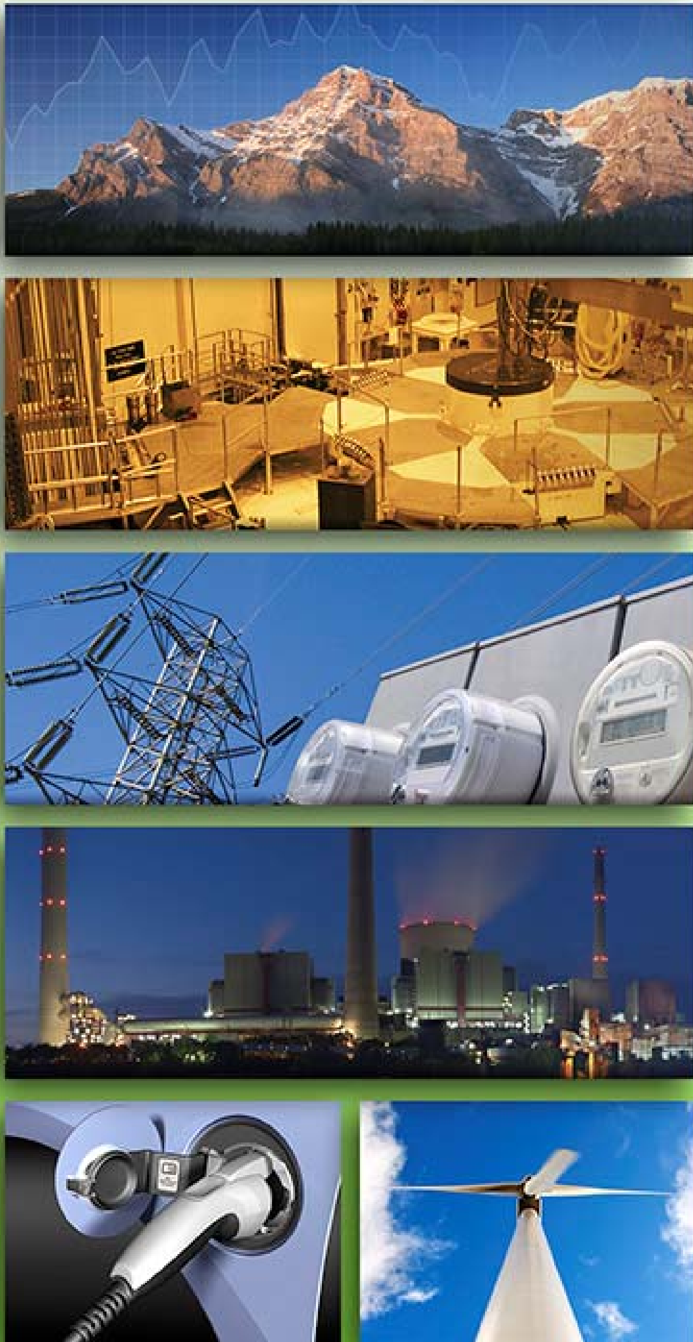

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Grid code evolution in Europe

Aidan Tuohy

Distribution Grid Codes Tutorial

4th International Conference on the Integration of Renewable and Distributed Energy Resources

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Speaker Information

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In September 2009, he completed his PhD at the Electricity Research Centre, University College Dublin, Ireland, with the topic of operational and policy issues for carbon constrained power systems. He graduated from Electrical Engineering at University College Cork, Ireland in 2005.

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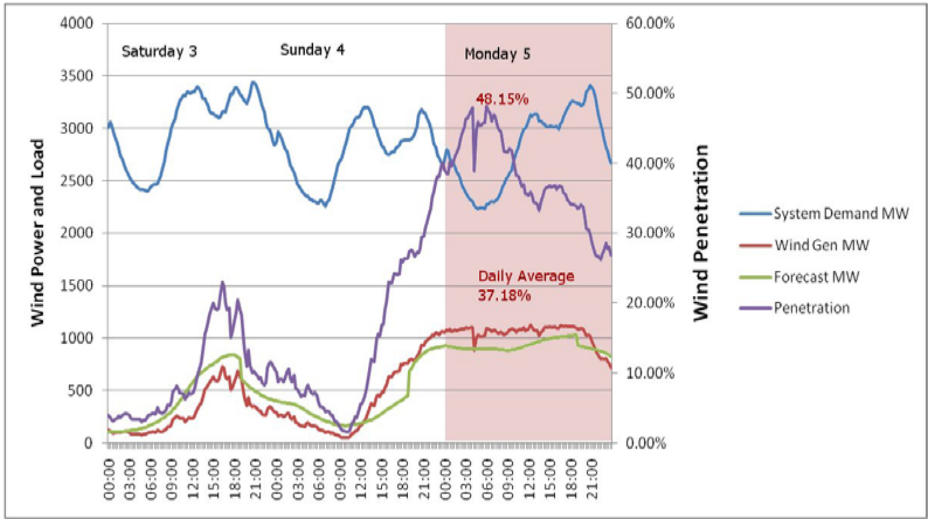
Overview

