RESILIENT ENERGY SYSTEMS

AN INTRODUCTORY GUIDE FOR SOUTHEAST FLORIDA

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Institute for Sustainable Communities (on behalf of the Southeast Florida Regional Climate Change Compact)

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North Carolina Clean Energy Technology Center

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ABOUT THE DOCUMENT

In the fall of 2018, the Southeast Florida Regional Climate Change Compact (the Compact), in partnership with the Department of Energy's Southeast Combined Heat and Power Technical Assistance Partnership, convened regional stakeholders—including local government staff, non-profit organizations, utility representatives, and institutional building facility managers—to learn from local and national resilient energy system experts during a two day-long implementation workshop titled *Resilient Energy System*s. The convening is part of a workshop series designed to advance the implementation of the Climate Compact's Regional Climate Action Plan and specifically focused on recommendations from the Energy and Fuel and Risk Reduction and Emergency Management chapters. This guidance report builds upon and supports the content presented at that workshop with the goal of providing local government staff and other stakeholders with a basic grounding in this topic. All event resources, including expert speaker presentations, can be found on the event webpage.

ABOUT THE AUTHORS

Institute for Sustainable Communities

Since 1991, the Institute for Sustainable Communities (ISC) has worked in the United States and around the world to help communities, cities, industry, and NGOs accomplish their environmental, economic, and social goals. ISC uses training, technical assistance, peer-to-peer learning, and demonstration projects to help unleash the power of local people and institutions to address immediate challenges and opportunities – all while building those on-the-ground solutions into national and international best practices and policy. At the heart of the organization's approach is results focused, authentic and pragmatic engagement with all stakeholders, which unearths locally-driven and equitable solutions to the biggest challenge we face – global climate change. ISC provides implementation support to the Southeast Florida Regional Climate Change Compact. Learn more at sustain.org and us.sustain.org.

Southeast Combined Heat and Power Technical Assistance Partnership (CHP TAP)

The Southeast Combined Heat and Power Technical Assistance Partnership (CHP TAP) is part of a network of 10 regional centers under the U.S. DOE CHP Deployment Program that promote and assist in transforming the market for CHP, waste heat to power, microgrids, and district energy with CHP throughout the United States. The CHP TAPs offer technical and educational resources to facilities considering deployment of resilient energy systems. The CHP TAPs also support stakeholders, including regulators, utilities, and policymakers, to identify and reduce the barriers to using CHP to advance efficiency, promote energy independence and enhance the nation's resilient grid. energy.gov/chp

North Carolina Clean Energy Technology Center

The North Carolina Clean Energy Technology Center was founded in December 1987 as the North Carolina Solar Center. For the last 30 years, the Center has worked closely with partners in government, industry, academia, and the nonprofit community while evolving to include a greater geographic scope and array of clean energy technologies. Through the Center's programs and activities, they envision and seek to promote the development and use of clean energy in ways that stimulate a sustainable economy while reducing dependence on foreign sources of energy, and mitigating the environmental impacts of fossil fuel use.

The Southeast Florida Regional Climate Change Compact

Established in 2009 through local government leadership, the Southeast Florida Regional Climate Change Compact (the Compact) is a ground-breaking regional collaborative between Broward, Miami-Dade, Monroe and Palm Beach counties focused on regional coordination and joint action to build climate resilience and reduce greenhouse gas emissions. For 10 years, the Compact counties have successfully collaborated on mitigation and adaptation strategies, built bipartisan support for action, and forged partnerships with key stakeholders, including economic development entities, community-based organizations, and the academic community, enabling the development of a regional voice and vision for future prosperity in Southeast Florida. The Compact provides a regional vision for addressing climate change in Southeast Florida through the Regional Climate Action Plan (RCAP). Regional planning standards, shared policy platforms, and informational resources for municipal action can be found at www.southeastfloridaclimatecompact.org.

What are Resilient Energy Systems?

Southeast Florida communities are faced with increasingly intense extreme weather events and changing weather patterns as a result of climate change. Hurricanes and extreme weather frequently causes widespread and extended power outages, which can result in significant economic and human loss.[1] Power outages at critical infrastructure facilities—such as emergency operations centers, shelters, hospitals, and nursing homes—limit and sometimes completely inhibit first responders and emergency managers from adequately providing emergency response services to communities. Vulnerable populations such as the sick, elderly, and those with lower-incomes are at the most risk during energy system failures in Florida, as they face an increased danger of being left without air conditioning during extreme heat[2] and may require electricity or refrigeration for life-saving medicine or medical equipment.

Building communities that are resilient to the impacts of climate change requires addressing the vulnerabilities of our energy system and critical infrastructure facilities that serve communities in the event of a disaster. Local governments and private building owners in Southeast Florida that oversee these facilities can benefit from creating energy systems that are increasingly resilient to climate-risks. While critical infrastructure facilities typically use diesel generators and other forms of fossil-fueled generation for backup power when the grid goes down, recent hurricane events have highlighted the risks of relying on diesel as the only backup power option given the potential of diesel supplies running out during a sustained outage, or equipment failure.

Resilient energy systems are electric and thermal generation technologies, software, and processes designed to maintain critical services through grid disruptions. Resilient energy systems are inherently flexible—often designed around location-specific energy solutions and scalable according to the facility's operational needs. Resilient energy systems often deploy prescribed, automated, and precise responses to systems changes, ensuring critical operations are maintained through a disruption without requiring continual decision making.

Designing energy systems to be resilient through extreme weather offers broader non-emergency benefits to the community. Increasing the diversity of energy sources ensures the overall stability of the electrical grid. Resilient energy systems promote ongoing monitoring and maintenance of energy system components, and can also reduce year-round energy costs through on-site energy generation and storage that offsets purchased electricity overall, and/or reduces electricity purchased at peak times.

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[1] Chittum, Anna, and Relf Grace. 2018. *Valuing Distributed Energy Resources: Combined Heat and Power and the Modern Grid.* White Paper, Washington, DC: American Council for an Energy-Efficient Economy

[2] Robinson, Marriele, and Seth Mullendore. 2019. "Resilient Southeast: Exploring Opportunities for Solar+Storage in Miami, FL." April 25. https://www.cleanegroup.org/wp-content/uploads/Resilient-Southeast-Miami.pdf.

The Climate Compact's Regional Climate Action Plan recommends increasing long-term community resilience and disaster recovery through distributed solar generation, battery storage, microgrids, CHP, and other techniques of distributed production and storage. Additionally, the Regional Climate Action Plan recommends prioritizing these resilient power systems at emergency command centers, shelters, hospitals, senior living centers, and multifamily affordable housing units.

