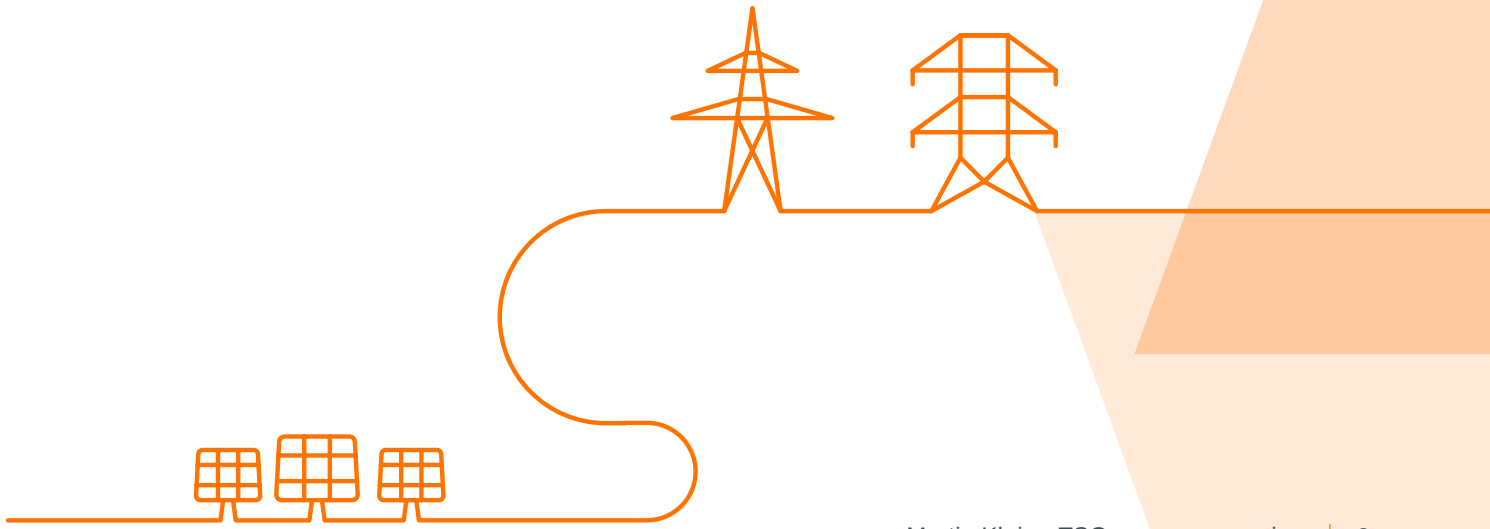
Use of energy scenarios at a TSO in Germany

Recent developments and opportunities for research

ENERDAY Dresden, 30.09.2022 | Dr. Martin Klein

Agenda

1. 50Hertz at a glance
2. Energy scenario planning – what is it for?
3. Grid development plan (NEP) - Overview
4. Most important assumptions in the current NEP
5. Topics under investigation and next steps



50Hertz at a glance

in Q1/2022:
71% RE
in our grid

	2021	2010
RE share of power consumption	56.1%	~ 25%
Installed capacity	60,602 MW	38,354 MW
of which wind power	20,588 MW	11,318 MW
of which solar power	15,156 MW	2,418 MW
Power consumption	approx. 103 TWh	approx. 98 TWh
Revenue	€7.9 billion	€5.6 billion
of which grid turnover	€1.664 billion	€0.6 billion
Employees	1,417	643

Our tasks

SYSTEM MANAGEMENT

We guarantee a **secure, reliable and efficient power grid**, every hour of the day.

GRID OPERATION

We are responsible for the **operation, maintenance and development** of the high and extra high voltage lines.

MARKET DEVELOPMENT

We **develop the European energy system** together with our partners.

