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WIND FORECASTING OBJECTIVES FOR UTILITY SCHEDULERS AND ENERGY TRADERS

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INTRODUCTION

The wind energy industry and electricity producers can benefit in a number of ways from increased wind forecast accuracy. Higher confidence in the reliability of wind forecasts can help persuade an electric utility to increase the penetration of wind energy into its operating system and to augment the capacity value of wind electric generation. Reliable forecasts can also assist daily energy traders employed by utilities in marketing the available and anticipated wind energy to power pools and other energy users. As the number of utilities with wind energy experience grows, and wind energy penetration levels increase, the need for reliable wind forecasts will likely grow as well. This period of wind energy growth also coincides with advances in computer weather prediction technology that could lead to more accurate wind forecasts. Thus, it is important to identify the type of forecast information needed by utility schedulers and energy traders. This step will help develop approaches to the challenge of wind forecasting that will result in useful products being supplied to utilities or other energy generating entities.

This paper presents the objectives, approach, and current findings of a U.S. Department of Energy/National Renewable Energy Laboratory (DOE/NREL) initiative to develop useful wind forecasting tools for utilities involved with wind energy generation. The focus of this initiative thus far has been to learn about the needs of prospective utility users. NREL representatives conducted a series of on-site interviews with key utility staff, usually schedulers and research planners, at seven U.S. utilities. The purpose was to ascertain information on actual scheduling and trading procedures, and how utilities could integrate wind forecasting into these activities. Representatives of the Electric Power Research Institute, who are involved in a European wind forecasting initiative (Landberg, 1997) with Riso (Denmark) National Laboratory also attended most of these interviews.

Background research conducted prior to the scheduling of these interviews resulted in the preparation of a report on the key operating procedures and requirements of utilities. This step oriented investigators to important aspects of energy scheduling and trading before their interviews with utility personnel. The report, prepared with the assistance of Power Technologies, Inc., an electric utility consulting firm (Puntel and Bailey, 1997), describes the basic hierarchy, procedures, and requirements of utility operations. Sections of the report describe generation control, voltage control, economic dispatch, unit commitment scheduling, resource scheduling, and operational planning.

APPROACH

The interview process consisted of several steps: the development of a pre-interview written questionnaire; the selection of utilities; the mailing of preliminary information to the utilities; and the on-site interviews. A discussion of these steps in greater detail follows.

The written questionnaire was designed to guide and document all the discussion points at the on-site interviews. It consists of 25 questions covering three broad topic areas: wind forecasts, general

information, and background information. The following is a partial list of questions within each topic area:

Area 1: Wind Forecasts

- Where within your scheduling hierarchy would wind forecasts be of use?
- When are forecasts needed, and how often should they be updated?
- What is the forecast lead time; the outlook period; the time resolution?
- What is the desired forecast product format?
- How should forecast uncertainty be expressed?

Area 2: General Information

- How much wind generation on your system is necessary to become incorporated into scheduling?
- What value would wind forecasts have when important wind penetration is reached?
- What are the operational concerns over significant wind penetration?
- How might restructuring impact the value of wind forecasts?

Area 3: Background Information

- What is your system's current generation mix, including intermittent sources?
- What is the shape of the average seasonal and diurnal load?
- How much existing wind capacity do you have?
- What is your current scheduling/dispatching/control hierarchy?
- Are weather forecasts used now for other purposes?

The original goal was to interview a representative sampling of utilities. A utility had to have some prior experience with wind energy or future plans to use wind energy in order to be considered for these interviews. Membership in the Utility Wind Interest Group was also welcome. The investigators compiled an initial list of candidate utilities and called a contact within each candidate utility to determine the utility's preliminary interest in participating in an on-site interview. In most cases, this contact was a research planner who had previously attended national wind energy-related meetings on behalf of the company. If the utility expressed interest in participating, the contact person then became instrumental in recruiting the key personnel within the company to participate in this study. This person also helped to plan the logistics for the on-site interviews. A follow-up informational letter was sent to the utility, together with a copy of the questionnaire. The questionnaire was provided in advance of the interview to enable utility staff the opportunity to make an informed decision about whether or not to participate. If a staff member decided to participate, having the questionnaire in advance also helped to formulate thoughtful responses at the interviews.

