Wind Energy Institute of Canada

ACOA Report – Wind Integration in the North East

‘Addressing Wind Integration Issues in North Eastern North America”

Reference # CP11064

Prepared by

Wind Energy Institute of Canada
21741 Route 12
North Cape, PE C0B 2B0

Thursday 27 March 2008

TABLE OF CONTENTS

TABLE OF FIGURES

1 EXECUTIVE SUMMARY

1.1 Introduction

In response to increasing focus on security of supply issues and greater public concern over climate change, wind energy has been growing rapidly in the North East of North America. It has the potential to continue such rapid growth for the foreseeable future.

In recognition of this fact on November 8 ACOA released a Request for Proposals (RFP) for a project that would "*Address Wind Integration Issues in North Eastern North America.*" The tender for this was subsequently awarded to WEICan.

The following document addresses the issues associated with wind integration in the North East by;

1) Evaluating issues that inhibit the transmission of wind
2) Identifying actions that will improve the integration of wind
3) Profiling processes that could facilitate the uptake of wind

1.2 Report scope

This report will seek to identify wind integration issues that either are or may in the next 5-10 year period, arise in the North East region. The report will focus on issues which, if not identified and addressed proactively, may restrict or otherwise inhibit the optimal integration of wind energy in the region.

Some of these issues are specific to the NE region and others are generic to North America. We believe that all of them will have relevance within the NE region although some will be more applicable than others.

1.3 Key integration lessons

The following summary of key grid integration lessons is distilled from comments made during the February 12-13 2008 '*NE Region Wind Integration Seminar'* in Montréal, Québec. This document also draws extensively from the experience and published literature of North America and Europe – two regions which at the end of 2007 had 80% of total global installed wind capacity.

The issues are outlined at a high level. Reaching agreement on each area will likely require a 'task force' that is specific to each issue and which is made up of technically competent interested parties. That various task forces would benefit from some form of central coordination and it is likely that it will take a number of months in order to draw up an agreed plan of action for each.

1.3.1 Technical Context

An understanding of some of the more common technical misconceptions that arise, regarding the large scale grid integration of wind energy, will provide a useful framework within which to assess the key technical recommendations. The main ‘contextual’ points are;

The cost of wind integration. Increased wind penetration results in increased costs associated with regulation, load following and unit commitment requirements. The combined impact of these effects has been shown to increase system operating costs by up to US$5/MWh <u>of wind generation</u> at capacity penetrations of 20-30%. These costs constitute 5-10% of typical wholesale electricity price. Other factors, which are not reflected in this amount and which would serve to reduce the overall cost of wind energy, are;

- avoided fuel costs (due to the displacement of thermal power stations) and;
- avoided carbon emissions.

Consideration should also be given to the fact that various studies have shown that since wind is ‘must run’ capacity it is a price taker and consequently serves to depress wholesale electricity prices. This effect has been shown to be significant in Germany.

Negative externalities and relative economics. The European Union notes that a significant barrier to the further network integration of renewables is the often poor relative economics vis-à-vis other forms of generation and it further notes that the reason for this is a failure to systematically include external costs (i.e. negative externalities) in market prices. This failure “*gives an economically unjustified advantage to fossil fuels compared to renewables.*”

While this is a policy, rather than a technical issue, the economic disadvantage for renewables is significant from a technical perspective as it means that any additional costs associated with technical issues such as transmission investment, additional balancing requirements etc., make wind look expensive relative to thermal sources when this may not be the case.

System stability and wind turbines. The view is sometimes expressed that wind turbines degrade power quality and do not benefit system stability. However there is evidence that modern wind turbines can actually aid system stability by providing low voltage ride through (LVRT) and reactive power support to reduce voltage excursions and dampen swings.

Energy resource vs. capacity resource. It is inappropriate to view wind primarily as a capacity resource since this tends to distort views of its efficacy. Wind is primarily an energy resource and not a capacity resource (although studies indicate that wind does actually provide some additional load carrying capacity).

Consequently no additional generation needs to be added to provide backup capability provided that existing generation remains in service and wind capacity is properly discounted in the determination of generation capacity adequacy.

Wind generation may however require system operators to carry additional operating reserves although various studies indicate that the requirement for additional reserves will likely be modest for broadly distributed wind plants (see ‘The Cost of Wind Integration’ above).

Wind plant technology trends. Early wind turbines were predominantly stall/active stall regulated and fixed speed and, from a mechanical and electrical point of view were relatively unsophisticated. Modern turbines are increasingly variable speed, pitch regulated. Such turbines allow for reduced drive train loads, lower aerodynamic noise, good reactive power control capabilities as well as reduced power and voltage fluctuations.

Modern turbines also have improved voltage control capabilities, better short circuit contribution, reduced flicker, significantly improved LVRT capabilities as well as having the potential to participate in Automatic Generation Control (AGC). Supervisory Control and Data Acquisition (SCADA) capabilities continue to improve enabling wind turbines to provide the features and information required by SOs.

Technology improvements continue such that and ignoring the non schedulable nature of wind, the electrical characteristics of wind plants are increasingly similar to traditional thermal plants.

1.3.2 Principle Technical Recommendations

Vision. High wind penetration levels are technically simpler and economically cheaper to achieve when broad consensus is gained early on about the expected wind penetration in the medium to long term. The starting point for any such consideration is an understanding of the potential for wind energy – in other words a long term vision which, if it is to be a ‘stretch target’ that fully explores energy export options, should go beyond meeting each region’s existing Renewable Portfolio Standard (RPS) or Renewable Electricity Standard (RES) requirements.

It will be difficult to realize the full potential of wind energy across the region while there are differing views as to the reasons for encouraging it. For instance if provinces/states within the region see locally constructed wind as being the best way to meet local RPS/RES targets and to foster local job creation, then it is hard to see how the region will ever meet its full potential for wind integration. If on the other hand there is initial agreement that the region has an excellent wind resource and great potential for working together to export that resource to other markets such as Ontario and New York (for example), then there is much more likelihood that it will be possible to achieve significantly more.

Wind Resource Assessment. A detailed understanding of the wind resource of the region will be vital to understanding both what is possible and more importantly, what it will cost to achieve it. Such understanding should go beyond a basic ‘wind energy map’ (of which a number already exist for the North East region) and instead should consist of a time-synchronised model of wind speeds at a variety of heights for one hour and ten minute time intervals. An approximate cost to develop such a model would likely be between $300,000 and $1,000,000 for the North East region however the actual amount will depend on the eventual geographic area covered by the study.

A model with this level of detail could be integrated with others that are being carried out in the United States. Such integration would materially assist in gaining a comprehensive understanding of the wind resource of North America.

Multi-user integration studies. Because of wind’s unique characteristics many System Operator (SO) and Transmission Operator (TO) concerns are based on challenges arising from the increased variability that wind contributes to the grid. As a result the growth in wind energy has caused many SOs/TOs to investigate the potential impact of wind on the power system.

Several such studies have already been conducted in individual provinces or states across the North East although as yet there has been no multi-user study conducted across the region. Any such study will require wind data from the ‘Wind Resource Assessment’ mentioned above if it is to be fully effective. The results of any such study should be compatible with the Joint Coordinated System Plan currently being undertaken across most of the US portion of the Eastern Interconnect.

Upgrading and expanding transmission systems. Some of the best wind resources are located far from major load centers. It is of relevance to the North East region that the major load centers of the US Eastern seaboard are located a considerable distance from the significant wind resource areas in the Canadian north east. This presents considerable opportunities (and challenges).

While SOs/TOs may be suitably incentivized to ensure adequate transmission capacity within their region, the same incentives may not be sufficient to ensure appropriate levels of investment in transmission capacity required to create strong linkages between regions.

Realizing the full potential of the North East's wind resource will require investment in new transmission capacity. It would appear that the barriers to such investment are not predominantly technical or economic.

Balancing area size. The net load that must be served after accounting for wind has more variability than the load alone. Dealing with this additional variability represents the single largest operating cost associated with integrating significant amounts of wind on the system (see 'The Cost of Wind Integration' below). One of the most cost effective ways to decrease balancing costs is to increase the size of the balancing area. Large diverse balancing areas with robust transmission networks tend to reduce wind's impact by reducing ancillary service costs.

Where it is not possible to increase balancing area size, other factors can mitigate ancillary service costs such as cooperative arrangements or markets for ancillary services, between adjacent balancing areas. One such example is the Area Control Error (ACE) Diversity Interchange (ADI). Consideration may also be given to regional coordination of unit commitment activities.

Forecasting. Electricity produced by wind turbines varies fundamentally from that generated by other 'traditional' sources in so far as the amount of that electricity depends on a non-controllable resource: the wind. Understanding the nature of the wind resource is therefore critically important.

It would be beneficial if there is, at an early stage, agreement on a common regional approach to forecasting. This will ensure that SO/TO concerns are addressed proactively. It will also provide clarity to SOs/TOs, wind farm developers and owners regarding their respective obligations. Consequently costs, associated with the adoption of sub-optimal forecasting procedures, can be minimized.

Geographical diversity. The variability in the total electrical output of a portfolio of individual wind plants can be substantially mitigated by ensuring that those wind plants are located in geographically diverse locations.

There is however an (understandable) tendency for wind farm developers to cluster their projects in areas where the best wind resource can be found. A mechanism that encourages a balance between clustering around good wind resources and geographical diversity will help to minimize balancing costs and to increase the amount of wind that can be safely integrated.

Increasing system flexibility. As increasing wind capacity is added, greater regulation, load following and quick start capability will be required from the remaining generators. The cost of providing this additional flexibility will depend on the nature of the dispatchable generation sources, their fuel cost, and other factors such as the market and regulatory environment in addition to the characteristics of the wind-generation resources as compared to load.

Flexible resources (such as hydro) will be able to provide these additional balancing services at lower cost than less flexible resources (such as coal) or relatively inflexible resources (such as nuclear). Until such time as negative externalities are fully included in the electricity price, recognition of the benefits of flexible generation will need to be factored into the decision making process when new (non wind) generation plant is being considered.

Wholesale markets. Deep, liquid markets are well suited to allowing entities to hedge the risks and costs associated with variable output generators. Consequently encouragement should be given to the development of well functioning region-wide real-time, hour-ahead and day-ahead energy and price responsive load markets and to ensuring broad access to those markets.

Market rules and tariff provisions should be adopted which are more appropriate to weather driven resources. For instance the imbalance settlement process should not penalize generators that cannot control their fuel source (i.e. wind turbines).

Transmission tariffs.

- ***Flexible-Firm tariffs***. Hourly analysis of line loadings often shows that interconnectors and feeder lines between regions are heavily loaded for only a limited number of hours in the year. Development of a flexible-firm transmission product for these locations, which makes the unused capacity available for other transactions when the line is lightly loaded, can be accomplished with minor modifications. For instance this can be achieved by flexible transmission tariffs which allow rates to be paid on an ‘as used’ basis rather than a ‘capacity reservation’ basis.
- ***Pancaking of transmission rates.*** As a result of this practice the total transmission charges levied can be in excess of the marginal cost of providing the transmission service. Such charges can serve to easily double the cost of power purchases that involve long distance transmission. This issue can be eliminated by forming TO/SO groups and/or collaborating on regional transmission pricing.

Demand response. Historically supply (i.e. the amount of electricity generated) has always been adjusted to meet demand (i.e. load). This is not because demand is inelastic per se and is simply because the predominant systems operation philosophy for many years now is that generation is altered to meet demand and not vice-versa.

Demand response is the term applied to mechanisms which are employed to manage the demand from customers in response to supply conditions and it is a relatively new concept in the electricity industry. Nonetheless it is increasingly being recognized as a powerful tool for reducing (or increasing) demand as required and consequently for reducing balancing costs associated with the integration of significant amounts of wind.

The successful recent ‘Forward Capacity Market’ Auction experience of ISO New England has demonstrated the potential.

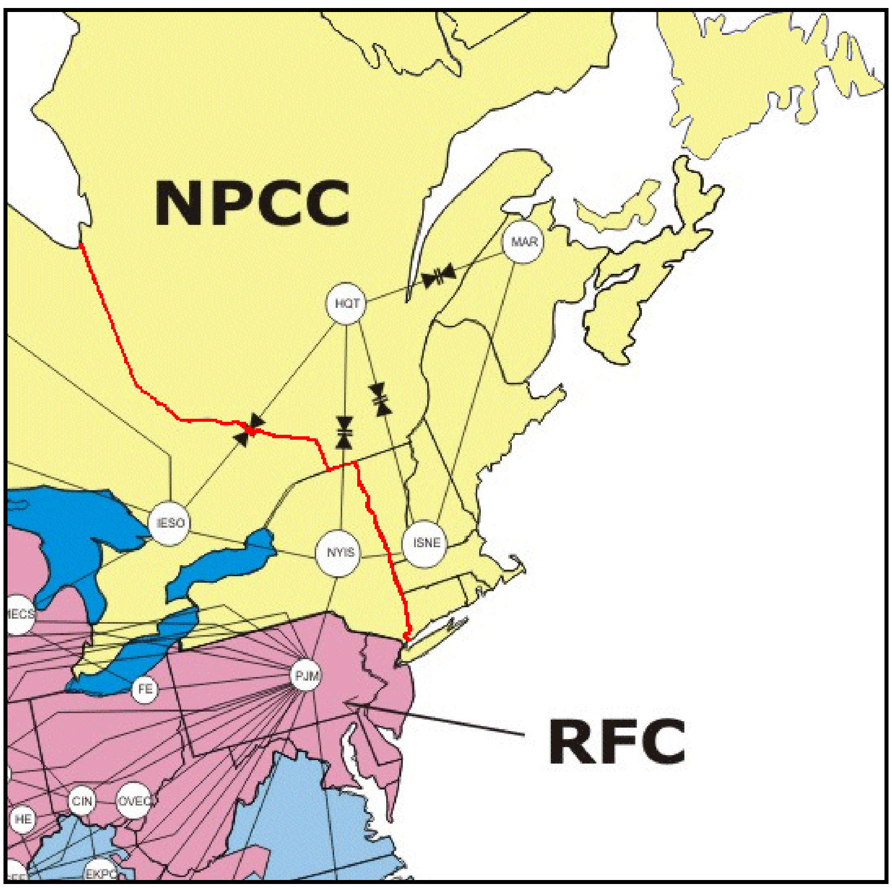
2 OVERVIEW OF THE NORTH EAST AND ITS WIND RESOURCE

2.1 Overview of the North East electricity market

Figure 1 shows the entire NPCC region (as well as Newfoundland and Labrador) in yellow. For the purposes of this document the North East region consists of everything to the East of the red line drawn through the NPCC. The region includes three NERC balancing areas (Hydro-Québec TransÉnergie, The Maritimes and ISO New England) as well as Newfoundland and Labrador.

The region encompasses 5 Canadian Provinces (New Brunswick, Newfoundland & Labrador, Nova Scotia, Prince Edward Island and Québec and) as well as 6 US States (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont).

Figure 1 The North East Region



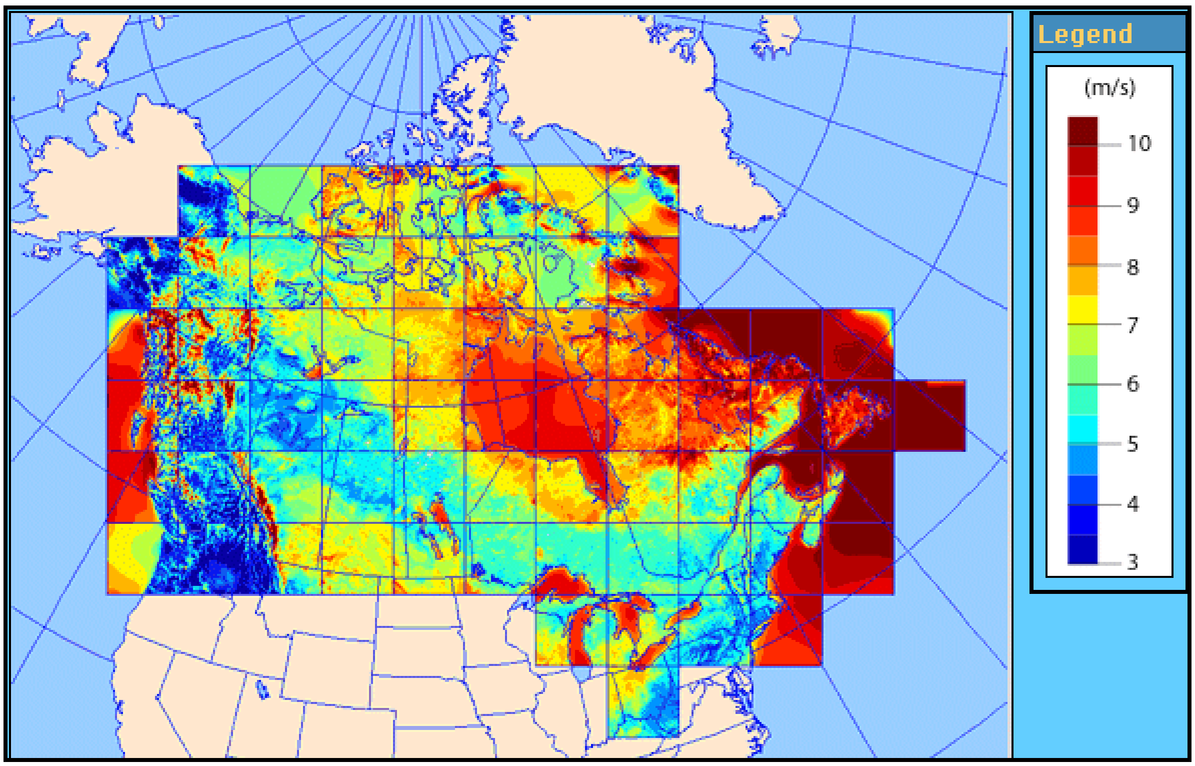
Source: NERC web site. 'Regions and Balancing Authorities at 1 August 2007' (with modifications)

The population of the North East is about 25 million with about 40% of those in Canada and 60% in the US. Also of significant interest are the populations in the neighboring regions of PJM, NYISO and IESO since these constitute significant potential markets for electricity generated from wind turbines in the North East.

