Southwest Power Pool

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Wind Power Capacity Accreditation White Paper

PREPARED BY

Southwest Power Pool Generation Working Group

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Revisions

Revision	Date	Description of Modification
0.a	September 9, 2004	Original for GWG Review
1.a	September 21, 2004	Bruce Walkup and Mike Sheriff comments
1.b	September 22, 2004	Changes per September 22 GWG conference call
1.c	September 23, 2004	Sherry Jensen comments
2.a	September 29, 2004	Changes per September 27 GWG conference call

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Background

The Generation Working Group (GWG) was assigned the task of determining how much capacity credit a wind turbine should receive for serving load in determining an entity's planning capacity margin, as well as for load flow model building purposes. This paper will discuss how this was done. It will cover:

- Participants
- Criteria
- Methodology
- Run-of-river Hydro Comparison
- Other Pool Ratings

Participants

The GWG received input from a broad group of participants. Team members represented American Electric Power, Arkansas Electric Cooperative Corporation, Calpine Energy Service, Oklahoma Municipal Power Authority, Oklahoma Gas and Electric, Southwest Power Pool (SPP) Staff members, Westar Energy, Western Farmers, and Xcel Energy. Additionally, to help develop the methodology, guests actively participated in many of the meetings, including those from Chermac Energy Corporation, National Renewal Energy Laboratory, Sleeping Bear LLC, Wind Coalition and Zilkha Renewal Energy.

Participants at the GWG meeting reviewed other capacity credits for other entities and evaluated pros and cons of numerous criteria and methodologies for possible inclusion. All participants actively provided insight and input.

Criteria

Early in the process, the GWG discussed some criteria to follow:

- The capacity credit rating for wind should be comparable to the methodology of assigning capacity ratings to thermal units during peak load periods. It should neither favor nor be an obstacle for wind.
- It should be simple so that any party could do the calculation and know the value.
- The value would provide dependable capacity for long term planning capacity margin values. The capacity value would be for long term planning margin calculation, and not operational uses.
- Reliability of the grid would need to be a major factor when evaluating any unit for capacity.

Methodology

NERC's *Compliance Templates for the NERC Planning Standards,* page II-20 states "Generating capability to meet projected system demands and provide the required amount of generation capacity margins is necessary to ensure service reliability. This generating capability must be accounted for in a uniform manner that ensures the use of realistically attainable values when planning and operating the systems or scheduling equipment maintenance."

The reliability and dependability of the wind generator equipment was not a question. The wind capacity question relates to the intermittent and unpredictable nature of wind for long range planning purposes. The largest challenge is estimating what the wind speed will be for long range planning capacity.

In rating other thermal units, one has a predictable and reliable fuel source. Wind speed is intermittent and unpredictable in nature, especially when one looks over the long term planning horizon as is required to determine planning capacity margin. Additionally, it varies greatly from geographic location to location, and varies in speed at different elevations. All these factors contribute to what degree reliable capacity from wind can be included.

Wind speed in the SPP has a negative correlation with respect to load. When SPP loads are at their highest, winds are typically at a minimum. The GWG was concerned that if a single value from historic wind production was used it would not fairly represent wind. Additionally, thermal units are represented by the rating at the exact peak load hour.

SPP existing criteria for rating of a generator (SPP Criteria 12.1.4 Rating and Testing Conditions) states: "Summer Capability Tests are to be conducted at an ambient temperature within 10 degrees Fahrenheit of Rating dry-bulb temperature."

The source of temperatures are defined in SPP Criteria 12.1.5.2 Seasonality, Paragraph d, which states: "The Rating dry-bulb and wet-bulb temperatures shall be obtained from weather data provided in the most recently published American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Fundamentals Handbook." Hence, rating a thermal unit can be done over multiple hours. Therefore, rating wind can be done over a select multiple of hours for a month. This would treat wind in a fair and consistent manner as other thermal units are rated.

