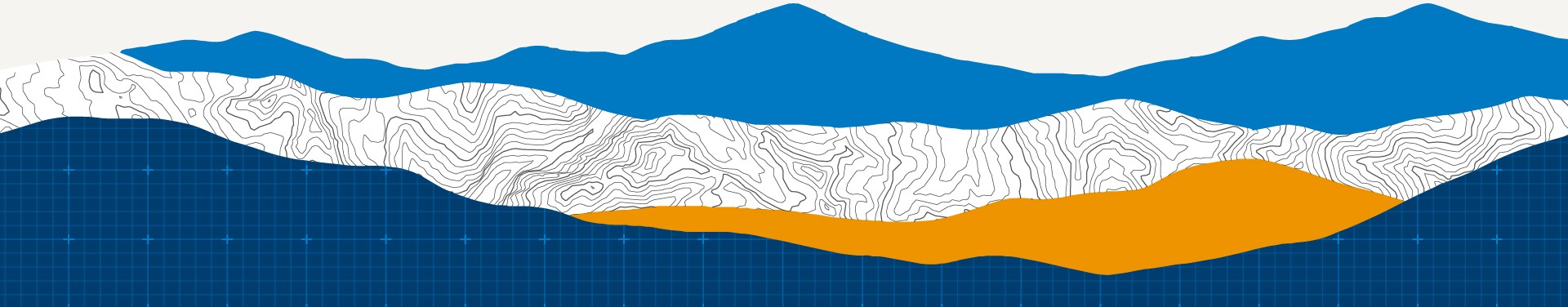
National Laboratory of the Rockies

Strategic Planning for Energy-Resilient Communities

State Energy Conference of North Carolina

Haley Clapper, Resilient Infrastructure and Security Center (RISC)

April 28, 2026



Background

What is Resilience?

NLR defines resilience as the ability to **anticipate, prepare for, and adapt** to changing conditions and **withstand, respond to, and recover rapidly** from disruptions through adaptable and holistic planning and technical solutions.

