Perspectives on Future Power Grids: Designing a More Resilient Electric Grid Through Decarbonization

International Solar Energy Society (ISES)

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PRESENTED BY

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Motivation

- The grid is the keystone infrastructure – central to the web of interconnected systems that support life as we know it.
- We want a future grid that is:
  - Sustainable
  - Reliable
  - Equitable
  - Decarbonized
  - Resilient
  - Low Cost
- During extreme events, prices do not reflect the value of all the services (food, water, shelter, etc.) that electricity provides
  - Consequence-focused **resilience is an externality** in power markets
  - Valuing and building for resilience is complex yet critical to our electric future

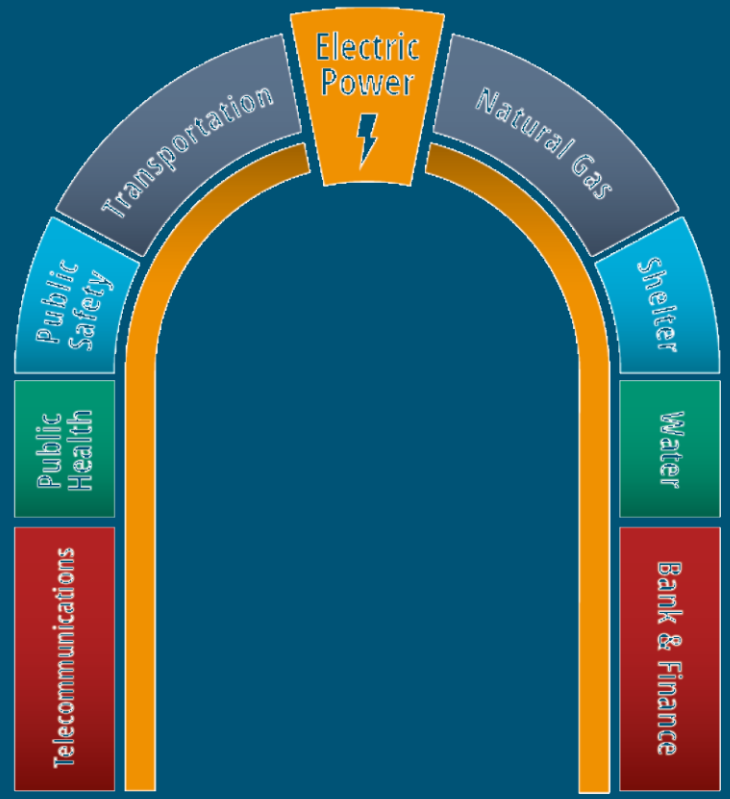






Image credit: Wikimedia Commons user "Mdf"

Resilience and Reliability

Resilience

Includes ***low probability, high consequence*** events.

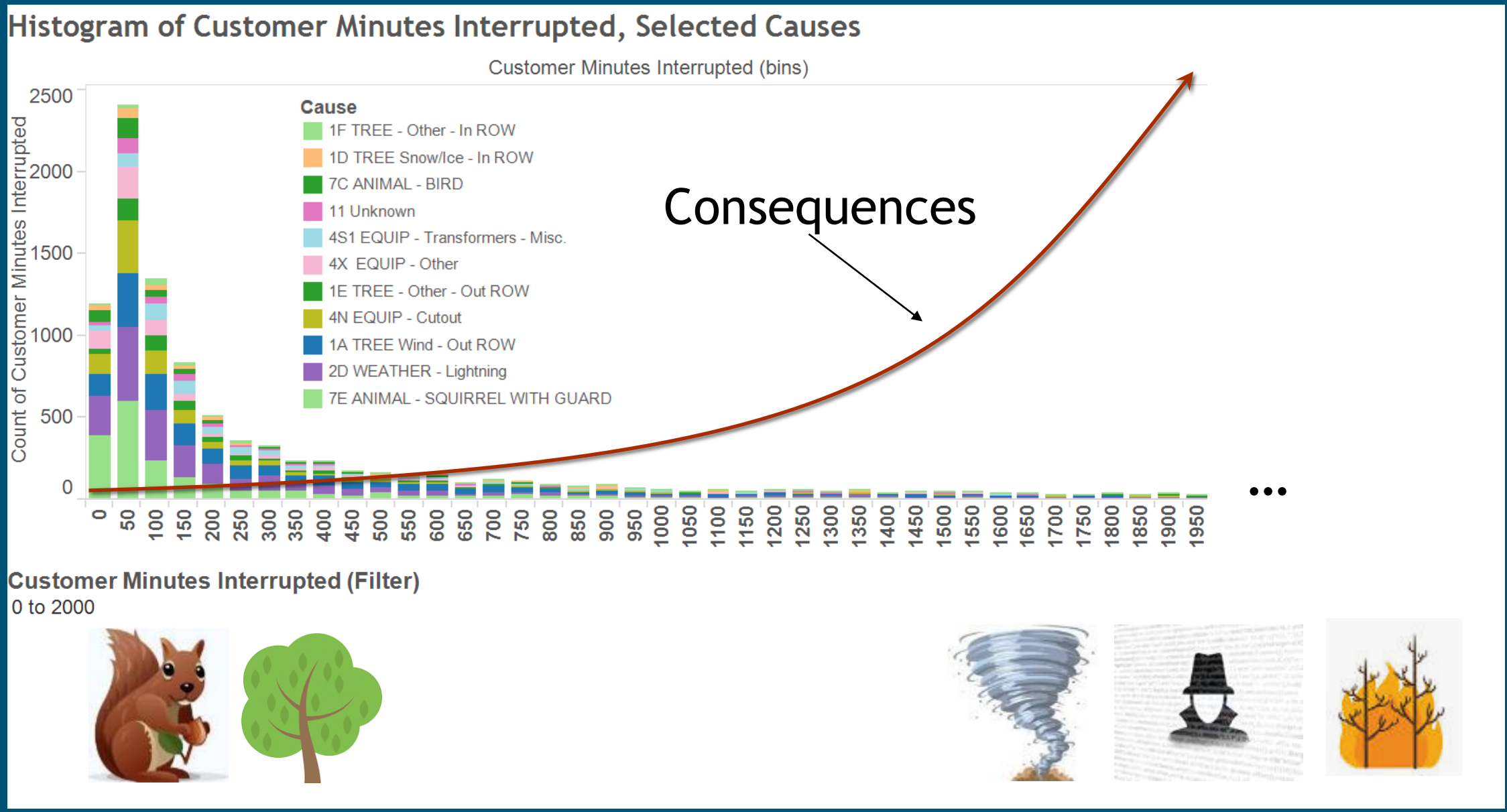
Not widely adopted. Still working on ***methods, metrics and tools***

