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Operator-in-the-Loop Grid-Interactive Efficient Building Evaluation

Michael Myer

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Tenfold Information Design Services: Andrea Silvestri, Donna Creason

For more information contact:

Principal Investigator Name: Michael Myer
Lab: Pacific Northwest National Laboratory
Email: michael.myer@pnnl.gov

GSA's Proving Ground (GPG) program and DOE's Office of Energy Efficiency and Renewable Energy enable federal and commercial building owners and operators to make sound investment decisions in next-generation building technologies based on the technologies' real-world performance.

Table of Contents

Introduction

Executive Summary

The U.S. Department of Energy (DOE) and U.S. General Services Administration (GSA) evaluated grid-interactive efficient building (GEB) technologies from late 2020 into late 2022. The focus of the evaluation involved Software-as-a-Service (SaaS) GEB technologies. This report focuses on GEB SaaS offered by Logical Buildings that GSA evaluated from July 2021 through the end of November 2022. This SaaS is an operator-in-the-loop GEB solution. For some GEB SaaS, the software has supervisory control of some or all building systems. In contrast, the operator-in-the-loop SaaS does not have supervisory control. The software shares recommendations to the building staff and building operators can choose to implement the recommended building operation.

As an operator-in-the-loop solution, this technology provides an assessment and checklist of how to operate the building for different GEB events that may include load shedding/demand response; load shifting, continuous demand response, etc. The vendor deploys a limited number of metering devices and monitors the building loads. The vendor's machine learning enables predictive algorithms to create alerts to the GSA building staff. The vendor issues an alert by email, text, software, or any combination of the foregoing (user selects methods), for demand response, load management and indoor air quality (IAQ) alerts. Once an alert is received, the GSA building staff choose how to address the alert. Because the building staff choose how to address the alert, this is the "operator-in-the-loop" aspect and there are no automatic functions. The vendor offers an automated solution, but GSA specifically opted to evaluate the "operator-in-the-loop" aspects.

The site evaluated was 20 Washington Place located in Newark, NJ. The federally owned building that is under the jurisdiction, custody and control of GSA was constructed in the 1920s. The building size is 149,883 ft^2 gross and 136,279 ft^2 rentable. The building materials are dense and limit wireless communication in the building. The primary occupant agency in the building is the U.S. Department of Veterans Administration.

The evaluation explored two GEB measures: demand response and load management/continuous demand reduction. Beyond the GEB measures, the evaluation also tested IAQ sensors as proof of concept to evaluate the wireless protocol LoRaWAN.

Table 1 presents the quantitative performance objectives of the field evaluation. For the load management, the on-site staff stated that it was hard to act upon alerts. The alerts required a quick response of 15-minutes once received. After about 90 days of the load management alerts, the staff opted to turn off the load management alerts because they could not act upon them in a timely manner. As a result, reduced energy use and load management resulted in N/A values. The vendor did not provide energy efficiency recommendations. Table 1 also shows results for demand response. For both 2021 and 2022, the building had seven (7) demand response events called by the GEB operator-in-the-loop vendor. The building was already enrolled in a demand response program prior to the commencement of this evaluation. In the previous five years, the demand response program never called a demand event. The GEB operator-in-the-

loop vendor called demand response events to reduce the building's installed capacity (ICAP) charges. These ICAP-related events resulted in $20,000 in savings for 2022. These savings were in the form of lower energy bills and no rebate checks were issued. These savings resulted in the GEB operator-in-the-loop subscription having a simple payback of less than 1 year and a savings-to-investment ratio (SIR) of 2.0.

Table 2 presents the qualitative objectives of this field evaluation. The three major elements of the qualitative evaluation include: ease of installation/commissioning; occupant comfort; and facility manager acceptance. Installation time for the equipment involved a limited number of hours, but occurred over a few weeks because of availability of the utility. Occupants were not interviewed or surveyed during the evaluation, but no requests for changes in temperature were received during the evaluation. The facilities team appreciated the software and operator-in-the-loop aspects of the vendor's platform.

Table 1. Quantitative Performance Objectives

Quantitative Objectives	Metrics and Data Requirements	Measurement and Verification Results
Reduce Energy/Water Use	Energy savings: kWh/year and % savings Energy intensity savings: kWh/ft^2/year (kWh/ft^2-yr)	N/A - vendor did not present energy efficiency recommendations
Continuous Demand Management (Monthly peak management)	Monthly peak demand reduction: kW and % Monthly demand charge reduction, site-specific and GSA average Summer and winter average peak kW reduction Summer and winter average demand charge reduction $ Winter: Nov. - Feb. (No winter charge) Annual Demand: $3.761697 / kW Summer: June - September (Demand: $8.949490 / kW) M&V: 2 weeks of vendor instructions 2-weeks of no vendor intervention Normalize for weather	N/A - site could not respond to load management alerts within the necessary time
Reduce Peak Demand	Demonstrated load shed a. Demand shed per event: Average kW reduction (for shed) over a specified time window b. Average % demand reduction c. Demand shed intensity: kW/kft^2	a. 76 kW b. 20% c. 0.56 kW / ft^2 (CBL/SAA method)
Reduce CO_2	Annual CO_2eq reduction: CO_2,eq/year Normalized annual CO_2eq reduction: CO_2,eq/ft^2/year	Average CO_2 cumulative reduction 2,011 lbs/yr (0.91 MT) per year Normalized: 15 lbs/1,000 ft^2-yr (0.007 MT / 1,000 ft^2-yr)
Reduce Costs	Cost savings due to load shed/shift: $/yr Simple payback	Simple Payback: <1 year SIR: 2

Table 2 lists the qualitative performance objectives of the field evaluation.

Table 2. Qualitative Performance Objectives

Qualitative Objectives	Metrics and Data Requirements	Measurement and Verification Results
Ease of Installation/ Commissioning	Calendar duration required for installation and commissioning (days starting at contract notice to proceed where vendor is cleared to work in the building) Labor hours required of site staff (days) Building owner/facility manager experience installing and commissioning (host site interviews, score on 1-5 Likert scale, 1 being worst, 5 being best)	Technology installed in a few hours
Occupant Comfort	Change in space conditions during occupied hours, based on the end uses/services affected in the control strategy (*e.g.*, ventilation, lighting), for a sample of zones: Thermal comfort: %Increase/decrease in hot/cold calls, and % incr/decr within/out of comfort range (*e.g.*, simplified ASHRAE model based on temperature, relative humidity, winter/summer). Visual comfort: change in accepted ranges of interior illuminance levels (%) Indoor air quality: change in accepted ranges of interior CO_2 levels	Occupants were not interviewed as part of the focus group (Focus group size *n* = 5) No increased requests by occupants
Facility Manager Acceptance	Facility management (FM) and operation and maintenance (O&M) survey and interviews, including (using 1-5 Likert scale) addressing: Level of skill and position required to operate the solution (describe the position level needed to operate the solution and any additional training that is required) Satisfaction with the operator interface(s) (1-5 Likert, with 1 not satisfied at all, 5 being highly satisfied) Satisfaction of implemented load flexibility control strategies (1-5 Likert, with 1 not satisfied at all, 5 being highly satisfied) Satisfaction of shift and shed controllability responding to dynamic signals (*e.g.*, changes in rate structure, seasonal changes) (Optional) # of system overrides (or recommendations rejected), normalized by a site-specific factor, such as # of events or hours of operation.	Operator focus group conducted, staff preferred the operator-in-the-loop functions, not automatic functions (Focus group size *n* = 5))

In general, the GSA building operators liked the GEB operator-in-the-loop technology. They preferred the "operator" aspect over any autonomous options. The GSA staff were aware of GEB measures, but liked the reminder presented in the vendor's platform.

Not shown in Table 2, the GSA staff was frustrated by the alert frequency, methods and tolerances of the alerts. The alerts that were the issue were IAQ alerts. The staff allowed the building to drift during off hours and the weekends. The vendor software sent alerts in the middle of the night, and some alerts were sent within minutes of each other and at other inopportune times. The vendor's software did not allow users to select which alerts could be received, when the alerts could be received, the frequency of the alerts, or the tolerance that triggered the alerts. Ultimately, the GSA staff requested the IAQ alerts be turned off. The IAQ alerts were a means of testing the LoRaWAN system and other aspects of the technology and were never expected to be acted upon.

The GEB operator-in-the-loop technology was evaluated for three major features: energy savings; load management; and demand response. Of those three features, energy savings results were not applicable; load management was not successful, and demand response was relatively successful.

No new building equipment was installed as part of the evaluation. The vendor did not provide any operational changes that would result in energy savings. Therefore, the energy savings results were not applicable.

Load management was not successful for the operator-in-the-loop option. Of the 29 alerts received, the building was unable to respond within the necessary 15-minutes to affect the load. It is probably unrealistic to expect building operators to be in the right place at the right time to respond, and available to respond to random load management alerts. During the evaluation period, GSA staff requested to stop the load management portion of the evaluation. Therefore, load management should not be relied upon with operator-in-the-loop technology in GSA buildings.

Fourteen (14) demand response events were initiated by the GEB vendor to reduce the installed capacity (ICAP) values for the building during the summer of 2021 and 2022. Neither the utility nor the Independent System Operator (ISO) initiated the demand response events.[1,2] Building management was able to respond due to the advance notices received the day before and the morning of the demand response events. The demand response events affected the ICAP calculations resulting in the technology to be cost effective due to the ICAP savings. During the subjective feedback portion of the technology evaluation, GSA staff stated they liked the operator-in-the-loop technology for demand response.

Although the technology was cost effective based on 2022 calculations, using 2021 as an example, the cost effectiveness would have been different. Further capturing and valuing ICAP savings is more complex than other traditional cost recovery mechanisms. Finally, GSA regional staff commented they had more discretion with demand response rebate funds and preferred those funds than savings generated from ICAP savings. Rebates from utilities are budget activity (BA) 63, Energy Rebate, funds. Sites have discretion to

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[1] Independent System Operators stem from orders issued by the Federal Energy Regulatory Commission (FERC). In later orders, FERC encouraged the voluntary formation of Regional Transmission Organizations (RTO) to administer the grid on a regional basis. https://www.ferc.gov/power-sales-and-markets/rtos-and-isos
ISOs operate within a single state or a smaller region, whereas RTOs operate across multiple states.
[2] Within this document, ISO and RTO may be used interchangeably.

use the BA-63 funds on qualifying energy and water projects. In contrast, ICAP savings translate to lower utility bills (via lower transmission charges) next year. The energy bills are lower, but GSA does not receive additional revenue like the participation in the demand response program, only spends less money for electricity. The bills would be required to be tracked in detail to demonstrate the savings.

As the need for dynamic building operations grows for GSA, GEB operator-in-the-loop technology should be considered as an option. The technology performed at 20 Washington Place with some success, but there are non-technological issues (e.g., policy, incentives) that need to be addressed.

Background

Grid-interactive efficient buildings (GEB) are buildings that achieve energy-efficiency goals while also maintaining electricity loads. This is achieved by employing different strategies and technologies, which are discussed in this section of the report, to enable buildings to increase or decrease electric loads in response to real-time utility changes with the power grid. The evaluation below includes three components: (1) GEB technologies/operator-in-the-loop; (2) wireless communication; and (3) non-GEB technologies. The primary aspect of this evaluation was a GEB-related technology.

Grid-Interactive Efficient Buildings

The U.S. General Services Administration (GSA) briefly describes GEBs as buildings that incorporate both energy-efficiency and demand flexibility measures. Under normal conditions, GEB buildings operate efficiently but they also have features for dynamic operation that enable loads to be curtailed. This dynamic operation may occur in response to an external or internal signal. The GPG program's GEB page directs to SFTool.gov[3], which characterizes GEBs as able to:

- Achieve ambitious climate and resilience goals by bringing buildings and the grid together;
- Draw from a toolbox that includes energy efficiency, renewables, energy storage, and load flexibility;
- Employ these capabilities to reduce, shed, shift, modulate, or generate electric load flexibly, as needed; and
- Respond to utility price signals to reduce costs and enhance resilience for both building and utility.