The GWG was advised that the financial institutions wanted a minimum of five years of wind speed at a site near the proposed site and one year of wind speeds at the proposed site, which would then be converted into estimated energy production using the manufacturer's proprietary formula. This was needed for the financial institutions to lend funds on the potential venture. Therefore, it was determined to initially use a minimum of five years of data for evaluation of the capacity of wind.

The GWG reviewed the multiple hour concepts as used by the Mid-Continent Area Power Pool (MAPP) and recommended by the National Renewable Energy Laboratory (NREL) in the Effective Load-Carrying Capability (ELCC) methodology.

MAPP's methodology of multiple hours is a set time frame which should usually span their peak load. The hours picked are set and are not tied to load. We found no documentation as to how this was developed.

The ELCC methodology utilizes the hourly wind production Loss of Load Expectation (LOLE) model. An initial simulation of LOLE is done with wind and then another simulation is done using the addition of a new gas turbine, without any forced outage factors. Reiterative simulations are done with changing gas turbine capacity, to determine what size new gas turbine provides the same LOLE as the proposed wind source provided. The new size of gas turbine that represents the same LOLE as the wind simulation is the value for the ELCC or capacity credit for wind. This methodology is guaranteed to cover their peak load. The GWG's major concerns with respect to the ELCC was that LOLE simulations require operating sophisticated and time consuming software that developers typically do not have. It was felt if the GWG could simplify the approach, it would be better for all parties.

In reviewing NREL work on ELCC it was determined that one would not need all the hours for the year, but that if one used the top 10% of the hours it would be a close approximation. This is documented in Figure 1 below. This figure was taken from Modeling Utility-Scale Wind Power Plants, Part 2: Capacity Credit.[1]

The load method calculates the capacity factor (defined as the ratio of the average output to the total output) for the hours during the utility system peak.

The Loss of Load Probability (LOLP) method also calculates the capacity factor, but uses hours in which the risk of not meeting the load is highest. These values are calculated as discussed above.

The weighted method used the same hours as method two. This final method uses normalized LOLP values as weights for the average capacity factor. This allows the method to recognize those hours in which LOLP is more severe and weight them accordingly. The capacity factors are then calculated in the same way as those in the other approaches.

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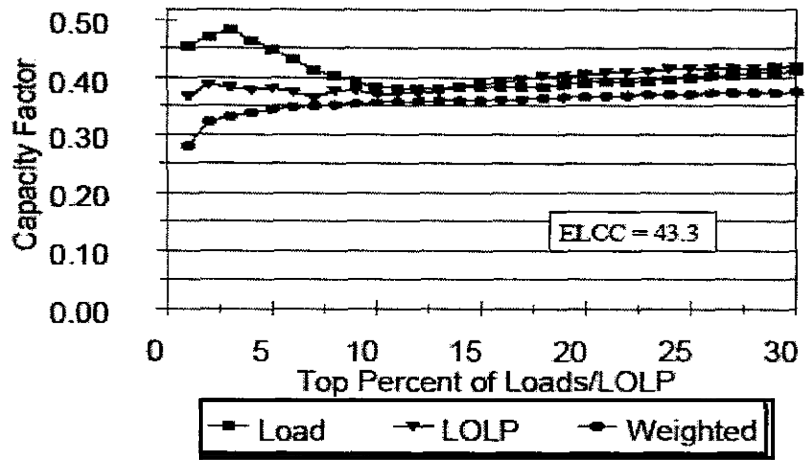
[1] Modeling Utility-Scale Wind Power Plants, Part 2: Capacity Credit by Michael R. Milligan, March 2002 • NREL/TP-500-29701
National Renewable Energy Laboratory

From Figure 1, all three methods appear to converge around the 10% of the load hours.

Figure 1



The GWG discussed using the single annual peak load hour and the wind capacity associated with that hour over multiple years. This value would represent the rated capacity for wind. This is similar to the methods utilities use to determine billing units for system loads. The GWG felt the single hour approach was too restrictive, and could vary wildly depending on the weather during the peak hour.

