VGB POWERTECH

Fluctuating feed-in of renewable energies – how German operators tackle technical and economical challenges

New Delhi, 16 December 2016

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Agenda

1. Who is VGB?
2. Framework and German energy market
3. Flexibility and system stability: flexible conventional fleet
4. Flexibility and system stability: storage options
5. Conclusions and outlook

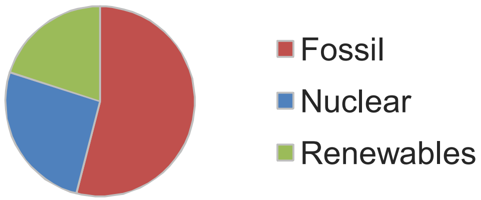
Our mission is…

…to support our members in their operational business.

…to support our members in strategic challenges.

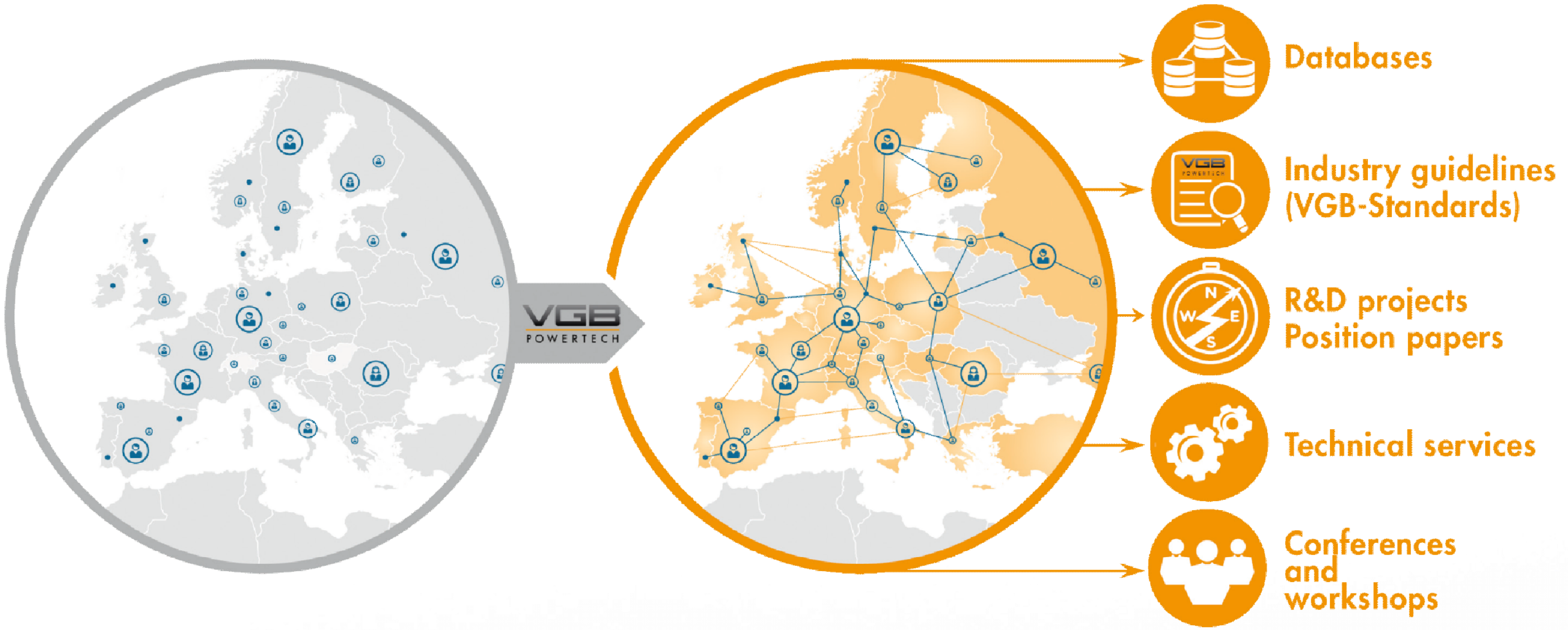
…to be a key contact for international energy stakeholders.

- We have **484 members in 35 countries**, over 90% are European based
- We represent an installed capacity of **458 GW** based on this energy mix:



VGB is the European Competence Center of Heat and Power Generators. Founded in 1920 it is based on a voluntary association of companies active in the energy business.

Over 1,700 experts are active in the VGB network.



VGB facilitates the exchange of experiences between the experts and document and disseminate the results for the benefit of all members.

1. Long-term co-operation with India

EEC Excellence in Power

igef Indo-German Energy Forum

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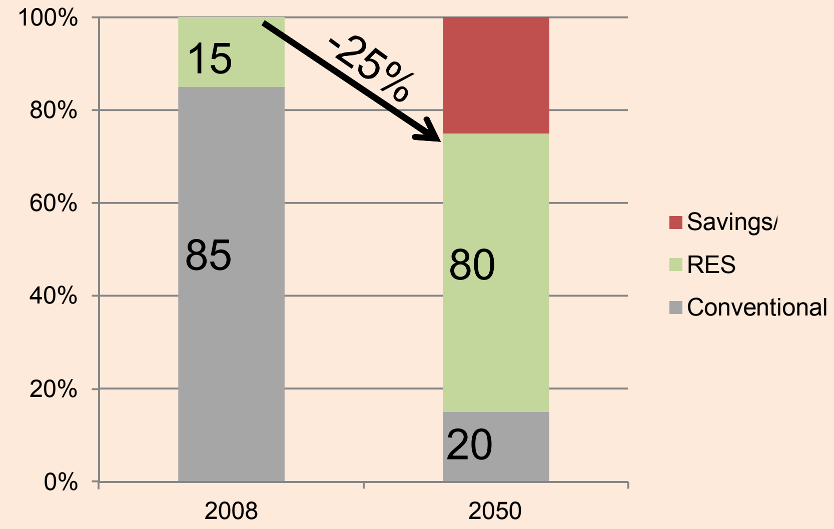
	- 20% Greenhouse Gas Emissions	20% Renewable Energy	20% Energy Efficiency	10% Interconnection
2020	- 20% Greenhouse Gas Emissions	20% Renewable Energy	20% Energy Efficiency	10% Interconnection
2030	at least - 40% Greenhouse Gas Emissions - 43% reduction from ETS - 30% reduction from non-ETS	at least 27%* Renewable Energy Consumption * Implies 45% RES in power generation	at least 20% (indicative) Energy Efficiency (to be reviewed by 2020)	15% Interconnection

