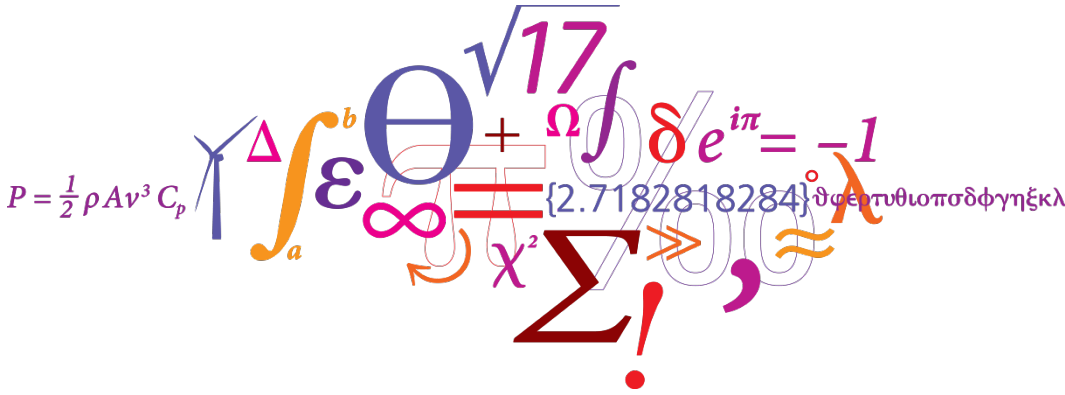
Grid Codes – part 2

a module of the

Grid Connection and Integration of Wind Power

part of the

DTU Online Master's Progamme



DTU Wind Energy
Department of Wind Energy

Learning objectives

After this module you should be able to:

- Understand what frequency-sensitive mode means
- List the different control modes for active power control
- Explain high wind ride-through control

Frequency sensitive mode

- The **frequency** in the power system depends on the **balance** between power **production** and **consumption**

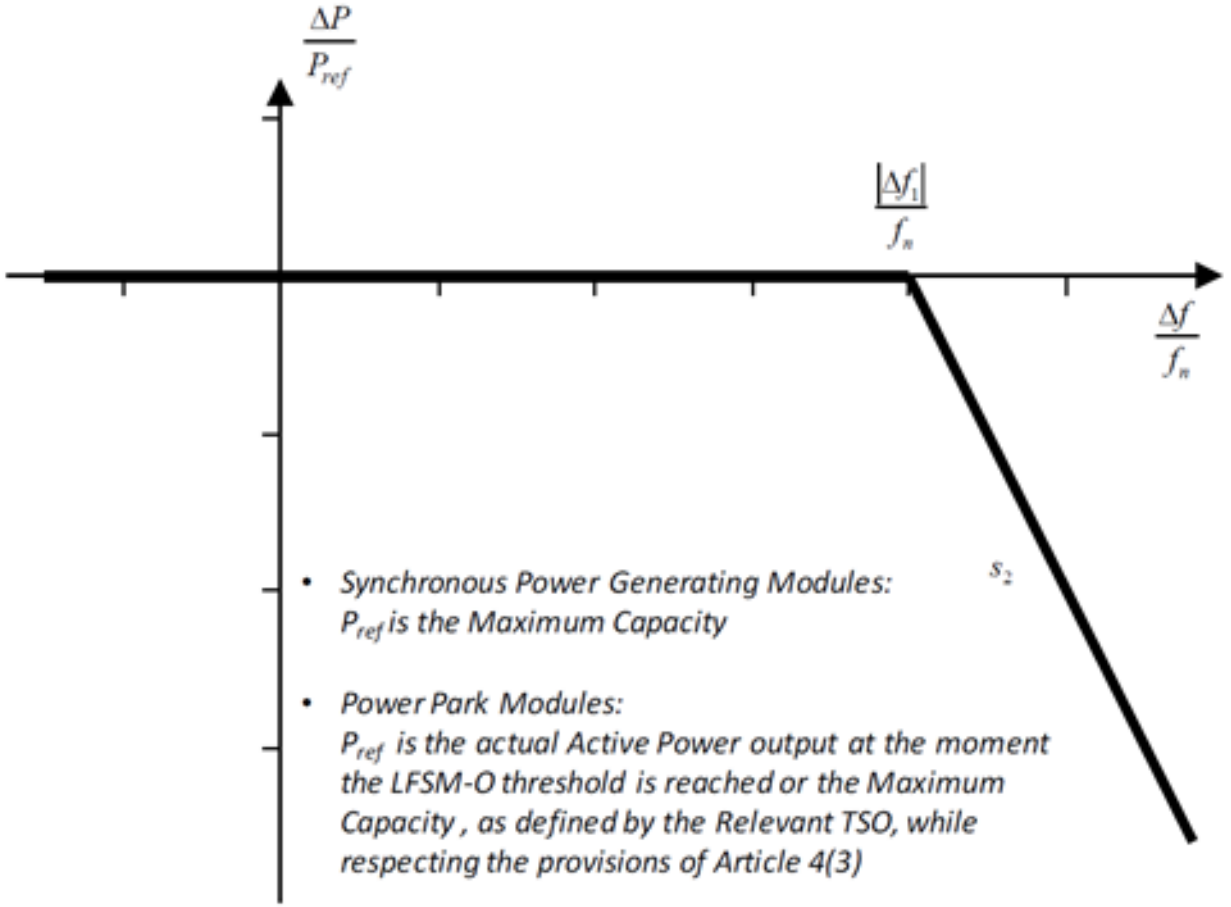
- A **shortage** of power **production** will cause the **frequency** to **fall**, while an excess of power production will cause the frequency to **rise**

