Overcoming barriers to flexibility in the generation fleet –

Germany case study

Dr. Claudia Weise, 5 June 2018, Manila

Agenda

1. Who is VGB?
2. Situation in Germany
3. Power plant flexibility – definition
4. Power plant flexibility – examples and experiences
5. System operation and market design in Germany
6. Summary

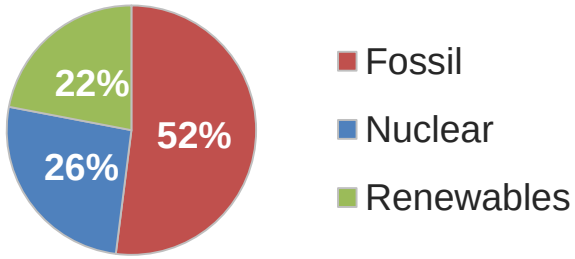
Our mission is…

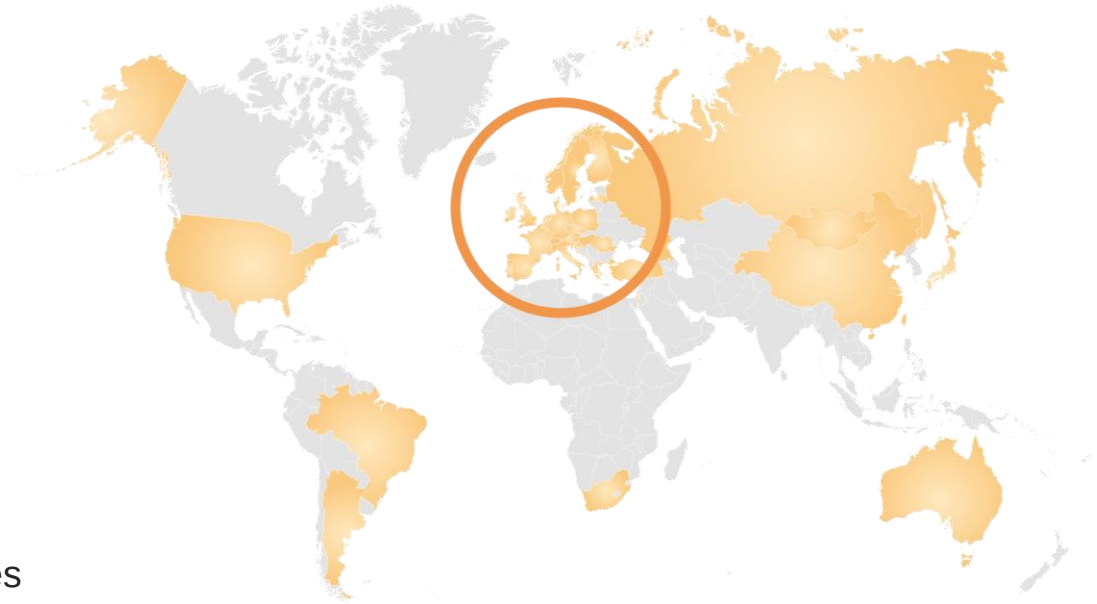
…to support our members in their operational business.

…to support our members in strategic challenges.

…to be a key contact for international energy stakeholders.

- We have **452 members in 33 countries**, over 90% are European based
- We represent an installed capacity of **433 GW** based on





VGB is the International Technical Association for Heat and Power generation and storage. Founded in 1920 it is based on a voluntary membership of companies active in the energy business.

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2. German power generation in 2017