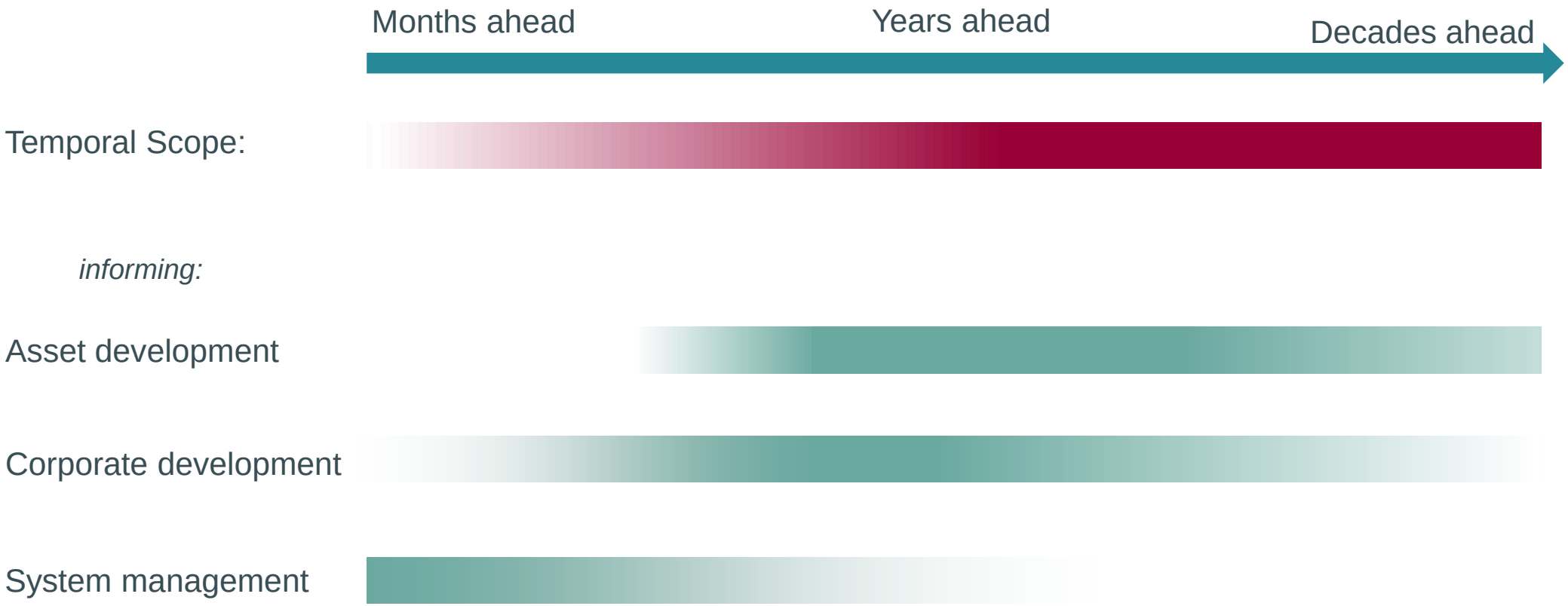
TRUSTEESHIP

We are trusted with the **EEG and KWKG cashflows**.

Energy scenarios

Set of consistent assumptions about a future energy system, not necessarily with a measure of probability

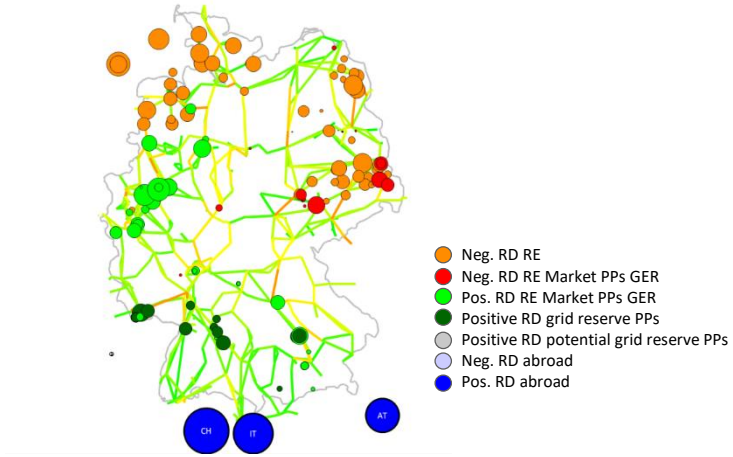
Energy scenarios in the strategic grid planning department - Time



Energy scenarios in the strategic grid planning department – Spatial

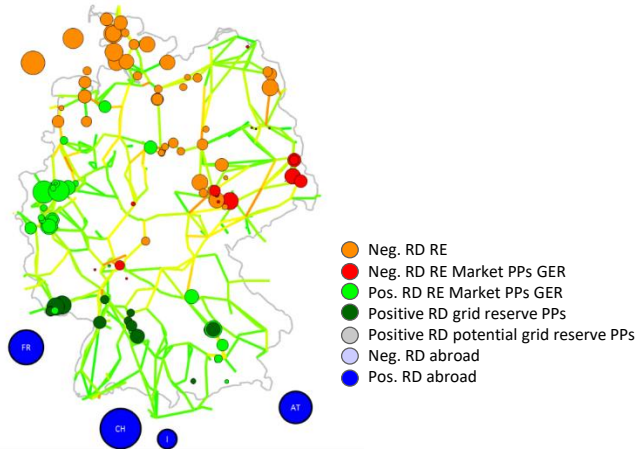
Example for the short term: “Stress test“ - Grid situation in Germany in stretch-out mode during the most critical hour

Scenario (++)



