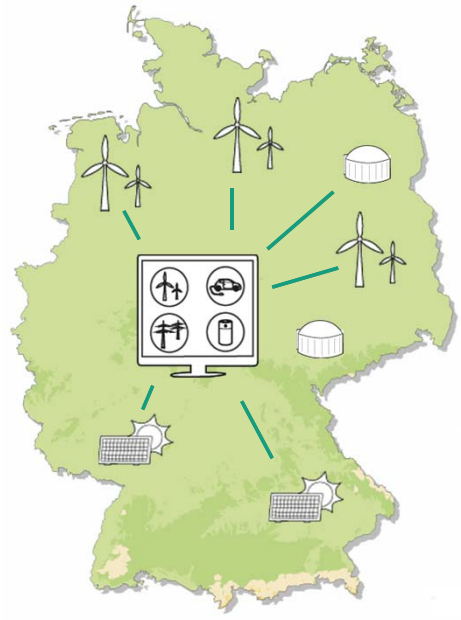
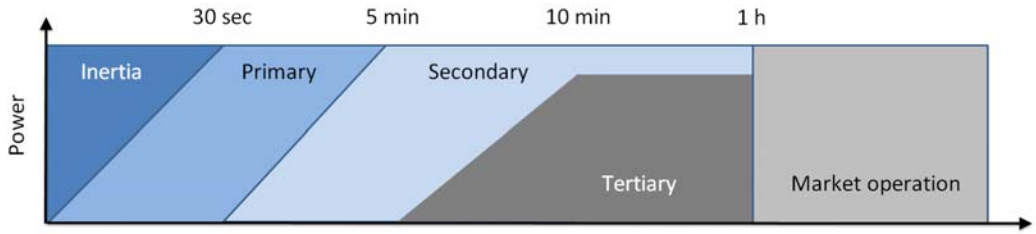
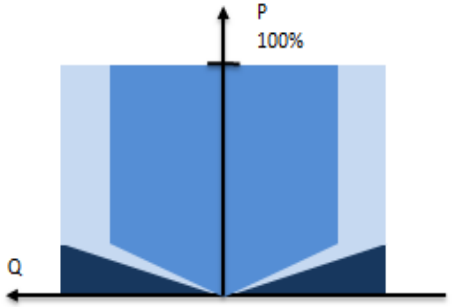
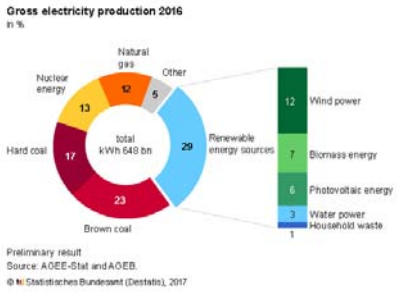
ANCILLARY SERVICES WITH RENEWABLE ENERGY GENERATORS

Dr.-Ing. R. Mackensen, Fraunhofer IWES, Germany









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Introduction - German power system

Germany is aprox. twice as big as Tamil Nadu and has slightly larger population

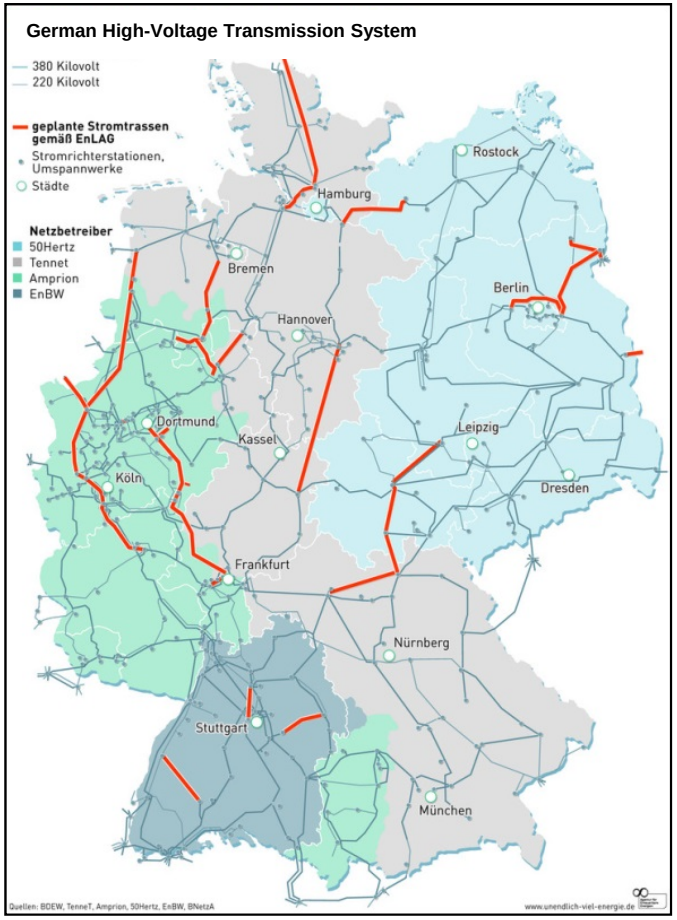
Energy system is unbundled → Different responsibilities for transmission system, distribution system and utilities

