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Resilience with Renewables

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Changing the World's Energy Future

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Resilience with Renewables

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MIRACL – Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad

Enabling wind-centered DER systems		
Accurately value grid system contributions from wind as a DER	Advance controls for wind-hybrid DER systems	Enhance resilience in distributed wind applications

Idaho National Laboratory

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Pacific Northwest
NATIONAL LABORATORY

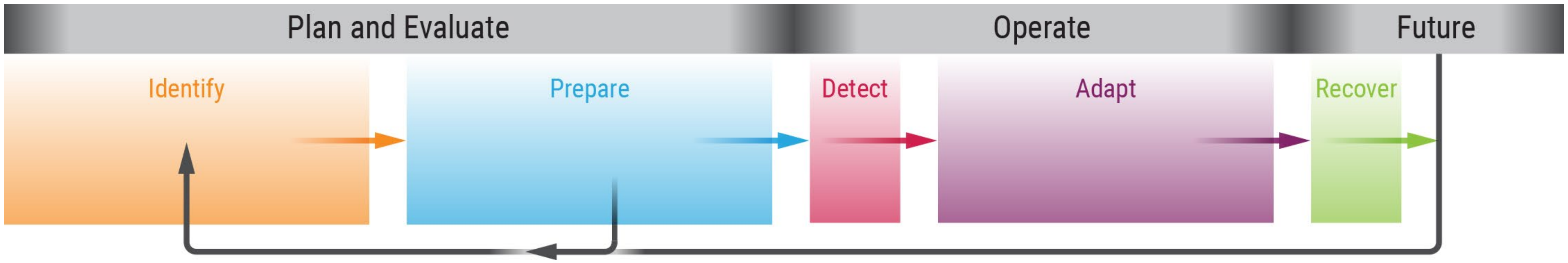
Sandia National Laboratories

Resilience Framework for Electric Energy Delivery Systems

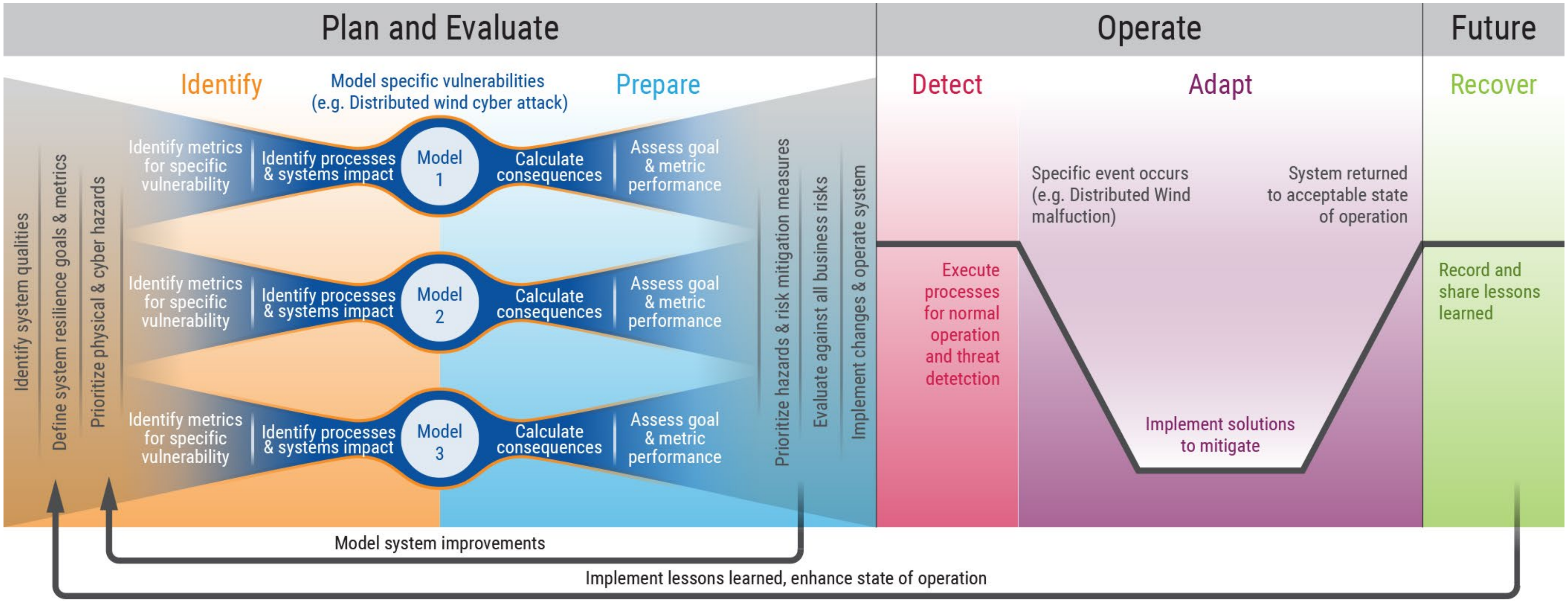
- Resilience defined as:

  "a characteristic of the people, assets, and processes that make up the EEDS and its ability to **identify, prepare for**, and **adapt** to disruptive events (in the form of changing conditions) and **recover rapidly** from any disturbance to an **acceptable state** of operation."

