Reduction of the market splitting occurrences: A Dynamic Line Rating approach for the 2030 Iberian day-ahead market scenarios

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***Abstract*—Typically, Transmission System Operators apply power flow models with Seasonal Line Rating prescriptions to compute the ampacity of power lines, in a process that enables to obtain the cross-border capacity for trading between different countries or market zones. These seasonal-dependent models rely on fixed conservative meteorological conditions throughout the year, underestimating the real-time transmission capacity of overhead lines. This can contribute to market splitting occurrences, i.e., a situation where the cleared power flow between different market zones of the coupled market is superior to the cross-border capacity, separating markets, which brings economic losses to market participants. Dynamic Line Rating analysis allows computing the overhead lines' capacity considering the weather conditions that influence the power line's thermal dynamics. This work presents a study that applies the CIGRÉ 601 model in cross-border power lines between Portugal and Spain to quantify the reduction in market splitting occurrences in the day-ahead Iberian market considering based on the installed capacities from the 2030 national energy and climate plans. Comparing with the seasonal approach, dynamic line rating enabled to reduce the number of market splitting occurrences from 1512 to 514, reducing the electricity costs by more than 1% and the price difference from 19 to 12 €/MWh.**

Keywords— Cross-border capacity; Day-ahead market; Dynamic Line Rating, Market splitting, Seasonal Line Rating.

I. Introduction

Most Transmission System Operators (TSOs) use a "steady-state" thermal equilibrium model using reference conservative weather conditions to design the maximum seasonal ampacity allowed per line, known as the Seasonal Line Rating (SLR) [1]-[3]. They use reference values for the incident wind speed between 0.5 and 0.61 m/s and for the irradiance between 1000 and 1150 W/m^2. Normally the reference value of the ambient air temperature is adjusted seasonally and the wind direction is neglected. These reference values are different from the ones used by the cables manufacturers in their tests, performed to define the limit ampacities of the cables [4]-[6]. On the other hand, numerical Dynamic Line Rating (DLR) models such as the IEEE 738-2023 [7], the Kuipers & Brown [8] and the CIGRÉ [9] models can enable to accurately assess the real-time transmission capacity of overhead lines. Several studies indicate that on average DLR allows to increase the energy transmitted over the estimated capacity using SLR between 10% to 30%, and also identify that the line rating is underestimated around 80% of the time [1]-[3],[10]-[12]. Considering forecast models with low errors is critical to a reliable DLR analysis used by TSOs and utilities [13]-[15].

Traditionally, electricity markets are divided into wholesale and retail markets. Wholesale markets are composed of long-term bilateral contracts and two spot markets based on auctions, the day-ahead (DAM) and the intraday markets. Spot markets are cleared using the system marginal pricing theory, which has the goal of increasing the general welfare of the participants [16]. TSOs have to evaluate the feasibility of the deals to avoid grid congestion events and guarantee the security of the power system. Therefore, when planning the power flow of such transactions, TSOs use the SLR approach to identify the maximum ampacity of the lines. This situation can make some of the bids unfeasible, leading to increased market prices and decreased the overall welfare of the participants [17]. In coupled regions, this can also result in market splitting occurrences in the interconnection exchange between regions. They also manage the balancing markets computing the hourly secondary and tertiary reserve requirements and prices considering the seasonal line limits and the real-time unbalance between supply and demand. Those prices are used in the imbalance settlement mechanisms to charge Balancing Responsible Parties for deviations [18].

Considering the 2030 ambitious European Union goals to increase the share of renewable energy sources (RES) in the power system and harmonize prices, as denoted in the Internal Market of Electricity goals, there is a need to reinforce the national and the cross-border transmission capacity of the grid [19],[20]. This reinforcement represents a costly and lengthy process, and it can be partially mitigated by adopting DLR