ACCIONA Windpower

Wind turbine active power regulation and grid frequency events control

Miguel Amézqueta
Bladed User Conference 2015
Hamburg, October 8th 2015

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Agenda

- **Acciona Windpower Overview**
- **Power Regulation and Frequency Events Control**
- **Control verification**
- **Conclusions and Open issues**

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1

ACCIONA WINDPOWER OVERVIEW

Pioneers in development and sustainability

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Manufacture of wind turbines

In-house turbine technology by ACCIONA Windpower

- **Reliable and robust machines** based on +15 years' experience in O&M and knowledge of 10 third-party technologies
- **3.0 and 1.5 MW platforms** with 98% of overall availability
- **Towers with hub height 60-137.5 m** made from steel or concrete
- **Near 6 GW in service, contracted or contingent** in 18 countries

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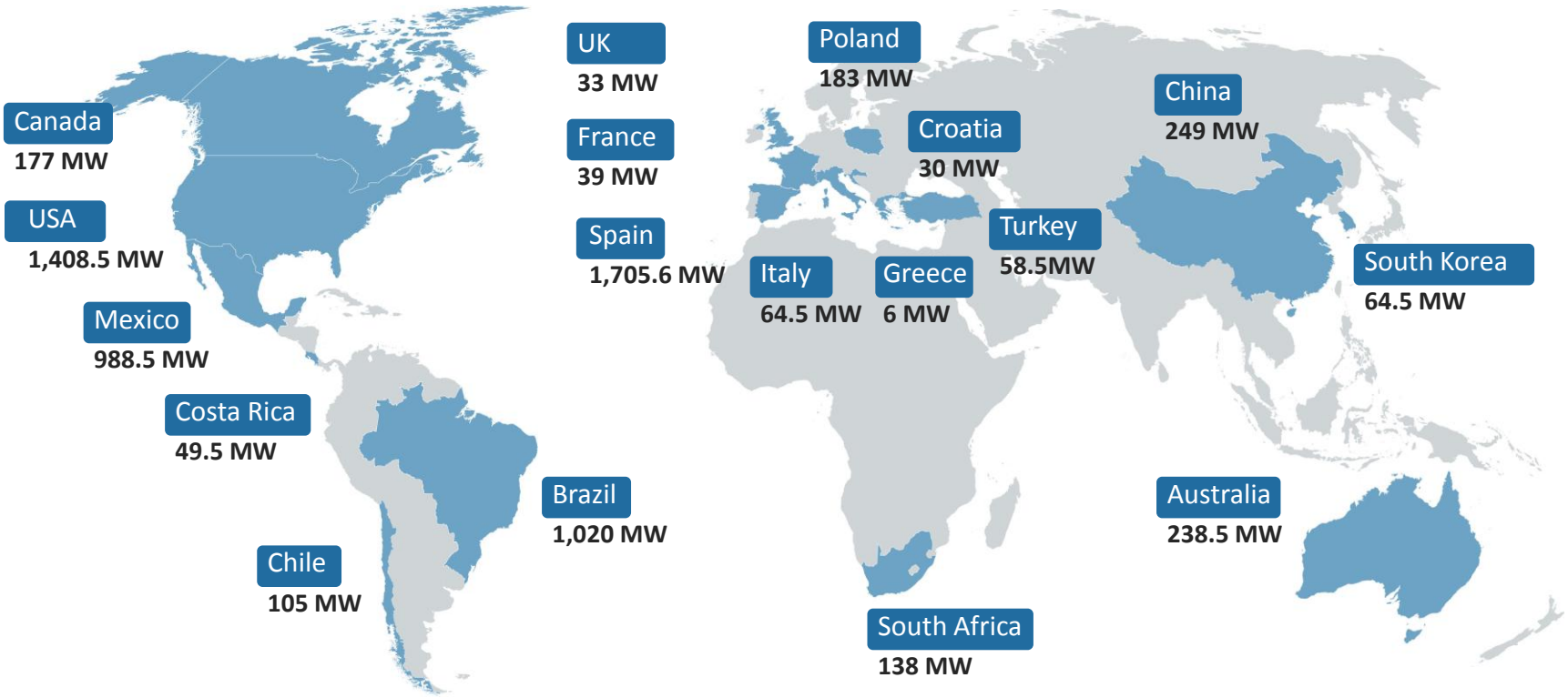
ACCIONA Windpower. More than 6.5 GW supplied worldwide



