附錄(七)：

西班牙國家再生能源中心(CENER)簡介

CENER | NATIONAL RENEWABLE ENERGY CENTRE

ADItech

LEA (WTG Laboratory)
Facilities & Capabilities

2018

CENER | NATIONAL RENEWABLE ENERGY CENTRE

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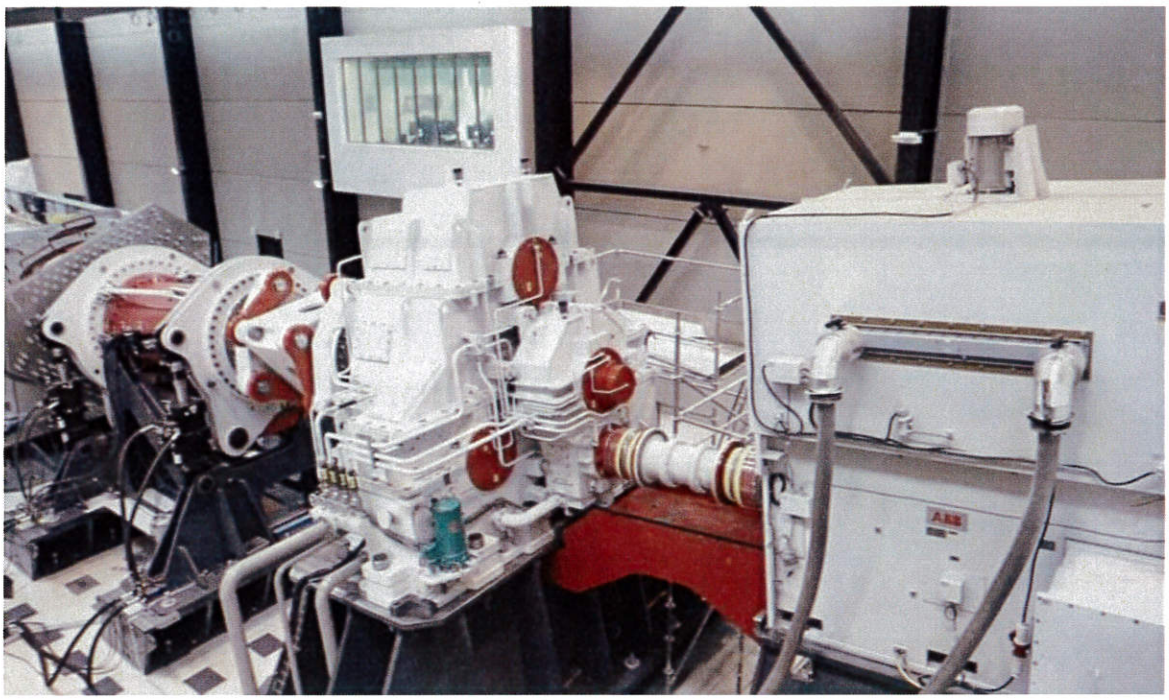
1. BETP Drive train test bench

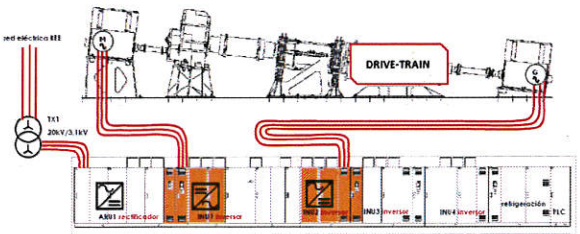
Overview



1. BETP Drive train test bench

Possible setups

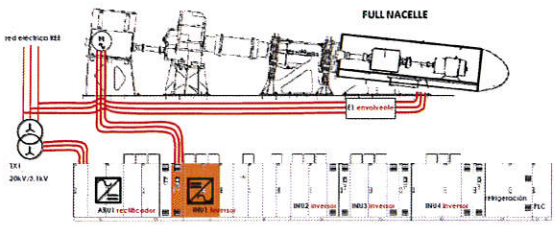
Drive-train configuration



- HALT (high accelerated life tests) -> increasing torque above nominal 120-140%
- Mechanical test

Full nacelle configuration

- Grid evacuation 20kV 50Hz
- Electrical & mechanical test



1. BETP Drive train test bench

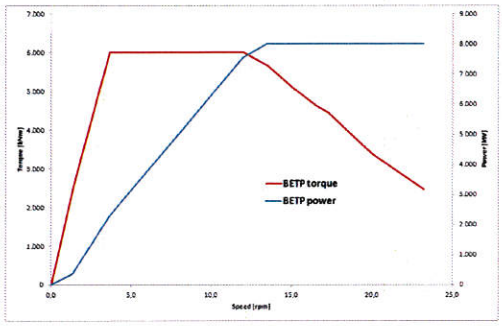
Driving system

8MW Induction motor

- 0-773 rpm
- Drive ABB ACS6000

Gearbox

- i=33,33

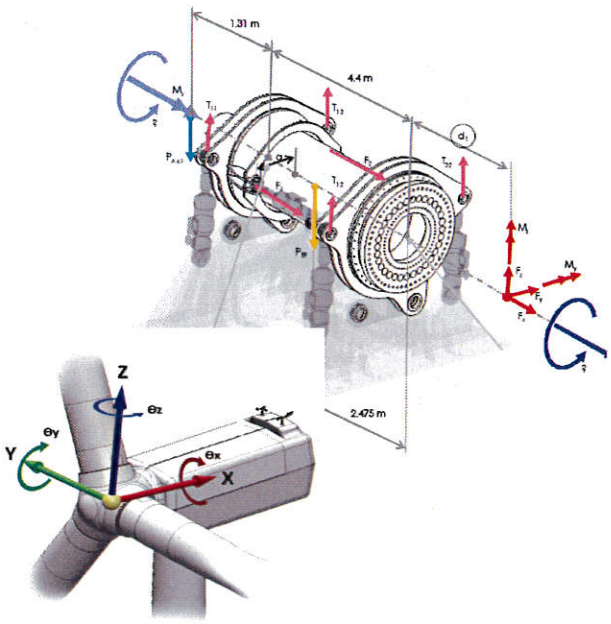


- Rated power 8 MW
- Speed range 0-23 rpm
- Max. Torque 6.000 kNm

1. BETP Drive train test bench

LAS Load application system

NON TORQUE LOADS - NTL

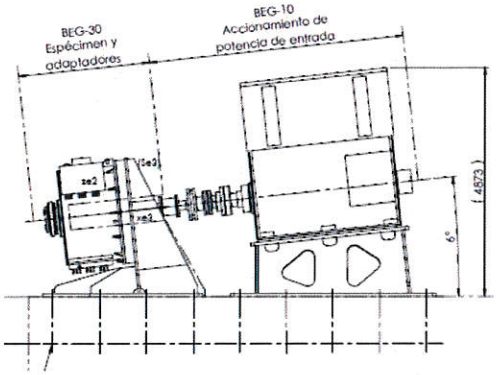


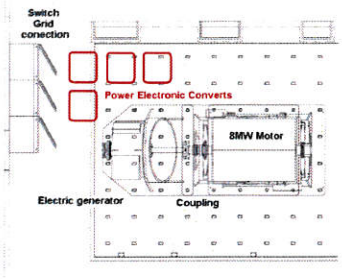
- 5 Degrees of Freedom (DOF)
  - Axial force (Fx)
  - Radial force (Fy)
  - Vertical force (Fz)
  - Bending moment (My)
  - Bending moment (Mz)
- Frequency response 0-1,5 Hz

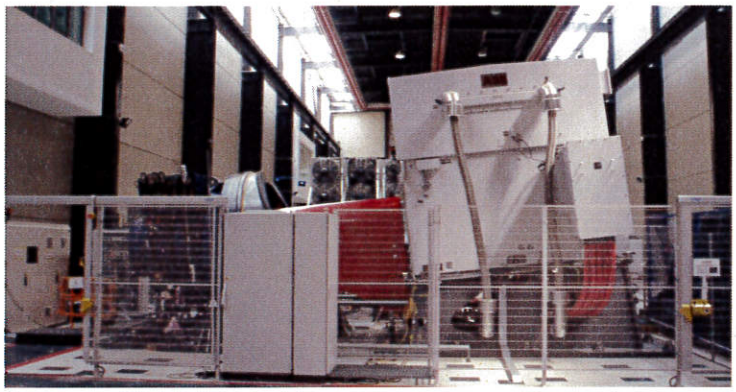
	EXTREME LOAD	OPERATIONAL LOAD
Fx [kN]	±1.000	± 750
Fy [kN]	±2.000	± 1.500
Fz [kN]	±2.000	± 1.500
My [kNm]	±10.000	± 7.500
Mz [kNm]	±10.000	± 7.500