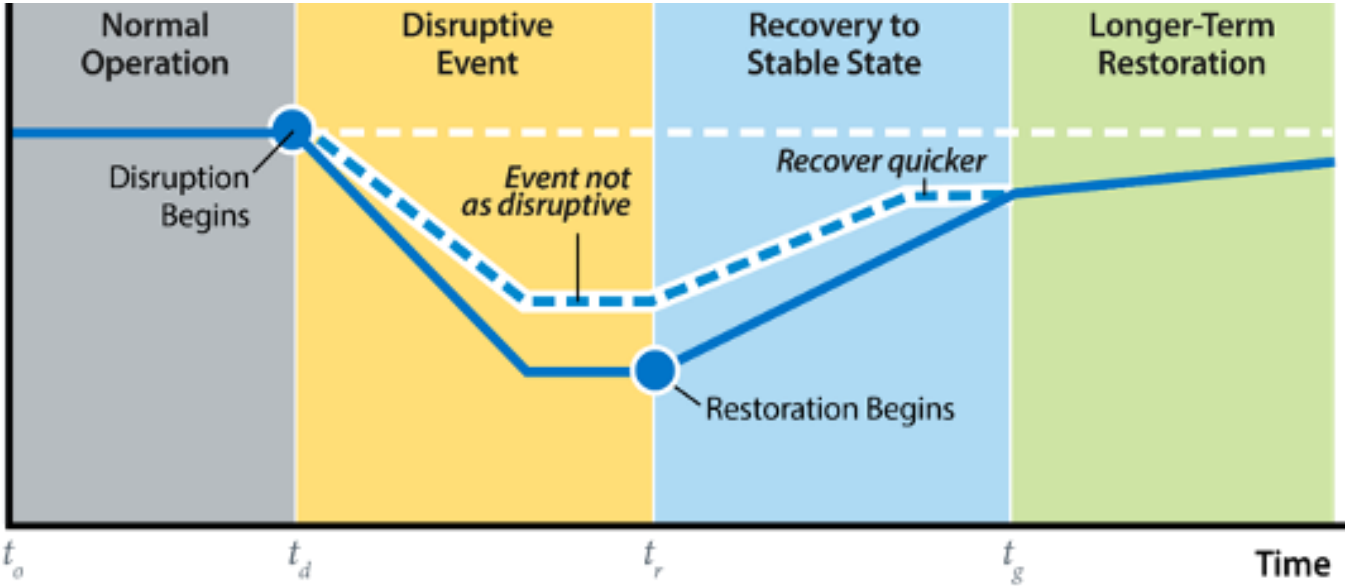
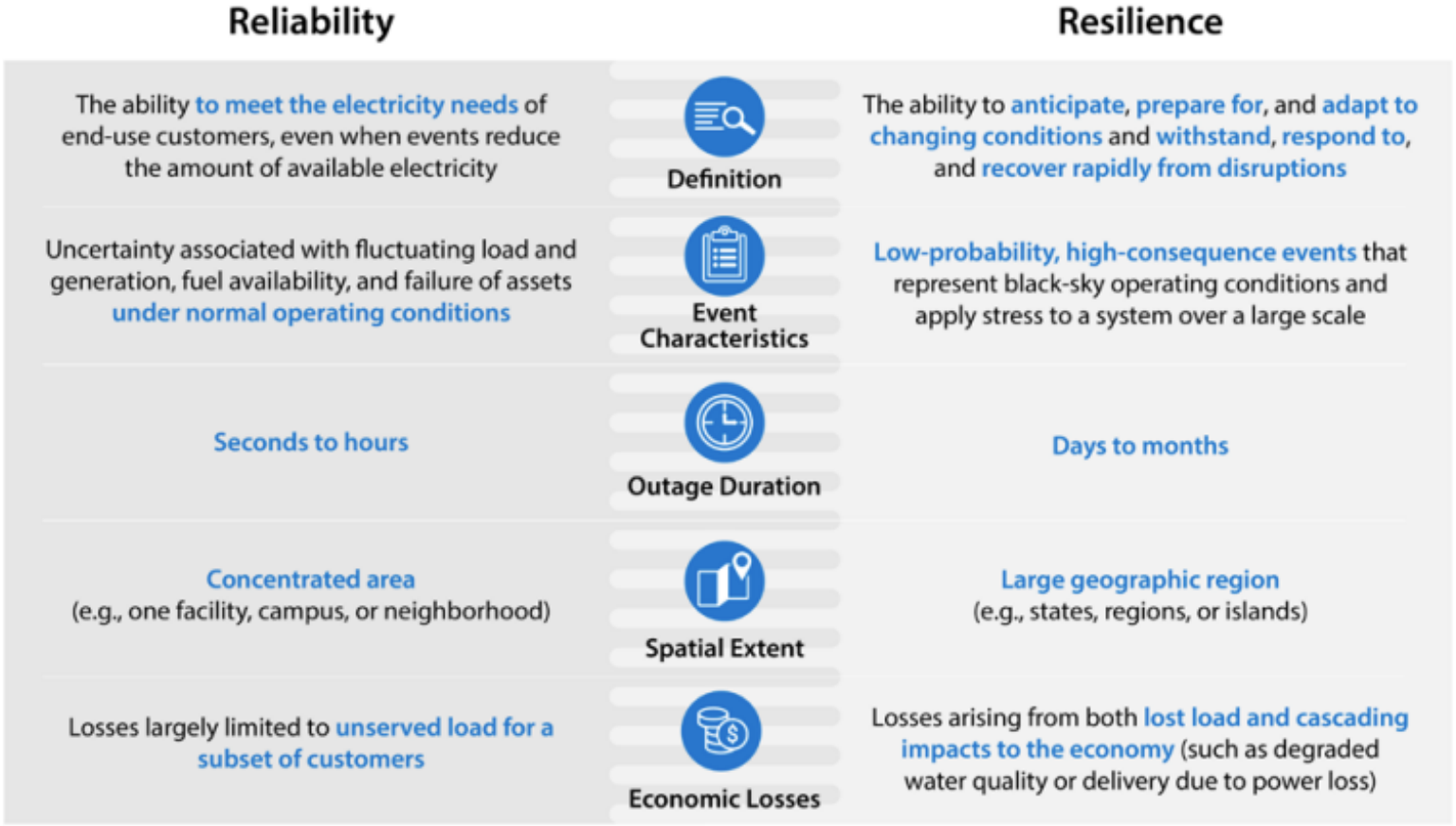


