ANGUS II Scenario Description

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Background

The ANGUS scenarios and their have been developed to model a pathway towards 100% renewable energy system in Germany. The assessed system aims to adhere with the COP paris agreement, i.e. providing a CO2-neutral energy supply in Germany. The developed scenarios are based on the TYNDP2018, the NEP2019, the e-Highway 100%-RES scenario and the UBA RESCUE scenarios. Their main purpuse is to generate storage profiles (power, energy) to assess underground storage technologies with regard to techno-ecnomic indicators. Therefore, the shadow prices of the developed techno-economic energy system model play an important role as economic signal for the storage dispatch and the model coupling (s. ANGUS Case Studies). Hence, high priority is given to sensitivies that have major effect on the storage dispatch and requirements of the future german energy system. The german energy system is modelled with greater detail as the neigboring countries due to the regional focus of this country.

Existing Scenarios

The *Netzentwicklungsplan (NEP)* is developed by the German TSOs to plan transmission grid in Germany. The NEP is based on a broad public consultation phase to enable high acceptance of planned grid expansion. Similarly, the Ten Year Netwok Development Plan (TYNDP) is developed by the European TSOs with regard to the European grid. The process of the national NEP and the TYNDP is aligned to ensure coherent national and international planning. The scenarios in both of these plans reflect current and expected socio-economic developments as well as relevant policy decisions. Due to the public consultation and their prominent nature, these scenarios constitute import visions for the future Eurpean energy system. However, both plans are focussin on the short to mid-term perpective. Therefore, within the ANGUS project another prominent scenario development project, the e-Highway2050 project, is used as a foundation for the scenario development. The e-Highway2050 project has been funded by the European Commission. The project aimed develop a plan for the European transmission network from 2020 to 2050. One important part of this study is the support of EU's overall policy objectives with regard to energy. The study is builds upon the TYNDP2016 and includes scenarios for 100% renewable energy supply in 2050. The TYNDP is developed by the network of European TSO (ENTSOE), therefore it also plays an important role for the NEP which is developed by the four german TSO.

Scenario Assumptions

Spatial and temporal resolution

Assumptions: The scenarios model the western europe energy system with one node per country. Countries modelled are: **AT, BE, CH, CZ, DE, DK, FR, IT, LU, NL, NO, PL, SE.** The model simulates the the system on an hourly basis for one year using a perfect foresight approach with the years 2030 and 2050.

Implications & Limitations: Intra-country grid constraints are not reflected by the model. Hence, renewable energy curtailment and/or storage demand may be underestimated.

Grid

The grid for 2030 and 2040 is based on the TYNDP2018 (s. Annex), while the grid for 2050 is based on the e-Highway 100% RES scenario. Figure 1 shows the installed transmission capacities of the 2050 electricity system. The transmission system is modelled with a transhipment approach assuming 0.03 loss on the lines.

