Grid-Interactive Efficient Building Case Studies In the Federal Portfolio

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GSA

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Introduction:

The federal government has made major strides in reducing the energy use and greenhouse gas (GHG) emissions of its buildings, yet the next generation of savings will require new levels of interaction and integration among buildings and the electric grid. The transition from a one-way electricity transmission system to a complex, multidirectional system involving many distributed energy sources, including intermittent ones, with efficiency itself treated as a resource, presents a wide array of new opportunities and challenges.

Rather than all energy efficiency being treated as equal, the value of use reduction during peak periods will continue to increase, as power production during these times is the most expensive and often the most polluting, while putting the most strain on the grid. According to the Energy Information Administration (EIA), building energy use drives 80 percent of peak demand. Peak demand determines utility company investments in energy generation and transmission which in turn influences the cost of electricity.

A grid-interactive efficient building (GEB) offers an array of solutions to these challenges, while providing new opportunities for building energy management and cost savings. GEBs gather, transmit and apply information about how and when they use energy through technologies such as meters, sensors, controls, and energy management systems. A GEB has the potential to both manage occupant comfort and save money on energy bills with an added benefit of reducing the reliance on the grid, increasing resiliency.[1]

The federal government is increasingly researching, demonstrating and implementing GEBs, but there still a lot to be learned about GEB practices and technologies. The Department of Energy (DOE) Building Technologies Office (BTO) has taken the lead in conducting research, developing metrics and convening stakeholders to define and establish this new set of strategies and technologies. BTO published a series of technical reports in 2019 that evaluate the opportunities for GEBs and provide background on core GEB concepts.[2]

Meanwhile, the U.S. General Services Administration (GSA) in 2019 began exploring how to demonstrate and introduce GEB strategies and technologies at federal facilities. The GSA Green Building Advisory Committee, an outside panel of experts, developed policy recommendations to the federal government to advance grid-integrated federal

[1] U.S. Department of Energy. Office of Energy Efficiency and Renewable Energy (EERE). Grid-Interactive Efficient Buildings Overview. https://www.energy.gov/eere/buildings/grid-interactive-efficient-buildings.

[2] U.S. Department of Energy. Office of Energy Efficiency and Renewable Energy (EERE). Building Technology Office. Grid-interactive Efficient Buildings Technical Report Series (2019): https://www1.eere.energy.gov/buildings/pdfs/75470.pdf.

buildings that leverage technologies and strategies to shape energy loads, enhance resilience and save taxpayer money.[3]

GSA followed these recommendations by funding a Rocky Mountain Institute (RMI) report that examined the costs and benefits a GEB strategy could have if adopted across GSA's entire portfolio.[4] GSA's Proving Ground program (GPG) then joined with the DOE High Impact Technology (HIT) Catalyst program to evaluate four GEB technology solutions for evaluation and verification.[5]

The purpose of this report is to look at examples in the federal portfolio where facilities have demonstrated and, in some cases, implemented some GEB technologies and practices. The case studies are samples and were selected based on available information and ability to interview facility management. The list of examples is an inclusive, but not an exhaustive list of GEB projects. GEB implementation in the federal government is most successful with a combination of emerging technologies and an alignment between utility planning and building operation. The following case studies highlight examples where pieces of the GEB puzzle come together to reduce peak demand, reduce energy consumption and increase grid flexibility and resiliency.

The case studies are organized into four sections:

- Overview: A description of the building, campus or installation.
- GEB Practices and Technologies: Descriptions of emerging technologies being tested and/or implemented at the building, campus or installation.
- Obstacles: Challenges faced by onsite personnel while introducing, testing, or implementing GEB-related practices and technologies.
- Lessons Learned: Summary points distilled from the case study research that should be considered in future GEB projects.

Some overall lessons learned from these case studies include:

- Partial GEB integrations provide valuable information. While different federal facilities have tested and implemented elements of GEBs, none has yet come close to realizing a fully integrated GEB solution. This is not surprising, as many of the GEB concepts and technologies are relatively new. Regardless, it is still useful for future GEB planning to document what federal facilities have achieved

[3] GSA Green Building Advisory Committee Federal Building & Grid Integration: Proposed Roadmap Advice Letter. Available: https://www.gsa.gov/governmentwide-initiatives/federal-highperformance-buildings/policy/green-building-advisory-committee/advice-letters-and-resolutions.

[4] Rocky Mountain Institute. Value Potential for Grid Interactive Efficient Buildings (2019). https://rmi.org/insight/value-potential-for-grid-interactive-efficient-buildings-in-the-gsa-portfolio-a-cost-benefit-analysis/

[5] U.S. General Services Administration. Emerging Building Technologies. Ongoing Assessments. https://www.gsa.gov/governmentwide-initiatives/sustainability/emerging-building-technologies/ongoing-assessments.

as well as what barriers they have faced in attempting even partial GEB solutions.