Resilient Energy Technologies

Resilient energy system designs vary depending on local vulnerabilities, electricity production, grid structure, and regulatory environments. However, the core design principle in resilient energy systems is ***distributed energy resources and generation*.** In order to maintain critical infrastructure and services when the centralized energy grid is disrupted, resilient energy systems rely on decentralized energy production and storage technologies, using a combination of production and storage technologies based on local needs. Distributed Generation (DG) technologies such as combined heat and power and rooftop solar can be combined with energy storage and management resources such as batteries, sensors, and monitoring technology for more localized control. Three key resilient energy technologies that cities and utilities deploy are ***combined heat and power***, ***microgrids***, and ***solar+storage***.

The resiliency of a specific technology can vary from location to location depending on what hazards it and the facility are exposed to. Some technologies and supporting infrastructure offer more reliable and resilient service from certain hazards. A resilient energy system should be designed based on the local natural hazards a community faces. The U.S. Department of Energy Distributed Energy Disaster Matrix (page 8) outlines the susceptibility of different energy technologies to natural disasters and weather events.

Ranking Criteria

Four basic criteria were used to estimate the vulnerability of a resource during each type of disaster event. They include the likelihood of experiencing:

1. *a fuel supply interruption,*
2. *damage to equipment,*
3. *performance limitations, or*
4. *a planned or forced shutdown*

○ *indicates the resource is unlikely to experience any impacts*

⊖ *indicates the resource is likely to experience one, two, or three impacts*

● *indicates the resource is likely to experience all four impacts*

Natural Disaster or Storm Events	Flooding	High Winds	Earthquakes	Wildfires	Snow/Ice	Extreme Temperature
Battery Storage	⊖	○	⊖	●	○	⊖
Biomass/Biogas CHP	⊖	⊖	⊖	●	○	○
Distributed Solar	○	⊖	⊖	●	⊖	⊖
Distributed Wind	○	⊖	⊖	⊖	⊖	⊖
Natural Gas CHP	○	○	⊖	⊖	○	○
Standby Generators	⊖	○	⊖	●	⊖	○

Source: DOE Better Buildings (2018). Issue Brief: Distributed Energy Resources Disaster Matrix

Distributed Generation for Resilience Planning Guide

Better Buildings, U.S. Department of Energy

This guide provides an introduction to the distributed generation technologies and planning guidance for state and local decision-makers to ensure energy supply to critical infrastructure. The guide also includes case studies of how public and private leaders have designed and invested in resilient energy for hospitals, universities and schools, correctional facilities, wastewater treatment plants, and multi-family homes.

Resilient Power Project Toolkit

Clean Energy Group

This toolkit includes reports and analysis by Clean Energy Group and partner organizations focused on the components of a resilient power system project: technology, financing, project evaluation, project development, and policy considerations.

Distributed Energy Resources Disaster Matrix

Better Buildings, U.S. Department of Energy, 2018

This issue brief provides an overview of the vulnerabilities and strengths of different resilient energy system technologies, and how they may perform in a variety of natural disasters or storm events. Local government and private property owners interested in investing in resilient energy systems can use this analysis to determine what technologies best suit their site, based on the local natural hazards.

COMBINED HEAT AND POWER

Combined Heat and Power (CHP), also known as ***cogeneration***, is a process of energy generation that captures the thermal energy emitted from a natural gas or biomass generator and uses that waste heat to heat or cool buildings and water on-site. CHP is typically 40–60% more efficient than non-CHP natural gas production.[3] Because of the on-site utilization of waste heat, CHP systems are used as on-site generation for large buildings or facilities, offsetting some or all of the electricity purchased from a utility. CHP systems can be designed to island from the utility grid, therefore offering high-capacity onsite generation that can continue to operate when the electricity grid fails. Currently, CHP systems account for 8% of U.S. electricity generating capacity through over 4,400 industrial and commercial facilities.

The basic design of a CHP system consists of capturing the waste heat through steam or water during generation, through a heat recovery unit, or by utilizing a steam turbine. CHP systems are designated by their ***prime mover technologies***, or the type of technology a system uses to generate electricity. Common prime mover technologies in CHP include reciprocating engines, gas turbines, micro turbines, fuel cells, and boiler/steam turbines. Each technology varies in size, electric efficiency, CHP efficiency, and cost.[4] For a full comparison of CHP technologies based on-site needs, refer to the U.S. Department of Energy's Combined Heat and Power Technology Fact Sheet.

U.S. Department of Energy CHP Deployment Program

The U.S. Department of Energy CHP Deployment Program provides stakeholders with the market analysis, research, and policy tools necessary to identify CHP market opportunities of cost-effective applications within commercial, industrial and institutional facilities.

- **U.S. Department of Energy CHP Technical Assistance Partnership (CHP TAP) - Southeast Region**
  The CHP TAPs offer no-cost resources including, screenings, technical assistance, and expert advice to help determine if CHP is a good fit for sites interested in efficiency, cost savings and resilience. The CHP TAPs provide fact-based, unbiased education to advance sound CHP programs and policies.
- **Packaged CHP Catalog (eCatalog)**
  This database provides public and private facility owners a comprehensive list of companies that provides packaged CHP that have been approved by DOE's performance requirements, and committed to responsible installation and maintenance of the energy system. The

[3] n.d. *Distributed Generation (DG) for Resilience Planning Guide: Combined Heat and Power (CHP) 101.* https://resilienceguide.dg.industrialenergytools.com/chp.
[4] 2017. "Combined Heat and Power Technology Fact Sheet Series." *Energy.gov.* November. https://www.energy.gov/sites/prod/files/2017/12/f46/CHP%20Overview-120817_compliant_0.pdf.

eCatalog also indicates when an equipment package is eligible for a state, local government, and utility incentive program, based on the location of the facility.

- **CHP Installations and Project Profiles Database**
  This catalogue of CHP installations and over 130 CHP project fact sheets from CHP Technical Assistance Partnership is searchable by geography, type of technology, and sector or application.
- **CHP Screening Tool**
  CHP Site Screening Tool can provide a quick individual site screening assessment for CHP, based on a few simple user inputs and predetermined metrics.

CHP Policies and Incentives Database (dCHPP)

Environmental Protection Agency

The CHP policies and incentives database is an online U.S. CHP policy database hosted by the Environmental Protection Agency. The dCHPP allows users to search for CHP policies and incentives at federal, state, and local levels including eligibility requirements. This information is updated annually.

Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities

ICF International, 2013

Through a series of case studies, this report outlines how different CHP energy systems serving critical infrastructure performed during Superstorm Sandy. The impacts of the storm provide a litmus test for how a variety of CHP technology, sizes, and fuel sources fared when faced with extreme stress on the power grid.

