

ABB Automation & Power World: April 18-21, 2011

# WRE-120-1

## Today's wind power converters designed for tomorrow's needs

# WRE-120-1

## Today's wind power converters designed for tomorrow's needs

- Speaker name: Arnd Becker
- Speaker title: Business Development Manager
- Company name: ABB Inc.
- Location: Houston, TX

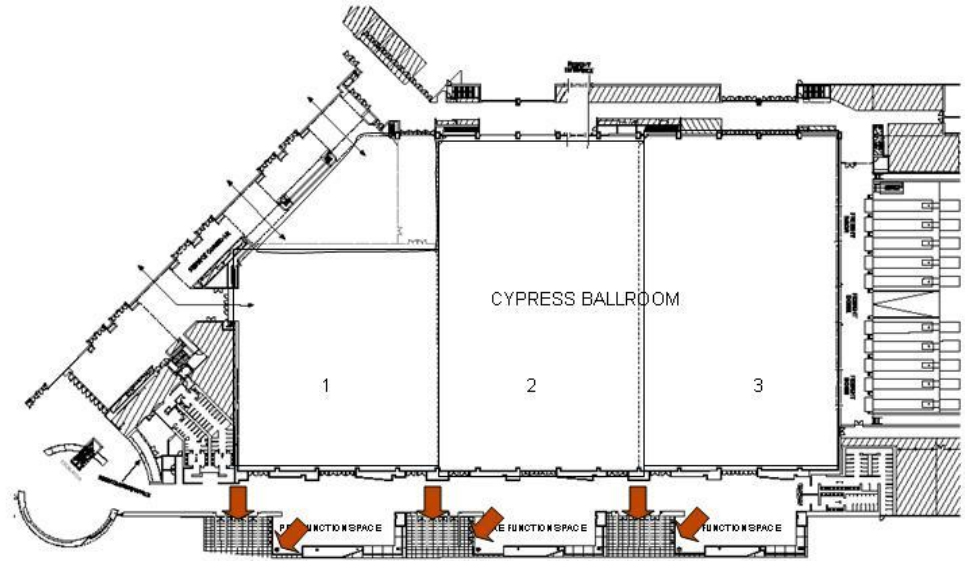
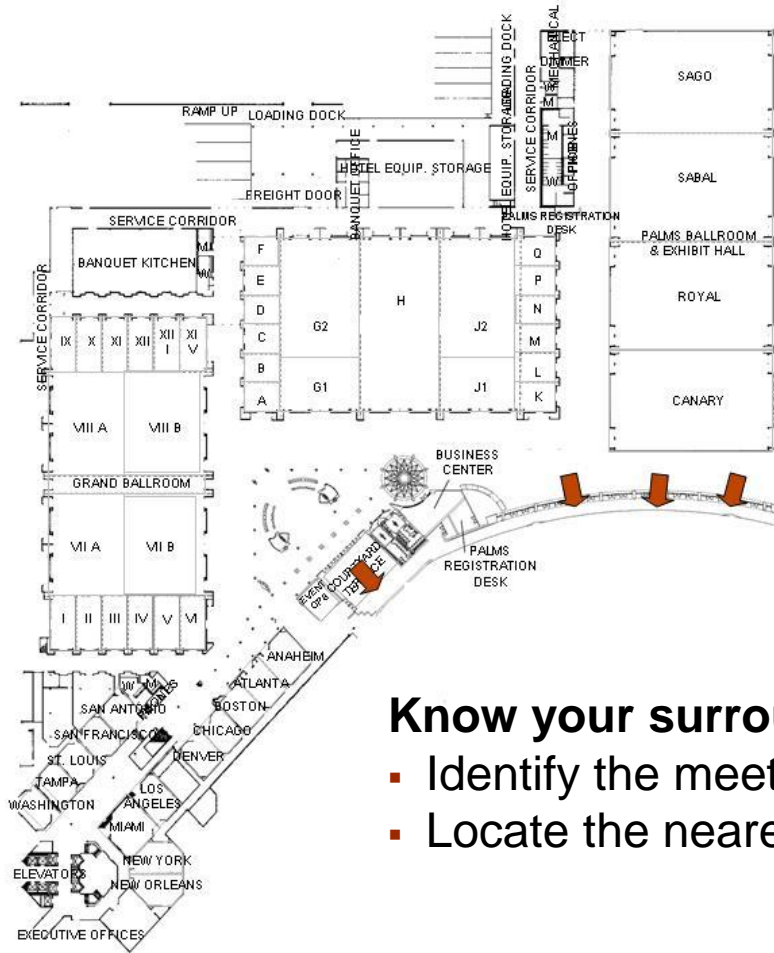
# Your safety is important to us

## Please be aware of these emergency procedures

- In the event of an emergency please dial ext. 55555 from any house phone. Do not dial 9-1-1.
- In the event of an alarm, please proceed carefully to the nearest exit. Emergency exits are clearly marked throughout the hotel and convention center.
- Use the stairwells to evacuate the building and do not attempt to use the elevators.
- Hotel associates will be located throughout the public space to assist in directing guests toward the closest exit.
- Any guest requiring assistance during an evacuation should dial “0” from any house phone and notify the operator of their location.
- Do not re-enter the building until advised by hotel personnel or an “all clear” announcement is made.

# Your safety is important to us

## Convention Center exits in case of an emergency



### Know your surroundings:

- Identify the meeting room your workshop is being held in
- Locate the nearest exit

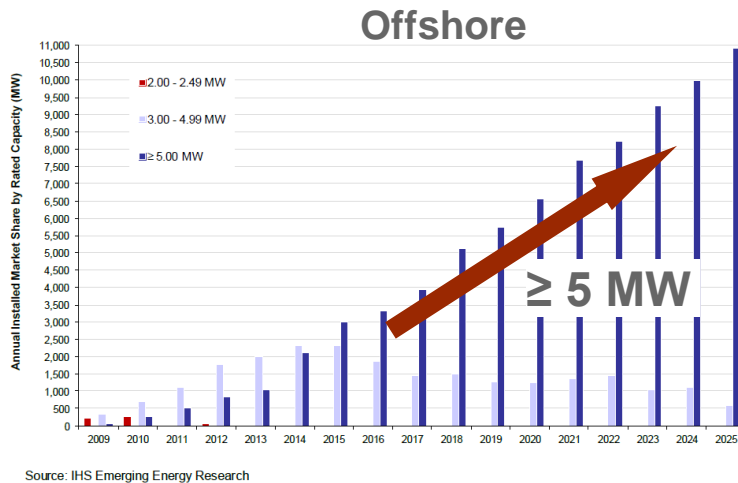
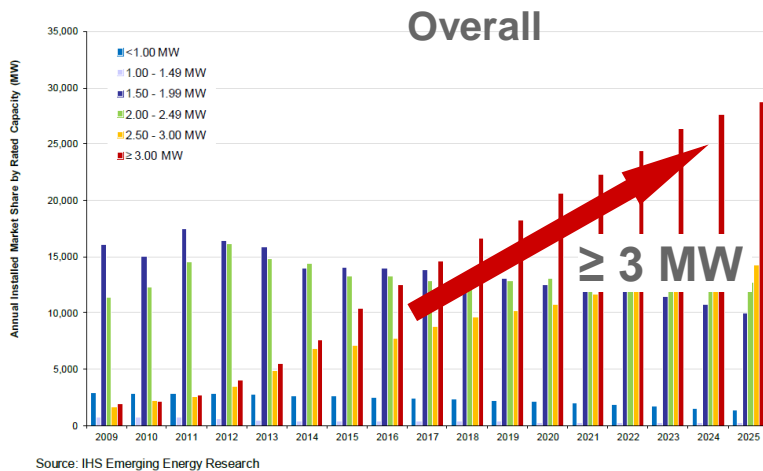
# Introduction to ABB MV Converter Technology

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- Full Power Converters
- MV and LV Converters Comparison
- ABB MV Converter Technology

# MV Converter Markets

## Future of Large Turbines



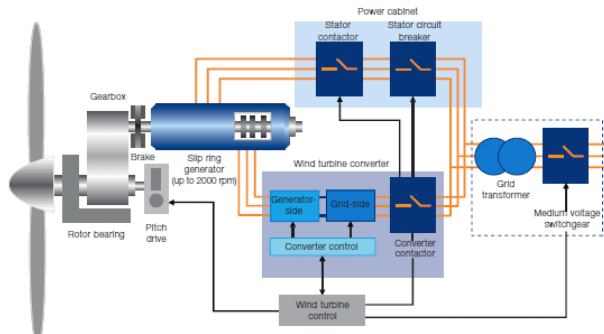
- Trend is that on- and offshore turbines have a different design
- Offshore turbines larger than 5 MW will be the majority of installed MW by 2015 and after that it will be the dominant size
- Offshore is a challenging and special segment; heavy research and development is required
- Focus is set on on simplicity and reliability



