Project Closeout

Global Optimal Technology (Ithaca, New York)
Final Technical Report
High Performance Solution for Security Constrained Optimal Power Flow

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Lead Recipient:	Global Optimal Technology, Inc.
Project Team Members	Dr. Hsiao-Dong Chiang, Mr. Gilburt Chiang, Dr. Bin Wang, Mr. Simon Wyatt, Mr. Pat Causgrove
Project Title:	**High Performance Solution for Security Constrained Optimal Power Flow**
Program Director:	Dick O'Neill
Principal Investigator:	Dr. Hsiao-Dong Chiang
Contract Administrator:	-
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Public Executive Summary

Solving the Alternating Current Optimal Power Flow (ACOPF) problem is key to economically efficient and reliable power networks with a good solution potentially saving utilities tens of billions of dollars annually (according to FERC).

The Grid Optimization (GO) Competition set up by ARPA-E saw several promising solutions in Challenge 1. While team GOT-TJU-OPF placed top 10 in Division 3 and 4, this was not a satisfactory performance, and the team has identified specific areas to improve and will be adding more members to round out the necessary skills and expertise needed to be more competitive. The team set out for redemption during GO Challenge 2 with an improved High-Performance Solution for Security Constrained Optimal Power Flow.

The (renamed) BSI-GOT-OPF Team ended up finishing top 2 overall in the competition. The algorithms developed have potential impacts for the electric power markets that are enormous. Optimal Power Flow technology can be an enabling technology to achieve energy-efficient power grids while enhancing renewable energy penetration, among others.

Acknowledgements

The team would like to thank Dick O'Neill and the ARPA-e GO Competition team as well as the other sponsors and supporters of the competition. Without them, we would not be able to have this competition and opportunity for innovation.

Accomplishments and Objectives

Bigwood Systems, Inc. (BSI) was awarded $420,000 in funding from the U.S. Department of Energy's (DOE) Advanced Research Projects Agency-Energy (ARPA-E) for finishing top 2 overall in Challenge 2 as part of ARPA-E's Grid Optimization (GO) Competition, which is a series of challenges focused on developing solutions to create a more reliable, resilient, and secure American electricity grid.

Project Activities

The project aimed to develop and integrate improvements to the previous algorithm in order to be more competitive in Challenge 2. The below work was proposed then completed:

- **Contingency Analysis:** In challenge 1, the team ran AC power flow on all contingencies which proved time consuming. Challenge 2 will leverage our patented method to screen out potential critical contingencies and run power flow for these critical contingencies to save contingency analysis time.
- **Robustness:** To guarantee robustness of the SCOPF method, our solution engines will be integrated in our implementation. Each computation engine has its own characteristics suitable various scenarios. Computational efficiency will be guaranteed with a distributed implementation to take full advantage of the computational resources available on the evaluation platform.
- **Feasibility Pump to handle Discrete Variables:** Challenge 2 brings the addition of adjustable control devices. Seeking to implement a Feasibility Pump (FP) algorithm to quickly find a high-performance solution by iteratively solving two subproblems (Multi-Integer Linear Programming (MILP) and non-linear programming (NLP)) and converges to a solution that satisfies the original nonlinear constraints. It is an effective method to solve the large-scale mixed integer nonlinear optimization problem (MINOP) in challenge 2.

- **Parallel Processing to improve speed:** One big weakness with the original algorithm was its sequential computation whereas other submitted methods used parallel computation. This put our team at a significant speed disadvantage. Therefore, the new submission algorithm will be built with a hybrid model of parallel programming such that the application can run on the computer cluster and utilize the available computational resource effectively. More specifically, OpenMP (node) MPI (between nodes) will be used for parallelism.

- **Transmission Switching Methods** for dealing with thermal limit violations and voltage violations. The team has worked on this methodology and developed tools for utilities such as UK Power Networks using line switching.
- **Price-Response Load Demand Model** can provide maximum value in relieving network constraints or improving system performance. Since price-based demand response data is not widely available, it is not enough for deriving accurate price-response load models. The team will consider loads represented by a fixed part and a linear price-response load representation as well as by non-linear price response functions which are monotonic decreasing functions.
- **Final Report Submission:** Once all development is completed, integrated, and tested – the team will compose and submit a final report detailing all development work completed for Challenge 2. This will be submitted at the close of the project. The combined team known as "BSI-GOT-OPF" will participate in Challenge 2 by submitting its algorithms for the trials and final event.

Project Outputs

Second place algorithm and foundational AC-OPF tool to be validated with industry partners.

Follow-On Funding

None.