The installed generating capacity in the North East totals almost 80000 MW and consists of 34000 MW - Québec, 31000 MW - ISO New England, 7300 MW - Newfoundland and Labrador, 4200 MW - New Brunswick, 2500 - Nova Scotia, 140 MW - Northern Maine and 70 MW - PEI.

The Canadian Wind Atlas (Figure 2) indicates that the region has some of the best wind resource in North America.

Figure 2 The Canadian Wind Resource (at 80 m)



Source: The Canadian Wind Energy Atlas. http://www.windatlas.ca

Notwithstanding the resource the installed capacity of wind in the region is only 550 MW currently (420 MW - Québec, 70 MW - PEI and 60 MW - Nova Scotia). However all SOs expected substantial expansion of wind energy in the next few years.

Hydro Québec expects to have 4000 MW of wind on its system by 2015, **Newfoundland & Labrador Hydro** is currently investigating "*the potential for large scale wind development in Labrador*". The focus is on export due to the small size of the domestic market.
ISO New England currently has 1580 MW in the connection queue and at this level does not see "*major operational or planning issues that would inhibit system operations*" however feels that more may be coming and that it needs to be ready for this.
Northern Maine is expecting about 1,000 MW of wind by 2010 and notes that the only way to cope with such numbers is through export due to limited domestic load.
Nova Scotia is expecting about 600 MW by 2013 simply in order to meet its own RES targets.

New Brunswick is expecting more than 400 MW of wind by 2016 in order to meet RPS targets.
Maritime Electric notes that expressions of interest from developers are "*far in excess of the existing transmission capacity.*" (current submarine cables to New Brunswick have a capacity of 200 MW).

Building any form of new generation capacity in New England and to the South and West in PJM and NYISO, is problematic and has been for some time. For this reason electricity prices are high throughout the US eastern seaboard from South Carolina all the way north to Maine. This represents a substantial export opportunity for the North East region provided that some of the hurdles preventing the development of wind power in the region can be overcome. These are discussed further in this document

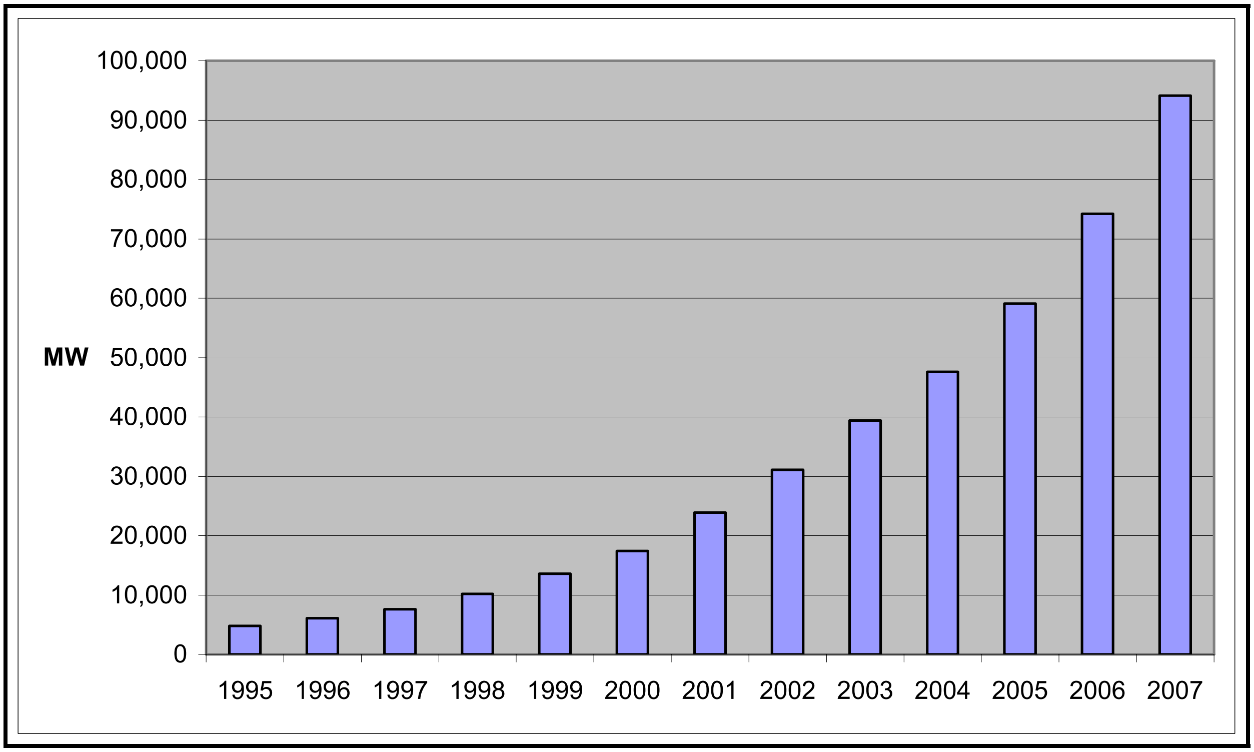
2.2 Wind energy overview

2.2.1 Global market

The modern wind industry began in the 1970s. Significant growth started in the late 1980's and at the turn of the century wind was, for the first time, beginning to be taken seriously by System Operators first in Europe and then latterly in North America.

Global total installed capacities since 1995 are shown in Figure 3. At the end of 2007 the global wind industry completed more than 10 years of year on year growth in excess of 25%. Total global installed capacity at that time was 94 GW.

Figure 3 Global cumulative annual installed wind capacity 1995-2007



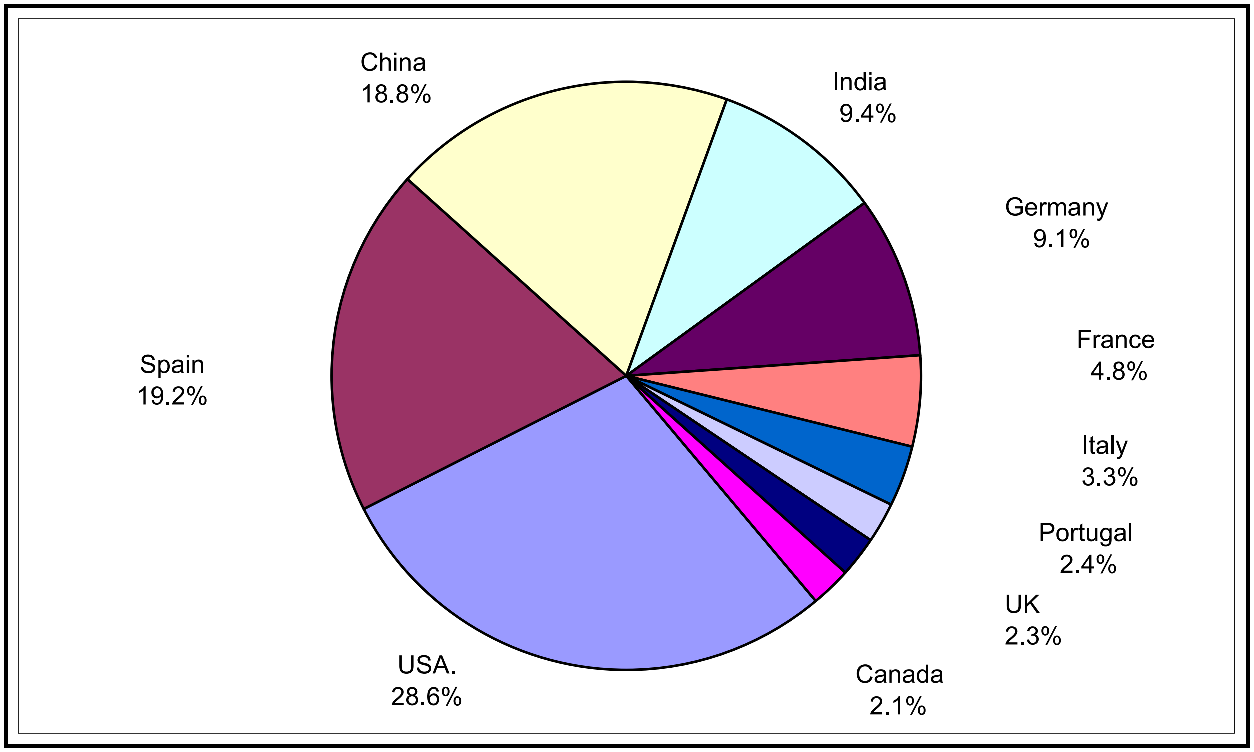
Source: Global Wind Energy Council

Up until 2005 growth of the wind industry was led by Europe. In 2007 the 27 countries of the EU were responsible for 8554 MW or 42% of all wind capacity installed that year and countries such as Spain, Germany and France constituted substantial markets. However the 'centre of gravity' of the wind industry is moving inexorably away from its traditional European base and that region's continued dominance of the industry is no longer assured.

Major turbine manufacturers have emerged n the last few years in the US, China and India and these countries have also emerged as sizeable installers of new wind capacity. The US, China and Indian alone accounted for 10423 MW or 52% of new capacity installed in 2007.

More than 30% of all new generation capacity added in the US in 2007 consisted of wind turbines. Last year the United States installed the largest number of new MW of wind capacity – 5200 MW which was more than 28% of the 18350 MW installed by the top 10 countries over that year. Those countries and their individual share of the 'top 10 market' is shown in Figure 4.

Figure 4 Global Wind Capacity installed in 2007 – Top 10 Countries



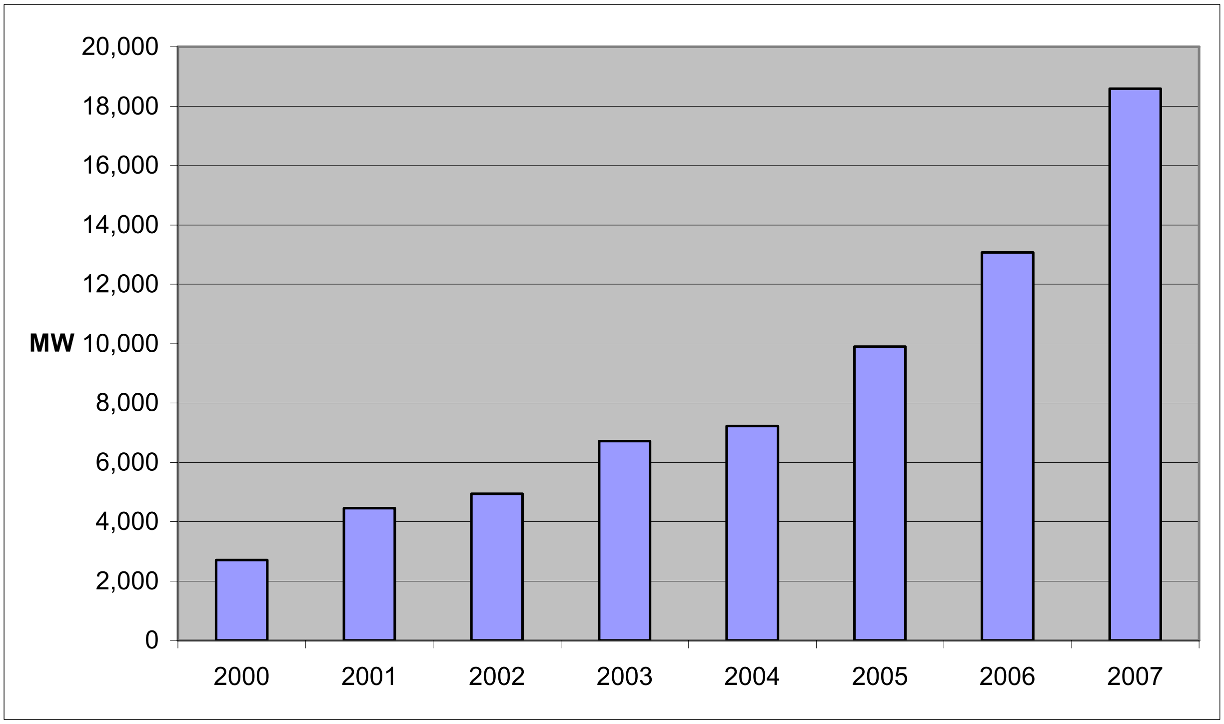
Source: Global Wind Energy Council

2.2.2 North America

Figure 5 illustrates that North America is experiencing an unprecedented period of wind plant growth. In 2007 30% of all new generation (all fuel types) installed in the US was made up of wind turbines. In 2006 alone Canada more than doubled its installed capacity of wind.

North American installed capacity of wind turbines was 18600 GW at the end of 2007 – equivalent to 20% of the world total and second only to Europe's 57000 MW and 60%.

Figure 5 North America cumulative annual installed wind capacity 2000-2007



Source: AWEA and CanWEA

This rapid growth rate is the result of many factors including the federal Production Tax Credit (PTC) in the US, the Wind Power Production Incentive (WPPI) in Canada, state and provincial renewable portfolio standards, security of supply considerations and the favorable economic and environmental characteristics of wind energy compared with other forms of power generation. This rapid growth rate has caused SOs/TOs and utilities with significant current or expected, wind energy in their service territories to have performed or to be in the process of carrying out, studies of the technical and economic impacts of incorporating wind plants in their systems.

Studies conducted to date indicate that it is both technically and economically feasible to incorporate and integrate substantial penetrations of wind energy in the electricity grids through North America. However the same studies indicate that it if the wind integration is to be optimized at minimal cost then effort and capital must be invested in transmission capacity, modifications to transmission planning as well as system and market operations. As is the case with most capital investments: costs can be minimized by careful, all-inclusive proactive planning carried out well in advance of when it is actually required. With rapid growth of wind energy being considered or already underway, throughout the North East, now is the time to take the proactive decisions required on a number of fronts.

2.3 Intermittent wind farms?

As we talk about wind turbines and their role in the current and future generation, it is important to consider the relevance of some terms often used to describe wind power and the electricity which can be extracted from it.

The terms are *wind mills*, *wind farms* and *intermittent*.

The terms *wind mill* (to describe a single wind turbine) and *wind farm* (to describe a collection of one or more wind turbines) are legacy words from days gone by. They conjure up images of one or two wind turbines installed on the sub-transmission and distribution networks. They were curiosities – sometimes they produced power and sometimes not but in any even it didn't matter since the amount of power was small and in the event of system disturbances they would be removed from the system to be re-connected once system stability was re-established.

Those days are gone. Wind plants are now as large as or larger than many conventional power plants. In 2006 Florida Power and Light (FPL) dedicated the largest wind plant in the world – the 735 MW Horse Hollow wind plant in Texas. In Europe a consortium called 'The London Array', consisting of Shell, E.ON and Dong Oil Company, is actively engaged in developing a 341 turbine, 1000 MW offshore wind plant in the outer Thames Estuary about 20km. from London. In the US more than 30% of all new generation capacity added in 2007 consisted of wind turbines. Texas, Shell and TXU last year announced plans to build a 3000 MW wind plant in Briscoe County.

Utilities now require the same sort of terminal behavior from a wind plant as from a 'conventional' plant. Wind turbines are industrial units and our terminology should change to reflect that. The terms *wind mill* and *wind farm* are therefore no longer appropriate and their places will be taken by the terms *wind turbine/wind turbine generator (WTG)* and *wind plant* throughout this document.

The other term which needs to be reexamined is *intermittent:* an adjective that is often used to describe wind energy. This is not only a term from the distant past; it is also one which is completely inaccurate in its description of the electricity produced by one or more wind plants. The Concise Oxford Thesaurus lists the following synonyms for intermittent*: irregular, fitful, spasmodic, broken, fragmentary, discontinuous, isolated, random, patchy…*

'Intermittent' gives the impression that wind plant output cannot be predicted and that it goes rapidly from no-load to full-load and back again on a random basis. This view was prevalent in the early days of the industry especially when the output of a single wind turbine was considered (see Figure 9 Variability and Wind Turbine Diversity). Now that there is a better understanding of the behavior of large modern wind plants, especially when several of them are interconnected on a single transmission network, it is clear that the term *intermittent* no longer applies[1]. Figure 6 illustrates the point: this shows the real-time output of all the wind plants in Spain over 20 hour period from 21:00, March 22 to 17:00 March 23, 2008. The total output (green line) is made up of the known output from wind plants with SCADA connections to the Spanish system operator (Red Eléctrica de España) (the yellow line) and the estimated output of those turbines with no SCADA system (the difference between the green line and the yellow line).

It shows that over the 20 hour period nation-wide wind output varied between a high of 8400 MW to a low of 6600 MW – a difference of 1800 MW. Over the period the maximum ramp rate of wind was about 700 MW/hr over a one hour period from midnight to 01:00 on the 23rd. Over the same period of time total system demand varied from a high of 33000 MW (21:00 on the 22nd) to a low of 20000 MW (07:30 on the 23rd) with a maximum ramp rate also between midnight and 01:00 on the 23rd, of approximately 3000 MW/hr.

