Federal Energy Management Program

Best Practices for Resilience in Smart Grid-Interactive Efficient Buildings

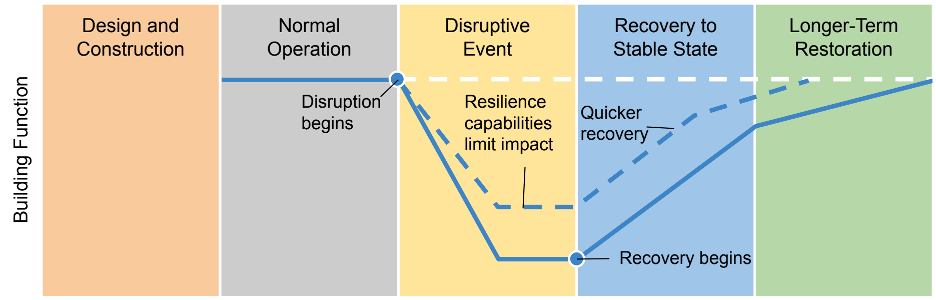

Figure 1. The resilience trapezoid shows a grid outage and the subsequent recovery process. *Illustration adapted from NRELs Resilience Roadmap: A Collaborative Approach to Multi-Jurisdictional Resilience Planning.*[1]

The Federal Energy Management Program (FEMP) supports federal agencies' energy decisions with information and guidance on design, funding, and operations to ensure federal buildings are efficient and resilient. The modernization of building infrastructure and the evolution of buildings to support decarbonization involves complex implementation of multiple components across several systems. This includes energy-efficient equipment, on-site energy generation and storage systems, and control systems. These systems have operational modes that can operate more efficiently if they are able to behave responsively to the conditions of the electrical grid. These grid-interactive efficient buildings (GEBs) allow facilities to manage power demand according to operational constraints and market signals issued by grid operators.

With proper design and planning, GEB's responsive capabilities have the potential to enable building and facility resilience—coordinating with microgrids, maintaining power on critical circuits to sustain essential operations, and monitoring building health and safety status during an outage. By managing the load of buildings, GEBs can also reduce the cost of backup generation and make better use of renewable power sources on site. This document outlines some of the processes and considerations to guide the design and operation of GEBs in ways that promote facility resilience.

GEB Resilience Capabilities

A building's energy resilience capabilities determine its capacity to withstand and rapidly recover from disruptions and power outages without loss of energy-dependent services such as heating, cooling, lighting, and ventilation.[2] Figure 1 illustrates the "resilience trapezoid," the chronological process by which system function degrades and then improves. Depending on the scale of on-site generation and the performance of the GEB, the white dotted line illustrates a scenario where power disruption has no impact for a facility's performance. Loss of power and disruptions can impact building and mission operations. A GEB with enhanced resilience capabilities will help limit the scope and impact of those events.

Resilience strategies can be deployed prior to, during, and following the phases of a disruptive event. Holistic planning and proper design can prepare a building and mitigate loss of functions. During an event, a buildings' response and design can reduce impacts and lengthen survivability. By configuring a system for restoration and recovery, the resilience of the operational control systems themselves can also be improved to support a rapid restoration in the event of a disruption.

Designing GEBs for Resilience

GEBs that support resilience are designed to optimize reliability of their critical systems and functions, to be responsive to disruption, and to recover from reduced function in a predictable way. Federal facility managers and building owners can take the following steps when designing GEBs for resilience.

Evaluate Mission-Critical Activities

The first step to designing GEBs for resilience is to evaluate the mission criticality of the activities that a building supports. Building design should follow best practices for efficient building design to reduce overall load during normal operations, such as integrating

> With proper design and planning, GEB technologies can enable building and facility resilience—coordinating with microgrids, maintaining power on critical circuits to sustain essential operations, and monitoring building health and safety status during an outage.

---

1 Hotchkiss, Eliza and Alex Dane. 2019. *Resilience Roadmap: A Collaborative Approach to Multi-Jurisdictional Resilience Planning*. Golden, CO. National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy19osti/73509.pdf.

2 Office of Energy Efficiency and Renewable Energy. "Energy Resilience." Accessed August 2024. https://www.energy.gov/eere/energy-resilience.

