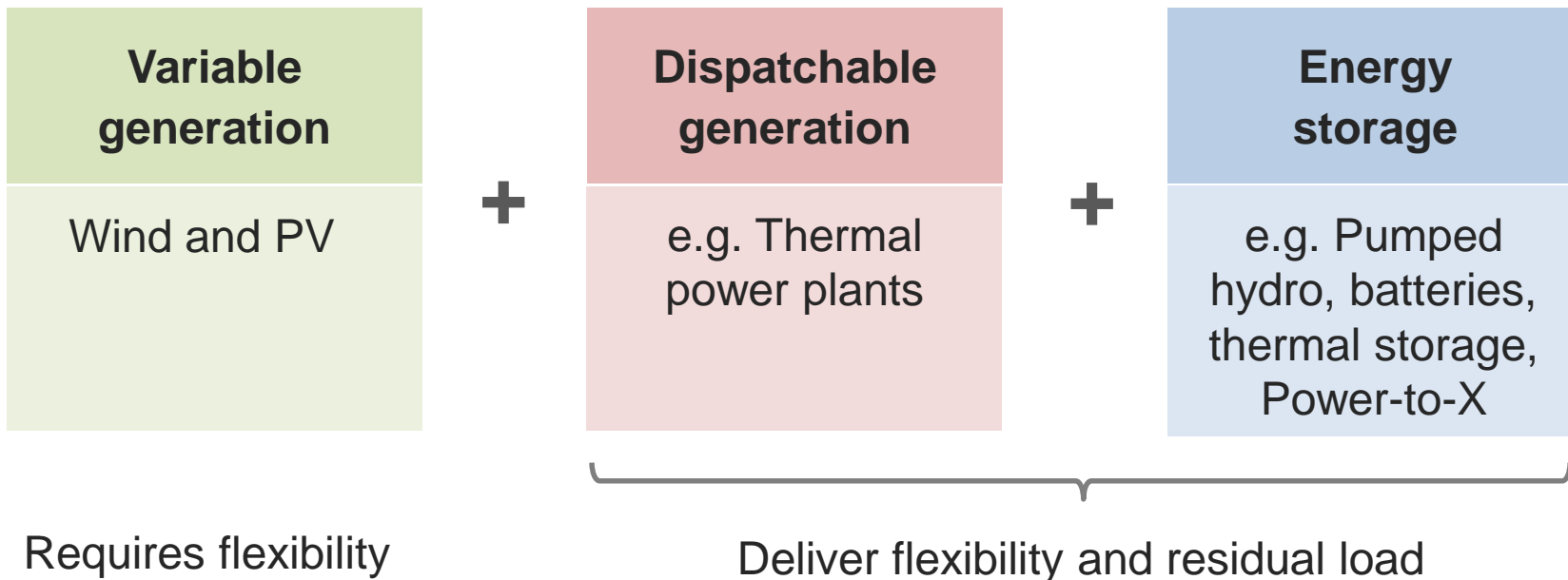


Ramping of coal-fired power plants

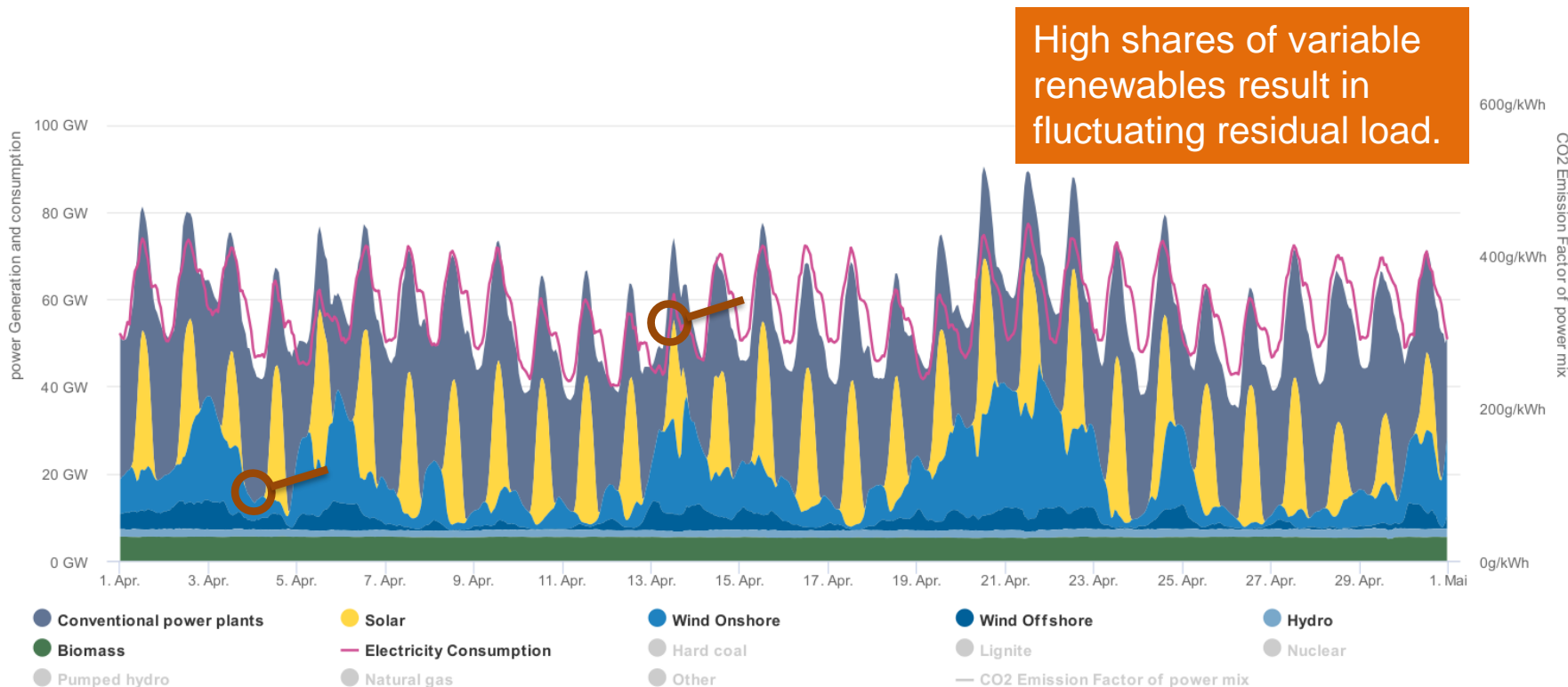
15 May 2020

Dr. Claudia Weise



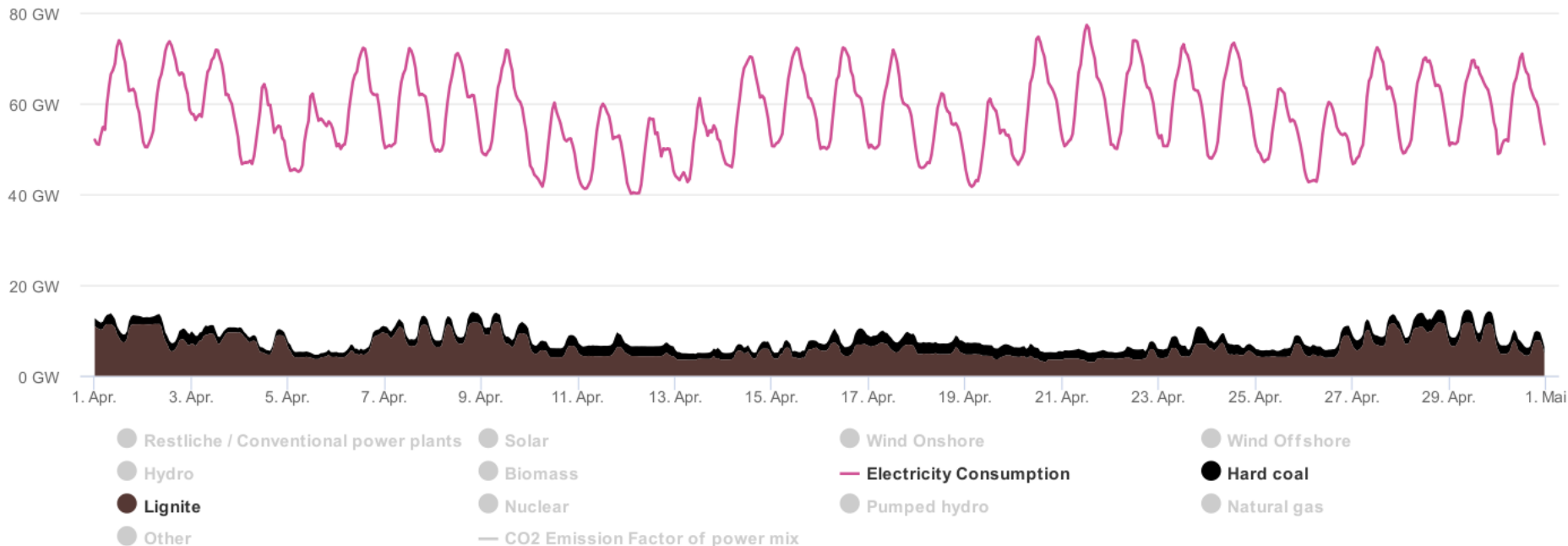


Power Generation in Germany



Generation portfolio in GW, Germany, April 2020, Source: Agora Energiewende/Agorameter

Power Generation in Germany: Coal-fired Power Plants



Generation portfolio in GW, Germany, April 2020, Source: Agora Energiewende/Agorameter



Minimum load operation

- important for the provision of residual load and for fast start up in case of high demand (e.g. two-shifting)
- more economic than shut-down of the whole plant

Advanced dynamics by high ramp rates

- high ramp rates ensure a fast reaction to changed market condition
- power plants with dynamic cycling abilities can participate in different markets

Short start-up and shut-down

