System Security The importance of connection requirements

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For power system expertise



Changing landscape

Developments with an impact on the system security motivate a revision of the connection requirements

Demonstration using recent black-out events



Rapid growth of PV power plants needs co-ordination

Harmonisation and revision of the requirements in ENTSO-E context

Facilitate Union-wide trade in electricity

Facilitate transparency and non-discrimination Increase competition

Facilitate the integration of Renewable Electricity Sources

Allow more efficient use of the network and resources

Ensure system security

Frequency stability Voltage stability Robustness System recovery System management (protection, instrumentation)

European connection code RfG

Significance of powergenerating modules determined by maximum capacity and voltage level

Туре	Capacity	Requirements
А	800 W – 1 MW	Basic
В	1 MW – 50 MW	Limited automatic actions
С	50 MW – 60 MW	Stable dynamic actions
D	≥ 60 MW or ≥ 110 kV	Grid stability and balancing

System security

- Frequency stability
 - Frequency range
 - Controllability and active power control range
 - Limited frequency-sensitive mode overfrequency (LFSM-O)
 - Limited frequency-sensitive mode underfrequency (LFSM-U)
 - Frequency sensitive mode (FSM)
- Voltage stability
- Robustness
- System recovery
- System management

Frequency stability

What happened 4 November 2006?

System Split 4 november 2006

Planned switching off of the Ems connection

Power exchange: 9,6 GW

Generation in Eastern Europe Demand in Western Europe

Unexpected, very large increase in production due to wind power

Overload caused automatic switch-off of another connection

Overload led to chain reaction of HV connections being disconnected

System Split 4 november 2006 – frequency during 24 sec

System Split 4 november 2006

Frequency fall: $\Delta f = 1 Hz$ in approximately 10 seconds

Maximum frequency gradient: $\Delta f/\Delta t = 0,1 Hz/s$

System Split 4 november 2006

Load shedding in Western Europe: 14,5 GW

Country	Load shed [MW]
Belgium	800
Germany	2400
France	5200
Italy	1500
The Netherlands	400
Austria	1540
Portugal	500
Spain	2100
Slovenia	100

LOAD SHED [MW]

Frequency stability requirements

Requirement: Low Frequency Demand Disconnection (LFDD)

- Automatic load disconnection between 48,0 Hz and 49,0 Hz
- 'Operating Time' within 150 ms
- Netcode elektriciteit: $\Delta P = 7,5\% / 0,2 Hz$
- Capability required for:
 - TSO,
 - DSO,
 - Transmission-connected demand facilities,
 - Transmission-connected closed distribution systems.

Frequency stability requirements

- Frequency range capability: 47,5 Hz to 51,5 Hz
 - Large deviations from 50 Hz will be more common
- Requirement: LFSM-O (overfrequency)
 - Active power reduction at frequency above 50,2 Hz
 - All power-generating units from 800 W
 - Purpose: emergency management
- Requirement LFSM-U (underfrequency)
 - Active power increase at frequency below 49,8 Hz
 - Contribution on contract basis
 - Purpose: emergency management
- Requirement FSM (Frequency Sensitive Mode)
 - Frequency support between 49,8 and 50,2 Hz
 - Contribution on contract basis
 - Purpose: active power balancing

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System Security

- Frequency stability
- Voltage stability
 - Voltage range
 - Supplying and absorbing reactive power
- Robustness
- System recovery
- System management

Voltage stability

Regional black-out 23 June 1997

Reactive power shortage Voltage problems Loss of power generation Within 15 minutes, province Utrecht full black-out

Regional black-out – Voltage during 1,5 hour

Tijd (hh:mm)

Voltage stability requirements

- Voltage range requirements:
 - Medium voltage: 0,85 1,10 pu
 - High voltage: 0,85 1,15 pu
- Voltage support by reactive power exchange
 - U-Q/P_{max} profile: reactive power within voltage range
 - P-Q/P_{max} profile: reactive power within active power range
- Reactive power control requirements
 - range, response time, tolerance
- Voltage control requirements
 - range, response time, tolerance

System security

- Frequency stability
- Voltage stability
- Robustness
 - Fault-Ride-Through (FRT)
 - Power Oscillation Damping (POD)
- System recovery
- System management

Robustness

Fault-Ride-Through 9 August 2019

England and Wales power cut

Customers affected in each electricity supply area

Robustness: time plot of the events

Robustness Fault-Ride-Through requirements

Measured voltage dips at 8 different locations in the British system

The Fault-Ride-Through requirement is the grey line

The dips are above the grey line and may not lead to disconnection

Robustness Fast Reactive Current Injection requirements

Fast Fault Current Injection by a Power Park Module or a HVDC-system

Simulation of the short-circuit current contribution of a synchronous machine

A current injected during and after a voltage deviation due to an electrical fault, for the purpose of:

- fault detection by the protection system during the initial stage of the fault
- support of the system voltage during fault
- restoration of the system voltage after shutdown of the fault

Rise time \leq 30 ms

Settling time ≤ 60 ms

Compliance

Each new facility must comply with the requirements of the regulations

Legal responsibilities and tasks

- The owner of a power-generating facility:
 - Shall ensure the compliance of a power-generating facility with the requirements
- The system operator:
 - Shall assess the compliance of a power-generating facility with the requirements

The purpose of the European Connection Codes

- The EU regulations support maintaining the large interconnected transmission grid (system security) also after the energy transition
- Amongst others, by:
 - Maintaining the system frequency
 - Maintaining the voltage within the desired bandwidth
 - Maintaining a dynamically stable transmission system
 - Preventing premature shutdown of production units in the event of a failure
 - Preventing blackout during calamities
- The impact on system security begins at the level of the LV distribution grids: many small PV plants together make one large

Thank you for your attention!

