From day-ahead to a 6-hour period-ahead market adapted to the stochastic behaviour of variable energy renewable sources

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***Abstract*— The existing electricity market design challenges the fair and competitive participation of variable renewable energy sources (vRES) due to their weather dependence and limited forecasting accuracy, especially for long-time horizons, as required in the day-ahead market (DAM). These challenges impact market clearing prices and create imbalances, leading to inefficiencies, such as market-splitting events. To enhance the market efficiency and fairness for vRES producers, this work proposes a period-ahead market (PAM) with a 6-hour rolling horizon instead of the traditional 24-hour DAM. A case study of the Iberian electricity market with 2030 energy mix scenarios for Portugal and Spain, demonstrates that, in PAM, vRES producers can reduce wind and solar power forecast errors by over 7% and 4%, respectively, when compared with DAM. This leads to a 2% decrease in electricity prices and an annual reduction of market-splitting events in 158 hours thus enhancing price harmonization between Portugal and Spain. Additionally, balancing prices also decreased in PAM benefiting the balance responsible parties. The findings highlight that PAM improves the market's efficiency, a key factor in the pathway for the decarbonization of power systems.**

***Index Terms*-- Day-ahead market, Electricity market design, Period-ahead market, power forecast, Variable renewable energy sources.**

I. Introduction

The non-dispatchable variable renewable energy sources (vRES), especially wind and solar photovoltaic (PV), have grown significantly in power systems in the recent years, and, contrary to conventional power plants, vRES have low or residual marginal costs [1]. Additionally, vRES are typically the marginal technology, operating at optimal capacity depending on weather conditions. These factors considerably influence the market outcomes by significantly lowering clearing prices [2]. As a consequence, in recent years researchers have focused on evaluating whether the current electricity market (EM) design remains efficient [2], especially in a context of energy transition with the increasing share of vRES that are expected to be attractive for investments without relying on support schemes.

The day-ahead market (DAM) is one of the most studied market designs in the literature due to its high participation rate and strong liquidity being normally used for the development and implementation of governmental subsidy policies [3], [4]. Research on DAM design covers various aspects [5], such as new clearing models [3], increased time granularity [6], [7] and adjustments to the gate closure time to bring it closer to real-time delivery [8], [9]. This research is important since, the current DAM design was established when dispatchable, mainly fossil fuel-based, power plants dominated the energy mix. These plants can efficiently set operational points to meet demand when scheduled several hours in advance. However, their restricted ramping rates limit their ability to adapt to periods of high demand/net load variability and are associated with increased overall system costs and significant environmental impacts. In contrast, vRES are weather-dependent, mostly constitute a non-dispatchable technology and face significant forecast errors, especially over longer periods [10].

In most electricity markets, the existing DAM requires power forecasts with at least 12 to 36 hours in advance [1]. As an example, on day "D" at 12:00 p.m. (CET), producers must submit bids based on forecasts for the entire 24-hour period of the next day ("D+1"). Despite significant advancements in forecasting systems, supported by the machine learning-based weather prediction models [11], power forecasts still exhibit substantial errors, due to the inherently chaotic nature of the atmosphere [12]. Since any discrepancies between the energy