Grid Code Compliance of Wind Energy Systems

Dr Sigrid M. Bolik

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Day's Agenda

10:15	*Introduction to grid code* **Sigrid Bolik** An overview of what grid code is, the history of development, its relevance to wind power, the process for change or review of existing grid code, the process for proving compliance
11:00	*Further grid code developments* **Sigrid Bolik** Comparisons with overseas markets, comparing requirements and the international transmission impacts, application of grid code offshore
11:45	*Discussion and questions*
12:00	*Lunch*
13:00	*Grid in Scotland* **Keith Maclean** An update on latest developments regarding grid issues in Scotland and in particular the grid queue and the Beauly-Denny public enquiry.
13:20	*Grid in Wales* **Peter Roper (Glasgow)** **Graeme Cooper (London)** An update on latest developments regarding grid in Wales and in particular the TAN 8 impact and lack of Grid in Wales.
Developments and technical challenges to grid code	
13:40	*Technical challenges to grid code compliance* **Sigrid Bolik** Wind farm control, compensation, fault ride through, generic modelling, validation/measurements/monitoring Implications for other renewable generation

Further Grid Code developments

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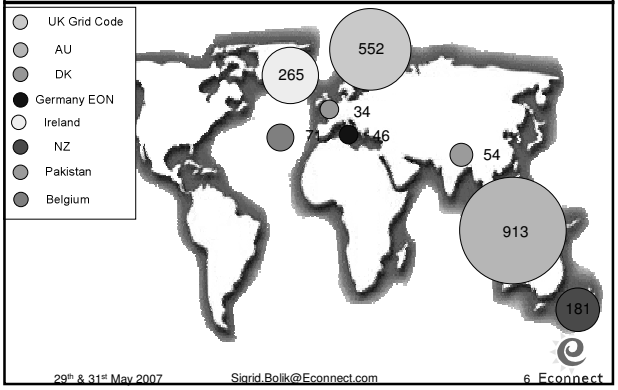
Agenda

1. Introduction international markeds
2. Voltage variability & PQ
3. Frequency variability
4. Validation & modelling intro

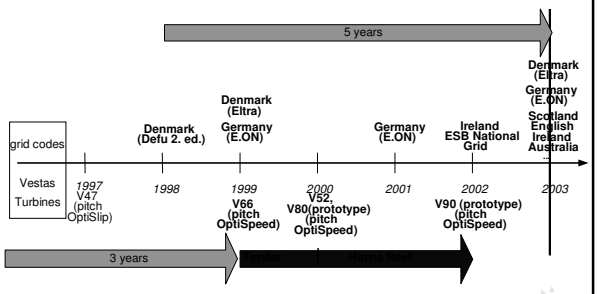
Grid Code vs. International standards

A big problem for manufacturers of wind turbines

Grid Code vs. International standards



2. Grid Codes — Grid codes vs WT development



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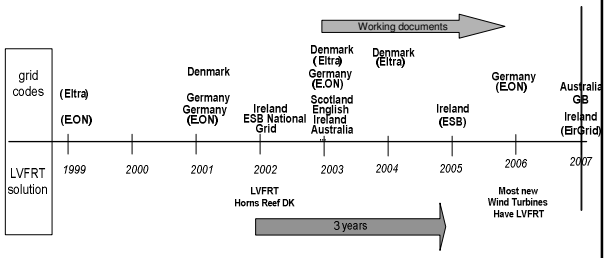
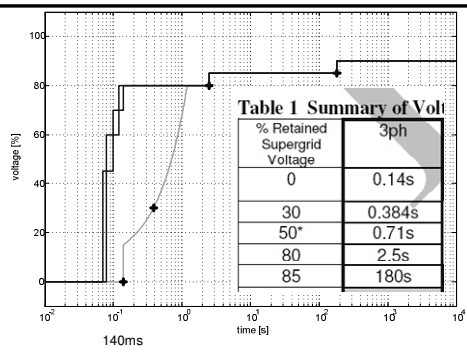
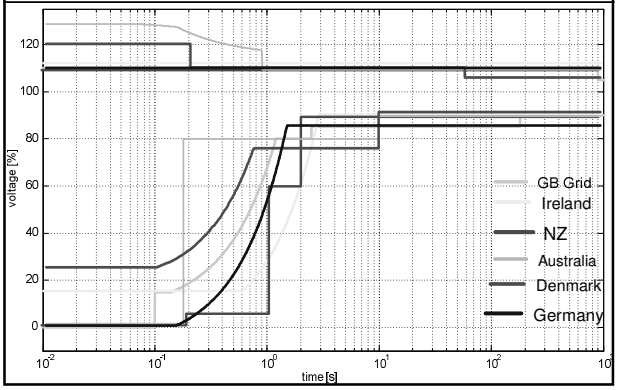