The investigators interviewed a total of seven utilities between June 1997 and February 1998 (Table 1). We believe that the seven utilities had sufficient diversity in geographic location and size to serve as a good cross-section of utilities involved in wind energy development. The interviews were conducted on-site at the utility for the convenience of the utility staff and to give the interviewers, in some cases, the opportunity to get a feel for the decision-making environment. It is interesting to note that the utility personnel identified by the contacts most often as being appropriate for a wind forecasting discussion were schedulers. The investigators interviewed one or more schedulers plus the research planner at each utility. Dispatchers and energy traders were also included in the interviews at some of the utilities.

RESULTS OF FORECASTING INTERVIEWS

The responses of the seven utilities to the questions in the wind forecasting section contained more similarities than contrasts. All agreed that "next day," defined as the period from midnight to midnight the following day, was an important forecast period. Reliable wind forecasts would aid in planning the utility's unit commitment schedule and its energy trading (buy/sell) activities. The next day forecast is usually needed by early morning (6 am-9 am) in order to meet the mid- to late-morning (10 am-noon) deadline for the next day's plan. There was also consensus among the utilities that forecast products would be most useful if they were expressed as on-line wind-based generation, in units of megawatts. In addition, utility staff preferred that the forecast products be computer based and integrated with current utility procedures.

TABLE 1. SCHEDULE OF UTILITY INTERVIEWS

Utility	Interview Location	Date
Green Mountain Power	Burlington, VT	June 1997
Public Service of Colorado	Denver, CO	July 1997
Northern States Power	Minneapolis, MN	August 1997
Niagara Mohawk	Syracuse, NY	September 1997
PacifiCorp	Portland, OR	December 1997
Central and South West	Dallas, TX	December 1997
Texas Utilities	Dallas, TX	February 1998

Most utilities want the "next day" forecasts in hourly increments of wind generation, though some would accept increments in 3 hourly or 6 hourly blocks. Another area where there was strong agreement among the utilities was how the forecast uncertainty should be expressed. The preferred way to express forecast uncertainty is a range of the maximum and minimum wind generation values. Some utilities also stated that putting a confidence level on a forecast would be quite useful. A couple of schedulers mentioned that a forecast with a confidence level of greater than 70% to 80% would be useful to them. The minimum forecasted wind generation value is the value that utilities would most likely use for scheduling/trading purposes since it's the most conservative. This approach would continue until utility staff gain confidence in the reliability of forecasts.

Utilities also expressed interest in same day and 3 to 7 day wind forecasts. Same day forecasts would be most valuable for dispatching decisions if they were extremely accurate or could reliably predict significant changes in available wind power. The longest forecast time frame that dispatchers would want is an hourly forecast. This would have to be presented to them at least one-half hour prior to the start of the forecast period. The dispatchers we interviewed were more conservative than the schedulers were in their attitudes towards using wind forecasts. A dispatcher mentioned that a forecast with a 95% confidence level would not be accurate enough to be useful. The longer range 3 to 7 day outlooks would be used for two purposes: (1) scheduling at utilities where staff does not work on holidays or weekends; and (2) anticipating the availability (or lack thereof) of all generation sources, especially during critical peak demand periods. The forecast resolution for these outlooks would not have to be hourly; daily trends or averages would suffice in most cases.

