Flexible Operation of Coal-Fired Power Plants in Germany and Flexibility Initiatives under the Auspices of IGEF

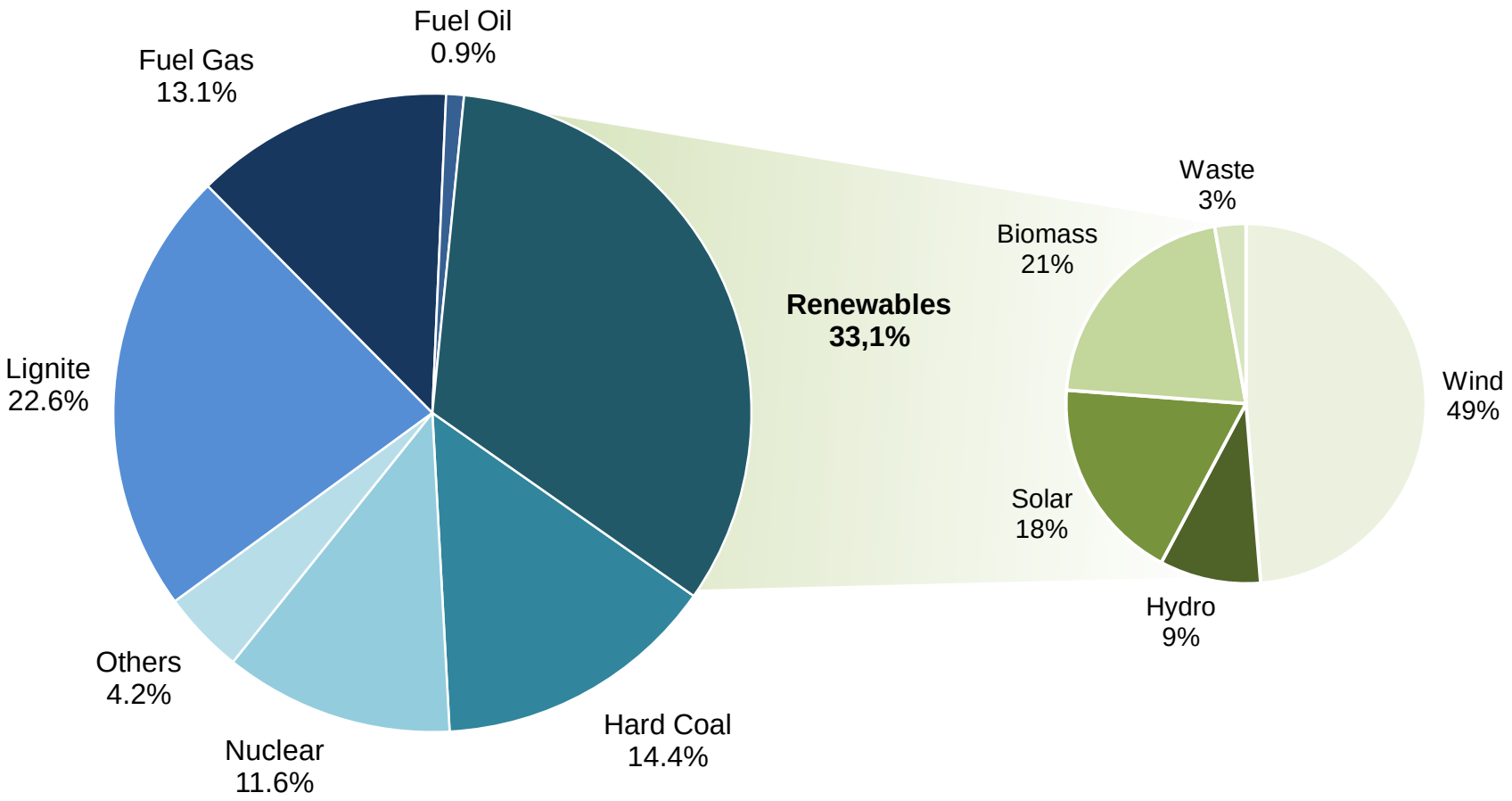
Dr. Thomas Eck, 30 November 2018, New Delhi

Agenda

1. Germany‘s Energy Mix
2. Utilization and Flexibility of Thermal Power Plants in Germany
3. Energy Market Design in Germany
4. Recent Trends and Developments in Germany
5. Flexibility Initiatives of the Indo-German Energy Forum
6. Summary

1. Germany's Energy Mix in 2017

- Inst.net capacity: 216 GW (thereof 113 GW RES)
- 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.