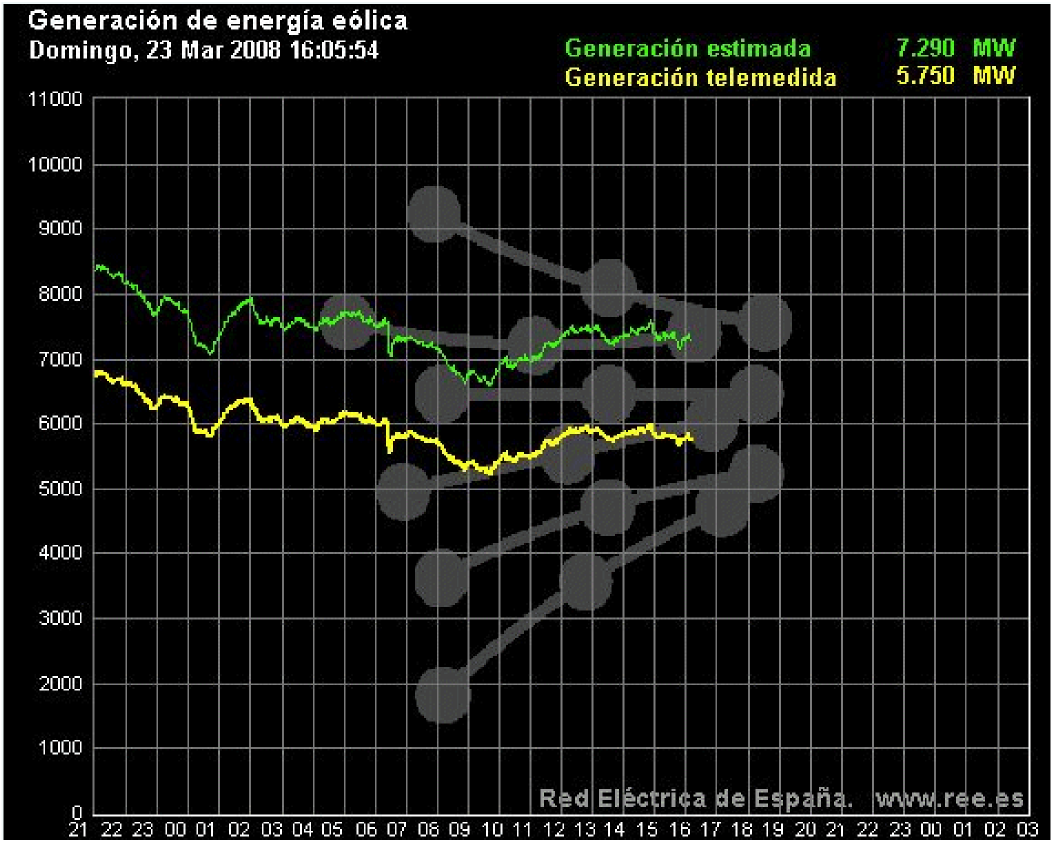
This chart takes no account of any transmission constraints that may have existed on the network: however that is not the point. Its purpose is to illustrate that it is not reasonable to label wind as intermittent when it is being considered over a sufficiently large geographical area (and that area need not be as large as Spain). While wind's variability brings with it additional balancing costs relative to existing costs required to cope with variable load and intermittent trips of thermal and nuclear plant, analysis reveals that these additional costs are not significant (See 4.6.1Summary of US Wind Integration Experience & Market Mechanisms).

The term *variable* better reflects the nature of the combined electrical output of interconnected wind plants and consequently this term will be used throughout this document in place of *intermittent*.

---

[1] J Charles Smith and Brian Parsons. 'What does 20% look like? Developments in wind technology and systems'. IEEE Power and Engineering Magazine. Wind Integration - Driving Technology, Policy and Economics. Nov./Dec. 2007

Figure 6 Output of All Spanish Wind Farms. 23 March 2008



Source: Red Eléctrica de España web site : http://www.ree.es/

2.4 New England Governors/Eastern Canadian Premiers

The Conference of New England Governors and Eastern Canadian Premiers was established in 1973. At their conferences, which are generally held annually, the Governors and Premiers discuss issues of common interest and concern and enact policy resolutions that call on actions by the state and provincial governments as well as by the two national governments. During the year the Conference convenes meetings of state and provincial officials, organizes roundtables and workshops and prepares reports and studies on issues of regional significance.

In advance of the 31st Conference of New England Governors and Eastern Canadian Premiers (held June 26th 2007 in Prince Edward Island), the New England Governors and Eastern Canadian Premiers (NEG/ECP) convened a 'Ministerial Forum on Energy and the Environment'. The recommendations and outcomes of that meeting are contained in a document which contains Action Items covering;

Energy Efficiency

Energy Trade

Renewables, and;

Transportation.

The Action Item contained in Paragraph 5e) (Energy Trade) states

"*Explore actions to ease integration of intermittent resources (like tidal and wind power) across the region to expand the amount of renewable power;*

Work with the New Brunswick ISO, Nova Scotia Power Inc., Hydro Québec, Newfoundland & Labrador Hydro, the ISO-New England, Inc., and other pertinent organizations to evaluate how the 'balancing' of intermittent resources may be enhanced and supported."

This document and the February 2008 seminar (See 4 ne region wind integration seminar) were compiled in cooperation with NEG/ECP with a view to ensuring that their particular requirements were addressed.

3 GLOBAL EXPERIENCE OF WIND INTEGRATION TO DATE

This section represents an attempt to distil the key issues from the extensive body of European and North American literature on the grid integration of wind energy. By endeavoring also to incorporate the key messages from the *NE Region Wind Integration Seminar*, held on the 12 & 13 February in Montréal, an attempt has been made to ensure that this global experience is made relevant to the NE region.

The key messages arising are as follows;

3.1 Long-term wind vision

High wind penetration levels are technically simpler and economically cheaper to achieve when broad consensus is gained at an early stage about the expected wind penetration in the long term. The starting point for any such consideration is an understanding of the potential for wind energy – in other words a long term vision. In the US that vision is being outlined in the '20% wind vision'; this is a collaborative exercise between AWEA, DoE and NREL the results of which are due to be announced in the next few months. It is not clear if a similar process is yet underway either in Canada or in the North East.

The decision was taken by the US wind industry not to lead on this project since it was felt that this would give the final results additional credibility. Consequently the study is a joint effort between AWEA, DOE and NREL with NREL undertaking the bulk of the work.

A similar visioning process has been undertaken at the EU level and preceded the EU announcement (March 2007) that by 2020 Europe would increase the proportion of its energy coming from renewable sources – from 6.5% currently to 20% by 2020[2]. Comparable 'visioning statements' have been produced by regions, states and provinces across North America.

3.2 Wind resource data set

Various wind maps of the North East already exist (e.g. Figure 2 The Canadian Wind Resource (at 80 m)) and these give a useful picture of the resource

[2] Commission of the European Communities. 'Renewable Energy Road Map. Renewable Energies in the 21st century: building a more sustainable future'. COM(2006) 848 Final. 10 January 2007.

available in the region. However they are not detailed enough to be employed in sophisticated integration models.

A detailed understanding of the wind resource of the region is obviously crucial. The wind data set will be a vital element of any wind integration study which itself is a critical component part in the optimization of the wind uptake in a region.

Since most such wind studies are done on a forward looking basis, wind data is generally not available at the outset of the study. As a result it has become common practice for modern wind studies to devote a significant effort to obtaining wind data that is derived from large scale meteorological modeling that can create the data (ideally in 10-minute intervals) corresponding to the year(s) of load data used[3].

3.3 Multi-user integration studies

Wind integration studies in the late 1990s and the early 2000s were limited in geographical extent. This approach was adequate when the amount of wind on the system was small and, as a result, insignificant from a System Operator perspective.

As the expected percentage contribution of the wind industry to annual electricity needs has risen into the double digits, grid integration studies have had to cover an increasingly larger area which has invariably meant multi user studies. Several wind plant integration studies have recently been performed in the United States[4] and Canada.

One such study[5] (the Northwest Wind Integration Plan, released in March 2007) is of note as it illustrates that it is possible to produce results relatively quickly even when multiple entities are involved. This study had a steering committee of 24 people and Technical Work Group of more than 80 individuals from across the US North-West. It nontheless managed, in only 8 months, to produce a concise 68-page report with 5 clear recommendations.

---

[3] J Charles Smith. Utility Wind Integration and Operating Impact State of the Art. IEEE Transactions on Power Systems. Vol. 22. No 3. Aug. 2007

[4] B. Parsons, M. Milligan, J.C. Smith, E. DeMeo, B. Oakleaf, K. Wolf, M. Schuerger, R. Zavadil, M. Ahlstrom and D. Y. Nakafuji. 'Grid Impacts of wind power variability: Recent assessment from a variety of utilities in the United States'. Presented at the European Wind Energy Conference, Athens, Greece, Mar. 2006. Available: www.nrel.gov/docs/fy06osti/39955.pdf (unpublished)

[5] Northwest Wind Integration Plan. March 2007. Available: http://www.nwcouncil.org/energy/Wind/library/2007-1.htm

The geographic extent of these studies continues to increase and some now being considered, such as the JCSP (See 4.7.3 - Cost Allocation of Transmission or Market Solutions), cover much of North America.

Examples from Europe include the EWEA-led TradeWind study first year reports which are publicly available[6] or the European TSO study[7].

The results of many European and North American studies are referenced in the November/December 2007 edition of the IEEE Power and Energy Magazine.

3.4 Upgrading and expanding transmissions systems

Some of the best wind resources are located far from major load centers. In the North East the major load centres on the US Eastern seaboard are located a considerable distance from the significant wind resource areas in the Canadian north east. Initial analysis indicates that such distances are both economically feasible and technically achievable.

A lack of transmission is a ‘show stopper’ as far as wind energy is concerned and it is clear that new transmission will be required to move large amounts of remote wind energy to market. In North America many regional transmission planning studies are underway to investigate the challenges, requirements and changes that must be made to existing rules in recognition of the unique characteristics of wind energy[8].

The challenge for wind energy transmission is a classic ‘chicken and egg’ problem: transmission owners are not able to build new high-voltage transmission lines to remote areas where there may be an excellent wind resource but limited existing generation or load. As a result wind plant developers are often not able to build wind plants in the most attractive (from a wind energy resource perspective) location and are forced to locate facilities in less attractive regions which are closer to existing transmission. This problem has been exacerbated by de-regulation which over the last few years has seen a functional separation of generation and transmission activities. With this

[6] TradeWind. First Year Reports. November 2007. Available: http://www.trade-wind.eu/index.php?id=13

[7] European Wind Integration Study. Final Report. ‘Towards a Successful Integration of Wind Power into European Electricity Grids. Final Report. 15 Jan 2007. Available: http://www.etso-net.org/upload/documents/Final-report-EWIS-phase-I-approved.pdf

[8] J Charles Smith. Utility Wind Integration and Operating Impact State of the Art. IEEE Transactions on Power Systems. Vol. 22. No 3. Aug. 2007

separation coordinated planning of transmission to serve new remote generation becomes a major conundrum[9].

Nonetheless various innovative solutions are being adopted. Some jurisdictions have created independent bodies to advise on RE transmission needs. One such is Nevada's RE Transmission Access Advisory Committee (RETAAC) which was created in May 2007.

Texas is developing a concept called Competitive Renewable Energy Zones (CREZs) (See 4.7.1 CREZs: Planning Transmission for New Wind Generation in ERCOT). Colorado recently enacted a similar policy. The California independent system operator (CAISO) won US FERC approval for creating a new transmission category to interconnect remote, locationally constrained resources such as renewables (See 4.7.2 Location Constrained Resources: CAISO).

At least five US states are forming transmission infrastructure authorities as a means of stimulating more transmission. New Mexico's 'Renewable Energy Transmission Authority' is required to finance only those new transmission lines which carry energy of which no less than 30% is from renewable sources.

In the US the Energy Policy Act of 2005 (EPACT 2005) is moving forward with identifying new 'National Interest Electric Transmission Interest Corridors' (NIETC). In August 2006 and using its authority under EPACT 2005, DOE identified "the Atlantic coastal area from metropolitan New York southward through northern Virginia" (and 'Southern California') as 'critical congestion zones'. Four 'congestion areas of concern' were also identified of which New England was one[10].

In the US some of the best wind resources in the country are in the Great Plains and Upper Midwest. Plans are already under way to build new transmission capacity to take those resources to the 'critical congestion zone' of US Eastern seaboard.[11] (See 4.7.3 Cost Allocation of Transmission or Market Solutions). This same market should represent an attractive export option for Canada's extensive NE wind resource.

---

[9] Richard Piwko, Robert DeMello, Robert Gramlich, Warren Lasher, Dale Osborn, Carl Dombek and Kevin Porter. 'What Comes First?' IEEE Power and Energy magazine. Nov./Dec. 2007. 'Wind Integration: Driving Technology, Policy and Economics'.

[10] National Electric Transmission Congestion Study, DOE Aug 2006. Available: http://nietc.anl.gov/documents/docs/NIETC_ExSum_8Aug08.pdf

[11] J Charles Smith. Utility Wind Integration and Operating Impact State of the Art. IEEE Transactions on Power Systems. Vol. 22. No 3. Aug. 2007

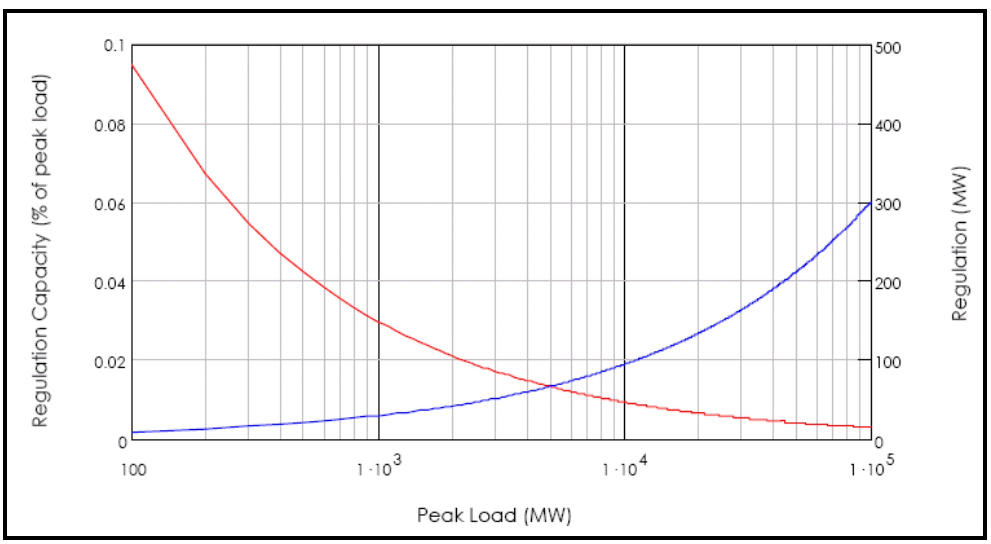
Resistance to the 'National Interest Electric Transmission Corridors' concept has caused some to suggest that it is not going to succeed. That the DOE, in early March 2008, denied requests for a rehearing of the NIETC designations suggests that there is however political will to overcome any such resistance.

3.5 Balancing area size

Large diverse balancing areas with robust transmission networks tend to reduce wind's impact by reducing ancillary service costs (See 4.6.1 Summary of US Wind Integration Experience & Market Mechanisms).

This inverse relationship between peak load (a proxy for balancing area size all other things being equal) and ancillary service costs, is shown in Figure 7 which is not quantitative and is based on conversations with operations personnel at MISO. The red line (LH axis) shows the amount of regulation required as a fraction of peak load. The blue line (RH axis) shows the product of the required fraction and the peak load. The required regulation increases as peak load increases however the regulation requirement increases at a slower rate than the corresponding load increase.

Figure 7 Regulation Capacity vs. Peak Load



Source: Enernex Corporation. 2006 Minnesota Wind Integration Study. Vol. 1. Nov. 2006

Where it is not possible to increase balancing area size, other factors can mitigate ancillary service costs attributable to variable wind. If several adjacent balancing areas can develop cooperative arrangements or markets for ancillary services, larger quantities of wind could be absorbed because of the greater load and wind diversity that would be expected across broader regions[12]. One such example to assist in this process is the Area Control Error (ACE) Diversity Interchange (See 4.6.2 ACE Diversity Interchange).

3.6 Forecasting

Electricity generated by WTGs varies fundamentally from that generated by other ‘traditional’ means in so far as the amount of that electricity depends on the available wind resource. Since the wind can neither be scheduled nor dispatched in the same manner as is the case with traditional (i.e. thermal, hydro and nuclear) generators; understanding the nature of the wind resource is critically important. For countries with a substantial share of wind power in the generation mix, such as Germany, Denmark and Spain, such models are already an essential part of grid and system control[13].

Wind power forecast accuracy is directly connected with the need for balancing energy and hence to the cost of wind power integration.

The balancing impact with the largest cost is found to be in the unit-commitment time frame (See 3.12 Balancing needs and the cost of wind integration). Day- or days-ahead wind plant output forecasting offers significant opportunity to reduce the cost and risk associated with the uncertainty in this time frame[14,15] (See 4.5.3 Hydro Quebec and Environment Canada Wind Forecasting Project).

‘Special event’ analysis is also proving to be important in order to understand, quantify and, where possible, minimize significant differences between forecast and actual wind events. Although such events are typically low probability they

---

[12] B. Parsons, M. Milligan, J.C. Smith, E. DeMeo, B. Oakleaf, K. Wolf, M. Schuerger, R. Zavadil, M. Ahlstrom and D. Y. Nakafuji. ‘Grid Impacts of wind power variability: Recent assessment from a variety of utilities in the United States’. Presented at the European Wind Energy Conference, Athens, Greece, Mar. 2006. Available: www.nrel.gov/docs/fy06osti/39955.pdf (unpublished) Energy Conference, Athens, Greece, Mar. 2006.

[13] Bernhard Ernst, Brett Oakleaf, Mark L. Ahlstrom, Matthias Lange, Corinna Moehrlen, Bernhard Lange, Ulrich Focken and Kurt Rohrig. ‘Predicting the wind’. IEEE Power and Engineering Magazine. Wind Integration - Driving Technology, Policy and Economics. Nov./Dec. 2007

[14] J Charles Smith. Utility Wind Integration and Operating Impact State of the Art. IEEE Transactions on Power Systems. Vol. 22. No 3. Aug. 2007

[15] M. Ahlstrom et al. ‘The future of wind forecasting and utility operations’. IEEE Power Energy Mag., Nov. – Dec. 2005, Special Issue: Working With Wind; Integrating Wind into the Power System.

can have a substantial financial impact when they happen (See 4.5.2 AESO Pilot Project in Wind Energy Forecasting).

