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Switch to the Future

Electricity Grid Development in Germany

Knowledge-exchange between US and German power system operators

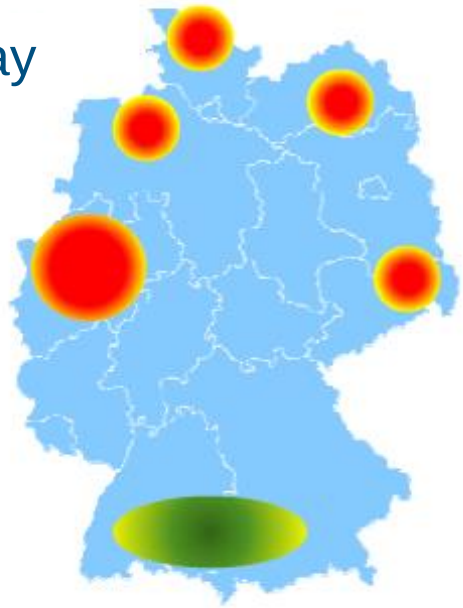
Dr. Kristen Huttner

IIIC1, National and European electricity grids and electricity grid planning

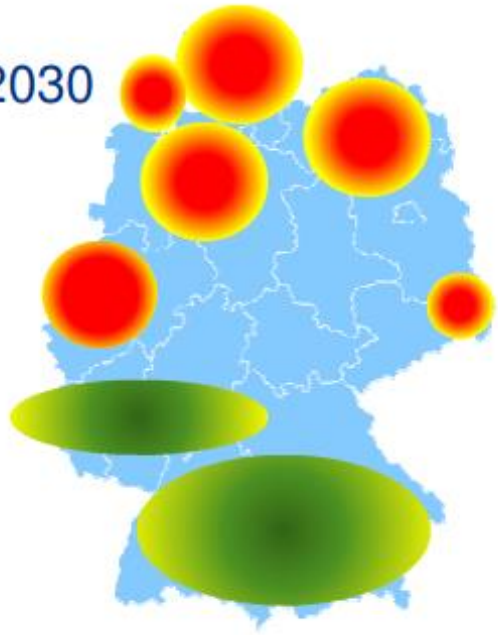
Berlin, September 25th, 2017

„Energiewende“ leads to structural change of generation and load

today



2030



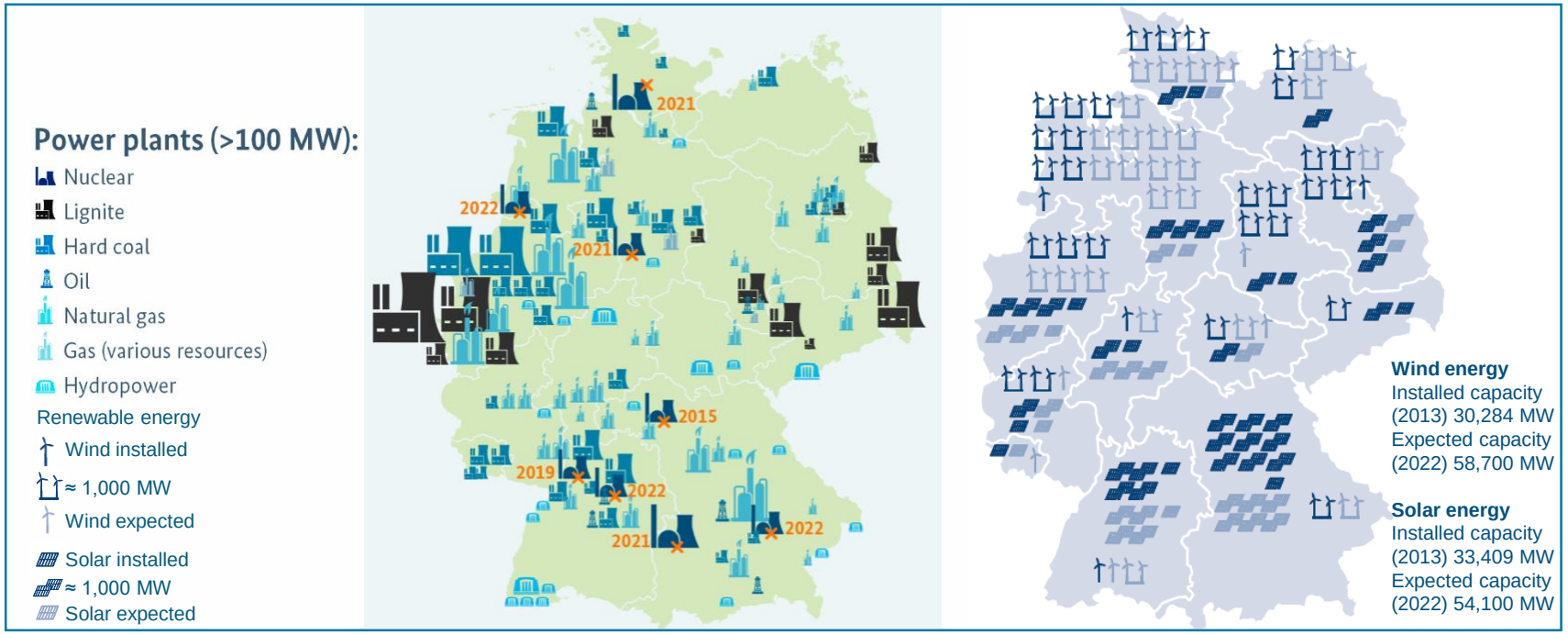
generation surplus

power

generation deficit

Source: : http://www.vbi.de/uploads/media/2012-05-24_TenneT.PDF

German power generation capacities by region



Source: UBA, BNetzA 2013, BDWi 2013 based on Netzentwicklungsplan 2012, Scenario B 2022

Challenge: connecting supply and demand

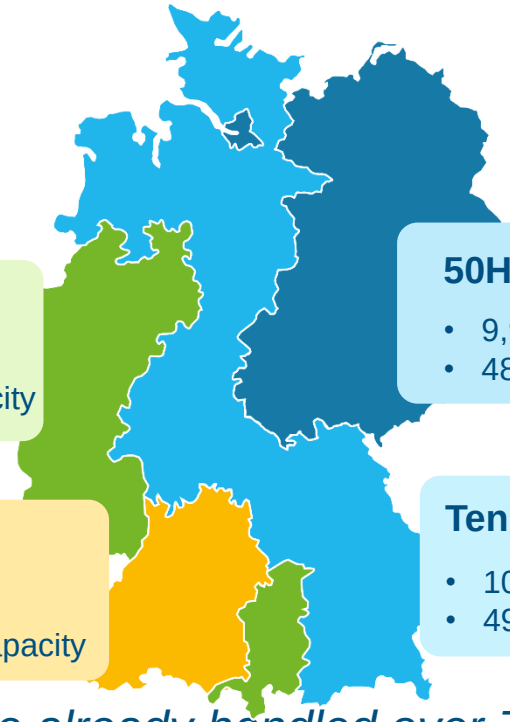
Source: DUH 2011

New power lines need to transport excess supply in northern Germany to southern Germany in order to prevent shortages.