POWERTECH

- Inst.net capacity: 216 GW (thereof 113 GW RES)
- Pow

ZEIT ONLINE

Erneuerbare Energie

Erneuerbare Energien bei Stromkapazität erstmals vor konventionellen

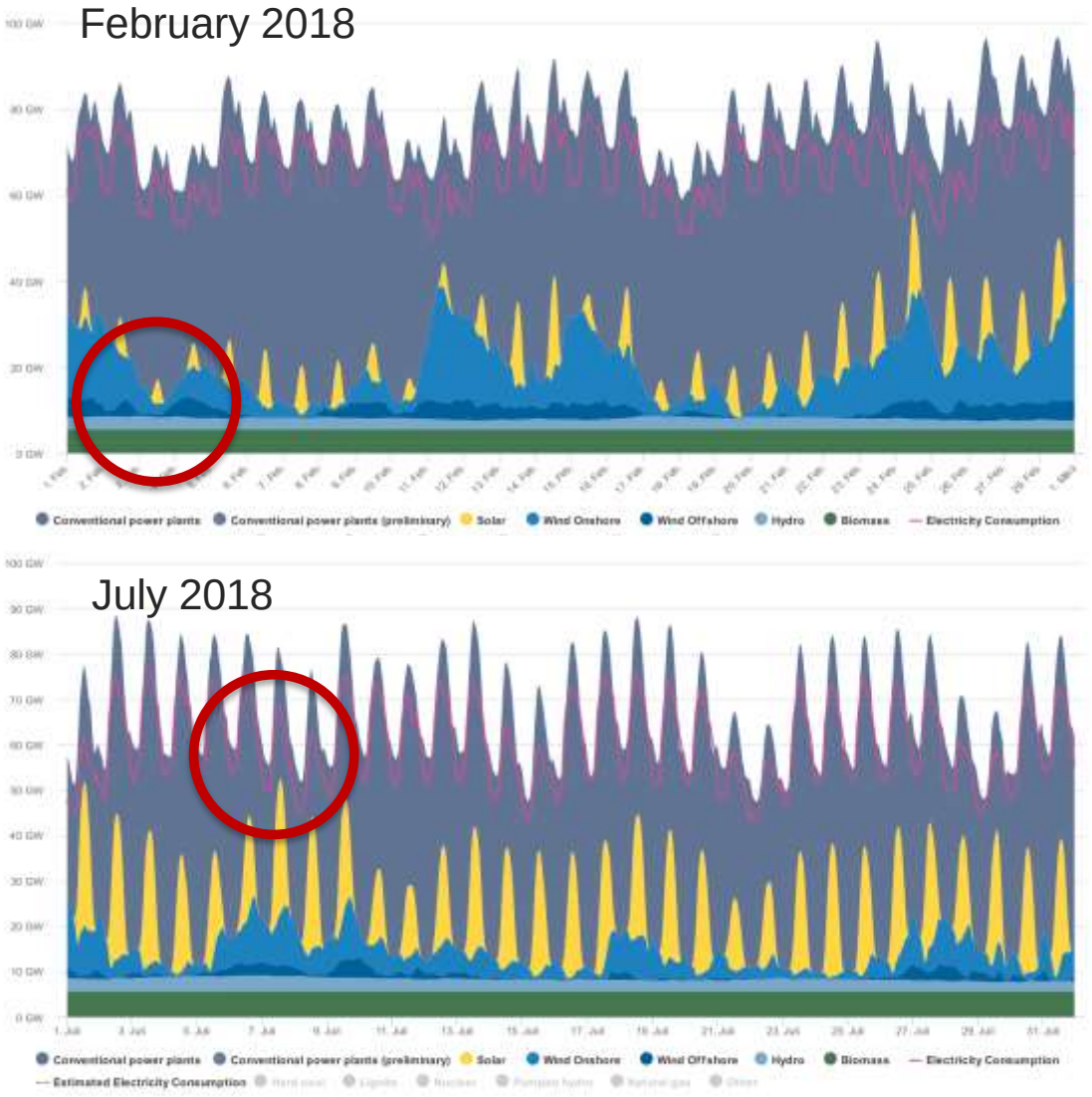
Die Kapazität der erneuerbaren Energien steigt in Deutschland weiter an. Bei der Stromerzeugung bleiben Kohle-, Gas- und Atomkraftwerke dennoch vorn.