MICROGRIDS

A ***microgrid*** is a locally controlled electrical power system of energy loads and resources with distinct boundaries that is both connected with the main electric grid, and can disconnect ("island") and function independently.[5] A microgrid connects to the grid at a point of common coupling, maintaining voltage at the same level as the main grid, until there is some sort of problem on the grid or other reason to disconnect. A switch can separate the microgrid from the main grid automatically or manually, and it then functions as an island.[6] Despite the title, there is no standard size that defines microgrids—they are smaller relative to the centrally regulated grid from which they can connect and disconnect.

There are two main categories of microgrids: customer microgrids ("true grids"), and utility microgrids (or "community microgrids"). ***Customer microgrids*** are systems developed by utility customers downstream of the regulatory utility metering. These microgrids rely on storage, transference, and

[5] 2019. *Microgrids at Berkeley Lab: About Microgrids.* https://building-microgrid.lbl.gov/about-microgrids-0.
[6] 2014. *Department of Energy: How Microgrids Work.* June 17. https://www.energy.gov/articles/how-microgrids-work.

generation technology that is separate from the centralized grid. ***Utility microgrids*** rely on subsections of existing regulated electricity grids in order to transfer electricity locally.

Microgrids: White Paper
Siemens, 2011

This report outlines the basic structure of microgrids and the value proposition based on utility grid vulnerabilities and challenges. It outlines the characteristics and design of different types of microgrids based on their market setting.

Microgrids: What Every City Should Know
Center for Climate and Energy Solutions, 2017

This brief seeks to introduce microgrids as a potential solution to local challenges, describes current financial and legal barriers, legal considerations, as well as the role that local governments can play.

SOLAR+STORAGE

Solar+storage refers to a microgrid system that pairs solar photovoltaic (PV) and battery technology, enabling buildings that have solar PV arrays to continue to generate and use solar power when the grid fails. With net metered, grid-tied solar arrays, the grid functions as an energy bank for any excess energy produced. However, under emergency situations when the grid shuts down, grid-tied solar arrays are designed to also shut down to prevent excess energy from being fed back into the grid and endangering line workers. With on-site battery storage and islanding capacities, solar+storage systems can disconnect from the central grid and rely on locally stored solar electricity to power buildings during grid failures.

Solar+storage systems offer added benefits outside of an emergency situation or grid failure. If net metering is allowed in the state, as is the case in Florida, solar PV-generated power can offset purchased electricity costs year-round. Additionally, having on-site storage can further reduce purchased electricity costs by minimizing a building's electricity burden during peak demand—times when utilities charge increased rates for electricity because of a surge in demand.

Resilient Southeast: Exploring Opportunities for Solar+Storage in Miami, FL
Clean Energy Group, 2019

This report evaluates the economic and political feasibility of solar+storage in the city of Miami, examining four types of facilities critical during a natural disaster: schools, nursing homes, fire stations, and multifamily housing buildings. The analysis models based on two different contexts, an economic scenario based on everyday bill savings, and a resilient scenario based on the benefits of backup power during grid outages. This report is part of a series of reviews of the potential for solar+storage in five southeast cities, produced under the Resilient Power Project.

Solar Market Pathways: Solar+Storage Toolkit

Solar Market Pathways, U.S. Department of Energy, 2017

This toolkit offers resources, case studies, and tools on the planning, technical design, and financing of resilient solar+storage energy technologies.

Solar+Storage 101: An Introductory Guide to Resilient Power Systems

Clean Energy Group, 2015

This report describes the structure and design of solar+storage systems, outlining the common options for hardware components (PV arrays, batteries, and inverters) and providing guidance on how building owners can plan on sizing their system. The report includes a project checklist to help building owners get started in planning a solar+storage systems, including critical questions to consider.

Solar+Storage Project Checklist

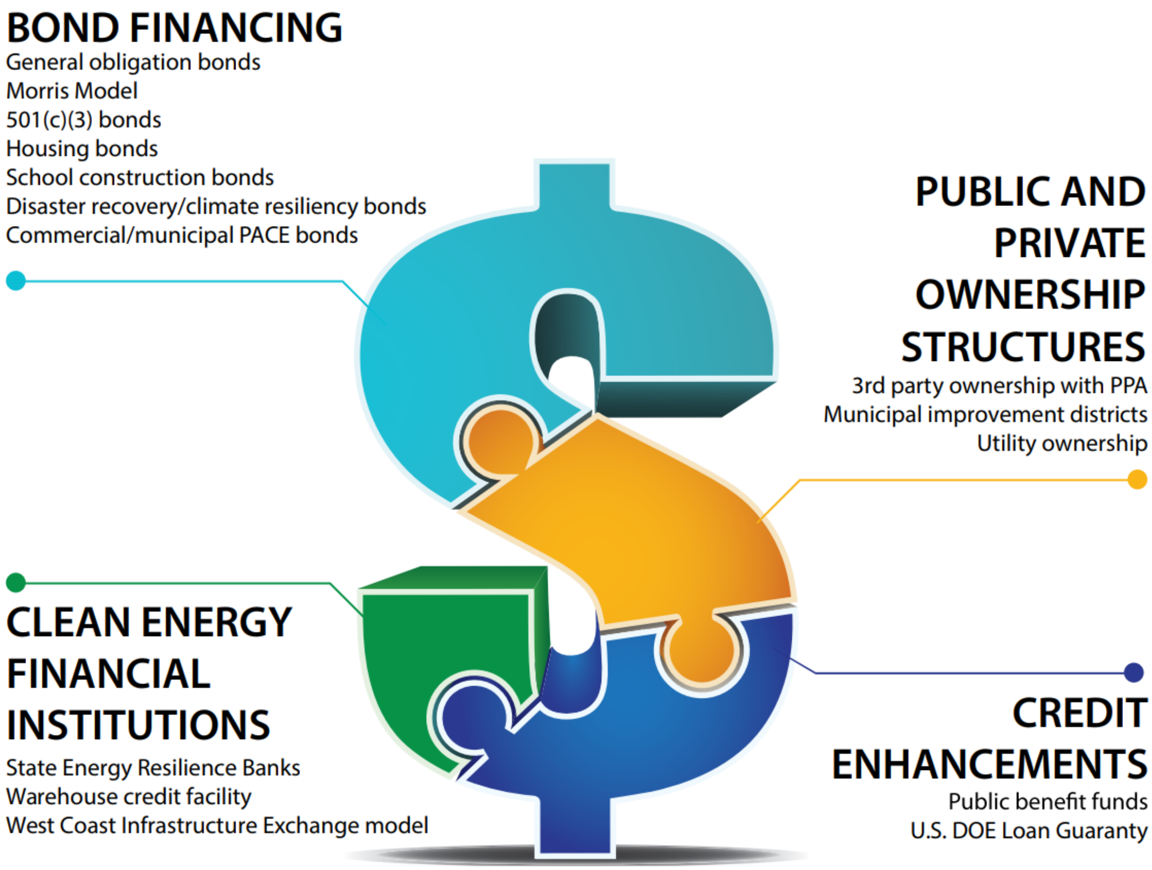
Clean Energy Group, 2016

The Solar+Storage Project Checklist was designed to help cities or developers assess whether solar storage battery systems make sense for their buildings. The checklist helps a building owner look at their utility bill, critical loads and solar needs, and evaluate how solar+storage systems might help them protect their occupants.