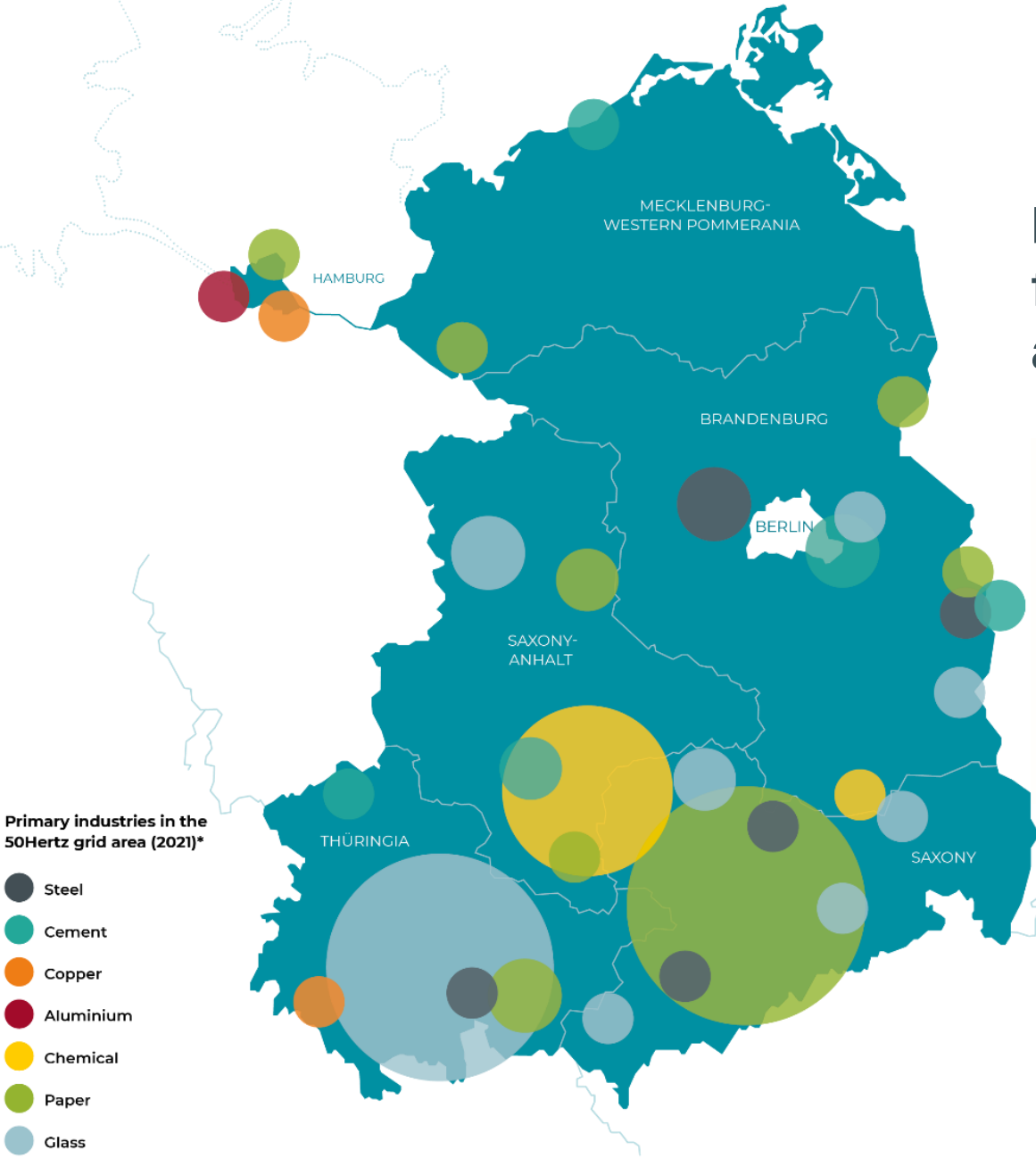
- **Total redispatch requirement:** 18.2 GW
- In Austria, a contractually guaranteed 1.5 GW is available for redispatch
- **Additional positive redispatch requirement of 5.1 GW abroad**

Scenario with NPPs (++)



- **Total redispatch requirement:** 16.8 GW
- In Austria, a contractually guaranteed 1.5 GW is available for redispatch
- **Additional positive redispatch requirement of 4.6 GW abroad**

Medium-term example: What we want: future-proofing north-eastern Germany as an industrial base!



* Illustration symbolises a concentration of indiviual sectors, non-exhaustive

Source: Wirtschaftsvereinigung Stahl, Verein Deutscher Zementwerke e.V., Deutsches Kupferinstitut Berufsverband e.V., TRIMET Aluminium SE, Verband der Chemischen Industrie e.V., Verband Deutscher Papierfabriken e.V., Bundesverband Glasindustrie e.V.