Energiewende (energy transition) → Several tasks for the development of the energy system (nuclear phase out, green house gas reduction, renewable energies in all sectors)

Four transmission system operators, responsible for system stability and ancillary services (Amprion, TransnetBW, TenneT, 50Hertz)

Fraunhofer supports the Energiewende with applied research in cooperation with stakeholders in the energy system

Fraunhofer IWES is involved into several research activities regarding integration of renewable energies



Source: German TSO, Agentur für Erneuerbare Energien e.V

Introduction - German power system

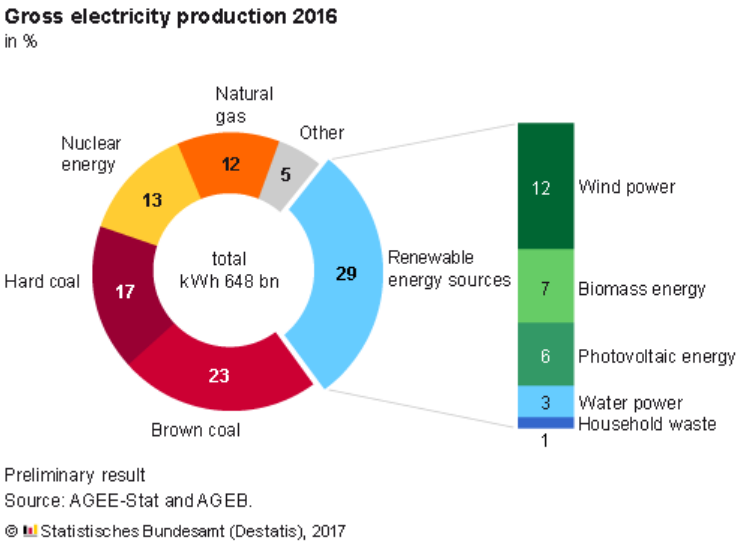
Total installed electrical capacity > 200 GW

Thermal power plants cover average demand (65-80GW)

Renewable energies share of gross electrical power production 30%

→ Future goals 40-45% (2025), 55-60% (2035), >80% (2050)

Power plants - Installed capacity [GW]		
Solar	42	
Wind	53	
Biomass	8	
Water	6	109
Natural gas	30	
Oil	4	
Coal	28	
Brown coal	21	
Nuclear	11	94
	Sum	203

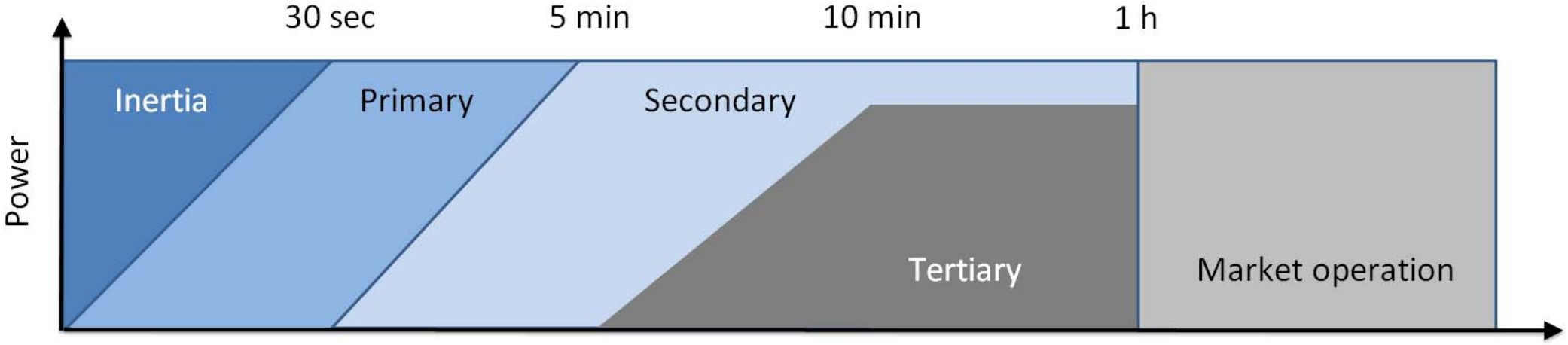


Power plants and wind energy in Germany Source: Federal Environment Agency (2015)