Reliability

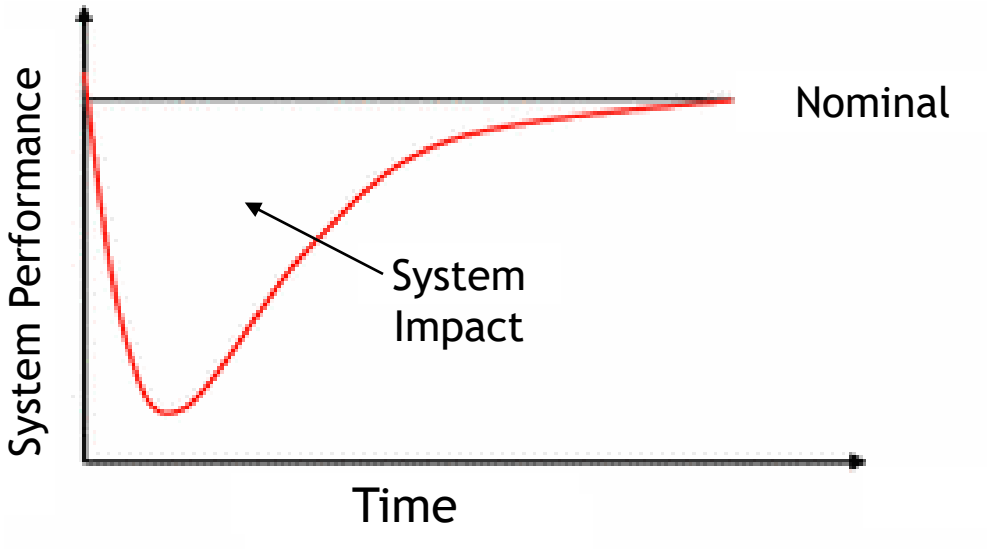
Focuses on system performance with respect to **commonly expected events** (component failure, etc.)

