Multiple Optimization Problems with Equilibrium Constraints

Optimization and Control of Electric Power Systems

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Abstract

We present a mechanism for describing and solving collections of optimization problems that are linked by equilibrium conditions. Included in this class are classical models such as the PIES model and agent based formulations arising from Nash Games. We demonstrate this mechanism in the context of energy planning problems, specifically for capacity expansion, hydro operation, and demand response.

We believe that optimization is part of a larger process, wherein optimization processes can be used to develop inputs for other parts of the solution (data processing), its strong theory (of duality for example) can enable more effective solution schemes to exploit model structure, and the interplay between collections of models treating stochastic effects, competition between independent agents, and a mixture of continuous and discrete approaches can provide richness for describing, solving and adapting the underlying system being modeled. Mechanisms to allow decision making in such circumstances can be informed by game theory and techniques from distributed computing.

In addition to the multiple time scales in the decision process, the problem is confounded by uncertainties in estimates and structural makeup of the system. The collection of all these optimization models (generator expansion and scenario dependent economic dispatch) forms an equilibrium problem (using the Nash definition), once each optimization model is replaced by its KKT conditions. Solution techniques exploiting the model structure facilitate finding global solutions of the underlying nonconvex problems, while still maintaining an overall equilibrium.

The extended mathematical programming (EMP) framework exists to provide access to modeling formats that fall outside the classical framework. We give examples of their use and their possible extensions to hierarchical modeling.