Ancillary Services Market Organization in Germany

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Fraunhofer IWES

Ancillary Services Market Organization in Germany

- **German Power System**
- Ancillary Services
- Frequency Control in Germany / Grid Region Continental Europe
- Voltage Control
- Outlook: Capabilities of Renewables to Provide Ancillary Services

Power System in Germany –Facts & Figures 1/4

Area: 357,340 km²

Population: 81 Mio.

Gross electricity generation 2014: 614 TWh

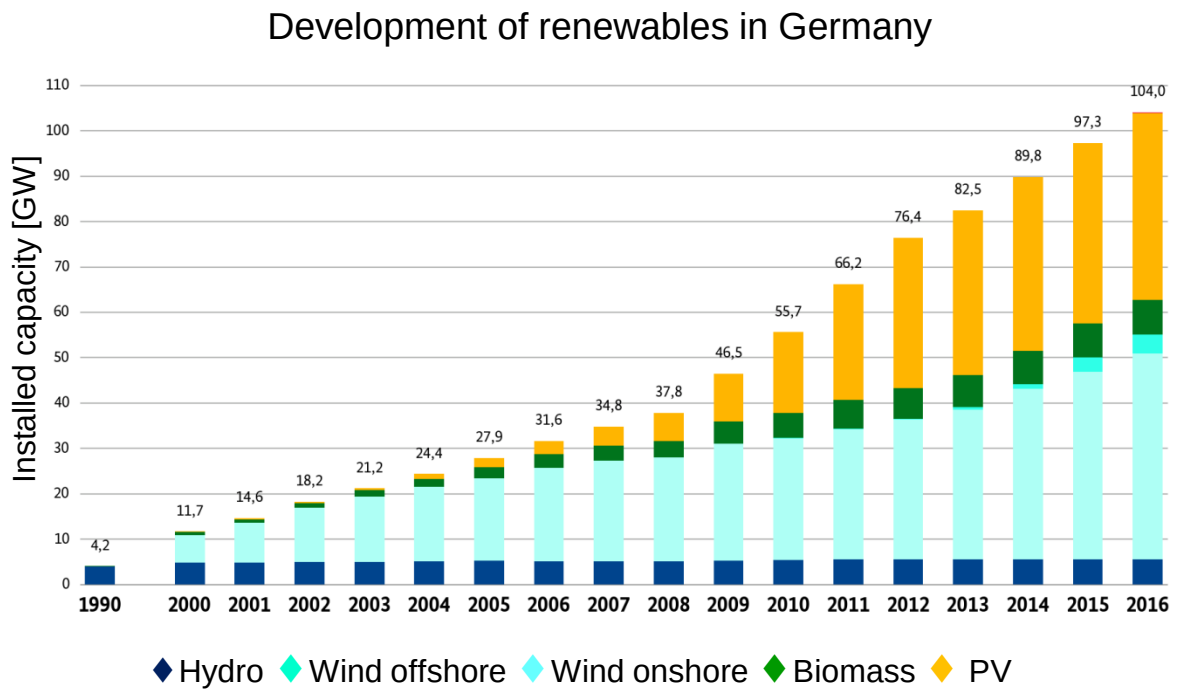
Share of Renewables 2016: > 33 % of demand

Capacity Conventional Generation 2013: 91 GW

Coal 29 GW, Lignite 23 GW, Nuclear 12 GW,
Gas 27 GW

Transmission Grid: 35,000 km (380 / 220 kV)