Total contracted capacity: **6,561.1 MW**

(Cumulative sales and orders as of 31.03.2015)

● Countries with supplied or contracted AW wind turbines

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AW 3000 wind platform: commercial success

2,448 MW contracted since 2013

84% capacity for customers

Competitive Costs 28% down in 2 years

Versatile 100-132 m rotors for any wind class

Global Demanded by growing markets -Brazil, Mexico, Turkey, Chile, S.Africa-and developed ones -USA, Canada-.

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El Perdón wind farm (20 MW) in Navarre (Spain). The first one installed by the Group (1994-1996)

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2

Power Regulation and Frequency Events Control

ACCIONA WINDPOWER approach

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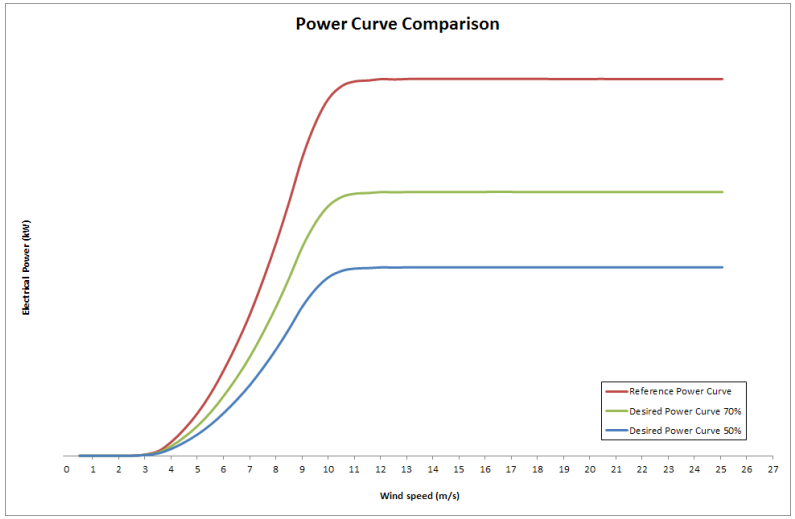
Power Regulation and Grid Frequency events control

- **Wind farm operators are demanding more control in total power supplied by their wind farms**
  - ✓ Grid codes demand systems of control and regulation of active power
  - ✓ As an example, Polish grid code says:

A wind farm should be equipped with a farm control and regulation system of:

(1) active power (system of control and regulation of active power),

  - ✓ Achieved by a combination of wind turbine and substation general controller system of the wind farm
  - ✓ The rate of power reduction should be according to the grid code
  - ✓ Up to 95% regulation of wind turbine rated power has been required



ACTIVE POWER DESIRED

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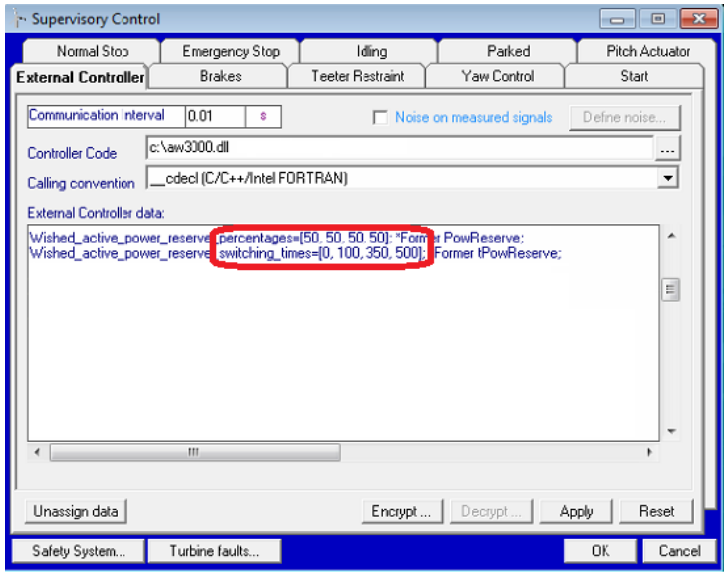
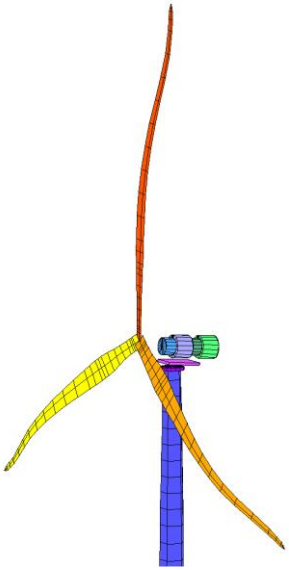
Power Regulation: solution adopted