The GWG then looked at multiple daily time blocks for each month. A concern about this approach was that it was not closely tied with load. It was discussed that in the summer peak hour the wind would be blowing less and using multiple hours would incorporate higher wind speed in hours before and/or after peak, or maybe even a storm in one part of the month, thereby raising the capacity value to something higher than could really be expected at the peak hour.

Summer loads in the SPP are closely correlated with temperature. This is the reason that thermal units must be rated at high temperature, per SPP Criteria 12.1.5.2. The Criteria states "The dry-bulb temperature for summer rating of equipment shall be taken as that which is equaled or exceeded 1% of the total hours during the months of June through September for the plant's geographical location." This restriction means that thermal units must be rated when temperature is above 90° F, for a typical unit in the SPP. If the criteria did not stipulate a temperature restriction, an entity could rate its GT, say at night, when temperatures were cooler and it would give the GT a higher capacity rating than what could be obtained at a higher temperature when peak load occurs.

Temperature restrictions are tied to thermal units making its rating consistent with peak load periods. This was done to ensure the capacity value would be accurate in similar weather conditions when the peak load occurred. The wind capacity should be tied to the anticipated peak conditions. Additionally, since temperature restrictions on rating of thermal units ties their anticipated capacity to peak load temperature conditions the GWG decided a similar approach should be taken with wind. Using the top 10% of the load hours would represent this. Additionally, after reviewing NREL information as presented above, the top 10% of load hours provided a favorable representation.

The GWG then determined to use a minimum of five years, increasing up to ten years of wind data, as actual unit data became available, from top 10% of the host control area load hours in each month in calculating a monthly capacity credit. This would provide one with 336 to 744 data points. Wind could receive a different capacity credit for each month, in a similar manner as thermal units can receive a different capacity credit for summer and winter. The multiple year approach would also normalize the wind over a long horizon. This would treat the wind in an equitable manner to evaluating other units with respect to when capacity can be determined.

The GWG considered using the average wind capacity from across the top 10% of the load hours for the month. However, the average could give you a value that could be larger or smaller than the median. Assuming the average gives you a value that would be achieved half of the time, implying 50% of the time the actual wind capacity would be less then planned wind capacity. A proposal of using one half of average wind capacity from the wind across the top 10% of the monthly load hours was recommended to the Markets and Operations Policy Committee (MOPC). Along with this proposal was a minority recommendation of using a lower value of wind capacity.

After reviewing the proposal of using one half of the average for the top 10% monthly load hours, the proposal was rejected by the MOPC. The MOPC said it was not comfortable with the high value. They directed the GWG to do the following:

- Provide additional justification for the capacity value, or present a method that results in lower value.
- Compare to other regions: ERCOT, WECC(California).
- Provide data from existing sites with at least a year of data: Gray County and White Deer.
- Determine if a maximum value is needed to prevent control areas from exceeding their operating reserve.

For capacity credit, the GWG returned to its concept that it had previously discussed. This was the prior minority recommendation of using a gas turbine (GT) as a proxy. The GWG realized a GT is not 100% reliable and if a 100% reliability criterion was applied to wind, it would not adequately value wind's capacity. When reviewing NERC GADS data for a GT for reliability and considering factors such as actual start, attempted starts, and forced outage, it was determined the reliability of the worst performing group of GTs was in the 85-90% range. For purposes of simplification, this was rounded off to 85%. The concept is to have a value for wind capacity credit wherein the capacity credit holder could expect that value or higher to be there 85% or more of the time, similar to a GT.

To determine the wind capacity credit after one has the control area load and hourly wind production, one takes the top 10% of the load hours for the respective month and the corresponding wind production associated with that hour. One then finds the value that states that 85% of the time that capacity value or higher was present in the top 10% of the hours in the last five years. This value can easily be found by using the "PERCENTILE" function in Microsoft Excel by looking for the 0.15 value. This returns a value for capacity that can be expected 85% or more of the time for the month. This is done for each month and one can determine a different capacity value for each month. The monthly capacity value to be used in determining an entity's planning capacity margin should correspond to the same month for which the peak load exists and for the control areas which are being served.