Image from Hotchkiss, Eliza, and Alex Dane. 2019. Resilience Roadmap: A Collaborative Approach to Multi-Jurisdictional Resilience Planning. Golden, CO: National Renewable Energy Laboratory.

Reliability vs. Resilience



Graphic from Leddy, Laura, Donald Jenket, Dana-Marie Thomas, Sean Ericson, Jordan Cox, Nicholas Grue, and Eliza Hotchkiss. 2023. Measuring and Valuing Resilience: A Literature Review for the Power Sector. https://doi.org/10.2172/1999382.

Reliability vs. Resilience: Metrics

Reliability

Average-based: SAIDI*, SAIFI*, CAIDI*, CAIFI*, MAIDI, MAIFI

Customer-based: Customers Experiencing Long Interruption Durations (CELID), Customers Experiencing Multiple Interruptions

**How do these differ from recovery/restoration times measuring resilience?*

Resilience

Attribute-based: Robustness, redundancy, resourcefulness, response, recovery

Performance-based: % energy delivered, % customer demand met, MWh of load curtailed, expected demand not supplied, avg or % of critical loads experiencing outage, restoration times*

Consequence-based: value of lost load (VoLL), number of fatalities, GDP reduction, repair costs, insurance claim values

Leddy, Laura, Donald Jenket, Dana-Marie Thomas, Sean Ericson, Jordan Cox, Nicholas Grue, and Eliza Hotchkiss. 2023. *Measuring and Valuing Resilience: A Literature Review for the Power Sector*. https://doi.org/10.2172/1999382.

Resilience Hubs

Community-serving facilities augmented with critical backup power to support residents, coordinate resource distribution, and provide services in blue- and black-sky conditions

Before Disruption

- Cost savings and potential revenue
- Reduced demand on centralized grid → less grid stress
- Potential islanding capabilities during peak demand

During Disruption

- Meets critical energy needs
- Shelter, provision of medical services, communications, device charging, EM coordination, and more

After Disruption

- Distribution of resources, food, and supplies
- Continuous power
- Community events and gatherings

Baja (2019)

Why Design for Resilience?

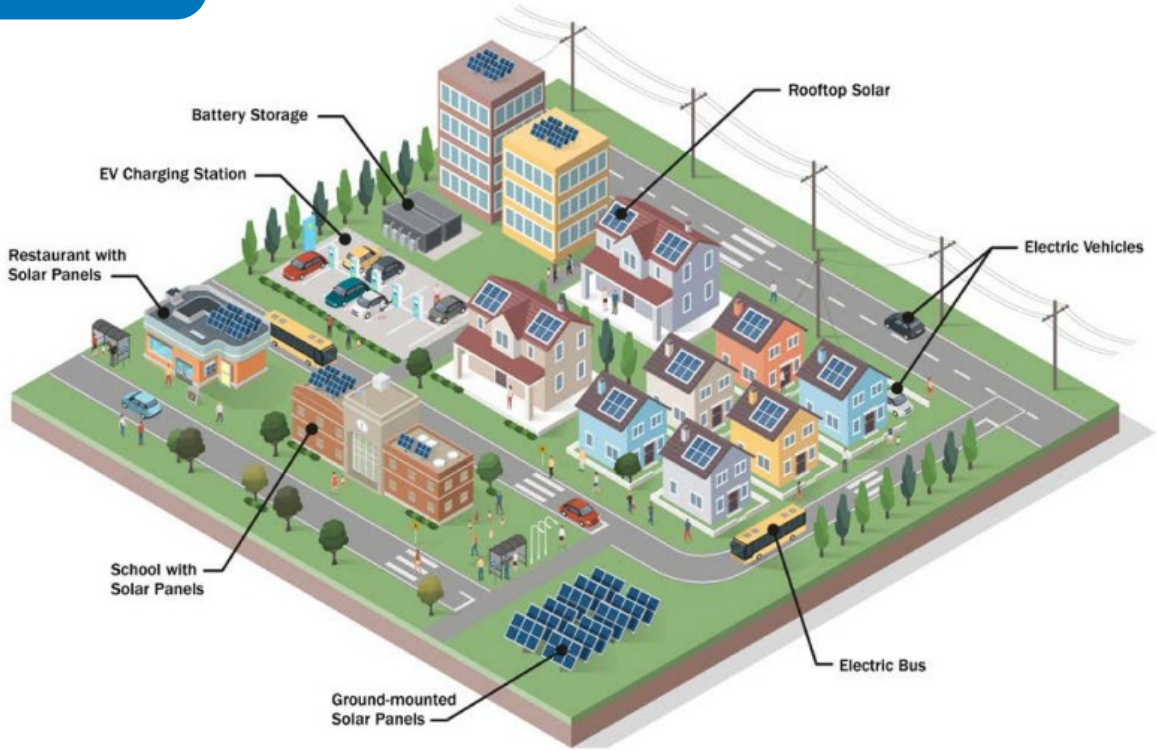
- Centralized grid is increasingly stressed
- Load growth driven by electrification, data centers, and extreme temperatures
- Increasing frequency and severity of extreme weather
- Cybersecurity threats to grid operations
- Distributed energy resources (DERs) offer flexibility