- **Solution adopted in Bladed environment:**
  - ✓ Implemented by using External Controller tool
  - ✓ Estimation of the total power capability has to be done
  - ✓ Different strategies depending on the wind speed
  - ✓ Total power reduction of every wind turbine should be done at proper rates



Power production regulation definition



Wind Turbine Model

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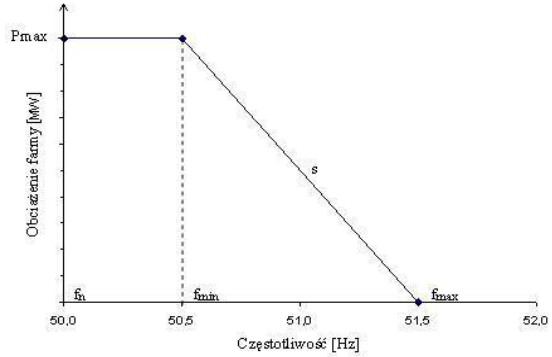
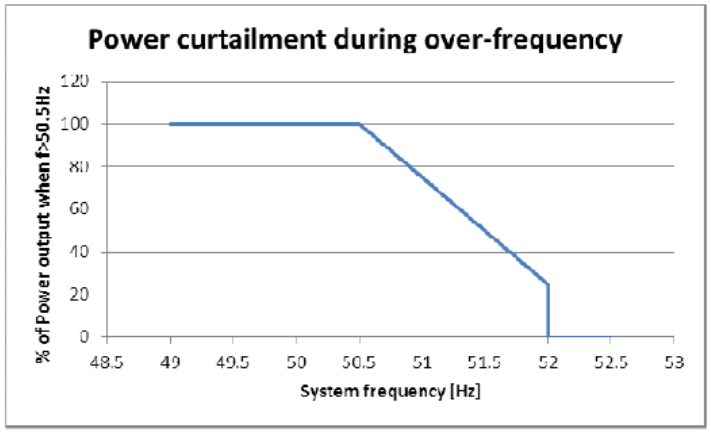
Grid Frequency events control

- **Active power regulation in grid frequency events**
  - ✓ Wind turbines are located in countries with grid codes increasingly stricter
  - ✓ Besides, wind turbines are increasingly located in countries where the grid is weaker than in industrialized ones
  - ✓ Each wind turbine must react to grid frequency events
  - ✓ The required behavior depends on the grid code of each country
  - ✓ Total active power reduction of every wind turbine should be done at proper rates during frequency events
  - ✓ As an example, Polish and South African grid codes demands:

In such a case, a default value of the decrease rate in the active power should be taken as 5% of the rated power of the wind farm per second for the entire range of the active power load of the wind farm.



(3) Once the *frequency* exceed 52Hz for longer than 4 seconds the *RPP* shall be tripped to protect the *NIPS*.



