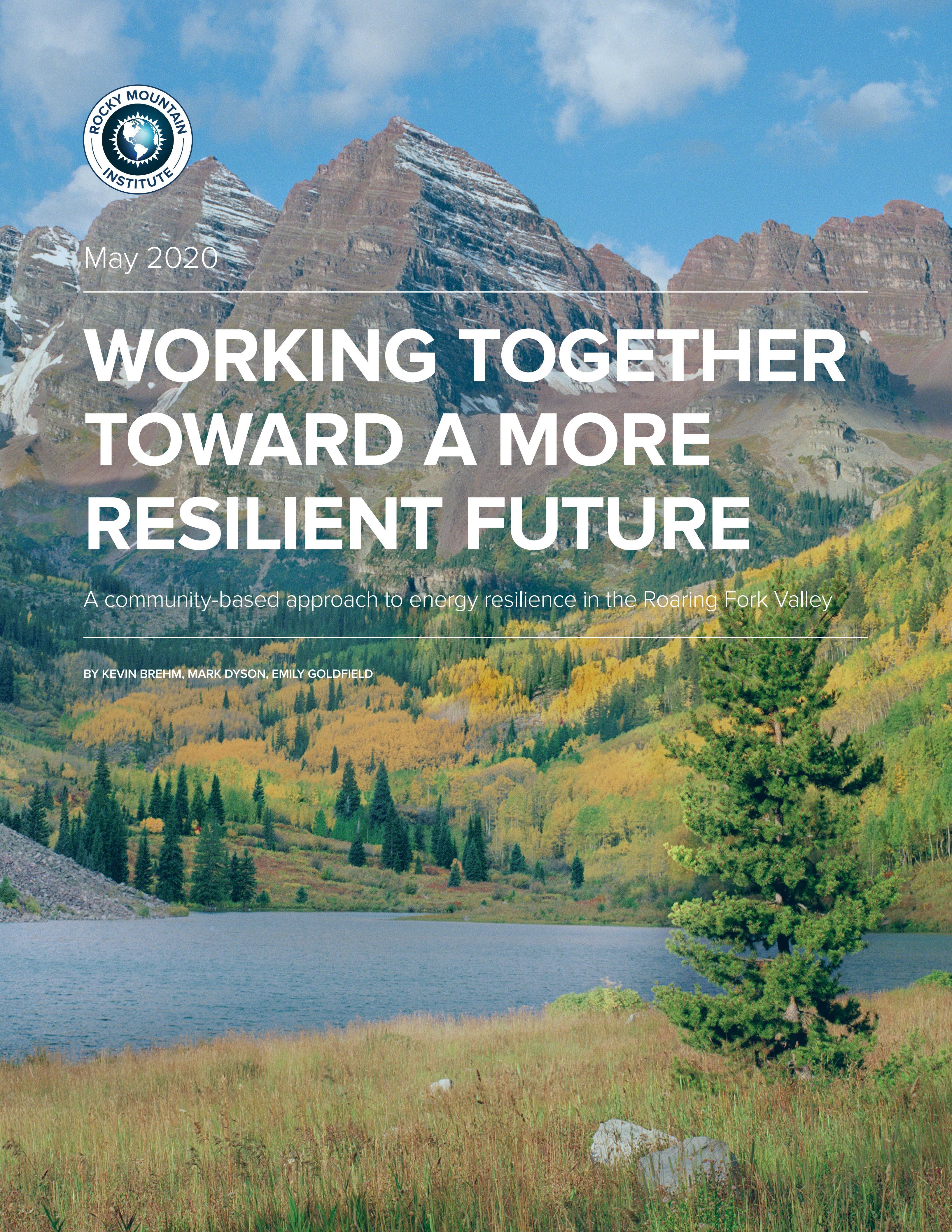

May 2020

WORKING TOGETHER TOWARD A MORE RESILIENT FUTURE

A community-based approach to energy resilience in the Roaring Fork Valley

BY KEVIN BREHM, MARK DYSON, EMILY GOLDFIELD

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ABOUT ROCKY MOUNTAIN INSTITUTE
Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; the San Francisco Bay Area; Washington, D.C.; and Beijing.

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EXECUTIVE SUMMARY

The risk of major power disruption from fires and other hazards seems to be increasing. At the same time, households and businesses are becoming more reliant on electricity-dependent services. As a result, energy resilience is a growing concern for electric utilities and the communities they serve.

When community stakeholders work closely together with the local utility, there is the potential for more efficient resilience solutions that have greater benefits to all parties involved. There is also an opportunity to leverage emerging technologies to ensure resilience-related investments simultaneously take advantage of cost declines for solutions such as solar and battery storage and advance regional clean energy ambitions.

This paper discusses the national need to increase the resilience of the electric power supply and profiles the work of one community and its electric utility—the Upper Roaring Fork Valley, Colorado, and Holy Cross Energy (HCE)—as it identified and scoped solutions to increase resilience. The Upper Roaring Fork Valley experience resulted in several conclusions relevant to the Valley and beyond:

- Distributed clean energy solutions should be considered as part of any resilience planning process
- Effective planning for power supply resilience through distributed solutions requires a partnership between the utility and its community
- Business model and ownership structure innovations may be necessary to ensure that resilience-related investments can provide year-round ("blue sky") benefits during normal operations as well as backup ("black sky") benefits in the event of an emergency or grid outage

This report is intended to update decision makers in the Roaring Fork Valley on the outcomes of a multi-month Rocky Mountain Institute (RMI)-supported process involving Holy Cross Energy and other community organizations. The report is also intended to highlight key lessons learned to inform resilience planning and implementation efforts among rural utilities, regulators, and community leaders across Colorado, the American West, and beyond.

To facilitate targeted review, throughout the main body of the report, sections specific to the Roaring Fork Valley are written in blue text, while general and national discussion is in black.

Images courtesy of Holy Cross Energy

BACKGROUND AND INTRODUCTION

On the evening of July 3, 2018, a wildfire broke out in Basalt, Colorado. This fire—dubbed the Lake Christine Fire—spread to engulf more than 12,500 acres and came within minutes of shutting down power to the Upper Roaring Fork Valley, home to the towns of Aspen, Snowmass Village, and Basalt. These communities have a year-round population of around 18,000, but this does not include the large numbers of tourists and workers who arrive seasonally or those who commute in from other areas, many of whom work in the tourist industry.

Three out of four transmission lines running into Aspen were disabled; had the fourth line gone down, it could have led to days to weeks of no electric service. The fire started during peak tourist season, as thousands of visitors filled the valley for Fourth of July week—a factor that would have exacerbated the impact of an extended power outage.

This event served as an important wake-up call to stakeholders across the valley of the importance of resilience planning. Motivated by this event, Holy Cross Energy (HCE)—the local electric cooperative that serves approximately 43,500 members across the Colorado River, Roaring Fork, and Eagle River Valleys in Western Colorado—partnered with RMI in early 2019 to explore community-based solutions for increasing energy resilience in the Upper Roaring Fork Valley.

The objectives of the project were four-fold:

1. Surface stakeholder priorities and shared opportunities for improving electricity and related service resilience in the Upper Roaring Fork Valley
2. Identify ongoing protection and resilience efforts in the region
3. Prioritize promising solutions that HCE could use, in partnership with stakeholders, to improve resilience
4. Align on near-term actions that HCE and other local actors can pursue

The initial phase of the project involved background research into existing resilience solutions that have been implemented around the country and interviews with local stakeholders to understand their energy use priorities and any backup plans already in place. This phase of the project culminated in a full-day workshop that brought together the stakeholders involved to collaboratively brainstorm resilience solutions for the Upper Roaring Fork Valley. Several of the ideas surfaced during this workshop were further explored by working groups over the course of several meetings; these working groups then presented their findings and progress in a second workshop.

A range of community stakeholders were involved throughout the five-month process, including first responders, city and county governments, school districts, transportation providers, and private business owners.

HCE's dedication to improving energy resilience in the Roaring Fork Valley mirrors a national trend of utilities and communities working toward a more resilient electricity supply. Though this project has focused on the Roaring Fork Valley, the conversations that arose around challenges and opportunities have echoed similar conversations taking place around the country and the world, and may provide an example to other regions interested in community-based resilience.

THE NEED FOR RESILIENT POWER SUPPLY

In the Roaring Fork Valley and across the country, the need for a more resilient power supply is increasing as communities are becoming more reliant on services provided by electric power and threats to power supply are increasing. At the same time, the electricity technology landscape is changing, shifting toward cleaner, distributed generation sources that have the potential to support communities' increasing need for resilient power.

THE ELECTRICITY TECHNOLOGY LANDSCAPE IS CHANGING

The electricity sector technology landscape is changing as new technologies are maturing and achieving scale. Renewable energy from wind and solar is now the lowest-cost way to generate electricity in much of the country.[1] Deployment of distributed energy resources and distributed generation is increasing, and is expected to double from 2018–2023, led primarily by solar photovoltaic systems (PV).[2]

This distributed generation model contrasts with the legacy model of large, centralized power plants, and is reshaping the energy landscape and changing consumers' relationship with energy. To support this increasingly distributed and complex energy system, communications and controls are also advancing in capability and rapidly declining in price.

While the technology landscape is changing, the demand for zero-carbon energy is increasing. Across the country, utilities and states are committing to 100% renewable energy targets. Over 145 cities, more than 10 counties, and seven states have adopted 100% clean electricity goals as of December 2019.[3] Utilities now need to optimize not only for cost and reliability, but also for the carbon intensity of their energy production. In Colorado and elsewhere, emerging solutions are allowing utilities to co-optimize for multiple benefits including resilience without compromising on price.

The communities of the Roaring Fork Valley have embraced decarbonization of the regional power supply. In the Roaring Fork Valley, two cities served by municipal utilities, Aspen[4] and Glenwood Springs[5] have achieved 100% renewable electricity through their power-supply contracts. Other Roaring Fork Valley communities including Basalt,[6] Carbondale,[7] Snowmass Village,[8] Eagle County,[9] and Pitkin County[10] all have renewable energy or greenhouse gas reduction plans in place.

In 2018, Holy Cross Energy introduced its Seventy70Thirty goals to increase clean and renewable electricity supply to 70% (from 39% currently) by 2030 and reduce greenhouse gas emissions by 70% by 2030 relative to 2014 levels.[11] HCE committed to accomplish these goals with no additional increase in the cost of power supply, given recent advances in technology and changes in energy markets that enable HCE to acquire new clean energy resources at costs comparable to its existing supply.