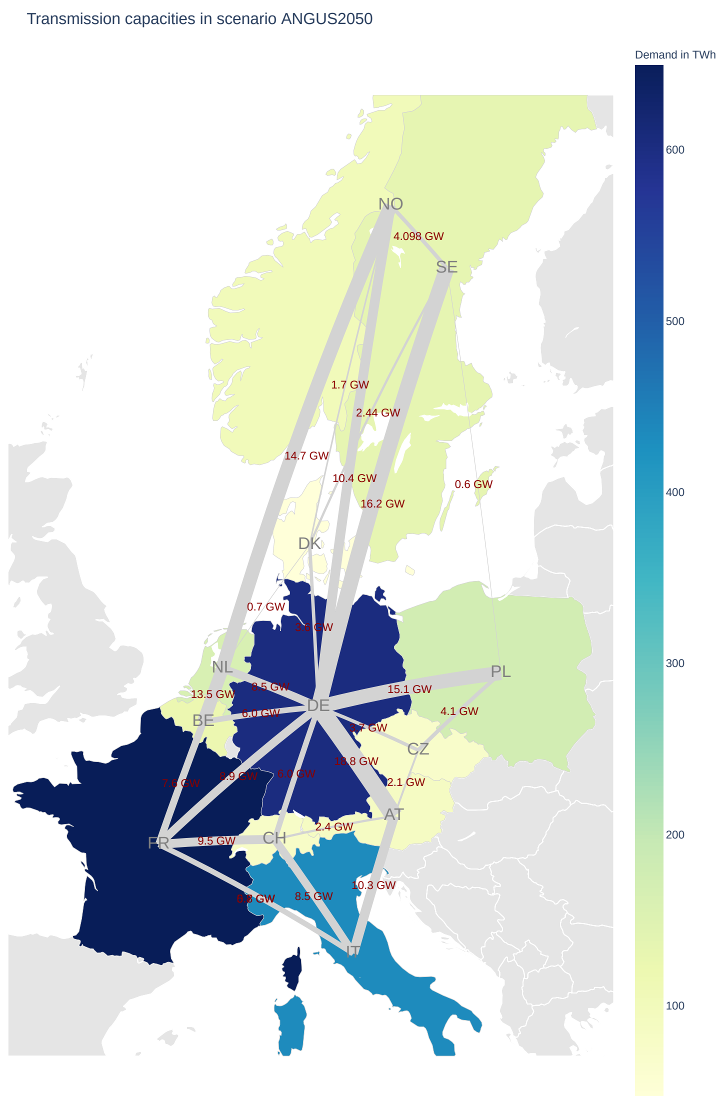

Figure 1: Installed tranmission capacities in 2050

Demand

Conventional electricity demand

The german goals regarding efficiency aim to reduce the electricity demand by 10% until 2020 and 25% by 2050 % compared to 2008 levels (403.8 TWh).
The development of future electricity demand strongly depends on demographic and economic development as well as implemented efficiency measures. In literature, different values can be found. Assumptions regarding the electricity demand are an important driving factor for the energy system. At the same time these values come with a high degree of uncertainty (Result of the ANGUS Scenario Workshop). While the *Basis Szenario* of the German *Langfristszenarien* the conventional electricity demand accounts for 441.2 TWh in 2030 and 417.2 TWh in 2050 respectively, the demand in the NEP2019 scenarios for 2030 is slightly higher (477 TWh).

Sector coupling

Despite a decreasing demand due to efficiency measures, the electrification of other sectors (heat, transport) will create an additional demand for electricity. Currently the heat demand for residential heating accounts for 122.4 TWh hotwater and 678.5 TWh space heating (2017). The German goverment set a goal of 60-80% reduction for this sector 2050. These values are very ambitious, as current values of insulation are lacking behind necessary rates. Heat demand in the RESCUE scenarios ranges from 436.8 TWh (GL) to 246.2 TWh (GS). These amounts correspond to a reduction of approx. 72 % to 50 % compared to 2008 (889 TWh). The supply for this heat demand is heavily based electricity (heatpumps) 74.6 % (GS) and 65 % (GL). The remaining energy is provided by district heating 62.4 TWh (GS) and in the case of the GL also additional decentral gas boilers.

In the NEP2019 2030C scenario additional 29 TWh electricity from heatpumps in residential heating and 25 TWh additional demand for electric vehicles are consumed. In contrast, the BMWI scenarios 17.8 TWh electricity for heatpumps is consumed. These values are in the range with the RESCUE green late (GL) and green supreme (GS) scenarios with 57 TWh_th and 95 TWh_th respectively (assuming coeffienct of performance of appr. 3). Therefore, for 2050 both RESCUE scenarios are used as a basis for additional electricity demand due to space heating.

Demand profiles are calculated from the OPSD dataset of the ENTSOE timeseries for the selected weather year (2012).

Implications & Limitations:

- Due to the historic demand profiles, future flexibilities like smart operation of certain applications and inducstry processes are not modelled.
- The model only covers the residential hotwater and space heating demand.
- EVH are modelled without specific profile for charging / discharging but only with a constant additional base load.

Generation capacity

The different scenarios are based on the NEP2019, TYNDP2018 and the e-Highway project.

- NEP2030C: Installed capacities in Germany are based on the NEP2019 scenario 2030C. The capacities of neigboring countries are based on the TYNDP2018-2030ST vision. The renewable share of produced energy in Germany in this scenario is approx. 68 %.
- 2040GCA: This scenario is based on the TYNDP2018-GCA vision.
- 2050ZNES: The base scenario is the e-Highway 100 RES scenario. This scenario strongly depends on hydro capacity expansion in Norway and also substantial biomass capacitiy/energy. Based on the input data, this scenario has an renewable energy supply share of approx. 95 % .

- 2050ANGUS: Therefore, the adapted ANGUS scenarios haven been developed to describe 100% renewable energy scenarios with different sensitivies such as the no-biomass (nb).

The installed capacities in Germany are shown in the Figure 2 below.