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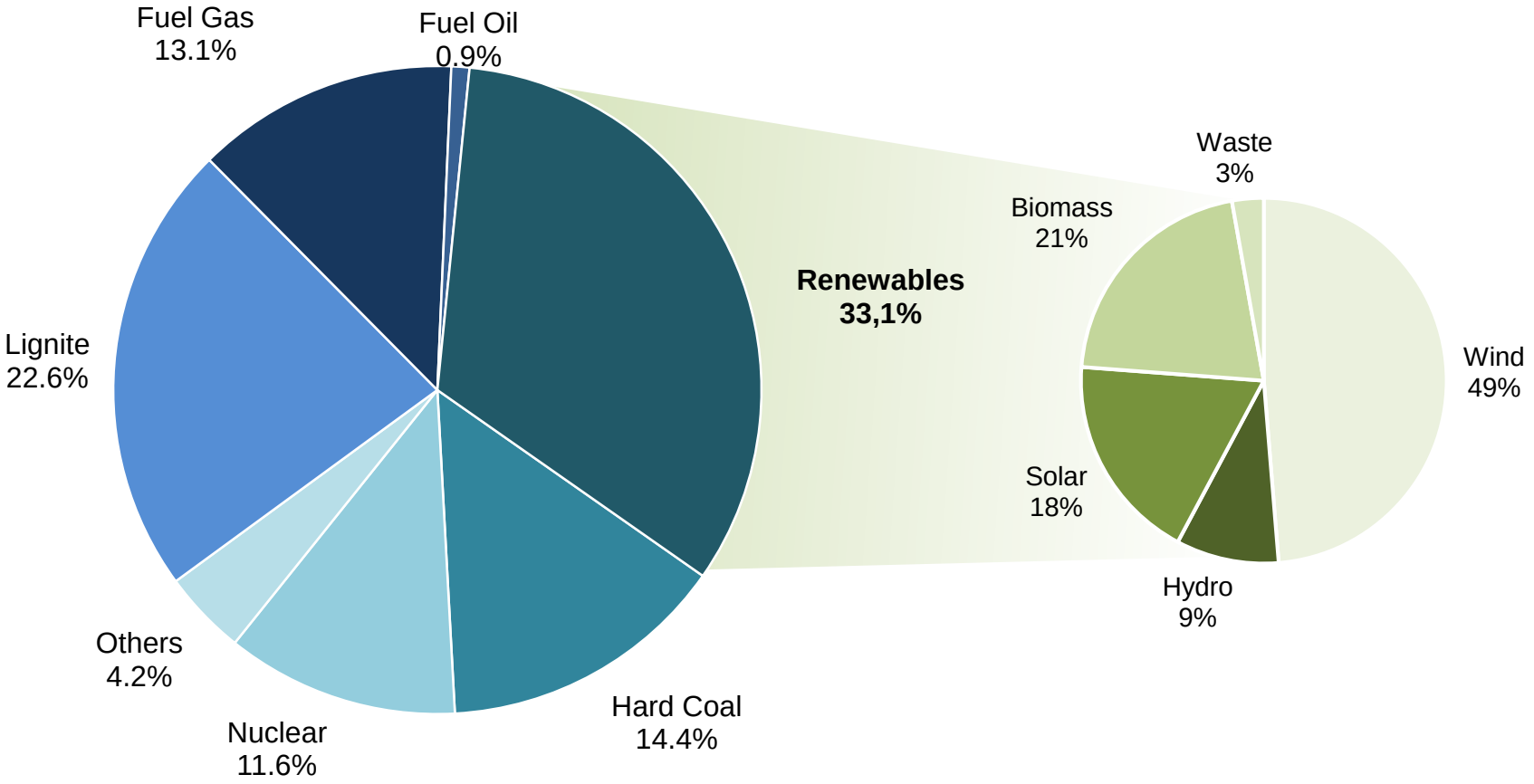
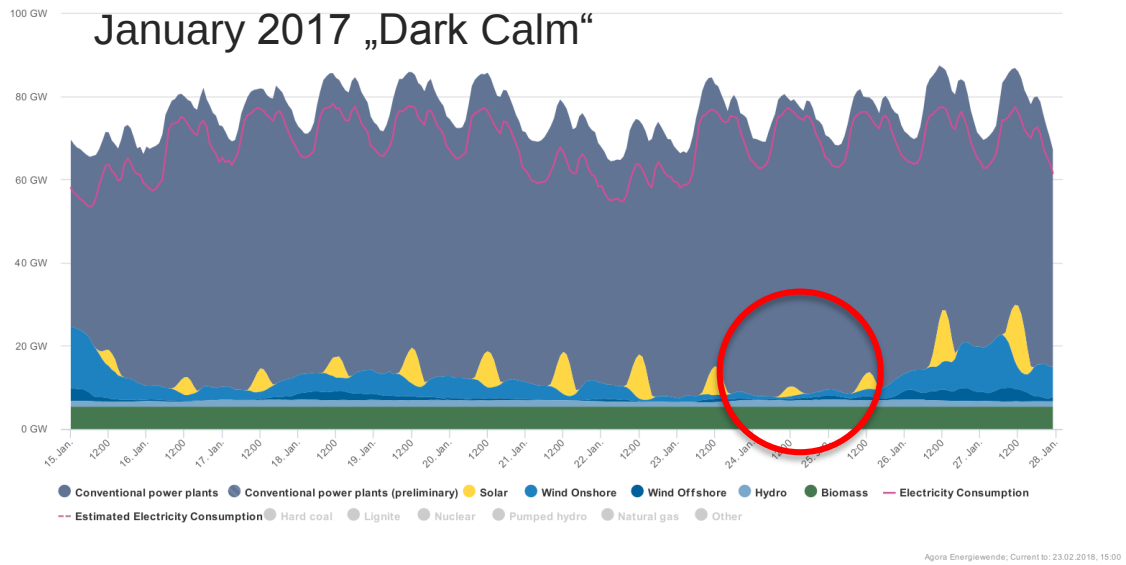
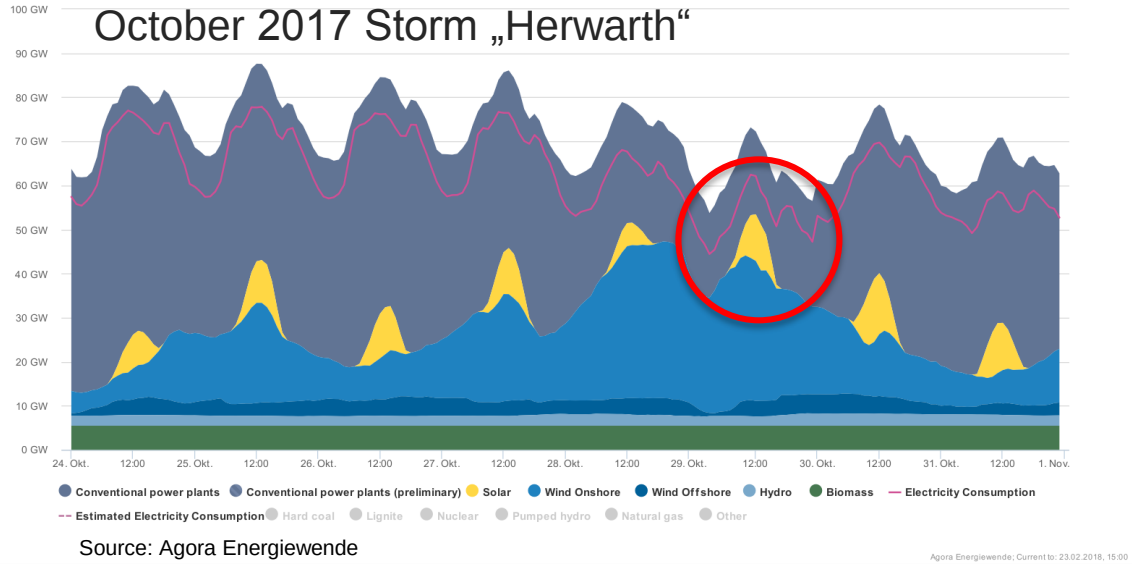
- Installed net capacity: 216 GW (thereof 113 GW RES)
- Gross power production: 654 TWh (consumption 600 TWh)