- Due to the emerging nature of GEB technologies, finding and keeping staff with GEB-specific skillsets is challenging for federal facilities. Onsite operational knowledge gaps were cited as an obstacle during many of the projects discussed below. Study participants suggest that implementing on-the-job training can help address the skillset gap.
- Agency leadership approval is critical to pave the way for a successful GEB project. In some of the case studies discussed below, leadership concerns about investing in GEB technologies included large upfront capital costs, security issues, and apprehension about savings failing to materialize. Participants reported leadership's positive interest in cost savings, energy savings, and grid resiliency. Identifying how GEB technologies and practices support the agency mission is an important first step for cementing leadership approval.

Case Study: Edward J. Schwartz Federal Building and U.S. Courthouse

GEB Project Start: 2018

Overview

The comprehensive renovation project at the Edward J. Schwartz Federal Building and U.S. Courthouse in San Diego was part of the GSA National Deep Energy Retrofit program. The budget-neutral Energy Savings Performance Contract (ESPC) implemented 37 energy conservation measures across 3.7 million square feet of GSA-owned buildings in five U.S. cities, including Las Vegas, Phoenix, Reno, San Diego and Tucson. The combined measures reduced the total energy consumption of the federal buildings by 30 percent. To support distributed generation, 462 kilowatts of solar photovoltaic systems on carports and rooftops were installed at the Edward J. Schwartz Federal Building and U.S. Courthouse in San Diego.

GEB Practices and Technologies at the Schwartz Federal Building

To support distributed generation, 462 kilowatts of solar photovoltaic systems on carports and rooftops were installed at the Edward J. Schwartz Federal Building and U.S. Courthouse in San Diego. The installation contractor also designed a follow-on battery storage system to be employed in conjunction with the on-site solar for energy demand-reduction and peak savings. The 750kW / 1,425 kWh lithium ion battery energy storage system (BESS) supplied by Tesla (Powerpack 1) came online in January 2018. The BESS provides controllable peak demand reduction to the site, optimizing utility consumption and minimizing costs. Demand cost savings is achieved by discharging the battery during peak times and recharging during off peak times.

The system has been operational since January 2018 with 99.8% uptime. The monthly on peak demand reduction to-date is $19/kW, with an average reduction of 186 kW, and a maximum reduction of 582 kW. The monthly non-coincident demand reduction to date is $24/kW, with an average reduction of 214 kW, and a maximum reduction of 397 kW.

Obstacles

- **Location:** The Schwartz federal building is in downtown San Diego and space is limited. The system had to be custom configured to fit into the irregularly shaped courtyard.
- **Quantifying savings:** A new robust calculation tool was built by Ameresco to analyze BESS opportunities and quantify the savings in order to provide a guarantee for performance contracts. This calculation is not trivial, and is significantly different from PV savings calculations, and unique to the project use cases.
- **IT Security:** The contracting team dad to work closely with GSA IT security on controller remediation and approval to use cellular modem for remote communications to the BESS controller. The system is not on the GSA network.

Lessons Learned

- **Plan for cybersecurity needs early in project development.** Cybersecurity is a critical element to implementing energy storage and GEB solutions. The GEB technology landscape has a wide variety of communication and control needs. Contracting teams need to start the planning process early to allow for adequate cyber resources to satisfy the project's requirements.
- **Location is an important consideration for project prioritization.** In high value regions, falling technology costs should create more opportunities for energy storage measures that can be self-funding within a performance period. This is a significant milestone, given that energy storage measures were rarely if ever self-funding five years ago. Consider prioritizing sites that have some combination of high electric demand rates ($/kW); time of use energy rate structures; incentives for energy storage; and accessible utility demand response programs.
- **Consider integrated solutions during project development.** To reduce project costs and increase performance, consider PV and storage systems as an integrated solution during development and design. When budget allows, include the relevant microgrid controls and protection to allow the BESS to support islanded site operation.
- **Plan for the distribution of incentive funding and resources to obtain that funding early in the project.**

Case Study: Fort Carson

GEB Project Start: 2017

Overview

The US Army Fort Carson installation is in El Paso County near the city of Colorado Springs, Colorado. The installation is noted for its successful implementation of environmental and clean energy programs with a broad array of technologies. The installation manages a diverse portfolio of both small and large buildings tied to the central control system with extensive metering.

