

Grid Optimization (GO) Competition

FERC Software Conference

Kory W. Hedman Kory.Hedman@HQ.DOE.GOV

June 27, 2019

. . . .

Outline

- Introduction
- Timeline
- Winning/Scoring/Divisions
- Competition Datasets
- Trial 1 Leaderboard
- Lessons Learned from Trial 1
- Summary
- Questions



INTRODUCTION



Fast Evolving Grid Requires Innovation in Management Systems / Decision Support Tools





What is Optimal Power Flow?

<u>Input</u>

- Transmission grid
- Generator characteristics and availability
- Other control device characteristics
- Demand characteristics
- Wind/Solar forecast



Optimization algorithm

<u>Output</u>

- Generator dispatch such that:
 - ✓ Overall cost is minimized
 - Reliability requirements are met
 - ✓ Demand is satisfied
 - ✓ Operating limits not violated



The heart of most grid software/optimization is Optimal Power Flow (OPF)



Optimizing Grid Power Flows is ARPA-E Hard



- Exact optimal solution methods are computational non-tractable
- Various approximations are widely used today (linearizations, iterative approximations)



1. I.A. Hiskens and R.J. Davy, "Exploring the power flow solution space boundary", IEEE Transactions on Power Systems, Vol. 16, No. 3, August 2001, pp. 389-395.

The GO Competition: Grid modernization requires software development modernization

- Impacts efficiency of a \$500B/year sector
- Impacts reliability and resilience
- New software can be an enabler of emerging technologies:
- Increased variability / stochasticity from wind and solar, distributed energy resources
- Decreasing stability and validity of steady state assumptions
- Decentralization with millions of distributed assets
- Power flow controllers
- Storage
- Responsive demand

Competition: identify breakthrough technologies & initiate overhaul of legacy management systems via a fair and transparent evaluation of innovative approaches





COMPETITION TIMELINE AND DIVISIONS



Competition Timeline

GRID OPTIMIZATION (GO) COMPETITION





Competition Divisions



Challenge 1: Final Event





1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1
1

TRIAL 1 DATASETS AND LEADERBOARD



Trial 1 Datasets Online

Network Model	Buses	Generators	Loads	Branches	Minimum Contingencies	Maximum Contingencies	Transformers	Areas	Fixed Shunts	Switched Shunts	Scenarios
1	500	90	200	468	349	422	131	1	0	17	3
2	500	224	281	540	784	786	193	1	5	39	3
3	793	210	568	769	86	97	143	1	49	50	3
5	2000	544	1125	2359	3139	3189	847	1	0	153	3
6	2000	384	1010	2743	2594	2618	896	3	32	141	3
7	2312	617	1529	2156	942	1014	857	18	121	201	3
70	2312	444	1529	2156	1008	1015	857	18	121	201	3
8	3013	865	1793	2836	1957	1968	1290	20	129	405	3
81	3288	379	4236	3421	4563	4650	1455	1	0	23	3
84	4601	408	3501	5135	7075	7094	2180	1	0	17	3
9	4918	1340	3070	4412	5058	5085	2315	31	246	486	3
12	9591	365	6659	10927	4377	4377	4988	1	0	122	3
13	10000	2089	3982	10819	9519	9622	2374	6	99	434	3
										Total	39



GRID OPTIMIZATION (GO)

COMPETITION

anna

Trial 1 Leaderboard Online



← ⊕ @ https://gocompetition.energy.gov/challenges/challenge-1/trial-event-1	Carlerboard - Challenge 1 ×		- ∂ ×
GRID OPTIMIZATIO COMPETITION	arpa•e N (GO)	Log In Register	^
Home Background - Re	ferences 🗸 Competitions 🗸 FAQs Forum News Defit	nitions	
Home » Competitions » Challens	 e 1 » Leaderboard - Challenge 1 - Trial Event 1 LEADERBOARD - CHALLENC Below are the initial results for Division 1, Division 2, and Divisions based on 39 (of 718) scenarios from the Trial Event 1 dataset Datasets webpage. This set has 3 scenarios from each of the There will be 4 leaderboards for Trial Event 1, one for each D Division 1 - real-time, objective value Division 2 - offline, objective value Division 3 - real-time, performance profile 	GE1 - TRIAL EVENT 1 ion 3 only of Trial Event 1. These initial results are t and can be downloaded from the <u>Challenge 1</u> a 13 network models. ivision:	
Problem Formulation	Division 4 - offline, performance profile		

