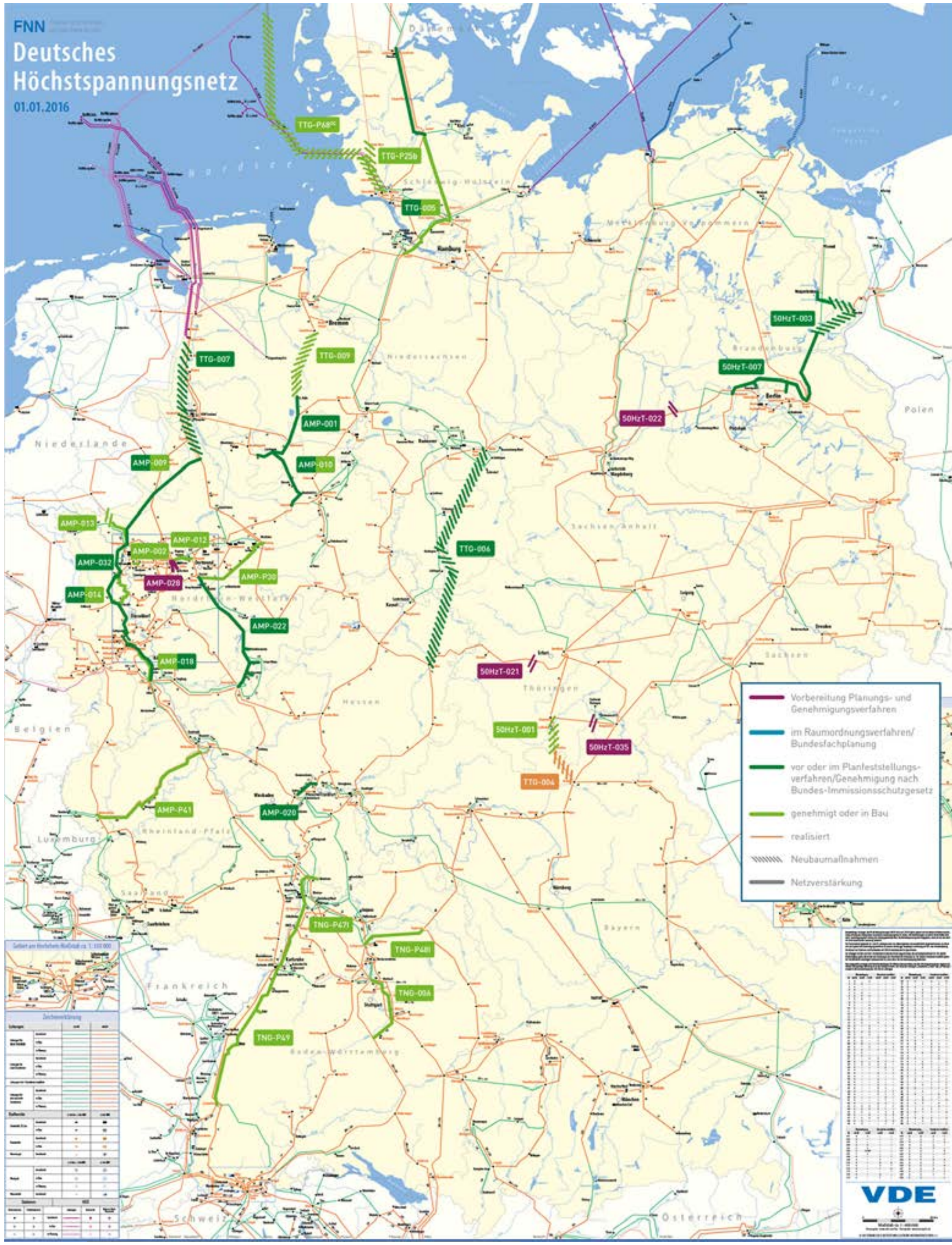
- **Secenario B 2035** shows that **focusing on the development of the AC-network** with point measures to control power flow, as in B 2030, **will no longer be sufficient**.
- To insure that the network runs efficiently and meets demands, **it is necessary to build additional DC connections** with a 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**’.



NETZ ENTWICKLUNGS PLAN STROM

Starting grid GDP 2030 (2017)

The starting grid comprises:

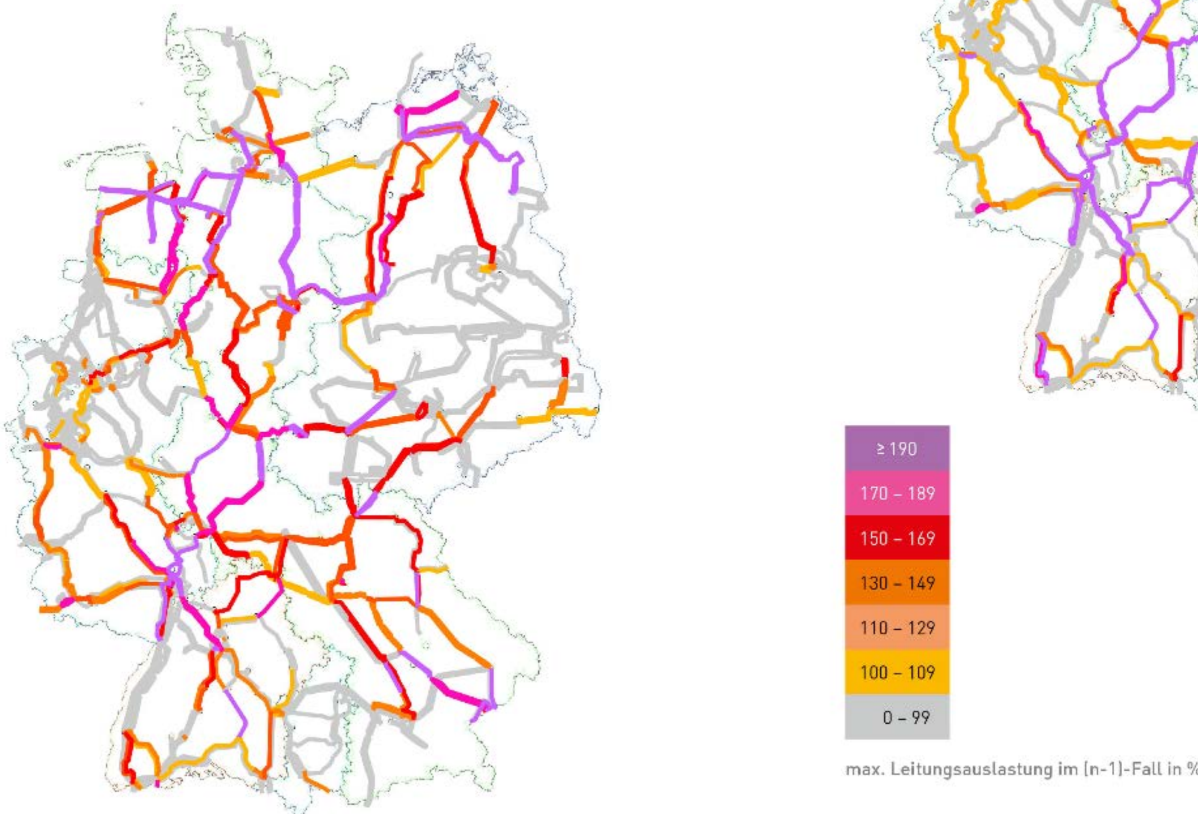
- actual grid (as of 31.12.2016)
- measures from Power Grid Expansion Act (*Energieleitungsausbaugesetz*)
- measures currently being implemented
- measures that are the result of other obligations – e.g. Regulation on Grid Connection of Power Stations (*Kraftwerks-Netzanschlussverordnung* or *KraftNAV*) or industrial commitments

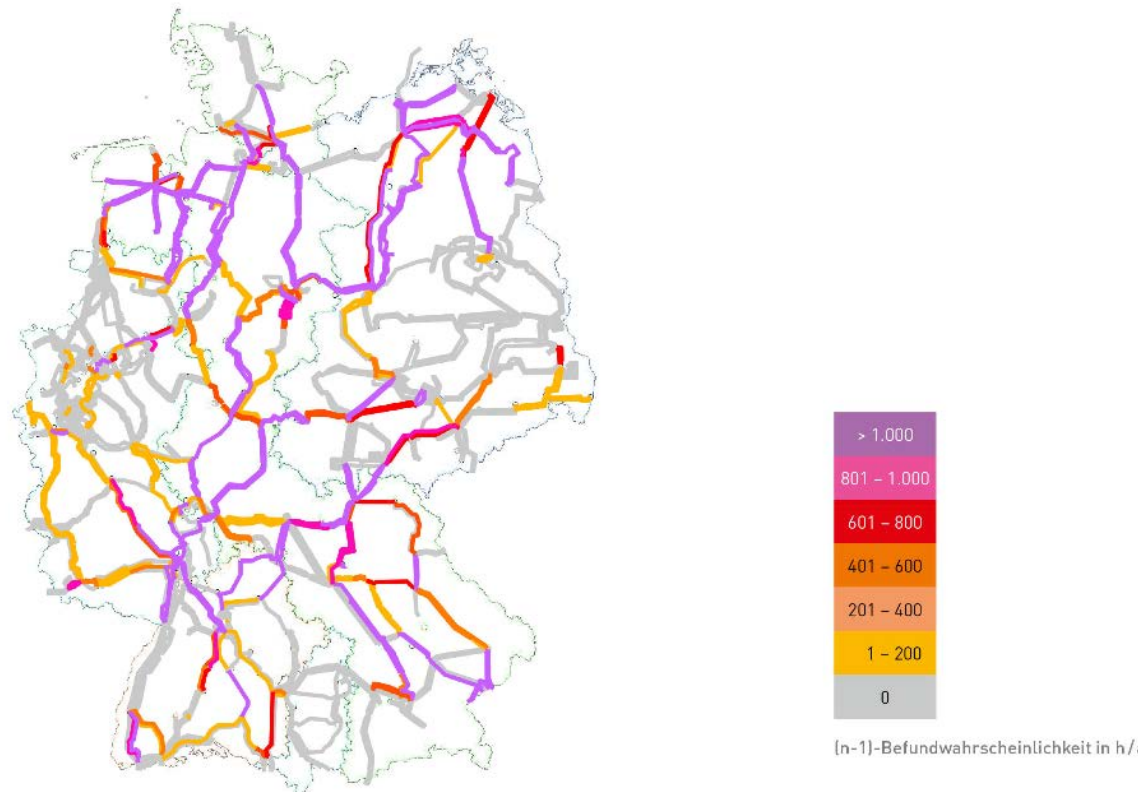
New AC lines in new routes:	500 km
New AC lines in existing routes:	1,200 km
Reconductoring of existing lines.:	200 km
New DC lines:	200 km
Investment:	EUR 6 billion

Grid Development Plan Power 2030 (2017)

