Background

Wind power penetration is increasing in many grid systems world-wide. In some areas in Europe, e.g. Northern Germany or Denmark, wind power supplies already more than 10% of the yearly average demand. Hence, during times with high wind speeds and low loads (at night), the wind power penetration can be well above 50% in some network areas.

As wind power penetration increases also in other areas of the world, e.g. Spain, Texas or California, the influence of large wind power penetration becomes more and more of a common international interest. The Danish and German experiences thereby provide valuable information; however, it has to be discussed how these experiences can be transferred to other network configurations.

In addition, a new challenge is the integration of large wind farms into the grid. At present, the largest wind farms have a power output of from 50 MW to about 150 MW. In the U.S. and Europe, wind farms with a power output of well over 150 MW are currently planned. In Europe, for example, large offshore wind farms with a total installed capacity of up to 1000 MW are investigated, and in the US, particularly on the West Coast and along the Great Plains, projects of more than 500 MW will soon be installed.

Participants

The meeting gathered 22 participants, representing grid owners, manufacturers and researchers. Grid representatives came from the UK, Scotland, Ireland, Italy and Spain. Researchers came from Denmark, the Netherlands, Finland, Sweden, Norway, Spain, Ireland and the UK.

Presentations

Hannele Holttinen from VTT in Finland presented a study regarding power balance and regulation in the Nordic Countries (Denmark, Norway, Sweden and Finland) at different wind power penetrations. Some of the conclusions were:

- 4-5% wind electricity will not be noted
- 10-15% gives a change in the production planning of the operation of the grid, resulting in increased export/import and a negligible cost increase
- More than 15% gives extra costs for regulation

She also showed that 10% wind does not give any contribution to the power variations on an hourly basis; this implies that there is no need for extra power capacity in the grid.

Jan Pierik from ECN in the Netherlands reported from an offshore study in which different grid layouts for a 500MW wind farm were studied. The calculations were made for a 5 MW wind turbine with a capacity factor of 50%. Among the studied layouts were ones including directly coupled induction machines with an AC-grid, generators connected via converters, a DC-grid in the wind farm and DC-connection on shore. The conclusion was that a simple
electrical system with an AC-connection on shore was the cheapest alternative for distances up
to 60km off shore.

Jan Bozelie presented a thorough investigation of grid manuals and regulations from the NL,
the UK, DK and DE. Great variations on the demands were shown in the different countries.
Participants proposed that the compilation should be extended with figures from other
countries.

Most of the participants thought that the utilities should have the possibility of setting
requirements or the performance in different situations, for example, in control of active and
reactive power at normal operation and at fault situations. Performance at faults should be
declared in a clear way. This leads to what all participants considered to be most important,
namely, to be able to develop and have access to reliable electrical models for simulation of
grid interaction. This is crucial for the safe transmission of electricity in the grid. A working
group of grid owners from the UK, Ireland and Scotland has been set up. The aim is to develop
reliable models of wind power plants incorporating:

- Induction generators directly connected to the grid
- Induction- and synchronous generators connected to the grid via converters
- Double-fed induction generators

There is also a need for advanced and simple models of single wind turbines. The simpler
models are important for connecting a large number (thousands) of wind turbines and
calculations with a rather slow time variation, up to 10 Hz. The more advanced models are
used when there is a need for calculations with a short time constant, less then 100 ms. Of
course, the computer calculation time is much longer for the advanced model.

Arne Hejde Nielsen from DTU in Denmark discussed the importance of incorporating the
power control of the wind turbine when analyzing three-phase short-cuts in the grid. It was
shown that wind turbines equipped with active stall in a wind farm of 150MW can help and
support the grid at a short circuit situation and will continue to produce when the fault is
repaired. On the other hand, if a wind turbine is equipped with passive stall control, a strong
oscillation will occur. These simulations were performed with PSS/E.

Conclusions

The conclusion from the meeting was that it is essential to have good simulation tools and
reliable models of the wind turbines when performing grid simulations. There was a great
interest for further co-operation within this field. At the meeting it was decided to prepare a
proposal for a new Annex covering these issues. The proposal should cover the following
points:

- Model exchange/evaluation/comparison
- A common database with model parameters and measurements
- Best practice guidelines, such as, grid connection codes specific for wind turbines

It was pointed out that it is essential that manufacturers of wind turbines participate in the
work. This will secure that the different ways of operating wind turbines will be covered.
In order to be able to formulate the proposal, an AdHoc group was set up with the following persons: John Tande (Norway), Jan Pierik (the Netherlands), Karsten Burges (the Netherlands) and Ola Carlson (Sweden). The intention is to present the proposal at the next ExCo meeting on April 16-17, 2002. The indicative time schedule for the work:

<table>
<thead>
<tr>
<th>Nov 2001</th>
<th>Send templates for starting an Annex to Tande</th>
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<tbody>
<tr>
<td>Nov01-Jan02</td>
<td>Prepare and circulate proposal and get comments</td>
<td>All</td>
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<tr>
<td>March 2002</td>
<td>Send proposal to ExCo secretary for circulation to members</td>
<td>Tande</td>
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During this process it is essential that the organizations that are interested in participating in the Annex, keep their national representative informed about the content of the proposal. This will facilitate discussion and decisions in this matter at the ExCo meeting.