TSOs in Germany and share of fluctuating renewables

Germany

- Highest volatile capacity: 42 GW at 60 GW load
- Hourly shares over 65%



Amprion

- 11,000 km
- 24.7% volatile peak capacity

50Hertz

- 9,995 km
- 48% volatile peak capacity

TransnetBW

- 3,420 km
- 31.6% volatile peak capacity

TenneT

- 10,800 km
- 49.5% volatile peak capacity

German TSOs have already handled over 75% of the power in the grid coming from renewables.

Source: Ecofys 2015, based on data from Transmission system operators 2014, Fraunhofer ISE 2014, Agora 2016

German transmission-grid planning

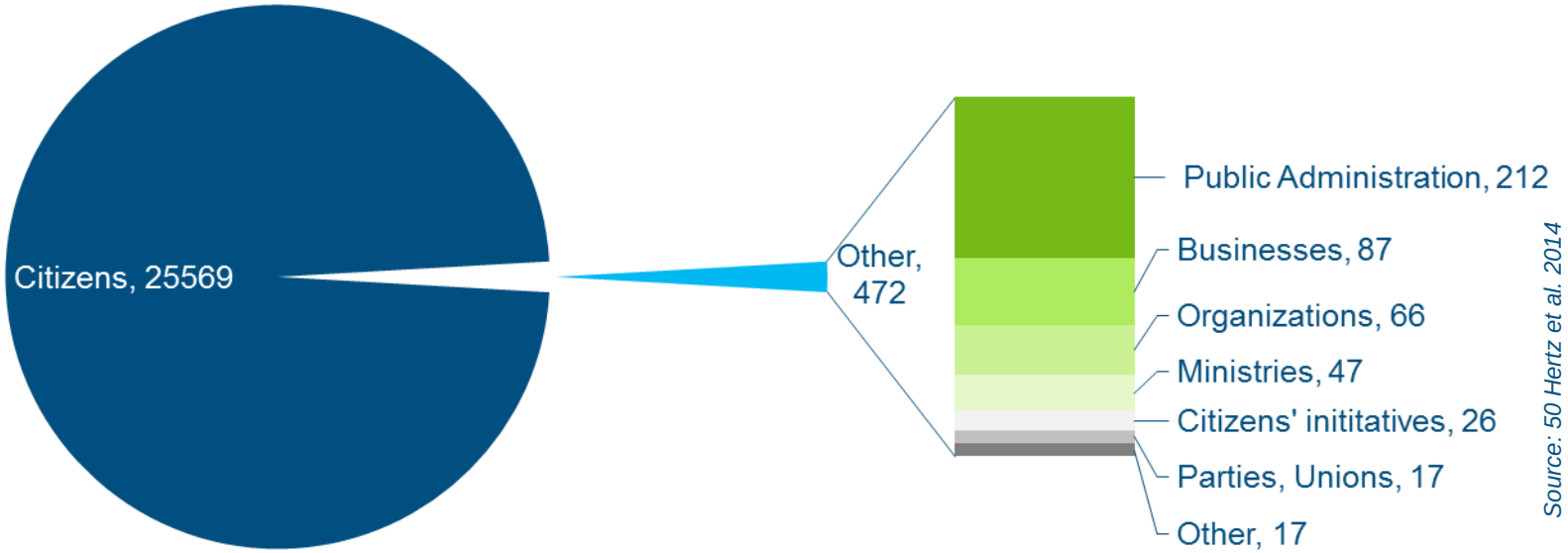
	Assessments of demand			Projects	
Process	 Scenario Framework	 Network Development Plan & Environmental Assessment	 Federal Requirement Plan	 Federal Sectoral Planning	 Planning Approval & Construction
Responsible	TSO/BNetzA	TSO/BNetzA	Bundestag	BNetzA	TSO
Public involvement	*Who*: everybody *What*: method and parameters	*Who*: everybody *What*: alternatives, technologies, environment	-	*Who*: everybody *What*: environment, public concerns	*Who*: affected citizens *What*: public and environmental concerns

Source: Ecofys 2016, Federal Network Agency 2013

The planning process ensures continuity through a "one-stop shop" authority and broad stakeholder participation.

Stakeholder participation in transmission-grid planning

- More than 26,000 opinions were taken into account in the first round of the Network Development Plan (NDP) 2014 cycle
- Stakeholders can input at two stages: during the grid planning process and during the authorisation phase.



Widespread stakeholder engagement shaped the NDP in 2014.

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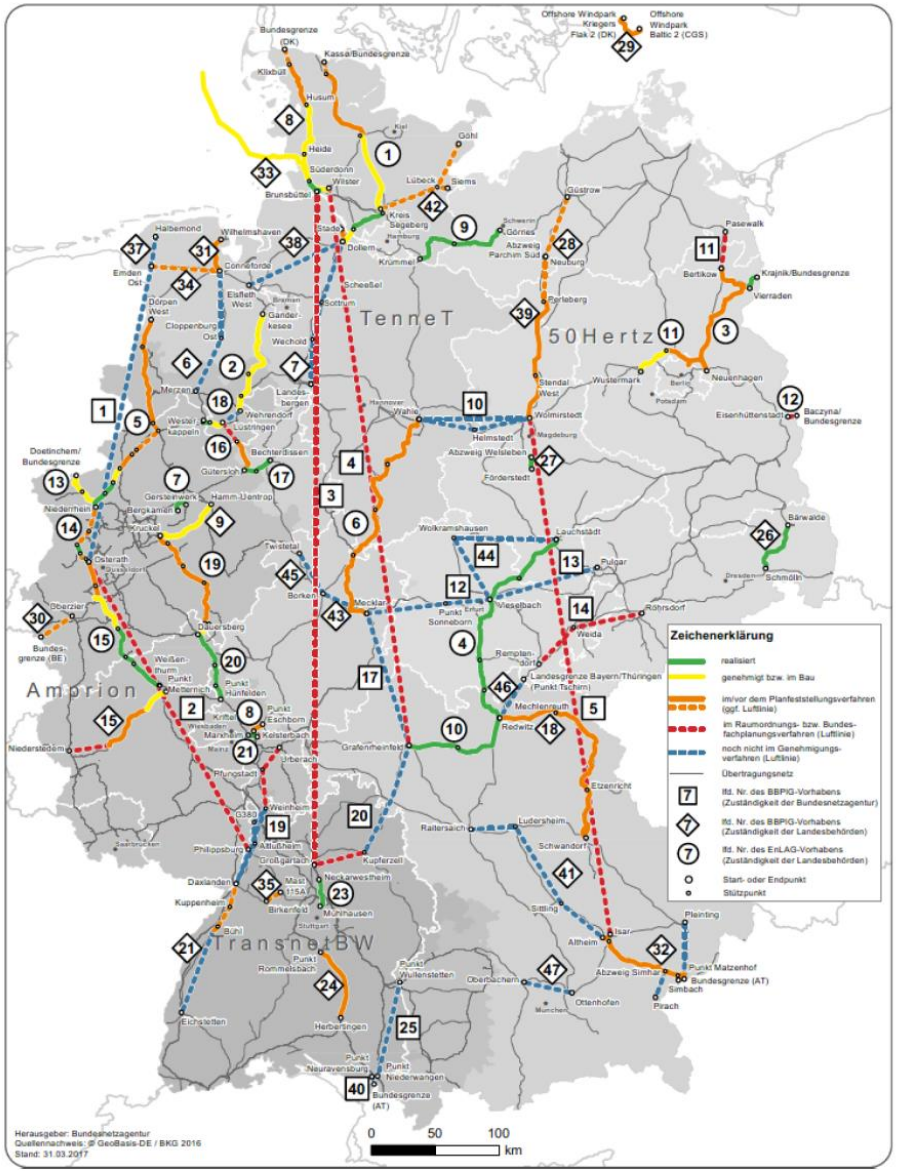
Challenge:
Ambitious Grid Expansion Plan