Source: Eurostat

Reduction of greenhouse gases by 40% in 2020, by 80% in 2050

Phase-out of nuclear power by 2022

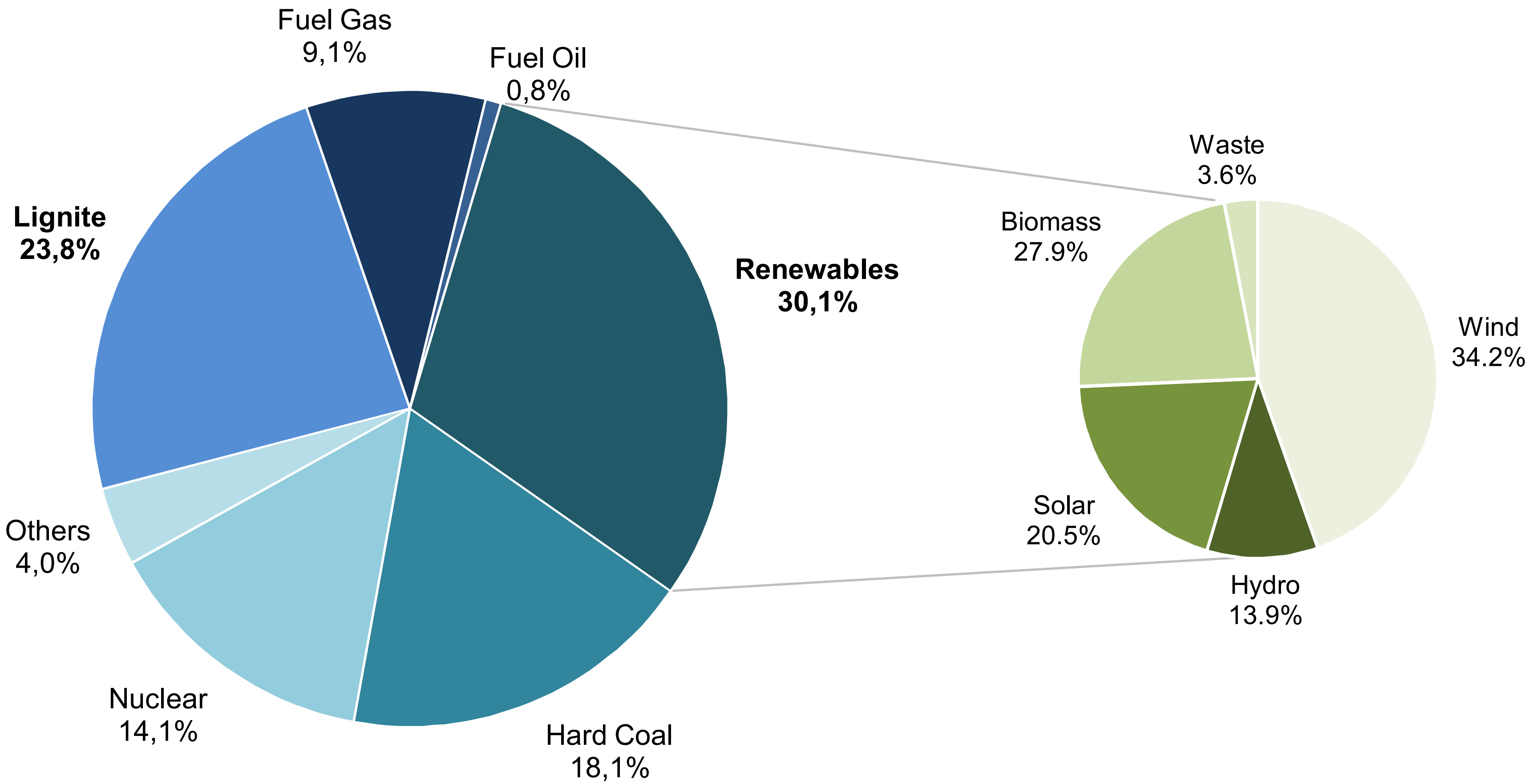
Increase of the share of renewables up to 80%, reduction of primary energy consumption by 50% and decrease of electricity consumption by 25% in 2050



Reference year for CO_2-reduction:1990

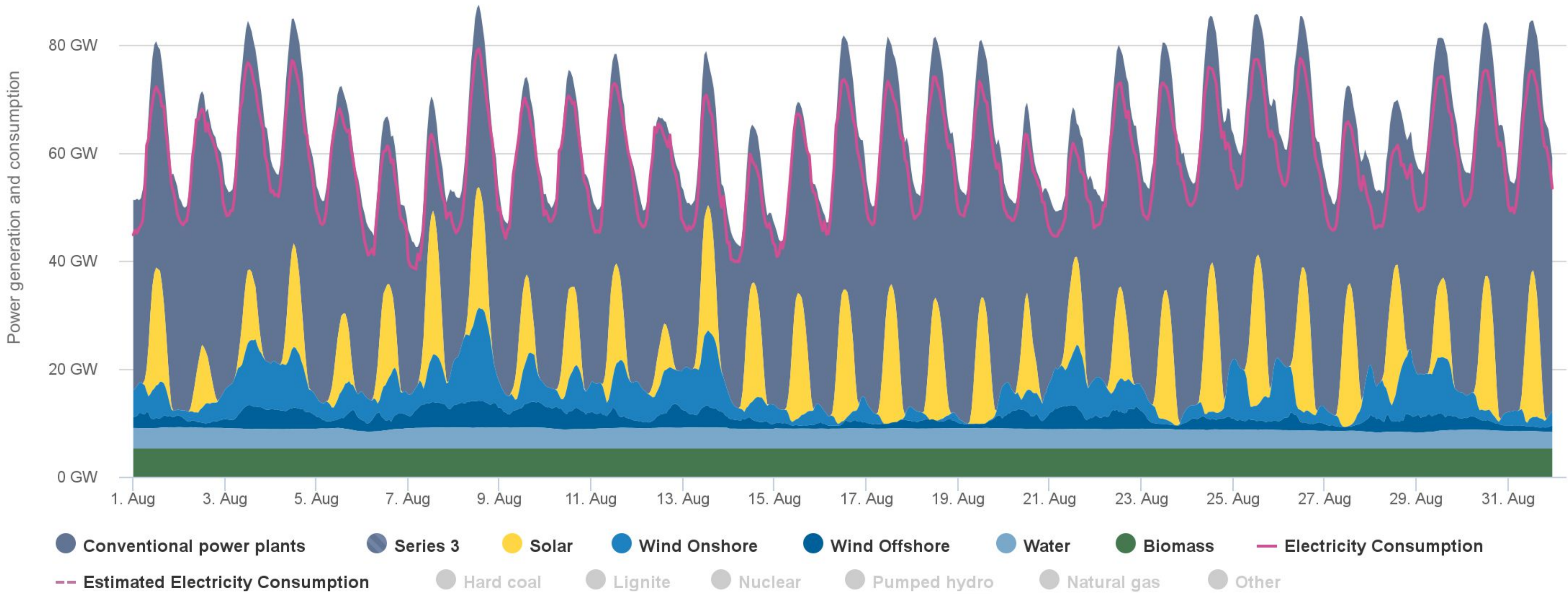
Power generation in Germany in 2015

- Installed capacity: 201 GW
- Gross power production: 652 TWh



In 2015 for the second time renewables have outscored lignite as No. 1 electricity generation source.

