Transmission System Operation

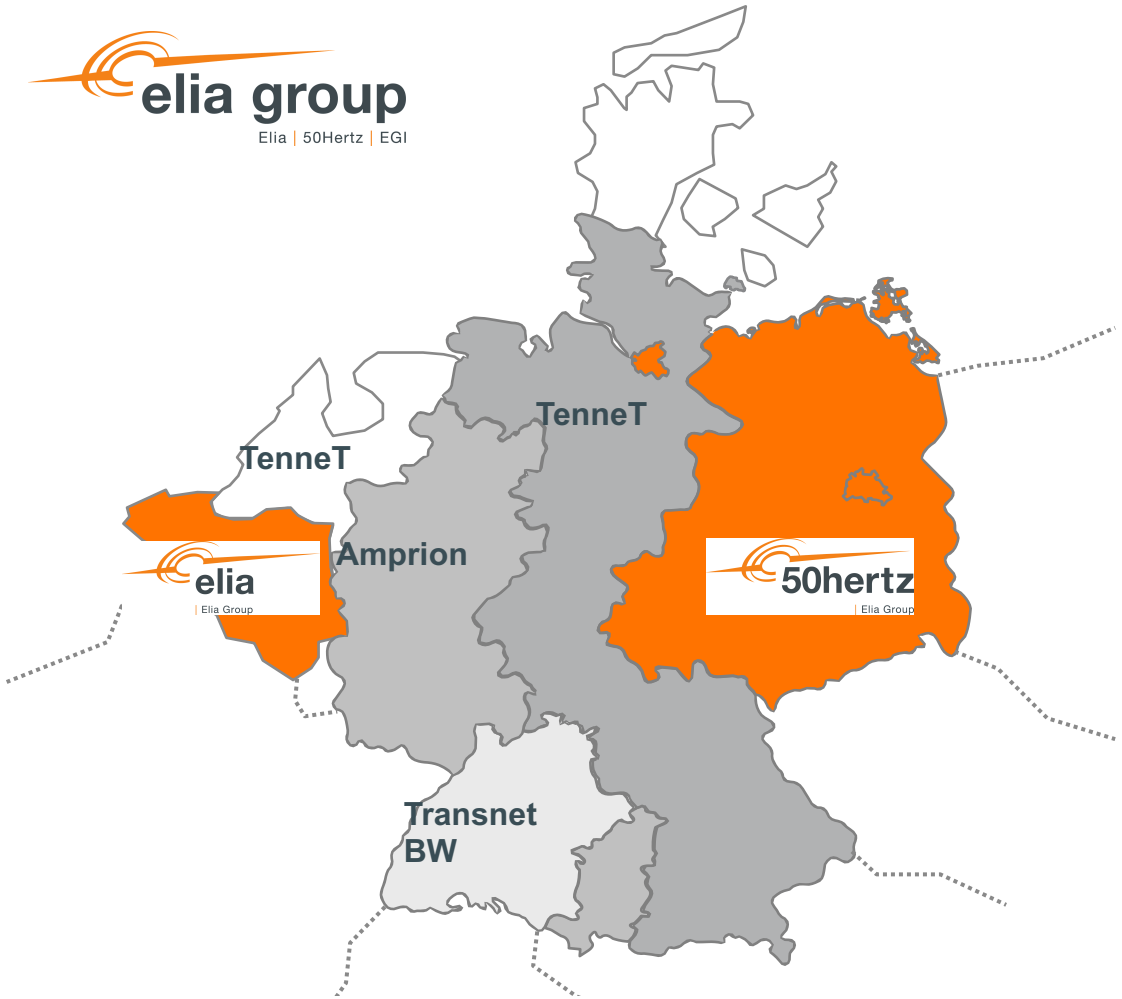
Effectively maintaining the real-time security and resilience of the transmission system as DERs replace conventional generation

October 1st 2019
Andreas John

Agenda

1. Overview 50Hertz & Legal / Regulatory Framework
2. Various Initiatives & Challenges
   - Increased Cooperation
   - Grid Extensions & Alternative Operational Measures
   - Redispatching, Voltage Management, Grid Restoration Schemes
3. Will the new complexity take its toll ?
4. Conclusion & The way to go

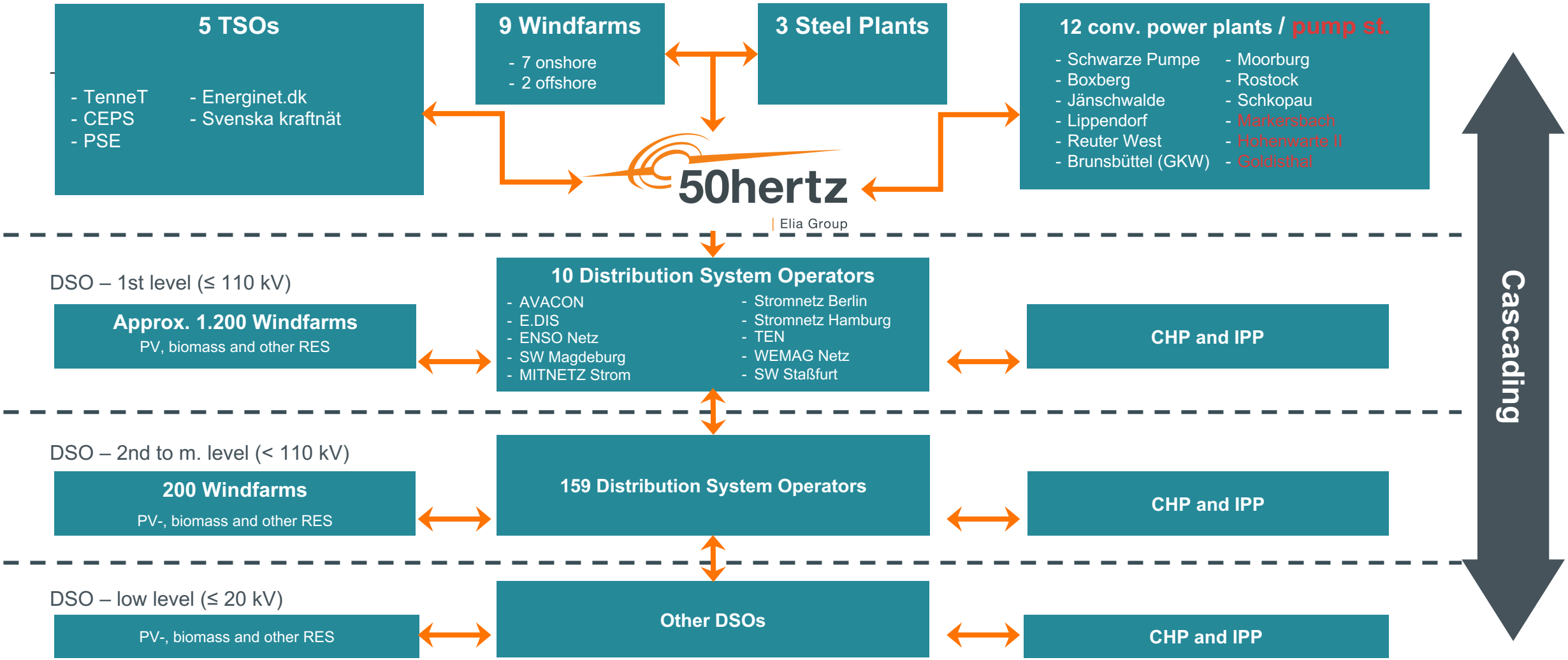
1) 50Hertz – a fully unbundled European TSO



