CURENT RESEARCH

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Large System Test Bed

Large System Test Bed (LST) 2 - US Grid Model Development

Overview

The objectives of the Large System Test Bed 2 project are to develop several reduced-order models of the US interconnected power for use in demonstrating the wide-area interconnections to transmit large amount of energy from renewable resources, and disturbance scenarios for the design and verification of wide-area control methodologies. Integral to this development also is the placement of PMUs and a communication system so that an ultra-wide-area control system can be implemented.

Technology Pathway

As the US power systems consists of three interconnected systems, reduced systems for each of these three systems are being developed. The load models of a previously available reduced US western electric (WECC) system model has been enhanced to ensure consistency with the real WECC performance. The reduced Eastern Interconnection (EI) model, developed from a 30,000-bus model, is close to completion (Figure 1). A reduced-order Northeast Power System (NPCC) model will be integrated with this EI reduced model. The reduced model for the Texas power system (ERCOT) is under development.

For ultra-wide-area control, especially for the transmission of energy from renewable resources to load centers, a multi-terminal HVDC system is being designed as an overlap network on the three separate synchronously connected AC power systems (Figure 2).

Sample disturbance scenarios, including cascading failures and frequency regulation with high renewable penetration (Figure 3), will be developed for each of the systems, as well as for the MT HVDC overlaid system. These scenarios will later be refined to demonstrate additional technological advances made by CURENT researchers.

Impact

- Reduced-order models will allow the dynamic analysis and ultra-wide-area control study of the EI system and the MT HVDC overlaid system.
- The LST systems will motivate a realistic development of the ultra-wide-area control architecture.
- The LST systems can be used to demonstrate the impact of attacks on PMUs and data communication networks on large power grids.• This platform will serve as the foundation for evaluating new controls and algorithms, especially in regard to ultra-wide-area measurements.

