Bi-level Flexible-Robust Optimization for Energy Allocation Problems

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Abstract

A common problem in energy allocation problems is managing the trade-off between selling surplus energy to maximize short term revenue, versus holding surplus energy to hedge against future shortfalls. For energy allocation problems, this surplus represents resource flexibility and is quantified as the surplus energy after meeting the demand. The decision maker has an option to sell or hold the flexibility for future use. As a decision in the current period can affect future decisions significantly, future risk evaluation of negative shocks (or uncertainties) is recommended for the current decision in which a traditional robust optimization is not efficient. Therefore, an approach to Flexible-Robust Optimization has been formulated by integrating a Real Options Model with the Robust Optimization framework. Real options analysis is an efficient economic model for risk evaluation in investment problems. In the energy problem, the real options model evaluates the future risk, and provides the value of holding flexibility, whereas the robust optimization quantifies uncertainty and provide a robust solution (i.e. a solution which is generally insensitive to uncertainties) of net revenue by selling flexibility. This integration or models has introduced compatibility issues which have been discussed extensively in the literature. However, the limitations have been overcome successfully by implementing bi-level programming in this work. Therefore, a complete general mathematical formulation of Bi-Level Flexible-Robust Optimization model is presented and results shown to provide an efficient decision making process in energy sectors.

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