19.10.2009

Determining the transmission capacity

1 Transmission capacities in the Finnish power system

Fingrid makes available to the electricity market all that transmission capacity which can be made available without compromising the system security of the Finnish power system. The Nordic transmission system operators have published a shared document “Principles for determining the transfer capacities in the Nordic power market”, June 29, 2009. This document presents in more detail the principles and criteria for determining the transmission capacity in the Finnish power system, and how the transmission capacity available to the electricity market is made up on the basis of these.

Figure 1 presents the commercial maximum transmission capacities in the Finnish transmission grid in 2009. Fingrid publishes more detailed information on the capacity available at any given moment on its website (www.fingrid.fi) and on the website of electricity exchange Nord Pool Spot (www.nordpoolspot.com).

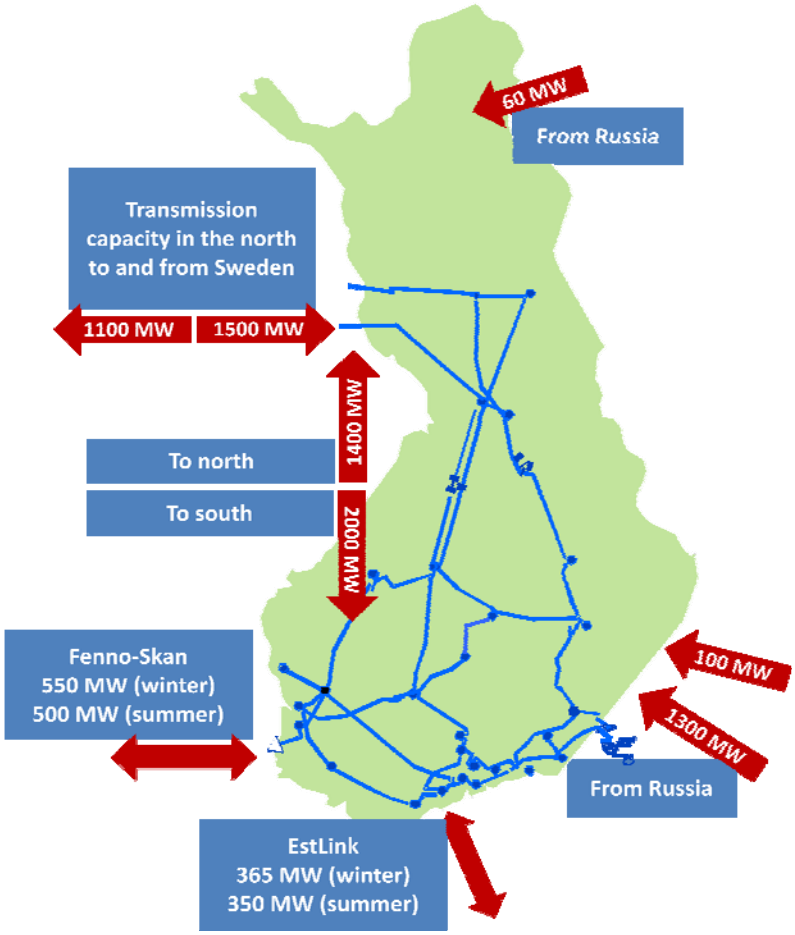

Figure 1. Commercial maximum transmission capacities in the Finnish transmission grid in 2009.

2 Principles for determining the transmission capacity

The Finnish power system must endure individual 400 kV faults without an interruption in electricity production and consumption. This principle is referred to as the (n-1) rule. Dimensioning faults in the Finnish 400 kV transmission grid include substation faults, tripping of the largest power plant unit from the grid, or faults on transmission connections between Finland and neighbouring countries. The fulfilment of the (n-1) rule, which constitutes the basis for system security in the transmission grid, is verified in various electricity consumption and production situations of the grid using network calculations when planning and operating the grid.