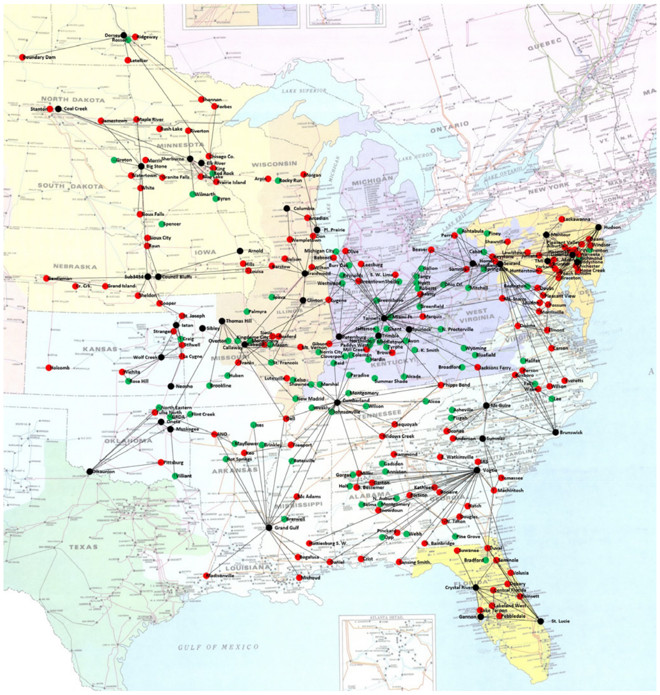

Figure 1: Reduced US Eastern Interconnection Model

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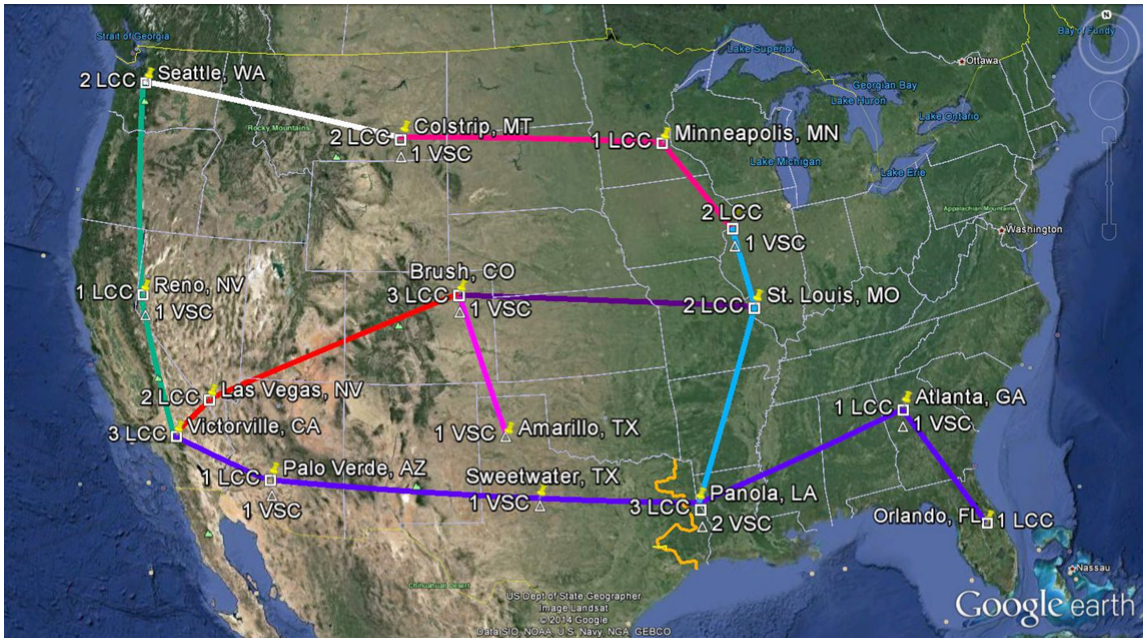

Figure 2 (right): HVDC overlap on US power grid

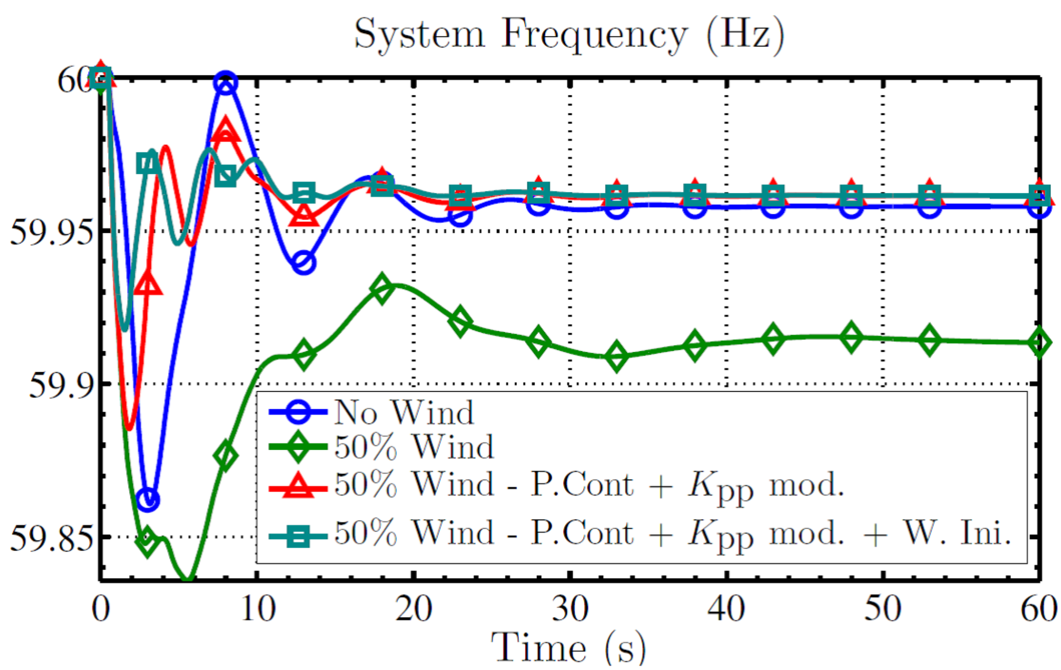

Figure 3 (left): *Frequency response of 10-machine New England System with 50% wind penetration, showing improved frequency regulation using wind turbine blade pitch control.*

