ARPA-E GO Competition Challenge 2: Scoring
Updated 2020-11-12

1. Terminology

The following terminology will be utilized throughout the GO Competition and in this scoring document:

- ***Power system network model***: each hypothetical grid with defined topological structure and characteristics including, but not limited to, locations of generators, loads, transmission lines, transformers, equipment detail, control equipment, and limits.
- ***Scenario***: an operating instance in time on a power system network model. The scenarios define an instantaneous demand at each bus, renewable resource availability, and other temporary system conditions.
- ***Dataset***: A collection of power system network models and scenario data on those models.
- ***A scenario score*** is calculated for each scenario of a power system network model.
- ***A power system network model score*** is calculated by taking the geometric mean across all scenarios associated with a network model.
- ***A dataset score*** is computed by taking the geometric mean of all power system network models in a given dataset.
- ***Code 1 algorithm***, the algorithm that determines the base case solution.
- ***Code 2 algorithm***, the algorithm that determines each contingency case solution at the conclusion of code 1.

2. GO Competition Divisions

The GO Competition will host four different "divisions" with separate leaderboards. Two divisions will be focused on real-time optimization (with a 5 minute time limit per scenario for Code 1) and two focused on offline optimization (with a 60 minute time limit per scenario for Code 1). For Code 2, there will be a dynamic time limit based on the dataset/problem dimensions rather than the division (see References/Time Limits for details). Unlike in Challenge 1, all four scoring divisions will now focus on the value of the objective function (maximizing the market surplus). The Eligible Entrants who rank at the top of each division will receive a prize based on their rank as either prize money or as a grant for follow-on research approved in writing by ARPA-E (for more details on prize money versus grant eligibility, see the Challenge 2 Rules document). Prizes and grants for placing in multiple divisions are additive. Figure 1 depicts algorithm scoring by division. Scoring for all four divisions is discussed below.

Figure 1. Breakdown of the Scoring Divisions and Prize/Grant Money for Eligible Entrants.

A. Objective Function Scoring:

A particular Entrant's solution score will be referred to as score z^{total}, and represents the total market surplus. A solution score exists for each network model and scenario; however, without loss of generality, we will suppress indices for model and scenario in the following discussion.[1] The scenario score is defined as:

$$z^{total} = z_{k0} + \frac{1}{|K|} \sum_{k \in K^{ct}} z_k \tag{1}$$

$$z_k = \sum_{i \in I} z_{ik} + \sum_{j \in J} z_{jk} + \sum_{e \in E} z_{ek} + \sum_{f \in F} z_{fk} + \sum_{g \in G} z_{gk} \;\; \forall k \in K \tag{2}$$

where I is the set of buses, J is the set of loads, E is the set of lines, F is the set of transformers, G is the set of generators, $k0 \in K$ is the base case, and $K^{ct} \in K$ is the set of contingencies. Z is the market surplus across each of these elements for the base case and for each contingency, and is further defined for each element (including constraint relaxations σ and penalty costs c_k^{σ}) within the full formulation document. Please note that, unlike Challenge 1, the costs to re-dispatch the fleet in response to a contingency are now included in the overall objective.

Thus, the score is the objective function value under a given network model, m, and scenario, s_m, which is defined to be the addition of the total benefits minus cost and linearly penalized slack variables, corresponding to real and reactive power nodal imbalances as well as branch overloading. The costs of these violations are captured by the penalty prices (see λ in the official formulation online) and will be provided as part of each power system network model and based on the prices used in real industry markets.[2] As discussed, Division 1 and 3 will

[1] Given a network model, $m \in M$, a scenario, $s_m \in S_m$, and an Entrant, $\tau \in \mathrm{T}$, the resulting score for that particular instance is represented as $c_{m,s_m,\tau}$. Note that $s_m \in S_m$ is indexed by model $m \in M$ as different models may have different number of scenarios. Therefore, each model m can have its own corresponding set of scenarios, $s_m \in S_m$.

[2] California ISO. Market Parameter Settings for MRTU Market Launch. February 2009.

evaluate this score after $t_1 = 5$ minutes on the competition platform, while Division 2 and 4 will do so with set-points returned after $t_2 = 60$ minutes of evaluation. Transmission lines and transformers may not have their status switched open or closed in Divisions 1 and 2, but competitors may use any other feature of the loads, generators, and transmission assets described in the formulation and within the limits of the input datasets to optimize each scenario for both the base case and each contingency response. Divisions 3 and 4 will allow competitors to employ all of these previously described features including switching the status transmission lines and transformers to either open or closed as permitted by the input datasets.

All algorithms will be assigned a penalty score (for infeasibility) of z_{m,s_m}^{inf} for a given power system network model m and a given scenario s_m if they do not return a solution in the given amount of time or the solution is infeasible to the official SCOPF formulation. Note that the official SCOPF formulation includes a relaxation of the nodal real/reactive power balance constraints and branch limits with the inclusion of slack variables and penalty prices on those slacks; feasible solutions for this relaxed SCOPF problem are scored based on (1). Infeasible solutions are those that violate constraints that are not relaxed in the SCOPF formulation (for example, power flow equations or a voltage limit). The infeasibility score z_{m,s_m}^{inf} for each network model scenario is determined by following a simple solution methodology that is described in the Challenge 2 Formulation document.

Figure 2 shows a visual representation of two notional algorithms, with Algorithm 1 winning Division 1, and Algorithm 2 winning Division 2. Entrants will be able to submit their executable program (source code) with the ability to adjust their algorithmic approach based on division; there will be an input parameter that will reflect the selected division.

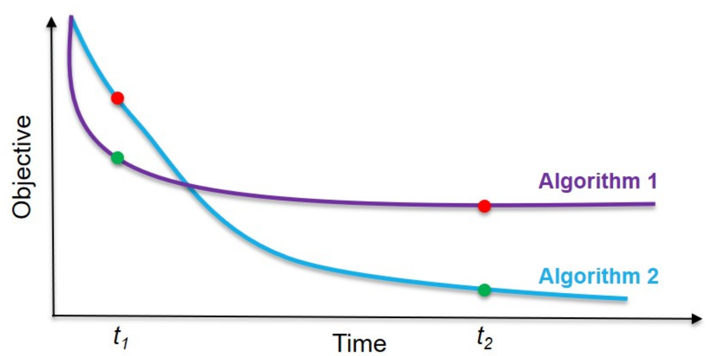

Figure 2. Algorithm Performance over Time.

Once an Entrant's executable program has a score for a given network model, $m \in M$, for each scenario, $s_m \in S_m$, the power system network model score is computed by taking a geometric mean over the number of scenarios for that network model:

$$Score_{m,\tau} = \sqrt[|S_m|]{\prod_{s_m} z_{m,s_m,\tau}} \quad (5)$$

Similarly, the total dataset score, for Entrant $\tau \in \mathrm{T}$, is a geometric mean over the power system network model scores:

$$Score_{\tau} = \sqrt[|M|]{\prod_{m} Score_{m,\tau}} \quad (6)$$

The winners of each division will be determined by their rankings evaluated during the GO Competition Final Event.