Financial and physical energy markets, by design, are intricately linked in restructured power markets. Consequently, bidding strategies of participants in one market are driven by, not only their own actions in the other market, but also the action choices of their “rivals” in the two markets. We used analytical model to establish a framework for the two-stage game to derive optimal joint bidding strategies of participants in two markets. It was observed that analytically derivable equilibrium solution to the two-stage game of strategic interaction might not exist. We then used agent-based modeling system to derive the joint-optimal bidding strategies. Market participants were modeled as adaptive learners and reinforcement learning was used to derive the bidding strategies in both markets. This method allowed analysis to proceed even in cases where no analytically derivable equilibrium solutions exist for the two-stage game problem. The results show dependence of bidding strategies of market participants in the two markets. It was also observed that the physical location of market participants on the power grid influenced the bidding strategies.

Specifically, financial transmission rights (FTR) are financial instruments used by market participants to hedge against price volatility in day-ahead (DA) energy markets. The payoff for holding an FTR from node $k$ to $m$ depends on the locational marginal price (LMP) differential between the two nodes, in the said direction. In view of this fact, it is reasonable to believe that market participants acquire FTRs with certain expectations of payoffs in the DA energy market settlement. Also, market participants upon acquiring FTRs, can bid strategically in the DA energy market in order to influence the LMP differentials, which affects the payoff from holding FTRs.

The two problems have been studied by various researchers, although in isolation i.e., in a partial-equilibrium like setup. Bidding in the FTR auction market is studied by taking as given, expected outcomes in the DA energy market, while the supply offer strategies in the DA energy market are modeled by assuming that a portfolio of FTRs has already been acquired. In essence, a feedback mechanism linking the bidding strategies in the two markets is yet to be studied extensively.

The original contribution of this paper is to develop an analytical model to establish the feedback mechanism between the two markets. Additionally, we use agent-based model to derive the joint-optimal bidding strategies where analytically derivable equilibrium solutions might not exist. The modeling methodology used in this study can be applied to other commodity markets that have a close inter-dependence in payoff structures between the physical and financial markets.