2. Electricity Production in Germany

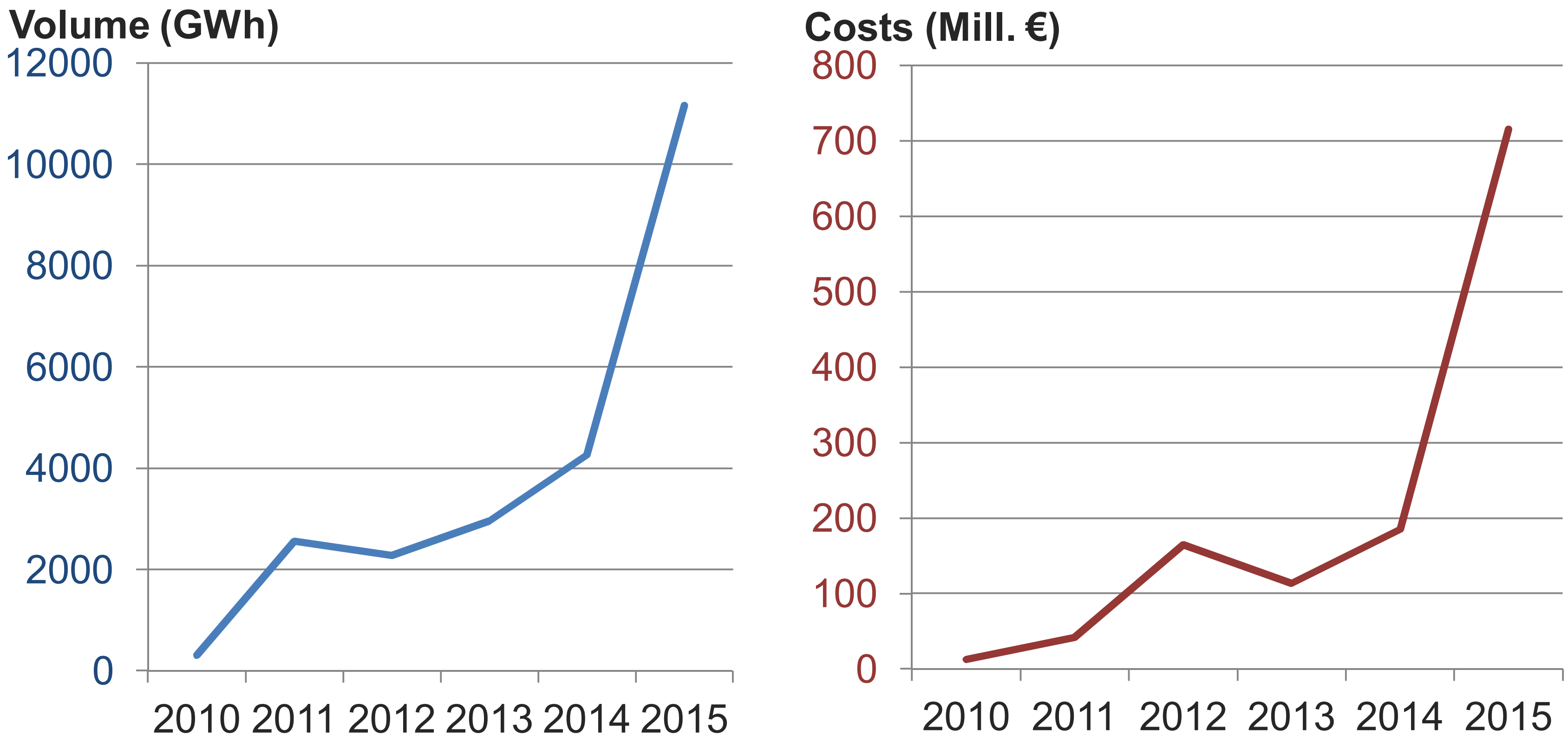


Agora Energiewende; Current to: 08.09.2016, 11:45

The profitability of conventional power plants, even on marginal costs, has deteriorated because of lower prices and reduced operating hours.

