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# LVRT test concerns for Offshore WTG

**Carlos Garcia de Cortazar**

2nd Annual International Workshop on Grid Simulator Testing of Energy Systems and Wind Turbine Powertrains
North Charleston, South Caroline, USA, Sept 17-18, 2014

GOBIERNO DE ESPAÑA | MINISTERIO DE INDUSTRIA, ENERGÍA Y TURISMO | MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

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1. CENER LEA
   WTG Test Laboratory

# Wind Turbine Test Facility

Sangüesa (NAVARRA), SP

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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


BLADE TEST PLANT Capabilities

## 1. LEA – WTG Test Laboratory

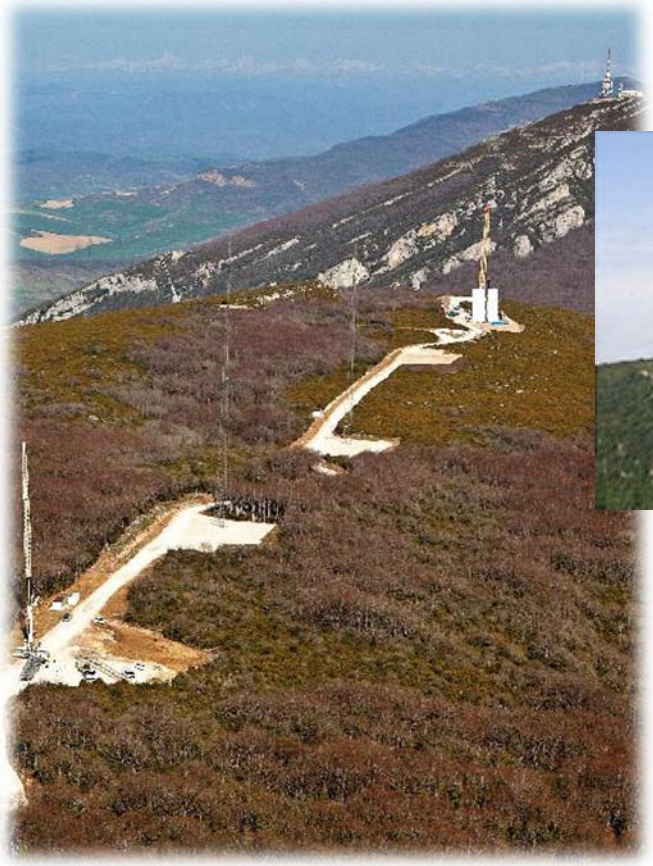
- Perform structural tests on WTG blades
  - •IEC TS-61400-23 standard / GL Guidelines
  - •Static/Fatigue
  - •Up to 75 m blade full length
  - •Sections of  up to 100m blades

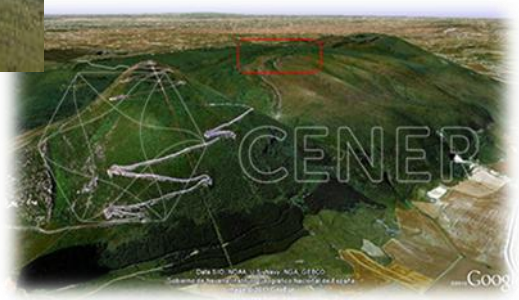
- **Static Tests**
  - •Mass, COG, moments of inertia
  - •Stiffness bending/torsion
  - •Ultimate strength