- Grid codes in transmission
  - Need for codes
  - European evolution
- Grid codes in distribution
  - Need for codes
- European distribution grid codes
  - Examples and characteristics

Grid codes for variable RE in transmission

- Large increase in RE: Approx. 3% of electricity demand now, 12% by 2020, 20% by 2030
- Challenges
  - Balancing
  - Adequacy
  - Transmission
  - Stability and power quality



Grid Codes

- **To ensure VG responds to faults**
- **To ensure VG does not adversely affect stability**

Grid code needs in transmission

- For VG connected to high voltage networks:
  - Maintain supply of energy
    - Balance of supply and demand over TSO area
  - Ensure transmission of power
    - i.e. maintain reactive power levels
    - Provide reactive power when needed
  - Respond to faults
    - Original codes mainly came about due to fear of what will happen with fault ride through
  - Provide communication
    - To ensure SO knows what is happening

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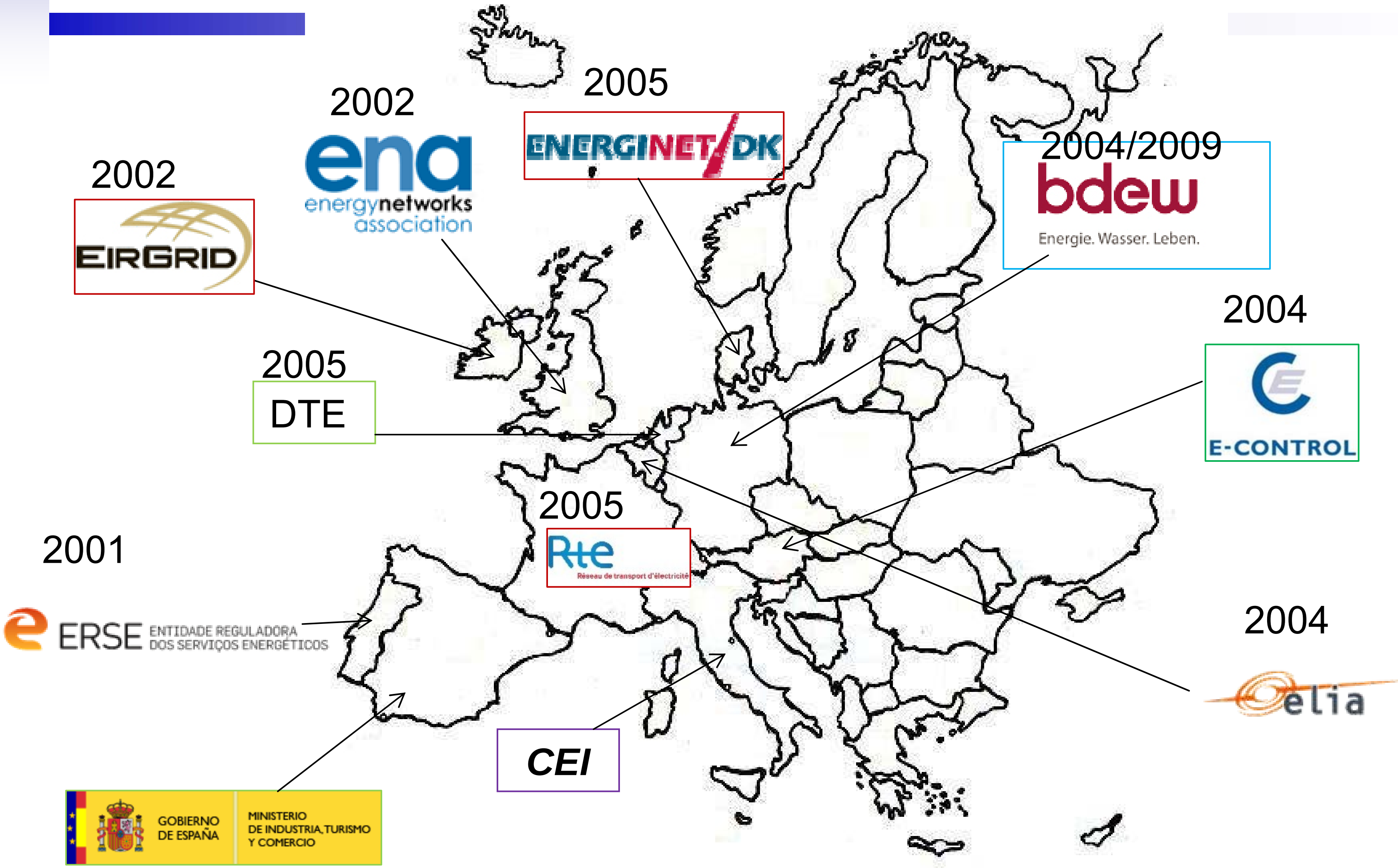
Transmission Grid Codes