GEB Strategies

There are six major GEB strategies: (1) Efficiency; (2) Load shedding; (3) Load shifting; (4) Load management; (5) Load modulation; and (6) Generation. Table 3 briefly defines these strategies and explains if the signal that initiates the process is internal or external to the building and key characteristics of the GEB strategy.

Table 3. GEB Services

Flexibility Mode	Definition	Signal	Key Characteristics
Efficiency	Persistent reduction in load Not dispatchable	Internal	Load change: Long-term reduction Duration: Equipment lifetime Response time: N/A Annual events: Continuous
Load Shed (demand reduction included)	Short-term load reduction to make up for a shortfall in generation	External	Load change: Short-term decrease Duration: Up to 1 hr Response time: <15 min Annual events: <20
Load Shed (demand reduction	Load reduction during peak load periods	External	Load change: Short-term decrease Duration: 30 min to 4 hr

[3] https://sftool.gov/learn/about/638/grid-interactive-efficient-buildings

Flexibility Mode	Definition	Signal	Key Characteristics
included)			Response time: 30 min to 2 hr Annual events: <100 hr, seasonal
Load Shift	Load shifting away from peak use periods	External	Load change: Short-term shift Duration: 30 min to 4 hr Response time: <1 hr Annual events: <100 hr, seasonal
Load Shift	Load shifting to periods of excess renewable generation Not dispatchable	External or Internal	Load change: Short-term shift Duration: 2 to 4 hr Response time: N/A Annual events: Daily
Load Management (Continuous Demand Reduction)	Building manages load to prevent and smooth monthly peak/demand charges	Internal	Load change: Short-term decrease/shift Duration: < 1 hr Response time: < 1 hr Annual events: Continuous
Load Modulate	Rapid load increase or reduction following a grid signal Rapid load reduction/increase to offset short-term renewable generation changes	External	Load change: Short-term decrease Duration: Seconds to minutes Response time: Seconds to minutes Annual events: Continuous
Generate	Feed excess on-site generated electricity to the grid	Internal	Load change: Negative load Duration: Entire generation period Response time: <1 hr Annual events: Continuous

Table modified from: *Blueprint for Integrating Grid-Interactive Efficient Building (GEB) Technologies into GSA Performance Contracts*

GEB Request for Information

This technology was part of a series of evaluations by GSA of different GEB technologies. GSA and the U.S. Department of Energy (DOE) released a joint request for information (RFI) seeking GEB technologies to evaluate. DOE and GSA received multiple submissions. After reviewing the submissions, GSA and DOE initiated the evaluation of selected technologies.[4]

Many of the technologies selected in the RFI process were automated GEB platforms. Automated technologies deployed on-site actively manage building systems for either optimization or GEB principles and other features, or any combination of the foregoing.

[4] https://www.gsa.gov/about-us/newsroom/news-releases/gsas-proving-ground-program-selects-gridinteractive-efficient-building-solutions-for-evaluation-07282020

The technology that is the subject of this report was selected specifically because of the non-automated aspects of the vendor's platform, SmartKit AI by Logical Building. The vendor offers an operator-in-the-loop platform. Operator-in-the-loop, or human-in-the-loop, means that the system may have automated features, but a human/operator is required to approve, initiate, or process the change in building operation. The operator-in-the-loop and other features of the technology will be addressed in the next section.

GSA GEB Experience

GSA commissioned the Rocky Mountain Institute (RMI) to analyze the value potential of GEB aspects for GSA buildings in *Value Potential for Grid-Interactive Efficient Buildings in the GSA Portfolio* (RMI, 2019), known as the GSA GEB Value Analysis in this report. That report defines GEB as an "efficient building with smart technologies characterized by the active use of energy efficiency, solar, storage, and load flexibility to optimize energy use for grid services, occupant needs and preference and cost reductions." GEB goes beyond energy management and focuses on demand and the time value of energy.

The report states that a GSA GEB strategy should prioritize:

- Investment in fully controllable systems (e.g., fully controllable lighting fixtures);
- Staging of large building loads (e.g., staging [operating at different times] air-handling unit fan motors offer an untapped source of demand savings and require little to no new equipment);
- Consistent demand management and peak saving—year-round demand management delivers greater value than demand response in most scenarios;
- Battery storage and solar photovoltaics panels—costs are expected to continue to decrease and the technologies make economic sense in many locations;
- Occupant comfort and building operations—GEB measures have little to no discernible difference in occupant comfort; and
- Interoperable, intelligent building controls—an ideal control system should balance available energy and demand flexibility, building operational needs, and grid price signals to provide grid benefit and reduce costs.

The report recommends three next steps:

1. Fold GEB measures into current projects and pipeline;
2. Develop dedicated-GEB pilots to generate proof points:
    a. Prioritize locations with high-demand rates or time-of-use rates (including New York City).
    b. Prioritize locations where GSA has a sizable local presence and high demand charges.
    c. Prioritize applying GEBs to all-electric buildings.
3. Develop or adopt a building performance metric that considers electric demand (e.g., demand load factor).

The National Renewable Energy Laboratory (NREL) produced a blueprint for GEB technologies in GSA performance contracts. Within *Blueprint for Integrating Grid-Interactive Efficient Building (GEB) Technologies into U.S. General Services Administration Performance Contracts* (NREL, 2021), known as the GSA GEB ESPC report within this document. NREL identified how GEB strategies can be integrated into energy savings performance contracts (ESPC). Keys to a successful GEB project are:

- Strategic selection of sites with utility rates and incentives favorable to GEB;

- Identification of GEB measures as a priority early in the project development process;
- Stakeholder engagement to promote understanding and to maximize GEB impact;
- Integration of GEB measures within major building renovations; and
- Careful consideration of GEB measurement and verification methodologies.

There are two major aspects to GEB technologies: (1) the control device(s) or methods, and (2) the equipment necessary for the GEB solutions. Both of the reports provide specific GEB control capabilities in the building for different GEB strategies. The actual measures used in the GEB evaluation will be discussed in the quantitative results subsections in the individual sections.

This report focuses on the control system for the GEB solution. GSA and DOE sought technologies through the RFI that provided GEB operations. At the time of the RFI, GSA had only a few evaluations of building-level systems that would provide GEB operations. This report will discuss the measures utilized by the site to achieve the GEB strategy, but the main focus of the report is on the control system.

Technology/Operator-in-the-Loop

The vendor, referred to in this report as the GEB operator-in-the-loop vendor, provided an operator-in-the-loop platform for building management and GEB strategies. In terms of GEB strategies, the vendor's platform ingests historical energy consumption data. The platform relies on local weather data, data gathered from an on-site engineering review of the building, local utility data, and machine learning to predict energy use of the building.

Figure 1 presents the GEB operator-in-the-loop vendor's commercial technology and flow of data. The vendor's platform shares data between both the web and a mobile application. The on-site operations team receives information from the GEB operator-in-the-loop platform and the on-site staff then have the option to act upon the information.

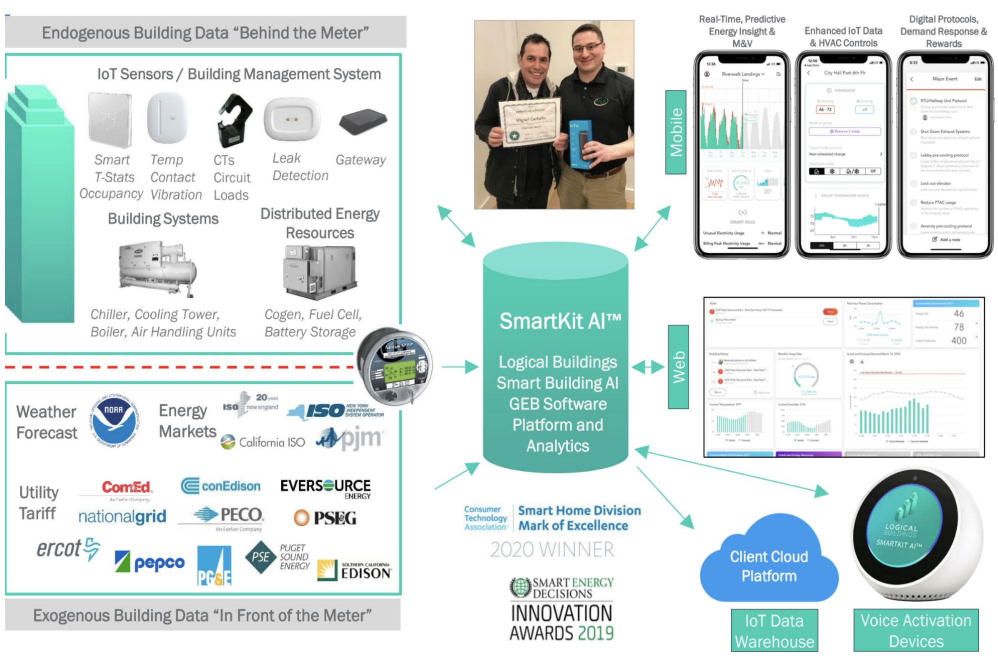

Figure 1. GEB Operator-in-the-Loop Flow of Data

The GEB operator-in-the-loop vendor provides a dashboard to users of the technology. Figure 2 shows an example of the dashboard, which indicates the outside temperature at the site, outside humidity at the site, aggregate energy usage, recent power, and a heatmap of the electricity usage for a period of days.

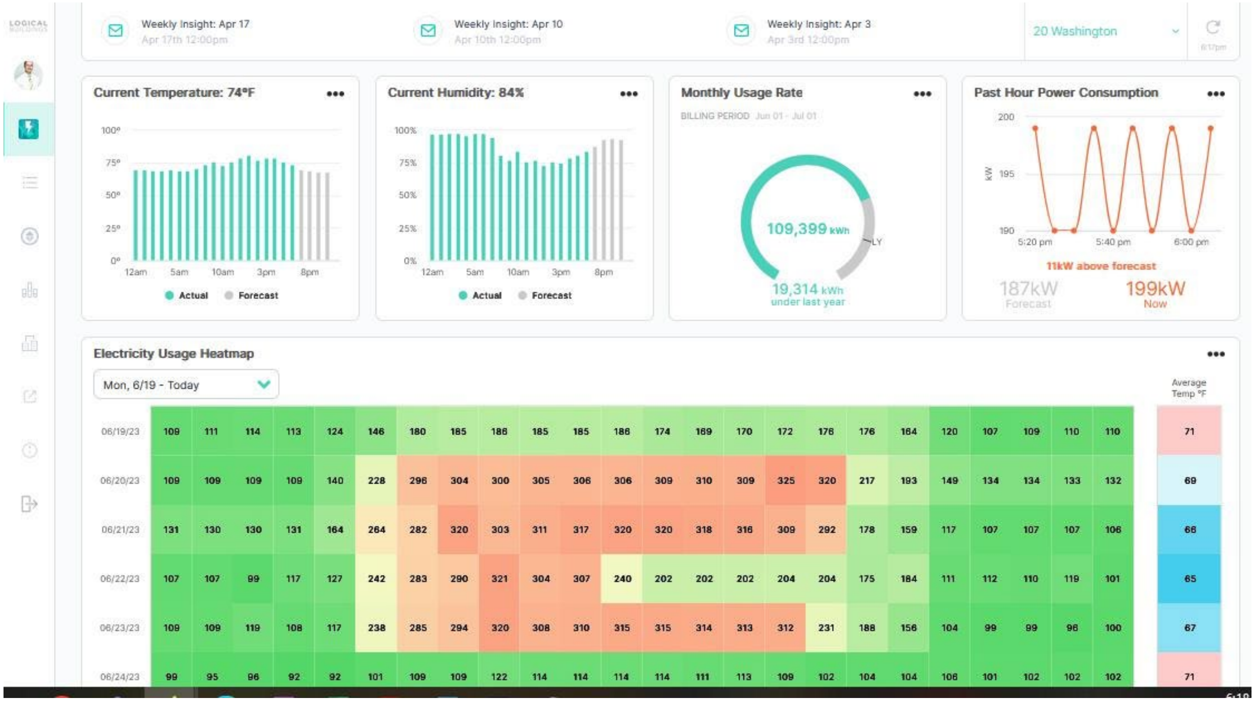

Figure 2. GEB Operator-in-the-Loop Dashboard

Wireless Communication/Cybersecurity

One of the challenges with some technologies is attenuation of wireless signals in GSA buildings. The age and construction of some of the GSA building stock results in large and dense walls that prevent wireless signals from passing through walls. One reason for the selection of this technology involved the evaluation of LoRaWAN wireless communication.