28. November 2018, 19:33 Uhr / Quelle: ZEIT ONLINE, dpa, Reuters, js / 188 Kommentare

Lignite 22.6%

Wind 49%

R
F ow.



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.

Source: Agora Energiewende

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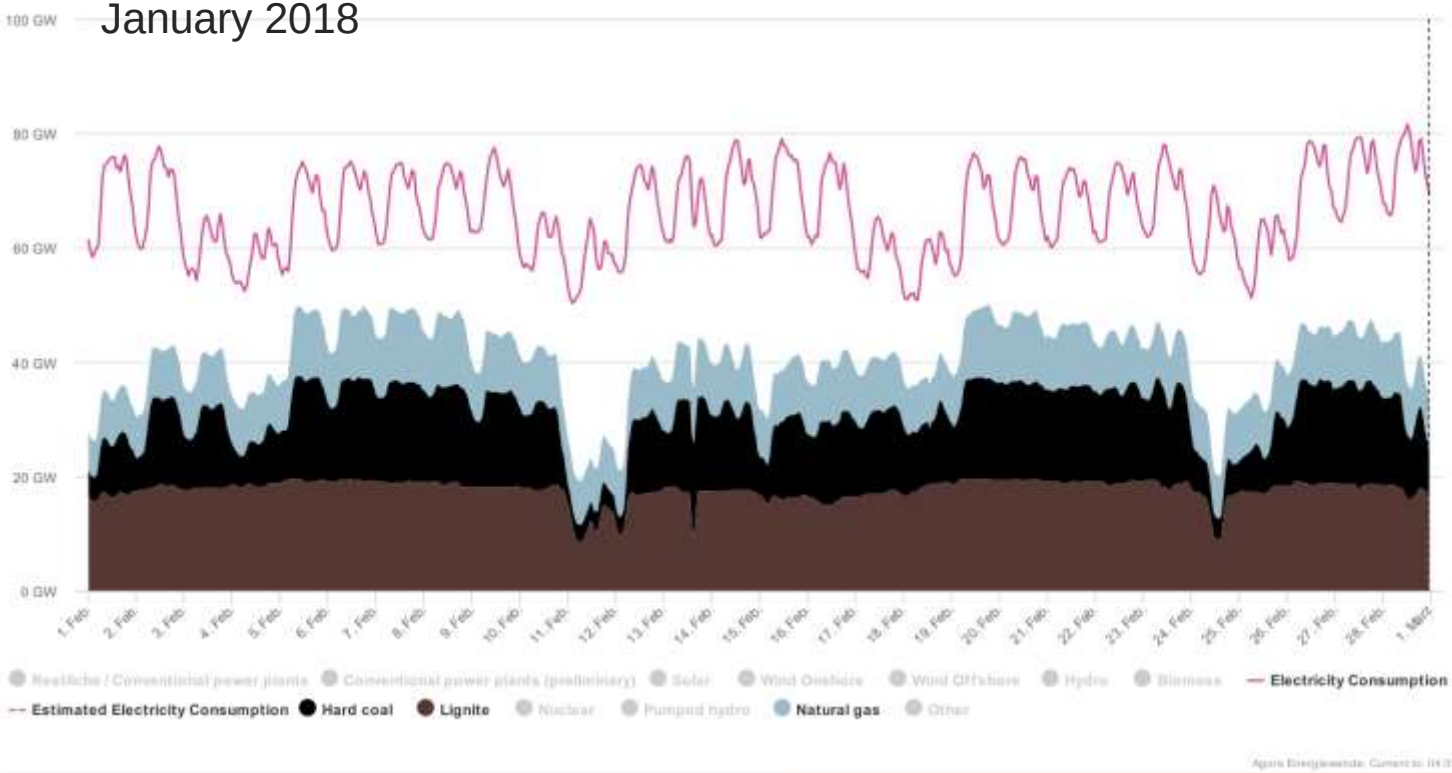
2. Utilization of Thermal Power Plants in Germany