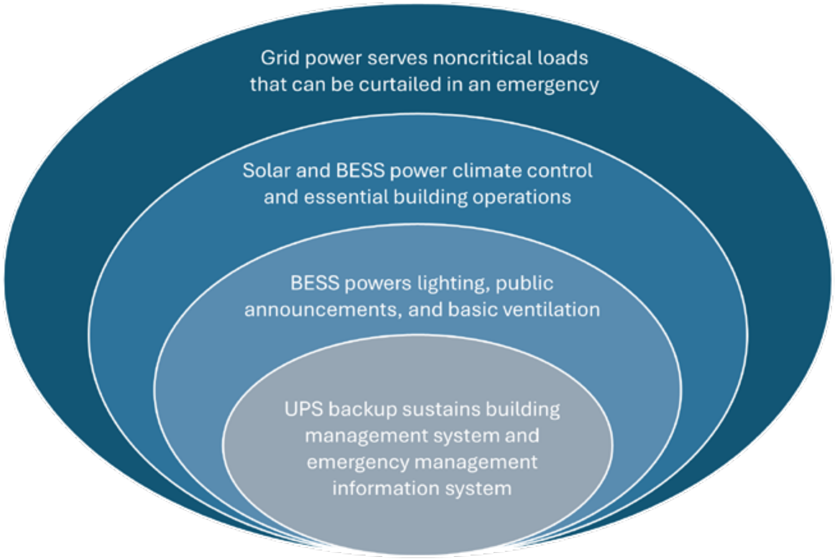

Figure 2. Sample operational hierarchy for a resilient GEB. *Illustration by Fred Zietz, NREL*

thermal mass; planning for passive heating and cooling where possible; and using energy-efficient heating, ventilation, and air conditioning (HVAC) systems. Programs and standards for building efficiency include ENERGY STAR®, Passive Building, and ASHRAE 100.[3] Building efficiency, particularly in new-build construction, can reduce the cost of long-duration energy storage and the size of on-site generation required to sustain building function during a power disruption.

Integrate Monitoring and Control Systems

The next step to designing GEBs for resilience is to integrate building monitoring and control systems to maintain situational awareness of the current system state and enable real-time responsiveness to disruptive events. Cybersecurity is a critical consideration in the integration of these systems, even more so where building uses include high-risk or industrial operations (for more information see Cybersecurity and Infrastructure Security Agency guidance on industrial control systems).[4] Government facilities must also ensure that all integrated systems have the proper Authorization to Operate clearance prior to integration and commissioning.

Critical loads should be prioritized by building operators early on to understand which energy circuits need to maintain power during a disruption. The building systems can be programmed to shift or shed load (delaying or disrupting building services) based on available energy from their utility, local generation source, or battery energy storage system (BESS). This capability helps to ensure continuous operations of critical loads (e.g., security and safety-related systems, such as fire alarms and sprinkler systems, building access, public announcement systems, and emergency lighting).

GEB Resilience During Disruptive Events

During a disruptive event, load flexibility, prioritized critical loads, and enhanced systems controls enable a resilient GEB to optimize mission performance whether grid-connected or islanded. Figure 2 illustrates how prioritization can support core functions while curtailing less essential energy uses.

Interaction with utilities can forecast future power availability and allow the GEB to plan accordingly, reducing or shifting operations and prioritizing critical functions. Facilities with on-site generation, such as backup generation, BESS, or cogeneration plants, can employ load flexibility to ensure critical resources have power and critical operations are sustained. Resilient GEBs can more actively control systems and operations by increasing ventilation to key building spaces, maintaining critical security access points, and prioritizing mission operations. Campuses can interact with utilities to provide

A resilience-supporting monitoring and control system should:

- Provide an overview of all relevant building functions and connections to the grid
- Bring detected anomalies to the operators' attention
- Allow operators to shut down lower-priority building functions as needed
- Guide the operator when returning from the lowest point of function in a way that is predictable
- Support grid interactions such as reducing load or sharing energy production and storage assets.

To ensure reliability, these systems must be well maintained with software patches installed on a timely basis and sufficient skilled workforce capacity with awareness of critical systems.

3 ENERGY STAR Certification for Buildings: https://www.energystar.gov/buildings/building-recognition/building-certification; Phius Passive Building Principles: https://www.phius.org/passive-building/what-passive-building/passive-building-principles; and ANSI/ASHRAE/IES Standard 100: https://www.ashrae.org/technical-resources/bookstore/standard-100.