100 percent by 2032

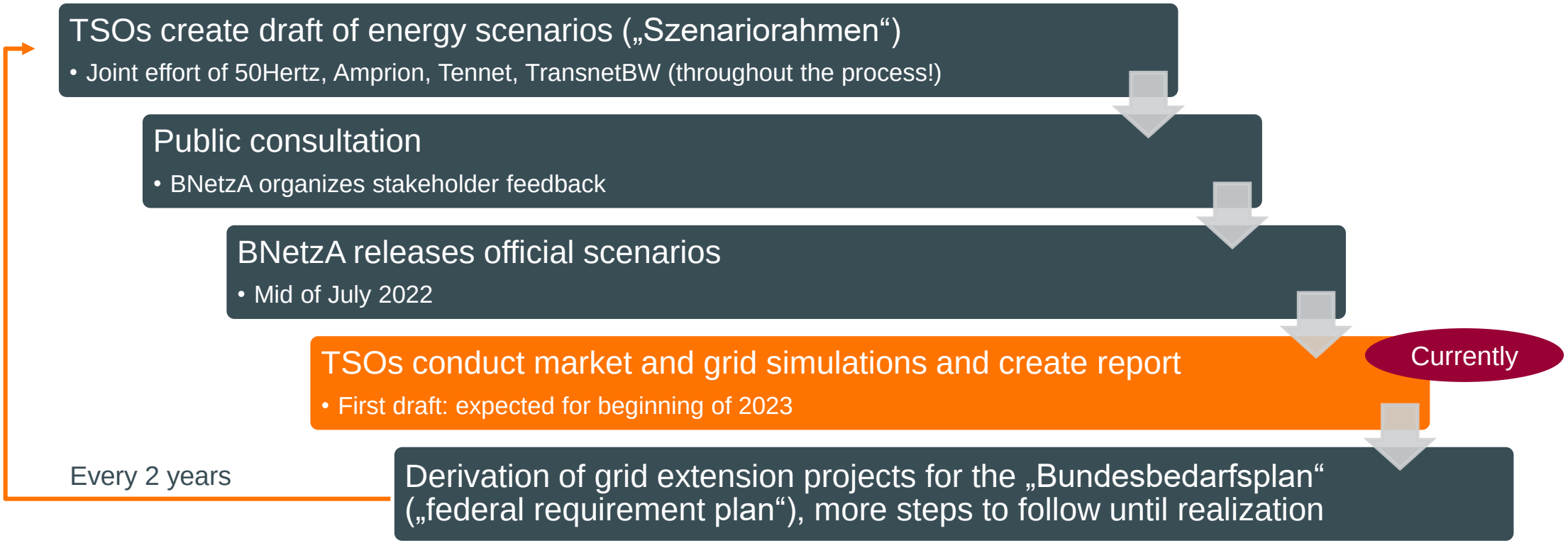
New energy for a strong economy

Increasing industrial demand for green electricity in north-eastern Germany

German Network Development Plan
Netzentwicklungsplan (NEP)

The grid development process in Germany

Regulated by law (EnWG 12a, 12b, …),



Grid development - Overview

– Network planning within the framework of the NEP Electricity is based on a fundamental determination and evaluation for a range of scenarios

Currently

Energy scenarios

- Based on public and TSO studies, among others
- Regionalization and time-series e.g. for RES, load and flexibility options

Market Modeling

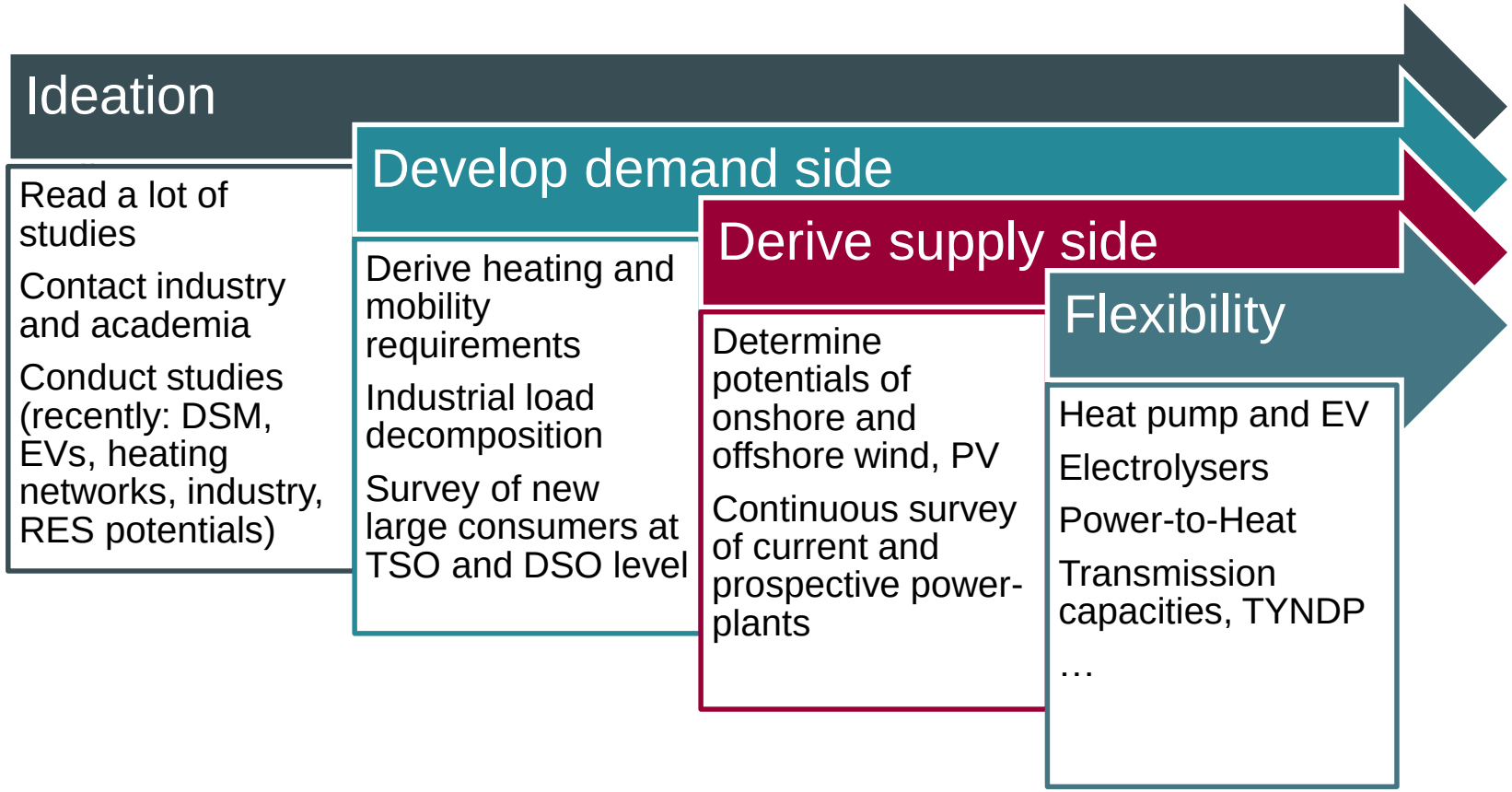
- Optimization of total cost of all power plants
- Modeling of the European electricity markets

