Advanced Technology and a Resilient Electric Grid

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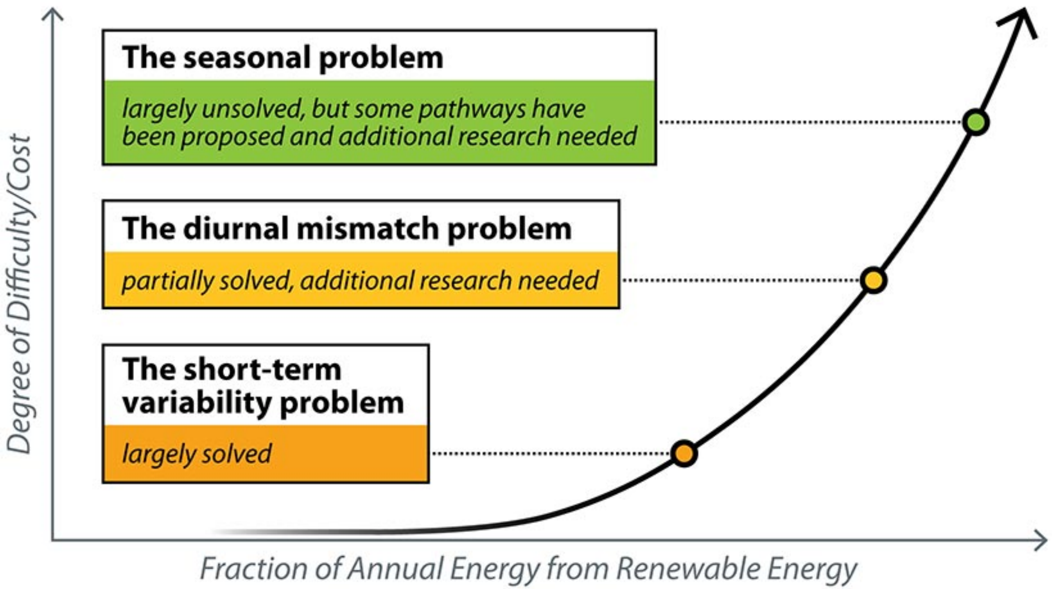
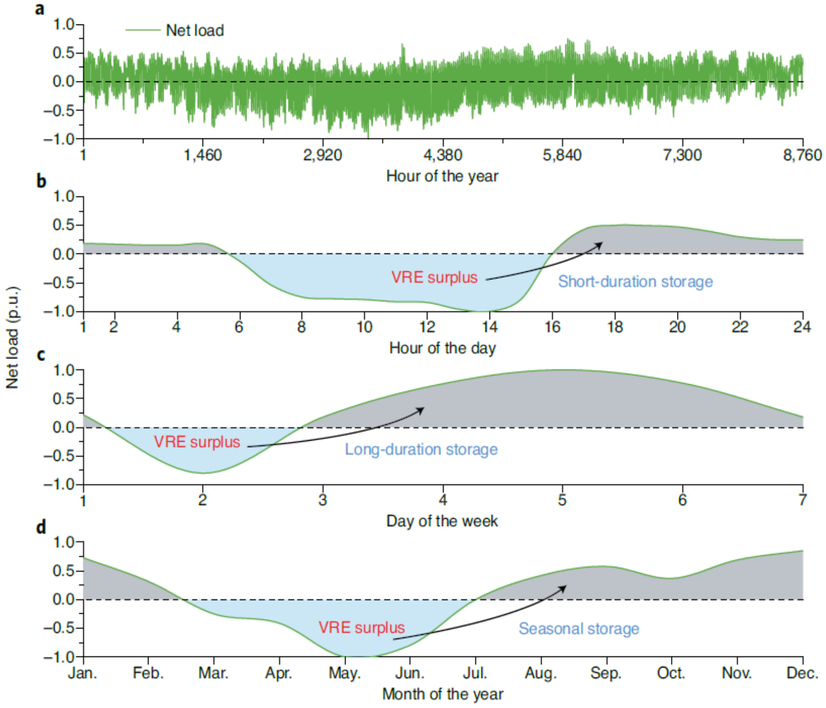
A Growing Need for Advanced Technologies on the Grid



Source: Denholm et al. “The challenges of achieving a 100% renewable electricity system in the United States.” (2021)
https://www.sciencedirect.com/science/article/pii/S2542435121001513



