Test Problem Selection and Support for ARPA-E Optimization Competition

# Feng Pan, Steve Elbert, Yuri Makarov

In the recent ARPA-E Optimization workshop in November 2014, the idea of organizing a competition of optimization models and algorithms was discussed. The main goal of this competition is to attract more diversified participants and promote novel robust and efficient methods to solve some of hardest optimization problems underpinning power system planning and operations.

This white paper, based on this recent ARPA-E Workshop, is to provide PNNL’s expert opinions on selecting problems for this competition and to show the PNNL’s intent to develop a testbed simulation environment to support ARPA-E’s Optimization Competition by evaluating and scoring models and algorithms.

Optimization problems are at the center of power grid planning and operation. The current capability gaps are about balancing between providing high quality of solution (how good) for power system operations and planning and providing such solutions within allowable time limit (how fast). These gaps are originated from the discreteness, sequential nature and nonconvexity of of some of these optimization problems and are amplified by uncertainties and system dynamics. With temporal expansion, geo-spatial span and explosion of scenarios, the real-world power system problems are extremely difficult to solve. Although there are various power system optimization problems, two of the fundamental optimization problems, AC-OPF and unit commitment, often underpin many power system planning and operation activities. One of the most common applications of such algorithms is electricity market, where the quality of solution is directly related to the energy prices. Therefore, these two well and clearly defined problems can be the problems for the first phase of the competition. Then, from these initial problems, the competition can branch out to other problems through the later phases. The resulting optimization models and algorithms from this competition may not provide immediate solutions for industries, but will pave a path to the near-future disruptive technologies in the power industry. Here are some candidate problems for the first-round competition formed around these two core problems.

|  |  |  |  |
| --- | --- | --- | --- |
| Problem | Discrete/Continuous | Deterministic/Stochastic | Static/Dynamic |
| ACOPF | Continuous | Deterministic | Static |
| Multi-period ACOPF | Continuous | Both | Static |
| ACOPF with N-K | Mixed | Both | Static |
| Unit Commitment | Mixed | Both | Static |

PNNL is the leading DOE’s national lab in power system research and has been performing extensive basic and applied research and industry and policy supports in the energy domain. PNNL intends to support ARPA-E Optimization Competition by providing dataset, setting up simulation systems, and evaluating participants’ models and algorithms.

PNNL’s power system research is built on the broad science foundation of the Laboratory including power engineering, operations research, computer science, chemistry, catalysis and material science. PNNL had over two decades of achievements and experiences in supporting DOE, BPA, ISOs and industries. These activities include planning to real-time system studies, power system monitoring and validation, information management, imbalance market design, and renewable integration studies and demonstration and etc. With years of research and development, PNNL cumulated strong capabilities and domain experts for transforming raw data sets into power system testbeds in which feasible and convergent flow solutions are guaranteed to exist. With the long and successful records of developing testbeds and performing simulation for research evaluation and industrial supports, PNNL produced multiple test systems in PNNL, including different sizes of IEEE testbeds, WECC base cases, simplified WECC base cases, TEPPC cases, NWPP cases, Duke Energy cases, ERCOT and FERC cases. These test systems have been used for state estimation, dynamic tracking, renewables integration and unit commitment studies. Depending on the competition requirements, the PNNL staffs based on their experiences can also generate power system models for algorithm training and testing purposes. PNNL can utilize its optimization expertise to utilize the current state-of-art optimization models and algorithms for selected competition problems. These models and algorithms will provide baseline performance metrics for evaluating competing models and algorithms. In addition to data and software support, PNNL has the state-of-art hardware systems and IT support required for hosting the competition. Models and algorithms utilizing high performance computing are a current active research area and should be included as one of the approaches. PNNL’s high performance computing center can provide supports for evaluating models and algorithms in this category. In the case if ARPA-E Optimization Competition may have several test cases and phases, in which variation of base problems may include dynamic, demand response, and topological controls, PNNL’s testbeds can be naturally extended for these variations based on the past case studies.

In conclusion, PNNL proposes to provide technical, hardware, and IT support for ARPA-E Optimization Competition. The resulting testbeds can be used for the competition and related power system researches in DOE.