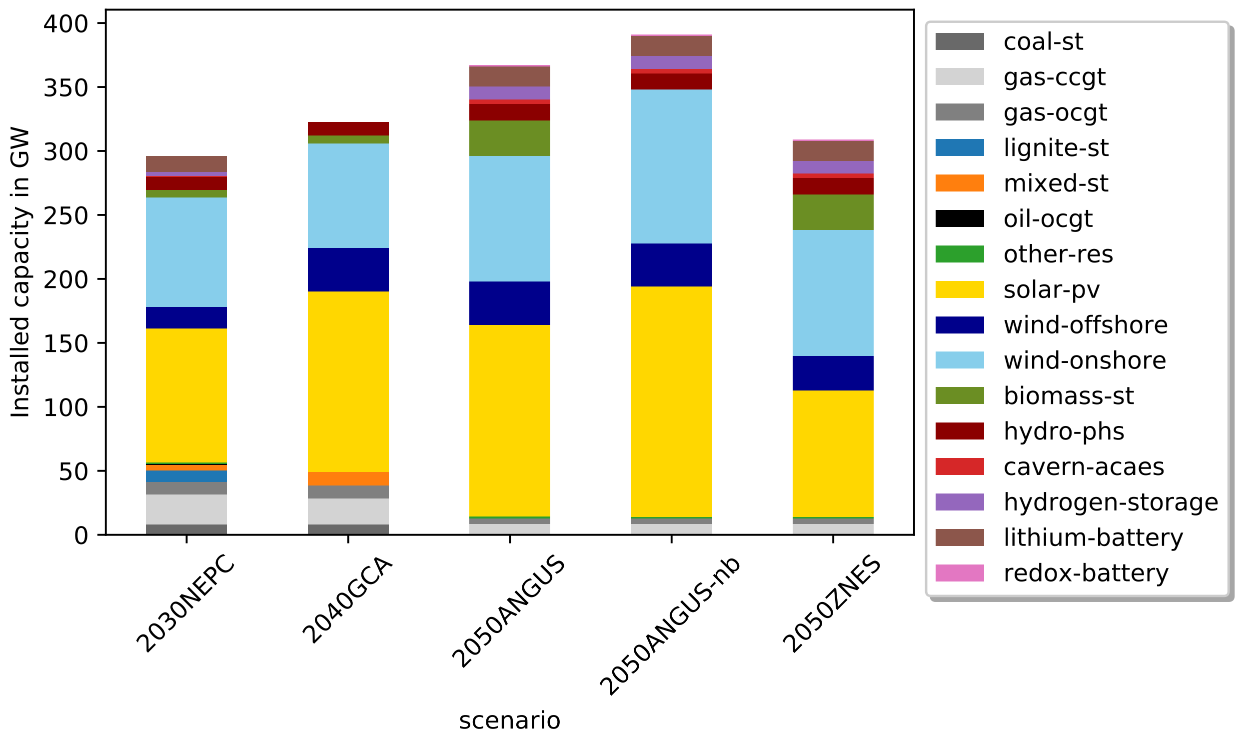

Figure 2: Installed generation capacity in 2050

Note that only the scenarios 2030NEPC, 2040GCA, 2050ANGUS-(nb) depict a path towards 100% renewable energy supply.

Renewables

For 2030 and 2040 the reservoir data has been calculated as follows:

- The reservoir (rsv) capacity is calculated by substracting the column 'hydro-pump from column 'hydro turbine' in the original data source. Therefore, it is assumed, that each pumped hydro storage (phs) has equal pump/turbine capacities.
- The max-hours (energy capacity) for PHS is based on Geth et al. 2018.
- The max-hours for rsv is calculated for each country based on the Restore2050 data, where rsv storage capacity in TWh is provided in addition to the installed capacity. It is assumed that all new rsv plants will have the same reservoir sizes in each country as provided in current data from the Restore2050 project.

Onshore wind and pv timeseries are based on renewables ninja for each country. The offshore profiles are take from the Venetzen-project and adapted with an correction factor of 0.8 which has been derived from the energy production in the e-Highway scenarios. The inflow in run of river and reservoirs is modelled with the inflow timeseries of the Restore2050 project.

country	offshore	onshore	pv	ror
AT	nan	1507	1291	2038

country	offshore	onshore	pv	ror
BE	3939	2406	1135	890
CH	nan	1354	1416	2555
CZ	nan	1875	1226	1316
DE	3976	1951	1151	3082
DK	4224	2670	977	0
FR	3295	2040	1265	1815
LU	nan	2917	1192	1947
NL	4025	1921	1095	1012
NO	4341	3562	811	2028
PL	3964	1834	1113	995
SE	3792	2654	862	2161

The maximum biomass potential per country is derived from the [hotmaps] project and is equal for all scenarios in the ANGUS project. The potential does not cover waste but only agriculture and forestry residues. With an efficiency of 0.487 for biomass to electricity conversion the potential in Germany is approx. 73 TWhel.

	Amount in TWh
AT	23.6111
BE	8.08333
CH	0
CZ	32.7778
DE	150.167
DK	13.5556
FR	149.556
LU	0.611111
NL	2.80556
NO	0
PL	71.3611
SE	86.75

