ANGUS II Scenario description

Overview

The developed scenarios are based on the TYNDP2018, the NEP2019, the e-Highway 100%RES scenario and the UBA RESCUE scenarios.

For the non-german countries the following data has been used:

- 2030: TYNDP2018 DG (distributed generation vision)
- 2040: TYNDP2018 2040 GCA (global climate action vision)
- 2050: E-Highway 100% RES

The e-Highway2050 [ehighway] 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.

For Germany the starting point for the pathyways is the NEP2019:

- 2030: NEP 2019 C
- 2040: Interpolated (TYNDP2018)
- 2050: RESCUE, E-Highway

The scenarios from literature and their different visions have been selected to model a pathway towards 100% renewable energy system in Germany to adhere to the COP paris agreement. As the e-Highway scenarios are based on the TYNDP2016 and the NEP2019 is aligned with the TYNDP2018, the scenario for the year 2050 has been adapted for the focus country of Germany.

Assumptions

Spatial and temporal resolution

Assumptions: The scenarios model the western europe energy system with one node per country, i.e. reflecting the market zones. Countries modelled are: **AT, BE, CH, CZ, DE, DK, FR, IT, 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, 2040 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.

Demand

Conventional electricity demand

The german efficiency goals to reduce the electricity by 10% until 2020 and 25% by 2050 % compared to 2008 levels (538.4 TWh) are ambitious but necessary. Development strongly depends on demographic and economic development as well as implemented efficiency measures. While in the basis scenario of the german Langfristszenarien 441.2 TWh (2030) and 417.2 TWh (2050) are consumed by conventional electricity applications, the demand in the NEP2019 scenarios for 2030 is higher 477 TWh.

For the ANGUS scenarios the NEP2019 Demand of 477 TWh for 2030 decreases until 2050 to 403.8 TWh (-25 % compared to 2008).

Sector coupling

Despite a decreasing demand due to efficiency measure, the electrification of other sectors (heat, transport) will create 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 goals 60 to 80% reduction in heat demand. With 436.8 TWh (GL) and 246.2 (GS) in the RESCUE scenarios the reduction is approx. 50 % and 72 % resp. compared to 2008 (889 TWh).

The supply fot this heat demand is based on electricity (heatpumps) to 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.

NEP2019 2030C 29 TWh for heatpumps in residential heating and 25 TWh additional demand for electric vehicles. In the BMWI 17.8 TWh electricity for heatpumps is assumend. 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 2040 and 2050 these both RESCUE scenarios are used as a basis for additional electric heat. For consistency, the electric demand is also based on these two RESCUE scenarios.

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.

Generation capacity

For Germany installed capacities of the NEPScenario 2019 2030C are implemented.

name	ANGUS2030	ANGUS2040	ANGUS2050
coal-st	8100	4000	0
gas-ccgt	23400	30000	13000
gas-ocgt	10000	0	0
lignite-st	9000	5000	0
mixed-st	4100	4100	2000
oil-ocgt	900	450	0
solar-pv	104500	127250	150000
wind-offshore	17000	26000	35000
wind-onshore	85500	105250	125000

In the TYNDP2018 and Ehighway scenario gas fired power plants are not seperated into CCGT and OCGT. Therefore a factor of 0.5 [ISE2011] is used to split the total gas capacity into these to technologies.

Conventional energies

Efficiencies and commodity costs are based on the TYNDP2018 and the NEP2030C for 2030. The availability factor (avf) of technologies and variable operation and maintenance cost (vom) are the same for all scenarios. The avf is based on the PRIMES model assumptions.[PRIMES2016] For detailed data see Annex I.

Renewable Energies

For the renewable profiles of wind and pv timeseries of renewables ninja has been used. The maximum biomass potential per country the hotmaps potential is used.

Hydro data is based on the TYNDP2018 GCA (global climate action) vision. However it should be noted, that due to the low cost and the limited potential of hydro power, the installed capacities within the vision and years of the TYNDP do not differ significantly.

- 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) have equal pump/turbine capacities.
- The max-hours 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 new rsv plants will have the same reservoir sizes in each country as provided in current data from the Restore2050 project.

The inflow in run of river and reservoirs is modelled based on the inflow timeseries of the Restore2050 project.

Grid

The grid for 2030 and 2040 is based on the TYNDP2018, while the grid for 2050 is based on the e-Highway 100% RES scenario.

