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

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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

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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

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Perceived Market Barriers

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

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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

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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

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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

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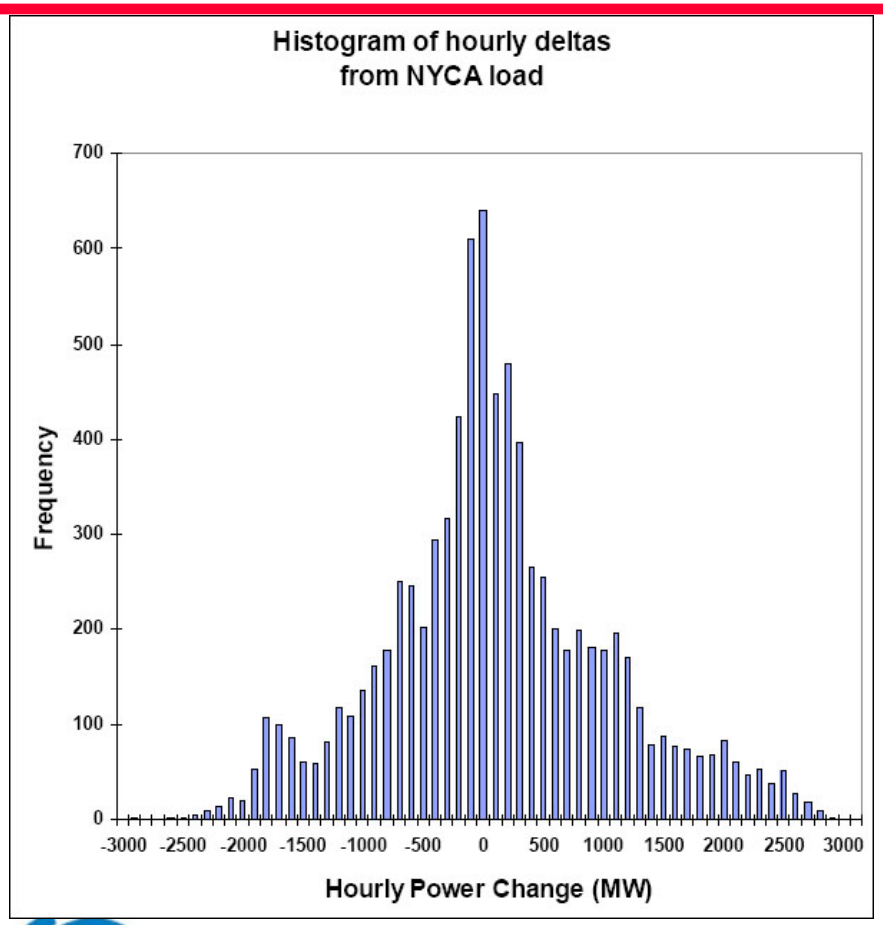
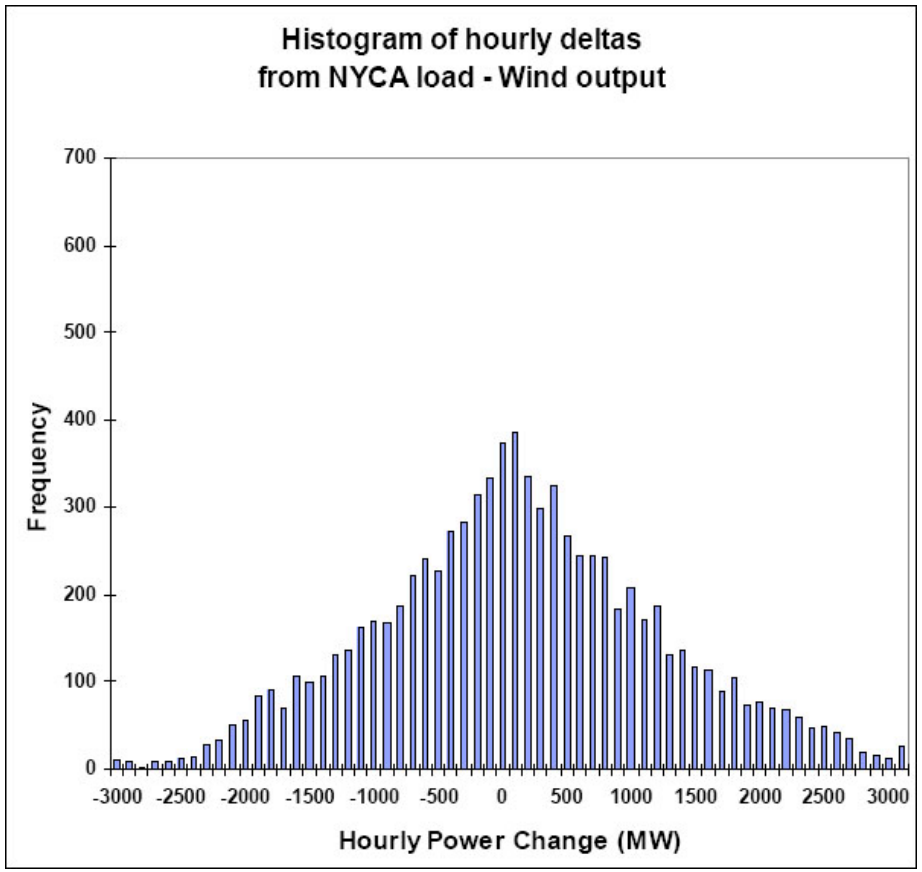
New York State Hourly Load Change Without and With Wind High Penetration



