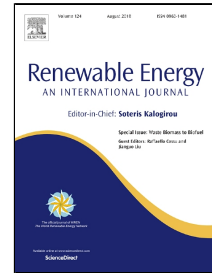# Accepted Manuscript

Optimal Bidding Strategy of Wind Power Producers in Pay-as-Bid Power Markets

Karim Afshar, Farshad Shamsini Ghiasvand, Nooshin Bigdeli

Please cite this article as: Karim Afshar, Farshad Shamsini Ghiasvand, Nooshin Bigdeli, Optimal Bidding Strategy of Wind Power Producers in Pay-as-Bid Power Markets, *Renewable Energy* (2018), doi: 10.1016/j.renene.2018.05.015

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Optimal Bidding Strategy of Wind Power Producers in Pay-as-Bid Power Markets

Karim Afshar, Farshad Shamsini Ghiasvand, Nooshin Bigdeli[1]

Department of Electrical Engineering, Imam Khomeini International University, Qazvin, Iran

Abstract –This paper presents a method to determine the optimal bidding strategy of the wind power producers with market power for a strategic presence in the day-ahead market with pay as bid method. Since the wind power producer is not capable of exact prediction of his power production, he has to trade the difference between the amount won in the day-ahead market and the actual production value in the balancing market. Uncertainties related to power generation is modeled by likely scenarios. However in order to model the punitive effect of trade in balancing market, the balancing market price is considered as a factor of the day- ahead market's clearing price. In the proposed model, optimal bidding strategy is formulated via a bi-level problem including the upper-level and lower-level sub-problems. The purpose of the upper-level sub-problem is to maximize the wind power producer's earning while the purpose of the lower-level sub-problem is to clear the day-ahead market. To solve both upper-level and lower-level problems, particle swarm optimization algorithm is applied. The results of three-bus test system and IEEE 24-bus RTS shows the efficiency of the proposed method.

Keywords: Wind power producer; bidding strategy; electricity market; pay-as-bid; optimization.

1. Introduction

Using renewable energies been considered as an alternative to fossil fuels which has shown destructive environmental effects and at the same a lot of price instability during recent years [1]. Among all sorts of energy, wind power is the most economic renewable energy source to this end [2]. The application of wind power in power systems has rapidly increased all over the world in the recent years. As these great developments are in progress, the governments have also shown support for increasing potentials for wind power to compete with traditional energy resources [3]. At the same time thanks to advancement in wind power technologies, this source of energy has become more competitive and the related subsidies will be greatly reduced or even omitted. As a result, the wind power producers (WPPs) will be more motivated for maximizing their profit through involvement in electricity markets [4].

Using wind energy has various advantages but it also accompanied by some problems in restructured power systems. These problems are rooted in two types of uncertainties: wind power and electricity market prices. The uncertain behavior of wind power and the large variability of prices in electricity market, means a large variability in profit. Therefore, the decision makers have to consider these two kinds of uncertainties, as well as several technical constraints associated with the operation of wind farms. The offer decisions are to be submitted to the electricity market every hour, without knowing exactly what will be the value of power generation. There are imbalances caused by the differences between the produced and supplied energy. The imbalances should be penalized by the balancing market. A WPP needs to know how much to produce just to make realistic bids