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A bi-level framework to analyse the alternative use of FTRs as a long-term risk hedging instrument. Application to a European case study

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Abstract-

A large portion of the Renewable Energy Sources generation investments occurs in remote areas, which are normally weakly connected to the rest of the system. Hence, relevant congestion occurs in the network linking these areas to the main load centres, where prices tend to be more stable. Congestion drives significant changes in the electricity price in remote areas that are difficult to predict. As a result, investors in remote areas face relevant long-term market price risk, which may prevent them from undertaking some socially beneficial generation investments. We address two main research questions. We investigate how Long-Term Financial Transmission Rights (LT-FTRs) affect the investment decisions made by risk-averse generation and transmission investors under perfect coordination. Together with this, we aim to determine what effect the use of LT-FTRs would have on the social welfare, considering the stakeholders' risk profiles and, related to this, the value that the stabilization of their revenues would have for them. In providing an answer to these questions, we, for the first time, determine the impact of the implementation of LT-FTRs on the efficiency of the system's expansion, considering the use of these rights as a tool to hedge the market price risk caused by network congestion that generation investors in remote areas are subject to. In doing so, we represent the effect of the market price risk on the generation investors' profits through the Conditional Value at Risk of these profits, considering the uncertainty factors affecting the price earned by the corresponding generators. The computation of the socially optimal expansion of the system, representing the ideal situation where the coordination of generation and transmission investments is socially efficient, is formulated, both considering LT-FTRs and not considering these, as a bi-level optimization problem. In the upper level of this problem, we represent the investment decisions that are made in the long-term, including, in the corresponding case, the contracting of FTRs to manage the price risk of generation investors, while the operation decisions are represented within the lower level of the problem. Finally, this problem is converted into an MPEC making use of the Karush-Kuhn-Tucker conditions. Finally, we explore the use of LT-FTRs in the European power system as a representative case study where the development of renewable generation in remote areas, such as the North Sea, has significant potential. Based on the results computed, we conclude that the availability of LT-FTRs to manage the price risk perceived by risk-averse generation companies in remote areas should trigger a relevant increase in the system's social welfare, and could also lead to relevant changes in the generation and, potentially, in the transmission socially optimal investment decisions, involving additional generation investments in remote areas, particularly in the North Sea within the European system.

Index Terms- FTRs; Generation expansion planning; Transmission expansion planning; Risk management

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