Annex I

Hydro data

country	year	rsv	phs	ror	ror-share	phs-max-hours	rsv-max-hours
AT	2030	4787.52	6055.33	4671.9	0.493889	33	857
AT	2040	4787.52	6055.33	4671.9	0.493889	33	857
AT	2050	5676	10733	7401.16	0.565961	33	857
BE	2030	158	1150	117	0.425455	4	500
BE	2040	158	1908	117	0.425455	4	500
BE	2050	0	2308	331.972	1	4	500
CH	2030	8987	4593	4139	0.315328	136	906
CH	2040	8987	6722	4139	0.315328	136	906
CH	2050	8130	5443	4122.7	0.336473	136	906
CZ	2030	50	1000	365	0.879518	5	1111
CZ	2040	50	1145	365	0.879518	5	1111
CZ	2050	819	1787	454.846	0.357065	5	1111
DE	2030	995.9	9791.6	4329	0.812973	6	592

country	year	rsv	phs	ror	ror-share	phs-max-hours	rsv-max-hours
DE	2040	620	10244	4329	0.874722	6	592
DE	2050	620	12799	4233	0.872244	6	592
DK	2030	0	0	6.6082	1	6	
DK	2040	0	0	6.6082	1	6	
DK	2050	0	0	13.3102	1	6	
FR	2030	8197	5500	13797	0.627307	15	1201
FR	2040	8000	5500	13600	0.62963	15	1201
FR	2050	18200	13420	10318.6	0.36182	15	1201
LU	2030	284	1026	34	0.106918	4	2840
LU	2040	284	1026	34	0.106918	4	2840
LU	2050	0	1650.68	149.203	1	4	2840
NL	2030	0	0	38	1	6	
NL	2040	0	2500	38	1	6	
NL	2050	0	0	104.435	1	6	
NO	2030	34702.2	1114.71	0	0	314	3139
NO	2040	34702.2	1114.71	0	0	314	3139
NO	2050	42473	17291	28141	0.398518	314	3139
PL	2030	0	1488	1033	1	5	5477
PL	2040	0	2292	1033	1	5	5477
PL	2050	0	3790	2078.8	1	5	5477
SE	2030	16184	0	0	0	793	3456
SE	2040	16184	0	0	0	793	3456
SE	2050	21383.3	0	10775.2	0.335066	793	3456

Carrier cost

scenario	carrier	value	unit	source
2030DG	biomass	30.32	EUR/MWh	HeatRoadMap
2030DG	co2	50	EUR/t	TYNDP2018
2030DG	coal	9.72	EUR/MWh	TYNDP2018
2030DG	gas	31.68	EUR/MWh	TYNDP2018
2030DG	lignite	3.96	EUR/MWh	TYNDP2018
2030DG	mixed	6.7	EUR/MWh	Own Assumption
2030DG	oil	78.48	EUR/MWh	TYNDP2018
2030DG	uranium	1.692	EUR/MWh	TYNDP2018
2030DG	waste	6.7	EUR/MWh	Own Assumption
2030NEPC	biomass	5	EUR/MWh	Own Assumption
2030NEPC	co2	29.4	EUR/t	NEP2019
2030NEPC	coal	8.4	EUR/MWh	NEP2019
2030NEPC	gas	26.4	EUR/MWh	NEP2019
2030NEPC	lignite	5.6	EUR/MWh	NEP2019
2030NEPC	mixed	6.7	EUR/MWh	Own Assumption
2030NEPC	oil	48.3	EUR/MWh	NEP2019
2030NEPC	uranium	1.692	EUR/MWh	TYNDP2018
2030NEPC	waste	6.7	EUR/MWh	IRENA2015
2040GCA	biomass	30.32	EUR/MWh	HeatRoadMap
2040GCA	co2	126	EUR/t	TYNDP2018
2040GCA	coal	6.48	EUR/MWh	TYNDP2018
2040GCA	gas	30.24	EUR/MWh	TYNDP2018
2040GCA	lignite	3.96	EUR/MWh	TYNDP2018
2040GCA	mixed	6.7	EUR/MWh	Own Assumption

scenario	carrier	value	unit	source
2040GCA	oil	50.22	EUR/MWh	TYNDP2018
2040GCA	uranium	1.692	EUR/MWh	TYNDP2018
2040GCA	waste	6.7	EUR/MWh	Own Assumption
2050ZNES	biomass	34.89	EUR/MWh	HeatRoadMap
2050ZNES	co2	150	EUR/t	Own Assumption
2050ZNES	coal	7.97	EUR/MWh	HeatRoadMap
2050ZNES	gas	43.72	EUR/MWh	HeatRoadMap
2050ZNES	lignite	6	EUR/MWh	Own Assumption
2050ZNES	mixed	6.7	EUR/MWh	Own Assumption
2050ZNES	oil	47.63	EUR/MWh	HeatRoadMap
2050ZNES	uranium	1.692	EUR/MWh	Own Assumption
2050ZNES	waste	30	EUR/MWh	Own Assumption