Renewables are the No.1 electricity generation source – VRE share is about 22 %.
Fossil fuels account for 50 % of the power production – hard coal is on a record low.



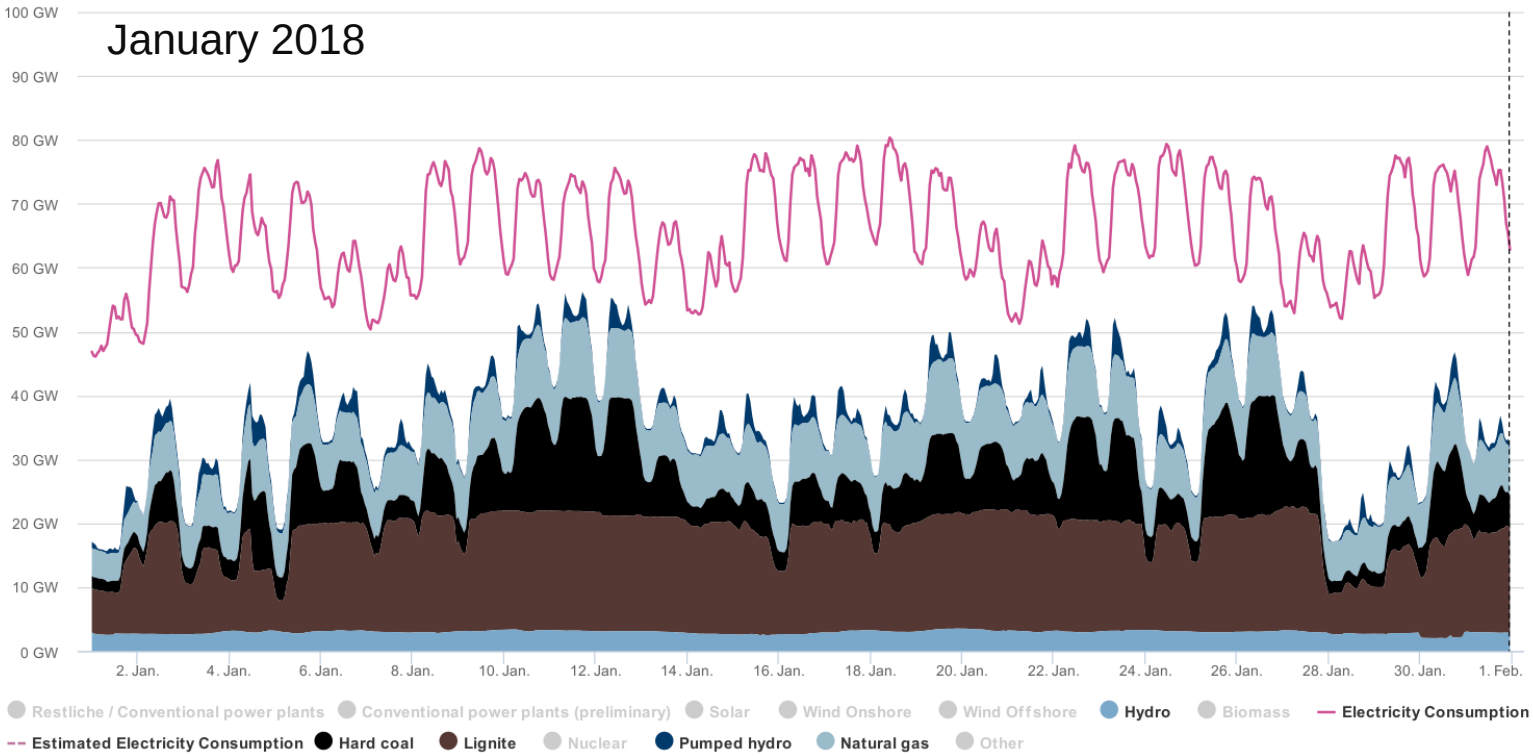


Source: Agora Energiewende

Residual load = power demand – VRE output

Wind and solar power are fluctuating on a hourly, daily, weekly and seasonal level thus imposing short- and long-term flexibility requirements on conventional power generation.