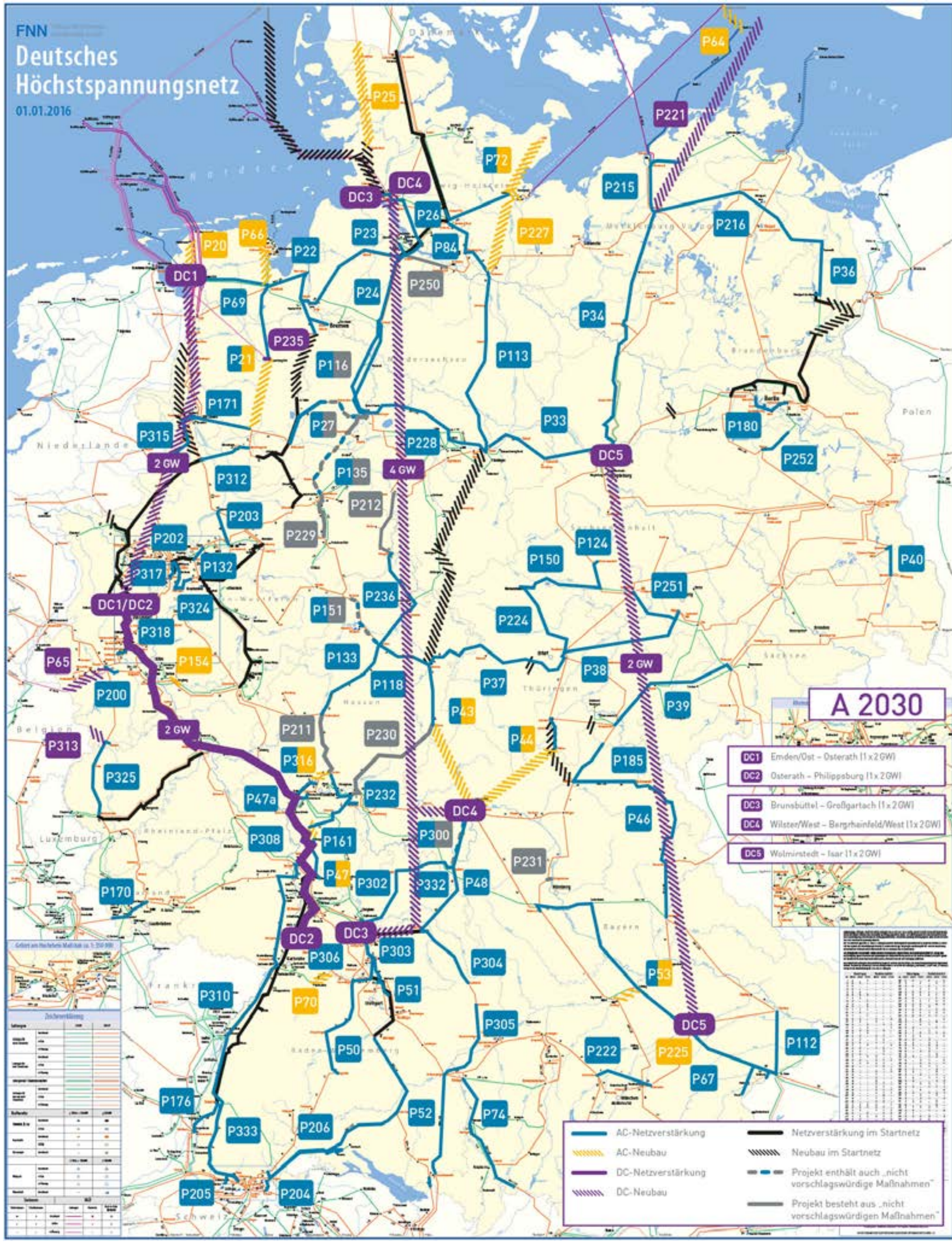
Overload in the starting grid

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





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



NETZ ENTWICKLUNGS PLAN STROM

Scenario A 2030 incl. starting grid

Construction of DC connections in Germany

- Length: 2,600 km
- Transmission capacity: 8 GW
- To Belgium, Denmark, Norway and Sweden: 330 km

