

Testing Wind Turbines Generators with ULYSSES



Barlovento - Energy to Quality
Spain

Contents

- Our company
- Introduction
- How our unit works
- Some technical procedures that requires field tests
 - Spain
 - Germany
 - IEC
- Logistics experiences
- Conclusions

Our company

ENERGY TO QUALITY: WHAT WE DO

- **FIELD MEASUREMENT:** ACCREDITED LVRT REPORTS OF WIND TURBINES ACCORDING TO SEVERAL GRID CODES (USA, Germany, Denmark, Ireland, UK, United States, etc...) AND POWER QUALITY ACCORDING TO IEC 61400-21 ed2, FGW TR3 rev 22 AND MEASNET
- **NUMERICAL SIMULATIONS:** RMS/EMT MODELING OF WIND TURBINES (POWERFACTORY, MATLAB, PSSE), ACCREDITATION OF EXISTING WIND FARMS AND NEW INSTALLATIONS.
- **MODEL VALIDATION:** WIND TURBINES, FACTS....

Our company

BARLOVENTO: HISTORICAL OVERVIEW

Barlovento is an independent technical assessor and laboratory in wind and solar energies:

1998

- **Creation Barlovento Recursos Naturales S.L.**

2002

- **Start-up testing laboratory**

2004

- **MEASNET membership**

2005

- **Energy to Quality, S.L. (E2Q)**

2009

- **Barlovento Renovables Latinoamérica, S.A.C.**

2011

- **Barlovento Dacia (Romania), Barlovento Brasil**

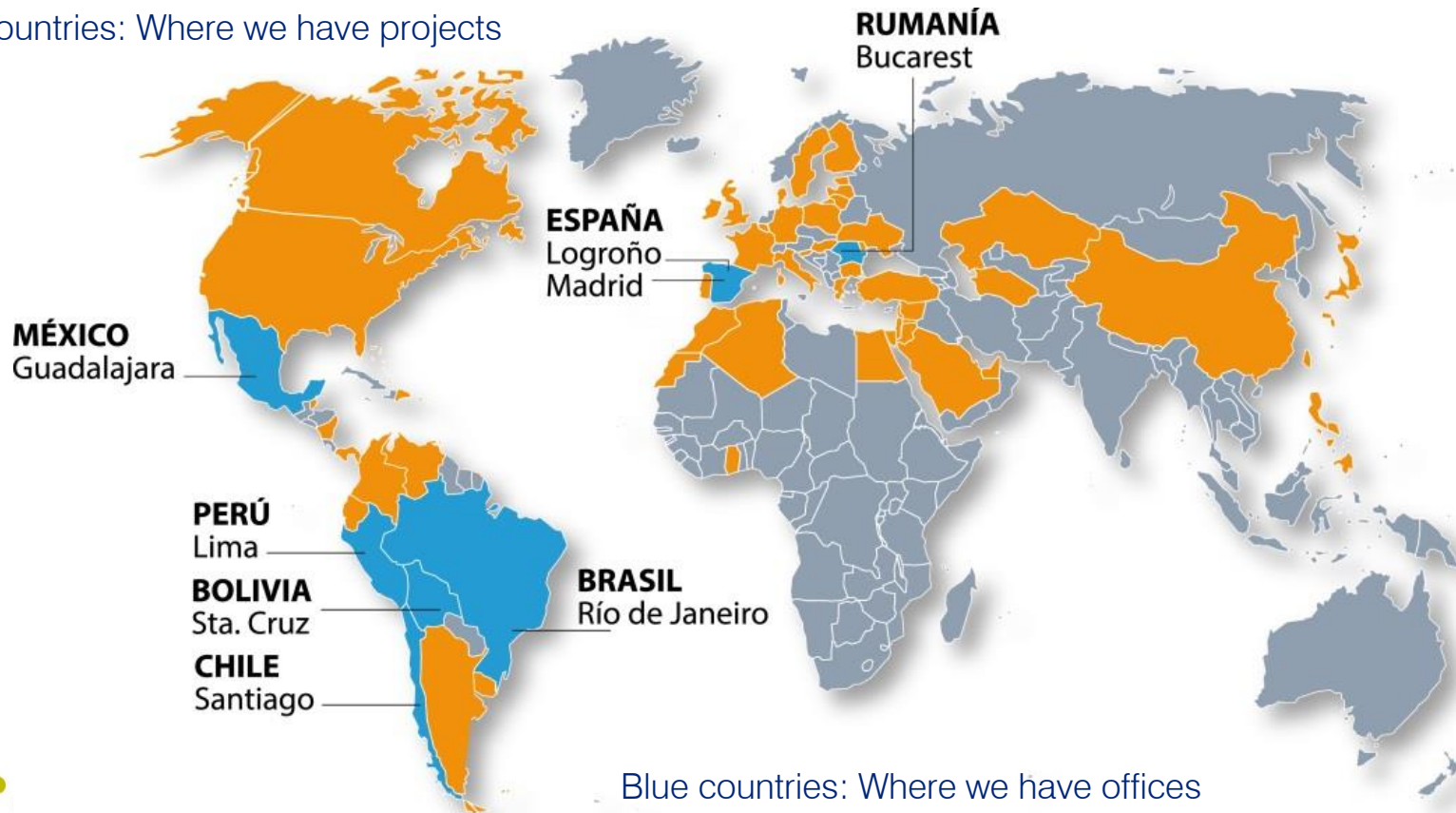
2012

- **Bolivia, E2Q de México, Chile**

Our company