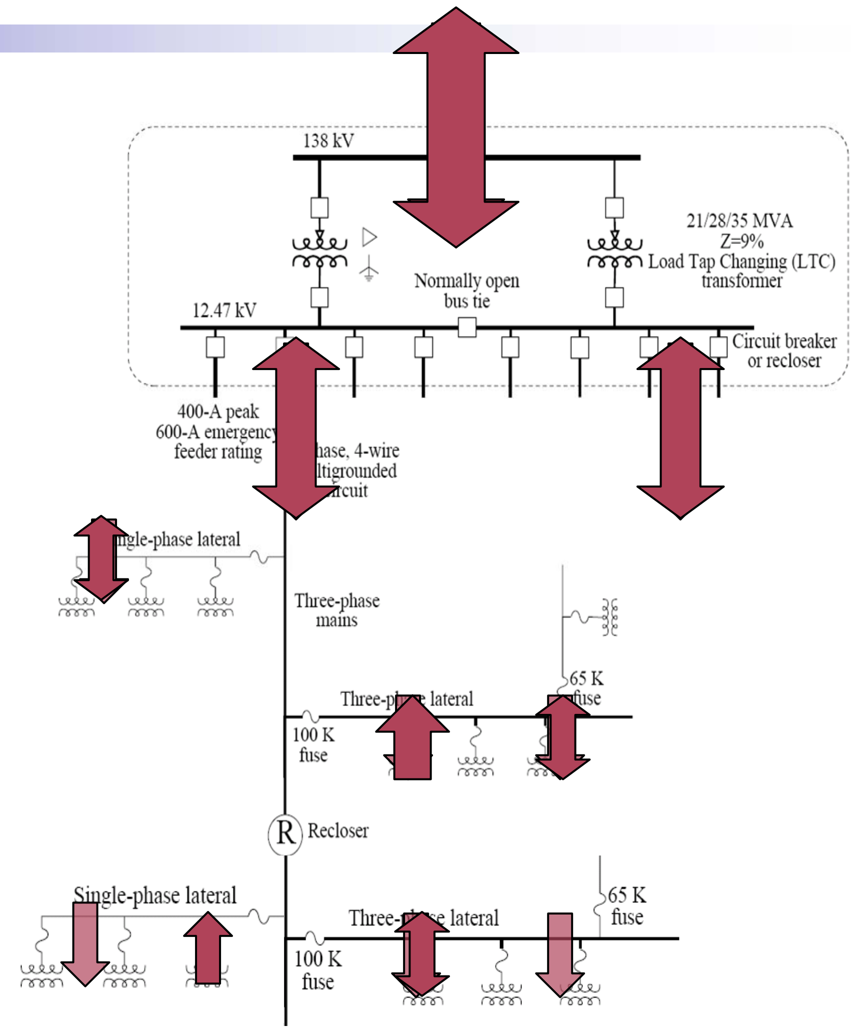
From information provided in European Wind Energy Association, *"Large Scale Integration of wind Energy in the European Power Supply: analysis, issues and recommendations"*, 2005

Moving towards harmonization

- ENTSO-E: European Network of Transmission System Operators for Electricity
- European wide studies – European Wind Integration Study, TradeWind:
  - Point to need for common understanding of needs
- European Grid Code working group (European Wind Energy Association initiated)
  - Manufacturers
  - Wind farm developers and operators
  - Consultants/ Service providers
  - Associations
- Addresses concerns about:
  - Changing and different codes
  - Languages
  - Incomprehensive / not clear when comparing

Need for grid codes - distribution

- Main issue: going from one way to two way power flow
- Similar type of standards – different aims:
- Maintain local stability
  - Voltage as main issue
- Ensure power is provided (when needed) to high voltage network in a stable, reliable manner
  - Reactive and active power
- Many codes taken and adopted from transmission (or same code)



