Wind Resource Integration Information for the Future

Beth Reid, Andrew Thornton, Bao Ngo, and Parviz Adib[1]

Abstract:

The global debate on climate change and the growing need for reasonably priced, environmentally friendly resources have brought "green" power to the forefront as an effective and economical resource in meeting the desired environmental goals. Renewable resources are expected to play a crucial role and various states within the United States, as well as countries around the world, are competing with each other to increase the share of energy provided by renewable resources. With this rapid growth, grid operators are facing new challenges, such as addressing the growing need for transmission upgrades and handling operational complexities while maintaining grid reliability. Some of the operational complexities include the need for more accurate generation output forecasting and an expectation from renewable resource operators to play a more responsive role in providing active and reactive power support. In this paper, the authors explore practical ways to enhance the coexistence of environmentally friendly renewable resources with system reliability and smooth market operations.

1 Introduction

The global debate on climate change and the growing need for reasonably priced, environmentally friendly resources have brought "green" power to the forefront of public attention as an effective and economical means to meet the environmental goals recently set by the Group of Eight industrialized nations (G8) in July 2008 in Japan, where they committed to adopt the goal of achieving at least a 50 percent reduction in global emissions of greenhouse gases by 2050.[2] Renewable resources, which include wind, solar, biomass, geothermal, and several other clean resources, are sometimes referred to as intermittent or uncontrollable resources due to the fact that most of these resources are not dispatchable in the same manner as are conventional resources such as nuclear, coal-based, or natural gas-based power plants. However, given the declining production costs and significant environmental benefits of renewable energy, integrating intermittent resources into the electric transmission system successfully is important to both system reliability and the environmental effort.

---

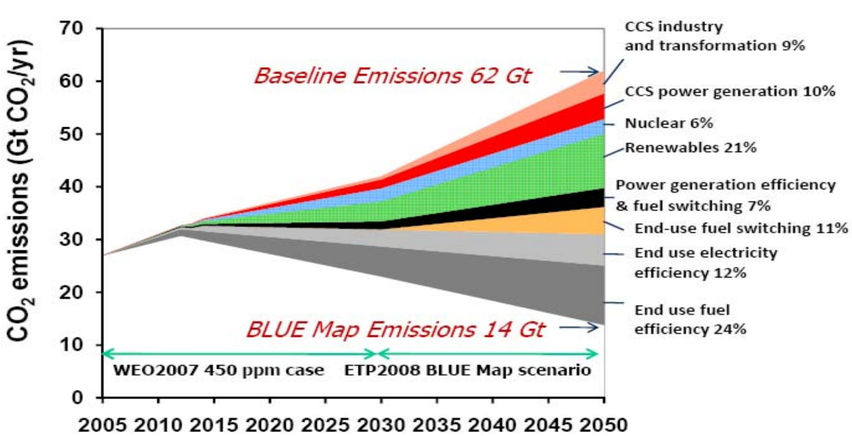
[1] The authors are employees of APX, Inc., Santa Clara, California. They would like to thank David Sagara, also with APX, for his invaluable comments on earlier draft of this paper.

[2] For a summary of all agreements see http://www.g8summit.go.jp/eng/doc/doc080709_10_en.html. For more details on global efforts that resulted in the recent decision by these industrialized countries, see the Kyoto Protocol posted at http://unfccc.int/resource/docs/convkp/kpeng.html and its final agreement that went into effect in 2005 posted at http://unfccc.int/kyoto_protocol/items/2830.php.

Major European countries have either maintained their reliance on fossil fuel sources or reduced it since 1980.[3] These countries are now taking further actions to address their carbon emissions. They plan for renewable resources to play a major role in these emission reductions. Among twenty seven European countries, Malta has the lowest target for renewable energy share of 10% and Sweden accounts for the highest target at 49% to be achieved by 2020.[4] Similarly, many states in the U.S. have established their Renewable Portfolio Standards (RPSs) to increase their shares of renewable resources in their power use. Texas, with over 6,000 MW of wind generation capacity, is leading such programs in the amount of additional installed capacity in the United States.[5]

Electric power generation is considered as a major source of carbon emission[6] and renewable resources are considered as part of the overall solution to replace some of the generation from fossil fuel resources. Recent reports by the International Energy Agency (IEA 2008a and 2008b) include projections of the amount of energy related carbon emission reductions needed to meet the commitment by G8 industrialized countries to achieve 50 percent reduction by 2050 compared to 2005. Under a "Business as Usual" scenario, the amount of global energy-related CO_2 emissions could reach 62 gigatons (GT) compared to 27 GT in 2005. To meet such a goal, significant steps have to be taken to reduce energy-related carbon emissions to below 14 GT. As shown below, renewable resources are expected to play a major role in achieving such carbon emission reductions.

Reducing Global CO2 Emissions by 50% by 2050



Source: International Energy Agency (2008a, Slide 5). This graph was originally appeared in IEA World Energy Outlook 2007.

Note: Baseline Scenario refers to Business as Usual. BLUE Scenario requires extensive emission reductions. WEO 2007 and ETP 2008 refer to the IEA World Energy Outlook 2007 and Energy Technology Perspectives 2008 Reports, respectively.