# MV Converter Markets

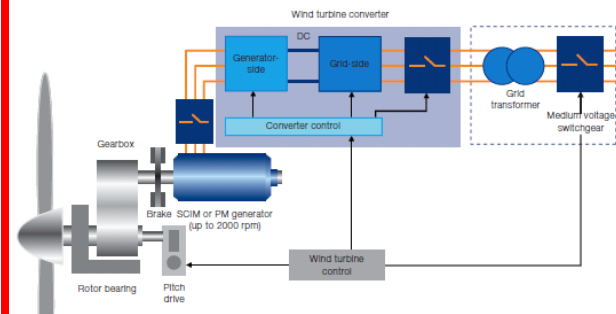
## Basic drive train concepts

**Doubly-Fed Induction Machine ( 30% speed)**



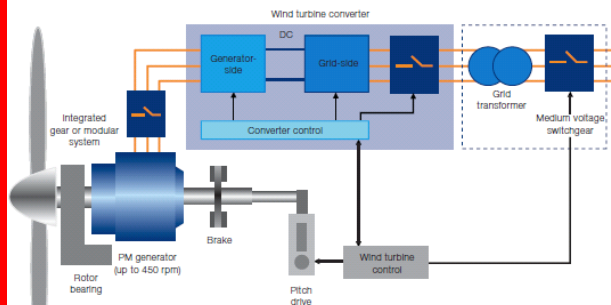
- Brushes & slip-rings
- 30 % Converter + 30 % StatCom Powerelectronics

**Squirrel-Cage Induction Machine (0-100% speed)**



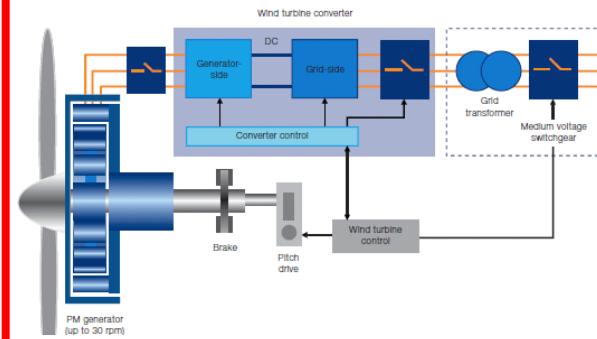
- Brushless
- 100 % Converter Power

**Permanent Magnet Machine (0-100% speed)**



- 100 % Converter Power

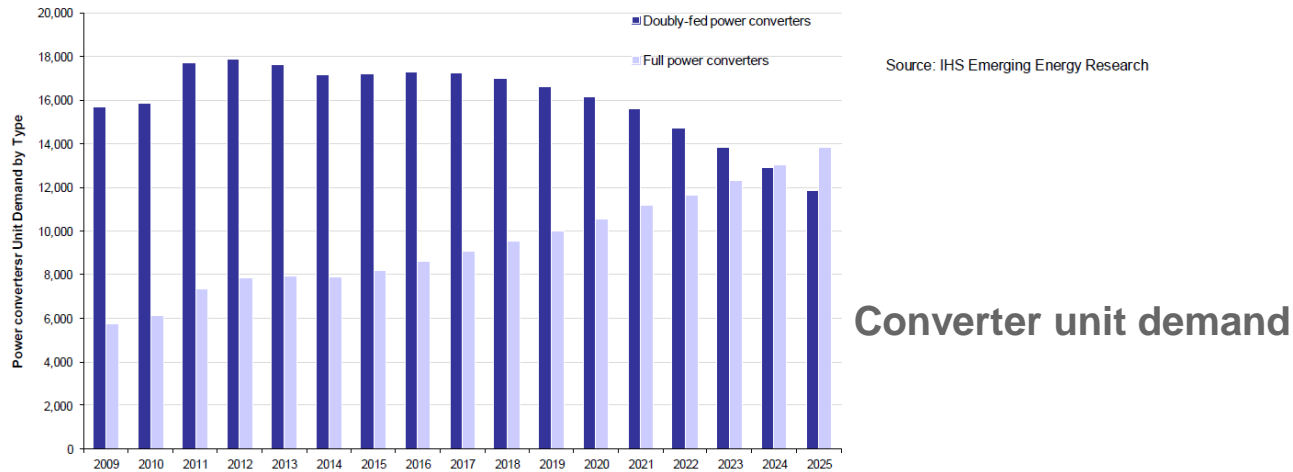
**Permanent Magnet DD Machine (0-100% speed)**



- Gearless
- 100 % Converter Power

# MV Converter Markets

## Advantages of Full Power Converters



- Most new turbines will be realized with full converter and permanent magnet generators
- Permanent magnet generators show high efficiency and high reliability
- Full converter systems allow decoupling of the mechanical and the electrical system, full grid code compliance and optimal power utilization
- Medium-voltage technology for large turbines

→ **More POWERFUL converters will be required!**



# Full Power Converters

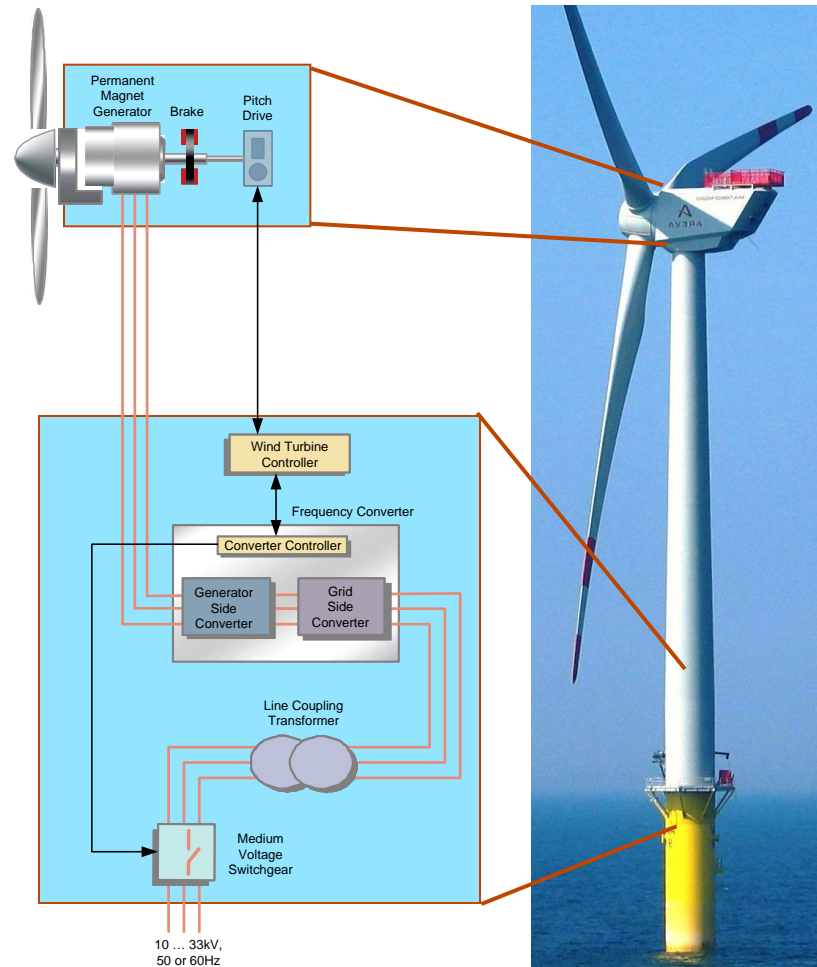
## Typical layout – large scale offshore turbine with full power converter

- Nacelle:

