Energy Security and Resilience Benefits of Electric Energy Storage

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Disclaimer

The following are my own views and not necessarily those of the Electricity Advisory Committee, the U.S. Department of Energy, or anyone else.

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Overview and Agenda

1. Many potential threats to reliable and resilient electricity supply
2. Energy storage can and has helped mitigate these
3. Market design and regulatory barriers remain

Possible Sources of Supply Disruptions

Natural

- Water availability
- Earthquake
- Storms
- Space weather
- Tsunami
- Volcanic event
- Wildfire

Human-Caused

- Physical attack
- Cyber attack
- Operational error

Cross-Cutting

- Fuel supply

More Frequent Than Expected

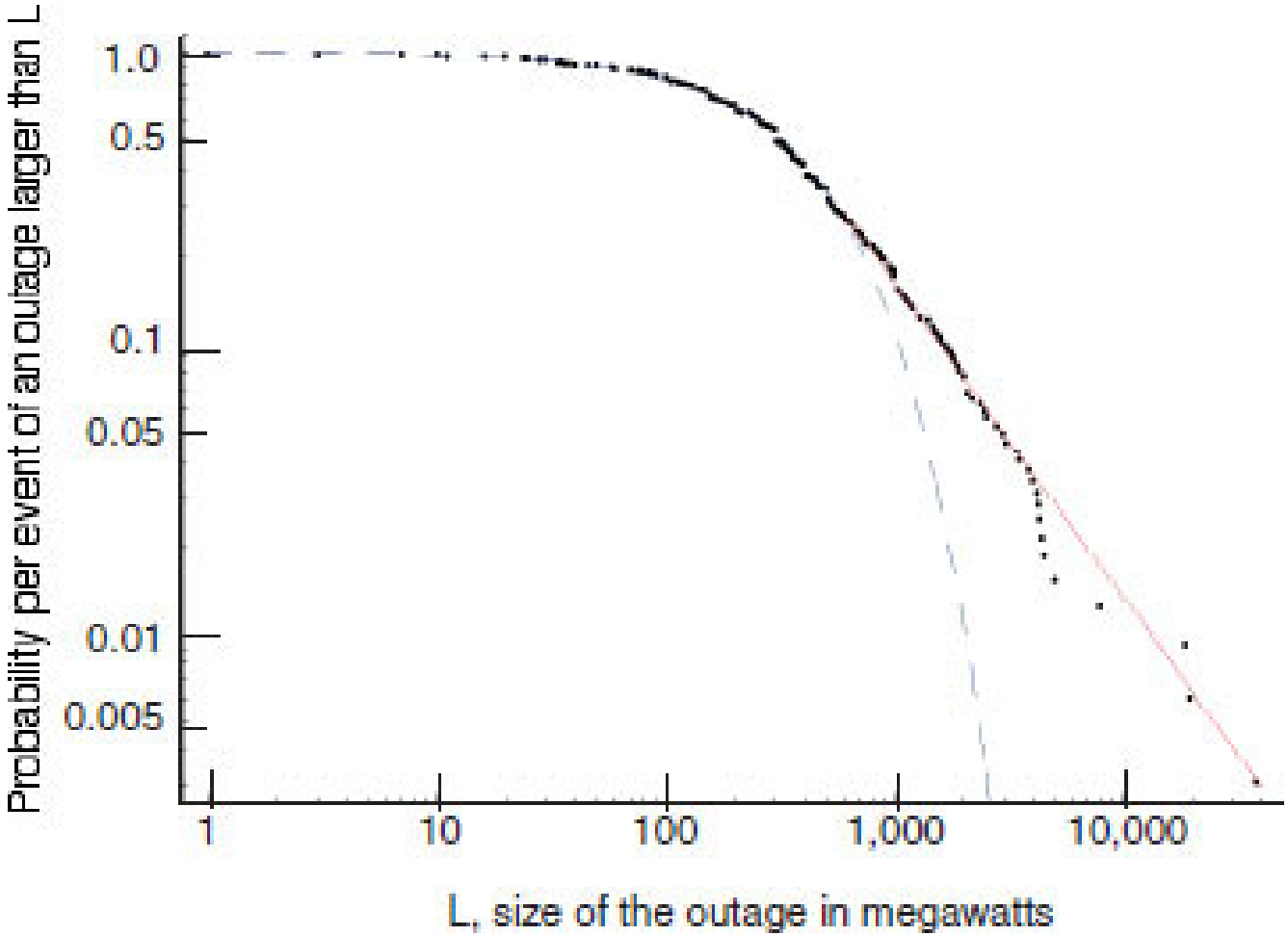

Figure: Dashed Line Fits an Exponential Distribution to Frequent Small-Scale Events

Source: `https://www.nap.edu/read/12050/chapter/3`

Terrorist Attack

https://www.doi.org/10.17226/12050

A terrorist attack on the power system would lack the dramatic impact of the attacks in New York, Madrid, or London. It would not immediately kill many people or make for spectacular television footage of bloody destruction. But if it were carried out in a carefully planned way, by people who knew what they were doing, it could deny large regions of the country access to bulk system power for weeks or even months. An event of this magnitude and duration could lead to turmoil, widespread public fear, and an image of helplessness that would play directly into the hands of the terrorists. If such large extended outages were to occur during times of extreme weather, they could also result in hundreds or even thousands of deaths due to heat stress or extended exposure to extreme cold.