By using this procedure, it is possible to obtain a dependable capacity value for wind that provides reliable service to customers, while neither promoting nor being an obstacle to wind. In other words, it is treating wind on a fair basis when compared to other thermal units.

Using the data the GWG had available from several wind sites and the application of the above recommended criteria, the following wind sites would have the listed associated capacity credit for the peak load month. It should be noted at this time some sites, as well as SPP, do not have the full five years of actual data; therefore, the values are based upon the years of data provided. The percentage is related to nameplate capacity.

Blue Canyon – 5.5 MW (7.4%) (2 years data)
Gray County – 4.1 MW (3.7%) (1 year data)
White Deer – 7 MW (8.8%) (2 Years)
Woodward – 2 MW (4%) (1 year) (Both OG&E and OMPA expect similar amounts)

Run-of-River Hydro Comparison

Each run-of-river hydroelectric power plant will be unique; however, there are characteristics that make the pattern of electricity production from run-of-river plants distinctly different from the pattern of production from wind plants.

For many run-of-river plants, the rivers on which they are located are not naturally flowing streams. As with the lower Arkansas River, upstream reservoirs exist from which electricity is generated. Hydro plants on reservoirs in the SPP area are generally used as peaking resources, meaning that releases of water for hydro production occur when the load is highest. For such plants, while total annual energy may be highly dependent on annual rainfall, energy generation for a particular day would not be highly dependent on recent rainfall. The same may be said of the run-of-river plants downstream from the reservoirs. Wind generation, in contrast, is totally dependent on current wind conditions.

River flows generally remain at fairly constant levels for at least a multi-hour period, even with releases from upstream reservoirs. This means that the generation from run-of-river hydro, dependent on the river flow, is also fairly constant. Wind generation, in contrast, can vary from moment to moment.

Other Entity Ratings

Several other entities have guidelines on how to determine capacity credit for wind. It must be remembered that different areas have different wind patterns and correlation to loads.

PJM has a small amount of wind. It uses average wind generation during peak hours, 1500-1800, June, July, and August. The capacity credit associated with the location and methodology is about 20%. PJM issues credit for wind but the GWG could find no documentation on the methodology to issue that credit. When the GWG reviewed this option, it was concerned about the difference in wind patterns over the broad spectrum of hours included in PJM's methodology. It was concerned that this would overstate the wind capacity during the peak; hence, the GWG determined that a more reliable value would be determined by using monthly capacity credits as opposed to seasonal. Seasonal credit could easily overstate the dependable capacity that would be present during the peak hour in a planning capacity model. Therefore, for increased dependability, a monthly capacity credit was adopted.

MAPP is similar to PJM; however, MAPP uses an average of a 4-hour window for each day; typical results are 13-30% of nameplate. Again, no documentation on the methodology to issue that credit was found. The GWG reached similar conclusions on the MAPP methodology as it did for PJM.

ERCOT has a large amount of wind and in Spring 2004 decided to use 10% of nameplate in their reserve margin equation. Again, no documentation on the methodology to issue that credit was found.

WECC has no standard. The California Energy Commission in December 2003 stated "wind has no dependable capacity." However, the California Public Utility Commission in July 2004, utilizing the ELCC methodology, determined that three specific sites had an average capacity of 24% of nameplate rating. The three sites are all located in mountain passes and have had wind turbines operating at their locations since 1984 and 1985. This provided 19 to 20 years of actual data. Additionally, at all three sites, new turbines have been added in the 1997 to 1999 time frame. This methodology is similar to the methodology ultimately adopted by the GWG, as they both rely on site specific data. However ,the GWG methodology specifies monthly data as opposed to an annual average, consequently, the value would be more reliable and treated in a similar manner to that of thermal units. The GWG methodology uses top 10% of load hours which Figure 1 shows is an approximation for the ELCC methodology.