- Resilience framework developed around this definition
- Emphasis is on an iterative process throughout system lifecycle

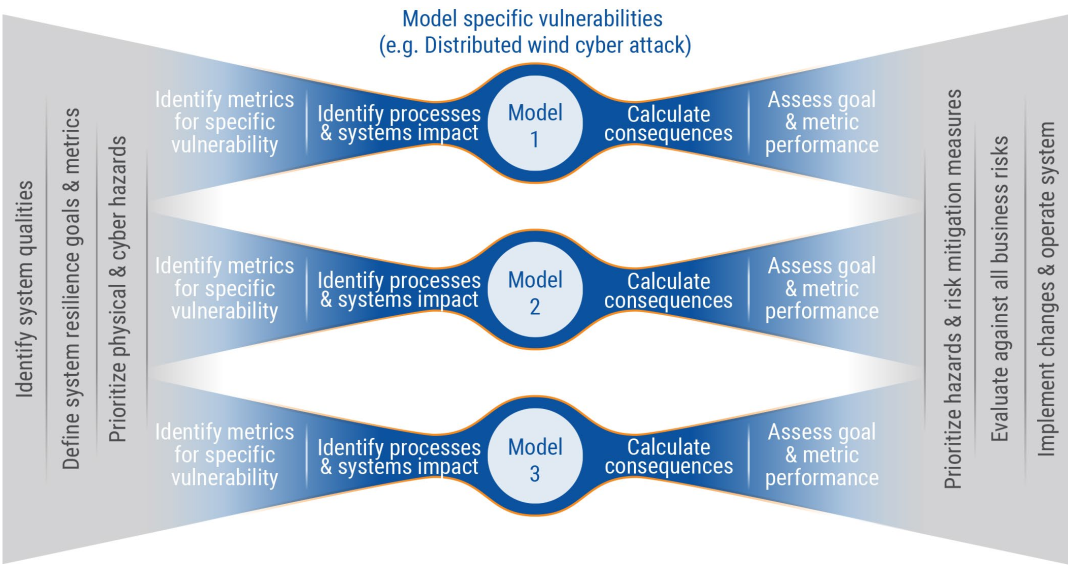


Resilience Framework for Electric Energy Delivery Systems



Planning for Resilience

- Bowtie analysis for planning stage
- System definition
- Goals definition
- Hazard consideration
- Cost/benefit evaluation prior to putting changes in effect
- Intended to help evaluate alternatives against each other



Key considerations at the facility level

- What are my resilience needs?
- Can I tolerate interruptions?
- What are my critical loads? Can critical loads be isolated?
- What is my current emergency backup plan?
- Are there ways to modify the emergency backup plan to rely on renewable sources?
- Can my facility be islanded?