LoRa means "long range" and communicates farther (less attenuation) than other wireless communication protocols. WAN means "wide-area network" referring to the architecture of the wireless system. LoRaWAN can connect battery-operated and other devices to the internet through a gateway in regional, national, or global networks. LoRaWAN is low power, low bit rate (0.3 kbit/s to 50 kbit/s) per channel. These features allow for LoRaWAN to provide limited data through a building through dense materials.

Cybersecurity remediation for GSA is a minimum 90-day process for GSA projects and can take longer if all the necessary components are not supplied or if a larger issue needs to be remediated. Another reason this technology was selected is that it bypassed the need for major cybersecurity mitigation. This GEB operator-in-the-loop platform does not connect to GSA systems directly and the network is entirely separate from GSA, greatly reducing the time to deploy the technology on-site.

Indoor Air Quality/Non-GEB Technologies

The vendor offers indoor air quality (IAQ) sensors, security sensors, door contacts, and other non-GEB technologies. Additional monitoring could be GEB-ready in that the monitoring allows for other GEB operations. This evaluation explored IAQ aspects of the non-GEB technologies. The GEB operator-in-the-loop platform can monitor IAQ elements and send alerts, as necessary, to the building staff. These aspects of the technology were not a major aspect of the evaluation. However, GSA was interested in evaluating the IAQ technology as a proof of concept.

Evaluation Plan

Demonstration Site

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Figure 3. 20 Washington Place, Federal Building, Newark, NJ

This GEB operator-in-the-loop technology was evaluated at the federal building located at 20 Washington Place in Newark, NJ. The building was constructed in 1920 and is located in the James Street Commons Historic District, which is one of the oldest sections of Newark, NJ. Figure 3 depicts the exterior of the building.

The principal occupant agency in the six-floor building is the Veterans Administration. There is a mezzanine between the first and second floors; it is above the public corridor and runs along the back (or south) side of the first floor. In the 1940s, the mezzanine was a pharmacy. Now, GSA maintains a small office in the mezzanine. Major restoration and rehabilitation projects occurred between 1995–2005.

20 Washington Place was the third GSA site seriously considered. The first site was a 15-story building in Portland, OR, known as Edith Green-Wendall Wyatt (EGWW). However, EGWW was not selected because it was an existing, efficient building with an energy use intensity (EUI) below the target minimum of 40 kBtu/ft^2-yr. EGWW has an EUI of 30 kBtu/ft^2-yr and net EUI after the photovoltaics generation of 28 kBtu/ft^2-yr. EGWW had on-site distributed-energy resources, but did not feed energy back to the grid, which limited its opportunity for load modulation. Finally, the existing rate structure for EGWW was very low and flat and weakened the economic case.

After EGWW was removed from consideration, an exhaustive review of Region 10 GSA's Northwest/Arctic Region) facilities was conducted. The criteria (as listed in Table 4) for the search involved buildings over 50,000 ft^2, engaged facility staff, an EUI greater than 40 kBtu / ft^2-yr, constructed pre-2010, and no major upgrades post-2015. A short list of 10 buildings was identified. The Wheeler Building in Oregon was selected after additional scrutiny. Ultimately, Wheeler and the remaining buildings in Region 10 were excluded from consideration.

After this secondary search of Region 10 buildings and no desirable option found, 20 Washington Place was suggested. 20 Washington Place was considered for another technology, but that vendor/technology was not available. Therefore, 20 Washington Place, a building on the national register of historic places, was selected for evaluating this technology. The site requirements for this technology includes careful consideration for historic buildings. Not all buildings on the registry may have technology that perform GEB operations. 20 Washington Place was selected because the building was available, having technology that could perform GEB operations, and higher than the minimum EUI.

This GEB operator-in-the-loop technology was then applied to 20 Washington Place. Table 4 lists the criteria for the technology and how 20 Washington Place applies to the desired criteria for the technology.

Table 4. Site Criteria

System	Site Requirements	Site Characteristics
Location	Sites with significant utility demand charges; variable time of use pricing; critical peak pricing	Building enrolled in a demand program, but no calls for demand response in last 5 years
Building Size	50,000–500,000 ft^2	Gross: 149,883 ft^2; Rentable: 136,279 ft^2
Historic Buildings	Careful consideration	Listed in National Register of Historic Places
Building Age	Buildings constructed pre-2010; no major construction post-2015	Building constructed 1920; no major upgrades since 2015
Site Engagement	Engaged on-site staff; willing to use the software and act on alerts	Engaged staff; willing to use the software and act on alerts
EUI*	>40 kBtu/ft^2-yr	75 kBtu/ft^2-yr
Distributed Energy Resources	Preferred	Not on-site
On-site Storage	Preferred	Not on-site
Lighting Controls	Centralized/networked lighting systems that can be dimmed or load shed	No lighting control system; breakers control floor lighting

System	Site Requirements	Site Characteristics
BAS	Required	Tritium Niagara
HVAC	Newer/flexible systems; avoid constant air volume systems	Two 480-ton box chillers

*** Site EUI value 11/2022 - 10/2023 ADE Energy Usage report**

No new building system equipment was installed as part of this evaluation. The only new equipment related to operational metering equipment necessary for the GEB operator-in-the-loop platform. The GEB operator-in-the-loop platform only addressed building operations.

The utility Public Service Electric & Gas Company (PSEG) serves the building. PJM Interconnection LLC (PJM) is the regional transmission organization that handles the Eastern Interconnection grid where the site is located. The building as part of the adjacent sites has been part of a demand response program for a number of years.

Technology Demonstration

For a GEB technology, the building-level power and major power using devices are critical measurement points. Some technologies could use the BAS for some of the power data. However, this technology did not interface with the BAS. Limited cybersecurity measures were needed with this technology because it did not interface GSA equipment and utilized a non-GSA network to communicate with the vendor's servers. As reported earlier, this technology was partially selected because it was independent of the building information technology systems and could reduce the time to deployment by avoiding a full GSA cyber mitigation process.

On-site metering equipment and setup

In the early phase of the evaluation, GSA provided a letter of authorization so the utility could share the utility data with the vendor. That interval data was gathered and processed by the utility, but there was a delay before that data was shared by the utility. Once the data was received from the utility, it was ingested into the vendor's dashboard, but the data was only available with a 24–48-hour lag time. To provide real-time data and improve the operational feedback, the vendor's typical process involves a pulse-drop utility meter interface to provide real-time building data to the vendor's dashboard.

PSEG installed a pulse-drop device adjacent to the PSEG utility building meter (Figure 4(a)) that is located in the mechanical area two floors below the lobby.[5] The pulse-drop device (Figure 4(b)) reads the same electrical signal of the meter as the utility in 15-minute increments. A LoRaWAN transmitter (Figure 4(c)) was connected to the pulse drop. This allowed the utility measurements to be shared to the vendor's dashboard via the LoRaWAN gateway. The dashboard provided the real-time power use of the building to the O&M staff via the dashboard (Figure 5). This equipment and related support from the utility cost less than $2,000.

(a) Utility meter | (b) Utility meter and pulse drop | (c) LoRaWAN transmitter

Figure 4. GEB Operator-in-the-Loop On-Site Metering Equipment

In addition to the pulse-drop device monitoring the building utility meter, current transducers (CTs) were installed on the two chillers in the building. The two chillers are the largest loads in the building. The chiller wires were placed inside the CTs. The CTs measure the current and that information can be calculated to the power draw of the devices under measurement. The CTs were connected to LoRaWAN transmitters and also shared with the gateway and ingested into the building dashboard (see Figure 7). For less than $1,000,

[5] Pulse-drop meters are common in the utility industry as well as by non-utility metering verification. Pulse-drop meters are offered as enhanced metering by utilities across the country.

an electrician came on-site and installed CTs on the chillers. The chillers were selected for CTs because they are the largest single loads in the building. Not only were the chillers the largest load, they were a load that could be used in the GEB protocols. Other larger loads (e.g., data servers or medical equipment) may not warrant being monitored unless those loads will be part of a GEB protocol.

Vendor Platform/Dashboard

The GEB operator-in-the-loop platform ingests data from the building monitored loads and utility meter, weather data, and other data sets. This information is provided in the vendor's dashboard.

Using the historical and real-time data, the software predicts either demand reduction alerts from the utility or periods of time when the building is approaching the monthly billing demand peak (load management strategy). Building operations and maintenance (O&M) staff sign up in the vendor's software to receive notifications via text, which are pushed to the vendor's mobile application or email.

The GEB operator-in-the-loop vendor team visited the site and performed an engineering assessment (more information in Table 5). During that assessment, the GEB operator-in-the-loop team developed protocols for actions the building operator can take when a load shed/demand reduction event occurs. Within the GEB operator-in-the-loop's platform, the GEB operator-in-the-loop vendor refers to load shed events as "kilowatt crush" (see Figure 5). For non-GSA commercial and residential sites, the GEB operator-in-the-loop vendor has a gamification incentive program. This incentive program is for demand response and known as "kilowatt crush." The gamification aspects of the GSA operator-in-the-loop vendor's platform were not analyzed during this evaluation. The incentives may include gift cards or other types of encouragement. Incentives were not included in this analysis because neither GSA nor GSA staff could directly receive the incentives. For these reasons, gamification was not explored nor were incentives explored or analyzed in this study.

The list in Figure 5 for monthly peak load management is the list of the load management/continuous demand reduction items the building can undertake (more information in Table 5) when an alert is received.

Once the building O&M staff receives an alert, the O&M staff choose whether to participate or not participate. If the O&M staff chose to participate, the staff identifies in the vendor's dashboard checklist which action(s) are taken (see Figure 5). The software captures which action was taken that day (e.g., chiller pre-cool on August 8, 2022).

