
The implications for PV of new codes for electricity grids in Germany



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Grid codes

Change in the grid structure due to the connection of generators in the lower and middle voltage levels

→ Demand for transfer of grid stability control from high to medium and low voltage level

New grid codes for generators in high, medium and low voltage grids in Germany

New requirements

grid codes	voltage band	fault ride through	reactive power supply			frequency band	active power derating	
	range		capability	capability	range		function	range
high voltage >110 kV	0,8 U _N ↔ 1,16 U _N	✓	✓	COS φ _{max} = 0,95 _{ind} COS φ _{max} = 0,90 _{cap} COS φ _{max} = 0,95 P _N < 100MW	Q(U) COS φ _{fix} Q _{fix}	47,5 Hz ↔ 51,5 Hz	✓	$\Delta\left(\frac{P}{P_M}\right) = 40 \frac{\%}{\text{Hz}} (50,25\text{Hz} - f)$ 50,25Hz < f < 51,5Hz
medium voltage <110 kV >10 kV	0,9 U _N ↔ 1,15 U _N	✓	✓	COS φ _{max} = 0,95	COS φ (P) Q(U) COS φ _{fix} Q _{fix}	47,5 Hz ↔ 51,5 Hz	✓	$\Delta\left(\frac{P}{P_M}\right) = 40 \frac{\%}{\text{Hz}} (50,2\text{Hz} - f)$ 50,2Hz < f < 51,5Hz
low voltage <10 kV	0,9 U _N ↔ 1,15 U _N	✗	✓	COS φ _{max} = 0,9	COS φ (P) COS φ _{fix}	47,5 Hz ↔ 50,2 Hz	✗	

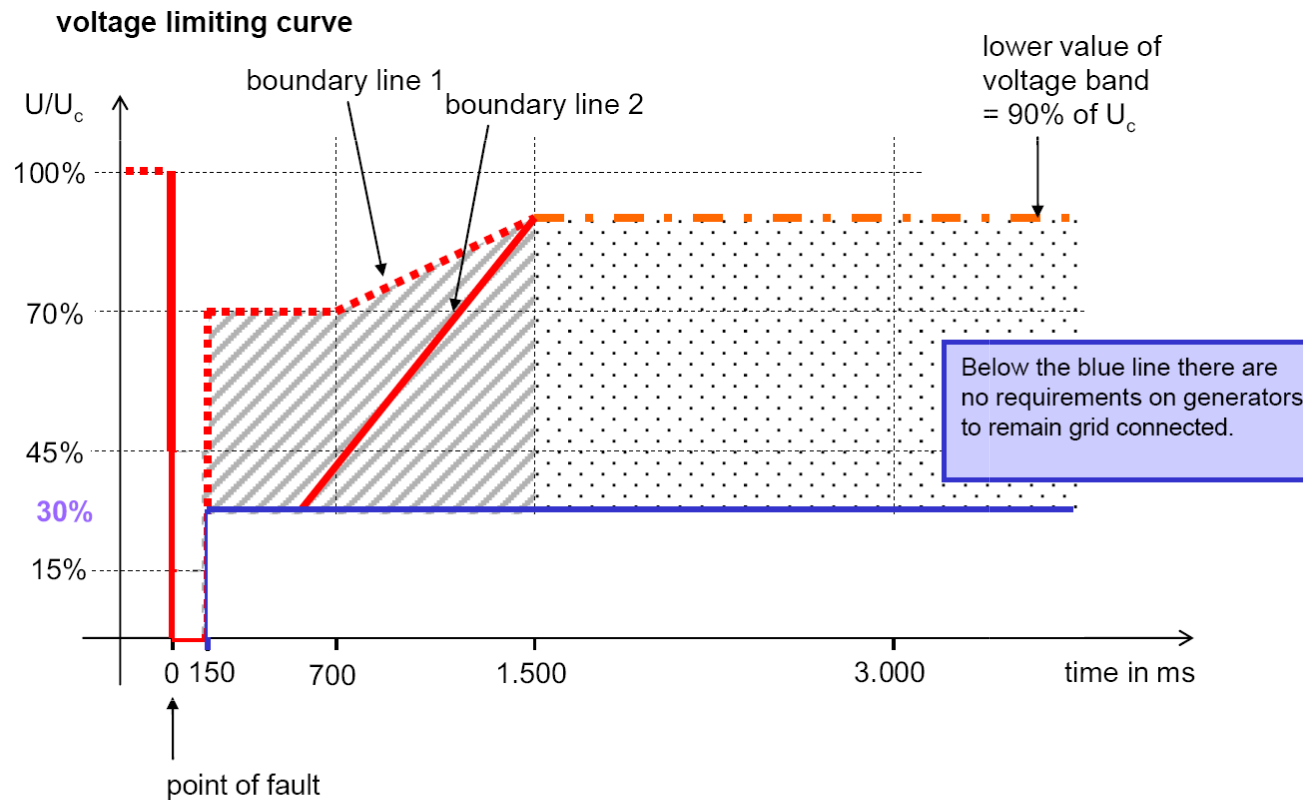
source:

HV VDN, Verband der Netzbetreiber VDN e.V.; August 2004

MV BDEW, Bundesverband der Energie- und Wasserwirtschaft e.V; Juni 2008

LV Forum Netztechnik / Netzbetrieb beim VDE; Juni 2008

Fault ride through capability – *Medium* voltage grids I



Generator model 1

(boundary line 1)

synchronous generator
directly coupled to the
grid

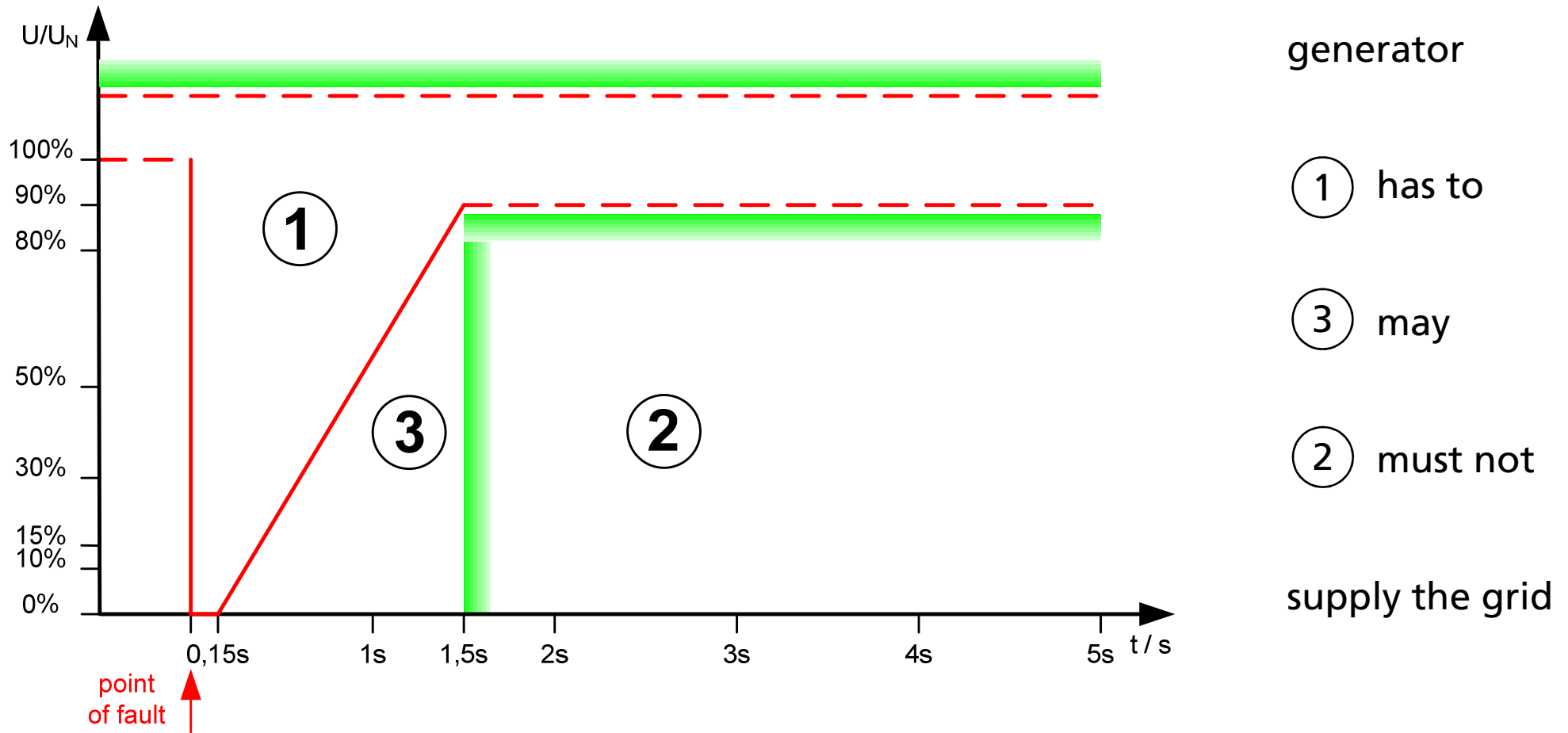
Generator model 2

(boundary line 2)