Risk Management Architecture

Risk = Likelihood x Consequence

Risk = Threat x Vulnerability x Consequence

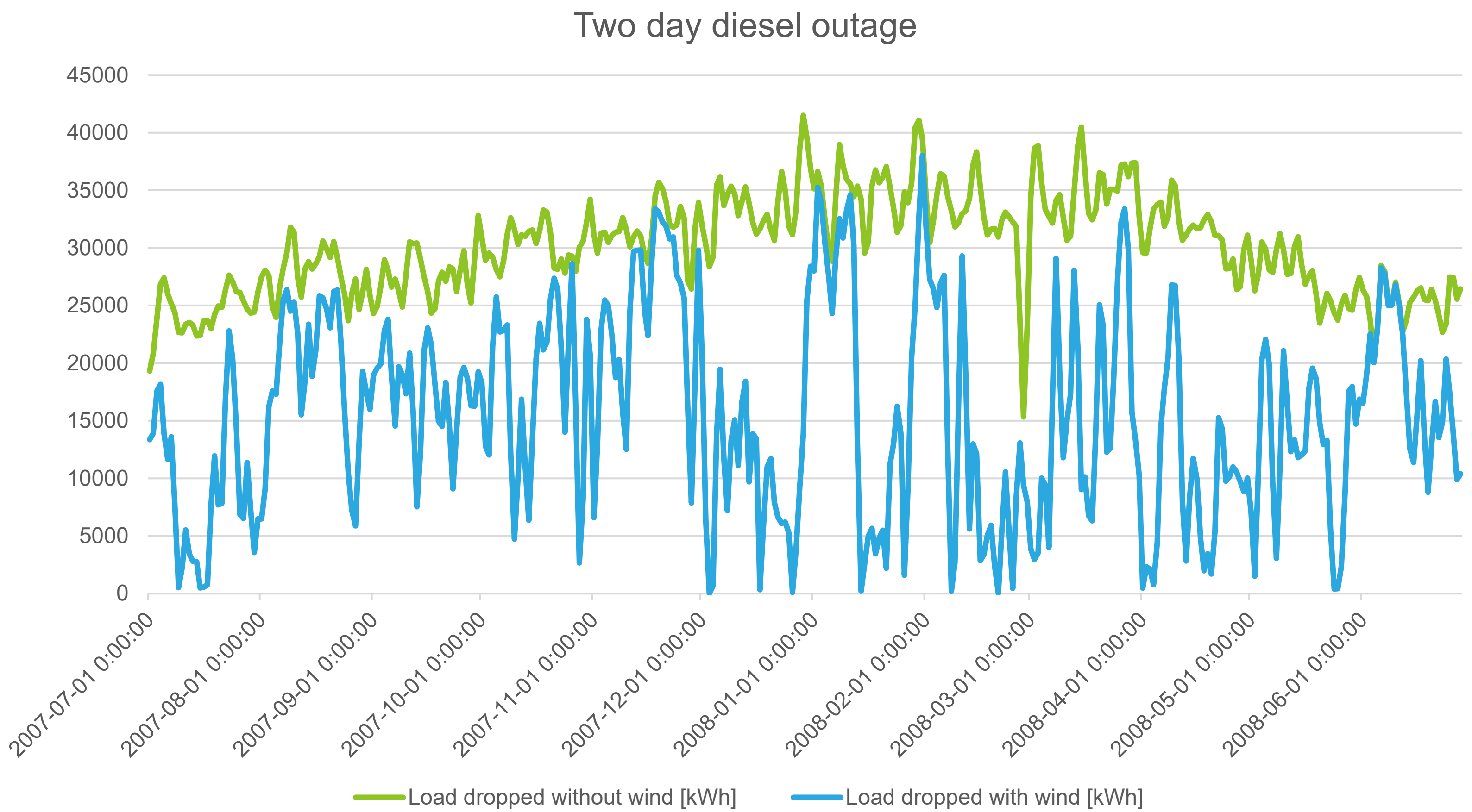
Risk = Threat - M_T x Vulnerability - M_V x Consequence - M_C

- Risk management comes from mitigating each element individually
- Resilience measures can apply to any element

Case Study: St. Mary's, AK

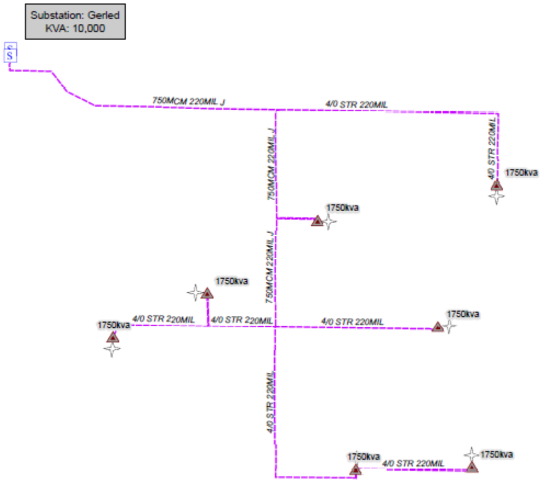
- 900 kW turbine installed 2019
- Resilience goals:
  - improve power quality
  - reduce dependency on fuel
- Resilience hazards:
  - Fuel shortage
  - Winter weather
  - Loss of turbine comms

