

Introduction to Wind Generation Forecasting

UWIG Webinar Wind Energy Production Forecasting

February 9, 2009

in partnership with
NRECA, APPA, WAPA, US DOE, NREL, AWEA, and NWCC



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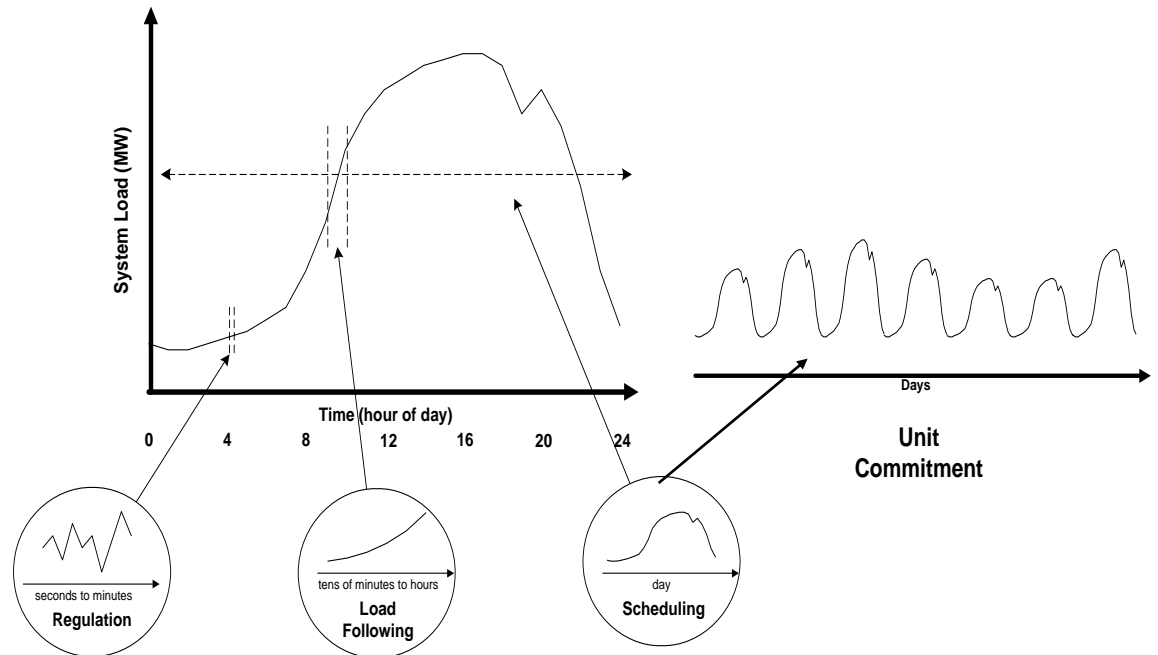
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Operating the Power System

- ◆ ...is a tough business
 - No inventory or warehouses
 - make and deliver product as orders are placed
 - Must have all the product that anyone would ever want - today and forever
 - New "factories" and "delivery trucks" take years to build
 - Also cannot have too much product because of cost

- ◆ Uncertainty has especially significant consequences

- Must error on "conservative" side to maintain high reliability
- Being conservative costs real (big) money, though



Some “Familiar” Uncertainties

- ◆ Load
 - Utilize projections from minutes to decades ahead
 - Significant investment in analysis for prediction
- ◆ Supply Resources
 - Short-term: very predictable, and coverage is provided for surprises
 - Long-term: basic choices have remained unchanged for years; more issues and choices as of late
- ◆ Fuel
 - Prices always subject to escalation
 - Volatility can be more difficult to consider
 - Availability(?)
- ◆ Regulatory & Policy

Wind Energy Characteristics

- ◆ Wind generation is an attractive source of **electric energy**
 - The electric power business traditionally based more on capacity
 - » System planning
 - » Reliability considerations
 - Wind energy doesn't fit this model well
 - » Uncontrollable fuel supply
 - » Cannot really be dispatched
- ◆ Relative to conventional sources, wind generation exhibits more **variability** and **uncertainty** (in operating time frames, anyway)
- ◆ Controllable resources must be used to manage delivery of wind energy in real time
- ◆ With these attributes, wind “looks” more like demand than a supply option