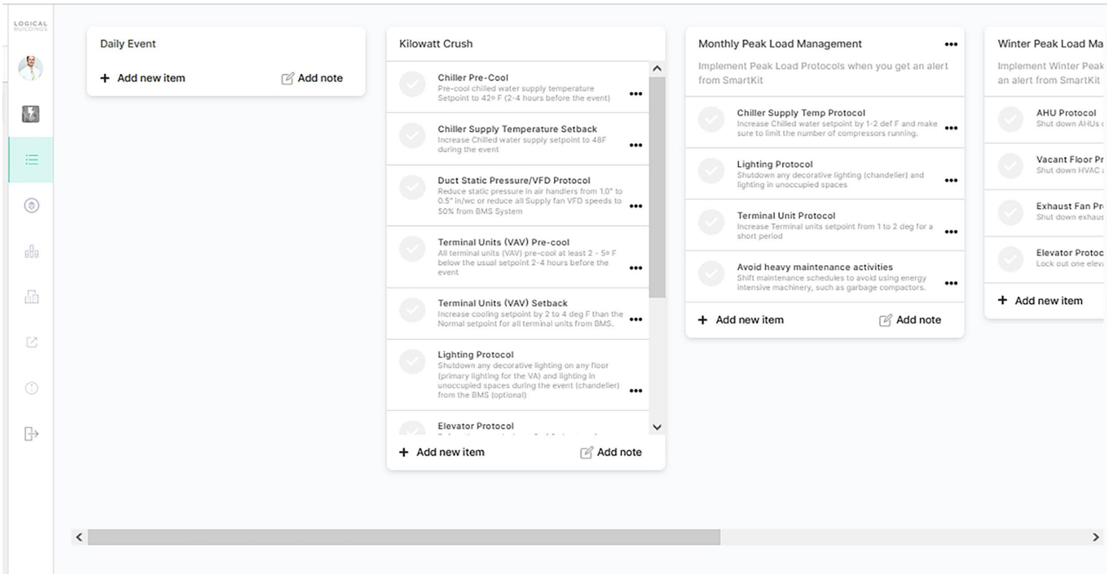


Figure 5. User Checklist

Building Energy

Data from the utility meter populated the dashboard. A heat map (red = high values; green = low values) is generated in the dashboard that shows the building power usage. Figure 6(a) shows a snapshot of the building energy usage for August 1 – 12, 2022. The x-axis is the time of day (24 increments). The left-hand y-axis are individual days of the week, thus each row represents a different day. The dashboard also includes a right-hand y-axis that represents the high temperature for the day, but this is not captured in the extraction to create Figure 6.

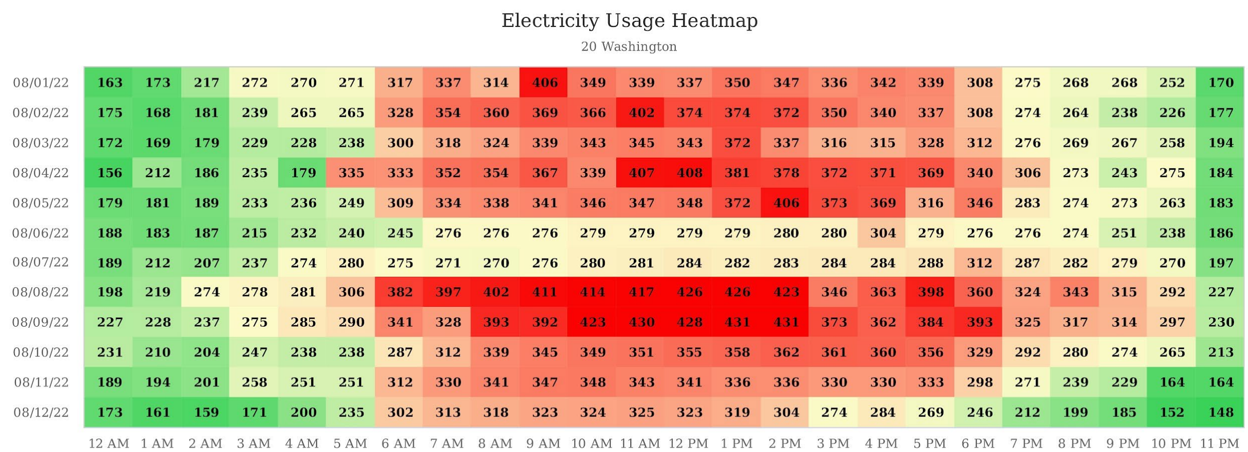


Figure 6(a). 20 Washington Place Building Power | August 1 – 12, 2022

Figure 6(b) shows August 1– 5, a standard Monday–Friday workweek. The building operations increase around 6:00 am to condition the building for occupancy. Most occupants leave around 6:00 pm and operations curtail. The red colors between 6:00 am and 6:00 pm show that increased energy usage of the building corresponds with the occupancy/operations of the building.

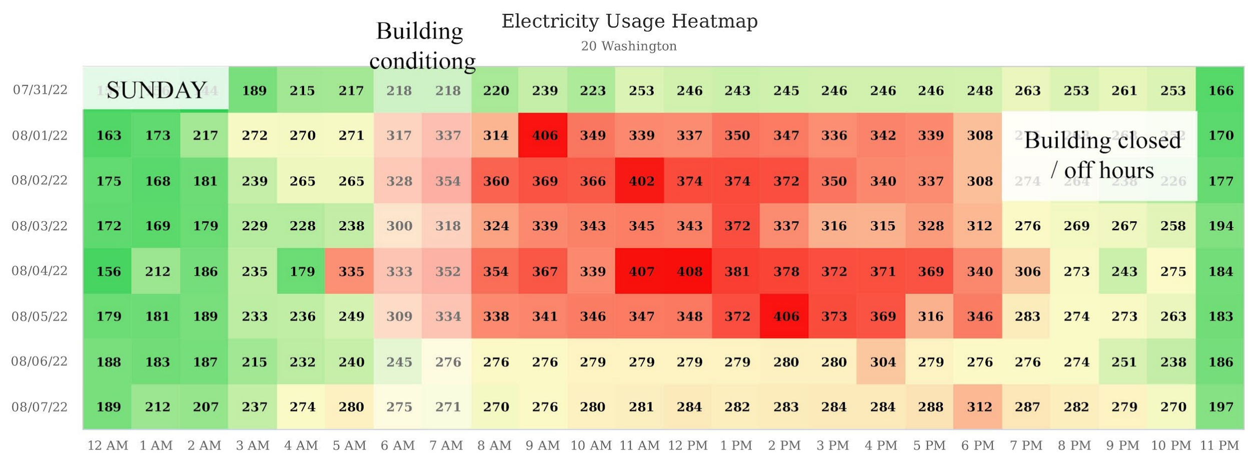


Figure 6(b). 20 Washington Place Building Power | July 31 – August 7, 2022

Figure 6(c) shows August 6 and 7, a Saturday and Sunday, respectively. The energy values are medium (yellow colored) on these days because the building is closed and background equipment is operating. Between 11:00 pm and 3:00 am the colors are green because these times are the middle of the night and represent the least amount of energy used by the building at any time.

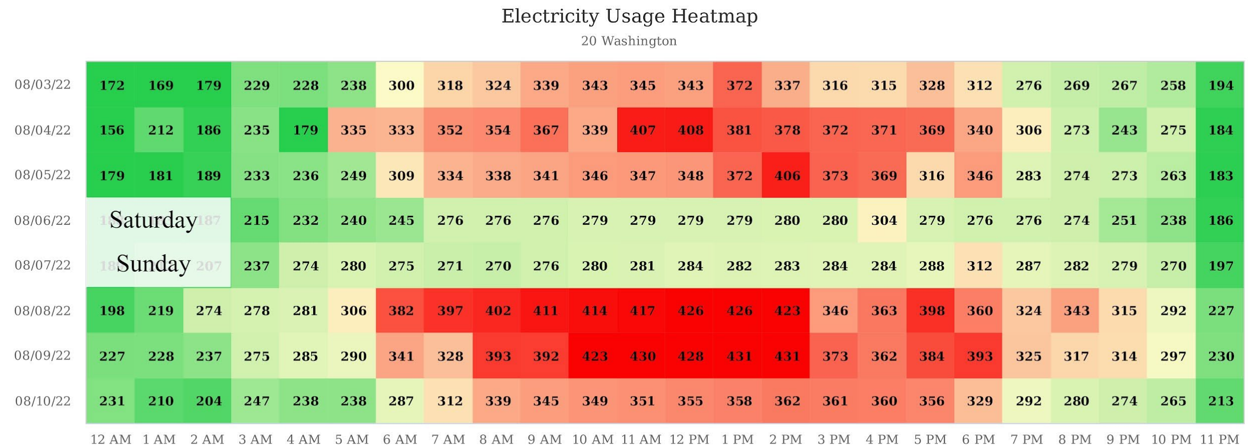


Figure 6(c). 20 Washington Place Building Power | August 3 – 10, 2022

Figure 6(d) shows August 8 and 9. On these dates, demand reduction events occurred from 3:00 – 6:00 pm The building shed load on these days and time periods. The load shed is visibly obvious by the less red/pink cells at 3:00 pm At 2:00 pm on those days, the building drew 423 and 431 kWh, respectively. At 3:00 pm (during the load shed event), the building only drew 346 and 373 kWh. This corresponds with a 77 kWh and 58 kWh reduction on August 8 and 9, respectively between 2:00 and 3:00 pm

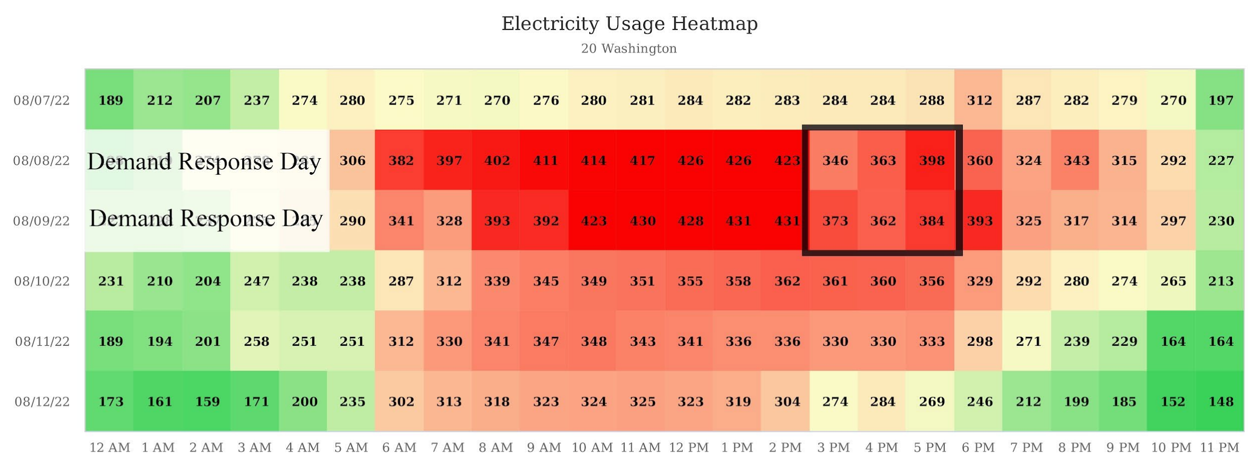


Figure 6(d). 20 Washington Place Building Power | August 7 – 12, 2022

Using the same metering equipment as the utility allows the building operator to track the same building-level data that the utility uses.

Chiller Power

The vendor dashboard included a heat map for the large loads (chillers 1 and 2) being monitored. Figure 7(a) is an example of the chiller 2 heatmap. Figure 7(a) is the same as Figure 6(a) where each row is a different day, each column is time of day, and red shows high power value and green lowest power values.