Power System in Germany –Facts & Figures 2/4



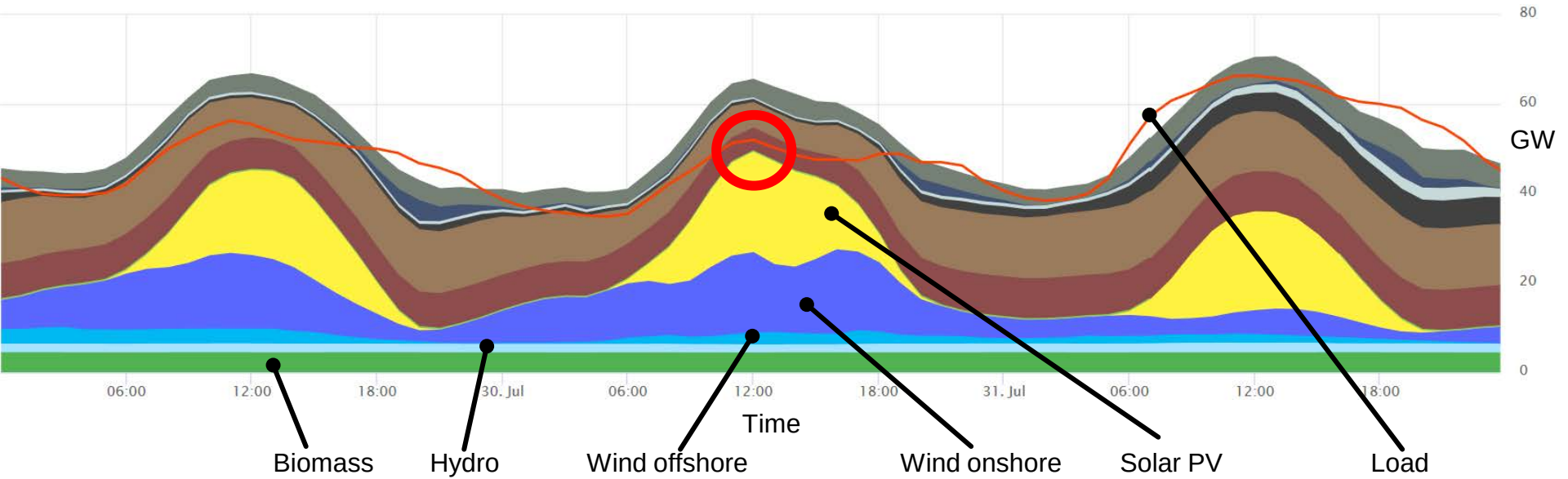
Total 2016: 104.0 GW

- Wind: 49.5 GW
- PV: 41.3 GW
- Biomass: 7.6 GW

Source: BMWi, http://www.erneuerbare-energien.de

Power System in Germany –Facts & Figures 3/4

German Power Generation, July 29-31, 2017



Source: **Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen, www.smard.de**