<u>Investment needs:</u>
≈ 50 billion €

<u>Main barrier:</u>
Time-consuming approval procedures



Lessons learnt

- **Early participation** of affected parties
- **Small stakeholder events** versus large events
- Decisions by the **federal network agency** (>< federal states)
- **Underlying cabling** versus overhead transmission lines
- Principle of **direct transmission lines**

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Thank you for your attention!

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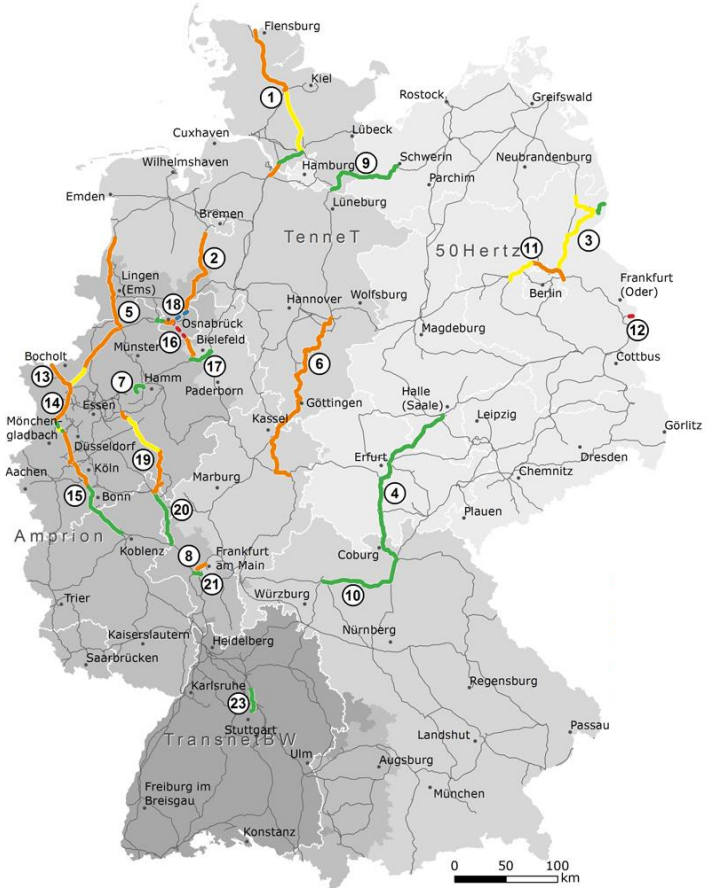
Back-Up

Grid expansion EnLAG: 2nd Q. 2017



2009 Priority Projects from EnLAG (Power Grid Expansion Act)

- **22 projects**
- **totalling > 1,800 km**
- **ca. 700 km finalised ≈ 40 %**

In approval process

Approved or currently under construction

Finalised

About one third of the most urgent additional grid kilometres have been built over the past five years.

Source: : Picture: ©GeoBasis-DE; Federal Network Agency 2015

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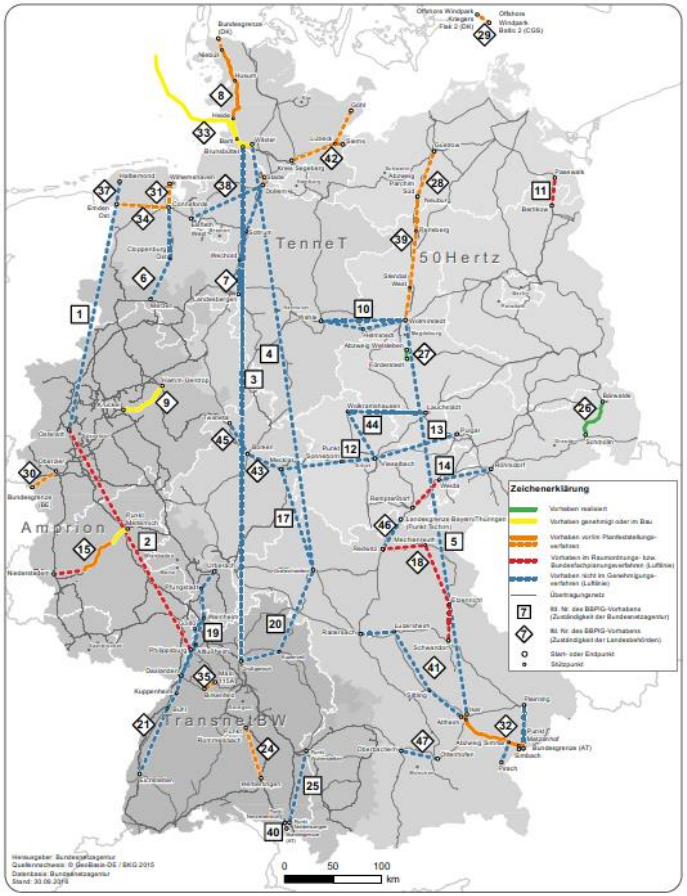
BBPlG-Projects – Status quo 2nd Q. 2017



>5,500 km of priority lines by 2024

- **43 projects**
- **350 km AC new**
- **2150 km DC new**
- **2,550 km AC optimisation**
- **ca. 450 km approved / 180 km ≈ 7,6% / 3%**