BARLOVENTO GROUP IN THE WORLD

Orange countries: Where we have projects

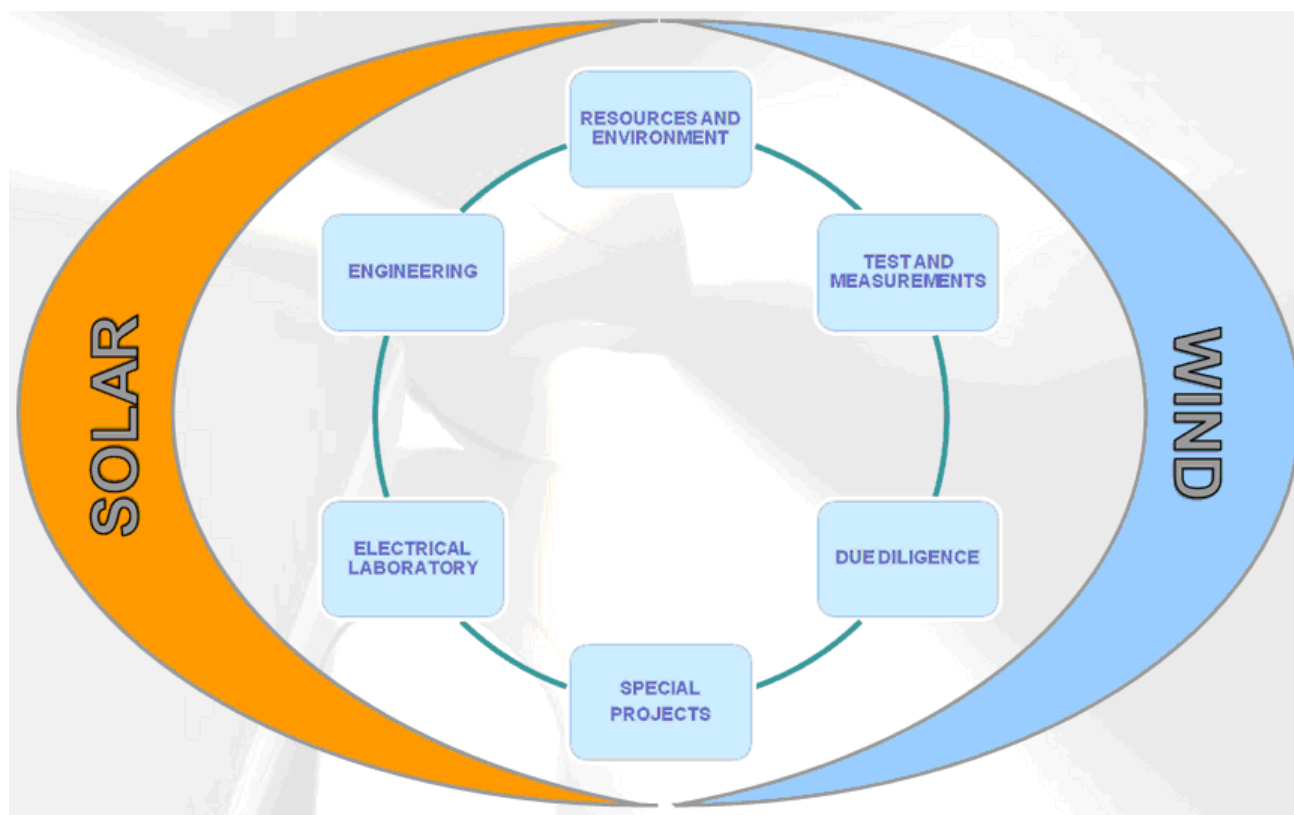


Blue countries: Where we have offices

Projects in more than 40 countries, along Europe, Asia, Africa and America

Our company

BARLOVENTO: ACTIVITIES



Our company

BARLOVENTO: AREAS OF WORK

- Barlovento Recursos Naturales has six main areas of work.

- **Resources and Environment** (measurement campaigns, site certification, site assessment, Wind Class studies, micrositeing, production studies,...)
- **Test and Measurements** (Power Curve test, Power Quality test, Grid code certifications, LVRT test, noise measurements,...)
- **Due Diligence** (“purchase and sale” audits, technical audits, normative consultancy, arbitration,...)
- **Engineering** (engineering projects, wind farms basic/execution projects, tender preparation, technical specification for tenders, projects supervision and certification, remote operation of installations,...)
- **Electrical Laboratory** (test of equipment like inverters and solar panels, design and commercialization of measurement equipment like LVRT test equipment,...)
- **Special Projects** (meteorological studies, problem diagnosis, complex flow characterization, R&D experiments, preparation of technical in-house courses,...)