Source: Geurra. “Beyond short-duration energy storage.” (2021)
https://www.nature.com/articles/s41560-021-00837-2

Supporting Resilience Today: Energy Storage

Recent analysis has explored the extent to which standalone energy storage can help reduce shortfalls

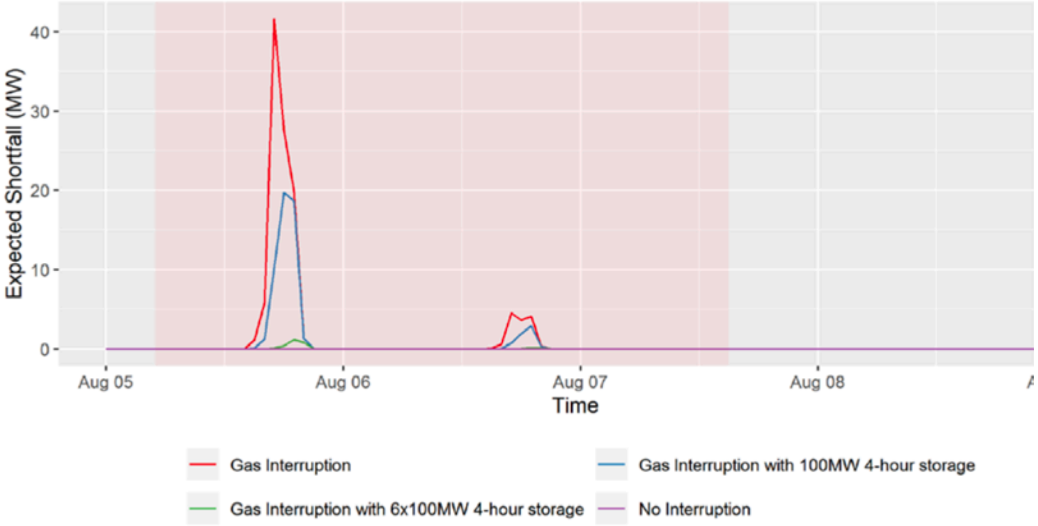
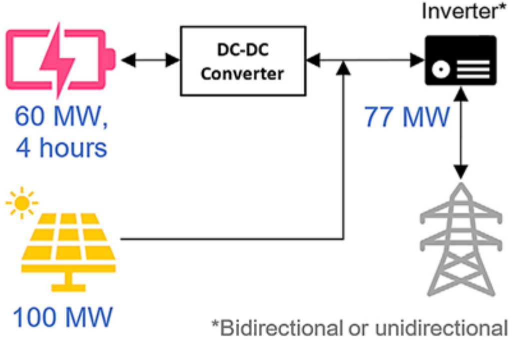
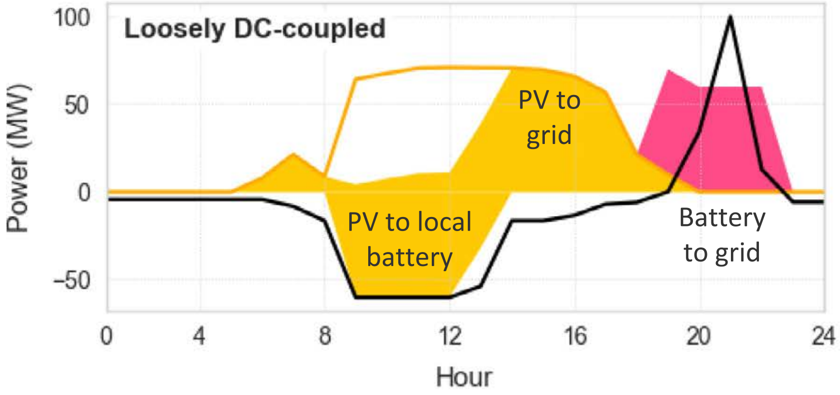


Figure 3. Expected unserved energy across natural gas disruption scenarios with varying levels of energy storage capacity, as modeled in PRAS

Source: Murphy et al. "Adapting Existing Energy Planning, Simulation, and Operational Models for Resilience Analysis." (2020) https://www.nrel.gov/docs/fy20osti/74241.pdf