COMMUNITIES RELY ON ELECTRICITY FOR CRITICAL FUNCTIONS

Nationally, there is a trend toward powering thermal comfort, mobility, and communications through electricity. This trend is driven largely by favorable economics and improved levels of service, as well as environmental considerations. As the electric grid becomes increasingly low carbon, electrification becomes a key component of economy-wide decarbonization strategies.

Electric heat pumps can now provide home heating and cooling at a lower cost with a lower carbon footprint than traditional heating and cooling sources.[12] As a result, many states and municipalities are taking steps to electrify both space and water heating.

Similar trends are underway in mobility, where the number of electric vehicles registered in the United States more than doubled between 2017 and 2018.[13]

Cellular communications also depend on grid electricity to power cell towers and repeaters. Although some of this infrastructure has backup power in place, much does not. This is an important detail given the vital role that communications plays in emergency response, particularly when it comes to first responders' ability to disseminate information to the public and individuals' ability to reach emergency responders.

Electrification of heating and mobility is underway in the Roaring Fork Valley. Local energy efficiency organizations are increasingly supporting building electrification through measures such as rebates for electric heat pumps;[14] Basalt Vista, a new housing development in Basalt, boasts all-electric heating.[15] In the mobility space, the Roaring Fork Transportation Authority (RFTA) has procured an initial eight electric buses, and has plans to replace old diesel buses with additional electric buses in the future.[16]

Given the large and mountainous footprint of the Roaring Fork Valley, backup power for cell communications is particularly necessary. First responders reported during interviews that communications is a top priority for them; in the case of a grid outage, people would be unable to make 911 calls using their cell phones.

"

Our biggest concern is cell towers—if we lose power, people won't be able to make 911 calls from cell phones. As long as we can get calls, we can respond.

—First responder in the Roaring Fork Valley

This increased reliance on electric mobility and electric heat, as well as the essential role of electricity-enabled communication, means that power disruption is more than an inconvenience.

NATURAL HAZARDS AND MALICIOUS ACTS POSE AN INCREASING RISK TO POWER SUPPLY

Even as society is becoming increasingly reliant on electricity, the likelihood of a major disruption to the electricity delivery system is increasing. Potential threats to the electricity system include extreme weather events, like wildfires and storms, and human-caused threats, such as cyberattacks and terrorism.

The frequency and severity of extreme weather events are increasing. In the Western United States, the average number of large wildfires per year has increased in every state over the past 12 years,[17] compared with the annual average from 1980 through 2000. The average length of wildfire season is also getting longer, at more than seven months per year, up from five months per year in the early 1970s. In some regions, research shows that the strongest hurricanes have increased in intensity over the past two to three decades, and there is a projected 45%–87% increase in the frequency of strong (Category 4 and 5) hurricanes for the continental United States in the Atlantic Basin.[18]

Cyberattacks and terrorism also pose a risk to electric power systems. Ransomware attacks are growing more than 350% annually,[19] IoT attacks were up 600% in 2017,[20] and phishing attacks saw a 70% increase in 2017,[21] to highlight just a few staggering figures. While the US electric system has thus far avoided any major disruptions due to malicious actors, an attack by Russian hackers on the Ukraine's power system in December 2015 compromised the information systems of three distribution companies, temporarily causing disruptions in power to more than 200,000 consumers.[22] Cyberattacks are now considered one of the major systemic threats to the US electric system.[23]

Threats to power supply in the Roaring Fork Valley are increasing as well. 2018 saw one of the most active fire seasons in Colorado history, from the Lake Christine Fire that came within minutes of shutting down HCE's system to fires blazing through numerous other Colorado counties. According to the Colorado State Forest Service,[24] about half of Coloradans now live in wildfire-prone areas, representing a 50% increase from 2012 to 2017. In addition to the fire threat, no community is safe from the risk of cyberattacks—one first responder organization in the Roaring Fork Valley reported fielding an average of 500 attacks per day on its IP address.

POWER SUPPLY DISRUPTION CAN COMPROMISE COMMUNITY HEALTH AND WEALTH

Disruption to power supply can interfere with critical life-saving services, put vulnerable populations at risk, and interfere with ongoing economic activity critical to a healthy and thriving community. Many critical life-saving services rely on electricity; key examples include communications—as described above—as well as heating, refrigeration, light, and internet. Vulnerable populations—including the elderly, sick, or people without options of where to go in the event of an evacuation—may be disproportionately affected by grid outages and emergency situations; additional thought must be put into contingency planning to ensure that these vulnerable populations are cared for.

RMI interviews in the Roaring Fork Valley found that overall, first responders generally have adequate on-site backup power generators in place to cover most on-site critical activities for a finite amount of time. The primary energy resilience concerns of emergency responders were related to access to reliable cellular communications.

Vulnerable populations were also top-of-mind for the first responders interviewed. These include individuals who depend on electricity for oxygen machines, or whose mobility is restricted. While emergency responders maintain databases of vulnerable individuals in order to ensure that they are accounted for in the case of an emergency, experience from past weather-related disasters shows that elderly and health-compromised populations are often the ones most likely to be impacted by a major power disruption.

The economic impacts of a prolonged power outage can also be severe, particularly for an area that is as heavily dependent on tourism as the Roaring Fork Valley. At the time the Lake Christine Fire broke out, thousands of visitors had flooded the Valley for Fourth of July week, the peak of tourist season. Hotels were full and restaurants had stocked up on food for the holiday weekend. Had the power gone out, most hotels reported that they would have chosen to evacuate guests after one or two days without electricity, and few, if any, of the restaurants had the backup power to prevent food spoilage. A disruption of economic activity caused by an outage would have had a huge impact on the more than $80 million of retail sales reported in Aspen in July 2018.[25] Furthermore, many individuals living in the fire area work in the region's service and tourism industries. During the fire, those individuals faced the risk of lost property as well as a disruption to income if their places of employment were closed due to power outage.

RESILIENCE VS. RELIABILITY

As it pertains to electricity, resilience and reliability are related yet separate concepts.

Reliability refers to a system's ability to routinely maintain adequate, safe, and stable electricity supply[i] to its customers.[26] Reliability standards are well-defined in the electricity industry; major electric utilities are required to report data such as the duration and frequency of sustained and momentary outages. North American Electric Reliability Corporation (NERC) defines system reliability as the combination of operating reliability and adequacy, or the ability of the electric system to withstand sudden disturbances coupled with sufficient resources to meet demand.[27]

Resilience typically refers to a system's ability to withstand and recover quickly from major events. Community energy resilience has been defined as the ability of a specific community to maintain the availability of energy necessary to support the provision of energy-dependent critical public services to the community following non-routine disruptions of severe impact or duration to energy systems.[28]

Reliability and resilience planning both aim to keep the power on, minimize the risk and impact of outages, and quickly restore the system; to be resilient, a system must first be reliable.

Given the societal trend toward electrification, the increasing risk and impact of events affecting power supply, and the threat to community health and wealth posed by power disruption, it is critical that energy resilience be considered as an element of emergency preparedness planning efforts. Throughout the country, there is a range of examples as to how energy resilience is covered in existing emergency plans and tabletop exercises; in many cases, a need exists for local governments and first responders to work with utilities in order to comprehensively account for energy resilience in these planning processes.

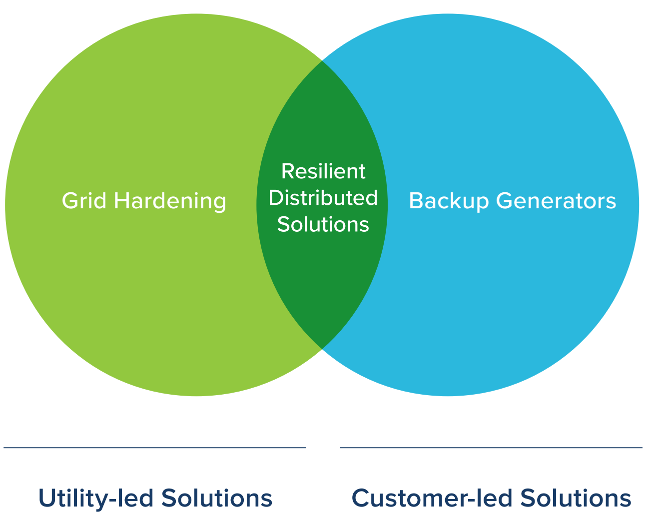
Image courtesy of Judy Hill Lovins

THE CHANGING LANDSCAPE OF RESILIENT ENERGY SOLUTIONS

Grid hardening and backup generators are the leading traditional approaches to enhancing electric system reliability and resilience. Emerging distributed solutions can also enhance resilience while providing economic and environmental benefits to the broader grid.

EXHIBIT 1

Traditional and Emerging Resilience Solutions



HISTORICALLY, ELECTRIC UTILITIES' RESILIENCY EFFORTS HAVE FOCUSED ON GRID HARDENING

Grid hardening—the core focus of utilities' resilience efforts historically—describes a set of actions aimed at strengthening and protecting physical infrastructure, including undergrounding wires, protecting or replacing vulnerable poles, and removing tree branches or other nearby threats to the function of the electricity system.

In HCE territory, active and aggressive fire mitigation and resilience efforts are ongoing. Some ongoing activities by HCE include vegetation management, system inspection and pole testing, and upgrades and additions to transmission lines. New initiatives include developing additional feeder switching capabilities, upgrading circuit ties between substations, and exploring options for protective wrapping on critical transmission line structures.

CUSTOMERS HAVE TRADITIONALLY RELIED ON ON-SITE GENERATORS

For facilities requiring resilient power supply, the default solution has been diesel or natural gas backup generators, which are known and trusted by facilities managers for a variety of electricity-dependent applications. The US market for diesel generators was estimated at over $2 billion in 2018 and is projected to reach $3 billion by 2024.[29]

In the Roaring Fork Valley, key energy-sensitive organizations generally have on-site backup generators, fueled either with diesel or natural gas. On-site fuel supply varied considerably, with one site having up to 20,000 gallons of fuel stored underground. Exhibit 2 summarizes the level and type of backup in place across various categories of organizations, as reported in interviews with stakeholders in the Roaring Fork Valley.