Active power regulation required in grid frequency events

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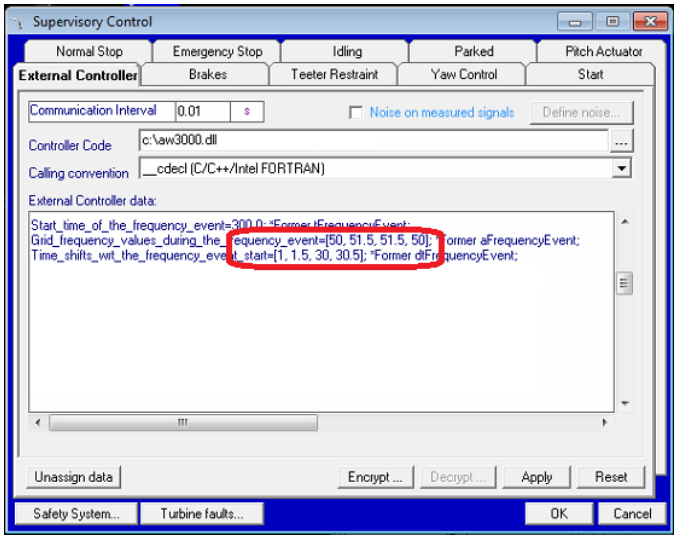
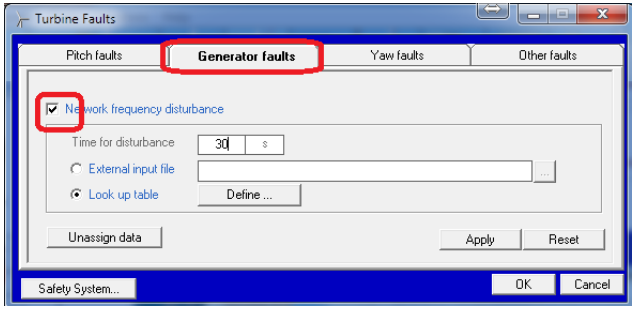
Grid Frequency events control: solution adopted

- **Solution adopted in Bladed environment:**
  - ✓ Implemented by using External Controller tool
  - ✓ Total power reduction of every wind turbine should be done at proper rates



Frequency Event Definition

  - ✓ Bladed Electrical module being studied by electrical department



Bladed network frequency disturbance definition

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3

CONTROL VERIFICATION

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Bladed simulation

- **Conditions considered**

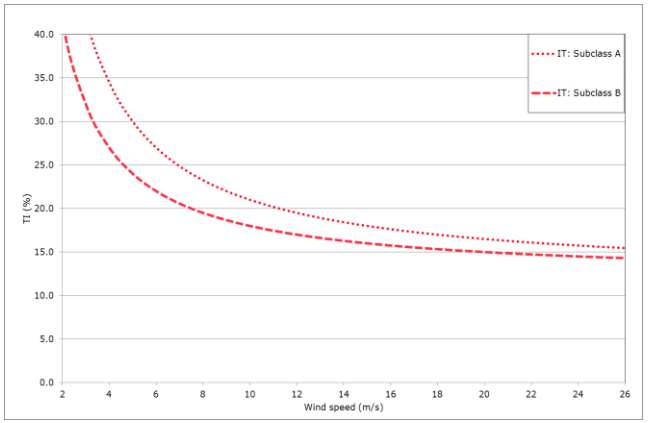
✓ Bladed simulations according to IEC 61400-1 ed.2 conditions

✓ Fatigue analysis performed considering active power regulation

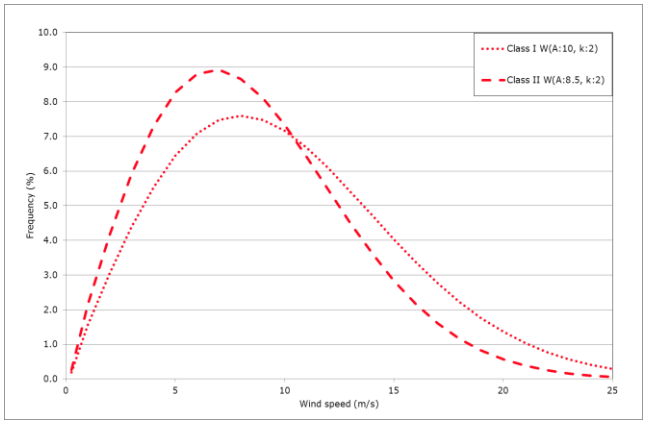
✓ Extreme analysis of the worst power production conditions performed

