U.S. DEPARTMENT OF
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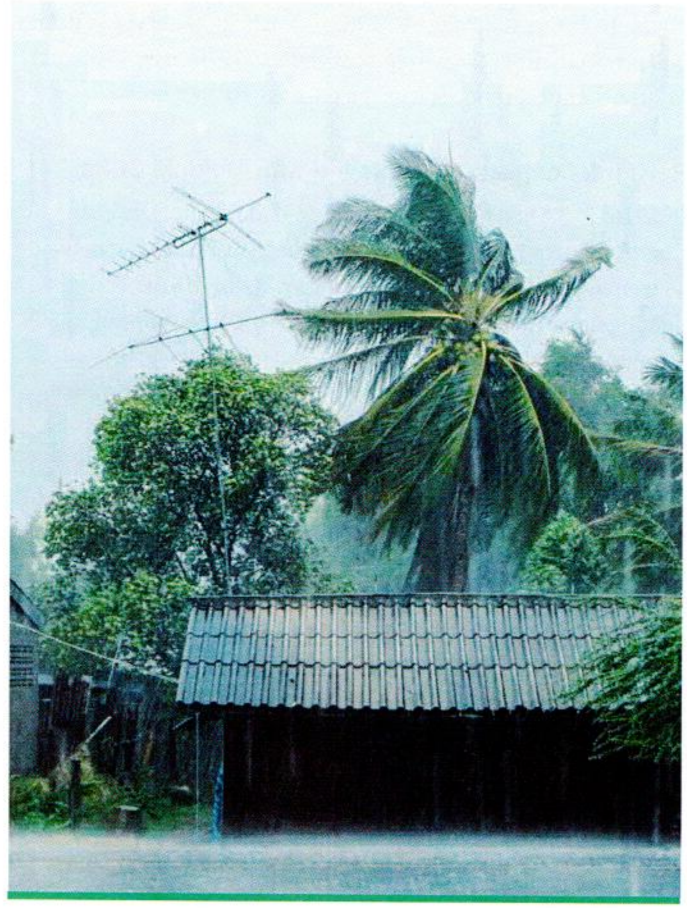
Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

Energy Efficiency and Distributed Generation for Resilience: Withstanding Grid Outages for Less



Communities across the United States experience extreme weather-related events that lead to disruptions in electric service.[1] In 2017 alone, the nation experienced droughts, floods, freezes, hurricanes, and wildfires that cumulatively cost over $300 billion in damages[2] and led to longer and more frequent disruptions in power.[3] Without on-site backup power, these disruptions endanger public safety, security, and health. To better prepare for future disruptions, state and local governments are reducing the electric demand of their critical operations through energy efficiency, as well as making new investments in microgrids with distributed generation to ensure continuous electric supply during extended grid outages to power critical facilities.[4]

The strategy is simple: when a critical public facility needs less energy to function, it also needs less backup generation on-site to operate when the grid goes down.[5] This strategy applies whether the site's resilience plan uses a diesel generator, combined heat and power (CHP), or battery storage combined with distributed renewable resources like solar photovoltaic (PV) or wind. For many public buildings, energy efficiency is a cost-effective investment that can also make it cheaper to power through a grid outage.[6]

Energy efficiency improvements also save money at public facilities during normal operations by lowering energy bills year-round. This spectrum of benefits can be especially appealing to public officials considering options for strategically investing in long-term energy resilience in their communities.

Case Studies: Energy Efficiency Integration into Resilience Planning

In the cases below, investments in distributed energy resources (DERs) were implemented in buildings where maintaining operations during a grid outage is a high priority. In each case, as part of a holistic strategy, energy efficiency helps the site maintain operations with less power needed:

[1] U.S. Energy Information Administration. (November, 2018). Average U.S. electricity customer interruptions totaled nearly 8 hours in 2017. https://www.eia.gov/todayinenergy/detail.php?id=37652.

[2] NOAA National Centers for Environmental Information (NCEI). (2019). Billion-Dollar Weather and Climate Disasters. https://www.ncdc.noaa.gov/billions/.

[3] U.S. Energy Information Administration. (November, 2018). Average U.S. electricity customer interruptions totaled nearly 8 hours in 2017. https://www.eia.gov/todayinenergy/detail.php?id=37652.

[4] National Association of Regulatory Utility Commissioners (NARUC). (April, 2019). The Value of Resilience for Distributed Energy: An Overview of Current Analytical Practices. https://pubs.naruc.org/pub/531AD059-9CC0-BAF6-127B-99BCB5F02198; U.S. Department of Energy, Better Buildings. (August, 2018). Promising Practices in Energy Resilience. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/Promising-Practices-Energy-Resilience.pdf.

[5] One recent report on microgrids and efficiency at U.S. military bases found that when a site "reduces those power needs through energy conservation and efficiency, its energy security costs drop proportionately," Noblis. (2017). Power Begins at Home: Assured Energy for U.S. Military Bases. https://noblis.org/wp-content/uploads/2017/11/Power-Begins-at-Home-Noblis-Website-Version-15.pdf.