Source: NYSERDA



Source: NYSERDA

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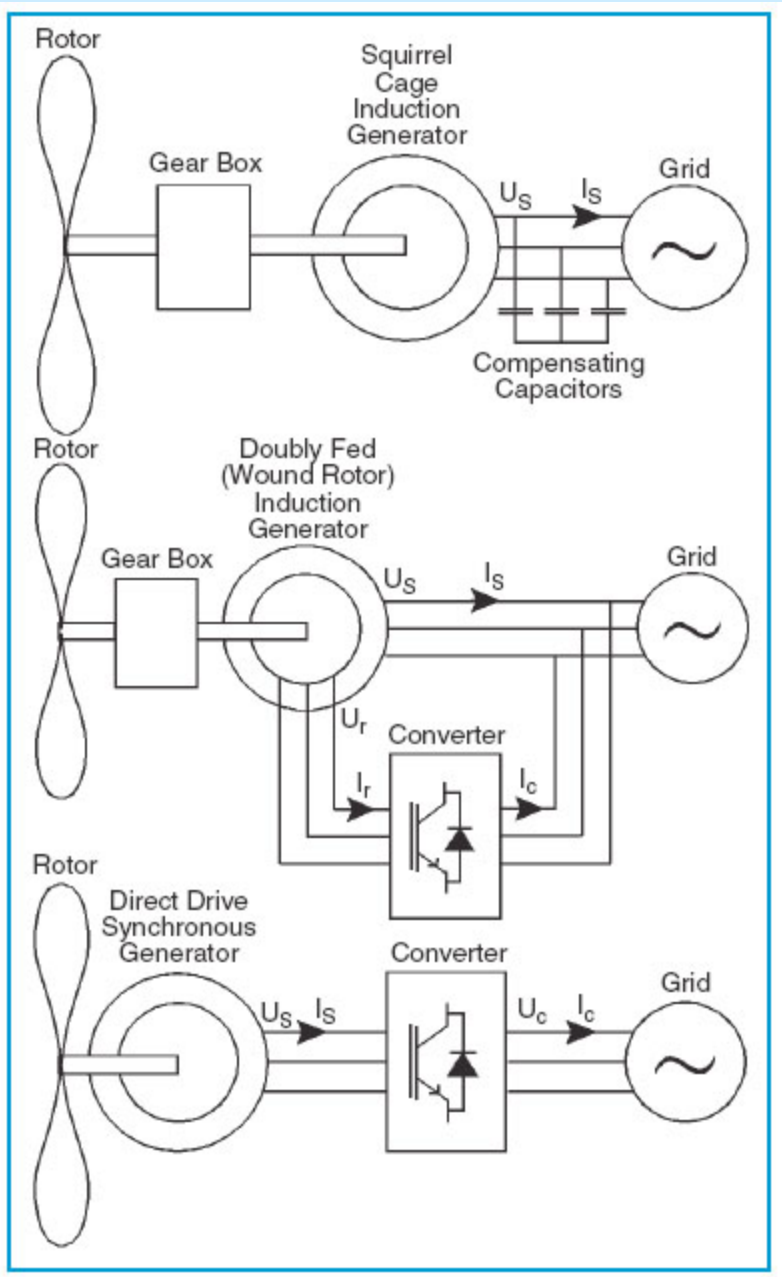
Evolution of Wind Turbine Technology