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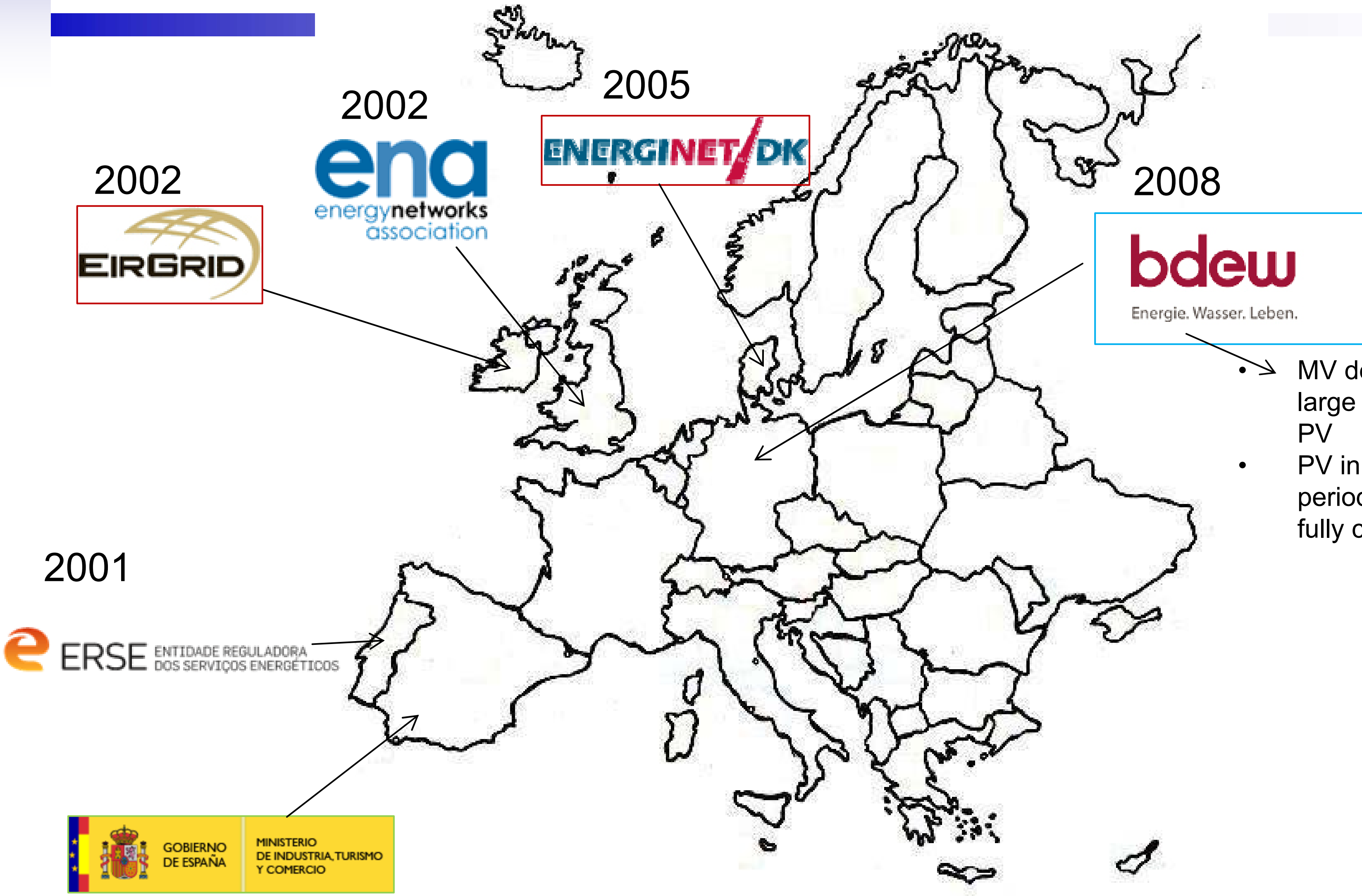