EXHIBIT 2

Survey of Backup Power by Organization Type

Organization Type	Number of Orgs. Interviewed	Backup Power	Completeness of Backup*
Health and Emergency Services	8	• Diesel generators & fuel storage • Natural gas generators • Mobile generators	●
Government	7	• Natural gas generators • Mobile generators	◑
Utility	3	• Natural gas generator • Diesel generators • Mobile generators	○
Private Business	2	• None on-site; can host mobile generator • Diesel generator & fuel storage	◔
School Districts	2	• None on-site • Can host mobile generator	○
Transportation	1	• Diesel generator & fuel storage *(for facilities)*	●

* Does not measure adequacy of generator fuel supply

TECHNOLOGY IS UNLOCKING NEW DISTRIBUTED SOLUTIONS FOR ENHANCED RESILIENCE

Emerging distributed solutions have become reliable and cost-competitive resilient power options. As shown in Exhibit 3, RMI evaluated five resilient solutions that are now more cost-competitive than ever, thanks to technology and business model advancements in recent years.

EXHIBIT 3

Summary of Resilient Power Supply Options

OPTION	DESCRIPTION	CONSIDERATIONS FOR IMPROVING ENERGY RESILIENCE
End-use efficiency	Technical and design solutions to reduce energy supply for the same productive use.	Does not in itself provide power during an outage but allows for more critical services to be delivered with limited generation capacity.
On-site backup generators	Backup generators convert fuel on hand into electricity when the grid is interrupted.	Requires non-local fuel supply (e.g., natural gas, diesel), which needs to be stocked to ensure continuity and reliability of backup.
On-site renewables + storage	A range of on-site generation solutions including solar PV, geothermal, waste to energy, wind, fuel cells, and generators.	Meteorological conditions (e.g., smoke) may affect energy availability during contingency events.
District heat and power	A system for distributing heat generated in a centralized location to serve the entire community.	Requires non-local supply (e.g., natural gas, diesel), which needs to be stocked to ensure continuity and reliability of backup.
Microgrid	Self-contained generation, distribution, controls, and loads on a microgrid.	Microgrids with distributed solar and generators were found to both improve resilience and reduce cost compared to backup generators alone.

Starting from the options described above, the Roaring Fork Valley community discussed several distributed resilience options during workshop 1, and selected five for further exploration through working groups:

- Mobile generation fleet: Most refuge/evacuation centers—particularly school campuses—as well as "secondary critical loads" (i.e., smaller loads essential to modern life, such as water, cellular service, and internet) do not have dedicated backup power. This working group explored two solutions: 1) creating an inventory of secondary critical loads without backup and sizing mobile generators to meet their needs, and 2) procuring electric school buses that could be used as backup power for schools.

- Community microgrids: Properly sized microgrids can allow each community or neighborhood to maintain power independently in the case of a larger grid outage. This working group explored the value and challenges of developing a microgrid and identified potential first sites for an initial microgrid pilot.

- Gasoline pump resilience: When the power goes down, so does the ability to pump gas at most gas stations in the Roaring Fork Valley. This working group explored what options exist to ensure that there is sufficient access to transportation fuel in the event of an extended outage or evacuation.

- Bulk power supply flexibility: Contractual and operational barriers make it complicated and difficult for HCE and the City of Aspen to share electricity generation resources, even if one of the utilities has an outage that could be supported by the other's resources and infrastructure. This working group involved HCE and the City of Aspen working together with their wholesale power suppliers to put in place formal arrangements to address contingent energy supply during emergencies.

- End-use efficiency at critical facilities: Critical facilities, such as emergency response facilities, may have different needs than other buildings in a region. Best-practice for efficiency at these facilities was investigated to potentially reduce the overall demand for energy supply in an emergency.

More details on the findings of each working group can be found in Appendix 4.

DISTRIBUTED SOLUTIONS CAN PROVIDE BENEFITS BEYOND INCREASED RESILIENCE

In addition to resilience, utilities and their customers may also take into account additional considerations when deciding between different investments.

These include:
- Economic value (Payback)
- Environmental/Climate impact
- Operations and maintenance for reliability
- Timeline to deployment

Exhibit 4 proposes a framework for evaluating whether or not a resilience solution satisfies each criterion.

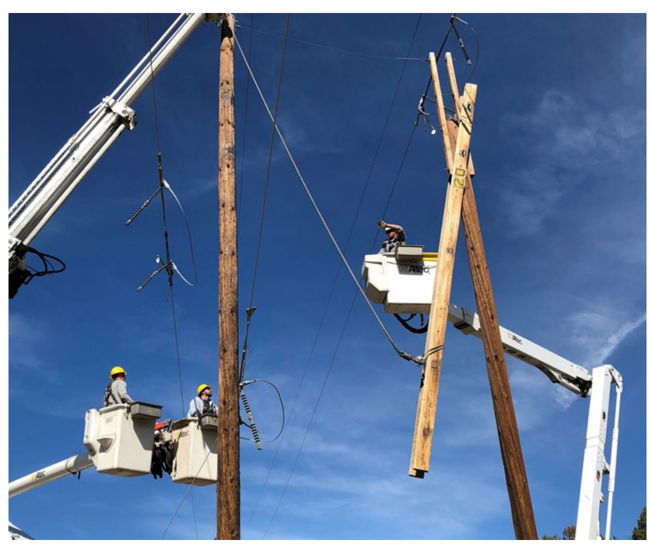


EXHIBIT 4

Criteria for Evaluating Resilience Options

Criterion		THIS CRITERION IS SATISFIED IF THE SOLUTION...	THIS CRITERION IS NOT SATISFIED IF THE SOLUTION...
	Payback	Generates financial flows capable of attractive payback	Does not generate predictable financial flows
	Climate	Results in a net reduction in operational greenhouse gas intensity	Does not result in net reduction in operational greenhouse gas intensity
	Reliability of Operations	Operates reliably and requires no more than two inspections per year	Requires more than two inspections per year to operate reliably
	Timeline	Can be readily deployed in less than six months from planning to execution	Requires more than six months from planning to deployment

Exhibit 5 presents how five resilience solutions measure up against these criteria.

EXHIBIT 5

Distributed Resilient Power Supply Options

Option		RESILIENCE CONSIDERATIONS	PAYBACK	CLIMATE	RELIABILITY OF OPERATIONS	TIMELINE
Option	**End-use efficiency**	Complementary measure; does not in itself provide power	✓	✓	✓	✓
Option	**On-site backup generator**	Relies on non-local fuel supply	✗	✗	✗	✓
Option	**On-site renewables + storage**	Weather may affect energy availability	✓	✓	✓	✗
Option	**District heat and power**	Relies on non-local fuel supply	✓	✓	✗	✗
Option	**Microgrid**	Can both improve resilience and reduce cost	✗	✓	✗	✗

While several of the distributed solutions investigated can also provide economic payback and climate benefit, traditional solutions, grid hardening, and back-up generators generally do not provide those benefits.

In the Roaring Fork Valley, there was particular interest in additional benefits available from distributed resilient power supply options. A recurring refrain throughout the process was the need to consider solutions that would ideally have benefits under daily, normal operations ("blue sky value") in addition to providing the necessary backup during power outages and emergency situations ("black sky value"). This framing led to interest in the use of distributed energy resources (DERs) not only for supporting resilience, but also for the utility to balance variable renewables and manage peak demand. A key question arose around how this "blue sky" value could help to justify the additional upfront cost to support "black sky" situations, relative to other backup technologies such as diesel or natural gas generators.

There were also concerns raised around the climate impacts of various technologies. While diesel and natural gas backup generators are often the cheapest solution, renewables plus storage present a cleaner option that serve to decarbonize energy supply in addition to providing resilience value. With climate change widely acknowledged as a key contributor to increasing fire risk and storm intensity, many participants felt that, as much as practicable, resilient solutions should be clean technologies that help mitigate climate risk.

> "
>
> As we overlay climate change, these events are going to be more frequent. There's a need for immediate solutions, but we also need to think about the long-term impact.
>
> —Local government representative

> "
>
> We should be looking for solutions that are also useful in normal operations… resilience efforts should also have daily—"blue sky"—value.
>
> —Workshop 1 participant

> "
>
> The backup generators are almost never used… maybe for about 30 minutes every year.
>
> —First responder in the Roaring Fork Valley

A NEW APPROACH TO RESILIENCE PLANNING

The changing electricity landscape demands a new approach to resilience planning, one that involves three elements:

1. Engagement between the electric utility and community stakeholders
2. Consideration of distributed energy resources
3. Development of new business and ownership models

ENGAGING COMMUNITY STAKEHOLDERS HELPS IDENTIFY NEEDS AND GENERATE COMMUNITY-CENTRIC SOLUTIONS

Despite the best intentions, an electric utility may not fully understand the diverse needs of its community, including which threats are of highest concern to emergency responders and other stakeholders. Additionally, the electric utility may not have full visibility into ongoing resilience activities within the region it serves, including existing and planned backup generation.

Conversely, community members may not consider the utility's or other community members' needs and capabilities when implementing facility or community-level resilience strategies, potentially leaving win-win strategies and outcomes on the table. Organizations tend to focus on their own facilities, and not consider the potential for "blue sky" benefits of investments to the broader grid. Community members are also unlikely to understand the utility's cost drivers, including which investments would be most likely to avoid or defer marginal costs to the utility.

Thus, it is beneficial to all parties involved to increase communication between community stakeholders and the electric utility. Stakeholders can be engaged through multiple strategies, including:

- Stakeholder interviews and surveys
- Multiparty needs assessment workshops
- Solution or problem-specific working groups
- Multiparty solution prioritization workshop

In the Roaring Fork Valley project, RMI used all four of these strategies.

1. Stakeholder interviews to understand community needs and resources:
   Between February and April 2019, RMI conducted interviews with 30 community stakeholders. RMI asked questions about facility energy demand, resilient power supply plans, and key external dependencies. Key findings from those interviews are found in Appendix 3.

2. Solution generation through multistakeholder meetings:
   In April 2019, 34 community leaders from local government, utilities, and critical services attended a workshop to align on the need for added resilience and brainstorm solutions. Key outcomes of the workshop included a shared recognition of the potential impact of a disruption to power supply, and five topics prioritized for further exploration through working groups.

3. Solution refinement through bilateral or multilateral working groups:
   Through the course of multistakeholder working group sessions, several promising solutions identified in the first workshop were further developed. Further details on working groups can be found in Appendix 4.

4. Multiparty solution prioritization workshops:
   In a final workshop in June 2019, stakeholders convened to share updates from working groups. Workshop participants provided valuable feedback on emerging ideas, and the ground was laid for future multiparty collaboration on implementation of solutions.