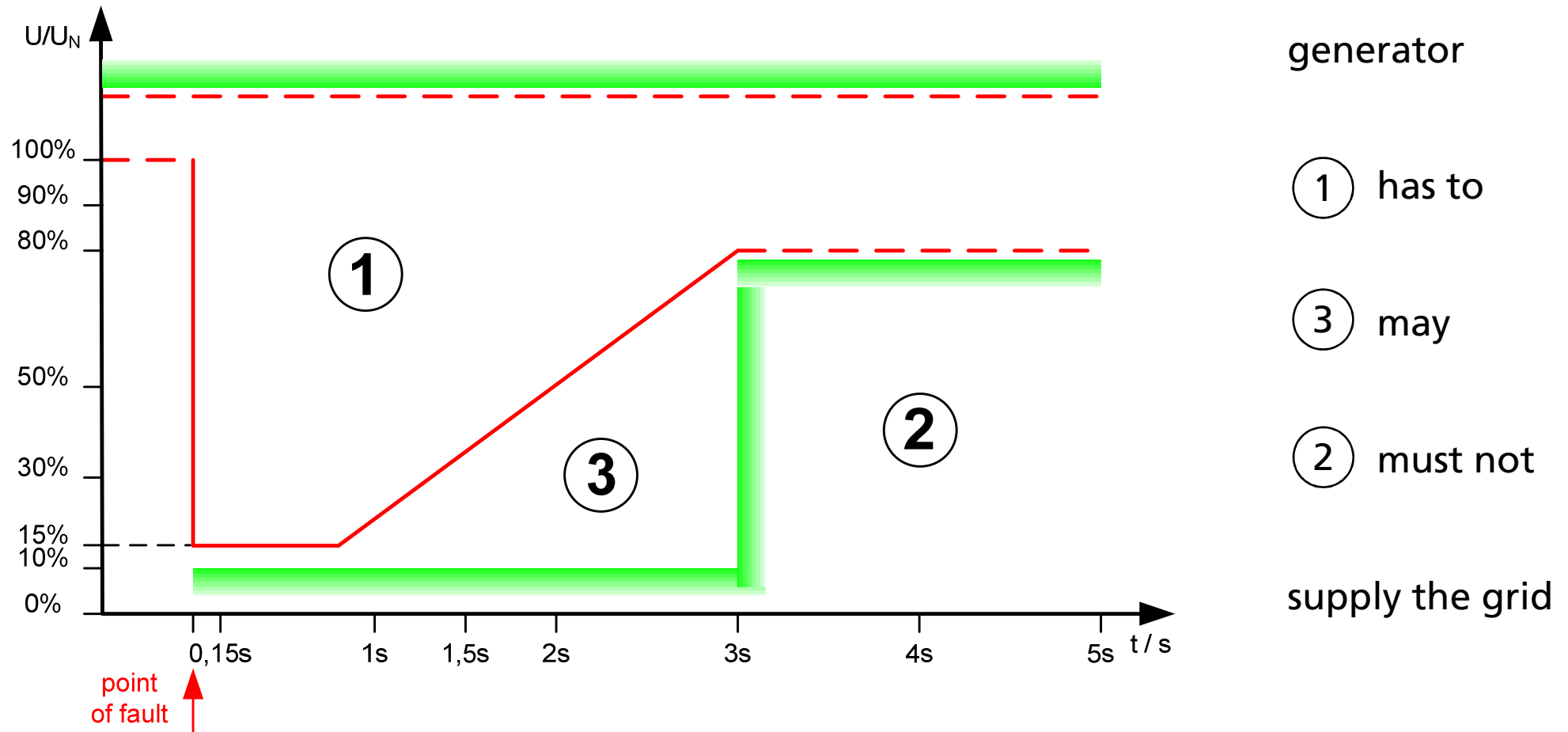
all other types of
generators