Photo by Dennis Schroeder, National Laboratoryy of the Rockies 046264

Microgrids

A microgrid is a localized group of **interconnected loads and DERs** that operates within **clearly defined electrical boundaries.**

Microgrids can be grid-connected or “island” off the grid during a disruption.



Graphic by Nicole Leon, National Laboratory of the Rockies

Resilience Planning Tools and Strategies

Resilience Planning Overview

Graphic from Hotchkiss, Eliza, and S. Stout. 2019. Best Practices in Resilience Planning. https://www.nlr.gov/docs/fy19osti/73036.pdf.

Planning Dimensions

Economic

Value proposition, technology costs, incentives, ROI

Technical

Performance, survivability, critical loads served

Social

Access, quality of life, community trust, high-risk groups

Environmental

Energy consumption and efficiency, air and water quality

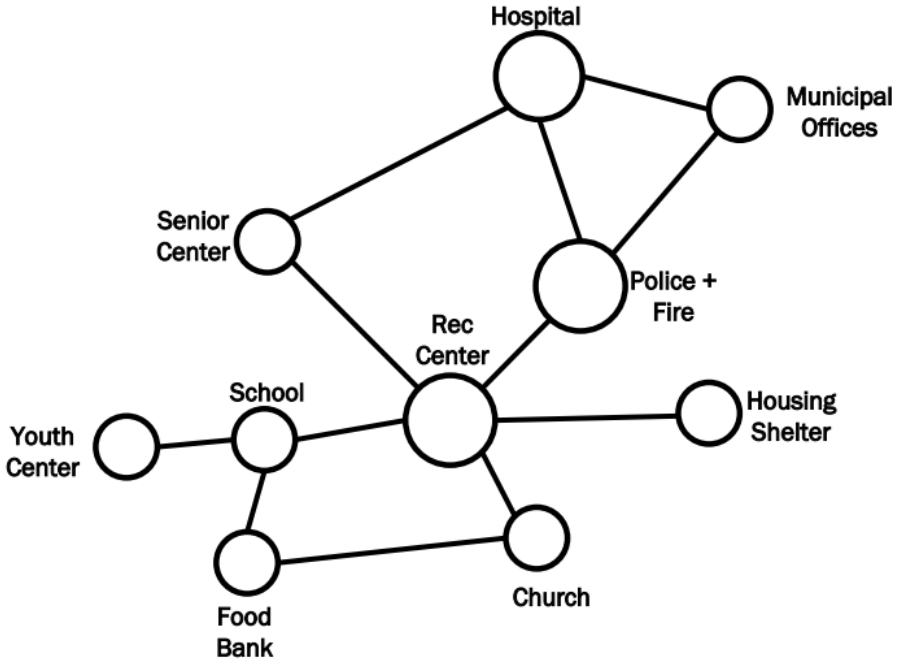
Regulatory

Policies, partnerships, siting, and capacity

Photo by Dennis Schroeder/NLR

Siting Considerations

- Building/site capacity and condition
- Assets (e.g., appliances, equipment, storage)
- Accessibility
- Community recognition and trust