Financing Resilient Energy Systems

A key barrier to deploying resilient energy technologies has been the access to capital with terms that make these investments economically viable to municipalities, communities, and developers. The Clean Energy Group's report *Financing For Resilient Power*, describes four categories of financing opportunities for resilient power projects in detail: bond financing, clean energy financial institution initiatives, credit enhancement, and public and private ownership structures.

Large, well-resourced organizations, such as large local governments and colleges or universities, may find self-financing using internal funds to be the lowest-cost source of capital. However, for the many communities under significant budgetary constraints, project finance is a key mechanism to allow the expansion of resilient, clean energy technologies.



Source: Financing for Clean, Resilient Power Solutions (2014), Clean Energy Group.

FINANCING OPPORTUNITIES FOR SOUTHEAST FLORIDA

Municipal Bond Funding or "Green" Municipal Bonds

The U.S. municipal bond market is a large, traditional financing vehicle for large-scale, long-term capital intensive projects and operational expenses in states and cities. A variety of bonds are available to local governments to finance clean energy projects, and can be employed with different tax liability and forms of security including general obligation or revenue. Standalone bond financing for small clean energy projects (i.e. less than $5 million) is uncommon because of the high transaction costs associated with bond issuance. However, smaller projects are frequently "wrapped" into larger bond issuances, or a municipality could issue a bond to create a loan pool for smaller projects.[7]

Green bonds offer the same benefits as a typical municipal bond. However, they have a few distinguishing features: proceeds are earmarked for a variety of climate mitigation and adaptation

[7] 2019. *Office of Energy Efficiency and Renewable Energy: Bonding Tools.* https://www.energy.gov/eere/slsc/bonding-tools

investments, inclusive of clean energy and storage projects; they are labeled as "green" by their issuer; and the issuer tracks and reports on the use of proceeds to ensure green compliance.[8]

Tax-exempt Low-income Housing Bonds

State-chartered bonds, including healthcare facility authorities, housing finance agencies, higher education facility authorities, among others, exist in every state.[9] These eligible authorities can use tax-exempt bonds at low-interest rates to finance renewable energy projects with the rehabilitation of an existing low-income or elderly housing project, or for the construction of a new project, provided the developer sets aside all or a portion of the units for tenants who have very low-, low- or moderate-income.[10]

Property Assessed Clean Energy (PACE) Financing

Property Assessed Clean Energy (PACE) is a financing mechanism that enables a property owner to access low-cost, long-term capital for energy efficiency, renewable energy (including solar+storage), and other wind-resistance/resiliency projects, and make repayments via an assessment on their property tax bill.

The State of Florida passed enabling legislation for PACE in 2010. Local governments can voluntarily adopt an ordinance or resolution to create a program that will allow them to provide the upfront funds to cover the financing costs for the qualifying improvements for residential and commercial building owners, secured by a non-ad valorem assessment on the property paid through the property tax bill. Broward, Miami-Dade, Monroe, and Palm Beach Counties have both residential and commercial (C-PACE) programs. Florida commercial PACE issued loans totaled over $13 million in 2017, covering a variety of energy projects in 79 buildings.[11] Although C-PACE has traditionally been used to finance energy efficiency improvements, in the past few years energy storage projects have begun to emerge. C-PACE funded its first solar+storage microgrid in 2016.[12]

Grant Funding

Many local governments subsidize their financing of resilient energy systems with direct external funding through grants. The most stable and substantial set of grant opportunities is within federal agencies, focused on emergency funding and community development. In recent years, FEMA and NOAA have allocated disaster funds towards pre-disaster risk mitigation. Often, local governments apply to fund their broad strategies for risk reduction, and resilient energy systems are a subsection of the application. Pursuing grant funding for specific resilient energy projects does require preparatory work

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[8] n.d. "How to Issue A Green Muni Bond: The Green Muni Bond Playbook." *Green City Bonds.* https://www.climatebonds.net/files/files/Green%20City%20Playbook.pdf.

[9] n.d. "Tax-Exempt Bond Financing for Nonprofit Organizations and Industries." *Office of Energy Efficiency & Renewable Energy.* https://www.energy.gov/eere/tax-exempt-bond-financing-nonprofit-organizations-and-industries.

[10] Sanders, Robert G. 2014. "Resilient Power: Financing for Clean, Resilient Power Solutions." *Clean Energy Group.* October. https://www.cleanegroup.org/wp-content/uploads/CEG-Financing-for-Resilient-Power.pdf.

[11] 2017. "2017 C-PACE Economic, Energy, and Environmental Impact Report." *PACE Nation.* https://pacenation.us/wp-content/uploads/2018/08/2017-C-PACE-Annual-Impact-Report-Optimized.pdf.

[12] n.d. *Commercial Pace Financing for Microgrid in Mixed-Use Building.* Accessed March 26, 2019. https://betterbuildingsinitiative.energy.gov/implementation-models/commercial-pace-financing-microgrid-mixed-use-building.

to develop the necessary relationships to apply. Local governments should seek to develop relationships with utilities and craft a plan for implementing resilient energy solutions prior to grant application, as these components are challenging to integrate after the fact.

Potential federal grant opportunities for resilient energy system investments include:[13]

- U.S. Economic Development Administration (EDA) 2018 Disaster Supplemental
- FEMA Preparedness Grants
- FEMA Hazard Mitigation Assistance
    - 2018 Pre-Disaster Mitigation Grant (PDM)
    - Hazard Mitigation Grant Program (HMGP)
- HUD Community Development Block Grant-Disaster Recovery (CDBG-DR)
- USDA Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Guaranteed Loans & Grants

Financing for Clean, Resilient Power Solutions
Clean Energy Group, 2014

This resource provides a comprehensive overview of the main types of financing mechanisms, finance institutions, and ownership structures that local governments have used for resilient energy projects in recent history.