For these reasons a large amount of research has been directed toward the development of good wind power forecast models over the last few years and still more is required in the coming years[16].

Agreement on a regional approach to forecasting at an early stage will ensure that SO/TO concerns are addressed proactively. It will serve to provide clarity to SOs/TOs, wind farm developers and owners regarding their respective obligations. Consequently costs, associated with the adoption of sub-optimal forecasting procedures, can be minimized.

A regional approach needs to ‘set the rules’ early on about such fundamentals as;

- Who is responsible for providing the forecast
- What is the appropriate incentive scheme to ensure forecasts are met
- Who is going to use the forecast and for what time frame
- How can forecasts best be integrated into the control room
- Is there any value to be had in a common regional R&D effort etc. (such as Europe’s ANEMOS project)

TOs/SOs in an increasing number of jurisdictions (e.g. Alberta (AESO)[17], Hydro Québec[18], Ontario IESO[19], New York ISO[20], California (CAISO)[21] and

16 J Charles Smith presentation. ‘Wind Forecasting Applications to Utility Planning and Operations’. UWIG/NREL Workshop. St. Paul, MN. Feb. 2008

17 Darren McCrank. Presentation. ‘Wind Power Forecasting Pilot Project’. UWIG/NREL Workshop. St. Paul, MN. Feb. 2008

18 Alain Forcione, Franco Petrucci and Wei Yu. Presentation. ‘Hydro-Québec and Environment Canada Wind Energy Forecasting Project’. NE Region Wind Integration Seminar. Montréal, Québec. Feb. 2008

19 Khaqan Khan. Presentation. ‘Wind Power Integration in Ontario: Experience and Key Issues’. NE Region Wind Integration Seminar. Montréal, Québec. Feb. 2008

20 David Edelson. Presentation. ‘Wind Forecasting at the NYISO’. UWIG/NREL Workshop. St. Paul, MN. Feb. 2008

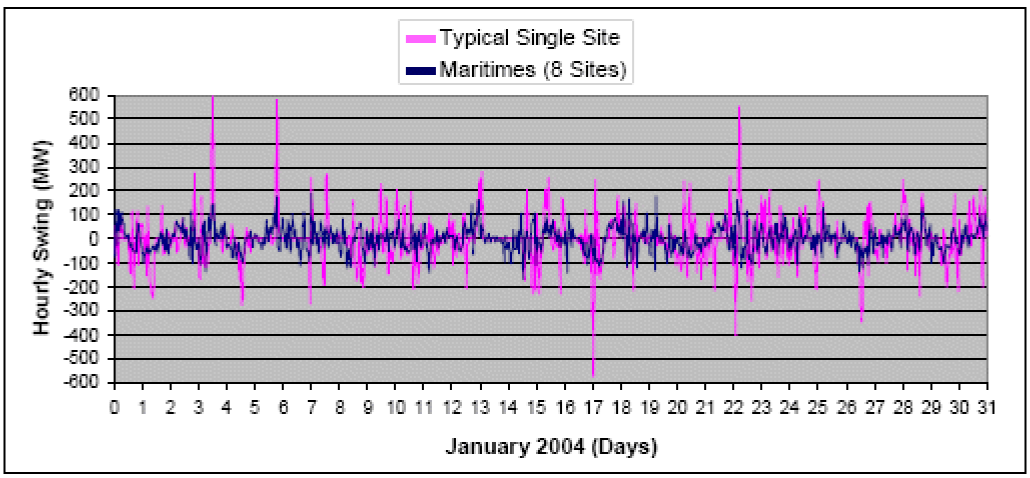
21 Jim Blatchford. Presentation. ‘Wind Forecasting System Requirements’. UWIG/NREL Workshop. St. Paul, MN. Feb. 2008

Texas (ERCOT) are becoming increasingly involved in forecasting as they recognize its importance to system operations.

3.7 Geographical diversity

Wind plants. The variability of the power output of each of the wind plants in a single geographical region will not be perfectly correlated. For this reason the variability of the power output of an aggregated portfolio of such wind plants will be less than the variability of the power output of any one of the wind plants in the portfolio. This relationship is illustrated in Figure 8. (See also Conclusion -iv in Location Constrained Resources: CAISO presentation)

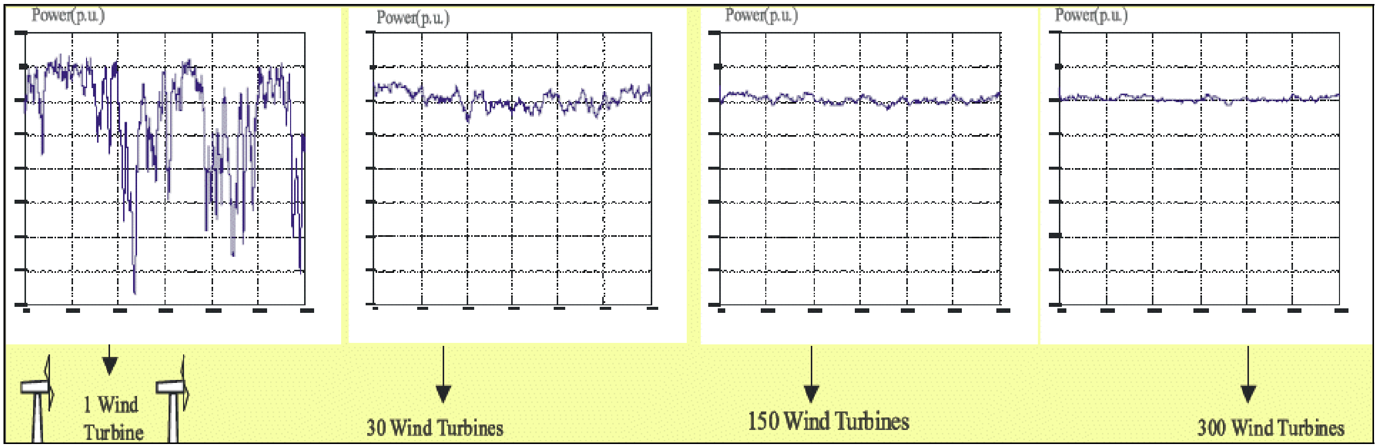
Figure 8 Variability and Wind Plant Diversity



Source: Maritimes Area Wind Power Integration Study. Summary Report. April 2007

Wind turbines. The variability of the power output of each of the turbines within a wind plant will not be perfectly correlated. For this reason the variability of the aggregate power output of the wind plant will be less than the variability of the power output of any one of the turbines within it.

Figure 9 Variability and Wind Turbine Diversity



Source: Thomas Ackermann. Energynautics. NE Region Wind Integration Seminar. Montreal. Feb 2008

3.8 Increasing system flexibility

As increasing wind capacity is added, greater regulation, load following and quick start capability will be required from the remaining generators (See 3.12 Balancing needs and the cost of wind integration). The cost of providing this additional flexibility will depend on the nature of the dispatchable generation sources, their fuel cost, market and regulatory environment in addition to the characteristics of the wind-generation resources as compared to load[22]. Flexible resources (such as hydro) will be able to provide these additional balancing services at lower cost than less flexible resources (such as coal) or inflexible resources (such as nuclear).

3.9 Wholesale markets

Develop well functioning real-time, hour-ahead and day-ahead energy and price responsive load markets and expand access to those markets[23]. Adopt market rules and tariff provisions that are more appropriate to weather driven resources. Imbalance settlement process needs to be improved[24].

---

[22] J Charles Smith. Utility Wind Integration and Operating Impact State of the Art. IEEE Transactions on Power Systems. Vol. 22. No 3. Aug. 2007

[23] American Wind Energy Association Board Resolution on Wholesale Electricity Markets. Jan 9. 2008. Available: http://www.awea.org/newsroom/releases/AWEA_Statement_on_Wholesale_Electricity_Markets_011008.html

[24] Frans Van Hulle. EWEA. EWEA Policy Conference on Large Scale integration of wind power. November 2006.

Tradable transmission rights. Make better use of physically (in contrast with contractually) available transmission capacity – this can generally be achieved through deep, liquid markets in tradable transmission rights. Pancaked transmission rates should be eliminated (See 3.10 Transmission tariffs).

3.10 Transmission tariffs

Flexible-Firm products. Hourly analysis of line loadings often shows that transmission lines are heavily loaded for only a very limited number of hours in the year. Development of a flexible-firm transmission product, which makes the unused capacity available for other transactions when the line is lightly loaded, could be accomplished with minor modifications to current practices.

Transmission tariffs should be flexible allowing rates to be paid on an 'as-used' basis rather than a 'capacity reservation' basis[25].

'Pancaking' of transmission rates. As a result of this practice the total transmission charges levied can be in excess of the marginal cost of providing the transmission service and they can easily double the cost of power purchases that involve long distance transmission[26] (See 4.1.1 CanWEA and 4.1.2 AWEA by UPC Wind).

This issue can be addressed by forming TO/ISO systems or collaborating on regional transmission pricing. One alternative to rate pancaking is for a transmission system to establish 'postage stamp' rates. A second alternative is a 'licence plate' system where rates for service increase across zones in the transmission system. FERC has expressed a preference for 'postage stamp' rates but have nonetheless permitted 'license plate' rates as they minimize cost shifting, allow a utility to maintain its existing rates and avoid rate averaging[27].

---

[25] American Wind Energy Association Board Resolution on Wholesale Electricity Markets. Jan 9. 2008. Available: http://www.awea.org/newsroom/releases/AWEA_Statement_on_Wholesale_Electricity_Markets_011008.html

[26] Western Governors' Association. Wind Task Force Report to the Clean and Diversified Energy Committee. Denver, CO. [Online]. Accessed: Mar 2008. Available: http://www.westgov.org/wga/initiatives/cdeac/TransmissionReport-final.pdf

[27] Federal Energy Regulatory Commission. 'Assessing the State of Wind Energy in Wholesale Electricity Markets'. Washington DC. Docket Number AD04-13-000. November 2004. Accessed: Mar 2008. Available: http://www.ferc.gov/legal/maj-ord-reg/land-docs/11-04-wind-report.pdf

3.11 Demand response.

This term refers to the steps taken to reduce power demand at peak load times by, typically, shifting some of it to off-peak times. This may be with reference to peak hours, peak days or peak seasons. Demand response efforts may be targeted at any or all of the industrial, commercial or residential user groups.

Historically systems have been managed to ensure that generation is altered to meet load and not vice versa. This is not because load is price inelastic it is simply a reflection of the predominant systems operation philosophy which, for many years now, has been that generation is moderated to meet demand and not the other way around.

Demand response is a relatively new concept but is nonetheless increasingly being recognized as a powerful tool for reducing (or increasing) demand as required. For instance on 13 February New England ISO announced the results of its first Forward Capacity Market (FCM) auction to secure a blend of new and existing generation and demand-side resources in order to supply the 32305 MW the region expects it will need in the 2010 – 2011 timeframe.

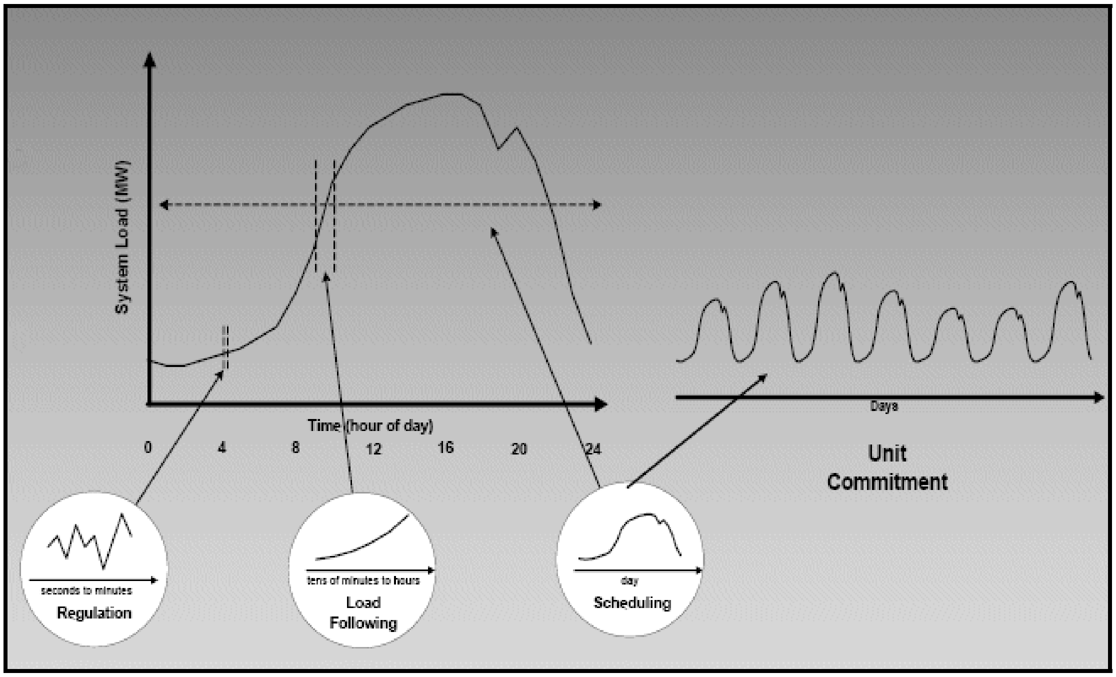
The FCM auction ran in eight rounds in early February 2008 the key highlight from that auction (in terms of load management) was that of the 1813 MW of new supply- and demand-side resources secured, 1188 MW (65%) were new demand-side projects such as energy efficiency, demand response and distributed generation. Demand response can directly assist the integration of wind by directly contributing to reduced balancing costs. Distributed generation can assist if suitable SCADA systems are employed and energy efficiency can also potentially help by freeing up transmission capacity.

Load management is an area in which SOs in Spain, Germany and Denmark (all countries with high wind penetration) see significant potential.

3.12 Balancing needs and the cost of wind integration

Most wind integration studies divide wind's impact into time frames which correspond to grid operation (See 4.6.1 Summary of US Wind Integration Experience & Market Mechanisms). These are illustrated in Figure 10;

Figure 10 Balancing requirements. Seconds to Days



Source: Bob Zavadil. Enernex Corporation. NE Region Wind Integration Seminar. Montreal Feb. 2008

Regulation Because wind and load are generally uncorrelated in short time scales the impact of wind on regulation requirements has been found to be modest. In two recent wind integration studies performed in the US, the addition of 1500 MW and 3300 MW of wind (15% and 10% respectively of peak load) increased the regulation requirements by 8 MW[28] and 36 MW[29] respectively.

Load following. The net load that must be served after accounting for wind has more variability than the load alone. Nonetheless it is neither necessary nor is it economic, to counter each wind movement with a corresponding movement in a load-following unit.

---

[28] Enernex Corp and Windlogics Inc. for Xcel Energy and the Minnesota Department of Commerce, Characterisation of the Wind Resource of the Upper Midwest, Wind Integration Study – Task 1. Xcel Energy and the Minnesota Department of Commerce. Available: http://www.state.mn.us/mn/externalDocs/Commerce/Wind_IntegrationPart_1_121506024141_MNWindIntegrationStudyVolI.pdf

[29] GE Energy. The effects of Integrating Wind Power on Transmission System Planning, Reliability and Operations: Report on Phase 2, Prepared for the New York State Energy Research and Development Authority. Mar. 2005. Available: http://www.nyserda.org/publications/wind_integration_report.pdf

According to UWIG, every wind study in the US has found the distribution of changes in net load to flatten and broaden when large amounts of wind are added to the system. In other words there will be more high ramp requirements with wind than without wind and a general reduction in small-ramp requirements compared to the no-wind case. The implication is that high-wind penetrations will likely increase the ramp requirements for many hours of the year.

Scheduling/Unit Commitment. In addition to the greater variability that wind imposes on the system, there is also an increase in the uncertainty introduced in the day-ahead unit-commitment process.

The combined impact of these effects has been shown to increase system operating costs by up to US$5.00/MWh of wind generation at capacity penetrations of 20%-30%[30].

It should be noted that these results do not include avoided fuel costs which some studies have shown to be considerable[31]. They also do not include the value arising from the fact that wind, since it is 'must run' and a 'price taker' tends to depress wholesale power prices by displacing the most expensive generators from the top of the generation stack. These effects have been shown to be significant in some regions[32]. Also not included are avoided carbon costs (See 3.13 Negative externalities and relative economics).

3.13 Negative externalities and relative economics

The European Union notes that a significant barrier to the further network integration of renewables is its (often) poor relative economics vis-à-vis other forms of generation.

"*Even though the cost of most renewable energy sources is declining – in some cases quite dramatically – at the current stage of energy market*

---

[30] J Charles Smith. Utility Wind Integration and Operating Impact State of the Art. IEEE Transactions on Power Systems. Vol. 22. No 3. Aug. 2007

[31] Commission of the European Communities. 'Renewable Energy Road Map. Renewable Energies in the 21st century: building a more sustainable future'. COM(2006) 848 Final. 10 January 2007.

[31] GE Energy. The Effects of Integrating Wind Power on Transmission System Planning, Reliability and Operations: Report on Phase 2, Prepared for the New York State Energy Research and Development Authority. Mar. 2005

[32] HWWA Discussion Paper 358. Sven Bode and Helmuth Groscurth. The Effect of the German Renewable Energy Act (EEG) on 'The Electricity Price'. Hamburg Institute of International Economics (hwwa@hwwa.de). December 2006

development renewable sources will often not be the short term least cost options. In particular, the failure to systematically include external costs in market prices gives an economically unjustified advantage to fossil fuels compared to renewables."[33]

This economic advantage can and often does, make wind appear economically inefficient relative to traditional thermals and nuclear.

While this is a policy, rather than a technical issue, the economic disadvantage for renewables is significant as it means that any additional costs associated with technical issues such as transmission investment, additional balancing requirements etc., make wind look expensive relative to thermal sources when this may not be the case.

