Increasing Energy Resilience at Tyndall Air Force Base

With increasing frequency of utility grid outages in the United States, there is growing interest in assessing risk and developing mitigations to reduce the impact of such outages. The U.S. Department of Energy's National Renewable Energy Laboratory (NREL) developed an all-hazards energy resilience assessment methodology to help sites develop a comprehensive suite of mitigation actions to increase site energy resilience.

NREL experts work with sites to assess baseline resilience, identify and score hazards and vulnerabilities, analyze risks based on hazards likelihood as well as vulnerability probability and consequence, identify and prioritize mitigation actions, and develop an action plan (Figure 1). The method focuses on risks to a site's primary missions, infrastructure, and population, as well as risks to infrastructure and population in the surrounding community that may impact the site. By considering the interdependencies between energy, water, transportation, and communication systems, this method also allows sites to understand the potential impacts of energy resilience on other critical systems.

Case Study: Tyndall Air Force Base

The Department of Defense has recognized severe weather as a growing hazard for national security, so the Air Force Civil Engineer Center engaged NREL to conduct an all-hazards energy resilience assessment at Tyndall Air Force Base. NREL worked with Tyndall staff to identify hazards and vulnerabilities, analyze risks, and develop mitigation strategies to increase resilience. Before the recommended mitigation strategies could be implemented, Hurricane Michael, a category 5 storm, hit Tyndall Air Force Base in October 2018

Figure 2. Damage at Tyndall Air Force Base after Hurricane Michael.
Photo credit: Airman 1st Class Kelly Walker, DVIDs 4860959.

Figure 1. Energy resilience assessment methodology process.
Image source: Anderson, Kate, Eliza Hotchkiss, Lissa Myers, and Sherry Stout. 2019. *Energy Resilience Assessment Methodology.* Golden, CO: National Renewable Energy Laboratory. NREL/TP-7A40-74983.

Defining Resilience Assessment Terms

Hazard: Anything that can expose a vulnerability or damage, destroy, or disrupt an asset is considered a hazard. Hazards are typically not within the site's control and can include natural or man-made events such as wildfires, hurricanes, storm surges, or cyberattacks. Hazards are scored based on their likelihood of occurring. The term "threat" is often used interchangeably with "hazard."

Vulnerability: Weaknesses within infrastructure, systems, or processes that are within a site's control are considered vulnerabilities. They can be modified or mitigated to prevent a disruption or lessen the consequences of a disruption. Vulnerabilities are scored based on their probability of occurring given a realized hazard, and the severity of their consequence or impact.

Risk: Risk is the combination of the likelihood of a hazard, the probability of a vulnerability occurring given a hazard, and the consequence of the vulnerability. A risk matrix enables analysis and identification of the highest risks.

Mitigation action: This includes changes to infrastructure, systems, or processes that reduce the exposure or consequence of each vulnerability to respective hazards. Mitigation actions are evaluated based on their potential to reduce risk, difficulty, and cost.

and caused significant damage (Figure 2). This unfortunate event provided a unique opportunity to validate and update the resilience assessment. Tyndall Air Force Base is now incorporating the recommended mitigation strategies into rebuilding the base.

Using the Air Force's "5 R" Framework (Table 1), NREL identified a range of mitigation strategies that increase multiple characteristics of resilience. For example, diesel generators alone provide redundancy in the event of a grid outage, but adding renewable energy and storage systems provides diversity in case diesel fuel is unavailable. Table 1 provides examples of the actions sites can take to increase overall resilience, which is improved when multiple characteristics of resilience are addressed.

The storm highlighted the importance of considering the interdependencies between the energy system and related systems, like communications, transportation, food, and water. Many of the most significant vulnerabilities in this storm, such as failures in buildings and communications, were not discretely within the energy system itself, but nevertheless had a considerable impact on the recovery of the energy system and the base operations. Additionally, Hurricane Michael underscored the importance of broader community resilience. Because many of the people who work on base live in the surrounding county and commute to work, the resiliency of the base is closely tied to the resilience of the surrounding community. For example, lack of housing in the broader community after the storm continued to inhibit base personnel and their families from returning to base a year later.

Learn More

For more information about NREL's energy security and resilience activities, visit nrel.gov/energy-solutions/resilient-systems.html.

Table 1. The "Five Rs" of Energy System Resilience. *Table adapted from Air Force Civil Engineer Center.*

Characteristic	Qualities	Examples
Robustness Are systems physically secure?	• Physically secure • Cybersecure • Hardened infrastructure • Performance monitoring	• Active performance monitoring and maintenance • Critical equipment and facilities physically secured and cybersecured • Resilient building and infrastructure design (drainage, underground lines, elevation) • Temporary or permanent relocation of critical missions
Redundancy Are there single points of failure?	• Eliminate single points of failure	• Backup power (i.e., generators or microgrid) and modular assets • Redundant electric, water, wastewater, transportation, and communication systems • Mesh or loop networks to route power from multiple directions • Mission capability duplicated at other sites and multiple staff trained in critical skills
Resourcefulness Do we have diverse options?	• Available power generation • Energy storage • Community coordination	• Diversified generation and fuel sources (generators, renewable energy, and storage) • Diversified water, wastewater, transportation, and communication sources • Load shedding • Community mutual aid agreements and diversified supply chain
Response Are systems automated and self-healing?	• Automated • Self-healing • Performance indicators • Training and exercise	• Training and exercises for outage scenarios, documented procedures • Fault tolerance (controlled cooldown for safe recovery) • Inclement weather response plans • Smart control systems
Recovery Can systems recover?	• Standardized components • Spare parts inventory • Damage assessment • Prioritization of repowering	• Spare parts inventory, preferably using commercial off-the-shelf parts • Utility coordination and agreements • Development of staff support programs to institutionalize resilience and build capacity

NREL
Transforming ENERGY

National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

NREL is a national laboratory of the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Operated by the Alliance for Sustainable Energy, LLC

NREL/FS-7A40-74847 • October 2019
NREL prints on paper that contains recycled content.