- Gearbox if used
- PM Generator
- Mechanical Brake
- Pitch Drive

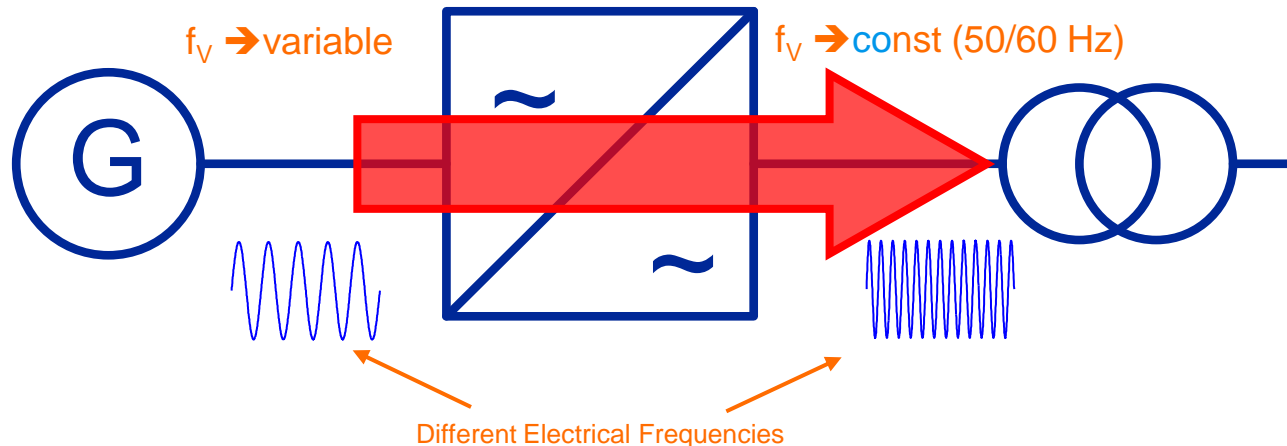
- Lower section of the tower

- Wind Turbine Controller
- Power Converter
- Main Transformer
- Auxiliary distribution
- MV Switchgear



# Full Power Converters

## Key Features

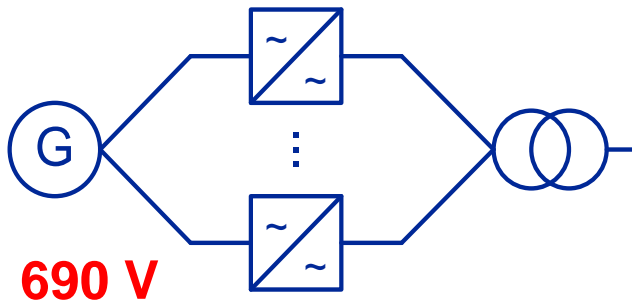


- 0...100% speed variability  $\rightarrow$  wind turbine operation at its optimum
- Decoupling of mechanical parts from the electrical grid  $\rightarrow$  maximal drive train damping
- Full generator control
  - Active and reactive power on the generator side controlled independently from the grid
  - Motor operation for testing and precise rotor positioning
- Full grid control
  - Active and reactive power control for optimal support of the grid  $\rightarrow$  grid code compliance
  - High and low voltage ride through

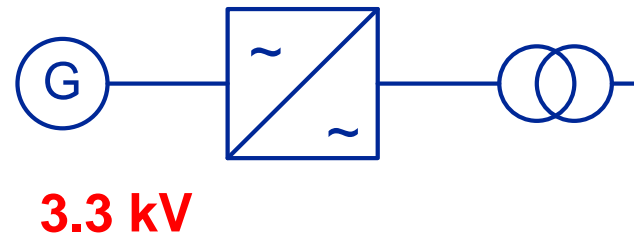
# MV and LV Converters Comparison

## Higher Power → Higher Current or Higher Voltage

- There are two different converter concepts that can be applied in order to reach higher power levels.
- Low voltage converters are operated in **parallel** to handle the current that increases when the power is higher.
- MV converters runs on a **higher voltage level**. Thus the currents are lower than in a system of the same power level operated at lower voltages



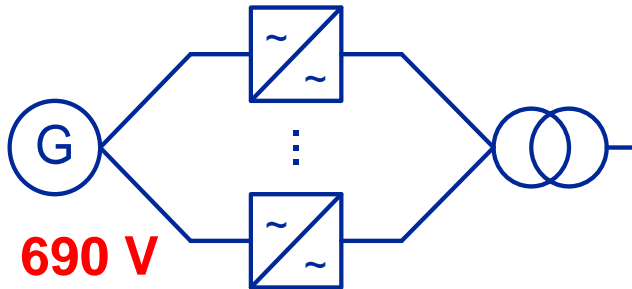
Paralleled LV converters



Single MV converter

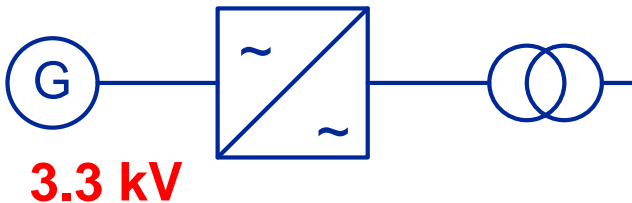
# MV and LV Converters Comparison

## Higher Power → Higher Current or Higher Voltage



- LOWER VOLTAGE  
HIGHER CURRENTS
- Modules in parallel
- More semiconductors
- Availability by redundancy

Paralleled LV converters

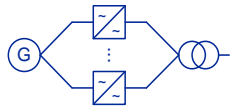


Single MV converter

- HIGHER VOLTAGE  
LOWER CURRENTS
- One single converter handles up to 9 MVA
- Less semiconductors
- Availability by low parts count
- As the power increases, MV is the only practical solution

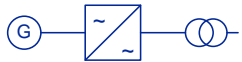
# MV and LV Converter Comparison

## ABB's converter portfolio



ACS 800

- 690 V
- Paralleled for larger powers
- Maximum of 6MW
- BU LV Drives (Finland)



PCS 6000

- 3.3 kV / 4.1 kV
- Up to 9 MVA
- BU MV Drives and Power Electronics (Switzerland)

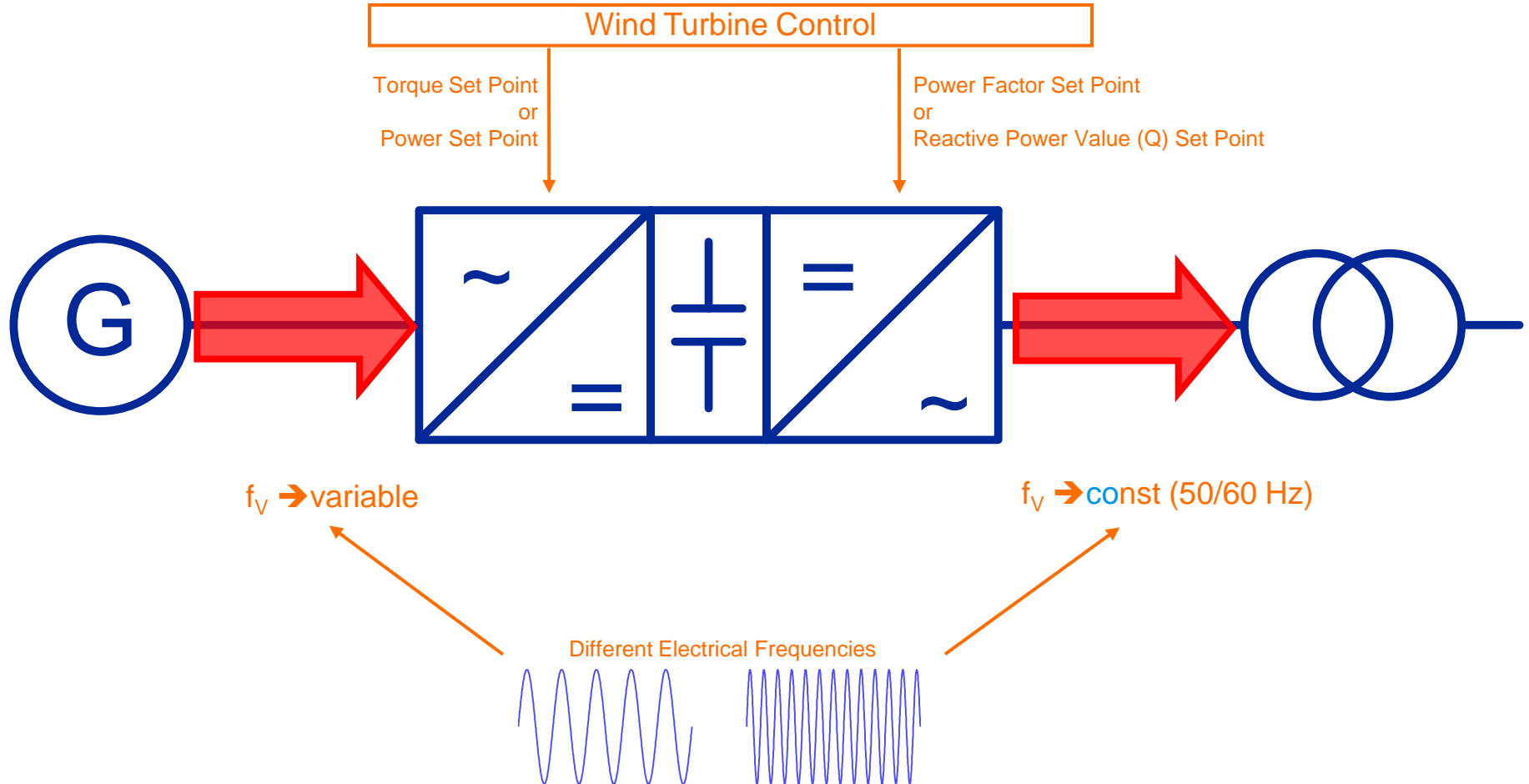
**Let's talk about ABB's  
MV converter technology today!**