3.14 System stability and wind turbines

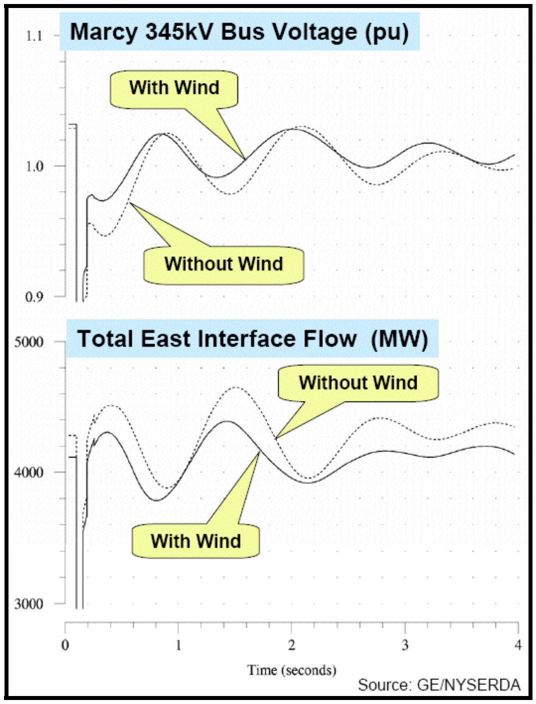
Detailed simulations of DFIGs shows that wind plants can actually aid system stability by providing LVRT and dynamic var support to reduce voltage excursions and dampen swings. Figure 11 is taken from a study carried out by GE for NYSERDA. The study simulated a fault at the Marcy 345kV bus. The results of the simulation, which assumed vector-controlled wind turbines, shows that wind turbines improve the post-fault response of an interconnected power grid[34].

---

[33] Commission of the European Communities. 'Renewable Energy Road Map. Renewable Energies in the 21st century: building a more sustainable future'. COM(2006) 848 Final. 10 January 2007.

[34] GE Energy. The effects of Integrating Wind Power on Transmission System Planning, Reliability and Operations: Report on Phase 2, Prepared for the New York State Energy Research and Development Authority. Mar. 2005. Available: http://www.nyserda.org/publications/wind_integration_report.pdf

Figure 11 Impact of Wind Generation on System Performance



Source: GE. The Effects of Integrating Wind Power on Transmission System Planning. For NYSERDA. Mar 2005

3.15 Energy resource vs. capacity resource

Wind has often been viewed, first and foremost, as a capacity resource and this has distorted views about its efficacy. Because wind is an energy resource, not a capacity resource, no additional generation needs to be added to provide backup capability provided that existing generation remains in service and wind capacity is properly discounted in the determination of generation capacity adequacy. It important that policy makers understand this point when they are talking about wind energy and its capabilities.

Wind generation may however require system operators to carry additional operating reserves; various studies indicate that the requirement for additional reserves will likely be modest for broadly distributed wind plants (See 3.12 Balancing needs and the cost of wind integration).

Wind generation will also provide some additional load-carrying capability to meet forecasted increases in system demand. This contribution is likely to vary from 10% to 40% of a typical project's nameplate rating, depending on local wind characteristics and coincidence with system load profile[35].

3.16 Wind plant technology trends

Early wind turbines were predominantly stall/active stall regulated and fixed speed. The industry seems to be moving towards turbines which are either gearless (with full power conversion capability) or which are geared. Turbines are increasingly variable speed, pitch regulated. Variable speed turbines allow for reduced drive train loads and lower aerodynamic noise as well as good reactive power control capabilities, reduced power and voltage fluctuations and as a result are much more 'grid friendly'. Modern turbines also have improved voltage control capabilities, better short circuit contribution, reduced flicker, significantly improved low voltage ride through (LVRT) capabilities as well as having the potential to participate in AGC. Supervisory Control and Data Acquisition (SCADA) capabilities are constantly evolving which is enabling wind turbines to provide the features and information required by SOs.

Technology improvements continue such that and ignoring the non schedulable nature of wind, the electrical characteristics of wind plants are increasingly similar to traditional thermal plants.

[35] J Charles Smith. Utility Wind Integration and Operating Impact State of the Art. IEEE Transactions on Power Systems. Vol. 22. No 3. Aug. 2007

4 NE REGION WIND INTEGRATION SEMINAR

After discussion between WEICan and various interested parties it was concluded that an invitation only System Operator seminar, to discuss integration issues, would be a critical component in addressing this ACOA RFP.

That seminar was held in Montréal in February and the seminar agenda is included as

Appendix 1 – Agenda NE region wind integration seminar).

It was decided that the seminar would be by invitation only; the reason for this was to ensure that discussion was focused on technical matters and not diverted by other priorities (such as commercial considerations).

The reasons for the seminar were;

1) To hear from international subject authorities on the latest developments and findings related to wind integration.
2) To give NE Region SOs a forum within which to meet, discuss and debate the region-wide technical issues associated with optimal integration.

The goals of the seminar were;

1) Evaluate the issues that inhibit the transmission of wind
2) Identify issues that will improve the integration of wind
3) Investigate processes to facilitate and promote the uptake of wind.

To achieve these goals the seminar was divided into 6 parts;

- Wind developer perspectives on NE integration
- A regional overview from each SO outlining key issues
- Technology Drivers
- Forecasting
- Balancing
- Transmission planning, cost allocation and regulation

The highlights of each presentation are summarized below.

4.1 Wind industry perspectives on wind integration in the NE

4.1.1 CanWEA

Wind in the Eastern Canadian provinces is expected to increase from 600 to 5,000 MW in the next seven years. The renewable energy targets announced by province are as follows;

Figure 12 Renewable Energy Targets by Canadian Province

Province	Renewable target	Equivalent MW	Comments
New Brunswick	10% by 2016	~550	All RE

Nova Scotia	10% by 2013	~580	All RE
PEI	15% by 2010	~60	Wind only
Quebec	~6% by 2015	4,000	Wind only

Source: CanWEA presentation at NE Region Wind Integration Seminar. 12 February 2008

● Transmission. Areas with good wind resource are not necessarily those with high load (and vice versa). Consequently substantial amounts of wind will be built to serve load remote from the point of generation. Transmission links will be key.
● Interconnection. Turbines are already able to provide basic support to grid: LVRT, voltage and frequency tolerance. More advanced capabilities are being developed and are available although the cost of such services must not be ignored.
● Integration. There is a need for integration studies both within and across jurisdictions.
● Economics. Various studies indicate that relatively high penetrations are possible without incurring substantial system costs.
● Key challenges for developers;

Intrajurisdictional

- High ancillary costs reduce wind's competitiveness
- Possibility of market caps on the amount of wind increases uncertainty.

Interjurisdictional

- Difficulties persist in undertaking commercial transactions across tie-lines
- Access to other markets is challenging
- 'Pancaking of tariffs reduces competitiveness.

● Efforts made to ease the integration of wind will allow provinces/states to achieve RPS compliance at lower cost.

● Increased wind acts as a hedge against future volatility in fossil fuel prices as well as against long-term variability in fluctuations of water levels in hydro reservoirs.

4.1.2 AWEA by UPC Wind

Experience with a wind plant in Hawaii indicates that the very high wind penetration there mirrors the very high penetration envisaged by AWEA in the 'Lower 48' in the long term. High Hawaii penetration is possible due to;

- System operator control of wind farm output
- Ramp rate control capability on WTGs
- Wind plant and/or turbine curtailment in certain instances
- Provision of additional reserves

UPC experience in Stetson, Maine, is an example of;

- Optimizing existing transmission through careful evaluation of ATC, non-firm service on the local network and interaction of local network rules for physical and ISO management of congestion.

Key AWEA transmission goals;

- Use the existing grid more efficiently
- Encourage more transmission investment
- Improve wind integration through better design of WTGs, markets and control rooms.

4.2 The Regional Perspective

The purpose of this session was to give each of the NE SOs the opportunity, in 10 minutes, to give an overview of their system, details of wind expected in the coming years, the resultant system impacts expected and any key challenges resulting.

4.2.1 Hydro Québec

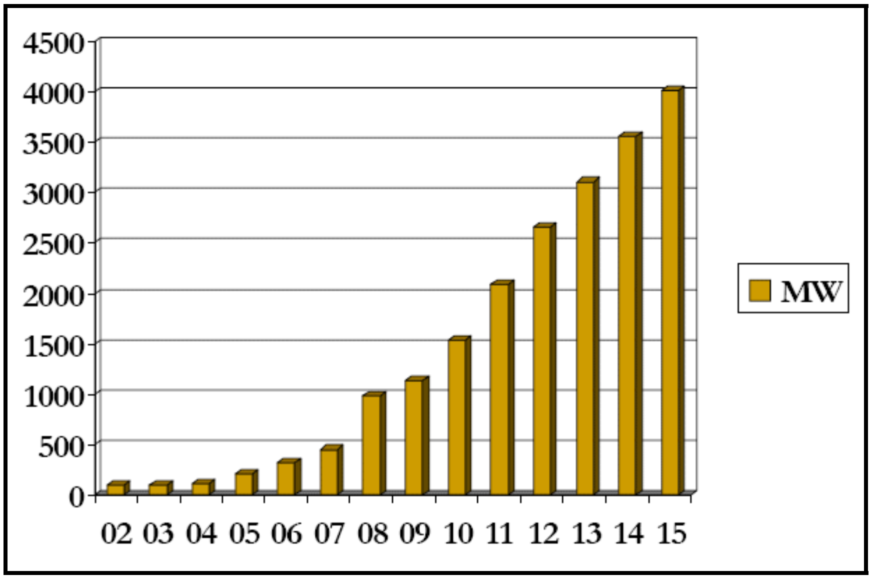
Principal system characteristics

95% hydro generation

- Large hydro storage capacity
- Generation centers are distant from load (± 1,000 km)
- Not synchronized w/ Eastern Interconnection
- DC interties with neighboring system (± 5,000 MW)
- Winter peak ± 38,000 MW
- Summer peak ± 18,000 MW

Expected new wind

Figure 13 Hydro Québec. Expected New Wind to 2015



Source: Hydro Québec presentation at NE Region Wind Integration Seminar. 12 February 2008

Impact on system management

● Operating tools and work processes are well adapted to relatively high uncertainty of internal load and short term market demand

● The integration of wind generation forecast capability will be completed this spring

● Various research projects will help anticipate the impact of high rate of wind integration.

4.2.2 ISO New England

Regional Transmission Organization for New England

Principal System Characteristics

- 6.5 million customer meters
- 8,000 miles of HV transmission lines
- 12 interconnections to 3 neighboring systems (New York, New Brunswick, Quebec)
- 31,000 MW of installed generating capacity
- Summer peaking system.
  i. Summer – 28,130 MW
  ii. Winter – 22,818 MW

Expected new wind

Currently there are no wind turbines or wind plants in the ISO NE Energy Management System. To this point there has been no impact to the ISO or its systems related to wind integrations. Various RPSs are in place in the different states of New England. 1,580 MW is in the queue (460 MW offshore and 1,120 MW onshore). No operational impacts expected at these levels.

Key wind issues

● Load following requirements. Opposing ramps of load and wind, ramp rates and impacts on other resources
● AGC requirements. Meeting control performance requirements
● Reserve requirements and contingency coverage. Requirements for loss of wind. Disturbance recovery standards
● LVRT and Reactive Power capabilities: Appears that new technology addresses these
● Forecasting. Who does it? Ensuring sufficient accuracy.
● Congestion management. Competing for limited transmission
● Minimum generation emergencies. High wind, high hydro, low loads and limited transmission capacity
● Maintaining wind's visibility to the SO

- Real time weather information
- Metering and telemetering
- Real time control of facilities (SCADA)
- Cyber security
- Voice communication
- Outage coordination

Key (non wind specific but related) issues in NE

- Forward capacity market (FCM) designed to meet capacity needs through price signals
- Developing additional resources in order to meet expected load growth. Includes both RE and demand side resources
- Price responsive load markets are key and must be incorporated into the ancillary services market
- Meeting peak demand. Peak demand is growing faster than overall demand
- Meeting growing environmental regulations (SO_X, NO_X, RGGI – CO_2, RPSs).
- Balancing reliability and reasonably priced supply
    i. Transmission improvements. System needs in NE have been identified
    ii. Resource diversity as a key part of a risk management strategy

4.2.3 Maritime Electric

Principal system characteristics

- 2007 peak load of 218 MW
- 138 kV transmission system on PEI
- 200 MW capacity submarine cables linking PEI to NB Power
- Current installed wind capacity of 72 MW

Key wind issues

- Recent EOIs from wind developers far exceeded current export capacity + current PEI demand

4.2.4 New Brunswick SO

Principal system characteristics

NBSO is reliability coordinator for the Maritimes Area System (New Brunswick, Nova Scotia, PEI and Northern Maine) which consists of two balancing areas

- New Brunswick, PEI and Northern Maine
- Nova Scotia.

Has interconnections with Maine, Nova Scotia, Quebec and PEI. Winter peak - 3,500 MW, average load - 1,900 MW and minimum load (labour day) – 1,250 MW. Installed generation capacity of 4,200 MW of which 600 MW peaking plant and 900 MW hydro.

Expected new wind

- NBSO
  - i. No operational wind plants
  - ii. 200 MW of committed plants
  - iii. 400 MW NB power plan by 2010
  - iv. System impact studies have been completed for 800 MW
  - v. System impact studies queued for a further 1,700 MW
- Maritimes Area
  - i. Currently 175 MW wind
  - ii. Further 580 MW committed
  - iii. 1,100 MW expected by 2013 or 1,800 MW if exports included
  - iv. 1,800 MW represents 75% of 2013 expected minimum load.

Key wind issues

● Mitigation
- Diversity of wind regimes development

- Accuracy of forecasting
- Sharing diversity across larger areas
- Increasing load following capabilities

● New inter area services required?
- Regulation
- Load following
- Intra hour dispatch (e.g. 30 minutes)

● Appropriate mechanisms for the region?
- Market solutions?
- Shared service arrangement
- Negotiated contract?

4.2.5 NL Hydro

Principal system characteristics

- Installed generating capacity: 7,289 MW
- 21 isolated diesel systems in Labrador and Newfoundland
- Island of Newfoundland:
  i. Installed capacity 1,919 MW
  ii. 65% hydro, remainder thermal

Key wind issues

- Newfoundland
  i. A world class wind resource
  ii. Is limited by the amount of wind that can be absorbed by island load
  iii. Focus is to meet load growth and displace thermal generation
- Labrador
  i. NL Hydro is investigating potential for large scale wind development and is currently monitoring the resource to determine the potential. Focus is on export markets due to the limited domestic demand
  ii. Intend to use existing hydro to firm and shape wind.

4.2.6 Northern Maine ISA

Principal system characteristics

- The NM transmission system consists of two non-interconnected systems: The Maine Public Service Company (MPS) (392 miles of transmission and 3 interconnections with NB Power) and the Eastern Maine Electric Cooperative (EMEC) (39 miles of transmission and 1 interconnection with NB Power).

- Maximum load 40 MW
- 62% of power generated by biomass

Key wind issues

- About 1,000 MW of wind expected in the area by 2010
- NM ISA plans to manage this by exporting to ISO NE

4.2.7 NS Power

Principal System Characteristics

- Winter peaking system of 2,300 MW
- Min demand ~800 MW
- Installed generation capacity – 2,450 MW. 51% coal fired
- 2005 generation: 73% coal, 13% oil
- 44 MW transmission connected wind
- 14 MW distribution connected wind
- Major power flows East – West. Stability constraints
- Interconnected to NB by one 345 kV and two 138 kV lines
  - i. Export capability 175 MW firm and 175 MW non-firm
  - ii. Import capability – up to 300 MW

Wind issues

- NS RES: Additional 5% RE by 2010. Additional 10% RE by 2013
- Expected wind: 300 MW – 2010. 600 MW – 2013
- $500,000/day penalty for not meeting RES
- Total wind interconnection requests:
  - i. 1,198MW transmission
  - ii. 250 MW distribution
- NS Wind Integration Study. Preliminary results:
  - i. High level of thermal plant cycling
  - ii. Coal plant start/stops
  - iii. Use of external resources, interruptible load and light oil combustion turbines to back-fill wind
  - iv. Significant increase in AGC and load following requirements.

Wind Challenges

- NS tie capacity only 15% of peak load
  - i. Potential cluster of wind at border
  - ii. NS-NB use tie to share reserve
  - iii. Tie capacity – reserve for balancing or commerce
- NS or Maritimes – islanded operation
- NS Wind Integration Study – initial results under internal review

- Thermal plant cycling – retrofit needs
- Erosion of Hydro Operating Flexibility
- Increased use of interruptible load
- Curtailment of wind for security – RES at risk
- Comments on FERC Order 2003.
- Building transmission to wind rich areas can void benefit of diversity

Wind opportunities

- Transmission intertie investment?
- Intertie transactions arranged by SO not marketers?
- Balancing services for sale?
- Dynamic Scheduling?
- DSM. Smart grid?

4.2.8 Ontario IESO

Principal System Characteristics

- Manages Ontario's integrated electricity system
- Administers the wholesale electricity market
- 31,000 MW installed capacity
- 36% nuclear, 25% hydro, 20% coal, 16% oil/gas, 2% wind

Wind Issues

- Monthly wind capacity factors range 12 – 40% since Mar-06
- Expect 4,500 MW wind by 2020
- Wind Power Standing Committee
  i. Identify issues & reduce barriers to wind integration
  ii. Regular meetings since November 2006
    1. Short term issues
      a. Connection requirements
      b. Market entry requirements
      c. Real time forecasting
      d. Near-term forecasting
      e. Operational control
    2. Long term issues
      a. Variable wind and constraining issues
      b. Long term forecasting
      c. Load following
      d. AGC
      e. Operating reserve requirements

f. Compliance with Standards Authorities' Standards
g. Dispatch wind issues

3. Other issues
    a. Transmission congestion management
    b. Embedded wind generation
    c. Installation size
    d. Regional wind power issues

IESO pursuing implementation of identified action items;

- Development of wind forecast performance metrics
- Analysis of cost to market of wind forecast errors
- Power management control tools
- Near term forecasting
- Investigate incentives and compliance with forecast obligations
- Investigate DG developments
- Exploring mid term wind forecasting method and options

4.3 International experience

4.3.1 European Wind Integration Experience

● Large scale integration of wind power into the power system is possible

● New approaches are needed with increasing penetration levels

- Wind plants must adapt to the power system (grid codes, curtailment etc.)