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Cyber Vulnerability

DOE 2017 QER

The current cybersecurity landscape is characterized by rapidly evolving threats and vulnerabilities, juxtaposed against the slower-moving deployment of defense measures. Mitigation and response to cyber threats are hampered by inadequate information-sharing processes between government and industry, the lack of security-specific technological and workforce resources, and challenges associated with multi-jurisdictional threats and consequences. System planning must evolve to meet the need for rapid response to system disturbances.

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Operational Error

NERC Analysis of 2003 Blackout

The first sign of trouble came at 12:15*, when MISOs state estimator experienced an unacceptably large mismatch error between state-estimated values and measured values. The error was traced to an outage of Cinergy's Bloomington-Denois Creek* 230*-kV line that was not updated in MISOs state estimator. The line status was quickly corrected, but the MISO analyst forgot to reset the state estimator to run automatically every five minutes.*

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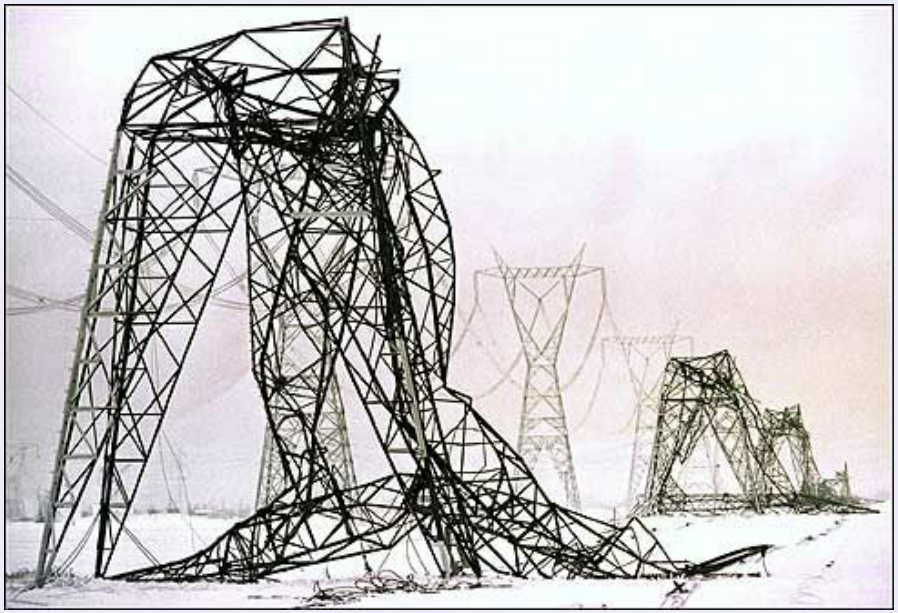
Natural Events

