Development and Testing of New Tools
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1. Project Objectives:

Current "smart grid" trends in the industry such as increased penetration of renewables, energy storage systems and increased participation from flexible demands continue to drive the need for the development of tools that take into account uncertainty in the context of multi-period scheduling and pricing. The goal is to create tools that facilitate just-in-time decision making, where as much uncertainty as possible is mitigated by using the most up-to-date information available at the point a decision is needed.

A major focus of the effort in 2012 is on developing the receding horizon framework for the multi-period SuperOPF, both by making explicit the temporal structure of the various energy, reserves and load following markets, and by creating tools for generating input data with the appropriate uncertainty statistics consistent with a receding horizon simulation.

The explicit receding horizon framework will also enable simulations involving hierarchical decision-making where, for example, market participants may make their own scheduling decisions for storage or flexible load, as opposed to having everything centrally scheduled by the ISO.

The scenario analysis portion of the project aims to develop a defensible methodology to represent low probability, high impact scenarios of wind generation, an essential component to the development of the ability of the SuperOPF to correctly incorporate extreme events to ensure power system security.

2. Major Technical Accomplishments to be completed this year

This year's efforts center around the design of the 3rd generation of the SuperOPF tool, with a particular focus on the explicit receding horizon framework. A two-stage model has been chosen and the design will include detailing the temporal structure and relationships between the two stages and their corresponding data inputs, optimization problem formulations and resulting outputs and contracts. A prototype of the 3rd generation SuperOPF solver, based on a DC network model and incorporating unit-commitment variables will be developed along with a corresponding receding horizon simulation framework for utilizing it.

Results from the input scenario creation work analyzing the optimal number of scenarios to use based on heuristics and a gap statistic were presented in a PSERC webinar entitled "Wind Output Forecasts and Scenario Analysis for Stochastic Multiperiod Optimal Power Flow". Techniques for creating input scenario data for the receding horizon simulations will also be developed, where the clustering is done using locational data for both wind and load and scenario selection is based on similar forecasted conditions.

In order to demonstrate and quantify the advantages of the stochastic formulation employed by the SuperOPF relative to more traditional tools, benchmarking test cases will be developed in which the uncertainty is driven by intermittent renewable sources such as wind. This involves the development of a multi-period OPF tool that uses a fixed zonal reserve requirement as well as the creation of a representative set of test scenarios based on a variation of the IEEE 118-bus system.

Other accomplishments include multiple enhancements to the problem formulations and corresponding software tools developed under this project. For the 2nd generation (multi-period) SuperOPF, this includes (1) improvements to price coordination scheme used in the AC network version by incorporating new adaptive strategies for some of the parameters and (2) improved modeling of the residual value of stored energy in terminal states. The SuperOPF Planning Tool, based on a modified 1st gen (single-period) SuperOPF, was modified to incorporate a new maximum build capacity constraint that limits the total amount of new capacity of a particular type that can be built in a given 10-year period. Enhancements to the MATPOWER package, which underlies all of the SuperOPF work, include support for additional state-of-the-art commercial solvers (Knitro, Gurobi, CPLEX 12.4), support for dispatchable DC lines, support for power flow studies on systems with islands, new tools for detecting and manipulating islands and isolated buses, generalized optimization model object for building and managing optimization models, and a uniform interface for solving MILP and MIQP problems.

Finally, this year's efforts also include preliminary work on flexibility rights, a demand-side counterpart to reserves, providing a way for an uncertain resource to express a willingness to pay for the ability to deviate from a contract and for a market to balance the need for flexibility with the resources required to accommodate it.

3. Deliverables and schedule for activities to be completed under FY2012 funding

The prototype of the 3rd generation SuperOPF solver is expected to be functional by the end of the summer, along with a prototype of the "traditional" fixed-reserves solver to be used for comparisons. The extended abstract of a paper entitled "Secure Planning and Operations of Systems with Stochastic Sources, Energy Storage and Active Demand", was accepted for the Special Issue of IEEE Transactions on Smart Grid on "Optimization Methods and Algorithms Applied to Smart Grid" and is expected to be completed by September. This paper will describe the multiperiod SuperOPF and present benchmarking results that include the results of the scenario selection work. A summary report of project activities through March 2013 will be prepared at that time. Two other journal papers are currently under review and presentations were made at a PSERC webinar and a FERC Workshop. Version 4.1 of MATPOWER was released this FY and 4.2 is expected to be released by the end of the FY.

4. Risk factors affecting timely completion of planned activities

Nothing is anticipated beyond the standard risk factors involved in software development, debugging and testing and application of numerical methods to new problems (e.g. sorting out convergence issues, performance tuning issues, etc.).

5. Early thoughts on follow-on work that should be considered for funding in FY2013

We will definitely want to continue to work on the receding horizon framework with updates and improvements as we get some initial experience with the tool and with the process of creating realistic input data needed to do simulations. We will probably also want to dedicate more resources to developing the investment planning formulation and tool now that the current SuperOPF planning tool is in use and is providing feedback pointing toward a full mixed-integer formulation with a view toward optimal transmission problems. Another potential direction is to develop the flexibility rights work and incorporate it into the SuperOPF.