Ancillary services – Types, measures and providers

	Goal	Measure	Provision
Frequency control	Frequency at 50 Hertz	Provision of Control reserve power (active power)	Conventional power plants, RE
		Control of flexible loads	
		Active power reduction (Curtailment of RE)	
Voltage control	Avoidance of voltage deviations	Provision of reactive power	Conventional power plants, RE
		Redispatch and voltage regulation	Technical equipments
System restoration	Restoration in case of faults and blackouts	Use of black-start capabilities	Conventional power plants
			Pumped storage plants
			RE systems
System control	Control of system operation	Coordination of ancilliary services on grid level	Network control units in combination with power plants
		Congestion management	
		Management of RE	

Frequency control – Control reserve power



	Activation		Products	Auctions	Total Size
Primary	Automatically	30 sec	pos+neg, 1MW, one week	weekly auction	+/- 1.5 MW
Secondary	Merrit order	5 min	pos and neg, 5 MW, 6 slots per day	daily auction	2 MW each
Tertiary	Merrit order	15 min	pos and neg, 5 MW, 6 slots per day	daily auction	3 and 2.5 MW

Definition in Transmission code 2003/2007

Prequalification process was set up for wind farms (negative tertiary reserve)

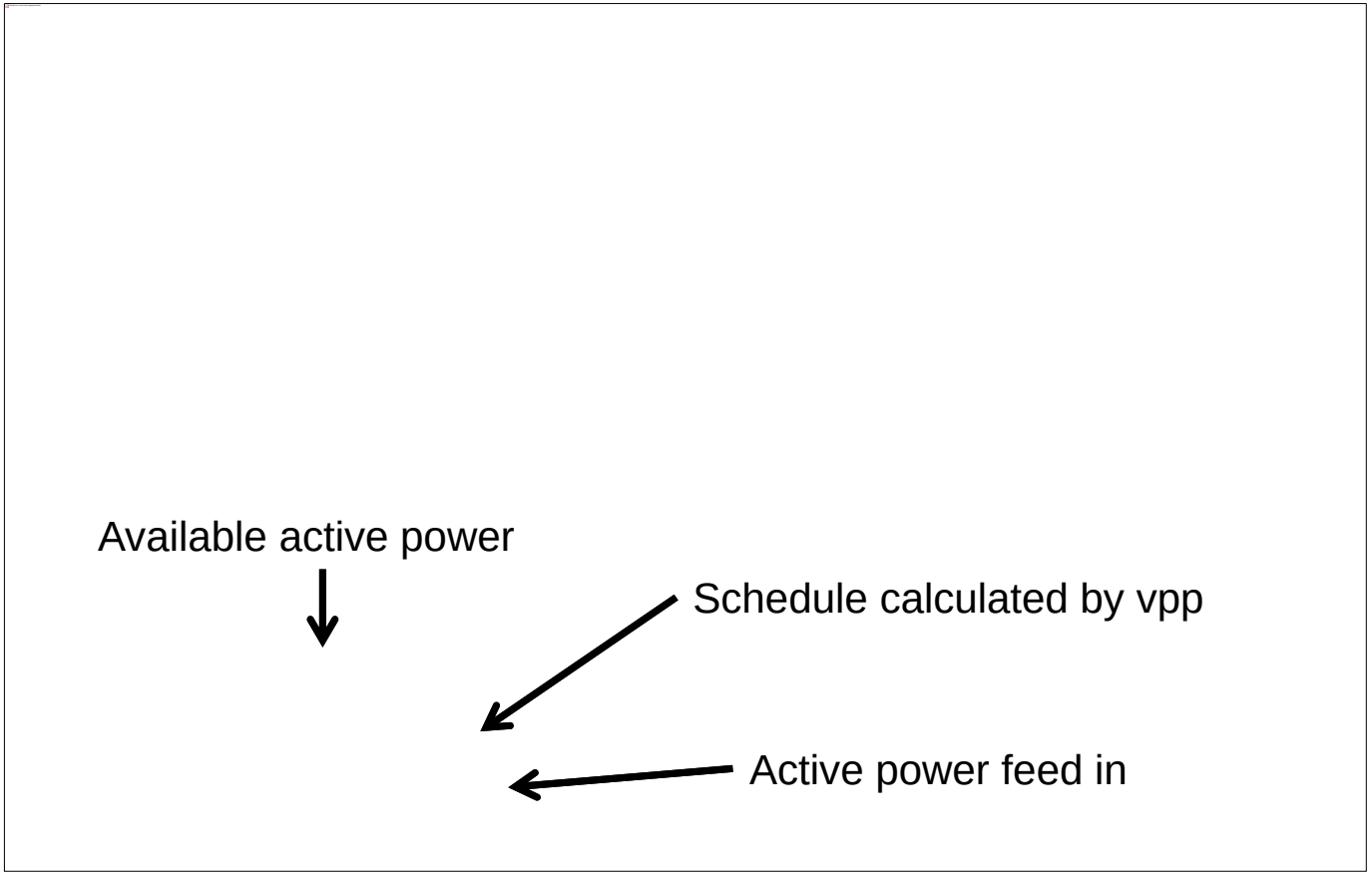
Research: Project ReWP, Federal Ministry for Economic Affairs and Energy