Technical parameters

year	parameter	carrier	tech	value	unit	source
2030	efficiency	biomass	st	0.35	per unit	DIW
2030	efficiency	coal	st	0.4	per unit	TYNDP2018
2030	efficiency	gas	ccgt	0.5	per unit	TYNDP2018
2030	efficiency	gas	ocgt	0.38	per unit	TYNDP2018
2030	efficiency	hydro	phs	0.75	per unit	roundtrip; DIW
2030	efficiency	hydro	ror	0.9	per unit	DIW
2030	efficiency	hydro	rsv	0.9	per unit	DIW
2030	efficiency	lignite	st	0.4	per unit	TYNDP2018
2030	efficiency	oil	ocgt	0.35	per unit	TYNDP2018
2030	efficiency	uranium	st	0.33	per unit	TYNDP2018
2030	efficiency	waste	st	0.26	per unit	Own assumption
2030	efficiency	mixed	st	0.26	per unit	Own assumption
2030	efficiency	lithium	battery	0.85	per unit	roundtrip;Own assumption
2030	efficiency	cavern	acaes	0.7	per unit	roundtrip;ZNES
2030	efficiency	hydrogen	storage	0.4	per unit	roundtrip;ZNES
2030	max_hours	lithium	battery	6.5	h	Plessmann
2030	max_hours	hydro	phs	8	h	Plessmann
2030	max_hours	porous	acaes	300	h	Own assumption
2030	max_hours	cavern	acaes	3	h	ZNES
2030	max_hours	hydrogen	storage	168	h	eGo
2030	capex	wind	onshore	1182	Euro/kW	DIW
2030	capex	wind	offshore	2506	Euro/kW	DIW
2030	capex	solar	pv	600	Euro/kW	DIW
2030	capex	gas	ocgt	400	Euro/kW	DIW
2030	capex	gas	ccgt	800	Euro/kW	DIW
2030	capex	lithium	battery	785	Euro/kW	IWES
2040	efficiency	biomass	st	0.4185	per unit	Own assumption
2040	efficiency	coal	st	0.425	per unit	Own assumption
2040	efficiency	gas	ccgt	0.53475	per unit	Own assumption
2040	efficiency	gas	ocgt	0.373	per unit	Own assumption
2040	efficiency	hydro	phs	0.75	per unit	roundtrip; DIW
2040	efficiency	hydro	ror	0.9	per unit	DIW
2040	efficiency	hydro	rsv	0.9	per unit	DIW
2040	efficiency	lignite	st	0.4	per unit	Own assumption
2040	efficiency	oil	ocgt	0.373	per unit	Own assumption

year	parameter	carrier	tech	value	unit	source
2040	efficiency	uranium	st	0.335	per unit	Own assumption
2040	efficiency	waste	st	0.26	per unit	Own assumption
2040	efficiency	mixed	st	0.28	per unit	Own assumption
2040	efficiency	lithium	battery	0.885	per unit	Own assumption
2040	efficiency	porous	acaes	0.57	per unit	roundtrip; Own assumption
2040	efficiency	cavern	acaes	0.7	per unit	roundtrip; ZNES
2040	max_hours	lithium	battery	6.5	h	Plessmann
2040	max_hours	hydro	phs	8	h	Plessmann
2040	max_hours	porous	acaes	300	h	Own assumption
2040	max_hours	cavern	acaes	3	h	ZNES
2050	efficiency	biomass	st	0.487	per unit	DIW
2050	efficiency	coal	st	0.45	per unit	DIW
2050	efficiency	gas	ccgt	0.5695	per unit	Avg; DIW
2050	efficiency	gas	ocgt	0.366	per unit	Avg; DIW
2050	efficiency	hydro	phs	0.75	per unit	roundtrip; DIW
2050	efficiency	hydro	ror	0.9	per unit	DIW
2050	efficiency	hydro	rsv	0.9	per unit	DIW
2050	efficiency	lignite	st	0.4	per unit	Avg; DIW
2050	efficiency	oil	ocgt	0.396	per unit	DIW
2050	efficiency	uranium	st	0.34	per unit	DIW
2050	efficiency	waste	st	0.26	per unit	Own assumption
2050	efficiency	mixed	st	0.3	per unit	Own assumption
2050	efficiency	lithium	battery	0.92	per unit	roundtrip; IWES
2050	efficiency	porous	acaes	0.57	per unit	roundtrip; Own assumption
2050	max_hours	lithium	battery	6.5	h	Plessmann, p. 90
2050	max_hours	hydro	phs	8	h	Plessmann, p. 90
2050	max_hours	porous	acaes	300	h	Own assumption
2050	avf	wind	onshore	1	per unit	Own assumption
2050	avf	wind	offshore	1	per unit	Own assumption
2050	avf	solar	pv	1	per unit	Own assumption
2050	avf	biomass	st	0.9	per unit	Own assumption
2050	avf	coal	st	0.85	per unit	PRIMES
2050	avf	gas	ccgt	0.85	per unit	PRIMES
2050	avf	gas	ocgt	0.96	per unit	PRIMES
2050	avf	hydro	phs	1	per unit	Own assumption
2050	avf	hydro	ror	1	per unit	Own assumption
2050	avf	hydro	rsv	1	per unit	Own assumption
2050	avf	lignite	st	0.85	per unit	PRIMES
2050	avf	oil	ocgt	0.9	per unit	PRIMES
2050	avf	mixed	st	0.9	per unit	Own assumption
2050	avf	uranium	st	0.9	per unit	Own assumption
2050	avf	waste	st	0.9	per unit	Own assumption
2050	avf	lithium	battery	1	per unit	Own assumption
2050	avf	porous	acaes	1	per unit	Own assumption
2050	vom	wind	onshore	0	Euro/Mwh	Plessmann
2050	vom	wind	offshore	0	Euro/Mwh	Plessmann
2050	vom	solar	pv	0	Euro/Mwh	Plessmann
2050	vom	biomass	st	10	Euro/Mwh	Own assumption
2050	vom	coal	st	6	Euro/Mwh	DIW, p. 78
2050	vom	gas	ccgt	4	Euro/Mwh	DIW, p. 78
2050	vom	gas	ocgt	3	Euro/Mwh	DIW, p. 78
2050	vom	hydro	phs	0	Euro/Mwh	DIW, p. 78

