Measuring Power System Resilience Based on Empirical Data

Molly Rose Kelly-Gorham, Paul Hines, Ian Dobson (Iowa State University)

Abstract

- Increase in number and severity of large storms from climate change show a need to understand resilience of critical infrastructure
- First step is to quantify resilience of a power system
- Developed an integrated approach to quantify resilience in transmission networks
- Model uses empirical data from large US utility to develop probability distributions of
  - Number of line failures that occur within an event
  - Recovery times for lines that fail
- Demonstrated by measuring impact of potential improvements to a power system

Resilience

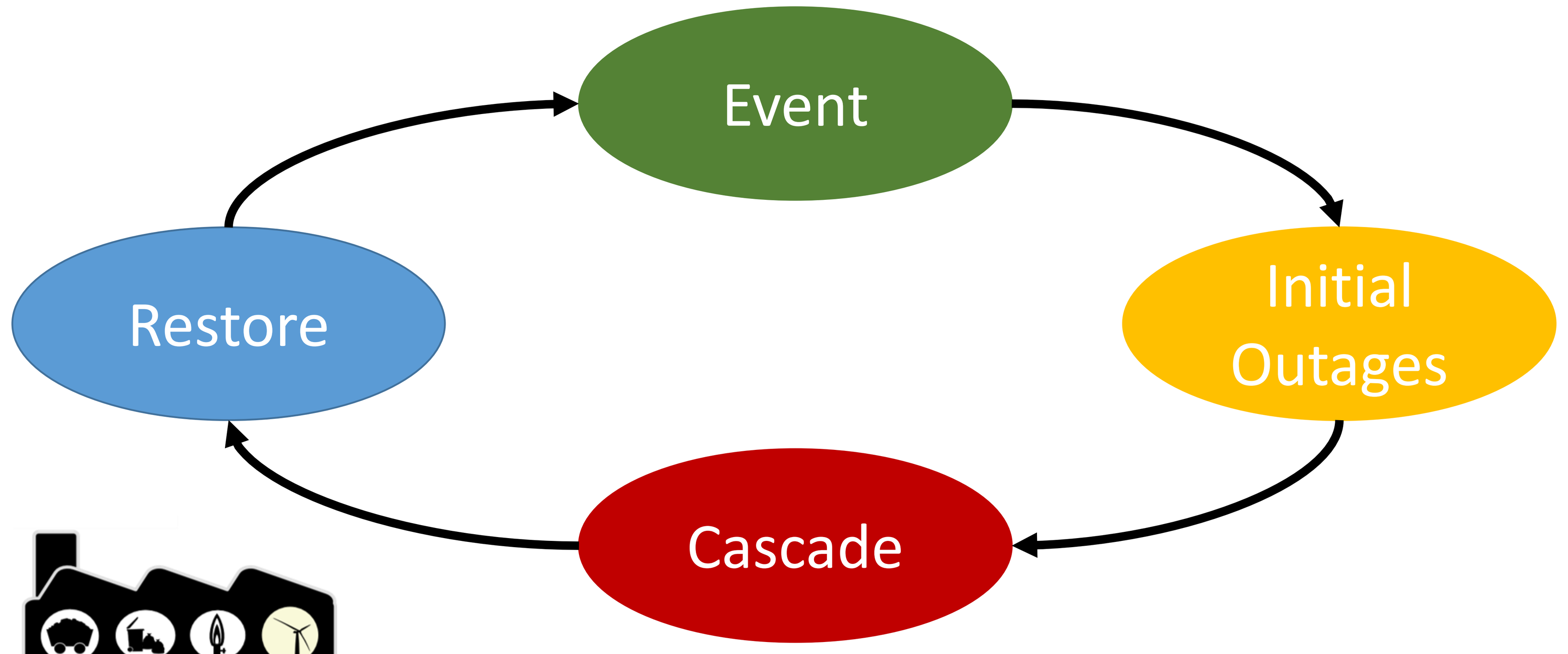
Measure
- Robustness
- Rapid Restoration

