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2006 Spring Electric Energy Conference

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RMEL
2170 S. Parker Road,
Suite 225
Denver, CO 80231
Phone: (303) 695-0089
Fax: (303) 695-0784
www.rmel.org

Executive Director
Ed Blum, CAE
Email: edblum@rmel.org

Associate Director
Tim Blum
Email: timblum@rmel.org

Education Director
Kevin Greene,
kevingreene@rmel.org

Administrative Assistant
Marian Burrell
Email: marianburrell@rmel.org

Communications Coordinator
Theresa Russo
Email: theresarusso@rmel.org

PUBLISHED BY:
Lester Publications, LLC
2131 NW. 40th Terrace Suite A
Gainesville, FL 32605
(877) 387-2700

President
Jeff Lester (866) 953-2189

Editor
Amber Billman (877) 387-2700

Art Director
Vince Saseniuk (866) 890-8756

Graphic Designers
Kevin Forde, Kyungmi Jin

Advertising Representatives
Maria Burgess-Martonick,
Heather Campbell, Sean Davis,
Shannon Evans, Louise Peterson,
Michelle Raike, Jennifer Shurvell

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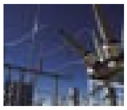
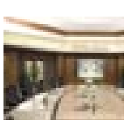
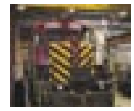
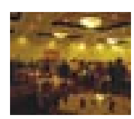




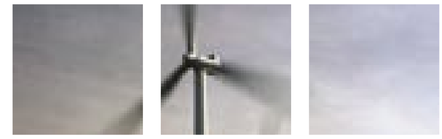




Departments

Questions about Utility Wind Integration

Courtesy of National Renewable Energy Laboratory



By J. Charles Smith,
Utility Wind Integration Group
Based on an editorial published in the November/December 2005 issue of IEEE Power & Energy magazine

Introduction

The winds of change are blowing. From the early 1980s through the end of 2004, we saw 6,400 MW of wind capacity installed in the U.S. In the three year period of 2005-2007, we expect to see the installed capacity more than double to 15,000 MW. This is a truly phenomenal growth rate for a new technology, and a truly exciting time to be a part of the power industry. This rapid change has brought with it the need to better understand the nature of this new technology and the impacts that it will have on the design and operation of the power system. As the Executive Director of the Utility Wind Integration Group (UWIG), I have the pleasure of working with a broad cross-section of people to understand the impact of those changes, and to learn from and help inform and educate those in the industry about the shape of the future.

UWIG works with a broad cross-section of many visionary and committed people both inside and outside the power industry, who have the determination and the energy to help turn the potential for wind energy into a commercial reality. For those of you who are not familiar with UWIG, we are a non-profit association organized in 1989 whose mission is to accelerate the appropriate integration of wind power into utility systems. We are a technical organization that has focused on identifying and helping to resolve technical issues associated with utility system planning, design, and operation to accommodate significant amounts of wind energy. This includes both large wind plants at the bulk transmission system level, and single turbines or small clusters of turbines on radial distribution feeders.

UWIG is at the forefront of dealing with the problems that are important to utilities, and helping to raise the awareness and understanding of the problems among the interested parties in the hopes of getting them resolved. The interested parties include utility planners and operators, turbine manufacturers, project developers, RTOs and ISOs, the North American Electric Reliability Council (NERC) and the Federal Energy Regulatory Commission (FERC), electrical consultants and meteorologists, and the R&D community. UWIG has been on the leading edge in identifying utility wind integration costs as a major issue and concern impeding the further addition of wind to the system, and initiating work to quantify and resolve the issue. The work has expanded and is now going on at a broad range of utilities across the country and around the world. The same can be said for engineering issues associated with the addition of distributed wind plants on distribution feeders.

The most recent issue identified by the industry as needing our concerted attention is that of model development and verification for use in the full suite of transmission planning programs. We are engaged with the WECC Wind Generator Modeling Group of the Modeling and Validation Work Group, as well as the IEEE Dynamic Performance of Wind Generation Task Force of the Power System Dynamics Committee on this issue, and look to build and strengthen the relationship between the wind community and the IEEE across the board. UWIG is working closely with the IEEE PES Wind Power Coordinating Committee, created at the PES Annual Meeting in San Francisco in June 2005, as well. We would welcome additional participation from the members of the RMEL in both UWIG and IEEE activities.

How is Technology Developing?