- short start-up and shut-down times are beneficial to quickly respond to acc. market requirements (e.g. two-shifting)
- thermal stress during start/ stop is most severe w.r.t. life-time consumption

Flexible operation aims at achieving low minimum load, high ramp rates and fast start and stop time. Measures might contribute to one or more targets.

Plant type	Hard Coal	Lignite	CCGT	Pumped Storage
Ramp rate [% / min]	2 / 4 / 9	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

Conservative / state of the art / very advanced; *as per emission limits for NO_x and CO

I&C optimization: high level of automation is beneficial; smooth operation at all loads

- Smooth and precise steam temperature control
- Optimization of the underlying control loops, i.e. coal supply, drum level, pressure, temperature, air control
- Automated operation and switch over of pumps, fans etc.; exchange of actuators might be necessary

Combustion optimization: fast increase/decrease of fuel supply

- Optimized mill operation
- Advanced monitoring of combustion parameters (fuel supply, air flow, flame scanners, temperature of thick-walled components)

Advanced unit control: use of inherent storage capabilities of the plant for power output adjustments

- Indirect (condensate throttling) and direct throttling of extraction steam (e.g. to LP pre-heaters, HP pre-heater or feed-water tank) – additional hardware (control valves) required
- Inclusion of feed-forward control

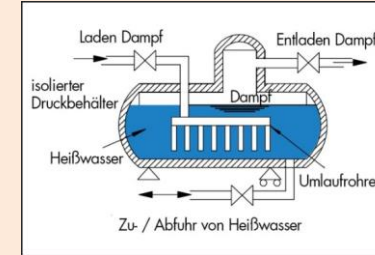
Liquid salt: indirectly integrated into the water-steam cycle



Solid material: indirectly integrated into the flue gas path



Ruth: directly integrated into the water-steam cycle



Integration of a **thermal storage system** into a coal fired power plant „Flexi-TES“