---

[3] See Mouawad (2008) and NewEnergyNews (2008).

[4] See Massy et. al. (2008). Major European countries, such as France, Germany, Italy, Spain, and United Kingdom have plans to increase the share of renewable resources to 23%, 18%, 17%, 20%, and 15% by 2020, respectively.

[5] For state by state information see Pew Center on Global Climate Change at http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm.

[6] See Forest Stewardship Council (2008). Also See Stern (2007) for a detail discussion of worldwide environmental emissions by various industries and economic sectors.

Legislative actions at the state and federal level, including continuing extension of the Investment Tax Credit for solar energy, the Production Tax Credit for wind generation, and similar incentives for other renewable resources by the U.S. Congress, further encourage more reliance on clean renewable resources to meet the growing demand for electricity. In addition, it is highly probable that carbon regulation in the U.S. will cause further reliance on renewable resources.

With this expected growth in renewable resources, which is mainly dominated by wind power generation, grid operators are facing new challenges in integrating these environmentally friendly resources into the electrical network while maintaining grid reliability. The lack of adequate transmission upgrades to match the growing increase in renewable generation capacity is one of the biggest challenges facing Independent System Operators (ISOs) throughout various electricity markets. This is an issue that needs to be addressed in a timely manner, given that major transmission upgrades typically take between three and five years to complete. In addition, grid operators are facing real-time operational challenges for which they are demanding that wind resource owners and operators meet the following operational requirements:

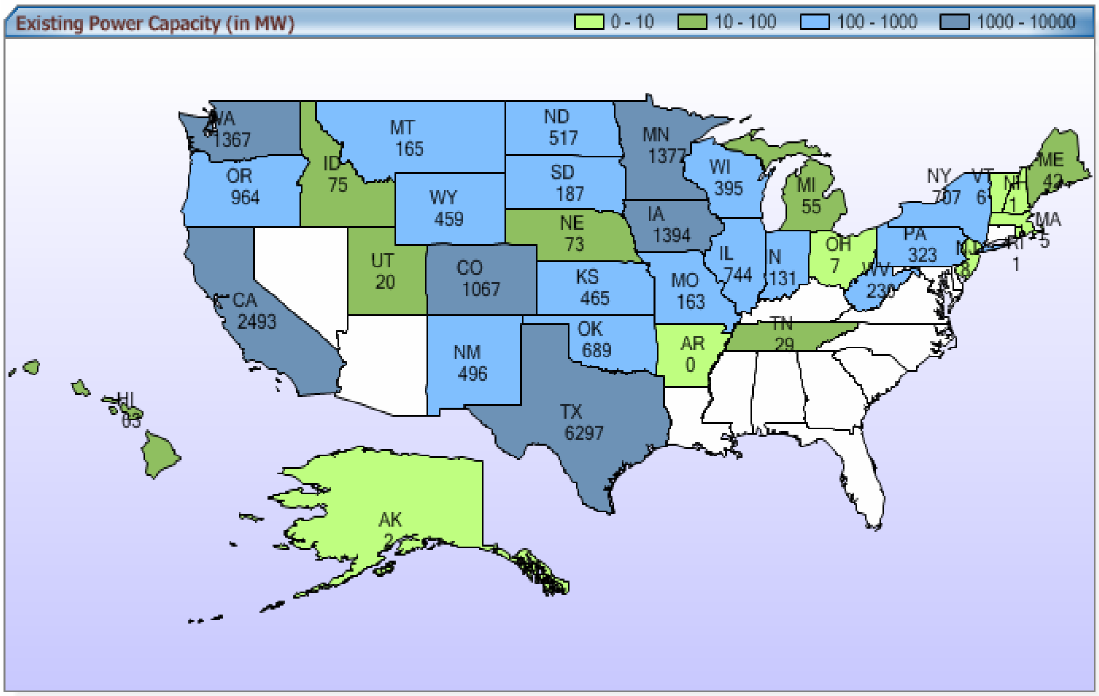
1. Aligning output schedules with more transparent, accurate and up-to-date forecasts
2. 24x7 control of active power – Control power output to handle Local congestion management requests and to provide down balancing power in over-generation conditions
3. 24x7 control of reactive power – Close cooperation and coordination with ISO Operators and transmission operators

Scheduling accuracy and responsive plant operations are critical both to grid operators and wind resource owners. Wind resources need a comprehensive integration system that converts up-to-date forecasts into power schedules, creates economic energy bids for excess power situations, and provide access to data and operational information to calculate financial settlements or address occasional disputes. Regional tariffs, in effect within various ISO markets, are also requiring that wind resources be under a 24x7 operational control to provide balancing power operations and participate in reactive power support.

This paper addresses the need for transmission upgrades, look at some major short term and real-time challenges to integrating wind and other renewable resources into the grid, and explores practical ways to use integrated systems to enhance the coexistence of environmentally friendly wind resources with system reliability and smooth market operations.