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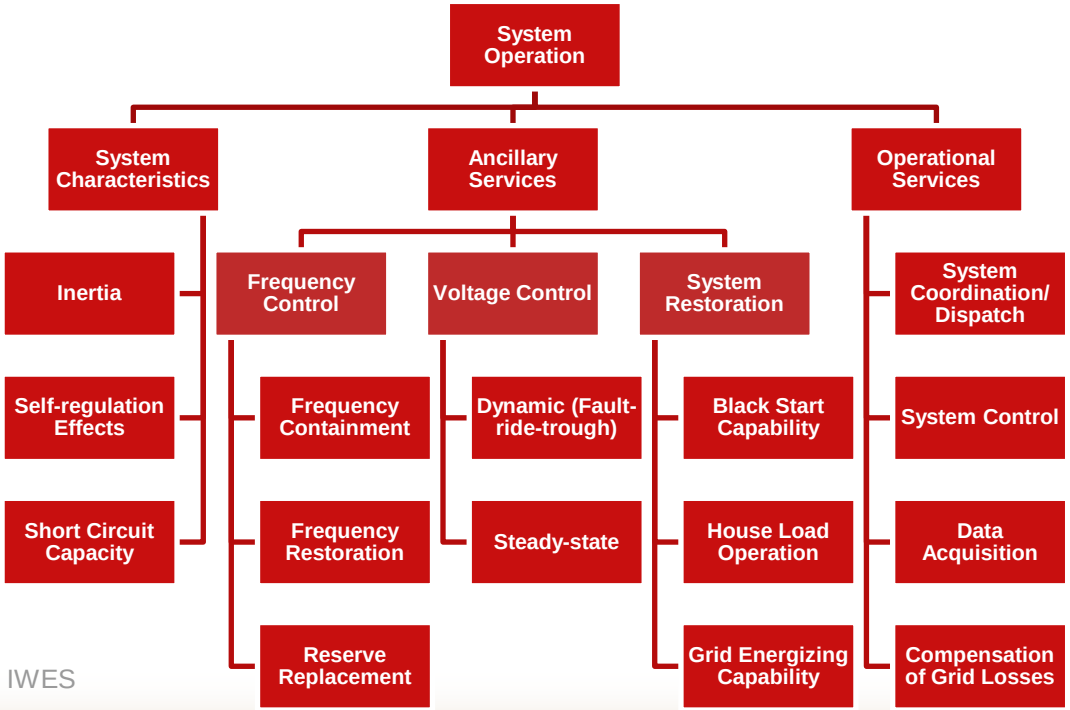
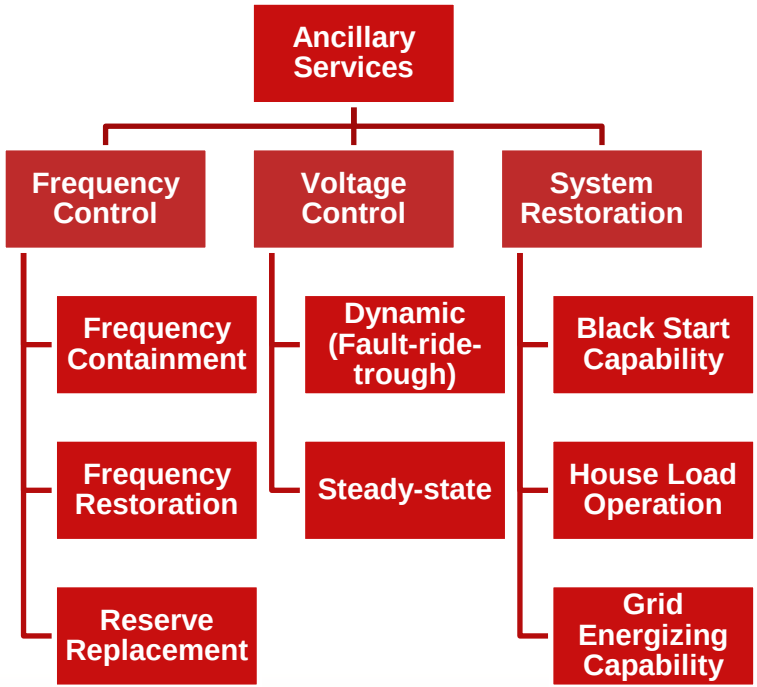
System Operation – Characteristics and Services



Source: Fraunhofer IWES

Ancillary Services – Bilateral or Market Based



- Frequency control
  - Global service
  - Market can be created
- Voltage control
  - Local service
  - Bilateral agreements or grid code requirements
  - Regulator approved prices

