Commercialization of the SuperOPF Framework: Phase 2

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1. Project Objectives:

The stochastic contingency-based security constrained AC Optimal Power Flow formulation behind the SuperOPF makes it very applicable to a variety of problems arising in power system planning and operations under deregulation. The ultimate goal of this project is to develop a commercial-grade SuperOPF in the context of co-optimization framework that correctly accounts for contingencies, ancillary services, static and dynamic constraints in determining both dispatch, price and operating reserve.

This phase is focused on the following: (i) enhancing SuperOPF (into SuperOPF-VS (voltage stability)) in its capability to deal with a large set of contingencies subject to voltage stability constraints, (ii) adjusting (or redispatching) both real and reactive control variables so that SuperOPF-contingency can perform the application functions needed in a ISO/RTO-scale Energy Management System (EMS), (iii) enhancing SuperOPF in its capability to deal with different objective functions needed in power system operation and planning, (iv) enhancing SuperOPF in its capability to deal with optimal load shedding, (v) continuing development a commercial-grade SuperOPF-contingency package.

Another objective of the phase II project is to apply the SuperOPF formulation to one particular class of OPF problems, specifically, the AVC (Automatic Voltage Control) problem. The history of developing AVC systems can be dated back to 1980s. In 1980s, a three-level hierarchical voltage control architecture, using the concepts of zone division and pilot bus, was implemented in France. This architecture was then extended to Italy. In 2000s, a hierarchical AVC system based on online adaptive zone division was proposed and then implemented in China, and was evaluated on the PJM power system. So far, the formulations of designing AVC systems contain proxy constraints. In this project, a comprehensive AVC formulation using the SuperOPF framework will be developed and a solution methodology for solving the AVC formulation will be designed.

2. Major Technical Accomplishments

1. A four-stage, multi-level, adaptive homotopy-enhanced Interior Point OPF solver has been developed and it is composed of four stages for robustness and efficiency, This four-stage Solver has been evaluated on practical power systems,
2. A patent application of the four-stage, multi-level adaptive, homotopy-enhanced Interior Point will be filed.
3. Develop a novel solution method to handle the discrete control variables in SuperOPF.
4. Implement the novel solution method in the commercial-grade core SuperOPF-discrete.
5. Evaluate the commercial-grade core SuperOPF-discrete on the PJM system model, a 13,000-bus EMS models in PSS/E data format. The simulation results

are encouraging.

6. Develop a commercial-grade core SuperOPF-VS (voltage stability) software, that supports the objective functions of cost, losses and minimum violations of target voltage profiles, equipped with a commercial voltage stability solver capable of handling the voltage stability constraint of a large set of contingencies, such as 2500 contingencies.
7. Evaluate the commercial-grade core SuperOPF-VS on the PJM system model, a 13,000-bus EMS models in PSS/E data format. The simulation results are encouraging.
8. Design the paths of developing a commercial-grade implementation of all the key functions of SuperOPF in the context of co-optimization framework that correctly accounts for contingencies, ancillary services, static and dynamic constraints in determining both dispatch and price.
9. Develop a commercial-grade core SuperOPF-Contingency software equipped with an optimal load shedding solver capable of handling up 10,000 loads.
10. Develop a comprehensive Automatic Voltage Control (AVC) formulation using the SuperOPF Framework.
11. Develop an effective solution methodology for solving the AVC formulation.

3. Deliverables and Schedule

1. A commercial-grade core SuperOPF-discrete software equipped with a commercial Power flow Solver and a homotopy-based interior point based solver. It will support various industrial-grade power system models such as 13,000-bus EMS models in CIM and PSS/E data formats. (90% finished and to be completed in Oct. 2012)

2. A commercial-grade core SuperOPF-Contingency software equipped with a commercial voltage stability solver. It will deal with the voltage stability constraint of a large set of contingencies, such as 2500 contingencies. (80% finished and to be completed in Dec. 2012)

3. A commercial-grade core SuperOPF-VS software equipped with an optimal load shedding solver with 10,000 loads. (20% finished and to be completed in Feb. 2013)

4. A commercial-grade core SuperOPF-VS that can dispatch all the control variables for both real and reactive power and support various objective functions of cost, transmission losses and minimum violations of target voltage profiles. (90% finished and to be completed in Oct. 2012)

5. Users’ manual and design manual of the commercial-grade core SuperOPF-VS software. (5% finished and to be completed in Feb. 2013)

6. A demonstration seminar of the extended, commercial grade core SuperOPFContingency software at PJM using PJM's operational data, with a large size of

contingencies such as 2500 contingencies. (The contact person at PJM plans to have this seminar in Sept. 2012)

7. A comprehensive AVC formulation using the SuperOPF framework. (70% finished and to be completed in Oct. 2012)

8. An effective solution methodology for solving the AVC formulation. (70% finished and to be completed in Oct. 2012)

9. A design document describing the paths of developing a commercial-grade implementation of all the key functions of SuperOPF-Contingency in the context of co-optimization framework that correctly accounts for contingencies, ancillary services, static and dynamic constraints (voltage stability) in determining both dispatch and price. (5% finished and to be completed in Dec. 2012)

4. Risk factors affecting timely completion of planned activities

We do not expect major risk factors affecting timely completion of planned activities.

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

The stochastic contingency-based security constrained AC Optimal Power Flow formulation behind the SuperOPF makes it very applicable to a variety of problems arising in power system planning and operations under deregulation. The ultimate goal of this project is to develop a commercial-grade SuperOPF in the context of co-optimization framework that correctly accounts for contingencies, ancillary services, static and dynamic constraints in determining both dispatch, price and operating reserve.

In FY2012, a design path of developing a commercial-grade implementation of all the key functions of SuperOPF-Contingency in the context of co-optimization framework that correctly accounts for contingencies, ancillary services, static and dynamic constraints (voltage stability) in determining dispatch, price and reserve will be completed.

In FY2013, we propose to implement a commercial grade core SuperOPF-Contingency software in the context of co-optimization framework that correctly accounts for contingencies, ancillary services, static and dynamic constraints (voltage stability) in determining both dispatch, price and reserve. In addition, we propose to evaluate the software using PJM's operational data, with a large size of contingencies such as 2500 contingencies.

In FY2013, we propose to develop a comprehensive User Interface which will consist of two components. The first component is a graphical user interface (GUI) program. This GUI program will offer users a convenient and feature-enriched interface to interact with the underlying SuperOPF computation. There will be three major engines in this GUI program, that is, the data selection and display engine, the parameter and model setting engine, and the resulting reporting engine. Besides the GUI program, a console program should be also considered in the implementation. This console program will eliminate all graphical interactions and can only be run in a command line environment. However, the user still has full control over the computation scenarios through specifying the parameters to the console command.

In FY2013, we propose to design a SuperAVC (Automatic Voltage Control) using the SuperOPF Framework. The SuperAVC system will be capable of dealing with uncertainties such as Wind and Solar.