The Total Transfer Capacity (TTC) is determined on the basis of the (n-1) rule or current carrying capacity. Some of the Total Transfer Capacity is reserved as a Transmission Reliability Margin (TRM), which is used for taking into account the following factors of uncertainty:

- Maintaining a balance between electricity consumption and production by means of automatically-activated reserves, which causes variations in transmissions.
- Changes in transmissions as a result of unanticipated variations in electricity consumption and production.
- Inaccuracies related to power measurement and data transfer.

The commercial transmission capacity made available to the electricity market, Net Transfer Capacity (NTC), is the Total Transfer Capacity deducted by the Transmission Reliability Margin:

$$NTC = TTC - TRM$$

The Transmission Reliability Margin used in the calculation of the Net Transfer Capacity between Finland and Sweden is at the moment 100 MW.

The transmission capacity calculations are updated whenever changes with a significant impact on the transmission capacity take place in the power system. The transmission capacity varies based on electricity production and consumption. The studies are carried out for various seasons of the year and times of day, especially considering the peak load situation (peak consumption in a single hour when the temperature in the whole of Finland is on average -25ºC) and a production situation where a small number of power plants are connected to the transmission grid.

Transmission capacities during outages in the transmission grid are calculated in good time so that there is enough time to inform the electricity market parties of the transmission capacity available during the outage.

3 Grid model used in determining the transmission capacity

A model of the Nordic transmission grid is used in the calculation of transmission capacity. The grid model contains detailed descriptions of the transmission grid and power plants as well as of electricity production and consumption. The direct current

connections between the Nordic countries and transmission grids outside them are modelled as positive or negative loads. Distribution networks of lower voltage levels are also modelled as positive or negative loads set at the connection points.

The grid model is updated continuously on the basis of changes taking place in the grid. Changes are caused by factors such as new transmission connections, new power plants, and changes in the electric values of the grid.

The correctness of results obtained from the calculation model is monitored constantly. Measurements carried out in conjunction with disturbance situations in the grid are utilised in this by comparing them to the results given by the simulation model. Tests for verifying the dynamic behaviour of the grid are also performed.

The following assumptions are made of electricity production in the grid model:

- Back-pressure power plants which produce both electricity and heat produce electricity on the basis of the need for heat.
- The operation of hydropower plants varies from one waterway to another on the basis of the times of day and seasons of the year.
- The production order of condensing power plants is determined on the basis of assumed variable costs.

4 Criteria for determining transmission capacity

4.1 Voltage

The voltage of the transmission grid must be within acceptable limits after a dimensioning fault. A momentary voltage reduction must not be so great that it causes tripping of power plants from the grid or problems to electricity users. The voltage level is verified using power flow calculation, and the fulfilment of the criterion concerning voltage oscillation is verified using a dynamic simulation model.

4.2 Damping

Power and voltage oscillations in the grid after a fault in the power system must be damped. This is verified using a dynamic simulation model.

4.3 Current carrying capacity

The transmission grid must not be overloaded in a situation following a fault. The current carrying capacities of components corresponding to the highest ambient temperature of the season of the year are used for each examined situation. Wherever possible, the short-term overload capacities of transmission lines, series capacitors and transformers are utilised.

4.4 Frequency

For the potential splitting of the Nordic transmission system, the transmission capacity between the subsystems must be determined so that the frequency of each subsystem after a fault must be within acceptable limits.

5 Factors limiting transmission capacity

The Finnish transmission grid and its connections to the neighbouring countries have two major congestions that need to be examined in transmission capacity calculation:

- Between Northern Finland and Southern Finland,
- Between Northern Finland and Northern Sweden.

When power is transmitted using the alternating current grid from Southern Finland to Northern Finland and further to Northern Sweden, the transmission capacity is restricted by the requirements relating to the power oscillation which follows faults in the grid. According to these requirements, the power oscillations need to be damped sufficiently quickly and the voltage level of the grid must be sufficient even during the power oscillations.