Widely adopted for infrastructure investment decision-making

Reliability focuses on average system performance…

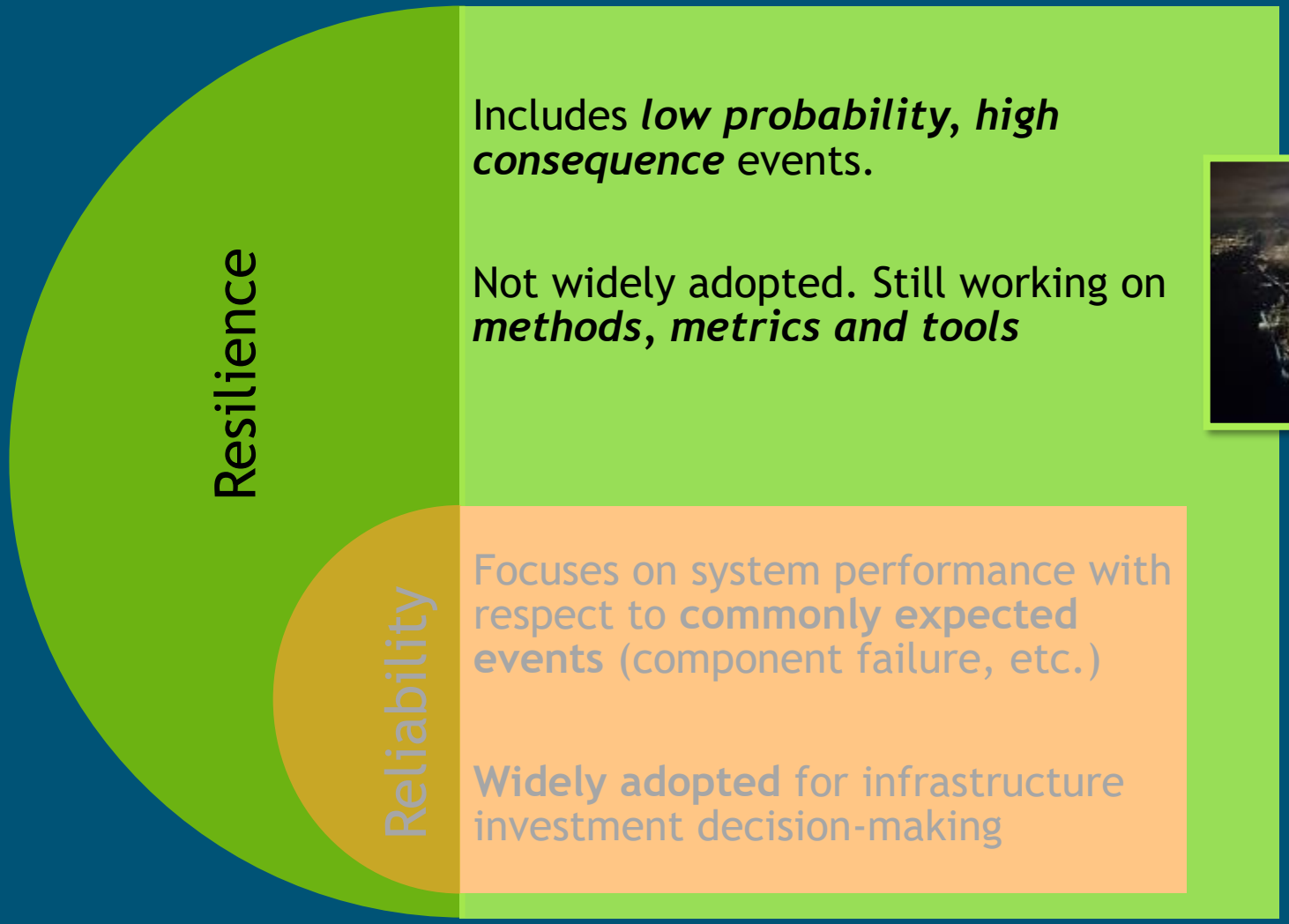


Defining Resilience

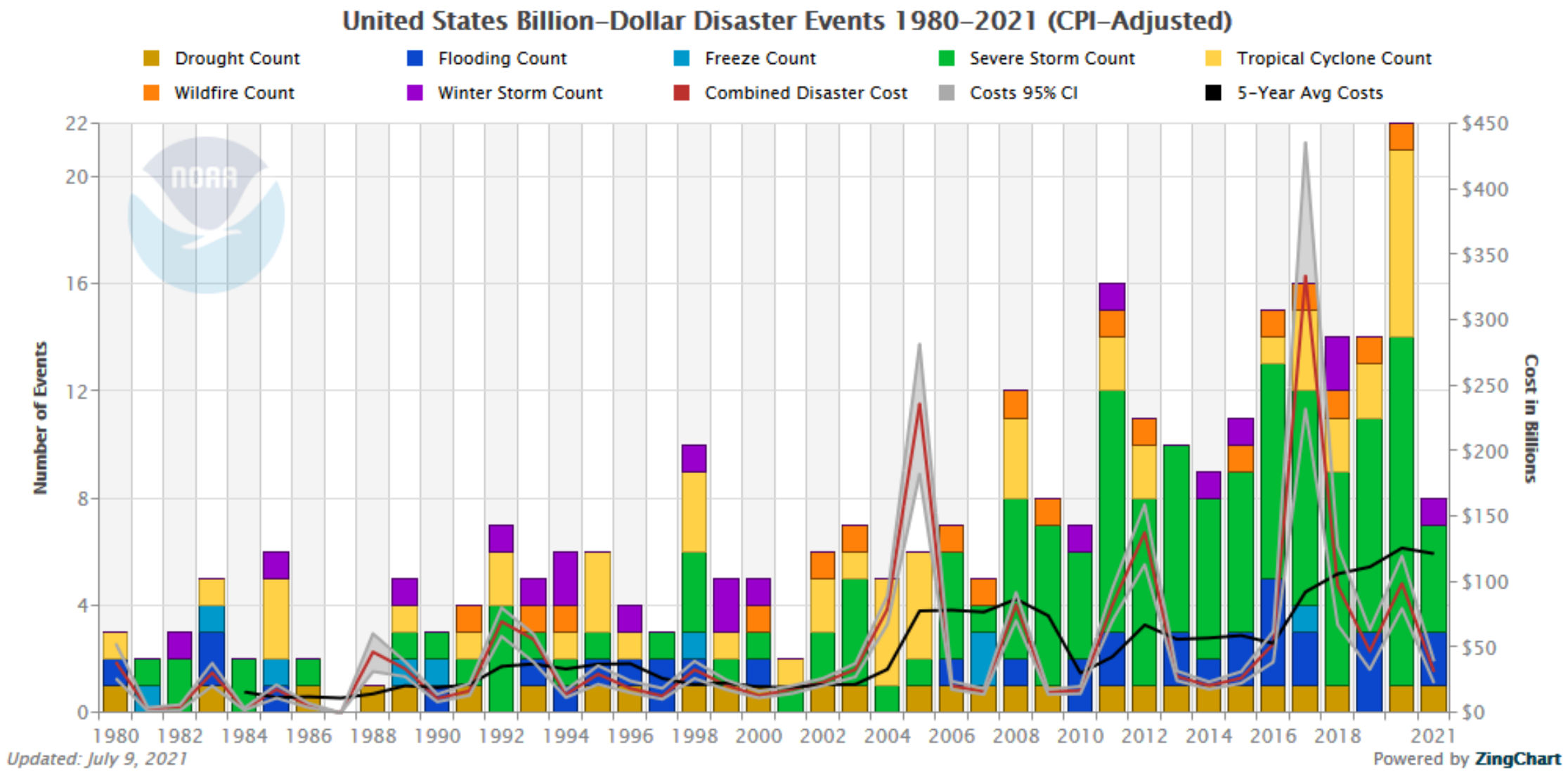


Ability to **Prepare for, Withstand and Recover from** disruptions caused by major **Accidents, Attacks, or Natural Disasters.**