2 Transmission expansion to meet 20% share for renewable resources

Like many European countries that have already begun taking actions to raise the shares of renewable resources in their total energy consumption, various states within the U.S. are moving aggressively in raising their shares of renewable resources. This trend includes 28 states plus the District of Columbia where statewide Renewable Portfolio Standards (RPSs) have been established to achieve goals ranging from a few percent to about 30 percent of their power use.[7] According to the American Wind Energy Association there were 21,017 MW of total installed wind generation capacity with more than 8,000 MW under construction as of the end of September 2008. The breakdown of this capacity by states within the U.S. is provided below.



Source: American Wind Energy Association website at http://www.awea.org/projects/.

The total current installed wind capacity in U.S. is increasing rapidly with Texas leading such development with a total of 6,297 MW (6,023 MW in the Electric Reliability Council of Texas or ERCOT) of installed wind generation as of September 2008 and is expected to pass 9,000 MW by 2010.[8] Such a rapid increase in the amount of wind capacity within any ISO managed electricity market creates significant planning and real-time challenges for decision makers and system operators. For these players, the biggest challenge for the next few years is to anticipate and identify potential difficulties and develop reasonable procedures and mechanisms to allow the increasing amount of renewable resources to coexist with other conventional resources in meeting environmental goals while serving end-use customers at reasonable electricity prices. The work has already begun and some challenges have been identified with regards to both short-term and real-time operational and reliability issues. The short-term and real-time operational and reliability issues will be addressed in detail in Section 3.

---

[7] See Pew Center on Global Climate Change at http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm.

[8] See Electric Reliability Council or Texas (2008). In addition, the report indicates that ERCOT is currently tracking 253 active generation interconnection requests totaling over 108,000 MW where wind resources account for almost 50% of that amount. For information regarding wind capacity in Texas see http://www.awea.org/projects/.

The locations with the highest potential for renewable resources are in Central U.S. (for wind resources) and the Southwest U.S. (for Solar). Problematically, these locations are usually located away from the major population centres and will require a massive transmission upgrades to facilitate integration of these clean resources into the U.S. grid. The transmission systems within the United States are expected to remain under regulation for the foreseeable future, and without a paradigm shift in transmission policy, it will be almost impossible for system planners and market operators to manage the massive challenges that face them in integrating this significant amount of renewable energy into the transmission grid. The need for such a paradigm shift was recognized by some state and federal legislative bodies in 2005 and resulted in the Energy Policy Act of 2005. This legislation authorized the Department of Energy (DOE), in cooperation with the Federal Energy Regulatory Commission (FERC), to take the necessary steps to designate transmission corridors to address transmission system shortcomings if the states involved did not act on an application by utilities for transmission expansion in a timely manner. This law is expected to accelerate the construction of needed transmission upgrades.

Similarly, states have taken legislative and regulatory actions to address the need for transmission expansion to incorporate more renewable resources into their power mix.[9] Several western states, including California, have engaged in transmission regional planning activities to facilitate integration of renewable resources into their grid. Texas passed a legislative mandate in 2005 and gave authority to the Public Utility Commission of Texas (Texas Commission) to approve the creation of several Competitive Renewable Energy Zones (CREZs) in a recent contested proceeding in July 2008.[10] The Texas Commission was facing several expansion scenarios that would add between 6,000 MW and 18,000 MW of additional transmission transfer capability and would cost between $2.9 billion and $6.4 billion to construct. The proceeding attracted significant national attention and many wind developers, as well as some Legislators, filed comments encouraging the Commission to approve a significant transmission expansion plan to facilitate the accelerated growth of wind development in Texas. In a landmark decision, the Commission approved a major transmission expansion plan estimated to cost $4.93 billion to increase transmission transfer capability of power to large population centers by more than 12,000 MW. The Transmission Service Providers have about twelve to eighteen months to file their applications for construction of these projects and the Commission is expected to finalize these applications in an expedited fashion. The transmission lines are expected to be operational by 2013.

As indicated in the latest reliability assessment report by the North American Electric Reliability Corporation (NERC) "More transmission needed to maintain bulk power system reliability and integrate new generation."[11] It is absolutely critical for legislative and regulatory decision makers to take necessary steps to improve the existing transmission network, to meet the increasing need for renewable resources. Decisions

---

9 The leading states are Texas, California, Minnesota, Colorado, Missouri, and New Mexico. For more details, see (WIRES, 2008).

10 Docket No. 33672, *Commission Staff's Petition for Designation of Competitive Renewable Energy Zones*, at http://interchange.puc.state.tx.us/WebApp/Interchange/application/dbapps/filings/pgSearch.asp.

11 See NERC (2008), pp. 5 and 15-17.

similar to the one by Texas Commission will provide the higher level of certainty sought by investors and wind developers.

3 Short term and real-time challenges for Grid Operators

Grid Operators face short term and real-time challenges to incorporate intermittent resources into their electric systems. These challenges have operational and reliability consequences, which, if not addressed in a timely manner, could result in undesirable outcomes, including load shedding and harm to grid infrastructure. One challenge is accurate forecasting for use in unit commitment, scheduling, real-time dispatching, and congestion management. Another challenge is determining the optimal amount of controllable online capacity that will allow for reliable operations while minimizing increases to the total cost of power. Grid operators need the ability to call on renewable resource owners to decrease active power output to manage over-generation situations and local congestion constraints. In addition, these resources are expected to participate in reactive power support to assist grid operators. These are some of the well known motivators for the many recent regional tariffs and protocol changes aimed to maintain reliable operations as the percentage of power coming from intermittent resources continues to grow.