Frequency control – Control Reserve Power by RE - Portfolio

Control reserve power with pools of fluctuating sources

Reliable forecasts and correct calculation of possible power feed-in is necessary

For managing pools fast data transfer is mandatory.



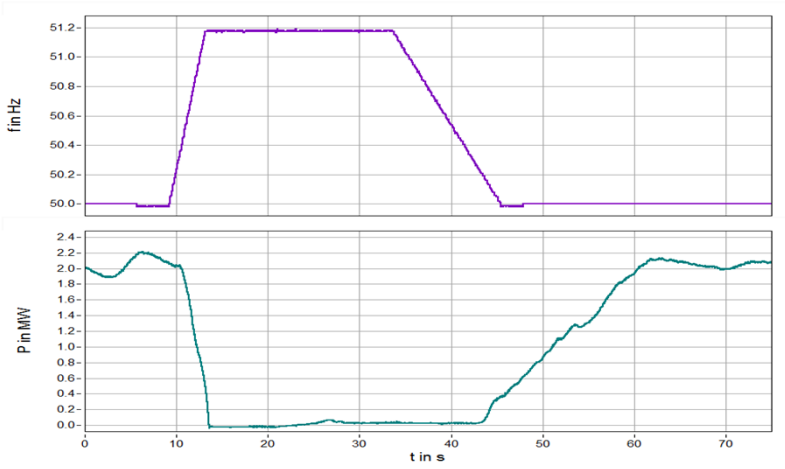
Research: Project ReWP, Federal Ministry for Economic Affairs and Energy

Frequency control – Inertia and dynamic power-frequency control

Dynamic power-frequency control:
Characteristic curve of power frequency regulation of an ENERCON wind energy converter

Inertia Emulation:

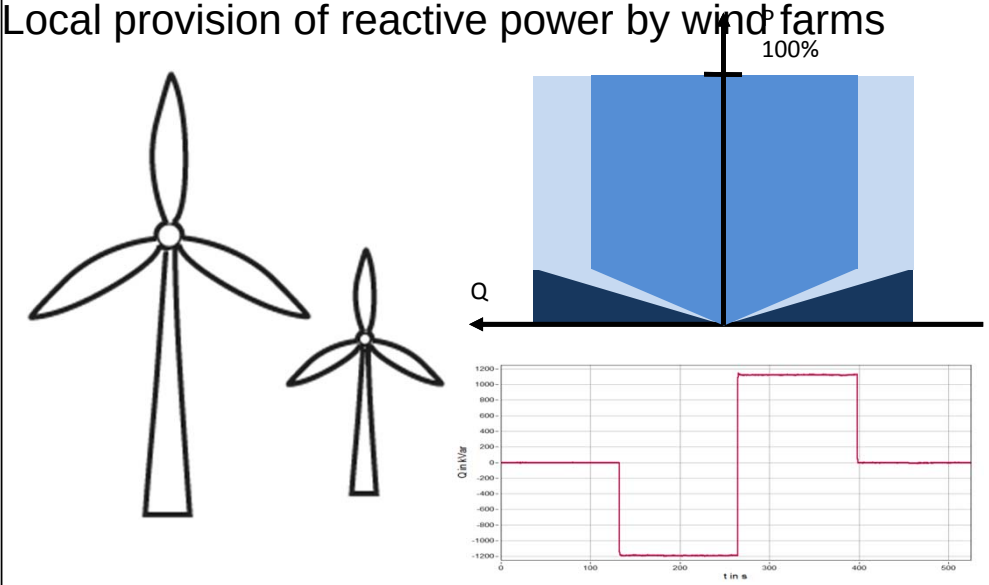
Active power curve of an ENERCON WEC with Inertia emulation on grid frequency drop



