Sustainable Energy, Grids and Networks, vol.46, pp.102295-1-102295-7, June, 2026.

The prologue of the Iberian Peninsula blackout on 28th April 2025

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Abstract-

A blackout occurred in the Iberian Peninsula electricity system at 12:33 on 28th April 2025, the first one in history caused by overvoltage, which refers to the cascading disconnection of renewable generation with fixed power factor control triggered by overvoltage generation protections. The blackout was not due to a single event, but rather a combination of multiple events and various phenomena. The root causes cannot be fully identified unless what happened in the days and even months preceding the event (the prologue) is recognized and well understood. Precisely, voltage instability phenomena occurred during the week preceding and the morning of the event. In this paper, the term “voltage instability phenomena” refers to uncontrolled rapid variations in network bus voltages. Such phenomena were preceded by an alarm as early as January 31, 2025. This paper shows that mere inspection of voltage evolution over time is insufficient to detect voltage instability and proposes novel metrics that can be implemented within control centers as an alarm to alert of voltage instability. The first one is based on the Rate of Change of Voltage (RoCoV). The second one is obtained by applying spectral analysis to the voltage signal.

Index Terms- Voltage stability; Voltage control; Rate-of-change of voltage; Spectral analysis

Citation:
Rouco, L.; Echavarren, F.M.; Lobato, E. "The prologue of the Iberian Peninsula blackout on 28th April 2025", Sustainable Energy, Grids and Networks, vol.46, pp.102295-1-102295-7, June, 2026.