Resilience and Reliability

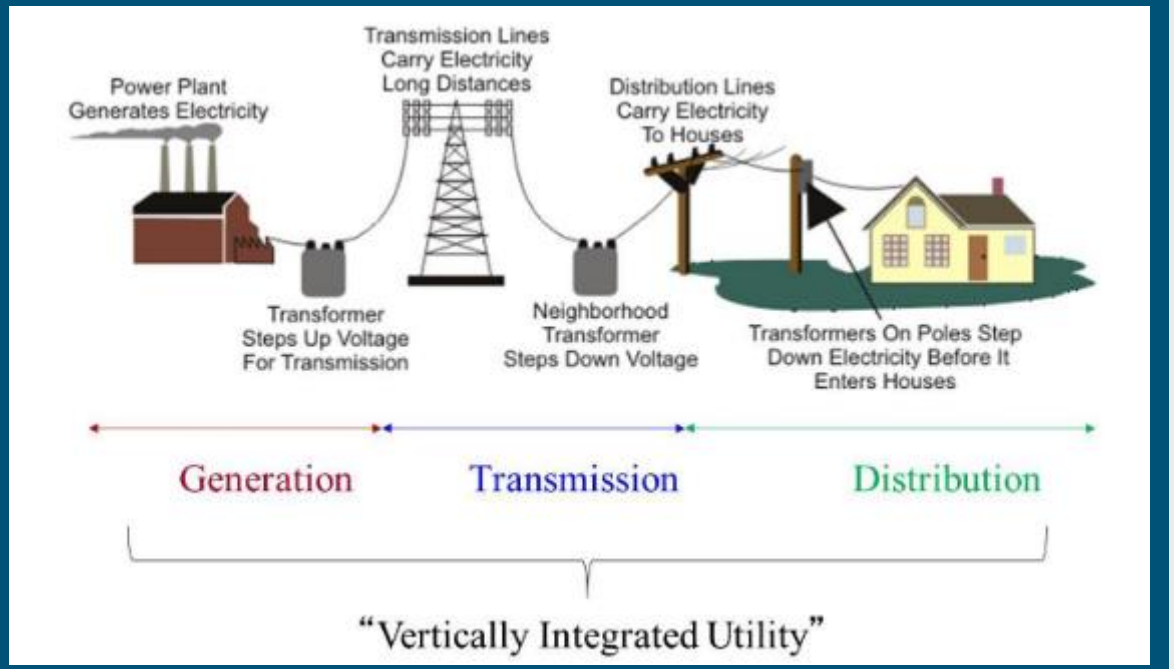


Large-scale events becoming more frequent…

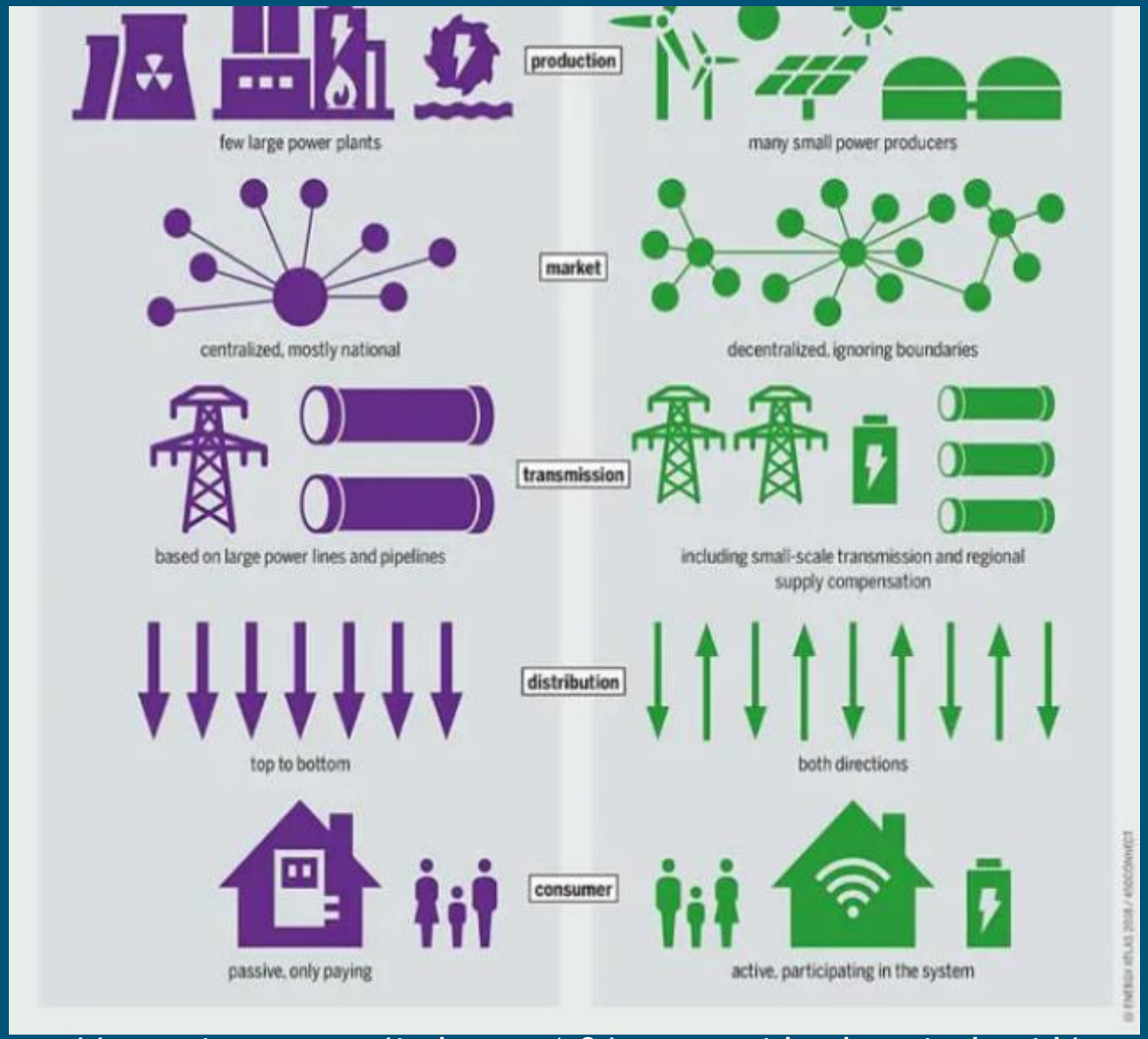


https://www.ncdc.noaa.gov/billions/time-series

Electric Power Grid – Increasingly centralized or decentralized?