year	parameter	carrier	tech	value	unit	source
2050	vom	hydro	ror	0	Euro/Mwh	DIW, p. 78
2050	vom	hydro	rsv	0	Euro/Mwh	DIW, p. 78
2050	vom	lignite	st	7	Euro/Mwh	DIW, p. 78
2050	vom	uranium	st	8.5	Euro/Mwh	DIW, p. 78, AVG
2050	vom	oil	ocgt	3	Euro/Mwh	DIW, p. 78
2050	vom	mixed	st	5	Euro/Mwh	Own assumption
2050	vom	waste	st	10	Euro/Mwh	Own assumption
2050	vom	lithium	battery	0	Euro/Mwh	Plessmann, p. 90
2050	fom	wind	onshore	35	Euro/kWa	DIW, p.78
2050	fom	wind	offshore	80	Euro/kWa	DIW, p.78
2050	fom	solar	pv	25	Euro/kWa	DIW, p.78
2050	fom	biomass	st	100	Euro/kWa	DIW, p.78
2050	fom	coal	st	25	Euro/kWa	DIW, p.78
2050	fom	gas	ccgt	20	Euro/kWa	DIW, p.78
2050	fom	gas	ocgt	15	Euro/kWa	DIW, p.78
2050	fom	hydro	phs	20	Euro/kWa	DIW, p.78
2050	fom	hydro	ror	60	Euro/kWa	DIW, p.78
2050	fom	hydro	rsv	20	Euro/kWa	DIW, p.78
2050	fom	lignite	st	30	Euro/kWa	DIW, p.78
2050	fom	oil	ocgt	6	Euro/kWa	DIW, p.78
2050	fom	lithium	battery	10	Euro/kWha	Schill2018
2050	capex	wind	onshore	1075	Euro/kW	DIW, p. 75
2050	capex	wind	offshore	2093	Euro/kW	DIW, p. 75
2050	capex	solar	pv	425	Euro/kW	DIW, p. 75
2050	capex	biomass	st	1951	Euro/kW	DIW, p. 75
2050	capex	coal	st	1300	Euro/kW	DIW, p. 75
2050	capex	gas	ccgt	800	Euro/kW	DIW, p. 75
2050	capex	gas	ocgt	400	Euro/kW	DIW, p. 75
2050	capex	hydro	phs	2000	Euro/kW	DIW, p. 75
2050	capex	hydro	ror	3000	Euro/kW	DIW, p. 75
2050	capex	hydro	rsv	2000	Euro/kW	DIW, p. 75
2050	capex	lignite	st	1500	Euro/kW	DIW, p. 75
2050	capex	oil	ocgt	400	Euro/kW	DIW, p. 75
2050	capex_energy	lithium	battery	187	Euro/kWh	Schill2018
2050	capex_power	lithium	battery	35	Euro/kWh	Schill2018
2050	lifetime	wind	onshore	25	a	DIW, p. 72
2050	lifetime	wind	offshore	25	a	DIW, p. 72
2050	lifetime	solar	pv	25	a	DIW, p. 72
2050	lifetime	biomass	st	30	a	DIW, p. 72
2050	lifetime	coal	st	40	a	DIW, p. 72
2050	lifetime	gas	ccgt	30	a	DIW, p. 72
2050	lifetime	gas	ocgt	30	a	DIW, p. 72
2050	lifetime	hydro	phs	50	a	DIW, p. 72
2050	lifetime	hydro	ror	50	a	DIW, p. 72
2050	lifetime	hydro	rsv	50	a	DIW, p. 72
2050	lifetime	lignite	st	40	a	DIW, p. 72
2050	lifetime	oil	ocgt	40	a	DIW, p. 72
2050	lifetime	lithium	battery	10	a	Plessmann, p. 90
2050	efficiency	redox	battery	0.75	per unit	roundtrip;ZNES
2050	efficiency	hydrogen	storage	0.4	per unit	roundtrip;ZNES
2050	efficiency	cavern	acaes	0.7	per unit	roundtrip;ZNES
2050	max_hours	redox	battery	3.3	h	ZNES