2. Some more consequences of German “Energiewende”

Development of TSO redispatch measures in Germany 2015

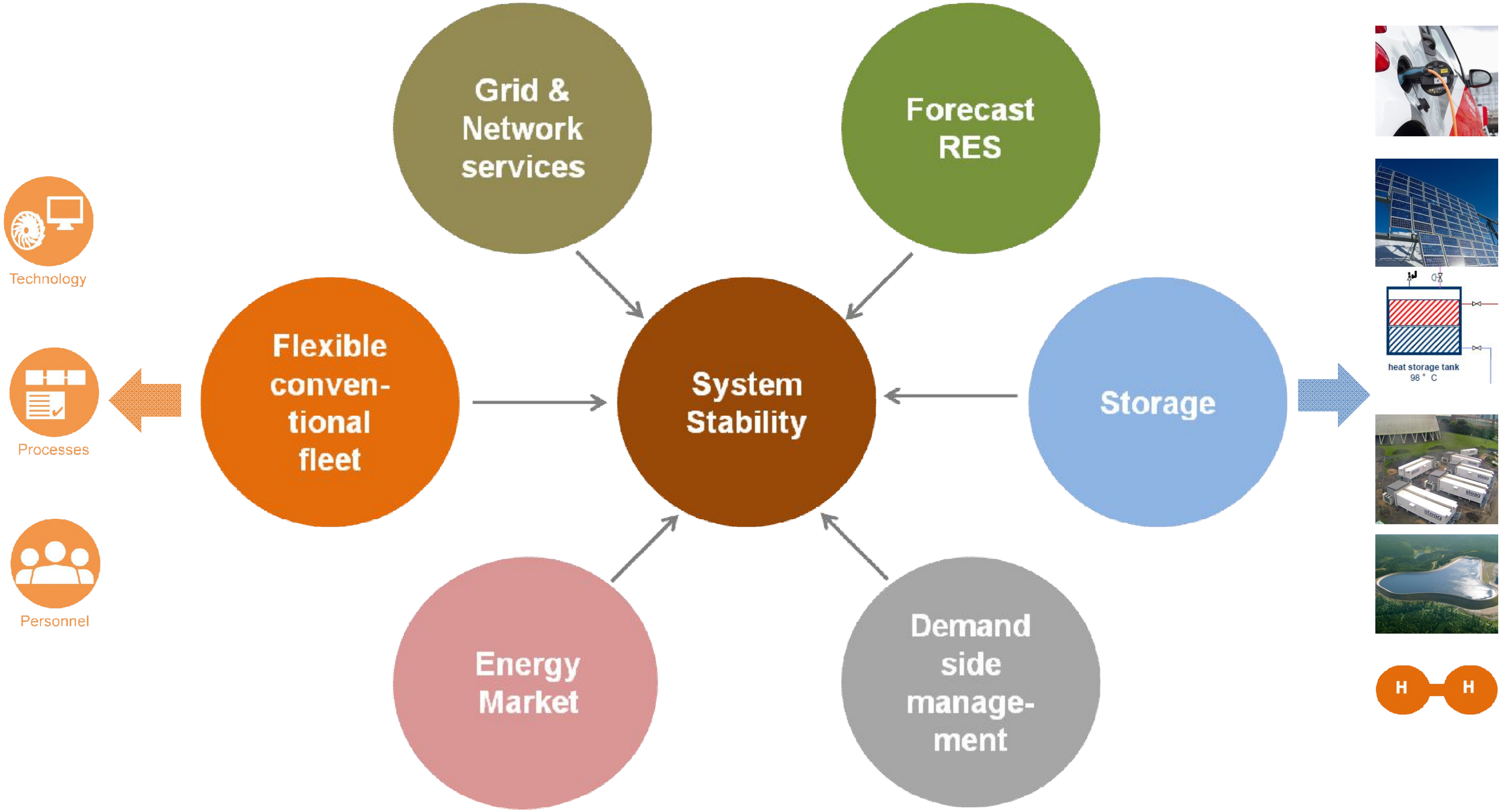


source: German Regulator BNetzA

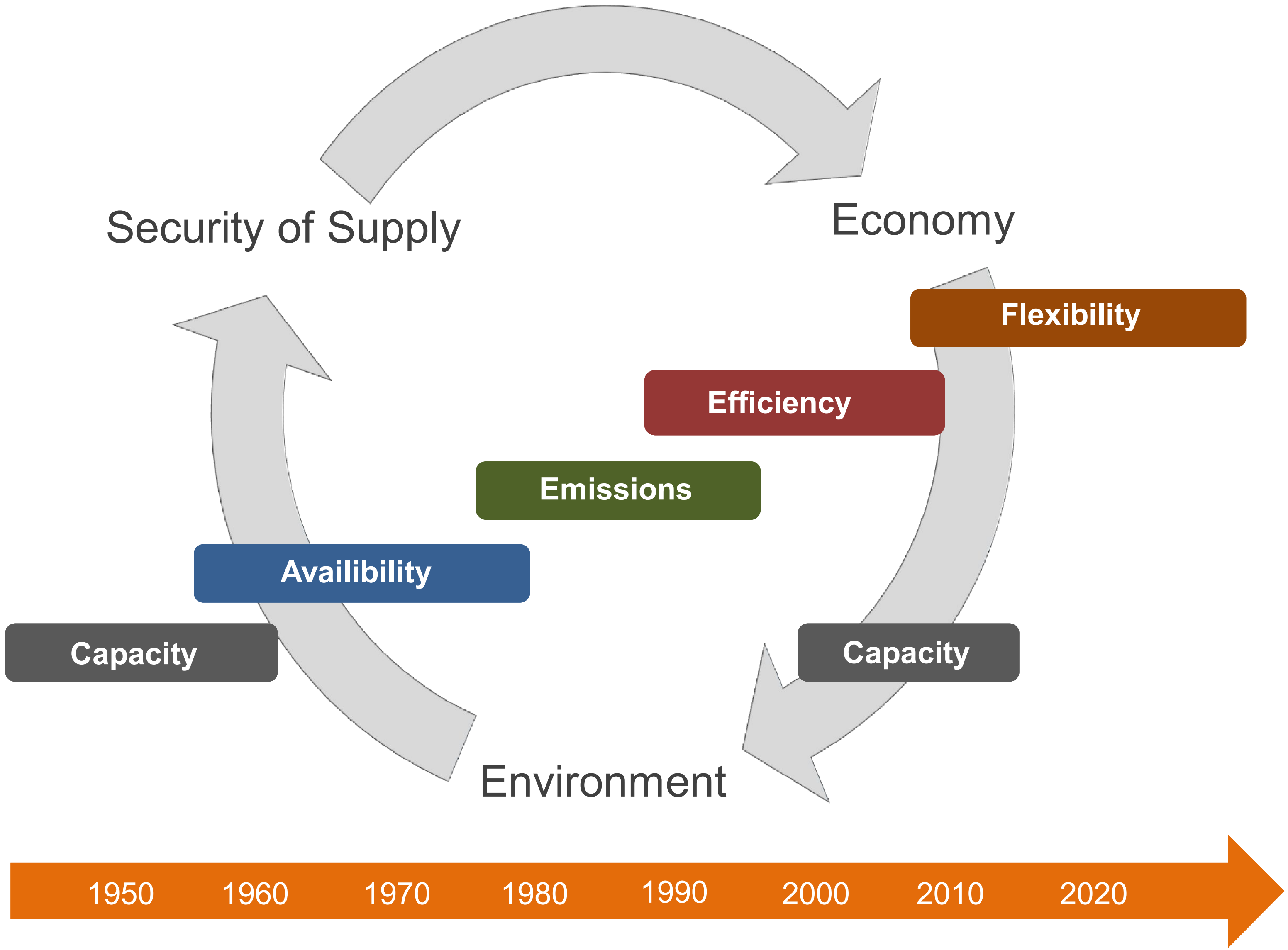
Total costs of TSO load management increased to appr. 1,3 billion € in 2015.
In 2020 German TSO estimate further increase to 5 billion €.

A recent study showed total Energiewende costs of 150 billion € until 2015 (power sector only). Until 2025 total costs are estimated to exceed 520 billion €.