# ABB MV Converter Technology



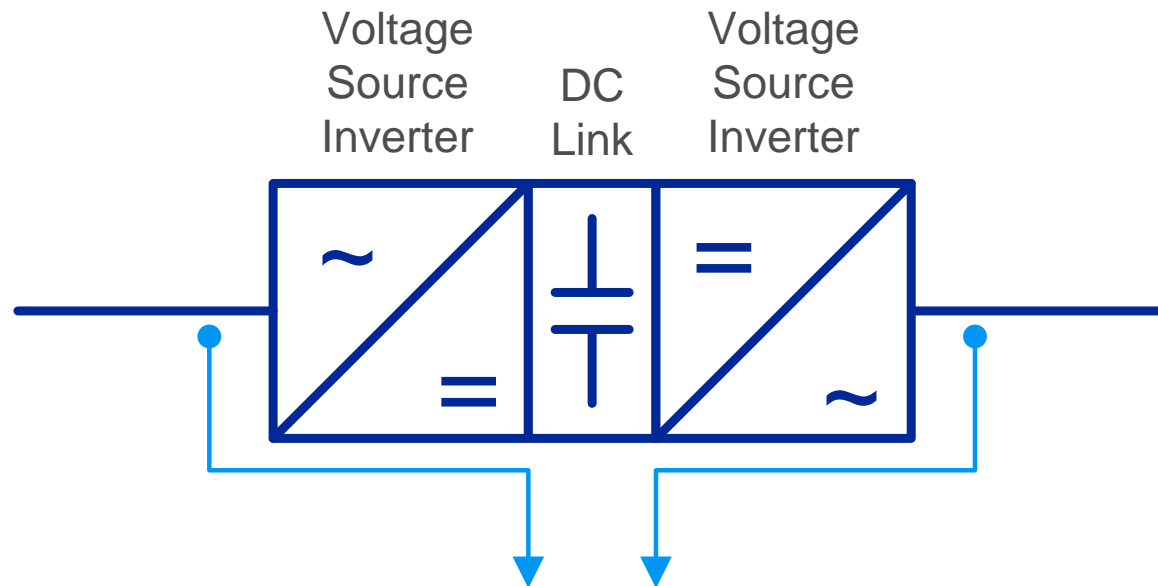
# ABB MV Converter Technology

## Operating Principle



# ABB MV Converter Technology

## Voltage source inverter basics



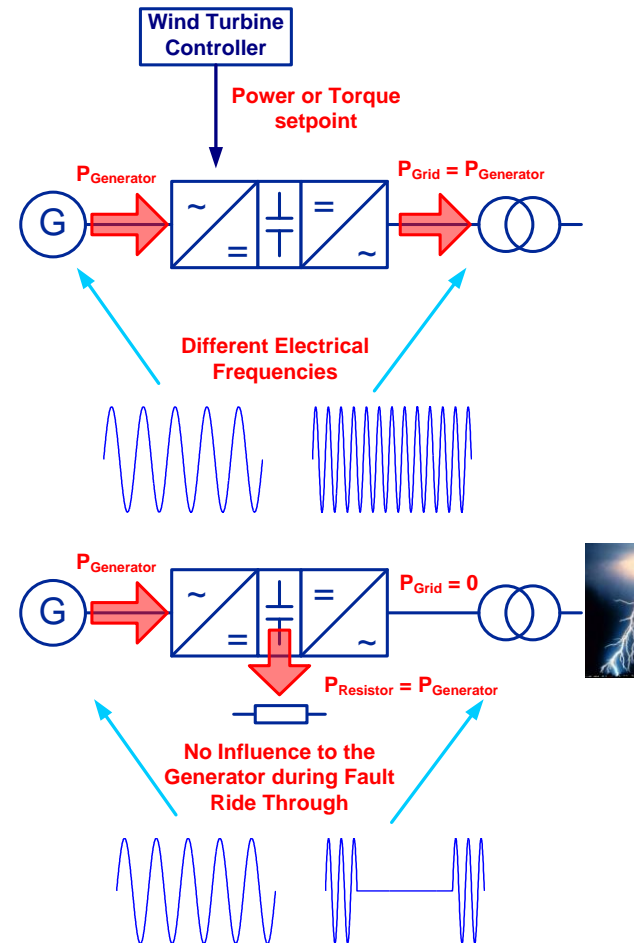
**Adjustable Parameters:**  
Frequency  
Voltage level  
Voltage phase shift



# ABB MV Converter Technology

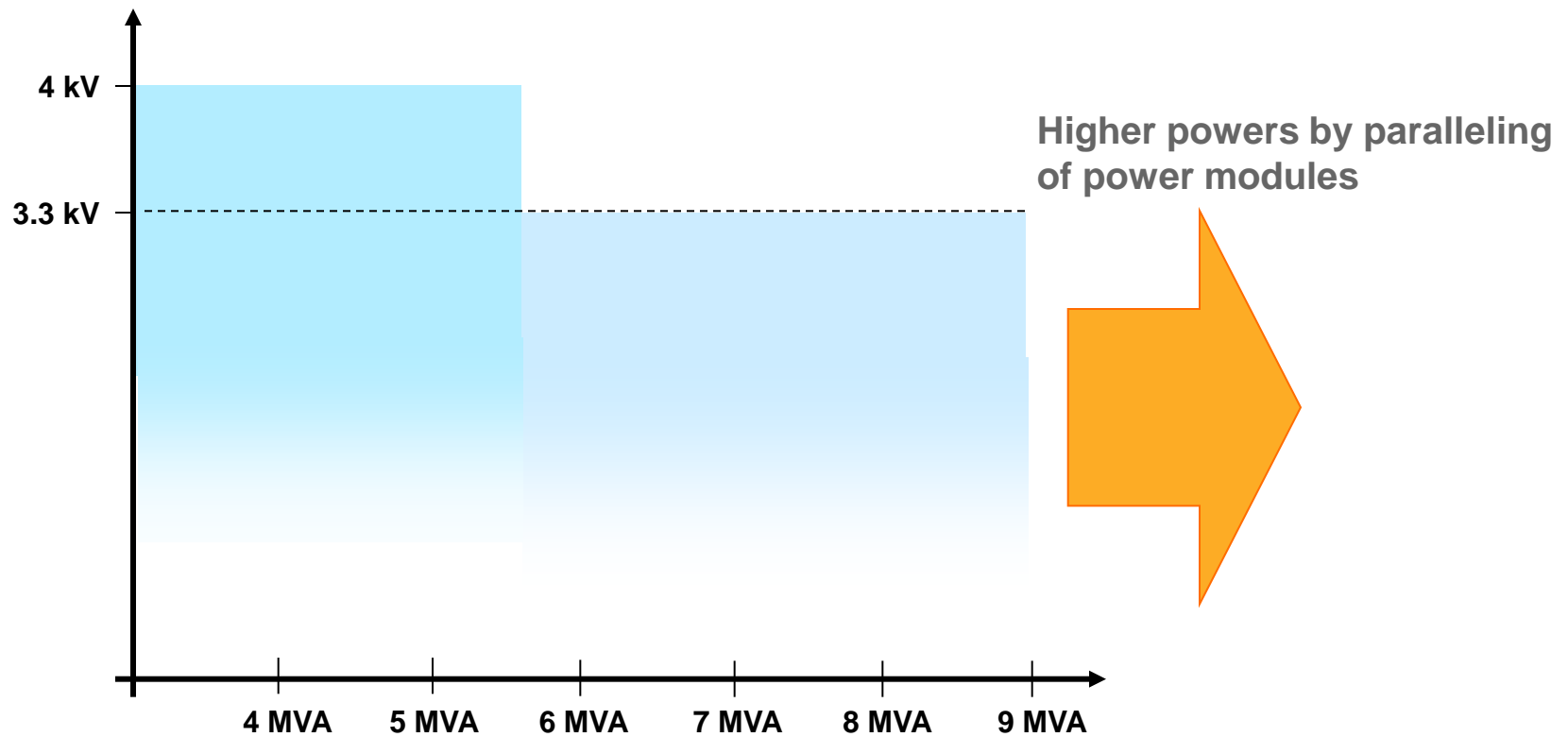
## Main tasks

- Active Power Control
  - The generator will be loaded with the torque value set by the wind turbine controller
- Decoupling the generator from the grid:
  - Full control of the generator speed and torque during normal and fault ride through operation
- Reactive Grid Power Control:
  - Grid stabilization
  - Operation at different power factors
- Special Tasks:
  - Rotor Positioning mode
  - Back to Back test operation