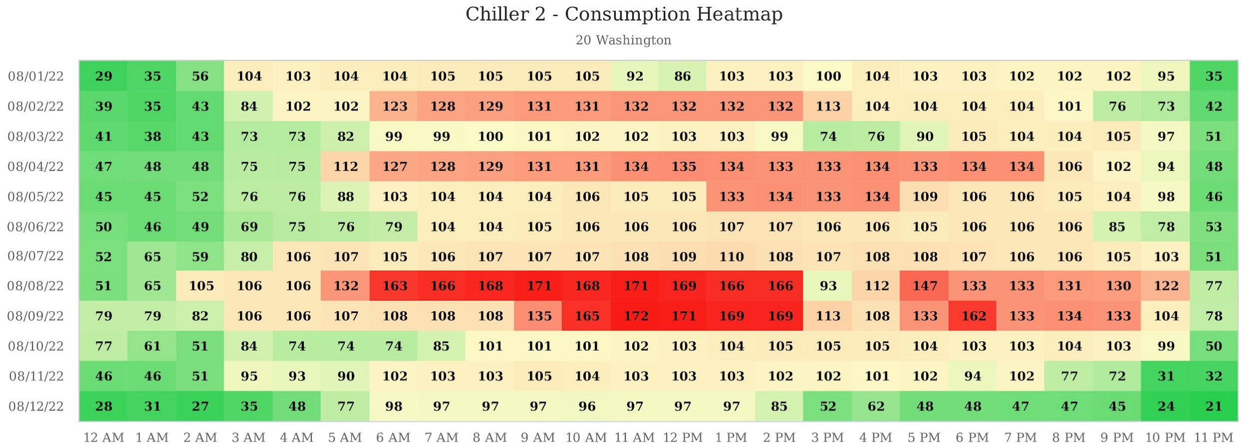


Figure 7(a). 20 Washington Place Chiller Power | August 1 - 12, 2002

As stated earlier, on August 8 and 9 demand events occurred from 3:00 – 6:00 pm The building staff reduced the use of the chiller during this period. The black border in Figure 7(b) shows when the chillers were reduced to meet the demand response event (shift from red to yellow). On August 8 the load on the chiller went from 166 kWh (2:00 pm) to 93 kWh (3:00 pm), a 73 kWh differential. A similar relationship occurred on August 9, another demand response event day. Figure 7(b) shows that when the building staff reduced chiller operations, this resulted in the overall building reduction shown in Figure 6(d). In Figure 6(d), building load went from 423 kWh (2:00 pm) to 346 kWh (3:00 pm), a 77 kWh differential. The difference between the 73 kWh and 77 kWh values may be because other building elements were part of the demand response, a function of metering and integration of the values, or a combination of multiple reasons.

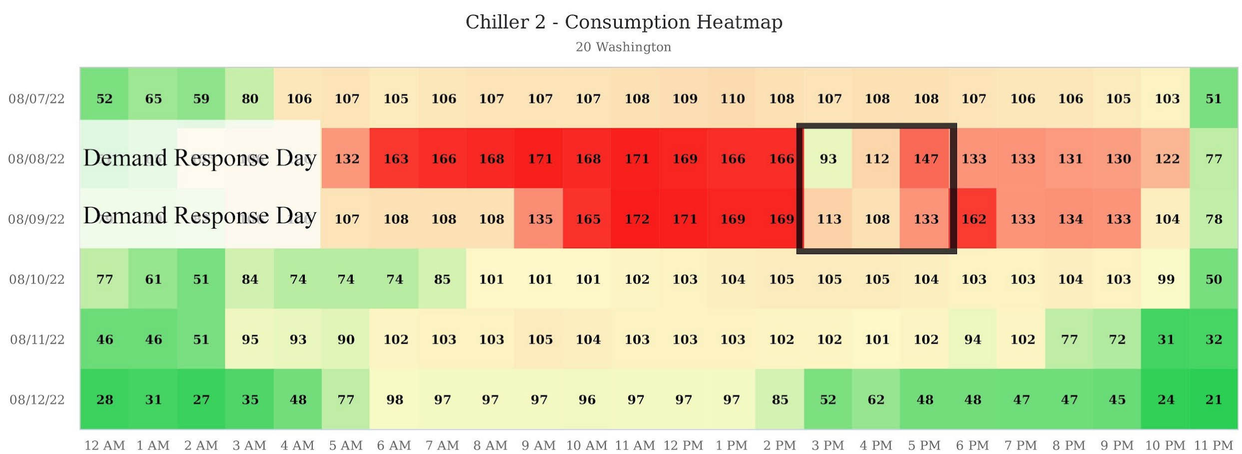
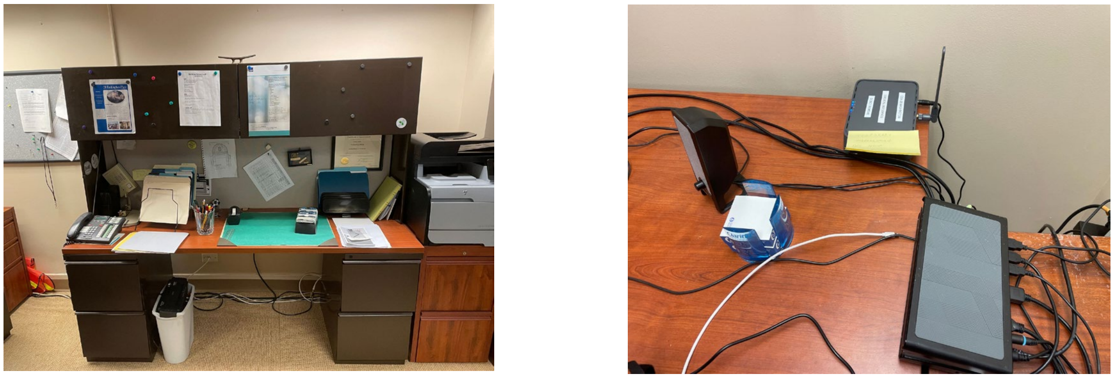


Figure 7(b). 20 Washington Place Chiller Power | August 7 - 12, 2002

IAQ Sensors

The GEB operator-in-the-loop vendor placed IAQ sensors in the mezzanine of the 20 Washington Place building. This is the location of the GSA on-site office. This evaluation did not consider the accuracy of the IAQ sensors, but only if the sensor provided data. Figure 8 shows the space with the IAQ sensors and the placement of the sensors.



(a) IAQ sensor on top of cabinet

(b) IAQ sensor/LoRaWAN transmitter

Figure 8. 20 Washington Place Mezzanine/IAQ sensors

GEB Measures Employed On-Site

Table 5 lists the GEB measures that the GEB operator-in-the-loop vendor's engineering team recommended for 20 Washington Place. The column headings in Table 5 are the typical GEB strategy names (e.g., load shed), but the GEB operator-in-the-loop vendor's dashboard and email alerts use different terms.

The vendor's approach is operator-in-the-loop and the building staff can first choose to participate in the GEB event as well as which measures recommended by the vendor. Table 5 lists the 10 demand reduction measures recommended by the vendor for 20 Washington Place. Early on, the facilities staff opted to not turn off the elevators or reduce the electric lighting in the building in a GEB event. There is no central lighting control system and the facilities staff would have to physically visit the spaces to turn off the lighting.

For demand reduction events, the facilities staff pre-cooled the chillers. The facilities team received notifications the night before and morning of the demand response events. This advanced notification allowed for sufficient time for the building staff to pre-cool the building and then reduce the chiller operation during the demand reduction event period.

Table 5. Measures/Equipment Studied in GSA GEB Value Potential Analysis

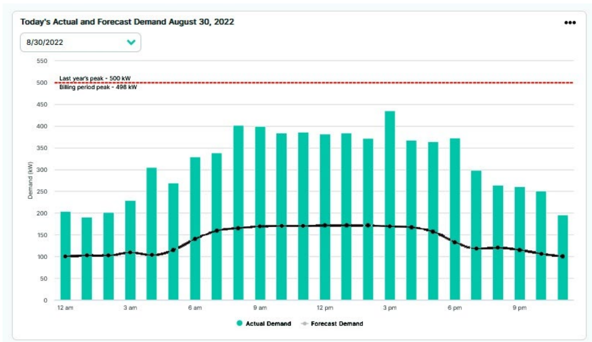
Building Measure	Load Shed/Demand Reduction	Load Management/Continuous Demand Reduction
Vendor Dashboard Checklist Name	"Kilowatt Crush"	Monthly Peak Load Management

Building Measure	Load Shed/Demand Reduction	Load Management/Continuous Demand Reduction
Email Alert Title	PJM Peak Demand Event Alert	Real-Time AI Alert
Chiller Pre-Cool	Pre-cool chilled water supply temperature setpoint to 42°F 2 – 4 hours before the event).	Increase chilled water setpoint by 1 – 2°F and make sure to limit the number of compressors running.
Chiller Supply Temperature Setback	Increase chilled water supply setpoint to 48℉ during the event.	-
Duct Static Pressure/VFD Protocol	Reduce static pressure in air handlers from 1.0" to 0.5" in/wc or reduce all supply fan VFD speeds to 50% from BMS system.	-
Terminal Units Pre-cool	All terminal units pre-cool at least 2 – 5℉ below the usual setpoint of 2 – 4 hours before the event.	-
Terminal Units Setback	Increase cooling setpoint by 2 – 4℉ than the normal setpoint for all terminal units from BMS.	-
Terminal Unit Protocol	-	Increase terminal units setpoint from 1–2°F for a short period.
Turn Off AHU	Turn off AHUs on unoccupied floors.	-
Turn Chiller Off	Turn chiller off for the night.	-
Lighting Protocol	Shutdown any decorative lighting on any floor (primary lighting for the VA) and lighting in unoccupied spaces during the event (chandelier) from the BMS (optional).	Shutdown any decorative lighting (chandelier) and lighting in unoccupied spaces.
Elevator Protocol	Before the event, turn off two of six elevators for maintenance.	-
Inform coworkers of demand response event	Inform co-workers and O&M staff about the event and avoid any heavy maintenance activity.	-
Avoid heavy maintenance activities	-	Shift maintenance schedules to avoid using energy intensive machinery, such as garbage compactors.

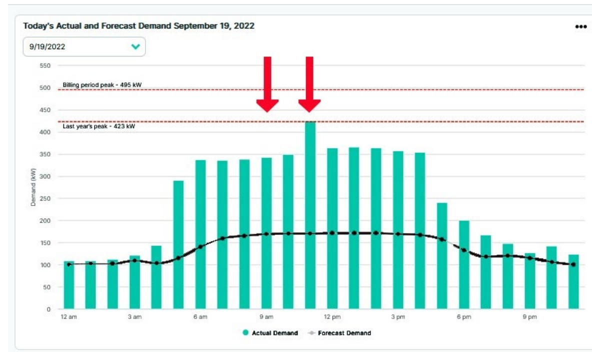
GSA O&M staff at 20 Washington Place would receive an alert either related to load shedding (*e.g.*, emails titled “PJM Peak Demand Event Alert,” “DOUBLE HEADER: PJM Peak Event TODAY - July 27th - From 3pm to 6pm,” and “DOUBLE HEADER: PJM Peak Demand Event Alert TODAY”) or load management (emails titled “Real AI Alert”) and then choose to implement one or more of the strategies from Table 5 related to that GEB category.

Continuous Demand Management

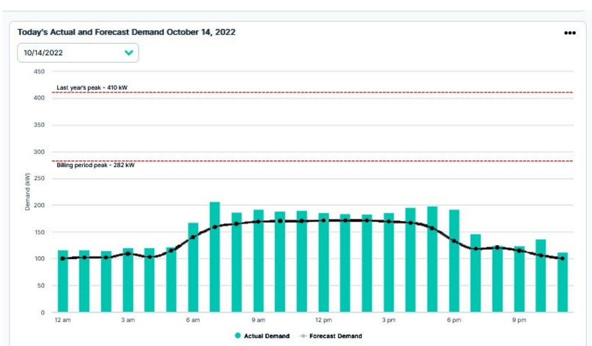
Figure 9 shows four days of load management examples from the vendor's GEB dashboard. The top dashed red line is last year's demand peak. The second/lower dashed red line is the billing period peak. The blue vertical bars are the actual demand of the building in hour increments. The GEB vendor's protocol uses machine learning and other methods to forecast the demand each day. The forecasted load is the black line with dots along the bar graph.