Construction of AC network

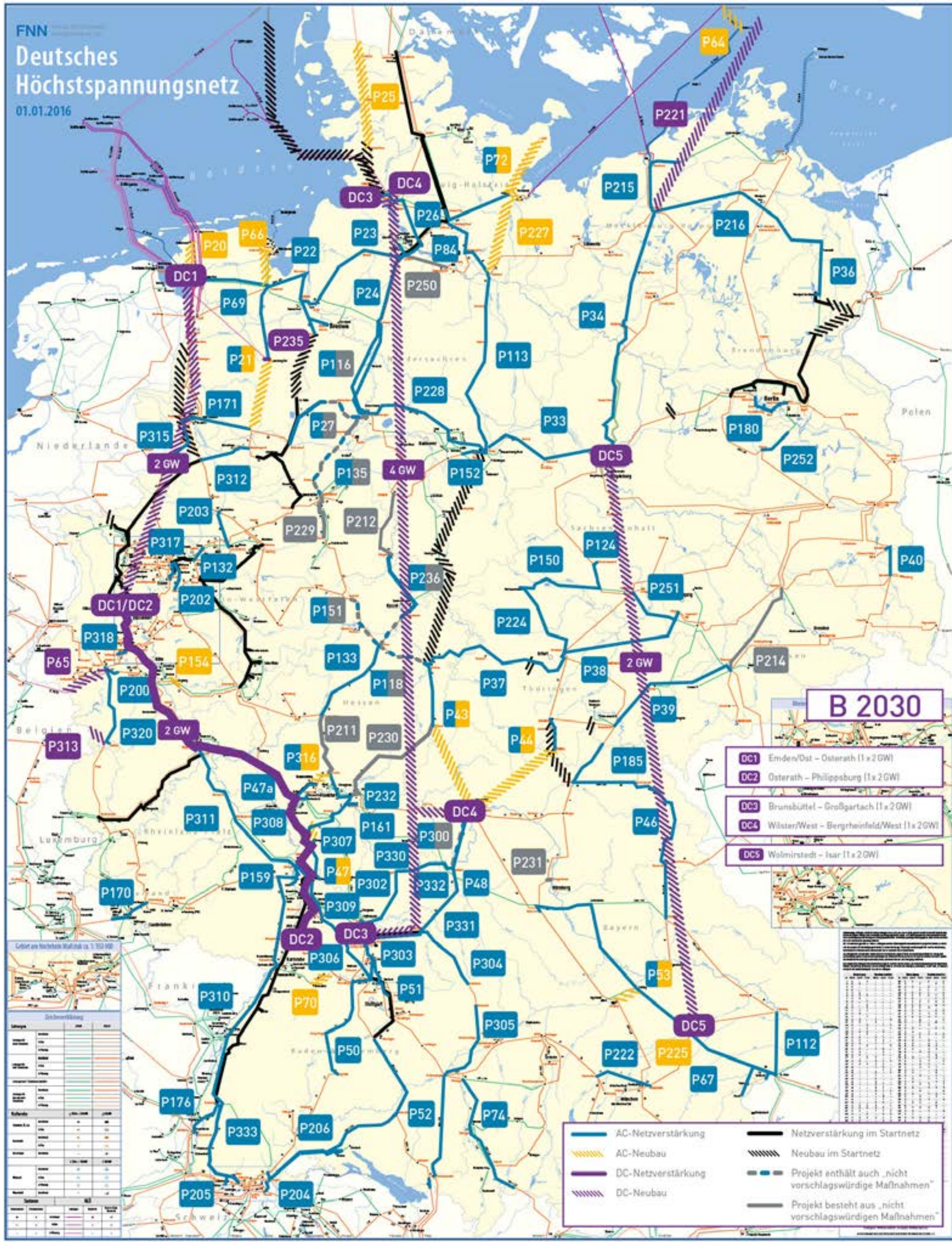
- Length: 1,200 km

DC/AC network development

- Length: 7,600 km

Investment EUR 34 billion

if all DC-lines (except DC2) are built as underground-cables.



NETZ ENTWICKLUNGS PLAN STROM

Scenario B 2030 inc. starting grid

Construction of DC connections in Germany

- Length: 2,600 km
- Transmission capacity: 8 GW
- To Belgium, Denmark, Norway and Sweden: 330 km

Construction of AC network

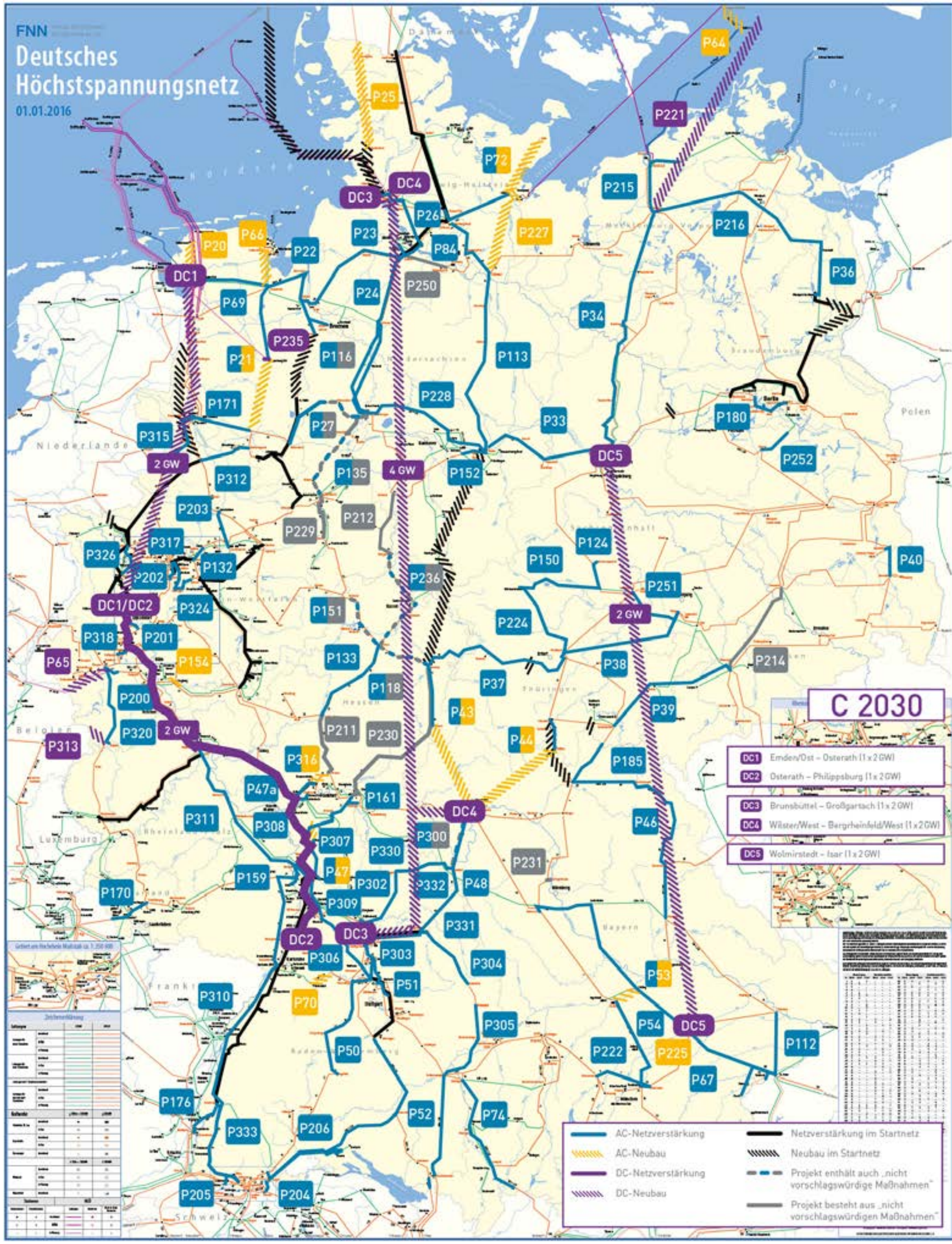
- Length: 1,200 km

DC/AC network development

- Length: 8,300 km

Investment EUR 35 billion

if all DC-lines (except DC2) are built as underground cables.