Renewable+Storage hybrids can also support resilience through local charging



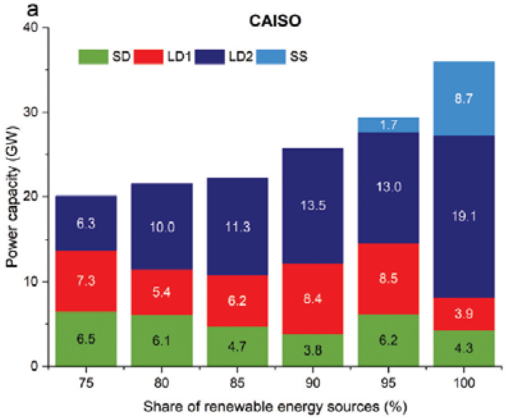


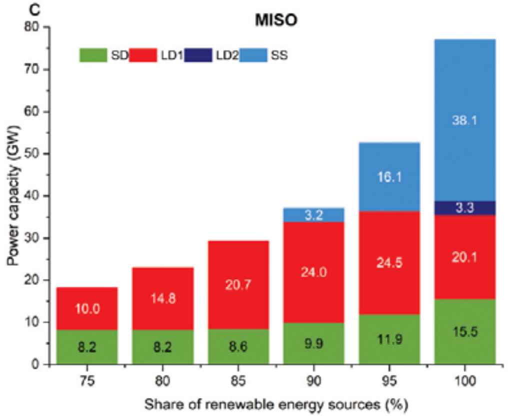
Source: Schleifer et al. "The evolving energy and capacity values of utility-scale PV-plus-battery hybrid system architectures." (2021) https://doi.org/10.1016/j.adapen.2021.100015

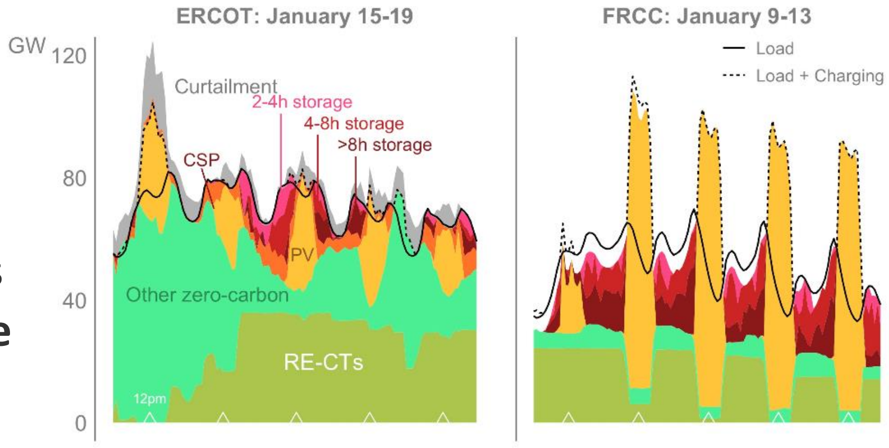
Planning for the Future Grid: Long-Duration and Seasonal Storage

The increasing value of long-duration and seasonal storage is consistently observed in analyses with very high renewable energy shares

- Many **types** of long-duration and seasonal storage being evaluated
- **Timing** of the emergence of long-duration storage depends on pace of grid decarbonization and competition with other firm capacity resources
- Optimal **mix** and **duration** of storage resources depend on regional factors
- Storage could enhance grid **resilience** against extreme weather events





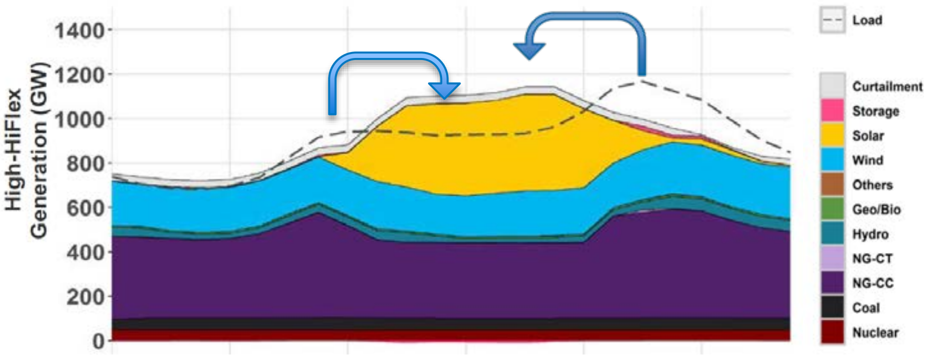


Source (above): Guerra et al. "Optimal energy storage portfolio for high and ultrahigh carbon-free and renewable power systems (2021) https://doi.org/10.1039/D1EE01835C