2. BEG Electrical generator test bench

LayOut







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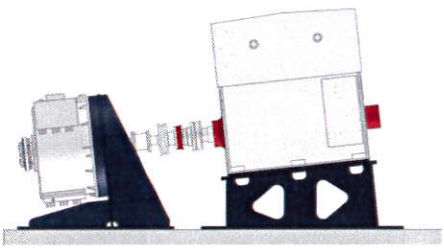
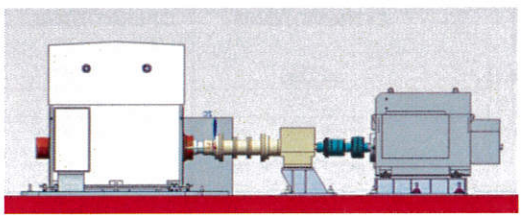
2. BEG Electrical generator test bench

Facilities: Driving System



Medium Speed

- Direct coupling motor to electric generator
- Speed range 0-770 rpm
- Max. Torque 190 kNm



High Speed

- Coupling through gearbox
- Speed range 0-2310 rpm
- Max. Torque 63 kNm

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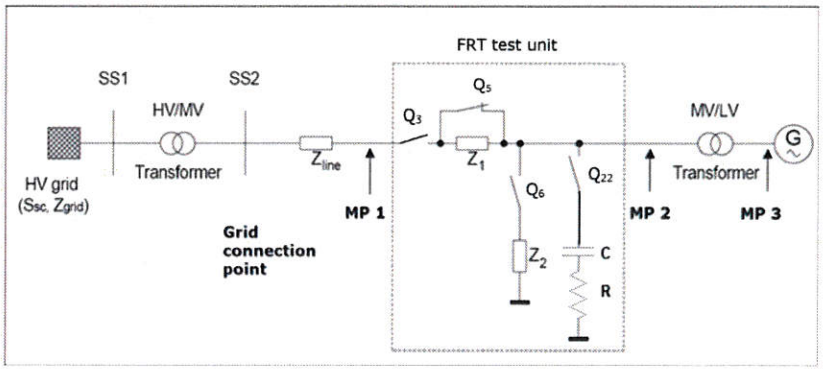
2. BEG Electrical generator test bench

Facilities: Electrical Configuration. Voltage dips test

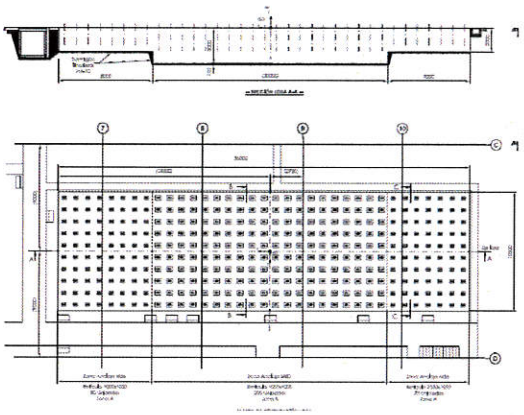


- Voltage dips:
  - LVRT: Z1-Z2
  - HVRT: Z1-C-R
- P.O. 12.3 and others grid codes
- Scc / Sn (spec) >= 5
- Grid frequency 50Hz.
- Scc (PCC) = 94 MVA

3. Common facilities

Foundations

- *2 independent structural foundations*
- *Dimensions: A) 35 x 10 m*
  B) 25 x 8 m
- *Foundation anchors: 1 x 1 m*
- *Bolts: M80 , M56 (T >1450 KN, S>425 KN)*



CARACTERISTICAS DE LOS PERNOS							CAPACIDADES DE CARGA Ptos. Anclaje	
ZONA	TIPO	METRICA	UNIDADES (max)	LONG TOTAL (mm)	LONG ROSCA (mm)	MATERIAL	VERTICAL Z	HORIZONTAL X-Y
A	Cabeza de Martillo DIN-7992	M56	72	1225	220	10.9	1450 KN	425 KN
B	Cabeza de Martillo DIN-7992	M80	128	1820	290	10.9	3125 KN	925 KN

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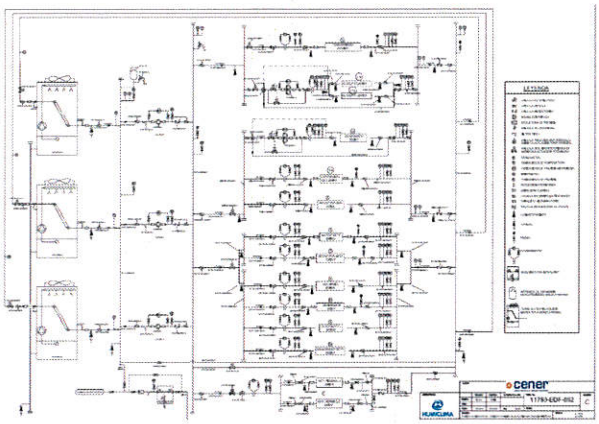
3. Common facilities
Cooling

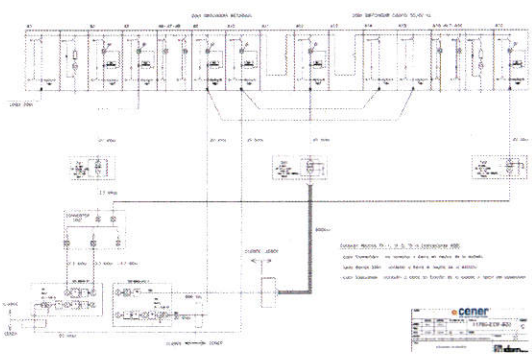
Cooling towers:

- *Maximum cooling Capacity: 3300 Kw*
- *Maximum flow: 500 m^3/h*
- *Separate outputs available for Test Components*



3. Common facilities
Switchgears and transformers

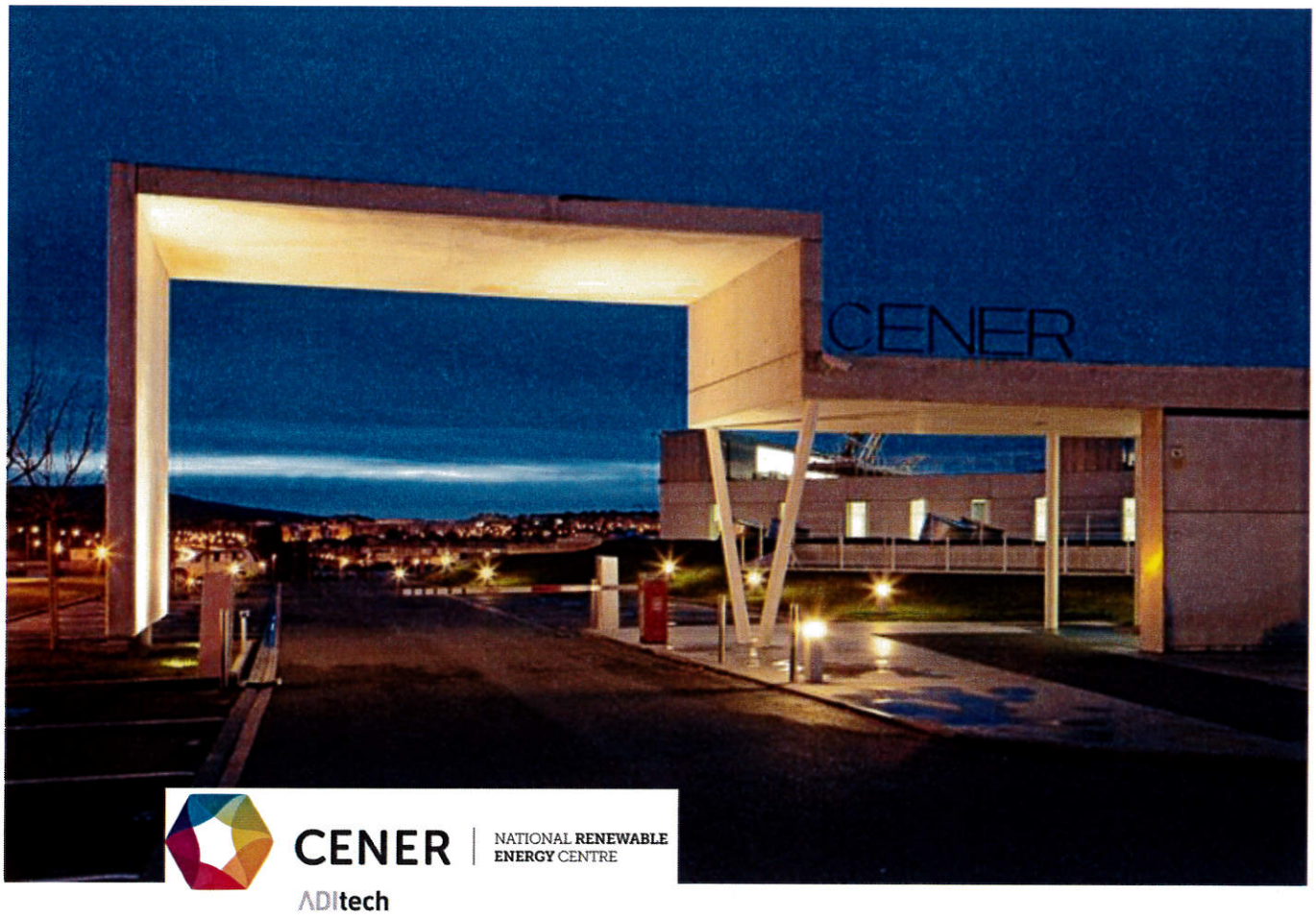
- *AC 20 kV Bus*
- *13 Test Components dedicated switchgears*
- *Transformer: 20kV/690V, 8 MVA*
- *Flexible configuration, including external devices (H-LVRT containers, load banks, etc.)*