2. Utilization of conventional power plants



Installed net capacity:
Hard coal: 25 GW
Lignite: 21 GW
Gas: 30 GW
Pumped hydro: 7 GW

Maximum load band Jan 18:
Hard coal: 2 to 19 GW
Lignite: 5 to 19 GW
Gas: 4 to 12 GW
Pumped hydro: 0 to 5 GW

Lignite plants typically go into part load at low demand, whereas hard coal plants shut down (over night, weekend) with some minor exceptions in very low load mode. CCGT plants are either CHP or cycling. Pumped hydro are operated at times of peak demand.

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3. Flexibility parameters of conventional power plants

Plant type	Hard-coal	Lignite	CCGT	Pumped Storage
Ramp rate [% / min]	2 / 4 / 8	2 / 4 / 8	4 / 8 / 12	> 40%
in the load range [%]	40 to 90	50 to 90	40* to 90	
Minimum load [%]	40 / 25 / 10	60 / 40 / 20	50 / 40 / 30*	10
Start-up time hot start <8 h [h]	3 / 2 / 1	6 / 4 / 2	1.5 / 1 / 0.5	< 0.2
Start-up time cold start >48 h [h]	7 / 4 / 2	8 / 6 / 3	3 / 2 / 1	< 0.2

Source: VDE and own studies
usual value / state of the art / potential
*as per emission limits for NOx and CO

Conventional power plants are able to significantly contribute to a modern energy system. Technology development is focused on realising the flexibility potentials.

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POWERTECH

I&C optimization at unit D

Ramp-rate and minimum load

Source pictures: Wikipedia, Fotolia

- 600-MW-unit was commissioned in 1975
- Reduction of minimum load from 400 MW to 270 MW $\Rightarrow$ 43 %
- Increase of ramp rate from 5 MW/min to 15 MW/min
- Increase of secondary reserve capability to 70 MW in 15 min