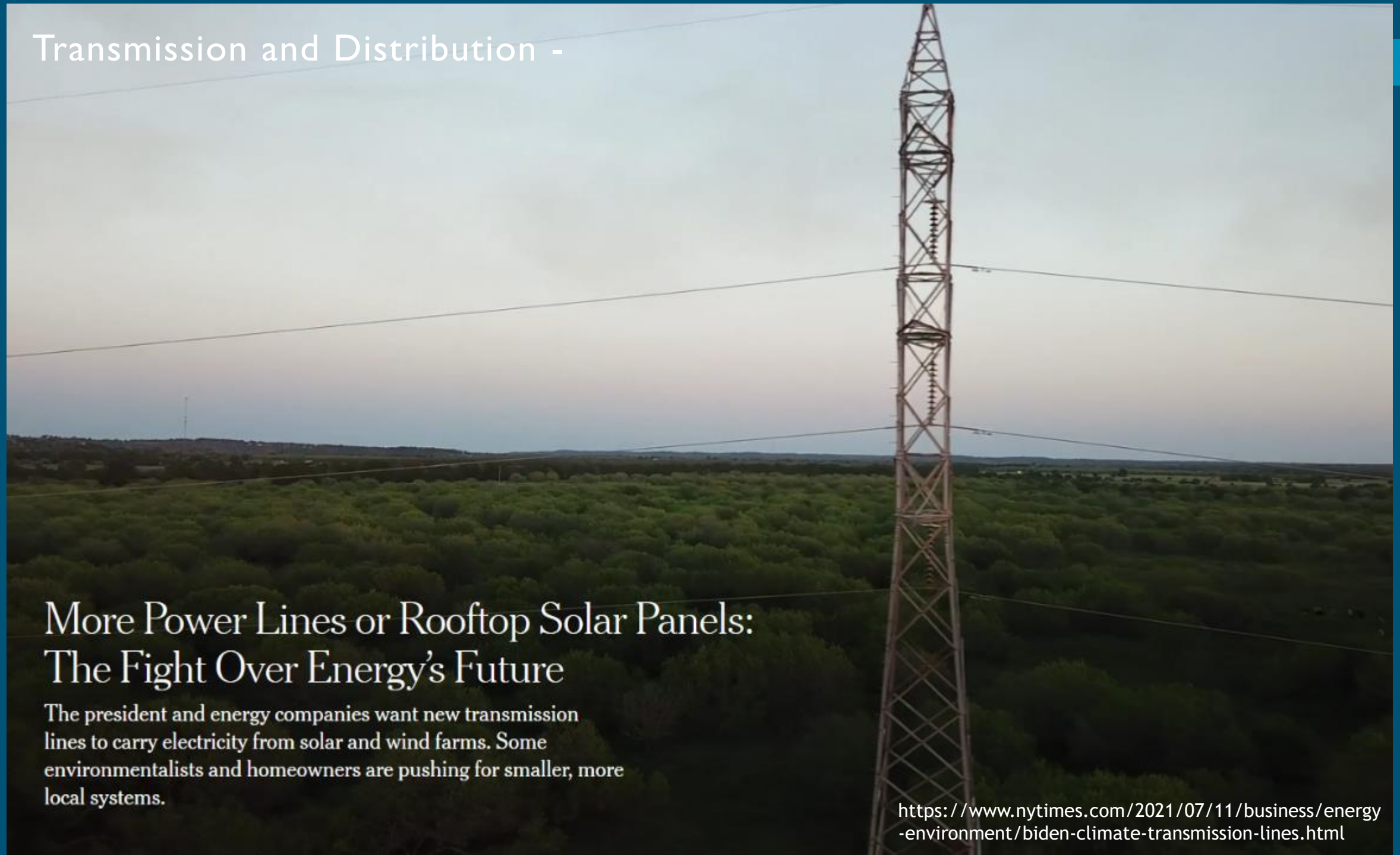


Source: Energy Information Administration



https://www.i-scoop.eu/industry-4-0/smart-grids-electrical-grid/

Transmission and Distribution -



https://www.nytimes.com/2021/07/11/business/energy-environment/biden-climate-transmission-lines.html

PV + Storage Microgrid supporting community resilience in Rutland, VT

Isn’t PV vulnerable to natural disasters?

Hurricane Maria, PR

- A major PV power plant and a major wind power plant (both second largest wind plan) were badly damaged.