3. Common facilities
Data Acquisition Systems

- *2 independent DAS*
- *Based on NI hardware*
- *Adaptable to sensor requirements*

DAS CHANNELS				
TYPE	Nº MODULES	TYPE MOD.	CHANNELS/MOD	TOTAL CHANNELS
TEMPERATURE (ADVANTYS)	16	STP_ART-0200	2	**32**
STRAIN	15	SCXI-1314	8	**120**
VIBRATION	6	PXI-4472	8	**48**
SOUND	1	PXI-4472	8	**8**
4-20 mA	2	PXI-6238	8	**16**
OIL QUALITY	1	PXI-8430	2	**2**
ANALOG	16	PXI-6224	2x8	**96**
DIGITAL	1	PXI-6515	32	**32**



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CENTRO NACIONAL DE ENERGÍAS RENOVABLES

GRID SIMULATOR TESTING OF WTG

Carlos Garcia de Cortazar

1st International Workshop on Grid Simulator Testing of Wind Turbine Drivetrains - Boulder, June 13, 2013

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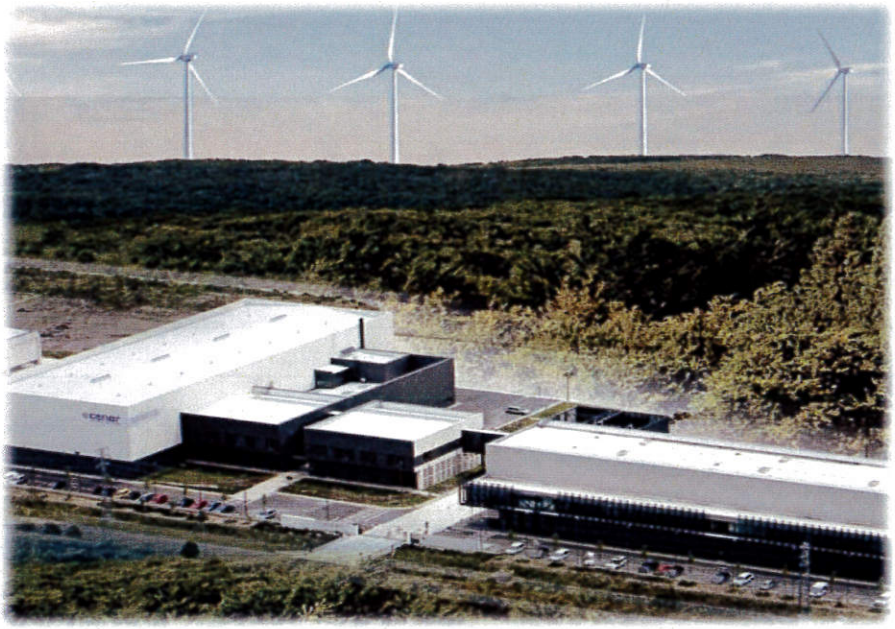
1. CENER LEA
WTG Test Laboratory

Wind Turbine Test Facility



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Gobierno de Navarra

Overview

LEA – WTG Test Laboratory

- Complements the research work of CENER in wind energy
  Dedicated to Tests of components, subsystems & full systems

- **Activities**

  - Blade tests
  - Experimental Windfarm
  - Power Train tests and Electrical Testing

BLADE TEST PLANT

1. LEA – WTG Test Laboratory

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BLADE TEST PLANT Capabilities

1. LEA – WTG Test Laboratory

- Perform structural tests on WTG blades
  - ❑ IEC TS-61400-23 standard / GL Guidelines
  - ❑ Static/Fatigue
  - ❑ Up to 75 m blade full length
  - ❑ Sections of up to 100m blades

- **Static Tests**
  - ❑ Mass, COG, moments of inertia
  - ❑ Stiffness bending/torsion
  - ❑ Ultimate strength

- **Fatigue Tests**
  - ❑ Modal analysis
  - ❑ Endurance/fatigue
  - ❑ Biaxial + Multipoint (UREX, GREX)

EXPERIMENTAL WINDPARK

2. CENER LEA – WTG TEST LABORATORY

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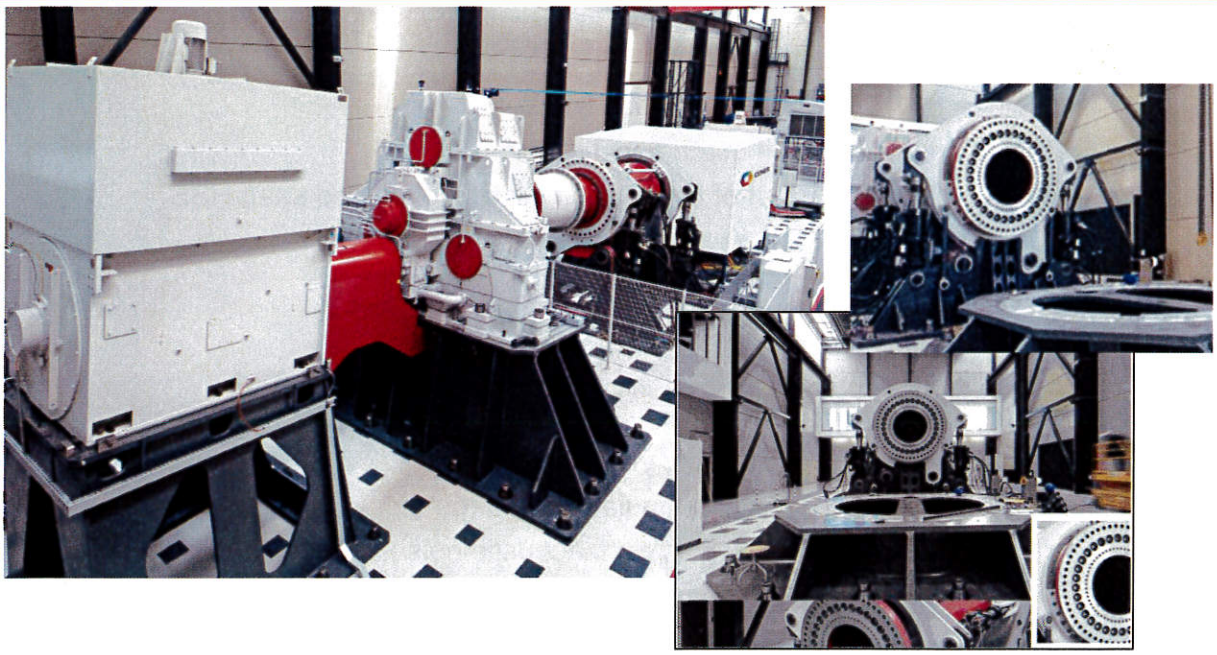
EXPERIMENTAL WINDPARK