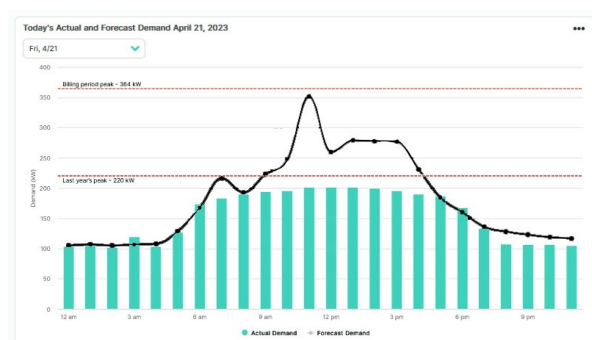
(a) August 30, 2022 - Forecasted load (black line) compared to actual demand (blue vertical bars). Last year's peak 500 kW (red dashed line) is very close to the billing period peak 498 kW (lower red dashed line). The two peak lines are on top of each other, as the load management aspects just started near the date of the graph and sufficient data may not have been available to include the billing period peak data.



(b) September 19, 2022 - **ALERT DAY.** At 9:21 am, an alert was received (Figure 10). The left red arrow is the building power when the first alert was received. This is the time in the day when the building is operating and the actual demand has significantly exceeded the forecasted demand (black line). A second alert was received at 11:52 am—this is the blue vertical bar that touches the bottom red dashed line (red arrow on right). The actual demand set a new billing peak for the month



(c) October 14, 2022 - Forecasted load very close to actual usage. The longer the platform is monitoring the building, the more accurate the predictive forecast. Figure 9(b) is 45 days into the monitoring period and the forecasted load is roughly half the actual load. In contrast, Figure 9(c) is 75 days into the monitoring period and the black forecasted line is nearly identical to the actual demand.



(d) April 21, 2023 - Forecasted demand exceeds actual usage. The black line is the forecasted load and in the afternoon significantly exceeds the actual usage (blue vertical bars). The GSA GEB vendor's platform may have forecast higher based on past usage on/near that date or other elements. In April 2022, the building turned on the chillers in preparation for the cooling season. The 2023 forecasted load could have factored in the historical usage when forecasting this day.

Figure 9. Load Management Examples

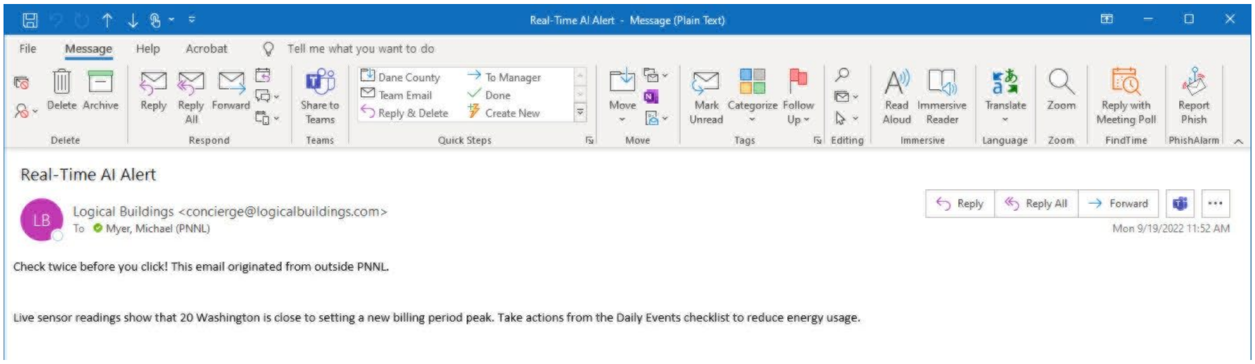


Figure 10. Load management alert from GEB operator-in-the-loop vendor

Figure 10 is an example of an email alert that the site received during the evaluation period. If the site staff also had access to the vendor's platform on mobile devices, the GSA site staff would have received a similar notification on the mobile devices. This alert was received at 11:52 am and corresponds to the second red arrow from the left in Figure 9(b).

Figure 9 visually depicts load management. Building operations staff need to know the current demand for the month, the real-time power usage, and potential changes that might occur in building operations. This information may enable the building operations staff to reduce the active power used by the building to prevent a new demand charge.

The following sections present the results from this evaluation.

Results

Quantitative Results

The quantitative results for each of the major GEB categories are discussed herein. The measurement and evaluation period started on July 15, 2021, for the load shed portion of the analysis. Additional equipment was necessary and installed later for the load management portion of the analysis. Evaluation period officially ended in spring of 2023 before any GEB events occurred in 2023.

Load Shedding/Demand Reduction

During this evaluation and the years prior to the evaluation, the local utility, PSEG, did not have a demand response program.[6] However, the PJM, the RTO, has two demand response programs: capacity performance and synchronized reserves market. NuEnergen, is a third-party curtailment service provider aggregating sites.[7] NuEnergen manages a program for demand response within the PJM territory (as well as New York Independent Service Operator (NYISO) and other territories). 20 Washington Place is 1 of 16 GSA buildings in New York and New Jersey enrolled with NuEnergen.[8] The GSA buildings in PJM territory and in the NuEnergen program are enrolled in the PJM capacity performance demand response program.[9] 20 Washington Place has been enrolled since 2012. Each year, the site has demonstrated load shedding capabilities; however, 20 Washington Place has not participated in a load shed/demand response event called by PJM since 2014. The two most recent PJM events applicable occurred in March 2014 and December 2022. This evaluation period was July 2021 - November 2022.

Capacity performance requires an advanced pre-estimation of the load that can be reduced during a demand event. The actual reduction is compared to the pre-estimation to determine the precision of the estimate. A certain level of precision is required for payment. Because no demand response events had been called by NuEnergen/PJM in the prior years, 20 Washington Place does not have any recent load shed data from participation in this program. 20 Washington Place received a financial payment for enrolling in the program each year. GSA receives payment if during the test event, the pre-estimated load reduction is met. However, if an event is called, meeting the reduction during the event determines payment regardless of success during the test event.

PJM Manual 11 includes seven methodologies for determining the customer base line (CBL) (PJM 2020b). One method is the default tariff standard, “3 Day Type with SAA (symmetric additive adjustment)” and the other six were created to provide options, especially for variable loads. Because power varies by type of day, weather, and occupancy, CBL provides a standardized method of determining the baseline to determine how much power was shed in an event. The values in Table 6 were calculated using this methodology. Table 6 lists the estimated potential values, the aggregate values for 2021, 2022, and the average of the 17-month evaluation period.

[6] A program is expected to start in 2025.

[7] https://www.pjm.com/markets-and-operations/demand-response/csps

[8] Six buildings in New York State (NYISO); six buildings within New York City (NYISO); and four buildings in New Jersey (PJM)

[9] https://www.nuenergen.com/solutions/demand-response/

Table 6. Load Shed/Demand Reduction

System	July 15 - Sept. 30, 2021	May 1 - Sept. 30, 2022	Average
# of Events	7	7	7
Method	CBL / SAA (Tariff Default)	CBL / SAA (Tariff Default)	CBL / SAA (Tariff Default)
Average shed	116 kW	76 kW	76 kW
Duration	3 hours	3 hours	3 hours
Time	3:00 – 6:00 pm	3:00 – 6:00 pm	3:00 – 6:00 pm
Percent Reduction	30%	9%	20%
Load per Area	0.85 kW/ft^2	0.27 kW/ft^2	0.56 kW/ft^2

During the 17-month evaluation period the existing demand response program managed by NuEnergen did not call for a demand event. The GEB vendor's platform initiated the load shedding based on their protocols related to Installed Capacity (ICAP). PJM, characterizes ICAP as "summer rated capability" or "summer rating," a physical characteristic of a unit (PJM, 2020). These are charges from the ISO for capacity and from the utility for transmission. Reducing the ICAP value translates to lower costs per month related to capacity and transmission. These load shed events were driven via the vendor's software alerts. The vendor sent three alerts for each event: the day before the event, the morning of the event, and sometimes at the start of the event period. A total of seven events occurred each year.

At the building level, shedding load to lower the ICAP value of the building reduces the overall demand charges throughout the year. PJM does not specify when the ICAP value is determined for the building; however, the GEB vendor's internal algorithm estimates the likely dates when the ICAP would have been calculated. This is the reason the GEB operator-in-the-loop platform initiated load shedding alerts even though the larger demand response program did not initiate any demand response events. The monetary value of this strategy is discussed in the cost effectiveness section of this report.

Although during the evaluation period PJM's demand response program did not call an official demand response event, it did initiate a test event on September 7, 2022, at 11:00 am This September 2022 event was a test event and a requirement to participate in the demand response program. In response to the simulated demand response, the GSA O&M team reduced energy use of the chillers at 20 Washington Place. Using the same methodology to calculate the savings, 20 Washington Place saved 101 kW via the CBL/SAA (tariff default) method.

This simulated demand event also occurred 4 hours earlier than the time of the demand response events in Table 6. The savings during this simulated event were similar to the average load (kW) shed during the demand responses initiated by the GEB operator-in-the-loop vendor in Table 5. This would be expected because during both the simulated and the GEB operator-in-the-loop vendor demand reduction events the GSA O&M turned off or reduced the chiller. Table 7 compares the average load shed (from Table 6) with the test event values.

Table 7. Average Load Shed/Demand Reduction Compared to Demand Response Program Test Event

System	Average (Entire Analysis Period)	Demand Response Program Test Event
Dates	July 21, 2021 – Sept. 30, 2022	Sept. 7, 2022
# of Events	14	1
Method	CBL / SAA (Tariff Default)	CBL / SAA (Tariff Default)
Average shed	76 kW	101 kW
Duration	3 hours	4 hours
Time	3:00. pm – 6:00 pm	11:00 am – 3:00 pm
Percent Reduction	20%	23%
Load per Area	0.56 kW/ft^2	0.74 kW/ft^2

Carbon Reduction

The project team acquired data from Watttime related to the hourly emissions in PJM territory to determine the carbon reduction resulting from the load shed events. The energy savings values from Table 6 were multiplied by the Marginal Operating Emissions Rate measured in CO_2 lbs/ MWh to determine the CO_2 lbs saved from the load shed events as shown in Table 8.

Table 8. Carbon Dioxide Savings from Load Shed

System	July 21 - Sept. 30, 2021	May 1 - Sept. 30, 2022	Entire Analysis Period
# of Events	7	7	14
Method	CBL / SAA (Tariff Default)	CBL / SAA (Tariff Default)	CBL / SAA (Tariff Default)
Average shed	116 kW	37 kW	76 kW
Average CO_2 Reductions/Event	159 lbs (0.07 mt)	52 lbs (0.02 mt)	105 lbs (0.05 mt)
Cumulative kW Shed	812 kW	256 kW	1068 kW
Cumulative CO_2 Reductions	2,924 lbs (1.33 mt)	1,098 lbs (0.50 mt)	4,021 lbs (1.82 mt)

The GEB operator-in-the-loop provides a year-end performance review of the project (full report from vendor can be found in the Appendices). Within that review, the vendor presents a carbon reduction value that the vendor assesses for the site. This vendor report estimates 45 metric tons of CO_2 reduced. This value is not related to the GEB actions, but rather that the vendor assessed that value to the reduction in energy used between the estimated baseline and the actual energy used in 2022. The CO_2 values in the vendor report should not be conflated with Table 8.

Load Management/Continuous Demand Reduction

The evaluation period for load management (August – November 2022) was shorter than the period for load shedding (July 2021 – September 2022). Some of the meters necessary for load management were delayed and this limited the evaluation period. During the 122-day evaluation period (August – November 2022), GSA received a total of 29 load management alerts. The alert message stated, "Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage." GSA staff had 15 minutes to respond to the message to manage the building loads to prevent a new billing peak. Table 9 lists the frequency of the load management alerts by day of the week and time of day.