COMMUNITY ENGAGEMENT AND THE COOPERATIVE MODEL

Rural electric cooperatives such as HCE have a unique relationship with their community and a history of collaborative, customer-centric decision-making. However, customer-centric decision-making is by no means unique to cooperatives; investor-owned utilities (IOUs), municipal utilities, and others can use all of the techniques described above. RMI's experience working with various types of utilities shows that early collaboration results in more-effective outcomes.

For additional guidance on best practice for stakeholder engagement processes see RMI's report ***Process for Purpose***.[30]

CONSIDERING DISTRIBUTED SOLUTIONS ENCOURAGES SHARED OWNERSHIP OF THE PROBLEM AND SOLUTIONS

Though the market for DERs is growing, they are still often overlooked by utilities, communities, and customers as resilience solutions. Utilities may need to help their communities consider the full spectrum of resilience solutions, including DERs. In some instances, the community can also help prompt the utility to consider distributed solutions.

To stimulate community thinking, RMI compiled case studies from distributed resilience solutions prior to an initial workshop with community stakeholders (see Appendix 2 for details). During the workshop, participants reviewed and discussed these solutions. Throughout this process, community members came to increasingly understand the role of DERs and the importance of being involved in resilience solutions. This led to increased buy-in and ownership of resilience solutions, demonstrated by the high level of participation in working groups and the continued bilateral conversations following the end of the project.

Through these workshops and working groups, participants' perceptions of the role of community stakeholders shifted significantly. Whereas initial conversations focused on utility grid hardening efforts and isolated actions taken to improve a single facility's resilience, by the close of the project, stakeholders demonstrated a willingness to consider solutions that provide wider community benefit. For example, one stakeholder with an oversized generator was open to exploring the use of its generation resources to support a larger community microgrid.

NEW BUSINESS AND OWNERSHIP MODELS CAN ALIGN UTILITY, COMMUNITY, AND CUSTOMER INCENTIVES

New business and ownership models may be necessary to ensure DERs provide "blue sky" as well as "black sky" value, in order to address barriers to DER implementation. New customer programs and rate structures might be necessary to maximize the value of resilience investments; for example, load management and battery storage for demand management/grid services can provide ongoing value during blue sky operations, while helping to island a facility or microgrid during a disruption to power delivery.

New ownership structures may also be necessary to address barriers to implementation. The customer may not have the upfront capital required to finance the project, while the utility may not have the ability to shift costs to cover a subset of customers. Instead, an opportunity may exist for split ownership of key assets for a microgrid or other resilience technology. For example, the customer could own distributed generation or storage, while the utility could pay for the required grid modifications. Utilities may also help to address upfront cost barriers through rebates, on-bill financing, or creative tariff structures. This stacked investment model—where each stakeholder pays for a piece that they directly benefited from—allows a project to be developed without being financially burdensome on any one stakeholder involved.

In the Roaring Fork Valley, HCE is laying the groundwork for new business models. Some changes are already in place, including a new DER services agreement option that allows consumers to spread the up-front costs of DER acquisition, installation, maintenance and warranty over multiple monthly utility bills.[31] HCE anticipates this approach will allow shared ownership of microgrid components, with HCE paying for and owning the grid controls while the customer finances (and ultimately owns) behind-the-meter solar, storage, and other DERs.

Image courtesy of Holy Cross Energy

CONCLUSION AND RECOMMENDATIONS

UTILITIES AND COMMUNITIES ARE RE-IMAGINING THEIR ROLES IN ENSURING RESILIENT POWER SUPPLY

A few key insights regarding the role of the utility and its key stakeholders emerged in the final workshop:

Everyone has a role to play. Resilience is a concern to many stakeholders including emergency responders, local officials, business owners, and community residents. Where there is shared interest, there is shared responsibility.

The utility can't do it alone. While the utility can strengthen and harden its power delivery capability, distributed and behind-the-meter solutions also require active participation from community stakeholders.

No single community organization can do it alone. While stakeholder organizations may be able to fortify their own facility independently, highly resilient solutions that harness the greatest value require multiple parties.

> "
>
> It takes a community to build resilience. Next time you have a great resilience idea and are about to go do it … call your neighbors, including your local utility.
>
> —Bryan Hannegan, *CEO of HCE*

EMERGING RESILIENCE SOLUTIONS CAN ADVANCE MULTIPLE COMMUNITY GOALS

The Roaring Fork Valley community seeks greater energy resilience while simultaneously decarbonizing their regional energy systems. Distributed solutions provide the opportunity to advance both environmental and resilience goals, and also can provide additional benefits, including community economic development and greater regional autonomy.

RECOMMENDATIONS FOR HOLY CROSS ENERGY AND THE ROARING FORK VALLEY

The aim of this project was to begin a community dialogue around energy resilience and to position stakeholders to implement high-impact solutions. While the following recommendations are targeted toward Roaring Fork Valley community members, they hold wider implications for actions that utilities, governments, and businesses around the country should consider as they plan for improved energy resilience.

Recommendations for Holy Cross Energy

HCE should continue to play a leading role in keeping this community dialogue going, and:

1. **Work with community partners to advance the priority projects and pilots identified through workshops and working groups**
   Community working groups identified several potential high-impact and high-interest solutions. Priority projects include implementing mobile generator policies or programs to meet near-term needs for resilient backup power, and exploration of a potential pilot community microgrid project.

2. **Consider the role of expanded customer programs to broaden access to resilience solutions**
   Appropriately designed customer programs and rates are important enablers of distributed resilient solutions. While HCE is already creating solutions that will help incentivize shared benefit from distributed resources and overcome some barriers to implementation, HCE should continue to evaluate customer wants and needs and consider new programs and rates that encourage energy resilience.

3. **Support resilience-focused stakeholder processes in other regions of the HCE service territory**
   Beyond the Upper Roaring Fork Valley, other regions of HCE's electric service territory may be at risk to major disruption. HCE should also evaluate these resilience risks in partnership with local stakeholders and consider how it may lead or support community-based resilience planning processes in those regions.

Recommendations for Local Roaring Fork Valley Governments

Town, county, and other regional governing bodies have a critical role to play in pushing this work forward. Some suggestions include:

1. **Evaluate localized risks in partnership with HCE and emergency services**
   The RMI/HCE partnership in the Upper Roaring Fork Valley focused on the risk to bulk power supply demonstrated by the Lake Christine Fire. Beyond that regional risk, certain communities of the valley might be at particular risk of other disruptions. Each community should further evaluate the risks particular to its location. This evaluation might consider particular regions that are vulnerable to power disruptions (e.g., distribution or transmission corridors at particular risk). It could also include identifying specific populations at particular risk (e.g., senior living communities).

2. **Partner with electric utilities on regional and facility-specific resilience planning**
   Given the increasing importance of resiliency in the supply of power, electric utilities should be included more integrally into resilience planning processes. Existing resilience and emergency plans should be looked at through a lens of energy resilience—for each contingency and plan in place, how does it rely on electricity? Do plans for backup power supplies exist? Will those backup plans continue to support operations under various circumstances, such as a prolonged outage or if access to fuel resupply were severed (e.g., natural gas lines go down, diesel resupply trucks can't make it into the valley)?

3. **Support resilience project implementation through pilots and programs**
   Local government can support and streamline project implementation by helping to increase public awareness, accelerating required permits or approvals, and providing or helping to identify sources of funding. Local governments can use their communications channels to raise awareness of existing programs and best practices for addressing power supply risk. Local governments may also support permitting of microgrid projects or clean energy projects that could enhance regional resilience. Finally, local governments can help identify state or federal grants that could be applied to local projects.

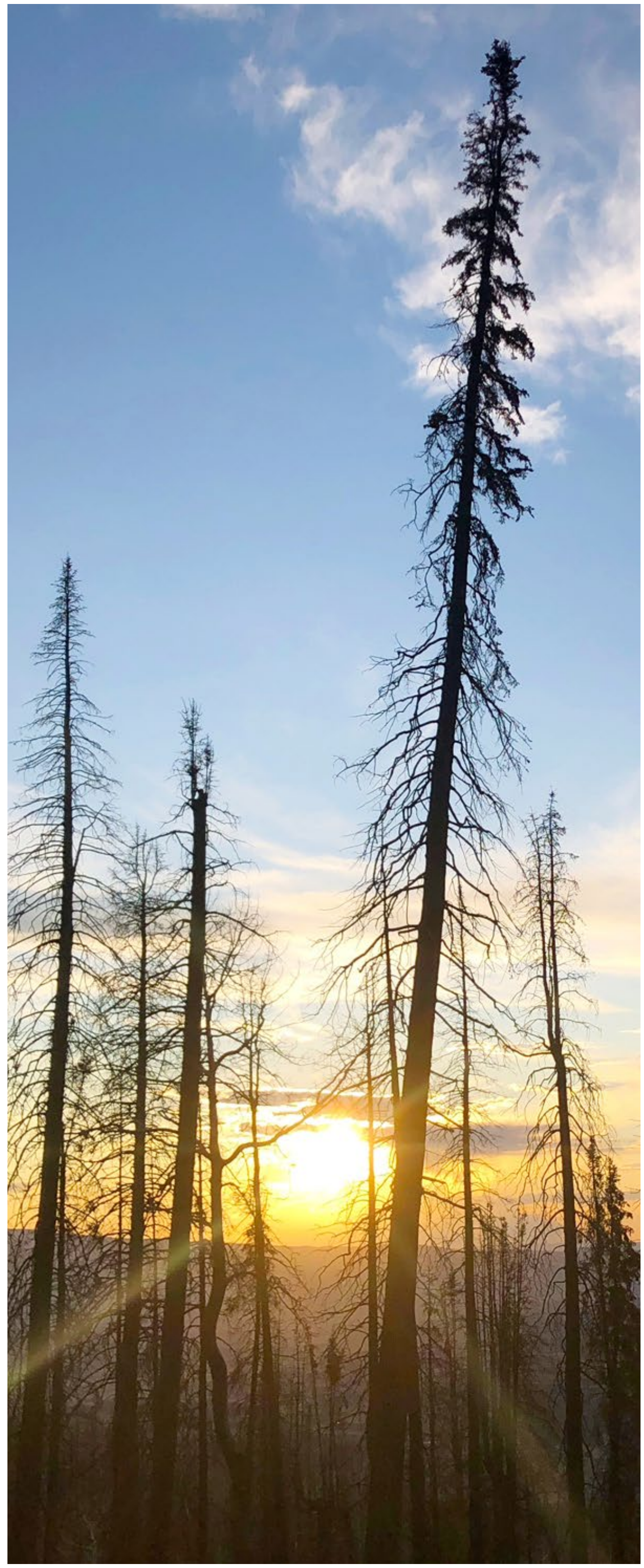
Recommendations for Emergency Services, Non-electric Utilities, and Businesses in the Roaring Fork Valley

Emergency services, nonelectric utilities, and private businesses must also consider their role in supporting increased community resilience. Some suggestions include:

1. **Evaluate power supply risk at key facilities**
   Facility managers should understand to what extent they rely on electric power and identify the factors most likely to disrupt their power supply. This evaluation could be conducted in partnership with the utility or the local community.

