Northwest Power and Conservation Council

September 4, 2008

MEMORANDUM

TO: Power Committee

FROM: Wally Gibson

SUBJECT: Presentation on Overview of System Operations and Ancillary Services

This presentation will describe the common ancillary services, generation services that are used to support system operations. It will focus on two of them in particular, regulation and load following, which have become issues as increasing amounts of wind generation enter the system. It will describe the control problem facing a Balancing Authority (formerly called a "control area") in balancing load and resources while maintaining system frequency in real time, given that most of the generation is scheduled in advance of the operating hour. It will address the additional problems raised by wind generation on the system for the provision of these services and suggest the general range of ways of addressing these problems.

851 S.W. Sixth Avenue, Suite 1100
Portland, Oregon 97204-1348
www.nwcouncil.org

Steve Crow
Executive Director

503-222-5161
800-452-5161
Fax: 503-820-2370

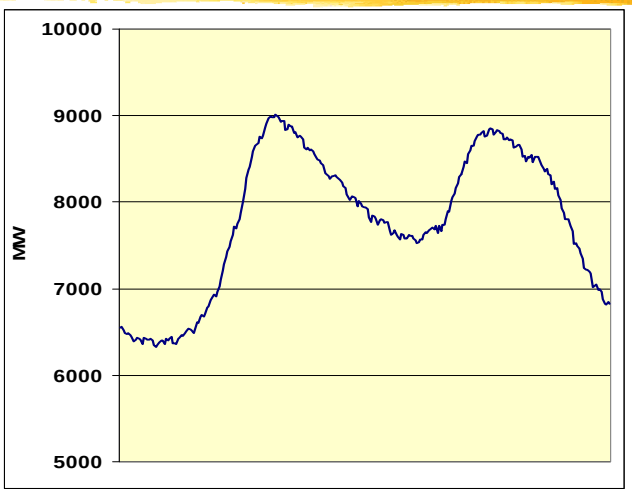
Overview of System Operations and Ancillary Services

Power Committee Meeting
Astoria, Oregon
September 16, 2008

Overview

- Ancillary services used by the system operator to balance loads and generation, deal with sudden outages and maintain system frequency and stability
- Presentation
  - What is the control problem?
  - What are the ancillary services?
    - Focus on regulation and load following
  - What special issues are raised by large amounts of wind in the system?
    - Kinds of solutions

Daily Load Curve – BPA 7 Jan 08



Ancillary Services

- Generation services (mostly) supporting reliable system operations – some required, some prudent practice
  - Contingency-related
    - Spinning reserve and non-spinning reserve
    - Replacement reserve
    - Black start capability (for severe contingencies)
  - Ongoing
    - Regulation
    - Load following
    - Reactive power provision and voltage control

What is the Control Problem?

- Balancing authorities (formerly “control areas”) balance loads and resources and maintain frequency
  - These two are tied together in Automatic Generation Control (AGC)
- Basic control problem driven by load changes and generator outages (will not address outages further)
- Wind, and some other renewables, add uncontrollable generation output to the problem
  - Both regulation and load following implications
  - Predictability, and forecast horizon, are important to addressing this problem

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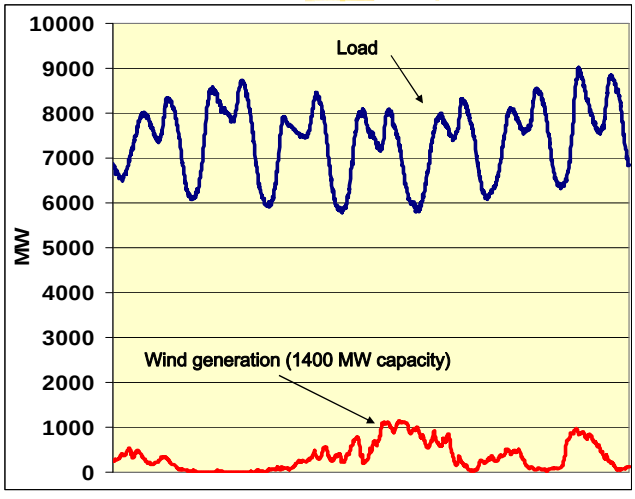
Example Load and Wind Patterns BPA 1 Jan 08 – 7 Jan 08