- The power system must adapt to wind power needs (flexibility)

● It is very difficult to get all relevant regulatory details right at the first attempt. As a result a continuous review of the relevant rules and regulations is needed.

The European Situation

- Total new 2007 wind power installation 20,000 MW of which 43% installed in Europe
- Germany leads in total installed capacity – 22,247 MW
- Denmark leads in energy penetration 16-20%
- TSO thinking
    i. Low wind penetration – wind is OK because it is irrelevant
    ii. Medium penetration – Start to be concerned and interested
    iii. High penetration – Motivated to find new, innovative solutions

- Despite large existing penetrations; Germany, Spain, Denmark and Ireland all have plans to significantly increase current levels of wind

The Danish Situation

- Denmark has gone from a situation in the 1980s when power was generated at a few locations and fed out radially to load, to a situation today where a large proportion of power is locally generated and managed accordingly by the SO
- Through a typical year there are now many days when load is met entirely with wind
- Distribution of production capacity
  i. A total of 3,562 MW (of which 160 MW wind) of generation is connected >= 150kV and can therefore be centrally controlled
  ii. A total of 3,870 MW (2,214 MW wind) of generation is connected at 60 kV or less and is invisible to central control.
- Total annual imbalance costs are €10mn or €0.0027 / kWh of wind generated.
- Key issue – more flexibility is needed

General Problems – Extreme situations

Faults and FRT capability

Should every generator provide the same capability or should we instead be looking for the cheapest solution?

4.3.2 International Grid Code Developments

- Inverse correlation noted between the length of a countries' grid code and the amount of wind connected to their network. Grid Codes of Denmark and Germany are 34 and 46 pages respectively and for the UK and Australia they are 569 and 1047 pages respectively.
- Key issues for System Operators
  i. Power quality
  ii. Power stability
  iii. Power dispatchability
- Key technical specifications for SOs managing wind are;

i. Reactive power capabilities
ii. Voltage variability (LVRT and HVRT)
iii. Frequency fluctuation
iv. Harmonics

- Major problem – grid codes are propagating in every system and sub-region whereas internationalization favors a single global standard. While standards are gaining in uniformity there is still a large amount of variability reflecting individual preference as well as regional needs. It can be expensive for WTG manufacturers to meet these.
- With the 20% renewable energy target in mind, Europe is now working to understand the issues and harmonize the rules. Two studies are underway;
  i. **European Wind Integration Study**. A study led by European Transmission System Operators which runs from Jan. 07 – Oct. 09 and which examines the integration of wind power, focusing on measures that need to be taken by legislators, regulators, grid operators and grid users aiming at establishing a harmonized set of rules for the integration of wind power[36].
  ii. **Tradewind**. A European project funded by the EU and led by the European Wind Energy Association. It runs from Nov. 2006 – Oct. 2008 and which in that time aims to address "*one of the most challenging issues facing wind today: its maximal and reliable integration in the trans-European power markets.*"[37].

4.4 Technology Drivers

4.4.1 GE

This presentation is not available for public dissemination

---

[36] European Wind Integration Study. Final Report. 'Towards a Successful Integration of Wind Power into European Electricity Grids. Final Report. 15 Jan 2007. Available: http://www.etso-net.org/upload/documents/Final-report-EWIS-phase-I-approved.pdf

[37] European Wind Energy Association. Available: http://www.ewea.org/index.php?id=685

4.4.2 Vestas

- The nature of NA Grid Codes within the multiplicity of regional markets. FERC LGIA Appendix G based on Order 661-A – defines specific interconnection requirements for wind power plants. Around Canada some TSOs (AESO, Manitoba-Hydro, Hydro-Quebec and BCTC) contain detailed wind supplements to the general requirements. Others (IESO, SaskPower, NBSO, Maritimes) do not have such requirements.
- Some TSOs apply FERC Order 661/661-A and some do not

4.5 Forecasting

4.5.1 European Experience – Ensemble Forecasts

- Excellent predictions required by the 4 TSOs in Germany as they are responsible (under the EEG - Renewable Energy Act) for balancing variable wind
- Day ahead prediction – combining different weather models

  i. Wind power prediction systems commonly use only one single numerical weather prediction model (NWP).

  ii. One approach: Combine different NWPs to minimize the error of wind power forecasts with a focus on finding an optimal combination of weather models with regard to different weather situations. i.e. ensemble approach

  iii. Convention Approach: Weighted average of all forecasts → one wind forecast → wind to power model → one wind power prediction

  iv. Novel Approach: Uses Artificial Neural Nets to learn which wind forecast method works best under which weather conditions. Hence weights forecasts depending on prevailing weather systems. There are a number of variants on this basic theme.

  v. Novel approach shows a significant (about 1% improvement) in RMSE.

4.5.2 AESO Pilot Project in Wind Energy Forecasting

- Need to be very clear what is required from a wind forecast (eg. minimize RMSE or minimize extreme errors)

- Need to clarify from the outset the purpose of any forecasting study;
  i. To evaluate different forecasting methods to find most effective and appropriate
  ii. To leverage the experience of other jurisdictions
  iii. To educate Alberta's power industry on wind power forecasting techniques and capabilities
  iv. To recommend wind power forecasting requirements to be implemented in Alberta
- Then need to design the program
- (Quantitative) Special event analysis is important (rather than simple 'sum of errors' analysis
- The purpose of special event analysis is to identify;
  i. How well forecasts capture ramping events
  ii. Trends to forecast error
  iii. A target or requirement for future event forecast error

4.5.3 Hydro Quebec and Environment Canada Wind Forecasting Project

Main conclusions

- Forecasting on an hourly basis to support next day planning and scheduling is the first priority for Hydro Québec (very short term 'nowcasting' and medium-to-long term forecasting is not a priority at present).
- High quality, high resolution numerical modeling of the weather is central, especially in 'complex terrain' territory
- Different operational needs require different forecasts optimized for different time frames and compatible with the system management decision process

Other conclusions and points

- Next day forecasts depend on good NWP models. However the capacity of such models to provide good representation of the terrain complexity around wind farms as well as local thermodynamics is limited

- HQ therefore working with Environment Canada to develop **S**ystème de **P**révision **ÉO**lienne (SPÉO) providing high resolution, 48 hours, hourly forecasts
- Finer spatial resolution, with dedicated numerical modeling of the area of interest, gives better, more precise, forecasts of tomorrow's wind
- The final value of a forecasting system depends on its compatibility with the electricity system's management tools and processes
- Before beginning the process one needs to be very clear what the forecast is required for. For instance at present, with low levels of wind on the system, HQ optimizes forecasts such that they can be targeted to scheduling services.

4.5.4 Getting forecasts into the SO control room

Main conclusions re wind integration

- First identify costs and operating impacts and then design the services, tools and methods to minimize costs at the <u>system</u> level
- Cost impacts can be reduced with adjustments to operating strategies, improvements in wind forecasting and access to real-time markets
- Operating impacts and operator confidence, even if they are issues of operator perception, are equally important…and perhaps more difficult
- Merchant wind plants will be popular in deregulated power markets, and the wind forecasting relationship may get "interesting" between the system operator and market participants.

Other conclusions and points

- Costs are incurred to accommodate wind generation variability and uncertainty of schedule. Some of these costs are real and others are likely artifacts of current tools and practices. As a result the question arises 'Do wind integration studies capture the operating reality?'
- Cost impacts can be reduced with adjustments to operating strategies and software tools, improvements in wind forecasting and access to real-time power markets

- Can we help operators with enhanced forecasts and information for planning defensive measures?
    i. High wind events
    ii. Vulnerable system situations
    iii. Integration into contingency analysis

    i.e. 'when should I be careful and when are things OK?"
- To achieve this – need to improve the accuracy of short-term forecasts
- Rapid update cycle forecasts are important. Frequency of forecast updates currently low due to computing power required to generate them
- Getting forecasts to Operators
    i. Involve operators early on to ensure forecasts add value
    ii. Forecast display medium is critical
    iii. Forecasts are one thing – how to make them valuable to Operators is another
    iv. 'Perception is reality': An important maxim for System Operator views of wind. Forecasting system should clearly demonstrate that the reality is manageable.
- The Value of Wind Forecasting

    First one needs to be clear to whom the value accrues.
    i. To System Operators
        1. Ancillary service cost impact to wind integration
        2. Transmission congestion and scheduling
        3. Forecast value grows with increasing wind penetration
    ii. To wind plant operators
        1. Depends on the rules and penalties
    iii. Merchant wind power plants
        1. Balancing wind risk through pooling (portfolio effects)
        2. Hedging and trading become very important

Some things to think about

- The motivations (and costs) of doing wind forecasting yourself (it will take longer and cost more but there may be good reasons to do it that way)
- Hedging, trading and LMPs etc leads to a necessary and active interest in trading
- The greater the difference between the System Forecast vs. Market Participant Forecast: the greater the overall value to the forecasting service provider. This leads to a conflict of interest and poses the question of whether the provider of one should be prohibited from being the provider of the other.

4.6 Balancing

4.6.1 Summary of US Wind Integration Experience & Market Mechanisms

Wind is an attractive energy source but does not fit well with an electric power industry model which has traditionally been based more on capacity. Controllable resources must be used to manage delivery of (i.e. balance) wind energy in real time.

- How does wind affect existing variability and uncertainty?
- What are the associated costs?
- Can system integrity be maintained with wind?
- The challenge and costs for managing wind generation are a function of control area make-up. Specifically;
  i. Size
  ii. Type and number of generating resources under control
  iii. Transmission ties to neighboring areas
- Maintaining system integrity involves balancing supply and demand on a continuous basis. Balancing, as this process is known, is carried out in three time frames
  i. Seconds to minutes (Regulation: fastest variation which tends to be carried out automatically)
  ii. Tens of minutes to hours (Load Following: following intra-hour load trends. Flebixble units are dispatched economically to meet changing requirements (5-10 mins))
  iii. Days (scheduling)

- Wind may change current ‘rules of thumb’ on which balancing is carried out;
  i. Forecast error
  ii. Expected variability
  iii. Sign of expected change
- While production from individual turbines can be quite variable: spatial diversity ‘smooths’ output from multiple turbines
- Wind generation contributes to but does not dominate requirement for regulation: Regulation impacts are “very modest.”
- Load following impacts may be significant in small balancing areas or with concentrated wind and can alter the characteristics of the net demand ‘trend’.
- Large diverse balancing areas with robust transmission networks tend to reduce wind’s impact and ancillary service cost.
- **Addressing variability**
  i. Conventional
     1. Reg up/down capacity deployed quickly and un-economically to support interconnection frequency
     2. Load following/flexible generation – resources dispatched economically at frequent intervals to follow load trend
  ii. Market Mechanisms
     1. Real time energy markets
     2. Ancillary services markets
     3. Traditional regulation
- **2006 Minnesota Wind Integration Study**
  i. Aims: (only 2 of a total of 5 given in the presentation)
     1. Evaluate reliability and cost impacts of wind generation in amount of 15%, 20% and 25% of MN energy sales in 2020
     2. ID and develop options to manage impacts of wind generation.

ii. Used 2003, 2004 and 2005 hourly load and wind patterns to evaluate;
    1. Wind's reliability contribution
    2. The extent to which wind increases operating costs

iii. **Results**. Wind impacts less than expected
    1. 20% penetration Operating Cost impacts range from just under $3.00 to $4.00/MWh of wind generation

- **Presentation Summary**
  i. Wind generation adds to balancing area variability on all time scales
  ii. Impacts 'inside the hour'
      1. Fastest variations – minimal
      2. 'Load following'
          a. Can be significant
              i. Dependent on balancing area size and resources
              ii. Wind generation characteristics
          b. Existing rules can make the situation worse
  iii. Spreading variability over largest amount of load and number of resources reduces impacts.

4.6.2 ACE Diversity Interchange

ADI is the pooling of Area Control Errors (ACE) to take advantage of control error diversity (sign differences associated with the momentary generation/load imbalances of each control area.

- By pooling ACE, participants are able to;
  i. Reduce control burden on individual control areas
  ii. Reduce generator movement
  iii. Reduce sensitivity to variable generation resources
  iv. Improve control performance and fewer CPS2 violations
- Relevance to wind integration

i. ADI is a 'first step' in coordinating balancing services as it represents the creation of a virtual control area

- Participating regions in this ADI project are shown in Figure 14 (APS, New Mexico and Sierra Pacific/Nevada Power are new signatories as of February 2008);

Figure 14 BCTC - Virtual Control Area for Western ADI Project

Source: Rohan Soulsby – BCTC. NE Region Wind Integration Seminar. Montreal Feb 2008

- Key points

i. ADI is a transmission function

ii. It does not change or impact system operations or control area functions

4.7 Transmission Planning Cost Allocation and Regulation

4.7.1 CREZs: Planning Transmission for New Wind Generation in ERCOT

The ERCOT region is one of the 3 NERC grid interconnections. Peak demand (Aug. 2006) was 62,339 MW. At the end of 2007 Texas had an installed wind capacity of 4,356 MW – 3,255 MW of this was installed in 2007 alone. At the end of 2007 Texas had the highest installed capacity of wind of any State.

- **Why the interest in wind in Texas**.
  i. Gas sets the marginal cost of electricity in most hours
  ii. Generators do not pay for transmission system upgrades
  iii. Excellent wind resource: 30 GW with CF > 40%, 100 GW with CF > 35%
  iv. ERCOT contains 3 of the 10 largest US cities
- **Current Queue Management**. Individual projects are evaluated independently in the interconnection process. While this ensures that projects move through the queue independently, the downside is that subsequent transfer capacity may be inadequate for multiple projects being developed in close proximity.
- **Historical wind activity**
  i. WTG construction in a prospective area (McCamey) stopped after export limits were imposed due to voltage constraints
  ii. Wind developers therefore sought out locations were transmission was available and the wind resource acceptable
  iii. Development is now focused on three areas where wind quality is sub-optimal. ERCOT is therefore not benefiting from all that wind has to offer.
- The CREZ emerges
  i. In 2005 the Texas legislature passed Senate Bill 20, instructing the PUCT to designate transmission for CREZs.
  ii. PUCT established contested-case docket 33672 in Jan 2007
  iii. Parties nominated CREZs and demonstrated financial commitment
  iv. Transmission service providers proposed transmission solutions

- **Final report**. A number of high level concepts are now under review with a final report due from ERCOT by April 2, 2008
    i. Following submission of the final report, the PUCT is expected to issue a final ruling which will include the transmission upgrades to be constructed and will designate the transmission companies that will build the upgrades
    ii. Increased transfer capacity could be available in 2012.
- **Other thoughts**
    i. Ancillary service requirements: a study of wind impacts has recently been completed
    ii. Nodal markets:
        1. ERCOT is transitioning to a nodal market January 2009
        2. Nodal price impacts from wind capacity growth
        3. Impact of growth of wind generation on new base-load generation
    iii. Emerging Technologies
        1. Energy storage
        2. Flexible generation
        3. Smart meters and intelligent load devices
- **Summary**
    i. CREZ process was designed to build transmission for wind generation in a timely manner, to take advantage of the best wind resources and to increase wind diversity
    ii. CREZ rulemaking began in 2005. Final ruling is expected summer 2008
    iii. New transmission capacity not expected to be available for at least 3 years
    iv. Plans under consideration represent significant changes to existing transmission infrastructure
    v. Local and system upgrades are on hold waiting for final CREZ ruling.

4.7.2 Location Constrained Resources: CAISO

Between end 2007 and 2020 CAISO expects to increase the nameplate capacity of renewables (excluding large hydro) from 13.6% of the total installed generation capacity to 35.6%. Just over 50% of this new RE generation capacity will be from wind.