NETZ ENTWICKLUNGS PLAN STROM

Scenario C 2030 inc. starting grid

Construction of DC connections in Germany

- Length: 2,600 km
- Transmission capacity: 8 GW
- To Belgium, Denmark, Norway and Sweden: 330 km

Construction of AC network

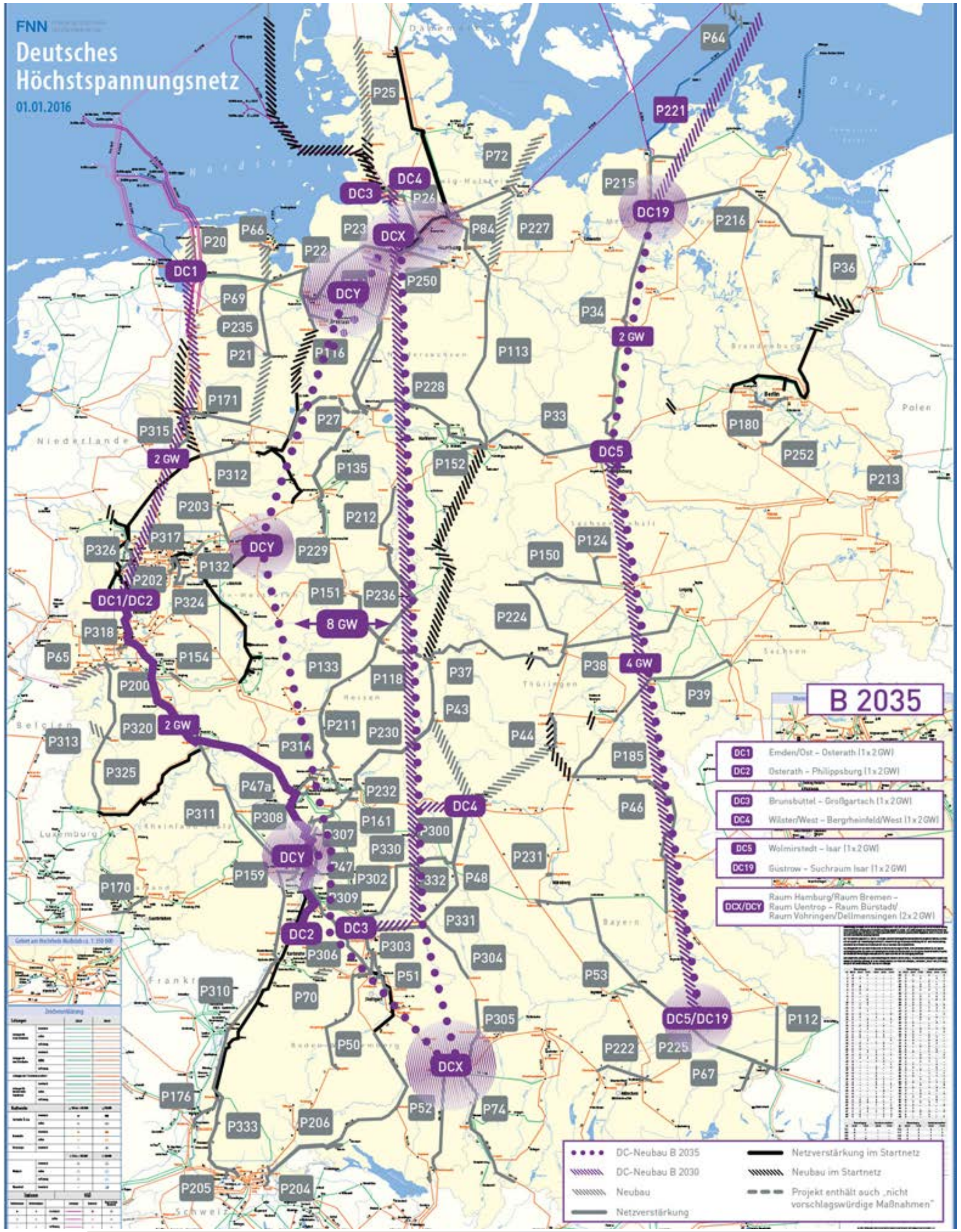
- Length: 1,200 km

DC/AC network development

- Length: 8,500 km

Investment EUR 36 billion

if all DC-lines (except DC2) are built as underground cables.



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Scenario B 2035: DC projects

- Growing transmission demands compared to B 2030
- Expansion of the AC grid beyond measures of the FRP 2015 no longer sufficient
- Additional DC lines amounting to 6 GW are required in 2035
  - 2 GW in the east, from Mecklenburg-Vorpommern to Bavaria
  - 4 GW in the west from Schleswig-Holstein/Lower Saxony to Hesse and Baden-Württemberg/Bavaria with a feed-in and withdrawal point in North Rhine-Westphalia
- Precise allocation of projects in western Germany is currently still being reviewed.

Grid Development Plan 2030 (2017)

Demand for grid development and expansion

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Angaben in km	AC-Verstärkung	DC-Verstärkung	AC-Neubau	DC-Neubau	Summe
Startnetz	1.400	0	500	200	**2.100**
Zubaunetz					
A 2030	5.900	300	600	2.400	**9.200**
B 2030	6.600	300	600	2.400	**9.900**
C 2030	6.800	300	600	2.400	**10.200**
Start- und Zubaunetz					
A 2030	7.300	300	1.200	2.600	**11.400**
B 2030	8.000	300	1.200	2.600	**12.000**
C 2030	8.200	300	1.200	2.600	**12.300**

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

This table provides an overview of the length specifications for all necessary grid development and new construction measures and – divided into grid reinforcement and construction measures.