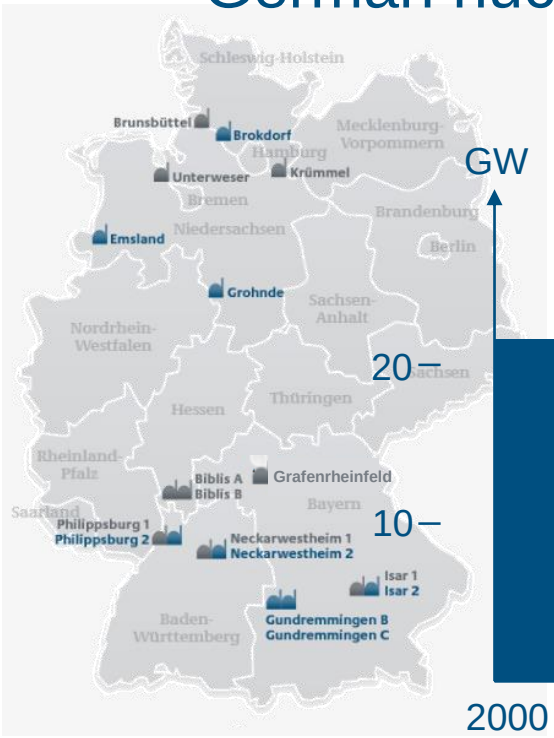
- In approval process
- Approved or currently under construction
- Finalised
- Other planned routes

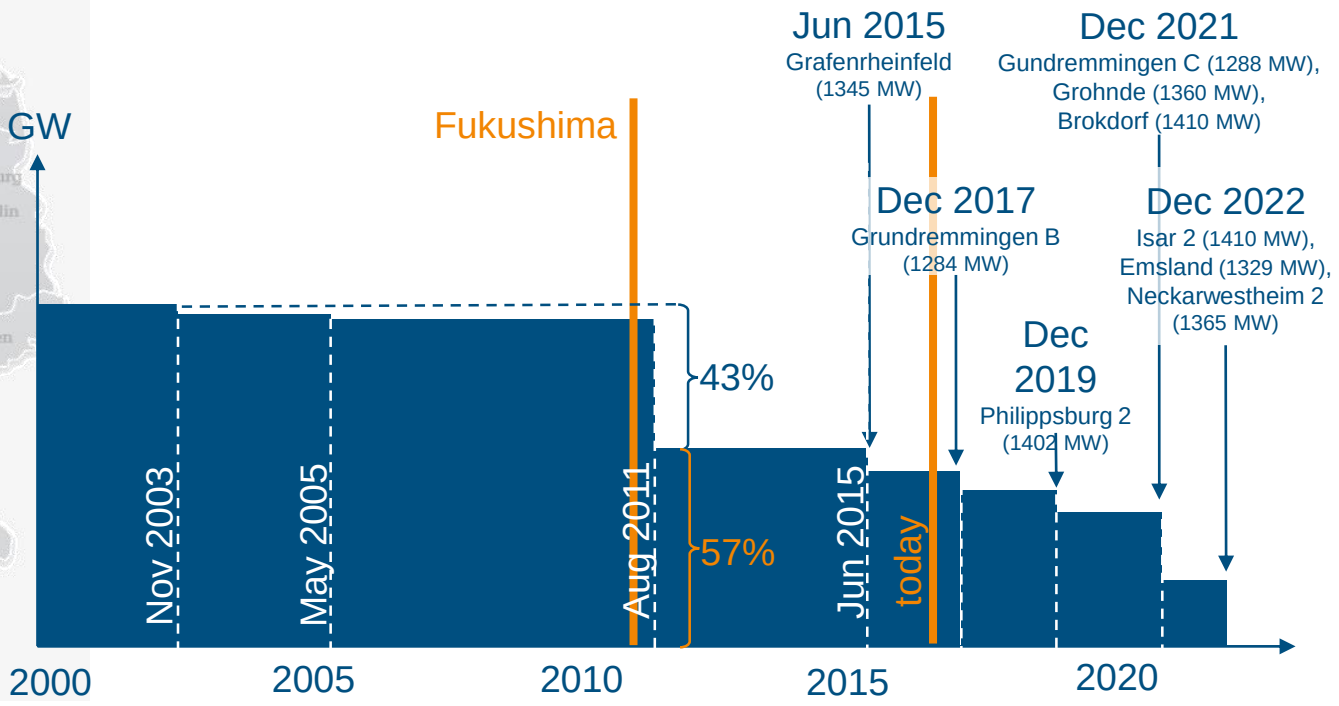
Costs for National Congestion Management

Costs (million €)	2011	2012	2013	2014	2015	2016
Redispatch	129	165	115	187	412	219
Curtailment of renewable infeed	34	33	44	183	478	373
Grid reserve	17	25	54	67	227	256
Total	180	223	213	437	1117	848

Source: Federal Network Ageny

German nuclear phase-out timeline





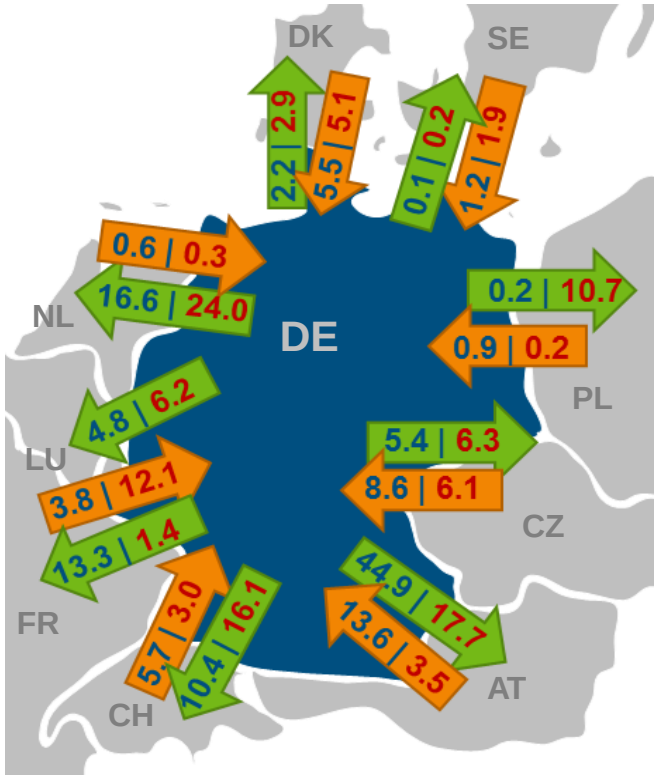
Source: Ecofys 2015, BMWi 2015

Nuclear phase-out will reduce Germany's total power capacity. The remaining 8 nuclear power plants will be phased out by 2022.