[6] U.S. Department of Energy, Better Buildings. The Efficiency-Resilience Nexus. https://betterbuildingsinitiative.energy.gov/sites/default/files/attachments/Resilience%20factsheet%20BBC.pdf.

Jackson, Mississippi–CHP for Continued Operation

The Mississippi Baptist Medical Center (MBMC) in Jackson, Mississippi, installed an on-site 4.2-MW natural gas-fueled combustion turbine CHP system,[7] which allowed MBMC to continue operations during Hurricane Katrina in 2005 for over 50 hours. To ensure reliability, MBMC was able to island (i.e., operate independently from the power grid) and reduce its energy demand to sustain critical services with the on-site CHP system.[8]

Hartford, Connecticut–Microgrid with Multiple DERs

In 2016, 777 Main Street, a mixed-use building in Hartford, Connecticut, implemented a suite of energy efficiency, renewable energy, and resilience solutions, including HVAC and lighting upgrades, a microgrid with a 92.7-kW rooftop solar PV system, and a 400-kW hydrogen fuel cell. This integrated project represents the nation's first microgrid financed through Commercial Property Assessed Clean Energy (C-PACE).[9] The building can now island itself from the energy grid and operate independently in case of natural disasters or extreme weather events. The mixed-use commercial and residential building has significantly reduced energy demand, with savings of over $300,000 in one year and approximately $1.7 million in estimated lifetime savings, which will result in lower utility bills for tenants.[10]

Birmingham, Alabama–Microgrid with Multiple DERs

The U.S. Department of Energy (DOE) is currently working with Alabama Power to complete a Smart Neighborhood[11] in Birmingham, Alabama. The homes built in this community are all high-performance homes, built according to high-efficiency construction techniques and rated with a Home Energy Rating System (HERS) score between 40 and 50, which means they are 50-60% more efficient than a standard new home. The homes are connected as a neighborhood-level microgrid, which integrates solar PV, a battery storage system, and natural gas-fired power generation. This is the first microgrid in the Southeast to support an entire residential community, while also supporting community-scale energy resilience.[12]

Resources to Explore Efficiency and Distributed Generation for Critical Infrastructure Resilience

DOE's Office of Energy Efficiency and Renewable Energy has developed a host of resources to explore how state and local governments can assess options for including energy efficiency and distributed generation for resilience planning. These include:

- ***The Distributed Generation for Resilience Planning Guide***, a recent Better Buildings resource, provides information about considering different distributed energy efficiency and renewable energy options for public buildings: https://betterbuildingsinitiative.energy.gov/resources/distributed-generation-dg-resilience-planning-guide.
- Another Better Buildings resource, ***The Efficiency-Resilience Nexus***, describes other ways energy-efficient technologies and practices can increase resilience: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Resilience%20factsheet%203.4.19.pdf.
- Even for efficient buildings, resilience investments (such as microgrids) can require substantial upfront costs. State and local governments can use financing mechanisms to help pay for and implement distributed generation technologies for resilience. For more information, visit:
  - Better Buildings Financing Navigator: https://betterbuildingsinitiative.energy.gov/financing-navigator
  - C-PACE for Resiliency Toolkit: https://betterbuildingssolutioncenter.energy.gov/toolkits/commercial-pace-financing-resiliency
  - Energy Savings Performance Contracting (ESPC) Toolkit: https://betterbuildingssolutioncenter.energy.gov/energy-savings-performance-contracting-espc-toolkit

[7]CHP systems can meet a site's electricity and heating needs more efficiently by using a single system, compared to purchasing grid electricity and running a separate heating system. For more information, see: https://www.energy.gov/eere/amo/combined-heat-and-power-basics.
[8]U.S. Department of Energy. (December, 2016). CHP in Hospitals - Improving Resilience and Lowering Energy Costs. https://www.harcresearch.org/sites/default/files/documents/projects/CHP%20in%20Hospitals%20%20Improving%20Resilience%20and%20Lowering%20Energy%20Costs.pdf.
[9]C-PACE is a financing mechanism for energy efficiency, renewable energy, and resilience upgrades on properties. C-PACE allows for funds borrowed to complete a project to be repaid through a voluntary property tax assessment. Learn more here: https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs.
[10]U.S. Department of Energy, Better Buildings. Commercial Pace Financing for Microgrid in Mixed-Use Building. https://betterbuildingssolutioncenter.energy.gov/implementation-models/commercial-pace-financing-microgrid-mixed-use-building.
[11]Alabama Power describes Smart Neighborhoods as neighborhoods with homes that feature "energy-efficient appliances, connected devices, innovative security solutions and home automation…all designed to simplify homeowners' lives and give them more control over their home and energy use." More information is available at https://www.smartneighbor.com/pages/neighborhood.
[12]U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. (June, 2018). The First Smart Neighborhood of its Kind in the Southeast. https://www.energy.gov/eere/buildings/articles/first-smart-neighborhood-its-kind-southeast.