Source: 50Hertz.

- 50Hertz is a fully unbundled TSO and part of **Elia Group.**
- Our shareholders are the Belgian TSO **Elia** (80% of shares) and the German state owned banking group **KfW** (20% of shares).
- 50Hertz owns and operates the transmission grid for **18 million people** in Eastern and Northern Germany**.**
- Within Elia group, 50Hertz is committed to **international cooperation** and supports partners in grid operations, RES integration and market design.

1) The power system in the 50Hertz grid area



1) 50Hertz at a glance

	2010 (share Germany)	2018 (share Germany)
Grid area	109,589 km² (~31%)	109,619 km²(~31%)*
Length of lines	9,800 km (~30 %)	10,200 km (~30 %)*
Max. load	~ 17 GW (~20 %)	~ 16 GW (~20 %)*
Power consumption (based on electricity supplied to end-consumers in acc. with Renewables Energy Law „EEG“)	~ 98 TWh (~20 %)	~ 97 TWh (~20 %)*
Installed capacities - of which Renewables - of which Wind	38,354 MW (~35%) 15,491 MW (~30%) 11,318 MW (~40%)	54,069 MW (~26%)* 32,931 MW (~29%)* 19,403MW (~35%)*
RES share in power consumption	~ 25 %	~ 56.5 %*
Turnover - of which Grid	5.6 bn. € 0.6 bn. €	10.3 bn. €* 1.4 bn. €*
Employees	643	1,043*

Source: 50Hertz; *preliminary data; as of 31/12/2018

1) The German energy transition in the electricity sector is characterised by five key elements

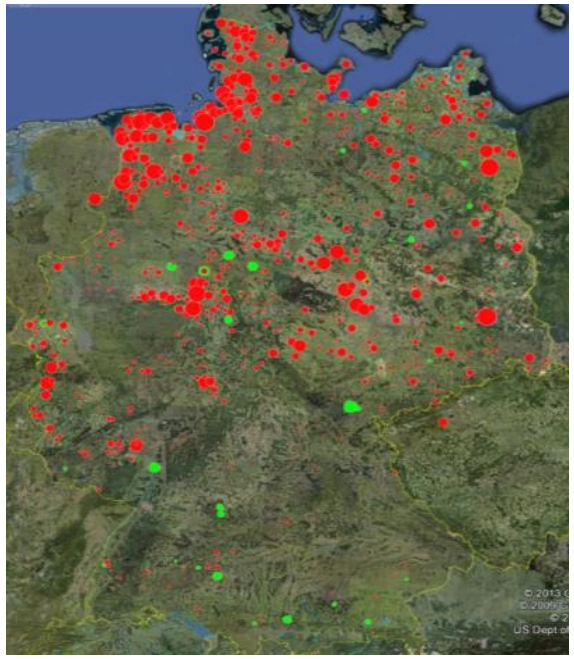
Politically motivated changes in the structure of the German energy system

1		**Complete nuclear phase-out** by 2022
2		**Quick development of renewable energy** 65 % share in gross electricity consumption by 2030, 80 % by 2050
3		**Reduction of CO_2 emissions:** Coal exit by 2038 at the latest Reduction of CO_2: 40 % by 2020, 55 % by 2030, 80 % by 2050, compared to 1990
4		**Energy efficiency** 20 % reduction in primary energy consumption by 2020, 50 % by 2050 (compared to 2008)
5		**Grid expansion** for the transport of renewable electricity to the consumption centres in the south and west of Germany

1) RES Development in Germany

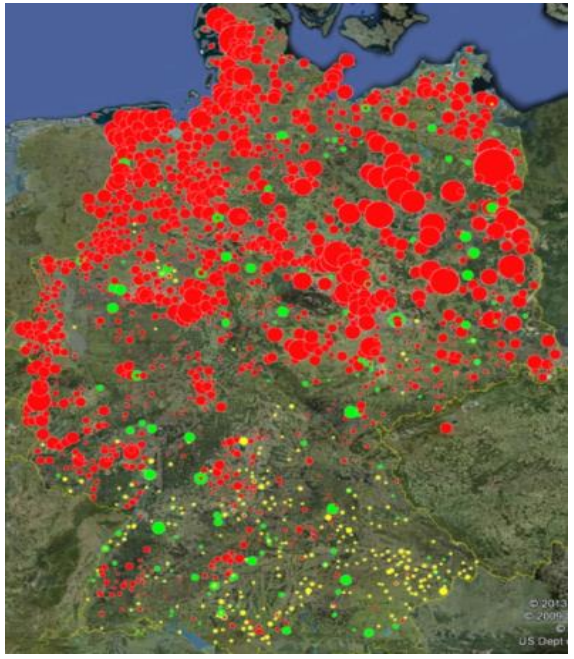
Area proportional to the installed capacities

