Grid Integration of RES for a Secure and Reliable Power Supply

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Wind Energy Business Conference, November 5th 2013, Chicago
Study of E.ON (now TenneT) in 2001 on voltage sags

Voltage-dip during 3-phase-fault in a 380-kV substation (Northern-Germany)

Szenario: 2001, Schwachlast
WEA-Modell: Umrichter
Kurzschluss: Dollem

<table>
<thead>
<tr>
<th>$U_{\text{Rest}}$</th>
<th>$P_{\text{WEA}}$</th>
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<tbody>
<tr>
<td>$\leq 40% U_n$</td>
<td>170 MW</td>
</tr>
<tr>
<td>$\leq 50% U_n$</td>
<td>1130 MW</td>
</tr>
<tr>
<td>$\leq 60% U_n$</td>
<td>2160 MW</td>
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<tr>
<td>$\leq 70% U_n$</td>
<td>2700 MW</td>
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$\Rightarrow$ Automatical shutdown of installed WTGs at $<80\% U_n$

$\Rightarrow$ Loss of about 3000 MW
Lessons learned – Motivation

Study of E.ON (former TenneT) in 2001 on voltage sags
Voltage-dip during 3-phase-fault in a 380-kV-substation (Northern-Germany)

Tripping of turbines is to be avoided in case of grid failures

Birth of the Fault Ride Through (FRT) requirement and other power plant capabilities for DG units in the E.ON 2003 grid code

FGH has consulted E.ON (and others later on) and developed the respective testing set up and labs

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Partial Blackout Europe, NOV 2006
(not induced by wind turbines; but turbines played a significant role in the re-synchronizing ....)
Lessons learned – Motivation

Challenge: Wind farms (and PV, and CHP, and ...) must provide power plant characteristics just like conventional thermal plants to maintain security and reliability of power supply even in today's power systems!

Grid design and operation has to be adapted!

FGH offers solutions and partnership for

- Manufacturer of WECs (PV converters, CHPs, generators)
- Project developers of wind/PV farms
- System operators

Consultancy  Certification  LVRT Test Labs  Software Solutions

90 years Experience in Electric Power Systems and Power Technology
80 years Experience in Grid Integration of Wind & Solar Power
9 years Accredited Certification Authority

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Replacement of conventional power plants requires mandatory system services of RES

Increasing penetration of RES

Technical Issues to resolve

Frequency Stability
Voltage Control
Dynamic Operation
Conditions of (Re-)connection
Adapted protection schemes

Strategies

Give precise definition of grid codes
Agree on precise definition of verification schemes
Set up the stage early – avoid retrofitting

Lessons learned – Basic Challenges
Lessons learned – Paradigm shift in Europe

Snapshot on European Grid Codes (End of 2011)

A compulsory European ENTSO-E Network Code is underway!!

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Standardization for reliable grid integration

In order to ensure a reliable operation and provision of systems services, dispersed power generators must provide grid code compliance based on:

- **Type Test** based on transparent testing standards by accredited testing laboratories
- **Type Certificates** on grid code compliance by accredited certification offices
  - Test results
  - WT design
- **Reliable Unit Models** based on measurements vs. simulation results
- **Farm Certificates** based on grid code type certificates plus validated models plus procedures for transient and steady-state calculations

Identification of Grid Code Requirements

Legislative framework for GC-requirements (national + international)

Use standards to trigger and push the industry!

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FGH at a glance

90 years tradition and experience in electric power supply

Office in Aachen
(including Testing Facilities for DPG and EV)

Headquarters in Mannheim
(including High Voltage Test Fields)

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FGH at a glance - Historical development and research focal points

being the central R&D platform of German electric power industry

at the forefront of each time’s challenges

Landmarks in 90 years

- Research on HVDC technologies
- Basic requirements on the electrical characteristics of WECs
- Invention of FRT testing procedure & respective test labs
- Advisor to the German ‘Energiewende’

- 1920s: Layout & design of the German transmission network
- 1950s: Advanced safety and insulation issues
- 1970s: Research on smart grid technology designs, i.e. interoperability
- 1990s: Nr 1 in grid code compliance verification
- 2000s: since 2008
- 2003: today

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FGH at a glance – 3 important players in the field of grid integration

FGH Group – Comprehensive engineering services for grid integration and grid code compliance

Research & Trainings  Consulting Services  Innovative Technologies

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FGH at a glance – 3 important players in the field of grid integration

**System Studies**
- Workshops, trainings & seminars
- Network planning, expansions and restructuring

**Power System Software**
- Development of new procedures and methods
- Network planning software
- Recording and evaluation of failure, damages & outage statistics

**Certification Body**
- All issues of electrical engineering; targeted to employees of DSO/TSOs; manufactures
- Network planning software
- Diagnosis of aged components, substations & systems
- Maintenance strategies

**Power System Technologies**
- Network planning, expansions and restructuring
- SCADA systems and usability of IEC 61850 for smart grid operation; electric vehicles; insulation

**Asset Management**
- For DGs (Wind, PV, CHP) and other grid assets.
- On Electrical Characteristics only!

The Business of FGH - Innovative services to face modern challenges
Core Competencies of FGH

Solutions for manufacturers
Engineering services in the field of grid integration

✓ **Analysis / Testing** according to international Grid Code requirements

✓ **Model validation and prevalidation** according to international validation standards

✓ **Measurements and testings** incl. the provision of testing laboratories + human resources

✓ **Full-Service-Package**
Prequalification incl. full support, measurements and testings,

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Solutions for manufacturers
Independent certification body

**Certification of:**

✓ **DG generation units**
(Wind, PV, CHP, etc.)