When power is transmitted using the alternating current grid from Northern Sweden to Northern Finland and further to Southern Finland, the transmission capacity is restricted by the requirements concerning a sufficient voltage level and a permitted loading of lines after faults in the grid.

The operating range of the transmission grid is shown in Figure 2. The transmission capacities of the congestions and the practical transmission situations determine the limits of the operating range.

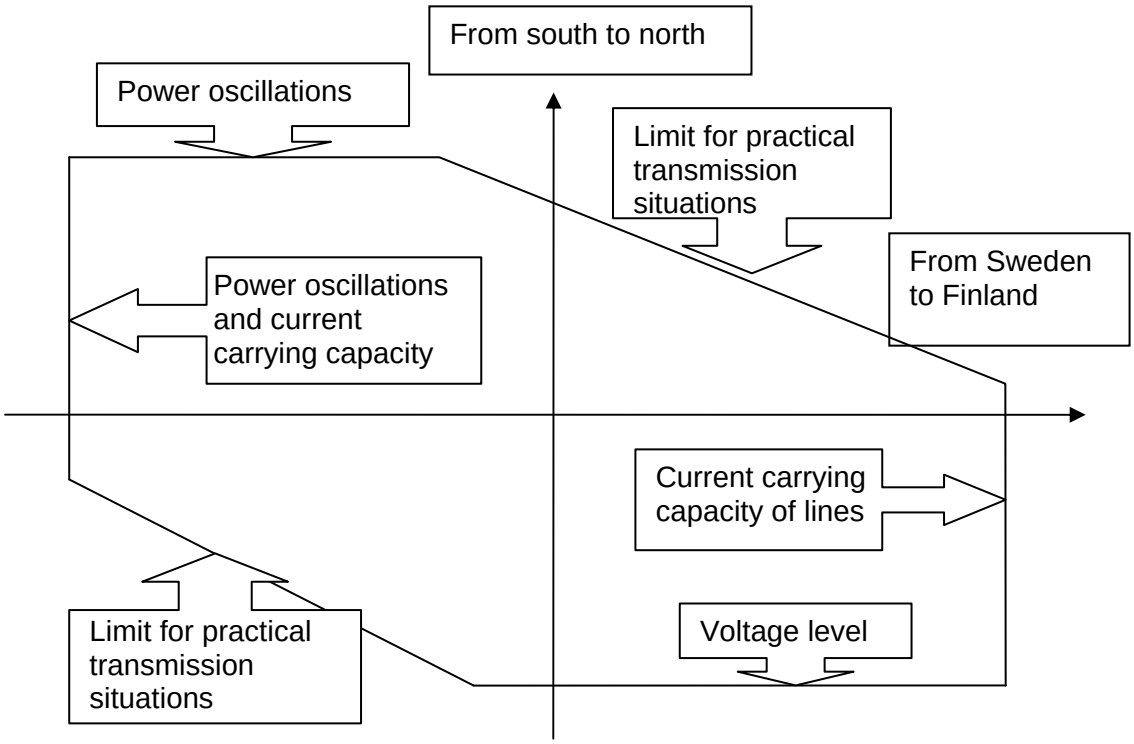

Figure 2. Operating range diagram, where the horizontal axis describes the transmissions from Sweden to Finland and the vertical axis the transmissions from south to north. The vertical and horizontal lines describe the determined transmission capacities. The diagonal lines are limits, which are not exceeded in practice even though the transmission capacity would allow this.

The transmission capacity on direct current links which connect the Finnish transmission grid to the grids in the neighbouring countries is determined by the thermal load capacity. In addition to congestions between Northern and Southern Finland as well as between Northern Finland and Northern Sweden, there may be occasional congestions also elsewhere in the grid when lines are out of operation because of construction work.

The Finnish transmission grid is connected to the other Nordic transmission system by means of alternating current connections in Northern Finland only. For this reason, it is not necessary to take loop currents usually occurring in extensive meshed alternating current networks into account in the calculation of transmission capacities.