Source: ENERCON GmbH, Wind turbine manufacturer

Voltage control

Local provision of reactive power by wind farms



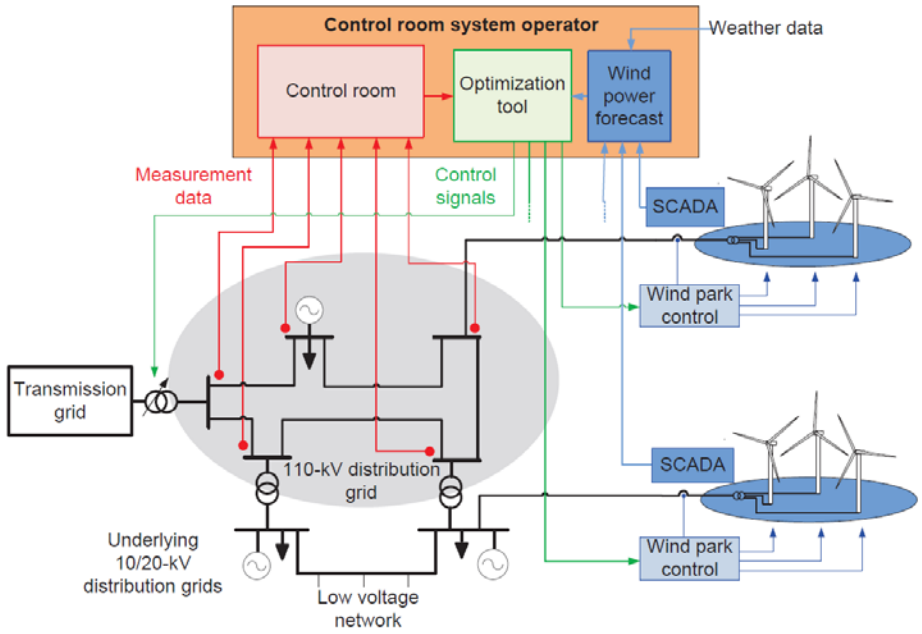
Typical reactive power range of a wind energy converter (WEC)

Range with advanced reactive power ability

Range including STATCOM option

Source: ENERCON GmbH, Wind turbine manufacturer

System wide provision using optimization



Source: Optimal Reactive Power Management for Transmission Connected Distribution Grid with Wind Farms, 2016 IEEE Innovative Smart Grid Technologies - Asia (ISGT-Asia)

Research: Project Imowen, Federal Ministry for Economic Affairs and Energy

http://forschung-stromnetze.info/projekte/windpark-cluster-sicher-ins-netz-integrieren/

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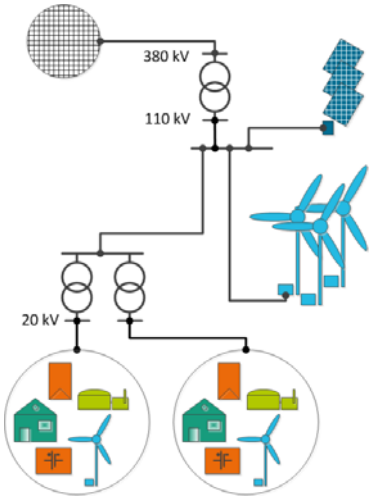
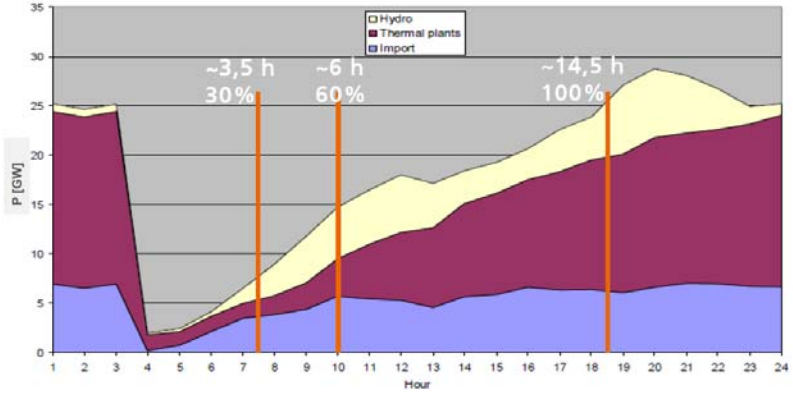
System restoration – Black start capability

Situation today: Restoration with still working or black start ready power plants

In case of total blackout restoration has to be done step by step (restoration planning)



Source: http://forschung-stromnetze.info/projekte/netzwiederaufbau-mit-zukuenftigen-kraftwerkstrukturen



Source: Berizzi, A., „The Italian 2003 blackout“, IEEE PES General Meeting 2004, Denver, 07.06.2004

Renewable energies have to be integrated into the restoration planning

Task can be to provide active (frequency stabilisation) and reactive (voltage control) power

RE suit this needs because of low self consumption and variable power feed in

Research: Project NETZ:KRAFT 01/2015 – 06/2018, Federal Ministry for Economic Affairs and Energy