✓ **DG plant Components**
(Farm controller, inverter etc.)

✓ **Storage solutions (electric power)**

✓ **General power grid assets** with respect to controlling characteristics (e.g. FACTS, automated transformers, active filter, etc.)

✓ **Type certification acc. to IEC 61400**
(for WEC only, with external partners)

The Business of FGH - Innovative services to face modern challenges
Core Competencies of FGH

Solutions for project developers
Engineering services in the field of grid integration

✓ Configuration and electrical design of power generation facilities
✓ Verification of grid code compliance (on an expertise basis)
✓ Preassessment and comparative analysis
✓ Full support within international projects
✓ Guiding technical discussion with system operator
✓ Increasing the bankability of your projects

Solutions for project developers
Independent certification body

✓ Certification or Expert opinion on the Grid Code Compliance on farm level (Wind, PV or CHP and other generation types like gas turbines, hydroelectric power stations, etc.)
✓ Declaration of conformity according to country specific grid codes (alternatively to certification)
✓ Declaration of conformity according to IEC 61400-1
✓ Project certification acc. to IEC 61400 (for wind farms only, with external partners)

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Core Competencies of FGH

Solutions for grid operators

- Grid connection assessment and evaluation of suitable grid connection points (PCC)

- Configuration of project specific requirements on power generation facilities

- Grid code development and definition of requirements

- System / area network studies (expansions; flexibility measures; generation scheduling; stability assessments, e.g. on voltage / power flow) – not only with respect to RES grid integration

- Grid planning, expansion and disturbance statistics (engineering software)
FGH at a glance

FGH’s USPs

Worldwide first definition of LVRT testing setup –
today incorporated in IEC 61400-21;

Originator and market leader in the field
of mobile LVRT- and OVRT- test labs

Co-Editor of up-to-date gridcodes; Worldwide
first definition of grid code compliance certification

Market leader in grid code compliance issues; strong collaboration
networks with TSOs/DSOs, manufacturers and R&D institutions

Project partner in Europe’s leading
research projects on future power systems

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Excerpt from our international references

**China:** Regular workshops and trainings for CEPRI-engineers (China Electric Power Research Institute); Consultation to Regulation Authority and State Grid

**Romania:** Grid connection study for a wind farm, consisting of 28 wind turbines and an installed capacity of 84 MW

**Mongolia:** Technical expert for a project of the German national metrology institute PTB

**Brazil:** Technical expert for a workshop by CIGRE (Brazilian national electric power generation and transmission committee)

**European Commission:** Study leader for a research study with respect to electricity grid codes in Europe

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The strong network of FGH

Our customers

- NORDEX
- GE
- Repower
- Vensys
- JUWI
- PNE
- SMA
- Vestas...

Further network partners:

- ABB
- Areva,
- Schneider electric,
- Siemens
- RWTH Aachen,
- ENTSO-E,
- European Commission
- TÜV Rheinland
- ...

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Conclusion and perspectives

1. RES integration is more than just markets – it’s an technical issue (first)!

2. Grid codes and their verification of compliance are needed for reliable grid integration

3. Well-defined, transparent and accepted requirements & compliance schemes are essential >> Use or adapt Standards!

4. FGH offers a broad range of services for manufacturers, project developers and system operators

5. FGH strives for establishing international cooperation networks with all stakeholders involved for exchange, business and R&D
Bernhard Schowe-von der Brelie, Executive Director of FGH GmbH

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Since 1921

Thank you for your attention!
Back-Up
Lessons learned – Proposal

Recommendations on grid integration of RES

- Verification of grid code compliance is essential to ensure power system’s stability with increasing amount of RES
- Experiences from other countries have shown
  - The higher the penetration of RES the more important is their dynamic performance and appropriate representation in power system studies
  - Advanced compliance schemes for RES increased power system’s stability significantly (reliable prediction of impacts in critical situation and conditions). **Verification is necessary!**
  - **Retrofitting is economically disadvantageous** (e.g. LVRT capability, 50.2 Hz) !
  - Standard-complying manufacturers **maintained and empowered market positions**
- Requirements in Grid Codes directly affect the technologies of RES
  - Market of ancillary services vs. compulsory technical requirements
  - **Appropriate transition schemes are crucial !!**
- **Key drivers** for successful integration
  1. Close cooperation and collaboration of system operators and RES sector
  2. Adequate incentives for grid code fulfillment and for the provision of system services
  3. Well-defined, transparent and accepted compliance schemes
- **Build up international cooperation on these issues !! The physics are the same!**
The FGH group – 3 important players in the field of grid integration

Research  Services  Technologies

FGH Test Systems GmbH

FGH e.V.
Research Association for Power Systems and Power Economics

FGH GmbH

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Research, Training, Network

- System studies on grid integration of distributed generation units
- SCADA systems and usability of IEC 61850 for smart grid operation
- World’s first definition of LVRT testing setup in 2003 (incorporated in IEC 61400)
- World’s first grid code compliance certification in 2005

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Commercial unit Certification, Software & Services

- Validation of unit models in accordance to international validation schemes
- Type & unit certification for grid code compliance (market leader)
- Consultancy services for grid code compliance
- Consulting on grid connection
- PCC Assessment

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Commercial unit
Customized Compact HV & MV Equipment

- Manufacturer of mobile LVRT/HVRT testing laboratories (up to 10 MVA)
- Customized design according to special requirements
- HVRT testing setup
- World market leader

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