GEB Practices and Technologies at Fort Carson

Fort Carson proactively manages its energy consumption across the installation. Active and iterative adjustments help optimize energy systems and provide realized cost savings. Due to high demand charges from its utility, approximately $18 per kilowatt ($18/kW) per month, Fort Carson implemented a BESS for peak load shifting, to flatten the energy consumption profile. BESS, along with an energy management control system (EMCS), lighting upgrades, and drive upgrades were accomplished through an ESPC in 2017.

Onsite energy managers worked with a performance contractor on the design and building of an occupancy-based HVAC control system. Fort Carson built the system to reduce heating and cooling when buildings are not occupied due to the rotational deployment of troops. As of May 2020, this implemented practice has reduced consumption by 60% when buildings are unoccupied. Fort Carson energy managers noted that smoothing the load profile for an installation tends to be more challenging than at the building level. Fort Carson continuously assesses the load profile and technologies to flatten the load curve, in turn increasing resiliency.

Fort Carson is one of several microgrid projects underway on U.S. bases under the SPIDERS (Smart Power Infrastructure Demonstration for Energy Reliability and Security) program.[6] The SPIDERS microgrid is a demonstration project that isolates critical facilities on the installation (e.g., headquarters buildings, data centers). Two diesel generators (3 MW) and one solar farm (1 MW) are part of the Fort Carson microgrid.

Obstacles

Fort Carson has implemented several GEB initiatives and the installation continues to execute interrelated projects to increase resiliency. While largely successful, Fort Carson energy managers identified the following obstacles to increasing GEB practices and technologies:

- **Security concerns.** Fort Carson energy managers successfully requested authority to operate (ATO) to address cybersecurity concerns with the EMCS. Cybersecurity requirements for any automated system in a DoD facility are rigorous.[7] IPERC (Intelligent Power& Energy Research Corporation) announced in 2017 that the DoD authorized its support of the installation's microgrid.
- **Technology Challenges.** In most instances, an EMCS is operated by a contractor, making integration with U.S. Army systems challenging. Integrating the Army's portfolio management system with installation-specific energy

[6] For more information on the SPIDERS program, please reference: https://www.energy.gov/sites/prod/files/2016/03/f30/spiders_final_report.pdf.

[7] https://iperc.com/wp-content/uploads/2018/06/iperc-fort-carson-press-release-1a.pdf

management systems requires robust IT support. This increases the cost of the project and adds to the security concerns.

- **Implementing "Smart Building" Technology.** Implementing multiple technologies to manage building energy loads based on occupancy was challenging. Though the buildings had smart building technology that was supposed to "learn" how many occupants were in the building, the technology would go through deep setbacks when the building experienced a major occupancy change. A lot of hands-on facility manager time is needed to get a building to adapt to major occupancy changes and automatically adjust energy loads.
- **Operational Challenges.** Although utilities provide financial incentives to bases to reduce their demand at critical peak times, program supporters need to make the case to leadership for how this supports the base mission and will not inhibit operations.

Lessons Learned

Despite the obstacles, Fort Carson demonstrates many successful GEB-related energy saving projects throughout the base. The following lessons learned should be considered when pursuing these types of projects in the federal space:

- **Engage with facility managers and tenants early and often.** Engaging facility managers is critical to the success of grid-integrated efficient building technologies. Engagement at Fort Carson has been augmented with cash rewards that drive motivation and success.
- **Employ intergovernmental support agreements.** Local government agencies often have contracting strategies to team with local communities and enter 20+ year agreements for energy conservation and resiliency work.

Case Study: Picatinny Arsenal

GEB Project Start: 2016

Overview of Picatinny Arsenal

Situated on a 6,500-acre military installation in Northwest New Jersey, Picatinny Arsenal provides almost all the lethal mechanisms used in Army weapon systems and other military services. Picatinny attempted to implement grid-integrated efficient building technologies through an automated demand response (ADR) program. The project was abandoned before execution, however, out of concern over unknown risks of these open systems and perceived conflicts with the mission of the base. The original project scope included the integration of market signals with ADR to reduce energy consumption and provide cost savings.[8]

[8]Overview and technology detail sourced from interview on 3/4/2020.

GEB Practices and Technologies at Picatinny Arsenal

Many DoD facilities participate in manual demand response programs, in which notifications from the utility company are received at a facility via email or phone. This approach usually limits the demand response to the next day. The concept of ADR allows for a faster response, more opportunities to reduce grid demand, and higher compensation.