Source: Fraunhofer IWES

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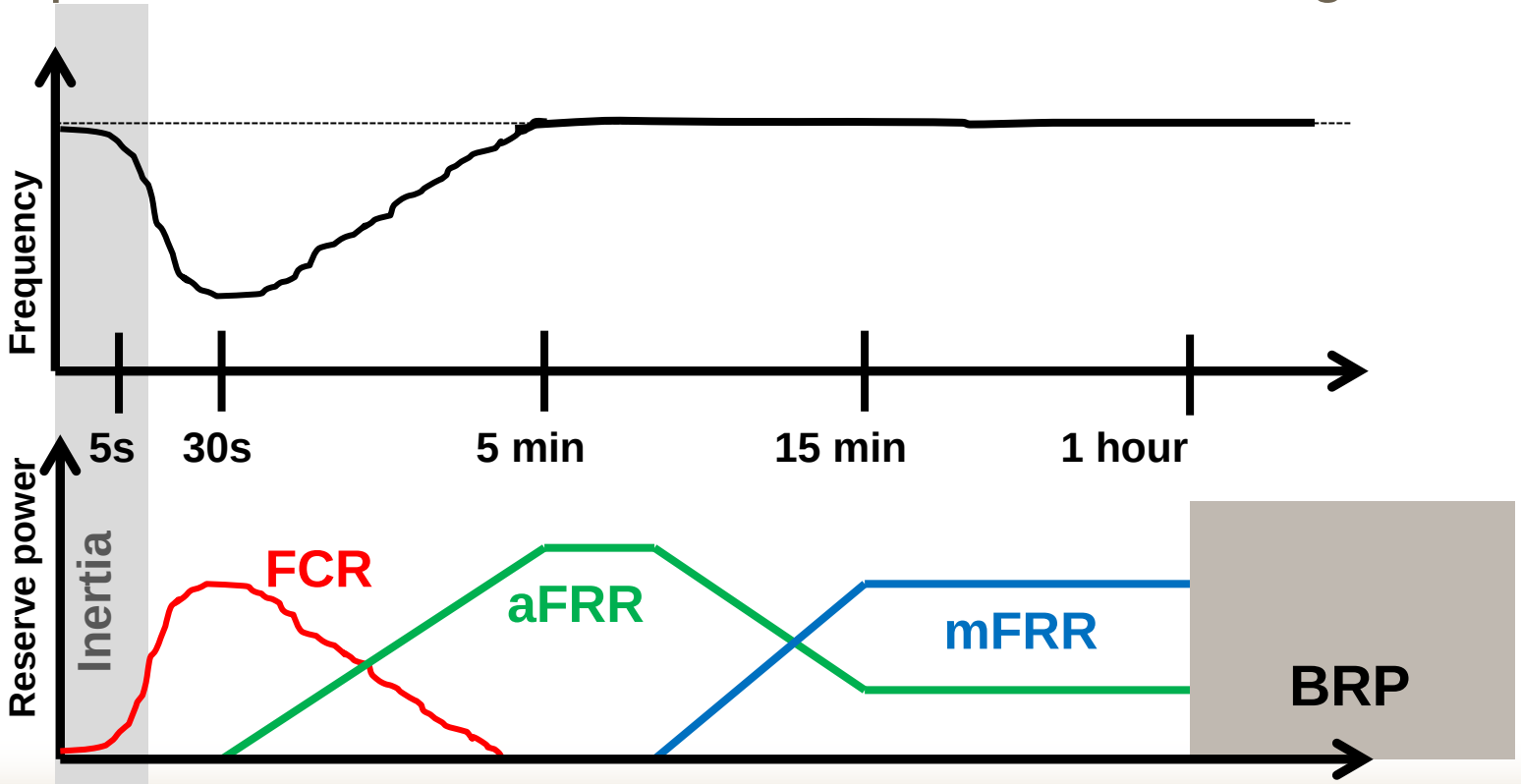
Dispatch of control reserve for real-time balancing



Reserve dimensioning – Primary reserve (N-1 and N-2)

- The basic dimensioning criterion is the maximum expected instantaneous active power deviation (N-1):
  - loss of the largest power plant; loss of a line section; loss of a bus bar; loss of the largest load at one connection point; loss of a HVDC interconnector.
- In larger systems like continental Europe (or all-India) with many units there is a larger probability of an additional loss before the system has recovered. Subsequent failures have to be considered (N-2).
- Probabilistic investigations resulted in a primary reserve of 2910 MW for continental Europe. Commonly known as sum of the two largest units, N-2 criterion, or 3 GW.