Grid analysis

- AC power flow calculation for identification of bottlenecks
- Modeling of weather-dependent transmission capacity
- Optimization of congestion management measures

Scenario creation process with the current NEP

Net-zero targets by 2045 as a guiding principle



3 scenario worlds:

A: „molecule world“

B: „electron world“

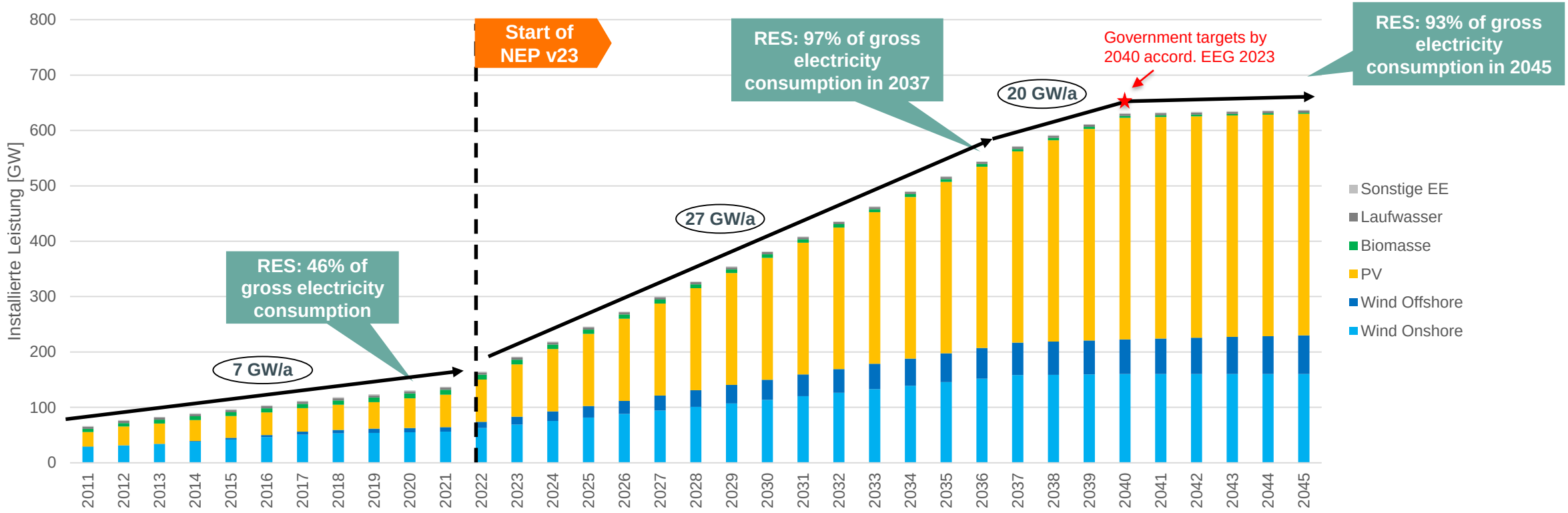
C: „inefficient electron world“

Electricity consumption

Doubles by 2045 compared to today

	2018	2037	2045	(NEP21 B2040)
Households [TWh]	129	157 – 183	143 – 186	138
Service Sector [TWh]	130	168 – 186	162 – 186	126
Industry [TWh]	226	268 – 352	311 – 469	256
Electrolysis [TWh]	~ 0	78 – 120	150 – 240	36
Mobility [TWh]	13	93 – 141	119 – 173	66
Power-to-Heat [TWh]	~ 0	22 – 37	25 – 43	11
Other [TWh]	74	71	81	71
Sum (gross) [TWh]	572	899 – 1053	1079 – 1302	704

Installed RES in Germany until 2045 (scenarios B)



5 GW/a PV and 2 GW/a Wind Onshore in 50Hertz zone alone assuming that 30% of RES are built there

Quelle: SR-Genehmigung NEP2023-2037/2045; Bestand & Historie aus Informationsportal Erneuerbare Energien (BMWK)

Renewables

	2020	2037	2045	(NEP21 B2040)
Wind Onshore [GW]	56.1	158.2 – 161.6	160.0 – 180.0	88.8
Wind Offshore [GW]	7.8	50.5 – 58.5	70.0	40.0
Photovoltaics [GW]	59.3	345.4	400.0 – 445.0	125.8
Biomass [GW]	9.5	4.5	2.0	8.2
Hydro [GW]	4.9	5.3	5.3	5.6
Other [GW]	1.1	1.0	1.0	1.3

Dispatchable Power plants

	2020	2037	2045	(NEP21 B2040)
Gas (natural gas/hydrogen) [GW]	32.1	> 38.4	> 38.4	42.4
Pumped Hydro [GW]	9.8	11.1	11.1	10.2
Coal [GW]	37.9	-	-	-
Nuclear [GW]	4.1	-	-	-
Other [GW]	4.3	1.0	1.0	4.8

Caveat: Network development plan **does not** assess security of supply

- Only consideration of known (gas) power plant locations
- Reserves (“slack generation”) near load centers to avoid distortions in the trade balances

Interconnectors

- Ten-Year Network Development Plan 2022 as basis for electricity consumption and installed capacity abroad as well as for fuel prices
- Selection of **Distributed Energy** scenario - with EU climate neutrality pathway to 2050.
- Interconnectors:
  - 2037: Consideration of interconnectors based on TYNDP project list in all scenarios
  - 2045: BNetzA specifies not to consider interconnector capacity for 2045 beyond the known 2037 projects

Flexibility

Assumptions on load flexibility become increasingly important!