Grid Development Plan 2030 (2017)

Investment costs

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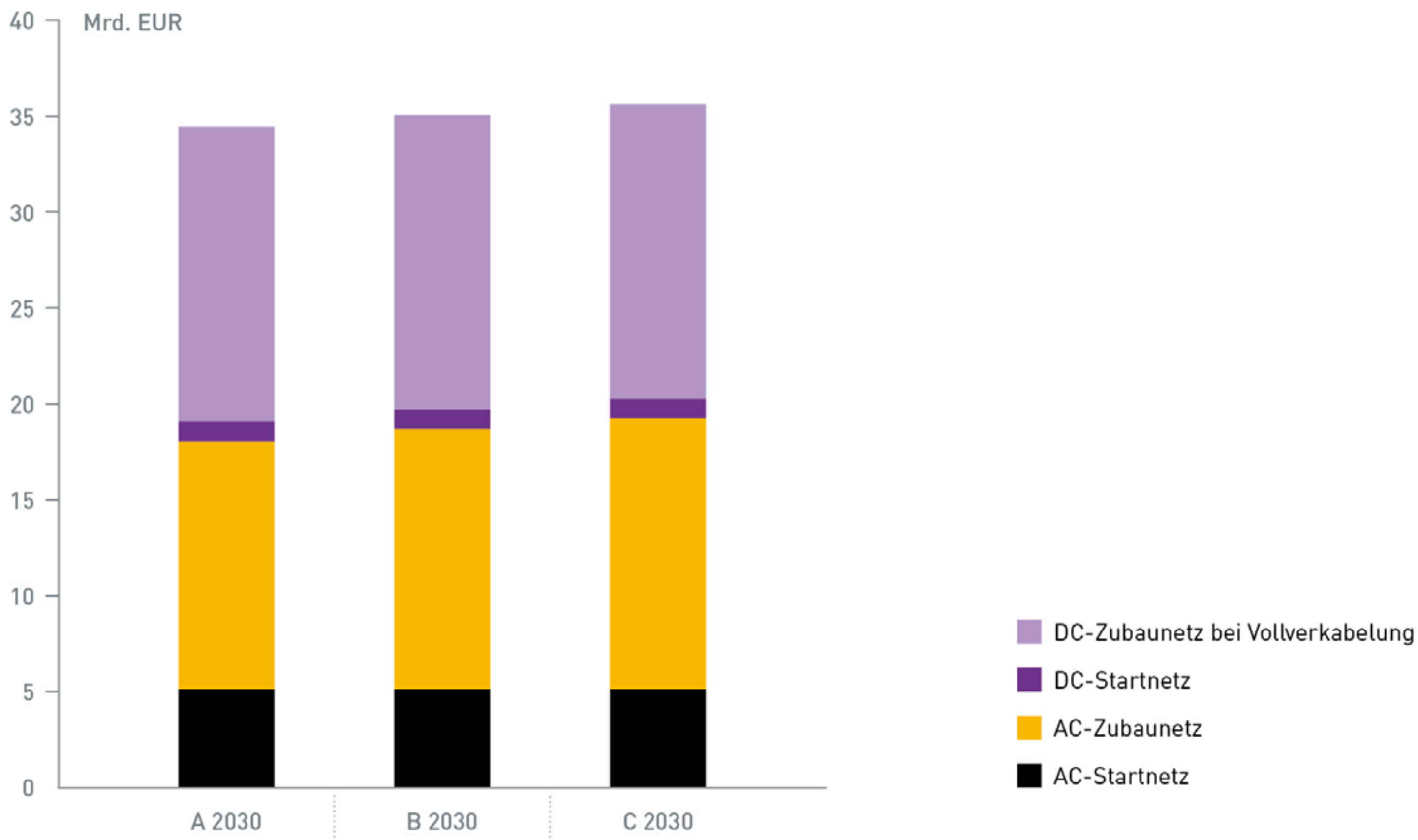
- Calculation of investment costs based on standard costs (provisional!)
- Standard costs for underground DC cables: EUR 4 million/km for 1 x 2 GW, EUR 8 million for 2 x 2 GW
- Volume of investments over ten years totals per scenario:
  - **EUR 34–36 billion** for 100% underground cabling of DC lines (except DC2)
  - **EUR 32–34 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 %	34	35	36
Kabel 75 %	32	33	34

Grid Development Plan 2030 (2017)