Reduce Risk, Increase Clean Energy: How States and Cities are Using Old Finance Tools to Scale Up a New Industry
Clean Energy Group and the Council of Development Finance Agencies, Report Prepared for the Clean Energy and Bond Finance Initiative (CE+BFI), 2013

This report identifies several financing strategies at the state and municipal level that can be adapted and implemented to accelerate clean energy deployment. The document outlines the ways in which well-established, conventional financing tools such as bonds can help dramatically increase investment in these solutions, through access to low-cost, long-term capital markets. It also explores the change that must occur to transfer conventional credit enhancement tools to the clean energy sector in order to raise capital to scale.

The Better Buildings Financing Navigator
Better Buildings, U.S. Department of Energy

This online tool helps public and private entities determine what financing options may work for building energy efficiency projects. By answering a few questions about a project, users will receive guidance on what financing options best fit their scenario. Users can also connect to *Better Buildings*

[13] Hampson, Anne. 2019. "Presentation at Resilient Energy Workshops." Miami.

Financial Allies – representatives from financing companies that have committed to energy efficiency, renewables, and generation project financing. Financial allies are active in all types of building sectors, from residential to governmental, and represent large and small companies.

Combined Heat and Power (CHP) Financing Primer

ICF, Prepared for U.S. Department of Energy Advanced Manufacturing Office, 2017

This financing primer provides checklists of information that financiers need to evaluate CHP investment opportunities, and discusses how CHP developers can best tailor their financing approach to a specific project. It provides an outline of various CHP financing options, a timeline for financing a CHP project, and information on making the business case for such a project.

Database for State Incentives, Renewables, and Efficiency (DSIRE)

North Carolina Clean Energy Technology Center

The Database for State Incentives, Renewables and Efficiency (DSIRE), managed by the NC Clean Energy Technology Center, lists more than 100 incentives surrounding various distributed energy resource opportunities.

U.S. Climate Resilience Toolkit: Funding Opportunities

United States Global Change Research Program, 2016

This component of the U.S. Climate Resilience toolkit provides a select list of public and private foundation grants that offer funding for local government resilience investments.

Resilient Energy in the Real World: Case Studies

CASE STUDY 1 – Montgomery County, Maryland Microgrid Public-Private Partnership


Photo credit: www.montgomerycountymd.gov

Project Summary

Montgomery County, Maryland, partnered with private utilities Schneider Electric and Duke Energy Renewables to develop resilient microgrid systems at two critical facilities: the county public safety headquarters and the Montgomery County Correctional Facility. These microgrid systems are designed to maintain a high threshold of critical service during county-wide grid failures by decreasing buildings demand and increasing production capacity. The public safety headquarters houses several services critical to the County during a weather emergency: transportation management resources, Office of Emergency Management and Homeland Security, and the central police station. With support from the Maryland Energy Association and in partnership with the U.S. Department of Energy's Combined Heat and Power for Resiliency Accelerator, Montgomery County implemented these two pilot microgrid projects in 2018.[14]

These pilot microgrid projects relied on an innovative public-private partnership to finance the resilience benefits at little to no cost to Montgomery County. While the County benefits from the resilience and microgrid capabilities of these energy systems, it does not fully own and operate them. The County partnered with Duke Energy Renewables to invest in and operate the system for its projected lifespan of

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[14] 2017. *Innovative Public-Private Partnership Will Improve the Resiliency of Key Public Facilities.* February 2. https://www2.montgomerycountymd.gov/mcgportalapps/Press_Detail.aspx?Item_ID=18742.

25 years, and Schneider Electric company to construct and maintain the systems. The County now purchases the electricity and generated heat from their private partners.[15]

Drivers

Montgomery County faced several extreme weather events between 2010 and 2012 that left many citizens in the County without power for long periods of time. Within Montgomery County, the Office of Energy and Sustainability worked with the Department of General Services to focus on energy resiliency and reliability for key sectors, starting with a series of assessments of government facilities that provide critical services. Additionally, changes in the local utility regulatory environment provided opportunities to explore and invest in resilient energy systems. The recent merger of utility companies Exelon Corporation and Pepco Holdings Inc. included new commitments to reliability and resilience standards, and the Maryland Public Service Commission started a "Grid-of-the-Future" initiative to consider deploying smart grid solutions.[16]

Energy System Design

These resilient energy systems function as individual microgrids with on-site energy generation through solar panels and natural gas. The public safety headquarters microgrid also utilizes combined heat and power (CHP), DC fast charging stations, absorption chillers, and cybersecurity controls. The combination of onsite generation through solar, and increased energy efficiencies through CHP will greatly increase the public safety headquarters site capacity for energy resources during extreme weather events.[17] This resilient energy system design is the first of its kind to receive a platinum certification from the Green Business Certification Inc.'s PEER rating system (a LEED green building rating corollary for power systems).

Approximate Specifications:

- Solar Photovoltaic Canopy: 2 MW
- Combined Heat and Power System: 800 kW
- Estimated Power Generation: 3.4 million kWh per year
- Reduction of greenhouse gas emissions: 5,900 metric tons per year[18]

Future Implementation

Montgomery County Department of General Services is assessing the resiliency of all County facilities in order to determine what other services are essential during a power outage and how to maintain those services. Learning from the two pilot projects implemented in 2018, Montgomery County and PEPCO are

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[15] ibid

[16] 2018. "Montgomery County, MD: CHP for Resilience Accelerator Partner Profile." *Better Buildings.* June. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Montgomery%20County.pdf.

[17] ibid

[18] n.d. *Office of Energy and Sustainability: Public Safety Headquarters Microgrid.* https://www.montgomerycountymd.gov/dgs-oes/MGP-PSHQ.html.

working to identify other potential facilities where microgrids or smaller installations of CHP could be deployed.[19]

Lessons Learned

- **Timelines for designing microgrid solutions are long,** especially when coordinating implementation with available utility or state program incentives.
- **Decision-makers need support to understand project details and benefits,** especially the county attorneys. Specifically, it is important to work with the Public Service Commission to show how resilient energy system projects will benefit ratepayers.[20]

CASE STUDY 2 – City of Coral Gables Emergency Operations Center Microgrid

Project Summary

The City of Coral Gables in Florida has committed to create a city energy system that can generate power during electric grid failures – saving lives and money, all while producing zero carbon emissions. Through a 2018 Bloomberg Mayors Challenge design award, the City of Coral Gables has the opportunity to build a resilient solar-powered micro-grid to prioritize power distribution to critical infrastructure during emergencies. With a 6-month planning grant, the City developed a prototype of a resilient energy grid centered around the City's Emergency Operations Center (EOC), which includes the public safety building and 911 center. The goal of this resilient energy system project is to ensure the city can conduct critical emergency response efficiently and quickly, regardless of the electrical grid status.