Markets operated by the California Independent System Operator (CAISO) and ERCOT will be relied upon in this paper because those regions currently contain a significant proportion of the intermittent resources in North America and provide an opportunity to analyze the lessons learned from real life examples. In addition, an emphasis is placed on wind resources for this paper because: 1) wind resources account for the great majority of renewable resources and 2) as indicated by a report by the CAISO, other renewable resources, such as small hydroelectric, biomass, geothermal, and the expected amount of solar resources to become operational within the foreseeable future do not present significant problems.[12]

The grid operators face a number of issues integrating renewable resources into the generation mix and onto the transmission grid. The following table contains a summary of the broad challenges facing grid operators and is based on various discussions by stakeholders in both the ERCOT and CAISO markets:[13]

Category	Challenges
Reactive Power Support	• Mandate for 24x7 communication between wind generation resource and grid operator or transmission service provider to address voltage support requests • Better defined voltage support requirements (i.e. Voltage Ride Through, VRT) for newly / recently developed wind generation

[12] See CAISO (2007), Executive Summary, p. 2.
[13] For more details, see CAISO (2007) and various presentation by the Wind Operations Task Force before the ERCOT Reliability and Operations Subcommittee. See http://www.ercot.com/committees/board/tac/ros/.

	projects • Address voltage support requirements for legacy wind generation projects. • System Inertia (generator governor response) • Use storage technologies as they become available to provide transmission loading and voltage support[14] • Build appropriate voltage controls into transmission expansion projects developed to serve "wind pockets"
Active Power Control	• Ability to decrease active power output in Real-Time from wind generation resources during over-generation, or local transmission congestion scenarios • Address ramping issues resulting from drastic changes in wind speed • Enforce ramping constraints on wind generation resources when output is curtailed and upon release from curtailment • System Inertia (generator governor response) in cases of frequency deviations • Identify and minimize the negative impacts (additional start ups, lower than optimal dispatch levels, and associated environmental costs) on the operation of conventional resources due to increase in wind generation
Forecasting and Scheduling	• Incorporate grid operator sponsored Day-Ahead, Hour-Ahead, and Real-Time forecasts into decisions on unit commitment, scheduling, and dispatching • Integrate site specific, real-time meteorological data and telemetry systems from wind generation resources into forecasts
Ancillary Services	• Determine minimum amounts of each type of ancillary service required to operate grid reliably considering changing resource mix • Use storage technology to minimize reliance on ancillary service and balancing energy driven the growth of wind generation resources[15] • Ensure sufficient "faster and more durable ramping" capability to address issues associated with transitions between peak and off-peak periods • Ensure sufficient "quick start" units to accommodate Hour-Ahead forecast error and intra-hour wind variations

Two of the biggest short-term challenges facing grid operators are: 1) handling the volatility of wind generation output and 2) calling on generation reductions from wind generation resources. This paper will cover these topics in more depth, while acknowledging that they are not the only challenges.

Volatility in Real-time Generation Output: Grid operators face constantly changing demand targets and need predictable generation output to manage the grid smoothly and economically. To accurately predict intermittent resource energy output, forecasts must

[14] CAISO (2007) page 9. See http://www.caiso.com/1ca5/1ca5a7a026270.pdf .
[15] CAISO (2007) page 9. See http://www.caiso.com/1ca5/1ca5a7a026270.pdf .

use up-to-date meteorological models incorporating real-time, resource specific weather data. An example of this need occurred in ERCOT on February 26th, 2008. During a short time period, ERCOT experienced a 1,400 MW decline in wind power production, while scheduled output for wind power production remained unchanged for several intervals. As a result, ERCOT went into the second stage of emergency procedures relying on demand response to address reliability concerns that lasted for three hours.[16] Review and analysis of this event prompted a recent protocol revision that requires wind resource owners/operators to schedule power output equal to an ERCOT provided forecast prior to ERCOT's Day-Ahead reliability study.[17]

In the CAISO region, the grid operator sponsors a program that also requires resource owners/operators to schedule expected output according to an ISO sponsored forecast. To encourage participation, the CAISO offers intermittent resource owners a financial incentive to participate in this Participating Intermittent Resource Program (PIRP). These CAISO sponsored forecasts incorporate site specific historical data, real-time energy output, and real-time meteorological data as inputs. Additionally, the CAISO uses resource specific outage and de-rate information from the Scheduling Logging for the ISO of California (SLIC) system to improve the accuracy of the forecasts.

Instruct Generation Reduction: It is also important for grid operators to be able to reduce the output of intermittent resources in cases where there is system-wide over generation or local transmission congestion. Intermittent resources use clean, free fuel, so curtailing intermittent resources is not an economical or environmentally friendly solution to solving system wide over-generation; however, in cases where all dispatchable resources are operating at their minimum levels, the grid operator needs to be able to curtail wind generation as needed.