Appendix A – July 15, 2004, GWG Report to the MOPC

SPP

Generation Working Group

Criteria 12.1

Rating of Generating Equipment

SPP

Criteria 12.1 - Rating of Generating Equipment

- Net capability not referenced to NERC definition
- Seasonal definitions do not match other SPP processes
- Wind Plant net capability not addressed

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SPP

Criteria 12.1.5.3.g. - Wind Plants OPC Direction

- GWG presented an option at the April OPC meeting; it did not pass.
- OPC direction was:
  - Provide additional justification for the capacity value, or present a method that results in lower value.
  - Compare to other regions: ERCOT, WSCC(California).

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SPP

Criteria 12.1.5.3.g. Wind Plants – OPC Direction

- Provide data from existing sites with at least a year of data: Gray County and Whitedeer.
- Determine if a maximum value is needed to prevent control areas from exceeding their operating reserve.
- Get input from ORWG.

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SPP

Criteria 12.1.5.3.g GWG

- SPP Staff updated their survey of other regions
  - PJM – Has a small amount of wind, uses average wind generation during peak hours, 1500-1800, June, July, Aug, about 20% of nameplate.
  - ERCOT – Has a Large amount of wind - Uses 10% of nameplate in their reserve margin equation.
  - MAPP – Similar to PJM, average of 4-hour window for each day; results are 20-30% of nameplate.
  - WSCC - Has no standard. Cal-ISO is not recognizing wind capacity – only energy.
  - ISO-New York – Small player – Based on average production.

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SPP

Wind Capacity – GWG Recommendation

- GWG met in Dallas on May 11. After much discussion the GWG Voted 4 to 1 for the 85% Ranking Option.
  - Use Wind Generation Data from top 10% Load Hours.
  - Rank this data High to Low and select the generation representing 85th percentile.
- This method forces wind availability to match the worst performing fossil units in the GADS database.
  - Older Gas turbine, 8% failed starts and 7% Forced outage Rate = 85% availability during peak

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Wind Capacity: Input from ORWG

- 2500 MW of Wind in SPP interconnection queue
- At 7% of Nameplate, this is a 175MW of Accredited Capacity.
- At 30% of Nameplate (former option) this is 750 MW of capacity.

Method Results

- White Deer: Using 2 years of Data, Summer Capacity = 7 MW (8.8%)
- Gray County: Using 1 year Data, summer Capacity is 4.05 MW (3.7%)
- Blue Canyon: Based on 3 yrs Wind data, Summer capacity = 5.5 MW (7.4%)
- Woodward: OGE expects 2.5 MW (5%)

Criteria 12.1.5.3.g Language

g. The net capability established for wind plants shall be determined on a monthly basis, as follows:

i. Assemble up to the most recent ten years, with a minimum of the most recent five years, of hourly net power output (MW) data, measured at the system interconnection point. Values may be calculated from wind data, if measured MW values are not yet available. Wind data correlated with a reference tower beyond fifty miles is subject to Generation Working Group approval. For calculated values, at least one year must be based on site specific wind data.

ii. Select the MW values occurring during the top 10% of load hours for the SPP region for each month (e.g., 72 hours for a typical 30 day month).

iii. Select the MW value that can be expected from the plant at least 85% of the time.

iv. A seasonal or annual net capability may be determined by selecting the appropriate monthly MW values corresponding to the host control area's peak load month of the season of interest.

v. The net capability calculation shall be updated at least once every three years.

SPP

ROSTER

Generation Working Group

Company	Representative
AECC	Andrew Lachowsky
AEP	Brock Ondayko
Calpine	Von Maynard
OGE	Mike Sheriff
OMPA	Lori Nutt
SPP	Bruce Walkup (Secretary)
SPS	David Lemmons/Steve Jones
Westar	Steve Massey
WFEC	Mitch Williams (Chairman)