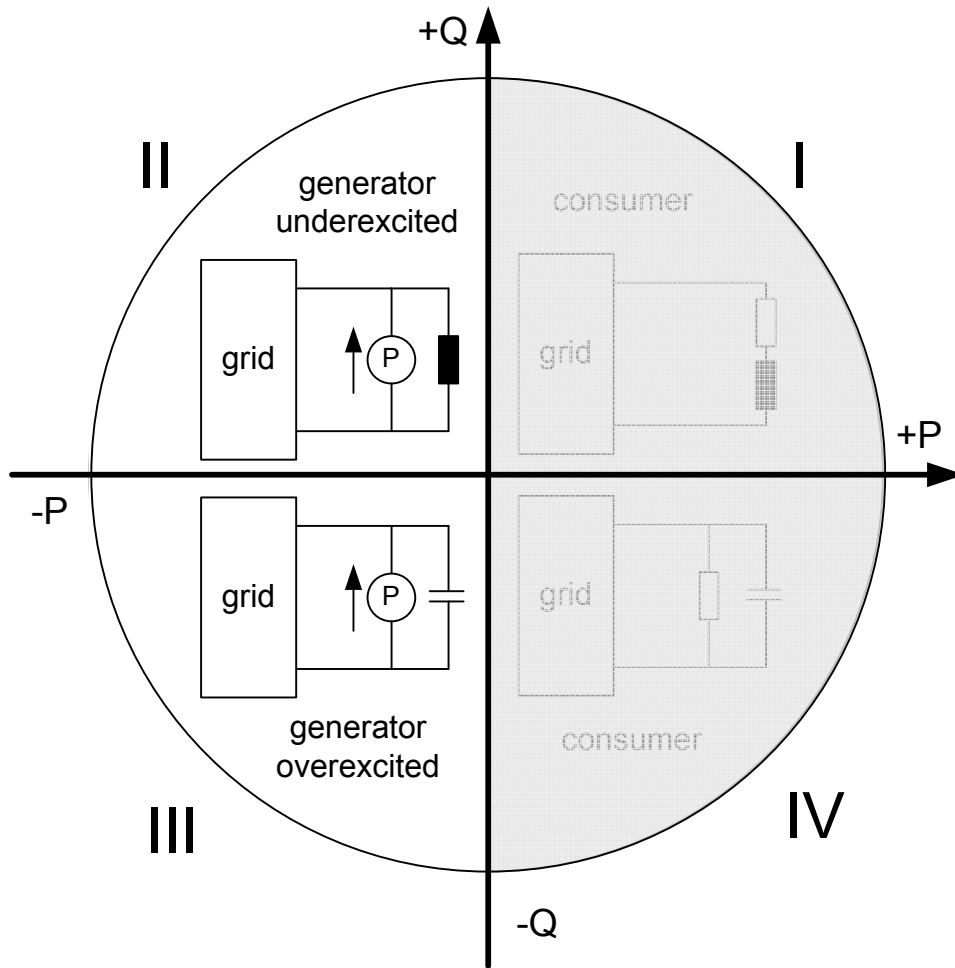
Fault ride through capability – *Medium* voltage grids II