Wind Generation Uncertainty

- ◆ Wind generation characteristics relative to load
 - Driven by meteorology; load only partially
 - Exhibits different “patterns” than load
- ◆ Predictions
 - Percentage magnitude of prediction errors much larger than load
 - MW errors can be significant with enough wind
- ◆ Familiarity
 - Little “seat of the pants” understanding about wind generation and forecasts to date
 - No intuitive understanding of how or when prediction errors are significant for power system operations

Wind Generation Forecasts & Applications

- ◆ Tens of minutes to hours ahead
 - Regulating reserve planning
 - Fast energy market administration
- ◆ Several hour-ahead
 - In-the-day optimization (starting or shutting down flexible resources)
 - Positioning of short-term storage resources (e.g. pumped hydro)
- ◆ Day ahead
 - Traditional unit commitment
 - Day-ahead transactions
 - Market interaction
 - Market clearing security assessment
- ◆ Week(s) ahead
 - Hydro system planning (balance-of-period, seasonal)
 - Expected energy rather than hourly production

Example: WECC Regulating Reserve

- ◆ Hourly regulating requirement based on
 - Variability
 - Forecast error (uncertainty)
- ◆ Methodology can be augmented to consider wind in BA
- ◆ However, wind generation may alter “rules of thumb” upon which current practice is based
 - Forecast error
 - Expected variability
 - Sign of expected change

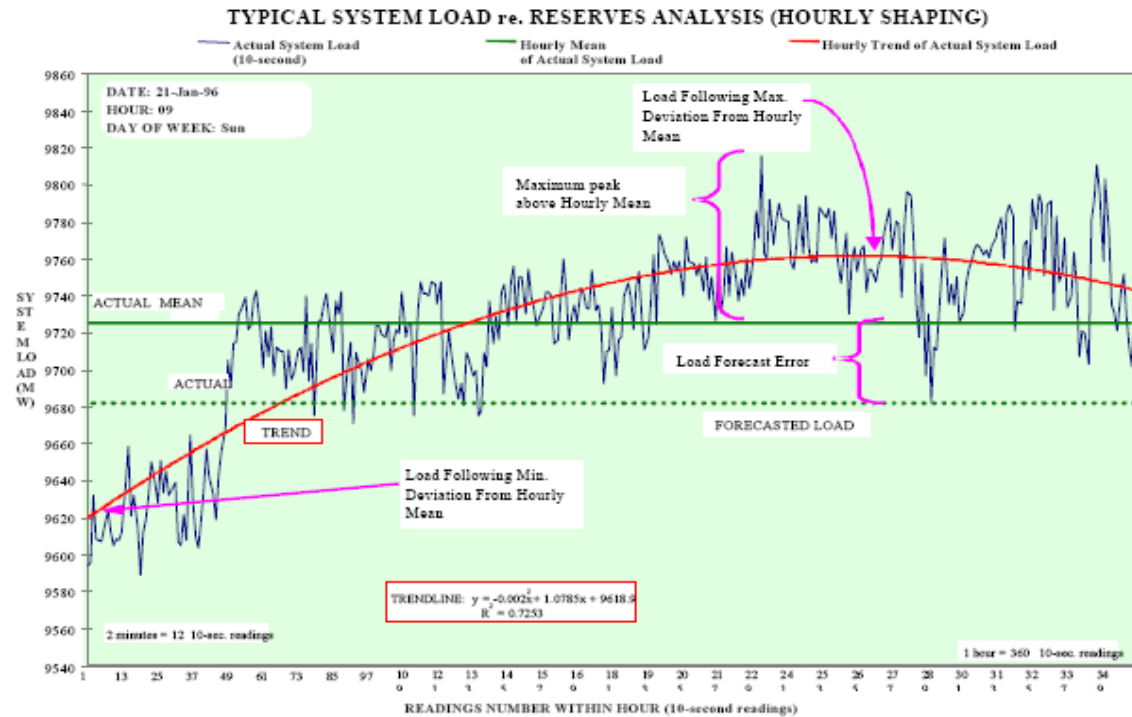


Figure 4

Uncertainty impact on Regulating Reserves

METHOD A: (percentage of load forecast)

$L_v = \pm xx\%$ of the hourly load forecast to account for expected variations about the forecast itself,

Plus

$\pm yy\%$ of the hourly load forecast to account for expected error in the forecast itself.