- Utilities and communications (e.g., water, Internet)
- Hazard risk
- Security



Graphic from Scarpitti, C., M. Day, and L. Weber. 2024. Codes and Ordinances for Clean Energy: Highland Park Pathways to Power. https://doi.org/10.2172/2311881.

System Design & Feasibility

- BESS is sized in alignment with community goals, (e.g., cost savings, resilience)
- Systems optimized for front-of-the-meter grid services, cost savings, and revenue generation may not power the site through extended outages, which require larger batteries, diesel generators, and/or controls (more capital!)

AES Lawai Solar Project on Kauai. Photo by Dennis Schroeder, National Laboratory of the Rockies 058009

Case Study: Waynesville, NC

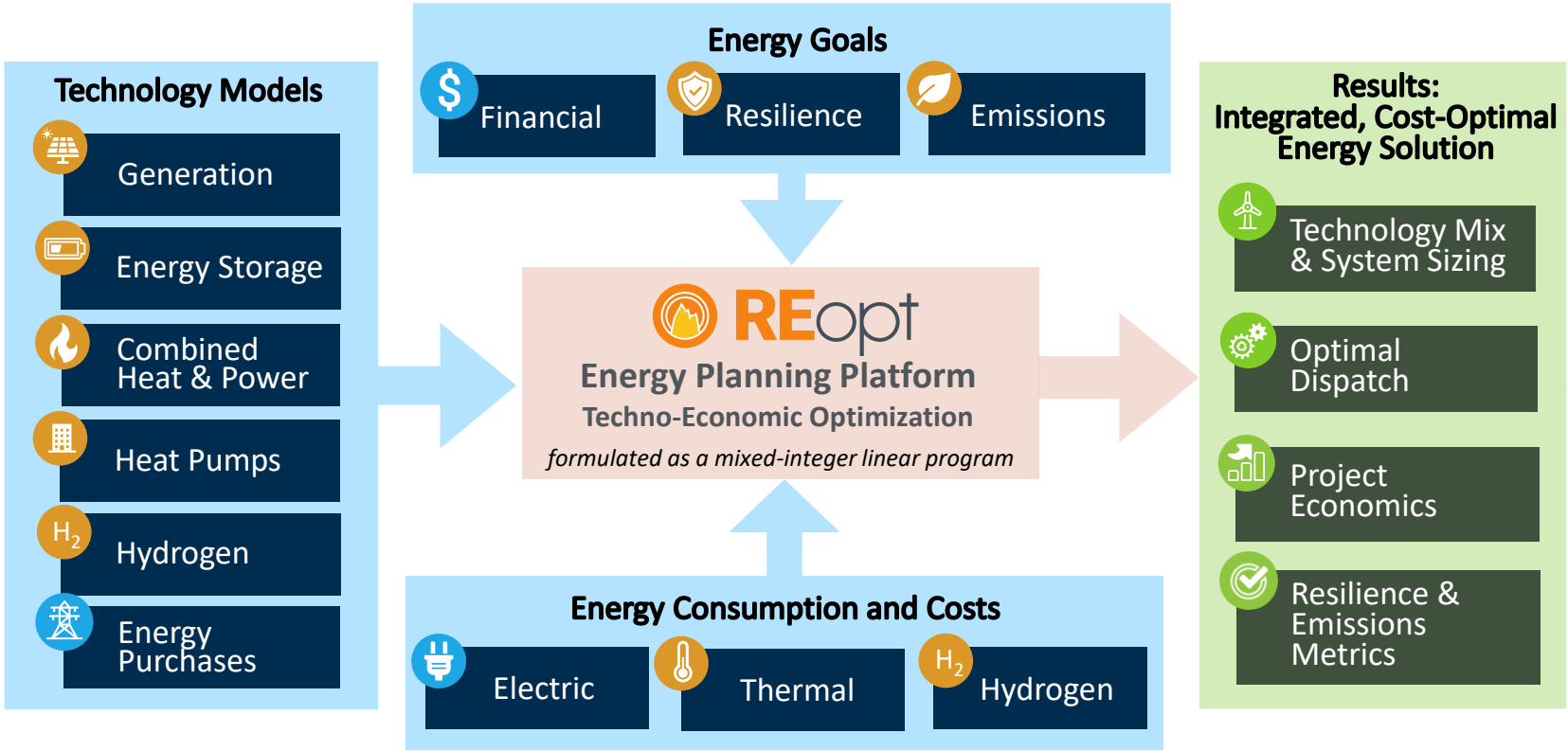
- Technical assistance through the Communities Local Energy Action Program (LEAP)
- Community goals included resilience, cost savings, reduced building energy use and emissions
- REopt analyses of solar-plus-storage solutions at Rec Center and Public Works Building
- Air quality and technoeconomic analyses to identify BESS alternatives to diesel generator for peak shaving
- Coalition was recently awarded a grant to build out projects!

