NREL’s Research and Needs in Transmission and Distribution Technologies

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NREL’s Current Research in T&D Technologies

• **Advanced Power Electronics and Smart Inverters**
  - Active Power Controls for Wind turbines
  - Smart Inverters and Distributed Controls

• **Equipment Testing**
  - ESIF and NWTC CGI

• **Power Hardware-in-the-loop (PHIL)**
  - Remote PHIL experiments

• **Generator Modeling**
  - Modeling PV inverters in PSCAD

• **Grid Sensing – PMUs and DMUs**

• **ADMS and Visualization**
Active Power Control from Variable Gen

- Understanding how Variable Generation (Wind and Solar) can provide primary and secondary reserves.

- Inertial control, Primary Frequency Control (PFC), and Automatic Generation Control (AGC) from Wind and Solar is feasible with negligible impacts on loading.
PMUs for Renewable Integration

- PMU provides millisecond level scan of the power system that can be used for:
  - Dynamic state estimation
    - Quasi-steady state estimation
    - Trajectory prediction
  - Measurement-based stability estimation
    - Transient stability
    - Small signal stability
    - Voltage stability
    - Frequency stability
  - Flexible and fast acting control of power system

- Investigating PMU-based control algorithms to improve the operation of renewable energy from the perspectives of WAMPAC (Wide Area Monitoring Protection and control) utilizing availability of power electronics
Developing Decentralized Controls

From grid-following controls

To next-generation grid-forming controls
Grid Modernization Lab Consortium – Testing Network

GMLC-TN Example
Integrated System:
Wind Turbines – Power System
ADMS with Utility Partners/Vendors

- Model large scale distribution systems using the HPC to replicate parts of a utility service territory and connect to a Advanced Distribution Management Systems (ADMS)
- Integrating distribution system hardware in ESIF using real devices to multiple nodes in computer simulation using power hardware in the loop co-simulation
- Advanced visualization capability at ESIF to simulate a mock utility distribution system operator’s control room.
Future Research needs in T&D Technologies

• Better characterization of emerging technologies (PV, wind, EV, FC, controllable loads) for providing the full range of grid ancillary services

• Advanced DMS system that incorporate full range of distributed technologies and controls

• Advanced control algorithms to enable large-scale deployment of distributed energy resources

• Integrated real-time testing of new technologies and power system controls
ESIF Showcase Event

• New Addition to PES General Meeting
• July 30, 1-3pm
  o High Performance Computer (HPC) and Visualization Room – See 3D visualizations of wind farms and electrical systems based on simulations run on the HPC.
  o Advanced Distribution Management System Simulator – See a demonstration of an advanced distribution management system that is helping manage the impact of high penetrations of renewable energy.
  o Smart Power Laboratory – See how home energy management systems, appliances, and electric vehicles are integrated into smart home applications.
  o Power Systems Integration Lab – See how utility-scale testing is conducted including microgrids applications and power hardware-in-the-loop (PHIL) testing at megawatt scale.
• Must register at: https://esif-openhouse.eventbrite.com
• by July 15, 2015
T&D Technology Research References

- E Ela; V Gevorgian; P Fleming; Y. C Zhang; M Singh; Eduard Muljadi; A Scholbrook; J Aho; A Buckspan; L Pao; V Singhvi; A Tuohy; P Pourbeik; D Brooks; N Bhatt; Active Power Controls from Wind Power: Bridging the Gaps, NREL/TP-5D00-60574, http://www.nrel.gov/docs/fy14osti/60574.pdf