	2020	2037	2045	(NEP21 B2040)
Power-to-Gas [GW]	<0.1	26.0 – 40.0	50.0 – 80.0	10.5
Power-to-Heat (large) [GW]	0.8	12.6 – 22.0	14.9 – 27.0	7.0
Heat-pumps (small) [mio.]	1.1	14.3	16.3	6.5
Electric Vehicles [mio.]	0.6	25.2 – 31.7	34.8 – 37.3	14.1
DSM [GW]	1.2	5.0 – 7.2	8.9 – 12.0	7.0
Batteries [GW]	1.8	91.0	141.0 – 168.0	18.7

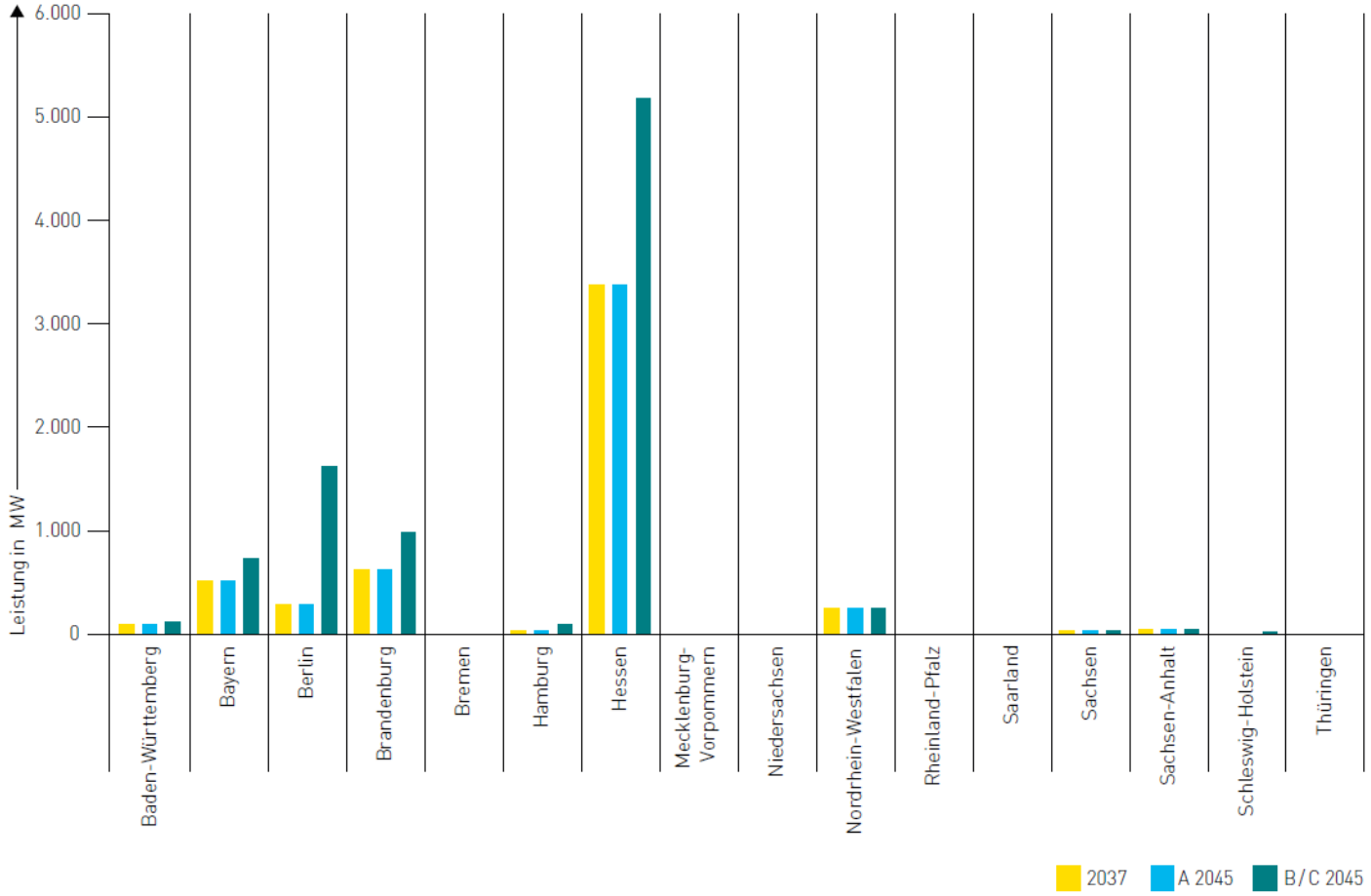
Market-based operation of PV-battery storage, charging of electric vehicles and heat pump; electrolysis and large-scale heat pumps and electrode boilers, almost no CHP restrictions

Topics under investigation and next steps

Consumer flexibility

- EVs, heat pumps and PV-battery systems are to be modeled to consider market price signals (approved report in German: „*marktorientiert*“)
- How realisitc is this? How to adequately model such consumer incentives?
- Pool of flexibility is large and has quite likely a large influence on the market and grid simulations if fully utilized

Data centers



Old graph! But:

- Data centers very concentrated in Hessia (Frankfurt), Berlin-Brandenburg; some more in Bavaria and others
- **50 TWh additional load** in all scenarios
- Waste heat not further considered
- Operation suitable for DSM and redispatch?