- The rest of the fleet were not damaged, could not connect due to grid issues and lack of provision to sustain electrical islands.

Example project use modeling, testing and development tools to understand and improve resilience

St. Marys, Alaska System

Goal: Can we use grid forming inverters with energy storage to provide spinning reserve in a high renewable microgrid to reduce diesel fuel usage.

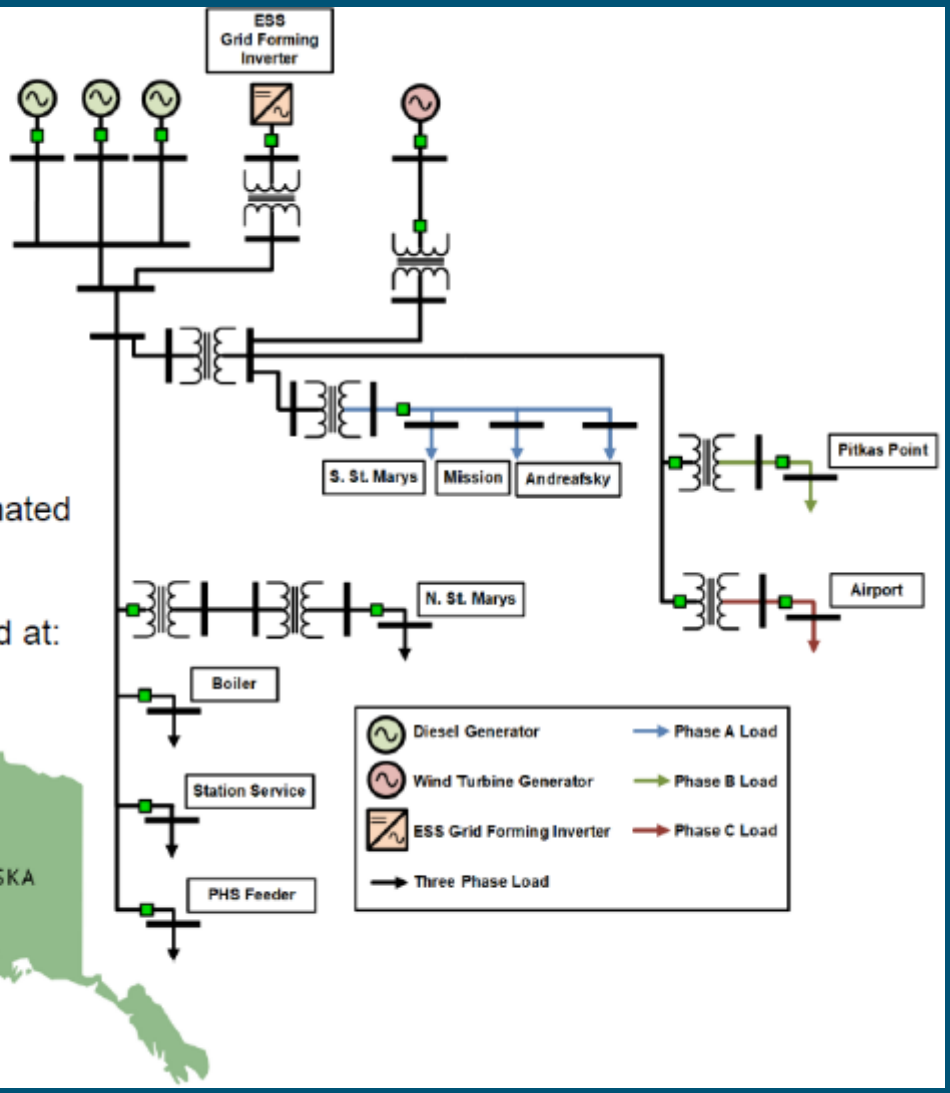
St. Marys is a small town in the state of Alaska with an estimated population of 568 [2019 US Census].