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

Maximum load band Jan 18:	
Hard coal:	4 to 19 GW
Lignite:	8 to 19 GW
Gas:	6 to 12 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.

2. Flexibility Parameters of Thermal Power Plants

Plant type	Hard-coal	Lignite	CCGT	Gas Turbine
Ramp rate [% / min]	2 / 4 / 8	2 / 4 / 8	4 / 8 / 12	8 / 12 / 15
in the load range [%]	40 to 90	50 to 90	40* to 90	40* to 90
Minimum load [%]	40 / 25 / 10	60 / 40 / 20	50 / 40 / 30*	50 / 40 / 20*
Start-up time hot start <8 h [h]	3 / 2 / 1	6 / 4 / 2	1.5 / 1 / 0,5	< 0.1
Start-up time cold start >48 h [h]	7 / 4 / 2	8 / 6 / 3	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

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

2. Ten steps to flexibility for thermal power plants

1. Raise the awareness for flexibility
2. Check the status of the plant
3. Plan and execute test runs
4. Optimize the I&C system
5. Implement mitigation measures
6. Optimize combustion
7. Optimize start-up procedures
8. Improve the plant efficiency at part load and the dynamic behavior of the plant
9. Improve the coal quality
10. Consider storage options

There is no generic implementation plan for thermal power plants. However, there are some steps that need to be taken in order to tap the flexibility potential of a single plant.

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Market based

- Energy-only-market
- Balancing power market

Non-market – security of supply

- Reserve power plants
- Capacity reserve
- Safety disposition

Area	Energy	Congestion management	Balancing power	Other ancil-lary services	Capacity
Market products	▪ exchange spot market with day ahead products 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 plants ▪ curtailment of VRE		▪ reactive power ▪ black start capability/ power system restoration	▪ additional capacity/ +safety disposition

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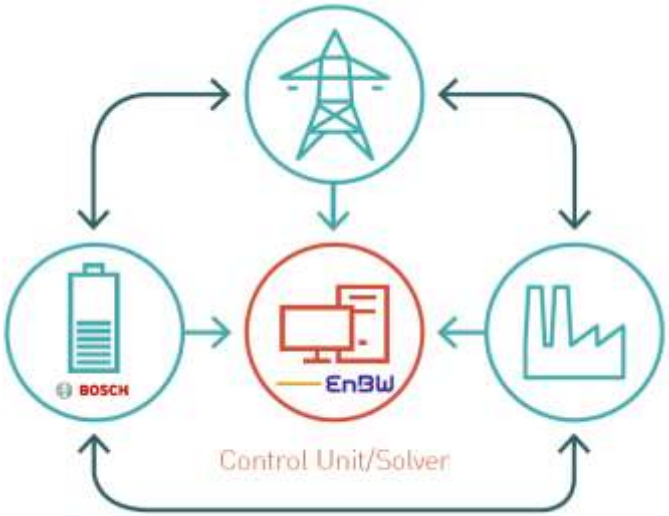
Efficient provision of control power by **battery storage systems** in a coal fired power plant

Example: Kraftwerksbatterie GmbH –
a joint venture of EnBW and Bosch

- 750 MW coal fired power plant
- 2 x containers of 2.8 MWh lithium-ion batteries
- 6 x 900 kW inverters
- 6 x 1000 kVA transformers
- Power supply and infrastructure
- Optimised system control
- Start of commercial operation in spring 2018
- Revenue optimization through scenario-based optimization taking into account market and system conditions