2. **Engage the electric utility to identify collaborative solutions and "blue sky" benefits**
   The best solutions likely involve a partnership with the electric utility. Facility managers should engage the utility around collaborative solutions. In some instances, it may make sense to bring additional parties into a multistakeholder discussion with the utility.

3. **Seek resilience solutions that meet multiple community and regional goals**
   As stated above, emerging solutions for energy resilience can advance multiple community and regional goals. Businesses may be motivated to reduce their greenhouse gas emissions, or to demonstrate leadership on climate and the environment. Business leaders, therefore, should evaluate options which provide not only resilience, but also additional benefits.



ACKNOWLEDGEMENTS

RMI and HCE would like to thank the individuals who have provided valuable input throughout this process, by participating in interviews, workshops, and/or working groups:

Aspen Airport	Scott Benesh, Facilities Manager
Aspen Center for Environmental Studies	Jim Kravitz, Naturalist Programs Director
Aspen Fire	Ken Josselyn, Battalion Chief Parker Lathrop, Deputy Chief/Fire Marshal Rick Balentine, CEO/Fire Chief
Aspen Police Department	Linda Consuegra, Assistant Chief Richard Pryor, Chief of Police
Aspen School District	Gary Vavra, Director of Facilities and Transportation
Aspen Skiing Company	Auden Schendler, VP of Sustainability Richard Burkley, SVP of Strategy and Business Development Ryland French, Energy Manager
Aspen Valley Hospital	Jon Albers, Assistant Director of Facilities Ray Knable, Emergency Manager Stephen Selby, Director of Facilities Management
Basalt Police	Greg Knott, Chief of Police
Black Hills Energy	Corey Koca, Director of Operations, Natural Gas Todd Ellsworth, Operations Supervisor, Distribution
Caucus and neighborhood representatives	Dale Combs, Frying Pan Caucus Jean and Monroe Dodd, Frying Pan Caucus Jeffrey Friday, Cedar Drive Road Association Joe Wells, Castle Creek Caucus Stacy Keating, Emma Caucus

City of Aspen	Ashley Perl, Climate Action Manager Chris Menges, Climate and Sustainability Programs Administrator David Hornbacher, Director of Utilities Sara Ott, Interim City Manager Tyler Christoff, Interim Assistant Public Works Director
Clean Energy Economy for the Region	Erica Sparhawk, Program Manager Katharine Rushton, Renewable Energy Program Director
Colorado Springs Utility	Matt Israel, Resource and Transmission Planning Engineer
Comcast	Kari Conley, Enterprise Account Executive
Community Office for Resource Efficiency	Mike Bouchet, Commercial Programs Manager Mona Newton, Executive Director Sarah Gruen, Community Sustainability Manager
Eagle County	Birch Barron, Emergency Manager Eric Boley, Energy Engineering Technician Eric Lovgren, Wildfire Mitigation Coordinator
Eagle County Sheriff's Office	James Van Beek, Sheriff Michael Bosley, Captain
Guzman Energy	Anna Hagel, Origination
Holy Cross Energy	Bo Jones, System Operations Engineer Bryan Hannegan, President and CEO Chris Bilby, Research Engineer David Bleakley, VP of Engineering David Munk, Board of Directors Jenna Weatherred, VP of Member & Community Relations Kristen Bertuglia, Board of Directors Mike Steiner, Key Accounts Robert Gardner, Board of Directors Steve Beuning, VP of Power Supply and Programs

Pitkin County	Catherine Christoff, Engineer Jodi Smith, Facilities Director John Loyd, CTO Rich Englehart, Deputy Manager
Pitkin County Human Services	Samuel Landercasper, Economic Assistance Manager/ESF 6 Lead
Pitkin County Sheriff's Office	Alex Burchetta, Chief Deputy of Operations Joe DiSalvo, Sheriff
Roaring Fork Fire Rescue	Pete Bradshaw, Deputy Fire Chief Scott Thompson, Fire Chief
Roaring Fork School District	Jeff Gatlin, Chief Operating Officer
Roaring Fork Transportation Authority	Dan Blankenship, CEO Jason White, Transport Planner Mike Hermes, Director of Facilities
Snowmass Police	Brian Olson, Police Chief
Snowmass Water and Sanitation District	Christie Duckett, Billing Manager/Water Conservation Officer/Lab Analyst John Bell, Supervisor/Foreman/Operator Kit Hamby, District Manager
Town of Basalt	Boyd Bierbaum, Public Works Director Sarah Nadolny, Planner
Town of Snowmass Village	Clint Kinney, Town Manager Travis Elliott, Assistant to Town Manager
US Forest Service	Jim Genung, Zone Prescribed Fire and Fuels Tyko Isaacson, Upper Colorado Fire and Aviation Management

APPENDIX 1: PROJECT OVERVIEW

PROJECT DETAILS

Project objectives

1. Discover stakeholder priorities and shared opportunities for improving electricity and related service resilience in the Upper Roaring Fork Valley.
2. Identify ongoing energy resilience efforts in the region.
3. Prioritize promising solutions for HCE, in partnership with stakeholders, to improve resilience.
4. Align on near-term actions that HCE and other stakeholders can pursue.

Project components and timeline

Stakeholder interviews
February and March 2019

Resilience research
February and March 2019

Workshop 1
April 3, 2019

Working group meetings
April, May, June 2019

Workshop 2
June 25, 2019

Final report
May 2020

Scope

- **Geographic:** The project considered the Upper Roaring Fork Valley, from the Basalt substation east through Aspen. This includes Snowmass Village and the Frying Pan up to and including Meredith.

- **Content:** The project focused on community-based resilience activities, and excluded activities that are solely within the utility's control, such as upgrades to bulk power transmission. The focus was also limited to energy resilience and excluded general emergency preparedness and fire prevention. Though these activities are outside the scope of the project, the results of this project may help support these broader activities.

Additional materials

The following materials have been developed as part of the project, and are available to the public upon request. Please contact Emily Goldfield (**egoldfield@rmi.org**) if you would like a copy of any of the following:

- Workshop 1 pre-read
- Workshop 1 follow-up report
- Workshop 2 pre-read

EXHIBIT 6

Impact of the Lake Christine Fire on Holy Cross Energy infrastructure

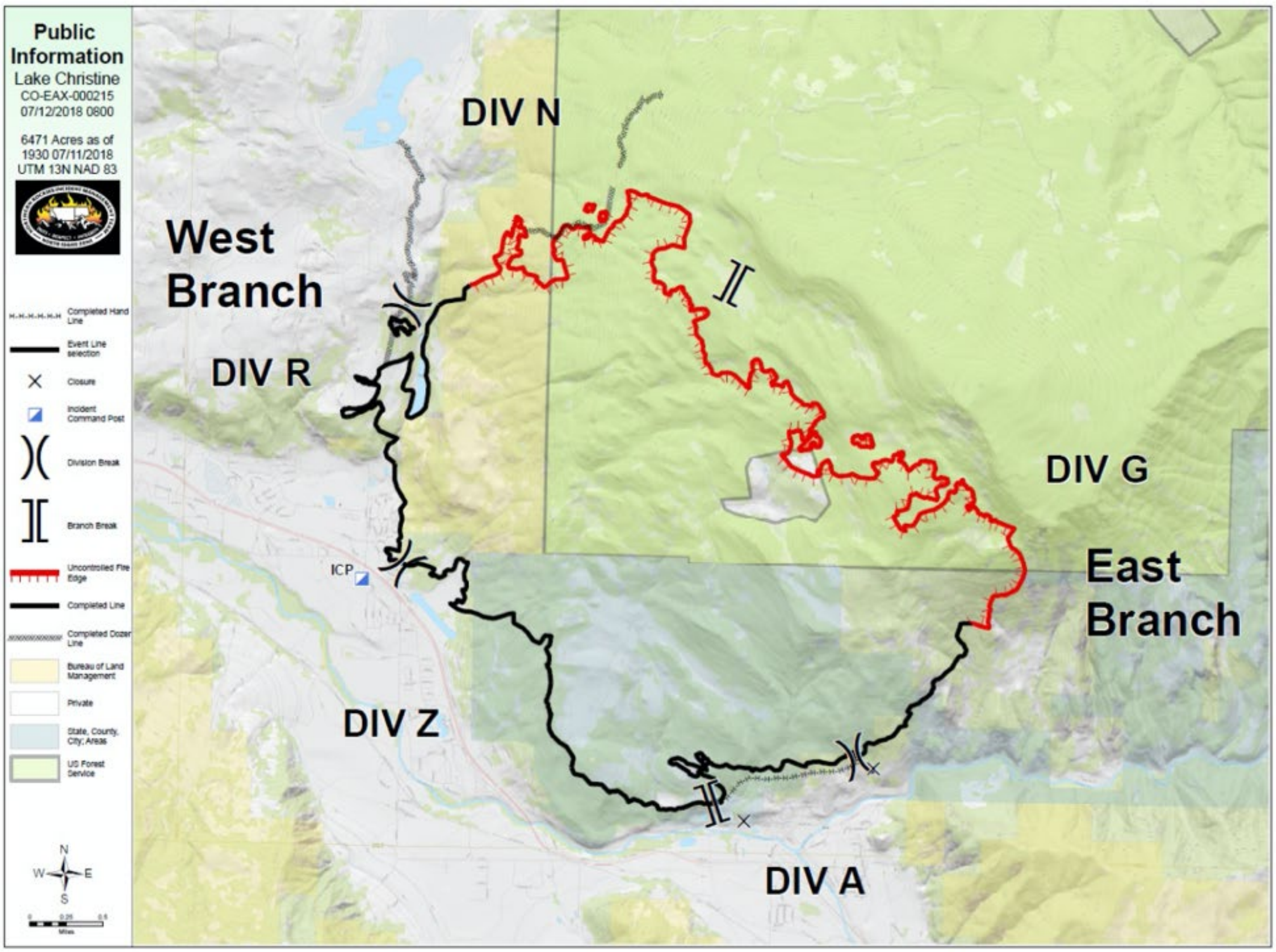


Image courtesy of Judy Hill Lovins

LIST OF STAKEHOLDER ORGANIZATIONS INVOLVED

The following organizations have participated in this process through the pre-workshop interviews, workshop 1, and/or workshop 2:

Aspen Airport
Aspen Center for Environmental Studies
Aspen Fire
Aspen Police Department
Aspen School District
Aspen Skiing Company
Aspen Valley Hospital
Basalt Police
Black Hills Energy
Castle Creek Caucus
Cedar Drive Road Association
City of Aspen
Clark's Market
Clean Energy Economy for the Region
Colorado Springs Utility
Comcast
Community Office for Resource Efficiency
Eagle County
Eagle County Sheriff's Office
Emma Caucus
Frying Pan Caucus
Guzman Energy
Holy Cross Energy
Pitkin County
Pitkin County Human Services
Pitkin County Sheriff's Office
Roaring Fork Fire Rescue
Roaring Fork School District
Roaring Fork Transportation Authority
Snowmass Police
Snowmass Water and Sanitation District
Town of Basalt
Town of Snowmass Village
US Forest Service

APPENDIX 2: REVIEW OF TECHNICAL SOLUTIONS FOR RESILIENCE

RMI considered five options for addressing power delivery risk: end-use efficiency, on-site backup generators, on-site renewables with energy storage, and district heat and power.