Based on a control area's experience, xx might be $\approx 1\%$ of the daily peak load forecast. For control area's that perform daily load forecasts, yy is typically 3% . For control areas that use adaptive load forecasts executed every hour, yy could average slightly less than 2% with hourly ranges of $<1\%$ to $\approx 5\%$. For this method, the expected changes during the hour are applied for all 10-minute intervals.

METHOD B: (load following method)

$L_v = \pm \text{MW}$ largest difference between the trend fit of:
last hour's actual load, this hour's and next hour's expected load

And

this hour's expected load over the next 10 minutes.

Plus

$\pm \text{MW}$ band width to account for short term historical load forecast errors that will not be corrected until the next official load forecast is executed.

Forecast error translates directly to regulating reserve requirement

Regulating Reserve Requirement (R_m)

$L_v = 10$ minute forecast change in load @ 95% confidence (increase +, decrease -) 100

Observations

- ◆ “Rules” can translate directly into reserve obligations
 - “hour-ahead” trading
 - Uncertainty must be covered by own resources
 - Wind generation forecast uncertainty can substantially increase overall
- ◆ Variability will be “treated” somewhere
 - Errors in short-term forecasts will increase requirements for shorter-term services (e.g. MISO: 5-min market deviation from actual spills to regulation)
 - Short-term forecast error could have significant economic consequences

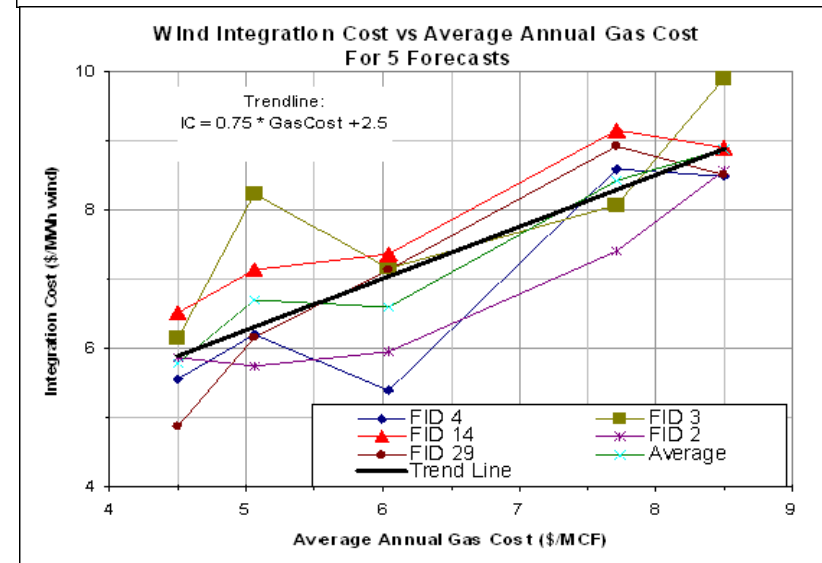
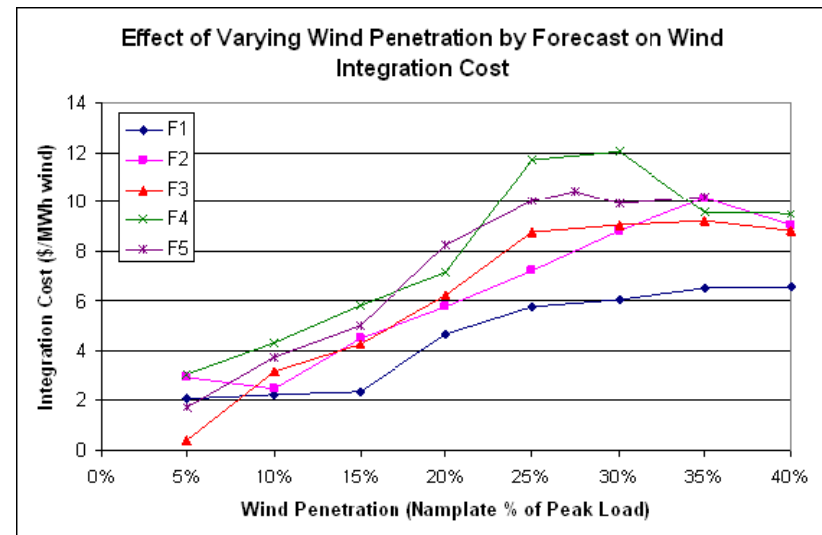
Market Impacts