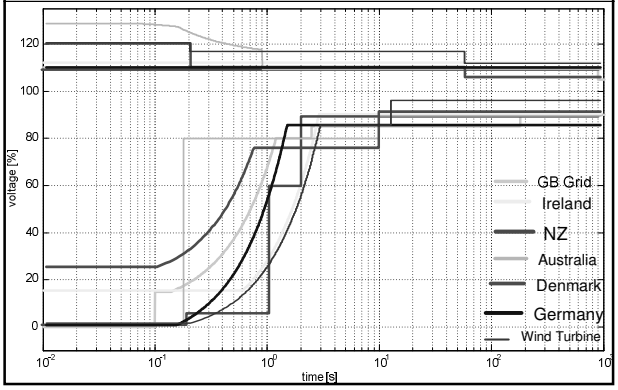
2. Technical Requirements — LVFRT 275kV/ 400kV



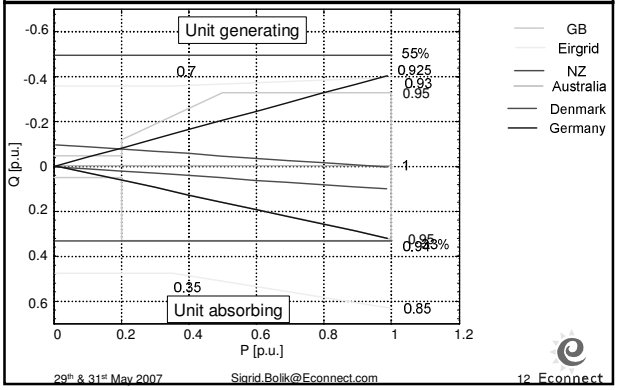
2. Technical Requirements — Voltage variability



2. Technical Requirements — Manufacturer response



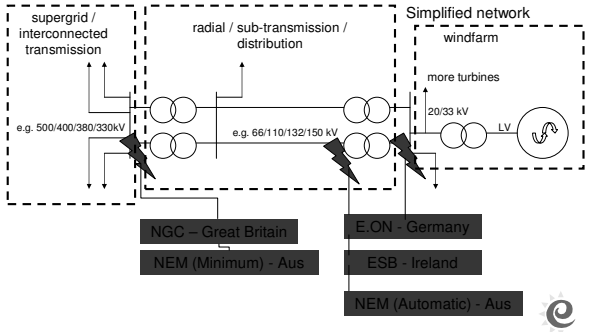
2. Technical Requirements — PQ variability



2. Technical Requirements

International Variations

Internationally specifications vary significantly in form & in detail



2. Technical Requirements

LVFRT Germany

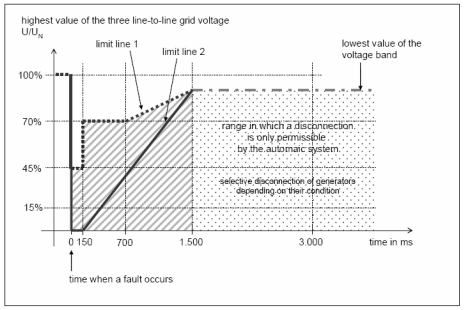
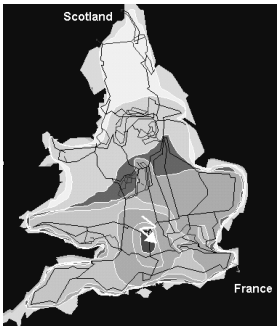


Figure 6 Limit curves for the voltage pattern at the grid connection for Type 2 generating plants in the event of a fault in the grid

Source: EON Netz Grid code 2006

Fault propagation (Voltage)

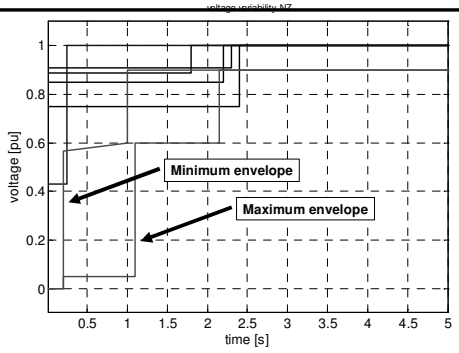
- For three phase zero voltage fault at Cowley.
- Retained voltage profiles across E&W in 10% steps.