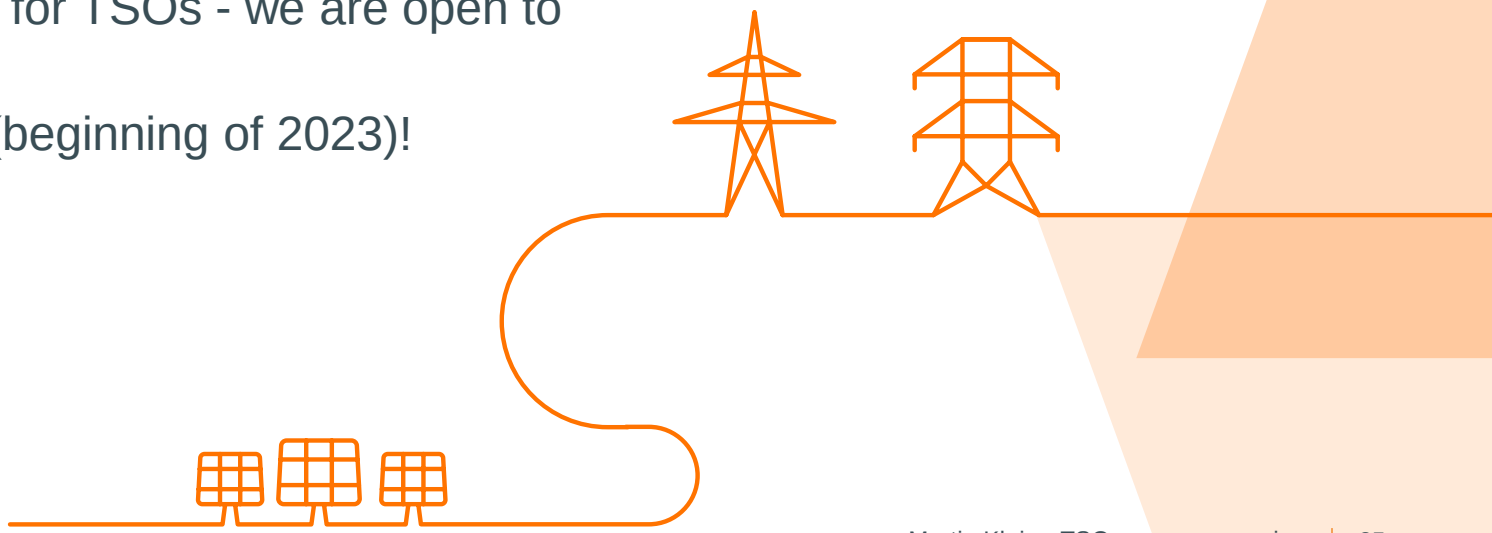
Electrolyzers

- Assumes hydrogen infrastructure (backbone) in all scenarios, large consumer survey revealed the location of many planned projects
- Where to place the rest? Currently, there are no monetary incentives for electrolysis operators to place plants in a „grid friendly“ way
- BNetzA:

  “(…) the remaining difference between the approved electrolysis capacity and the remaining capacity is to be located in a grid-friendly way (German: “netzdienlich”*). Specifically, the electrolysers are placed at locations where they do not cause any additional bottlenecks in the power grid. These are presumably regions with a high feed-in from renewable energies in Northern Germany.”*

Conclusion

- New German network development plan will consider climate neutral energy system
- Electricity consumption doubles by 2045 compared to today, mostly covered by wind and PV
- Large influx of new consumers like PtX, data centers, EVs; very important to adequately model load curves and flexibility in a system that relies heavily on RES
- Energy scenarios are an essential tool for TSOs - we are open to research cooperation
- Stay tuned for the full NEP document (beginning of 2023)!



Thank you! There is time for questions and discussion

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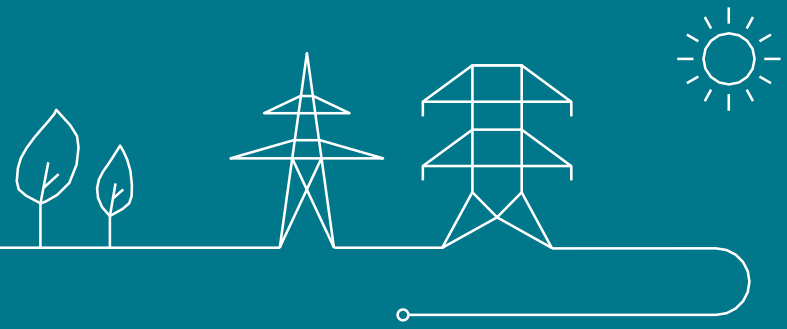