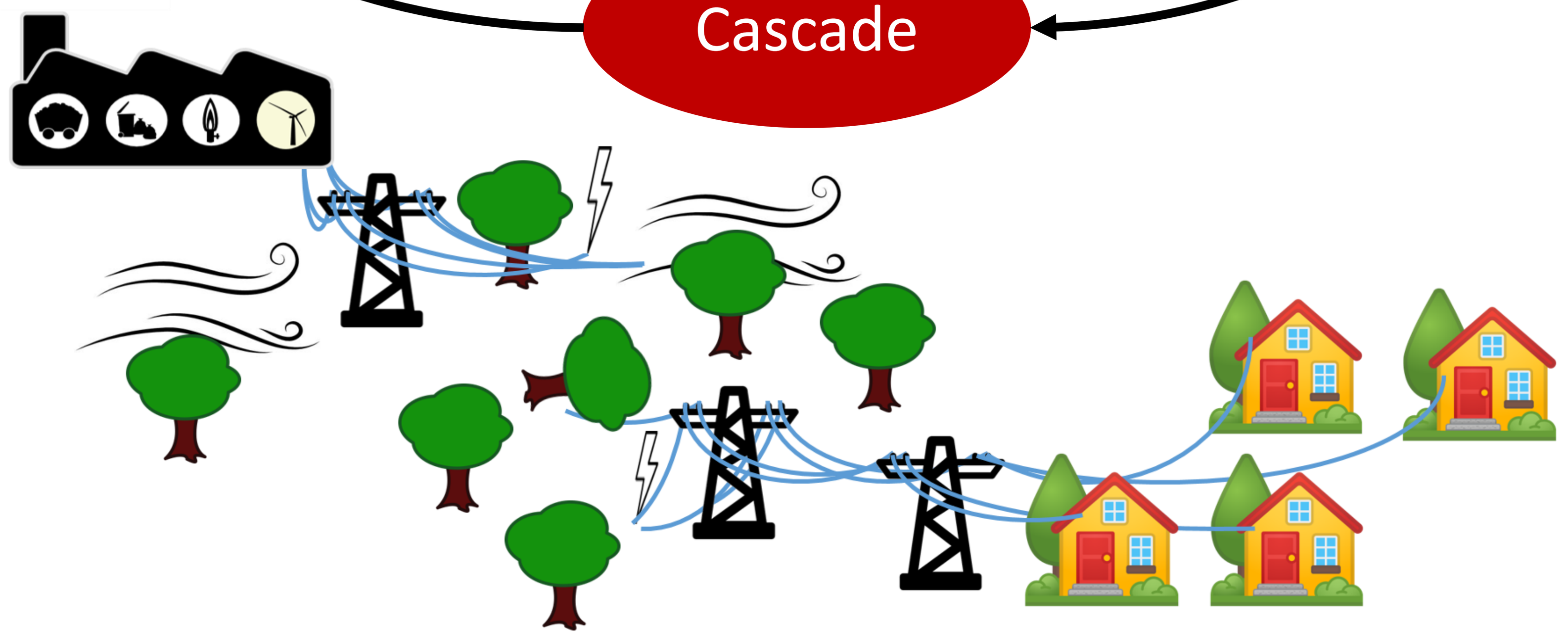
Update
- Redundancy
- Resourcefulness

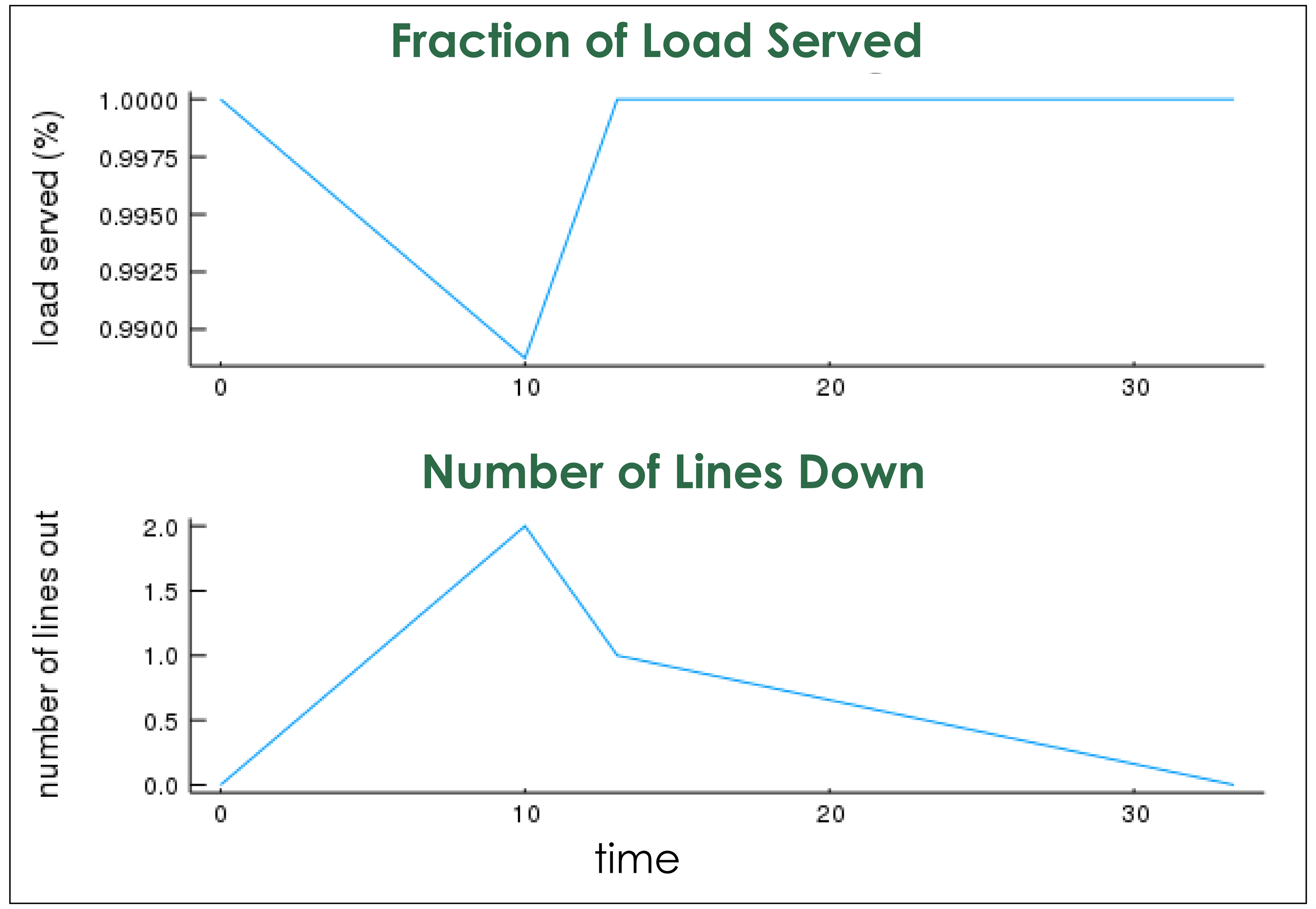
Background

- Most existing literature focuses on individual stage of resilience: component reliability, cascading failures, or restoration
- A few early comprehensive efforts have produced frameworks and metrics to measure resilience [1]
- Preliminary work has estimated system resilience to certain hazards; combining a good measure of component outages given a level of stress and probabilities of that stress occurring into a resilience framework [2].