Annex I

Efficiencies

carrier	tech	2030	2040	2050
biomass	st	0.35	0.4185	0.487
coal	st	0.4	0.425	0.45
gas	ccgt	0.5	0.53475	0.5695
gas	ocgt	0.38	0.373	0.366
hydro	phs	0.75	0.75	0.75
hydro	ror	0.9	0.9	0.9
hydro	rsv	0.9	0.9	0.9
lignite	st	0.4	0.4	0.4
oil	ocgt	0.35	0.373	0.396
uranium	st	0.33	0.335	0.34
waste	st	0.26	0.26	0.26
mixed	st	0.26	0.28	0.3
lithium	battery	0.85	0.885	0.92
air	caes	0.57	0.57	0.57
wind	onshore	NA	NA	NA
wind	offshore	NA	NA	NA
solar	pv	NA	NA	NA

Cost

scenario	carrier	value	unit	source
2030C	biomass	27.29	EUR/MWh	Prognos2013
2030C	co2	29.4	EUR/t	NEP2019

scenario	carrier	value	unit	source
2030C	coal	8.4	EUR/MWh	NEP2019
2030C	gas	26.4	EUR/MWh	NEP2019
2030C	lignite	5.6	EUR/MWh	NEP2019
2030C	mixed	6.7	EUR/MWh	Own Assumption
2030C	oil	48.3	EUR/MWh	NEP2019
2030C	uranium	1.692	EUR/MWh	TYNDP2018
2030C	waste	6.7	EUR/MWh	IRENA2015
2040GCA	biomass	40	EUR/MWh	Own Assumption
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
2040GCA	oil	50.22	EUR/MWh	TYNDP2018
2040GCA	uranium	1.692	EUR/MWh	TYNDP2018
2040GCA	waste	6.7	EUR/MWh	Own Assumption
2050-100RE	biomass	50	EUR/MWh	Own Assumption
2050-100RE	co2	150	EUR/t	Own Assumption
2050-100RE	coal	8	EUR/MWh	Own Assumption
2050-100RE	gas	54	EUR/MWh	Own Assumption
2050-100RE	lignite	6	EUR/MWh	Own Assumption
2050-100RE	mixed	6.7	EUR/MWh	Own Assumption
2050-100RE	oil	60	EUR/MWh	Own Assumption
2050-100RE	uranium	1.692	EUR/MWh	Own Assumption
2050-100RE	waste	30	EUR/MWh	Own Assumption

