



Connection of a Wind Farm to the Main Grid

Instructions and Requirements set by Fingrid Oyj

General connection terms for Wind Farms

As a starting point the same connection requirements are set for wind generation as for other electric power generation plant

- General requirements are defined in Nordel Connection Code for Wind Turbines (November 2006)
- Requirements for wind turbines connecting to Finnish power system are specified in General Connection Terms of Fingrid Oyj's Grid and in Specifications for the Operational Performance of Power Plants
 - In Finland the requirements are valid for wind farms with total power >10 MVA or for several single turbines whose aggregated power exceeds 10 MVA at the connection point to the main grid
 - Due to special characteristics of wind power generation some additional requirements mainly related to power control and stop of the plant have been set for wind power plants

Market view on Connection Terms

- The premise for Fingrid is equal treatment of market players
- transparency of costs and allocation of those is important – no hidden support
 - holder of the connection himself is responsible for connection costs – otherwise in total extremely expensive siting of generation may occur
 - wind power producer is in charge of his electricity sales
 - wind power producer is in charge of balancing his own production balance - like other power producers – by market-based means

Fingrid is responsible for providing adequate transmission and reserve capacity

Connection of a Wind Farm to the Main Grid

- Connection to 400 kV grid, when
 - wind farm ≥ 250 MVA
 - wind farm 100-250 MVA and connection to 110 kV grid is not feasible due to its existent technical characteristics
- Connection to 110 kV grid, when
 - wind farm 100-250 MVA and connection to 110 kV grid is considered feasible based on its existent technical characteristics
 - wind farm ≤ 100 MVA. Adequacy of transfer capacity of the grid has to be checked
- Fingrid will carry out necessary studies in the main grid in co-operation with the project developer.
 - Grid connection study will be carried out before the start of EIA-process
- Geographically sufficient decentralization in relation to the existing wind power at power system shall be observed while siting wind power to be connected to the main grid

Wind turbine or group of turbines connected to sub-transmission network or distribution network

- Because Fingrid do not have contractual relations with parties behind sub-transmission network, shall sub-transmission system operator be in charge of that wind turbines connected to his system will fulfil at connection point to the main grid General Connection Terms of Fingrid Oyj's Grid and Specifications for the Operational Performance of Power Plants set by Fingrid
 - fulfilment of given terms and specifications is required if there is more than 10 MVA wind or other power generation connected to sub-transmission or distribution system behind one main grid connection point

Sharing of the Costs of Wind Farm Grid Connection when Connection Point is at Main Grid

- Fingrid will specify from the overall standpoint (environmental aspects, grid topology and structure, other power plants, planned reinforcements etc.) technically and economically acceptable connection points or a connection point
- Holder of the connection is responsible for the costs of the connection line
- Holder of the connection will pay his own switchgear and apparatus at connection substation
- Fingrid is in charge of the costs of necessary reinforcements in the main grid and in power system