ADR technology consists of three parts: (1) A cloud-based server to distribute market signals from an energy provider according to a standard format; (2) facility-side end points to convey market signals to facility energy management systems or assets; and (3) firewall technology to perform inspection of all signals.[9] In 2016 Picatinny Arsenal, in partnership with DoD's Environmental Security Technology Certification Program (ESTCP), participated in a demonstration of ADR. The demonstration included a single automated platform and a direct, machine-based connection between energy providers and consumers with appropriate security approvals. Although the project was supposed to conclude in 2017, however the project was ended prematurely in response to concerns over unknown risks of implementation.

Obstacles

- **Security concerns.** ADR is considered a new technology and a lack of understanding of it periodically halted progress for the Picatinny project over the course of the project. Leadership, at the time, remained hesitant to authorize implementation of the ADR system due to security protocols.
- **Operational knowledge gaps.** A lack of onsite staff with the ability to provide guidance to contractors during installation was another factor in the decision not to proceed on this project.

Lessons Learned

- **Address operational knowledge gaps and onsite turnover:** emerging building technologies such as ADR require specialized skills. Hiring or contracting staff with specific skillsets and/or offering on-the-job training for ADR and other GEB-related technologies is important to reduce project execution risks.
- **Obtain buy-in for the project early in the project lifecycle.** Gain approval at all organizational levels to reduce project risk and help support understanding and implementation.
- **Consider alternatives to ADR where it is unlikely to be accepted.** While ADR systems provide significant grid-integration benefits, manual systems can work in cases where ADR is not feasible. Under such traditional approaches, tracking and response are managed by operators receiving the market signals and adjusting energy consumption in response. This work-around can still reduce energy and save money.

[9] Strategic Environmental Research and Development Program (SERDP); Demonstrating Secure Demand Response in DoD: https://www.serdp-estcp.org/News-and-Events/Blog/Demonstrating-Secure-Demand-Response-in-DoD.

- **Identify how GEB technologies and practices support the agency mission**. Although installation and facility leadership may not be inclined to see GEB technologies as mission critical, energy supply, resilience and security are fundamental to the readiness and mission of the U.S. Army and many other agencies. Projects with clear resilience features -- including microgrids and combined heat and power systems – support the case as part of a suite of GEB technologies that reduce risk and provide commanders with increased flexibility and mission assurance.

Case Study: The National Institute of Standards and Technology (NIST) Headquarters
GEB Project Start: 2010

Overview
The 580-acre National Institute of Standards and Technology (NIST) headquarters campus in Gaithersburg, Maryland was designed in the early 1960s by GSA. The campus consists of 62 buildings, including 45 main buildings, with 6.2 million square feet under a roof. Much of the campus is composed of specialized research buildings.

GEB Practices and Technologies at NIST Headquarters Campus
The NIST campus has been implementing demand response strategies for about 10 years, employing direct load control programs which provide the facilities the ability to cycle air conditioners on and off during periods of peak demand in exchange for financial incentives and decreased electric bills. NIST does not work with the local utility company (PEPCO) directly to manage its demand response program but leverages a consortium that functions as the third party between power companies and NIST.

The NIST campus has a central utility plant that makes demand response relatively easy to control. NIST has a manual process to start generators, but automatic programming is used to control the campus-wide system. Also, as part of the manual process, NIST facility managers request that staff close blinds, turn off lights, and shut off unnecessary equipment (monitors, copy machines, etc.) when it's safe to do so. Lab facilities do not experience temperature change during demand response times, and lab temperatures and climate are controlled separately from other NIST buildings.

NIST's base purchased electric load has been significantly reduced due to its use of solar photovoltaic (PV) and cogeneration capabilities. Cogeneration and PV have been successful energy producers and have reduced the number of kilo-watt hours bought from PEPCO. NIST personnel noted that it took longer than contractually expected to fully establish its cogeneration capabilities, whereas solar installation was completed quickly and in its first year of operation, produced 14% more energy than expected.

Notably, when NIST employees were required to work from home in April and May during the onset of the COVID-19 pandemic, NIST's electric demand was significantly reduced and became too low to have both the co-generation and PV array generating power for consumption. The PV array had to be turned off for about 45 days. The NIST facility managers noted that this was a one-time, exceptional situation brought about by a once-in-a-century global pandemic.

Obstacles

NIST's implementation of GEB technologies such as demand response and renewable energy programs have been successful. Still, NIST encountered several challenges when trying to establish and maintain its demand response program, and some GEB technologies were cost prohibitive for NIST to establish and maintain. In particular:

- **Contracting challenges.** When trying to establish a demand response program, NIST found that it did not have the correct contracting models in place. The NIST contract department had to overcome this challenge before the program could begin.
- **Operational and technological challenges**. A period of electric meter inoperability on the incoming supply feeds suspended the NIST demand response program for two years.
- **Large upfront investments.** NIST investigated adding geothermal heating and cooling capabilities, but deployment for a selected building was deemed cost prohibitive.