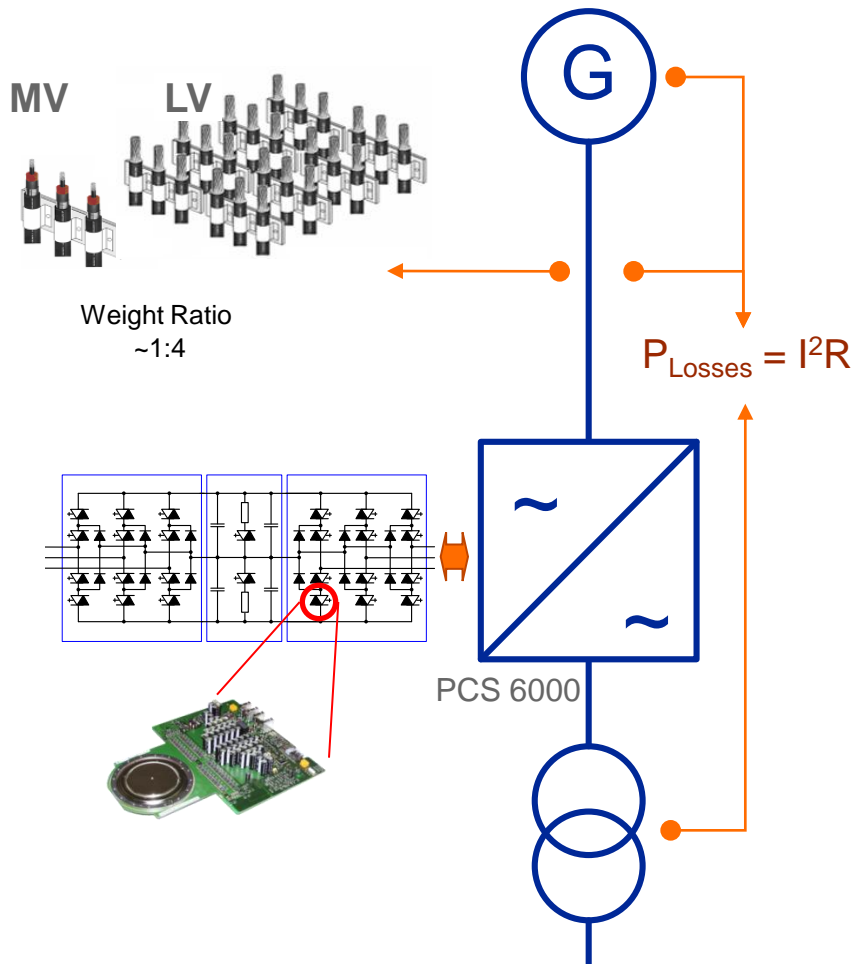
# ABB MV Converter Technology

## Power Range of the PCS 6000 Wind



# ABB MV Converter Technology

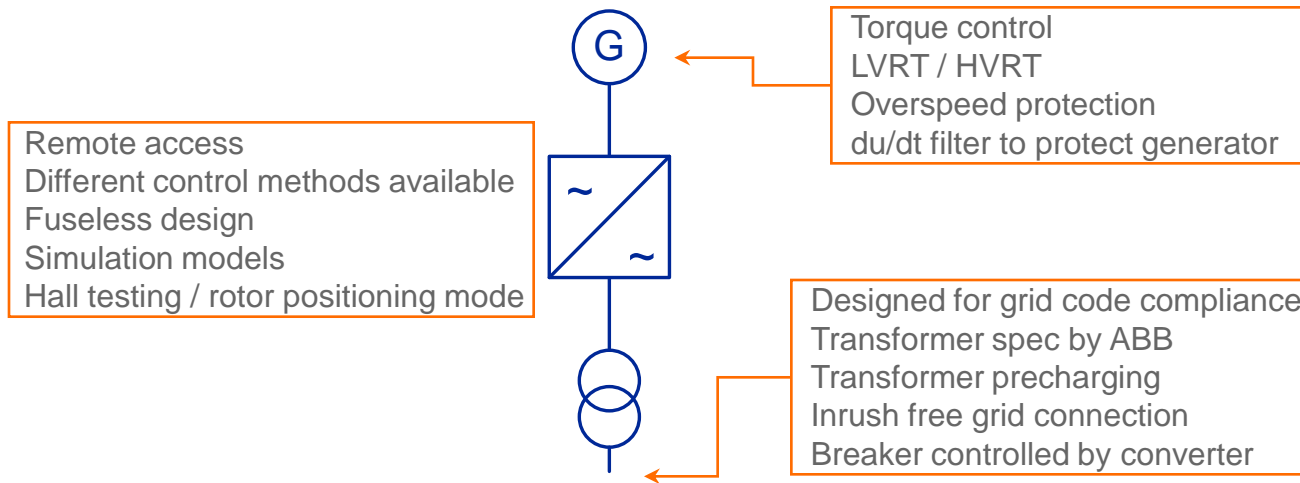
## Features of the PCS 6000 Wind



- **LESS LOSSES**  
Lower currents and thus less losses ( $I^2R$ ) in generator, converter, transformer and it's interconnections
- **EASY CABLING**  
Much smaller cabling, easy arrangement of converter and transformer in tower foot  
→ saving nacelle weight
- **ONLY 26 SEMICONDUCTORS**  
With MV technology, no paralleling of components is required. This leads to reduced parts count and thus higher reliability, less complexity and less footprint.
- **PROVEN INDUSTRY STANDARD**  
MV converter technology is standard in industrial applications of comparable power levels

