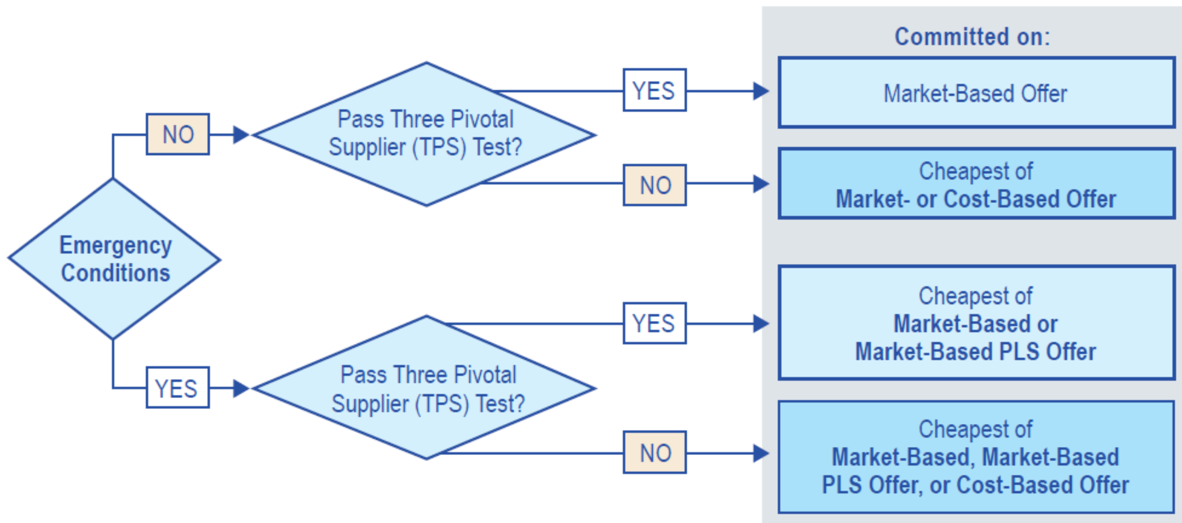
Performance Impact of multi-schedule model in Market Clearing Engine (MCE) in nGEM Enhanced Combined Cycle (ECC) and Energy Storage Resource (ESR) models

Problem / Opportunity Statement

Currently, PJM Markets allow Generation resources to submit three types of schedules in the Day-ahead and Real-time energy markets: a market-based schedule (non-parameter limited) and two types of schedules used for mitigation: a cost-based schedule and a market-based parameter limited schedule. The figure below illustrates when PJM considers market-based offers (non-parameter limited), market-based parameter limited offers, and cost-based offers in determining the appropriate schedule of a unit for commitment and dispatch.



PJM's Day-ahead commitment software is designed to commit resources based on the appropriate schedule offers that results in the lowest total system production cost. The schedule that results in the lowest total system production cost depends on a combination of many factors such as the level of output needed from a unit's schedule, the incremental offer up to the needed output level, Start-Up cost, No-Load Costs and other operating parameters submitted in a schedule - all of which are considered when determining various offer schedules in the unit commitment process. As a result, the schedule selection is performed by the optimization in the Market Clearing Engine (MCE). The MCE selects the cheapest schedule from the eligible schedules as described above by modeling each individual schedule as a logical resource. This results in a market resource being modeled in as many logical resources as number of eligible schedules. If each market resource has two eligible schedules, on which it can be committed, then there will be twice as many logical resources as market resources in the optimization formulation. Additionally, other associated constraints are modeled to make sure only one eligible schedule is committed at a given time. This modeling of a market resource with as many logical resources as eligible schedules is what is referred here as multi-schedule model in MCE optimization.

The multi-schedule model in MCE has the effect of increasing the number of logical resources compared to a single schedule model and, in turn, increases the optimization problem size. This increase in optimization problem size impacts the optimization solution time such that the commitment software requires more time to solve under the multi-schedule model. The increase in solution time is not linearly proportional to the problem size but it is exponentially proportional. For example, in the current Day-ahead production software, in the absence of any emergency conditions, a price-based resource will have one eligible schedule, a cost-based resource will have as many eligible cost based offers as available schedules, and if a price-based resource fails Three-Pivotal Supplier (TPS) test then the resource will have one eligible price-based schedule and as many eligible cost-based schedules as available cost based schedules. Currently, approximately 24% of market resources are cost-based resources with an average of two eligible cost based schedules with only a few market resources failing the TPS test on a daily basis. If this case is considered as the base case, then under emergency conditions, a price-based resource may have two eligible price based schedules from which the commitment software would need to pick the cheapest one if it needed to commit the market resource. The optimization solution time increases approximately 10 fold despite the increase in Mixed Integer Programming (MIP) convergence tolerance by 100 times. Ideally, if the optimization problem size is the same and the convergence tolerance is higher the solution time should decrease. This exponential increase in solution time due to the multi-schedule model in the MCE is manageable in the current 2.5-hour Day-ahead clearing window.

As descried above, each eligible schedule for a market resource is modeled as a logical resource. In the ECC model, each configuration for a combined cycle plant will be modeled as a logical resource. For example, a typical 2X1 combined cycle plant would have at least six configurations and therefore have six logical resources modeled. If each of these six configurations has two eligible schedules then the number of logical resources modeled for a single combined cycle plant would be 12 (6 configurations * 2 eligible schedules = 12). This would drastically increase the number of logical resources for the approximately 100 combined cycle plants modeled in PJM’s markets and will exponentially increase the optimization solution time.

Based on the last several years of experience with a multi-schedule model in the current MCE and discussions with GE, it is apparent that the multi-schedule model in the MCE with the ECC model will have a significant performance impact that will jeopardize the clearing of the Day-ahead and Real-Time energy markets in the approved clearing timeframe with sufficient accuracy.

The performance impact of the multi-schedule model in the MCE will not be limited to the nGEM ECC model. It will also impact the future nGEM multi-configuration based Energy Storage Resource (ESR) model and hybrid resource model. The current ESR model does not have a concept of different operating models. Therefore, the MCE solution time is not effected by the current self-scheduled ESR model. However, the nGEM ESR model will be a configuration based model, similar to the ECC model to accommodate the characteristics of energy storage resources that the current production model does not have. The nGEM ESR model will also be extended to model the characteristics of future hybrid resources. The performance impact of the nGEM ESR and hybrid models may cause further deterioration of the MCE solution time due to the multi-schedule model in the MCE optimization depending upon how many resources participate in these nGEM models.