



Bidding Generation Tool

Final Project Report

M-45G

Power Systems Engineering Research Center
*Empowering Minds to Engineer
the Future Electric Energy System*



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Executive Summary

Research Problem and Motivation

The increasing penetration level of Distributed Energy Resources (DERs), such as intermittent Renewable Energy Resources (RERs) and Energy Storage Systems (ESSs), in modern power systems, has initiated the need for adjustments of traditional electricity markets practices. The essential modifications include, but are not limited to, the need for developing new market designs and regulations for DER accommodation, the need to find effective ways to communicate and coordinate with DERs while integrating with the market, the need for more accurate forecasting due to the intermittent nature of RERs, and the need for aggregation of small-scale DERs in order to make sure fairness in having access to the market. Due to resource size and performance requirements by regional grid operators, DER entry and participation in the wholesale electricity market has been challenging. As a result, Federal Energy Regulatory Commission (FERC) Order No. 2222 has been implemented to facilitate the participation of DERs in electricity markets through aggregation. It is essential to highlight that the primary aim of FERC Order No. 2222 is to promote DER participation in the wholesale electricity market and, in extension, exploit the benefit of higher grid resilience and increased competition. This highlights the need for optimal scheduling and bidding strategies for DER aggregators' participation in electricity markets. These strategies need to be compatible with the different techno-economical constraints associated with the operational aspects of DERs across various markets with different time horizons, such as Day-Ahead (DA) and Real-Time (RT) horizons. This study proposes a new and comprehensive bidding decision support tool for optimizing the participation of aggregated DERs in DA and RT energy and Ancillary Service (AS) markets under NYISO's regulatory requirements. The tool aims to maximize the profit of DER aggregators while ensuring the reliable participation of DERs in the wholesale electricity markets.

Research Method

In the proposed tool, two multi-period and interdependent frameworks (DA and RT scheduling frameworks) have been integrated. Using a DA scheduling framework, a mixed-integer linear programming (MILP) optimization problem is solved by the DER aggregator, the output of which is aggregator's DA price-quantity pairs. Afterwards, by receiving the cleared DA bids, the RT scheduling framework aims to calculate optimal RT price-quantity pairs using the respective optimization problem. It is worth mentioning that the RT framework is run on a rolling horizon basis. Figure 1 is a high-level flowchart of the adopted research methodology, which illustrates the inputs and outputs of the DA and RT scheduling frameworks, DER capability estimator module, and price predictor module.

The modules included in the proposed tool are as follows:

- I. **DER Capability Estimator:** This component leverages forecasting tools to estimate and forecast the available DER capability, specifically targeting Photovoltaic (PV) systems. Location and time considered as well as the characteristics of DERs (such as the size of PV panels and efficiency) are used as the input of the DER capability estimator module. Based on these inputs, it calculates the forecasted output power of PV units and generates solar scenarios using the fitted normal distribution function. By accounting for the variability and

uncertainty in solar generation, this component provides crucial insights for market participation strategies.

- II. **Wholesale Market Price Predictor:** This component considers historical DA and RT market prices and weather conditions to generate scenarios for wholesale market Locational Marginal Prices (LMPs) and to forecast ASs marginal prices. By receiving these inputs, this module calculates the forecasted E & AS prices while taking the uncertainty of energy prices into account using the scenario generation module. These energy prices scenarios along with AS forecasted price are used as the input of the respective DA (or RT) scheduling frameworks, and at the same time, they are used in the price breakpoint calculation procedure, the output of which is also used as the input of DA (or RT) scheduling frameworks. By incorporating market price uncertainties, the proposed model enhances the accuracy of profit forecasts for DER aggregators.
- III. **Bid Generation Algorithm:** This algorithm consists of the DA and RT scheduling frameworks, through which two interdependent optimization problems have been developed. These optimization problems are implemented for the maximization of profits that aggregators can achieve while considering their risk aversion level, techno-economic constraints of DERs, and market dynamics. In order for DER aggregators to participate in NYISO DA energy and AS markets, the DA framework calculates the bid-quantity pairs by using the outputs from the previously mentioned DER capability estimator and price predictor modules. The cleared DA bids would be then used by the RT scheduling framework to produce RT price-quantity pairs. It is essential to highlight that the outputs of the DER capability estimator and market price forecaster are updated based on the length of the RT intervals and then used as the inputs of this framework. The algorithm satisfies technical and economical constraints for the provision of services by the DERs while dealing with the uncertainties of the forecasts.