2. CENER LEA – WTG TEST LABORATORY

- 6 calibrated positions
  - WTG prototypes for up to 30 MW evacuation capacity
  - Field tests on complex terrain (Wind Classes IA, IIA)
  - Fully CFD Characterised
- Wind Park features
  - 120 m high Met Masts instrumented at 5 different heights & Lidar
  - Field Offices & Redundant communications
  - Substation 20KV/66KV
- Technical Services
  - IEC Certification tests (Power Curve, Noise, PQ, Mechanical Loads)
  - Verification of response to voltage dips (LVRT)
  - Others (design, optimization, validation, etc.)
- Energy Production Income RD661/2007

POWER TRAIN Facilities

3. LEA – WTG Test Laboratory



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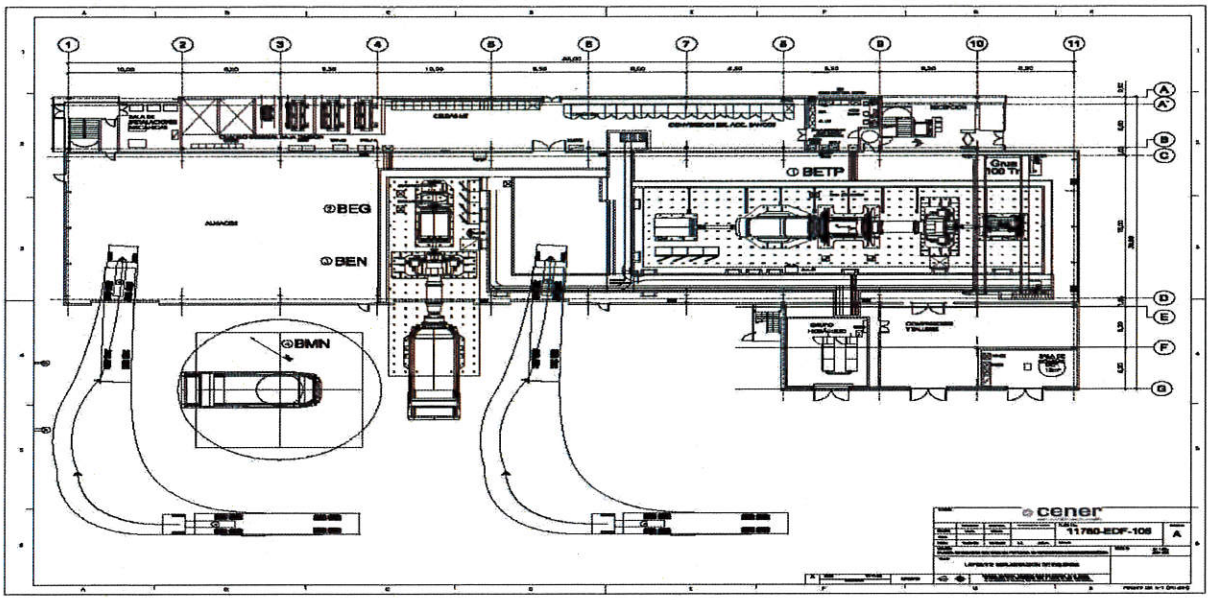
TEST BENCHES Configuration

3. CENER LEA – WTG TEST LABORATORY



TEST BENCHES Capabilities

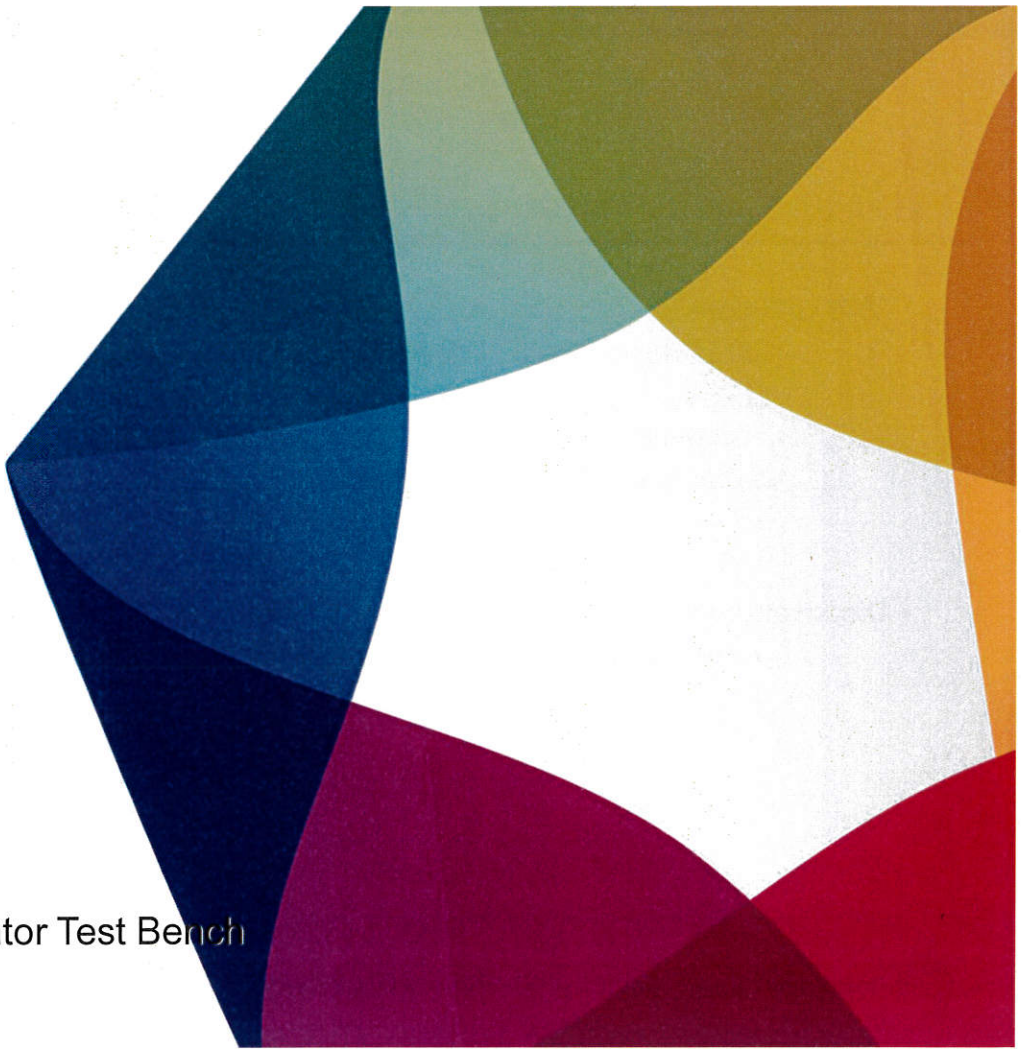
3. LEA – WTG Test Laboratory

- **Power Train test bench**
  - ❑ Test of WTG power train up to 8MW
  - ❑ Functional tests on mechanical parts
  - ❑ Functional/load test of brake/coupling at high speed shaft HSS
  - ❑ Concentrated life test and HALT
    - ➢ bearings in the main shaft (LSS)
    - ➢ gears and bearings in the gearbox

- **Generator test bench**
  - ➢ Functional test of generator and power electronics
  - ➢ Electrical transient simulation (voltage dips)
  - ➢ Functional tests, vibration, acoustic noise, heating, etc.
  - ➢ Overspeed tests and transients surges

- **Nacelle test bench**
  - ❑ functional, emergency stop, overspeed, climatic conditions, etc.
  - ❑ electrical transient simulation "Voltage dips"
  - ❑ EMC and acoustic test
  - ❑ Reactive power measurements

