A RELIABILITY-RESILIENCY-ADAPTABILITY FRAMEWORK FOR POWER SYSTEMS IN THE LIGHT OF THE 2020 TEXAS BLACKOUT

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Overview

The 2020 Texas blackout demonstrates the importance of reliable and resilient power systems to cope with extreme weather events. Based on this experience and other major blackouts, this paper identifies the need to define a new analytical framework for power systems that better consider resiliency in the context of extreme weather. It presents a reliability, resiliency and adaptability policy framework for power systems. Our framework incorporates the entire power system and supply chain into the analysis, including common-cause failures, characterizing outages in a detailed manner, enhancing the concept of the loss of load probability, considering social costs beyond economic ones, and explicitly assessing the probability that the supply-demand mechanism succeeds. Our framework is applicable to all types of power systems, including those with liberalized wholesale electricity markets or those with high levels of variable renewable energy. In the context of liberalized power systems, our analysis shows that it is necessary to consider explicitly the probability that the real-time energy market clears.

Methods and Results

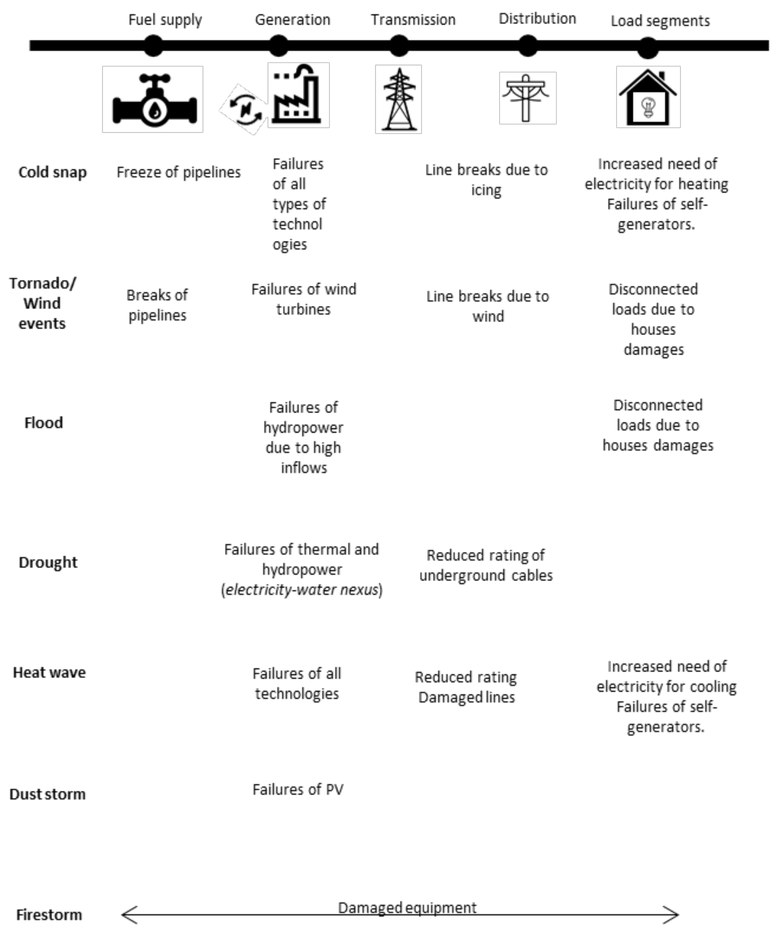
First, we analyse the 2020 Texas blackout and other major blackouts to identify key lessons for reliability and resiliency analysis. Particularly, we identify two major trends for improvements. First, such analyses need to consider the power system in a broad manner by including the entire electricity supply chain as well as actions available to consummers (adaptability). Second, events characterized by high impacts and low probability, such as extreme weather events and other caused by common failures, must be better considered when assessing reliability and resiliency. See Figure 1.

Second, we identify the challenges related to intermittent and variable renewable energy sources of electricity. Based on a literature review, we show that technical solutions exist to implement high levels of renewables, despite the difficulties related to the transition phase, although the costs may be substantial.

Third, we discuss the role of electricity markets in the context of liberalized powr systems and renewables development. Electricity markets play a role in helping matching supply and demand but are not explicitly consider in classical reliability frameworks. We propose how to integrate them into reliability-resiliency analyses.

Finally, we combine these elements and propose a resliability resiliency adaptability framework based on an optimization formalization. We discuss its key parameters and how it can be used to inform policy makers.

Figure 1: Common-cause events (non-exhaustive list) related to weather events.



Conclusions

This paper provides a conceptual framework for the reliability, resiliency and adaptability of the power sector, with a particular emphasis on the case of implementing high levels of renewables in real-time electricity markets. The reliability and resiliency of electricity markets cannot be analyzed in isolation but must be considered in the complete context of the entire power system supply chain and adaptability policies within and outside the sector. Furthermore, common-cause failures of the entire value chain (fuel infrastructure, generation, network) need to be explicitly considered.

Policymakers should integrate reliability, resiliency, and adaptability policies by starting with an integrated analytical framework, such as that proposed in this article, instead of focusing on the classical Loss Of Load Probability (LOLP) approach, which is a useful starting point for the reliability of wholesale electricity markets. Analysing power systems with the proposed framework, including those with electricity markets, would help in improving effective policies' performances in avaoiding rolling and cascading blackouts and minimizing their social and economic impact.

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