Photo by Aparna Keshaviah

Photo by Rory McIlmoil, National Laboratory of the Rockies

NLR Capabilities and Resources

REopt Identifies Integrated, Cost-Optimal Site Energy Solutions



REopt is accessible via user-friendly web tool and transparent open-source software.

REopt answers important questions about on-site energy investments.

What is the **optimal mix and size of distributed energy resources** to minimize my site's cost of energy?

What is the most cost-effective way to **sustain a 1-day grid outage**? What about **7 days**?

What the expected **capital cost, cost savings, and emissions reduction** from these DER systems? systems?

How should my site's DERs be **optimally dispatched** across **multiple value streams** to maximize their value?

REopt is designed for the conceptual and pre-feasibility stage of project development.

Image by: Dennis Shroeder, NREL 48977, 10926, 45201, Werner Slocum 65552

Technical Assistance Programs

Image from https://www.nlr.gov/state-local-tribal/energy-to-communities

Energy to Communities (E2C)
- Expert Match, In-Depth Partnerships, and Peer-Learning Cohorts

Energy Technology Innovation Partnership Project (ETIPP)
- Strengthens resilience in island and remote communities

Community Microgrid Assistance Partnership
- Microgrid planning, development, or improvements in remote, underserved, and/or Indigenous communities

For full list of TA programs, visit https://www.nlr.gov/state-local-tribal/technical-assistance

Technical Assistance Services

Resilience Assessments and Risk Quantification

Economic & Workforce Development

Whole-Community Disaster Planning & Recovery

Stakeholder Engagement and Implementation Assistance

Data Analysis and Modeling

Energy-Efficient and Resilient Buildings

Visit https://www.nlr.gov/security-resilience/energy-resilience to learn more.

Key Takeaways

Key Takeaways

- Resilience planning helps communities prepare for disruptions to minimize impact and expedite recovery
- The centralized grid faces increasing stress from load growth, demand during extreme temperatures, and aging infrastructure
- Distributed energy resources (DERs) can offer economic and environmental benefits during normal conditions and meet critical needs during disruptions
- Resilience hubs provide communities with critical services before, during, and after disruptions
- Microgrids provide localized energy connected to or independent of the grid
- NLR provides technical assistance and tools such as REopt to help communities plan and implement resilient energy systems

References

1. Hotchkiss, Eliza, and Alex Dane. 2019. *Resilience Roadmap: A Collaborative Approach to Multi-Jurisdictional Resilience Planning*. Golden, CO: National Renewable Energy Laboratory.
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Thank You

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NLR/PR-5R00-99839

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This work was authored by the National Laboratory of the Rockies for the U.S. Department of Energy (DOE), operated under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Critical Minerals. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

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