# ABB MV Converter Technology

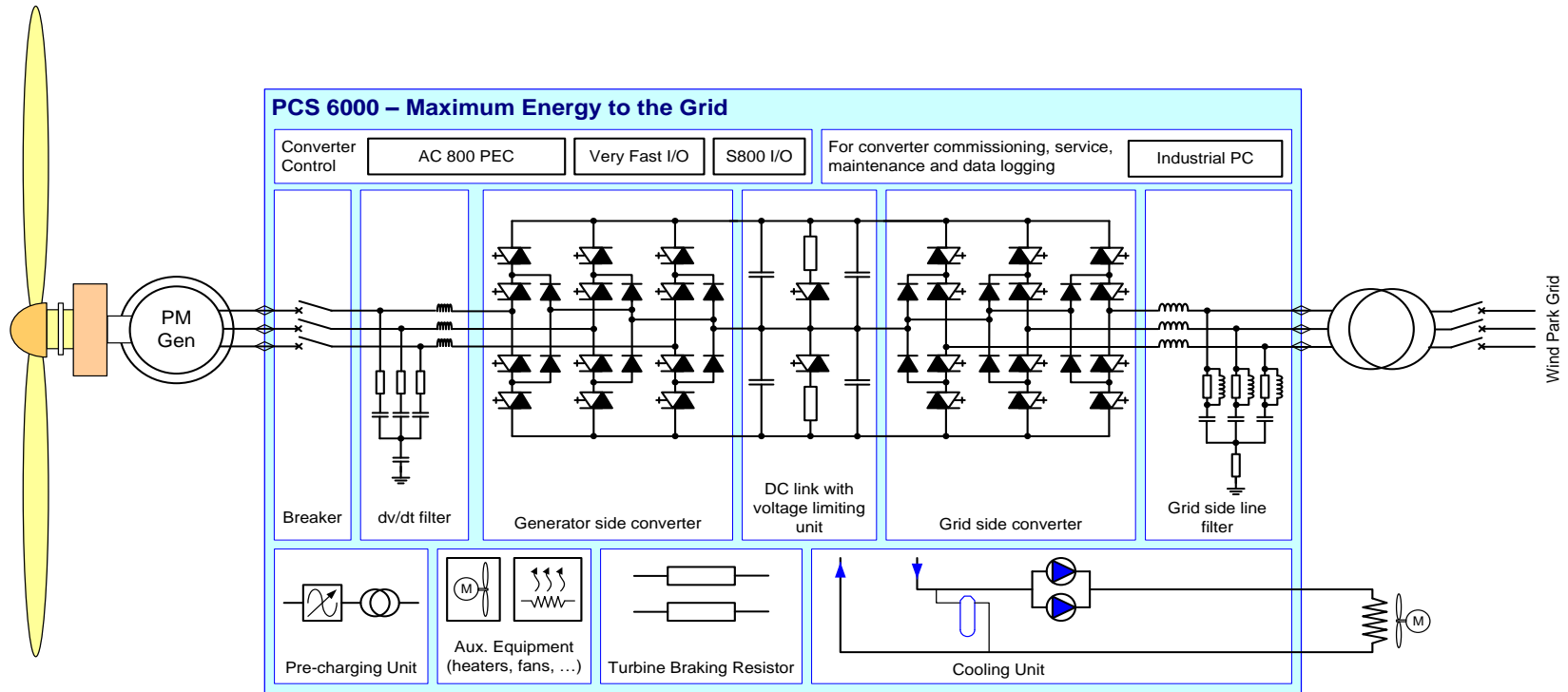
## Our System-Oriented Approach



- The converter system has a strong influence on the whole drive train
  - Several drive train components depend on the power converter
  - Power converter acts as link between mechanical system and electrical grid
- We provide a broad experience and deep system knowledge
  - ABB has dedicated specialists for grid code requirements and certification
  - Various simulation models are available - even customized models on request
  - Specifications for system relevant components such as transformer and main circuit breaker are provided by ABB

# ABB MV Converter Technology

## The Modular Concept at a Glance

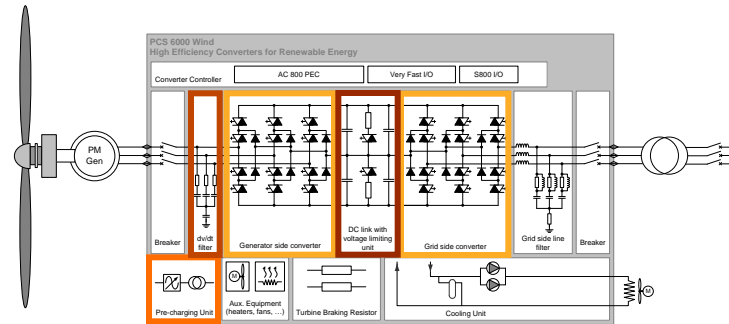


The PCS 6000 modular converter family has a range from 3 to 9MVA with an output voltage of 3.3kV or 4kV. The modular concept allows high flexibility for customized converter solutions at the advantage of standardized high volume production of the different modules.

The cooling unit, filters, circuit breakers and auxiliaries can be integrated in the cabinets of the converter system and thus allow a very compact footprint.

# ABB MV Converter Technology

## Main Components



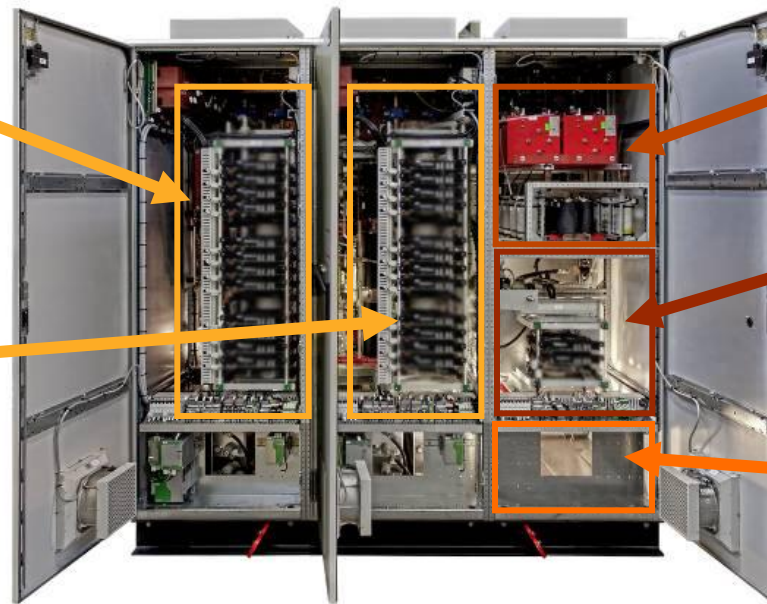
Grid-side Converter

Generator-side Converter

du/dt filter

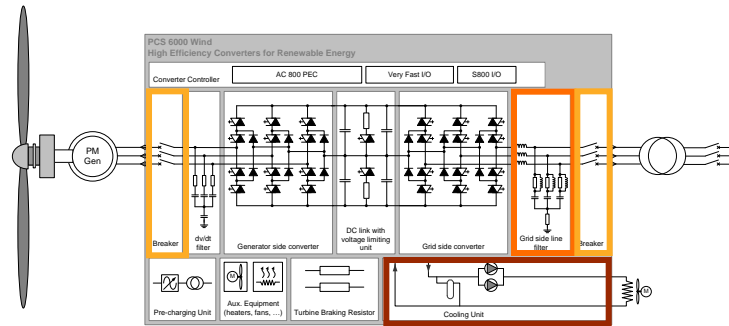
Voltage limiting unit (brake chopper)