Past →

Present →

Future →



Source: IEEE Power & Energy Magazine

How Does Wind Plant Performance Compare?

	Past	Present	Future
Voltage Control	√-	√	√+
Short Circuit Contribution	√-	√	√+
Flicker	√-	√	√+
Low Voltage Ride-Through	√-	√	√+
Stability Behavior	√-	√	√+
AGC Participation	√-	√	√+

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What's the Outlook for Wind Plant Output Forecast Accuracy?

	Currently	5-10 Years
Hour Ahead	4-6%	3-5%
Day Ahead	15-20%	10-15%

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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?”

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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

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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

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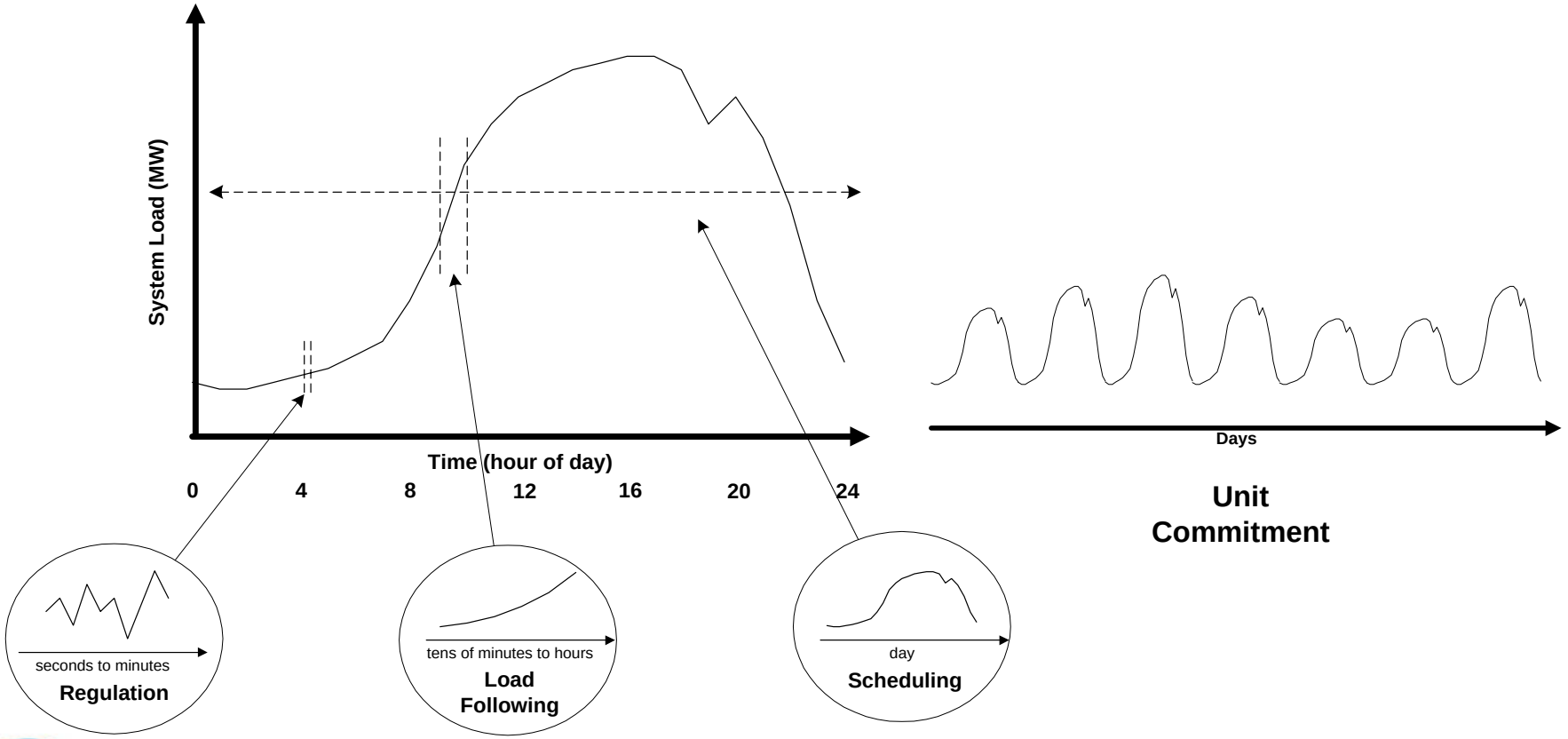
Time Scales of Interest