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

NETZ ENTWICKLUNGS PLAN STROM

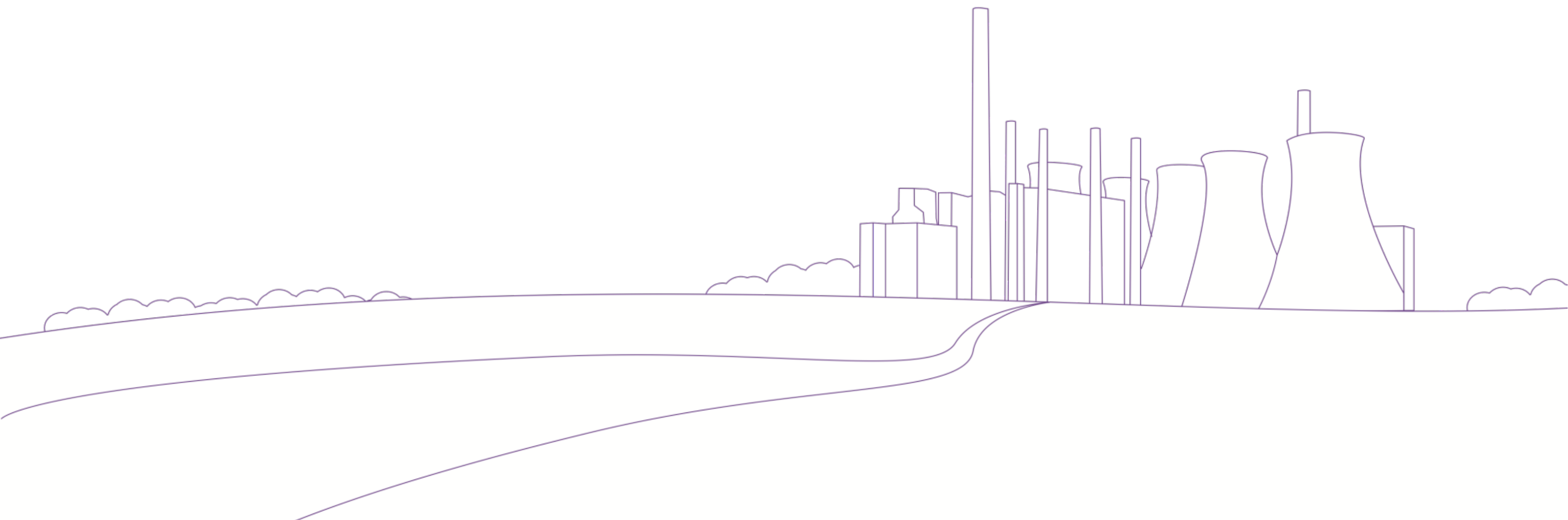


Grid Development Plan 2030 (2017)

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 not considered in the scope of the GDP.

Evaluation of measures



Grid Development Plan 2030 (2017)

Pilot project for evaluating measures

NETZ ENTWICKLUNGS PLAN **STROM**

- The TSOs have continued to work on developing their methodology for evaluating measures for the GDP 2030.
- The GDP 2030 includes an evaluation of (n-1) proven measures, based on a range of different criteria:
  - Criteria correspond to different aspects such as avoiding redispatch, avoiding feed-in management for renewable energy, fulfilment of transportation tasks and planning security
  - **Improved characterisation** of measures due to the evaluation criteria
  - Measures described in the GDP 2030 are identified using (n-1) verification and are necessary in order to build an energy network that satisfies demands and is largely free of congestion.
  - The evaluation of measures does not concern the validation of the necessity of the measures.
- The evaluation of measures is carried out in parallel with the publication and consultation procedure for the first draft of the GDP 2030.
- The results of the measures evaluation (extension grid Scenario B 2030) will be presented in the second draft of the GDP 2030.

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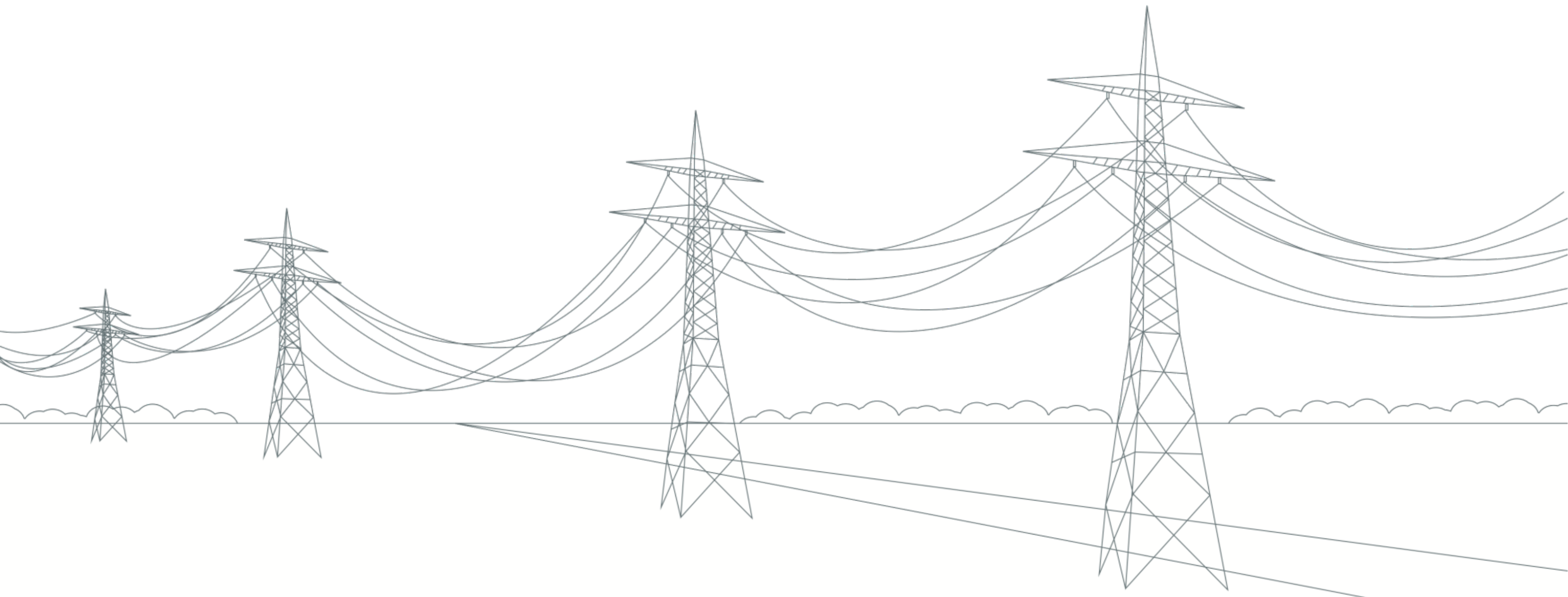
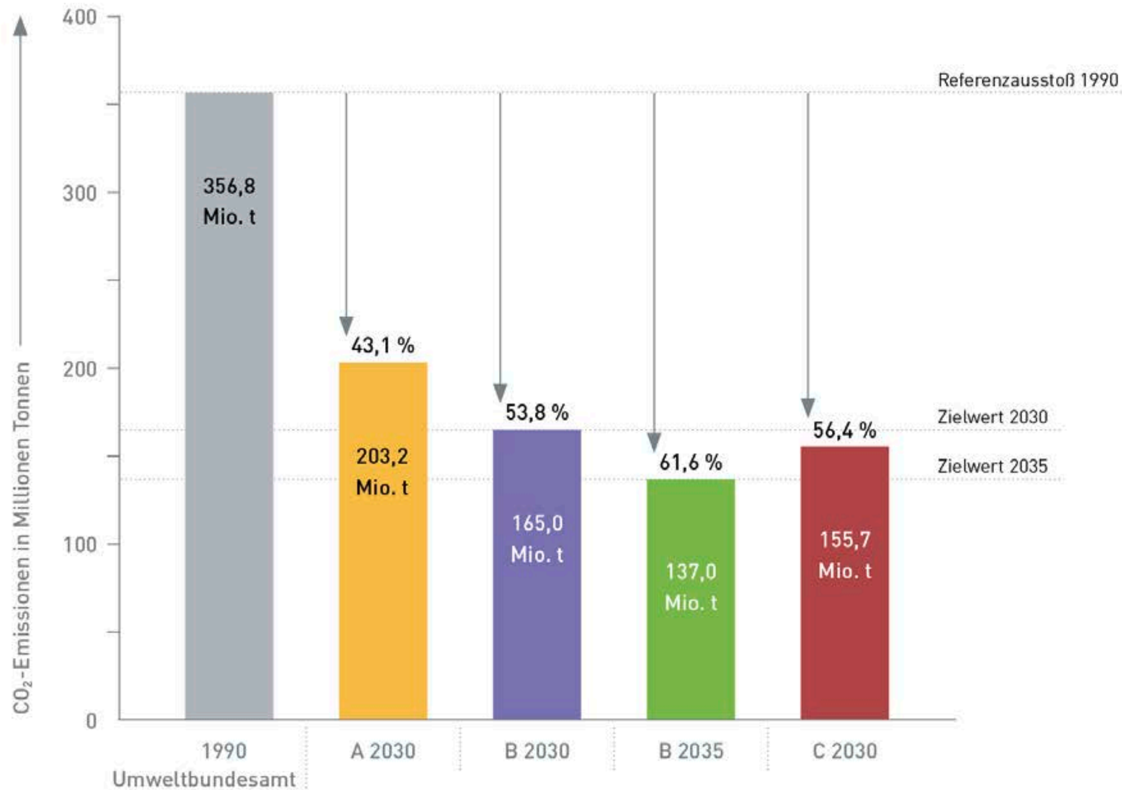
Backup