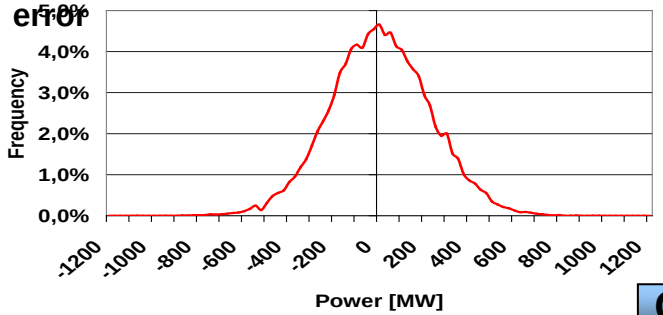
Reserve dimensioning – Secondary and total reserve

Error type	Determination	Secondary reserve	Total reserve
Load noise	Empirically determined distribution based on time series of vertical net load	X	X
Forecast errors	Empirically determined distribution based on actual reserve activations corrected for power plant outages		X
Schedule steps	Stochastic ramping model for the sum of schedule steps with foreign TSOs	X	X
Power plant outages	Stochastic distribution based on convolution of historic outages of all power plants > 100 MW	X	X
Hour steps	Empirically determined distribution of the difference between 15-min. and 1-h mean value of the forecast error	X	

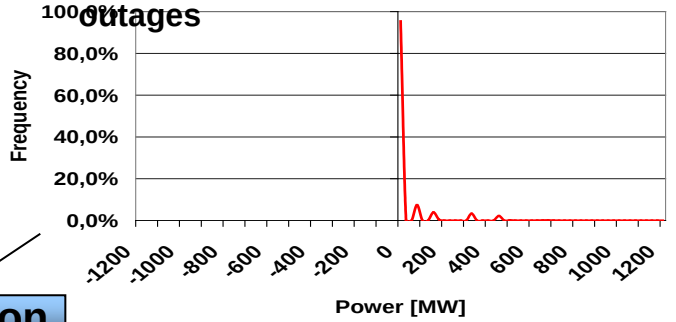
Source: Consentec

Reserve dimensioning – Secondary and total reserve

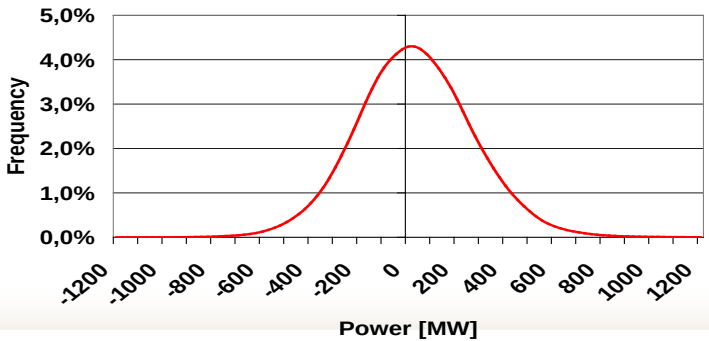
Frequency distribution of load forecast error