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Ancillary Services Cost Comparison

Source: UWIG

		$/MWh			
Study	Relative Wind Penetration (%)	Regulation	Load Following	Unit Commitment	Total
UWIG/Xcel	3.5	0	0.41	1.44	1.85
PacifiCorp	20	0	2.50	3.00	5.50
BPA	7	0.19	0.28	1.00-1.80	1.47-2.27
Hirst	0.06-0.12	0.05-0.30	0.70-2.80	N/A	N/A
We Energies I	4	1.12	0.09	0.69	1.90
We Energies II	29	1.02	0.15	1.75	2.92
Great River Energy I	4.3				3.19
Great River Energy II	16.6				4.53

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

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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

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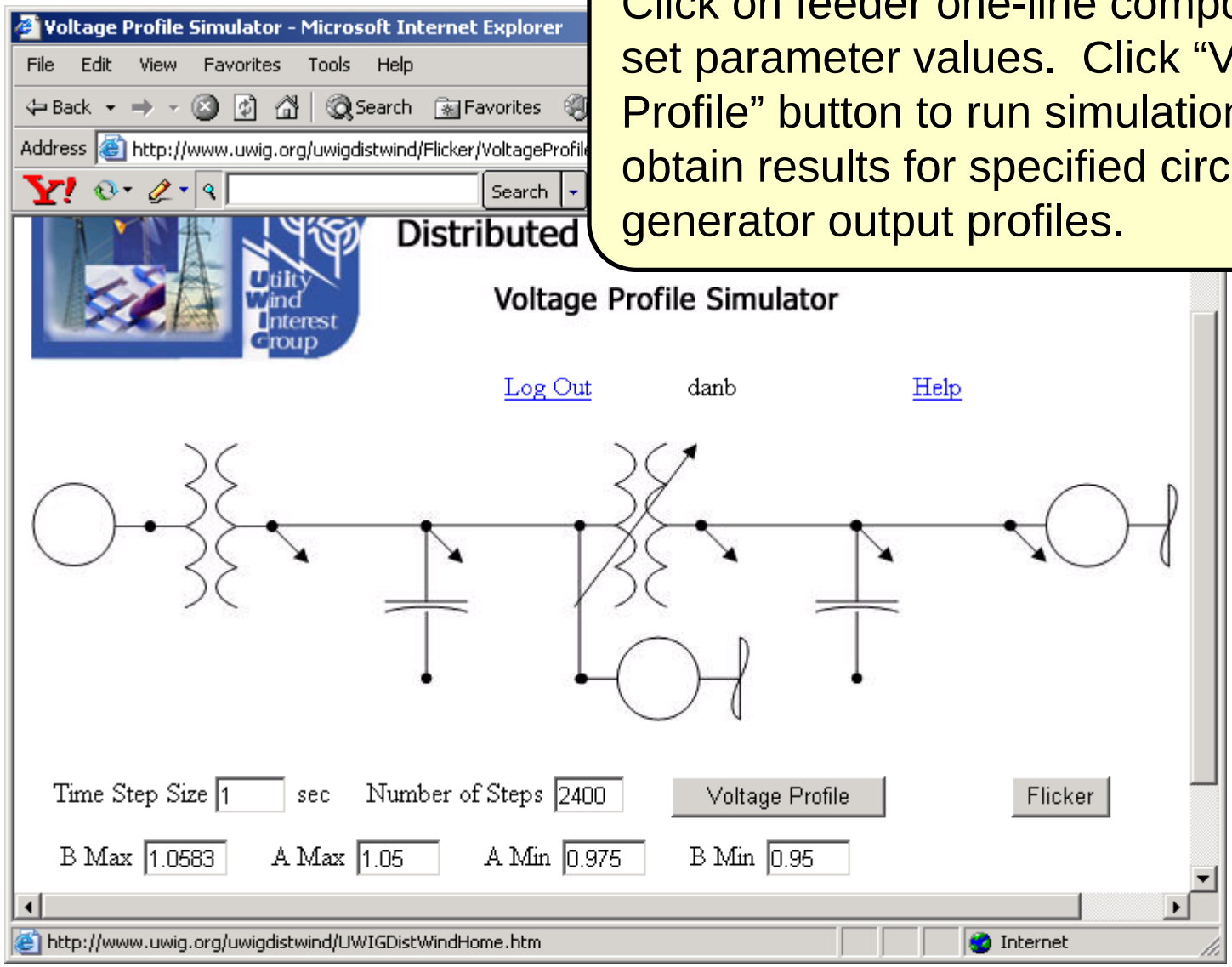
Voltage Profile Simulator Page