Our company

BARLOVENTO: EXPERIENCE OVERVIEW

- Barlovento Recursos Naturales is an Independent Technical Consultant on Renewable Energies:
 - Site Assessment: More than 1.500 Wind Farms worldwide
 - Wind resource consultancy : More than 15.000 MW already built
 - Solar resource consultancy: More than 500 MW already built
 - Lenders advising for project finance: More than 1600 MW
 - Wind measurement campaign: More than 1650 mast installed
 - Post-Construction Yield Analysis: More than 1000 MW
- Barlovento has more than 70 employees, 90% of them Renewable Energy specialists.
- Barlovento has been awarded on several international tenders as Morocco, Colombia, Peru, Egypt, Ecuador ...
- Independent verification of performance guarantees, availability, power curve, power quality, ... on wind and photovoltaic installations.
- **Energy to Quality S.L. – E2Q** (100% owned by Barlovento) is a **Laboratory dedicated to Electrical Consultancy and Tests for Renewable Energy**:
 - LVRT Test, Power Quality test, Grid code validations, ...
 - Grid simulation,
 - Grid integration expertise.
- Active member of international organizations and Normalization bodies (IEC, Measnet, ...)

Our company

BARLOVENTO: ACTIVITIES OVERVIEW

■ WIND ENERGY

- Measurement Campaigns
- Resource and Production Reports
- Regional Planning and Development
- Wind Farm Design
- Technical Advising and Assistance
- Finance Due Diligence
- Wind Turbine Testing
- Post-Construction Analysis
- Wind Farms in Exploitation: Guarantees
- Engineering
- Environmental Impact Assessment

■ SOLAR ENERGY

- Measurement Campaigns
- Resource and Production Reports
- Regional Planning and Development
- Wind Farm Design
- Technical Advising and Assistance
- Finance Due Diligence
- Inspection of operating plants
- Testing and Monitoring
- PV CONTROLERGY: WEB monitoring
- Operation

• GRID INTEGRATION (E2Q)

- Integration studies of renewable energies
- Impact studies of wind farms in weak grids
- Grid Integration of offshore wind farms
- Monitoring of grid incidences
- Electrical test
- Power Quality
- Voltage dip test
- Simulation models of Grid Integration

• METEOROLOGY & ENVIRONMENT

- Accredited Measurement Campaign
- Wind & Solar Campaigns
- Agrometeorology and environmental measurements

• DISTRIBUTED GENERATION

- Energetic potential calculation
- Feasibility studies
- Measurements
- Modeling of electric integration
- Design and sizing of hybrid systems and generation micro-grids
- Installation of hybrid systems and generation
- Web applications

Our company

BARLOVENTO: QUALITY ACCREDITATIONS

Certificate of R&D&i Management AENOR³ UNE 166002.



Test Laboratory, accreditation ENAC following ISO 17025:

- Wind Turbines (Power curve^{1,2}), member of MEASNET
- Wind Turbine noise measurements¹
- Condition Monitoring
- Meteorological measurements^{1,2}
- Photovoltaic systems monitoring¹
- Power Quality^{1,2} (E2Q)
- Electrical model validation¹ (E2Q)
- LVRT test¹ (E2Q)



Barlovento and E2Q are members of MEASNET

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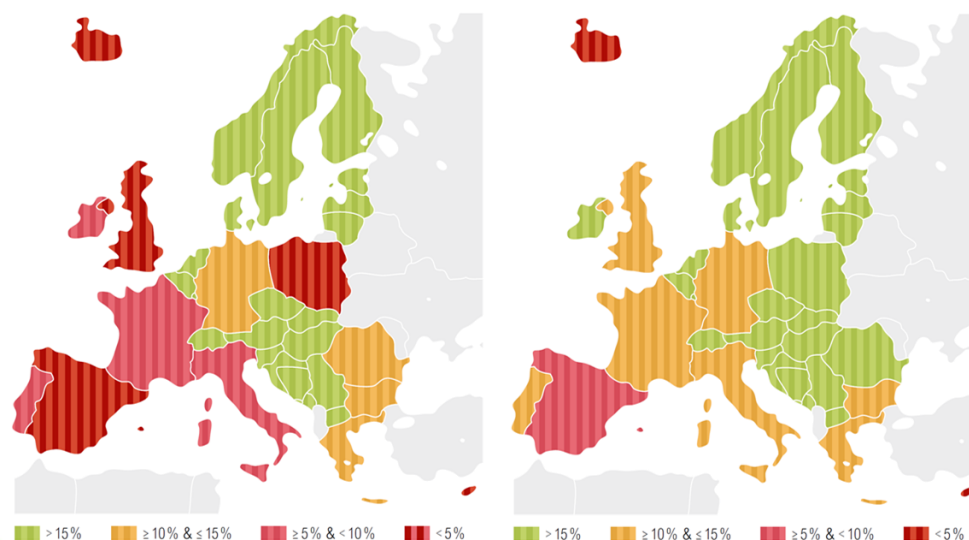
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Introduction

SPANISH FIGURES

Spain is an example when talking about wind power integration due to:

- Huge experience in all technologies. First wind farm in 1986
- Wind power installed: **more than 20%** of the total power installed
- Spain is an island (in terms of electric energy production). That means that the Spanish power system is sensitive in terms of stability



Import capacity / net generation capacity

Source: ENTSOE

Introduction

SPANISH FIGURES

Spain is an example when talking about wind power integration due to:

- Spain is the first country with a control center dedicated to renewable energies (CECRE).