Source: National Grid

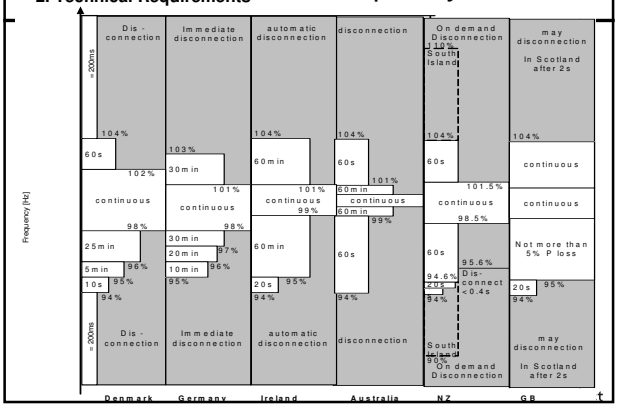
2. Technical Requirements

Voltage variability NZ



2. Technical Requirements

Frequency fluctuation



Data submission &

Model

	Germany	Ireland	Denmark	New Zealand	Australia
	Grid Code EON Netz (April 06) Appendix E, T2	**Grid code v 1.2 (May 05) PCA4.10.1.2.2**	**TF 3.2.6 (May 04) section 11 & Annex 2**	**EGR (Sept 05) Part C Schedule C3 Technical Code A 2.5**	**NER v 9 (July 06) S 5.2.4 NEMMCO Guide (March 06)**
Special for WT	No	Yes	Yes	No	Yes
Validity	> 110kV	> 5MW	< 100kV	All	Not specified
Type of information (Data, model)	Steady state design data,	Dynamic model, electrical data, control specification	Measurement & simulation report	Asset capability statement (ASC) - plant operation, load flow Specified by System operator (TSO - Transpower)	Generating unit design data & model Data (model required for ancillary services and changes of the unit)
Information format	Block Diagram description, single line diagrams	Block diagram description	Report	Completed ASC, including all modelling data, model (Spec by TSO), Block Diagram & basic electrical data	Block Diagram and Schedule 5.5.1 generating unit design data
Purpose	Grid connection agreement	Connection Application - System impact assessment	Type approval test	Assessment for system operation	Connection application

Data submission & Model

	Germany	Ireland	Denmark	New Zealand	Australia
Study type	Evidence Grid connection compliance, through, steady state & dynamic analysis	Power system Angular and voltage stability	WT Capability assessment & grid interaction	Load flow, fault studies, system stability	Load flow, transient, dynamic stability analysis
Performed study	Capability assessment, short circuit & load flow calculation, system interaction, grid code compliance study	low short circuit level at PCC, faults studies, Voltage excursions, Frequency excursions, large wind speed variations.	Over voltage (islanding), short circuit, voltage & frequency disturbance/ capability, voltage quality (harmonics)	Grid system security, Power quality, Grid emergencies, Operational communications, Equipment, Dispatch, Outage Co-ordination	Fault studies, line and other plant switching or tripping; voltage disturbance, frequency disturbance
Documentation	Plans specification, Specified data sheet, inspection protocols/ certificates	detailed model structure, interface, setup	Specified template	Information in ASC, detailed functional description, Block Diagram	Detailed Block diagram description completed 5.5.1 generating unit design data

	Germany	Ireland	Denmark	New Zealand	Australia
Additional information	Possible	Source code on request (confidential)	Not specified	Possible	Possible
Software requirements	Not specified	PSS/E	User specified	Not specified, DigSilent (TSO)	Power system simulation software
Update requirement	No	Yes	No	Possible	Yes
Operation mode	Note specified	Not specified	Rated full load, full compensation	Not specified	All possible operation modes
Time step requirements	Not specified	5ms	Rms	Not specified, correct response 0,5 s	> 2ms
Information characteristics	Single line diagrams, Dynamic equivalent circuit diagrams	Output: reactive, active power, speed etc. depending on voltage at terminal	Test on Model in form of Thevenin equivalent, active & reactive current characteristics,	Not specified	Single line diagrams, Transfer functions

	Germany	Ireland	Denmark	New Zealand	Australia
Control information	Control Block diagrams	WT control system & any relevant wind farm power station control	Interface to external control	Yes	Yes
Compliance during information delay	No	Yes, with shown time frame	No (only connection, when data sent)	No	No
Validation	Yes	Yes, agreed with TSO	As described	Yes	Yes
Validation type	Type test	Type validation with laboratory or on-side data	Type test	Indication and measurements confirmation compliance at grid interface	Minimum Type test

Thank you for your attention

Contact information:

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