✓ Wind turbine design rules applied to the verification of the turbine behavior

- NTM
- NTM plus occurrence of fault
- NWP plus Normal Shut down
- Normal Production plus ECD, EOG_{50}, EWS
- Normal Production plus EOG_1 plus grid loss



Turbulence Intensity distribution



Wind Speed Distribution

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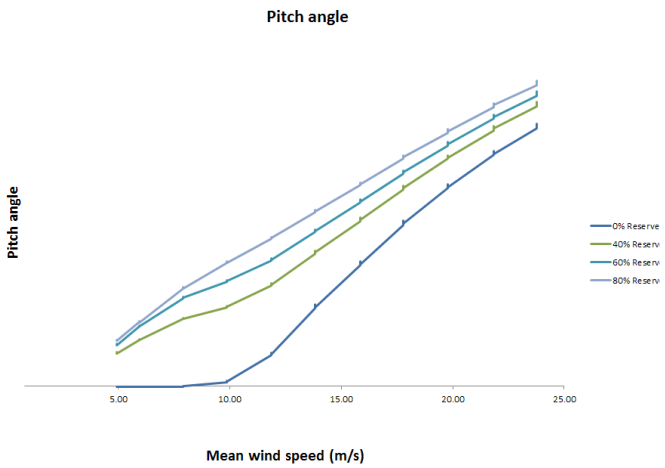
Control Verification

- **Verification of control behaviour**
  - ✓ Active power regulation reserves have been checked
  - ✓ Better accuracy at rated power and small active power reserves
  - ✓ Wind turbine works as expected

Mean wind speed (m/s)	Electrical Power Ratios		
	40% Reserve/ 0% Reserve	60% Reserve/ 0% Reserve	80% Reserve/ 0% Reserve
8.00	40.5%	58.0%	71.2%
10.00	41.3%	60.3%	78.0%
12.00	41.1%	60.9%	80.2%
14.00	40.9%	61.0%	81.2%
16.00	40.5%	60.8%	81.4%
18.00	40.5%	60.9%	81.6%
20.00	40.5%	61.0%	81.8%
22.00	40.5%	61.1%	82.0%
24.00	40.5%	61.3%	82.3%

Active power regulations achieved



Wind turbine behaviour

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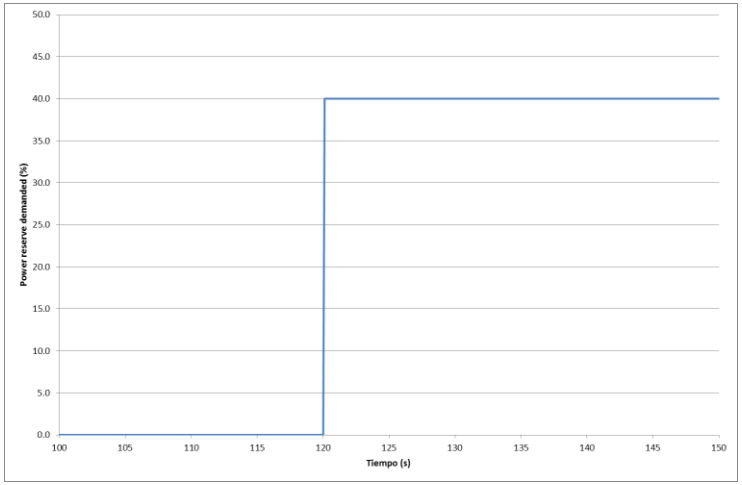
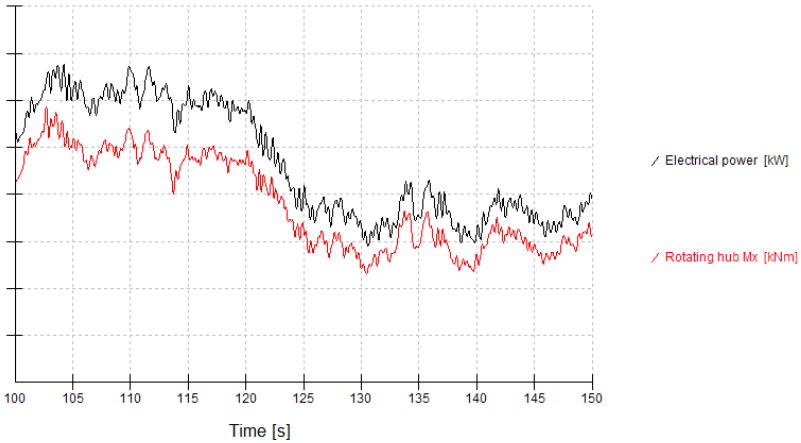
Simulations for control verification