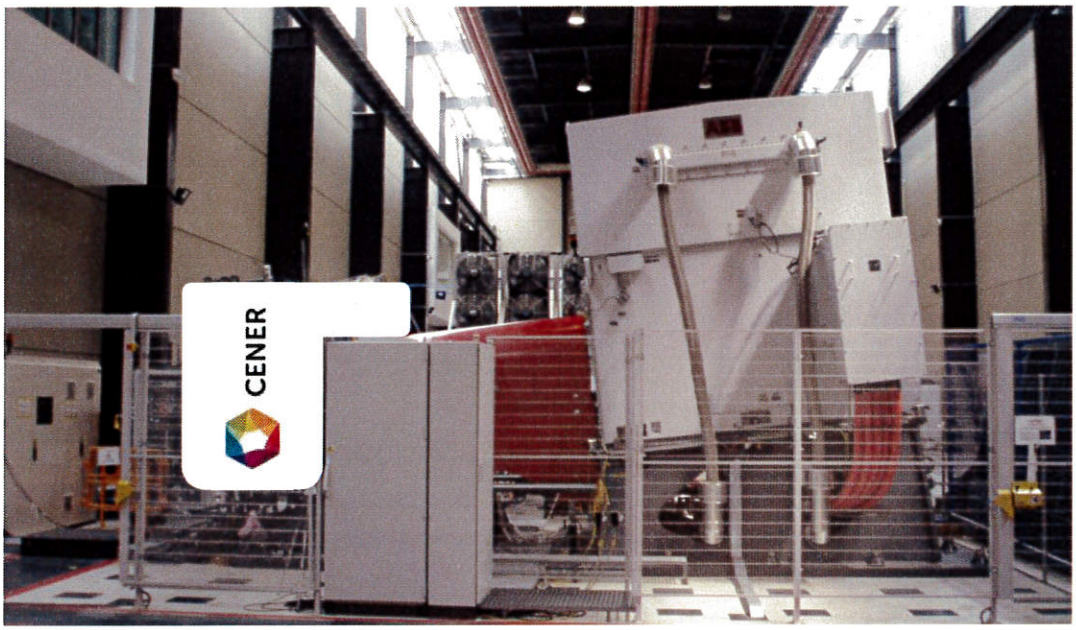
- **Nacelle assembly bench**
  - ➢ WTG erection and nacelle setup procedures
  - ➢ Use of auxiliary assembly cranes
  - ➢ Simulation of maintenance exercises, including major corrections
  - ➢ Staff training in the assembly and maintenance of WTG
  - ➢ Training in evacuation and security operations in WTG



2. BEG
Electrical Generator Test Bench

BEG

Electrical Generator Test Bench Overview



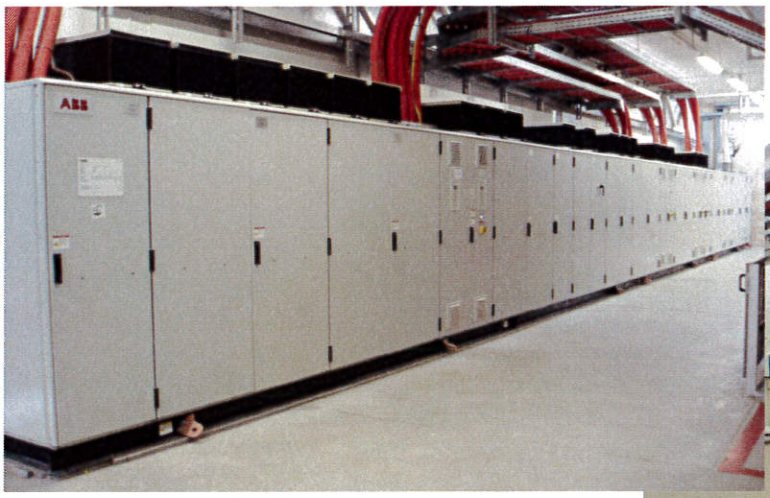
BEG

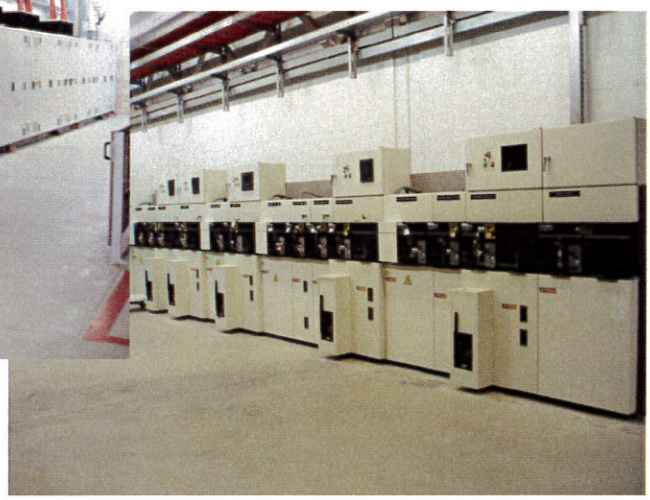
2. Electrical Generator Test Bench

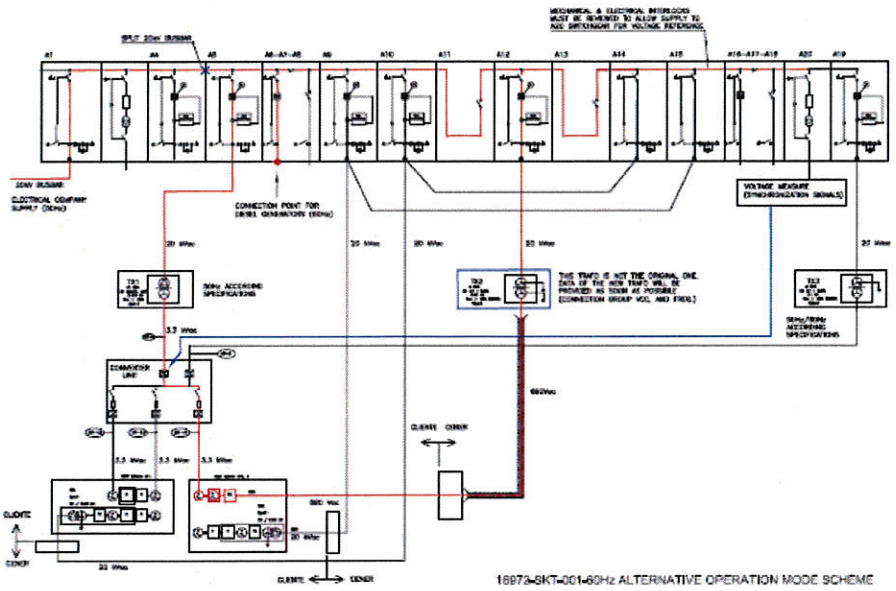
- **Adavantages**
  - ❑ Not depending on Wind conditions: maximum productivity
  - ❑ Development laboratory conditions: measurement devices, communication, working conditions, etc.
  - ❑ Easily different working points reproducibility

- **Disadvantages**
  - ➢ High frequency wind and mechanical forces not considered
  - ➢ On the field certification still required

3. Grid Simulator Test Experience
5 MW full converter generator Test







Proposal for Discussion

- ❑ Laboratory Tests accepted for certification
- ❑ Bidirectional influence in Grid Simulator Tests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WTGS Rotor Blade Testing Laboratory
2018

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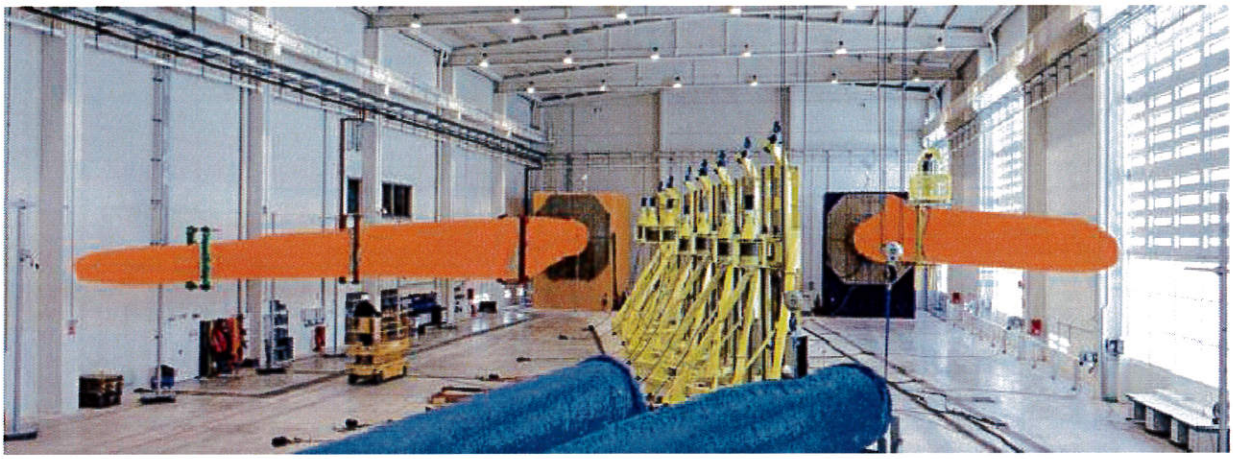
LEA WTGS Rotor Blade Testing Lab

