SUNSHOT INITIATIVE

Title: Model-Based Integrated High Penetration Renewables Planning and Control Analysis

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Organization of Prime Awardee: Pepco Holdings, Inc. (PHI)

Prime Awardee Physical Address: 701 Ninth St. N.W., Washington, DC 20068

Project Location: Washington, DC 20068 & Blacksburg, VA 24060

Background:

This project is bringing together analysis and control development from a number of research efforts [1, 2], and applying it to high penetration Photovoltaic (PV) interconnect evaluation, planning analysis and operations management at Pepco Holdings Inc., (PHI). Work is being built off a centralized detailed Transmission and Distribution (T&D) model that users can download as individual or a combination of circuits, which is used to structure model-based analysis and data integration. The model is also being used to structure data interface and validation with Geographic Information System (GIS), Supervisory Control and Data Acquisition (SCADA), Sky data (PV output) and Customer Load Data systems.

The key advancements resulting from this work are:

- Developing a new 'Voltage Headroom' - feeder voltage control setting concept, to provide a voltage control range specifically designed for use with high penetration PV.
- Modeling and costing out an advanced voltage regulation strategy based on changing control settings rather than other types of more costly infrastructure upgrades and determining the penetration levels this approach will support.
- The ability to automate detailed PV system analysis and simulation on a large number of integrated T&D circuits.
- The ability to perform detailed planning analysis, simulation and performance evaluation on circuits that include high penetration PV.
- The ability to use the same models for planning, operation management and control.

Objectives:

The primary goal of this project is to combine, refine and standardize the capabilities of each project partner for the purpose of fully integrated innovative planning, operations management and control solutions that will facilitate efficient and reliable use of high penetration renewables.

Major activities being performed to achieve this objective include:

- Detailed simulation based evaluation of PHI standard planning and operation practice to support high penetration renewables operation.
- Technical and economic evaluation of new design, operation and control practices using integrated T&D models and integrated system time series performance analysis, simulation of new autonomous voltage control device operations strategies, and development and simulation of model-based supervisory level volt–var coordinated control of advanced PV inverters and feeder level voltage control devices.
- Implementation of standardized DER/PV analysis tools:
    - Utility planner DER interconnect analysis application, including voltage rise calculation at the meter, for use on a portable computer.
    - Automated system wide PV performance and impact analysis that can be run for both planning and operations monitoring and forecast.
    - Conduct a pilot circuit field test of Headroom setting concept for autonomous voltage control device operation that will result in potential increase in renewable resource penetration levels.
- Model based demonstration of new high penetration DER/PV supervisory level coordinated control simulation that can be used for both planning analysis and operations management.
- Evaluate and review new analysis, standard practice, and monitoring and control simulation capabilities for potential use in PHI strategic planning.

Key Findings & Outcomes:

The majority of work to date has been spent on building and validating a representative set of 60 study feeders; working with PHI data management groups to configure GIS, load data, and measurement data for the study feeders; initial programming for high penetration PV operation forecast simulation and monitoring analysis, which is named as 'Forecast, Simulation, Monitoring and Adjust' (FSMA); and generation of detailed historical solar data for the PHI region. The selected study feeders include feeders that are short and stiff, long with high impedance, highly loaded, lightly loaded, mix of different types of customers – residential, industrial, commercial, overhead, underground, feeders with high PV saturation, feeders that are part of a Distribution Automation scheme that can't currently operate because of a large solar farm, and a grouping of feeders and substations where high penetration will have an impact on the transmission system.

This work also include development and testing of automated model correction and GIS error feedback. As advanced inverter simulation work is being completed, the team has begun automated analysis of large sets of circuits for Transformer Load Management (TLM) evaluation using a PHI 200 circuit build that will soon be completed. These same circuits and core analysis capabilities will be used for simulation and analysis of PV. Proposed PV hosting capacity batch feeder analysis is outlined in Figure 1.

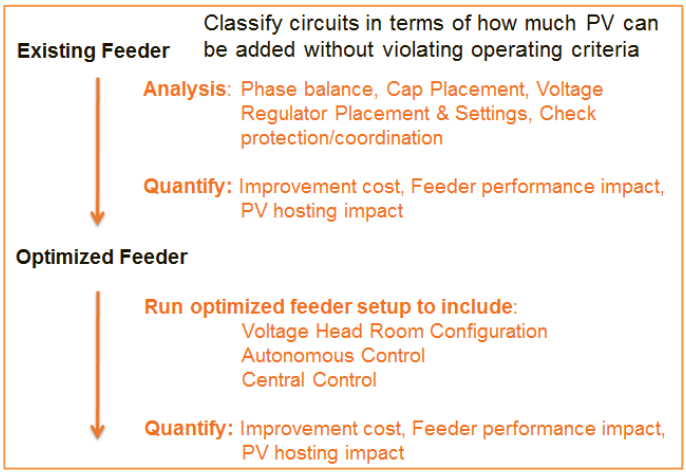

Figure 1. PV Hosting Capacity Automated Analysis

The team is now running FSMA development code to simulate volt-var control using LTC's, voltage regulators and capacitors as shown in Figure 2. Advanced PV inverter simulation and control will be integrated into the volt-var simulation next. This will be used to support voltage 'Headroom' simulation and design, and be used for initial high penetration PV monitoring and control development.

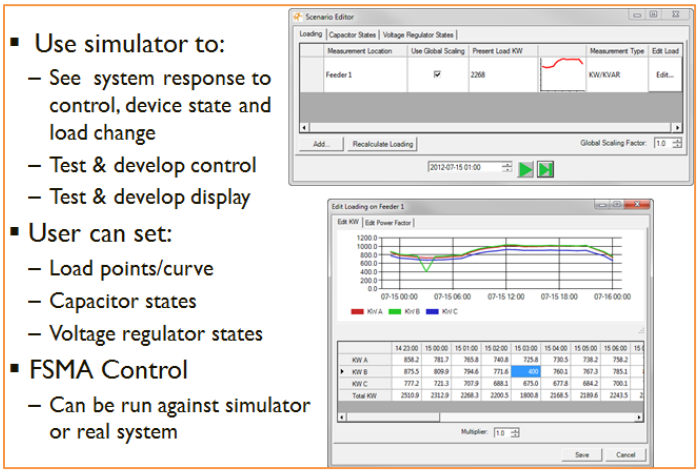

Figure 2. FSMA Simulator Development

References & Resources:

[1] Onen, A., Cheng, D., Arghandeh, R., Jung, J., Woyak, J., Dilek, M., and Broadwater, R., 2013, "Model Based Coordinated Control Based on Feeder Losses, Energy Consumption, and Voltage Violations," Electric Power Component and Systems, Volume 41, Issue 16.

[2] Hambrick, J., Broadwater, R., 2011, "Configurable, Hierarchical, Model-based Control of Electrical Distribution Circuits," *IEEE Transactions on Power Systems*, Vol. 26, Number 3, pp. 1072-1079.