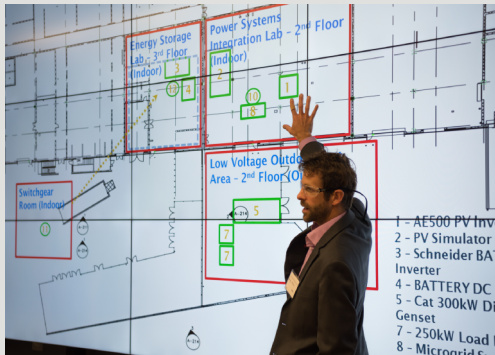


Distributed Energy Generation for Climate Resilience

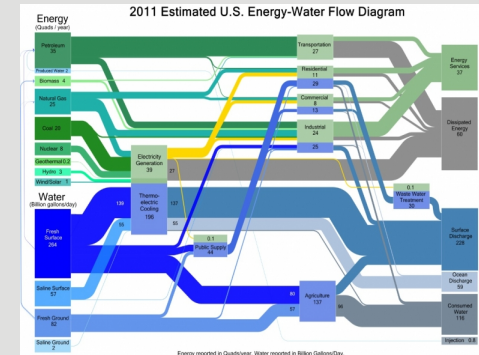
Sherry Stout, NREL
Eliza Hotchkiss, NREL



Modeling energy distribution systems is one aspect of understanding 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, which is the geographic distribution of electricity sources.



A hybrid Sankey diagram from "The Water-Energy Nexus: Challenges and Opportunities" report, issued by the U.S. Department of Energy (DOE) in 2014, how major energy and water flows in the United States are interconnected.

ABSTRACT

At various levels of government across the United States and globe, climate resilient solutions are being adopted and implemented. Solutions vary based on predicted hazards, community context, priorities, complexity, and available resources. Lessons are being learned through the implementation process, which can be replicated regardless of level or type of government entity carrying out the resiliency planning. Through a number of analyses and technical support activities across the world, NREL has learned 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.

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 the stakeholders involved in resilience planning and the end-goal, the methodologies deployed could include community engagement, resilience planning, policy analysis, microgrid modeling, renewable energy feasibility studies, vulnerability and risk assessments. A best-practice approach or methodology would include most of the processes highlighted to the right.

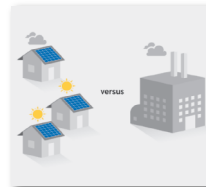


CONCLUSIONS

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 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.

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. Increased spatial diversification reduces the vulnerability of the energy supply from a single event or a single critical location, which increases overall energy system resilience.



Microgrids

Microgrids powered by distributed generation (DG) can disconnect from the central grid during a major climate event to maintain electricity supply to critical loads. With microgrids serving critical loads during a blackout, utilities have more flexibility in restoring generation stations, responding to critical outages, and shutting down in systems before a major event to prevent damage. Islanded renewable energy 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 plays a large role in resilience at many levels. Water is used for energy generation in hydro-electric plants and in cooling systems for nuclear plants. Alternatively, energy is used for treating and pumping water supplies. Technical solutions from making power-generation plants more efficient, 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 MW of installed solar capacity when Hurricane Sandy hit the Northeastern 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, transfer switches, or energy storage solutions prevented the islanding of systems. Without appropriate policies and codes, the installed DG capacity in New Jersey did little to aid resilience. Jurisdictions wishing to enhance resiliency through islanded renewable energy DG systems should adopt policy on interconnection and islanding to realize the full benefits of these technical solutions.

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, 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 right.