Lay-out



LEA WTGS Rotor Blade Testing Lab

Lay-out

- Two Test Benches
- Both can operate at the same time:
  - Test Rig Nr1: Static & Fatigue Tests
  - Test Rig Nr2: Fatigue Tests
- 2 Overhead Cranes ⇒ 2 x 32 Tons
- Test Hall dimensions ⇒ 85m (l) * 32m (w) * 15m (h)

LEA WTGS Rotor Blade Testing Lab

Lay-out

- Clearance for deflections
  - Static test: 25m
  - Fatigue test: 15m (peak to peak)
- Static test bench sized for blades up to 100m length
- Fatigue test bench sized for blades up to 75m length
- 5.5m max root diameter

LEA WTGS Rotor Blade Testing Lab

Type of Tests---IEC 61400-23 2014

Accredited tests by ENAC	Approved tests by GL	Not accredited tests
Mass & Cdg	Mass & Cdg	Mass Distribution
LPS	Natural Frequencies & Damping	Modal Analysis
Natural Frequencies & Damping	Static test	
Stiffness test		
Static test		
Fatigue test		

ENAC ENSAYOS Nº 355 / LE 803

GL Approval No: 73931/09

- Members of IEC 61400-23 MT23 & IECRE groups

LEA WTGS Rotor Blade Testing Lab

Type of ACCREDITED STATIC Test

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LEA WTGS Rotor Blade Testing Lab

Type of ACCREDITED STATIC Test

STATIC test MAIN features

- Loading perfomed Horizontally
- **Multi-point** syncronized **Single-axis** loading by electric winches controlled by an accurate MTS FTGT controller
- 8 winches available
- Max bending moment for Static --- 100.000 kNm
- Max allowable tip deflection --- 25m
- Ultimate failure static test can be performed

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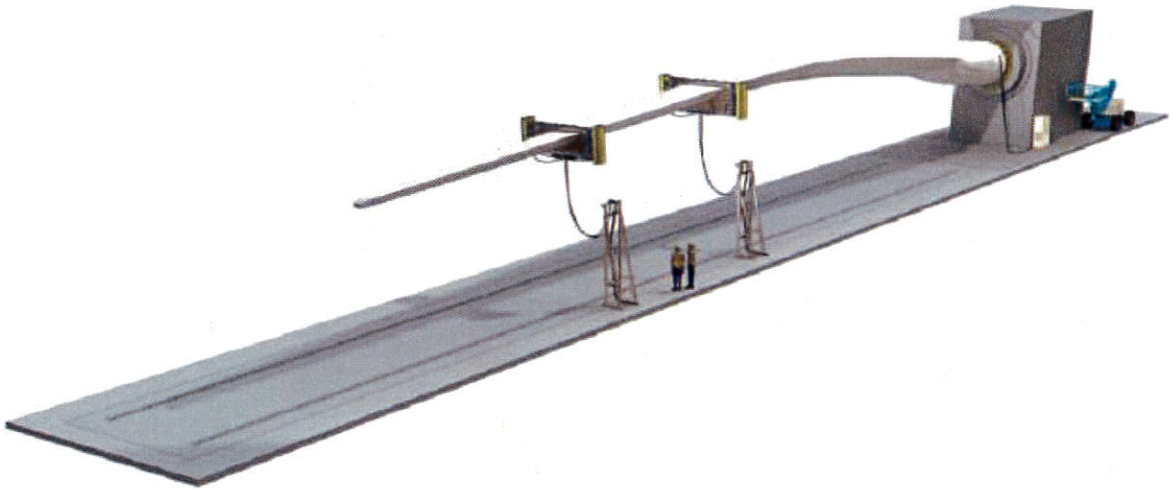
LEA WTGS Rotor Blade Testing Lab

Type of ACCREDITED FATIGUE Test



LEA WTGS Rotor Blade Testing Lab

Type of ACCREDITED FATIGUE Test

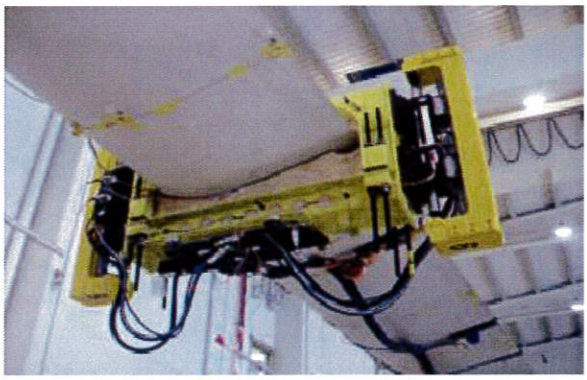
❑ FATIGUE test MAIN features

- Loading perfomed Horizontally and/or Vertically
- Loading types:
  - ✓**Single-point** - **Single-axis**
  - ✓**Combined Single-axis**
  - ✓**Multi-point** - **Single-axis**
  - ✓**Multi-point** - **Multi-axial**
- Hydraulic syncronized loading --- Exciters controlled by an accurate MTS FTGT controller

LEA WTGS Rotor Blade Testing Lab

Type of ACCREDITED FATIGUE Test

- **Exciter Type-1**: 50kN, 160-1010kg, 4ud



- Fatigue FLAPWISE: exciters suitable for blades up to 50m long
- Fatigue EDGEWISE: exciters able to test blades up to 75m long

LEA WTGS Rotor Blade Testing Lab

Type of ACCREDITED FATIGUE Test

- **Exciter Type-2 GREX: 100kN, 1ud**
  - Focused on testing blades up to 75m in FLAPWISE direction
  - Innovative Design & Reliable & Safe
  - "Ground Exciter" Advantage --- ↓ Test Period

LEA WTGS Rotor Blade Testing Lab

Highlights + Recent Developments

FOCUSED ON QUALITY – SAFETY – LEAD TIME

- DAQ&Test Control under Virtual Machine Concept → HW+SW Redundancy
- HBM MGCplus DAQ System: 500ch, 2400Hz, configurable, backups
- Fatigue Test: Biaxial static calibration → ↓Uncertainty on load calculations
- GREX: a 2nd unit will be ready by Q2 2018 → ↑ Complete the spare list
- Thermography available for blade inspections
- Automatic control of the tests --- Permits unnattended operation 24h
- Automatic report generation
- Upgrade for Q4 2018: ↑ Height clearance for fatigue deflections 15m→20m

LEA WTGS Rotor Blade Testing Lab

General Services

- Services for all the tests
  - Video cameras are in place to monitor/record the tests
  - FEM software available for Test&Test-Tooling design
  - Management of Test Design & Manufacturing of Saddles & Test-Tools to customer requirements
  - At customer request Consulting Services for Test Plan design
  - At customer request Transportation Management of Blades

LEA WTGS Rotor Blade Testing Lab

Experience

- Number of tests conducted ⟶ *Blades from 10m to 70m long*
  - Static **x170**
  - Ultimate Static **x16**
  - Fatigue Flapwise + Edgewise **x30**
  - Fatigue: a total of **60,000,000** cycles applied

LEA WTGS Rotor Blade Testing Lab

Experience

- Tests conducted confidentially by Qualified & Highly Skilled staff
  - Engineers x**4**
  - Technician x**12**
- Business Calendar:
  - Availability: **24h** ⟹ **365 days**

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附錄(八)：

西班牙馬德里 SGS 公司及其專案驗證服務內容簡介

RENEWABLE ENERGIES

WIND ENERGY SERVICES

DELIVERING TRUST AND TRANSPARENCY

Madrid, July 2018 / SGS - TIER meeting

WHEN YOU NEED TO BE SURE

SGS

AGENDA / INDEX

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- Certification Schemes for Wind Turbines
  - Type Certification:
    - Design evaluation
    - Tests
  - Differences in between IEC 61400-1 and IEC 61400-3 (Offshore)
  - Loads analysis and Lifetime Extension
- *[Coffee Brake ~10 minutes]*
- Quality Assurance and Inspections
- Certification of Power Converters
  - Safety tests and normative
  - Grid connection codes compliance

