Frequency Response Concerns & Renewable Generation

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Declining Frequency Response Has Been Recognized As A Serious Reliability Concern For Over a Decade

- J. Ingleson and M. Nagle, 1999, *Decline of Eastern Interconnection Frequency Response*, Fault and Disturbance Conference at Georgia Tech, May 3-4
- J. Ingleson and D. Ellis, 2005, *Tracking the Eastern Interconnection Frequency Governing Characteristic*, IEEE
- NERC, 2004, *Frequency Response Standard Whitepaper*, Prepared by the Frequency Task Force of the NERC Resources Subcommittee, April 6

The Cause of Frequency Response Decline Has Also Been Recognized

- Generator regulation is going down mainly because of the quest for efficiency.
  - Steam plants are increasingly operated in sliding pressure mode, that is, in such a way that turbine governors are ineffective.
  - Gas turbines are often operated in exhaust temperature control mode.
  - Although all generating units of significant size have frequency governing in place, an increasingly number are being operated in such a way that they are not capable of picking up additional MW, thus their frequency governing is ineffective. **(J. Ingleson and M. Nagle, 1999)**
- AC motor loads provide damping of frequency changes. Because of the increase in use of solid-state drives, it is reasonable to believe that damping of frequency changes due to motors is decreasing. **(J. Ingleson and M. Nagle, 1999)**
- The first group of generating units has been observed to be without significant governing characteristic. These are, generally speaking, the nuclear units. Some fossil fired units would probably fall in this category, but we do not have a sufficient number of observations to make this judgment. **(J. Ingleson and M. Nagle, 2005)**

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The Cause of Frequency Response Decline Has Also Been Recognized

(Continued)

- Steam turbine generators operating on "sliding pressure" or "boiler-follower" control and/or with "valves wide-open" (VWO) operation.
- Blocked governors on nuclear units for licensing reasons.
- Less heavy manufacturing in North America (proportionally fewer large motor loads and a reduction in "load rejection").
- Variable-speed drives on motors that do not provide the traditional "load rejection".
- A larger proportion of combine cycle units being installed on the system. Combined-cycle units when operating at full output operate in temperature control mode. When the frequency declines, there is a drop in combustion air volume that results from the slowing of compressor speed. This drop in combustion air volume can cause a reduction in the unit output. Figure 6 is a graph of the output of a combine cycle unit responding to a frequency decline.
- Mandatory requirements for governors, even if adopted, do not guarantee that the unit would not be operated at wide-open valves and, therefore, have no response for an under-frequency condition. (NERC, 2004)

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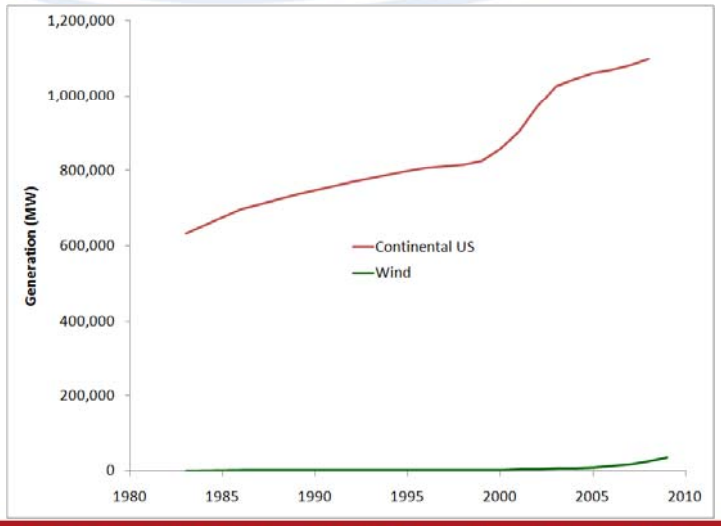
Wind is Still a Small Portion of the Total Generation Fleet



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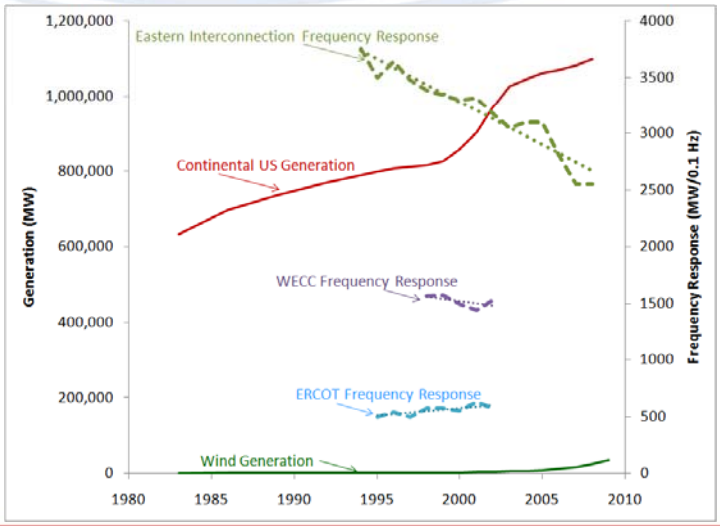
Clearly, Wind Generation is Not the Cause of Declining Eastern Interconnection Frequency Response



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NERC, 2010, *Overview of Frequency Response Initiative* Concerns With Focusing on the Wrong Problem

- Identified frequency response concerns
  - Deadband – currently typical setting is at ±36 mHz
    - ERCOT greatly improved frequency response by reducing deadband to ± 16.6 mHz
  - Sliding pressure controls
  - MW setpoints – limited time for response
  - Blocked governor response
  - Once-through boilers
  - Gas Turbine inverse response
- Inappropriately focused on wind and solar
  - Primary Inertial generation being supplanted by non-inertial resources – wind, solar, electronically coupled resources
    - What is their response to frequency excursions?
    - What is their susceptibility to tripping during frequency excursions?
  - Consider impacts of integration of new generation technologies (such as wind, solar, and significant nuclear expansion)
  - Explore how displacement of inertial generation with electronically-coupled resources might influence Inertial Response

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NERC, 2010, REQUEST OF THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION FOR CLARIFICATION AND REHEARING OF THE ORDER SETTING DEADLINE FOR COMPLIANCE, April 19

- (pg10) "For example, there may be a need to engage generator equipment manufacturers, including wind, solar, and other emerging technologies regarding their control systems used to integrate these resources within the bulk power system."
- … "Additional time may also be required to perform computer simulations of power system dynamics to analyze the inertial response issues. Those analyses will address the potential impacts of the expected displacement of inertial generation with non-inertial resources on arresting frequency excursions in order to assure sufficient 'headroom' from potentially impacting frequency sensitive load and resources." *(emphasis added)*

These are puzzling since the problem predates the introduction of significant amounts of non-inertial generation and the Eastern interconnection still does not have a significant amount of wind or solar generation. NERC would be better served by spending time analyzing the actual problem first.

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Potential Wind & Solar Frequency Response Capability

- Technical capability is excellent
  - Fast and accurate frequency response
  - Synthetic inertia possible with wind
  - NREL, EPRI and others initiating multi-year project testing frequency control on wind turbines
- Capital costs for controls and communications
- Opportunity costs to respond to under frequency
  - Lower energy production cost results in higher opportunity cost
  - Wind and solar are the most expensive sources of frequency response based on opportunity cost

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Possible Solutions

Wind and Solar generation do not cause major frequency events: *Individual generators are small, contingencies are small*

- Technology neutral interconnection requirements may be appropriate for future installations
- Market based solutions to motivate and obtain frequency response may be appropriate

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