Measuring Resilience of Power Systems







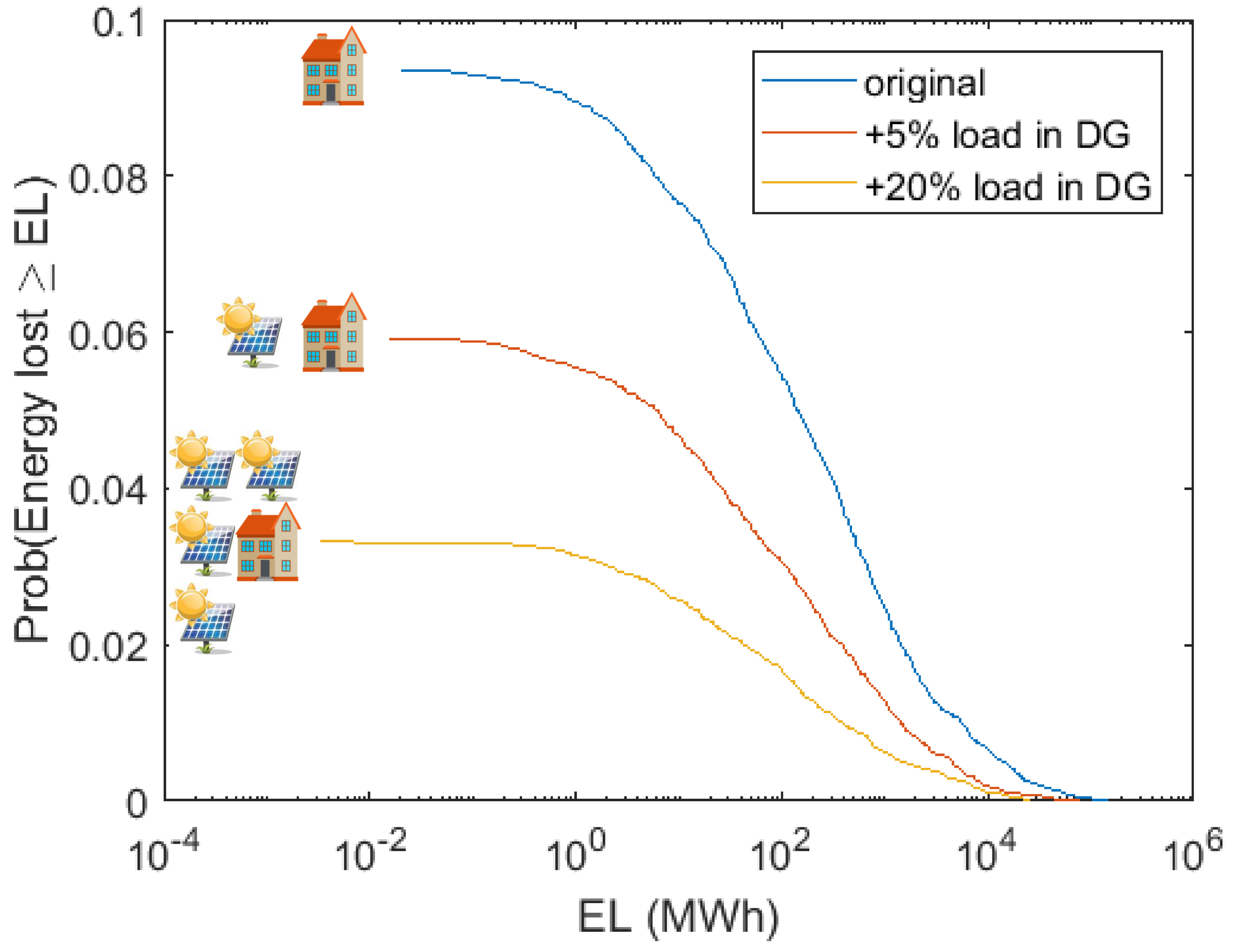
- Integrating unserved demand over time (lost energy) provides a measure of the resilience for a power system to a single event.
- A distribution of many potential events leads to a distribution of energy losses and is a measure of the resilience of the power system.