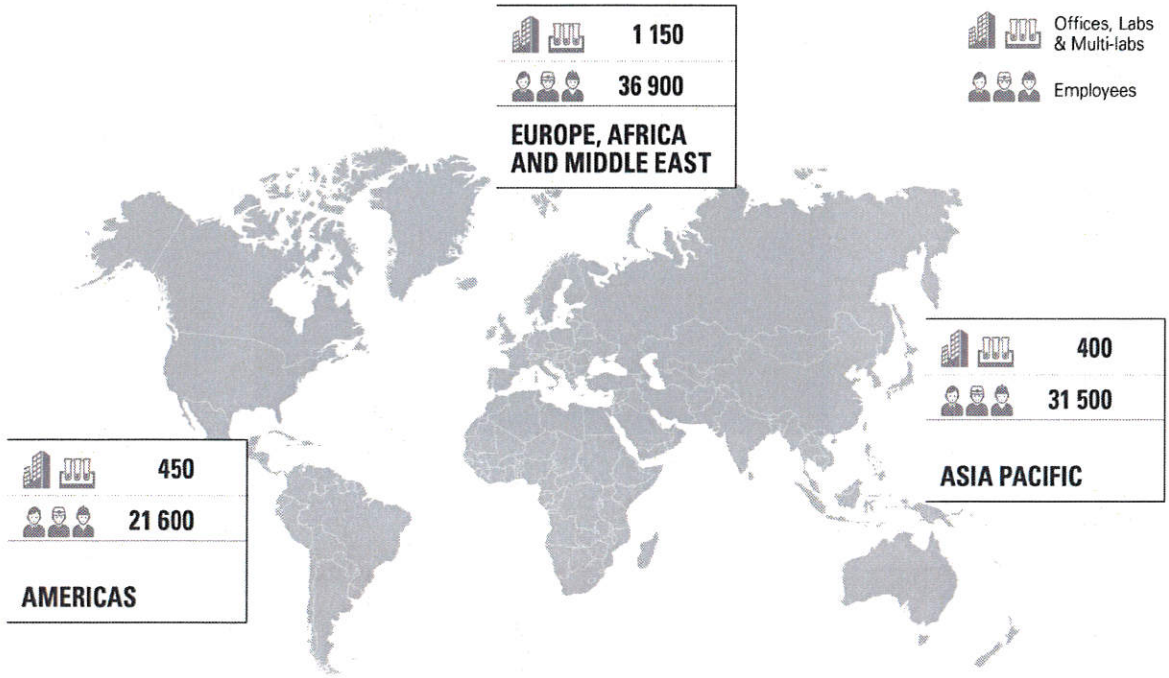
SGS CORPORATE AT GLANCE

SGS IN BRIEF

SGS MEANS **RELIABILITY**

- Founded in 1878
- HQ in Geneva, Switzerland
- World's largest independent service provider in verification, testing, certification and inspection
- SGS has been evaluated by external audit (CEOC) and keeps leading the growth, mainly driven by the following factors:
  - Rapid globalization
  - Rising concerns about the quality and safety
  - Rise in outsourcing of the certification, testing and inspection services
  - Growth in the regulations and industrial standards

95 000[1] EMPLOYEES AND 2 000 OFFICES & LABS WORLDWIDE FOR REACH AND LOCAL SUPPORT



1. Average number of employees in 2017.

COMPETITIVE ADVANTAGES

- Our range of geographical network
- We ensure one-full-stop to our customers
- The skill and leadership of our people
- The depth of our expertise
- The quality of our laboratories
- Our Brand
- Our independence
- Our culture of integrity and our performance ethics

WIND TURBINES CERTIFICATION

WIND TURBINES CERTIFICATION SCHEMES

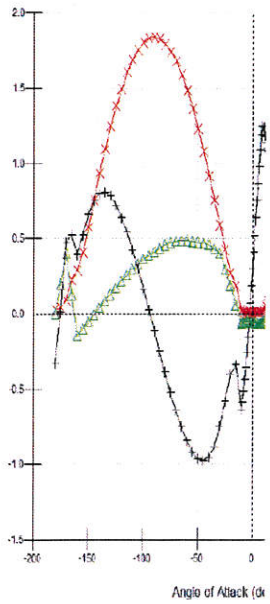
- IEC 61400's -from the International Electrotechnical Commission- are the reference standards, including:
  - IEC 61400-1 for the design of Wind Turbines
  - IEC 61400-3 for Off-shore specific conditions
  - IEC 61400-12-1 for power performance measurement
  - IEC 61400-23 for Blades approval.
  - These are just some examples of the main standards involved.
- SGS is an accredited Certification Body (ISO-IEC 17065) for IEC 61400-1 and -3.

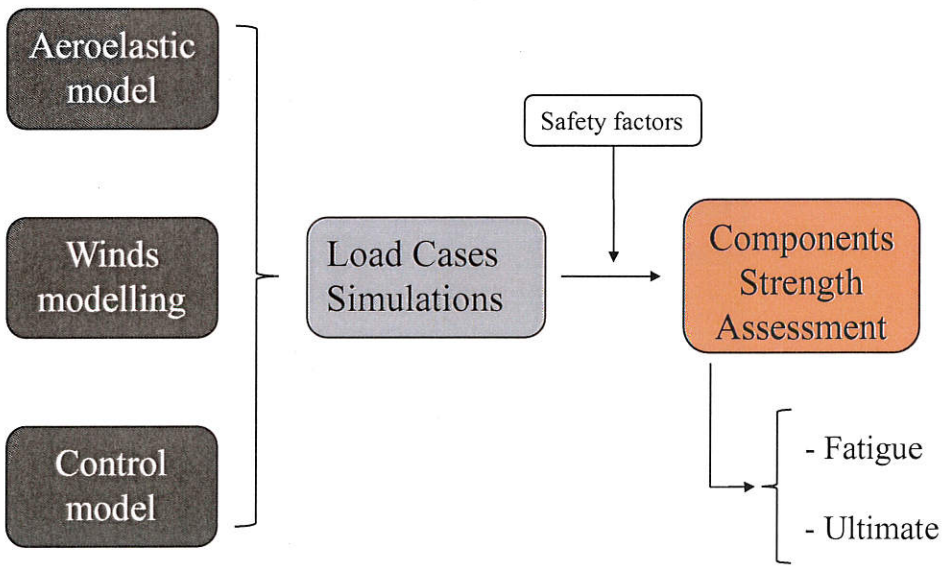
WIND TURBINES CERTIFICATION SCHEMES

- Type Certification is applicable for prototypes of Wind Turbines covering design and manufacturing.
- It is required for the bankability of its production in series and installation on site, and covers:
  - Design assessment (based on a lifespan of 20 years)
  - Manufacturing approval through inspections
  - Testing including:
    - Power performance
    - Loads measurement
    - Noise measurement
    - Safety and functions
- Project Certification is applicable for site-specific conditions.

WT CERTIFICATION – DESIGN REVIEW

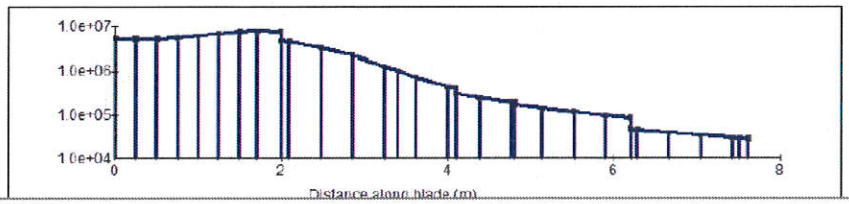
- Design review consist of:
  - Structural reliability – lifespan study up to 20 years



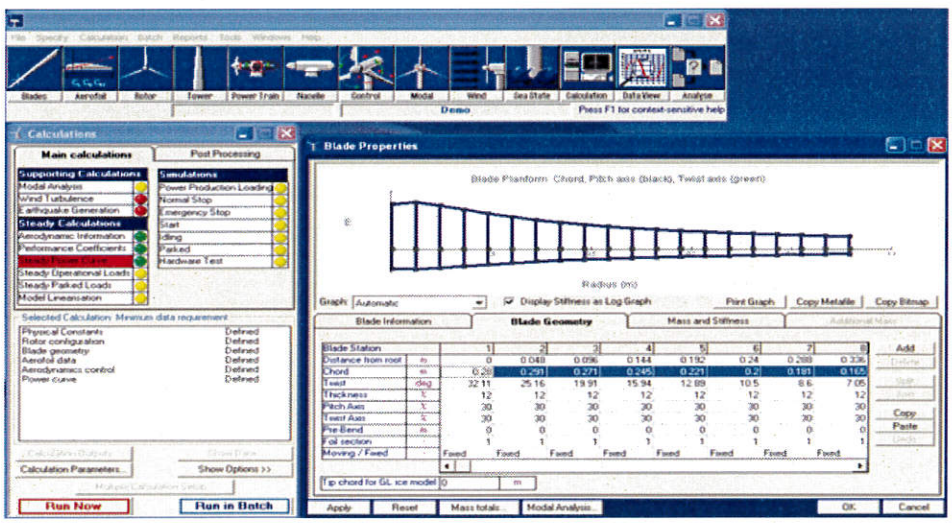


- Aeroelastic calculations to obtain loads require:
  - Wind modeling: depending on the Class of the unit
  - Aeroelastic model: based on geometry and validated with:
    - Loads measurement
    - Design data
  - Modeling of the Control System
- For offshore, loads coming for waves shall be considered.
- Different software (such as GH Bladed, FAST, etc) are used for the simulations.