Cross border electricity trading and physical flows (net values, TWh)

Import DE
trading | physical flows

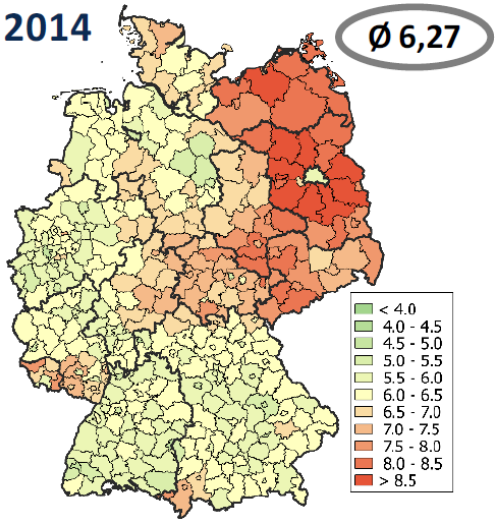
Export DE
trading | physical flows

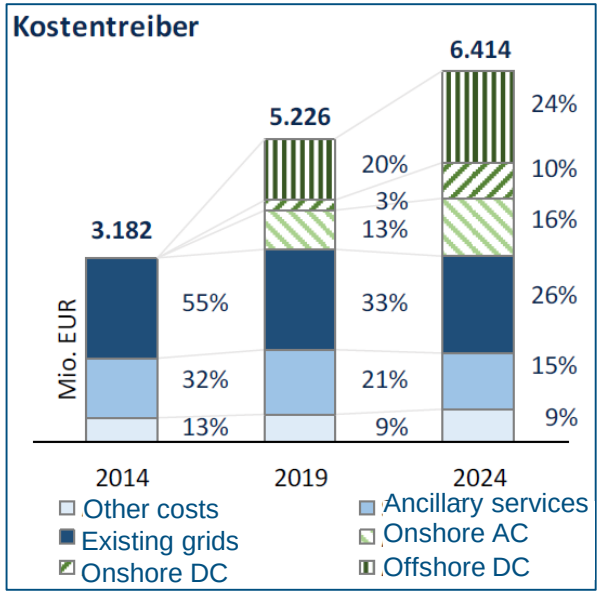


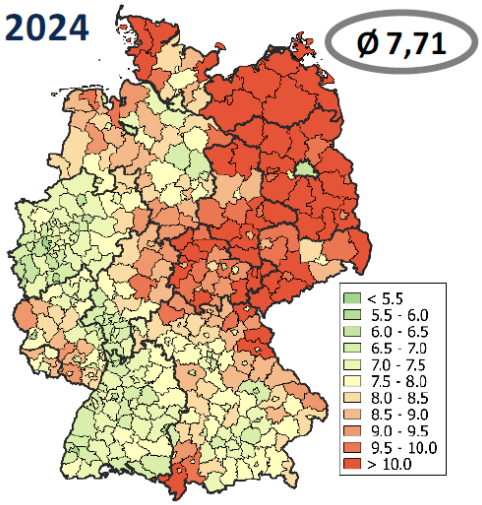
ENTSO-E (2016); Agora Energiewende (2015)

Grid capacity is adjusting to European trade – markets don't necessarily depict the actual physical flows.

Future development of network charges for households







Source: TU Dresden 2014

Network charges are likely to rise. The extension of offshore DC grids is the largest driver of increasing costs.

Bundesnetzagentur

National regulatory authority

Federal authority for planning approval of cross-state and cross-border the extra-high voltage power lines

One stop shop for PCI

System characteristics affecting power system security **Resulting Challenges**

- Increasing **inter-regional transport**

  → grid expansion, congestion management (TSO intervention)

- Increasing **volatility** of generation (prospectively: demand)

  → gradients, short-term balancing (incl. forecasts, flexibilities)

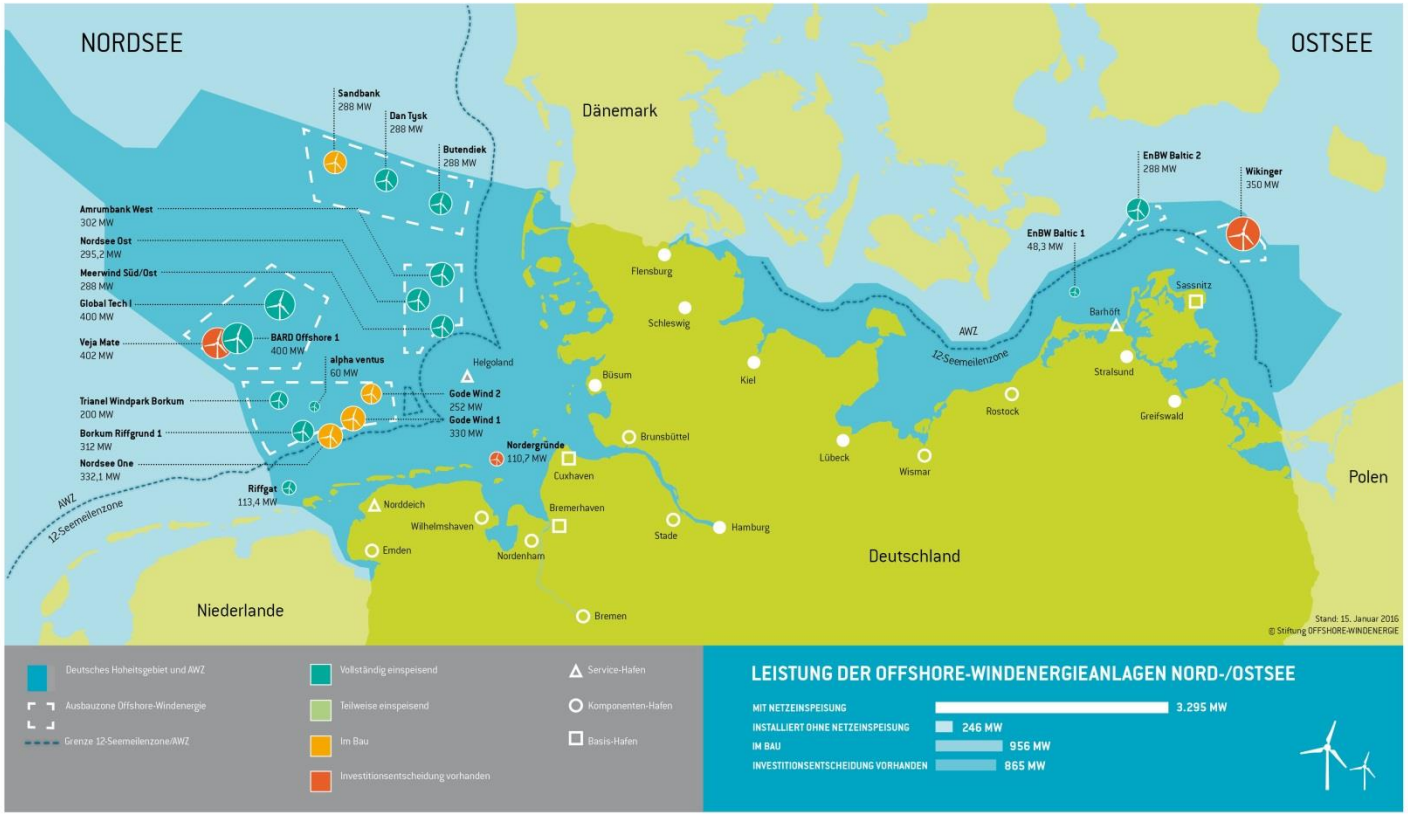
- Increasing **number of generation plants and market actors**