- **Time series**
  - ✓ Correct behavior of the transitions have been checked

Transitions between active power reserves



Active power regulation required



Answer of the wind turbine

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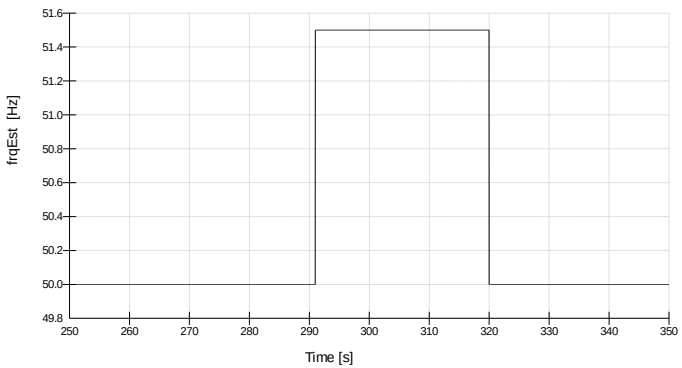
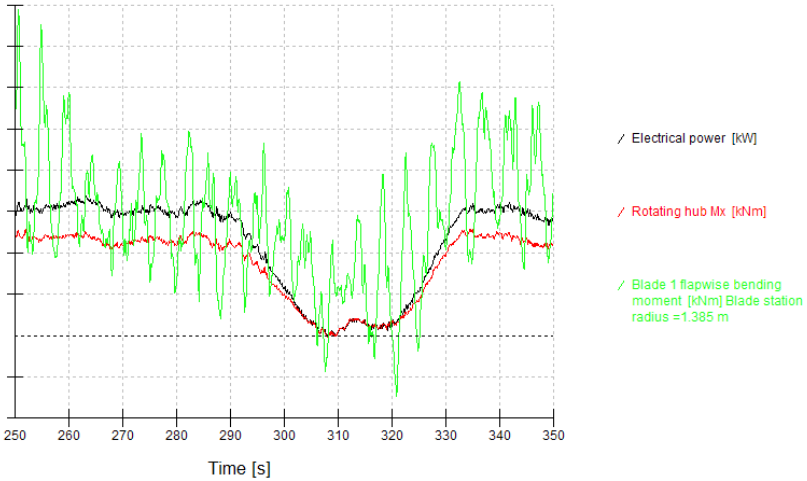
Simulations for control verification