Lessons Learned

- **A third-party consortium can help implement a successful demand response program.** The NIST team noted that the most significant issue that they encountered with their demand response program was inoperable meters which led to a lack of historical consumption data and inability to participate in a program for a few years until the meters were fixed.
- **Demand response programs have both direct and indirect financial benefits.** The implementation of a demand response program had direct financial benefits for NIST via payouts. The program also led to reduced energy utility bills, and reduced reliance on the utility company and the grid. Additionally, NIST has used its energy-savings payouts to further invest in GEB technology.
- **Renewables and co-generation capabilities allow onsite flexibility.** NIST's use of solar and cogeneration capabilities have allowed facility managers to keep occupants comfortable and reduce utility costs by actively managing energy use.
- **ESPCs can help implement GEB technologies**. NIST used an ESPC to build both the co-generation/chiller replacement and solar array. Obtaining traditional appropriations for such large upfront expenditures would have been challenging.

Case Study: Joint Base Cape Cod

GEB Project Start: 2009

Overview

The Joint Base Cape Cod (JBCC) in Massachusetts is a complex facility with tenants including the Coast Guard, Army National Guard, Otis National Guard and Air Force, plus a Veterans Affairs Cemetery and about twenty additional non-military tenants on its 22,000 acres. Each JBCC tenant operates with its own mission, lending diversity to the way it approaches building and facility management.[10]

GEB Practices and Technologies at JBCC

All major energy-using military tenants of JBCC have implemented GEB technologies and practices within their portfolio of buildings and facilities to reduce reliance on the grid. At JBCC, energy conservation programs have served historically as the start for larger and more complex energy grid projects.

US Air Force

The Air Force Civil Engineer Center (AFCEC) manages the Installation Restoration Program (IRP) at Joint Base Cape Cod. The IRP operates and maintains nine pump and treat systems to address groundwater contamination. In response to large utility bills ($2.5M per year historically), the IRP implemented a project to offset the pump and treat energy use with renewable energy provided by wind turbines. Currently, AFCEC operates three 1.5-megawatt wind turbines that provide approximately $1.5M in energy credits towards utility costs. Combined with a robust optimization effort, the three wind turbines offset the energy use by 100% making the AFCEC IRP at JBCC the only large-scale restoration program completely run with renewable energy.

In addition, AFCEC/JBCC enrolled 860 kilowatts (kW) in an energy demand response program and evaluates utility rate structures to ensure accounts are on the most appropriate rate plan. The pump and treat systems can be shut down for the short duration energy curtailments without impact plume capture. Curtailment payments are used for other energy savings projects such as replacing old doors and windows with new energy efficient ones and installing energy efficient air conditioning systems instead of using antiquated window units. As a next step, AFCEC is working with Otis Air National Guard (ANG) Base to integrate one of the 1.5 MW wind turbines into a microgrid project that will support the ANG mission.[11]

Air National Guard (Otis)

In 2011 the Air National Guard explored a potential solar array at a landfill site that would have provided up to 12 MW of renewable power. The project was discontinued after seven years due to operational delays and a new requirement/rule change. The new requirement was that all renewable energy projects needed to include a microgrid.

[10] Overview and technology detail sourced from interview with JBCC staff on 5/15/2020.

[11] Hybrid Microgrid with High Penetration Wind for Islanding and High Value. https://www.serdp-estcp.org/Program-Areas/Installation-Energy-and-Water/Energy/Microgrids-and-Storage/EW-201606.

The project would have been contracted through the Defense Logistics Agency (DLA) and the work was awarded to Ameresco.

Otis had success in 2018 with an onsite microgrid that included one of the AFCEC's 1.5-MW wind turbines, a 1.6-MW diesel backup generator, an intelligent, 1.6-MW/1.2-MWh lead-acid battery energy storage and management system, and a microgrid controller developed and installed by Raytheon, the lead contractor for the project. The Otis microgrid will be the first operational wind-powered microgrid in the DoD once activated.[12]

Obstacles

The implementation of GEB initiatives at JBCC is challenging due to the complexity of the property and missions of multiple tenants operating on the base. Potential projects receive varying levels of stakeholder approval and energy managers have often faced logistical hurdles. For example:

- **Lack of financial incentive.** Coast Guard utility bills are paid by an off-site office, therefore, there is a disconnect between the bill payer and the energy user, reducing the organization's incentives to claim potential energy savings.
- **Cost concerns.** Leadership has expressed concerns over the upfront costs of GEB investments.
- **Security concerns.** Cybersecurity requirements for any automated system in a DoD facility are rigorous. Interim authority to test is a way to implement automated systems on a temporary basis; however, technologies may be removed after expiration of interim authority.
- **Operational knowledge gaps.** GEB technologies often require a specific skill set to run them successfully. Turnover in building management can lead to lag and/or abandoned technologies and projects.
- **Permitting delays.** Diesel generators and other GEB technologies often require varying degrees of environmental permitting which can cause lengthy delays.