3. What keeps the grid stable?



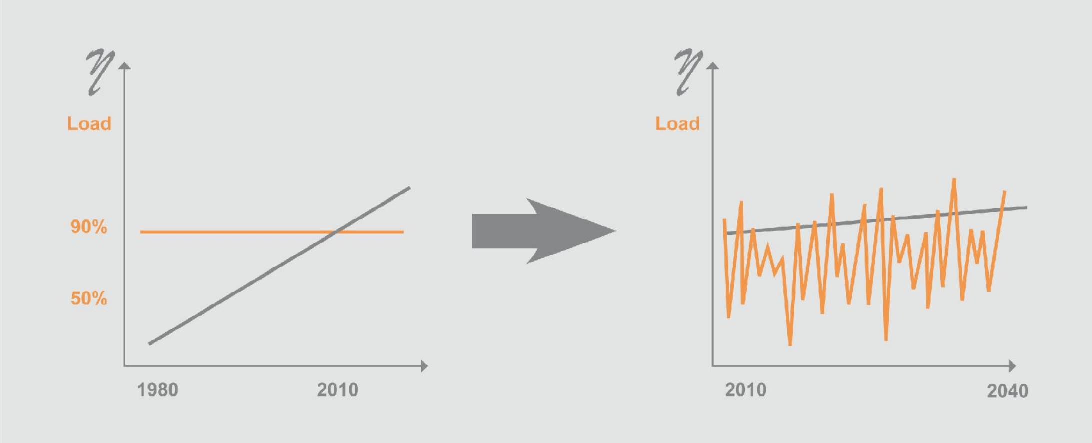
Achieving system stability is key to a successful energy transition. Therefore a flexible conventional power plant fleet is essential.

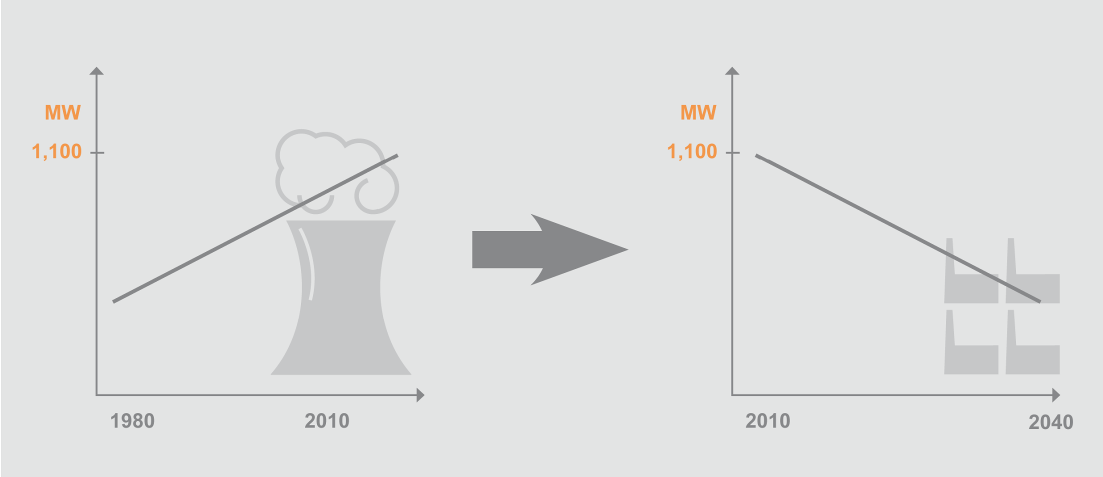

Security of Supply
Economy
Environment
Flexibility
Efficiency
Emissions
Availibility
Capacity
Capacity
1950
1960
1970
1980
1990
2000
2010
2020

The energy systems transforms from centralized and fossil-based to decentralized and renewable-focussed.

→ **the value of flexibility will overrule the value of efficiency**

→ **the economy of scales will be replaced by a low-cost & low-risk approach**





Technology development and O & M concepts need to adapt to the changed market requirements. A new thinking towards smaller, flexible, low-cost plants is required.

3. Flexibility parameters of thermal power plants

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Flexible conven-tional fleet

Main flexibility contributors are: **high load gradients, low minimum load, short ramp-up times**

Plant type	Hard-coal	Lignite	CCGT	Gas Turbine
Load gradient [% / min]	2 / 4 / 8	2 / 4 / 8	4 / 6 / 12	8 / 12 / 15
in the load range [%]	40 to 90	50 to 90	40* to 90	40* to 90
Minimum load [%]	40 / 25 / 15	60 / 40 / 20	50 / 40 / 30*	50 / 40 / 20*
Ramp-up time Hot start <8 h [h]	3 / 2 / 1	6 / 4 / 2	1.5 / 1 / 0,5	< 0.1
Ramp-up time Cold start >48 h [h]	7 / 4 / 2	8 / 6 / 2	3 / 2 / 1	< 0.1

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

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

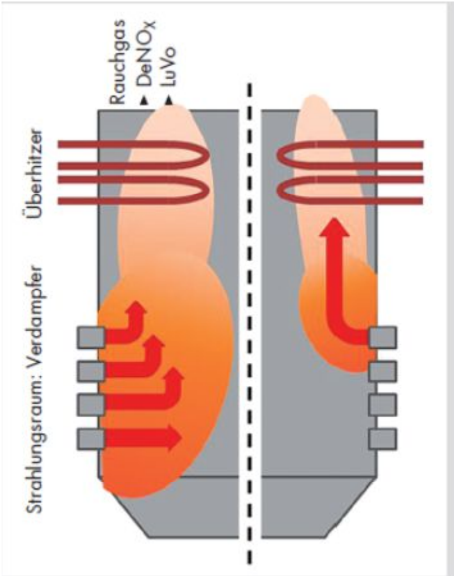
3. Reduction of minimum load

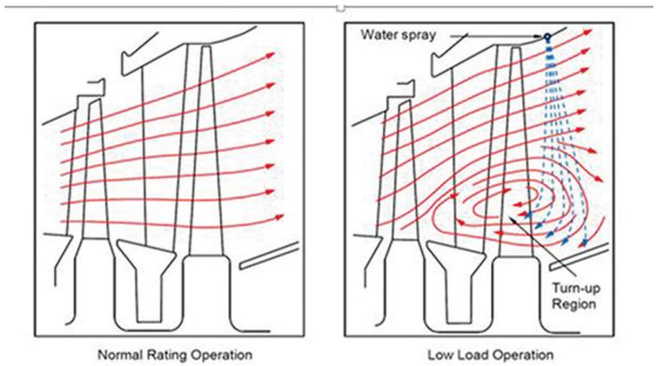
→ **Boiler**
- improve milling process
- increase numbers of mills
- switch to 1-mill operation
- advanced flame and temperature monitoring and control

→ **Water Steam Cycle / Turbine**
- advanced temperature monitoring system
- bypass operation
- adjust design buffer for minimum feedwater flow

→ **Turbine**
- advanced temperature monitoring
- improve turbine ventilation protection

→ **Flue Gas Cleaning**
- improve NH_3 dosing control for DeNOx technologies
- flue gas reheating or Eco-Bypass
- improve pump operation regime in wet FGD process





