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INTEGRATION OF WIND TURBINE GENERATION (WTG) INTO UTILITY GENERATING SYSTEMS

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Extensive progress has been made in the 1970's along the path of integrating wind turbine (WT) generators into utility systems. Analytical tools have been developed for determining the impact of wind generation on utility cost of generation and generation planning. However, little has been done either in determining the sensitivity of study results to wind power modelling techniques nor in developing methods for determining how WT generation would effect the operation of a utility in meeting its daily load requirements. This abstract describes the analysis performed by JBF Scientific Corporation, for the Pacific Northwest Laboratory, in order to examine the sensitivity of a utility's cost of generation to its ability to accurately forecast wind speeds. The study also examined the sensitivity of utility cost of generation to both wind speed sampling frequency and wind turbine performance model. The objective of the study was to determine the information that a utility would require in order to economically integrate WT generation into the operation of its system.

The study used two-minute wind speed data, measured in 1979 at the DOE meteorological tower located in the San Gorgonio Pass, California, for the available wind resource. The wind turbine simulated on the study was the MOD-2 built by the Boeing Engineering Corporation. Four different simulation methods were used in calculating the expected performance of MOD-2 wind turbines in the San Gorgonio wind environment:

1. A time-dependent performance simulation of machine operation that calculates power output from the 2-minute wind data and includes control logic for startup and shutdown, yawing, and system time constants. For each hour, the 2-minute power calculated is integrated to obtain the WTG's average hourly power output.

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2. An integrated hourly performance model that calculates machine output every 2 minutes. Hourly power output was calculated by integrating 2-minute power output over each hour.

3. An hourly sampled wind speed performance model that uses the last 2-minute wind speed sample taken every hour to represent the hourly wind speed. This method is similar to that used when using SOLMET wind speed data.

4. An hourly averaged wind speed performance model that uses hourly averaged 2-minute wind speed samples in calculating hourly machine output.

The hourly MOD-2 outputs defined by the four techniques were used as load modifiers in defining the net load that must be serviced by conventional utility generating sources. On this study net loads were calculated for the projected 1995 Los Angeles Department of Water and Power (LADWP) generating system assuming a 10 percent WTG penetration. These loads were then supplied to a production cost simulation to estimate LADWP's 1995 annual cost of generation. The results were then used in establishing the sensitivity of LADWP's annual production costs and WTG value to the particular technique used in calculating hourly wind turbine generation.

The study also examined the impact wind forecasting accuracy would have on LADWP operation and costs. The objective of this analysis was to establish the sensitivity of LADWP production costs to wind speed forecasting accuracy in an effort to define realistic goals for wind speed forecasters.

The following results were obtained from the analysis performed on this study. Caution must be exercised in generalizing these results since they were obtained by analyzing a single utility under very specific assumptions.

- Using three different non-time-dependent methods for calculating hourly WTG performance resulted in less than a 3 percent difference in the calculated MOD-2 capacity factor. Similarly, WTG life-cycle value calculated also varied by less than 3 percent regardless of the non-time-dependent model used.

- Averaging 2-minute wind speeds each hour does not appreciably (less than 3 percent) change MOD-2 capacity factor, single-year production cost savings, or life-cycle value from that calculated using wind speed samples taken once every hour when WTG power is calculated using a performance envelope.

- Modeling machine performance with a time-dependent simulation and using 2-minute wind speed data does appreciably change the MOD-2 capacity factor, production cost savings, and life-cycle savings from those calculated using a static performance model. Using this simulation decreased MOD-2 performance by approximately 13 percent. This resulted from a combination of increased machine downtime and a decrease in the time the WTG is computed to be operating at rated capacity.

- The ability of LADWP to accurately forecast wind speeds (WTG power) can increase LADWP's operating savings by as much as 20 percent.

- The ability of LADWP to accurately forecast wind speeds (WTG power) can decrease its dependency on swing fuels such as oil.