Key results: St. Mary's, AK case study Two-day diesel outage

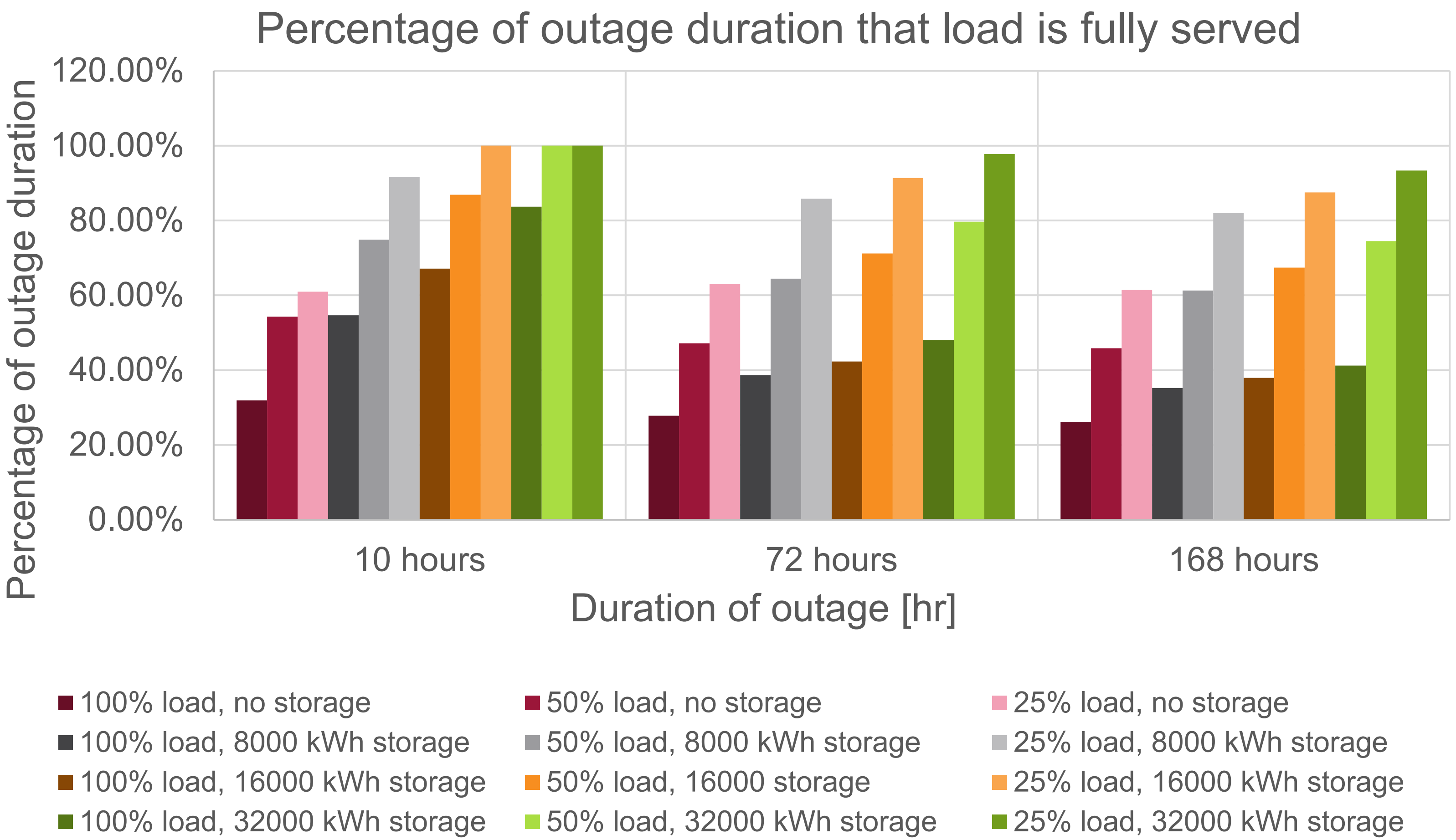


Case Study: Iowa Lakes, Iowa

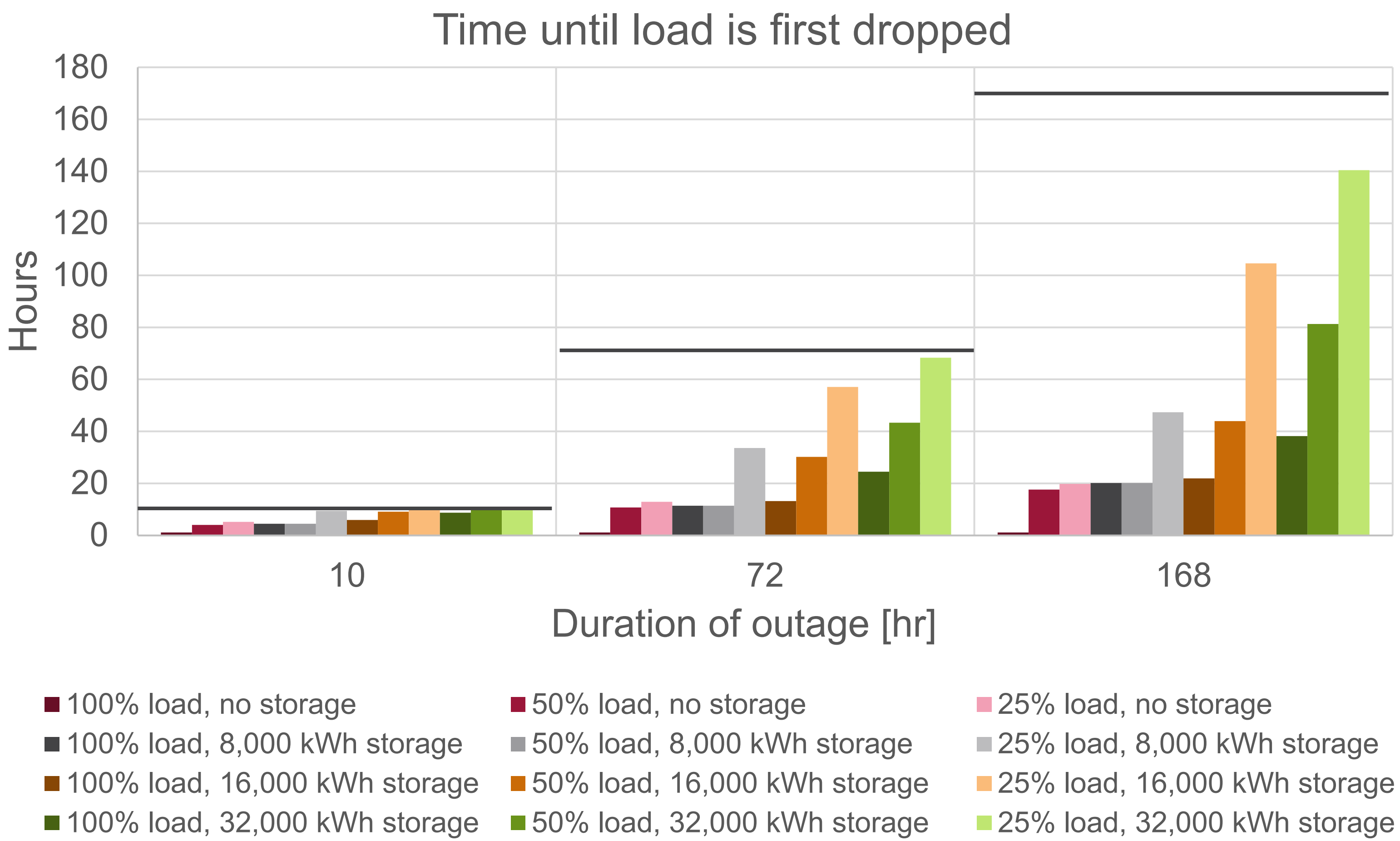
- Two 7-turbine wind farms serve two ethanol plants 6-8 MW each
- Resilience goals:
  - Reduce dependence on transmission system
  - Maintain power under cyber or other disruption



Key results: Iowa Lakes case study Transmission feeder lost



Key results: Iowa Lakes case study Transmission feeder lost



Resilience Valuation

100% Outage Mitigation Scenarios
With and Without Energy Storage

	Outage Duration (hours)					
	10		72		168	
Storage (kWh)	Hours Mitigated	Outage Mitigation Value	Hours Mitigated	Outage Mitigation Value	Hours Mitigated	Outage Mitigation Value
0	1.14	$34,709	1.14	$34,709	1.14	$34,709
8,000	4.48	$106,976	11.42	$258,971	8.74	$198,083
16,000	5.94	$137,652	13.20	$303,994	24.48	$501,760
32,000	8.74	$198,681	21.92	$460,408	38.91	$758,659

*Assumes that plants cannot tolerate interruptions, so value provided is only the value until first outage

Maximizing Value from Storage

- Variable resource smoothing
- Peak shaving
- Voltage and frequency support (sold as grid services)
- Congestion relief (sold as grid services)
- Inertial support

Tradeoffs will always exist in the operation of storage assets

- *How much capacity to reserve for emergency backup?*
- *How to operate assets for grid support vs. local load support during disturbances?*

Key Takeaways

- Resilience performance dependent on system goals
- On-site DER can boost resilience against certain hazards
- Storage helps smooth power availability
- Consider other operational measures to add to storage
- Tradeoffs exist between maximizing resilience values and maximizing other value streams

Thank you