Five key takeaways emerged from a survey of these distributed resilience options:

1. All identified options can reliably contribute to energy resilience under the right set of conditions.
2. All options are technically mature and have been implemented in the real world.
3. Upfront cost of all options can be covered through electric utility or third-party finance arrangements.
4. While backup generators have long been the predominant option, a suite of viable options have recently emerged due to technological advances.
5. Energy efficiency is a complementary option: it does not in itself provide power during an outage.

End-use efficiency at critical facilities

Relying only on the most efficient critical loads to maximize the impact of available supply

DEFINITION

Critical load efficiency uses technical and design solutions to reduce energy consumption to ensure provision of services even if electricity supply is limited or interrupted. During outage events, efficiency measures enable buildings to continue to operate and be habitable even if energy supply fails. Facility operators may conduct energy audits on all energy-consuming devices (loads) that are required to support critical functions. Replace or retrofit devices to secure best available efficiency. For packed equipment with embedded energy-consuming components, aggregate demand and go upstream to equipment suppliers.

KEY CONSIDERATIONS

- Efficiency reduces the energy demand that a complementary resilience solution must supply, but a critical load will not function without supply.
- For a facility with on-site generators and stored fuel, efficiency can stretch fuel supply by days or weeks.
- Facility operators and maintenance personnel are a first and often under-utilized resource for identifying energy efficiency opportunities.
- Where more focused expertise is needed, most towns and cities have access to a local chapter of the **Association of Energy Engineers** or community energy office.
- Where indoor temperature is critical to maintaining functions, the building envelope (windows, doors, walls, roof, and floor system) as well as climate control systems (heating and cooling) should be considered.

FEATURED CASE STUDY: NEW YORK CITY, NEW YORK

The Hellenic American Neighborhood Action Committee in **New York City** has constructed a 68-unit housing development to Passive House building standards intended to house low-income senior citizens. The new buildings help keep senior citizens in their homes during a period with no power and are expected to be able to maintain thermal control in the units for a period of at least five days.

SPOTLIGHTS

Pennsylvania – Carnegie Library of Pittsburgh, PA, has built the first Passive House Certified library in North America. The library can maintain a comfortable interior climate without active heating or cooling systems, through an airtight envelope and a ventilator system.

Wisconsin – The energy efficiency of Madison Police Department's new station will save the department an estimated $22,123 a year in energy costs.

United Kingdom – The Department of Health has made £50 million ($62 million) available to help hospitals across the country implement energy efficiency projects.

On-site backup generators

On-site on-demand power for outage events

DEFINITION

Backup diesel- and gas-powered generators convert stored fuel into electricity when grid supply is interrupted. Generators have been deployed at critical loads for decades. Many building operators appreciate the easy-to-source and install aspects. Backup generators are commonly deployed to either power a whole building or a critical load panel, with loads connected via red outlets.

KEY CONSIDERATIONS

- For diesel generators, energy production is limited to the fuel stored on site. Facility operators must decide how many days of fuel supply should be stored to ensure that backup generators keep running.
- Long duration outage fuel rationing protocols may be established in advance to manage decision-making under extreme circumstances.
- Fuel storage and distribution systems have been found to be a source of environmental liability and unreliability. The National Electric Code (NEC) Section 700 has redundancy guidelines for critical facilities.
- A battery-based uninterruptible power supply (UPS) is commonly required by NEC for electrical continuity during generator startup sequences.
- Generators require routing operation and maintenance to ensure functionality during an outage. A quarterly inspection is commonly required.
- Gas-powered fuel cells are gaining market share as backup generators.

FEATURED CASE STUDY: SYLACAUGA, ALABAMA

The Coosa Valley Medical Center in **Sylacauga, Alabama,** installed a 150 kilowatt diesel-powered backup generator to have reliable backup power to protect the life and safety of its patients in the event of a utility power outage.

SPOTLIGHTS

California – The Emergency Services Training Center in San Marcos, CA, keeps operating in the event of a power outage thanks to standby power from a 300-kilowatt diesel generator.

Massachusetts – A backup generator testing plan prepared for state hospitals requires monthly testing of the emergency power supply system using actual installed loads.

Washington, D.C. – The Museum of the Bible installed a 500 kilowatt backup power generator fueled by natural gas to ensure continuity of operations and preserve its collection.

On-site renewables and storage

Energy independence for critical loads during normal operations and outages

DEFINITION

Renewable technologies generate electricity by converting on-site resources including solar, geothermal, waste, and wind. The variety of available resources allows one or more options to be used independently or in combination. Key differences exist including space requirements, cost, capacity, maintenance, operating time, and environmental impacts. For resources that are not available 24/7, such as solar PV, on-site storage is critical to ensure facilities have on-demand energy. Advances in chemical storage products, including lithium-ion batteries, have made battery storage a cost-effective solution in many applications, especially those that can take advantage of time-of-use rates or other compensation. Beyond chemical batteries, diverse storage technologies are available including active thermal storage and passive storage (e.g., concrete slabs).

KEY CONSIDERATIONS

- Solar installed with existing generators can stretch the fuel supply by weeks or months.
- Buildings that require higher energy production may consider pole-mounted trackers and solar carports.
- If designing PV for the worst case (e.g., cloud-covered day), count on 1 kilowatt-hour of production per day for each 1 kilowatt of installed capacity.
- Battery storage prices are halving every four to five years.
- A battery management control system is a key component of achieving your energy goals with battery technology, especially when the battery should be used for both resilience and market participation.
- If outages are likely during snow events, a snow removal plan should be considered for rooftop solar.

FEATURED CASE STUDY: FREMONT, CA

Fremont City's Police Complex has installed 872 kilowatts of solar carport structures on-site and three electric vehicle charging stations. They will soon begin a pilot program to test electric vehicles customized for patrol operations, which will allow the police to operate even in the event of fuel supply disruptions or power outages.

SPOTLIGHTS

California – Walmart installed 40 megawatt-hours of energy storage at 27 Southern California stores. The systems will allow the retailer to reduce peak electricity demand.

India – The Government of India has mandated that 75 percent of rural and 33 percent of urban cell phone base stations will need to run on renewable energy.

District and large-facility CHP

System for distributing heat generated in a centralized location

DEFINITION

Combined heat and power (CHP) is a suite of efficient technologies that generate electricity and thermal energy in an integrated system. A CHP system has the advantage of using the heat that is normally wasted in conventional fuel generation, making the entire system more efficient. The primary resilience benefit of CHP is its ability to serve power and thermal needs, and keep vital services like hospitals online, even when the grid is down. The value of CHP deployments has been notably proven during extreme weather across the United States.

KEY CONSIDERATIONS

- Unlike traditional backup generators, which only operate during outage events, CHP systems typically operate continuously and can use a variety of fuels to efficiently serve local energy demand.
- Most CHP systems are fueled by natural gas, which can increase resilience because natural gas-fueled CHP can operate as long as pipelines are working, even during power outages.
- Some CHP installations can use biomass or biogas, which can be equally reliable in times of disaster.
- In addition to providing emergency power, CHP systems can also save customers money and reduce overall net emissions.

FEATURED CASE STUDY: HOUSTON, TEXAS

The **Texas Medical Center**—the largest medical center in the world—was able to sustain its air conditioning, refrigeration, heating, and hot water needs throughout Hurricane Harvey thanks to a 48 megawatt CHP system that uses natural gas to provide reliability and security to the 19 million square foot medical campus in the event of prolonged outages.

KEY CONSIDERATIONS

Maryland – The US FDA campus has a 26 megawatt gas-fueled supply for heating and cooling that can operate mission-critical functions independent from the grid.

New Jersey – Bergen County Utilities Authority uses a 2.8 megawatt CHP plant to keep its sewage treatment facilities working during prolonged power outages.

Armenia (Asia) – Avan in Armenia chose a 121 megawatt gas-fired CHP for its district heating network to provide heating below the price of residential gas boilers.

Microgrid

Microgrids are being developed commercially as a resilience solution across the United States

DEFINITION

Microgrids connect electric sources and loads across multiple buildings. Some facility-scale microgrids utilize fully redundant power distribution and controls, while other “utility” microgrids utilize existing distribution wires with upgraded controls and isolation equipment. During normal operations, a microgrid may run low operating cost (e.g., renewable) generators with two-way power flow. During an outage event, the microgrid may sever electrical flow (“island”) to provide local power continuity.

KEY CONSIDERATIONS

- Balancing generation and demand is a key design consideration often made easier with storage and flexible loads.
- Advanced metering infrastructure, distribution automation, and cybersecurity often serve critical functions in microgrid operations.
- In a US Department of Defense study, microgrids with distributed solar and generators were found to both improve resilience and reduce cost compared to backup generators alone.
- Modern microgrids are commonly deployed for four use cases: 1) energy cost reduction, 2) carbon reduction, 3) resilience, and 4) utility operations (demand management).