More commonly, grid operators need to curtail wind generation to solve local or regional transmission congestion because they are typically located in areas that lack sufficient controllable generation. This requirement is even more critical in regions where the development of intermittent resources has outpaced the development of sufficient transmission capacity to bring that power to market. For example, when the wind is blowing hard in West Texas, ERCOT has at times restricted the output of wind resources due to insufficient transmission to deliver this power to population centers in the Dallas or the Central Texas regions where demand exists. This situation is not unique to either ERCOT or wind resources. This past spring in the Mid-Columbia River region where large amounts of hydro power are produced, part of the spring runoff had to be diverted due to a combination of high winds, recent regional wind generation capacity additions, and high water levels because these factors combined to cause output to exceed the transmission capabilities in the region.[18]

---

[16] See ERCOT Operations Report at http://www.ercot.com/meetings/ros/keydocs/2008/0313/07._ERCOT_OPERATIONS_REPORT_EECP022608_public.doc.

[17] See Protocol Revision Request 763 (PRR763), which was passed by stakeholders in ERCOT where Wind Generation Resource Production Potential (WGRPP) is recommended to be used as Planned Operating Level in Day-Ahead Resource Plan for Wind Generation Resources. Also available at http://www.ercot.com/mktrules/issues/prr/750-774/763/index.

[18] See Hill (2008).

While transmission upgrades are planned to reduce such operational difficulties, there will not be adequate transmissions to deliver the growing amount of power generated by wind resources to population centers for the next few years. Rather, grid operators and renewable resource owners have to rely on existing tools, such as adjusting output of generation resources or managing transmission maintenances, to handle such operational realities until transmission upgrades are in operation.

Other Useful Options: While there are several practical options available to grid operators to address operational and reliability challenges, the following two options receive special attention: 1) procuring additional ancillary services, and 2) optimizing the transfer capability of a transmission network through better managed and coordinated planned transmission outages. Several studies conducted by GE Energy Consulting for both ERCOT and CAISO markets concluded that within the next few years the electric grid will be able to handle increasing amount of wind resources assuming certain actions are taken to secure system reliability. For example, such increases in the amount of renewable resources will result in a need for additional ancillary services to provide adequate reserve to maintain system reliability.[19] In response to such a need, the ERCOT Board of Directors approved a new ancillary service methodology in its October 21, 2008 meeting authorizing ISO to procure more regulation and non-spinning reserve service to address the increasing amount of wind resources and their forecast inaccuracy.[20]

Finally, Transmission Service Providers (TSPs), through better coordinated and planned transmission outages for maintenance, can play a critical role in enhancing grid operators and wind resource owner's ability to address operational and reliability challenges. Historically, most of the planned transmission outages have taken place during off peak periods which coincide with the spring and fall seasons. However, such seasons have the potential for higher electricity generation from wind resources. A close re-evaluation of planned transmission outages may reveal that some of these scheduled outages could be optimized to minimize negative impacts on wind generation.[21]

Practical Remedies: Success in adequately addressing the challenges discussed in this paper are critical to a lot of other electricity markets who are going to have similar experiences in increasing the share of renewable resources in their total electricity generation mix as those seen in ERCOT and the CAISO. The lessons learned from both ERCOT and CAISO indicate that such challenges can be managed through steps taken to improve the resource interconnection process, incorporate necessary changes to protocols/operating guides, enhance compliance performance through key performance indicators, and provide adequate training to both grid and wind resource operators.

[19] See CAISO (2007) for study regarding CAISO market. For study regarding ERCOT market, see PUCT (2008).

[20] See materials listed under Item 7d in the agenda for October 21, 2008 ERCOT Board Meeting at http://www.ercot.com/calendar/2008/10/20081021-BOD .

[21] Wind resources in ERCOT faced difficulties and prices were negative in many intervals during spring 2008. One of the main factors was TSPs' planned transmission outages resulting in much lower transfer capability that caused price war among wind resources to avoid curtailment.

4 Day-to-day operational requirements and challenges facing wind resource owners/operators

The challenges that grid operators face in integrating intermittent resources such as wind are driving protocol, tariff, and operating guideline changes that formalize and add to the operational requirements for wind resource owners/operators. These requirements present both compliance and profitability challenges.

4.1. Operational requirements

The tariff-based operational requirements for intermittent resources include the three major categories which include 1) forecast to schedule integration 2) a need for maintaining a 24x7 operations desk, and 3) a need for a close cooperation and coordination with grid operators regarding reactive power support and voltage control.

Forecasting and Schedule Integration: Many grid operators require wind generation resource owners to electronically communicate real-time, site specific meteorological data and current plant output. The meteorological data includes wind direction and speed, temperature, and barometric pressure. Resource owners/operators are also required to communicate outages or de-rates that affect plant production capabilities by using the grid operator's outage reporting interface (Outage Scheduling Software). The grid operator uses all of this information to build accurate Day-Ahead, Hour-Ahead, and Real-Time forecasts.