Reference: RWE

One-mill operation at unit 7

Low minimum load

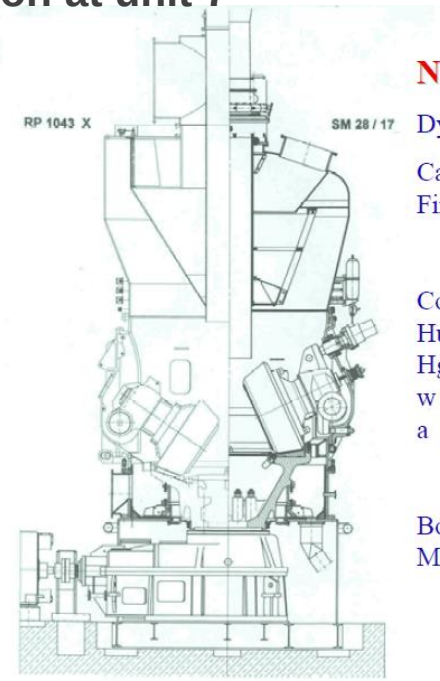
OLD

Static Separator

Capacity 77 t/h
Fineness 20 % R 90 µm

Coal Range
Hu 26.6 bis 29.6
Hg 60 bis 90
w < 9
a 8

Bowl - ∅ 2,670 mm
Motor 650 kW



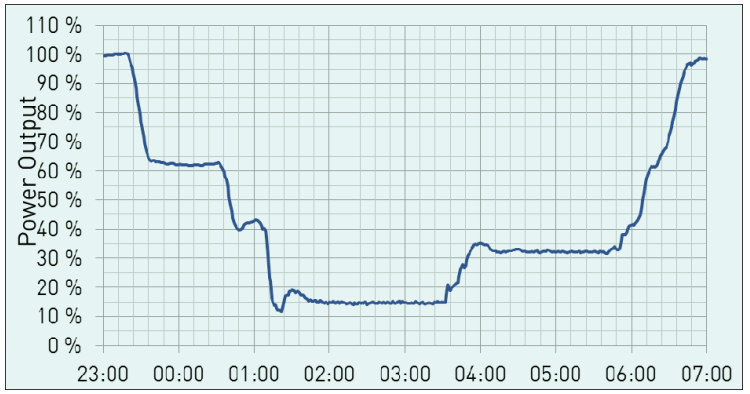
NEW

Dynamical Separator

Capacity 105 t/h
Fineness 10 - 25 % R 90 µm

Coal Range
Hu 23.0 bis 28.5
Hg 45 bis 100
w < 15
a 8 - 16

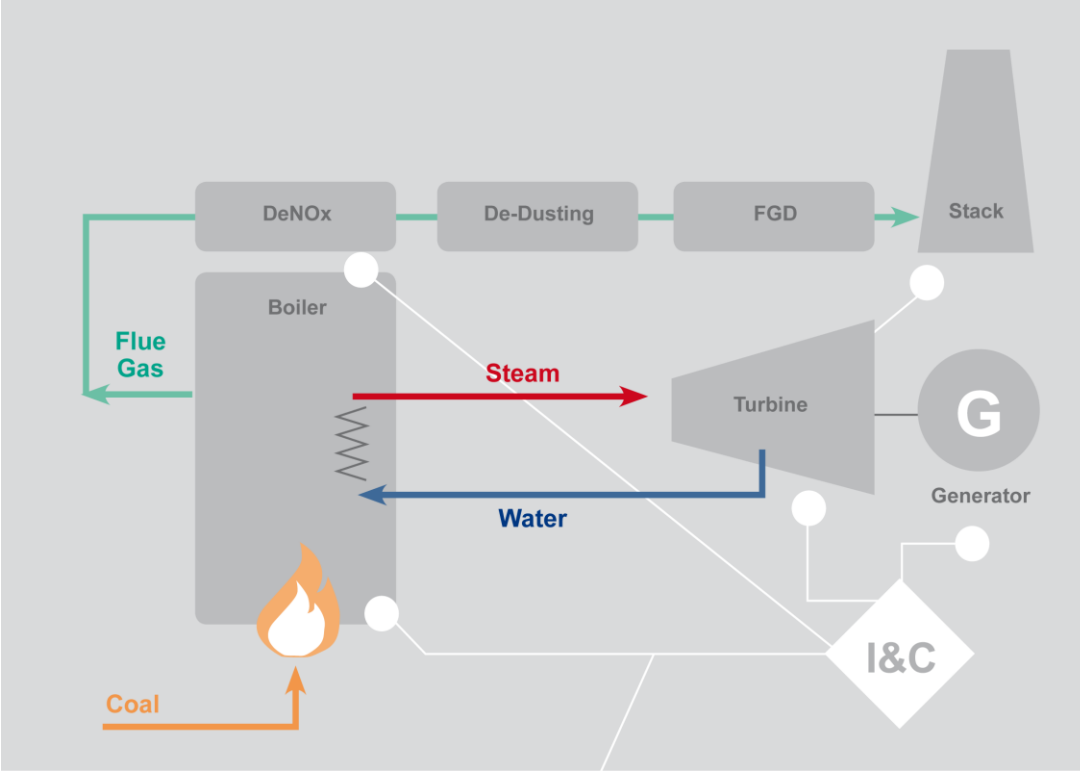
Bowl - ∅ 2,800 mm
Motor 650 + 45 kW



- Replacement of four mills to realize higher capacities – modification of outlet ducts and primary air adjustments
- By introduction one-mill operation, minimum stable firing capacity could be reduced down to **15% of the nominal capacity** (800 MW)
- Operation with one mill at the highest burner level is more stable than the operation with two mills – additional flame scanners necessary

Reference: EnBW/Alstom

Report available at www.vgb.org



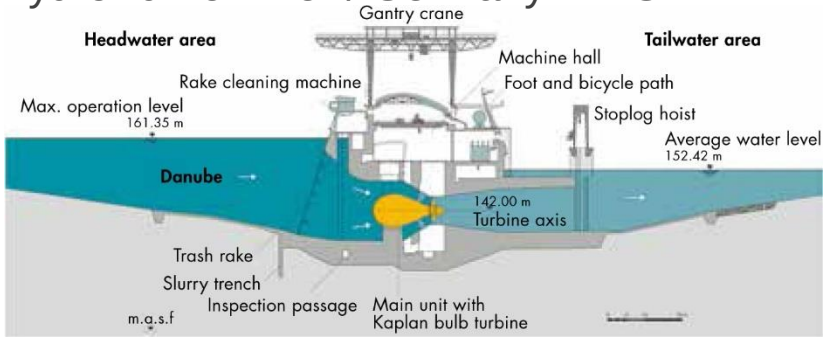
Measure
Flexibility impact
Limitation addressed by the measure
Description
Investment estimation
Time for implementation
Best practice

The toolbox includes 40 technical retrofit measures for main systems of the power plant – combustion, water-steam cycle, turbine, I&C, flue gas cleaning and auxiliaries – as well as storage technologies.

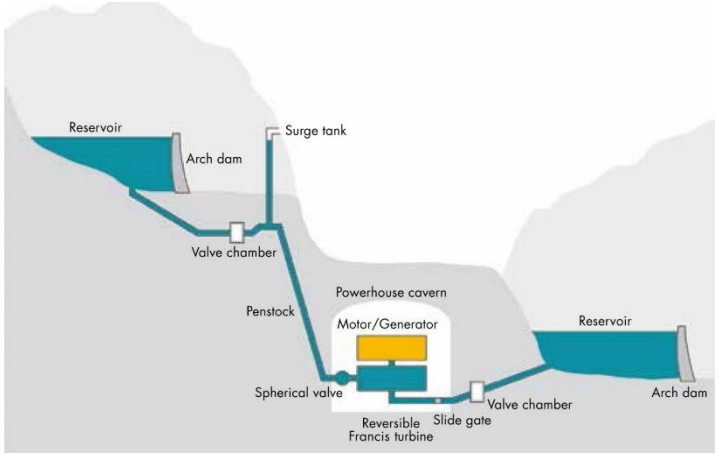
Hydro power is:

- **renewable**
- **a firm energy source**
- **a mature electricity storage technology**
- **provides all system services**

Hydro-run-of-river / Germany 4.7 GW



Pumped storage hydro / Germany 6.7 GW



Hydropower is the largest renewable energy source in the world. Moreover, pumped storage account for 99 % of the worldwide installed storage capacity.

