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Evaluation of Regionally Conditioned Climatic Hazards Affecting Electrical Distribution Systems during Heatwaves and Cold Spells

Ongoing climate change is accompanied by an increase in the frequency and severity of extreme weather events, including heavy rainfall, extreme heatwaves and cold spells [1, 2]. These events represent climatic hazards that can significantly affect electrical distribution systems, potentially leading to power outages [3]. To achieve maximum energy efficiency in the electrical distribution system, a resilient power supply system is essential. This requires the identification of vulnerable equipment and the evaluation of appropriate countermeasures.

Beyond analyzing the general climatological frequency of such events, this contribution focuses on region-specific conditions that influence their local impact. For this purpose, publicly available datasets - including digital elevation models, building structures, and road networks - are used to examine prevailing environmental parameters. These parameters inform a vulnerability assessment by linking hazard exposure with site-specific factors affecting the resilience of the electrical distribution system.

Extreme heatwaves and high temperatures can cause individual equipment to fail or degrade, particularly in secondary systems such as control and protection devices. These hazards are exacerbated by the urban heat island phenomenon, where densely built and sealed city centres exhibit significantly higher temperatures than surrounding rural areas [4]. Accordingly, influencing factors such as building density, surface sealing, and vegetation type are central to evaluating heat-related impacts.
In contrast, the same factors can mitigate rapid temperature drops during cold spells by retaining heat. However, additional hazards such as snow and ice must also be considered. In this context, other influencing factors - including slope inclination, slope orientation, and regional altitude - become increasingly relevant.

The presented analysis enables the identification of vulnerable equipment and supports the evaluation of locally adapted mitigation strategies to improve the resilience and hence the efficiency of electrical distribution systems. The methodology is applied to the supply area of a German distribution network operator.

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