Although this article does not deal in any detail with wind technology, wind plants have benefited from steady advances in technology that have been made over the past 15 years. Much of the advance has been made in the components dealing with the utility interface, the electrical machine, the power electronic converter, and the control capability. We have come a long way from the days of the simple induction generator with soft start. We can now control the real and reactive power output of the machine within some design range subject to “fuel” availability, we can limit the positive ramp rate of the machine, we can control voltage, we can limit power output, we can design for low voltage ride through, and soon will be able to provide governor functions and controlled ramp down during high wind speed events. All of this comes at a price, but it is a quickly moving technology that has a great deal of capability. It takes a good understanding of the needs of the power system, knowledge of the machine capabilities, and good applications knowledge of the power converter and controls capability to put the whole picture together.

Wind Power Status

The wind industry is young by power systems standards, but has made great strides in the past 20 years. Wind turbine capacity has grown from 50 kilowatts to production machines of two to three MW and more. The unsubsidized cost of energy at the bus bar has dropped by more than 80 percent from 15-20 cents/kWh to the range of 4-6 cents/kWh today. Increasing reliability has contributed to the cost decline, with availability values of modern machines of 97-99 percent. Other major contributing factors include economies of scale associated with larger rotors, improved energy capture with customized airfoils and variable speed controls, taller towers reaching higher wind speeds and manufacturing learning curve effects.

Deployment is being driven by cost competitiveness, increasing concern about high natural gas prices and volatility, and public policy goals reflected by state renewable portfolio standards (RPS) requiring a percentage of electric generation to come from renewable sources. By January 2005, 18 states had a RPS, with three to five additional states looking likely to add to the number in 2005. Wind expansion has been aided by a Production Tax Credit (PTC), which, on a 30-year levelized basis, reduces the bus bar cost of wind energy by about $.01/kWh. Although there is broad political support for this credit, which is intended to compensate to some degree for subsidies enjoyed by all other major energy sources, the PTC has been available erratically over the past several years. This has hampered orderly growth of the wind industry.

The attractiveness of the wind business is being increasingly recognized by established, diverse energy and utility companies. Two of the largest developers and owners in the U.S., FPL Energy and PPM Energy, are unregulated subsidiaries of utility holding companies. AES Corporation recently acquired long-time wind developer/operator SeaWest Wind Power. Goldman Sachs has acquired another significant developer, Zilkha Renewable Energy, and the electrical equipment supplier Siemens has just acquired the Danish turbine supplier Bonus. Since its acquisition of Enron Wind, GE has become the largest wind turbine supplier in the U.S. These and other similar actions add new capital and capabilities to the burgeoning industry and illustrate that wind is moving into the mainstream of generation sources.

FERC Rules Getting Updated

The technology advances are taking place in a quickly changing regulatory environment. The Federal Energy Regulatory Commission is dealing with an important set of issues that will have a significant impact on the future of wind integration. This provides a regulatory backdrop for activities taking place in the commercial marketplace. Many power engineers have not dealt with FERC in the past, that having been the province of lawyers. Things have changed recently with the prominence of wind issues on the national agenda.

In late 2004 and early 2005, FERC held three technical conferences related to wind energy. The first dealt with the issues of reactive power control, low voltage ride through, and communication and control capability for wind plants as a result of the AWEA grid code filing. This resulted in a grid code Notice of Proposed Rulemaking (NOPR), and a subsequent Order 661 in the summer of 2005. The second was an open forum on changes that needed to be made to market rules to enable wind to better compete in wholesale electricity markets. This conference also resulted in a NOPR, this one dealing with the reduction of imbalance penalties for deviations from scheduled wind energy deliveries in return for providing a short-term wind plant output forecast. This is a very critical issue for non-RTO areas operating under the FERC Order 888 tariff, as in most of the RMEL footprint. The third conference was devoted to an examination of alternative transmission products that could allow use of transmission capacity that may be contractually committed, but physically unused. This is described as a flexible-firm product, which would require modifications to the existing tariff language. Both BPA and PacifiCorp are pursuing this alternative at the present time.