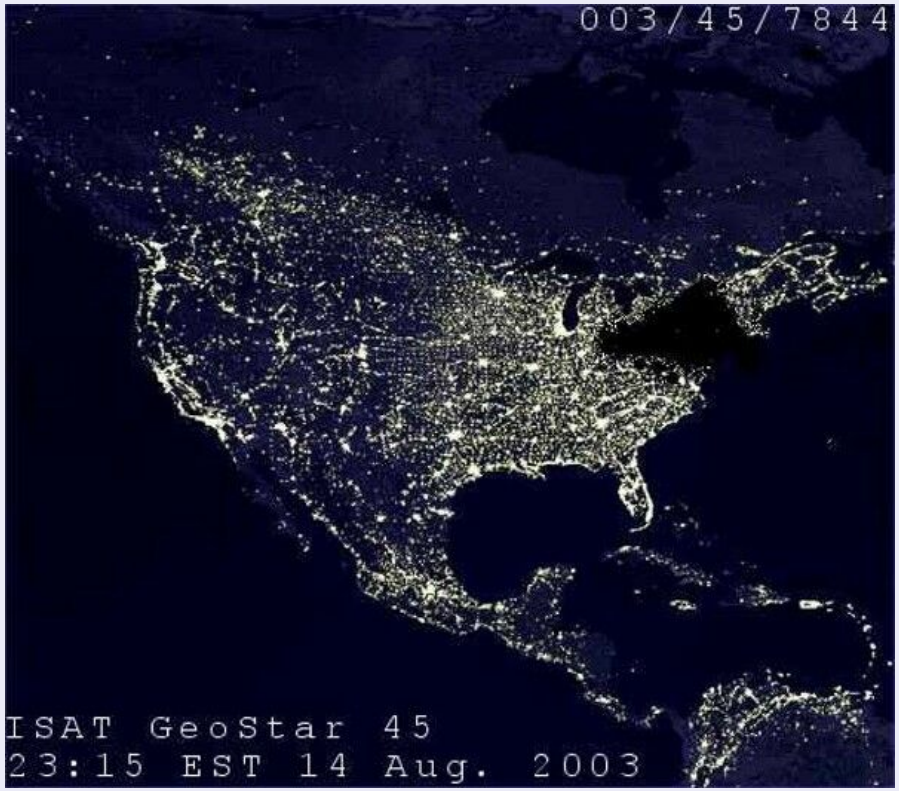
1998 North American Ice Storm



- 4 million without power
- \$5 billion–\$7 billion in losses
- 35 deaths

Superstorm Sandy

- Affected over 4 million people
- $>$\$40 billion in losses
- 147 deaths

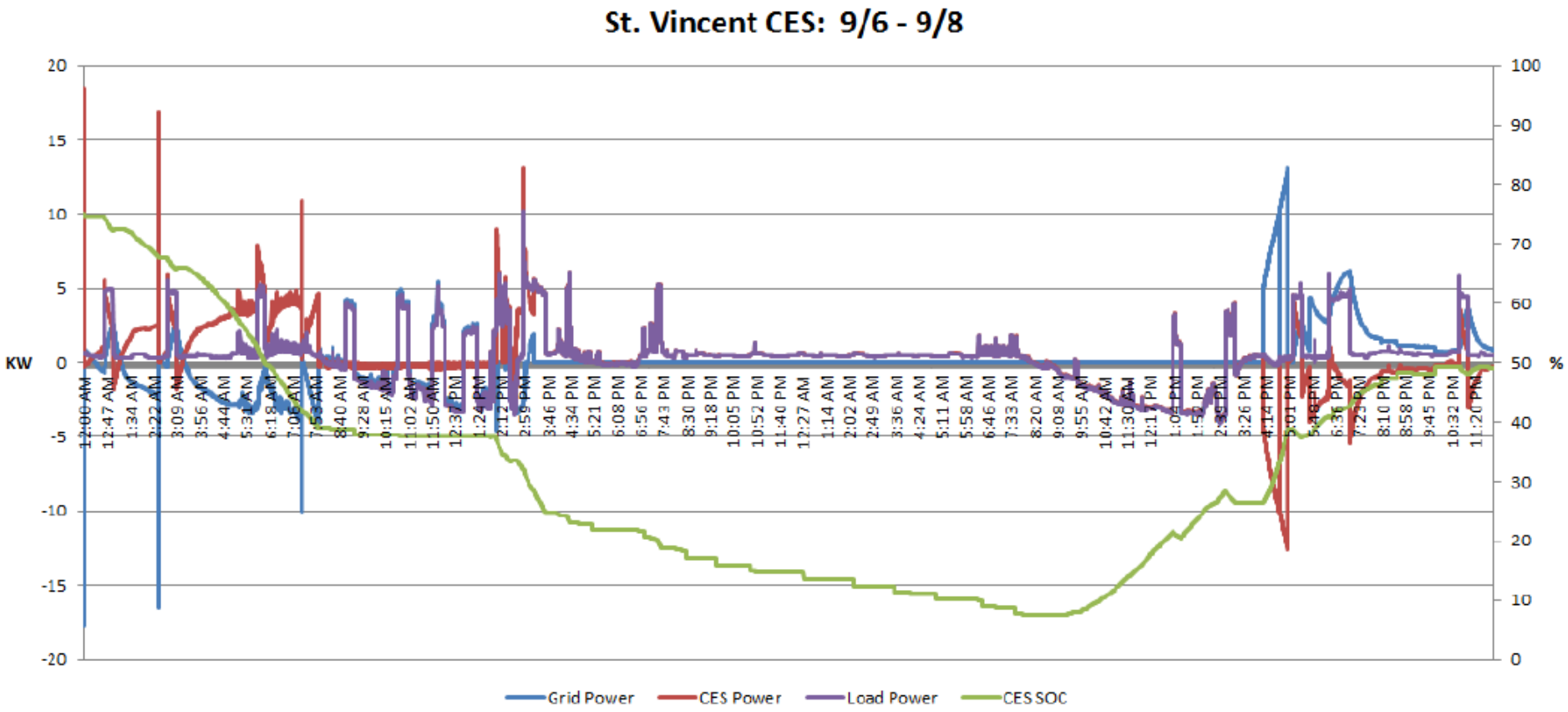


Aliso Canyon

- Large natural gas storage facility in Los Angeles basin
- Initially shutdown following leak discovered in 2015
- Subsequently available for withdrawal only on an emergency basis
- California desires reducing the reliance on brittle natural gas infrastructure

