Utilities and Wind Power Integration

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Utility Wind Interest Group

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UWIG – A Short History

- Established by 6 utilities in 1989 with support from EPRI and DOE/NREL
- Includes Associate Members from wind development community
- Non-profit corporation governed by Board of Directors from utility and ISO/RTO members
- Ex officio members include APPA, NRECA, EEI, and EPRI
- Currently has approximately 60 members
- Focus on technical issues
UWIG Mission and Evolution

- The mission of the Utility Wind Interest Group (UWIG) is to accelerate the appropriate integration of wind power into the electric system through the coordinated efforts and actions of its members in collaboration with wind industry stakeholders, including federal agencies, trade associations, and industry research organizations.

- Evolving from role of
  - Self-education and sharing experience to
  - Addressing research topics and providing knowledge
Wind Industry Is Maturing

- Number and size of wind plants
- TSOs are taking note
- Domestic Activities
  - FERC Order 2003
  - AWEA Grid Code
  - UWIG Modeling User Group
- International Activities
  - National Grid Codes
  - IEC Activities
- Application of Traditional Power System Engineering Disciplines
Perceived Market Barriers

- Siting
  - Avian
  - Noise
  - Aesthetics
- Transmission constraints
- Energy cost
- Financing
- Variable output
  - Large system impacts (transmission level)
  - Small system impacts (distribution level)
Why is Transmission Important?

- Wind is remote – needs transmission
- Wind is intermittent – doesn’t need transmission all the time
- Wind is new – must compete for transmission with established generators
- Project financing requires transmission certainty
- Transmission issues have the potential to derail wind development
National Transmission Scene

- **FERC Order 2000**
  - Encourages formation of open competitive markets for transmission and ancillary services
  - Encourages formation of Regional Transmission Organizations (RTOs)
  - Rewriting the “rules of the road”

- Need to increase awareness of wind in transmission sector

- Need to ensure wind is treated fairly
What’s the Big Deal With Wind – How is Wind Different?

- Normally schedule firm generation to meet a variable load
- Now we need to schedule variable generation to meet a variable load
- Need to realize that wind behaves more like load than generation (origin of the concept of “negative load”)
- Need to understand the load statistics with and without wind
New York State Hourly Load Change Without and With Wind High Penetration

Histogram of hourly deltas from NYCA load

Histogram of hourly deltas from NYCA load - Wind output

Source: NYSERDA
Evolution of Wind Turbine Technology

Past

Present

Future

Source: IEEE Power & Energy Magazine
## How Does Wind Plant Performance Compare?

<table>
<thead>
<tr>
<th></th>
<th>Past</th>
<th>Present</th>
<th>Future</th>
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<tbody>
<tr>
<td>Voltage Control</td>
<td>√-</td>
<td>√</td>
<td>√+</td>
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<tr>
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<td>√-</td>
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<td>√+</td>
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<tr>
<td>Contribution</td>
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<td></td>
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<tr>
<td>Flicker</td>
<td>√-</td>
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<tr>
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<td>√-</td>
<td>√</td>
<td>√+</td>
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<tr>
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<td>√-</td>
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<td>Participation</td>
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What’s the Outlook for Wind Plant Output Forecast Accuracy?

<table>
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<tr>
<th></th>
<th>Currently</th>
<th>5-10 Years</th>
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<tbody>
<tr>
<td>Hour Ahead</td>
<td>4-6%</td>
<td>3-5%</td>
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<tr>
<td>Day Ahead</td>
<td>15-20%</td>
<td>10-15%</td>
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</table>
Changing Perceptions

- Wind plants are different from conventional power plants
- Wind plant technology is constantly evolving towards better performance
- Question has changed from “Can wind plants be integrated into utility systems?” to “How much does it cost to integrate wind plants?”
UWIG R&D Survey

- Periodic survey of member R&D needs conducted
- Members asked to identify top concerns related to adding increased wind capacity
- Top two priorities identified by members are:
  - Operating impact cost of large wind plants
  - Impact of distributed wind on distribution feeders
- UWIG initiated funded research projects to address these concerns
Problem Introduction

- Reliable power system operation requires precise balance between load and generation
- Output of wind plants cannot be controlled and scheduled with high degree of accuracy
- Wind plants becoming large enough to have measurable impact on system operating cost
- System operators concerned that additional variability introduced by wind plants will increase system operating cost
Time Scales of Interest

- **Time (hour of day)**
  - 04 8 12 16 20 24
- **System Load (MW)**
- **Unit Commitment**