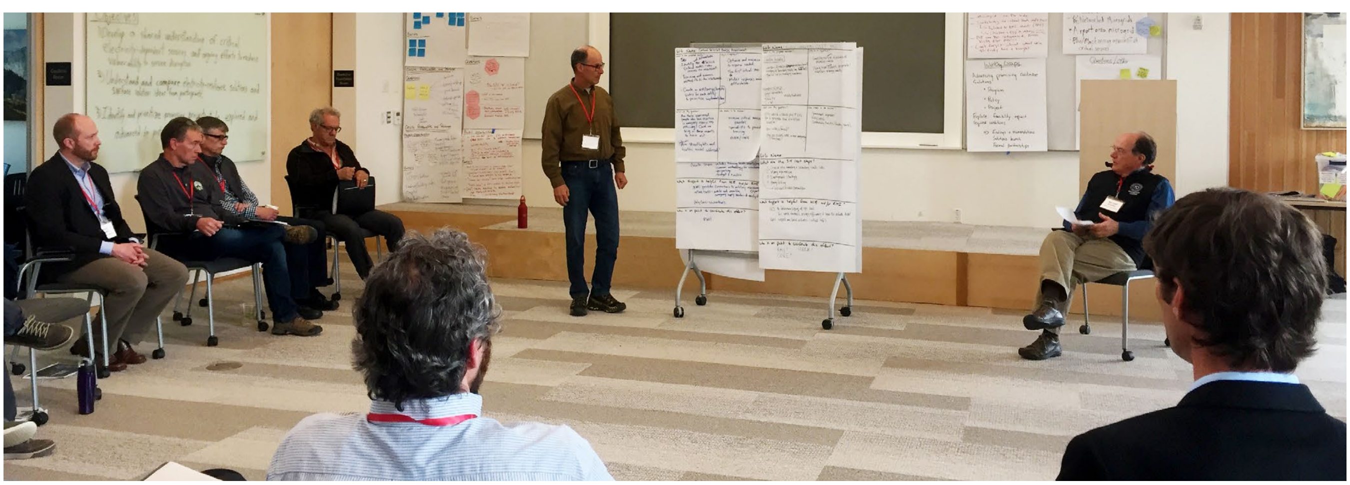
FEATURED CASE STUDY: BORREGO SPRINGS, CA

Massachusetts – The Longwood Medical Area microgrid near Boston, MA, supplies five local hospitals to ensure continuation of critical operations.

Wyoming – A microgrid in Yellowstone National Park manages two solar arrays, four battery arrays, a water turbine, and a backup generator.

Ontario, Canada – The University of Toronto is set to install a microgrid that will provide the university with power resilience and reduce electricity costs.

Colorado – The Fort Collins Utility implemented a utility microgrid by connecting distributed generators, PV, and flexible loads across its distribution grid with the benefit of enhanced resilience and peak load reduction.



APPENDIX 3: STAKEHOLDER INTERVIEW TAKEAWAYS

RMI interviewed 30 community stakeholder organizations that represent vulnerable populations or provide critical services:

- **Government entities:**
  - City of Aspen
  - Eagle County
  - Town of Basalt
  - Town of Snowmass Village
  - US Bureau of Land Management
  - US Forest Service

- **Health and emergency services:**
  - Aspen Fire Department
  - Aspen Police Department
  - Aspen Valley Hospital
  - Basalt Police
  - Basalt & Rural Fire Protection District
  - Eagle County Sheriff
  - Pitkin County Sheriff
  - Snowmass Police

- **Transportation:**
  - Aspen Airport
  - Roaring Fork Transportation Authority (RFTA)

- **Private businesses:**
  - Aspen Skiing Company
  - Clark's Market

- **School districts:**
  - Aspen Valley School District
  - Roaring Fork School District

- **Utilities:**
  - Aspen Municipal Utility
  - Black Hills Energy
  - CenturyLink
  - Comcast
  - Snowmass Water & Sanitation

- **Community caucuses:**
  - Castle Creek (including Aspen Center for Environmental Studies)
  - Cedar Drive
  - Emma
  - Frying Pan

SUMMARY OF SELF-REPORTED CRITICAL INFRASTRUCTURE AND SERVICES

EXHIBIT 7

	ORGANIZATIONS	CRITICAL INFRASTRUCTURE / FACILITIES	CRITICAL SERVICES PROVIDED
Health and Emergency Services	8	• Communications equipment • Fuel pumps • Life-sustaining equipment • Essential lighting • Boilers • Chillers	• Emergency response services • Life support services • Communicating with the public
Government	7	• Potential evacuation/shelter sites • Communications equipment	• Communicating with the public • Providing shelter • Supporting evacuations
Utility	3	• Water treatment and supply plants • Pumping stations • Surface structures for natural gas • Cell towers	• Communications and internet • Fuel for heat and backup generators • Providing drinking water and treating wastewater
Private Business	2	• Refrigeration • Essential lighting • Heating	• Providing shelter • Providing food
School Districts	2	• Circulating pumps • Boiler • Freezer • Essential lighting	• Serving as incident command or evacuation shelter
Transportation	1	• Facility for fueling, maintaining, and dispatching buses	• Maintaining transportation service • Supporting evacuations

Six key themes emerged from stakeholder interviews:

1. Regional resilience and emergency preparedness activities are ongoing.
2. Adequacy of energy resilience plans depends on nature and duration of an outage event.
3. Most critical services have backup diesel or natural gas generators.
4. Sustained provision of critical services depends not only on electricity, but also access to workers and other utility services.
5. Stakeholders are interested in identifying collaborative solutions that maximize community benefit.
6. Stakeholders are beginning to evaluate renewable energy plus storage, but common obstacles have constrained implementation of these solutions.

SURVEY OF EXISTING BACKUP POWER IN THE UPPER ROARING FORK VALLEY

During interviews leading up to the first workshop, stakeholders were asked about existing backup generation in place and their ability to provide services in the event of a grid outage. Most critical services reported having backup diesel or natural gas generators, and being able to perform critical functions in case of a grid outage. The responses were more varied across organizations of other types. Exhibit 8 below summarizes the completeness of backup and types of backup for the organization types surveyed.

EXHIBIT 8

Organization Type	Number of Orgs. Interviewed	Backup Power	Completeness of Backup*
Health and Emergency Services	8	• Diesel generators & fuel storage • Natural gas generators • Mobile generators	
Government	7	• Natural gas generators • Mobile generators	
Utility	3	• Natural gas generator • Diesel generators • Mobile generators	
Private Business	2	• None on-site; can host mobile generator • Diesel generator & fuel storage	
School Districts	2	• None on-site • Can host mobile generator	
Transportation	1	• Diesel generator & fuel storage *(for facilities)*	

 On-site back-up generation capacity adequate to cover 100% of critical load

 On-site back-up generation capacity adequate to cover 0% of critical load

* Does not measure adequacy of generator fuel supply

APPENDIX 4: WORKING GROUP DETAILS

Five ideas surfaced during the first workshop were further explored by working groups. Each of these projects and the findings/next steps produced by the working groups are described in more detail below.

1. COMMUNITY MICROGRIDS

Scoping of community-level microgrids

Background and need

Developing a microgrid would allow the selected geography to operate independently of the grid, to keep power during a grid outage; this improves resilience by ensuring that towns can deliver critical services to their citizens in case of an emergency. A long-term vision was proposed for a network of microgrids throughout the Roaring Fork Valley that could operate together or independently such that in the case of a larger grid outage, a select geography within the valley would retain power in order to support emergency operations and provide a safe haven for vulnerable populations. This working group explored the potential for an initial grid-connected microgrid that has the ability to island itself in the case of an emergency grid outage, while keeping in mind the potential to eventually scale up to a network of microgrids throughout the valley.

Working group objectives

- Articulate the values that community stakeholders wish to access through microgrids
- Identify and outline potential community microgrid pilot projects
- Develop criteria for evaluating potential microgrid pilot projects
- Connect lessons learned from other microgrids to work in the Roaring Fork Valley

Key findings

Potential Shortlisted microgrid pilot sites

- Aspen Airport Business Center: could potentially include the airport, RFTA bus barn, emergency services (fire department and communications), houses, and/or additional facilities
- Snowmass Village: could potentially include town hall, police department, Clark's market, gas station, and/or additional facilities
- Aspen Valley Hospital region: could potentially include Aspen High School, Aspen Recreation Center, assisted living, ambulance dispatch, and/or City of Aspen water treatment plant
- Aspen downtown core

Evaluation criteria for choosing pilot footprint

- Resilience value
- Environmental/sustainability
- Economic
- Technical
- Political/social feasibility
- Scalability
- Grid value

Key outstanding questions

- How can resilience be balanced with financial feasibility?
- Do microgrid benefits/costs outweigh known backup generation?
- Which footprint/partners is the best fit?

Insights

- Need to make a clear distinction between backup generation and microgrid
- Need to establish a clear footprint; clearly define what is in and what is out
- Clear expectations are essential
- Size (number of loads and DERs) will determine both cost and complexity
- Partnership with utility is critical to building a microgrid
- Most successful microgrids that have been implemented have used a split financing model (different parties pay for different pieces that make up the microgrid)
- HCE can potentially help with initial capital outlay through a new tariff
- Lots of questions need to be asked, such as:
  - What problem(s) are you trying to solve? (starting point)
  - How will it be used?
  - Is it built only for supporting during black sky events, or for operating during blue sky circumstances as well?
  - Is it designed for 24/7 operation for complete backup or for a few key hours after an event?
  - Will it be renewable only or use traditional generation supplemented with renewables?

Process flow and implementation arc

Now

- Review community response plan/regional risk assessment
- Develop problem/project definition
- Review concept with consultants
- Assess financial feasibility
- Assess technical feasibility
- Secure partners (e.g., developers, consultants)
- Evaluate financial options
- Revisit/refine concept
- Align with stakeholders
- Go through location and extent review

↓

Initial microgrid commissioned

↓

Networked microgrids

Next steps and recommendations

Immediate next steps

- Determine partnership interest
- Align potential footprint with regional resilience planning
- Interview interested microgrid partners
- Formalize financial commitments

Image courtesy of Judy Hill Lovins

2. BULK SUPPLY RESILIENCE

Exploring contractual and operational barriers to resilient emergency power management

Background and need

The Upper Roaring Fork Valley is served by two utilities: Aspen City Utilities and Holy Cross Energy. There are overlaps in the infrastructure used by each utility, though each procures power from different resources and providers. Current contracts between each utility and its wholesale power provider would make it challenging for the utilities to support one another in the case of an emergency power disruption. This project was a collaboration between Holy Cross Energy and Aspen City Utilities to examine and resolve contract impediments to effective resilience options by creating formal arrangements to address contingent energy supply during "black sky" conditions. This would allow the region to operate independently—as a "mesogrid"—for some period of time under contingency conditions.