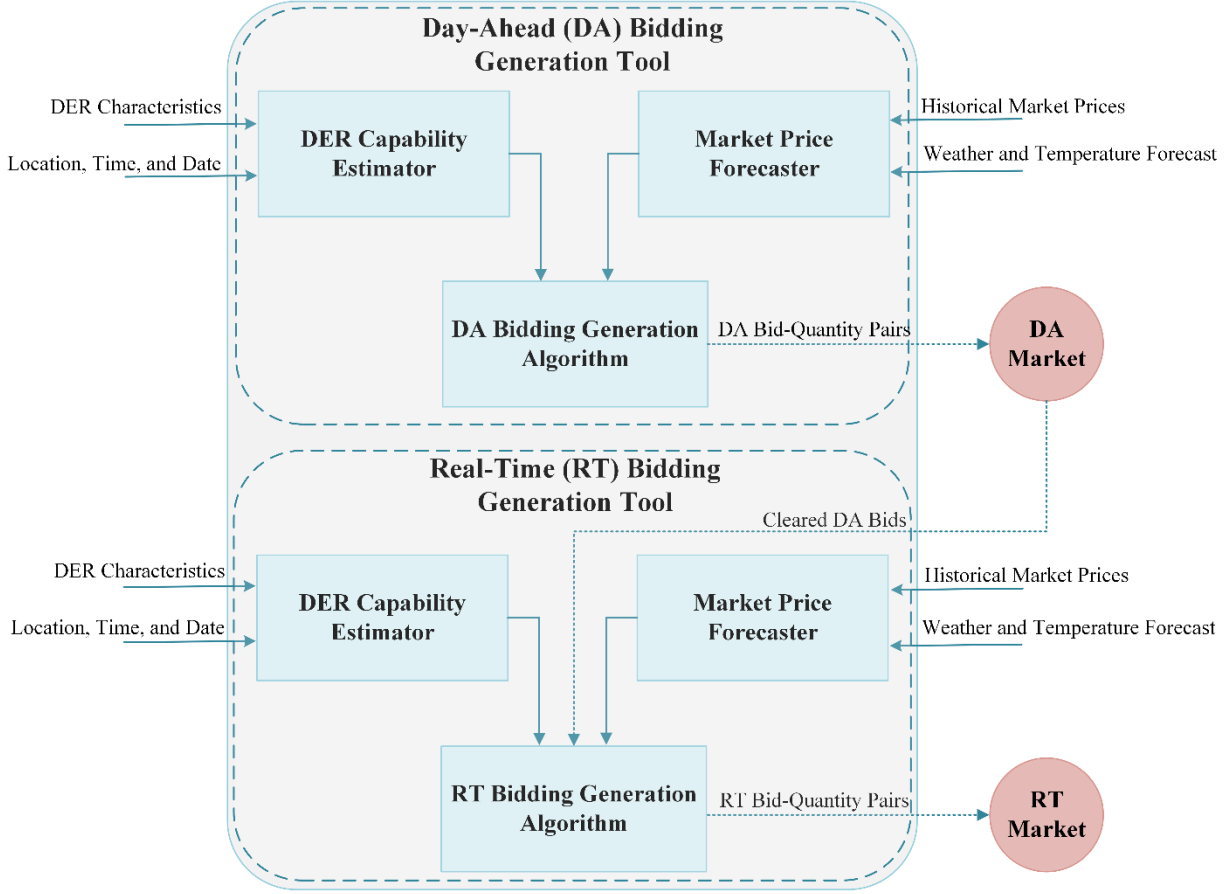


Fig. 1. Main Components of the Proposed Bidding Generation Tool.

Research Findings

The proposed tool has been designed and developed in order to maximize the profits for DER aggregators' by utilizing the price predictor and capability estimator modules as well as by accommodating several adjustments in the proposed bidding generation algorithm. The tool has the ability to calculate the optimal DA and RT bid-quantity pairs while considering price forecasts and the dynamics of the markets. It also ensures that DER aggregators' participation in different markets is conducted in an efficient, profitable, and reliable manner by uncertainty management and RT adjustments while considering the NYISO's regulatory requirements and managing risk. By integrating the DA and RT scheduling frameworks, the coordination of DER aggregators in DA and RT energy and AS markets has been strengthened. This enhances operational efficiency and effective utilization of available resources. The tool has been designed to be customizable and scalable, which makes it suitable for real-world implementation and useful for handling multiple DERs simultaneously.

Implications, Research Products, and Future Applications

The implication of the study is that it underlines the potential ability of the DER aggregator to obtain higher profits with more reliable market participation because of the usage of enhanced scheduling and pricing as well as risk management strategies. In the design process, the tool has

been made practical, comprehensive, and flexible to be applied in different market timeframes and to be adaptable to different DER aggregation configurations. This research effort has produced a bidding decision support tool that can be made available for PSERC members or other stakeholders interested in optimizing DER participation in electricity markets. Moreover, the proposed tool could be utilized to mimic DER aggregators' behavior in power system studies. Future steps to move the research toward applications include collaborating with market operators to integrate the tool with existing market platforms for seamless bid submission and activation. This component ensures the effective activation of bids, which can guarantee compliance with economic and technical constraints for energy and grid service provision.

Student Theses:

- [1] Nirupama Pudukkarai Srinivas. A Day Ahead Bidding Decision Support Tool for DER Aggregators. Master's thesis, Arizona State University, June 2024.