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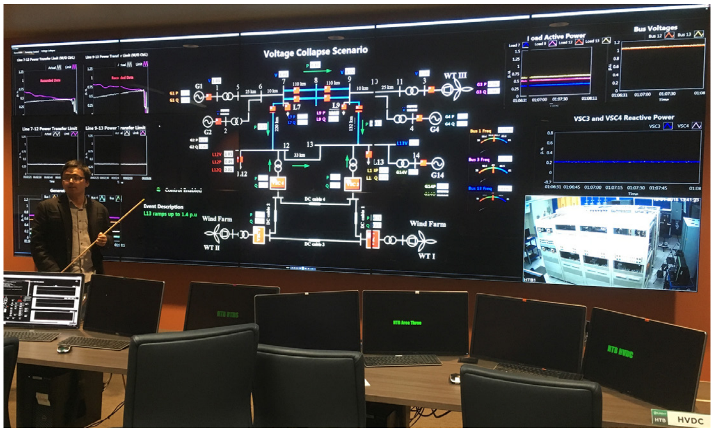
Hybrid Voltage Stability Assessment

Overview

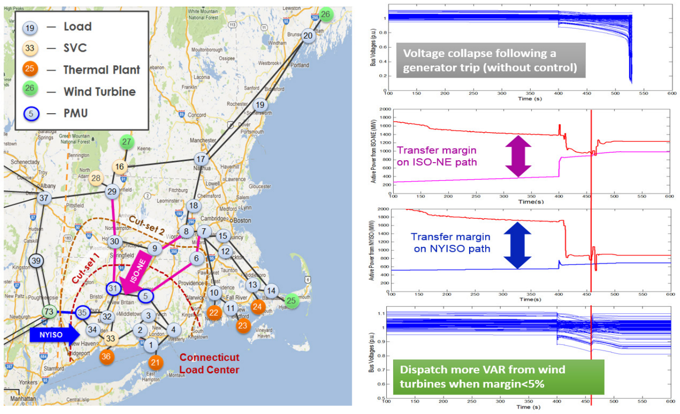
Voltage stability is a major concern in daily power system operations and a leading factor to limit power transfers in a prevailing open access environment. CURENT is developing a new hybrid voltage stability assessment method combining the traditional simulation-based approach and a new measurement-based approach. The hybrid method aims at calculating voltage stability margin directly from real-time measurements to identify vulnerable areas, and then identifying post-contingency voltage instability and remedial actions by simulations on those areas.



Technology Pathway

Presently, model- or simulation-based voltage stability assessment (VSA) programs are widely applied to study voltage stability following given contingencies. If applied in the online environment, such a simulation-based approach helps operators foresee the next most critical contingencies that may cause voltage problems based on the current system state estimate. However, its performance may be influenced by inaccurate models of generation, load, and transmission facilities, or divergence in state estimation under, e.g., stressed conditions. An alternative measurement-based approach is to directly use real-time measurement data to assess voltage stability. To integrate the two approaches, comprehensive voltage stability assessment would be achieved by the following tasks:

- Identify locations (e.g. load buses, transmission corridors, load centers, or grid interfaces), which are more vulnerable to voltage insecurity.
- Develop an accurate measurement-based algorithm to estimate real-time voltage stability margins at those locations. Low margins indicate that additional contingencies may cause voltage problems at those locations.
- Perform simulation-based VSA by high-performance computers (HPCs) focusing on the contingencies related to the locations with low margins based on the most recent state estimate. Identify potential post-contingency voltage insecurity and determine remedial actions.



Impact

- System operators would be aware of real-time voltage stability issues and be provided with decision support.
- For such a hybrid scheme, the more accurate the measurement-based approach is, the fewer burdens the simulation-based approach will have.

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