- **Need for a new transmission financing plan**
  i. Lack of transmission facilities is a significant barrier to RE
  ii. Cost of new transmission facilities is an issue
  iii. Renewable resources must be located by the renewable fuel
  iv. Financing transmission is key if California is to meet its RPS
- **The financing mechanism**
  i. Participating TOs will finance the cost of the interconnection through their revenue requirements
  ii. Generators would become responsible for their *pro rata* share of these costs as they come on line and use the facility

     i.e as more generation is developed in the area the revenue requirements for the facilities would be transferred from the CAISO access charges to the specific generation developers until such time as the developers/wind plant owners/operators are fully responsible for the entire cost of the transmission facilities
- **LCRI tariff revisions address four policy areas**
  i. Criteria to qualify a project for consideration as an LCRI facility
  ii. Transmission planning criteria to determine whether a proposed LCRI facility is needed so as to qualify for inclusion in the CAISO transmission plan
  iii. Mechanism to recover the cost of an LCRI facility and;
  iv. The allocation of the costs of an LCRI facility.
- **Integration of Renewables Report**
  i. To identify Transmission and Operating Issues and recommendations for integrating renewable resources on the CAISO grid.
  ii. Includes both existing and new wind installations

iii. Some key findings;
    1. Power factor control is critical. New WTGs must meet WECC criteria for ± 0.95 power factor control
    2. All new WTGs must meet WECC LVRT standards
    3. New WTGs should be DFIGs or have full converter interface
    4. Existing conventional induction generators in the Tehachapi area do not meet LVRT standards and will probably be lost in the event of a voltage collapse
    5. 20% RPS standard can be met without adverse transmission system impacts.
    6. Focus should be on operational issues
    7. Maintaining existing generation is essential (although replacement or re-powering will work)

- **Additional integration services.** While the 20% RPS target can be met (as stated above) the variability and timing of wind generation will create the need for integration services;
  i. Increased need (20-30%) for morning and evening ramp resources
  ii. Increased need for regulation capacity and a much deeper supplemental energy stack due to potential wind forecast errors
  iii. Over generation in certain hours can be mitigated by minimal curtailment
  iv. Additional integration services can be met by;
      1. Hydro IF there is enough water
      2. New thermal IF it has the right characteristics
      3. Existing thermal IF it is kept operating at certain levels
  v. Other integration measures are also necessary
      1. Curtailment mechanisms
      2. Improved technology
      3. Better forecasting tools

- **Next steps – Major initiatives for 2008-2009**

i. Develop operational tools
    1. Create new wind forecasting capability
        a. Day ahead – for AS and unit commitment
        b. Hour ahead – Participating Intermittent Resource Program (PIRP)
        c. 5 minute – load following dispatch
        d. Link with new market system - MRTU
    2. Develop ramp forecasting and graphic displays for operators

ii. Regulatory rules, tariff changes and other Regional Agreements

iii. Perform requisite additional studies

iv. Market product assessment and development

v. Changes to generator interconnection and transmission planning process

- **CONCLUSIONS**

i. Majority of the resource to meet load growth will be renewables

ii. Majority of the renewables will be wind

iii. The majority of the cost effective wind is located distant from load centers

iv. Regional diversity will be crucial for both reliability and economics

v. Transmission is standing in the way of reliable and economic resources

vi. New generation, storage technology and demand response programs will be increasingly important for integration of renewables

4.7.3 Cost Allocation of Transmission or Market Solutions

- **Presentation considers**

i. Present tariffs in MISO

ii. Future cross border tariff with MISO-PJM

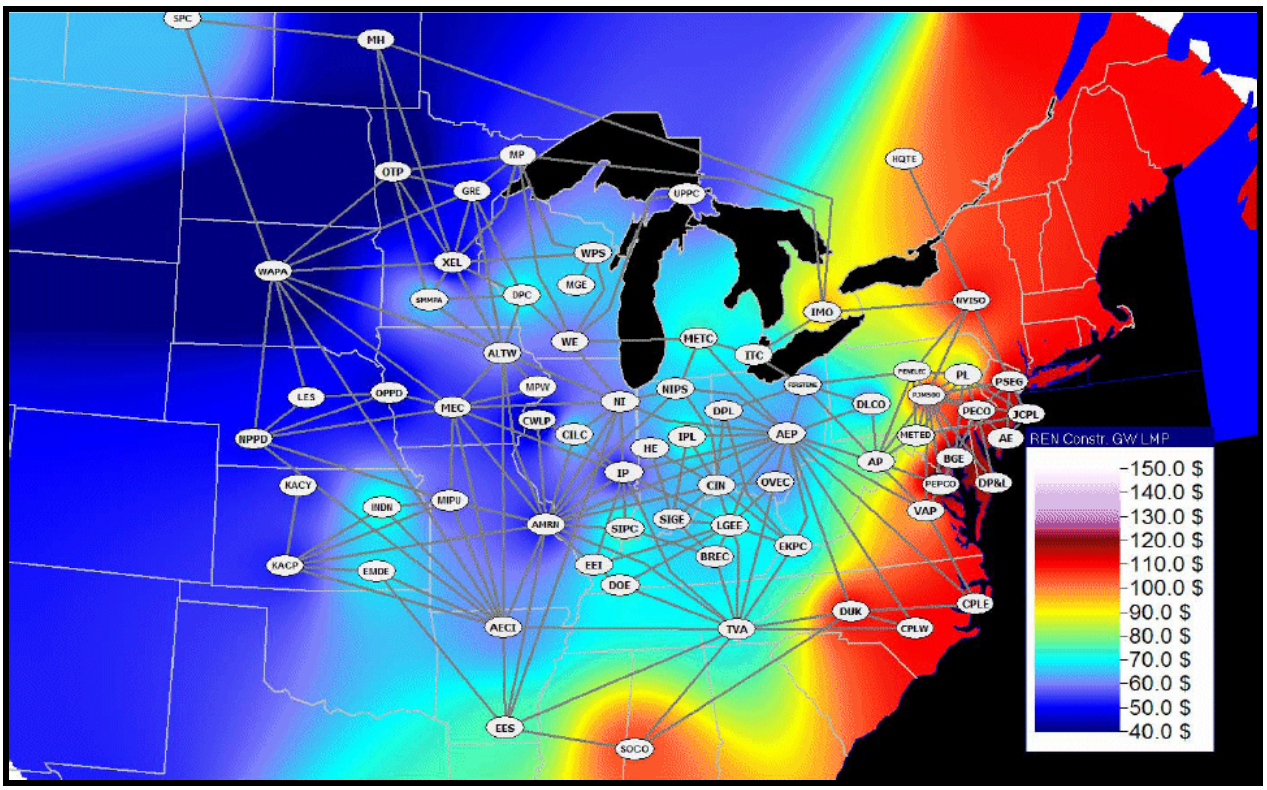
   iii. Considerations of a wide-area tariff
   iv. Market- and Physical-based cost allocation to transmission users

- Current tariffs are based on recovery on license-plate rate structure and not ideal
- **Future tariff considerations. Physical flow or Market based**
   i. Of these two the Market Method is considered preferable
- **Transmission investment**
   i. Studies show a positive benefit /cost ratio for transmission expansion between MISO and PJM
      1. B/C ratio of 1.1 on $40bn investment for 20% wind in MISO
      2. 10% CF difference for wind would offset transmission costs
      3. $22/MWh would pay for the annualized cost of transmission on energy sales only.
      4. JCSP, to be undertaken in 2008-2009, to provide better information
- **What does the JCSP supply**
   i. Coordinated analysis of the economic and physical operation of a conceptual future transmission plan with wind models that are time synchronized to load-inputs for a business model
   ii. Wind integration results will be key in order to calculate;
      1. Ability of the proposed generation to have adequate ramp rates to follow wind and load patterns
      2. Cost of ancillary services to integrate a 20% wind energy mandate in the US Eastern Interconnection
- **The potential**
   i. Wind resource map of the US indicates that there is a very good wind resource in the MISO region.
   ii. Generator LMP plot shows high prices on the Eastern seaboard and low prices in the MISO region

iii. Potential congestion relief (i.e. a 765 kV backbone) would be worth more than $20bn annually (2021 dollars)

iv. The cheapest transmission over the distance (1,200 km) would be HVDC

Figure 15 MISO 20% Wind Energy Future without Transmission Expansion Generator LMPs.



Source: Rohan Soulsby – BCTC. NE Region Wind Integration Seminar. Montreal Feb 2008

- **SUMMARY/CONCLUSIONS**

i. Tariffs to address both the present and potential future situations would probably not have the same structure due to the beneficiary participation

ii. Large scale wind and the mining of present generation could produce sufficient revenues to pay for a substantial transmission addition with added benefits to the loads

- **iii.** A physical use and a market based method both have the ability to resolve the problems (a market based method is simpler to implement)
- **iv.** Canada: Manitoba, Ontario and Québec are modeled BUT there is no wind data. Canada could cooperate with NREL to produce wind models

5 ABBREVIATIONS

ACE – Area Control Error

AGC – Automatic Generation Control

ATC – Available Transmission Capacity

AWEA – The American Wind Energy Association

BA – Balancing Area

BA – Balancing Authority

BAA – Balancing Authority Area

CAISO – California Independent System Operator

CF – Capacity Factor

CPS2 – Control Performance Standard 2 (CPS2)

CREZ – Competitive Renewable Energy Zones

DFIG – Doubly Fed Induction Generator

DOE – US Department of Energy

DSM – Demand Side Management

EOI – Expression of interest

ERCOT – Electric Reliability Council of Texas.

EWEA – European Wind Energy Association

GW – Gigawatt (10^9 watts)

HVDC – High Voltage, Direct Current

HVRT – High Voltage Ride Through

IESO – Independent Electricity System Operator

ISO – Independent System Operator

IVGTF – Integration of Variable Generation Task Force

JCSP – Joint Coordinated System Plan

LCRI – Location Constrained Resource Interconnection

LMP – Locational Marginal Pricing

LVRT – Low Voltage Ride Through

MISO – Midwest Independent System Operator (aka Midwest ISO)

MRTU – Market Redesign and Technology Upgrade
MW – megawatts (10^6 watts)
NEG/ECP – New England Governors/Eastern Canadian Premiers
NERC – The North American Electric Reliability Corporation
NREL – National Renewable Energy Laboratory
NWP – Numerical Weather Prediction
PIRP – Participating Intermittent Resource Program (PIRP)
PJM - PJM (a Regional Transmission Organization)
PUCT – Public Utility Commission of Texas
RE – Renewable Energy
RTO – Regional Transmission Organization
RES – Renewable Electricity Standard
RES – Renewable Energy Standard
RGGI (or ReGGIe)– Regional Greenhouse Gas Initiative
RPS – Renewable Portfolio Standard
SCADA – Supervisory Control and Data Acquisition
SO – System Operator
SPP – Southwest Power Pool
TO – Transmission Operator
TSO – Transmission System Operator (aka Transmission Operator)
UWIG – Utility Wind Integration Group
WECC – Western Electricity Coordinating Council
WEICan – Wind Energy Institute of Canada
WTG – Wind Turbine Generator

6 DEFINITIONS

Area Control Error. The instantaneous difference between a Balancing Authority’s net actual and scheduled interchange taking into account the effects of frequency bias and correction for meter error.

Ancillary Services – Those services (such as operating reserves, frequency control, voltage control, black-start capability and load following) that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the transmission system.

ANEMOS – “*Development of a Next Generation Wind Resource Forecasting System for the Large-Scale Integration of Onshore and Offshore Wind Farms*”. ANEMOS is a EU R&D Project. It aims to develop accurate models that outperform considerably actual state-of-the-art, for onshore and offshore wind resource forecasting (statistical and physical). Emphasis is given to integrating high-resolution meteorological forecasts. An integrated software, ANEMOS, will be developed to host the various models. This system will be installed by several utilities for on-line operation at onshore and offshore wind farms for local/regional/national wind prediction. The on-line operation by the utilities will allow for validation of the models and analysis as to how predictions can contribute to a competitive integration of wind energy in the electricity market

Automatic Generation Control. Equipment that automatically adjusts generation in a Balancing Authority Area from a central location to maintain the Balancing Authority’s interchange schedule plus Frequency Bias. AGC may also accommodate inadvertent payback and time error correction.

Balancing Area – See ‘Balancing Authority Area’.

Balancing Authority – The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing.

See map under definition of ‘Regional Reliability Organization’ for information showing location of North American Balancing Authorities

Balancing Authority Area – Previously termed ‘Control Areas’ and this terminology is sometimes still used. In every day usage the term ‘Balancing Authority Area’ is commonly abbreviated to ‘Balancing Area’.

The collection of generation, transmission and loads within the metered boundaries of a single ‘Balancing Authority’. The ‘Balancing Authority’ maintains load-resource balance within this area

Figure 17 (NERC Regions and Balancing Authorities) illustrates, albeit indistinctly, that the Maritimes Balancing Area, which includes Nova Scotia, New Brunswick, Northern Maine and PEI, connects with the Hydro Quebec TransEnergie balancing area in the West and the ISO New England balancing area to the South

California Independent System Operator (CAISO) is a not-for-profit public-benefit corporation charged with operating the majority of California's high-voltage wholesale power grid. Balancing the demand for electricity with an equal supply of megawatts, the ISO is the impartial link between power plants and the utilities that serve more than 30 million consumers. The ISO provides equal access to the grid for all qualified users and strategically plans for the transmission needs of this infrastructure

Capacity Factor is the wind turbine's actual energy output for the year divided by the energy output that would be achieved if the machine operated at its rated power output for the entire year. A reasonable capacity factor would be 0.25 to 0.30. A very good capacity factor would be 0.40

CPS2 – NERC Control Performance Standard defines a minimum acceptable control performance that a control area is expected to maintain over all operating conditions. Control Performance Standard 1 (CPS1) is a frequency-related parameter. Control Performance Standard 2 (CPS2) relates to a limit on the ten minute average of ACE.

Competitive Renewable Energy Zones. Under Senate Bill (SB) 20, the PUCT, after consulting with ERCOT and SPP,is responsible for designating areas with sufficient renewable resource potential as CREZs. The PUCT is then responsible for developing a plan to construct transmission capacity to deliver CREZ output to electric customers in a manner that is most beneficial and cost-effective to customers.

Control Area – See 'Balancing Authority Area'

Doubly Fed Induction Generator. In the context of WTGs, an asynchronous generator in which the stator windings are connected directly to the grid while the rotor windings are connected through an AC-DC-AC converter. Two thirds of the energy output of the WTG is typically transferred from the stator, one third form the rotor.

Demand Side Management refers to utility programs intended to affect the timing or amount of customer electricity use. These include energy efficiency programs aimed at reducing the energy required to serve customer needs and programs that shift electricity demand to reduce peak loads or to make more economic use of utility resources.

Eastern Interconnection - Is one of two major alternating current (AC) power grids in North America.

See ‘Interconnections – Major and Minor’ for illustration.

Ensemble Forecasts – Instead of using just one model run, many runs with slightly different initial conditions (and possibly with different models) are made. An average, or ‘ensemble mean’ of the different forecasts is created. This ‘ensemble mean’ will likely be a better predictor since it average over the many possible initial states and essentially smoothes the chaotic nature of the climate.

Electric Reliability Council of Texas (ERCOT). The ERCOT region is one of 3 NERC grid interconnections. (Eastern, Western and ERCOT). The mission of ERCOT is to direct and ensure reliable and cost-effective operation of the electric grid and to enable fair and efficient market-driven solutions to meet customers’ electric service needs.

FERC Order 661 requires public utilities that own, control, or operate facilities for transmitting electric energy in interstate commerce to append to their standard large generator interconnection procedures and large generator interconnection agreements in their open access transmission tariffs, standard procedures and technical requirements for the interconnection of large wind generation.

FERC Order 890 is designed to;

- Strengthen the existing Open Access Transmission Tariff (OATT) to ensure that it achieves it original purpose of remedying undue discrimination
- Provide greater specificity to reduce opportunities for undue discrimination and facilitate FERC’s enforcement
- Increase transparency in the rules applicable to planning and use of the transmission system.

Gigawatts (10^9 watts). One watt – the unit of electric power required to work at the rate of 1 joule/second of energy.

High Voltage Ride Through - As per Low Voltage Ride Through but with voltages that are in _excess_ of standard operational levels.

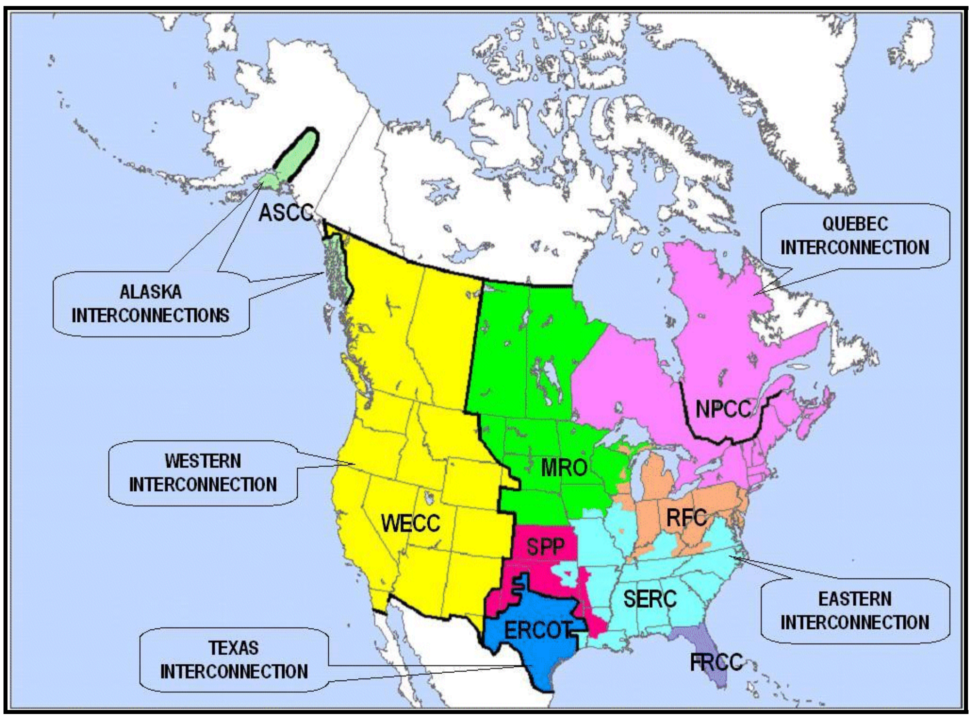
HVDC (High Voltage, Direct Current) The advantage of HVDC is its ability to transmit large amounts of power over long distances with lower capital costs and lower losses than AC. It also allows for power transmission between unsynchronized AC networks which can assist in increasing system stability. The longest HVDC link in the world is currently the Inga-Shaba 1,700 km 600 MW link connecting the Inga Dam to the Shaba copper mine, in the Democratic Republic of Congo.

Independent Electricity System Operator. The Ontario ISO.

Independent System Operator is generally the same as a Regional Transmission Organization however they typically cover a smaller geographic area or are not subject to FERC jurisdiction, like ERCOT. See RTO below

Interconnections – Major and Minor. The North American electricity grid consists of two major alternating current (AC) power grids (the Eastern Interconnection and the Western Interconnection) and three minor interconnections (the Québec Interconnection, the Alaska Interconnection and the Texas Interconnection).

Figure 16 North American Interconnections



Source: Wikipedia. December 2006

Integration of Variable Generation Task Force. This NERC initiative was publicly announced in March 2008. NERC will seek membership of the IVGTF Task Force from industry's subject experts, with final selection to be agreed by the officers of the Planning Committee and Operating Committee.