year	parameter	carrier	tech	value	unit	source
2050	max_hours	hydrogen	storage	168	h	eGo
2050	max_hours	cavern	acaes	3	h	ZNES
2050	lifetime	redox	battery	25	a	Schill2018
2050	lifetime	hydrogen	storage	22.5	a	Schill2018
2050	lifetime	cavern	acaes	30	a	Schill2018
2050	capex_energy	redox	battery	70	Euro/kWh	Schill2018
2050	capex_energy	hydrogen	storage	0.2	Euro/kWh	Schill2018
2050	capex_energy	cavern	acaes	40	Euro/kWh	Schill2018
2050	capex_power	redox	battery	600	Euro/kW	Schill2018
2050	capex_power	hydrogen	storage	1000	Euro/kW	Schill2018
2050	capex_power	cavern	acaes	750	Euro/kW	Schill2018
2050	fom	redox	battery	10	Euro/kWha	Schill2018
2050	fom	hydrogen	storage	10	Euro/kWha	Schill2018
2050	fom	cavern	acaes	10	Euro/kWha	Schill2018
2050	vom	redox	battery	1	Euro/Mwh	Schill2018
2050	vom	hydrogen	storage	1	Euro/Mwh	Schill2018
2050	vom	cavern	acaes	1	Euro/Mwh	Schill2018

Grid

Data Sources

- ehighway
- PRIMES2016
- ISE2011
- TYNDP2018a
- TYNDP2018b
- NinjaWind
- NinjaPV
- OPSDa
- OPSDb
- OPSDc
- NEP2019a
- NEP2019b
- Restore2050
- Brown
- ANGUS
- hotmaps