2000



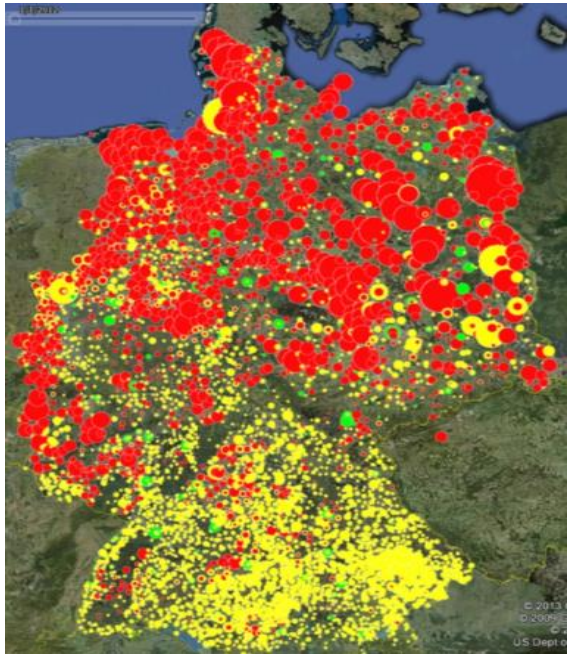
- ~30,000 plants
- 1,665 MW wind power

2006



- ~221,000 plants
- 2,233 MW wind power

2018

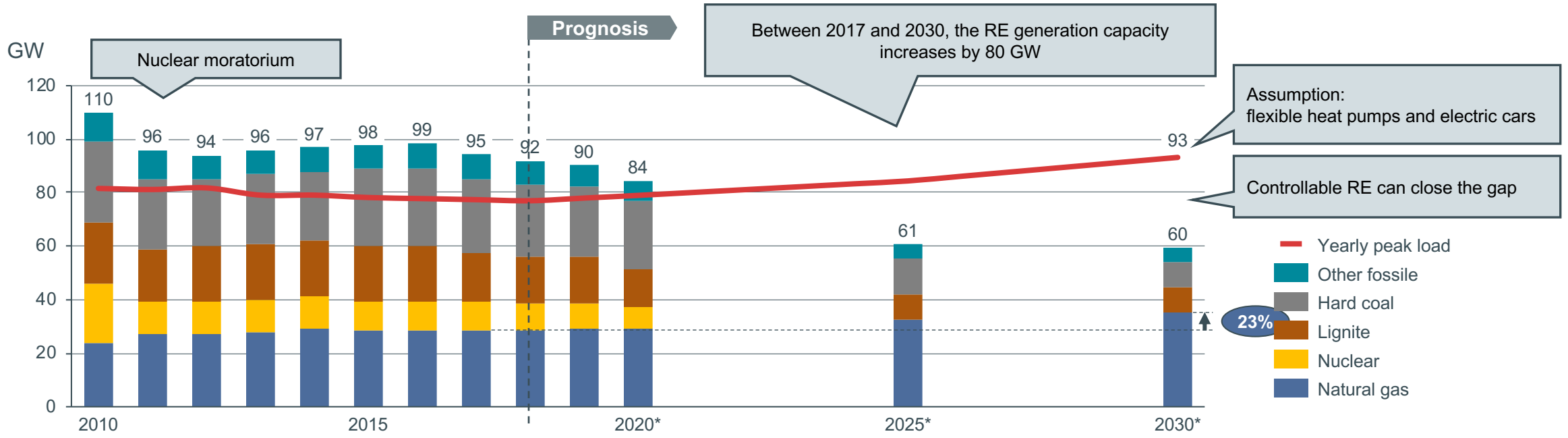


PV Wind Biomass

- > 1,600,000 plants
- 49,628 MW wind power
- 41,687 MW PV

1) Nuclear phase-out and coal exit reduce fossil generation base by 30 GW until 2030

Conventional generation capacity[1] and annual peakload in Germany

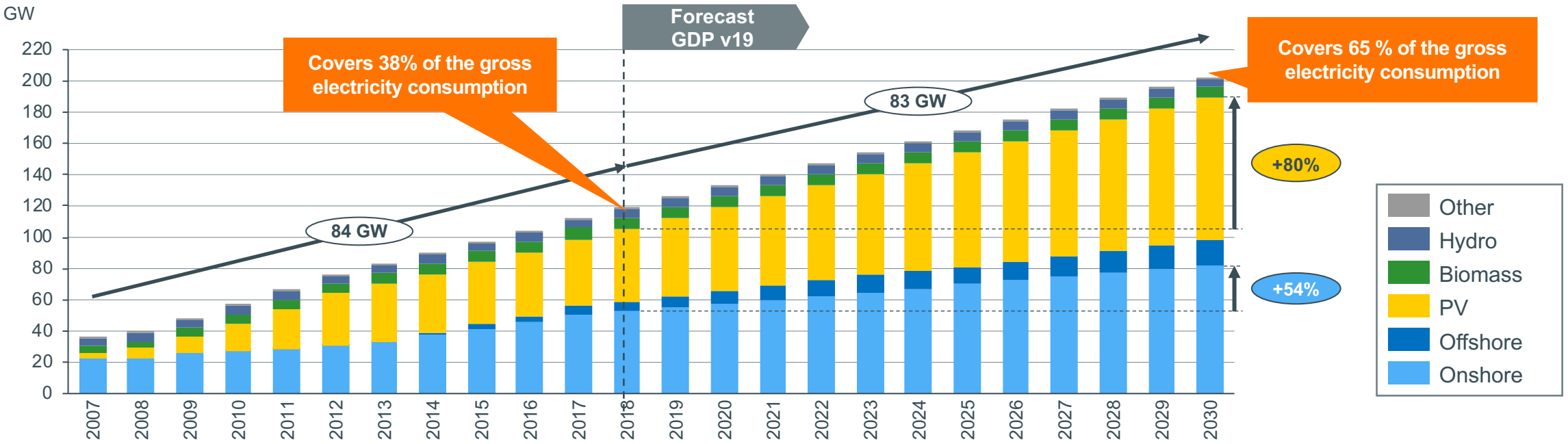


[1] Controllable RE capacities (pumped storage and biomass) not taken into account
Source: German Grid Development Plan 2019, scenario B

In 2030, the peakload can be covered securely by a massive expansion of gas turbines, controllable RE capacities and demand side management.