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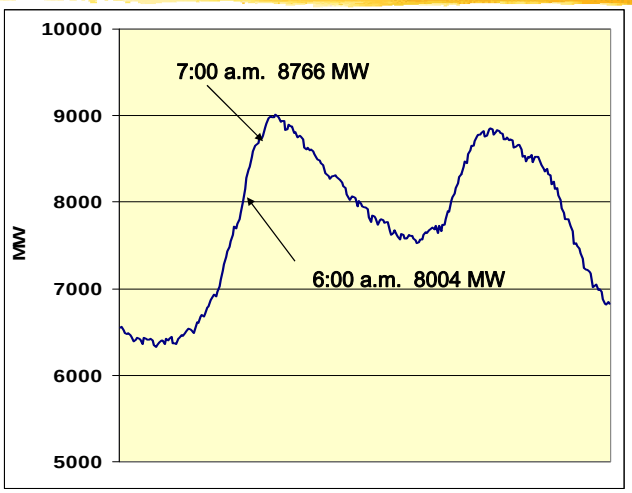
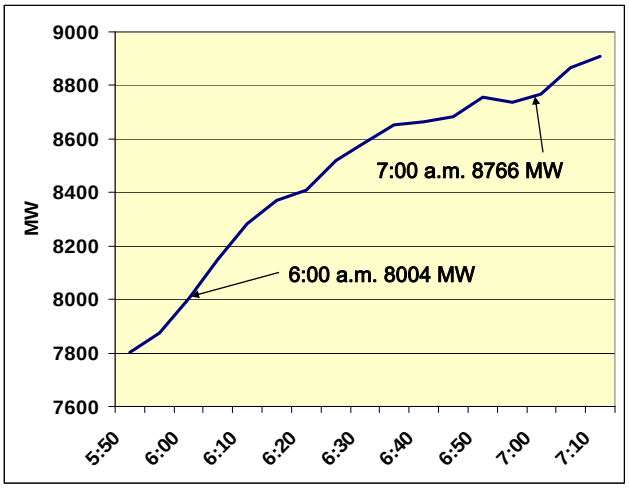
Daily Load Curve – BPA 7 Jan 08



Hourly Load Curve – BPA 7 Jan 08 6:00-7:00 a.m.



Context for Balancing Authority Action

- Commercial scheduling in WECC is done on an hourly basis (except CAISO)
  - Schedules tell the balancing authority what generation and load to expect
  - Schedules are flat and ramp in across the hour, from 10 minutes before to 10 minutes after the hour
  - Schedules can be set from 24 hours to 20 minutes ahead
- Within-hour actions are the responsibility of the balancing authority

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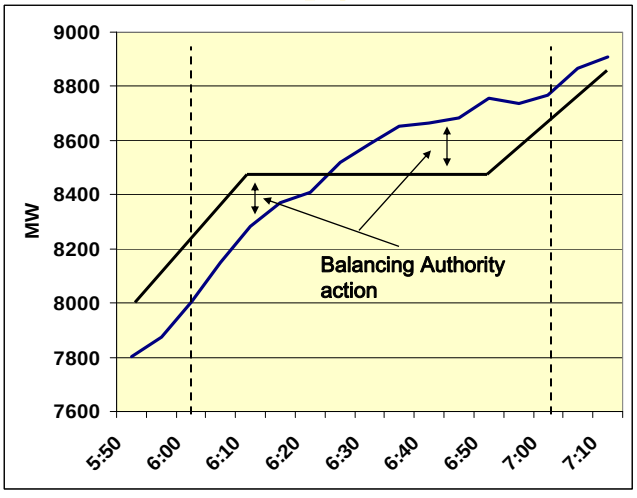
Hourly Load Curve – BPA 7 Jan 08 6:00-7:00 a.m. – Example Hourly Scheduling



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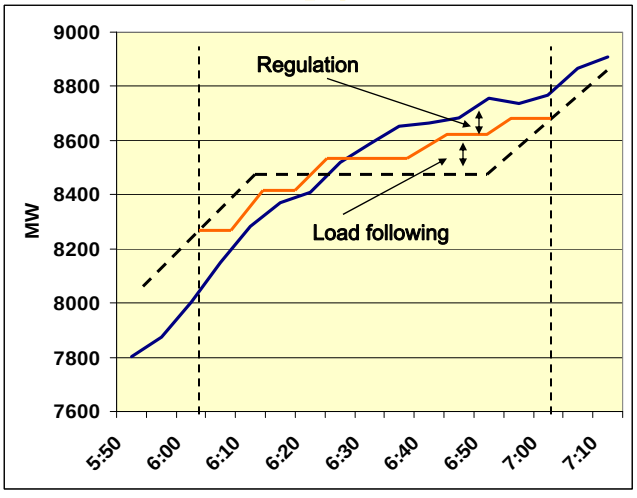
Balancing Authority Action

- Maintain balance between load and resources in its area:
  - While maintaining schedules across boundaries with other balancing authorities (interchange schedules)
  - While contributing to maintaining system frequency
- Two kinds of actions
  - Regulation – follows actual instantaneous load
    - Automatic, 4 second scan, seconds to minutes response
  - Load following – limits amount of regulation required
    - Operator instigated, 5-15 minutes duration

Hourly Load Curve – With Hourly Scheduling and Illustrative Load Following



Regulation

- Required by NERC standards
- Done with Automatic Generation Control (AGC)
  - Operated by balancing authority computer control system
  - Responsive to:
    - System frequency deviations
    - Internal generation
    - Net scheduled interchange
    - Net metered actual interchange
- If interchange is held to schedules and frequency is maintained, generation is exactly meeting load