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

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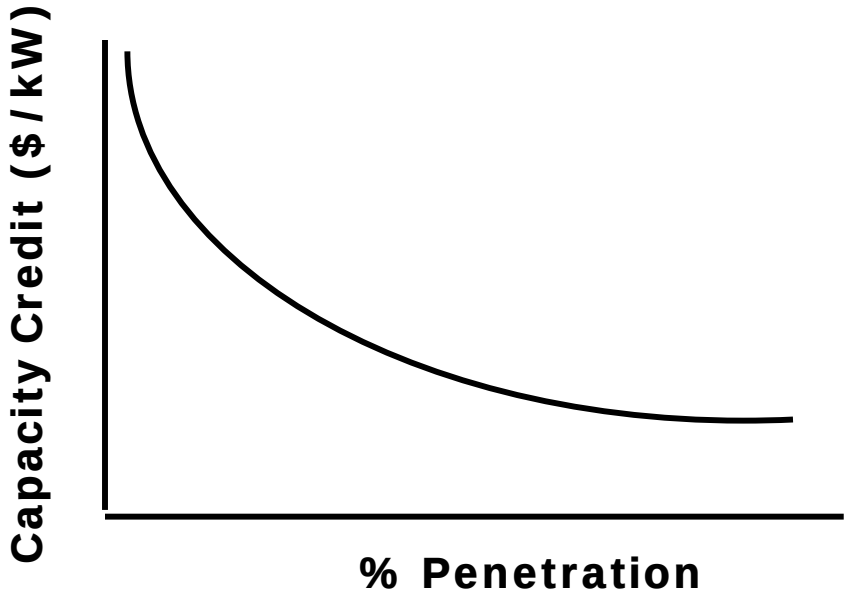
Operating Impact and Integration Study User Group Scope

- 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



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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

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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