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

EXPERIMENTAL WINDPARK

## 2. CENER LEA – WTG TEST LABORATORY





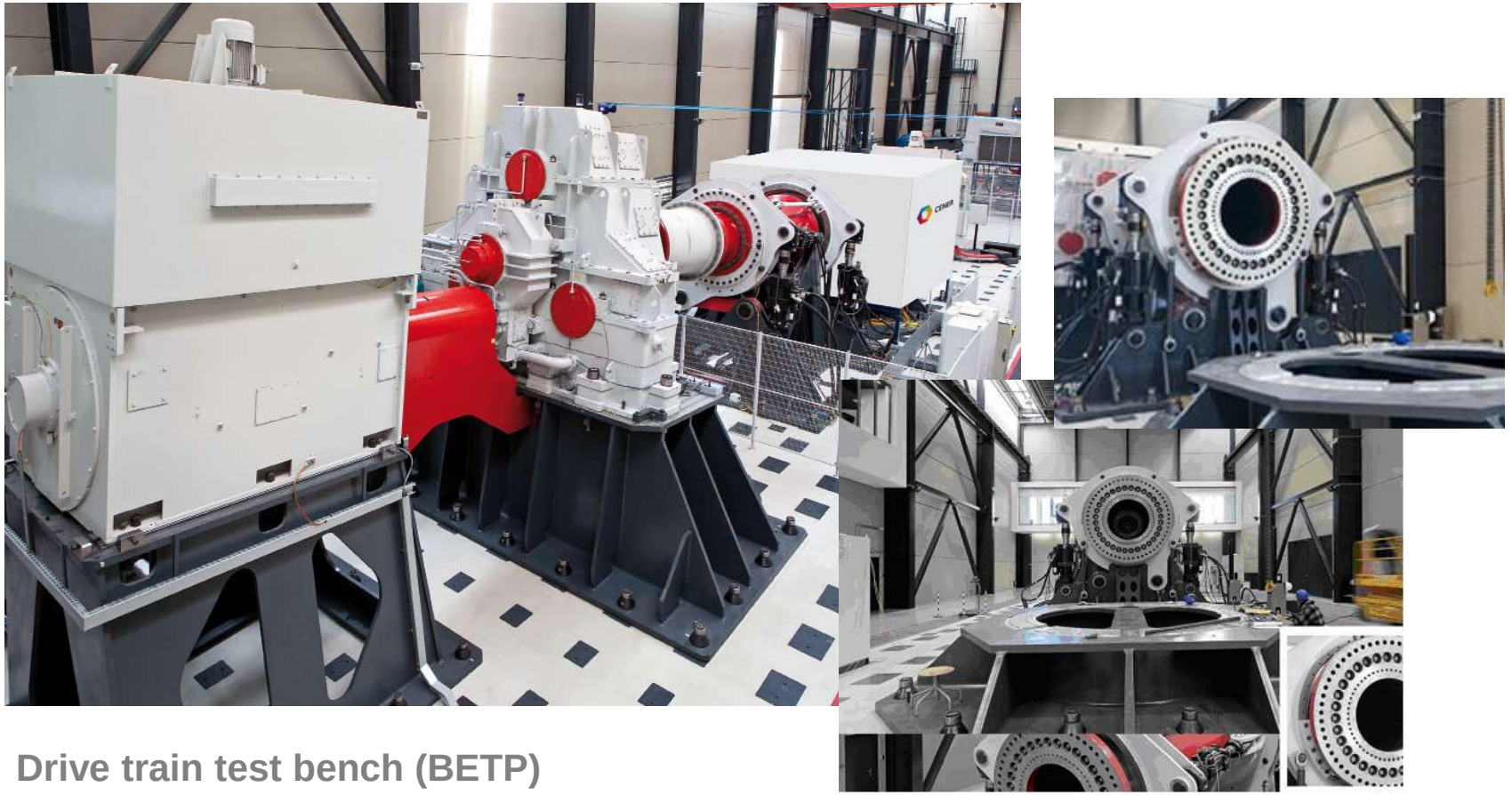
EXPERIMENTAL WINDPARK

## 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



**Drive train test bench (BETP)**

TEST BENCHES Configuration

## 3. CENER LEA – WTG TEST LABORATORY

**Electrical Generator Test Bench (BEG)**

## 3. LEA – WTG Test Laboratory

- **Drive train test bench (BETP)**
  - •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