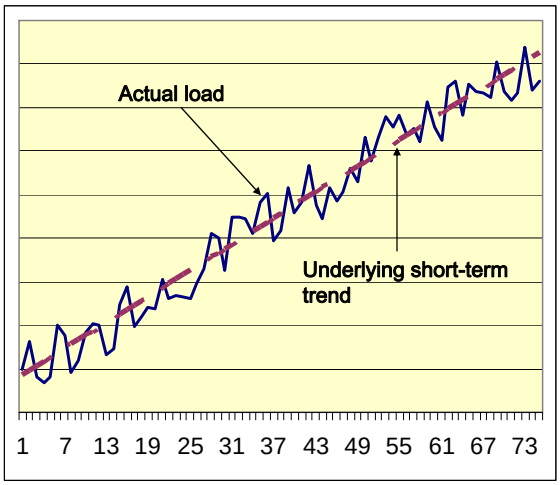
Area Control Error

- AGC calculates Area Control Error (ACE) and acts to return it to zero
- ACE = Actual minus scheduled interchange, adjusted for system frequency deviation
- Statistical measures of ACE are metrics for meeting NERC reliability standards
  - Target is average behavior of ACE
- Goal: small random variations around zero
- Amount of regulation required is empirical determination of what is necessary to meet NERC standards

Load Following

- Not required by NERC standards
  - No uniform metric, though 5 or 10 minute step duration is common
- Done to limit machine movement under AGC
- Done to minimize overall amount of AGC-connected generation required across the day

Example Load Curve – 5 Minutes at 4 Seconds



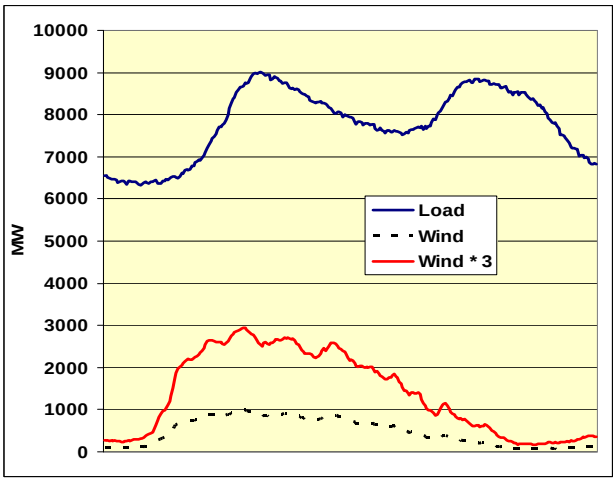
What Does Wind Do to this Situation? – Regulation

- Can make the regulation problem somewhat worse
  - Additive random processes make extremes larger but less frequent
  - Important – NERC standard requires statistical (average), not absolute compliance
    - Being better than the standard doesn't count

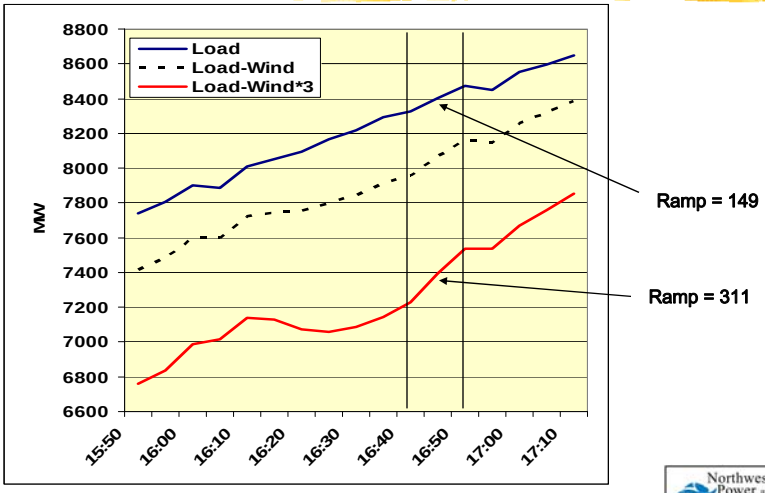
What Does Wind Do to this Situation? – Load Following

- Wind generation can move as fast as load ramps
  - Can make the load ramp problem worse (steeper net ramp) or better (shallower net ramp)
  - Depends on coincidence of wind and load ramps (e.g. both rising, one rising while the other drops, etc)
  - Can affect the system at vulnerable time, e.g., at minimum loads with generators close to minimum output
    - Depends on status of rest of the system
    - Depends on percentage of wind in the balancing authority area

Wind Can Add to the Ramp Problem – Example BPA 7 Jan 08 – Load and Wind



Wind Can Add to the Ramp Problem - Example BPA 7 Jan 08 15:50 – 17:10



Potential Solutions to Load Following – Issues for Future Presentations

- Hardware and institutional changes offer potential solutions
  - One-hour scheduling is a business practice not a reliability requirement
    - Some parts of the country have intra-hour markets for load-following (CAISO in the West)
    - NTTG, Columbia Grid and WestConnect examining this
  - Generation with wider range of efficient operation
  - Fast storage technologies
  - Demand response
  - Better short-term forecasting to narrow the uncertainty