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Market based

- Energy-only-market
- Balancing power market

Non-market – security of supply

- Reserve power plants
- Capacity reserve
- Safety disposition

5. System operation and market design in Germany

POWERTECH

Area	Energy	Congestion management	Balancing power	Other ancil-lary services	Capacity
Market products	▪ exchange spot market with day ahead pro-ducts and intraday tra-ding in 15-min. blocks ▪ OTC (over the counter)		▪ primary control ▪ secondary control ▪ Minute reserve ▪ sheddable loads		
Non-market measures		▪ redispatch of conv. Plants ▪ reserve power plants ▪ curtailment of VRE		▪ reactive power ▪ black start capability/ power system restoration	▪ additional capacity/ +safety disposition
Involved disp. gen. capacity	**~ 95,000 MW**	**~ 7,000 MW**	**7,400 MW**	**~ 30,000 GW** (demand for reactive power)	**~ 5,000 MW**

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POWERTECH

Technical barriers:

- They are no major technical challenges related to the flexible operation of conventional power plants.
- The implementation of a flexible operating regime requires a comprehensive approach with awareness rising, transparency about status quo, test runs and optimization of the I&C as priorities.

Economic barriers:

- Ensuring economic viability is the main challenge for flexible power plant operation.
- This calls for an according market environment rewarding flexible operation and compensating the losses due to reduced operating hours – e.g. by short-term energy markets and markets for ancillary services.

In Germany, the role of conventional power generation (especially coal) has changed drastically – from a dominant base-load power generator to a flexible partner of renewable energies meeting the residual load demand and supporting system operation.

Thank you
for your interest!