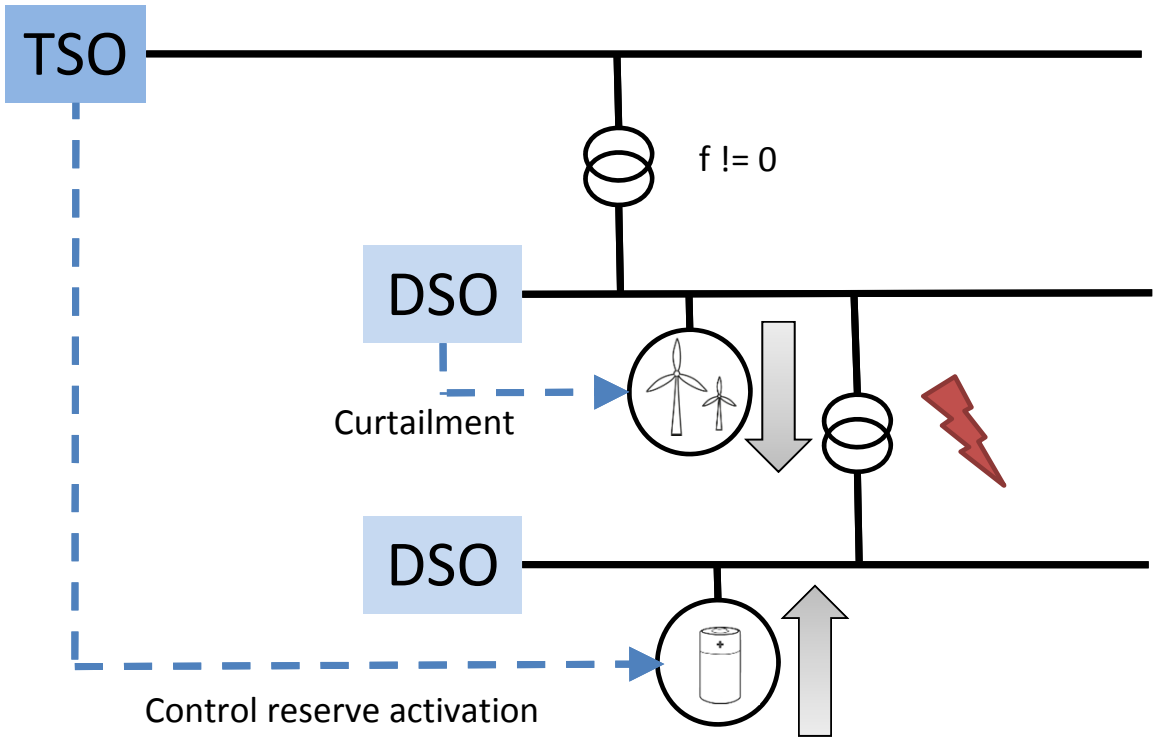
System control

Transmission system operator is responsible for system stability

TSO has to maintain the n-1 criterium

Additionally TSO is responsible for solving grid constraints on transmission level

For the system control communication to distribution system operators is necessary



Research: Project SysDL 2.0, Federal Ministry for Economic Affairs and Energy

System control

Task: Solve grid restriction on transmission level

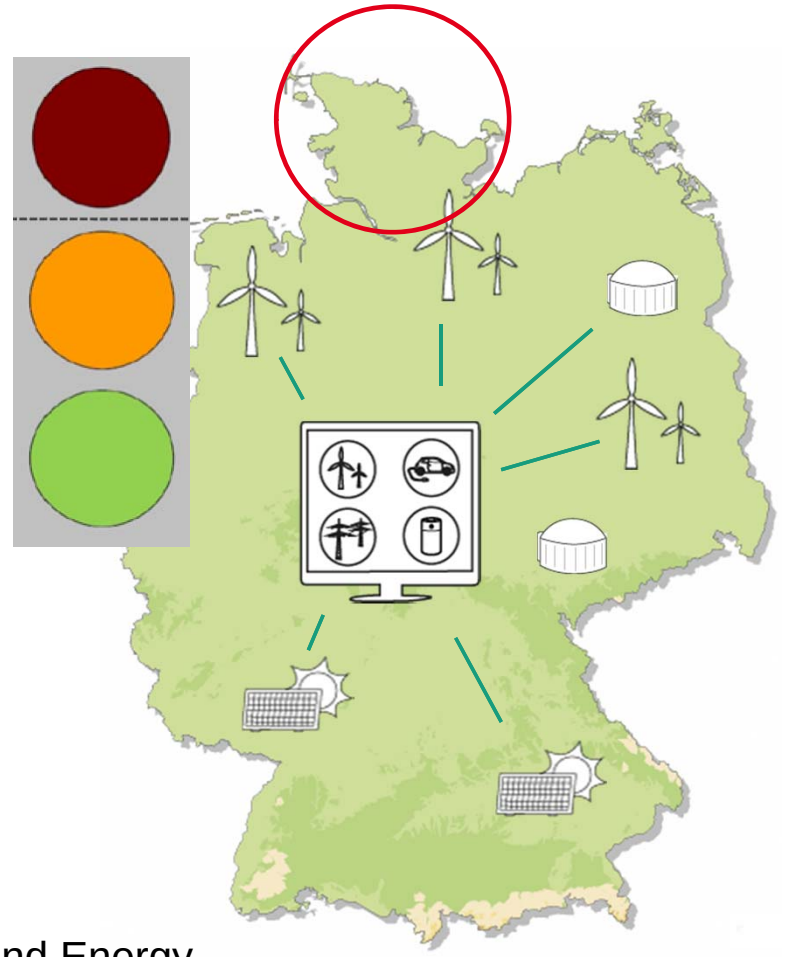
Solution: Redispatch and curtailment on distribution level, windfarms can be controlled by DSO (older SCADA systems 0/30/60/100%, newer system variable)