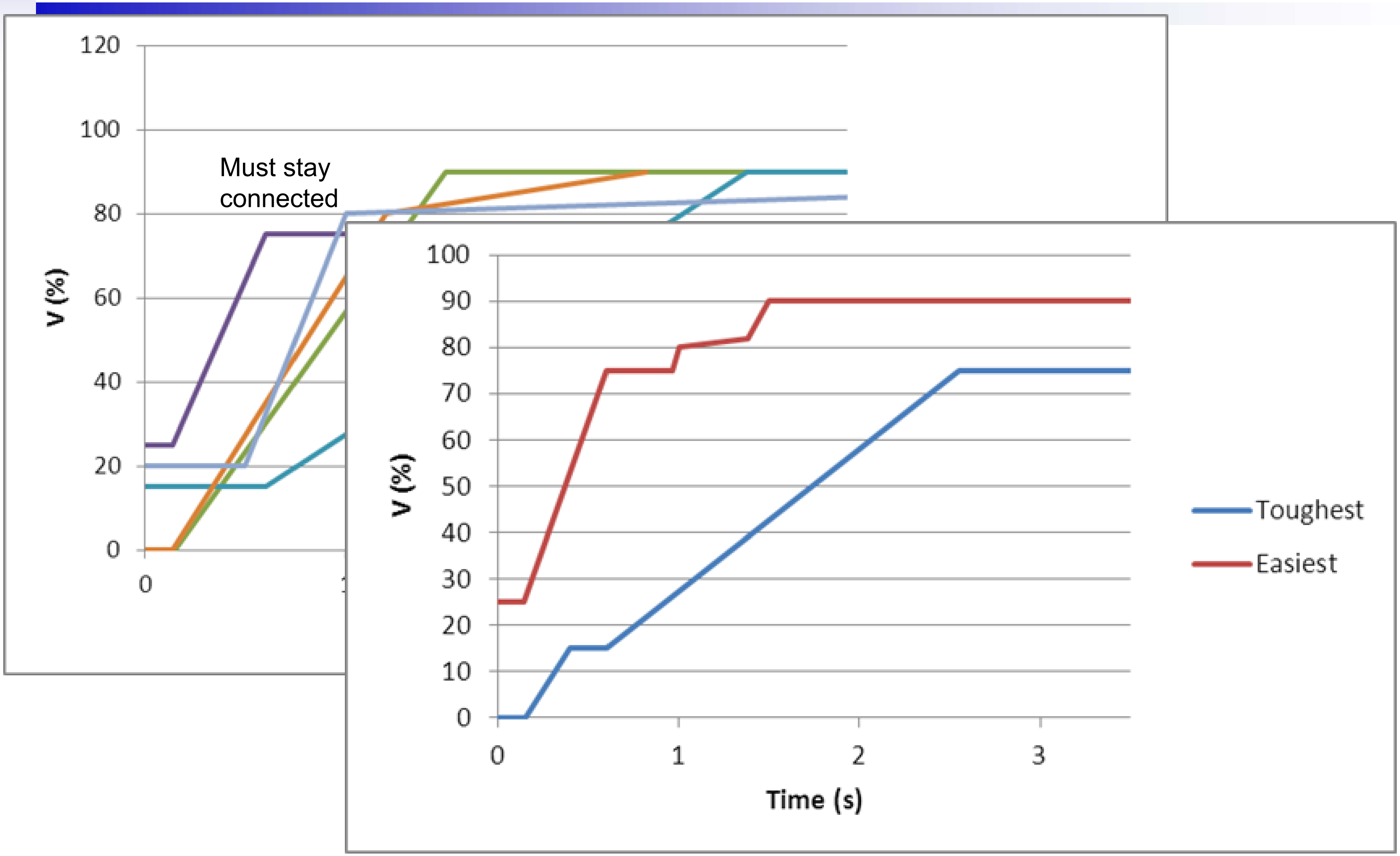
Distribution Grid Codes in Europe