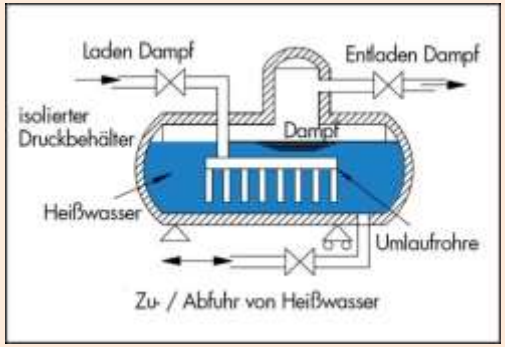


Source: Kraftwerksbatterie GmbH, www.kraftwerksbatterie.de

Liquid salt: indirectly integrated into the water-steam cycle

Solid material: indirectly integrated into the flue gas path

Ruth‘s/Phase Change Material: directly integrated into the water-steam cycle



Integration of a **thermal storage system** into a coal fired power plant

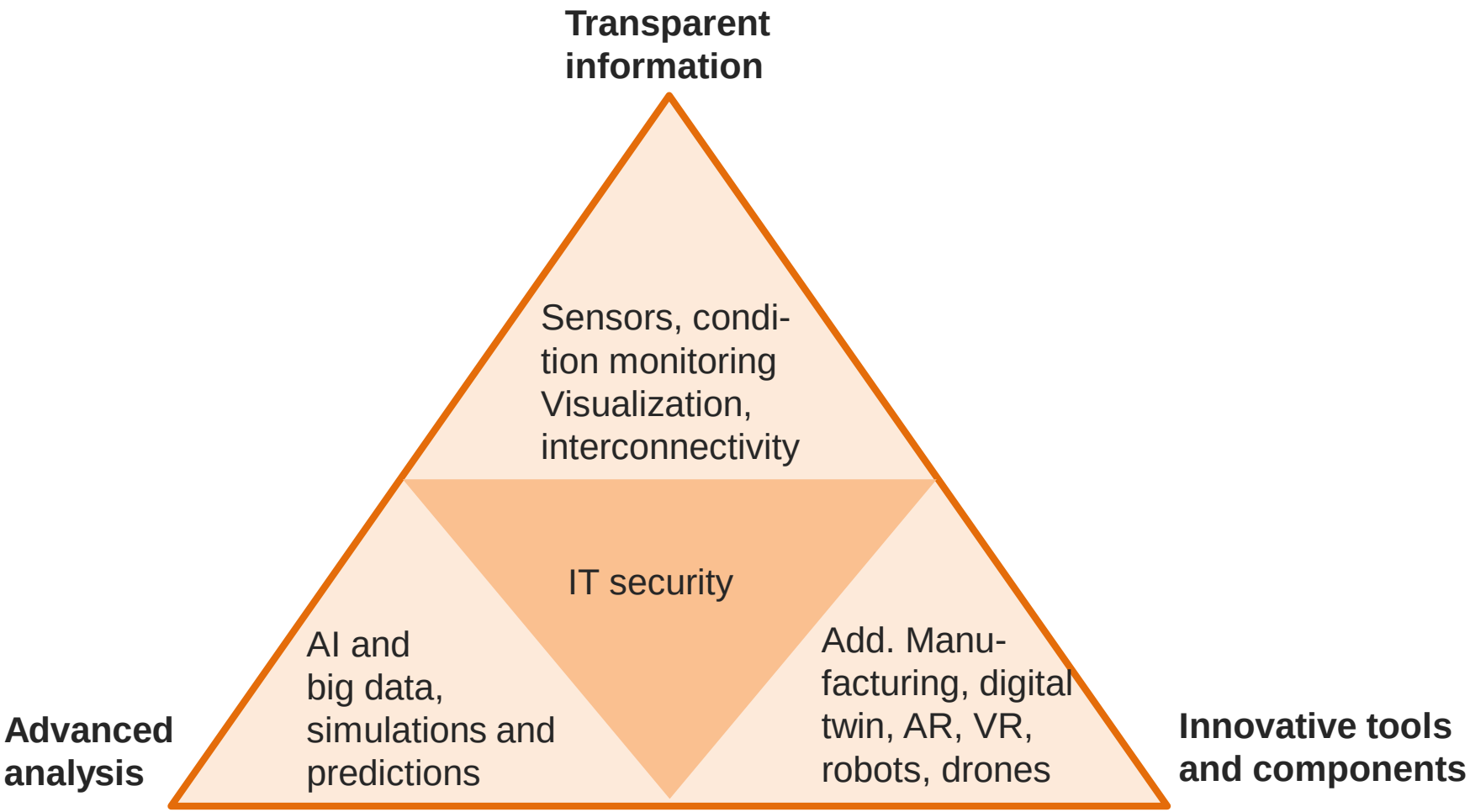
- Duration from January 2017 to December 2019
- Assessment of different storage concepts and their integration into new built and existing plants
- Specification of a cost-efficient and low-risk design