Introduction

RECORDS IN SPAIN

Wind power hits:

- **Coverage of power demand: 64.25%** (24/Sep/2012 - 3:03 am)
- Power production: 17056 MW (06/Feb/2013)
- Month generation 5632 GWh (april 2012)
- Instant production 16636 MW (18/04/2012)
- **2011: 22e6 tons of CO₂ saved**

Introduction

ORIGIN OF PO12.3

- Wind turbines affected by voltage dips
 - Mechanical stress
 - Increasing of the current through power electronics

- Disconnections not allowed anymore

- The operational procedure appeared
 - PO 12.3 (2006)



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LVRT UNIT

ULYSSES DESIGN

1.- INNOVATION:

- Prototype
- **Mobile equipment** → Not site-specific
- Restrictions on the size of components

2.- ELECTRICAL CONSIDERATIONS: VERSATILITY

- Voltage level??(12kV, 20kV, 30kV)
- **Sc at the connection point??**
- Rated power of the equipment under test??
- Contribution to the Icc from the WT??
- Selectivity of the protection scheme??
- Protection against Short-Circuits/allowing Short-Circuits??

3.- SAFETY OPERATION:

- **Remote control**
- Testing WT ride through capabilities, not the NETWORK ride through capabilities → Important to limit Icc_{network}
- **Settings** of the internal protection system: site-dependent and test-Dependent
- Measurement at MV level

LVRT UNIT

ULYSSES

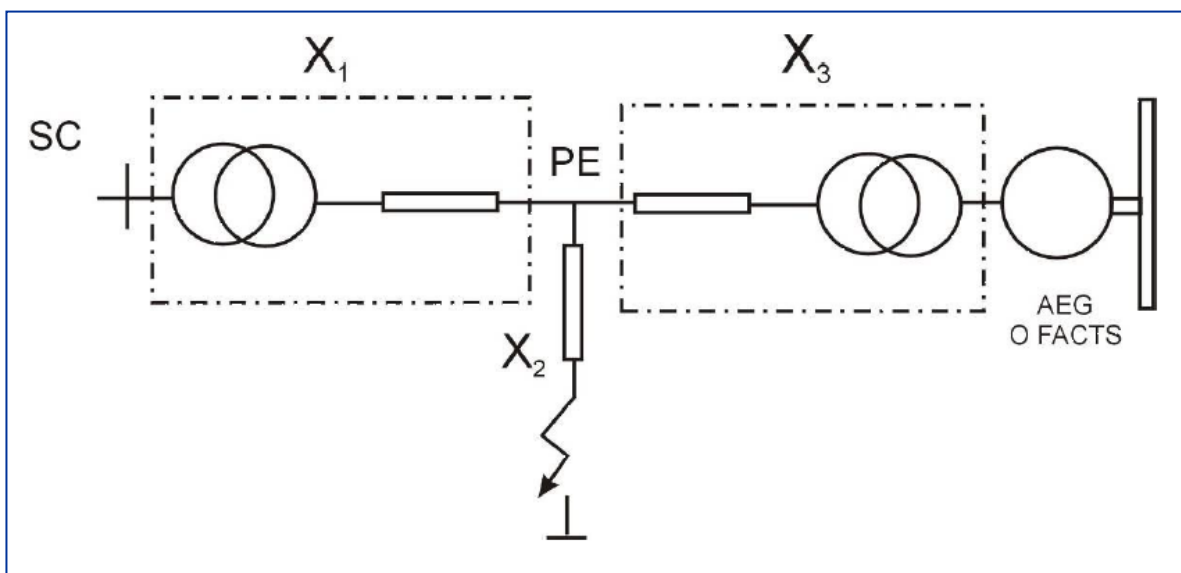
The unit is able to perform short circuits of the **desired residual voltage** with **precise duration**.

Finished at the end of 2005 in Madrid, Spain



LVRT UNIT

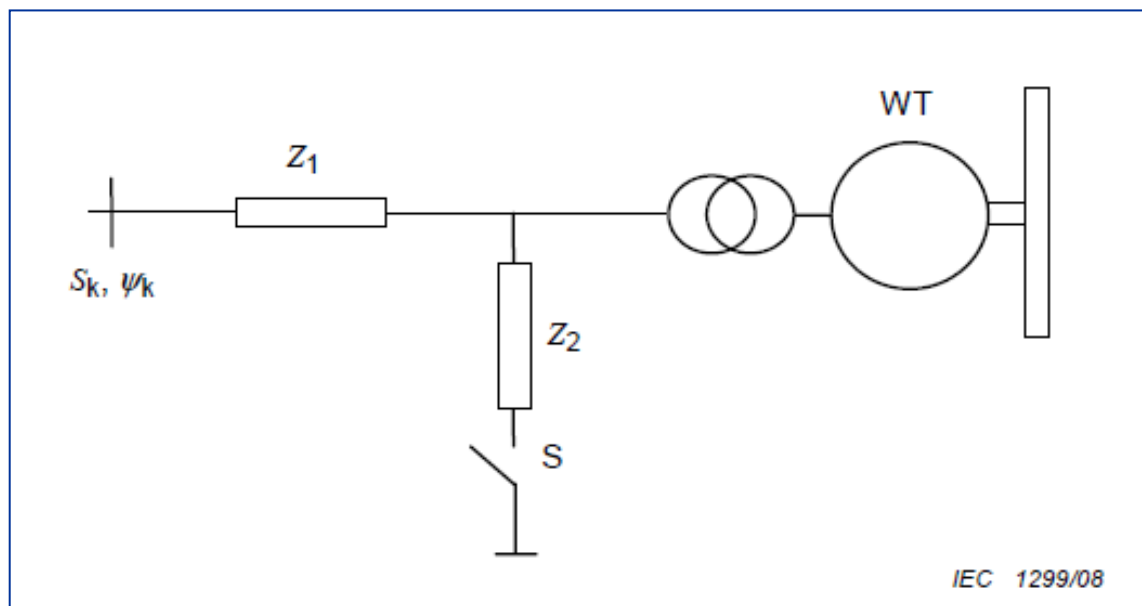
SCHEME OF THE LVRT UNIT DESIGNED BY E2Q



PVVC (2007)