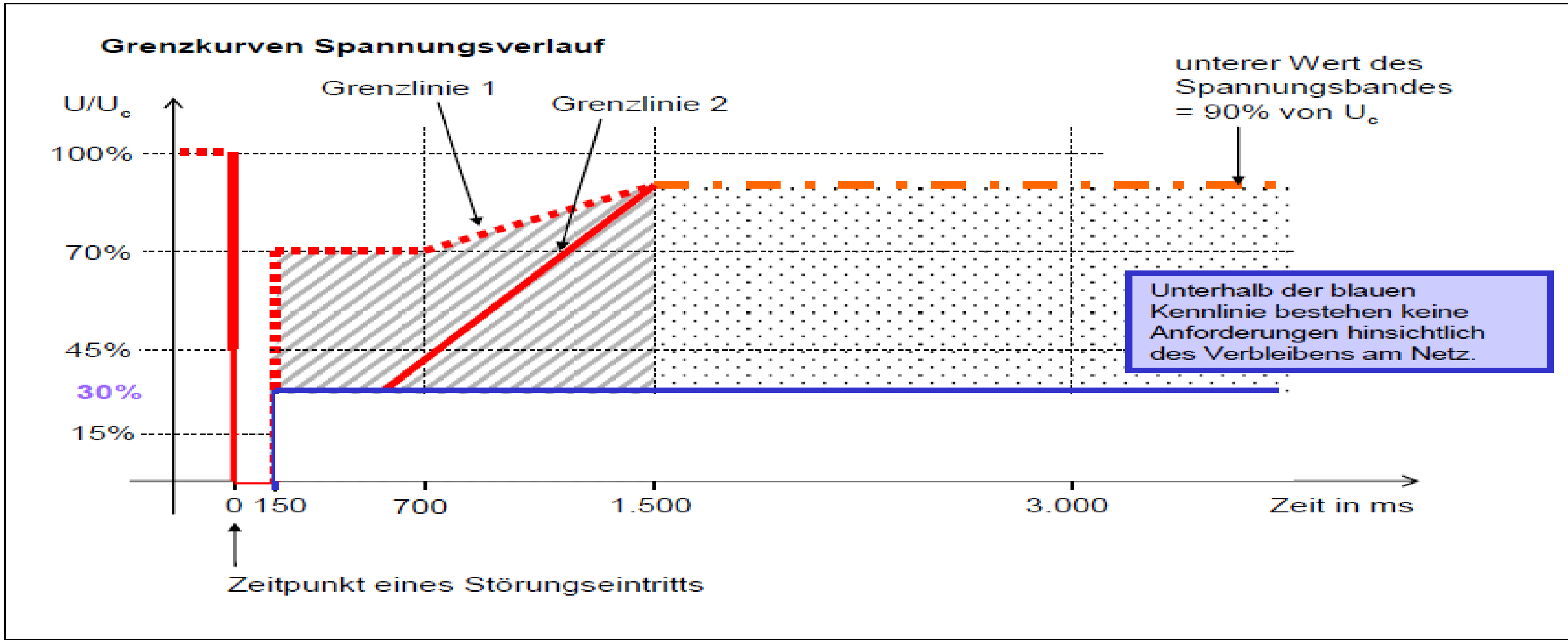
- MV developed for large increase in PV
- PV in transition period, will need to fully comply in 2011