  → coordination and communication processes, IT (security)

- Decreasing **number of conventional power plants**

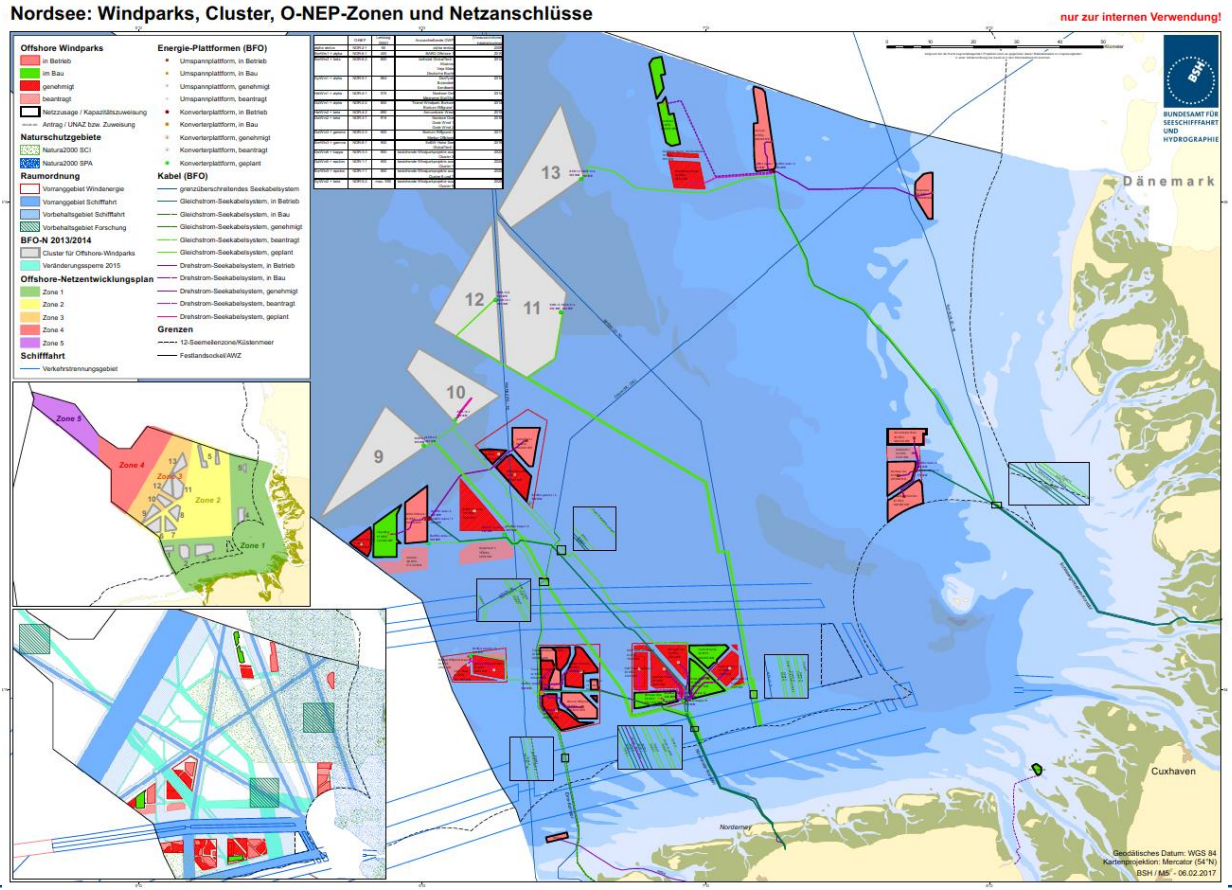
  → grid stability (ancillary services), system restoration

Offshore Wind: installed capacity 3500 MW (2015)

