Renewable Energy and Synchrophasors: Bridging a Critical Knowledge Gap

North American SynchroPhasor Initiative Working Group Meeting

February 24-25, 2010

University of Texas at Austin

Austin Texas

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Role of Models in Bulk Power System Planning

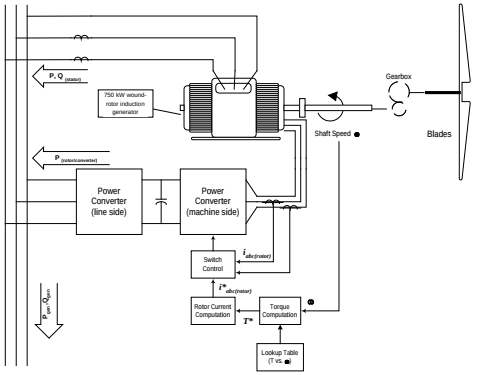
- Adequate simulation models are indispensable for maintaining grid reliability
  - Identify and address impact of new generator, transmission equipment additions
  - Perform planning studies to ensure system reliability at the local and regional level
- Modeling focus for grid studies
  - Steady-state: power flow for voltage and reactive compensation assessment, contingency evaluation
  - Dynamic: behavior of system and individual elements during and immediately after major system disruptions (e.g., short-circuits, loss of major generators, etc.)
- Model requirements addressed in existing (and future) NERC standards

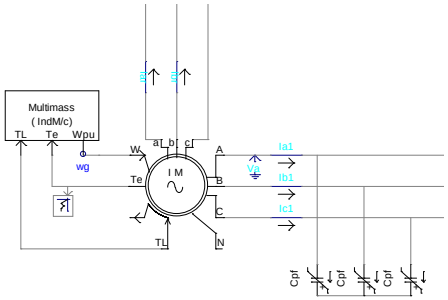
Wind Generation Modeling and Study Challenges

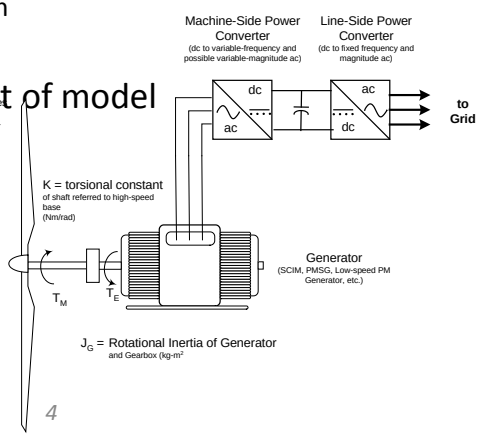
- The need for better modeling and analytical tools is becoming acute
  - Increasing wing wind generation levels on many systems
  - Impacts on system can no longer be ignored
  - Interconnection requirements becoming more rigorous
- Wind generation technology is **novel** relative to conventional generating equipment and systems
- Wind generation is an **energy** resource in a **capacity** world
- **Experience** with wind generation is nonexistent compared with conventional generating resources

Energy Conversion Technology for Wind Generation

- Wind turbine technology
  - Conventional induction machines
  - Induction machines w/ static power converter control
  - more exotic technology (e.g., direct drive, PM synchronous generators)
  - Unconventional prime mover and mechanical system, control
- Wind plant technology
  - Substantial influence on behavior as seen by the grid
    - » Turbine terminal characteristics – PF compensation, control
    - » Distributed reactive power compensation
    - » Reactive losses (I*I*X) within plant
  - Turbine technology is but one aspect of model for grid studies