Backup

Overview (1)

Installierte Leistung [GW]

Energieträger	Referenz 2020*/2021	Szenario A 2037	Szenario B 2037	Szenario C 2037	Szenario A 2045	Szenario B 2045	Szenario C 2045
Kernenergie	4,1	0,0	0,0	0,0	0,0	0,0	0,0
Braunkohle	18,9	0,0	0,0	0,0	0,0	0,0	0,0
Steinkohle	19,0	0,0	0,0	0,0	0,0	0,0	0,0
Gaskraftwerke (zzgl. endogenem Zubau)	32,1	> 38,4	> 38,4	> 38,4	> 34,6	> 34,6	> 34,6
Öl	4,7	0,0	0,0	0,0	0,0	0,0	0,0
Pumpspeicher	9,8	11,1	11,1	11,1	11,1	11,1	11,1
sonstige konv. Erzeugung	4,3	1,0	1,0	1,0	1,0	1,0	1,0
Summe konventionelle Erzeugung	**92,9**	**> 50,5**	**> 50,5**	**> 50,5**	**> 46,7**	**> 46,7**	**> 46,7**
Wind Onshore	56,1	158,2	158,2	161,6	160,0	160,0	180,0
Wind Offshore	7,8	50,5	58,5	58,5	70,0	70,0	70,0
Photovoltaik	59,3	345,4	345,4	345,4	400,0	400,0	445,0
Biomasse	9,5	4,5	4,5	4,5	2,0	2,0	2,0
Wasserkraft	4,9	5,3	5,3	5,3	5,3	5,3	5,3
sonstige regenerative Erzeugung	1,1	1,0	1,0	1,0	1,0	1,0	1,0
Summe regenerative Erzeugung	**138,7**	**564,9**	**572,9**	**576,3**	**638,3**	**638,3**	**703,3**
Summe Erzeugung	**231,6**	**615,7**	**623,7**	**627,1**	**685,3**	**685,3**	**750,3**

Overview (2)

Stromverbrauch [TWh]							
Nettostromverbrauch	478*	828	891	982	999	1025	1222
Bruttostromverbrauch	533*	899	961	1053	1079	1106	1303
Treiber Sektorenkopplung							
Elektromobilität [Anzahl in Mio.]	1,2	25,2	31,7	31,7	34,8	37,3	37,3
Power-to-Heat [GW]	0,8*	12,6	16,1	22,0	14,9	20,4	27,0
Wärmepumpen (HH und GHD) [Anzahl in Mio.]	1,2	14,3	14,3	14,3	16,3	16,3	16,3
Elektrolyse [GW]	<0,1*	40,0	26,0	28,0	80,0	50,0	55,0
Weitere Speicher und nachfrageseitige Flexibilitäten [GW]							
PV-Batteriespeicher	1,3*	67,4	67,4	67,4	97,7	97,7	113,4
Großbatteriespeicher	0,5*	23,7	23,7	24,2	43,3	43,3	54,5
DSM (Industrie und GHD)	1,2*	5,0	7,2	7,2	8,9	12,0	12,0

Overview

[TWh]	Szenario A 2037	Szenario B 2037	Szenario C 2037	Szenario A 2045	Szenario B 2045	Szenario C 2045
Haushalte	**156,9**	**156,9**	**183,2**	**143,4**	**143,4**	**185,7**
davon Geräte	104,0	104,0	114,3	90,4	90,4	114,3
davon Wärmepumpen	52,9	52,9	68,9	53,0	53,0	71,4
GHD	**168,0**	**168,0**	**185,9**	**161,5**	**161,5**	**186,3**
davon Rechenzentren	50,0	50,0	50,0	50,0	50,0	50,0
davon Wärmepumpen	14,9	14,9	19,3	14,6	14,6	19,7
davon Geräte	103,1	103,1	116,6	96,9	96,9	116,6
Industrie	**267,5**	**334,0**	**352,0**	**310,5**	**382,9**	**469,0**
Verkehr	**93,4**	**131,1**	**140,6**	**118,8**	**160,6**	**172,8**
Elektrolyse	**120,0**	**78,0**	**84,0**	**240,0**	**150,0**	**165,0**
Fernwärmeerzeugung	**22,2**	**22,6**	**36,7**	**24,6**	**26,9**	**42,8**
davon Elektrodenheizer	4,0	8,0	8,0	5,5	11,0	11,0
davon Großwärmepumpen	18,2	14,6	28,7	19,1	15,9	31,8
Nettostromverbrauch	**828,0**	**890,6**	**982,4**	**998,8**	**1025,3**	**1221,6**
Verteilernetzverluste	**34,8**	**34,8**	**34,8**	**34,8**	**34,8**	**34,8**
Übertragungsnetzverluste	**30,0**	**30,0**	**30,0**	**40,0**	**40,0**	**40,0**
Speicherverluste	**3,7**	**3,8**	**4,1**	**4,7**	**5,3**	**5,3**
Kraftwerkseigenbedarf	**2,0**	**2,0**	**2,0**	**1,0**	**1,0**	**1,0**
Bruttostromverbrauch	**898,5**	**961,2**	**1053,3**	**1079,3**	**1106,4**	**1302,7**

Tabelle 10: Zusammenfassung des Stromverbrauchs in den Szenarien