Advances in VG Integration

Southeastern Wind Coalition
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What is UVIG?

♦ Non-profit corporation established by 6 utilities in 1989 with support from EPRI and DOE/NREL
♦ Expanded scope from wind to include solar PV in 2011, now Utility Variable-Generation Integration Group (UVIG)
♦ Over 180 members, including ISOs, utilities, developers, manufacturers, consultants, government organizations
♦ Focus on technical issues
♦ Mission: To accelerate the development and application of good engineering and operational practices supporting the appropriate integration of solar and wind power into the electric system
Outline of Topics

♦ Recent Industry Trends and Findings
♦ Flexibility and Forecasting
♦ Transmission and Interconnection Policy
♦ Reliability and VG Integration
♦ Implications for the Future
Relative Position of Major Wind-Producing Countries

Note: Figure only includes the countries with the most installed wind power capacity at the end of 2013
NERC Essential Reliability Services Task Force (ERSTF) highlights:
- Growing interdependence between gas and electricity markets
- Concern over coal plant retirements
- Increased levels of wind and solar
- Maintaining future system reliability

Clean Power Plan (CPP) final rule required 32% CO2 reductions below 2005 levels from power sector by 2030 before stay

New carbon emission rules and coal retirements continue to drive concern for capacity adequacy

Capacity flexibility issue gaining attention

Cost of renewables continues to drop
Renewable Energy is Very Competitive

♦ Lazard reports on lowest unsubsidized energy costs for:
  – Rooftop residential solar:  $180/MWh
  – Simple Cycle GT               $165/MWh
  – Nuclear                                $97/MWh
  – Coal                                     $65/MWh
  – Combined Cycle GT:                  $52/MWh
  – Utility scale solar:               $50/MWh
  – Wind energy:                        $32/MWh

♦ Other reports from industry pubs on recent PPA prices:
  – Utility scale solar       $37-$50/MWh
  – Wind energy               $18-$30/MWh
Some Active Issues and Questions

♦ NERC Essential Reliability Services Task Force (ERSTF)
  – Is the transition to less coal, more gas, more renewables and more demand response a threat to reliability? Specifically:
    ♦ Frequency support (inertial response, frequency response)
    ♦ Voltage support (reactive power)
    ♦ Ramping (mostly CAISO’s concern presently)

♦ EPA Clean Power Plan
  – Early reports from some system operators were quite negative
  – NERC reports are moderately negative, but concerns are generally addressed with the addition of a safety valve

♦ How will markets respond to the ERSTF concerns, the carbon constrained future, and continuing decline in renewable energy prices?
Operational Flexibility in the US

- Flexibility - the ability to change output rapidly to accommodate rapidly changing system conditions.

- Flexibility measures
  - short start up time
  - ability to ramp up or down quickly
  - more daily start-up and shut down cycles
  - high turn-down ratio

- Sources of flexibility
  - Flexible thermal and hydro
  - VG, DR, and storage
  - 5 min dispatch
  - Co-optimization of energy and A/S in competitive markets

- ERCOT rethinking entire ancillary service market design
At 2:45am, RT Operator initiates curtailment to 300MW due to high ACE.

At 4 am, RT Operator initiates AGC regulation. Note that the ACE stays within +/- 50.
Operational Flexibility from Forecasting

- Most ISO/RTO systems now include wind in Day Ahead Unit Commitment and Security Constrained Economic Dispatch
- Wind dispatch done with a 10-minute-ahead forecast or faster
  - Using the current telemetered value (a fast “persistence” forecast)
    - NYISO, ERCOT, SPP
  - Using a rolling five-minute forecast (“persistence + model” forecast)
    - MISO, PJM, IESO
- Not a markets issue (markets can help, but this works anywhere)
  - Forecast wind into day ahead unit commitment
  - Dispatch the entire system (including wind) every five minutes using a very short term wind forecast or the current telemetered output value
- Dispatch is not arbitrarily telling a generator what to produce, but rather knowing what is available for the dispatch period, and optimizing the system as a whole.
Balancing Cost - Summary of Results

