• Information contained in the following expresses general views and shall not be construed as an expression of the policies or views of Vestas.

• Information contained in the following shall not be construed as detailed description of the properties or functioning of wind turbines manufactured by Vestas.

• Information contained in the following should merely be viewed as a contribution to the debate on the development of grid code requirements and the utilization of the potential of wind turbines in securing grid stability.
Contents

• Vestas information
• Situation
• Vestas Wind turbines
• DFIG (8 slides)
• ASG (5 slides)
Vestas information

- Global installed capacity in 2004: 8,154 MW (source BTM 2005)
- Global accumulated installed capacity 2004: 47,912 MW (source BTM 2005)
- Market position 2004: 1º 34,1% (source BTM 2005)
- Market for W.T. Up to 1,5 Mw: 42 % (source BTM 2005)
- Wind turbines:

![Wind Turbines Chart]

<table>
<thead>
<tr>
<th>Year of installation</th>
<th>Capacity (kW)</th>
<th>MWh/year</th>
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Situation

- Electrical grids with a high number of wind turbines
- Weak grids

Solutions:

It is necessary to create wind turbines with the same behaviour as traditional generators (big synchronous)

- Improve the response of the WT during faults in the grid (no disconnection and injection of reactive current).

- Systems Prediction of the energy that the wind turbines will produce.

- Possibility to use, if the grid operator demands it, frequency and voltage controls.
Vestas wind turbines

• Double feed induction generator (DFIG):
  - Pitch control
  - Variable speed

• Asynchronous generator (ASG):
  - Active stall
  - Fixed speed
DFIG

- IN THE PAST: INSTANTANEOUS DISCONNECTION OF THE DFIG TO PROTECT ELECTRONIC DEVICES

- NOWDAYS:

GRID SUPPORT ➔ NO DISCONNECTION ➔ A.G.O. solution (advanced grid option)

REACTIVE CURRENT SUPPORT ➔
• VOLTAGE TOLERANCE FOR SYMMETRICAL FAULTS (LOW VOLTAGE SIDE)

![Graph showing voltage tolerance for symmetrical faults (low voltage side)](image)

• VOLTAGE TOLERANCE FOR ASYMMETRICAL FAULTS (LOW VOLTAGE SIDE)

![Graph showing voltage tolerance for asymmetrical faults (low voltage side)](image)
• Pitch system: The system control pitch has been improved in order to have good response during the faults in the grid.

• U.P.S: A back-up power system has been installed in order to supply the energy required to the control systems and necessary devices during the grid faults, at most during 30 seconds.
● Converter:
The rotor converter has been reinforced in order to support the greater currents during the faults. Because of this, the control of the converter will not be lost during the fault.

Current contribution for symmetrical faults

● Chopper:
The Chopper is the system for dissipating the excess energy in the D.C. Bus that could be created during the faults.
• Velocity sensor:
  A velocity sensor is used to control the position during the fault.

• Control:
  The system control of the wind turbine has been improved, in order to gain a better dynamic response. (storage of cynetic energy, damping oscillations, etc)
• TEST BENCH RESULTS (2MW WIND TURBINE):
ASYMMETRICAL FAULTS (500ms- 75% OF RATED POWER)
• HVDC TEST RESULTS (2MW WIND TURBINE):
  SYMMETRICAL FAULTS (500ms – U*0.2 - 100% RATED POWER)
• Pitch system: Design modifications to pitching system

• Design changes and modifications to protection philosophy, controller algorithms and settings

• U.P.S supply on all auxiliary systems

• Dynamic power factor correction with 20ms response time
• VOLTAGE TOLERANCE FOR SYMMETRICAL AND ASYMMETRICAL FAULTS FOR SPANISH MARKET (LOW VOLTAGE SIDE)
• FIELD TEST RESULTS (1,65MW WIND TURBINE):
  ASYMMETRICAL FAULTS (400ms - U*0,5 - 100% OF RATED POWER)
• FIELD TEST RESULTS (1,65MW WIND TURBINE):
  SYMMETRICAL FAULTS (500ms - U*0,2 - 67% OF RATED POWER)