Lessons Learned

Despite the obstacles, JBCC boasts many successful GEB-related energy saving projects throughout the base. JBCC stakeholders identified the following lessons learned for pursuing these types of projects in the federal space:

- **Need to make the case to management.** Leadership approval is often essential to clear logistical problems and other obstacles.
- **Draw attention to financial incentives.** Demand response programs can generate significant savings and funds can be used to support other energy savings projects or offset utility bills. Energy programs are more likely to gain

[12] Otis Microgrid. Available: https://cleantechnica.com/2018/09/10/otis-microgrid-cape-cod-military-base-to-run-fully-on-renewable-energy/.

support if they have the potential to generate revenue, and GEB strategies and technologies are easier to justify when they can directly offset large utility bills.

- **Leverage internal resources where possible.** Internal resources such as the Air Force Office of Energy Assurance must be engaged early in the planning stages. These organizational entities are critical when assessing security and other concerns.
- **Plan for cyber security.** Security practices and protocols must be planned and designed early in the process to gain authorization to use and install GEB technologies.

Case Study: Moorhead Federal Building

GEB Project start: 2008

The William S. Moorhead Federal Building is a skyscraper in downtown Pittsburgh, Pennsylvania, built in 1964. This GSA-owned facility explored operational changes to reduce peak energy consumption.

GEB Practices and Technologies at Moorhead Federal Building

A thermal storage system had been in place at the Moorhead building since the early 1990s but was not being optimally utilized by the facility. Using Federal Energy Management Program (FEMP) technical assistance the site switched from fixed to day-ahead dynamic electricity purchasing. There are two ice storage tanks with approximately 7,000 ton-hours of thermal energy storage capability (TES). During the summer, the operators would assess the day-ahead utility rates and program the next day's TES charge (overnight ice production) and discharge (afternoon melting for A.C. purposes), including an assessment of weather predictions. The thermal storage system is semi-automated and integrated into existing building controls.[13]

Obstacles

Building operations staff turnover. Moorhead experienced a high turnover rate for building operators with institutional knowledge about the thermal storage and dynamic programing. There was a gap in training, which led to challenges with implementation and operation of the dynamic programing.

Lessons Learned

- **Robust training programs with hands-on learning and oversight are key for knowledge transfer between building operators.** All buildings are unique. When implementing GEB practices and technologies, on-the-job training and long-term succession planning should be included in the project plan.
- **When planning for control systems integration, engage with vendors early in the process**. Vendors can provide varying degrees of oversight and it is worth engaging them early in the process to assist with project planning.

[13] Overview and technology detail sourced from interview 2/27/2020.

Case Study: Marine Corps Air Station Miramar
GEB Project Start: 2008

Overview

Marine Corps Air Station Miramar (MCAS Miramar) is home to the 3rd Marine Aircraft Wing, in Miramar, California, 15 miles north of San Diego. The installation sits on 23,000 acres and has a population of over 15,000 people, with 800 facilities and 6.1M square feet of building space.

MCAS Miramar partnered with the National Renewable Energy Laboratory (NREL), Naval Facilities Engineering Command, DoD, Schneider Electric, Black and Veatch, Raytheon, and Primus Power to establish an installation-wide microgrid that supports critical installation facilities. This initiative was driven by the DoD's goal to establish "net zero energy installations," or NZEIs, defined as military installations that produce as much energy on site from renewable energy generation, or through the on-site use of renewable fuels, as they consume in their buildings, facilities, and fleet vehicles.[14] Miramar was selected by the task force to be the prototype installation for net zero energy assessment and planning based on the installation's strong history of energy advocacy and extensive track record of successful energy projects.[15]

GEB Practices and Technologies at Miramar

Initially funded by $20 million from Congress, the Miramar microgrid is considered one of the most sophisticated under development with five distributed energy resources, including solar, energy storage, landfill gas, diesel and natural gas plant, and EV charging. The microgrid enhances energy resiliency by allowing the installation to operate even when the utility is down, using redundant/on-site fuel sources.[16]

The microgrid at Miramar has been rolled out in phases. The first phase of the demonstration project paired solar and fossil fuels. Its second phase demonstrated the use of landfill gas and energy storage. The microgrid was fully complete at the end of calendar year 2019. The grid can allow Miramar to operate and keep the air station running should local power providers become unavailable. MCAS Miramar's microgrid delivers capabilities that make it one of the most energy-forward defense installations in the nation.[17]

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[14] National Renewable Energy Lab (NREL), NREL Enhances Energy Resiliency at Marine Corps Air Station Miramar. Available: https://www.nrel.gov/energy-solutions/partner-mcas-miramar.html.