Table 9. Load Management Alerts by Day and Time (August – November 2022)

Time of Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
12-2	-	-	-	-	-	-	-
2-4	-	-	-	-	-	-	-
4-6	-	-	-	-	-	-	-
6-8	1	-	1	-	-	-	-
8-10	4	2	1	1	1	-	-
10-12	3	1	1	1	1	-	-
12-2	2	1	-	1	1	-	-
2-4	1	-	1	-	1	1	-
4-6	-	1	-	-	-	-	-
6-8	-	-	-	-	-	-	-
8-10	-	-	-	-	-	-	-
10-12	-	1	-	-	-	-	-
Total	11	6	4	3	4	1	0

During the evaluation period, the GSA O&M staff never acted upon any of the alerts. It was determined that the time window for action was too short at this site because staff were either not located in the building or in places where the alert could not be received. For these reasons, the evaluation period for load management ended in November 2022, per the GSA O&M staff request and in agreement with the project team.

Upon review of the frequency of the alerts, more than 40% of the alerts occurred on the first business day after a weekend (mostly Mondays, but also the Tuesday after Labor Day). The building had been closed over the weekend and was ramping up. Over 60% of the alerts occurred by 12:00 pm Many of these alerts were related to the building operations coming online after drifting overnight or the weekend.

A few of the alerts occurred at times when the building was closed (e.g., Saturday 2 - 4 pm; Tuesday 10 – 12 pm). A local utility substation or external element outside the building caused some electrical spikes in the building power. This was a known issue by GSA staff and some of the 29 alerts from the GEB operator-in-the-loop vendor were false-positive alerts from the spikes in the adjacent utility equipment.

Qualitative Results

Indoor air quality (IAQ) sensors, wireless building communication, alerts, and user experience aspects of the operator-in-the-loop platform were qualitatively evaluated. The IAQ and LoRaWAN evaluation was secondary to the GEB evaluation and is included in Appendix A.

User Experience

Pacific Northwest National Laboratory hosted a focus group (PNNL IRB # 2022-23) with GSA O&M staff (*n = 5)* related to their experiences with the software, the GEB strategies, and use of the technology in other GSA facilities.

O&M staff were consistent in their opinion of the alerts. The staff desired being able to customize which alerts were received when the building was closed. The staff also desired a method to customize which alerts were received via text versus email. More than 80% of the total number of alerts were IAQ alerts; therefore, most comments related to alerts were related to IAQ. A staff member stated that they should not receive temperature/humidity alerts when the building operations are setback because the building was closed.

Carbon/Greenhouse Gases

O&M staff stated that the current primary driver is cost savings. However, as GSA incorporates carbon and greenhouse gas (GHG) metrics into monitoring and reporting, these might drive other decisions. At the time of this report, GSA did not have a clean fuel efficiency standard (but some form is expected). A clean fuel efficiency standard could affect operations. During some GEB operations, the building might move to fossil fuel sources related to costs, but that could be changed if they are following a GHG-based approach.

The GEB operator-in-the-loop vendor did state that a planned upgrade to the platform in the summer 2023 (after the end of the evaluation period), would incorporate GHG alerts and guidance.

Usefulness

The focus group was asked about the usefulness of the platform. One of the staff members mentioned that he already had the information (e.g., measures for GEB strategies), but the reminder was useful. GSA has provided to staff GEB measures that can be deployed in buildings, which include the measures recommended by the GEB operator-in-the-loop, as shown in Figure 5. GSA staff know the GEB measures to enact but, as mentioned in their comment, appreciate the remainder of the measures.

A member of the focus group did appreciate the “peak shaving” alerts. GEB terminology varies by ISO, utility, and other entities. The O&M staff alluded to the building not having advanced notification of peak events. The building was enrolled in a demand response program as previously noted. If there was an expected demand response event from the ISO/RTO, the facilities team would have received some advanced notification. As noted, the last time the ISO/RTO had a demand event applicable to the location of this building was 2014. However, some buildings in Region 2 are also enrolled in a program that provides advanced notification of potential "ICAP" days/events. Though that program does not use the term ICAP and may use many other terms. The peak shaving that the staff referenced during the focus group, is similar to the "ICAP" days/events. In summary, the building does currently receive demand response alerts, but not "ICAP" alerts. The focus group comment is more related to a GEB strategy than a functionality.

Another GSA O&M staff member stated that the technology worked. However, there were too many alarms (alerts) for humidity and energy. The staff member turned off the text messages, but was curious if GSA had to pay for the messages or if turning off the alerts would affect other operations. Another staff member turned off the alerts as well. That staff member stated that the GEB operator-in-the-loop software should allow the users to customize how/when to communicate with the staff. Users can select alerts via app, email, and text, but that is the only customizable option. Staff cannot select which alerts they want to receive during certain time periods (e.g., IAQ during building operating hours) or the frequency of the alerts (e.g., multiple examples of the same alert being received within a short time period of the first alert).

The O&M staff did appreciate the GEB operator-in-the-loop dashboard showing how much energy the building used and when the energy or power use was high. One staff member did check the dashboard daily. A staff member who was not part of the focus group stated later that many of the GSA clients have their own energy (or similar end goal) targets. Being able to submeter and show the client its energy usage would help those agencies with their goals. The staff also stated the desire/need for metering and monitoring non-electrical elements like gas and water. The GEB operator-in-the-loop vendor does have meters and can ingest that data into their dashboard as well.

In general, the O&M staff found the heat maps (Figure 6) were usable and easy to understand. The staff found the software well-developed. The fact that the platform did not have active control over building operations was noted during the usefulness discussion. The staff liked how the peak hour of usage and weather-dependent variables were presented in the dashboard.

O&M staff discussed the load management (more frequent, short duration load reduction from an internal rationale) process. Staff were not able to act upon load management alerts. This site is part of a series of buildings and the O&M staff that actively manage this building are based in a different building. Therefore, when a load management alert was received, many times the staff were not in the building to shed the load. One focus group member stated that the GEB operator-in-the-loop software would perform better in more modern buildings and buildings with 24-hour operation. In these buildings, the O&M could get the alerts quickly.

The O&M staff commented that the communications within the 1920s building are challenging. The LoRaWAN did communicate through the dense walls to the gateway, but other wireless protocols like WiFi and cell signals, have a harder time reaching O&M staff—especially in the basement.

Alert Frequency/Clarity

O&M staff discussed the load shedding (infrequent, 3-hour period reducing load via an external rationale) process. One alert for load shedding was received the day before the event and then a second reminder was received in the morning. Staff found this to be both the right quantity and timing of the alerts. These alerts were actionable, timely, and set up well.

Staff had a different opinion of load management alerts. The load management alerts typically arrived on Monday mornings. Staff stated that the building needed to be cooled for tenants. The Monday morning alerts were probably a byproduct of the building being idle all weekend and then ramping up for occupancy. Staff stated that a staggered startup process should be considered to avoid the Monday morning load management alerts. Beyond the Monday frequency of the load management alerts, staff stated that the 15-minute time period post-load management alert was too short and did not allow for adequate time to adjust building operations to address the load management alert. However, to avoid establishing the new monthly peak, the loads need to be curtailed in a timely manner. Therefore, the short time period is necessary regardless of the GEB platform.

The load management alert frequency is also believed to involve false-positive signals. The false-positive signal is a by-product of poor power quality from the utility. The adjacent energy substation had quality issues and it caused some spikes in the power signal in the building. Table 9 Tuesday 10:00 pm – 12:00 am alert is an example of a false-positive signal. The building was offline and, therefore, should be in a lower power state. However, a load management alert was sent to the building. The building does setback during the unoccupied hours, equipment cycling to maintain building temperatures during the unoccupied period could be a reason for the power spike, but was considered less likely. This is an example of a load management alert received, but not acted upon. Some of these false-positive alerts also occurred during the workday. The GSA staff has engaged with the utility related to the energy quality of the adjacent substation.

GEB Measure Recommendations

Overall, the staff only found some of the GEB measure recommendations helpful. The Monday morning frequency of load management alerts did cause staff to reconsider some operations. Monday startup typically starts at 6:00 am and staff had to address hot/humid summer weather. The operations could have started earlier to reduce the Monday load ramp-up. However, staff raised concerns with this suggestion of longer (earlier start time) for pre-cooling. The chillers require on-site staff to start. Therefore, this change to avoid the Monday load management alert would have required staff to start earlier to turn on the chillers earlier.

Staff stated that they only reviewed the load management checklist with the vendor once. The staff stated ideally the checklists would be evaluated quarterly, or at the least yearly. Although the overall evaluation period was 17 months long, the load management evaluation period was less than 6 months long. Had the evaluation period continued, a secondary checklist review may have occurred again.

Finally, the staff stated that many of the GEB measures recommendations by the vendor were similar to the recommendations from NuEnergen, the DR program implementer. The building regularly demonstrates the ability to participate in the DR program using similar measures recommended by the GEB operator-in-the-loop vendor.

Operator-in-the-Loop Versus Automation

The focus group was asked about their preference of operator-in-the-loop, full-automated control, or a hybrid mixture of some operator-in-the-loop and some automation. All of the focus group (*n = 5)* of GSA O&M staff were in agreement that an operator-in-the-loop system was the preferred approach rather than the other two options.

Cost Effectiveness

The focus group in general found that although the cost recovery was short, the pricing structure as presented in the project was atypical for GSA sites. The focus group desired the pricing in a different structure. The focus group requested a software-as-a-service fee structure. After the focus group, the vendor did provide a revised pricing structure to GSA.

A staff member stated the value depended on the final costs of the system. The staff elaborated that the savings were real, but limited. If incentives exist to reduce the amount of energy, the GEB operator-in-the-loop platform may be helpful. In contrast, a different member of the focus group stated that GSA is shifting towards Scope 1 emissions and other carbon-related metrics, thus focusing on energy reduction may be less prudent. The vendor did note that they can provide alerts related to carbon operations or other non-energy inputs.

At the time of the focus group, the vendor's pricing structure was not standard for GSA operations. A focus group member stated that the pricing structure does not match industry standard including it as a bundle, Federal Acquisition Regulations (FAR), and curtailment service provider. After the focus group, the vendor did provide a price structure more accustomed to GSA operations and protocols.

Cost-Effectiveness

The following text addresses the cost-effectiveness analysis of the technology.

Equipment and Subscription Costs

The GEB operator-in-the-loop platform involved little equipment on-site. As part of the operator-in-the-loop system, a subscription is necessary. The vendor offers two subscription models. The following text explains the two options, as well as the price for GSA sites of similar size.

> Option #1: The fee for on-site hardware (*e.g.*, LoRaWAN communication devices and gateways) is $9,000. An engineering (assessing the options for the building) and training fee is $6,000, and a monthly subscription fee of $500 per month. A 3-year term is required for the subscription. This totals $33,000 ($0.24/ft^2 for 20 Washington Place) over the 3-year period. If the building uses less than 1 million kWh annually, the monthly subscription fee shifts to $300/month.
>
> Option #2: The hardware fee, engineering and training fee, and subscription are part of one monthly fee of $975/month. There is a 3-year term required as well; therefore, the costs total $35,100 ($0.26) for over the 3-year period. Again, if the building uses less than 1 million kWh annually, this monthly subscription fee shifts to $775/month.

20 Washington Place used more than 1.5 million kWh for 2022.

This analysis uses Option #1 for pricing in Table 12.

Installation Costs

The GEB operator-in-the-loop technology involved very little installation costs. For this site, the cost and installation of that equipment was roughly $4,000. The vendor's platform included three major meters/sensor elements.