1) The decline of fossil generation capacity is overcompensated by the growth of RES
BUT the traditional capacity argument denies reality – even in times of climate change

Installed RES capacity in Germany



Source: approved scenario framework of the GDP 2019 - scenario 2030B

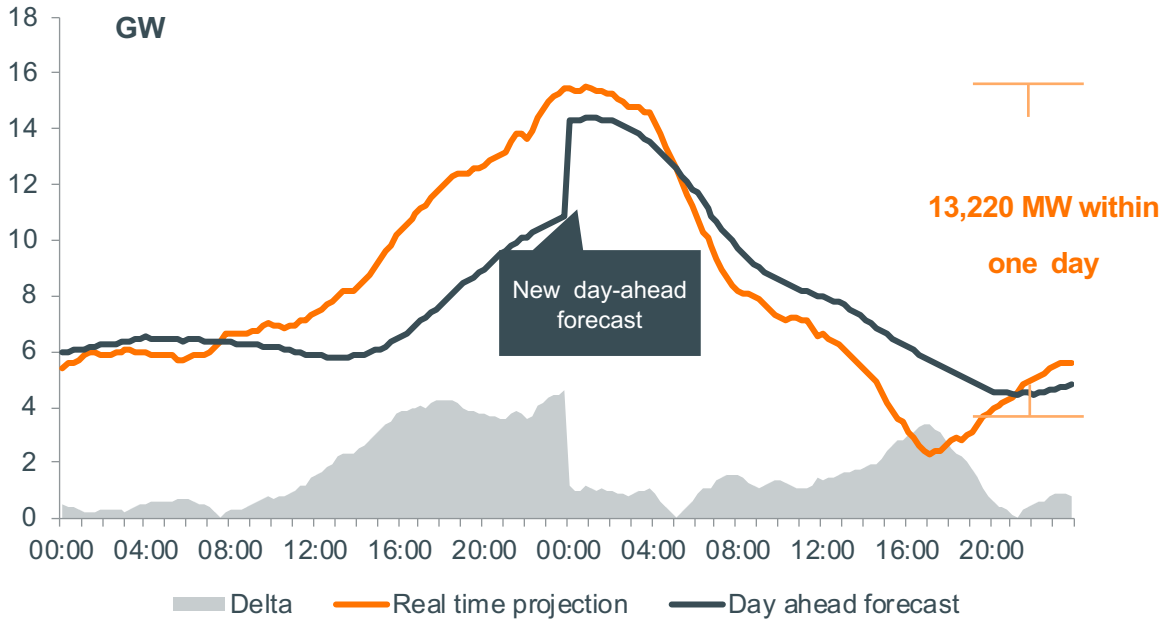
Capacity does not equal a guaranteed availability. On Sunday September 8th 2019 at 3:30pm the Power generated by wind was 0,2GW, by PV 3,2GW inside the 50Hertz control area – that day imports secured the coverage of the load.

1) Volatile RES feed-in increases within the 50Hertz grid area

Wind feed-in data in 50Hertz grid area 2018

Maximum feed-in	15,672 MW
Minimum feed-in	11 MW
Strongest feed-in increase within a ¼ hour slot	918 MW
Strongest feed-in drop within a ¼ hour slot	-1,039 MW
Strongest feed-in difference min. and max. in one calendar day	13,220 MW

Wind energy feed-in (21.12.-22.12.2018)

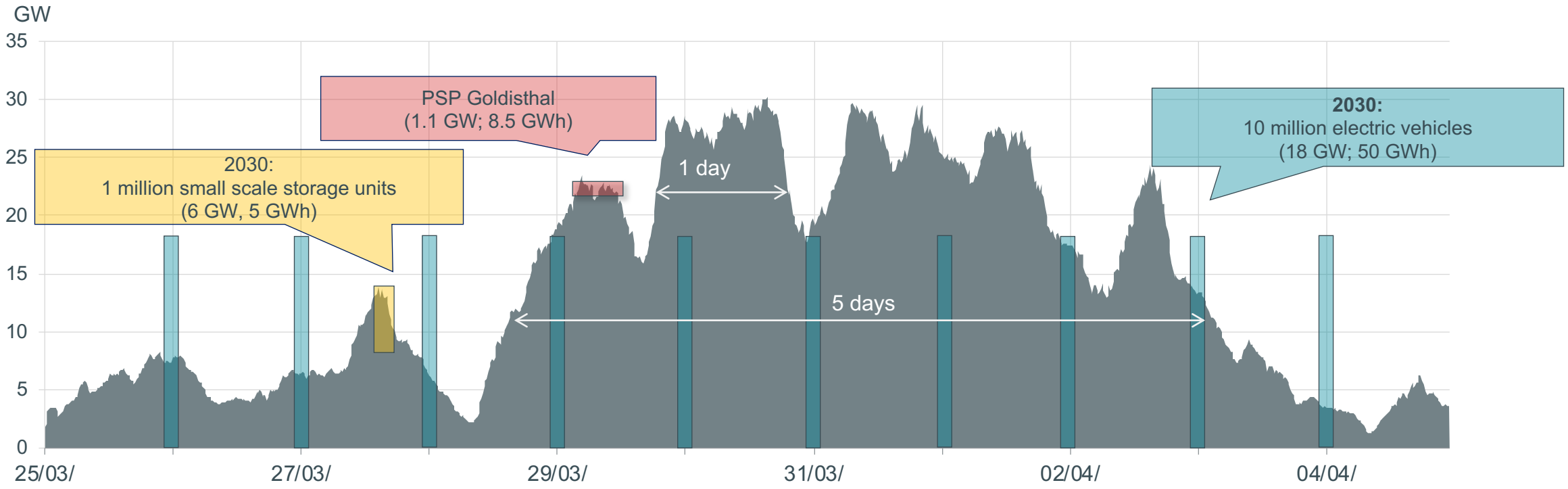


Source: 50Hertz

Exact forecasts and an extremely flexible and a fast-reacting control systems as well as flexibility markets in all means are essential to compensate fluctuations.

1) Neither small storage units nor electric vehicles can replace the need for long-term and large scale storage

