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Severity of variable renewable energy droughts in Germany and Europe

Martin Kittel

German Institute of Economic Research (DIW Berlin), Energy, Transportation, Environment, Germany (mkittel@diw.de)

Increasing the generation of variable renewable energy sources (VRE), such as wind or solar photovoltaics, is one pivotal element in the decarbonization of our energy systems. VRE availability depends on prevailing weather conditions. During a period with high VRE availability, surplus energy needs to be integrated into the system. Times of VRE shortage require flexibility options that can serve demand. These options need to cover VRE droughts, i.e., long-lasting periods of low VRE availability. They may challenge the security of supply, notably in the case of simultaneity with high demand phases, and vary largely across time and space. This paper evaluates VRE droughts in terms of severity, duration, timing, and simultaneity in Germany and Europe using the Pan-European Climate Data Base by ENTSO-e, which provides VRE availability factors for 35 years.

Two definitions apply to VRE droughts (Ohlendorf & Schill, 2020). First, droughts as periods of consecutive hours with availability factors constantly below a certain threshold (CBT). Second, droughts as periods of consecutive hours with a moving average of VRE availability factors below a certain threshold (mean below threshold – MBT). While the CBT notion identifies drought periods in the narrow sense, the MBT definition also accounts for longer stretches of low VRE availability on average, with short instances of VRE availability above a threshold possible. Contrasting results from these two approaches reveals insights on the short- and long-term need for flexibility, for instance, by different types of storage.

Additionally, there are two options to count VRE droughts: First, a drought window denotes a period of consecutive availability factors with a fixed duration, qualified either according to the CBT or MBT notion. Windows are counted for increasing window size, starting with a few hours up to multiple months. This method identifies flexibility slices that the system needs to provide for all relevant time scales. Second, a drought event is a period of consecutive availability factors with variable duration. The algorithm counts in descending order from the longest event lasting multiple months to events lasting only a few hours. Consequently, each qualified CBT or MBT period is counted only once. Results reveal the number of drought events with a minimum duration that the system needs to balance.

This paper analyzes VRE droughts of individual VRE generation technologies, all VRE generation technologies combined, and, to account for simultaneity with demand peaks, residual load time series to identify periods with an energy deficit in the system (Ruhnau & Qvist, 2022). Insights allow for a distinct assessment of the relevance of energy droughts concerning VRE technologies individually and in terms of simultaneity for the transition of our energy systems, both in the German and European context (Raynaud et al., 2018; Kaspar et al., 2019).

References

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