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Back-up

Flexibility of power systems

Dispatchable generation

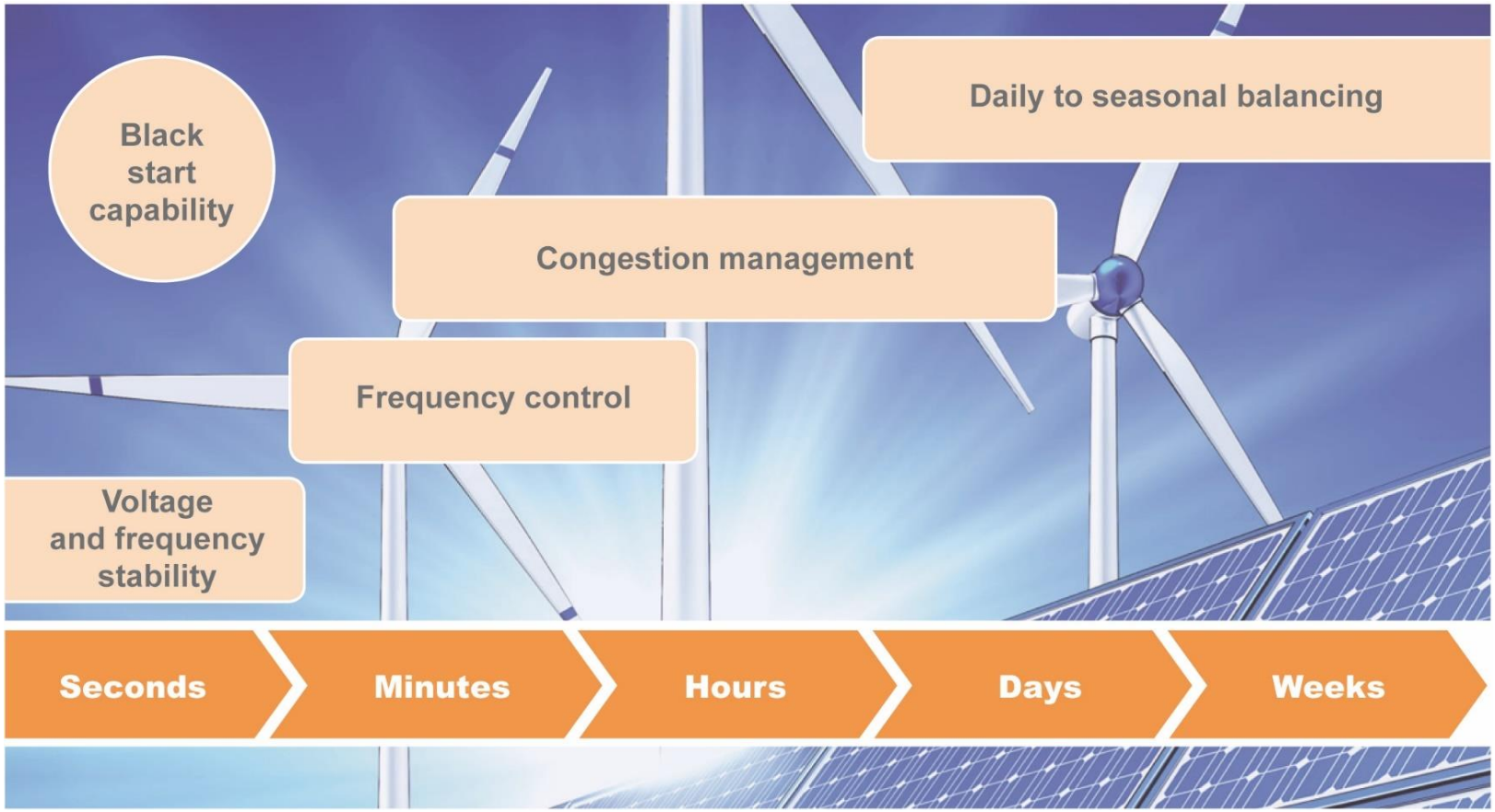
Demand-side-integration

Flexibility

Grid

Storage

Ancillary services

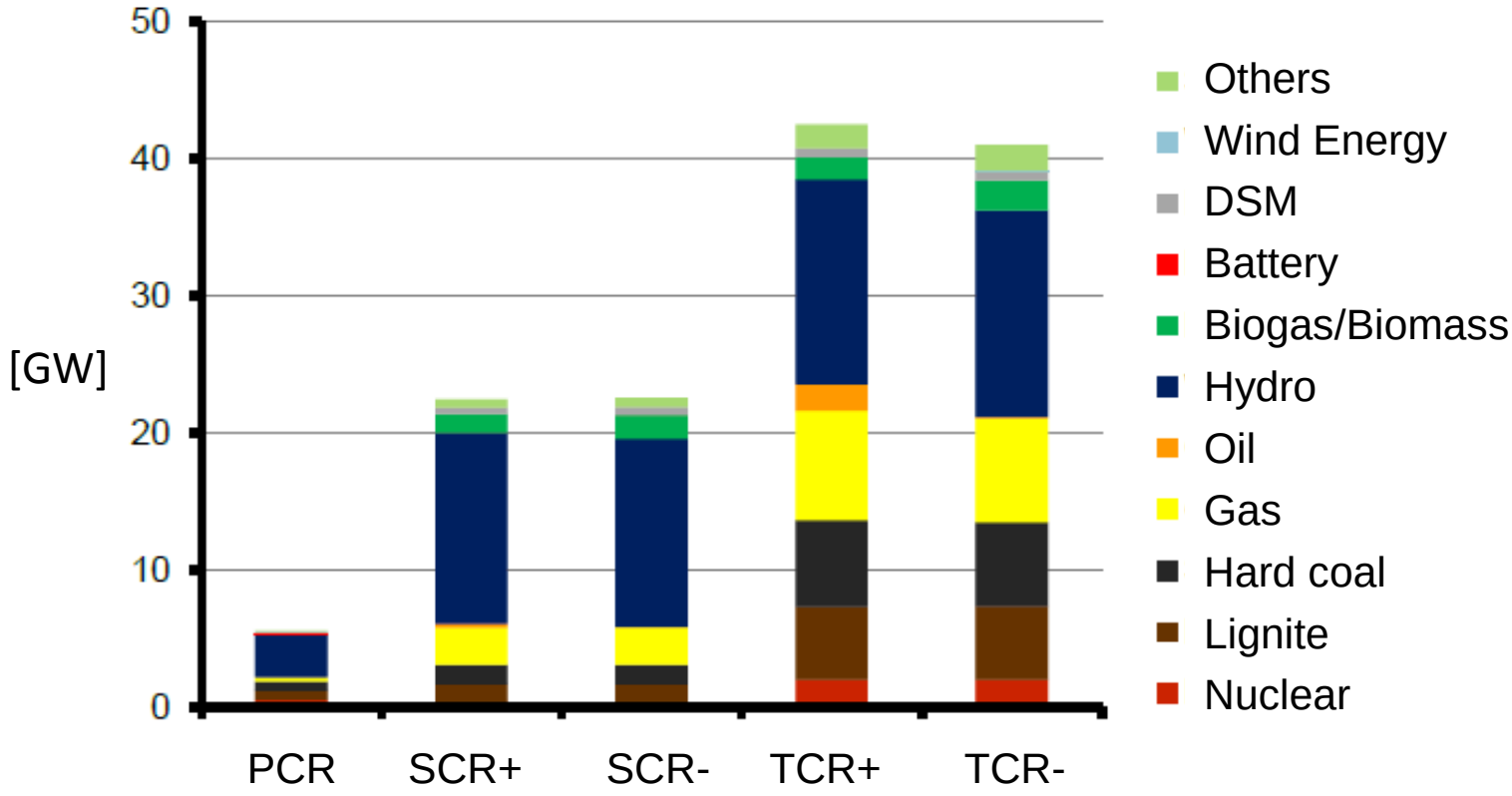


Ancillary services in Germany

POWERTECH

	Primary control	Secondary control	Tertiary control / minute reserve	Sheddable loads
Demand in Germany in MW	~ 583 MW (~ 1,390 in D, B, NL, F, CH, A)	+ >1,900 - >1,800	+ >1,350 - >1,800	▪ SOL: 881 ▪ SNL: 1,052
Auctioning schedule	weekly (+/- 1 MW)	weekly (+/- 5 MW)	daily (Mo-Su) (6x4h; 5 MW)	weekly (5 – 200 MW)
No. of pre-qualified bidders	23	37	52	▪ SOL: 3 ▪ SNL: 7