Curtailment: 3,000 GWh (300 Mio Euro) in 2015

Current research: Traffic light - Distribution grid operators develop market platforms to avoid critical situations based on market products

Aim is to activate flexibility from loads and energy producers

Tool to provide such products are for example virtual power plants managing renewable energies



Research: Project NEW 4.0, Federal Ministry for Economic Affairs and Energy

Summary and Outlook

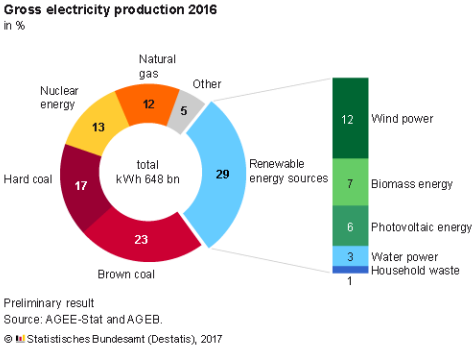
The Energiewende raises the need for renewables to provide ancillary services

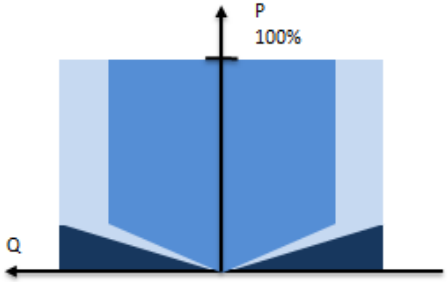
Research activities support the process to strengthen the capability of renewables

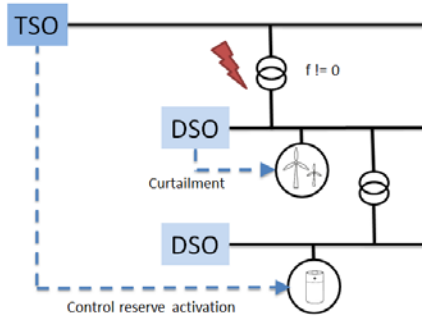
Existing rules and regulations have to be adjusted

Communication between grid operators as well as to energy producers becomes an urgent task

Aggregation of renewables like virtual power plants can take over the role of conventional power plants







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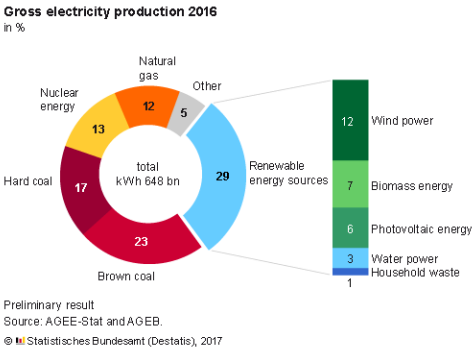
Ancillary Services with Renewable Energy Generators



Thank you very much

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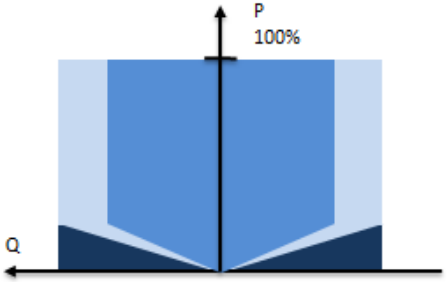

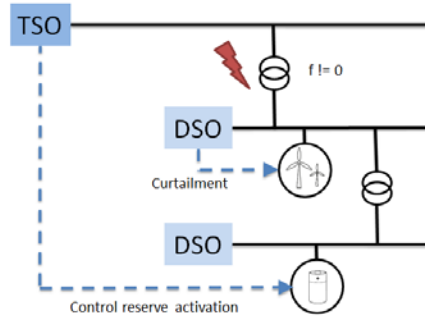

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Further readings

ENTSO-E: Continental Europe operation handbook
https://www.entsoe.eu/publications/system-operations-reports/operation-handbook/Pages/default.aspx

