DOE Survey on Best Practices in Wind Power Integration

A worldwide survey[1] has identified nine best practice tools for wind power integration. Two of the nine praised tools were found at Energinet.dk.

A new operating paradigm

Alstom Grid Inc. has made a worldwide survey on wind power integration for the US Department of Energy (DOE). This is a highly needed initiative.

The present high reliability of electricity in most countries is based on experience rather than on science. Wind power will change the operational conditions. Many operating rules will no longer be valid and the power system security may be affected. A systematic exchange of experiences can reduce the future risk of power failures.

From the conclusion:

"*The industry is on the verge of a new operating paradigm as high levels of wind and other variable generation and increasing operational uncertainty become the norm today and even more so as we move towards 2030.*"

72% of installed wind capacity in the world included in the survey

The survey includes operators of 141 GW of wind capacity or 72% of installed wind capacity in the world. 33 grid operators have responded to the survey. The investigation team has visited three grid operators in USA and three in Europe including Energinet.dk between August and October 2010.

Some of the main issues of the survey are
- Wind Power Forecasting
- Decision Support Systems and Operational Processes
- Impact of Smart Grid Technologies on Wind Integration
- Wind Power and Situation Awareness in Control Centers

The survey acknowledges that the control centers have different challenges. The integration tools are correspondingly different. The survey does not recommend any solutions as universal tools, but it emphasizes certain practices which seem appropriate for meeting specific local needs.

According to the report best practices must:
- Be innovative and take advantage of technology
- Have the potential to be replicated
- Place the organization in a top ranking in the particular industry
- Have been implemented
- Be recognized by peers

The Danish examples of excellence

(3,752 MW wind power at the end of 2010)

The Nordic countries, Denmark, Norway, Sweden and Finland, have a long tradition for close cooperation on power supply. The coordination between grid operators has particular impor-

[1] Strategies and Decision Support Systems for Integrating Variable Energy Resources in Control Centers for Reliable Grid Operations – Global Best Practices, Examples of Excellence and Lessons Learned, Lawrence E. Jones, Alstom Grid Inc.

tance for the prevention or limitation of power failures. The access to updated information on neighboring grids and is a decisive factor.

The Nordic Operational Information System (**NOIS**) provides the transmission system operators of the four Nordic countries with relevant data on capacity, balance, reserve and outage management functions for the entire Nordic area. NOIS has proven its value, and a continued development is expected. NOIS is one of the nine best practices.

Energinet.dk has developed an Operational Planning System (Danish abbreviation: **DPS**) looking 2 to 3 hours ahead. The tool combines several wind power forecasting tools with SCADA measurements and with 5 minutes schedules for production and exchange. The expected power imbalance is a key operational quantity. The tool provides the operator with essential data necessary for making decisions. DPS is also among the nine best practices.

Other best practices

Alberta Electric System Operator, Canada (777 MW wind power in January 2011):
Dispatch Decision Support Tool (**DDST**).

> Based on wind power forecast, load forecast and real-time information DDST presents estimated system conditions for the next 60 minutes including real-time "what-if" analyses. The visualization is very clear. The tool was also selected as an industry best practice by NERC[2]

Bonneville Power Administration, USA (3,372 MW wind power in 2010):
Integrated Curtailment and Re-Dispatch System (**iCRS**).

> iCRS displays in real-time on a single screen balancing reserves, wind generation and other system-wide data. The tool is characterized as a unique, intuitive and easy way to monitor reserves.

Eirgrid, Ireland (1,425 MW wind power at the end of 2010):
Wind Security Assessment Tool (**WSAT**).

> As an island system with a relatively high wind power penetration the Eirgrid power grid requires special operational attention. WSAT has been developed as a supplement to online Voltage Stability Assessment (VSAT) and online Transient Stability Assessment (TSAT). The operator can interact with these tools and with the Energy Management System (EMS) via the WSAT Manager.
>
> The necessary wind power curtailment is handled by another interesting tool, Wind Dispatch Tool (WDT).

Electric Reliability Council of Texas, USA (9,400 MW wind power at the end of 2010):
Ercot Large Ramp Alert System (**ELRAS**).

> Wind ramp events are frequent in Texas due to geography and climate. ELRAS provides probabilistic wind power forecast information to operators for the next 6 hours. Weather observations for historical hours and forecasted weather for the next 6 hours can also be seen. The probability of wind power output ramp events of various MW changes occurring over different time frames is displayed.

[2] North American Electric Reliability Corporation

50Hertz – A unique experience of wind integration

50Hertz Transmission GmbH is one of four TSOs in Germany. At the end of 2010 the installed wind capacity was 11,513 MW.

About 90% of the wind generation is connected to the distribution system level, which is not operated by 50Hertz. The 50Hertz operators do not have real-time access to all the wind power generation. They must make decisions with incomplete information, thus introducing more operational uncertainty.

Challenges caused by wind power:
- Overload on internal power lines and interconnections
- Overload on transformers linking the transmission level with the distribution level
- Problems with local voltage stability
- Problems with frequency stability and system balance

Wind generators are guaranteed priority dispatch according to the EU renewable energy directive, except when the stability of the power grid is endangered. Curtailment of wind power occurs. As a last measure, 50Hertz must manually curtail wind power by orders to the distribution grid operators.

Based on official German sources 50Hertz reports the following maximum power ramps in Germany caused by wind power and photovoltaic (PV):

Germany Maximum power ramps		GW per ¼ hour		GW per hour	
		Up	Down	Up	Down
Wind	2010	1.77	-1.54	2.52	-2.39
	2020 prediction	3.08	-2.68	4.39	-4.16
PV	2010	0.70	-0.60	2.20	-2.20
	2020 prediction	2.48	-2.13	7.79	-7.79

A range of tools

The 222 pages report presents an overview of the wind power integration issue together with some very informative cases and a comprehensive bibliography.

The cases demonstrate that the system operators have invested development resources in different types of tools depending on local conditions. The categories mentioned in this note are:
- Predictive tools minutes and hours ahead including visualization
- Security assessment
- Curtailment planning and procedures
- Large ramp alert
- Updated information on neighboring grids

Most system operators are planning a further development of their wind power control tools. Hopefully new reports will follow up in the future and present status and more details on wind power integration.

With growing wind power penetration each system operator will need a range of tools. This will require an increasing development effort. The development and maintenance of a full

range of wind power monitoring tools could be prohibitive to some system operators. Exchange of experiences and replication of suitable tools could be an inevitable next step. Gradually standard procedures and tools could evolve as a result of intensified international cooperation.

Most countries have high ambitions on wind power penetration. Therefore the development of tools could be a race against the time. This is a further argument for joint development projects.