Data Sources

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

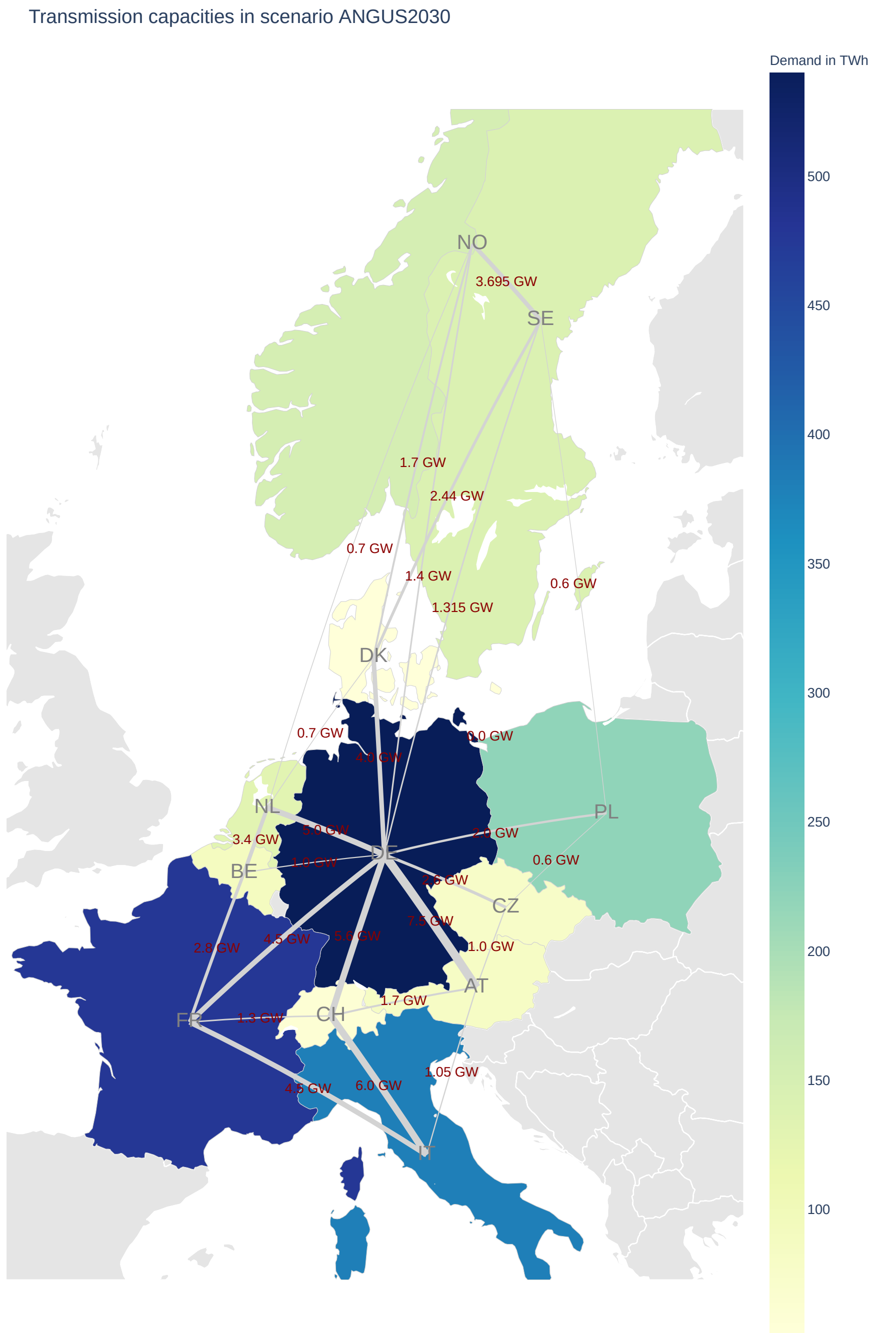

Figure 1: Installed tranmission capacities in 2030