ENERCON GmbH: Integrated solutions for compliance with demanding international grid codes
http://www.enercon.de/en/technology/grid-technology

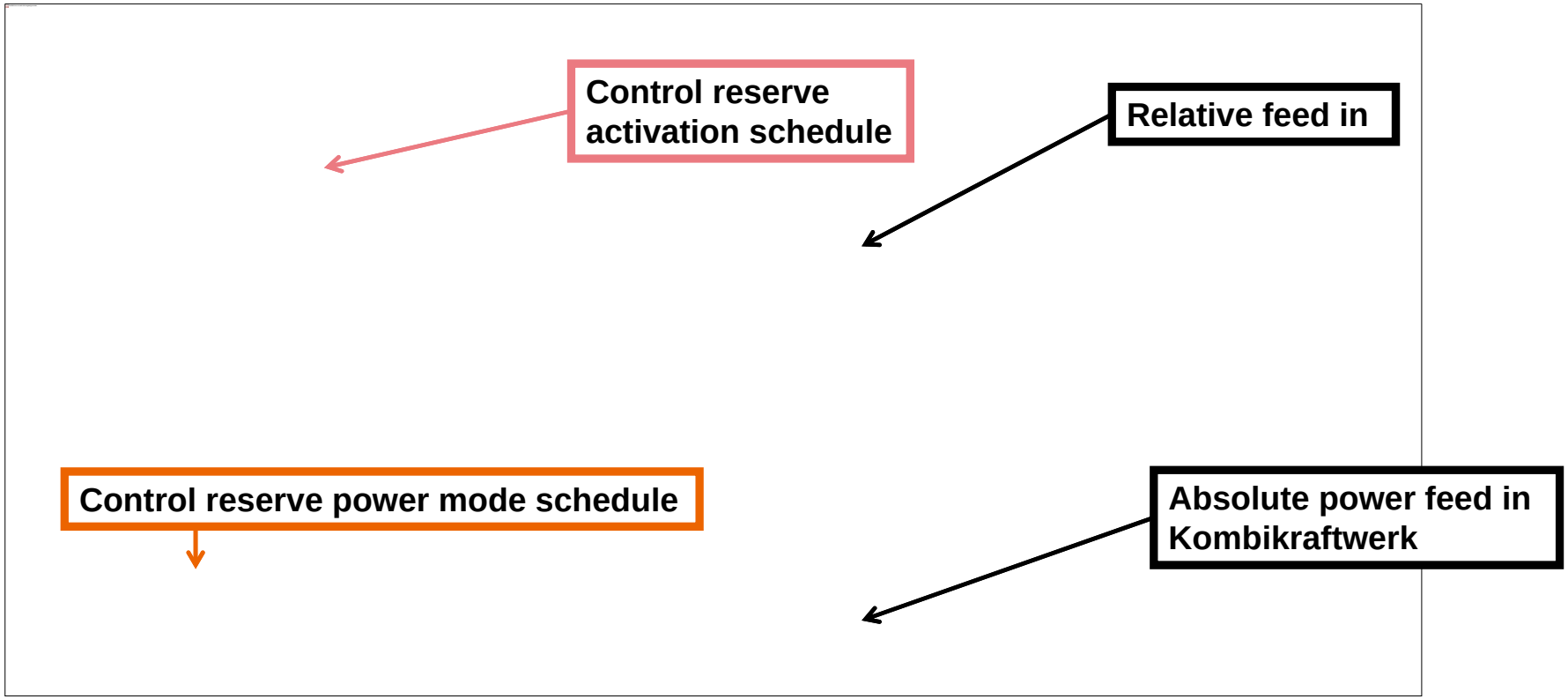
German Energy Agency: Ancillary Services Study 2030
https://www.dena.de/themen-projekte/projekte/energiesysteme/dena-studie-systemdienstleistungen-2030

regelleistung.net: General information on control reserve - technical aspects
https://www.regelleistung.net/ext/static/technical?lang=en and https://www.regelleistung.net/ext/static/prequalification

Bdew: Grid codes and guidelines
https://www.bdew.de/internet.nsf/id/EN_Publications and https://www.bdew.de/internet.nsf/id/DE_NetzCodes-und-Richtlinien

Bdew: Rechtlicher Hintergrund: Systemstabilitätsverordnung (SysStabV)
http://www.clearingstelle-eeg.de/files/SysStabV_juris_120720.pdf

Frequency control – Control Reserve Power by RE - Portfolio



Research: Project Kombikraftwerk 2, Federal Ministry for Economic Affairs and Energy