[15] NREL, Lessons Learned from Net Zero Energy Assessments and Renewable Energy Projects at Military Installations. Available: https://www.nrel.gov/docs/fy11osti/51598.pdf

[16] Miramar Microgrid to Demonstrate One Solution to World's Waste Problem. Available: https://microgridknowledge.com/miramar-microgrid-landfill-waste/.

[17] MCAS Miramar conducts successful test on microgrid. Available: https://www.mciwest.marines.mil/News/News-Article-Display/Article/1949253/mcas-miramar-conducts-successful-test-on-microgrid/.

Lessons Learned

Some general observations and lessons reported by NREL's project experience with microgrid analysis are that:

- **Resiliency projects don't always result in a positive financial return when economic savings are analyzed.** A microgrid project can have a positive financial return, but this requires a unique combination of installation location, financial incentives, and existing infrastructure. If resiliency is a mission requirement, a project may not need to demonstrate cost savings, due to the overriding value of the microgrid reducing risk for the installation in the event of a power outage.[18]
- **Project refinement can change funding and financing needs.** NREL found that in many cases, a project needs to be modified during the development or implementation phases as new information is revealed or conditions change. With the Miramar microgrid, funding to implement all the desired project options was unavailable. To match the funding available, the project scope had to be reduced and certain components such as energy storage had to be removed from the initial implementation.[19] A phased approach to microgrid implementation can help with financing challenges by spreading out the funding needs.

Case Study: Philadelphia U.S. Custom House

GEB Project Start: 2005

Overview

Built in the 1930s under the Works Projects Administration, the U.S. Custom House is considered an architectural monument to Philadelphia's status as one of the nation's largest ports. GSA completed a major restoration of the structure in the early 1990s.[20] In the early 2000s, FEMP, in partnership with Lawrence Berkley National Labs (LBNL) and GSA, began assessing the Custom House to identify ways to limit its energy demand. As GSA was paying very high demand charges (nearly $30/kW per month, along with an 80% demand "ratchet" clause) to its utility, PECO, the agency sought to reduce demand and tested a series of GEB approaches.[21]

GEB Practices and Technologies at the U.S. Custom House

LBNL recommended and Custom House implemented an automated "pre-cooling" and "demand limiting" protocol. On the summer's hottest nights, the one of the building's chillers turned on in the early morning and pre-cooled the building starting at 2:00 AM.

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[18] National Renewable Energy Lab (NREL). Microgrids for Energy Resilience: A Guide to Conceptual Design and Lessons from Defense Projects. Available: https://www.nrel.gov/docs/fy19osti/72586.pdf.

[19] National Renewable Energy Lab (NREL). Microgrids for Energy Resilience.

[20] U.S. General Services Administration. U. S. Custom House Philadelphia. Available: https://www.gsa.gov/historic-buildings/us-custom-house-philadelphia-pa.

[21] Overview and technology detail sourced from interview 2/27/2020.

Then, building operators would try to hold the temperature (approximately 70 degrees F) with just one of the two 650-ton chillers for the rest of the day. This reduced peak demand by approximately 20%. The historic design and limestone structure of the building meant it had enormous “thermal mass” for this programmed pre-cooling.

The automated pre-cooling and demand limiting protocol resulted in utility savings of approximately $100,000 per year, representing about 14 percent of a $700,000 annual electric bill.

Obstacles

- **Historic building challenges.** Implementing emerging technologies in a historic building can be challenging due to both extra permitting requirements and structural limitations. However, historic buildings can also offer benefits, e.g., the thermal mass of the Custom House’s limestone structure provided the perfect medium for pre-cooling.
- **Local utility rate structures.** Changing state utility regulations and substantial increases in rate changes made cost savings less attractive over time.

Lessons Learned

- **Historic buildings can provide opportunities for energy savings.** Structural features such as thermal mass should be analyzed early in the process of implementing an emerging or GEB-related technology or practice, as the structure of a building can help or hinder the goal of demand reduction. Leveraging passive features of any facility should be done to optimize systems implementation.
- **Get experts in place early to execute the project.** It is often worthwhile to engage experts to help adapt practices and technologies, especially in the case of historic buildings.

