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TradeRES Research Bulletin

Cross Entropy Covariance Matrix Adaptation Evolution Strategy for Solving the Bi-Level Bidding Optimization Problem in Local Energy Markets

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Full paper: https://www.mdpi.com/1996-1073/15/13/4838

Summary

Local energy systems (LES) are gaining popularity due to more renewable energy in electricity distribution networks. LES support small-scale transactions and can be viewed as a bi-level optimization problem in which parties (consumers, prosumers, or producers) attempt to maximize earnings and a the LES market maximizes energy traded. Local energy strategic bidding is NP-hard and nonlinear. This research provides a hybridized Cross Entropy Covariance Matrix Adaptation Evolution Strategy (CE-CMAES) to address a bi-level problem. CE-CMAES uses cross entropy to explore global search space and covariance matrix modification locally. Step-size inhibits early convergence while searching in CE-adaptive CMAES. A practical energy distribution system with renewables validates the algorithm's performance. CE-CMAES beats state-of-the-art algorithms in cost, fitness, and Ranking Index (a competition metric). Wilcoxon Signed-Rank test demonstrates CE-CMAES findings are superior to others.

Highlights

- An effective approach to tackle a non-linear and difficult bidding optimization issue in LEMs
- The problem is treated as a multi-period bi-level optimization in which upper-level actors try to maximize earnings (i.e., a multi-leader problem)
- The agent bids/offers affect the market clearing price response calculated at a lower-level problem (a single-follower problem)
- CE-CMAES is described in-depth. The algorithm won the international competition "Evolutionary Computation in Uncertain Environments: A Smart Grid Application" in GECCO 2020 and WCCI 2020, highly conferences.
- A comparison showed that CE-CMAES delivers higher profitability for all agents than other state-of-the-art algorithms.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864276