Frequency distribution of power plant outages

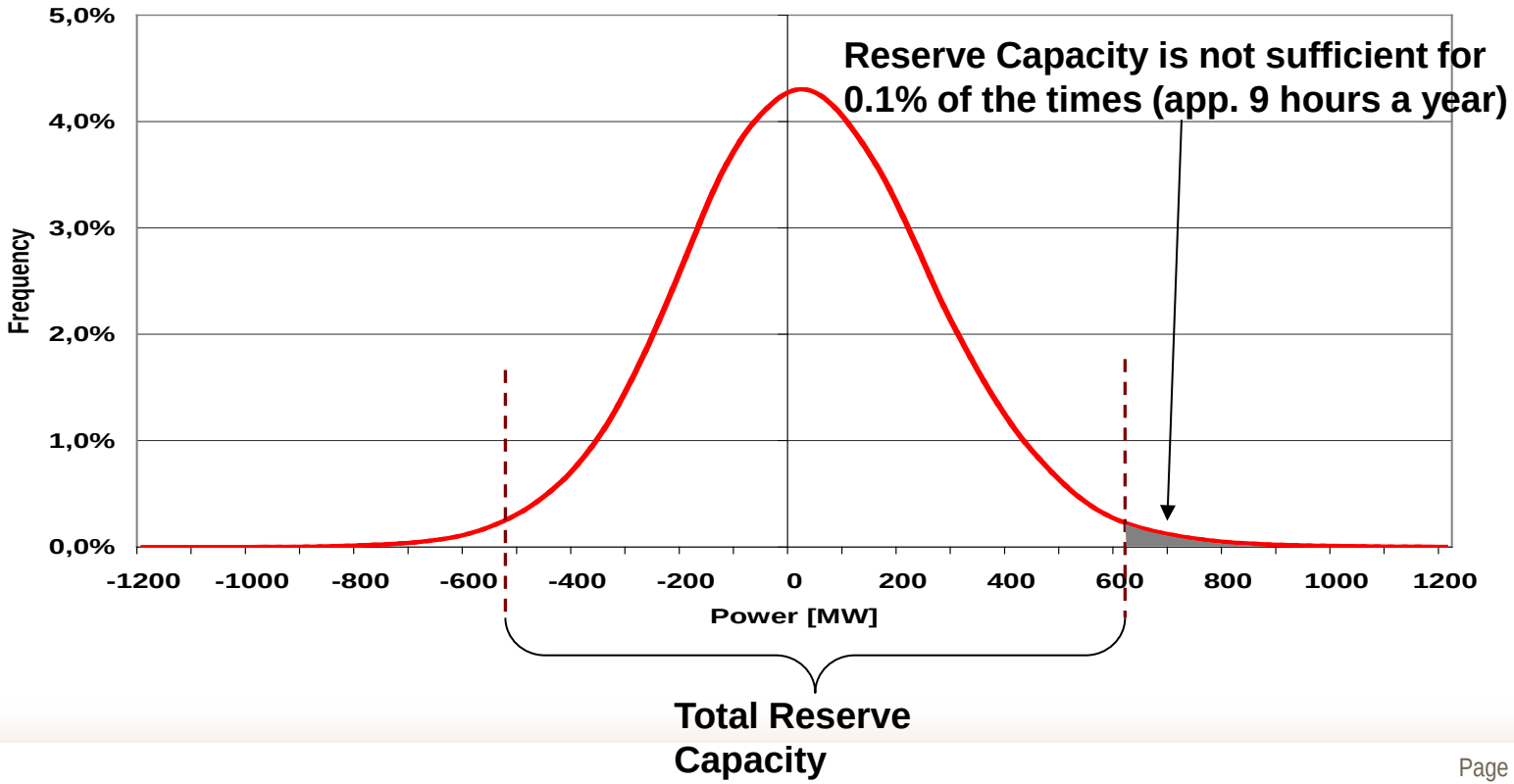


Convolution

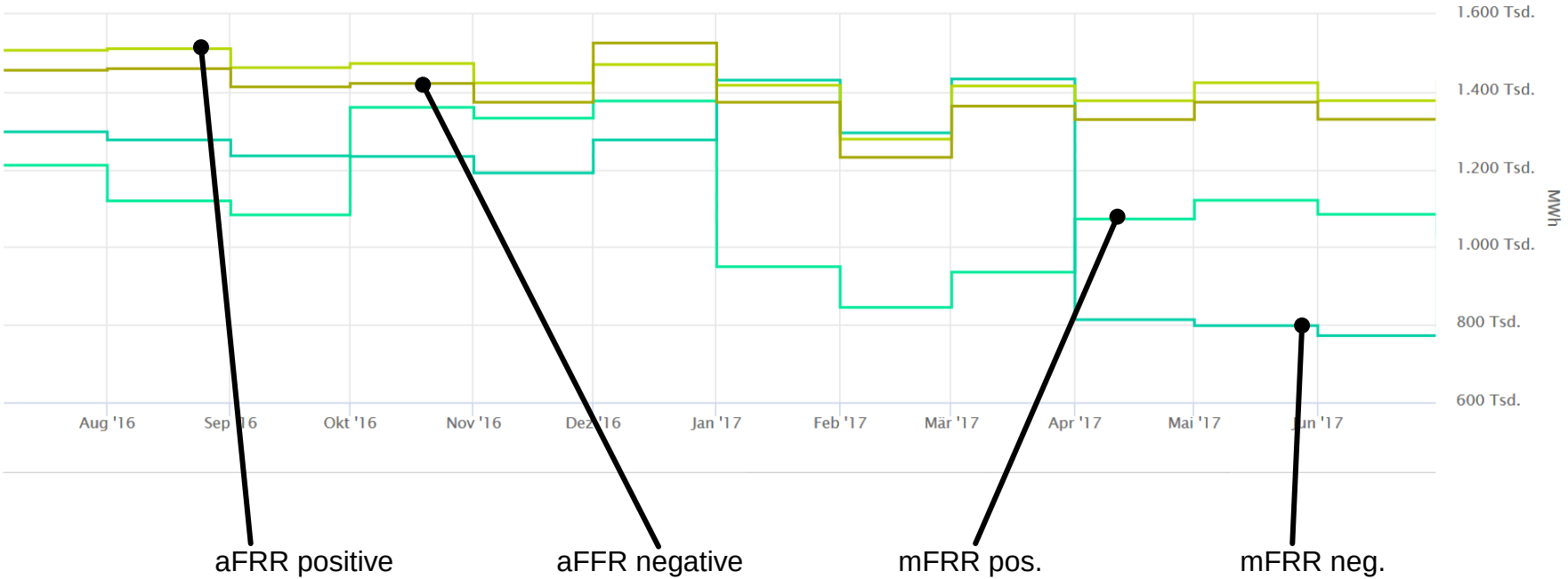


Frequency distribution of total demand of reserve

Reserve dimensioning – Secondary and total reserve



Reserve dimensioning – Actual values in Germany



Source: BMWi, http://www.erneuerbare-energien.de

Reserve product specification

	Primary control reserve (FCR)	Secondary control reserve (aFRR)	Tertiary control reserve (mFRR)
Auction time	Weekly (on Tuesdays for the next week)	Weekly (On Wednesdays for the next week)	Daily (10:00 for next day and following weekend or holidays)
Product time period	One calendar week	**Peak** (Monday to Friday from 8:00 till 20:00) or **off-peak**(Monday to Friday from 0:00 till 8:00 and 20:00 till 24:00 as well as **weekends** and national holidays from 0:00 till 24:00) of one calendar week	4 h (6 time slices per day)
Product type	Positive and negative reserve in one product	Positive and negative reserve separated	Positive and negative reserve separated
Product size	≥ 1 MW symmetrical positive and negative reserve	≥ 5 MW	≥ 5 MW
Product increment	1 MW	1 MW	1 MW
Compensation	Capacity price	Capacity and energy price	Capacity and energy price

Market design - Influencing factors on market liquidity

Influence on demand	Tendency	Influence on supply	Tendency
Extension of control zones	reducing	Reducing duration for offered services, allowing pooling of units, reducing minimal offered power	increasing
Increased balancing activities using intra-day markets	reducing	Allowing for new providers, e.g. decentralized generators (including power-to-heat or backup generators)	increasing
Growing installed capacity of renewables, absolute effect of forecast failure rises	increasing	More power plants operating in partial load, reducing minimal load of power plants	increasing
Optimizing of feed-in forecast of renewables	reducing	Increased grid/ line contingencies and lagged grid extension on transmission level	reducing

Source: Consentec

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Voltage Control - Objectives

- Voltage profile management and reactive power dispatch (steady state):
  - The aim is to keep the voltage profile close to the desired profile and within the tolerance band margins with time frame of minutes to hours.

- Maintaining voltage stability (dynamic):
  - The aim is to prevent a voltage collapse event or limit its depth and extension in case of an incident (line fault, loss of generation unit).

Voltage Control – Market requirements

- Reactive power should be supplied close to the point of demand.
- The demand for reactive power is relatively low compared to the demand for active power.

  ➔ Possible market size is limited.

- The need for reactive power and the need to diversify reactive power sources grows with the increased penetration of renewables.
- Voltage support induces costs for generators but can help system operators to manage their network in the most efficient way.

  ➔ If the number of service providers is large enough, voltage support could be tendered.

