NATIONAL RENEWABLE ENERGY LABORATORY

Distributed Energy Planning for Climate Resilience

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ABSTRACT

Climate resilient solutions are being adopted and implemented at various levels of government across the United States and globally. Solutions vary based on predicted hazards, community context, local priorities, complexity, and available resources. Lessons being learned through the implementation process across various levels and types of government can inform resiliency planning in different contexts. Through providing analytical and technical support across the world, the National Renewable Energy Laboratory (NREL) is documenting key lessons related to resilience planning associated with power generation and water distribution. Distributed energy generation is a large factor in developing resilience with clean energy technologies and solutions. The technical and policy solutions associated with distributed energy implementation for resilience fall into a few major categories, including:

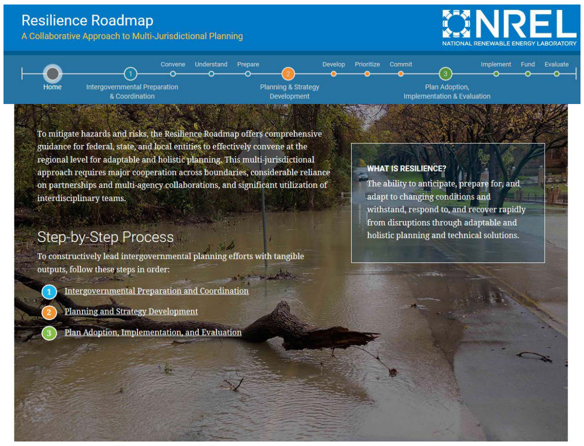
- Spatial diversification
- Microgrids
- Water-energy nexus
- Policy
- Redundancy

KEY POINTS

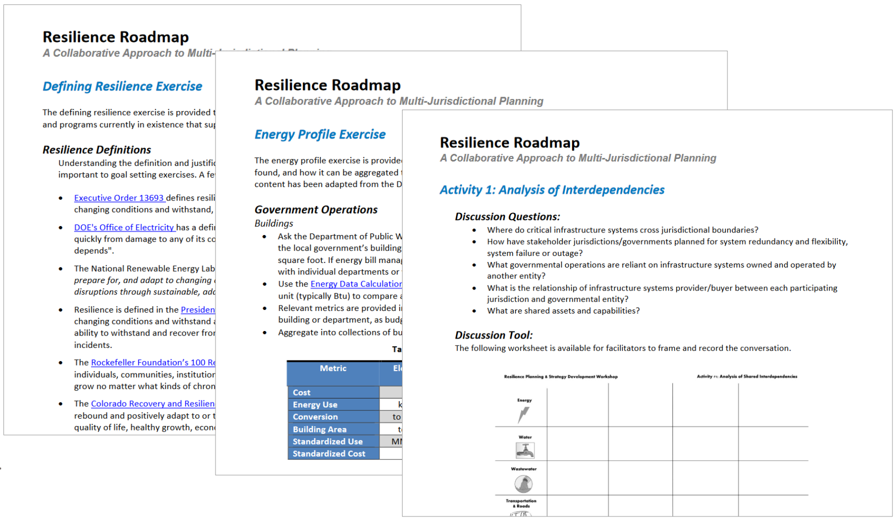
- Power sector vulnerabilities and potential hazards may impede the provision of the energy services necessary to achieve economic growth and development goals.
- Planning for resilience can help communities avoid and recover from potential threats and vulnerabilities to the power sector.
- Renewable energy-based generation can enhance resilience due to its modular nature, ability to operate in severe weather when designed to do so, and lack of fossil fuel requirements.
- Decision makers may consider enacting policies that enable resilience strategies; coordinate their implementation; and evaluate their effectiveness on a regular basis.
- NREL's Resilience Roadmap can help decision makers identify challenges and opportunities through an all-hazards approach to holistic resilience planning.

Resilience Roadmap

The Resilience Roadmap offers comprehensive guidance for federal, state, and local entities to effectively convene at the regional level for adaptable and holistic planning. A step-by-step process offers guidance, exercises and aggregated data lists to support decision makers. Learn more on the online at: www.nrel.gov/resilience-planning-roadmap



Source: NREL. "Resilience Roadmap." National Renewable Energy Laboratory (NREL), 2018.



