Thrust Area 7: Storage & Delivery

The Future Florida Grid: Ensuring a Reliable and Resilient Electrical Energy Transmission and Delivery System in a Changing Environment

PI: Steinar Dale **Co-PIs:** Tom Baldwin, Omar Faruque, James Langston, Peter McLaren
Rick Meeker, Karl Schoder, Mischa Steurer
Students: Thamer Alquthami, Harsha Ravindra (MS Electrical Engineering)

Description: The project research goal is to address the challenges of the reliable flow of electrical energy throughout the state as the power system is transformed to include significantly more renewable and alternative sources, possible expansion of new very-large centralized base load (nuclear), and incorporation of new power conversion, transmission, measurement, communication and control technologies (smart grid). This project has also supported ongoing participation and contributions in national, state, and local power and energy stakeholder groups, including the Gridwise Alliance, the North American Synchrophasor Initiative (NASPI), the American Society of Mechanical Engineers' (ASME) National Energy Committee, the Institute of Electrical and Electronics Engineers (IEEE) Power Engineering Society (PES), Florida's Great Northwest Alternative Energy Advisory Council, and the Tallahassee-Leon Economic Development Council (EDC) Energy and Environment Roundtable.

Budget: $359,642
University: FSU

Executive Summary

There has been substantial progress in the development of research-oriented models of the Florida electric power grid, the ultimate aim being models with sufficiently representative behavior for investigation of wide-ranging scenarios and options in future development of the grid. The analysis of the Florida Power Grid Disturbance has been used as a means for an initial comparison and validation of model behavior against real grid response. This approach has been demonstrated using an aggregated 14-Bus dynamic model with refinements in the data and protection related switching events, with results matching the recorded data observed in the incident report with minor discrepancies. Results suggest that the reduced, 14-bus model version may be useful, with reasonable assumptions, for some simplistic studies. Work is underway to construct parametric studies to determine the parameters sensitivity in the simulation using factor screening and other statistical techniques.

Though the 14-bus Florida grid model may be sufficient for some simple studies, the project's objective requires a more detailed benchmark system of the Florida grid. Therefore, a 154-bus notional electrical grid of Florida was built with detail representation using data available in the public domain. Reasonable model power flow results have been produced, and, efforts have proceeded to develop a dynamic model for the 154-bus system. The dynamic model requires data for each unit of generators, exciters, turbine governors, power system stabilizers, automatic generation controls and all the required protective devices with accurate settings. Where lacking complete details on each power plant's generation units, models for generators, exciters, and governors were chosen for the large plant or known plant at that bus. If information is available, models for the exact type of generation units are chosen. Typical data were assigned for the specified dynamic model parameters.

The development of a dynamic solar PV model with Maximum Power Point Tracking has been initiated and completed. The model will contribute to the general power system modeling and simulation community as we intend to make it publicly available and to the envisioned Florida Grid studies of future load and generation growth specifically. Initial studies of the impact of solar PV-based resources have been undertaken, and significant implications for power system operation and stability have been

observed. The depicted bus frequency traces after tripping of a solar PV-power plant at different penetration levels reveal unacceptable frequency deviations in the present model.

Advanced dynamic excitation systems and controls were added to the notional Florida grid model based on detailed, IEEE recommended, models for exciters and power system stabilizers. Case studies have been performed using PSS/E to evaluate the dynamic performance. Protections are also being added to the model so that realistic responses with respect to disturbances can be simulated.

A simulation effort was completed for a major municipal electric utility in the state to examine power system restoration from a complete system outage. This is expected to continue with further examination of system dynamics under different scenarios and possible development of simulation-assisted training.

Project Impact and Conclusions: The goal of this project was to address the challenges of the reliable movement of electrical energy throughout the state as the power system is transformed to include more renewable and alternative sources, increased use of distributed energy resources and microgrids, possible expansion with very-large centralized base load generation, and incorporation of new power conversion, transmission, measurement, communication, and control technologies. Consistent with this goal the researchers conducting this project

- have developed knowledge and understanding of the unique geographical challenges and their spatial solutions, which a Florida specific sustainable energy economy must address for aspects of a successful sustainable energy strategy, specifically transmission, base load and distributed generation, renewable resource integration, and their impact on Florida grid reliability and accommodating a range of energy conversion options. Initial work focused on collection and organization of information relating to load and generation projections for the state over the next 10-20 years. This information, based primarily on load and generation projections from ten year site plans submitted to the FRCC by Florida utilities and county-based population projections, will form the basis for probabilistic models of loads in future years.
- have developed several reduced models of the Florida transmission grid for research use and have conducted preliminary validation and investigations into effects of high amounts of intermittent resources on Florida grid performance with these models.
- have engaged with Florida's governing and advisory entities, such as the FRCC, Governor's Energy Office, Tallahassee EDC Energy and Environment Roundtable, in strategic power and energy matters for a sustainable energy economy.
- have leveraged synergies with work from other funding sources such as DOE
- have disseminated results through publications.
- have written a number of proposals, several successful.

This project also engaged graduate students in rigorous, relevant, and impactful research.

Proposed Future Activities and their Potential Impact: Future steps involve further refinement of the dynamic model of the Florida grid and development of relevant case scenarios to study the possible impacts of variability due to the intermittent power sources. In addition, the future plan also involves continued engagement with the FRCC and FL utilities toward the validation of the notional Florida grid model for the purpose of conducting studies of major variations in the make-up of the grid, providing insight into model reduction for large (many thousands of buses) grid models, providing insight into real-time and EMTP type grid modeling versus load-flow and dynamic single phase grid models, and supporting the utility industry and other stakeholders involved in the operation, maintenance, and planning of the electric power grid.

This project is completed.