Drivers

With increasing frequency and intensity of extreme weather events impacting the Florida coast, Coral Gables will need more resilient energy systems to provide emergency services during natural disasters. The damage caused by Hurricane Irma in 2017 highlighted the vulnerabilities that South Florida communities like Coral Gables face. After Hurricane Irma, over 80% of buildings in Coral Gables faced power outages for a week after the storm. These outages affected residential and public buildings, including public safety and fire stations. In one instance, a fire station that relies on natural gas was without power for several days due to tree debris blocking roadways and hampering refueling.

Energy System Design

The EOC prototype, designed in partnership with the University of Miami, will integrate efficient hardware that reduces energy demand, new smart software technology that manages energy supply,

[19] 2018. "Montgomery County, MD: CHP for Resilience Accelerator Partner Profile." *Better Buildings.* June. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Montgomery%20County.pdf.
[20] 2018. "Montgomery County, MD: CHP for Resilience Accelerator Partner Profile." *Better Buildings.* June. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Montgomery%20County.pdf.

and a comprehensive standard operating procedure that prioritizes services across city departments during emergencies.

Hardware

The main hardware design of the resilient energy system is on-site energy storage and generation at the EOC, with a transfer switch that enables disconnection from the central electric grid. The EOC will store high efficiency Tesla batteries on-site, install solar panels on the rooftop of the public safety building, and shift from physical to virtual servers that require less energy to operate. This hardware allows the EOC to use energy from back-up storage when the central energy grid fails and continue to replenish that battery storage through solar energy.

Approximate Specifications:

- Roof Size: 40,000 sq ft
- Solar Panels: 144 sq ft - 320 sq ft
- On-site Batteries: 4 x 5 x 6 feet
- Estimated Power Load: 50 kW (power for servers and back-up 911 systems)

Software

The new software integrated into the resilient energy system, programmed by a research team at the University of Miami, can prioritize energy load in real time based on a system of sensors and an internal decision-making model. The Coral Gables system manages three critical energy loads during storms: servers from the emergency data center, the 911 response system, and electric lighting of the EOC.

A Smarter Standard Operating Procedure

In addition to changes in the physical design and technology of the electric system, the City of Coral Gables proactively developed decision-making protocol to guide city personnel during an emergency. The city anticipated that when relying on stored battery power as the sole source of energy for emergency systems, they will have to make critical decisions to shut down equipment as the battery charge depletes. To prepare for that, the City developed a comprehensive management plan that includes an incident response plan for power outages that prioritizes power differently at different energy thresholds. The City worked with emergency and public safety staff from every department to plan the priority protocol for their services considering power interruptions or extended outages. The resulting "Smart Standard Operating Procedure" also integrated existing building codes, rules, regulations, and emergency management requirements into one response process. For example, the operating procedure includes both fire watch and the required period of generator fuel autonomy.

Future Implementation

The City of Coral Gables is currently seeking external funding to implement the emergency microgrid system prototype for the EOC. The design will cost $1.5 million to implement, with City funds to match.

If implementation funding is not available for immediate scaling, Coral Gables plans on integrating these design parameters into their new LEED Silver municipal building.

Lessons Learned

- **Start with a prototype of one building and focus on the most critical emergency systems.** Shifting localized energy supply and distribution design is difficult and time intensive. With Bloomberg funding and a partnership with the University of Miami, Coral Gables was able to design this system within one year. While the City of Coral Gables recognizes the public enthusiasm for a city-wide, non-emergency microgrid, immediate plans must first test the applicability of this design for reducing risk.
- **Educate the community on emergency systems and gather community input.** For Coral Gables, it was important to both educate and engage the public on this energy system design. The City invested in figuring out how to communicate technical design components to the general public, and gathering the community's input on how they wanted their emergency systems to respond. Through a storyboard, the City walked the community through the progression of events during a hurricane, what issues public safety officials regularly experience, and what the new system could do to mitigate those issues.
- **New operating procedures were just as important as new hardware and software.** The combination of solar panels, battery storage, and software that can manage the distribution of power to different emergency departments gives Coral Gables the physical capacity to prevent sudden disruption of service. But it was Coral Gables' proactive decision-making with each emergency department that truly enables the City to respond and adapt in the face of a natural disaster.

CASE STUDY 3 – Miami-Dade County Water and Sewer Department South District Wastewater Treatment Plant Combined Heat and Power Facility

Project Summary

Miami-Dade County's Water and Sewer Department (WASD) first invested in a cogeneration facility (CHP – Combined Heat & Power) to generate electricity at the South District Wastewater Treatment Plant in 1991 using biogas from anaerobic digestion as part of its wastewater treatment process. WASD's CHP projects at individual facilities were initiated and have evolved through multiple capital improvement projects.

In 2011, Miami-Dade County recognized that methane gas produced at the landfill adjacent to its South District wastewater facility, coupled with digester gas produced within the plant (and natural pipe-line gas when required), could significantly reduce electricity demand at the wastewater facility. To this end, the County upgraded and replaced the previous 2.7 MW cogeneration system at the South District Plant with state-of-the-art CHP equipment.

Completed in 2014 by Brown and Caldwell and its design-build partner Poole & Kent, the 8 MW cogeneration system uses three different fuel types (digester biogas, landfill biogas and natural pipe-line gas) with potential annual cost savings to the County between $650,000–$1.5M. Additional upgrades to the plant's electrical distribution system and its connection to the local electric utility are estimated to increase annual savings to the County of between $650,000–$2.5M.

Drivers

WASD is Florida Power and Light's single largest customer in South Florida. Energy use by WASD represents 27% of the County's total energy bill and 3.5% of WASD's operating budget. Key factors driving WASD's approach to expanding CHP and energy efficiency at its facility are its focus on utility and county-wide emissions reductions, resilience improvements, sustainability commitments, as well as the desire for energy security and cost savings. Additionally, WASD is shifting to an integrated utility management approach, which includes effectively managing utility costs, reducing environmental impacts and performance-based decision making strategies which aim to improve operational efficiencies and reduce energy. These considerations make the deployment of CHP technology an attractive solution to meeting WASD's goals.

Energy System Design

The South District Wastewater Treatment Plant's CHP facility consists of four, 2MW cogeneration engines, using several waste to energy sources, including biogas, landfill gas, and waste heat. Anaerobic digestion produces biogas and methane captured from the adjacent landfill is piped to the plant, producing both electricity and heat. The waste heat can then be used within the digesters, to dry biosolids, and to cool the cogeneration building.

Approximate Specifications:

- Four cogeneration engines - 2 MW per engine
- CHP system with parallel interconnection to local electric utility provides up to 30% of the South District Wastewater Treatment Plant's energy needs
- Annual savings potential between $650,000 - $1.5M

Future Implementation

Miami-Dade WASD has partnered with the U.S. Department of Energy Better Buildings Combined Heat and Power (CHP) for Resiliency Accelerator and well as the Better Buildings Sustainable Wastewater Infrastructure of the Future Accelerator (SWIFt).