Wind feed-in in Germany from 25/03/2015 to 04/04/2015



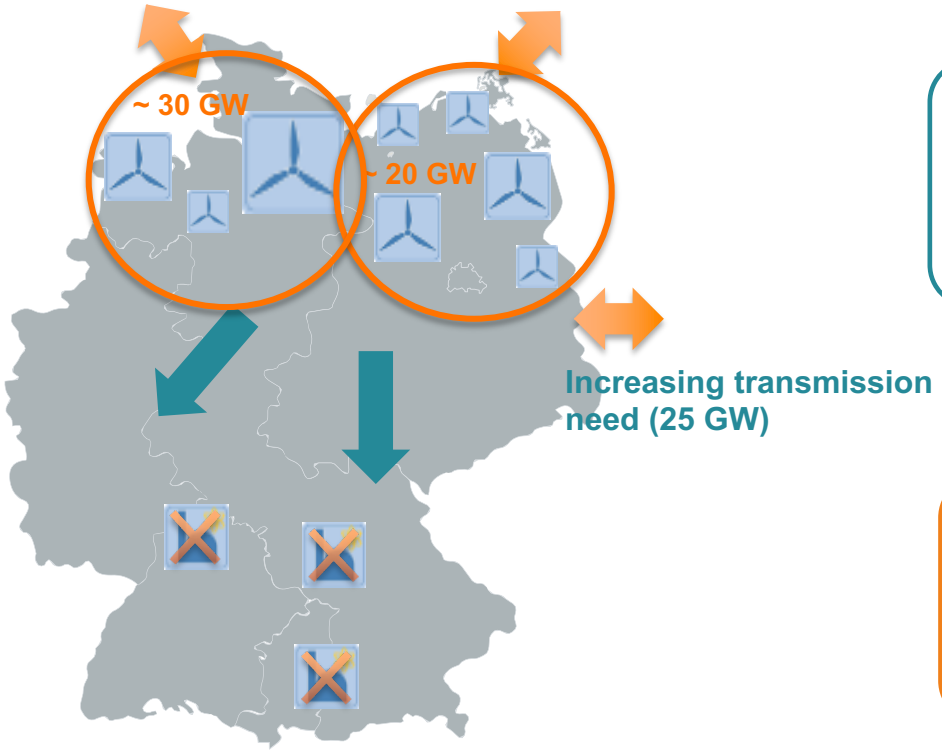
For storage on all wind fronts, incentives are needed for investments in long-term storage systems – P2X a potential way to go.

1) The challenges faced by TSO's today and in the future.

- Realize required grid extension as fast as possible
  - Intensify involvement of politics and public to make use of new technologies to find acceptable solutions
- Increase loading of existing grid
  - Use of assets that can control power flows - e.g. Phase Shifting Transformers & HVDC Interconnections
  - Sophisticated Dynamic Line Rating & Grid Boosters
  - Consequent dynamic Reactive Power Management with passive and active assets
- Manage congestions efficiently
  - Appropriate market design - this will only help in cases where grid expansions are realized
  - Increase quality of forecasts and intensify country and regional cooperation – or even beyond ?
- Ensure secure grid operation
  - Close cooperation between grid development and grid operation
  - Introduction of above mentioned new flexible and innovative assets and operational concepts. Thus avoiding regional blackouts caused by outages due to large regional active and reactive power imbalances and missing inertia

To date RES could be integrated into the grid without significantly changing proven concepts. This is now changing.

1) Renewables growth requires an adaptation of the transmission grid infrastructure and its operation



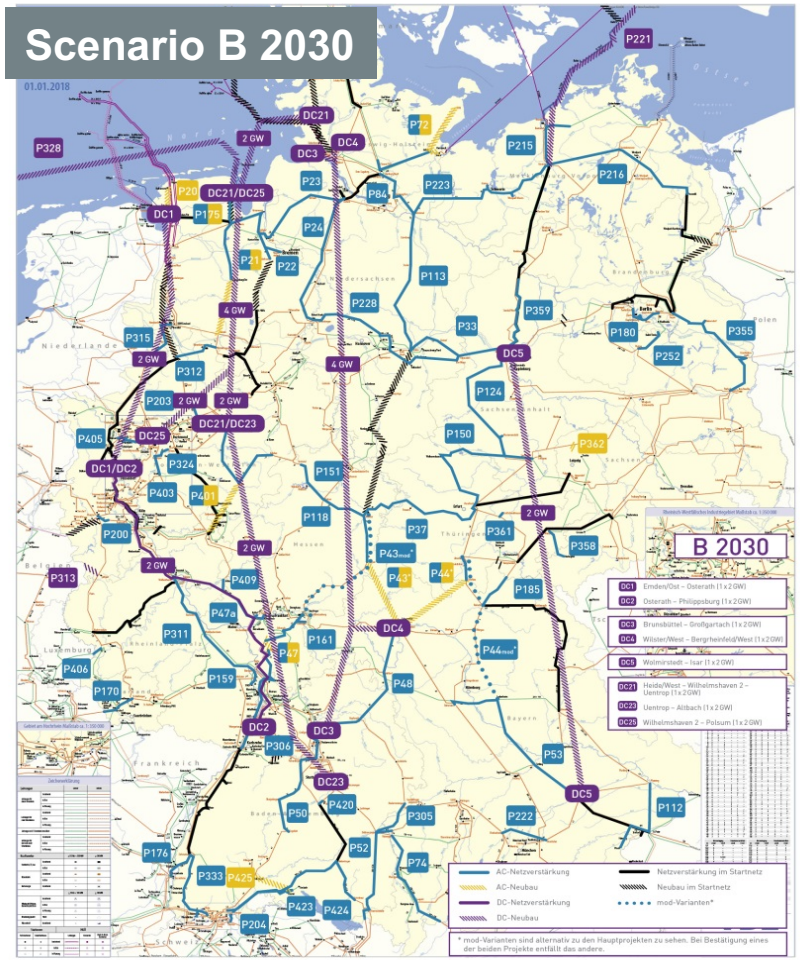
Increasing power transport capacities to connect RES generation with consumption centers

Targets

Increasing European connectivity to improve RES and market integration – the key element of EU energy policy