And So Are the NERC Rules

We are in a time of transition now with regards to some time-honored utility terms, like control area and CPS2. We are all having a hard time getting used to saying balancing area and balancing authority (BA), but we are getting there, slowly but surely! NERC has taken note of the changing industry structure with its new functional model and new vocabulary, and it is now taking note of wind developments, as well. NERC created a Wind Energy Task Force chaired by Mahendra Patel of PJM in December of 2004, as part of the Planning Committee. The task force represents a broad cross-section of industry, and includes a UWIG representative. NERC recognizes that the grid code issues will deal with issues of reliability, and believes that it has something to say about reliability standards for the electric power system. The task force is charged with examining existing NERC reliability standards for applicability to the issues dealing with wind generation, and reporting back to NERC on whether any additions or modifications need to be made to the standards to deal with specific issues related to wind. The low voltage ride through issue has already been identified as one that may fall in this category.

Courtesy of Utility Wind Integration Group

A Look at a Few of the Integration Questions

As with any new technology, wind technology brings with it a whole host of new issues and questions to be dealt with. The remainder of this article will discuss four of the most commonly asked questions from utility planners and operators. A great deal of additional information dealing with these questions can be found in the November-December 2005 issue of the IEEE Power Engineering Society magazine, *Power & Energy*, in a special issue devoted to utility wind integration. The articles also mention a number of studies for those interested in more detailed information.

Look at it in Terms of the N-1 Criteria

One issue that is often raised is what happens if the wind stops blowing everywhere simultaneously, and the output of all of the wind plants goes to zero at once. How will we handle such a large loss of generation? The application of meso-scale wind forecasting techniques has shed a great deal of light on this question in the past two years. We now know that there is a significant benefit to geographic dispersion, because the wind patterns vary considerably over large geographic regions, and there are significant benefits to both the dispersion of the wind turbines and to their aggregation. This aggregation provides substantial smoothing of the output, especially at the shorter time scales, while the dispersion provides smoothing in the longer time frames. The wind is always blowing somewhere! The recent study performed by GE for the New York Independent System Operator provides a good example of this point. The study investigated a 10 percent wind penetration scenario, or about 3,300 MW of nameplate wind capacity on a 33,000 MW peak load system. The capacity was located across the state at 30 different locations. There was no credible single contingency that led to the loss of all capacity in the state. The system is already designed to handle a single contingency of the loss of 1200 MW, and there was no need to revise that planning criterion at that level of wind penetration.

New Challenges of Variable Output

Another concern that I often hear raised about wind power from knowledgeable professionals is what to do about the fact that the wind doesn't blow all the time, and you cannot count on the wind power being there when you need it. This is a valid concern and should be raised by those who are charged with the responsibility of designing a reliable power system that meets our conventional LOLP expectations of one day in 10 years. As a profession, we have built up a substantial body of knowledge over the past 50 years dealing with that question. Roy Billington's work on probabilistic reliability methods is a prime example.

Given adequate data, the contribution of a wind plant to system reliability, in the form of effective load carrying capability (ELCC) can be quite adequately calculated. Quite often, the wind plant output is significantly out of phase with the daily load shape, and when that is the case, there is only a small contribution to reliability. Once you know that, you accept it, and you move on with the system planning task of designing a reliable system, factoring in the contribution of the wind plant to system reliability, whatever it may be, even if it is zero. The fact of the matter is that a wind plant is generally an energy resource, not a capacity resource. We live in a capacity world, and we have to think about a wind plant differently. It supplies cheap energy when it is available, and it is a valuable contribution to a well-designed system.

A number of investigators have pointed out that you need to look at wind plants, which are an unconventional form of generation, in an unconventional way. And that way is to look at them as load – negative load that is, and not generation. An examination of the statistics of wind production shows that it behaves much more like load than generation. Instead of talking about "firming up" the wind to make it look like something that it is not, accept it for what it is, and deal with the net load accordingly. We're used to dealing with the aggregate load, which has a large degree of random behavior and uncertainty, so let's begin to think about dealing with this new net load in the same way. We don't try to balance each load on the system, so let's not try to balance each wind generator on the system. It is the net system load that's important.

We also have to think about the evolution of the generation capacity mix in a future where there is a growing fraction of energy from wind. Several studies have shown that simple cycle gas turbines with very low capacity factor are an economic complement to wind plants from a system point of view.