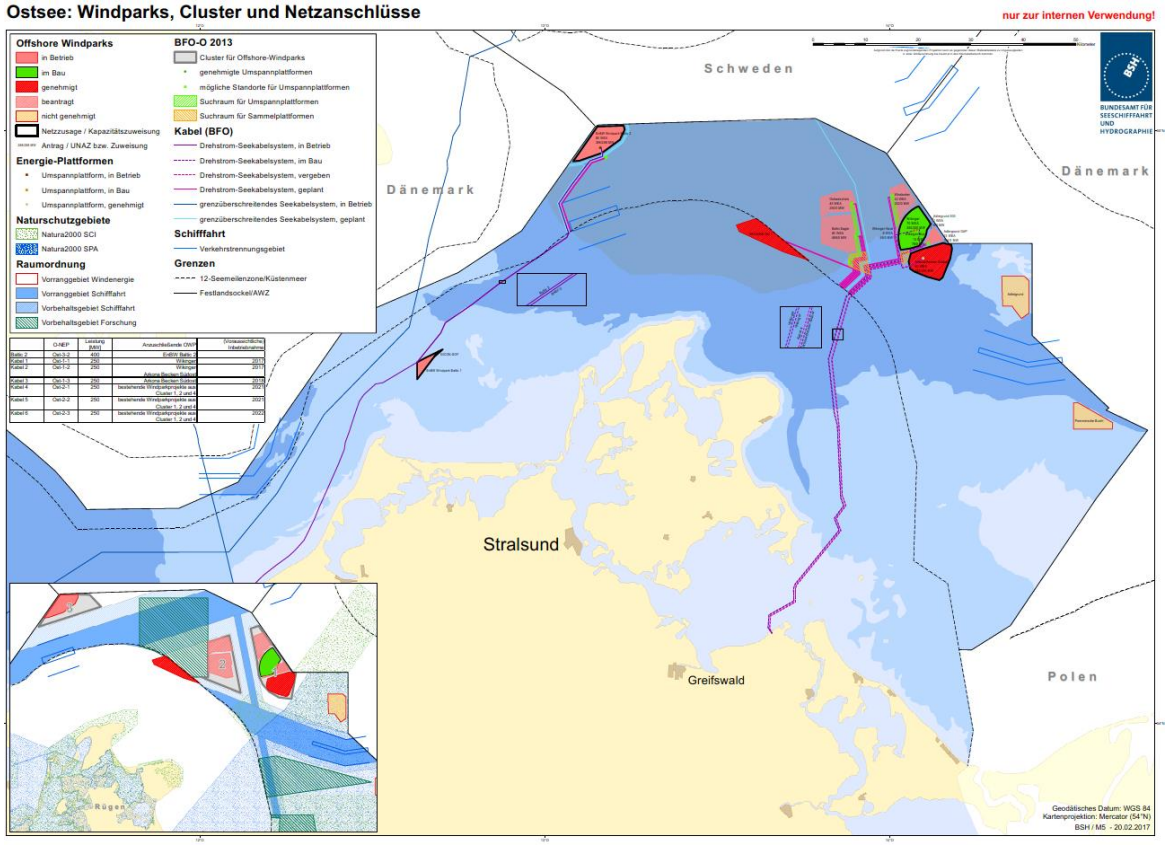


Source: Offshore Stiftung Windenergie

Northern Sea – grid development



Baltic Sea – grid development



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Scenarios of Grid Expansion Plan 2030

Installed Capacity [GW]					
Electricity Source	**Reference 2015**	**Scenario A 2030**	**Scenario B 2030**	**Scenario B 2035**	**Scenario C 2030**
Nuclear Power	10,8	0,0	0,0	0,0	0,0
Lignite	21,1	11,5	9,5	9,3	9,3
Hard Coal	28,6	21,6	14,7	10,8	10,8
Gas	30,3	30,0	39,3	43,0	39,3
Oil	4,2	1,2	1,2	0,9	0,9
Pump Storage	9,4	12,2	12,2	15,3	12,2
Others (convetional)	2,3	1,8	1,8	1,8	1,8
Capacity Reserve (5% of maximum load)	0,0	4,2	4,2	4,2	4,2
Total conventional generation	**106,7**	**82,5**	**82,9**	**85,3**	**78,5**
Wind Onshore	41,2	54,2	58,5	61,6	62,1
Wind Offshore	3,4	14,3	15,0	19,0	15,0
Photovoltaics	39,3	58,7	66,3	75,3	76,8
Biomass	7,0	5,5	6,2	6,0	7,0
Hydropower	5,6	4,8	5,6	5,6	6,2
Others (renewable)	1,3	1,3	1,3	1,3	1,3
Total renewable generation	**97,8**	**138,8**	**152,9**	**168,8**	**168,4**
Total Generation	**204,5**	**221,3**	**235,8**	**254,1**	**246,9**
Net Electricity Consumption [TWh]					
Net Electricity Consumption	532,1	517,1	547,1	547,1	577,1
Maximum Load [GW]					
Maximum Load	83,7	84	84	84	84

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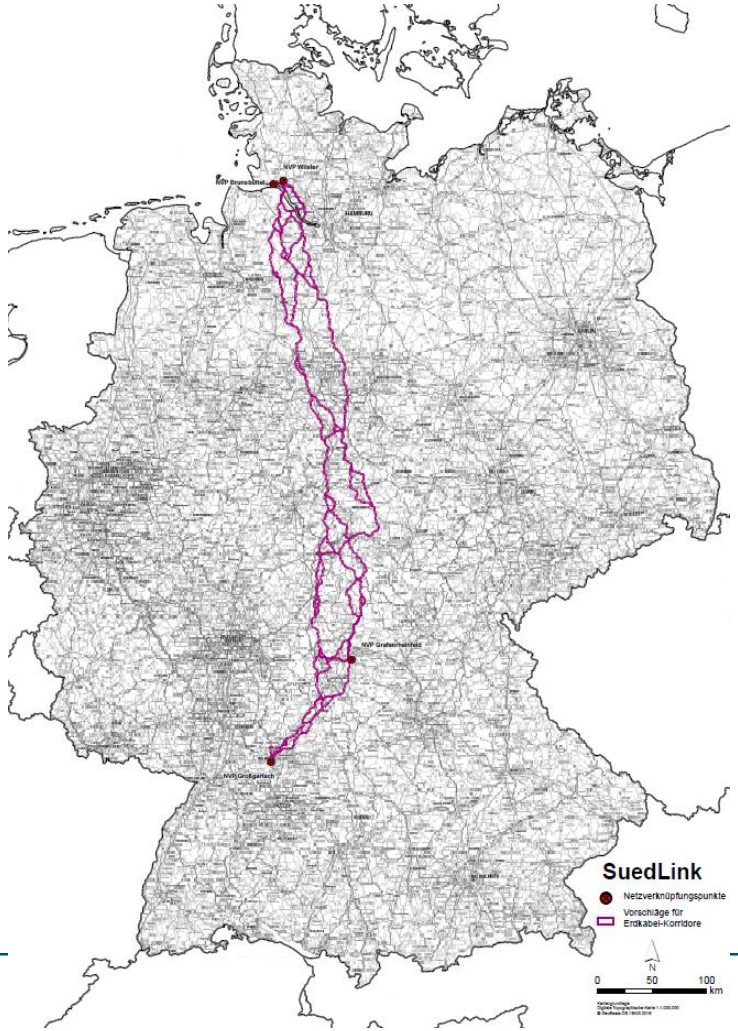
SuedLink: Project Overview

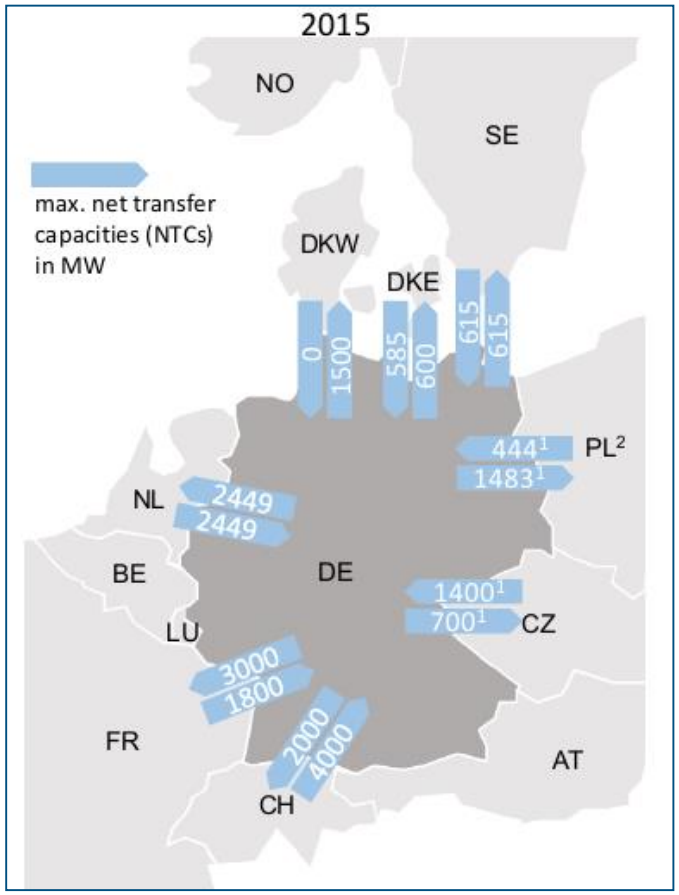
Capacity	2 x 2.000 MW
Voltage level	525 kV (preferred alternative 1A) 320 kV (fallback alt. - state of the art)
Converter stations	3 realized and owned by TenneT 1 realized and owned by TransnetBW
Route length	approx. 700 km
Extraord. structure	tunnel crossing of river Elbe