Precharging unit



# ABB MV Converter Technology

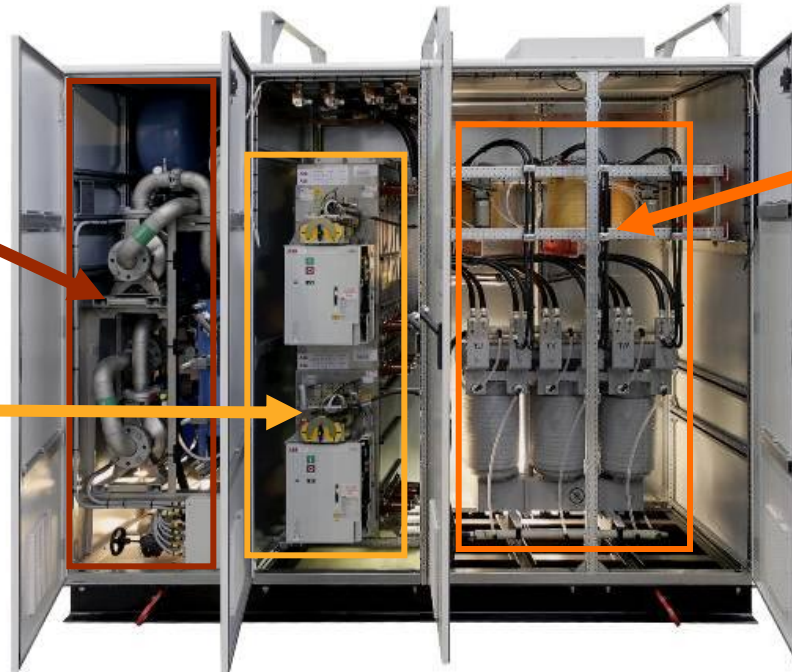
## Main Components



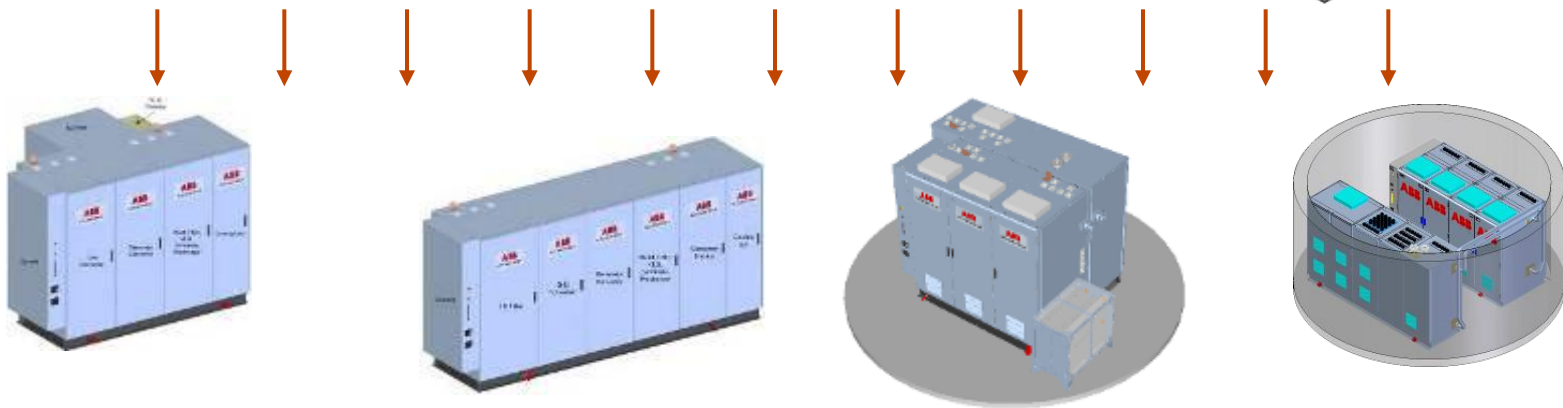
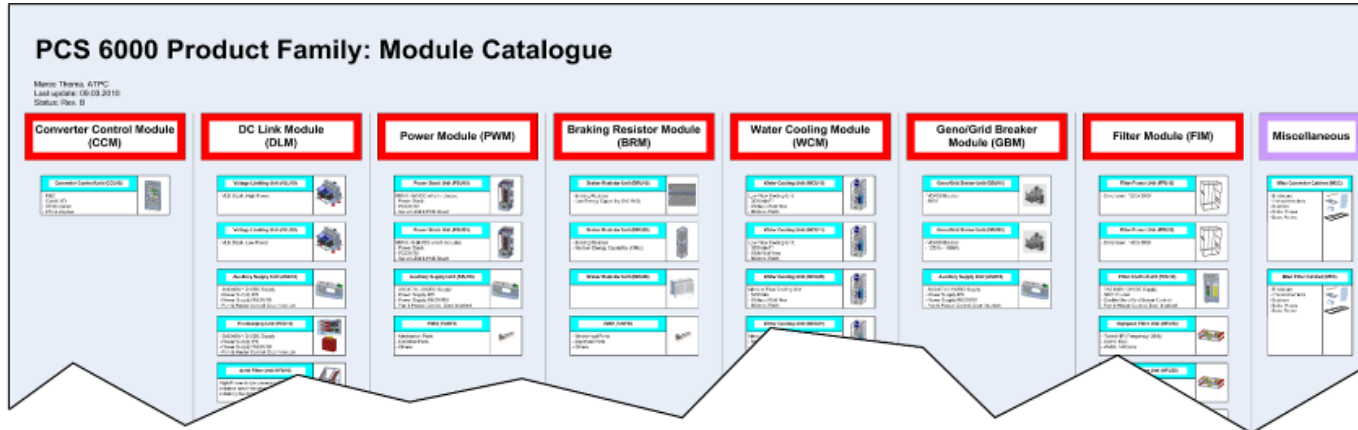
Cooling unit

Circuit breakers

Grid side filter



# ABB MV Converter Technology PCS 6000 Family Modularization



High degree of standardization  
High degree of flexibility  
High degree of integration



# ABB MV Converter Technology

## References of the Technology Platform



PCS 6000 Wind  
 Frequency converter for application in wind turbines  
 > 300 MVA delivered



ACS 6000 MV Drive  
 Frequency converter to drive an electrical motor  
 > 13'000 MVA delivered



PCS 6000 STATCOM  
 Frequency converter for reactive power control  
 > 200 MVA delivered



PCS 6000 Rail  
 Frequency converter to connect railway with regular grid  
 > 950 MVA delivered



# ABB MV Converter Technology

## References of the PCS 6000 Wind

### Alpha Ventus

- First German offshore wind park
- 6 PCS 6000 successfully commissioned in the Areva M5000 wind turbine
- First offshore wind turbine applying MV converter technology
- 5 MW permanent magnet generator



### PCS 6000 Wind



### Series Production

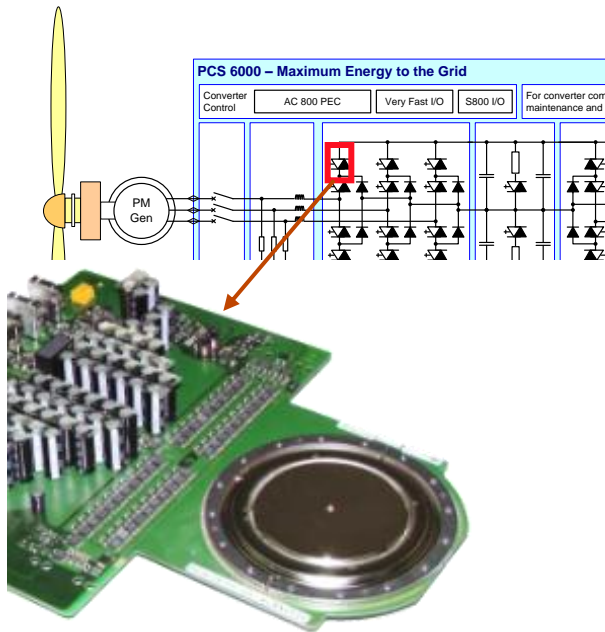
- New factory in Poland with annual capacity of 200 units (+600)
- Ongoing production of PCS 6000 for 5MW offshore turbine

### Prototypes

- Factory in Switzerland with annual capacity of 30 prototype units
- Several prototype projects
- Wind and tidal applications
- Power range 1.1 to 6.5 MW

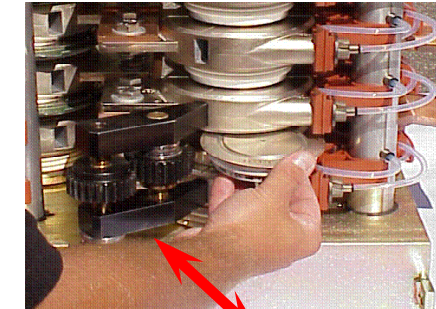
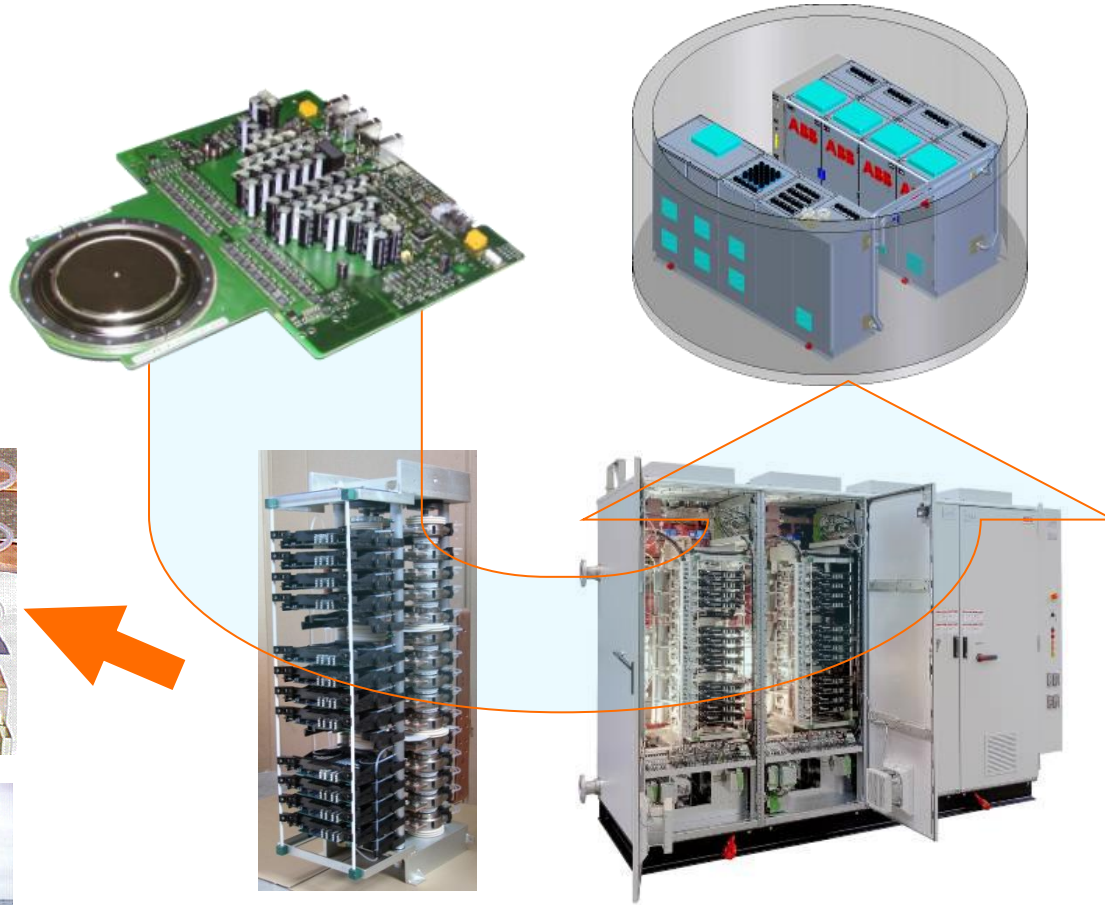
# PCS 6000 Wind Key Components