Source: R&D project Flexi-TES

Project Consortium

EnBW · Mitsubishi Hitachi Power Systems Europe · DLR · PtJ · LEAG · SIEMENS · ewi Energy Research & Scenarios gGmbH · Gefördert durch: Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages · VGB PowerTech · Universität Duisburg-Essen Open-Minded

4. Digitization drives Flexibility and Operational Excellence



Digitization enables O&M optimisation – by use of predictive maintenance, advanced controls and sophisticated life cycle management. The results are less downtimes, better efficiencies and higher productivity.

Current situation in Germany

- 16.724 GWh electricity produced from solid biomass in 2016
- Power plants are limited to 20 MW installed capacity according to EEG
- The majority of biomass is utilized in grate firing systems and fluidized bed combustion
- Co-firing is not applied due to the absence of incentives

Flexibilisation options

- Co-firing of up to 10% biomass in existing pulverised coal fired power plants with only minor adaptations
- Conversion of existing pulverised coal fired power plants to 100% biomass; e.g. Rodenhuize Power Plant (BE), AvedørePower Station (DK)

Flexibilisation of biomass combustion is possible by utilisation of pulverised fuel combustion technology – potentials are comparable to coal combustion. The conversion of coal fired power plants into biomass plants is also an option for decarbonization.

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Based on a feasibility study at two references plants - NTPC operated Dadri and Simhadri power plants – test runs at unit 6 of the Dadri power plant (500 MW coal fired) were executed jointly by a EEC, NTPC, Siemens and VGB team in June 2018

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Achievements:

Stable operation at 200 MW (40 % load) for four hours at Dadri unit 6 achieved on 21 June 2018

Successful ramping tests on 22 June 2018:

✓500 MW to 200 MW to 500 MW at 5 MW/min

✓500 MW to 200 MW to 500 MW at 15 MW/min

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Measures to ensure stable operation at minimum load of 40%

1. **Optimization of existing controls**
   - Automatic Mill Operation (Mill Scheduler)
   - Main Steam Temperature Control
   - Reheat Steam Temperature Control
   - Automated Start of Fans and Pumps
   - Flue Gas Temperature Control

2. **Transparency about process conditions**
   - Thermal feasibility study
   - FEM analysis
   - Condition monitoring

3. **Installation of a modulating mechanism type recirculation valve** across the boiler feed pump to enhance the controllability of the process

KWS PowerTech Training Center

EEC Excellence in Power

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Based on study on required training for flexible power plant operation several training for Indian power plant personnel is conceptualized.

Kick-off will be a one-week training in Germany in cooperation with Kraftwerksschule e.V. including simulator trainings and site tours.

Further trainings at EEC are planned for 2019.

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- The flexible operation of coal fired power plants is daily business in Germany.
- A lot of innovations and developments aiming at further flexibilization e.g. by digitization and integration of storage systems are taking place.
- The Indo-German Energy Forum provides a platform for the exchanges of experiences in flexible operation and for further projects as well as training programs in this context.

www.eecpowerindia.com

www.energyforum.in

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Thank you
for your interest!

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