Problem Formulation

Input Files and Format

INTERIM TRIAL EVENT 1 - DIVISION 1

Output Files and Format					
	Team Name	Team Leader	Leader's Organization	Team Members	Score
Datasets				Dr. Hassan Lionel Hijazi,	
Evaluation	gravityx	Dr. Nathan Lemons, Ph.D.	Individual	Dr. Nathan Lemons, Ph.D.	116,354.50
Scoring				Elizabeth Wong, Prof. Frank Edward Curtis, Ph.D., Ermin Wei, Daniel	
Trial Event 2 🔹	GO-SNIP	Prof. Frank Edward Curtis	Lehigh University	Kenneth Molzahn, Andreas Waechter	276,313.64
Code2 Time Limit				Prof. Kyri Alysa Baker,	
Code2 Open Source				Kaitiyn Gariti, Prof. Javad Mohammadi, Mr. Mohammadhafez	
Trial Event 1 Leaderboard	Tartan Buffs	Prof. Kyri Alysa Baker	University of Colorado Boulder	Bazrafshan, Prof. Soummya Kar	295,271.14



https://gocompetition.energy.gov/

Variation in Performance by Teams: Trial 1





LESSONS LEARNED FROM TRIAL 1



Key Lessons From Trial 1 (for competitors)

Software Development is an Iterative Process

- Many teams had initial trouble preparing "industry-ready" programs which reliably solve new datasets and problems.
- Successful teams submitted their programs for testing on the GO Competition platform early and often.

Minimize Penalties and Solve Problem within Scope of Competition

- Industry is not looking for the very best theoretical solution to this problem which takes infinite time to solve, they need decision-making tools which provide a very good solution, very quickly.
- Successful teams prioritize their approach to find the best, secure solution possible within the competition time limits.

Not All Development Platforms are Equal

- In order to accommodate as many teams and approaches as possible, we offer a wide range of software and platforms for competitors to use in this competition.
- Some software packages are more useful for commercial software applications than others.



Key Lessons From Trial 1 (for ARPA-E)

- If you give teams unlimited evaluation time...
 - ...they will use it.
 - For Trial 2 we are applying new time limits for contingency analysis to keep competitors on track to build innovative new approaches that are commercialready for industry deployment.

Streamline Hardware and Evaluation Processes

- Licensing, hardware, and evaluation process issues.
- For Trial 2, PNNL has prepared a uniform testing environment for both development and evaluations for all competitors.
- We will follow a tighter evaluation schedule for trial 2.

New focus on development

- Contingency screening and SCOPF solution is crux of the GO Competition.
- ARPA-E has provided a sample open-source algorithmic approach for contingency analysis so that all teams may re-focus their efforts on innovating in the SCOPF space.



Summary

- Legacy grid software systems inhibit emerging technologies, innovative solutions
- The GO Competition provides a platform for open and fair evaluation of innovative grid software
- The competition starts with an existing problem that is core to most grid software -- SCOPF
 - ARPA-E Hard
 - Could save beyond \$10B in costs per year
- Mission: start here and continue to break ground to bring innovative grid software solutions to practice
- Be an enabler for emerging grid technologies



Continued Evolution of Grid Software

Today	GO Competition Challenge 1	GO Competition Challenge 2	Future			
 Simplified and sub- optimal OPF Software built for conventional resources 	 Traditional SCOPF Ability to model new resource types 	 Advanced SCOPF Advanced power flow controllers and topology control Multi-stage 	 Unit Commitment Stochastic optimization Cyber- security 			
Enabled b DAT	y GRID A					



Questions?



Kory W. Hedman Program Director ARPA-E, US Dept of Energy Kory.Hedman@hq.doe.gov