LVRT UNIT

SCHEME OF THE LVRT UNIT DESIGNED BY E2Q



IEC 61400-21 (2008)

LVRT UNIT

INSIDE THE TRUCK

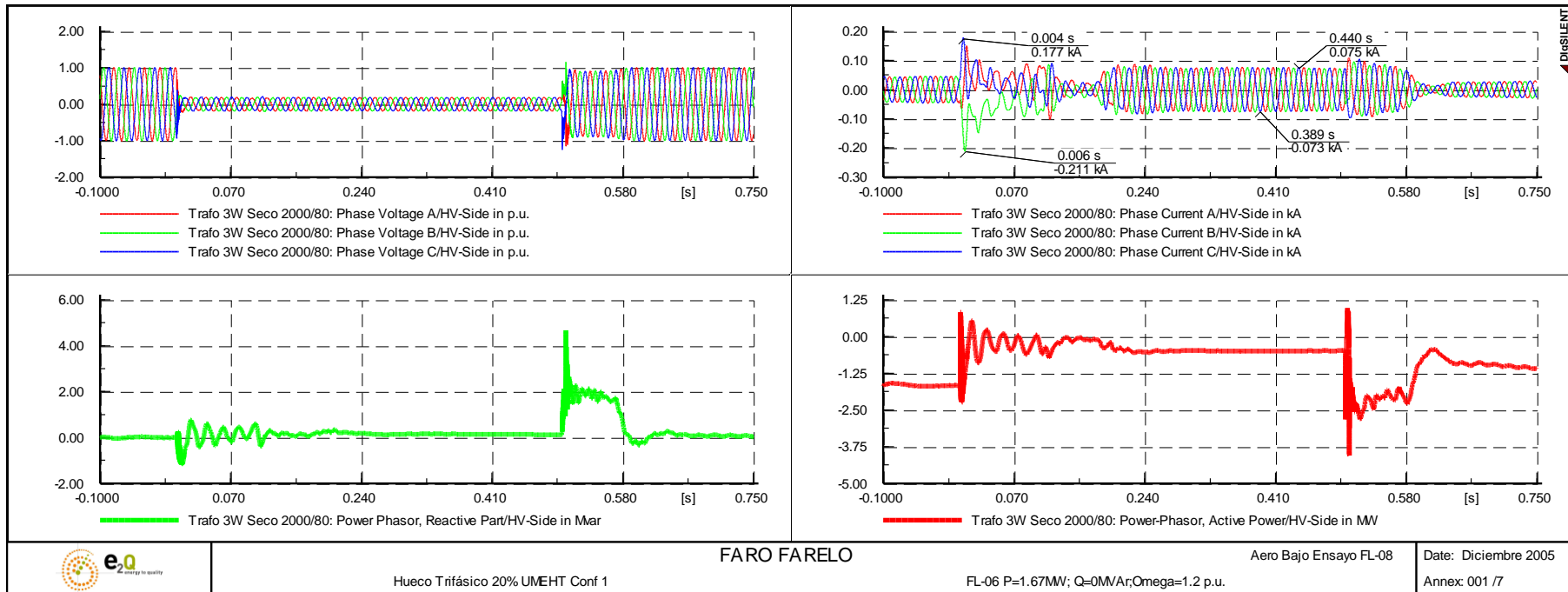


Reactance room



LVRT UNIT

PRE FIELD-TEST STUDIES



After finishing these simulations, we can start the LVRT test campaign

LVRT UNIT

FIELD TESTS

ULYSSES

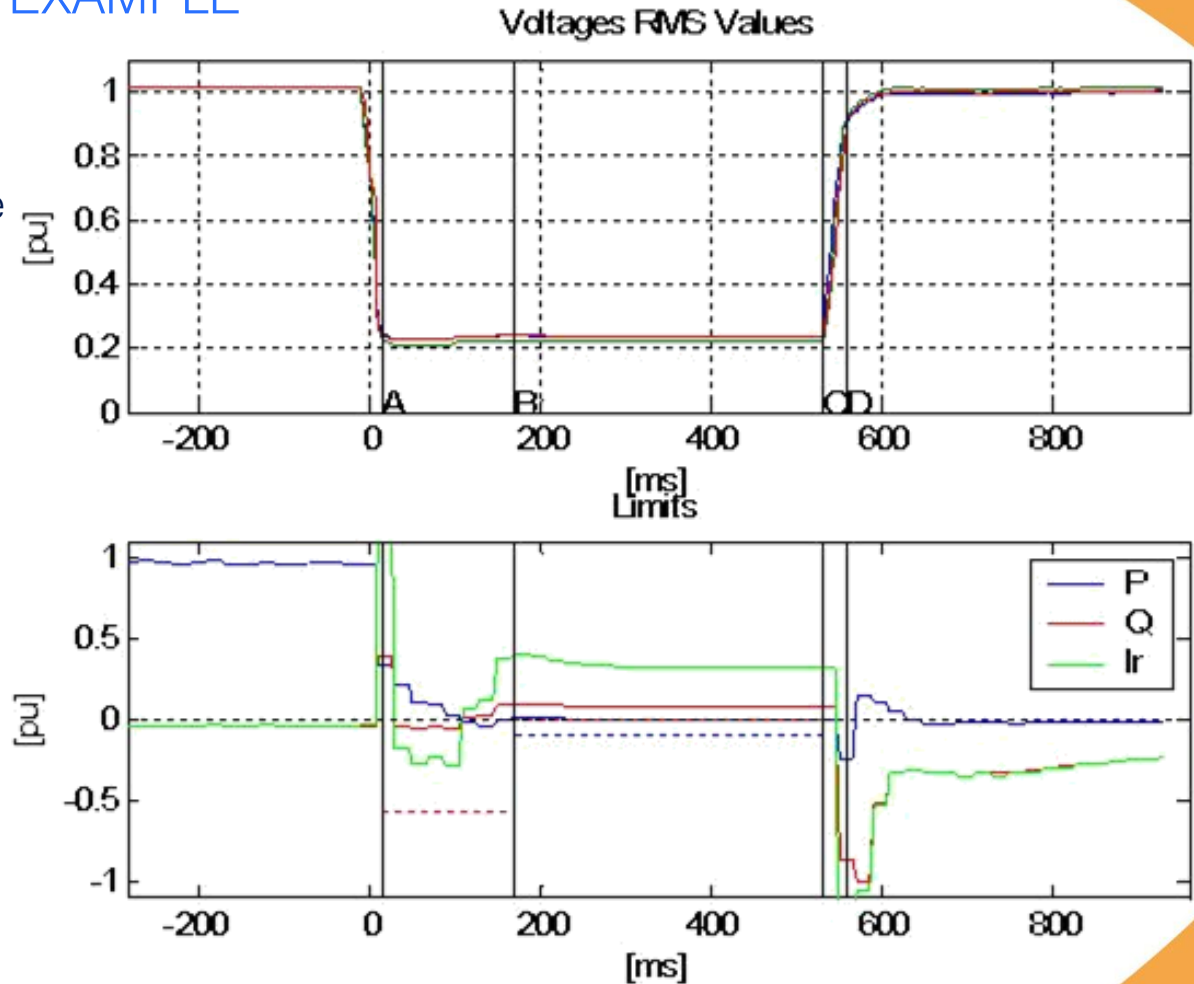


LVRT UNIT

FIELD EXPERIENCE, AN EXAMPLE

Example of measurement
according to the Spanish grid code

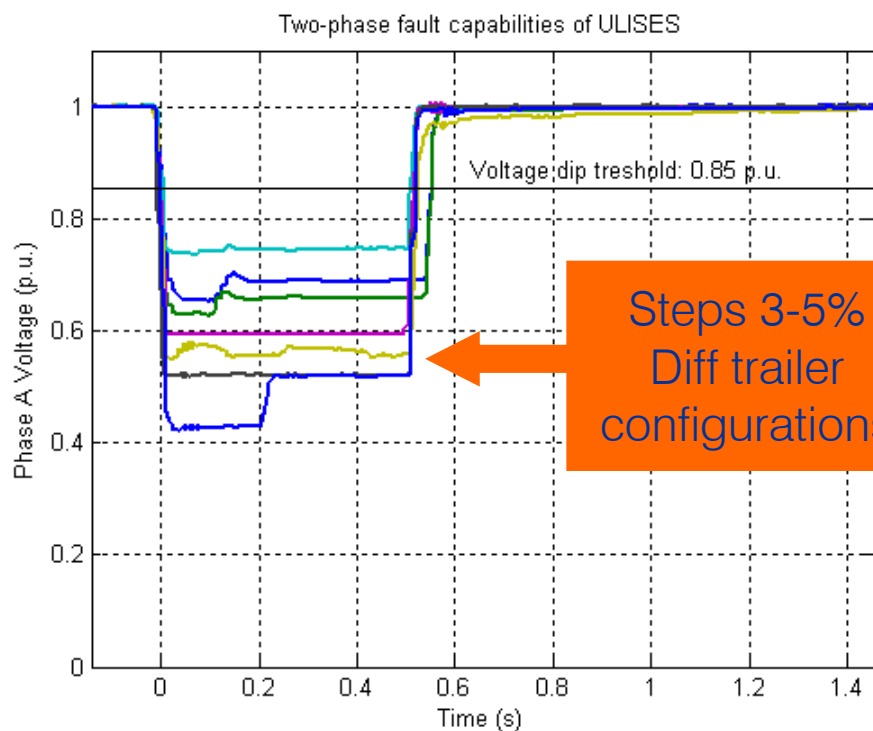
20%Un, 500ms



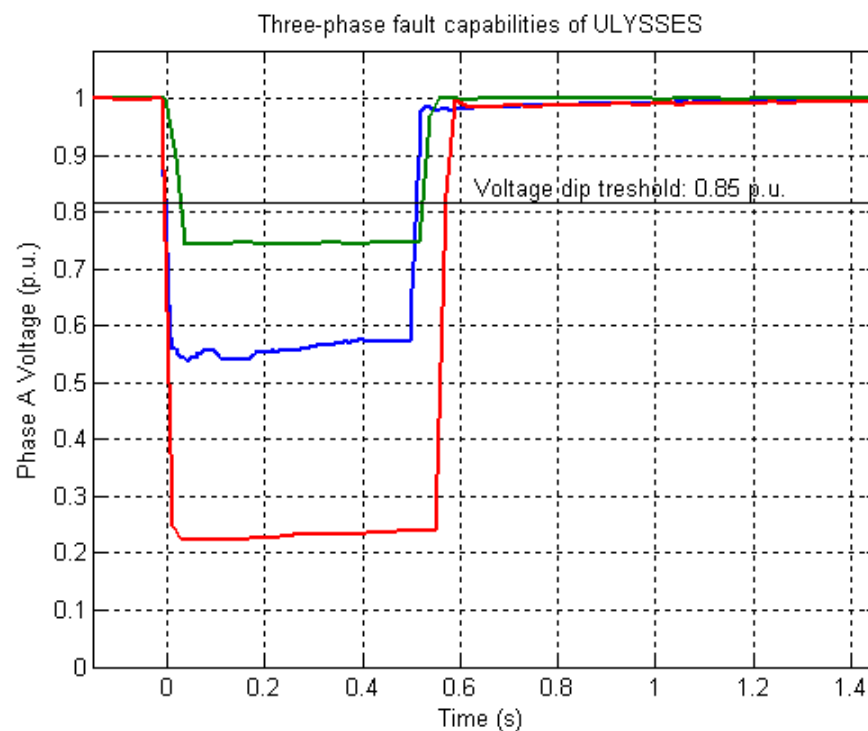
LVRT UNIT

FIELD EXPERIENCE, DIFFERENT TYPES OF VOLTAGE DIP

2-Phase voltage dip
Phase A



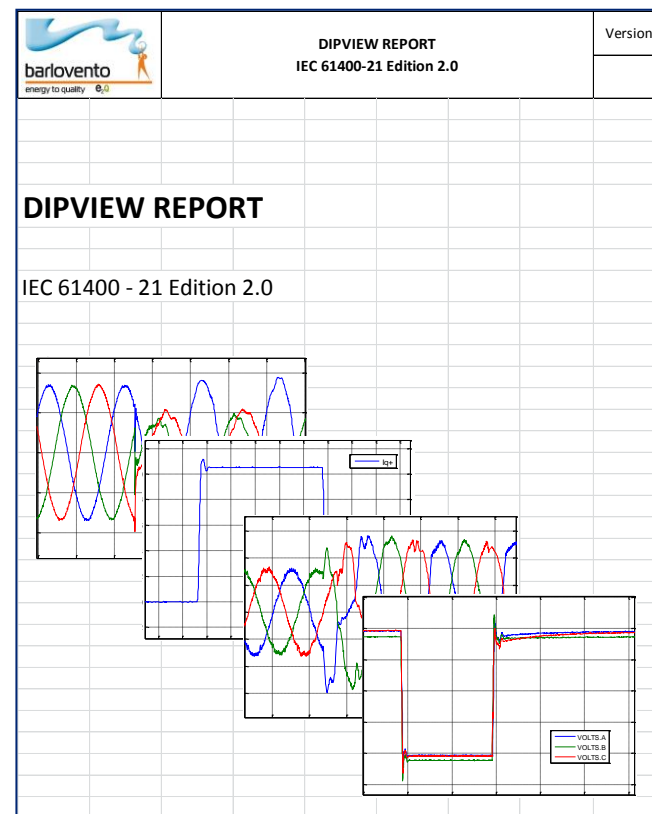
3-Phase voltage dip
Phase A



LVRT UNIT

ANALYSIS OF THE RESULTS