- **seconds to minutes**
  - Regulation

- **tens of minutes to hours**
  - Load Following

- **day**
  - Scheduling

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*Utility Wind Interest Group*
### Ancillary Services Cost Comparison

| Source: UWIG |

<table>
<thead>
<tr>
<th>Study</th>
<th>Relative Wind Penetration (%)</th>
<th>Regulation</th>
<th>Load Following</th>
<th>Unit Commitment</th>
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Operating Impacts Results

- Comparison of study results shows costs are low at low levels of penetration and rise with increasing levels of penetration (~$5/MWh @ 20%)
- Costs are driven by uncertainty in wind plant output
- Variations in wind and load are important in determining true cost
- Debate has shifted from if it can be done to how much does it cost
- So far, costs appear to be moderate
UWIG Distributed Wind Work

- Large funded research project to develop software tools and application guides for installation of wind turbines on distribution systems
- Provide guidance and direction for new efforts through resource materials in the form of measurements database and case study library
- Driven by recognition that analytical tools for distribution system planning, design, and operation with radial distribution feeders may no longer be valid for feeders interconnected to distributed generators
Voltage Profile Simulator Page
Click on feeder one-line components to set parameter values. Click "Voltage Profile" button to run simulation and obtain results for specified circuit and generator output profiles.
Evolution of the User Group R&D Agenda

- Recognition of the need for UWIG to take more proactive role in addressing the ongoing technical challenges related to wind generation for the utility industry
- Outgrowth of the favorable response to the leadership provided through UWIG funded research projects
- Response to need for analysis and dissemination of information targeted to utility audience
Operating Impact and Integration Study User Group Scope

- Cost of ancillary services for wind plant
  - System regulation
  - Spinning reserve
  - Operating reserve
  - Unit commitment
- Ancillary service cost sensitivity
  - Penetration level
  - Generation mix
  - Fuel cost
- Capacity credit studies
- Domestic and international studies
- Assumptions and methodologies
- Information dissemination
Distributed Wind Application
User Group Scope

- Engineering software tools
  - Voltage regulation and flicker
  - Overcurrent protective device coordination
  - Economic screening
- Application guides for P1547 and flicker
- Case study library
- Measurement database
- Maintain and disseminate information
Wind Plant Modeling and Interconnection UG Scope

- Advance state of the art in modeling wind turbines and plants for power system studies
- Develop, document, verify, and support model and techniques for planning and operating studies
- Generate confidence in those studying power system performance, stability, security, and reliability
- FERC Order 2003A, Appendix G
Wind Turbine Models
Market Operation and Transmission Policy
Best Practices UG Scope

- Transmission planning process
- Balancing markets
- Markets for transmission rights
- Interconnection standards and policies
- Congestion management
- Rate pancaking
- Flexible-firm tariff
NWCC Transmission Planning Principles

- Wind – widely available resource, short lead time
- Transmission – scarce resource, long lead time
- Dilemma – how to make the two ends meet
- Action - At January 2003 meeting, NWCC identified a common agreement on transmission planning principles as essential to winning public acceptance and regulatory approval of needed transmission additions and upgrades
- Result – January 2004 – set of consensus principles developed and posted at www.nationalwind.org
Systems Integration Task Relationships

Capture Benefits of New Turbine Designs
- Wind generator
- Electrical Models for Interconnection studies

Tools and Methods Development
- Transmission & Generation Planning

Characterization of Operational Impacts

Critical Data
- Wind Farm Output Monitoring

Application & Implementation
- Grid Rules Development

By 2012, complete program activities addressing electric power market rules, interconnection impacts, operating strategies, and system planning needed for wind energy to compete without disadvantage to serve the Nation’s energy needs

Mitigation strategies

Barriers removed, Large deployment rates are possible

Source: NREL
Wind Development – A Future Vision

### 2003

**Bulk Power Generator**
- 4-6¢ at 15mph
- Land Based
- Bulk Electricity
- Wind Farms

**Potential 20% of Electricity Market**

### Land Based Technology Path
- **Land Based LWST**
  - Large – Scale
  - 2 - 5 MW

### Offshore Technology Path
- **Offshore Turbines**
  - 5 MW & Larger

### Wind-Hydrogen Path
- **Land & Ocean**
  - Large & Small
  - “Hydrogen Turbines”

### Transmission Barriers
- **Cost and Regulatory Barriers**

### Future

**Low Wind Speed Technology**
- 3¢/kWh at 13mph
- 20% of Electricity
- 2012

### Unique Offshore Designs
- Shallow water
- *Deep water*
- Higher Wind Sites
- 2012 & Beyond

### Cost and Infrastructure Barriers
- **Dual Output Turbines**
  - Transportation
  - Firm Electricity
  - Industrial
  - Residential
  - Multi-sector Market
  - 2030 & Beyond

Source: NREL
For More Information

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