The CHP Accelerator worked to support and expand the consideration of CHP solutions to keep critical infrastructure operational every day and night regardless of external events. As a collaborative effort with states, communities, utilities, and other stakeholders, partners examined the perceptions of CHP among resiliency planners, identified gaps in current technologies or information relative to resiliency needs, and developed plans for communities to capitalize on CHP's strengths as a reliable, high-efficiency, lower-emissions electricity and heating/cooling source for critical infrastructure.

The Sustainable Wastewater Infrastructure of the Future Accelerator (SWIFt) works over three years with state, regional, and local agencies that are engaging with water resource recovery facilities in their jurisdiction to accelerate a pathway toward a sustainable infrastructure. This DOE initiative will build upon and leverage a substantial portfolio of work, resources and partnerships established by the U.S. Environmental Protection Agency (EPA) and various industry partners to add a new set of partners focused on developing actions and solutions in the energy-water nexus. DOE recognizes EPA's Office of Wastewater Management (OWM) leadership and will coordinate with EPA and this growing coalition on approaches to assist Accelerator partners chart pathways to sustainability.

The Accelerator aims to catalyze the adoption of innovative and best-practice approaches in data management, technologies, and financing for infrastructure improvement. SWIFt Partners will seek to improve the energy efficiency of their participating water resource recovery facilities by at least 30%. Partner solutions will provide model plans and road-tested examples that other water resource recovery facilities can follow on their path to a sustainable wastewater infrastructure. The Accelerator concludes with a detailed infrastructure improvement plan including an adopted enterprise-wide energy policy, detailed cost measures (processes, data, energy storage, renewables, hardware, controls, etc.) with outlined time scheduling and financing, as well as catalyst programs for further development like USDOE Better Plants and ISO 50001 Ready Program.

Lessons Learned

- Engage operations staff at the project planning phase to ensure effective design and to maximize operation.
- Develop a persuasive cost-benefit analysis to underpin the business case for the project and ensure buy-in from stakeholders and decision-makers.
- Consider long-term plant power load to enable expansion of cogeneration to offset new demand.
- Establish performance measurement data and tools.
- Designate an Energy Team to support troubleshooting, continued improvement, and reporting and messaging.
- Develop enterprise-wide energy policy.
- Partnership is key for continuous improvement. Partners involved in the WASD project include:
    - U.S. DOE CHP Accelerator
    - U.S. DOE SWIFt Accelerator
    - University of Miami Industrial Assessment Center, Department of Industrial Engineering
    - Florida International University Department of Civil and Environmental Engineering

Pro Forma: Resilient Energy Design Examples for Southeast Florida

There are various energy system designs that offer increased resilience and energy reliability in the Southeast Florida context, with differing costs and potential savings associated with each. This pro forma provides a comparative analysis of potential design scenarios that offer a range of resilience potential and level of service, examining energy storage capacity, space requirements, costs, and financial savings of each.

This pro forma analysis is based on a theoretical resilient energy site in Southeast Florida that is closely modeled off the Coral Gables Emergency Operations Center (EOC) (profiled above). The modeled municipal EOC site consists of a 120,000 sq ft building with a 40,000 sq ft roof. The EOC consumed three million kWh of electricity in 2018, with an average demand of 350 kW and a peak demand of 424 kW. The blended electricity rate (an average of energy and demand charges) for the facility was $0.0696/kWh. Using these values, the following resilient energy system scenarios were analyzed: a theoretical SEFL Municipal EOC microgrid; combined heat and power (CHP), solar+storage; solar+storage and CHP; and solar with CHP (without storage).

CATEGORY		1 - THEORETICAL SEFL MUNICIPAL EOC MICROGRID	2 - COMBINED HEAT & POWER (CHP)	3 - SOLAR+STORAGE	4 - SOLAR+STORAGE, & CHP	5 - SOLAR & CHP
System Design	PV Solar (kW-DC)	54.4	-	1650	54.4	54.4
	Battery (kW)	50	-	350	50	-
	CHP (kW)	-	350	-	300	300
Capacity Factor (%)		17%	85%	18%	90%	90%
Electricity Produced Annually (kWh)		82,595	2,606,100	2,601,720	2,316,395	2,316,395
Backup Power Available (kW:kWh)		50 : 1999	350 : 25200	350 : 25630	350 : 23599	300 : 22399
Building Electricity Serviced Annually (%)		3%	85%	84%	75%	75%
Thermal Energy Produced Annually (MMBtu)		NA	11,693,570,700	NA	10,393,665,262	10,393,665,262
System Space Required (Sq ft)		5,580	500-1,000	359,370	1,180-6,580	1,180-6,580
Capital Cost ($)		320,000	994,000	2,490,400	1,172,000	960,800
Lifetime Cost ($)		566,960	4,151,759	3,385,900	4,125,610	3,689,210
Annual Savings ($)		5,748	181,384	181,079	161,221	161,221
Lifetime Savings ($)		148,006	5,020,087	4,662,154	4,450,938	4,450,938
Simple Payback (years)		55.67	5.48	13.75	7.27	5.96

Assumptions

- **Solar (54.4 kW)**: Capital $2,000/kW, Operations & Maintenance (O&M) $20/kW, Capacity Factor calculated from Helioscope Design.
- **Solar (1650 kW)**: Capital $1,360/kW, O&M $16.7/kW, Capacity Factor of 18% derived from efficiency of scale, 5 acres/MW.
- **Battery (Lithium Ion)**: Scenario 1 & 4 = 24hr duration, Scenario 3 = 4hr duration, Capital cost $176/kWh, O&M cost $14/kW-yr.
- **CHP**: Technical and Financial costs based on reciprocating engine values from DOE's CHP Technology Fact Sheets - 2017 [Capital cost $2,840/kW, O&M cost $0.021/kWh, 4,487 Btu/kWh]
    - Natural Gas Price $4/MMBtu ($0.0396/kWh).

- **Backup Power**: based on a 72-hour period, this is the peak demand and energy supplied by the system.
- **Costs**: Lifetime - 20 years, (includes capital, replacement, and O&M).
- **Savings**: Lifetime - 20 years, includes avoided electricity purchased (excludes potential thermal energy savings and avoided outages), annual electric rate escalation 3%, annual system production degradation 0.7%.
    - An electricity rate (blended) of $0.0696/kWh was used for all avoided energy cost calculations.
- **Capacity Factor**: The ratio of how much electricity is generated versus what theoretically could have been generated if the system was operated 24/7 at full-power over a given time period.