- 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

Project Consortia

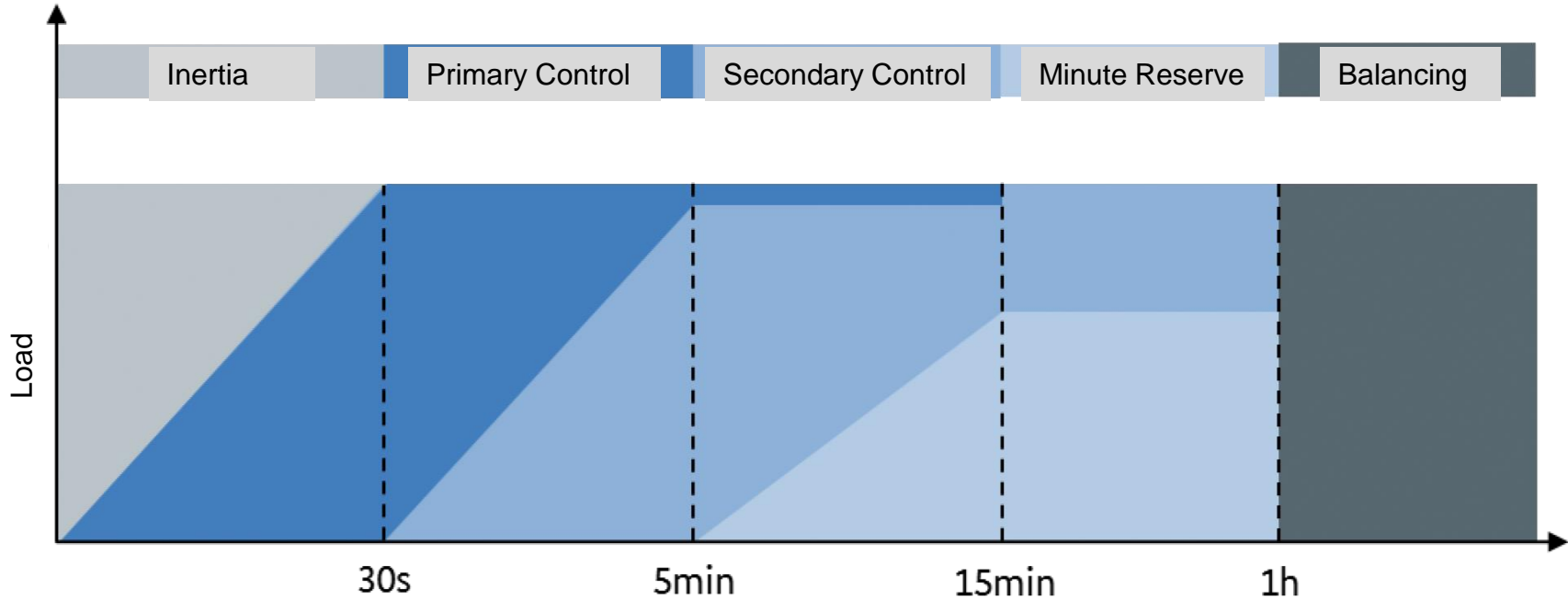


Gefördert durch:



aufgrund eines Beschlusses des Deutschen Bundestages

Source: R&D project Flexi-TES



Source: Bundesnetzagentur, Monitoring-Bericht 2019

	Primary control	Secondary control	Tertiary control / minute reserve	Sheddable loads
Demand in Germany in MW 2018	~ 620 MW	+ >1,900 - >1,800	+ >1,350 - >1,800	Immediate: 800 Fast: 1600
Auctioning schedule/bid size	Daily / 1 MW	Daily / 1 MW	Daily / 1 MW	weekly / 5 – 200 MW
Product time slice	6 x 4 hours	6 x 4 hours	6 x 4 hours	
No. of pre-qualified bidders	31	37	45	Immediate: 10 Fast: 27
Remuneration scheme	capacity	capacity and energy	capacity and energy	capacity and energy
Usage	Automated	Automated	Manual	Automated / remote
Costs in Mio EUR	<ul style="list-style-type: none"> ▪ 2014: 103.4 ▪ 2018: 64.5 	<ul style="list-style-type: none"> ▪ 2014: 227.6 ▪ 2018: 52.5 	<ul style="list-style-type: none"> ▪ 2014: 106.0 ▪ 2018: 6.2 	2014: 18.8 2018: 28.1

Source: Bundesnetzagentur, Monitoring-Bericht 2019 and www.regelleistung.net



- Facts and figures about flexibility provided by dispatchable generation
- Reports and publications as downloads available – e.g. “Flexibility Toolbox for coal-fired power plants“

धन्यवाद

Thank you
for your interest!

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