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

# 2. Offshore WTG development
## State of the art

# Offshore Overview


## Offshore European Key Numbers

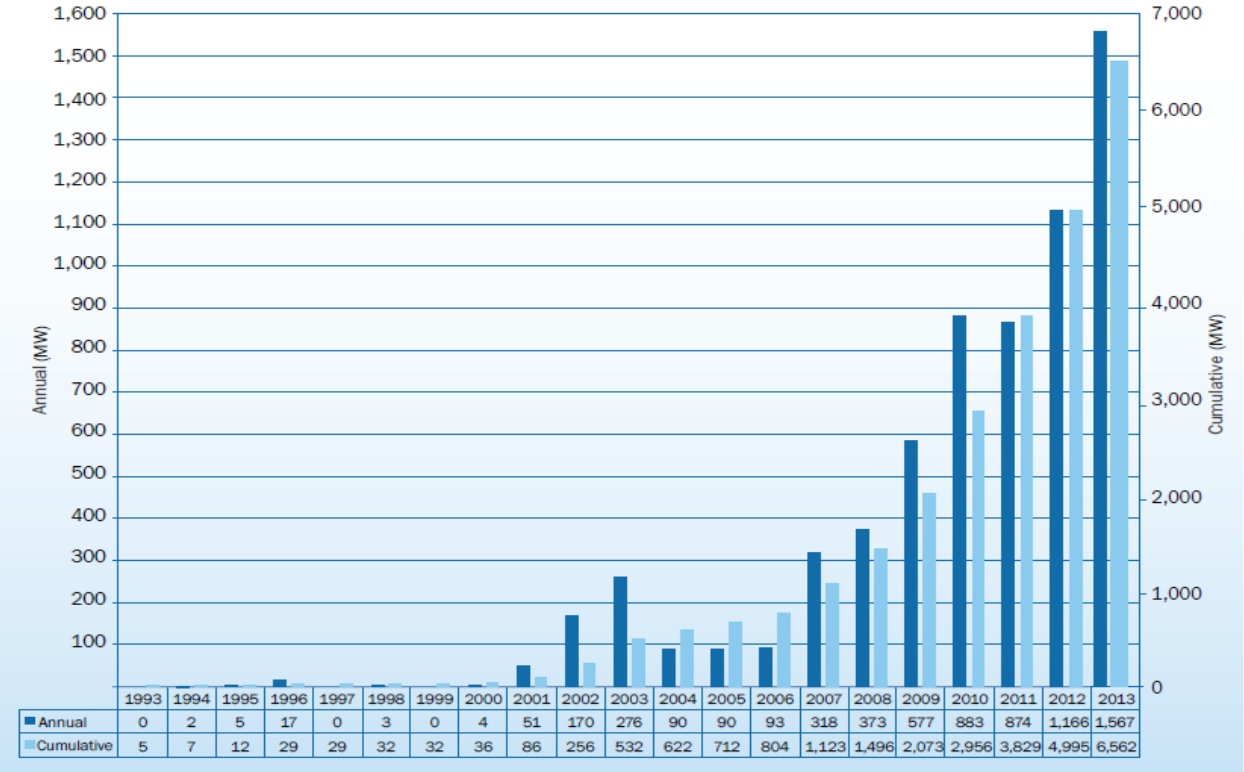
- **Key numbers 2013 (EWEA):**

  - 418 offshore turbines came online in 2013 in Europe,
  - 1,567 Megawatts (MW) of new capacity.
  - This is one-third more than the capacity installed in 2012.
  - This makes a new total of 6,562 MW of offshore wind power - enough to provide 0.7% of the EU's electricity.

Overview

## Offshore European Key Numbers (EWEA)

FIG 11: CUMULATIVE AND ANNUAL OFFSHORE WIND INSTALLATIONS (MW)




| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual | 0 | 2 | 5 | 17 | 0 | 3 | 0 | 4 | 51 | 170 | 276 | 90 | 90 | 93 | 318 | 373 | 577 | 883 | 874 | 1,166 | 1,567 |
| Cumulative | 5 | 7 | 12 | 29 | 29 | 32 | 32 | 36 | 86 | 256 | 532 | 622 | 712 | 804 | 1,123 | 1,496 | 2,073 | 2,956 | 3,829 | 4,995 | 6,562 |