3. Shorten the ramp-up time

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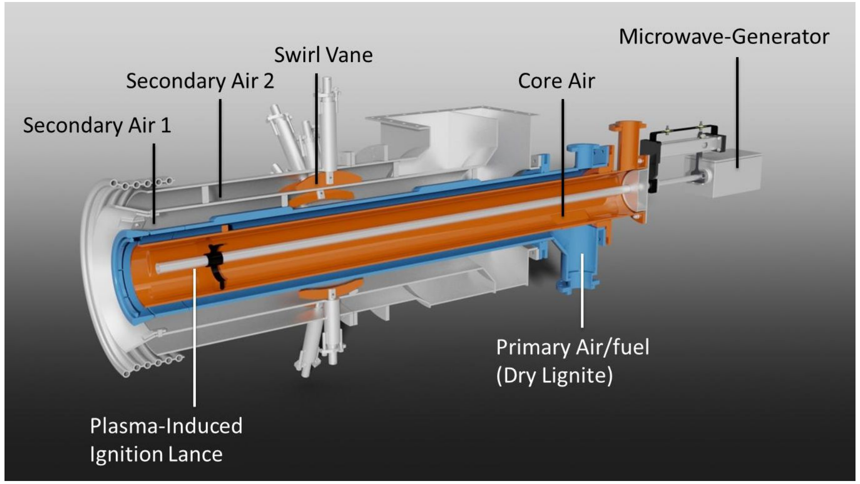
Flexible conventional fleet

Technology

→ **Fuel/Boiler**
- separating milling and combustion process
- advanced monitoring of flames and temperatures
- advanced combustion control
- dry lignite supplementary firing
- decrease wall-thickness

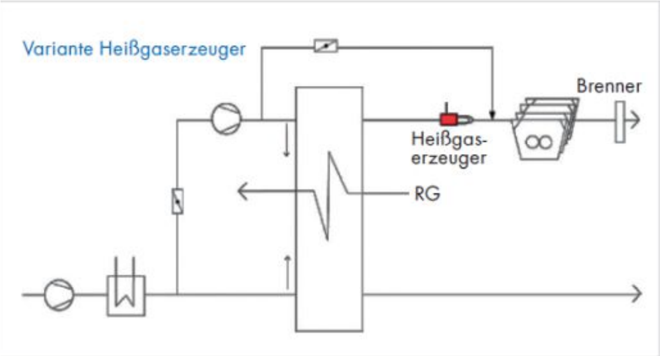
→ **Water Steam Cycle / Turbine**
- installing bypasses
- matched component design
- steam stowage
- reconditioning of turbine rotor (first blade groove)
- temporary heating of turbine (e.g. by hot air)



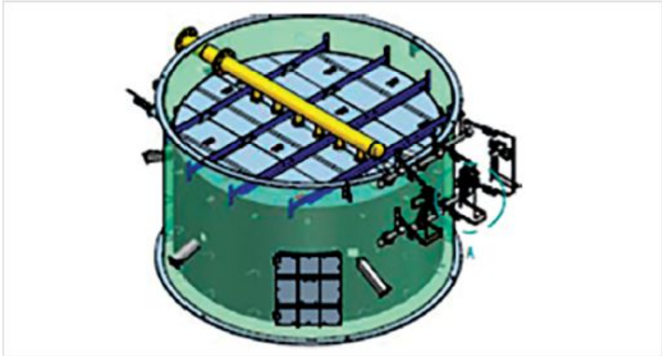
Dry lignite burner, Source: BBS, Vattenfall

→ **Auxiliaries**
- adjustment of pumps, fans and other aux. equipment (e.g. switch to variable speed-driven motors)
- Advanced monitoring, data assessment and analysis (I&C-system upgrade)

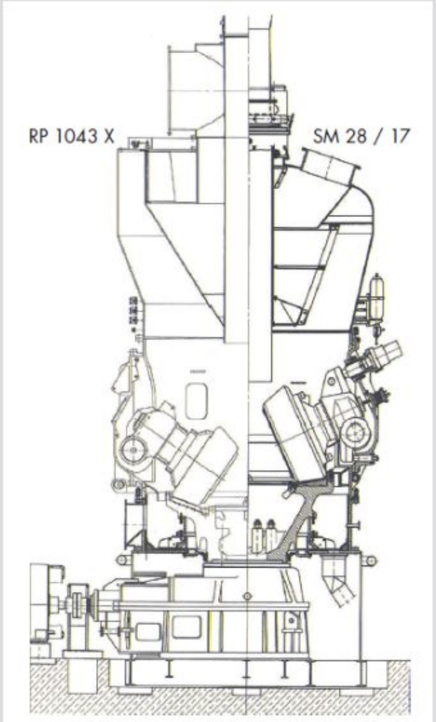
Enhance drying and pulverizing: Power Plant Weiher/Bexbach, 700 MW hard coal



Drying and pulverizing scheme

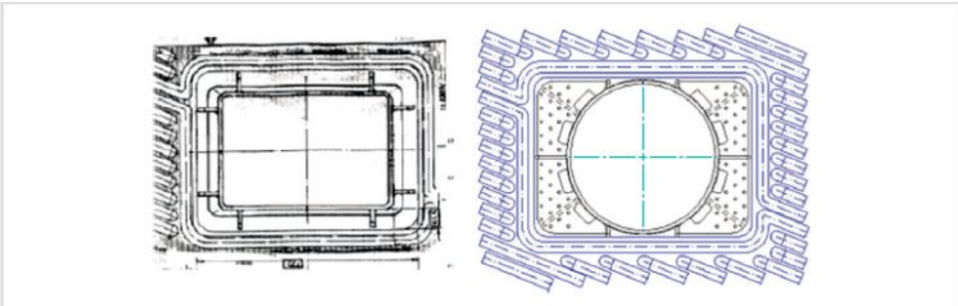


Additional hot gas generators



Enhanced mill capacity:
Power Plant Bergkamen, 750 MW hard coal

Improved burner geometry:
Power Plant Bergkamen, Bexbach



Source: STEAG/GE & Alstom

Flexible conventional fleet

Technology

3. Flexible operation – flexible processes and advanced skills

O&M:

- new operation regime for low load and fast load changes affecting all areas of the plant (from fuel supply to flue gas cleaning)
- need to develop preservation concepts
- adjustment of maintenance and overhaul strategies
- adjustment of shift-planning, staffing and organisation
- re-assessment of coal-supply and byproduct strategies
- new control and data strategies

Skills:

- flexible technologies and processes go along with high level of automation – training is essential
- familiarise the staff with new requirements arising from flexible operation
- define new requirements and re-work job profiles
- long-term training strategies need to be developed for all types of personnel

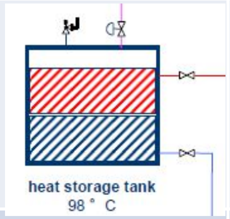
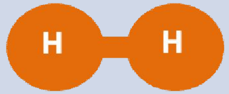
Flexible conven-tional fleet

Processes

Personnel

Flexible operation has an impact on all aspects of power plant operation. Training and skill development is as important as the implementation of new technologies.