- Active power frequency response is defined as an **automatic adjustment** of active power output in response to a **change** in system frequency from the **nominal frequency**.

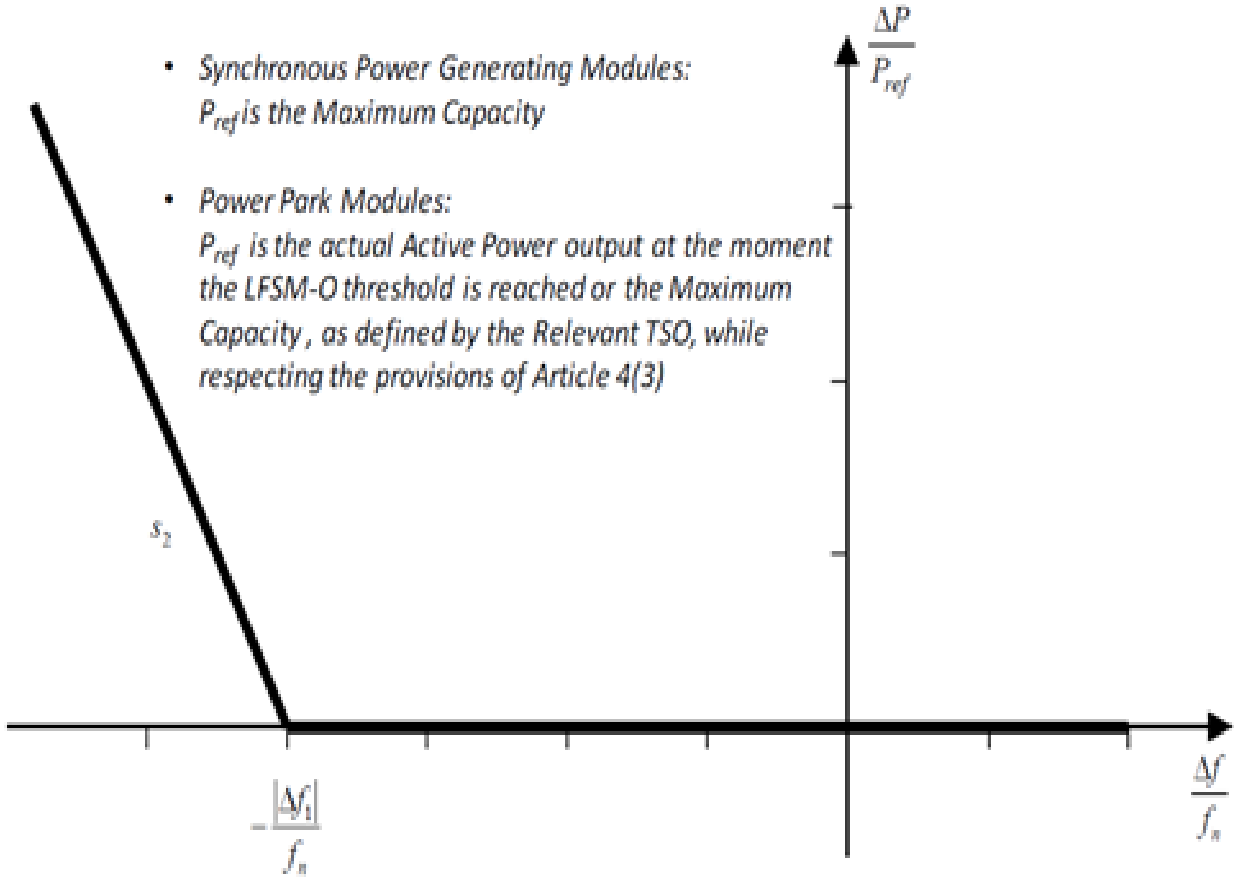
- The **purpose** of such capability is to support a **stable system frequency**, increasing power output when the frequency is low and/or decreasing power output when the frequency is high.