Overview

# Offshore European Key Numbers (EWEA)

## Annual market share in 2013 - wind turbine manufacturers

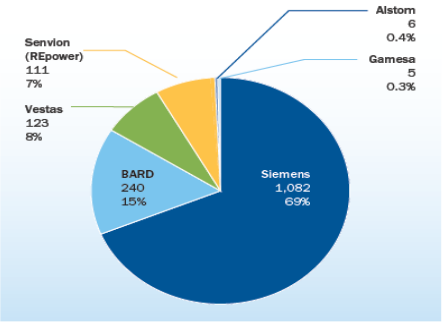
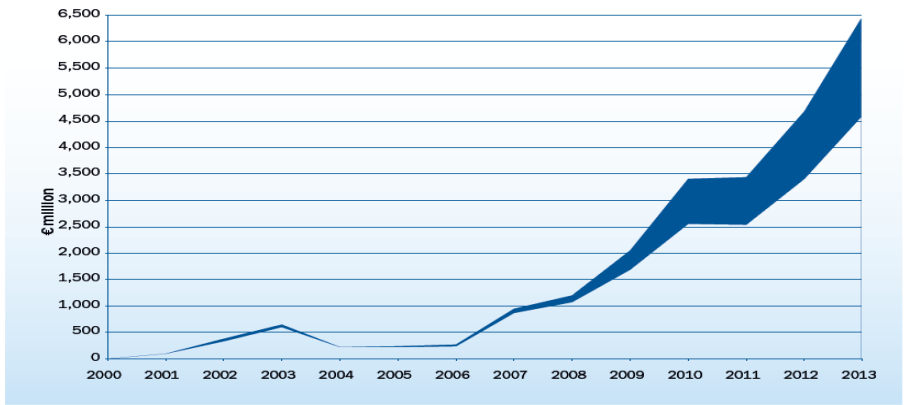



FIG 3: WIND TURBINE MANUFACTURERS' SHARE OF 2013 ANNUAL INSTALLATIONS IN MW

Siemens continues to be the top offshore turbine supplier in terms of annual installations. With 1,082 MW of new capacity connected, Siemens accounts for 69% of the market. BARD (240 MW, 15%), Vestas (123 MW, 8%) and Senvion (REpower) (111 MW, 7%) are the other three turbine manufacturers who had turbines grid connected in full-scale wind farms during 2013. Alstom and Gamesa both installed their first demonstration turbines and Siemens installed the first two of its 6 MW turbines.

FIG. 29: ANNUAL INVESTMENTS IN OFFSHORE WIND FARMS



Overview

## Offshore WTG Power Ranges

- **Current Offshore WTG Power:**





- Vestas V164 8MW
- Enercon E126 7.5MW
- Samsung S7.0 171 7MW
- Siemens SWT 6.0 150 6MW
- Almston Haliade 6MW
- Areva M5000 5MW
- Gamesa G128 5MW

## Offshore WTG Power Ranges

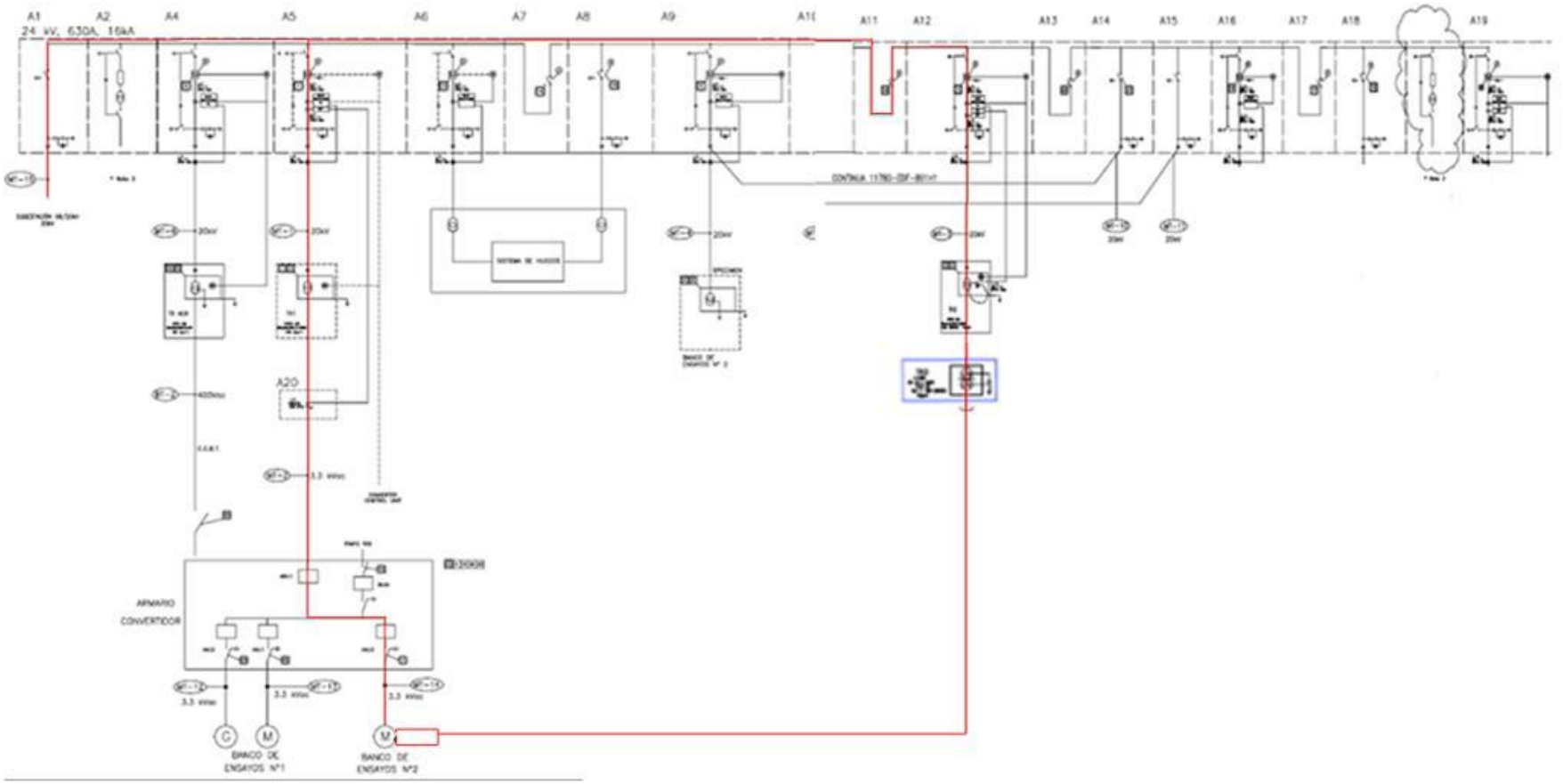
- LEA-CENER Objetive 2015-2016:

GAMESA GXX 8 MW OFFSHORE

3. LVRT test
based on inductance technology concerns

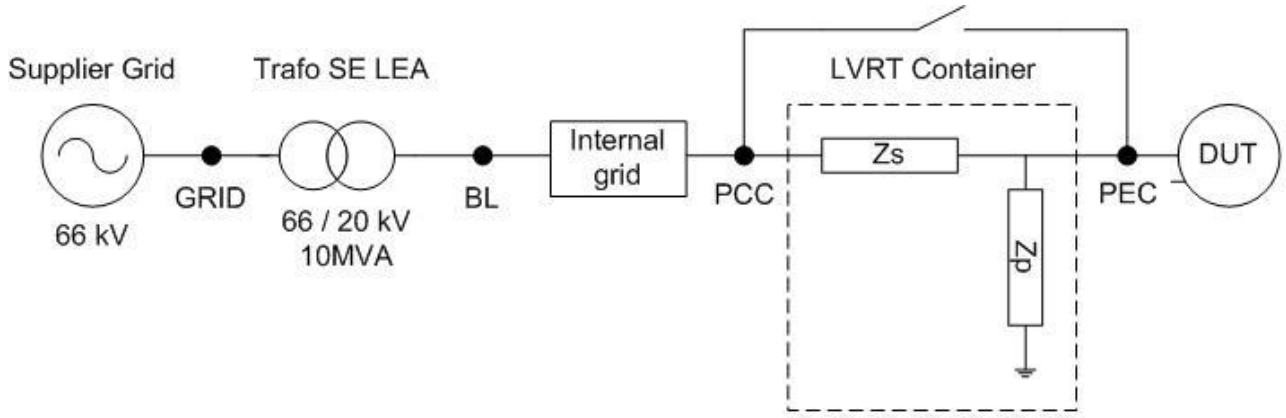
Electrical Generator test bench

## 3. Configuration for LVRT test based on inductance



Electrical Generator test bench

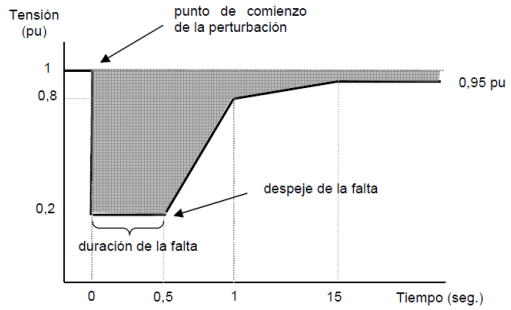
## 3. Configuration for LVRT test based on inductance