Its has a peak load of 600 kW and the generation assets are rated at:

- 2.018 MW of distilled fuel oil
- 0.9 MW of wind generation

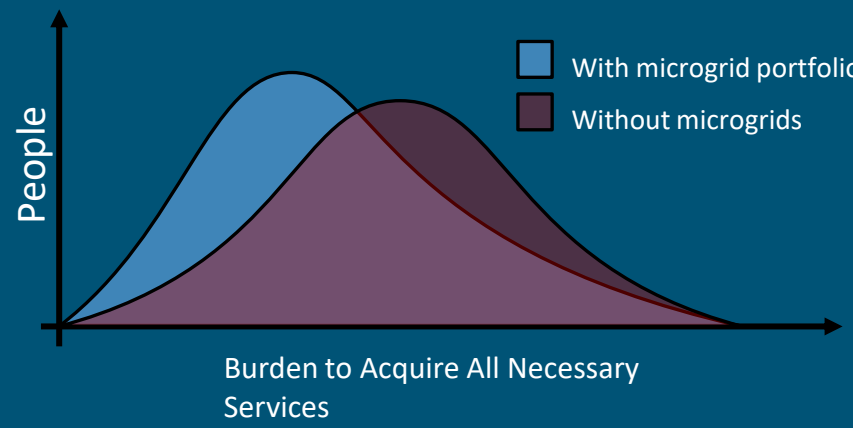
Note: St. Marys is currently procuring a 1.00 MW energy storage system (ESS).

For experimental results, a reduction in wind generation is considered.



Performance Based Metric: Social Burden

The **social burden metric** calculates how hard society is working to achieve their basic human needs.



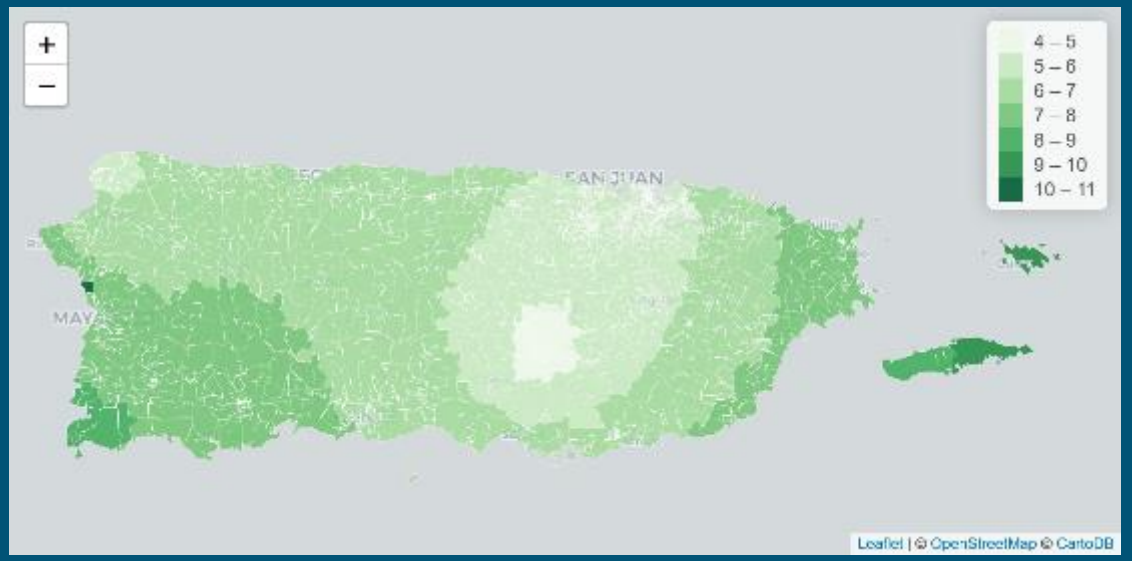
Effort
Time + money spent to achieve basic level of human needs