SCENARIO 1: THEORETICAL SEFL MUNICIPAL EOC MICROGRID

Scenario 1 represents a back-up system for emergency outages at a theoretical municipal EOC center, which is modeled off the Coral Gables EOC microgrid system profiled in this report, but does not exactly match Coral Gables' system's specifications. The system modeled in Scenario 1 provides minimal electricity to the facility annually, but has the potential to power necessary operations in emergency situations. It maximizes both roof space and battery storage capacity. It assumes a 24-hour battery (based on international fire code and DOE backup power guidelines), providing 1,200 kWh of stored energy, capable of providing adequate service in conjunction with the solar array for up to 72 hours. It also assumes that the solar array would be limited to the useable building roof space after accounting for physical and shading limitations (~5,600 sq ft), producing a 54.4 kW-DC solar array was designed.

PV solar has a relatively low capacity factor of 17%, since the system only generates power when the sun is out. Therefore, the simple payback based on avoided energy costs for this scenario was 55 years. This payback could be improved if the system utilized the battery for multiple revenue streams, such as to reduce demand during peak times, or if avoided outage costs were accounted for (discussed in more detail below).

SCENARIO 2: COMBINED HEAT & POWER

Scenario 2 represents a CHP system that is designed to meet the average electrical demand for the facility. It is assumed that the generator has a capacity factor of 85% to allow for engine service and downtime. This means that while it will provide the majority of the annual electricity the EOC needs, it will not be able to meet peak demand requirements. The simple payback of this CHP scenario based solely on electric load offsets is 5.48 years, the shortest of all scenarios examined. One can assume the payback to be even greater for this scenario since CHP would also lower operational and utility costs by offsetting the facility's thermal loads (heating, hot water, etc.). In Southeast Florida, the generator should be paired with absorption chillers to supply cooling using waste heat.

SCENARIO 3: SOLAR & STORAGE

Scenario 3 represents solely a solar+storage system sized to power most of the EOC facility annual electricity needs, matching that of the solely CHP system in Scenario 2. This system has a marginally higher capacity factor than solar+storage in Scenario 1 because larger PV systems tend to operate more efficiently. This has a simple payback period of 13.75 years, far more advantageous than Scenario 1 due to economies of scale. However, the system designed in this scenario is intended to be an illustrative example only. Given the system space required to generate 85% of the EOC's annual power through solar (359,370 sq ft), space constraints would make this scenario an implausible possibility within a municipality. Scenario 3 is included here to demonstrate that solar+storage, while financially competitive, is an unlikely functional solution to power annual demands based on the space constraints.

SCENARIO 4 & 5: SOLAR, STORAGE & CHP AND SOLAR & CHP

Scenario 4 and Scenario 5 both represent an integrated approach, combining CHP, solar, and storage for onsite generation. The CHP system was assumed to be slightly smaller in these scenarios to create an equal comparison between the scenarios' electricity generation. Based on energy offsets alone, both scenarios offer a simple payback under 10 years. Both Scenario 4 and Scenario 5 systems also provide greater levels of redundancy and year-round utility service by using a variety of technologies. The CHP offers dispatchable power and can service the thermal load. The solar and battery can provide immediate response to power outages and offer additional resilience and redundancy.

While Scenario 4 has high upfront capital and a slightly longer payback than Scenario 5, it provides the resilience benefit not captured in a simple payback: back-up power in rare emergency situations when the grid fails and natural gas supply is disrupted.

ECONOMIC BENEFITS

Ensuring that a resilient energy system is economically beneficial is an important factor to consider when comparing potential designs. For a public building in Southeast Florida, similar to the Coral Gables EOC, the majority of the financial savings from installing a backup system will be accrued through avoided energy costs rather than credits or rebates. Local government are not eligible to use the federal investment tax credit (ITC), one of the most commonly utilized renewables incentives. FP&L, the region's utility, does not currently offer any solar rebates. However, Florida does allow net metering, meaning that excess energy produced on site will be credited to the account and building owners will be compensated financially at the avoided cost to create that electricity. For the larger CHP system in Scenario 2, other costs such as standby costs could incur, which could lower the economic value of the project and increase payback period.

Further analysis using more detailed facility data could improve the savings associated with avoided energy costs via demand reduction. If the solar, battery, or CHP are serving the EOC's load during peak demand, monthly demand charges could be lowered. Demand reduction is especially relevant to CHP, because its thermal energy could be used to offset cooling and heating loads that often drive the largest demand in a building. Finally, there are other benefits which are hard to monetize and account for, most notable for the EOC is avoided outage costs.

AVOIDED OUTAGE SAVINGS

The savings associated with avoiding an electrical outage is derived from what cost would have been incurred if electrical service was lost. Creating a resilient energy system is largely about avoiding these outages and the associated costs from both a societal and financial standpoint. Determining the value associated with unmet electrical need is both difficult and highly variable, and therefore was not included in the simple payback presented in the above table. The cost variability of an outage is unique to the function of an electrical system or building. A hospital and an office building, for example, would place largely different values on avoiding an outage.

Attempts have been made to quantify the avoided costs for a variety of facilities. The Clean Energy Group estimated the savings for five cities in their Resilient Southeast Report, where they note that the values calculated using SADI and SAFI were conservative and did not capture the full societal value associated with lifesaving facilities.[21] For Miami, Florida, the avoided cost of a medium/large commercial & industrial organization was determined to be $740.69/kW for the demand associated with the potential down time, and $46.29/kWh for the energy used during this period. For illustrative purposes, assuming the EOC facility avoided an average downtime of five hours twice a year, an additional savings of $97,214 we be accrued for Scenario 1. Using these conservative values demonstrates that when accounting for avoided outages in a single year, the payback of the system decreases exponentially from 55.6 to 3.1 years for the same scenario. The avoided outage savings are even harder to predict because outage duration and frequency vary from year to year, and the impact of an outage will change in relation to the facility. The value of avoided downtime at an emergency center is even more valuable during extreme events when outages are likely, making the case for backup and resilient energy systems that much stronger.

CONCLUSIONS

There are many technical considerations that would need to be addressed before moving forward with any of the resilient microgrid options presented. The space required to install each system may limit one scenario while making another more beneficial. The capital cost for the systems discussed are different by orders of magnitude. However, they supply different levels of service and resiliency. If a system is installed that provides more of the facility’s electrical and utility needs, the annual savings will be much greater and may reveal a shorter payback than a smaller system. This could be especially true for CHP, which offers to offset the facility's thermal load as well as its electrical load.

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[21]Robinson, Marriele, and Seth Mullendore . 2019. "Resilient Southeast: Exploring Opportunities for Solar+Storage in Miami, FL." April 25. https://www.cleanegroup.org/wp-content/uploads/Resilient-Southeast-Miami.pdf.