PCE. Point of especimen coupling
PCC. Point of common coupling
BL. 20kV Bus LEA
Zs. Serial impedance
Zp. Parallel impedance
DUT. Device under test

## 3. Required LVRT test and constraints

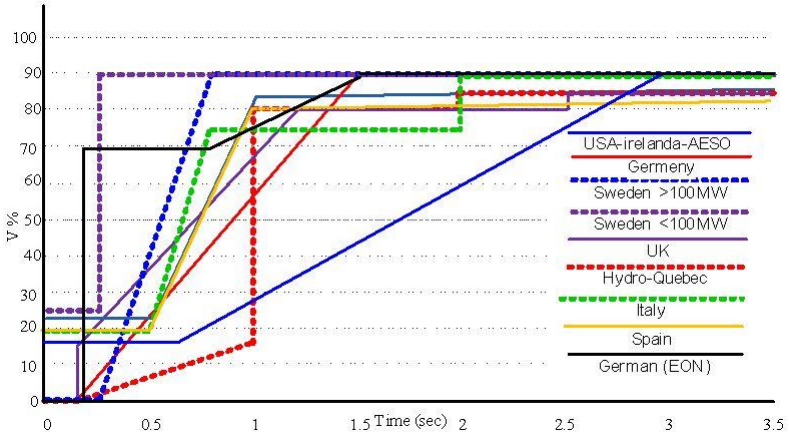
- **Main constraint due:**
  - Grid code requirement (Ex. Spain: P.O.12.3)
  - Power electronic requirement




**Scc = 5x (WTG Power) = 40 MVA**

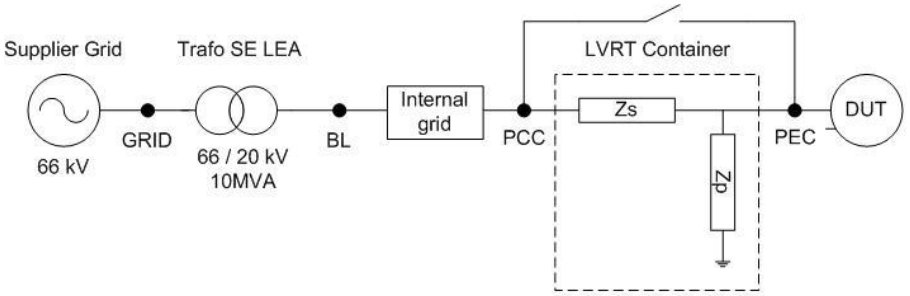
- **Required LVRT Test values:**

| ΔV in PEC [%] | Time [ms] |
|---|---|
| 0 | 160 |
| 20 | 560 |
| 50 | 960 |
| 75 | 1.700 |



