Strategic Wind Power Investments Considering Electricity and Green Certificates Markets

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ABSTRACT

In recent times, the ongoing energy transition underscores a heightened dependence on Renewable Energy (RE) as a pivotal solution for mitigating carbon emissions. In this context, new environmental policies are implemented to promote new RE investments [1]. Renewable Portfolio Standards (RPS) together with Green Certificates Markets (GCM) act as market mechanisms toward this goal and have been employed in many countries [2]. However, within the market framework the increasing RE penetration leads to lower electricity prices in the electricity sector, therefore challenging the attainability of new RE investments [3]. Based on the above, owning an RE asset is regarded as an economically attractive decision for investors due to the implementation of incentive policies towards RE. Nevertheless, it can be a risky decision considering electricity prices. Thus, the analysis of RE investments is crucial to be made within a market framework which takes into account new environmental regulations through GCM as market-based instruments.

This work presents, a bi-level model to ascertain optimal investment decisions and bidding strategies for an investor participating in both the electricity and green certificates markets. The upper-level problem aims at maximizing the profit of the producer exercising market power, while the lower-level problem implements the sequential clearing of the interrelated electricity and green certificates markets. The bi-level algorithm is initially recast into a Mathematical Program with Equilibrium Constraints (MPEC) and is further transformed into a Mixed Integer Linear Program (MILP) by utilizing the Karush-Kuhn-Tucker (KKT) optimality conditions, strong duality theory and binary expansion method. Moreover, stochasticity is introduced into the system to capture the inherent uncertainty associated with RE sources, enhancing the model's realism. Towards the precise system operation, load shedding and RE curtailment are also included in the model. Results demonstrate that the proposed stochastic bi-level model captures new investment opportunities arising from the implementation of GCM while providing optimal strategic offers to ensure competitiveness for the strategic agent owing RE assets.

KEYWORDS: Bi-level optimization, Strategic investment, Electricity market, Green certificates market, Renewable portfolio standards

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