The Task Force will prepare:

- A concepts document that includes the philosophical and technical considerations for integrating variable resources into the Interconnections, and;

- Specific recommendations for practices and requirements, including reliability standards, that cover the planning, operations planning and real time operating environments.

A final paper is expected by September 2008

Joint Coordinated System Plan is a coordinated analysis of the economic and physical operation of a conceptual future (2024) transmission plan for the majority of the US Eastern Interconnection with 20% and 30% wind models that are time synchronized to load inputs for a business model. It consists of three 'phases';

Future load and generation scenarios
Eastern Interconnection wind study to assess the wind resource
Wind energy integration models

'License-Plate' Transmission Tariff. The name given to a rate structure which ensures that each transmission customer pays a rate that recovers the embedded transmission investment in the zone where that customer takes delivery of the power

Load-following. Together, regulation and load-following address the temporal variations in load (and generation that does not accurately follow control signals). The key distinction between load-following and regulation is the time period over which these fluctuations occur. Regulation responds to rapid load fluctuations (on the order of one minute) and load following responds to slower changes (on the order of five to thirty minutes).

Location Constrained Resource Interconnection is the term used in the CAISO region to describe a grid interconnection between the existing electricity grid and areas which contain significant amounts of renewable energy resources which, by virtue of their dependency on a location specific fuel, suffer from a lack of transmission capacity.

Locational Marginal Pricing. The marginal cost of serving the next increment of demand (load) at a point (usually 'a node') on the network with existing transmission facility constraints and the performance characteristics of resources.

Loop flows. Electricity flowing between a generator and load moves between all lines connecting the two (and not just along the shortest path). Where neighboring transmission systems are connected this property can arise in complications where electricity might initially flow out of the first network, into the second and back into the first. This is termed a 'loop flow' – they are difficult to control and can damage transmission equipment.

Low Voltage Ride Through refers to the ability of generators to be able to continue operating (hence ‘ride through’) when system voltage falls significantly below standard operational levels

Midwest Independent System Operator (aka Midwest ISO) The Midwest ISO is an independent, nonprofit organization that supports the constant availability of electricity in 15 U.S. states and Manitoba. This responsibility is carried out by ensuring the reliable operations of nearly 94,000 miles of interconnected high voltage power lines that support the transmission of more than 100,000 MW of energy in the Midwest, by administering one of the world's largest energy markets, and by seeking to identify improvements to the wholesale bulk electric infrastructure that will best meet the growing demand for power in an efficient and effective manner.

Market Redesign and Technology Upgrade is a comprehensive program that enhances grid reliability and fixes flaws in the CalISO markets. It keeps California compatible with market designs that are working throughout North America and replaces aging technology with modern computer systems that keep pace with the needs of California’s energy industry. The program is scheduled for implementation March 31, 2008

Megawatts (10^6 watts). One watt – the unit of electric power required to work at the rate of 1 joule/second.

National Renewable Energy Laboratory (NREL). NREL’s scientific and technological centers support the research and development efforts of the US Department of Energy. DOE, through the Office of Energy Efficiency and Renewable Energy, provides annual funding to NREL of about $200mn ($209 mn in 2006). NREL conducts renewable energy and energy efficiency R&D in 12 main programmatic areas one of which is ‘Wind and Hydropower Technologies’.

NERC Regions – See ‘Regional Reliability Organization’

North American Electric Reliability Corporation. NERC’s mission is to improve the reliability and security of the bulk power system in North America. To achieve this NERC develops and enforces reliability standards; monitors the bulk power system; assesses future adequacy; audits owners, operators, and users for preparedness; and educates and trains industry personnel. NERC is a self-regulatory organization that relies on the diverse and collective expertise of industry participants. As the Electric Reliability Organization, NERC is subject to audit by the U.S. Federal Energy Regulatory Commission and governmental authorities in Canada.

Numerical Weather Prediction uses current weather conditions as input into mathematical models of the atmosphere to predict the weather. Manipulating the resultant large datasets and performing the complex calculations necessary to do this on a resolution fine enough to make the results useful requires significant computing capacity. The basic idea of numerical weather prediction is to sample the state of the atmosphere at a given time and to use the equations of fluid dynamics and thermodynamics to estimate the state of the atmosphere at some time in the future.

Open Access Transmission Tariff. Electronic transmission tariff accepted by FERC requiring the Transmission Service Provider to furnish all shippers with a non-discriminatory service comparable to that provided by Transmission Owner to themselves.

Pancaking. Transmission customers outside of one TO/ISO system can incur multiple charges or access fees for contracting electric transmission on a path between the generator and the delivery point on the grid. The practice of imposing separate fees by multiple transmission owners is known as ‘rate pancaking’.

‘Postage Stamp’ Transmission Tariff is used to denote a tariff system where all RTO customers pay the same per unit transmission rate irrespective of their location on the transmission network.

Power factor measures the efficiency of an AC power system. Power factor is the real power per unit of apparent power. A power factor of 1 is perfect and 99% (or 0.99) is good. When the waveforms are purely sinusoidal, the power factor is the cosine of the phase angle between the current and voltage sinusoid waveforms.

Participating Intermittent Resource Program (PIRP). This CaISO initiative focuses upon understanding the cost drivers for wind generation resources and if improving the forecast accuracy can significantly reduce cost impacts. It also includes development of a tariff filing to address the appropriate charges associated with the export of Energy from Participating Intermittent Resources Program resources.

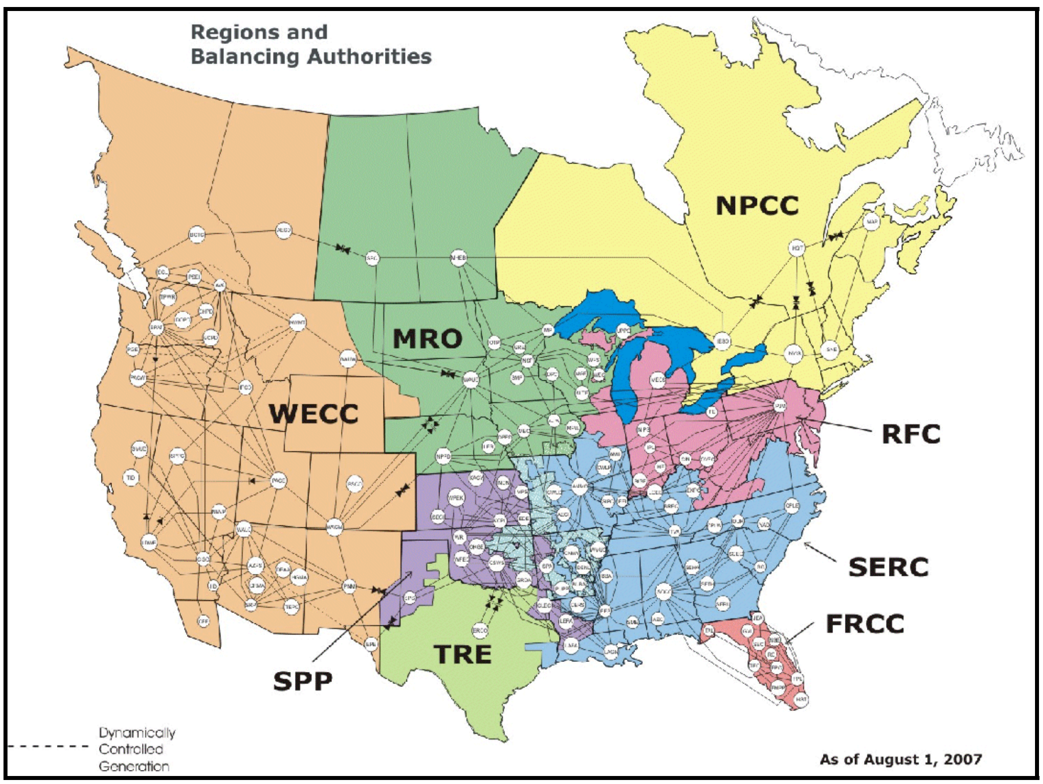
PJM is a Regional Transmission Organization that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

Acting neutrally and independently, PJM operates the world’s largest competitive wholesale electricity market and ensures the reliability of the largest centrally dispatched grid in the world.

Public Utility Commission of Texas is responsible for implementing the Public Utility Regulatory Act and in so doing for fostering market competition and promoting high quality electric utility (and telephone) infrastructure.

Regional Reliability Organization aka NERC Regions - NERC works with eight regional entities to improve the reliability of the bulk power system. The members of the regional entities come from all segments of the electric industry: investor-owned utilities; federal power agencies; rural electric cooperatives; state, municipal and provincial utilities; independent power producers; power marketers; and end-use customers. These entities account for virtually all the electricity supplied in the United States, Canada, and a portion of Baja California Norte, Mexico. The 8 regions (illustrated in Figure 17) are **WECC** (Western Electricity Coordinating Council, **SPP** (Southwest Power Pool), **TRE** (Texas Regional Entity), **MRO** (Midwest Reliability Organisation), **NPCC** (Northeast Power Coordinating Council), **RFC** (Reliability *First* Corporation), **SERC** (SERC Reliability Corporation) and **FRCC** (Florida Reliability Coordinating Council). The geographical location of each is depicted below (each Balancing Area Authority is shown with a small white circle);

Figure 17 NERC Regions and Balancing Authorities



Source: NERC. August 1, 2007

Regional Transmission Organization is an organization that is established to control and manage the transportation (at high voltage) and flows of electricity over an area that is generally larger than the typical power company's distribution system. RTOs were created by the Federal Energy Regulatory Commission as a way to handle the challenges associated with the operation of multiple interconnected independent power supply companies.

Today seven ISOs and RTOs operate in the US. The five RTOs are ISO New England, PJM Interconnection, MISO, SPP and CalISO, and the two ISOs are New York ISO and ERCOT. In Canada

Regulation. Together, regulation and load-following address the temporal variations in load (and generation that does not accurately follow control signals). The key distinction between load-following and regulation is the time period over which these fluctuations occur. Regulation responds to rapid load fluctuations (on the order of one minute) and load following responds to slower changes (on the order of five to thirty minutes).

Renewable Electricity Standard also called a Renewable Portfolio Standard. See RPS definition below.

Renewable Energy Standard. As per a Renewable Electricity Standard however it pertains to all forms of energy and not just electricity.

Regional Greenhouse Gas Initiative (RGGI (or ReGGIe))is a regional initiative by states in the Northeastern United States region to reduce greenhouse gas emissions. The RGGI is designing a cap and trade program for emissions from power plants. Ten states currently participate in the initiative. Pennsylvania, which is a major coal producer and manufacturing state, only participates as an observer.

> **Participating states**. Maine, New Hampshire, Vermont, Connecticut, New York, New Jersey, Delaware, Massachusetts, Maryland, Rhode Island
> **Observer states and regions**. Pennsylvania, District of Columbia, Eastern Canadian Provinces.

Renewable Portfolio Standard. These are provincial, regional (or state in the US) policies mandating a province, region or state to generate a given percent of its electricity from renewable sources. Current details on RPS status across the US are available on the FERC[38] web site.

---

[38] FERC Market Oversight. March 2008. Available: http://www.ferc.gov/market-oversight/mkt-electric/overview/elec-ovr-rps.pdf

Scheduling. See ‘Unit Commitment’.

Supervisory Control and Data Acquisition is software for process control. It gathers data in real time from remote locations in order to control equipment and conditions. SCADA is used in a variety of electricity industry applications as well as in oil and gas refining, telecommunications, transportation, and water and waste control.

System Operator. A control center (Balancing Authority, Transmission Operator, Generator Operator, Reliability Coordinator) whose responsibility it is to monitor and control that electric system in real time. NERC recognizes the term ‘System Operator’ as an individual although in the industry the term is often used to refer to the control centre.

Southwest Power Pool manages the electric grid for all or part of seven states: Arkansas, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas. SPP has members in the above states and Mississippi.

Transmission Operator. See Transmission System Operator below

Transmission System Operator (aka Transmission Operator). The entity responsible for the reliability of its ‘local’ transmission system and that operates or directs the operation of the transmission facilities.

Unit Commitment. The process of preparing a unit to generate at some point in the future, usually at least one day ahead. Large thermal units can take several hours to start hence a start-up instruction issued to such units can represent a significant and relatively inflexible forward commitment.

Western Electricity Coordinating Council Regional forum for promoting regional electric service reliability in Western Canada and the Western United States. WECC also supports efficient competitive power markets, assures open and non-discriminatory transmission access among members, provides a forum for resolving transmission access disputes, and provides an environment for coordinating the operating and planning activities of its members.

Western Interconnection - Is one of two major alternating current (AC) power grids in North America.

See ‘Interconnections – Major and Minor’ for illustration.

Wind plant. A collection of two or more operational wind turbines.

APPENDIX 1 – AGENDA NE REGION WIND INTEGRATION SEMINAR

Day 1. Tuesday 12 February

		Seminar Room 519. Palais des Congrès, Montréal
		Moderators for both days of this event will be;
		Charlie Smith, Executive Director - UWIG
		Rob Cary, President - Rob Cary and Associates
7:30	**8:00**	**Continental breakfast served in Seminar room**
8:00	**8:15**	**Introduction - Key regional political drivers.**
		John Shea. Director of Policy and Programs. New England Governors' Conference
8:15	**10:15**	**An overview of key drivers behind wind industry growth**
8:15	8:35	Global drivers of wind integration. *Andrew Garrad - CEO, Garrad Hassan*
8:35	9:10	Wind Plant Integration in North America. *Charlie Smith, Executive Director - UWIG*
		Wind industry perspectives on integration.
9:10	9:35	CanWEA. *Sean Whittaker - CanWEA Policy Director*
9:35	10:00	AWEA. *Mike Jacobs, VP Transmission - UPC Wind*
10:00	10:15	Group discussion of issues and solutions in the North East context
10:15	**10:30**	**Break**
10:30	**11:50**	**The regional perspective. An SO overview of wind integration in the North East**
		A 10 minute summary of key issues from each SO
10:30	10:40	Hydro-Québec TransÉnergie. *Richard Mailhot - Manager Support and Integration*
10:40	10:50	ISO New England. *John Norden - Manager of Renewable Resource Integration*
10:50	11:00	Maritime Electric. *Bob Younker - Director Corporate Planning*
11:00	11:10	New Brunswick SO. *George Porter - Director Market Development & Settlement*
11:10	11:20	Newfoundland and Labrador Hydro. *Greg Jones - Senior Business Development Analyst*
11:20	11:30	Northern Maine ISA. *Ken Belcher - CEO*
11:30	11:40	Nova Scotia Power SO. *Mike Sampson - Director Control Centre Operations*
11:40	11:50	Ontario IESO. *Khaqan Khan - Senior Engineer/Technical Officer Reliability Standards and Assessments*
11:50	12:00	Group discussion of issues and solutions in the North East context
12:00	**13:00**	**Lunch**
13:00	**13:50**	**The European experience of wind integration. Thomas Ackermann, CEO - Energynautics**
13:50	**14:40**	**International Grid Code Developments. Sigrid Bolik, Head of Power Systems - Econnect Consulting**
14:40	15:00	Group discussion of issues and solutions in the North East context
15:00	**15:15**	**Break**
15:15	**17:15**	**Technology drivers. Developers/manufacturers present how they plan to meet the grid codes**
15:15	16:10	GE. *Jason MacDowell, Senior Engineer - Energy Applications and Systems Engineering, GE*
16:10	17:05	Vestas. *Steve Saylors, Chief Electrical Engineer - Vestas Americas*
17:05	17:15	Group discussion of issues and solutions in the North East context
17:15	17:30	Day 1 closing discussion. Summarise action items and agree tasks
19:30	21:00	Seminar Dinner. Aix Cuisine du Terroir. 711 Côte de la Place d'Armes, Old Montreal

Day 2. Wednesday 13 February

Seminar Room 519. Palais des Congrès, Montréal

8:00	**8:30**	**Continental breakfast served in Seminar Room**
8:30	**10:35**	**Forecasting**
8:30	8:55	European experience. Ensemble forecasts. *Bernhard Ernst - RWE Transportnetz Strom GmbH*
8:55	9:20	Alberta's forecasting studies. *Darren McCrank, Senior Systems Engineer - AESO*
9:20	9:45	Hydro Quebec and Environment Canada Wind Energy Forecasting project. *Alain Forcione - Hydro Quebec*
9:45	10:10	Getting forecasts into the SO Control Room. *Mark Ahlstrom, CEO - WindLogics*
10:10	10:35	Group discussion of issues and solutions in the North East context
10:35	**10:50**	**Break**
10:50	**12:20**	**Balancing**
10:50	11:40	Summary of US wind integration experience and related market mechanisms. *Bob Zavadil, VP - Enernex*
11:40	12:05	ACE Diversity Interchange - Sharing area control errors. *Rohan Soulsby - Director Business Development. BCTC*
12:05	12:20	Group discussion of issues and solutions in the North East context
12:20	**13:05**	**Lunch**
13:05	**14:35**	**Transmission planning, cost allocation and regulation**
13:05	13:30	Texas Competitive Renewable Energy Zone (CREZ) process. *Warren Lasher. Manager System Assessment - ERCOT*
13:30	13:55	Providing transmission for locational constrained resources in the CAISO. *Dave Hawkins. Principal Investigator Integration of Renewables - CAISO*
13:55	14:20	MISO: The proposed 765kV backbone for wind energy and cost allocation *Dale Osborn. Transmission Technical Director - MISO*
14:20	14:35	Group discussion of issues and solutions in the North East context
14:35	15:05	Seminar closing discussion. Summarise action items and agree tasks
15:05		End of wind integration seminar

APPENDIX 2 – PRESENTATIONS FROM NE REGION WIND INTEGRATION SEMINAR

The size of the 25 presentations arising from this seminar is in excess of 30 MW. As a result it was not feasible to include them all within this document – nonetheless they are available on the WEICan web site;

http://www.weican.ca/projects/events/080212-ne-grid-seminar.php