Case Study: John F. Shea Federal Building
GEB Project Start: 2003

Overview

The John F. Shea Federal building in Santa Rosa, California houses 40,000 square feet of courthouses and 40,000 square feet of office space. The building was one of nine federal sites in California and Nevada selected to have solar panels installed as part of a program to meet White House renewable energy goals. Long before the addition of the onsite renewables, the Santa Rose Federal Building was chosen as a test building for a LBNL Peak Demand Reduction from Pre-Cooling with Zone Temperature Reset study. The office building demonstrated success with the pre-cooling.[22]

[22] Peak Demand Reduction from Pre-Cooling with Zone Temperature Reset in an Office Building. Available: https://www.aceee.org/files/proceedings/2004/data/papers/SS04_Panel3_Paper31.pdf.

GEB Practices and Technologies at the John F. Shea Federal Building

In this demonstration project, the building reduced peak electrical demand by implementing the demand shifting strategy with the building's structural mass (thermal mass precooling). Understanding the mass of the building design and construction allowed for better use of building thermal mass in the control of HVAC systems for precooling and zonal temperature reset to align with energy and demand reduction goals.

Building managers initiated a precooling program in 2003 to begin efficiently shifting a significant component of the building's energy consumption to off-peak hours. The strategy of precooling with zonal temperature reset shifted the peak demand to the off-peak morning period while maintaining thermal comfort for the occupants. In addition to leveraging its structural mass for precooling, the building's demand response program leveraged:

- Whole building power meters
- Submeters for the chiller and air handling unit fans
- On-site weather station data
- HVAC performance data from the EMCS
- Operative temperature sensors for accessing the thermal comfort
- Measurement and verification of demand response performance

To reduce overall energy consumption costs, the demand response program was designed on a Critical Peak Pricing (CPP) model to encourage customers to reduce their electricity usage during CPP event hours. In this study, the electricity peak demand was successfully reduced as much as 2.3 W/square foot without having any thermal comfort complaints.

Obstacles

Building technology. There were some challenges for building managers to overcome with the building's technologies. For example, the building was fully equipped with digital direct controls, but had no global zone temperature reset strategies implemented before the study. There was one undersized cooling coil limiting the precooling effect in the serving zone and a lack of reheat coils in a single-duct system causing temperature control problems. Additionally, the HVAC system was oversized which caused the inefficiency in the extended night precooling.

Operational knowledge gaps. More research is needed to improve understanding of pre-cooling and its role in shifting/reducing peak demand. One issue is the need to quantify the relationship between peak demand reduction and load shifting along with the risk of occupant discomfort for different building and HVAC system types in different climates. Another issue is how the different types of thermal mass (i.e., materials, specific heat capacity, thermal conductivity) contribute to the duration and depth of the zonal temperature reset.

Lessons Learned

- **Pre-cooling can be done without thermal complaints.** The two pre-cooling and zonal temperature reset strategies that were tested shifted 80-100% of the chiller power from the on-peak to the off-peak period without comfort complaints, even with relatively high outside temperature conditions (above 90 degrees F).
- **Combine GEB strategies for energy saving success.** When performed together, economic savings can be made by integrating various GEB strategies in the participation of demand response programs.

List of Abbreviations and Acronyms

ADR	automated demand response
AFCEC	Air Force Civil Engineering Center
AFCEE	Air Force Center for Engineering and the Environment
ATO	Authority to Operate
BESS	battery energy storage system
BTO	Building Technologies Office
CPP	critical peak pricing
DLA	Defense Logistics Agency
DoD	Department of Defense
DOE	Department of Energy
EIA	Energy Information Administration
EMCS	Energy Management Control System
ESPC	Energy Savings Performance Contract
ESTCP	Environmental Security Technology Certification Program
EV	electric vehicle
FEMP	Federal Energy Management Program
GEB	Grid-interactive efficient building
GPG	GSA's Proving Ground Program
GSA	General Services Administration
HIT	High Impact Technology
HVAC	Heating, ventilation and air conditioning
IPERC	Intelligent Power & Energy Research Corporation
IRP	Installation Restoration Program
JBCC	Joint Base Cape Cod
LBNL	Lawrence Berkley National Labs
MCAS	Marine Corps Air Station
MMR	Massachusetts Military Reservation
MW	Megawatt
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
NZEI	net zero energy installations
PECO	Philadelphia Electric Company
PPA	power purchase agreement
PV	photovoltaic
RMI	Rocky Mountain Institute

SPIDERS	Smart Power Infrastructure Demonstration for Energy Reliability and Security
TES	thermal energy storage