From information provided in European Wind Energy Association, *“Large Scale Integration of wind Energy in the European Power Supply: analysis, issues and recommendations”*, 2005

Low Voltage Fault Ride Through



German MV grid code fault ride through

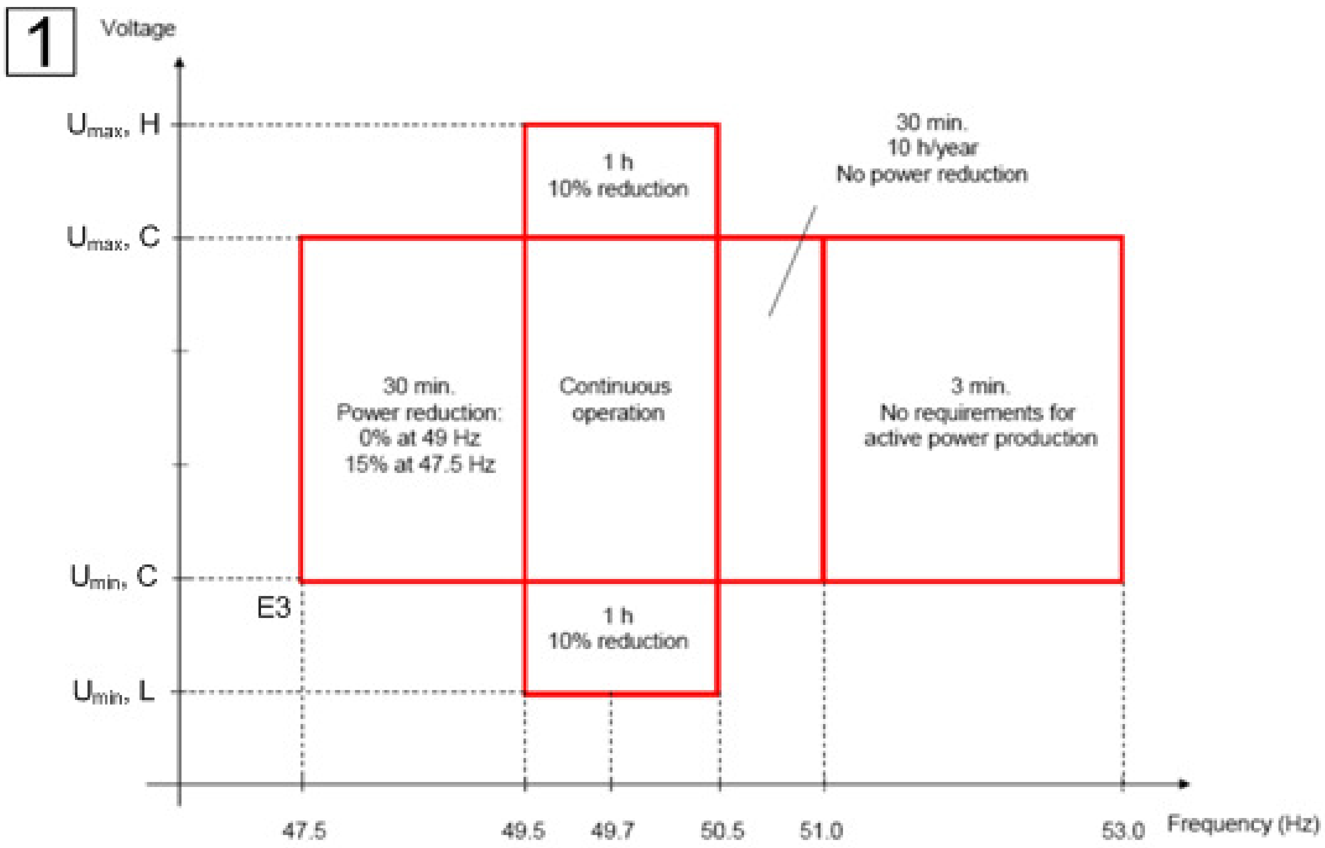


- Not to disconnect from network in the event of network faults
- Support with reactive current
- After fault clearance not to extract more inductive reactive power than prior to fault
- Reactive current on LV side of transformer 2% of rated current for each 1% of voltage dip (outside 10% deadband)

*(Taken from BDEW, Technical Guideline, Generating Plants connected to MV network, 2008)

Steady state performance

- Stay within these limits



*Taken from **Generic Grid Code Format for Wind Power Plants, EWEA, 2009**

Short Circuit Current

- Aim: Not to increase short circuit current beyond desirable/ manageable levels

- Germany: Max admissible short circuit current:
  - Assume the following for contribution:
    - Synchronous: 8 times rated,
    - Asynchronous and doubly fed: 6 times rated
    - Inverters – Rated current

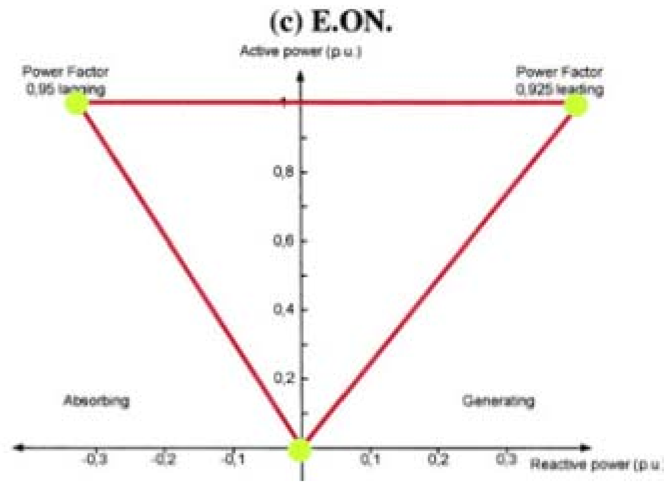
- If above causes increase in MV network short circuit current, then limit short cct current (e.g. I_s limiters)