## IGCT



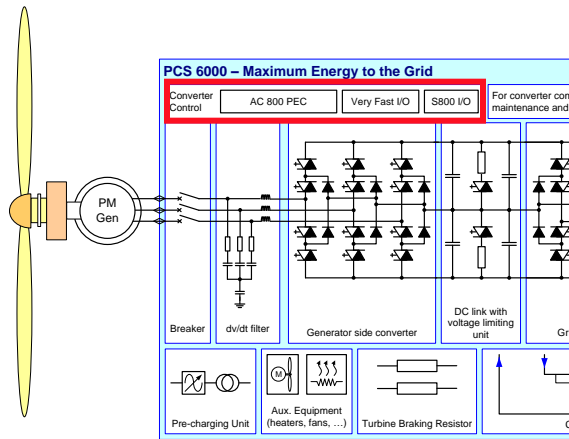
- The IGCT (Integrated Gate Commutated Thyristor) is a switch, which can be turned on and off by a fibre optic signal.
- The IGCT is of a very robust design and has the best balance between robustness, efficiency, cost and reliability for medium voltage converters.
- The IGCT is explosion safe and optimal for load cycling as faced in the wind industry.
- Reverse conducting 6kV IGCT's for the lower power range (4kV AC) and asymmetric 4.5kV IGCT's for the higher power range (3.3kV AC) are used

# PCS 6000 Wind Key Components From IGCT to a 9MVA Converter

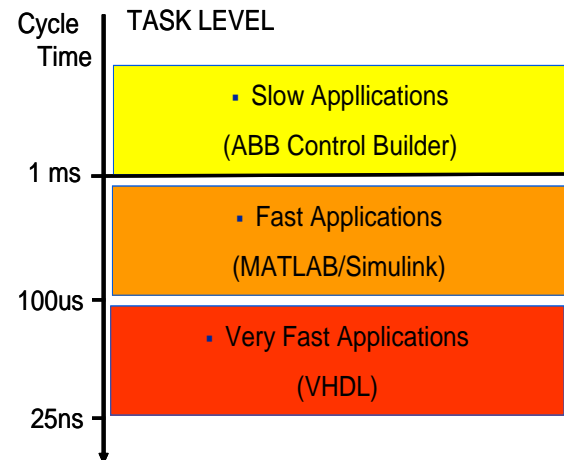


# PCS 6000 Wind Key Components

## The control hardware



- The AC 800PEC (Power Electronic Controller) is used as the main controller. The 600MHz RISC 64-bit processor allows complicated control circuits
- All the control equipment is running on 24VDC and fiber optics.



# PCS 6000 Wind Key Components

## The P3 Pfisterer© PLUG System

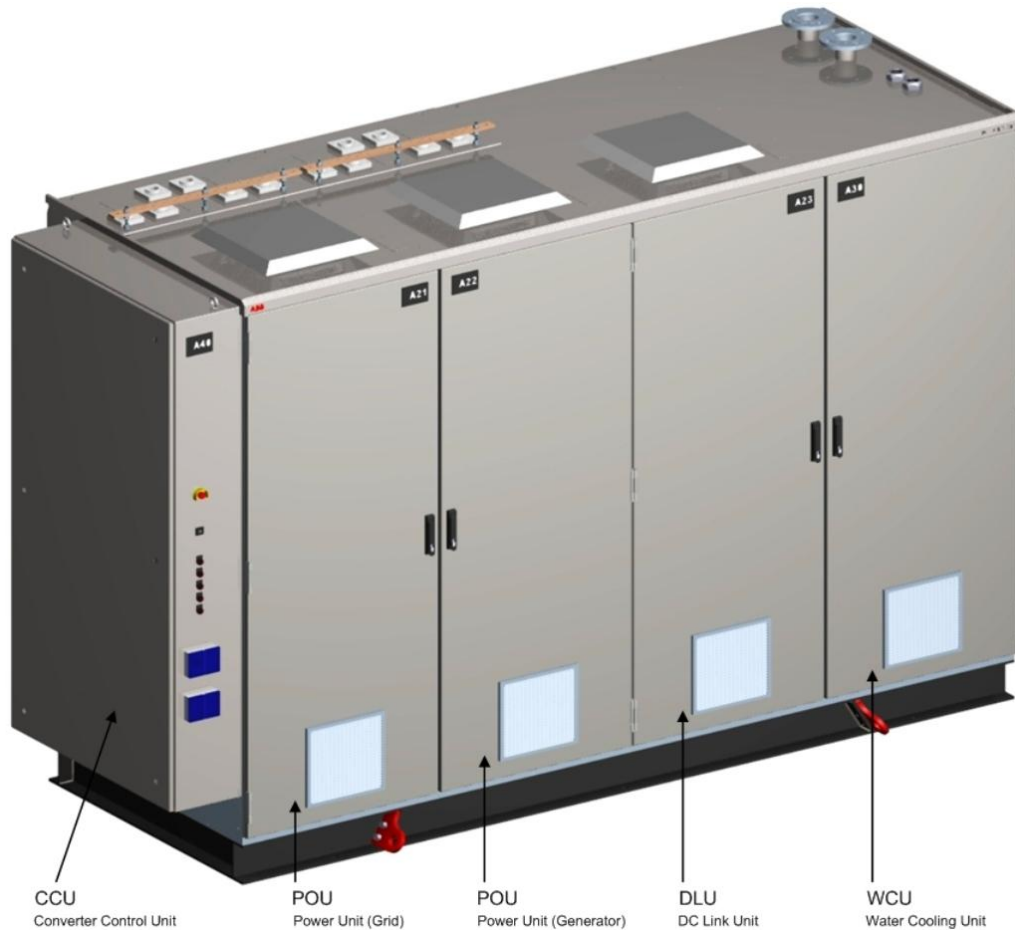


- Pre-manufactured and tested cables with plug
- No opening of cubicles during installation
- 100% water proof



# PCS 6000 Wind Mechanical Layout

## Typical Dimensions Converter Cabinet



3200 x 1200 x 2445

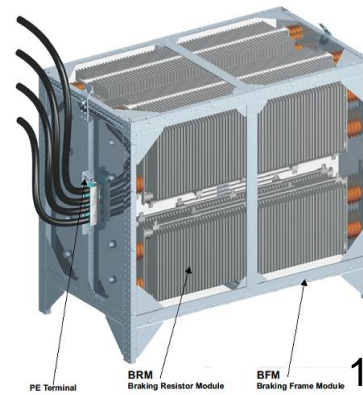
126" x 47" x 96"

(L x W x H / mm)

Approximately 5000 kg/11000lbs

# PCS 6000 Wind Mechanical Layout

## Typical Dimensions Filter Cabinet / Braking Resistors



1200 x 650 x 1025

47" x 25" x 40"

(L x W x H / mm)

Approximately 360 kg

2200 x 1000 x 2445

86" x 39" x 96"

(L x W x H / mm)

Approximately 3200 kg/7000 lbs



# Questions?

# Reminders

## Automation & Power World 2011

- Please be sure to complete the workshop evaluation
- Professional Development Hours (PDHs) and Continuing Education Credits (CEUs):
  - You will receive a link via e-mail to print certificates for all the workshops you have attended during Automation & Power World 2011.
  - **BE SURE YOU HAVE YOUR BADGE SCANNED** for each workshop you attend. If you do not have your badge scanned you will not be able to obtain PDHs or CEUs.

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for a better world™