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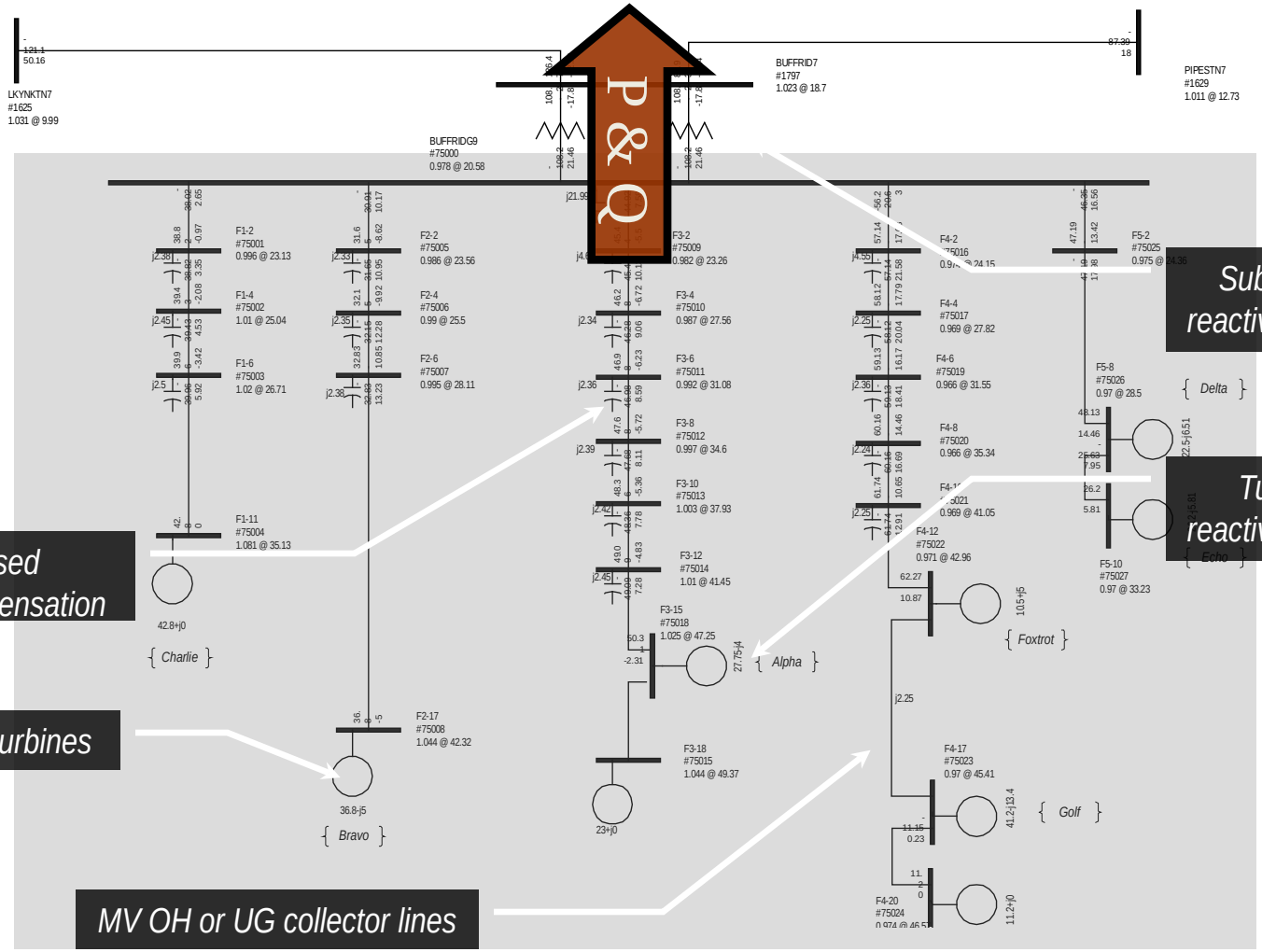
Wind Plant Components