Fault ride through capability – *High voltage* grids



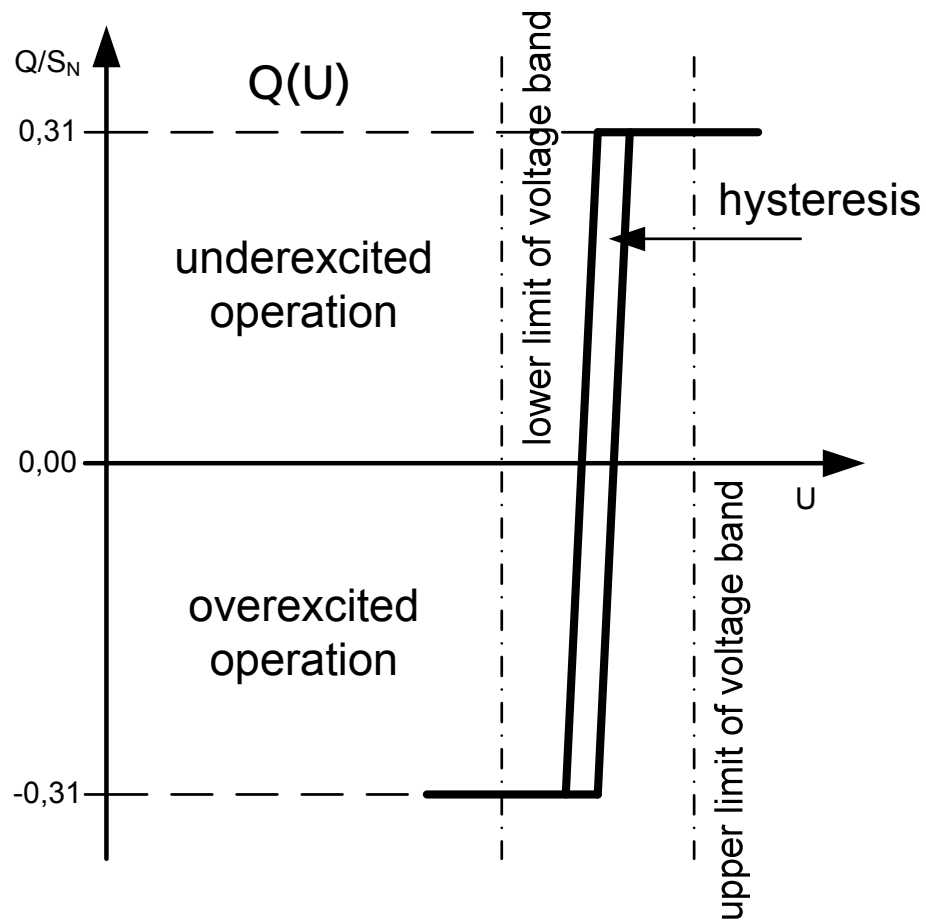
Consumer based system



- QII An under excited generator loads the grid inductively
- QIII An over excited generator loads the grid capacitively



