European Journal of Operational Research 240 (2015) 457–475

Contents lists available at ScienceDirect

European Journal of Operational Research

journal homepage: www.elsevier.com/locate/ejor

Decision Support

Weekly self-scheduling, forward contracting, and pool involvement for an electricity producer. An adaptive robust optimization approach

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ARTICLE INFO

Article history:
Received 9 January 2014
Accepted 4 July 2014
Available online 18 July 2014

Keywords:
OR in energy
Robust optimization
Electricity market
Renewable energy

ABSTRACT

This paper addresses the optimization under uncertainty of the self-scheduling, forward contracting, and pool involvement of an electricity producer operating a mixed power generation station, which combines thermal, hydro and wind sources, and uses a two stage adaptive robust optimization approach. In this problem the wind power production and the electricity pool price are considered to be uncertain, and are described by uncertainty convex sets. To solve this problem, two variants of a constraint generation algorithm are proposed, and their application and characteristics discussed. Both algorithms are used to solve two case studies based on two producers, each operating equivalent generation units, differing only in the thermal units' characteristics. Their market strategies are investigated for three different scenarios, corresponding to as many instances of electricity price forecasts. The effect of the producers' approach, whether conservative or more risk prone, is also investigated by solving each instance for multiple values of the so-called budget parameter. It was possible to conclude that this parameter influences markedly the producers' strategy, in terms of scheduling, profit, forward contracting, and pool involvement. These findings are presented and analyzed in detail, and an attempted rationale is proposed to explain the less intuitive outcomes. Regarding the computational results, these show that for some instances, the two variants of the algorithms have a similar performance, while for a particular subset of them one variant has a clear superiority.

1. Introduction

In general, electricity producers operating in electricity markets sell their energy through bilateral contracts or in the pool. The details of these operations depend on the specific market design where the producer is integrated. For a review on market structure and designs see Conejo, Carrion, and Morales (2010) and Oliveira, Ruiz, and Conejo (2013).

From the point of view of the electricity producer, the selling strategy for each time period should take in consideration the power generation capacity of the producer, and to some extent also to the option to buy electricity from the market to meet the committed sales. Therefore, in this decision making problem the producer faces two integrated challenges: (1) the self-scheduling of the generation units and (2) the optimal forward contract selection and pool involvement.

The basic problem involving unit self-scheduling determines the optimal power outputs of the producer's generation units subject to feasible operation, which provides a basis to define the market involvement. In general, self-scheduling problems are related to Unit Commitment (UC) problems of thermal and/or hydro units. These are classical scheduling problems that have been addressed by a number of authors using decomposition strategies such as Lagrangian Relaxation, and in the last decade with Mixed Integer Linear (MILP) models, see for example Arroyo and Conejo (2000) and Li and Shahidehpour (2005). Several authors have proposed UC MILP models for systems with thermal units, aiming at developing: (a) tight linear relaxations, by generating facets of the ramping up and down constraints of the units (Ostrowski, Anjos, & Vannelli, 2012), convex hull formulations for the minimum up and down time constraints (Lee, Leung, & Margot, 2004; Rajan & Takriti, 2005), and tight approximate formulations for the linearization of the quadratic objective function (Frangioni, Gentile, & Lacalandra, 2009); (b) compact formulations (Hedman, Ferris, O'Neill, Fisher, & Oren, 2010; Morales-Espana, Latorre, & Ramos, 2013a); and (c) accurate representations of the operations and

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http://dx.doi.org/10.1016/j.ejor.2014.07.013
0377-2217/