PLANNING A RESILIENT POWER SECTOR

Ensuring reliable, secure, safe, and affordable electricity

What is power sector resilience?

The provision of reliable, secure, and affordable electricity is essential to power economic growth and development. The power system is at risk from an array of natural, technological, and man-made threats, which can cause everything from power interruption to chronic undersupply. To that end, it is critical for policy-makers, planners, and system operators to safeguard their systems and plan for and invest in the improved resilience of the power sector in their countries.

Through holistic resilience planning actors can anticipate, prepare for, and adapt to the threats and stresses on the power system. Resilience planning identifies the threats, impacts, and vulnerabilities to the power system, and devises strategies to mitigate them.

Fig. 1 Severe weather can cause flooding, landslides, and other threats to power system infrastructure and affect energy resource availability. Renewable energy generation can enhance resilience due to its modular nature, and lack of fuel requirements.[5] *Photo from iStock 155353280*

What is Resilience?

Resilience is the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions.[1]

What are threats to the power system?

Power sector vulnerabilities—weaknesses within infrastructure, systems, or operations—are susceptible to natural, technological, and human-caused threats. Impacts from these threats include potential fuel supply shortages for transportation and energy generation, physical infrastructure damage, shifts in energy demand, and disruption of electricity supply to the end user.[2] These disruptions, in turn, adversely affect critical services and facilities (e.g. hospital services, water treatment, and communications networks). As such, it is vital to understand threats to the power system and their associated impacts.

Natural threats include long-term climatic changes such as variations in precipitation patterns and changes in air and water temperatures, as well as severe weather events such as storms, flooding, and storm surges. For example, warmer water and drought may impact the availability of cooling water for thermal generation and increase competition between hydroelectric generation facilities and other users. Altered precipitation patterns and more intense storms can impact hydropower output and biomass resource availability. Changes in wind direction, speed, and availability can alter wind power generation and damage transmission and distribution lines. Flooding and extreme weather events such as hurricanes, severe storms, and wildfires can damage generation, transmission, and distribution infrastructure.[3,4] This damage can cause both short and long-term outages as seen in the United States after hurricanes Irma and Maria.

Technological threats are unpredicted equipment and infrastructure failures. For example, dam failure, nuclear power station accidents, generation station fires, and power outages caused by faulty system equipment are all considered technological threats. These threats can be stand alone or tied to human-caused or natural threats. For example, the Three Mile Island nuclear incident was an isolated technology failure whereas the Fukushima nuclear incident was directly tied to a 15-meter tsunami caused by the Great East Japan earthquake.[5,6] Aging or undersized electricity transmission and distribution infrastructure are also a common threat that can cause the failure and interruption of electricity.

Human-caused threats can be broken into two categories: accidents and malicious events. Accidents involve unintentional actions that damage systems—for example, a driver running into a transmission pole and causing an outage. Malicious-human threats are the result of deliberate, malicious actions such as physical terrorism or cyber-attacks on power infrastructure and control systems. Physical attacks could injure workers and destroy energy infrastructure, such as fuel pipelines or transmission lines. Cyber-attacks can impact system operations or take confidential information—targeting power control systems, generators, or critical data infrastructure.[7]

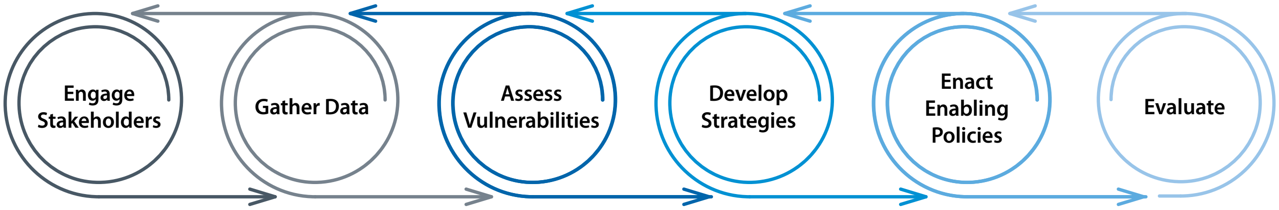
How do I improve power sector resilience?

Improving power sector resilience requires systematically identifying and addressing vulnerabilities through proactive resilience planning. Power sector resilience planning can be done at many geographic scales and should be included within the existing power sector planning processes in place, such as integrated resource planning or power development planing.[7,8]

Planning for power sector resilience

Planning for power sector resilience requires engaging stakeholders in a common vision for a resilient system, gathering needed system data and information, assessing vulnerabilities, and developing strategies and enabling policies to improve the resilience of the sector. To perform a vulnerability assessment, planners initially gather data on critical loads, threats, energy resources, energy system infrastructure, and other relevant areas. The Resilience Roadmap (nrel.gov/resilience-planning-roadmap) and the Renewable Energy Data Explorer (re-explorer.org)

Fig. 2 Planning for power sector resilience can happen at different geographic scales (local, national, or regional), and should be incorporated into existing power sector planning and policies to ensure effectiveness.



- Engage Stakeholders: Include entities beyond utilities and governments to enhance decisions, provide outreach, and ensure buy-in
- Gather Data: Identify necessary energy systems and resources, gaps and vulnerabilities, and impacts of system failure
- Assess Vulnerabilities: Define and assess threats together with their impacts and likelihoods as well as the associated power sector vulnerabilities and their severities
- Develop Strategies: Identify and prioritize solutions to address vulnerabilities and incorporate guidance into existing power sector plans
- Enact Enabling Policies: Adopt policies to realize full benefits of power system resilience strategies and coordinate their implementation
- Evaluate: Learn what is effective and support periodic updates

provide data lists (relevant polices and plans, electricity generation characteristics, transportation systems profiles, energy costs, and government and community operations) and aggregated spatial data (energy resource availability and location of energy infrastructure, among others) that can support resilience planning.

After gathering data, planners conduct a vulnerability assessment that considers the risks (calculated as the product of the likelihood of the threat and the severity of the vulnerability) and exposure (how power systems may respond to threats) posed by certain threats that a system faces.[9]

After assessing vulnerabilities, planners identify and prioritize solutions to improve power sector resilience. These solutions can then be integrated into existing power sector plans and policies.[10]

Solutions may include options such as spatial diversification of generation and transmission, development of microgrids for critical systems, and introducing redundancy to the most vulnerable systems. Any of these solutions should be completed within an appropriate policy framework that values and enables resilience through infrastructure development and operational planning. It is also vital to identify financing that enables implementation of these solutions. The effectiveness of actions and policies should be evaluated regularly, as the resilience process is iterative.[10]

Resilient Power Platform

The Resilient Power (RePower) Platform is an expertly curated collection of resources, training materials, data, and tools that enable decision makers to assess power sector vulnerabilities, identify resilience solutions, and make informed decisions to enhance power sector resilience at all scales. Find out more at www.nrel.gov/usaid-partnership.

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