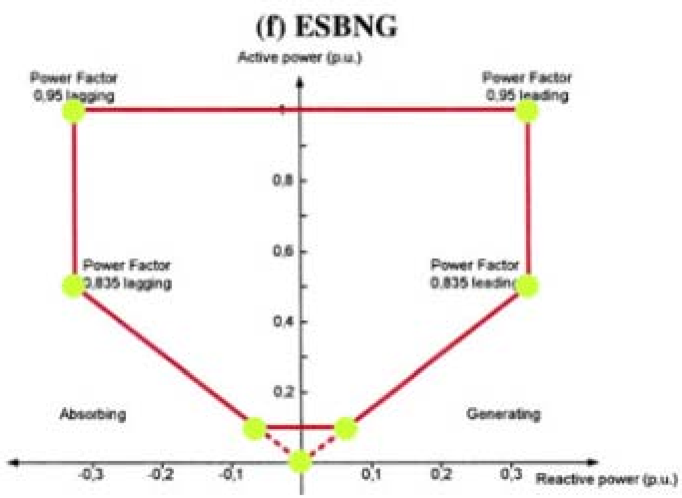
Reactive power control

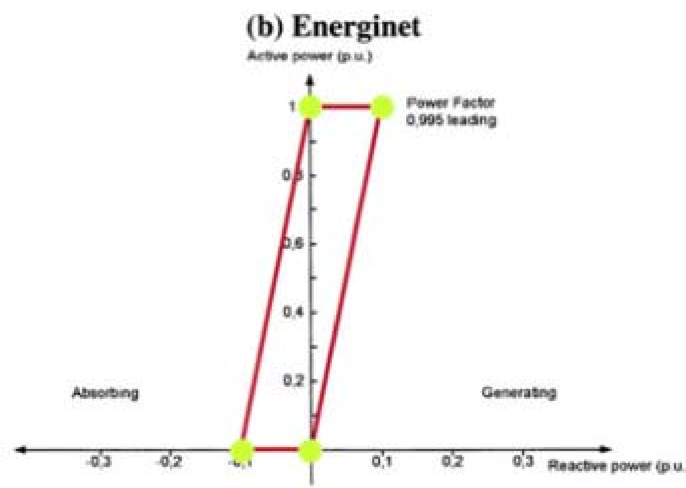
- System generating plants to provide static grid support, i.e. voltage stability, through reactive power
  - Cos (φ) = $0.95_{underexcited}$ to $0.95_{overexcited}$ (German MV)
  - Currently, PV designed for active power only
    - Expensive to also provide reactive power
    - E.g. 950kW rated active power will need to be 1000kVA
  - Setpoint is either fixed or operator signal
    - Fixed cos φ or variable depending on cosφ (P)
    - Fixed Mvar or variable depending on Q(U)
    - Reach within 10 seconds

Reactive power provision

- Steady state reactive power provision
  - Externally providing a reactive power factor or power factor
  - At point of connection or more distant node
  - Requirements vary depending on active power (at lower active power, tend to be further from unit PF)
  - Or depending on voltage







*Taken from **Generic Grid Code Format for Wind Power Plants, EWEA, 2009**

Active power control / frequency support

- Network operator will temporarily limit or disconnect the DG if there is risk of:
  - Unsafe system operation
  - Bottlenecks or congestion
  - Unintentional islanding
  - Static or dynamic grid instability
  - Instability due to frequency increase

- Setpoints provided by network operator
  - Operators do not interfere with actual operation
  - Currently, e.g. in Germany, 100%, 60%, 30%, 0%

Active power control / frequency support

- Germany: 10% of grid connection capacity per minute
  - Above 50.2 HZ, active power reduces at 40% per Hz

- Ireland, ramp rate 1-30MW/min
  - Active power depends on frequency:
    - Above 52 Hz, no active power,
    - 50.5 -52 Hz, power goes from 100-20% active power

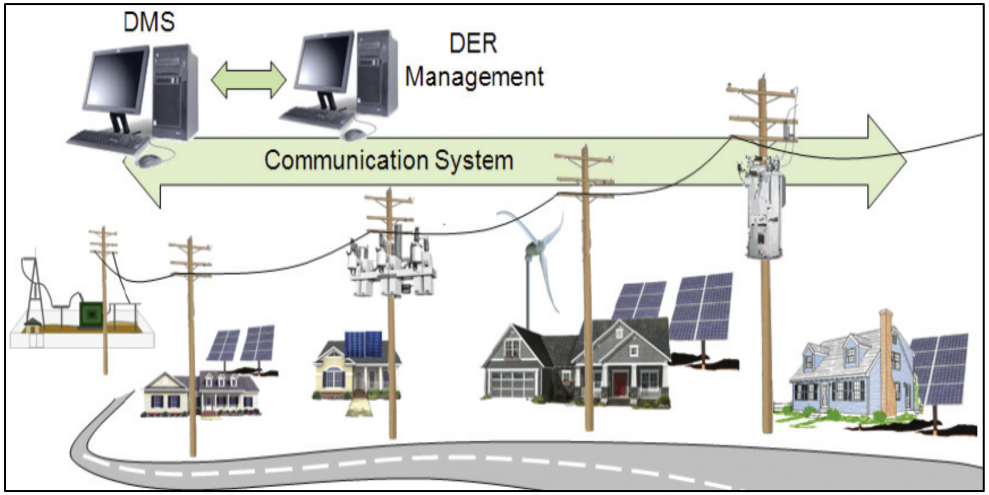
- Nordic: 10% of rated power per minute
- Denmark: Active power depends on frequency

- GB: Frequency control device for primary and secondary frequency control, plus over frequency control

Monitoring and control

- Communication is key to smart grid
  - TSO/ DSO communication
  - DSO/ customer

- Grid Codes often ask for:
  - Power production at point of connection
    - P and Q
    - Voltage
    - Frequency
    - Transformer tap position
  - Plant Status
    - Out for maintenance
    - Out for high wind/fault etc.
  - Meteorological Information
    - Current, past and (possibly) future (forecasts)



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