Working group objectives

- Identify, discuss, and evaluate options for bulk power continuity at various time scales
- Ensure electric supply and delivery system design options are evaluated and selected to sustain impacted communities
- Review the technical, contractual, and policy considerations to assess the feasibility of a "meso-grid" approach
  - Technical: Designing for separation and re-integration
  - Contractual: Wholesale and subregional energy supply
  - Generation planning: wires, controls, resource technology options, siting, resilience design criteria (four hours, four days, forever?)

Key findings

Supply and demand balance

A desired outcome of the resilience plan is to enable islanded operation of the electricity supply system in a post-disaster or post-contingency scenario. Islanded operation means that generation and storage resources supply electricity to users without the broader bulk electric system providing backup at a regional level. Considerations:

- Maintaining generation and load balance with an acceptable level of grid frequency control
- Response plans for contingent resource loss during islanded operations
- Re-synchronizing the RFV system to the bulk grid upon return to normal operations
- Maintaining power quality including compliance with voltage limits
- Establishing contracts to address relationship to external wholesale supplier roles and equity issues during contingent operations
- Opportunities to control/reduce customer load to match generation capacity during critical operations

Wholesale electric supply

- Impact to and expected support from wholesale electric suppliers external to the RFV:
  - Municipal Energy Agency of Nebraska (MEAN): The full requirements power supplier to Aspen City Utility; their supply contract permits the City with some local resource development options for small hydro and local solar
  - Public Service Company of Colorado (PSCO): The full requirements power supplier to Holy Cross Energy; their supply contract permits HCE to secure alternative supply in some cases
  - Western Area Power Administration and other providers

- There is a need to develop a business model and contracts to provide for operational efficiency improvements from resilience infrastructure during noncontingency operations that contribute system support during post-contingent islanded operations
  - For example: Peak management (CP and NCP), balancing generation/load from renewables, voltage control, and other ancillary services

Next steps and recommendations

Short term (2019–2020)

- Develop emergency procedures to isolate electric delivery system elements and ensure backup supply for critical infrastructure uses
- Coordinate with the Mobile Generation task group in their efforts to secure options for emergency/backup portable generation assets as needed to address critical infrastructure need
- Develop engagement plan and resource allocations to support medium- and long-term plans
- Develop resource solicitations for next phases of system design that support RFV resilience (e.g., HCE's upcoming all-source resource solicitation, ACU's upcoming pumping station backup power generation plans for existing water distribution pump stations)

Medium term (2019–2022)

- Develop local supply or storage resources necessary to sustain a limited, islanded operation capability for critical systems and infrastructure
- Evaluate delivery system upgrade options for redundancy to avoid need for islanded operation
- Develop technical capability to maintain generation/load balance and power quality during islanded operation and for restoration of parallel operations with the bulk electric system
- Develop plans to address any applicable reliability standards compliance requirements during islanded operations

Long term (2020–2030)

- Resource and delivery system acquisition or construction in order to fulfill selected plan elements
- Monitor plan assumptions and developing capabilities
- Hunker down and wait

3. MOBILE GENERATION FLEET

Planning for deployment of mobile backup power solutions for schools and other refuge centers

Background and need

Aside from emergency services, many facilities in the Upper Roaring Fork Valley do not have backup power, including numerous "secondary critical loads" such as evacuation centers (e.g., schools) and grocery stores. For these sites, the cost of installing on-site backup generation may not be warranted or feasible. In the case of a prolonged grid outage, they would either plan to shut down or may consider bringing in mobile backup generation. This project aimed to explore the coordinated deployment of mobile generation resources—particularly diesel or gas generators and electric vehicles integration—to "secondary" loads without existing backup power. ("Secondary" loads were considered to be smaller loads essential to modern life, such as water, cellular service, and internet.)

Working group objectives

This working group began to develop two plans for supporting backup power at schools, refuge centers/safe havens, and other "secondary" loads:

1. Creating a deployment plan for mobile generation resources, which included making a list of "secondary" loads and critical loads without backup and sizing mobile generators to support those loads.
2. Exploring the possibility of using electric school buses and light duty vehicles as backup power for Aspen School District.

Key findings

Mobile generation fleet process

- Identify secondary loads without backup generation
- Size based on actual metering data and mate them to the appropriate mobile generator
- HCE will help provide data sheets of the appropriate generator size at the locations in need of backup power

EXHIBIT 9

Test Case Studies, Assuming a Three-Day Outage

	Type of Facility		
	SCHOOL	WATER PUMP STATIONS	COMMUNICATION TOWER
Phase	3 phase	3 phase	1 phase
Demand	150 kilowatts	36 kilowatts	20 kilowatts
Energy	8 megawatt-hours	0.8–1.7 megawatt-hours	1.1 megawatt-hours
Refuel Rate	350 gallons every 22 hours	80 gallons every 29 hours	77 gallons every 29 hours

Electric school buses: Vehicle-to-grid and an optimizing aggregator

- School buses are a great resource for backup power
  - Loads and usage are predictable
  - Spend majority of their life stationary in the same location
  - Able to store and move energy

- Optimal dispatch strategy for integrating:
  - Solar PV generation
  - Flexible building loads
  - Stationary and mobile storage
  - Vehicle integration (V2G)

Insights

- Schools, water pumps, and cell towers can easily be broken into simple categories to size backup generations
- Manual transfer switch can range from $8,000 to $20,000 for easy pull-up and power-up option
- AC coupled vehicle-to-grid is very near

Key outstanding questions

- Mobile generation fleet:
  - What is the plan for dispatching the generators?
  - Who should be responsible for procuring and paying for the rental?
  - Who should call if the lights go out?

- How to continue the conversations with relevant stakeholders to keep these projects moving beyond the workshop?

Next steps and recommendations

Mobile generation fleet

- Develop a plan for dispatching generators
- Determine the party/parties responsible for implementing the plan

Electric school buses

- Held a workshop for the school district and manufacturers to provide education on electric fleet options (August 2019)
- Help with procurement and grid integration using HCE’s Community Charging Program
  - Look into different ownership scenarios and help calculate payback
- Model charging infrastructure and capacity
- Work with Eaton and NREL for bus-to-building integration for demand management
  - Vehicle-to-grid testing at NREL
- Work with vendor on grid forming inverter/bus discharger

4. GAS PUMP RESILIENCE

Exploring the need and opportunity for resiliency at gas stations

Background and need

Service stations provide a critical service during an emergency. In the case of a major evacuation, access to gas would be essential to support vehicles leaving the valley. Modern gas pumps rely on electricity to be able to pump gas; in the event of a grid outage, gas stations without backup power would be unable to provide gas. Additionally, in the case of most gas stations, the pumps and building (e.g., convenience store) are on the same meter, making it challenging to install backup power to only support the critical function of pumping gas.

Working group objectives

- Assess what resilience measures are being taken by gas stations across the country
- Understand if gas stations in the Roaring Fork Valley are already taking resilience measures, or have identified this as a need
- Explore what options exist to ensure that there is sufficient access to transportation fuel in the event of an emergency
- Identify which near-term and long-term solutions should be considered in the area

Key findings

Locally

- Eleven service stations serve the Upper Roaring Fork Valley
- No backup power is required for any pump/station in the Roaring Fork Valley
- Of the service stations surveyed, none had backup power in place, and none were currently considering backup solutions. All had the pumps and convenience store on the same meter

Nationally

- Several states have introduced programs or laws to enhance service station resilience:
  - In Florida, gas stations are now required to have backup generators for quick reopen following storms
  - In New Jersey, a grant program offered support for installing backup generation at any retail fuel station with minimum 18,000-gallon capacity
  - In Massachusetts, the Massachusetts Clean Energy Center issued an RFP for projects to provide backup power to gas stations during power outages

EXHIBIT 10

Comparison of Three Types of Solutions

	Technology Considered		
	SOLAR + STORAGE	STORAGE	ON-SITE GENERATOR
Pros	• No fuel cost • Potential economic return • Environmental benefits • Opportunity to use battery during blue sky scenarios	• Lower upfront cost than solar + storage • Opportunity to use battery during blue sky scenarios	• Uses on-site primary fuel • Lower upfront cost
Cons	• Battery storage fire risk • Upfront cost	• Battery storage fire risk • Upfront cost	• Fuel access dependent • Does not provide blue-sky benefits
Examples in Practice	• None identified	• None identified	• Multiple

Insights

- Service stations should not be overlooked as part of resilience and emergency planning
- Critical loads at service stations include fuel pumping and credit card payment
- Typical fuel pump is sub-1 kilowatt
  - Pumps' load can be as low as a few kilowatts to hundreds of kilowatts in large gas stations with complex storage set ups
- Available backup energy (in kilowatt-hours), should be sized to fully evacuate the available gas supply
- For now, the most reliable solution is use of on-site generator

Next steps and recommendations

- Survey all service stations in the valley to better understand their needs
- To meet near-term resilience needs, consider recommending on-site or mobile generators
- Continue to monitor emerging technologies including efforts in Massachusetts and elsewhere to implement new/clean solutions as they emerge

5. CRITICAL END-USE EFFICIENCY

Assessing the energy use of critical services and proposing energy efficiency measures

Background and need

Energy efficiency has been identified as a key complementary measure to increase energy resilience. While the region has well-established practices and practitioners in the areas of home and business energy audits for energy efficiency, there was a perceived gap in the ability to extend energy audits to critical and emergency facilities (e.g., emergency response services).

Objectives

- Research and survey best practices from military and other critical services to identify practices that could be implemented in the Roaring Fork Valley
- Consider recommendations for implementing those best practices with Holy Cross Energy and in the Roaring Fork Valley

Key findings

- Many buildings have emergency circuits for critical equipment, so in the case of an outage the backup supply (e.g., diesel generator) only has to support critical systems such as communications and emergency lighting. An energy audit should focus in particular on the devices powered by these circuits
- While traditional energy audits tend to focus on energy use (kilowatt-hours), peak demand (kilowatts) should also be carefully considered for this application
- US Department of Defense has spent considerable time evaluating energy resilience at its facilities and the role of efficiency in increasing resilience. Improved metering and monitoring as well as increased investment in energy efficiency have been identified as two opportunities for enhancing critical facility efficiency

Next steps and recommendations

- Hold an initial site visit to critical facilities by HCE staff to better understand critical service requirements and existing backup
- Consider engaging local energy audit experts to review energy efficiency opportunities starting with critical system circuits

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