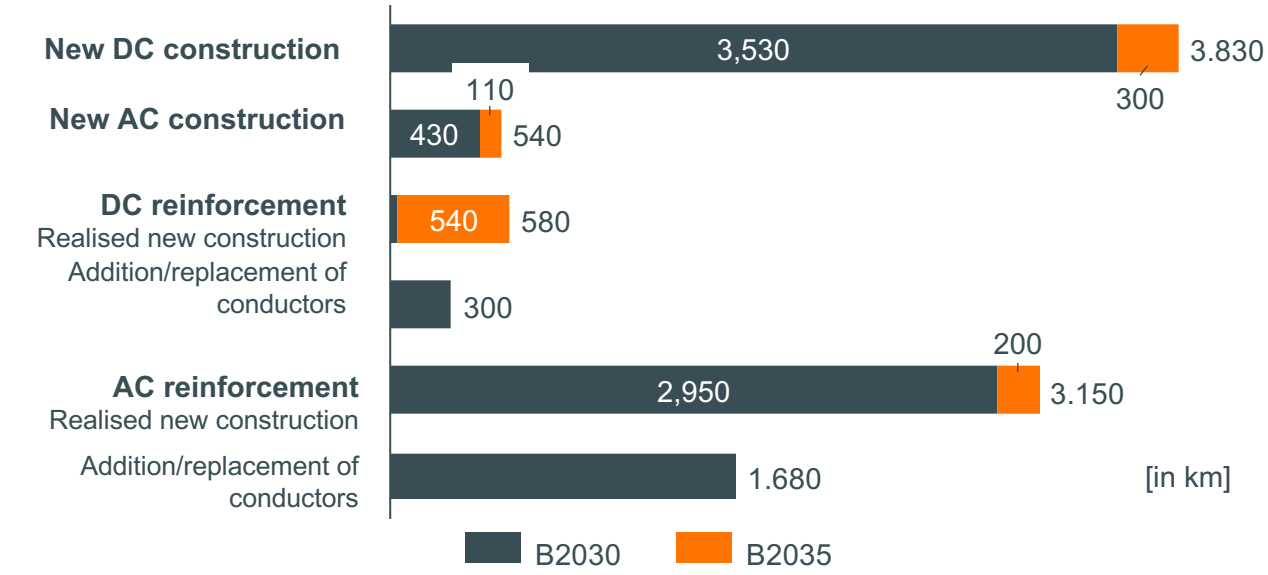
A strategic grid development in a European context is the key for a successful energy transition. Operational schemes must be adapted, skills of the operators must be extended and SCADA / EMS functionality must be developed rapidly to support the Energy Transition incorporating all aspects.

2) Grid expansion in Germany is urgently required to achieve energy transition goals



Quelle: VDE | FNN/Übertragungsnetzbetreiber [21]

Additionally required grid expansion compared with the starting grid[1]

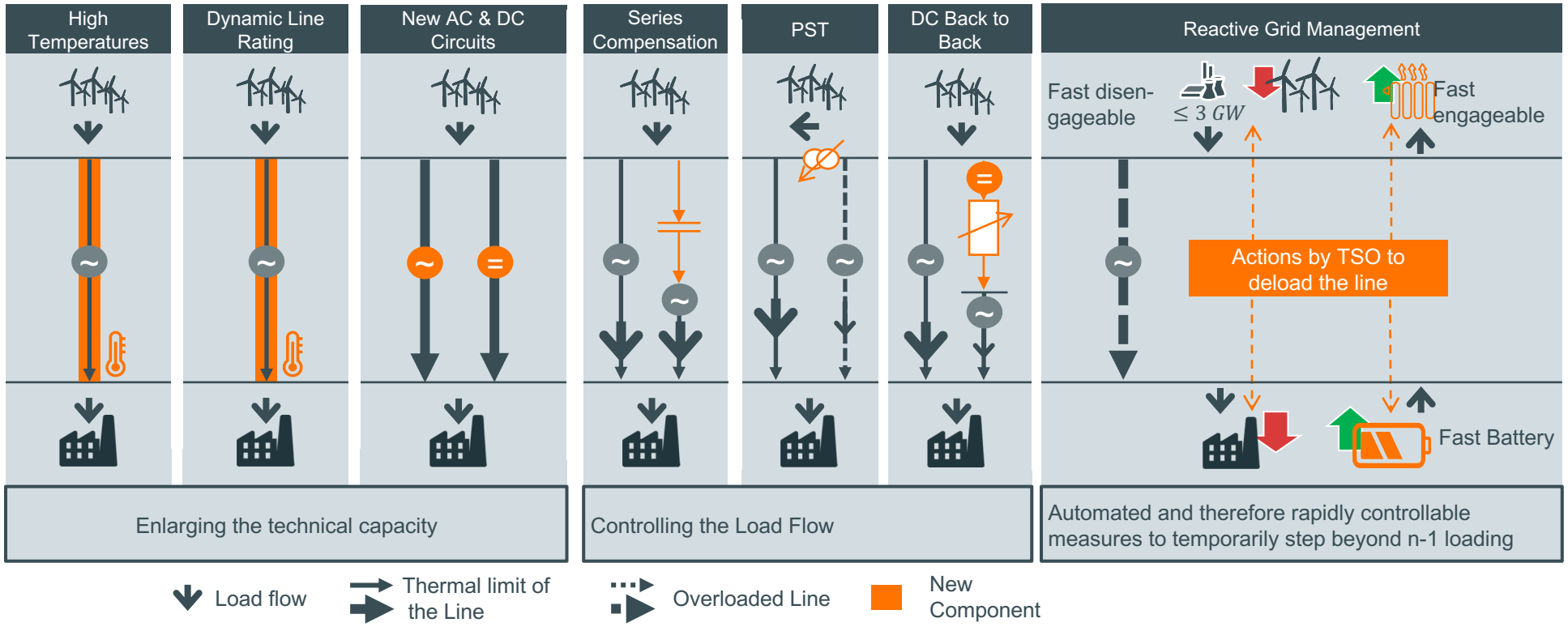


In scenario B 2030, an extra 11,600 km need to be constructed to enable the integration of 65 % renewables. Approx. 3,800 km of newly constructed DC lines are the most important projects.

[1] Starting grid = current grid + EnLAG measures + measures in the plan approval procedure or under construction + measures under other obligations
Source: German Grid Development Plan 2019

2) Measures planned to be applied before 2025 in the German Transmission Grid

Security of Supply
Dynamic Security Assessment



2) Reactive Power Compensation and Grid Restoration Schemes

- Reactive Power Compensation
  - As traditional Power Plants are phasing out an active contribution for reactive power & voltage management is needed
  - Higher dynamics in the grid are demanding new assets and operational schemes
  - Higher grid utilization increases the reactive power demand dramatically
  - Continuous discussion with EU legislation whether reactive power compensation devices are part of the System Operators´ Asset Base or shall be put under a market regime

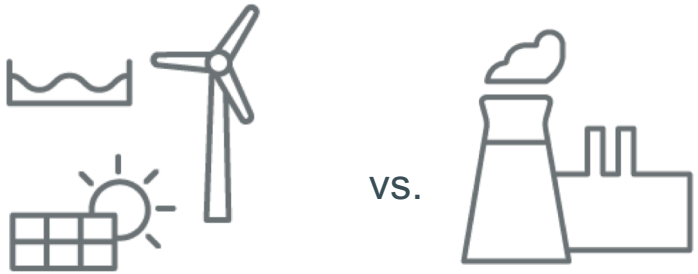
- Grid Restoration Schemes
  - Today Grid Restoration concepts are still based on traditional power plant assets under the responsability of the TSO
  - Coal phase out is putting the traditional schemes at risk
  - DSOs and wind park operators are preparing themselves to take a more active part
  - Efforts needed to apply an effective grid restoration scheme are often underestimated and ”political“ interests are driving statements
  - 50Hertz is actively developing the future schemes incl. RES and storages in cooperation with our DSOs

For both sides a close operational coordination is mandatory. Higher line loading demands massive investment in reactive power assets. New grid restoration schemes demand a high number of distributed ressources and a very close cooperation.