Figure 5: Flapwise Bending Stiffness [Nm²]



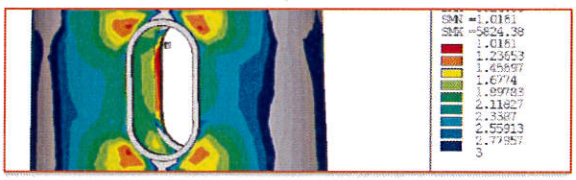
- The manufacture provides the design information and SGS repeats the modeling and calculations:



- Outputs from the simulations:
  - Loads on different areas of the Wind Turbines (forces and torques).
  - The results are compiled on a set of loads per case, point of the WT and direction and the maximum values are extracted for their analysis:

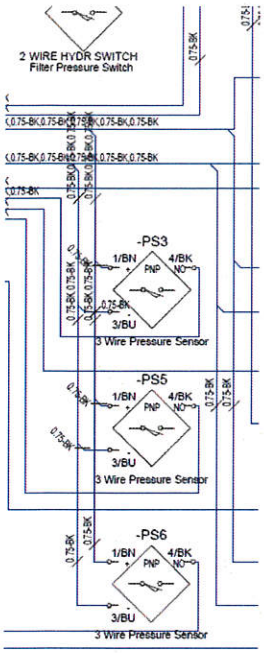
WT CERTIFICATION – DESIGN REVIEW

- Components assessment:
  - Using the loads coming from the simulations and applying safety factors, a component-by-component analysis is carried out.
  - Finite Element Models: stresses distribution and hot spots ID.



  - Safety factors, materials and curves S-N are considered to evaluate the fatigue of the components and their suitability for a defined design lifespan (>20 yrs).
  - Fatigue is calculate through Damage Equivalent Loads (DEL).

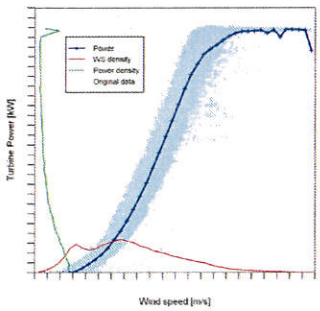
WT CERTIFICATION – DESIGN REVIEW



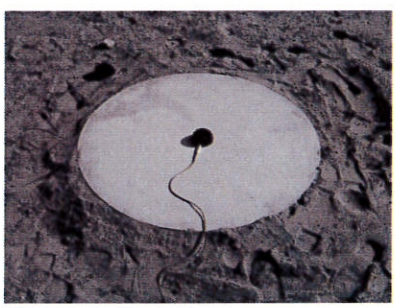
- Design review also consist of:
  - Electrical and control evaluation, covering:
    - Safety of the system
    - Coherence in the control system
    - Sizing of components and ratings
    - Failure Modes and Effects Analysis (FMEA):
      - Strategies reducing potential risks
      - Evaluating severity versus probability
  - Validation tests (among others):
    - Blades – static and dynamic tests (IEC 61400-23)
    - Generator - According to IEC 60034's series, including short-circuit and temperature.
    - IEC 62477-1 for electrical safety of power converters.
    - IEC 61400-4 for gearboxes

WT CERTIFICATION – TYPE TESTS

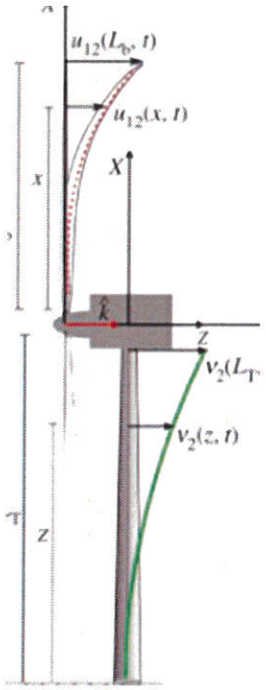
- Power Performance IEC 61400-12-1
  - Wind bins VS Power
  - Measure of power without obstacles nearby the Wind Turbine



- Noise Measurement IEC 61400-11
  - The objective is to characterize the noise emissions of the Wind Turbine



WT CERTIFICATION – TYPE TESTS



- Loads measurement IEC 61400-13:
  - Vibration measurements through accelerometers
  - Extensometer gauges
  - By obtaining real loads it is possible to validate the loads calculations coming from the aeroelastic model
- Safety and Functions test IEC 61400-22:
  - Similar to a commissioning test
  - The operational modes and behaviors of the controller are tested
  - Usually the test is performed following a check list

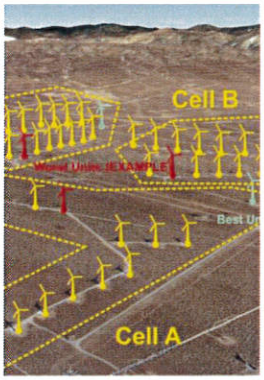
Make sure to do this test with low winds, rotor blocked, brake applied and out of wind direction

1. Block the rotor shaft mechanically ☐
2. Yaw the nacelle until it is not oriented upwind ☐
3. Press emergency stop button and ensure the brake is activated ☐
4. Read pitch angle, it should be 88º. Otherwise pitch angle in emergency is ..... º. ☐
5. Release emergency button and reset security relay ☐
6. Force relay D210 by activating DO18 in DC532 (safety chain should be closed) ☐
7. Check that the relay D210 is deactivated when the emergency button is pressed ☐

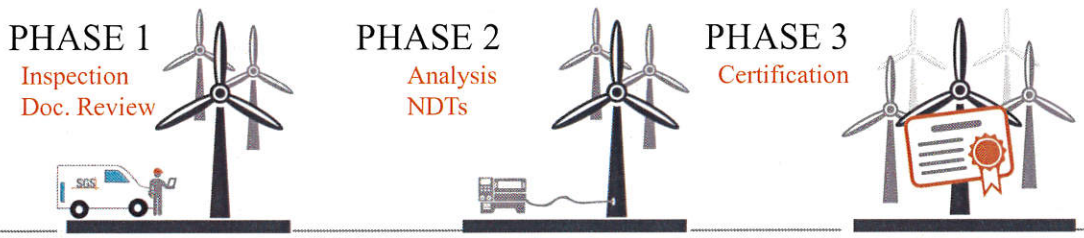
WT CERTIFICATION – MANUFACTURING EVALUATION

- A product Certification (such as a Type Certification) implies the need to assure that there are no deviations from the approved design.
- Required a manufacturing QMS certified to ISO 9001.
- Annual inspections are performed by SGS at the manufacturers facilities.
- Document control (manufacturing procedures, design documents) is reviewed during each inspections.
- Samples of components are checked, and routine tests are usually specified (e.g. dimensioning or safety tests on electrical components).

LIFETIME EXTENSION CERTIFICATION



- Is it possible to extend the life of a Wind Turbine over the 20 years of design?
- Yes. SGS is pioneer in Lifetime Extension Certification.
- Comparing real conditions versus design conditions.
- Adjusting the Operational and Maintenance procedures of the wind farms.
- A detailed analysis is performed wind farm per wind farm to state the real condition of the machines.



SUMARY

- SGS is capable of providing:
  - TYPE CERTIFICATION
  - COMPONENT CERTIFICATION
  - LIFETIME ANALYSIS OF WIND TURBINES
  - LIFETIME EXTENSION CERTIFICATION
  - BLADE TESTING AND CERTIFICATION
- Please do not hesitate to question us.

WWW.SGS.COM

WHEN YOU NEED TO BE SURE

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