4. Storage options

	Short-term storage < 30 min	Medium-term storage 1 – 5 hours	Long-term storage > 1 day up to months
Small scale & modular storage **1 kW – 1 MW**	mobile storage (Lithium) 	home storage + PV (Lithium) 	
Medium scale & modular storage **1 kW – 100 MW**	stationary storage (Lithium / lead-acid) 	heat and stationary storage (redox flow) 	
Large scale & central storage **100 MW – 1 GW**		pumped storage 	Power to X - gas - liquid - chemicals 

Source: VGB based on Prof. Sauer, RWTH Aachen

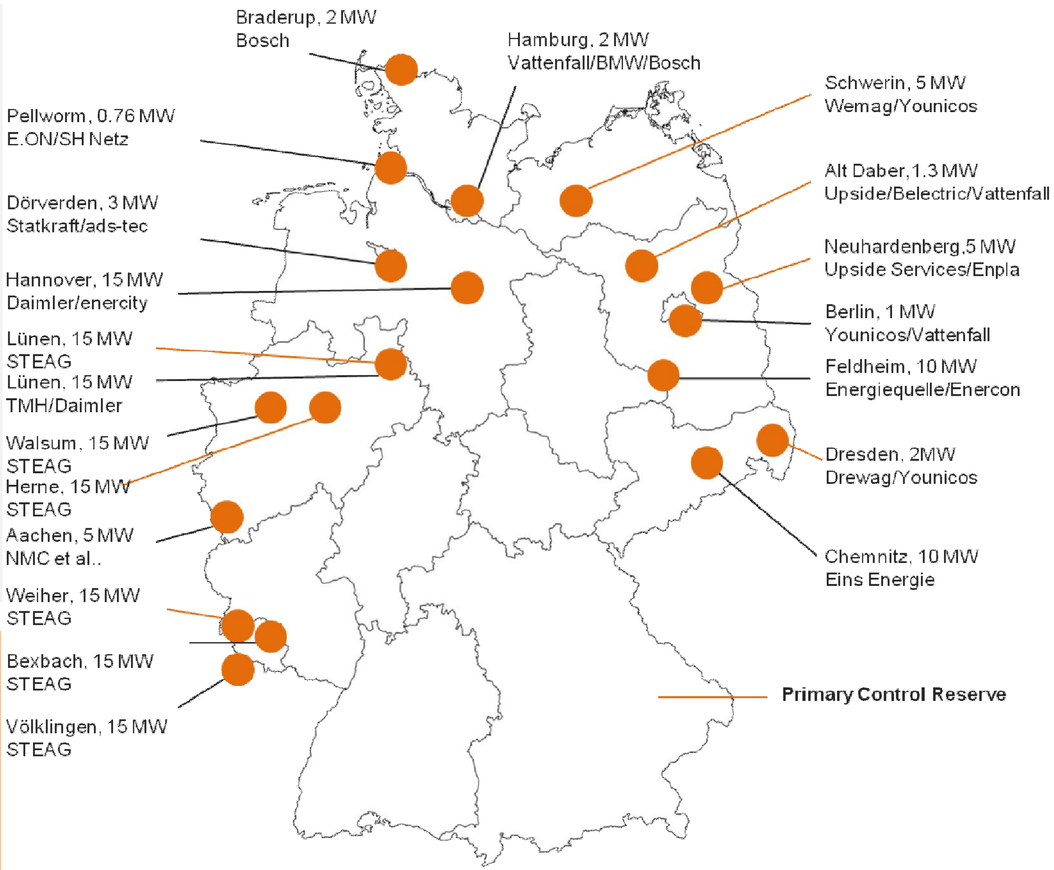
Different technology options are available. Further technology development aiming at cost reductions is key for enhancing storage options.

Using options:

- Provision of control power and control capacity
- Supply of back-up power
- Peak Shaving
- Black start of power plants
- Even fluctuating generation
- Control of grid voltage
- Increase of short cut current

Example: **STEAG Large Battery Systems**

- 90 MWel Primary Control
- Costs: 100 Mio Euro
- Containerized solution
- Implemented at 6 sites
- COD end of 2016



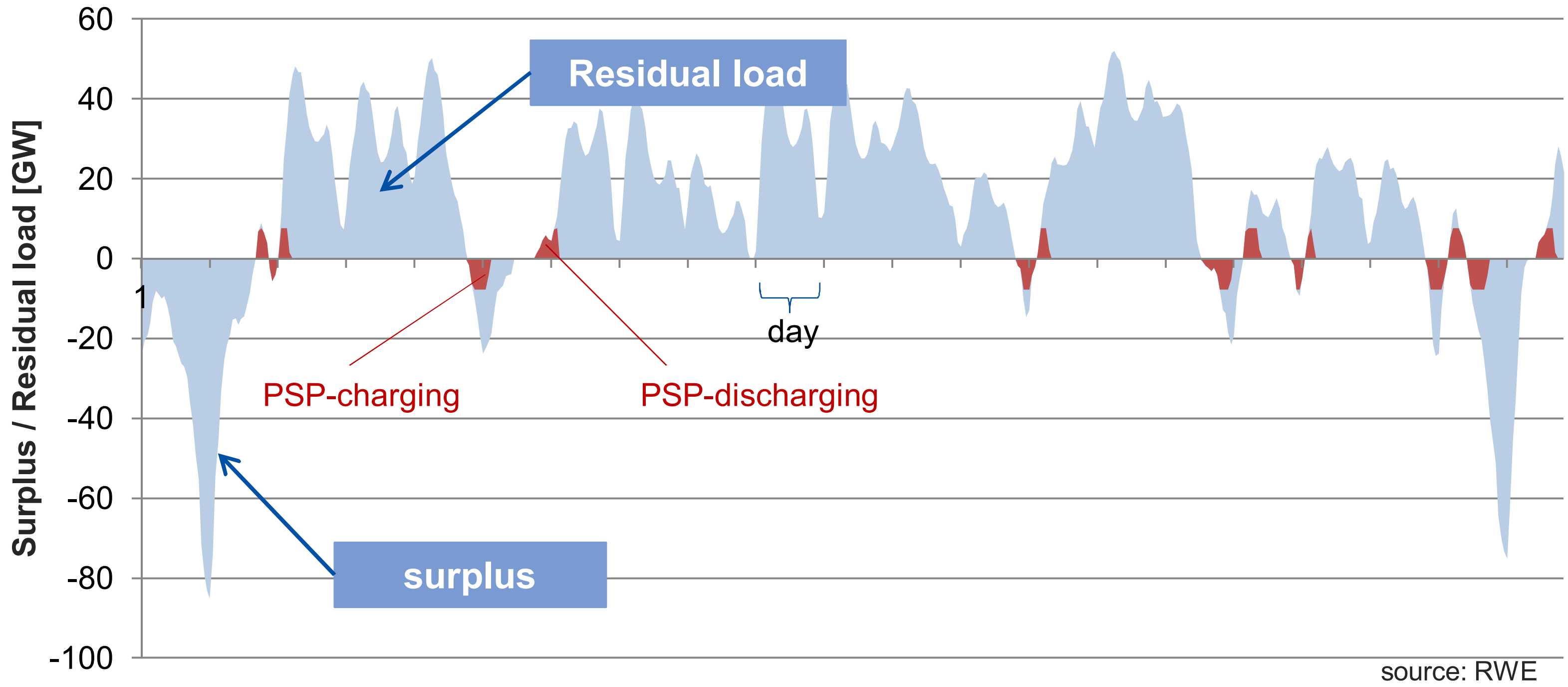
Overview of battery storage parks in Germany