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 unserved demand/load with Load Shedding Optimal Power Flow
3. As lines are restored, find unserved load with the Restoring Load Optimal Power Flow
4. Measure resilience
5. Repeat 1-4

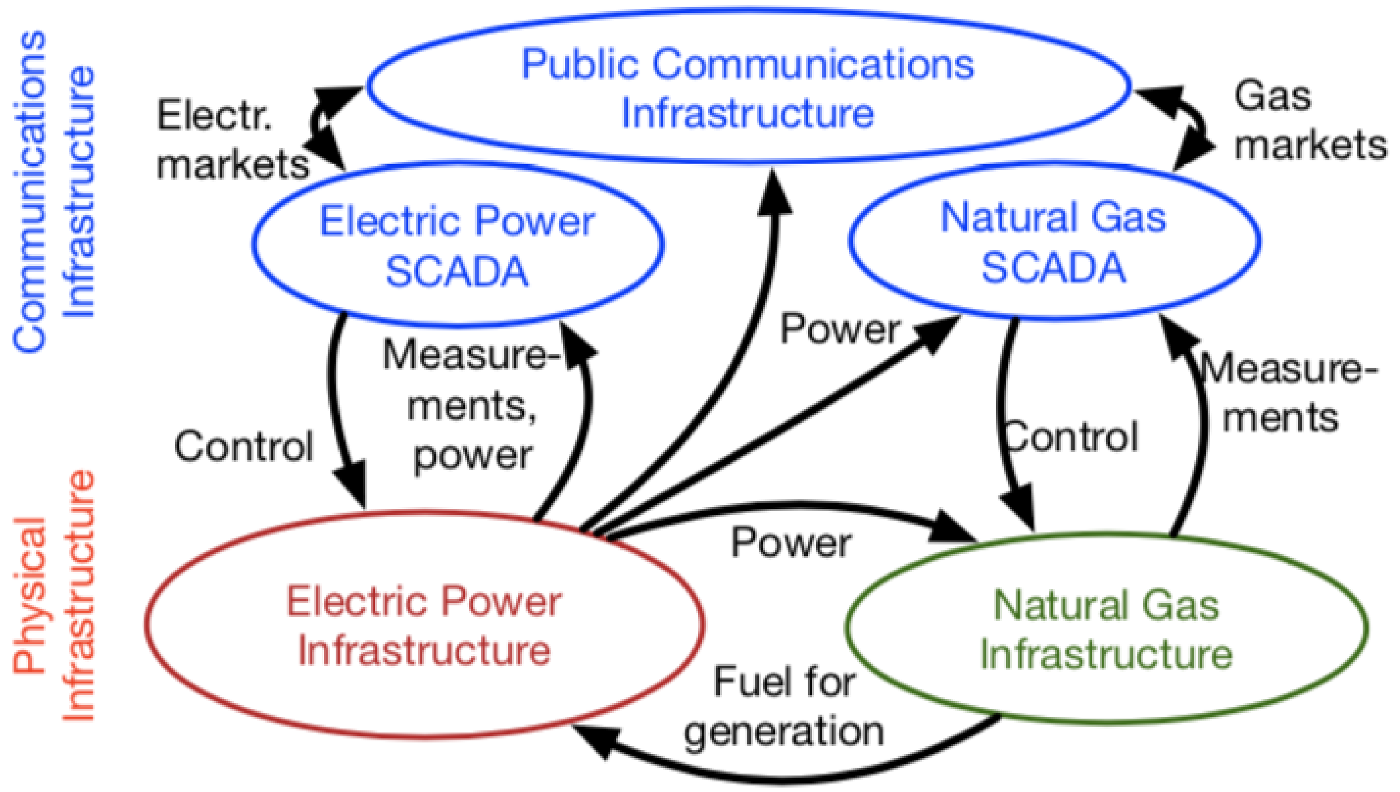
Preliminary Results

Resilience Distributions



Future Work

Coupling power system, natural gas and communication system models



References

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