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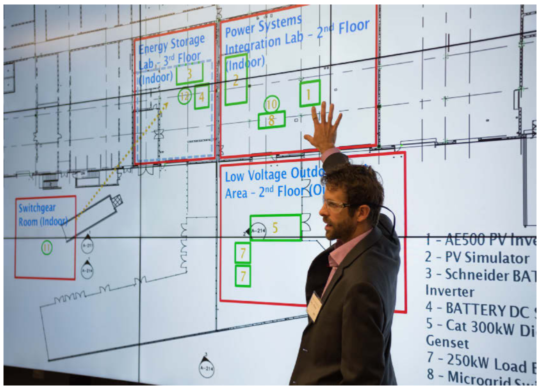
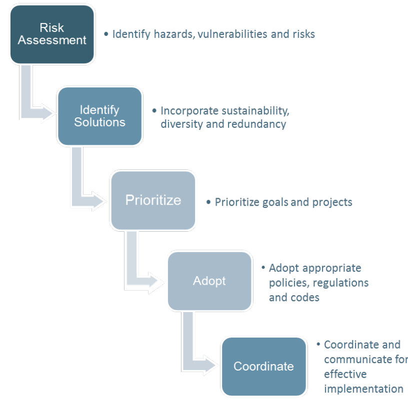


Modeling energy distribution systems is one aspect of energy resilience. National Renewable Energy Laboratory (NREL) experts analyze energy storage options and clean-energy solutions for creating resilient grid systems.

Solar photovoltaics, wind turbines, and other renewable energy technologies enhance resilience through spatial diversification.

METHODOLOGIES

At its most basic level, resilience refers to the ability to recover after the application of stress. Taking an all-hazards approach, NREL has worked with numerous communities to increase resilience to various threats and vulnerabilities. Depending on local priorities and the stakeholders involved in resilience planning, the specific actions deployed to enhance resilience may vary. The resilience planning methodology for developing and implementing an action plan can include community engagement, policy analysis, vulnerability and risk assessments microgrid modeling, and renewable energy feasibility studies. A resilience planning process framework is outlined in the figure at right.



International Case Study - Colombia

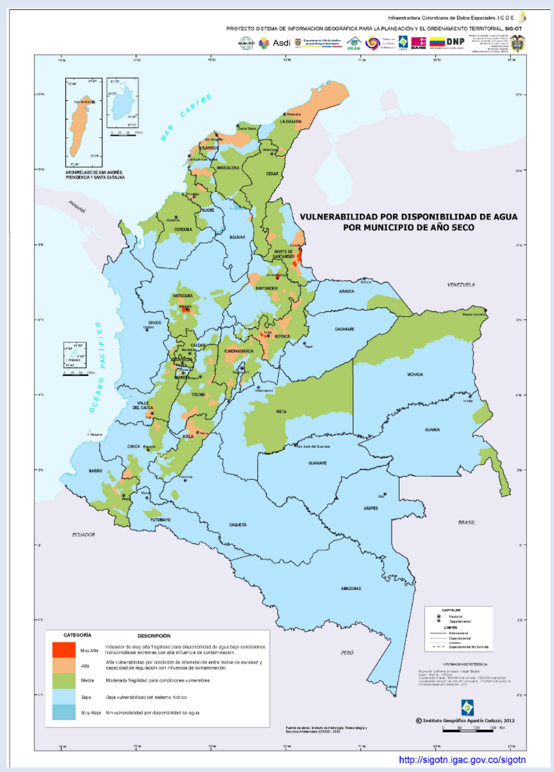
Power sector resilience is a concern to decision makers around the globe. In 1992, droughts caused by the El Niño effect resulted in widespread power shortages across hydropower-dependent Colombia. The severe shortages precipitated planned blackouts from 8-10 hours daily across the country. The power rationing was called an “economic crisis” as the estimated cost of the blackouts reached $35 million per week in lost productivity. The Colombian president at the time, Cesar Gaviria, famously noted that “Jamás volveremos a padecer algo similar” or “We will never suffer like this again” (authors’ translation) [2]. The president even temporarily changed the time zone to take better advantage of daylight hours [1].

Echoes of the 1992 crisis were heard in 2016 when severe El Niño-caused droughts impacted hydropower availability in Colombia. Through a concerted effort of energy savings and new billing practices, Colombia avoided blackouts despite a 63% reduction in water storage in hydroelectric dams.

Colombia is now preparing for the next El Niño event. The country, which depends on hydropower for over 70% of electricity generation, is seeking to diversify its energy portfolio. Colombia has updated its grid codes to incorporate greater levels of non-hydropower renewable energy-based generation. A new regulation creates a pathway to interconnect distributed generation resources to the grid to provide spatially-diverse, locally-produced power. The first ever, large-scale energy auction in Colombia that incorporates non-hydropower renewable energy was announced in early 2018. The goal of these projects is to provide reliable, cost-effective power to Colombia and to minimize the impacts of El Niño droughts on the Colombia energy sector.