- **Limited Frequency Sensitivity Mode**(LFSM) and is defined for **overfrequency** (-O) and **underfrequency** (-U)

Limited Frequency Sensitivity Mode – Overfrequency (LFSM-O)



Limited Frequency Sensitivity Mode – Underfrequency (LFSM-U)



Active power control functions

"A *wind power plant* must be equipped with active power control functions capable of controlling the active power supplied by a *wind power plant* in the *Point of Connection* using activation orders with set points"

"In case of frequency deviations in the *public electricity supply grid*, the *wind power plant* must be able to provide *frequency control* to stabilise the grid frequency (50.00 Hz)"

"A *wind power plant* must be equipped with constraint functions, i.e. supplementary active power control functions"

*Technical regulation 3.2.5 for wind power plants above 11 kW – Energinet.dk, Denmark

Active power constraint functions

1 - Absolute power constraint

"An a*bsolute power constraint* is used to limit active power from a *wind power plant* to a set point-defined maximum power limit in the *Point of Connection*."

2- Delta power constraint (spinning reserve)

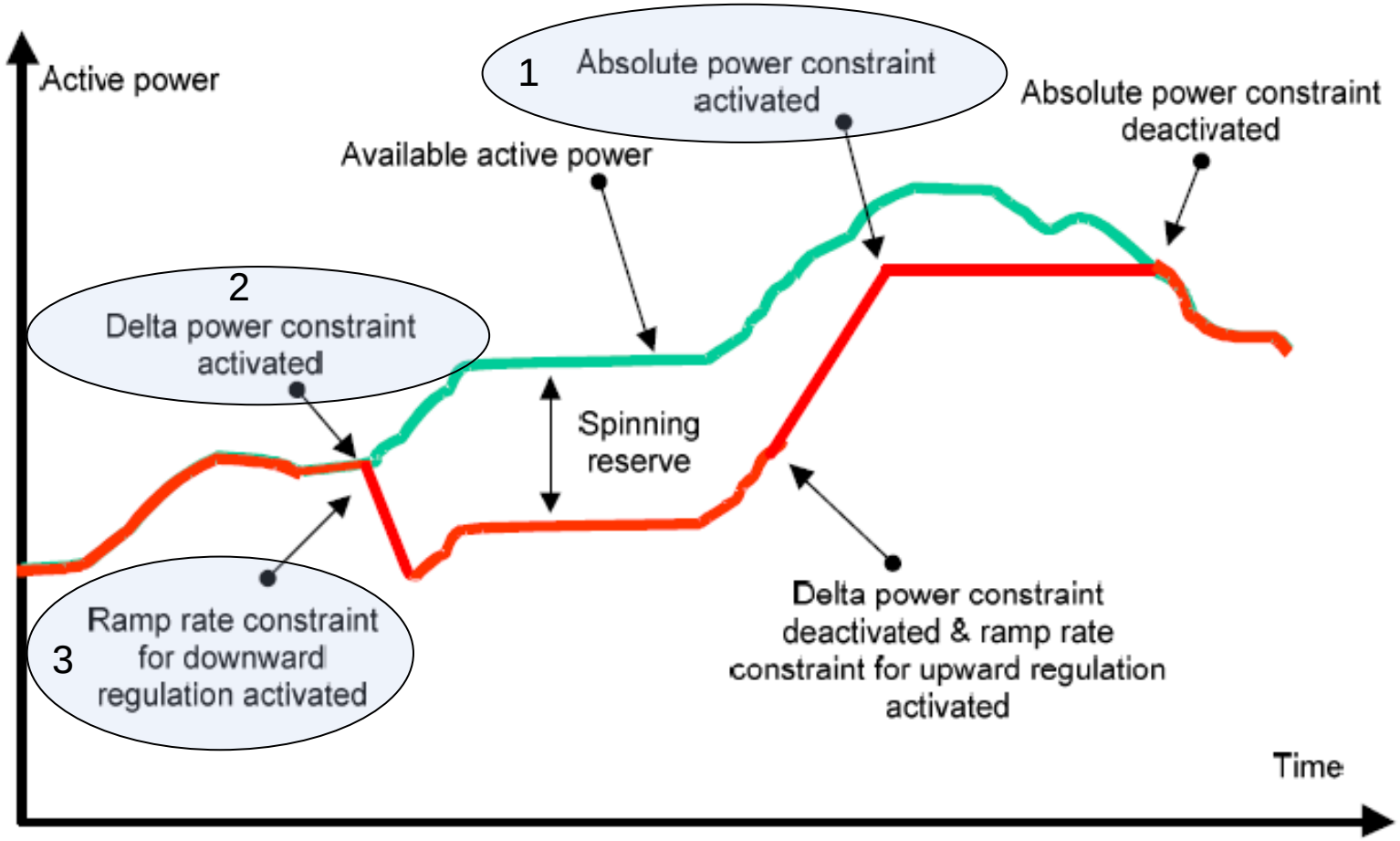
"A *delta power constrain*t is used to constrain the active power from a *wind power plant* to a required constant value in proportion to the possible active power."

3- Ramp rate constraint

"A *ramp rate constraint* is used to limit the maximum speed by which the active power can be changed in the event of changes in wind speed or active power set points."