2) Redispatch according NABEG 2.0: Principles of a new legal act (§§13, 13a und 14 EnWG)

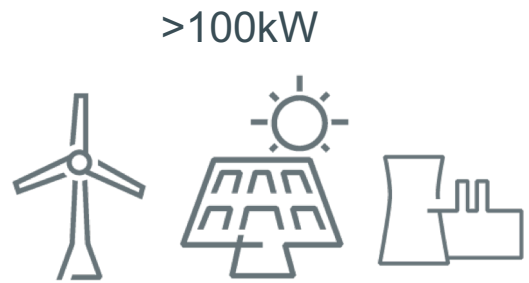
Lower Total Costs

Relativization of Priorities



§ 13.2 Emergency Measure

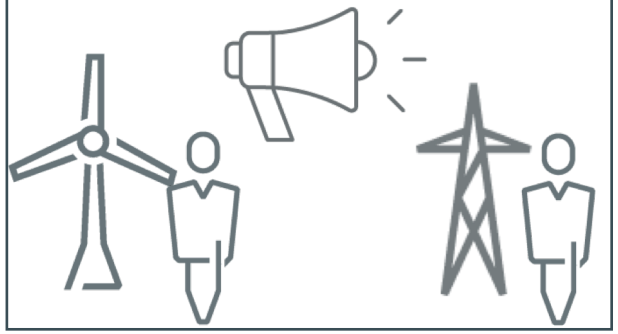
Plants larger 100kW



Right on Balance Adjustment

Right on Compensation

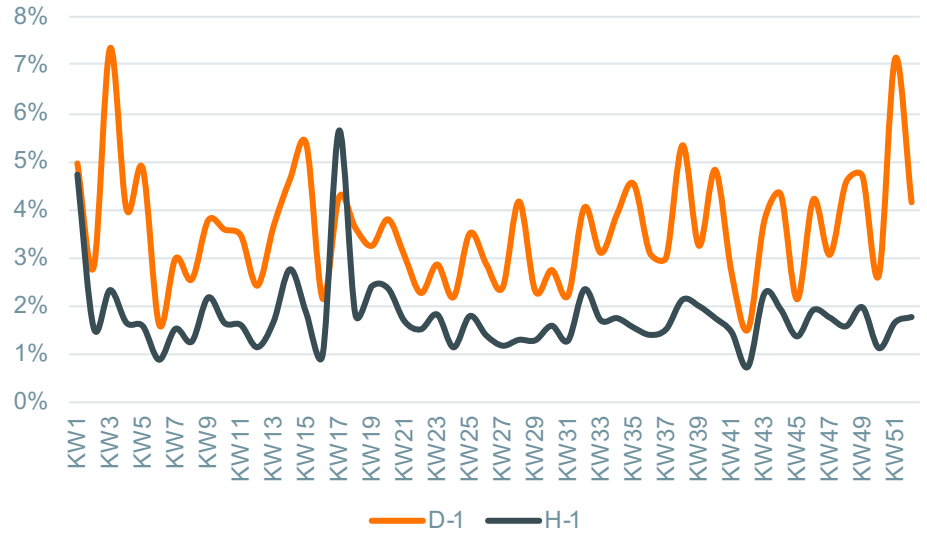
Call via Owner or DSO



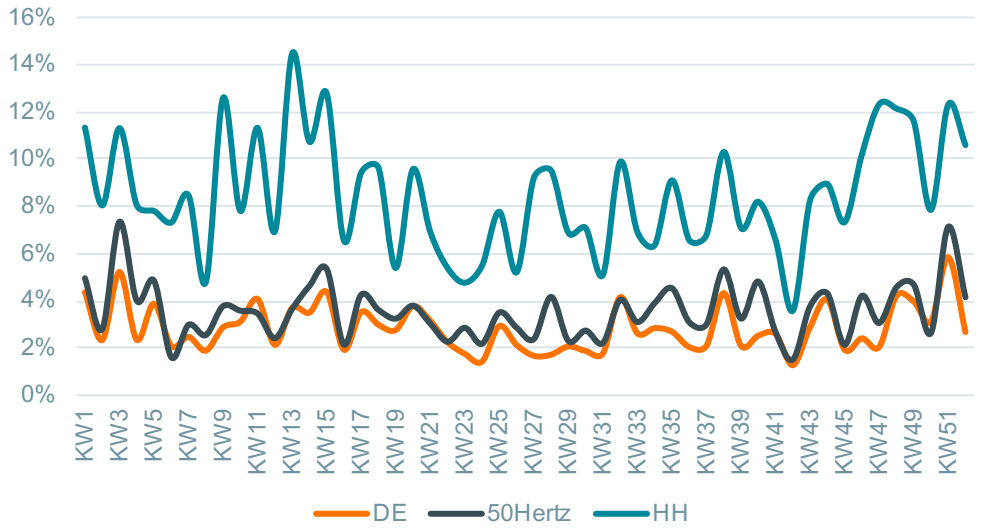
1.10.2021

2) Challenges with Feed-In Prognosis for RES

RMSE* for the combined Wind Prognosis within the 50Hertz Grid Area



RMSE* Comparison for the D-1 combined Wind Prognosis on various regions in 2018

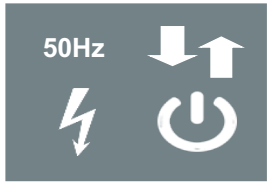


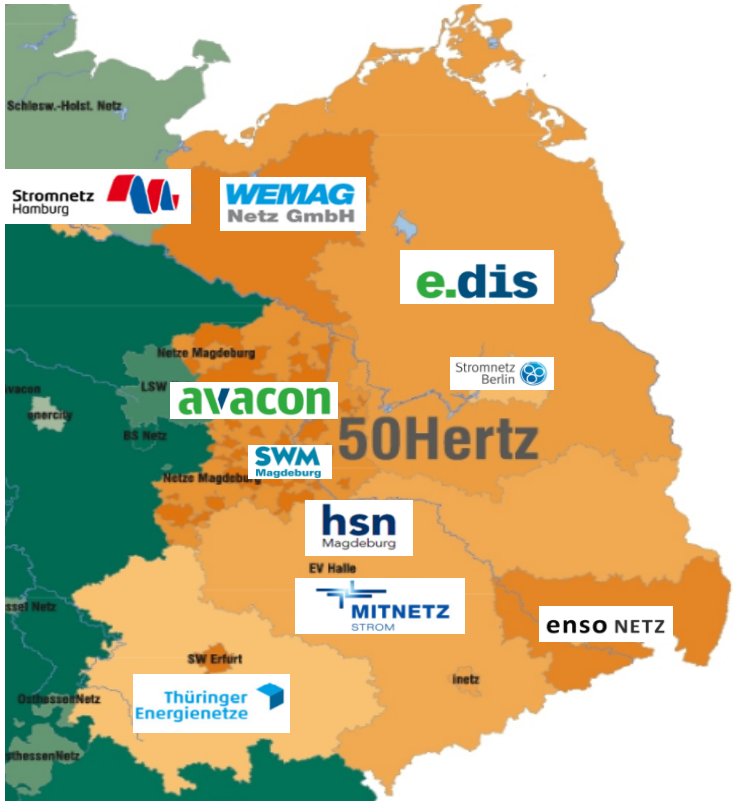
* Root Mean Square Error normiert auf die installierte Leistung
D-1 relates to day ahead.
H-1 relates to 1 hour ahead

Quality of Prognosis highly depending on the temporal horizon as well as the oberservation area.

2) The Ten Point Programme defines the fields of action for the 50Hertz-DSO cooperation

Objective

	Further development of the system security for the integration of renewable feed-in
	In future, coordinate ancillary services across grid levels; carry out pilot projects and trainings
	Mutual standardised exchange of operational data
	Common efforts to bring about changes in the legal and regulatory framework



An interconnection of system management processes across grid levels boosts efficiency advantages when integrating RES units.

2) InnoSys 2030 develops the system management for a maximum integration of renewable energy in the system

Motivation

- Increasing need for transmission
- Steeper RES ramps
- Issue of low acceptance for grid expansion

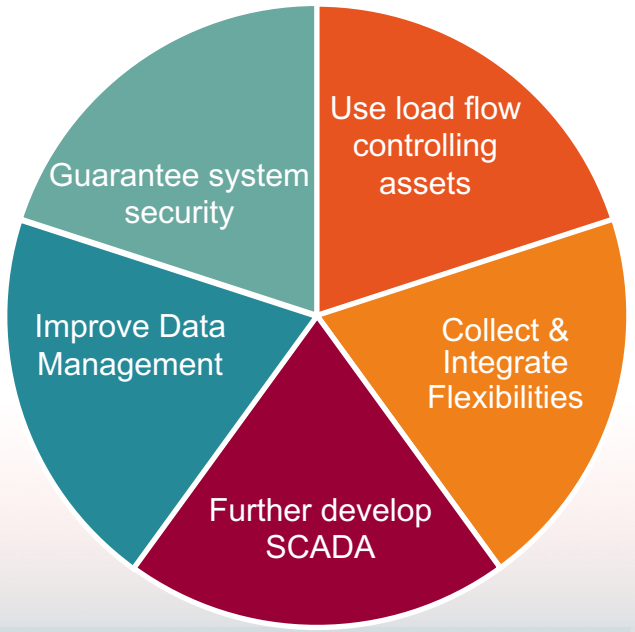
Vision

- Higher grid load at constantly high level of security
- Partial automation for shorter response times
- Reduce costs for grid interventions

Technological innovations & digitisation

Concepts for optimised system management

Fields of research and goal



Roadmap as of 2021
for the system operation of the future

Automated system management does not replace the system manager but makes it possible for him to first integrate large RES shares into the grid.

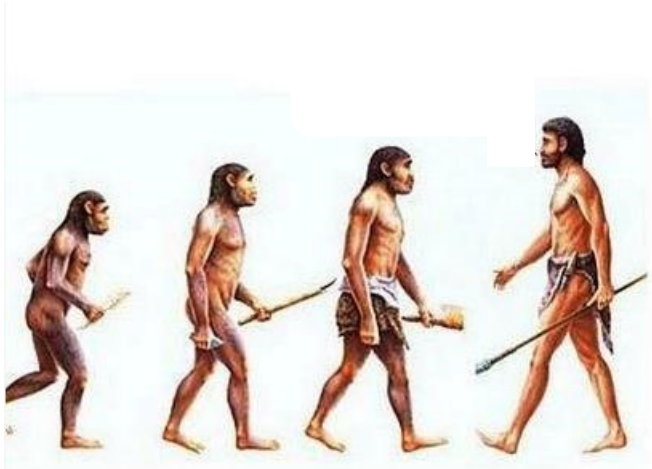