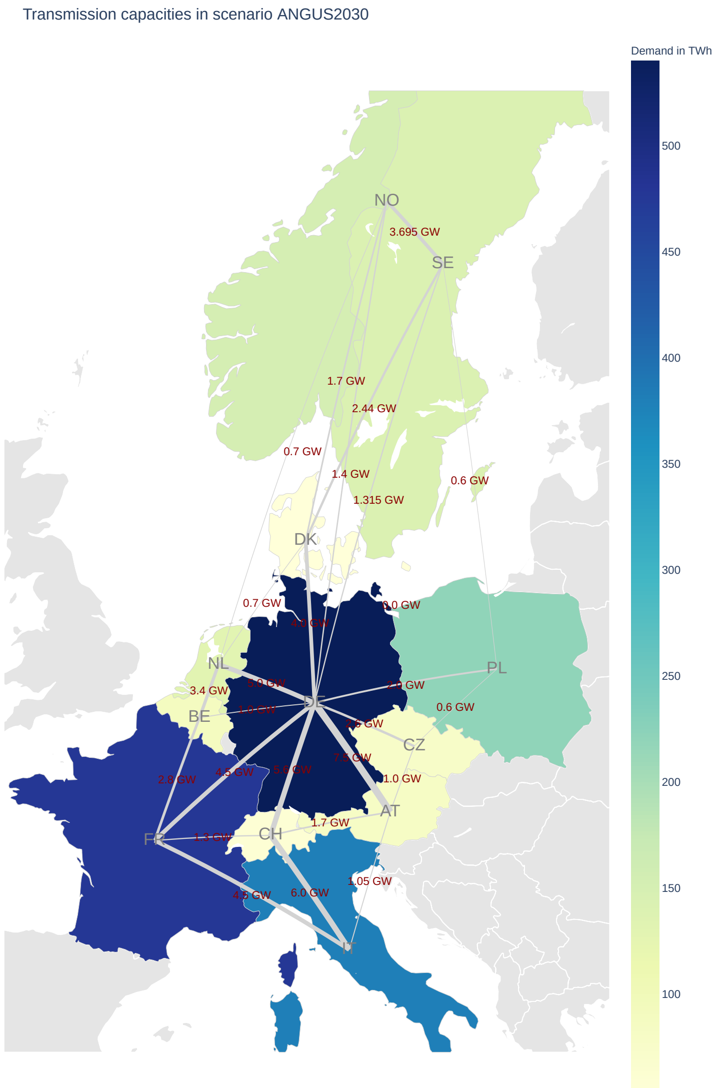

Figure 3: Installed tranmission capacities in 2030

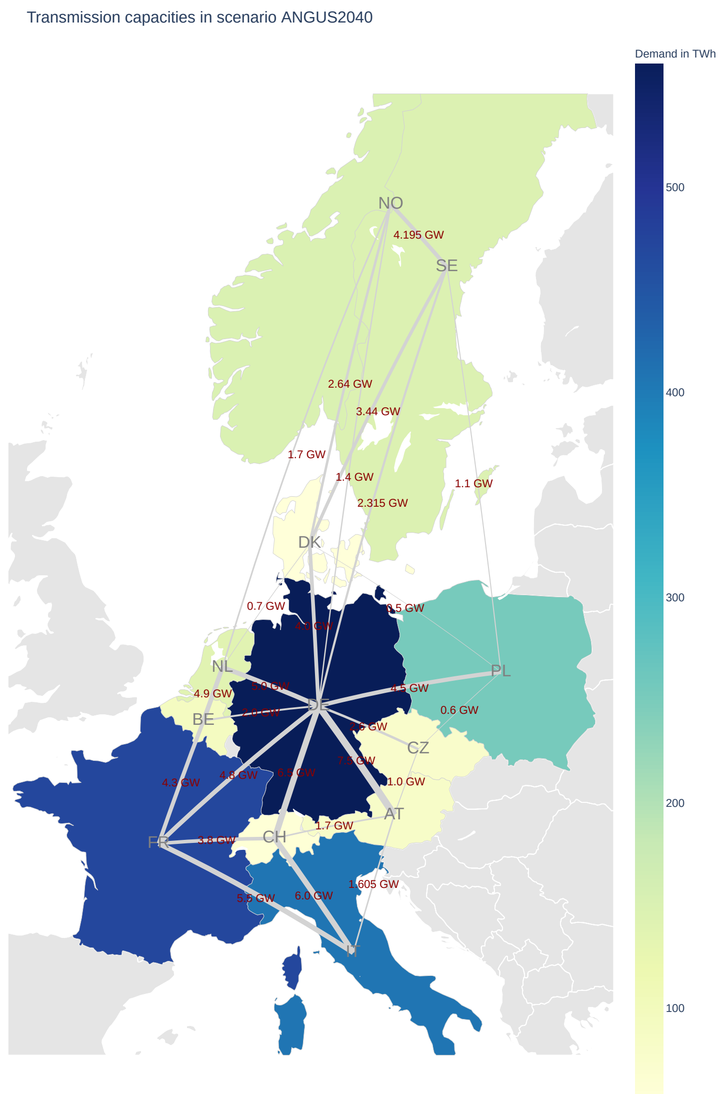

Figure 4: Installed tranmission capacities in 2040

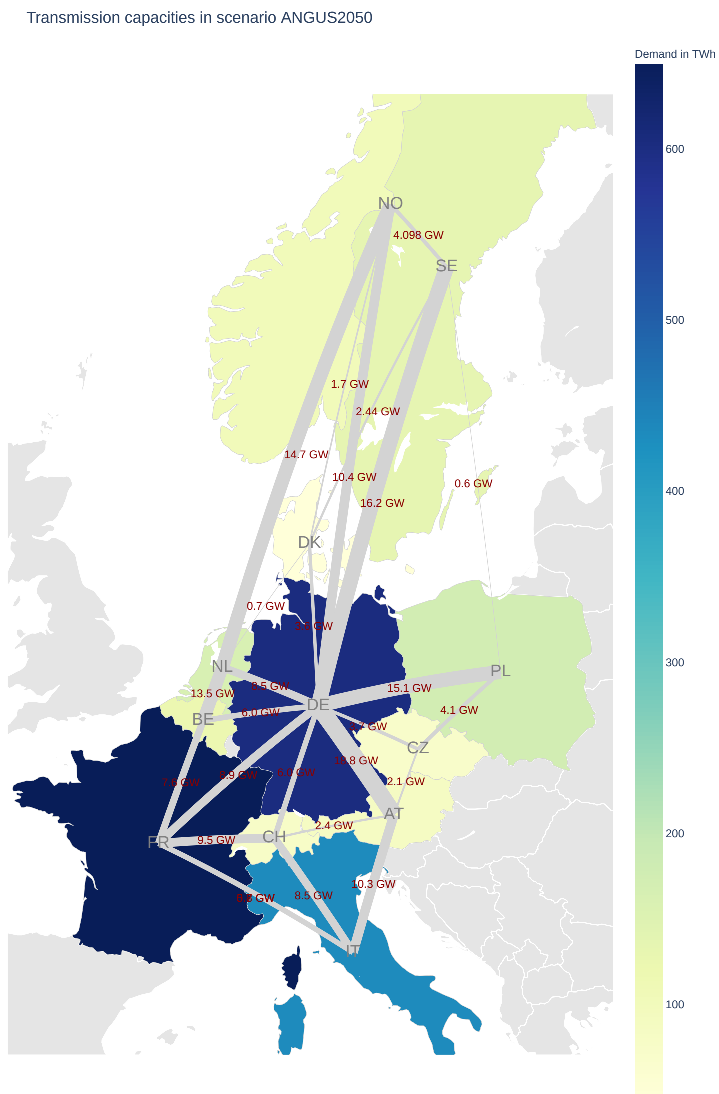

Figure 5: Installed tranmission capacities in 2050