The specific scheduling requirements for wind resources vary by region, but the CAISO and ERCOT share the basic requirement that the wind resource owner submit a schedule or resource plan that matches the grid operator provided forecast. ERCOT recently implemented a Protocol Revision Request (PRR)[22] that requires that Day-Ahead resource plans match the ERCOT provided forecast prior to ERCOT's Day-Ahead unit commitment process. Specifically, ERCOT requires that the High Sustainable Limit (HSL) reported in the resource plan for each wind resource to match the Day-Ahead forecast (PRR 763). ERCOT stakeholders are also working on a new PRR which will require wind resource owners/operators to provide a Low Sustainable Limit (LSL) that is lower than HSL and allows wind output to be curtailed under certain conditions (pending PRR 773). The CAISO requires intermittent resources to submit an Hour-Ahead schedule that matches the CAISO provided forecast which is provided 30 minutes prior to the scheduling deadline for each hour.

These requirements are imposed to eliminate some of the difficulties facing grid operators, and it is absolutely necessary for wind resources to maintain up to date resource plans and schedules that reflect the latest and most accurate information on their generating capabilities. Failure to update resource plans and schedules will result in non-compliance and possible penalties in many markets.

24x7 Operations Desk: Grid operators require that wind resource owners/operators maintain a real-time operations presence to respond to various system operator

[22] Additional information on various ERCOT PRRs is available at http://www.ercot.com/mktrules/protocols/prr .

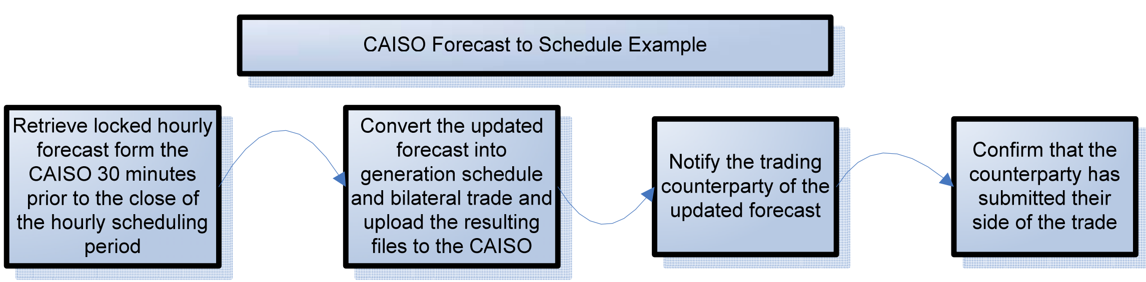
instructions, including verbal instructions that are critical during grid emergency situations, and to report outages and de-rates. ERCOT requires wind resources to respond to curtailment instructions according to the same timeline that applies to traditional generation. A requirement that wind resources limit their ramp rate to 10% per minute of the resource's online installed capability when responding to or being released from a deployment (pending PRR 771) is being developed. The CAISO does not currently require intermittent resources to respond to real-time curtailment requests. However, there are plans to implement such tariff provisions in the near future.[23]

Reactive Power Support and Voltage Control: Reactive power is an essential factor in voltage control and the efficient operation of an electric network. The CAISO will be requiring new wind generation to have the capability to meet +/- 0.95 power factor targets, of which at least a minimum portion of the required power factor range is provided dynamically. ERCOT currently requires that wind resources maintain the ability to respond, in real-time, to voltage requests issued by ERCOT or the regional transmission provider to address local reactive power issues with the amount of voltage support dependent on output level and site setup. Precise coordination, clear procedures and training for all involved parties is necessary to ensure that requirements are well understood and to avoid communication issues and delays in voltage support. Both the CAISO and ERCOT are working with stakeholders to better define such requirements.

4.2. Operational challenges

The proliferations of tariff revisions that target wind generation present many challenges for wind resource owners, who must meet these requirements ***in a reliable and cost effective*** manner. As discussed, the major challenges include implementing forecasts to scheduling integration requirements, providing 24x7 operations support, and meeting key compliance rules and regulations.

The first major challenge for wind resource owners/operators is to implement a reliable method for updating scheduling information based on changes to forecasts. Depending on the region and generation contracts, the resource owner may be required to change schedules, bids, trades, and resource plans within Day-Ahead and Hour-Ahead scheduling timelines. The frequency of forecast updates is a driver in determining the relative cost of a manual vs. automated scheduling solution. The CAISO PIRP program requires participating resources to match schedules to forecasts that are updated hourly. A typical CAISO example of this process would be:



[23] See CAISO (2007), p. 10.

ERCOT requires all generation resources, including wind generation, to bid a percentage of the resource's expected output into the down balancing energy service (DBES) market that will allow for the curtailment of the wind farm by ERCOT operations through the price-based bid or through an out of market curtailment instruction. In addition ERCOT will, in the future, require each wind resource's telemetered HSL to match the real-time output of the resource.[24]

The second challenge for wind resource owners/operators is to staff a 24x7 operations desk that has the knowledge and skills to understand regional tariffs and operating guides and can communicate and respond in real-time to various instructions issued by system operators. This staff must also report resource outages and de-rates to the grid operator in a timely fashion, and must have access to plant controls for active and reactive power output. This requirement is further complicated by the wide and numerous distribution of wind farms that a given owner may operate. The detailed requirements for real-time control vary by region, but increasing requirements are the national trend. In addition, 24x7 staff may need interaction with plant managers on some occasions, particularly in those instances where there may be financial or non-compliance consequences, to ensure proper responses to system operator instructions. To maintain frequency control in areas with large amounts of wind generation, voltage support requests to wind resources have required remote engaging or disengaging of reactive capacitors.

