##### The Department of Electrical and Computer Engineering

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## Final Defense of Dissertation

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Title: ﻿Optimal Market Participation of Energy Resources in the Wholesale Electricity Markets: An Optimization-Based and Data-Driven Approach

**Abstract**

﻿By introducing the wholesale electricity markets, the power networks are expected to reach higher reliability in a least-cost manner. Participants in the wholesale electricity markets seek to maximize their own profit through strategic bidding. Optimal electricity market participation through bidding is thus a central component to a well-functioning electricity market. In this regard, several fundamental questions arise: 1) What is the optimal method to predict the electricity market prices as a key factor of decision making process? 2) How different resources can optimally bid into the new electricity market services which are recently introduced in the US? 3) How these new services can reflect the actual value of different resources? 4) And finally, how merging technologies such a flexible loads and energy system storages can optimally bid into the global electricity markets to maximize their own profits without violating the local constraints? This thesis aims to address these fundamental questions based on optimization and machine learning methods.

First, we developed a machine learning model to forecast the exact values and class labels of the day-ahead market prices in the California Independent System Operator (CAISO) market. Such predictions make it easier for those involved with the market to make decisions pertaining to short-term operating schedules, bidding styles, and other market elements.

To answer the second and third questions, we focused on a new market design named performance-based regulation market. We developed a new analytical framework that streamlines large price-maker generation firm bids to the performance-based regulation markets. A Mathematical Program with Equilibrium Constraints, or MPEC, with system dynamics, is developed. Our design was not bound by the constraints of any single technology. We focused on identifying the key concepts from participants point of view. With this design, we uncovered the conditions for optimal bidding strategies in the performance-based regulation market and also by using real-world data, we determined how poorly performing resources manipulate market prices. We also conducted an in-depth analysis of the distinctions between the Mid-Continent Independent System Operator (MISO) and the CAISO accuracy scores, employing real-world ISO data to demonstrate the root causes for the distinct scores, and offering solutions to fix apparent issues.

finally, to answer the fourth question, we proposed a new mathematical model based on two stage stochastic-robust optimization to handle the optimal bidding of distributed energy resources located in a distribution network. The model handles the optimal distributed energy resource operations in the wholesale electricity markets while simultaneously handling the distribution network constraints. In order to ensure that distributed energy resources provide service in effective and reliable ways, we also introduced some novel indexes that assist in identifying the best investment avenues. The results are validated using the real-world data from a feeder in Riverside, CA.