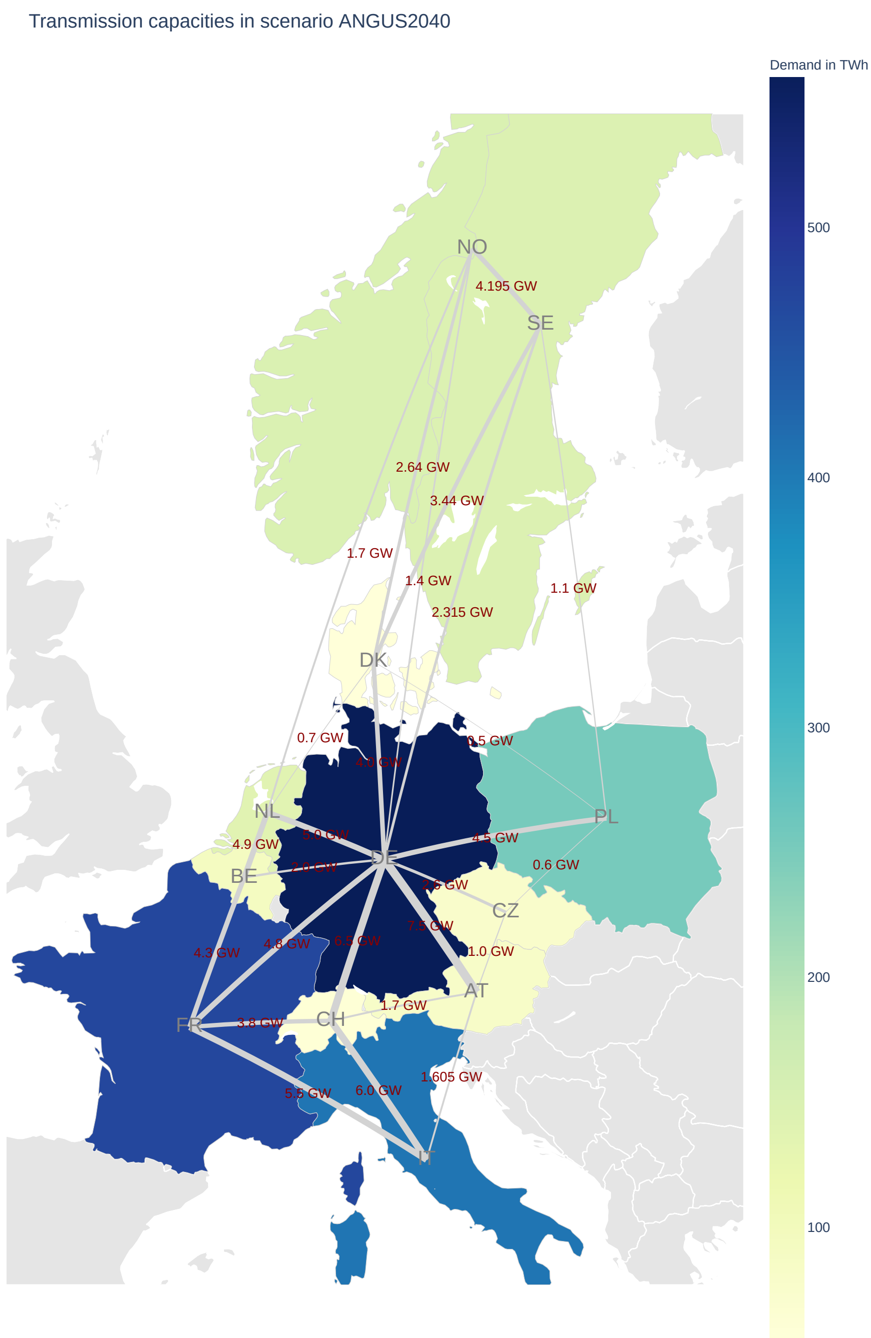

Figure 2: Installed tranmission capacities in 2040

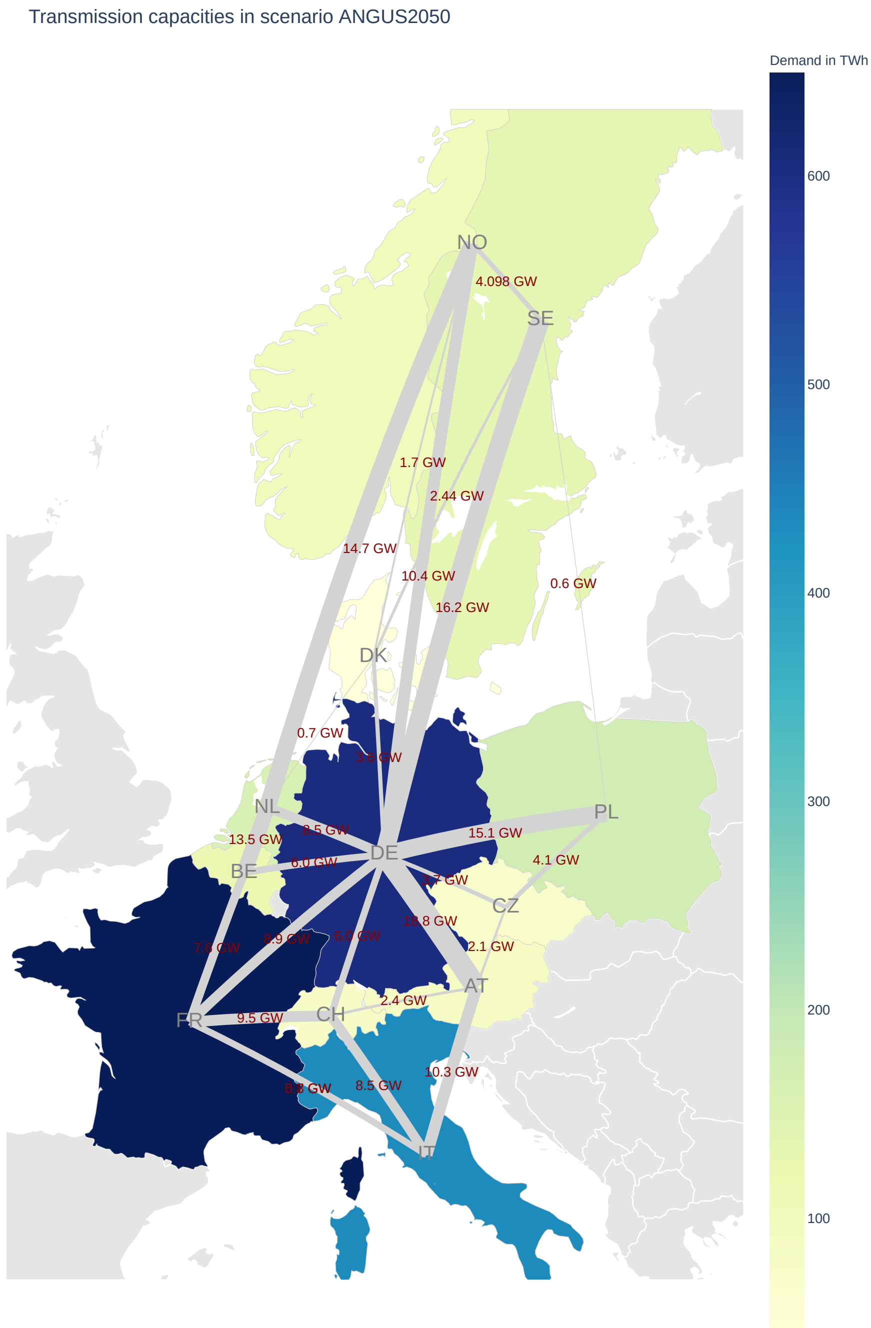

Figure 3: Installed tranmission capacities in 2050

- ANGUS
- hotmaps