The third major challenge facing wind resource owners/operators is to meet key compliance rules and regulations. Failure to meet such requirements often results in financial consequences and may sometimes result in regulatory investigations. These requirements are usually developed with consideration for the technological differences unique to intermittent resources. For example, wind resources are currently exempt from meeting the required 90% success criteria set forth for all resources in ERCOT regarding Scheduling Control Error (SCE). However, wind resources are encouraged to maintain a reasonable difference between their High Sustainable Limit (HSL) and Low Sustainable Limit (LSL) output to allow some flexibility to grid operators in issuing necessary instructions. Protocol revisions are in progress to stop a current practice by some wind resources who equate these two output limits, which prevents the system operator from being able to curtail output to manage congestion or over-generation conditions.[25]

Failure to meet resource plan update timing requirements or down balancing bid requirements in ERCOT will result in failed performance metrics, and potential fines and sanctions from the Texas Regional Entity (TRE). In the CAISO, failure to report significant outages or de-rates within 60 minutes of an outage results in a tariff violation and repeated failures result in quickly escalating fines.

To a large extent, a resource owner's ability to reliably, and cost-effectively, meet these requirements will play a pivotal role in the long term profitability of their projects.

---

[24] See ERCOT Nodal ICCP Handbook at http://nodal.ercot.com/docs/pd/irt/odfr/icchb/ERCOT_Nodal_ICCP_Communication_Handbook_Ver.1.0.doc .

[25] See ERCOT Protocol Revision Request 773 (PRR773), Setting the LSL Requirement for WGRs, at http://www.ercot.com/mktrules/issues/prr/750-774/773/index.

5 Practical ways for resource owners/operators to address operational requirements and challenges

There are two key options for an intermittent resource owner to consider when purchasing or developing a new wind project. The first option is for the resource owner to retain control of their resource's output and scheduling responsibilities. The resource owner may enter into a term agreement to sell the energy to a specific buyer or may simply sell the power into the Day-Ahead and/or Hour-Ahead energy market. The second option available to a resource owner is to enter into a longer term agreement where the buyer takes ownership of the resource's output as well as the responsibility for forecasting, scheduling, compliance, and 24x7 operations support. There are also arrangements that are a combination of options one and two where some responsibility for compliance and real-time operations remain with the resource owner even though the buyer provides scheduling services and takes on some of the regulatory compliance responsibilities.

Regardless of how responsibilities are split, whichever entity is required to provide market operations services for a wind resource must find a cost effective solution to meet regional scheduling and operational requirements. Our experience with multiple wind farms in several different regions indicates that wind owners/operators can meet these responsibilities by using the following best practices to create a comprehensive integration solution.

5.1. Best practices

When deciding how best to meet regional operational requirements wind resource owners/operators should investigate best practice service options. These service options apply to the entity or entities that bear the scheduling and operational responsibilities regardless of whether that entity is the resource owner/operator or a buyer of generated energy who has assumed those responsibilities. Unlike most traditional generation, wind farms are not typically staffed 24x7. Rather, operating such facilities require remote monitoring and control capabilities. Additionally, wind resource owners must assess the best method to address the costs and risks associated with forecast to schedule integration.

The decision on how to provide around-the-clock operations support hinges on the size of responsible entity's portfolio. An entity, particularly one with a large mixed generation portfolio, may have a 24x7 staff in place with sufficient capacity and experience with wind generation to handle grid operator communications (i.e. outage reporting, dispatch instructions) and to control active and reactive power output. However this is frequently not the case. Another attractive option, particularly for entities with small generation or wind-only portfolios, is to outsource these responsibilities to an experienced service provider. The service provider will manage some of the risk associated with operational activities and can leverage economies of scale and scope to provide cost effective 24x7 services.

The entity responsible for scheduling a wind resource can implement either an automated or manual method for converting forecasts into schedules, and submitting them to the grid operator scheduling interface in accordance with Day-Ahead and Hour-Ahead scheduling timelines. This work can also be done by hand, but the need for a highly reliable method for completing this repetitive task makes a manual approach extremely unattractive. Depending on the resource specific contractual arrangement, scheduling may also include creating and uploading a trade schedule to the grid operator interface, and communicating the details to the counterparty.

There are several options for meeting the scheduling and operational requirements for wind resource generation. The responsible entity can decide to meet all of the requirements internally, outsource some specific responsibilities, or outsource all of the responsibilities to a third party that offers a comprehensive integrated solution under a Software as a Service (SaaS) arrangement. Many wind developers are selecting the last, more comprehensive option so they can focus on their core competency of development and/or wind farm operations.

