Abstract: In a competitive energy market, instead of, or in addition to, a centralized unit commitment, individual generation owners will make independent unit commitment decisions. They will seek to maximize their profits against the predicted market clearing price. Their unit commitment strategy will be expressed in their bids, so that they shut-down or start-up when the market price indicates such activity. In this chapter, we develop a unit commitment based price-taking (UCPT) bidding strategy with a simple price prediction mechanism and explore it using a market simulator. Simulation results show that an individual generator has higher profits with UCPT bidding than with simple price-taking bidding, and that the cost of supplying price-inelastic loads achieved by the market is lower when all generators use UCPT bidding. It appears that UCPT bidding gives results similar to those from a Lagrangian relaxation unit commitment (LRUC), without a fix-up step, and it has problems with convergence and feasibility similar to LRUC. We observe cyclic behavior in market prices with UCPT bidding, and we show that it depends on the price prediction mechanism. Alternative price prediction mechanisms can reduce cyclic behavior. Finally, we conceptually explore potential strategic behavior and market power arising from unit commitment constraints.

1. INTRODUCTION

The unit commitment problem – scheduling generator start-ups and shut-downs over a period of time to minimize the cost of serving expected loads – has been applied by the power industry and studied by researchers for decades. Since unit commitment was typically performed for a set of generators all owned by one company—to meet load exclusively served by that company—it was natural for the algorithm to assume that one central authority controlled the status of every generator. This case is called centralized unit commitment.

Deregulation has invalidated the assumption of centralized control. A number of different companies now own generators. Each company must make its own individual start-up and shut-down decisions, and cannot control
the decisions made by other companies. This case is called decentralized unit commitment, because the commitment decision making is carried out in a decentralized control structure.

Recent publications that consider deregulation and unit commitment deal mostly with centralized unit commitment. In some cases (such as the England and Wales Power Pool), the market structure requires generators to submit to centralized unit commitment [1]. In other cases, researchers have assumed the existence of a centralized unit commitment in decentralized markets [2, 3, 4].

Oren et al. [5], however, identify the problems inherent in the use of centralized unit commitment. Specifically, they point out that due to the near-optimal nature of the solutions obtained by practical unit commitment algorithms, small changes in total cost can have large consequences for individual generators. When all generators are owned by one company, these differences are not important. When generators are owned by different companies, these differences are highly problematical.

The problems with centralized unit commitment have been recognized in practice by various deregulated markets. California and the Nord Pool market in Norway have no centralized unit commitment in the market process. The PJM Interconnection has a voluntary centralized unit commitment, but allows market participants to self-commit. Based on economic simulations the California tariff proposed an iterative energy market bidding scheme [13] to account for start-up costs, but has so far decided not to implement it due to the cost of implementation and time constraints of the required communications.

Even if centralized unit commitment is required by, for example, connection agreements, it seems unlikely that it can practically be enforced. If a generator is required to run, and thinks that it should be shut down, it may suffer an operating problem of some kind that forces it off-line. Generators are well known to be the least reliable components of the power system and separating intentional shut-downs from truly inadvertent ones is likely to be impractical. If a generator wants to run, but is required to shut down, it could, perhaps, claim restraint of trade, especially if its bid for the time period in question shows that it is willing to run at minimum power for any price.

Note that we base this discussion of generator non-compliance on economic motivations over a relatively long period of time, and it does not address compliance during emergency conditions.

In [6], Li et al. introduce a market model that uses generator self-commitment to determine generator bids over a fixed time period, and then the usual market resolution process resolves the bids to determine market prices. Then generator bids are redetermined for the same time period using the new prices. The concept of individual self-commitment to maximize profits given future market prices and the decentralized nature of the commitment problem are new. But the idea that bidders would have several opportunities to bid for the same time period is unworkable, as mentioned above.