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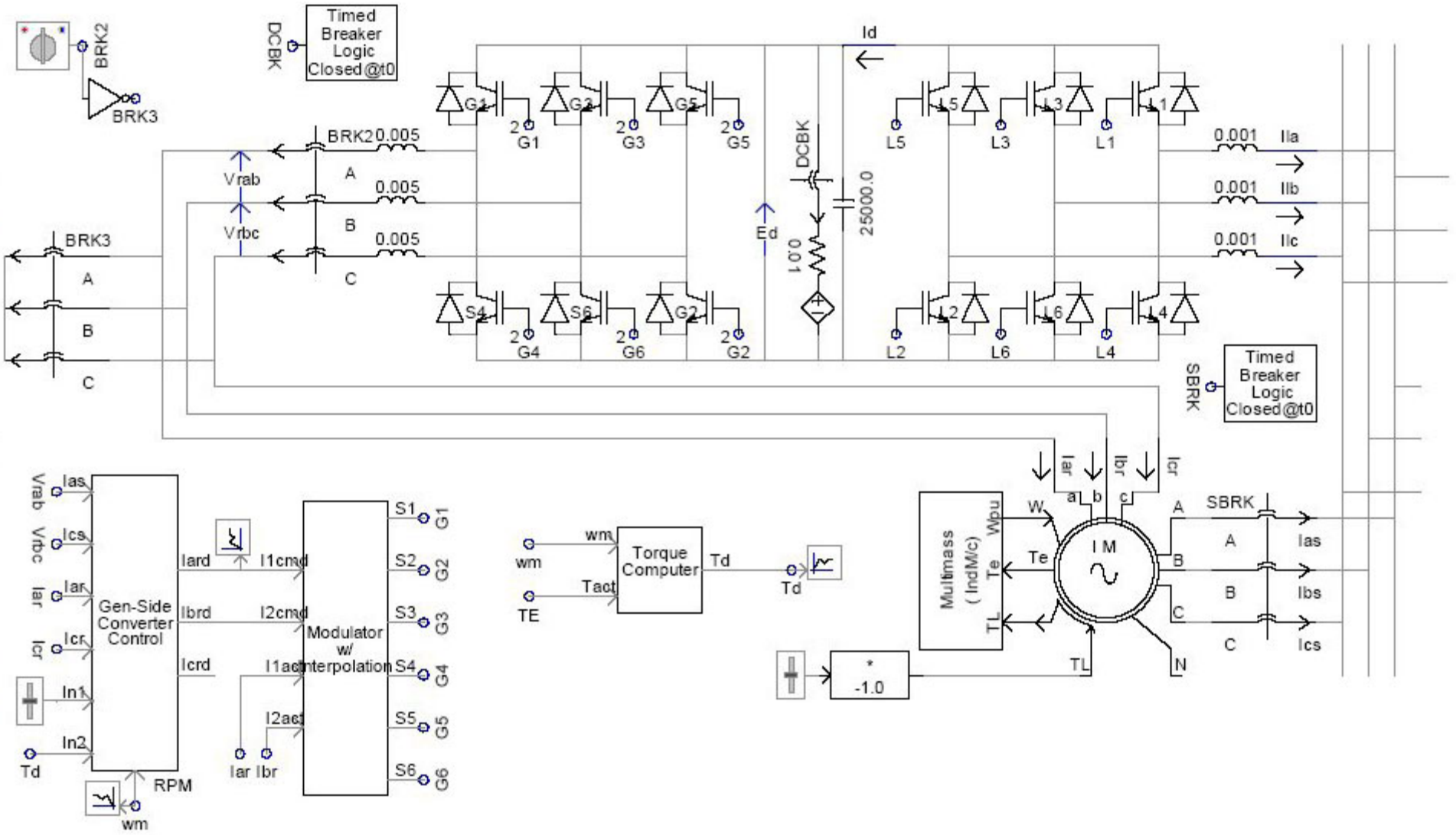
Wind Turbine Models



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

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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