- California Public Utilities Commission ordered Southern California Edison to procure energy storage
- Result:
  - Three contracts with third parties, two completed (22 MW/88 MWh)
  - Two utility-owned projects (two 10 MW/40 MWh facilities built by Tesla, two 10 MW/4.3 MWh facilities built by GE)

Borrego Flood 'Outage'



- During intense thunderstorm, Borrego microgrid (including distributed energy storage) was able to provide power to 1000 customers during 'outage' lasting more than 20 hours

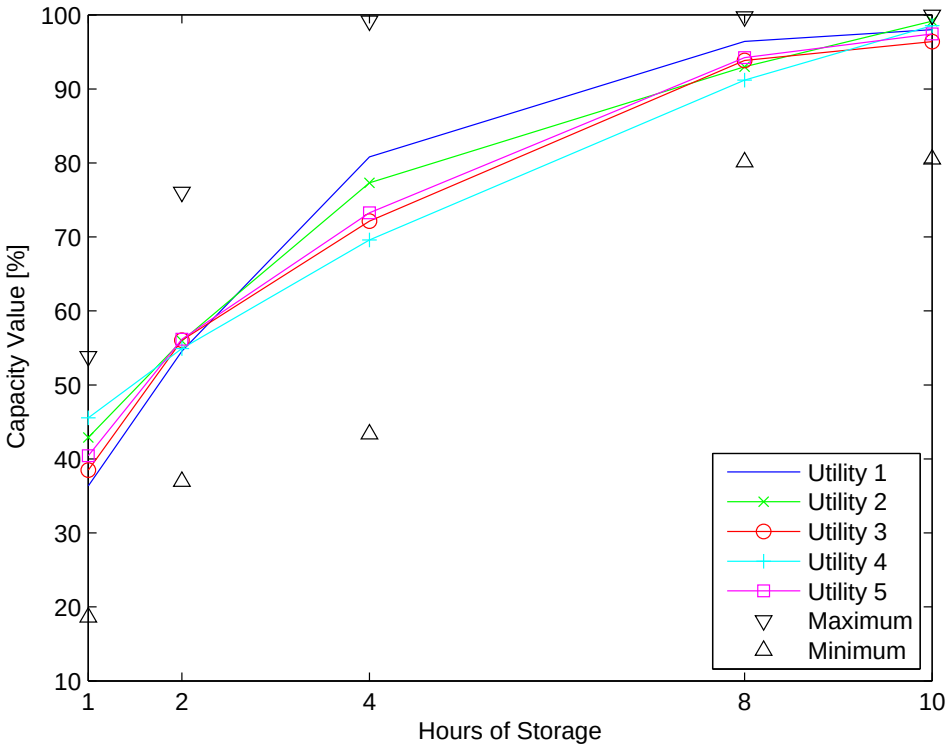
IID Blackstart

http://www.iid.com/Home/Components/News/News/557/30

- Imperial Irrigation District used a 30 MW/20 MWh battery storage system to blackstart a 44 MW combined-cycle gas turbine
- Believed to be a first for the industry

Source: Jay Calderon/The Desert Sun

Market Valuation



- Energy storage's reliability/capacity value is closely related to how it is operated
- Signaling when energy must be in store is critical
- Even without an explicit mechanism, storage provides some capacity value due to energy and other prices
- Most capacity markets are not designed for storage participation

- Federal Energy Regulatory Commission is currently looking into this under proposed *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators* rulemaking
- Designs are tied to signaling good operations and valuing storage's capacity

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Customer Valuation

- How much are customers willing to pay for reliability?
- Engineers have avoided this question and set arbitrary reliability standards (*e.g.*, one day in 10 years)
- Implied value of lost load is probably too high
- Principle of revealed preferences may not work
  - Exploding cows
  - Hospitals signing interruptible-load contracts

Operational Planning

- Highly inefficient to dedicate storage *exclusively* to backup/reliability/resiliency
- Knowing when to have energy in store and when not makes for a challenging forecasting/optimization problem
- Off-the-shelf models cannot handle this
- State-of-the-art academic/research models (kind of) can

Co-Mingling Market-Priced and Unpriced Services

- Some of these services are market-priced, others are not
- Regulatory paradigm assumes that an asset only provides one type of service and handles cost recovery and benefit valuation accordingly
- Energy storage (especially distributed) cuts across the two, breaking the current regulatory mold

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