Ability
Median household income
Additional predictors

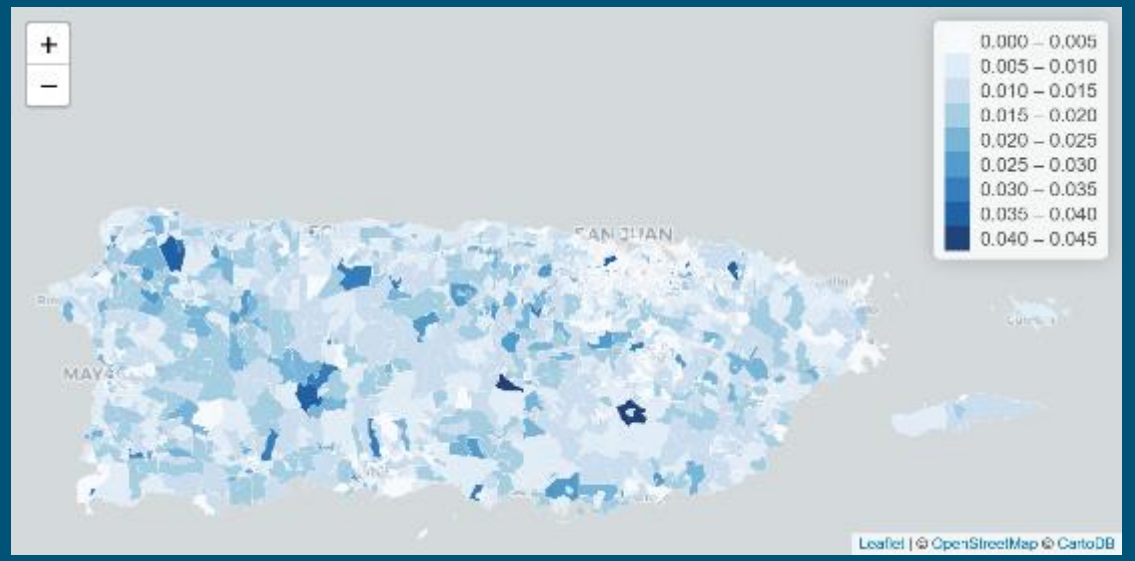
Burden

$$B_C = \sum_{inf} \sum_{pop} \frac{E_{inf,pop}}{A_{pop}}$$

Effort for a portfolio of 80 microgrids



Social Burden for the same portfolio



Necessary Institutional and Technical Considerations

Resilience-based planning methods

New regulatory & business models

Proactive codes and standards

Grid-tied grid-forming inverters

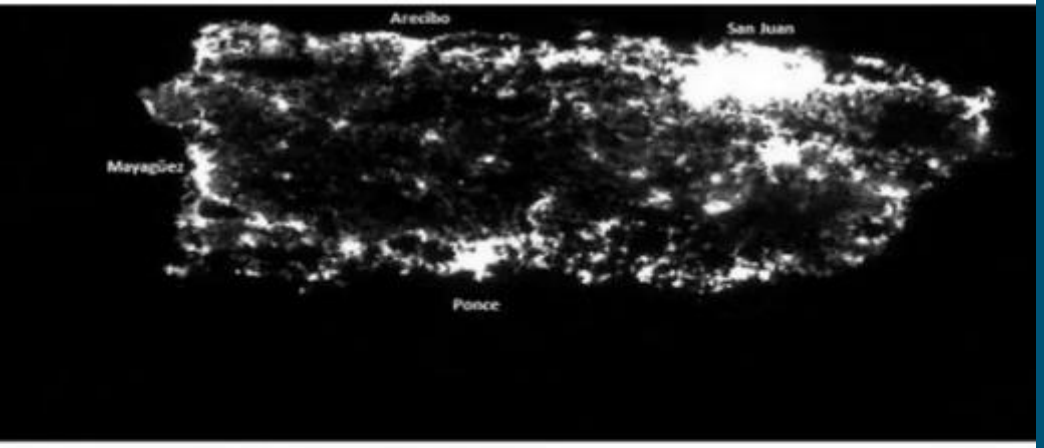
Dynamic and Networked microgrids

Built-in Physical and Cyber Security

What problem will we solve with a fleet of PV-based resilient microgrids?

☒ Improve resilience of the whole grid

☑ Improve resilience of infrastructure that supports critical services at selected locations



Closing Points

- Planning for resilience is an imperative
- Need practical methods, models, tools
- Renewables can play a key role
- Time to think really big: **We can enable a decarbonized and resilient energy future.**

Questions?

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https://energy.sandia.gov/programs/electric-grid/renewable-energy-integration/