Grid Development Plan 2030 (2017)

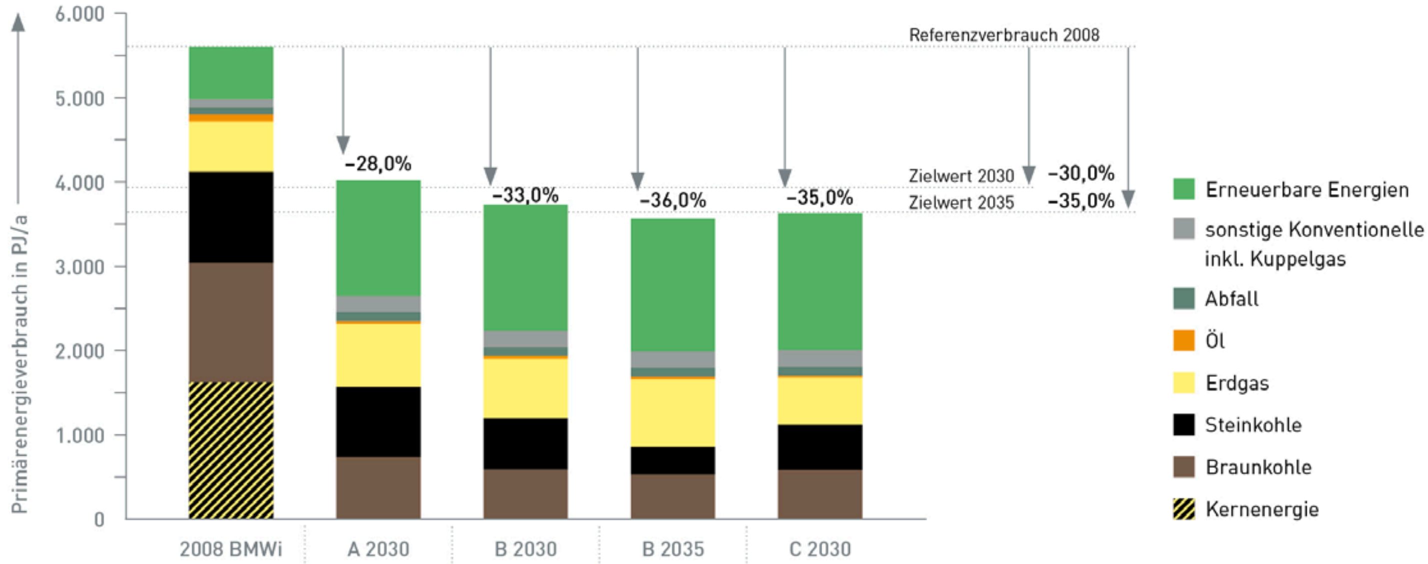
CO_2 emissions in German electricity generation in all scenarios of the GDP 2030

NETZ ENTWICKLUNGS PLAN STROM



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