- ◆ Wind generation forecasting shown to be beneficial for power markets
- ◆ Without forecasting, market players act on bad information

	Unit Commitment	
	With Day-Ahead Wind Forecasting	Without Wind Forecasting
Total variable cost reduction <i>(includes fuel cost, variable O&M, start-up costs, and emission payments)</i>	\$ 430M	\$ 335M
	\$ 95M	
Total variable cost reduction per MW-hour of wind generation	\$48 / MWh	\$38 / MWh
Wind revenue	\$ 315M	\$ 305M
Non-wind generator revenue reductions	\$ 795M	\$ 960M
Load payment reductions <i>(calculated as product of hourly load and the corresponding locational spot price)</i>	\$ 515M	\$ 720M

Observations

- ◆ Wind generation forecast error can substantially increase the magnitude of the overall next-day uncertainty
- ◆ Wind generation can also substantially alter the “shape” of the aggregate daily demand profiles
- ◆ Largest fraction of integration costs attributable to these factors



“Significant” Wind Events

- ◆ Large wind generation changes
 - Loss of production usually of more concern
 - Have been observed in regions with significant wind generation
 - Infrequent, but real
- ◆ Operational policies must make provision for these events
- ◆ Ability to forecast could have substantial effect on operating costs

Challenges for Market Administrators

- ◆ To maximize economic efficiency of market, wind energy to be delivered must be accounted for
- ◆ To insure security, adequate resources to meet maximum expected demand must be lined up in DA time frame
 - SCUC (MISO RAC process after DA market clearing)
 - Input data is net demand forecast, not bids
- ◆ Treatment of wind generation in RAC
 - Ignoring wind
 - » safest from security perspective
 - » results in chronic over-commitment
 - » Market inefficiency due to “integration cost” (RSG payments)
 - “Best” DA forecast
 - » Leaves possibility of being “long” in wind
 - » RAC solution may not provide adequate resources for wind energy delivery that does materialize

“Closing the Loop”

- ◆ Real-time information from operating wind plants is said to be critical for production forecasting
- ◆ Interfacing to control centers and EMSs will be required to fully leverage wind generation forecast information
- ◆ Attention should be paid to the design of these interfaces
 - Be vendor (forecaster or EMS) independent
 - Utilize standard architectures and protocols
 - Examples: IEC 61400-25, Pi Historian archives

e.g. IEC 61400-25

- ◆ A wind industry standard that no one in the wind industry talks about!
- ◆ Is actually very relevant to the wind generation forecasting problem
- ◆ What is IEC 61400-25?
 - A communication protocol to facilitate communications between individual wind machines, their constituent components, wind power plants, area control, and other external systems
 - Utilizes standardized models of individual components to simplify and reduce the cost of system integration

Status

- ◆ Development of forecasting science and technology has been underway for a few years
- ◆ The need for and value of wind generation forecasting is apparent and has been quantified in some assessments
- ◆ Investigation of applications just beginning