Electrical Generator test bench

## 3. Simulation values with current configuration




PCE. Point of especimen coupling
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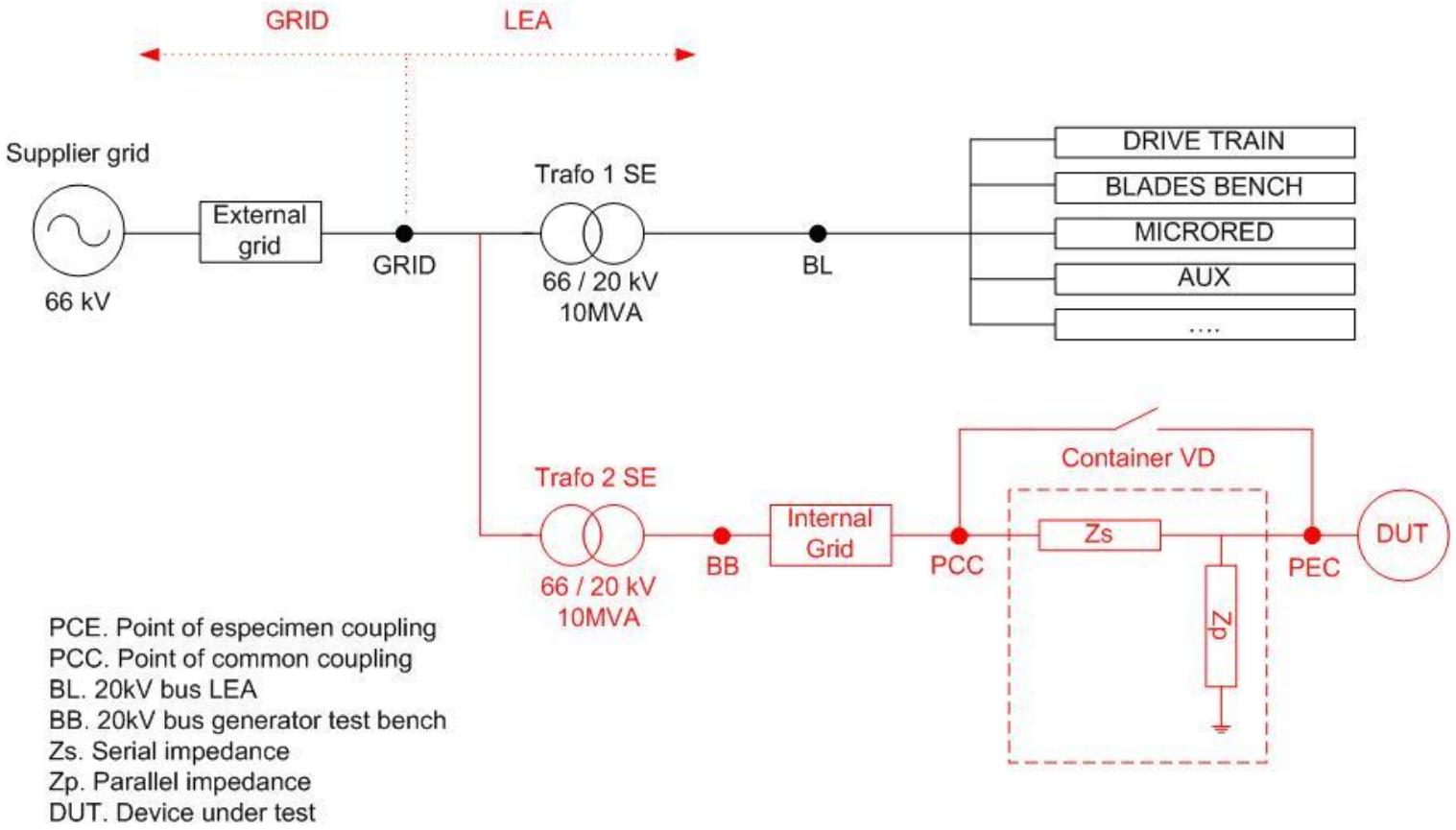
DUT. Device under test

| Zs [Ohm] | Zp [Ohm] | Current CENER GRID 20kV [A] | ΔV in PEC [%] | Scc Point GRID [MVA] | Scc Point BL [MVA] | Scc Point PCC [MVA] | Scc Point PEC [MVA] | ΔV in GRID [%] | ΔV in BL [%] | ΔV in PCC [%] | Time [ms] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5,7 | 0,0 | 1.154,7 | 0 | 603 | 94 | 94 | 40,00 | 6,63 | 42,63 | 42,73 | 160 |
| | 1,1 | 2.161,7 | 20 | | | | | 5,99 | 38,52 | 38,61 | 560 |
| | 4,3 | 1.351,0 | 50 | | | | | 4,65 | 29,87 | 29,94 | 960 |
| | 12,8 | 675,5 | 75 | | | | | 2,91 | 18,68 | 18,73 | 1.700 |

Electrical Generator test bench

## 3. Alternative




PCE. Point of especimen coupling
PCC. Point of common coupling
BL. 20kV bus LEA
BB. 20kV bus generator test bench
Zs. Serial impedance
Zp. Parallel impedance
DUT. Device under test

## 2. Conclussions

- **Current offshore WTG Power will difficult LVRT test using inductance technology**

- **It is not clear yet due to the different wind farm connection (maybe using HVDC stations) the test that will be required. Initially grid operators will requrie the same as in Onshore**

- **Even using some alternatives that could help finally the disturbances in the grid suggest to rethink this kind of test.**

## 2. Conclussions

- **The right way would be using Grid Simulators, and new Scc requirements will be defined according to offshore WTG Power and connectivity.**

- **CENER plans to upgrade the Electrical Generator Test bench with Grid Simulator capability mainly for LVRT mandatory tests.**

- **It will be very important to obtain the certification from grid operator for laboratory test based on Grid Simulator: WTG manufacturers.**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