SuedLink: Planning Proposal

- suggests possible alternative routing for a final corridor
- high involvement of local municipalities, local stakeholders and the public to optimize the net
- information regarding public remarks, suggestions and request for changes are being evaluated

Cross border capacities (NTCs) in 2015



Source:

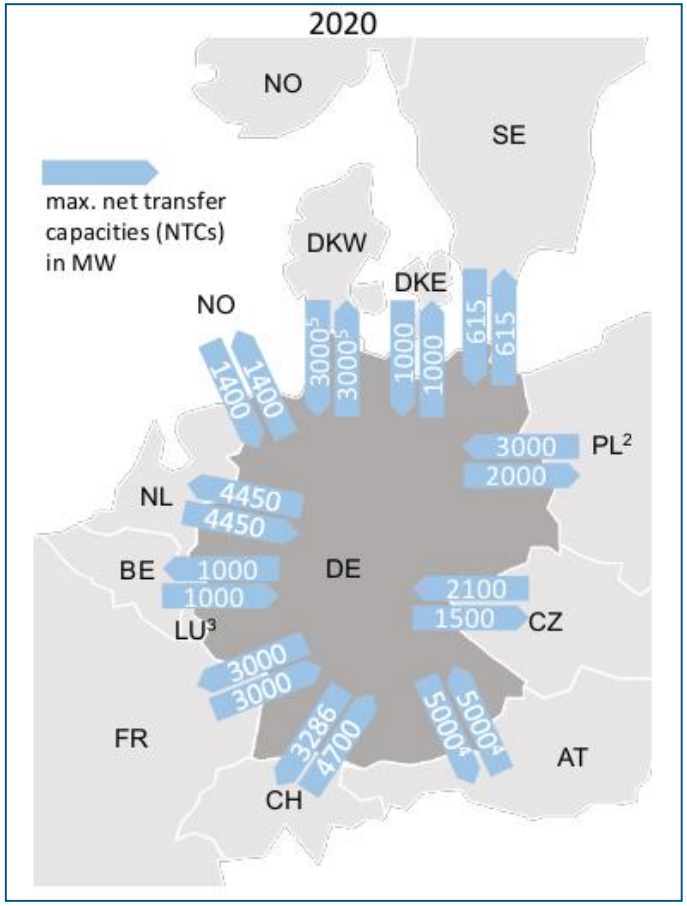
Information of German TSOs respective the approved capacity model of the German Federal Network Agency (BNetzA)

Currently Germany, Luxemburg and Austria are a common bidding zone, therefore no official NTC available for 2015

[1] based on available data of ENTSO-E Forecast Transfer Capacities – Day Ahead in 2015

[2] NTCs to and from Poland are dependend on the total polish profile which contains the sum of Germany, Czech Republik and Slovakia

Cross border capacities (NTCs) in 2020



Source:

Based on the reference capacities of the TYNDP 2016

[1] based on available data of ENTSO-E Forecast Transfer Capacities – Day Ahead in 2015

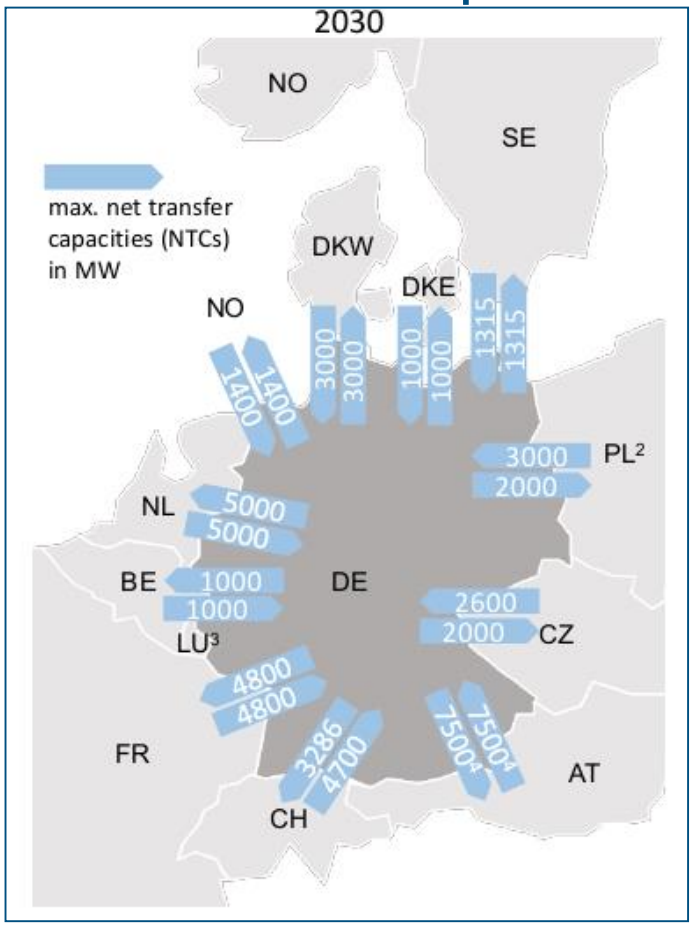
[2] NTCs to and from Poland are dependend on the total polish profile which contains the sum of Germany, Czech Republik and Slovakia

[3] NTCs between Luxemburg and Germany, in both directions, are assumed to 2300 MW for 2020 and 2030 considering the reference capacities in the TYNDP 2016

[4] NTCs between Austria and Germany are under reserve of a bidding zone split

[5] is is expected that the NTCs between Denmark and Germany can be realized only after 2020 because of internatl bottlenecks within Germany

Cross border capacities (NTCs) in 2030



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