There was strong agreement among the utilities that wind forecasts would be important when the installed wind capacity enabled potential wind generation to reach a significant penetration level within their systems. This level ranged from 20 MW to 65 MW depending on the particular utility. After a significant level of potential penetration was reached, utilities would incorporate wind forecasts into the

utility's scheduling/dispatching operations. In addition to generation-related decision making, wind forecasts would help utilities anticipate and manage potential transmission constraints during peak periods. During periods with extreme temperatures, for example, high winds could add to the stress on transmission facilities. Reliable wind speed forecasts would help the utility to better manage any transmission problems. This example points out that wind forecasts can serve more than one need within a utility. The utilities were also unanimous in believing that the industry electricity restructuring would, if anything, increase the value of wind forecasts primarily by providing a competitive edge to schedulers and energy traders.

The major concern that utility staff expressed about the integration of wind energy into their system was related to its intermittent nature. They emphasized the importance, to them, of significant wind generation impact on system reliability and spinning reserve requirements and that forecasts are necessary for each wind plant within a utility system. Their questions about the reliability of forecasts also added to their concerns about integrating wind generation into their systems. Their experience with using meteorological forecasts, primarily temperature, to forecast loads have not always been satisfactory and this skepticism extends to the reliability of wind forecasts.

IMPLICATIONS OF INTERVIEW RESULTS

The interview process determined that wind forecasts would be an essential component of utility scheduling and energy trading operations once a significant potential penetration of wind generation is reached. This has several implications for the future of forecasting for wind plant generation:

1. Several utilities in the United States plan to have significant penetration levels of wind energy within the next few years, indicating that there will soon be a demand for reliable wind generation forecasts.

2. Standard next day wind forecasts would have an outlook period from approximately 18 to 42 hours and would likely rely on a different set of forecast tools than same day forecasting. Same day and next day forecasts serve different functions within the utility. The confidence level necessary to be reliable may be considerably lower for "next day" forecasts than for same day forecasts. Thus, there may be more "margin for error" in next day forecasts.

3. If data from numerical weather prediction models are used to prepare wind forecasts, a mechanism(s) is needed to ensure the wind forecasts used by the utilities are based on the most recent model output available.

4. The accuracy of wind forecasts available from current forecasting methodologies should be evaluated to determine if they would satisfy utility requirements. Potential improvements in forecasting accuracy and spatial resolution could be offered by the mesoscale weather prediction models.

5. Utility schedulers have had little or no experience with wind or other forms of intermittent generation. Thus, there will be a learning curve as utilities integrate this form of generation. The learning curve will also apply to the adaptation of wind forecast information. Future interactions with schedulers would benefit from activities that would familiarize them with such topics as the relationship between the wind and turbine operating characteristics, average diurnal and seasonal trends in local wind characteristics, and the intermittency of electricity output from a wind farm as opposed to a single turbine.

CONCLUSIONS

The value of wind energy to a utility can increase if reliable wind forecasts can be provided. The value of wind forecasts to any particular utility will depend on factors such as the penetration level of wind energy, the utility system's load following capability, the spatial dispersion of wind plants, and the reliability of the forecasts. To date, a relatively small number of utilities have experience with operating intermittent renewable energy generation technologies within their systems. However, as the number of experienced utilities grows and wind energy penetration levels increase, the need for wind forecasts will likely increase as well. It is important to identify the forecast information needed by utility system operators so that forecast approaches can be properly developed and the appropriate products supplied. The results of this utility interview initiative have laid the groundwork for the design of future wind forecasting research. With the help of utility staff, this initiative has clarified their needs and operating constraints and also has established relationships that may prove invaluable when developing and testing wind forecast tools.

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REFERENCES

Landberg, L. (1997). *Short-Term Prediction of Windfarm Power Output-From Theory to Practice.* 19th Conference of British Wind Energy Association Proceedings, pp. 397-402, London, United Kingdom: British Wind Energy Association.

Puntel, W.R; Bailey, B.H. (1997). *Electric Utility Operating Procedures and Considerations*. Work performed by AWS Scientific Inc. Albany, New York. Under Subcontract to the National Renewable Energy Laboratory.