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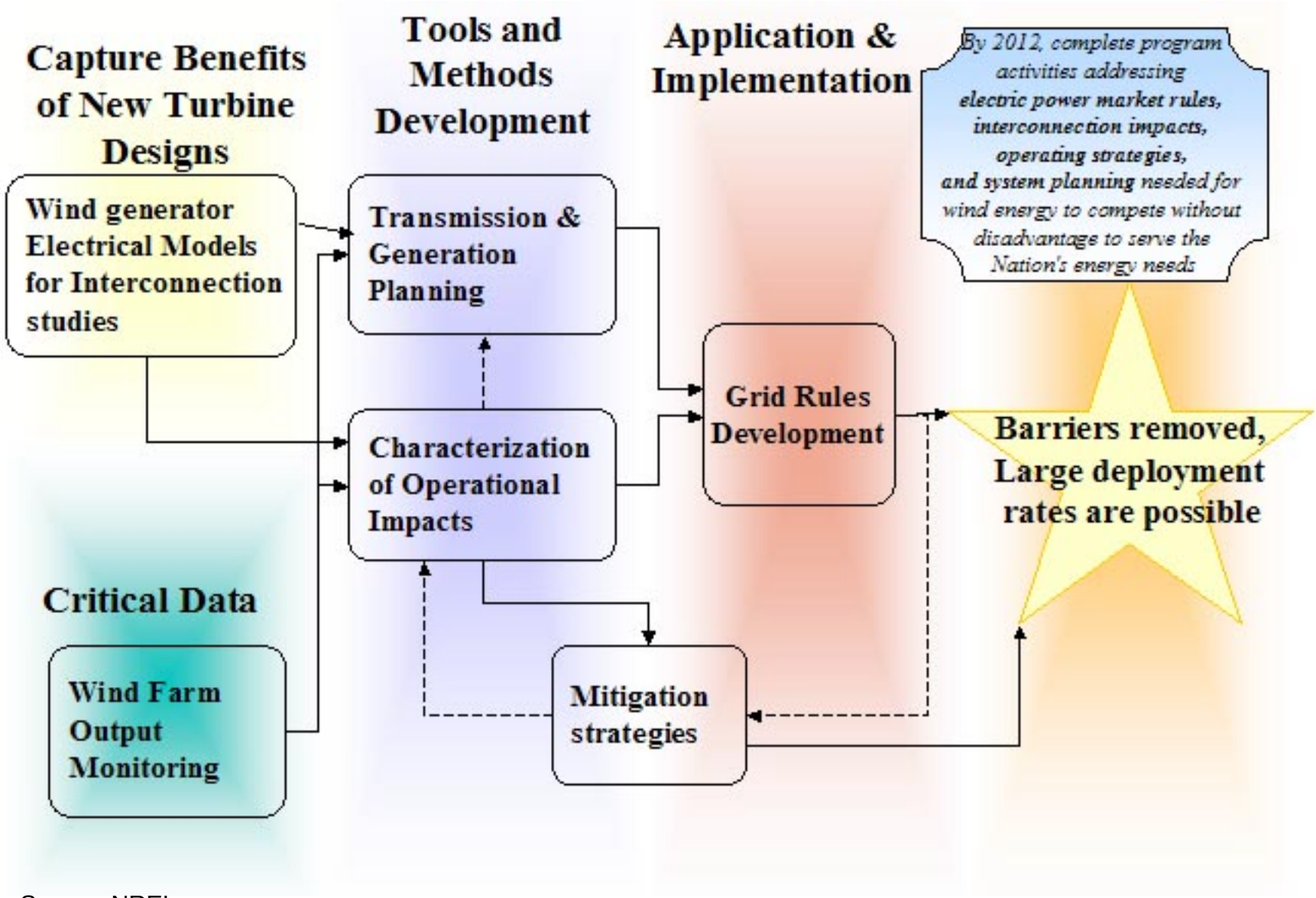
Systems Integration Task Relationships



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

Transmission Barriers

Offshore Technology Path

Offshore Turbines
5 MW & Larger

Cost and Regulatory Barriers

Wind-Hydrogen Path

Land & Ocean
Large & Small
"Hydrogen Turbines"

Cost and Infrastructure 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

Dual Output Turbines
- Transportation
- Firm Electricity
- Industrial
- Residential

Multi-sector Market
2030 & Beyond

Source: NREL

For More Information

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