- **Time series**
  - ✓ Correct behavior of the transitions have been checked

Overfrequency event



Grid frequency event simulated



Answer of the wind turbine

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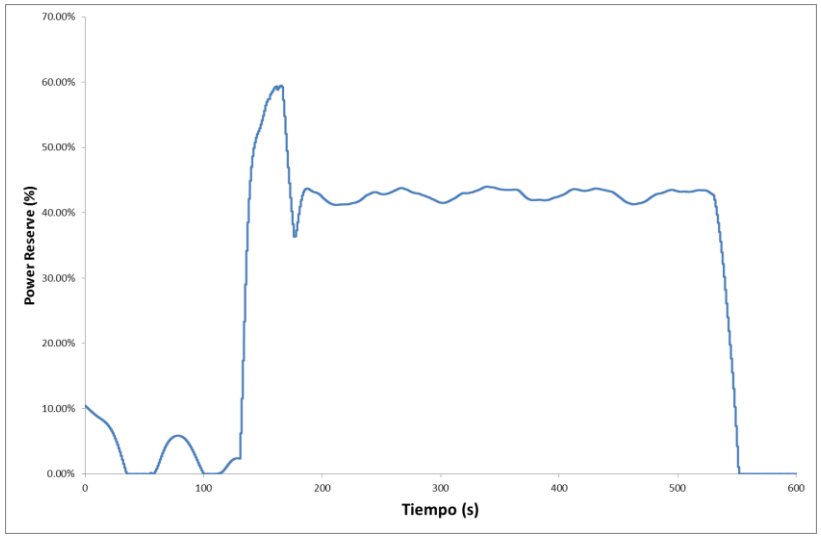
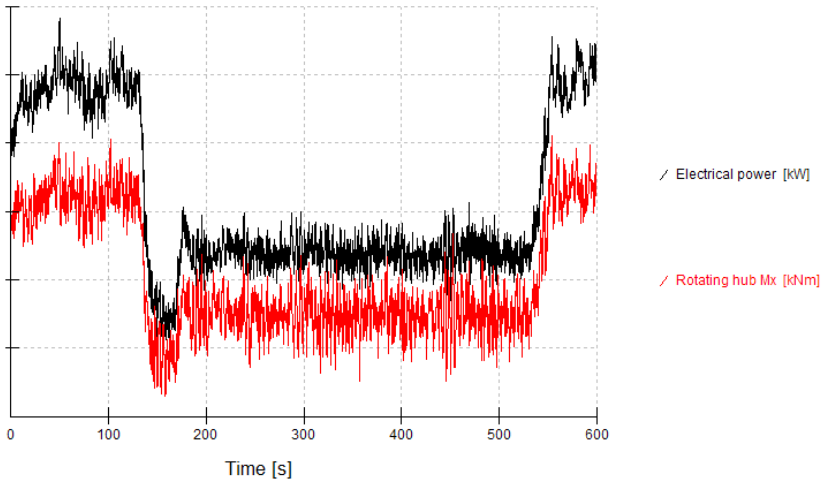
Simulations for control verification

- **Time series**
  - ✓ Correct behavior of the transitions have been checked

Power Reserves Personalized



Power Reserves Simulated



Answer of the wind turbine

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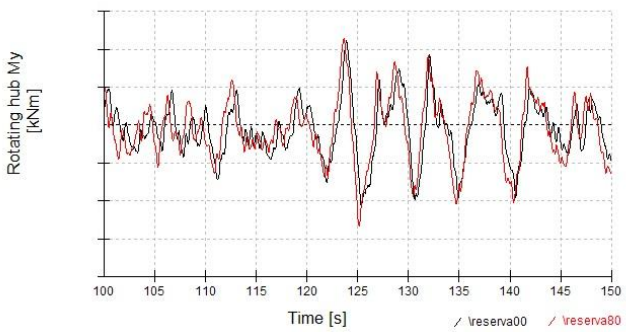
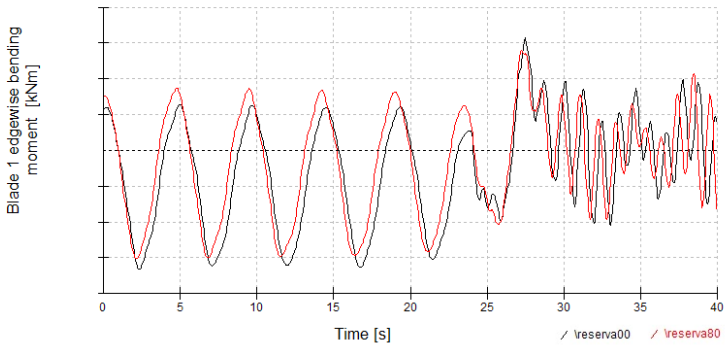
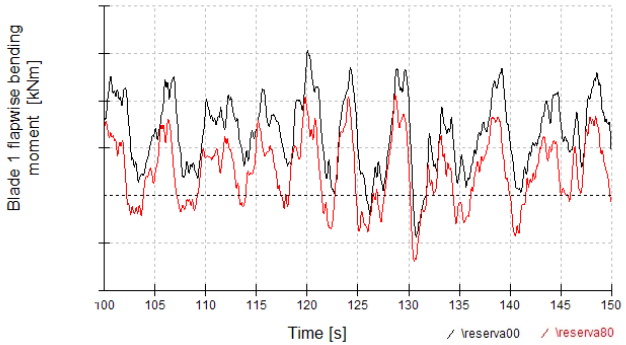
Load Calculation