The status quo for wind generation is no longer acceptable

- Wind generation is no longer “invisible”
  - Requirements for models have not been strictly enforced by transmission providers
  - Engineering judgment has played large role in previous studies
- Present approach is incompatible with the current system modeling practice
  - Vendors have characterized their equipment in appropriate models
  - Issues
    - » Models can be confusing or cumbersome: features, versions, etc.
    - » Considered proprietary; made available after signing NDAs
- Cannot be maintained in base cases once plant is built
  - Base cases used for planning going forward
  - NDA riders not feasible under structures for model development, maintenance, and distribution

Status

- Wind turbine and plant modeling remains at top of power industry needs list
- Landscape is much different than it was 5 years ago
  - Many parallel activities
  - Increased and widespread interest
  - The clock is now ticking (NERC)…
- Much progress made since over past five years
  - Individual efforts (turbine vendors, TSPs)
  - WECC initiative w/ voluntary contributions
- Progress needs to be accelerated as firm deadlines are now probable

NERC IVGTF Phase II Task 1.1 - Scope

- From recommendations of Phase I report
- Focus on modeling for interconnection and other bulk system studies
- Phase II recommendations complete

Item #	Proposed Improvement	Abstract	Lead	Deliverables	Milestones
1.1	Standard, valid, generic, non-confidential, and public power flow and stability models (variable generation) are needed and must be developed, enabling planners to maintain bulk power system reliability	Valid, generic, non-confidential, and public standard power flow and stability (positive-sequence) models for variable generation technologies are needed. Such models should be readily validated and publicly available to power utilities and all other industry stakeholders. Model parameters should be provided by variable generation manufacturers and a common model validation standard across all technologies should be adopted. The NERC Planning Committee should undertake a review of the appropriate Modeling, Data and Analysis (MOD) Standards to ensure high levels of variable generation can be simulated. Feedback to the group working on NERC Standards' Project 2007-09 will be provided.	*Ad Hoc* group: Members from IVGTF - Planning	Make recommendations and identify changes needed to NERC's MOD Standards	• Draft report ready by December 2009 PC meeting • Final report sent with recommendations to PC for endorsement in February 2010 • Develop SAR with Standards Committee if required.

UWIG Generic Modeling Initiative

- Build on efforts initiated by WECC in 2005 to develop generic models for wind turbines and wind plants
- Utility Wind Integration Group / EnerNex project team
- DOE FOA 68
  - "20% Wind by 2030"
  - Topic 4A: Utility Wind Energy Integration
- Commitment of support from turbine vendors, National Laboratories, NERC, IEEE, RREs
- Work began 1Q '10
- **Overall goal is to accelerate model development process for wind generation**