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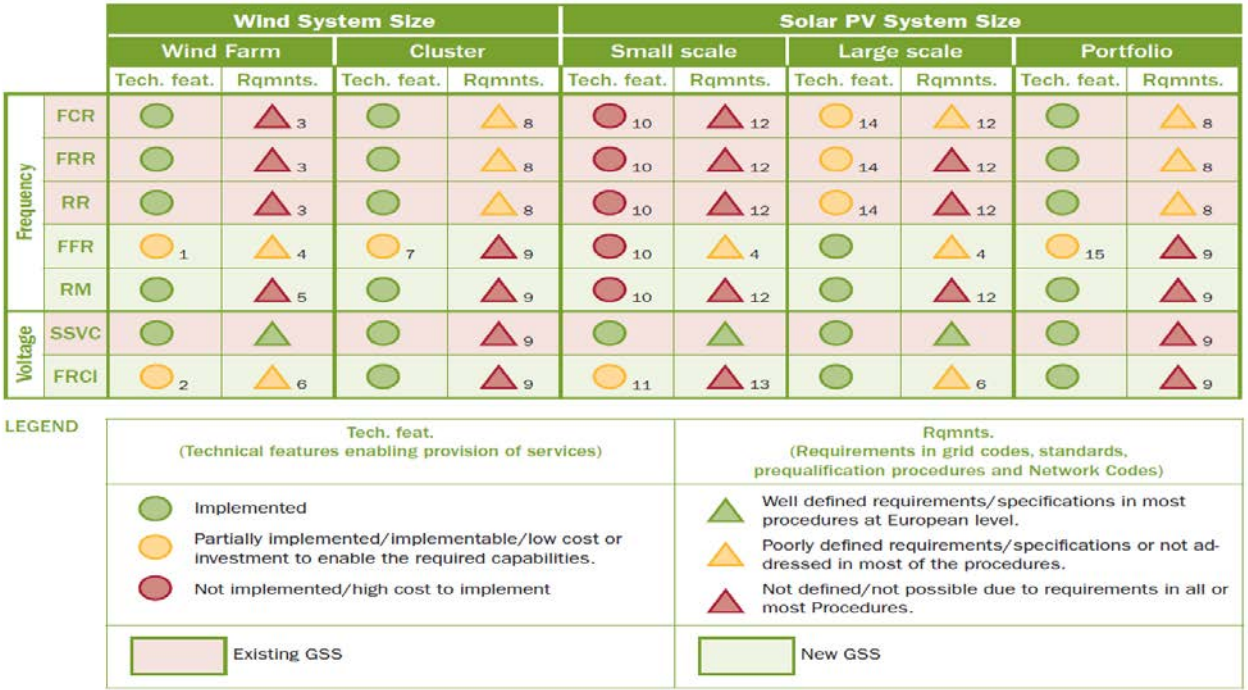
Capabilities of Renewables



		Wind System Size				Solar PV System Size					
		Wind Farm		Cluster		Small scale		Large scale		Portfolio	
		Tech. feat.	Rqmnts.	Tech. feat.	Rqmnts.	Tech. feat.	Rqmnts.	Tech. feat.	Rqmnts.	Tech. feat.	Rqmnts.
Frequency	FCR		3		8	10	12	14	12		8
	FRR		3		8	10	12	14	12		8
	RR		3		8	10	12	14	12		8
	FFR	1	4	7	9	10	4		4	15	9
	RM		5		9	10	12		12		9
Voltage	SSVC				9						9
	FRCI	2	6		9	11	13		6		9

Source: REserviceS project

Legend

FCR: frequency containment reserve

FRR: frequency restoration reserve

RR: replacement reserve

FFR: fast frequency response

RM: ramping margin

SSVC: steady state voltage control

FRCI: fast reactive current injection

GSS: grid support services

Conclusions

- Ancillary Services are market based where possible
- Some services are regulated (e.g. voltage control)
- Growth of variable generation influence amount and specifications of services
- Variable generation can provide ancillary services (and need to)

Questions?

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