Measuring Power System Resilience Based on Empirical Data

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Abstract

This work provides a new integrated approach to quantify resilience in electric power transmission networks and demonstrates the approach by measuring the impact of potential improvements to a power system. A novel aspect is the use of empirical data to develop the probability distributions of the number of line outages and the line restoration times that drive the model. Research on power system resilience is motivated by climate change, which increases the severity of large storms, and concerns about potential attacks on the electricity infrastructure. A key first step is to quantify the overall resilience of a particular power system.

Resilience

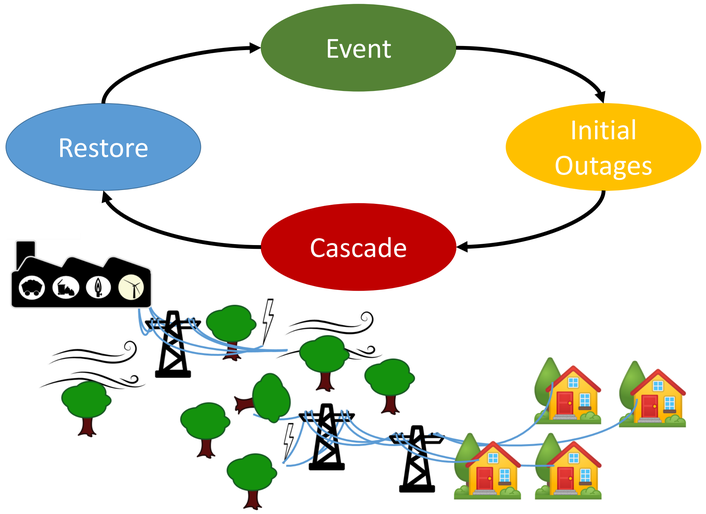
Measure
- Robustness
- Rapid Restoration

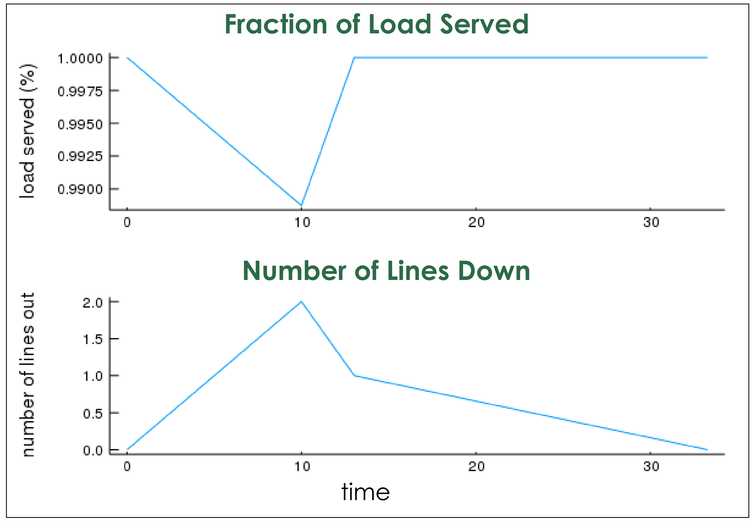
Update
- Redundancy
- Resourcefulness

Background

There is a broad existing literature which focuses on each individual stage of the resilience problem, such as component reliability, or cascading failures, or restoration, but there is not much previous work that analyzes all the stages of resilience together to quantify the overall resilience. Some comprehensive efforts have produced frameworks and metrics to measure resilience [1] and have estimated system resilience to certain hazards by applying a good measure of component outages into a resilience framework [2].

Measuring Resilience of Power Systems



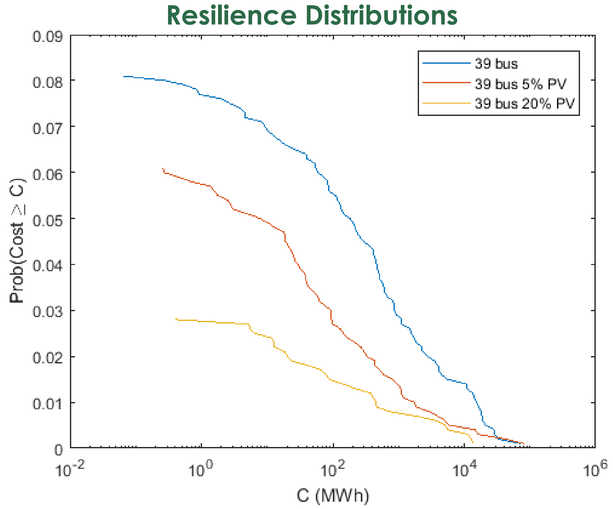


Integrating unserved demand over time (lost energy) provides a measure of the resilience for a power system to a single event. A distribution of many potential events leads to a distribution of energy losses and is a measure of the resilience of the power system.

Empirically Based Model

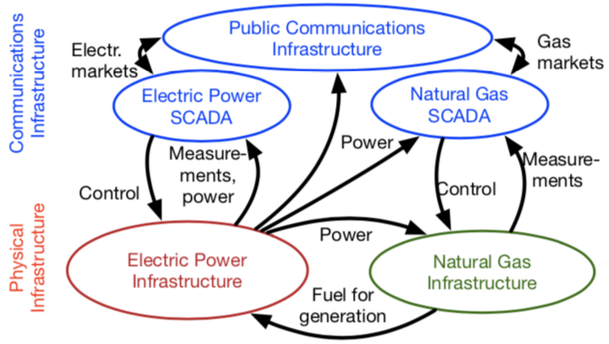
1. Use distributions of number of line outage and recovery time data from a large US utility [3,4] to initiate outages and find restoration times.
2. Find initial lost load with Load Shedding Optimal Power Flow
3. As lines are restored, find lost load with the Restoring Load Optimal Power Flow
4. Measure resilience
5. Repeat 1-4

Preliminary Results



Future Work

Coupling power system, natural gas and communication system models



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