Remune-ration scheme	capacity	capacity and energy	capacity and energy	capacity and energy
usage	fully automated	fully automated	on call	automated / remote
Amount in GWh		▪ 2014: + 1.200 - 1.600	▪ 2014: + 287 - 327	
Costs in Mio EUR	▪ 2010: 107 ▪ 2016: 74	▪ 2010: 505 ▪ 2016: 91	▪ 2010: 85 ▪ 2016: 33	2016: 25

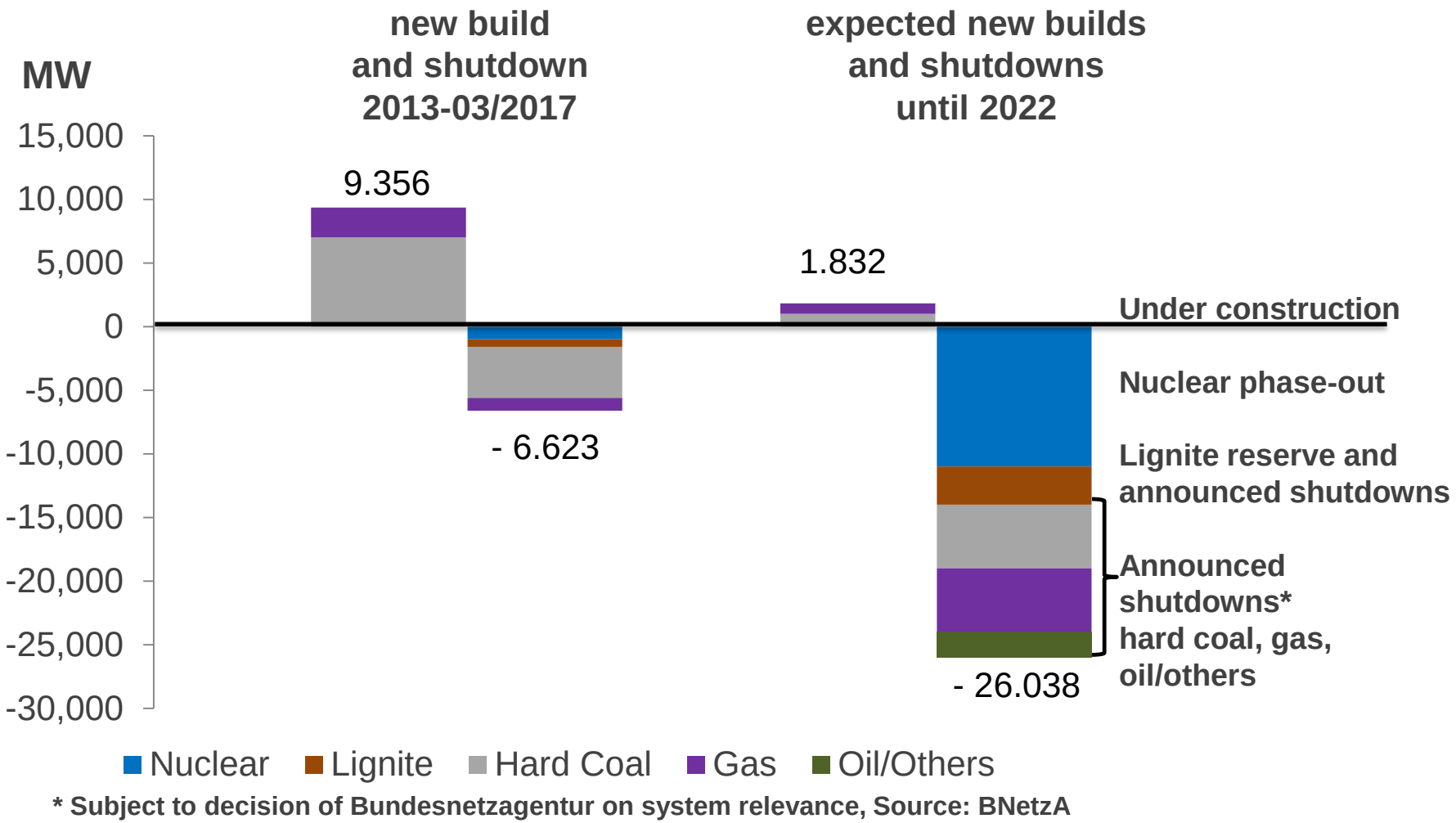
Overview of prequalified control reserve capacities in Germany (01.2017 - 11.2017)



Hydro	PCR	SCR+	SCR-	TCR+	TCR-
[GW]	3,08	13,93	13,76	14,94	15,04
[%]	55%	62%	61%	35%	37%

PCR … primary control reserve
SCR … secondary control reserve
TCR … tertiary control reserve

Development of thermal power plant capacity



*** Subject to decision of Bundesnetzagentur on system relevance, Source: BNetzA**