4 Cybersecurity and Infrastructure Security Agency. "Recommended Cybersecurity Practices for Industrial Control Systems." Department of Homeland Security. Accessed August 2024. https://www.cisa.gov/sites/default/files/publications/Cybersecurity_Best_Practices_for_Industrial_Control_Systems.pdf.

responsive behavior in support of the local utility. This can include dispatching additional generation assets as well as reducing campus loads.

GEB Recovery After Disruptive Events

Critical operational functions in a GEB with a building management system and responsive controllers should be configured with an uninterruptable power supply (UPS) to sustain the control systems and essential communications equipment upon which they depend. A UPS reduces an outage's impact on operation and a buildings' ability to come back online quickly and efficiently following a disruption. The detection and monitoring of system functionality allows a GEB to come back online in a predictable manner.

Beyond the narrow UPS sustaining the controller itself, a BESS, as well as other forms of on-site generation, can help the building or facility to sustain functionality. In general, a GEB is not resilient if it is unable to sustain basic function during an outage, a capability that is fundamentally dependent on access to energy storage and/or generation. A resilient GEB is uniquely capable of restarting operations and in some narrow cases can be used to help a campus or community restart. Continuous monitoring and anomaly detection in a GEB allow a building operator to identify and repair any systems or equipment that were damaged during a disruption.

GEB Resilience Risks

GEBs include a potentially significant list of internet-connected devices. Working in concert, these devices have the potential to reduce peak demand and energy costs, and to adjust to power disruptions to ensure operational continuity. At the same time, the devices themselves can present a potential access pathway for threat actors, thereby increasing a building or facility's cybersecurity risk profile.

Authorization to Operate warrants careful consideration in the design and operation of GEBs, as does the resilience of different operational modes that assume a disruption in the performance of specific devices within the overall system. Effort should also be made to consider disruptions to communications and cyber risk scenarios that could disrupt building operations and to know how these disruptions would be managed.

Operational best practices for cybersecurity include:

- Ensuring awareness of all internet-connected devices
- Making updates on a timely basis
- Isolating operational networks from internet connectivity wherever possible
- Working closely with GEB vendors and manufacturers to delineate risk accountability within subcontracts and purchase agreements.

Other risks include the physical security risk of the control systems, the risk presented by a centralized system that relatively few users can repair or recover if an issue occurs, the need for ongoing testing and maintenance, and the possibility of communications disruptions during a grid outage.

Applicable Incentives

GEB capabilities and associated enabling smart technologies are often funded through capital upgrade funds, utility incentives, the structure of energy tariffs, and performance contracts. These types of incentives may not be available for some resilience features, such as energy storage, because a BESS held in reserve for outages is not available during normal operations. However, other aspects of the incremental cost of designing and operating a GEB with resilience capabilities in mind may involve relatively minor software modifications that do not add significant additional cost to the overall system. In fact, relative to the cost of emergency generation capacity (e.g., a distributed energy system and/or BESS), the emergency flexibility of the GEB provides significant potential cost reductions in the distributed energy and BESS system capacity and related circuit sizing.

Key Resources

- Browse training opportunities: www7.eere.energy.gov/femp/training
- Learn about federal energy management requirements: www7.eere.energy.gov/femp/requirements/
- Request technical assistance: www7.eere.energy.gov/femp/assistance
- Read FEMP news and subscribe to FEMP Digest: energy.gov/femp/femp-newsroom
- Follow FEMP on LinkedIn: www.linkedin.com/company/doefemp/

Learn More

Learn more about the following FEMP programs and initiatives.

Grid-Interactive Efficient Buildings: energy.gov/femp/grid-interactive-efficient-buildings-federal-agencies.

Resilience Planning and Valuation: energy.gov/femp/resilience-planning-and-valuation.

Energy Savings Performance Contracts: energy.gov/femp/energy-savings-performance-contracts-federal-agencies.

Utility Program and Utility Energy Service Contracts: energy.gov/femp/utility-program-and-utility-energy-service-contracts-federal-agencies. ■

Federal Energy Management Program

For more information, visit:
energy.gov/femp

DOE/GO-102024-6454 · October 2024