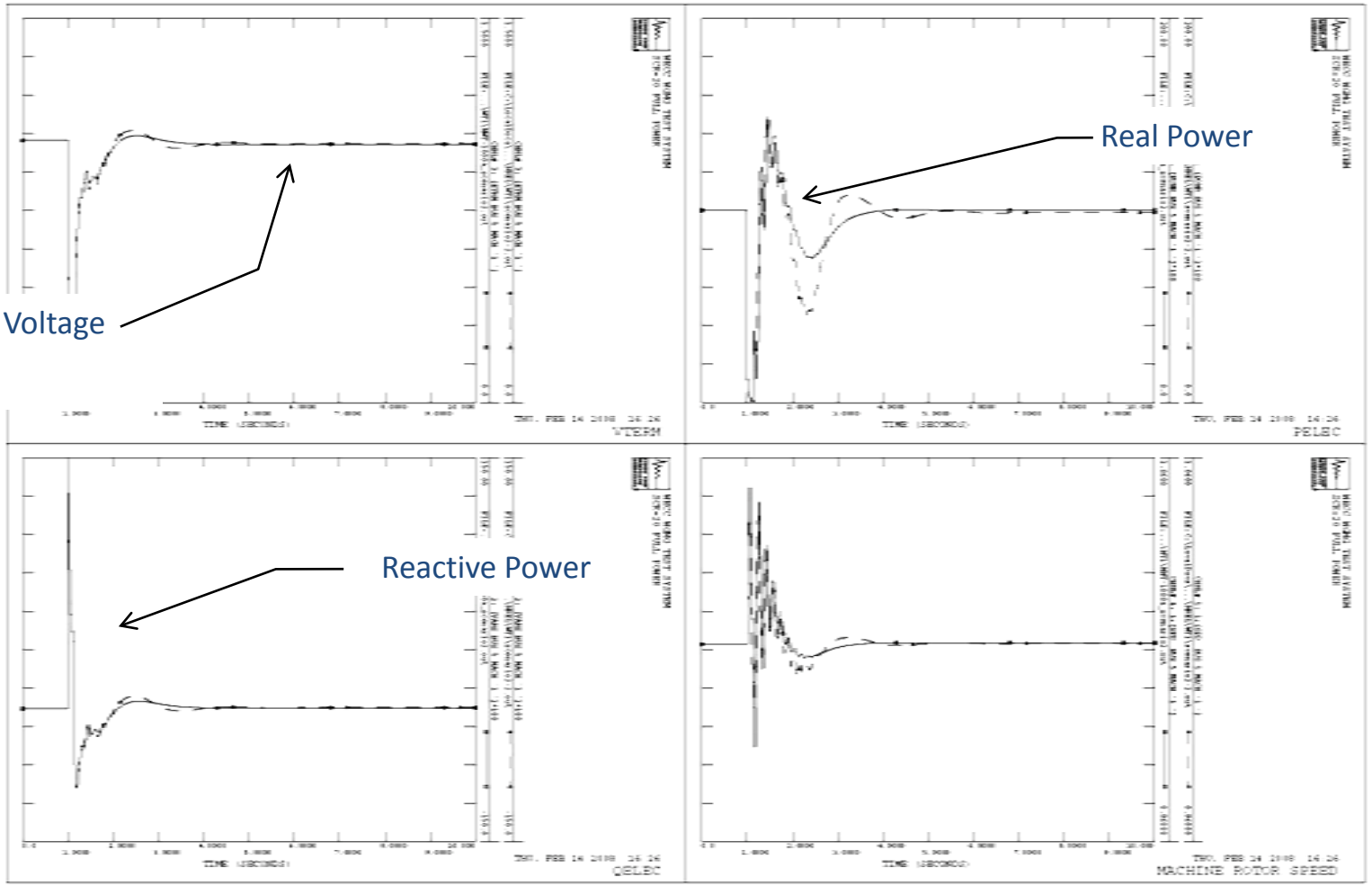
Project Objectives

- Complete characterization and documentation of the four generic models
- Define and implement proposed enhancements to the generic wind turbine model structures
- Comparative testing of the generic models against more detailed (and sometimes proprietary) versions developed by turbine vendors
- Develop recommended parameters for the generic models to best mimic the performance of specific commercial wind turbines
- Documentresults of the comparative simulations in an application guide for users
- **Acquiring data for validation**
- Conduct technology transfer activities

Phase II Tasks

A. Inventory available data for model validation
B. **Devise program for collection of field data from archives, ongoing activities (e.g. NREL), or new field measurements**
C. Perform comparative simulations of generic, vendor-specific, and other available models for events with available data
D. Develop addendum for application guide

Data For Model Validation



Dashed: Vendor-specific detailed model. Solid: WT1 model

Data for Model Validation

- First-principle quantities (i.e. voltage, grid injection current) at ~20 Hz resolution
- Response of wind plant to large-signal disturbances on grid
  - Voltage (short-circuits)
  - Frequency excursions
- PMU resolution is consistent with bandwidth of dynamic simulations in major bulk system analysis tools

Can NASPI provide required data for model validation?

- PMUs at wind plant buses
  - Data capture resolution adequate for validation
  - Large population of PMUs could provide required data in more timely fashion that individual measurement activities
- Would require monitoring of current injection from wind plants
- Issues
  - Data management and access questions
  - Timing
  - Additional information requirements

If so, what are the next steps?