Examples of Critical Infrastructure

Depending on community needs, a wide range of public facilities may be high-priority candidates for EE and distributed generation:

- Correctional Facilities
- Designated emergency shelters, such as schools or community centers
- Emergency operation centers
- Food preparation and storage facilities
- Hospitals, nursing homes, and other health care facilities
- Police and fire stations
- Waste storage and treatment facilities
- Water and wastewater treatment facilities.

Example Scenarios: Exploring the Impacts of Efficiency on Resilience Costs

In each of the three examples below, a model of an illustrative building with energy usage based on a specific purpose and specific location is analyzed to estimate the cost of a microgrid system with enough solar and storage to provide 50% of normal electricity needs for up to 48 hours.[13] Then, an energy efficiency scenario is analyzed to estimate the cost of meeting the same grid outage if the same building makes a 20% reduction in baseline energy usage—a level of savings that has been achieved and even exceeded by partners that include public sector organizations across the United States through DOE's Better Buildings Challenge. More than 360 Better Buildings Challenge partners have saved more than 1.38 quadrillion Btus and $3.8 billion since the program's inception.[14]

These examples were developed using the National Renewable Energy Laboratory's (NREL's) REopt Lite tool to illustrate the potential cost savings of reducing energy needs through efficiency before investing in a resilient "islandable" microgrid.[15] The REopt Lite tool is free and can be used by state and local governments to explore options for their own buildings. For more information, visit: https://reopt.nrel.gov/tool.

Example 1: Model of a Hospital in Nashville, Tennessee

Hospitals are high-priority sites for ensuring a resilient power source is available during an outage. In this example, a hospital would reduce its investment cost by nearly $2 million by pursuing energy efficiency measures to achieve 20% energy savings before sizing its microgrid to run critical loads during a 48-hour grid outage.

Electricity Use Scenario	Solar Generation Capacity	Battery Storage Capacity	System Cost[16]
Baseline Annual Usage: 8.9 million kWh	*4,065 kW*	*6,944 kWh*	*$9,308,000*
20% Energy Savings: 7.1 million kWh	*3,252 kW*	*5,555 kWh*	*$7,446,000*

[13]Examples were chosen to show a range of building types in a range of different climate zones, where the patterns of energy use and energy needs during an outage could vary.

[14]These energy efficiency investments pay for themselves over time, and through a variety of financing mechanisms, can be installed with little or no upfront cost. More information on financing is available in the resources described in the previous section of this document. More information at https://betterbuildingsinitiative.energy.gov/challenge and https://betterbuildingssolutioncenter.energy.gov/sites/default/files/program/DOE_BBI_2019_Progress_Report.pdf.

[15]In each example scenario, the site is not assumed to already have any backup generation. For each site, baseline electricity load is taken from REopt Lite default setting for the specific building type.

[16]This amount, calculated in REopt Lite, includes "The installed system cost, including the capital cost of the system (after tax and incentives) and the present value of future operation and maintenance costs." More information is available at https://reopt.nrel.gov/tool/REopt%20Lite%20Web%20Tool%20User%20Manual.pdf#page=47.

[17]Results are based on a local General Service Demand Time of Use Tariff.

Example 2: Model of a High School in Orlando, Florida[17]

K-12 school buildings serve as emergency shelters in many communities. In this example, the estimated upfront cost of a resilient microgrid goes down by about $400,000 if energy efficiency investments can reduce energy needs by 20%.

Electricity Use Scenario	Solar Generation Capacity	Battery Storage Capacity	System Cost
Baseline Annual Usage: 3,421,024 kWh	*661 kW*	*1559 kWh*	*$1,966,000*
20% Energy Savings: 2,736,819 kWh	*531 kW*	*1,247 kWh*	*$1,575,000*

Example 3: Model of a Police Station in Boulder, Colorado

In this example, the modeled police station has significantly lower electricity needs than the school or hospital. But even in this case, achieving efficiency savings at a police station allows critical operations to continue during a multi-day outage for an estimated $12,000 less in initial investment.

Electricity Use Scenario	Solar Generation Capacity	Battery Storage Capacity	System Cost
Baseline Annual Usage: 84,900 kWh	*42 kW*	*82 kWh*	*$110,000*
20% Energy Savings: 67,920 kWh	*33 kW*	*66 kWh*	*$88,000*

Conclusion

Ensuring critical facilities have a resilient, reliable power supply is a priority for states and communities across the United States. Incorporating energy efficiency as a part of a holistic approach to resilience planning, particularly in the context of microgrids to withstand grid outages, can make resilience investments more affordable and more effective. DOE technical resources can help inform officials about how energy efficiency and other distributed energy technologies can support states and communities, so they can achieve their energy and resilience goals.

For more information visit:

DOE's State and Local Solution Center: energy.gov/eere/slsc

Better Buildings Solution Center:
betterbuildingssolutioncenter.energy.gov

Contact us:
stateandlocal@ee.doe.gov

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