Scenarios

Overview

The developed scenarios are based on the TYNDP2018, the NEP2019, the Ehighway 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

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.

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.

Efficiencies are based on the TYNDP2018. However, For germany the OPSD powerplant register is used to calculate efficiencies for the conventional powerplants in 2030. Commodity costs are based on the NEP2030C and TYNDP2018 cost assumptions The availability factor (avf) of technologies and variable operation and maintenance cost (vom) are the same for all scenarios.

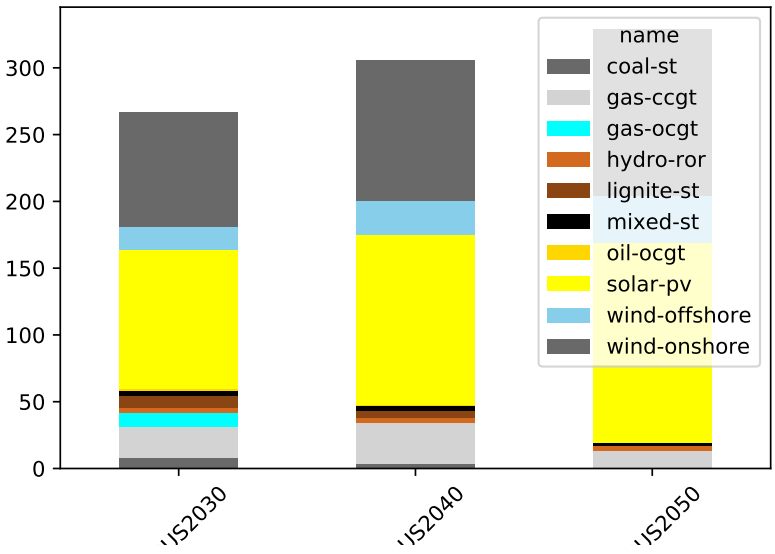

Figure 1: Installed capacities

- Maximum biomass potential per country the hotmaps potential is used. The installed capacity of biomass is assumed to be `biofuels` and `others-res` from the TNYDP2018.
- For the renewable profiles of wind and pv timeseries of renewables ninja has been used.
- Hydro reservoir and run of river capacities are assumend to be the same as in 2015. The inflow in run of river and reservoirs is modelled based on the inflow timeseries of the Restore2050 project.

Annex

Installed capacities Germany

name	ANGUS2030	ANGUS2040	ANGUS2050
coal-st	8100	4000	0
gas-ccgt	23400	30000	13000
gas-ocgt	10000	0	0
hydro-ror	3993.6	3993.6	3993.6
lignite-st	9000	5000	0
mixed-st	4100	4100	2000
oil-ocgt	900	450	0

name	ANGUS2030	ANGUS2040	ANGUS2050
solar-pv	104500	127250	150000
wind-offshore	17000	26000	35000
wind-onshore	85500	105250	125000

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
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

scenario	carrier	value	unit	source
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

All capacities

	coal-st	gas-ccgt	gas-ocgt	hydro-ror	lignite-st	mixed-st	oil-ocgt	solar-pv	uranium-st	wind-offshore	wind-onshore
AT	0	0	2969	5566	0	984	174	5600	0	0	5500
BE	0	0	4956	10	0	1710	0	22000	0	8300	7700
CH	0	0	0	385	0	985	0	12600	0	0	2590
CZ	251	0	995	150	1297	1505	180	5230	3277	0	1330
DE	4000	30000	0	3994	5000	4100	450	127250	0	26000	105250
DK	0	0	0	0	0	99	337	7453	0	7807	7180
FR	0	0	8892	10243	0	0	990	60000	37640	20000	49050
IT	4759	0	30734	5720	0	5785	3337	58271	0	11437	17785
NL	3358	0	7593	0	0	3539	0	46000	0	23433	7400
NO	0	0	0	2211	0	0	0	3000	0	400	10036
PL	8326	0	2741	708	1936	7276	3945	42507	7500	7000	32927
SE	0	0	0	6520	0	390	0	6703	3682	1303	17418

	coal-st	gas-ccgt	lignite-st	mixed-st	oil-ocgt	gas-ocgt	hydro-ror	solar-pv	wind-offshore	wind-onshore
AT	0	0	0	0	0	1500	5566	12090	0	6880
BE	0	0	0	0	0	2500	10	24087	3000	10903
CH	0	0	0	0	0	2000	385	15000	0	1382
CZ	0	0	0	0	0	1750	150	13048	0	10234
DE	0	13000	0	2000	0	0	3994	150000	35000	125000

	coal-st	gas-ccgt	lignite-st	mixed-st	oil-ocgt	gas-ocgt	hydro-ror	solar-pv	wind-offshore	wind-onshore
DK	0	0	0	0	0	1000	0	2038	25600	18708
FR	0	0	0	0	0	16000	10243	103055	0	124197
IT	0	0	0	0	0	9000	5720	91415	0	41290
NL	0	0	0	0	0	3000	0	22247	15900	14997
NO	0	0	0	0	0	0	2211	5364	3000	12175
PL	0	0	0	0	0	3000	708	24220	0	81918
SE	0	0	0	0	0	0	6520	8919	3000	24211

	coal-st	gas-ccgt	gas-ocgt	hydro-ror	lignite-st	mixed-st	oil-ocgt	solar-pv	uranium-st	wind-offshore	wind-onshore
AT	0	0	3928	5566	0	984	174	7803	0	0	5000
BE	0	0	6352	10	0	1157	500	6851	0	2310	3298
CH	0	0	0	385	0	985	0	9371	1190	0	370
CZ	0	0	995	150	4760	1505	0	6993	4055	0	950
DE	8100	23400	10000	3994	9000	4100	900	104500	0	17000	85500
DK	410	0	0	0	0	99	817	5113	0	2905	5596
FR	0	0	8892	10243	0	0	6424	41600	37640	7000	36336
IT	2811	0	32705	5720	0	5785	354	46386	0	654	15575
NL	4608	0	7593	0	0	3539	0	14084	486	11500	6723
NO	0	0	435	2211	0	0	0	2972	0	0	3330
PL	13771	0	2741	708	7405	7276	1000	24870	3000	2250	9200
SE	0	0	0	6520	0	390	0	5384	6852	190	10780

Data Sources

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