5.2. Desired features of a comprehensive Integrated Solution

One good option for meeting the scheduling and operations requirements is to contract with a comprehensive integrated solution provider that would handle the logistics related to wind generation operations and scheduling. The ideal solutions vendor would provide the following features in the service package:

- A proven, hosted solution that simplifies and shortens the setup process and in the long term, insulates the responsible entity from the cost and distraction of implementing internal scheduling processes and procedures, including addressing ongoing changes in market rule and compliance requirements. This service provider would host the technical infrastructure to provide all of these services and would therefore absorb the cost of developing, managing, and updating a reliable integrated solution that includes production quality hardware and communications.
- An experienced 24x7 operations support desk to meet grid operator requirements and to avoid regulatory compliance issues. This desk would take advantage of regional experience managing wind resources to minimize the risk of regulatory penalties and investigations. These risks are becoming an industry wide source of concern and are becoming a greater risk for intermittent resources as grid operators and regulators implement tariff changes to address their own challenges.
- Ready to provide data and operational information as requested by wind resource owners/operators and assist them in disputes and possible regulatory notice of investigations as required.

This approach is quick to implement, provides a fixed cost for service, and defers much of the risk associated with operating a wind resource in a changing regulatory environment.

6 Conclusion

Renewable resources are too important to be overlooked in addressing global climate change and are expected to play a major role in meeting goals to improve the quality of the environment worldwide. Therefore, it is instrumental to take the necessary steps to upgrade transmission systems to enhance the transfer of significant amounts of reasonably priced and environmentally friendly resources to major population centers. Given the fact that the investment in transmission upgrades is a small fraction of the overall cost of meeting power needs and such upgrades last for several decades, it makes economic sense to enhance the transmission system.

Operationally, the key challenge is to identify practical solutions to enhance the coexistence of renewable resources with other conventional resources. These operational requirements for intermittent and non-controllable renewable resources need to be more than an after-thought for resource owners. Grid operators are, justifiably, putting more requirements in place on existing capacity, and thus owners/operators of renewable energy must be prepared to meet these increasing operational requirements. Both resource owners and grid operators will benefit from the resulting smooth operations as renewable resources become a larger part of the nation's resource portfolio.

As described in this paper, system operators, resource owners, and solution providers have already taken positive steps to enhance further integration of renewable resources into transmission grid. The lessons learned and steps taken to address various operational concerns should enhance the smooth transition to an electrical system that is increasingly reliant on environmentally friendly and economical renewable resources. The authors have full confidence that time will provide successful solutions to the early challenges and that renewable resources will demonstrate their well deserved place among various energy sources in meeting both the growing demand for electricity and the desired environmental objectives.

References

California Independent System Operator (2007), Integration of Renewable Resources: Transmission and operating issues and recommendations for integrating renewable resources on the California ISO-controlled Grid, November. Also available at: http://www.caiso.com/1ca5/1ca5a7a026270.pdf .

Electric Reliability Council or Texas (2008), System Planning Division Monthly Status Report to Reliability and Operations Subcommittee, Austin, Texas, September. Also available at: http://planning.ercot.com/reports/sysplanning/ .

Forest Stewardship Council (2008), Benchmarking Air Emission, May.

Hill, Gail Kinsey (2008), "Extra water, wind strain Northwest power grid", The Oregonian, June 27. Also available at: http://www.oregonlive.com/news/oregonian/index.ssf?/base/news/1214537148233820.xml&coll=7&thispage=1.

International Energy Agency (2008a), Energy Technology Perspectives: Scenarios and Strategies to 2050, A Luncheon Presentation in Support of the G8 Plan of Action, Tokyo, Japan, June 6.

International Energy Agency (2008b), IEA Work for the G8-2008 Messages: Report to the G8 Summit, A Report Provided in Support of the G8 Plan of Action, Hokkaido, Japan, July.

Massy, Janice, Knight, Sara, Moller, Torgny, McGovern, Michael, O'Brian, Heather, and Dodd, Jan (2008), "An Acceptable Basis For Negotiation", Wind Power Monthly, February, p. 57-61.

Mouawad, J. (2008), Barreling Along: The Big Thirst, The New York Times, April 20. Also available at: http://www.nytimes.com/2008/04/20/weekinreview/20mouawad.html?pagewanted=1&ei=5070&en=004f68ff2f7b1db7&ex=1209355200

NewEnergyNews (2008), Why In the World Is the Oil Prices So High?, June 22. Also available at: http://newenergynews.blogspot.com/2008/06/why-in-world-is-oil-price-so-high.html

North American Electric Reliability Corporation (2008), 2008 Long-Term Reliability Assessment: 2008-2017, Princeton, New Jersey, October. Also available at: http://www.nerc.com/files/LTRA2008.pdf

Public Utility Commission of Texas (2008), Docket No. 33672, *Commission Staff's Petition For Designation Of Competitive Renewable Energy Zones*, ERCOT`s Informational Filing of The GE Ancillary Services Study, April 2. Also available at: http://interchange.puc.state.tx.us/WebApp/Interchange/application/dbapps/filings/pgSearch_Results.asp?TXT_CNTR_NO=33672&TXT_ITEM_NO=1014 .

Stern, Nicholas (2007), The Economics of Climate Change: The Stern Review. Cambridge, UK, Cambridge University Press.

Working Group for Investment in Reliable and Economic Electric System (WIRES, 2008), Integrating Locationally-Constrained Resources Into Transmission Systems: A Survey of U.S. Practices, in Conjunction with CRA International, October. Also available at: http://www.wiresgroup.com/index.html.