[1] Douglas Farah, “COLOMBIA RATIONS ELECTRICITY, BLAMING DROUGHT,” Washington Post, April 22, 1992, https://www.washingtonpost.com/archive/politics/1992/04/22/colombia-rations-electricity-blaming-drought/a5dc2083-7cad-46b7-9d90-2ed9e94e1416/

[2] “What’s Really behind the Energy Crisis in Colombia?,” Barranquilla Life, accessed April 10, 2018, https://www.barranquillalife.com/single-post/2017/08/22/What%E2%80%99s-really-behind-the-energy-crisis-in-Colombia.



Vulnerability for Water Availability by Municipality in a Dry Year – Colombia. Red, tan, and green zones are vulnerable in a dry year such as those caused by El Nino Events. These areas also coincide with hydrological areas that Colombia relies upon for hydropower.

Source: Geographic Institute Agustín Codazzi (IGAC), 2018
http://sigotn.igac.gov.co/sigotn/

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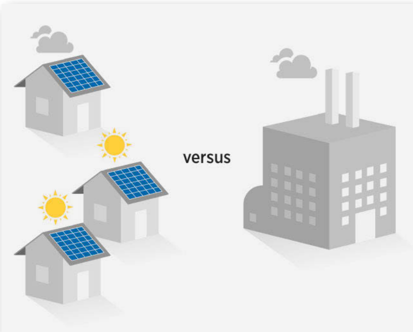
CONCLUSIONS

Reliable, safe and secure electricity is essential for economic and social development and a necessary input for many sectors of the economy. However, electricity generation and associated processes make up a significant portion of global greenhouse gas (GHG) emissions contributing to climate change (IPCC, 2014). At the same time, electricity systems are vulnerable to climate change impacts—both short-term events and changes over the longer term. This vulnerability presents both near-term and chronic challenges in providing reliable, affordable, equitable, and sustainable energy services. Within this context, NREL works to identify challenges and solutions in the energy sector including the need to reliably meet growing electricity demands in developing countries, lessen dependence on imported fuels, expand energy access, and improve stressed infrastructure for fuel supply and electricity transmission for climate resilience.



Source: Cost-Optimal Pathways to 75% Fuel Reduction in Remote Alaskan Villages, 2015

Spatial Diversification

The modular nature of renewable energy technologies, such as wind turbines and solar photovoltaics (PV), allows greater spatial diversification of energy supplies compared to conventional power generation systems, which deliver power from a concentrated point or central location. This increased spatial diversification reduces the vulnerability of the energy supply to cause damage from a single event or a single critical location, which increases overall energy system resilience.

Microgrids

Microgrids capable of islanding based on distributed generation (DG) can disconnect from the central grid during a major climate event to allow energy to be diverted to critical loads. This allows utilities flexibility in restoring generation stations, responding to critical outages, and shutting down systems before a major event to prevent damage. Islanded DG systems ensure consumers have access to power during long-term power outages that severely impact central grid systems, which can occur after major natural disasters.

Water and Energy

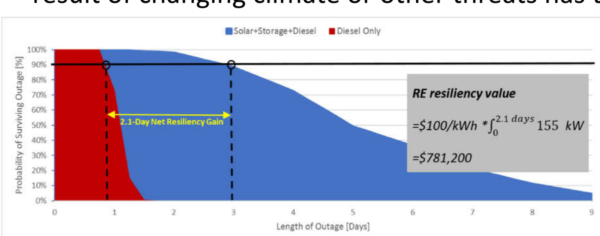
The water-energy nexus is a critical factor in resilience. Water is used for energy generation in hydro-electric plants and in cooling systems for nuclear plants. Simultaneously, energy is used for treating and pumping water supplies. Technical solutions ranging from making power-generation plants more efficient, to using clean-energy technologies, and designing systems to utilize gravity-fed options can enhance resilience of both energy and water systems.

Policies

New Jersey had more than 1,000 megawatts (MW) of installed solar capacity when Hurricane Sandy hit the Northeast United States. However, only two solar PV systems provided power in the days following the hurricane (Hotchkiss et al., 2013). At the time, a combination of interconnection policies and a lack of dynamic controls or transfer switches prevented the islanding of systems. Without appropriate policies and codes, the installed DG capacity in New Jersey did little to aid resiliency. Jurisdictions wishing to enhance resiliency through DG may adopt appropriate policy on interconnection and islanding to realize the full benefits of these energy generation systems.

Redundancy

Redundancy is critical to most operations, but is essential for resiliency. The increased stress on infrastructure systems as a result of changing climate or other threats has the potential to increase the likelihood of failure of one or more parts of a system. Communities served by only one power line or water supply have limited resilience. Increasing supplies, routes, or incorporating redundancy to overall systems will reduce the risks of those systems. In an analysis conducted for a community in New England, NREL determined that pairing renewable energy and energy storage technologies with conventional backup power systems increased the number of days a system could operate without grid connection, illustrated in the image to the left.



Source: Quantifying and Monetizing Renewable Energy Resiliency. Anderson et al. 2018

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