Energy to quality has developed his own software tool for analyzing the results of the voltage dip test campaign. It's called **Dipoffice 4.0** and it is possible to **analyze results according to any grid code** by introducing the requirements in an easy way.



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TECHNICAL PROCEDURES

SPAIN

- In the P.O. 12.3, the requirements to be fulfilled are defined. However, it is not defined the way of testing.
- The Spanish Wind Energy Association (AEE) wrote the technical document where the way of testing according to PO 12.3 was defined. It is called “*Procedure for verification validation and Certification of the requirements of the PO 12.3 on the response of wind farms and photovoltaic plants in the event of voltage dips*” (PVVC)

TECHNICAL PROCEDURES

SPAIN

- The PWVC offers two ways for certifying wind farms:
 - **Particular procedure**
 - The fulfillment of LVRT is proved by means of field test carried out by an accredited laboratory
 - **General procedure**
 - The fulfillment of LVRT is proved by means of a simulation. The model must be validated by means of field tests

TECHNICAL PROCEDURES

GERMANY

- In Germany field test are required as well
- FGW is a set of technical rules for renewable energy measurements.
 - TR3: regarding **power quality measurement** (similar to IEC 61400-21)
 - TR4: regarding **validation of the model** by using field tests of TR3 (similar to IEC 61400-27)