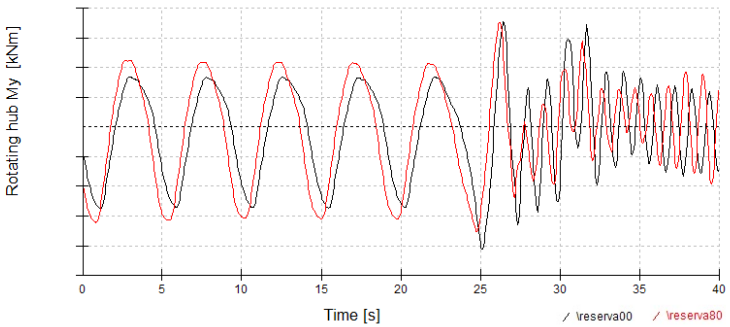
- **Fatigue and extreme load comparison**
  - ✓ Most relevant sensors loads have been calculated
  - ✓ Wind turbine integrity can be checked







Normal Production



Fault event

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4

CONCLUSIONS & OPEN ISSUES

Lessons learned

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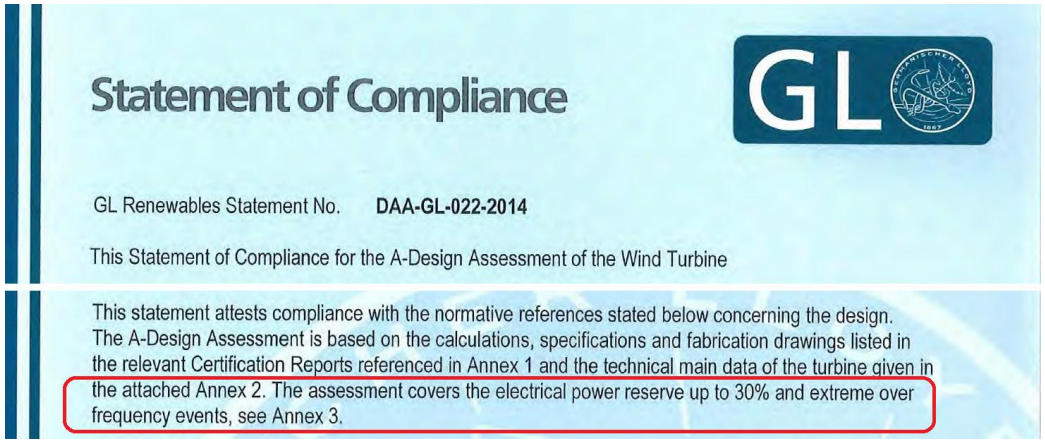
- **Control verification**
  - ✓ Wind turbines are increasingly located in countries with stricter grid codes and, also, in countries with weaker grids
  - ✓ Control algorithms have been developed in order to comply the grid codes of every country
    - Active Power Regulation
    - Grid frequency events
  - ✓ Bladed simulations have been carried out in order to:
    - Verify correct control behaviour
    - Verify the safety of the wind turbine
  - ✓ Control algorithms have already been certified by an independent certification body



Statement of Compliance

GL

GL Renewables Statement No. **DAA-GL-022-2014**

This Statement of Compliance for the A-Design Assessment of the Wind Turbine

This statement attests compliance with the normative references stated below concerning the design. The A-Design Assessment is based on the calculations, specifications and fabrication drawings listed in the relevant Certification Reports referenced in Annex 1 and the technical main data of the turbine given in the attached Annex 2. The assessment covers the electrical power reserve up to 30% and extreme over frequency events, see Annex 3.

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- **Open Issues**
  - ✓ Grid codes depend on the country where the wind turbine will be installed
  - ✓ Bladed electric module is currently being studied by the Acciona Windpower Electrical Area
  - ✓ A model of the substation general controller system of the wind farm should be implemented in order to check the wind turbine behaviour

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Any questions?

Thank you for your attention

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