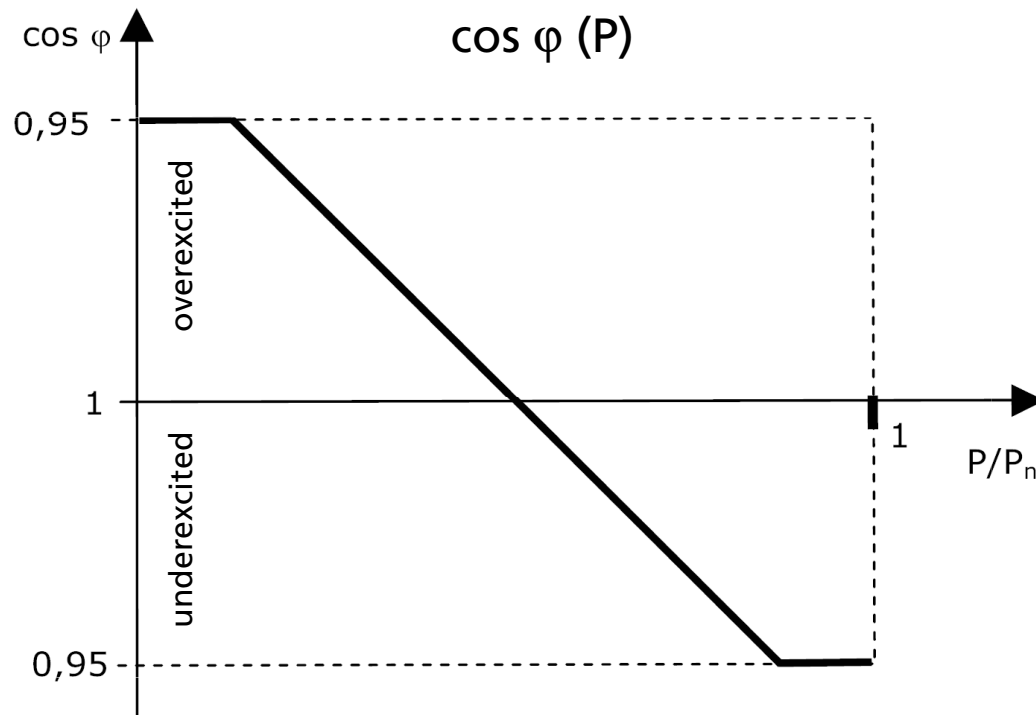
Reactive power supply – *High* and *Medium* voltage grids



- Power factor is controlled by voltage at point of connection
- Power factor must be controlled within 1 second



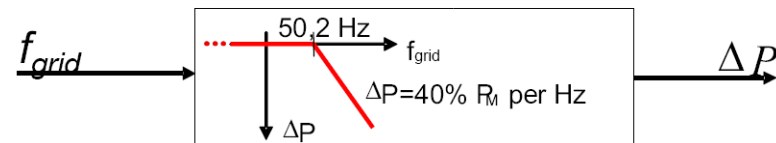
Reactive power supply – *Medium* and *Low* voltage grids



- Power factor is controlled by active power
- Power factor must be controlled within 10 seconds



Active power derating – *High* and *Medium* voltage grids



$$\Delta P = 20 P_M \frac{50,2 \text{ Hz} - f_{grid}}{50 \text{ Hz}} \quad \text{at } 50,2 \text{ Hz} \leq f_{grid} \leq 51,5 \text{ Hz}$$

P_M momentary available power

ΔP power reduction

f_{grid} grid frequency

In the range of $47,5 \text{ Hz} \leq f_{grid} \leq 50,2 \text{ Hz}$ no constraint

At $f_{grid} \leq 47,5 \text{ Hz}$ and $f_{grid} \geq 51,5 \text{ Hz}$ disconnection



Problems and requirements

- Over dimensioning of the inverter due to reactive power control capability

$$S = \frac{P}{\cos \varphi} = 1,11 \cdot P \quad @ \cos \varphi = 0,9$$

- Additional losses, lower efficiency when delivering reactive power
- Communication interface with network operator for reactive power settings
 - Communication hardware definition
 - Communication protocol definition