Source (left): Solar Futures Study

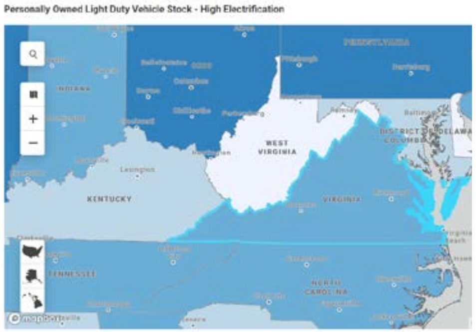
Other Advanced Technologies and Resilience

- The scaling up of **demand-side flexibility programs** can support resilience by shifting loads out of high-stress periods

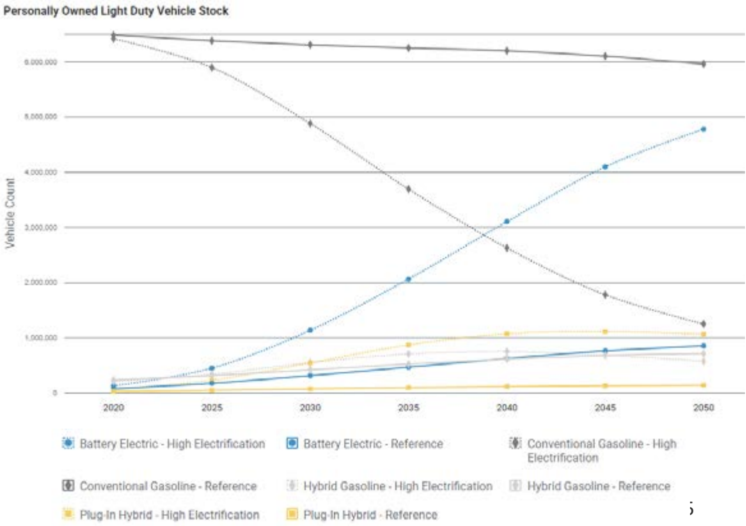


Source: Zhou et al. "Electrification Futures Study: Operational Analysis of U.S. Power Systems with Increased Electrification and Demand-Side Flexibility." (2021) https://www.nrel.gov/docs/fy21osti/79094.pdf

- **Small modular reactors** are increasingly being incorporated into planning models, but their role on the future grid depends on highly uncertain safety, cost, and performance characteristics
- As with any new technology, the potential for new **resilience risks** must be evaluated and addressed



Source: *State and Local Planning for Energy*, accessed 11/15/2021, https://gds.nrel.gov/slope



Approaches for Customer and Community Resilience

Customers' ability to remain in their homes during an extended grid outage depends on how long the indoor temperatures remain livable (among other factors)