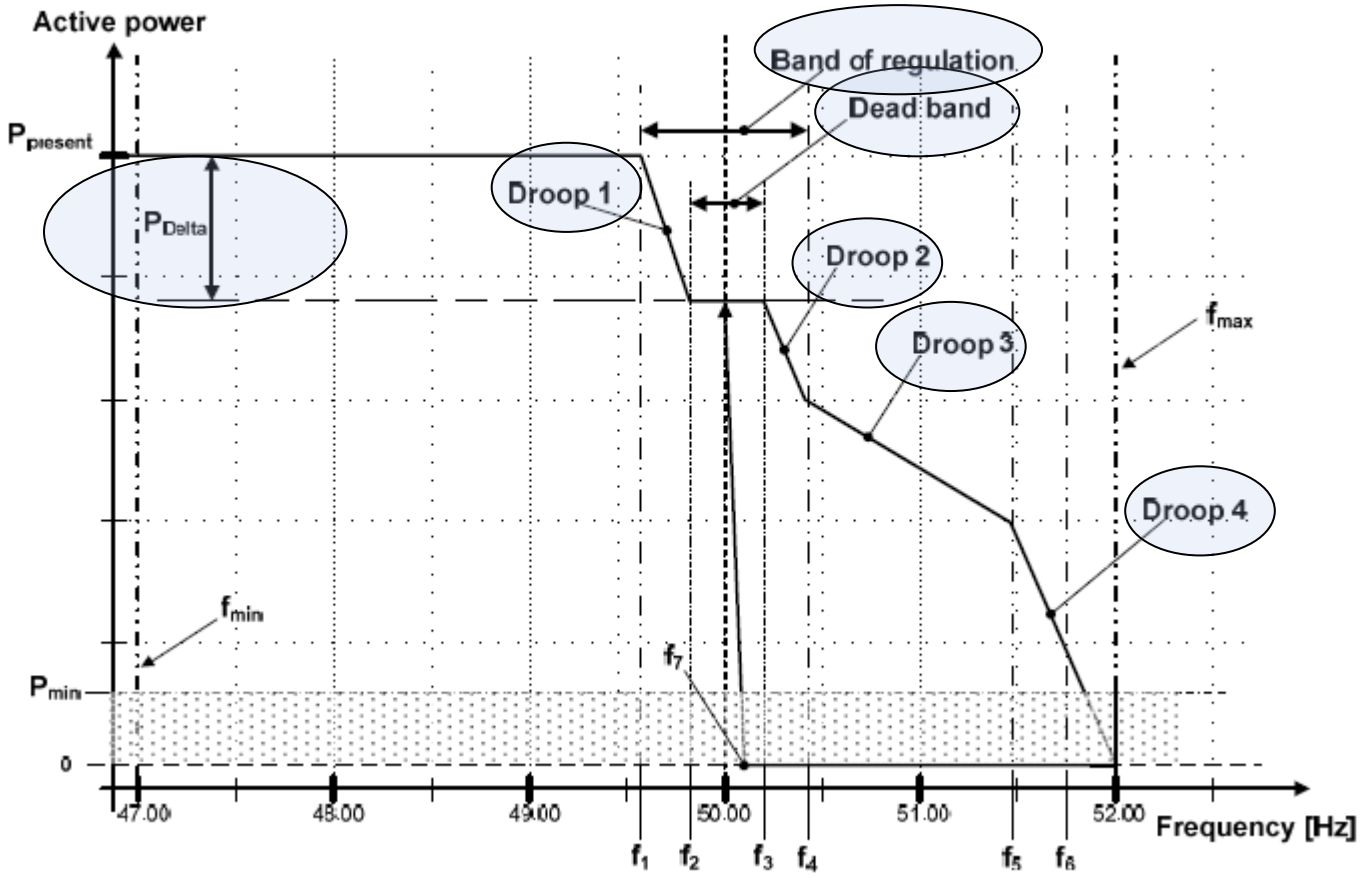
*Technical regulation 3.2.5 for wind power plants above 11 kW – Energinet.dk, Denmark

Active power constraint functions



*Technical regulation 3.2.5 for wind power plants above 11 kW – Energinet.dk, Denmark