TECHNICAL PROCEDURES

INTERNATIONAL

- **IEC 61400-21** ed2 (2008) defines a set of **power quality measurements** to be carried out in a wind turbine generator. With those, the wind turbine generator can be characterized.
- **IEC 61400-27** (draft) will define the way of **validating models** of wind turbine generators through the results obtained by measuring according to IEC 61400-21

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LOGISTICS EXPERIENCE

FIRST VISIT



LOGISTICS EXPERIENCE

AND AFTER

sometimes the roads are not in the same conditions



LOGISTICS EXPERIENCE

PLACING THE UNIT



LOGISTICS EXPERIENCE

WAREHOUSES



LOGISTICS EXPERIENCE

RECEPTION OF THE MATERIAL & FENCE AROUND



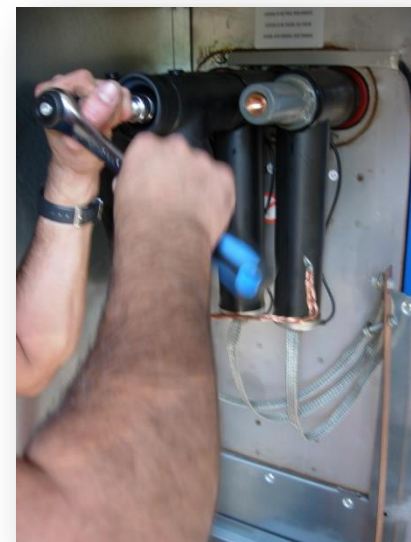
LOGISTICS EXPERIENCE

BAD WEATHER



LOGISTICS EXPERIENCE

INSTALLING THE UNIT



LOGISTICS EXPERIENCE

MULTIBRID AND ULYSSES



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SUMMARY

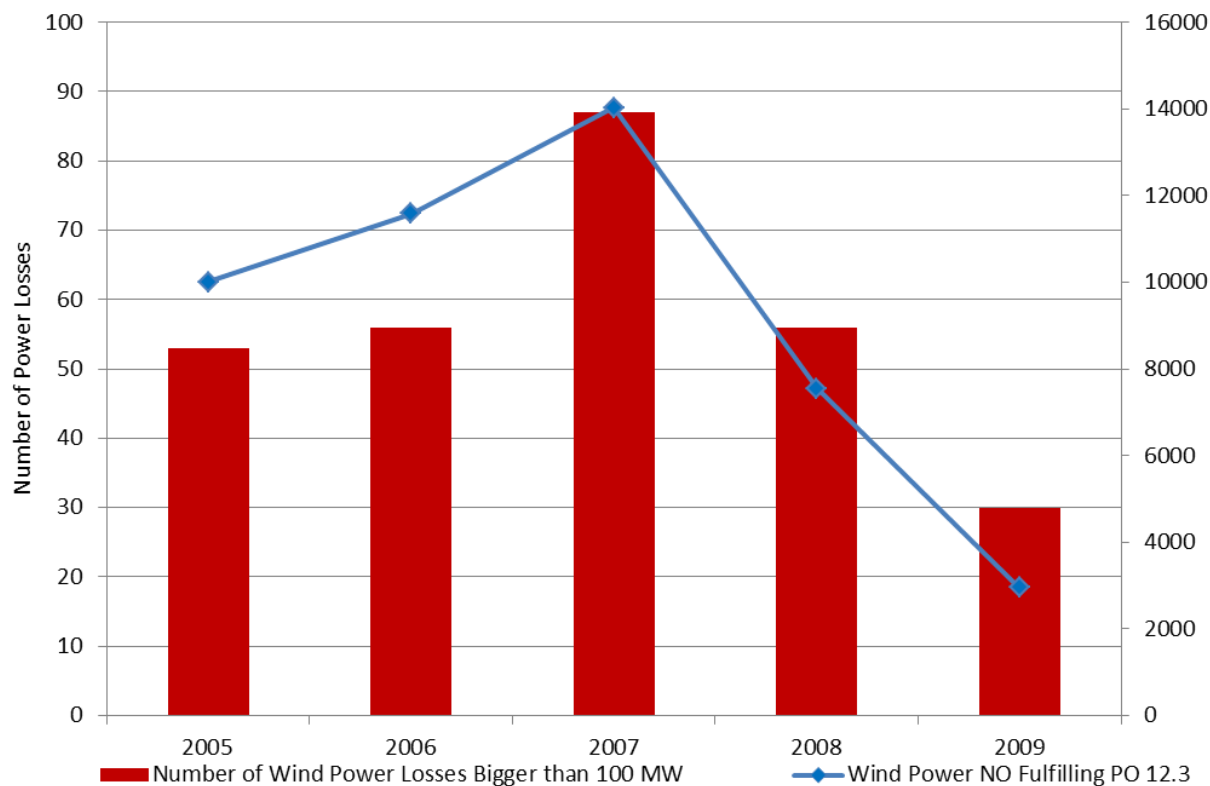
TO TAKE INTO ACCOUNT

- Field tests needed for a complete characterization of the WTG (IEC -21)
- Field tests guarantee accurate information to TSO
- Field tests avoid inappropriate results and derived problems
- Accredited entities guarantee quality results
- Field tests are a quality mark in the renewable energy market

FACT

SUCCESS AFTER FIELD TESTS

- Number of losses of more than 100 MW of wind energy per year (red columns) and wind energy without LVRT capability (blue line)



Source: REE

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Thank you for your attention!
info@energytoquality.com