How to Handle Variability

Recent integration studies have shown the benefits of having a deep, liquid well-functioning spot market in which to conduct financial settlements of deviations from wind plant output forecasts. It is the system that needs to be balanced, not every plant and load on the system. At penetration levels of 10-20 percent, as measured by the ratio of wind capacity to peak load within some boundary, there is usually a small but measurable increase in the ramping requirement of the balancing area that can be met by existing generation. At penetrations pushing 30 percent, the more serious problem that starts to appear is minimum load at light load conditions when the wind is blowing strong. Even without wind plants, utilities sometimes run into minimum load problems on baseload units that must be available to serve the next day's load. This problem can be aggravated by the presence of wind plants and can lead to the need for wind plant curtailment in some circumstances. Alternatively, it can be addressed through the addition of price responsive load and more flexible generation in the future. This situation is another example of the need for energy markets spanning broad geographical regions and providing increased flexibility in operating the system. A more natural barrier defining the geographical limits over which systems can be balanced and operated is transmission constraints, which limit the ability to provide ancillary services and scheduling flexibility to resources within the constrained area.

Control Area Implications

Now that we have all made the transition from control area to balancing area, and control area operators to balancing authorities, we take note that some concern has been expressed by small BAs facing the location of a sizable wind plant in their balancing area. They are concerned over how it will impact their control performance, particularly CPS2. Once they get that figured out, they may then have to forget about CPS2 and start looking into the Balancing Authority Area Limit (BAAL), if we have a new balancing standard. But the issue is still how to maintain system balance. When I recently asked this question of a system operator, I got a surprising answer. He said maybe we should start thinking about consolidating small balancing areas, so we could afford to concentrate our resources on larger balancing areas with more modern hardware and software facilities, and better training for personnel who have that responsibility. I thought that was a pretty insightful response. That's really what happened in the Electric Reliability Council of Texas (ERCOT) about five or six years ago, when they went from a dozen control areas to one. Imagine what would have happened to CPS2 for West Texas Utilities with the McCamey wind plants, which total about 750 MW. It would have been nearly impossible for them to balance such a small control area with the generation resources they had available. With a simple stroke of the pen, the boundaries were redrawn, the balancing problem was solved, and new transmission is being built to solve the congestion problem. Additional studies are being done of how to better manage the system operation through the integration of improved wind forecasting techniques into the operations planning process.

Put Energy into Solving Problems

A lot of energy from a lot of people is going into the discussion of how to deal with the growing presence of wind plants on power systems. A whole host of issues is up for discussion – how to handle the new interconnection requirements; how to handle the changes in the planning process; how to cope with the need for new transmission; how to figure out the additional costs and

benefits associated with wind energy; what if any changes need to be made in operating practices; what technology developments may help to better manage the process of change; and what rules need to be changed so that wind generators are not disadvantaged in a system designed for fossil generators. So far, good progress is being made, and a significant body of operating experience is being developed. We have the European pioneers of Germany, Spain, and tiny Denmark and Ireland to whom to look for some early guidance and lessons from overseas. In this country, the can-do attitude exhibited by ERCOT, California Independent System Operator, and Xcel Energy, three of the pioneers in integrating wind into their systems, continues to be a source of inspiration for the rest of us, as well as providing us some valuable experience and lessons learned from the U.S.

Most Complex System in the World

It has been said many times that the electric power system is the most complex machine ever devised by man, more complex even than the manned space flight program. The design and operation of such a machine could only be carried out by an incredibly talented, capable, intelligent group of people. That group of people, of course, is the long list of scientists, engineers, technicians, mathematicians, computer scientists, and ordinary people who have dedicated their lives to the development, care and feeding of this machine. I would submit that this is still the most creative, talented, intelligent, and dedicated group of any professionals in the world. We have been faced with challenges and problems throughout the history of the industry, and we have always risen to the occasion, solved the problems, and moved on to the next one. I have every reason to believe that we will do the same here.

New Day Dawning

A new day is dawning. Wind generation is the fastest growing source of energy worldwide. This has created the necessity of a fundamental realignment in our thinking for many of us. We need to figure out what the implications of all this are, and get on with the business of helping to create the future. The right combination of new technology, new rules, adequate investment, and positive attitudes will get the job done. There is a wealth of experience available in every corner of the industry to help deal with the issues, and I look forward to working with you to do it! RMEL

Mr. Smith is a Senior Member of the IEEE PES and a member of CIGRE. He received his BSME and MS degrees from MIT in 1970. He is currently the Managing Director of the consulting company Nexgen Energy, and also serves as the Executive Director of the Utility Wind Interest Group (UWIG). Previously, he served as President of Electrotek Concepts. He has 35 years of experience in the electric power industry. The author may be contacted at charlie@uwig.org