Balancing cost – summary of results

Increase in balancing cost

- Ireland (SEA)
- UK, 2002
- UK, 2007
- Colorado US
- California US
- EWTS, US
- Greennet Germany
- Greennet Denmark
- Greennet Finland
- Greennet Norway
- Greennet Sweden

NW Entities
ISO Markets
March 20 European Solar Eclipse in Germany

weather forecast for Friday

- Forecast Germany of Friday, 2015-03-20, for Friday, 2015-03-20

Maximum: 20.63 GW

Gradient (10:00 – 10:15 UTC): Wednesday
4.02 GW/15min

Satellite image 20.03.15, 9:00
Source: Woksat.info
How Low Can You Go?

SIPREOLICO ERRORS 2008-2014

% Mean Absolute Error / Installed power

Prediction horizon, hours

2008 2009 2010 2011 2012 2013 2014
What To Do When the Wind Doesn't Blow

♦ Good question!
♦ Must deal with energy resource in a capacity world
♦ Dealt with through probabilistic reliability methods used to calculate Effective Load Carrying Capability (ELCC)
♦ Contribution may be large (40%) or small (<5%)
♦ Once the ELCC is determined, get on with the job of designing a reliable system
♦ And that means adding more flexible capacity in the future!
An Energy Resource in a Capacity World

ELCC as % Rated Capacity

- NYSERDA Onshore
- NYSERDA Offshore
- MN/Xcel(1)
- CO Green
- MN/Xcel(2)
- MN 2006
- PacifiCorp
- CA/CEC

Atlanta, March 2016 -- 15
Transmission and Interconnection Policy in the US

♦ Major activities covered under transmission policy include:
  – Planning
  – Permitting
  – Paying (cost allocation and recovery)
♦ Many political and regulatory jurisdictions now explicitly recognize that significant amounts of VG cannot be delivered to load without a corresponding expansion of the transmission
♦ This realization has been enshrined in policy through FERC Order 1000, which requires joint and coordinated transmission planning between neighboring transmission entities, transmission operators and RTOs/ISOs
Grid Code and Model Requirements for Power Plants

- Strong grid code is in the best interest of both the manufacturer/developer and the utility
  - Wind and solar power plants are very capable machines
  - Plants must support system reliability requirements
- Grid code should identify the following requirements
  - Real power
  - Reactive power
  - Voltage and frequency ride through
  - Frequency and inertial response
  - Provision of ancillary services
  - Detailed dynamic models for facility interconnection study
  - Communications between wind plant and grid operator
Wind and Solar Plants are Power Plants

- **Dispatchable**
  - Easy if done right, high errors if “fuel characteristics” are ignored

- **Ride through disturbances**
  - Wind ride-through requirements exceed those of conventional generators per FERC Order 661A and exceed NERC Standard PRC-024 requirements

- **Provide frequency response and voltage control**
  - Implemented for wind in ERCOT and other regions

- **Impressive ramping and active power control**
  - Very fast and accurate response over entire capability range

Utility-scale solar plants can support similar capabilities

Mark Ahlstrom, UVIG, 2015
General Recommendations

♦ Require all new power plants to have the capability of providing essential reliability services i.e. voltage regulators and governors
  – All plants should be capable of contributing to system reliability
  – Operational use of plants to provide services will vary based on economics (need for service, value of service, opportunity cost)
  – Not every plant needs to provide every reliability service at all times, but we can’t perfectly predict future needs or values
  – All power plants should ride through disturbances
♦ Leave it to tariffs and markets to compensate generators for their services
♦ Wind and PV must participate in the markets
♦ Requirements should be technology-neutral to the extent possible
♦ We will learn and adapt as the generation mix, load characteristics and markets evolve and change
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