Connection Terms of Fingrid for Wind Farms

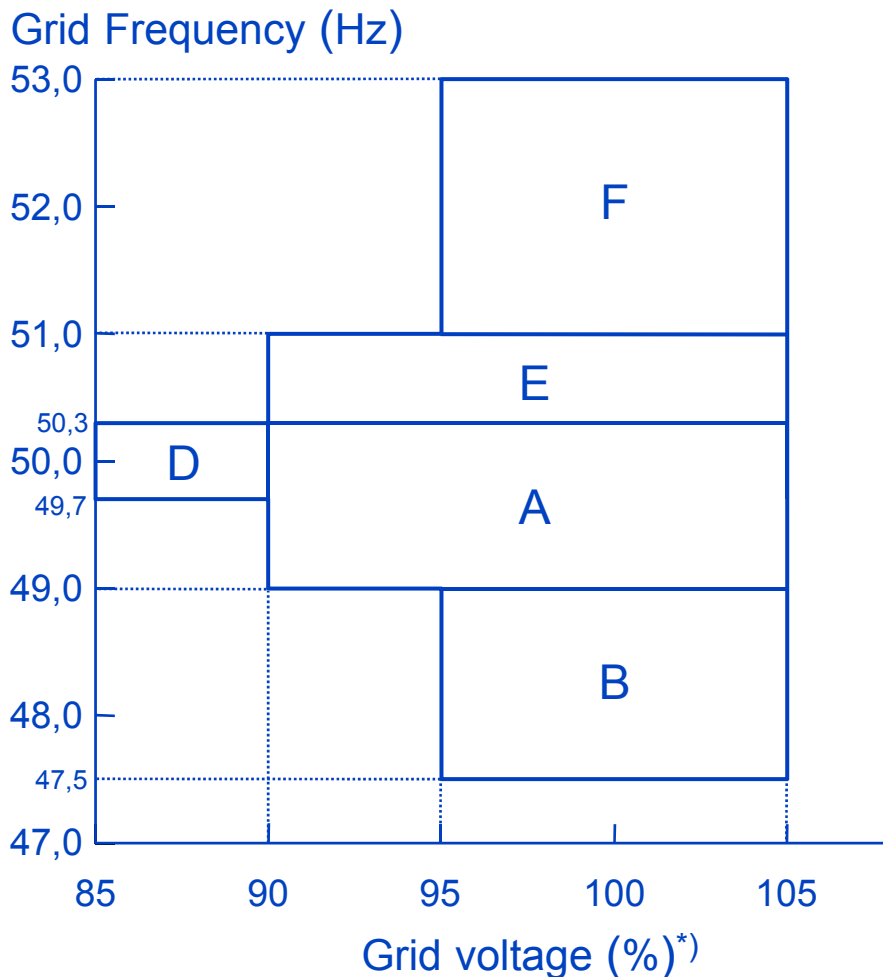
Country-specific supplementary specification

- Control of active power shall be possible
- Sufficient reactive power capacity
 - shall be able to operate continuously at nominal active power with power factor $\cos \phi$ not more than
 - 0,95_{overexcited}, while grid voltage is in the range of 90 % - 100%
 - 0,95_{undexcited}, while grid voltage is in the range of 100 % - 105%
 - if a wind power generator type is utilized which do not fulfil the requirement by definition, the wind power producer shall provide the required reactive capacity at connection point e.g. by means of SVC
- Automatic voltage control is required
 - on normal operation about zero reactive power exchange at connection point, dead band shall be adjustable
 - reactive power statics is adjustable and is capable of regulating in given range

Connection Terms of Fingrid for Wind Farms

- Dimensioning voltage and frequency (slide #9)
 - requirements for operation in different operation points
- Operational characteristics during grid disturbances (slide #10)
 - plant shall withstand given voltage profile without disconnection
- Start and stop
 - stepped stop of Wind Farm at high wind speeds
- Remote control must be possible and operational measurements shall be made available to the TSO
- In order to verify the fulfilment of the requirements a specific test programme must be agreed with the TSO
- As a part of the test programme a simulation model of the wind plant shall be provided to the TSO

Operation at off-nominal voltage and frequency



A: Normal continuous operation. No reduction in active or reactive capability is allowed due to system voltage and frequency.

B: Uninterrupted operation in minimum 30 minutes shall be possible. The active output is allowed to decrease as a linear function of the frequency from zero reduction at 49.0 Hz to 15% reduction at 47.5 Hz.

D: Uninterrupted operation at least 60 minutes shall be possible. The active output may be reduced 10%.

E: Uninterrupted operation at least 30 minutes shall be possible. The possible active output is allowed to be slightly reduced. (The total duration of these operating conditions is normally not more than 10 hours per year).

F: Uninterrupted operation at least 3 minutes shall be possible. The active output may be reduced to any level, but the turbines must stay connected to the system

^{*)} in 400 kV grid 100 % = 400 kV
 in 220 kV grid 100 % = 233 kV
 in 110 kV grid 100 % = 118 kV

Deep voltage dip

Requirement: wind plant shall withstand deep voltage dip without disconnection

Wind plants connected to ≥ 110 kV grid

- voltage dip on the high voltage side of step-up transformer

Wind plants connected to < 110 kV grid

- voltage dip on the nearest connection point to the main grid