Source: general project description InnoSys 2030

3) Will the new complexity take its toll ?

- Most likely it will, because
  - we have a large number of competing targets to be implemented within an extremely short time horizon,
  - targets by themselves are independent but in a large system have strong interrelations and dependencies,
  - the System Operators are rarely asked when targets are fixed to provide a visionary reality check,
  - what we are doing is a live surgery on a living system upon which our entire welfare is dependent. Whereas political and regulatory frameworks are different in other areas of the world,
  - the tools and applications to manage the new setup do not exist yet and the market for SCADA / EMS systems is rather limited and unattractive for vendors,
  - vendors claim to have the solution and understand the System Operators‘ challenges but when it comes to the crunch they shrug their shoulders
  - the switch from a good natured and well (over-) dimensioned system with predominantly big central units to an agile, difficult to predict system with thousands of units managed by distributed controls and communications makes it more vulnerable.

4) Conclusion & The Way to go

- The fact that we need to change our behaviour is undisputed
- 50Hertz as part of the Elia Group will stay as a frontrunner in supporting & implementing new methods and tools – therefore becoming & maintaining its status as a facilitator for the Energy Transition and Industry 4.0
- To achieve that we need
  - more honest and open minded dialogues and cooperation amongst leaders and technology providers – such as we have here in London,
  - to wrap up new ideas and approaches in digestable steps to give appropriate but ambitious timescales for robust concepts and secured implementation timelines,
  - more engineers with professional experience in new technologies and other professionals that remain grounded but show passion for making it happen
  - the support of the public for potential drawbacks and a development towards higher energy costs.
- I am sure that we will make it happen but not with everything at the same time.



Thank you for your Attention

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