as of Nov 2016, source: Büro F

Large battery systems enhance the power plant operators' options for participating in the control power market.

4. Long-term storage: limited potential of existing solutions

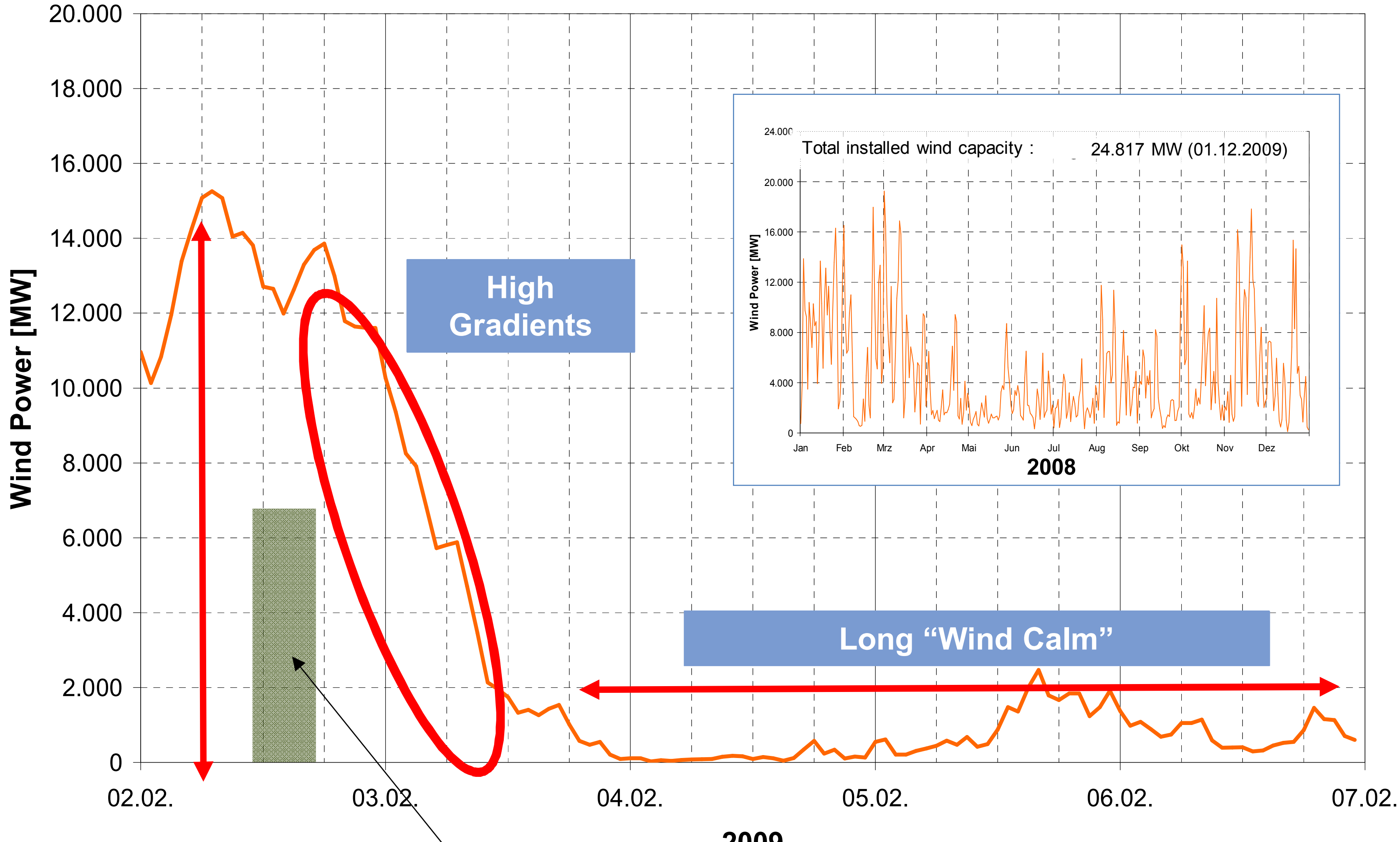
German hydro pumped storage plants (PSP) operation over a 3 weeks period in June. Installed capacity: 39 GWh / 6,300 MW



* EU FP7-project eStorage

Although PSP will not be able to resolve the storage challenge, further significant potential could be realised – 2,291 GWh according to a recent European study*.

4. Significant demand for long-term storage options



Total installed PSP capacity in Germany

Data Source: ISET

The storage solutions as of today are not sufficient – the potential needs to be assessed carefully.

5. Conclusions and outlook

- → Power Generation in Europe and Germany is driven by very ambitious de-carbonization targets.
- → An rapidly increasing share of RES generation needs a dispatchable and reliable support for meeting residual load demand and achieving system stability.
- → Flexible technologies are available for new builds as well as for existing assets, high level of automation is essential.

- → Priorities for conventional power plants have changed from efficiency and economies of scale to flexibility and costs.
- → The presently available energy storage solutions have only limited potential.
- → Market conditions currently hardly allow a minimum of investment and business – a new political framework is needed

Conventional power plants are still needed in Europe even in times of decarbonisation and energy transition but they are currently struggling.

धन्यवाद

**Thank you
for your interest!**

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