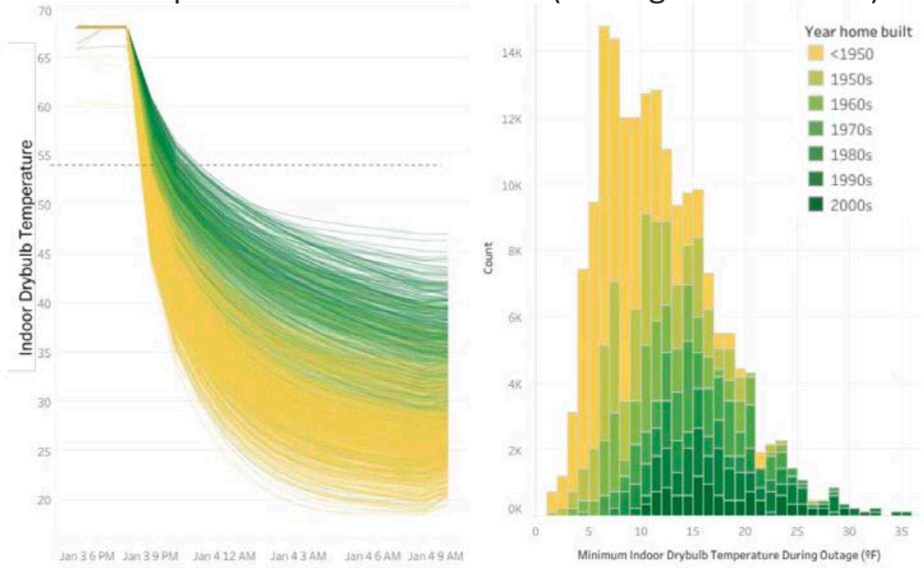
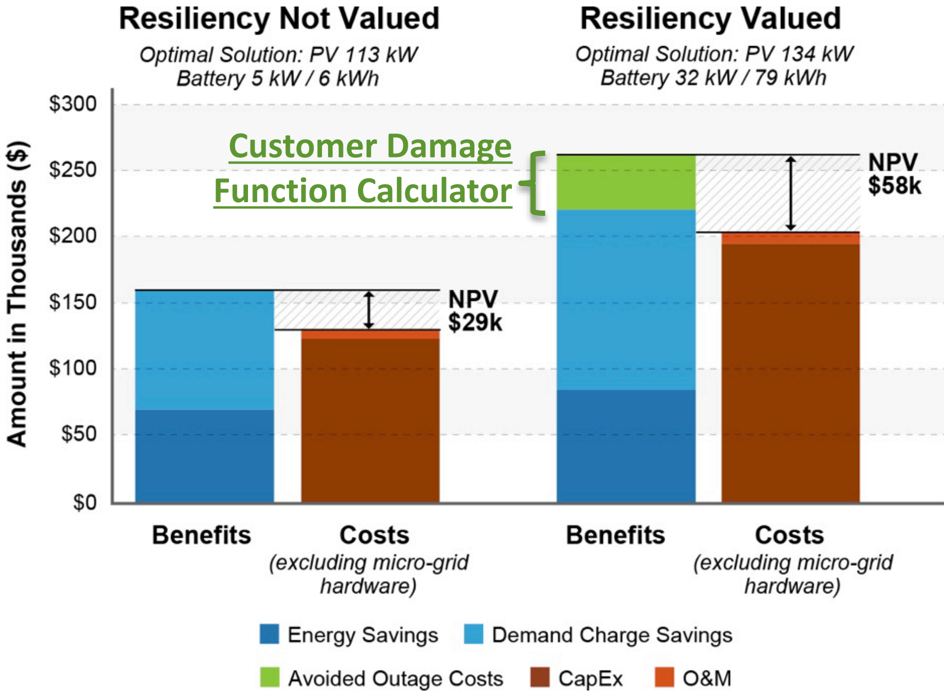


Figure 1. Internal temperature trajectories (left) and distribution of minimum indoor temperatures (right) for buildings in Buffalo, New York, during a power interruption resulting from a hypothetical 12-hour ice storm, as modeled in ResStock

Newer homes, presented in green, typically maintained a livable internal temperature for longer during the hypothetical ice storm, and they maintained higher temperatures overall over the course of the outage.

Source: Murphy et al. "Adapting Existing Energy Planning, Simulation, and Operational Models for Resilience Analysis." (2020) https://www.nrel.gov/docs/fy20osti/74241.pdf

Strategically placed and designed microgrids can support community resilience by ensuring that vulnerable populations can access critical services during extended grid outages



Source: Laws et al. "Impacts of valuing resilience on cost-optimal PV and storage systems for commercial buildings." (2018) https://doi.org/10.1007/s12667-018-0314-8

NREL hosts a multidisciplinary research center for enhancing energy resilience and enabling transformation to address urgent challenges.

Exercises **leadership in the scientific fundamentals** of energy resilience through research, publications, and convening of interested communities

Conducts **all-hazards threat analyses** for changing conditions to inform frameworks, metrics, and methodologies for resilience

Develops **frameworks, modeling capabilities and visualization** to enable techno-economic analyses of energy components, systems, operational approaches, and recovery strategies.

Extends data sets, visualizations, and **tools for decision support and market transformation** to minimize impacts associated with disruptive events.

Create a consistent, cohesive portfolio of research enabled by cross-functional teams.

Resources from Select Projects Led or Supported by NREL

- Adapting Existing Energy Planning, Simulation, and Operational Models for Resilience Analysis
- Storage Futures Study
- Solar Futures Study
- Electrification Futures Study
- SLOPE
- Renewable energy hybrids research
- Standard Scenarios (new release soon)
- Customer Damage Function Calculator

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