Frequency control for wind power plants



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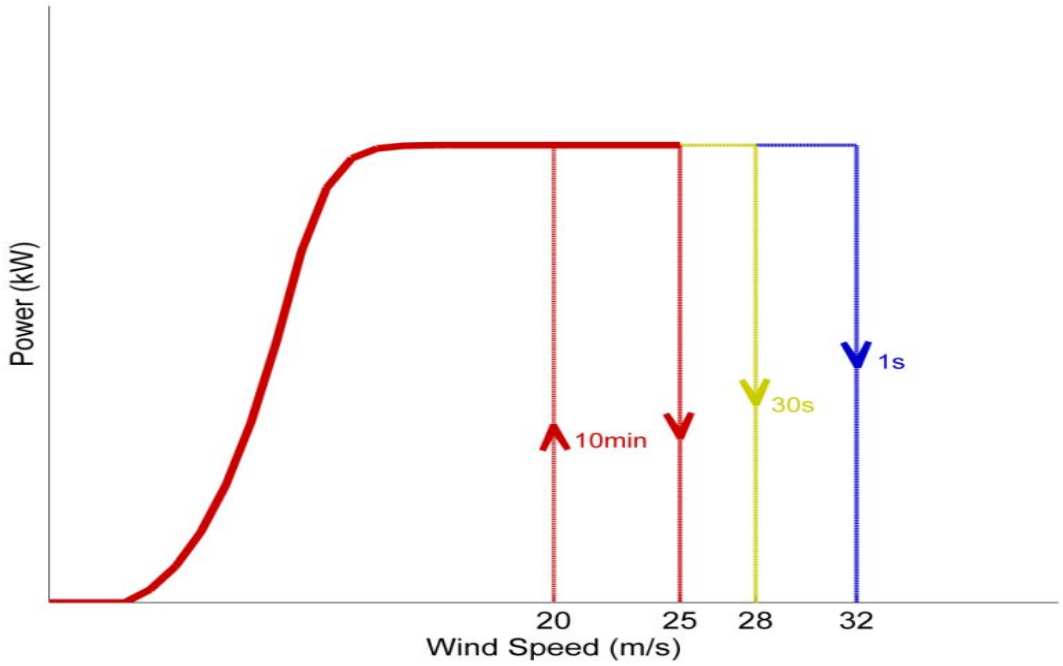
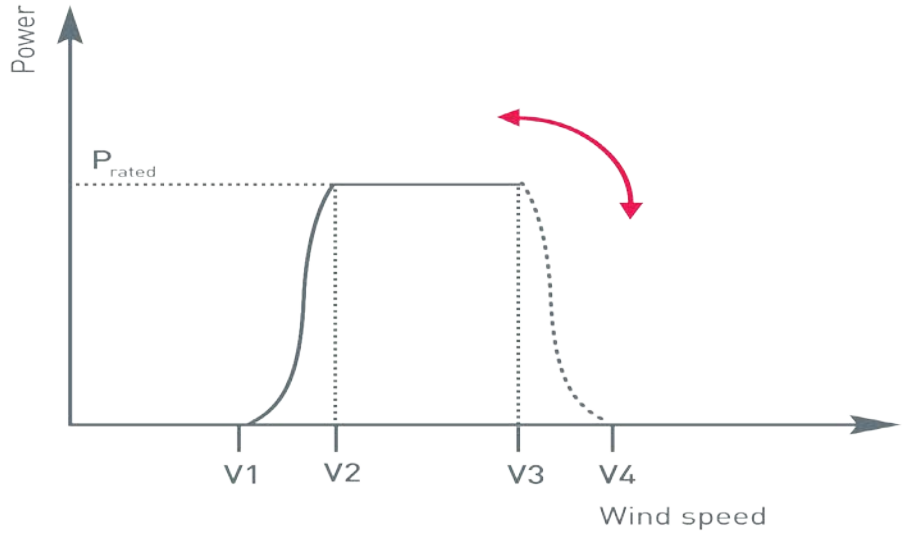
Storm control

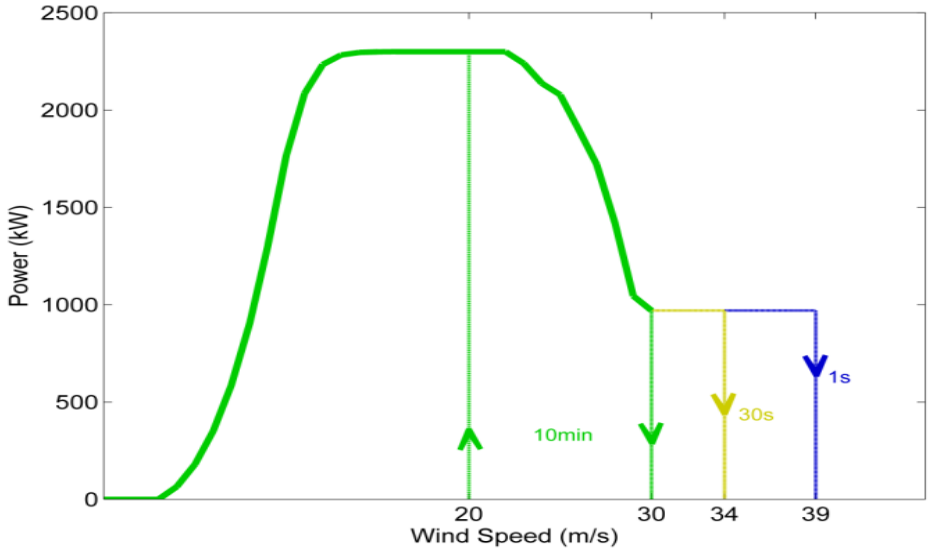
High Wind Shut Down



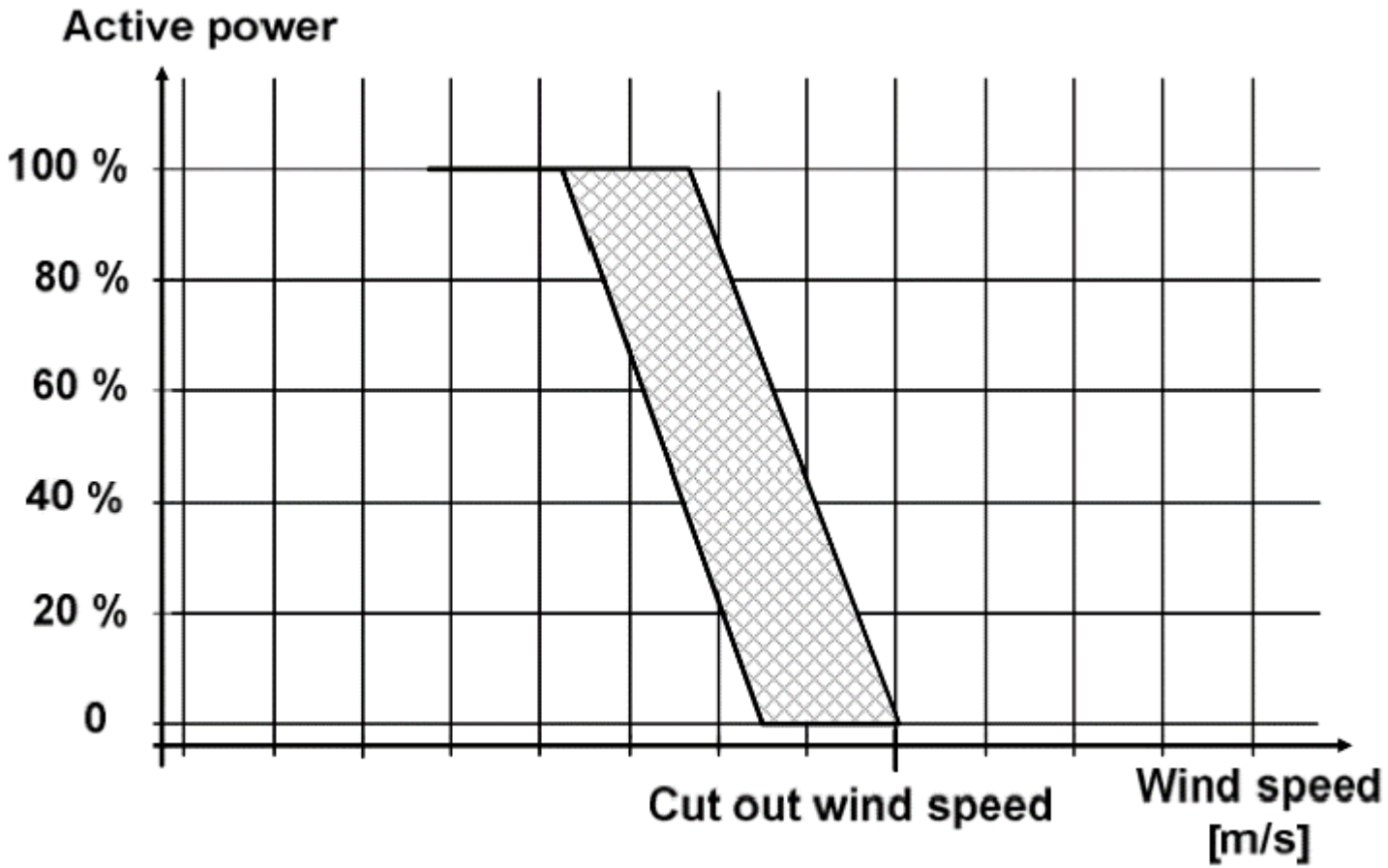
ENERCON storm control



SIEMENS HWRT™ (High Wind Ride Through)



Downward regulation of active power at high wind speeds



*Technical regulation 3.2.5 for wind power plants above 11 kW – Energinet.dk, Denmark

Summary

- Wind power plants today are required to be able to operate in frequency-sensitive modes, i.e. modify their power output depending on the changes in the system frequency

- Besides that, wind power plants in Denmark are also required to have capabilities of controlling their active power output, like absolute power, delta and ramp rate constraint

- Wind turbines are required to be able to control their shut-down process due to extreme wind speeds