1. The six CTs monitoring (one per phase) the two chillers were installed by an electrician in less than half a day at 20 Washington Place. This is consistent with other installations of CTs as CTs typically only require a few hours for installation.
2. The pulse-drop meter provided by the utility also was installed in about two hours. The pulse-drop meter attaches to the existing utility meter and provides the data to a secondary source. Because pulse-drop meters attach to existing infrastructure, the installation time should typically be short.
3. Additional IAQ sensors were deployed in select spaces in the building. The IAQ sensors plugged into wall electrical receptacles and were also deployed in a few hours.

LoRaWAN transmitters were integrated with the CTs, pulse-drop meter, and IAQ sensors. The LoRaWAN transmitters sent the metered data to the cellular router which shared the on-site data with the vendor.

Although the actual installation time of the CTs and pulse-drop meters was only a few hours, the installation spanned multiple months. The pulse-drop meter had to be installed by the utility and the work queue was very long. The pulse-drop meter was critical for the load management aspect of the evaluation. The long queue was why the load management aspects of the evaluation occurred much later than when the demand response portion of the evaluation started.

As an operator-in-the-loop system, very little commissioning was needed/performed. The vendor's staff visited the building and reviewed building information. The vendor developed a checklist of actions to perform for the different GEB events. After the meters/sensors were deployed, the meters quickly communicated with the vendor's cloud and did not require any additional commissioning.

Capacity and Transmission (ICAP)

The value stream for 20 Washington Place is different from other standard energy efficiency projects. The GEB operator-in-the-loop provides a year-end performance review of the project (full report from vendor can be found in the Appendices). Within that review, the vendor presents five reductions/savings: 1. Electricity usage savings; 2. Electricity usage reduction; 3. Capacity/transmission reduction savings; 4. Total annual energy; and 5. Carbon dioxide reductions.

The vendor's report estimates 208,000 kWh (non-weather adjusted) saved in their report. This is based on the difference between the baseline energy usage and actual energy usage. Per the report, this translated to a 14% reduction and valued at $25,008. However, this vendor neither provided energy-efficiency recommendations, nor any new equipment was installed. Although there may have been a differential between baseline energy and actual energy, that differential was not a result of the GEB operator-in-the-loop platform. Therefore, this $25,008 presented by the vendor will not be included in this cost-effectiveness analysis.

The carbon reductions were addressed earlier in the Carbon Reduction section. No value has been assigned to carbon reductions. Therefore, carbon reductions will not be considered part of this analysis.

The remaining savings stem from capacity and transmission reductions (ICAP savings), which equate to approximately $20,000 per year. PJM and PSEG have capacity and transmission charges, respectively. These are charges assessed monthly during the following year based on the use in the prior year. PJM and PSEG determine after the demand season (May - September) is over the date and times when the ICAP charges would be assessed. The vendor has a predictive algorithm that estimates when the ISO and utility might assess the ICAP charges. The vendor initiated demand response events seven times in both 2021 and 2022 from 4:00 - 5:00 pm. Those events were based on the vendor's predictive algorithm of when the ICAP dates/times would be determined. By shedding load during an assumed ICAP calculation period, the transmission and capacity charges will be lower the following year.

The savings from the demand response events to reduce ICAP charges uses data from Table 10. PJM and PSEG do not report in advance the dates when the ICAP values will be assessed, but the ICAP charges will be assessed based on usage of five dates between June 1 - September 30. The GEB vendor initiated seven demand response events (rows in Table 10) anticipating that these dates would coincide when PJM and PSEG would actually calculate the ICAP charge.

Table 10 lists the dates of the vendor-initiated demand response event. For 2022, the vendor's algorithm correctly predicted when the PJM or PSEG day/time ICAP event may occur. The values in the cells of the table represent the load of the building during the day/time the ICAP event occurred. If a value occurs in a cell, it indicates that the demand response action taken by 20 Washington Place coincided with a day and time when either PJM or PSEG calculated the ICAP values for the following years. For example, 7/20/2022 was a date and time where PJM and PSEG calculated the ICAP value. Conversely, 7/22/2022, only PJM used that date for ICAP calculations.

Table 10: 2022 Demand Response Events and ICAP Dates/ Times

Date	Temp	4:00 pm	4:00 pm	5:00 pm	5:00 pm	6:00 pm	6:00 pm	7:00 pm	7:00 pm	8:00 pm	8:00 pm	9:00 pm	9:00 pm	Monthly Maximum
Program	-	PJM	PSEG	PJM	PSEG	PJM	PSEG	PJM	PSEG	PJM	PSEG	PJM	PSEG	
Units	-	*kW*	*kW*	*kW*	*kW*	*kW*	*kW*	*kW*	*kW*	*kW*	*kW*	*kW*	*kW*	*kW*
7/20/2022	87	-	-	-	-	323	*323*	-	-	-	-	-	-	-
7/21/2022	88	-	-	337	-	-	*336*	-	-	-	-	-	-	June Max 398
7/22/2022	86	-	-	-	-	335	-	-	-	-	-	-	-	July Max 456

Date	Temp	4:00 pm	4:00 pm	5:00 pm	5:00 pm	6:00 pm	6:00 pm	7:00 pm	7:00 pm	8:00 pm	8:00 pm	9:00 pm	9:00 pm	Monthly Maximum
8/3/2024	81	328	-	-	-	-	-	-	-	-	-	-	-	Aug Max 463
8/4/2022	82	-	-	-	-	-	*369*	-	-	-	-	-	-	Sep Max 477
8/8/2022	86	-	-	-	-	346	*398*	-	-	-	-	-	-	-
8/9/2022	89	-	-	-	*362*	-	-	-	-	-	-	-	-	-
Average	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	PJM: 334 | *PSEG: 358*	June - Sep. Avg 449

Note: PJM values are indicated by underlined text. *PSEG* values are indicated by italicized text.

The monthly maximum was the highest power draw for the applicable month. The average maximum load for June, July, August, and September 2022 was 449 kW. The building shed load in response to the vendors demand reduction email on the dates listed in Table 10. This reduced the loads during the periods when the ICAP values may be assessed. The GEB vendor correctly predicted when PJM would assess the ICAP value in 2021. From the demand reductions, the average load during PJM ICAP events was 334 kW (see Table 10 values 323, 337, 335, 328, 346). The PJM ICAP savings are determined by subtracting the average load during the specified ICAP dates from the monthly maximum and multiplying the capacity charges times this differential for each month. The 2022 PJM ICAP savings are 115 kW (449 kW [maximum] - 334 kW [average during ICAP events]) x $5.701 / kW (capacity charges) x 12 months (reduced capacity charges each month) = $7,847.

The process is similarly repeated for the ICAP (transmission) charges related to PSEG. The same average maximum load for June, July, August, and September 2022 of 449 kW is used in this calculation. The average load during PSEG ICAP events was 358 kW (see Table 10 values 323, 336, 369, 398, 362). The PSEG ICAP (transmission) savings are determined by multiplying the transmission charges times the differential of the monthly maximum and the average load during the specific ICAP PSEG periods. The 2022 PSEG ICAP savings are 91 kW (449 kW [maximum] - 349 kW [average during ICAP events]) x $11.608 / kW (transmission charges) x 12 months (reduced transmission charges each month) = $12,662.

This method of predicting when the ICAP values involves risk. Although in 2022, the GEB vendor successfully predicted when the ICAP assessments would occur, the GEB vendor was not as successful in 2021. In 2021, the GEB vendor only correctly predicted a portion of the dates when the PJM and PSEG ICAP events would occur.

This analysis monetizes the ICAP savings for 2022 because it was the only full season of evaluation. However, had the 2021 evaluation included a full season, there are dates and times that the vendor's predictions would not have overlapped with the respective ICAP events. Monetization of ICAP values where the vendor did not correctly predict all of the events will be addressed in the Summary Findings section.

Table 11 presents the cost effectiveness analysis of the GEB operator-in-the-loop technology at 20 Washington Place.

Table 11. Economic Assessment Worksheet

Cost/Savings	Tested Technology (Initial Cost)	Annualized Data
Equipment Cost[1]	$15,000 ($9,000 metering hardware and $6,000 engineering and training)	$5,000 / year (initial cost / 3 years for subscription period)
Installation[2]	$4,000 (Labor, pulse-drop meter, CT meters)	$1,333 / year (initial cost / 3 years for subscription period)
Subscription Cost[3]	$500 / month	$6,000 / year
Total Cost	$0.27 / ft^2 ([equipment + installation + 3-year subscription]/building area)	$12,333 / year (equipment + installation + annual subscription)
Annual Energy Savings[4]	No values shown as vendor did not provide energy savings recommendations	$0
Annual Load Management Savings[5]	No values shown because load management was not successful at this site	$0
Annual Demand Response Savings (Utility Program)	Site is enrolled in a separate DR program not part of this evaluation	N/A
Annual PJM Capacity Reduction (ICAP)	-	115 kW
Annual PJM Capacity Savings	-	$7,847
Annual PSEG Transmission Reduction (ICAP)	-	91 kW
Annual PSEG Transmission Savings	-	$12,662
Annual ICAP Savings	-	$20,509 / year
Simple Payback (testbed)	-	<1 yr ($12,333 / $20,509)
Savings-to-Investment Ratio (testbed and 3-year period)	-	1.6

Notes: 1. Initial site engineering; 2. Includes on-site metering equipment and electrician for installing metering equipment; 3. Requires 3-year subscription, but monthly price shown; 4. No values shown as the vendor did not provide energy savings recommendations for this site; 5. No values shown because load management was not successful at this site

ICAP savings are not applicable across GSA sites, the ICAP savings depends on location in the country.

Realized Cost Effectiveness

As stated many times elsewhere in this report, 20 Washington Place is already participating in a demand response program with NuEnergen. NuEnergen pays a fee to GSA for both participation in the DR program and then a second amount if a DR event is called by NuEnergen. GSA staff commented that this money is separate from the normal budgeting process and GSA regions can reinvest this money in buildings with more options than normal budgeted funding.

The ICAP reductions may be valuable, but they are not directly realized. They are only realized first by comparing the building operations during the summer to the post-summer ICAP events determined by the utility and ISO. Following comparing the building operations and the ICAP events, the ICAP savings are determined. However, the bills will need to be compared year over year to verify that the ICAP savings are translating into operational savings for the building.

Conclusion

Summary Findings

The non-GEB aspects of the evaluation were mostly positive. The LoRaWAN was able to communicate through the dense building materials. Although the accuracy of the IAQ alerts was not evaluated, they were received and could have been acted upon if that was the focus of this evaluation. The only negative aspect was that the GEB operator-in-the-loop software did not allow GSA to specify the time period alerts were desired (e.g., no IAQ alerts between 12 am and 5 am). Similarly, GSA staff could not specify the frequency of the alerts (e.g., some alerts occurred within minutes of each other). During the evaluation, the ability to specify alert windows and alert frequency as a desired feature was conveyed to the GEB vendor.

In terms of building operations necessary for GEB measures, Table 4 and Table 5 show that GSA is aware of building operations that can perform GEB functions. This is supported by the statement from the GSA staff focus group who stated that the GEB recommendations from the GEB operator-in-the-loop vendor were not new to them. Based on this evaluation and the review of GSA-produced materials, GSA is familiar with the concept and measures necessary for GEB operations.

Energy efficiency is a component of GEB. Because this was an operator-in-the-loop GEB solution, there were no automatic control functions. The vendor could have recommended some changes in operations the staff could have performed for more efficient operation, but that did not occur. Therefore, energy efficiency was not an aspect of this evaluation, but could be included by the vendor in other sites. Making the building more efficient is a first step before engaging in GEB measures. In other applications, either the vendor or others could make energy efficiency recommendations.

Load management/continuous demand reduction was not successful at 20 Washington Place. Once a monthly new peak value is detected, the load needs to be reduced within 15 minutes in order not to be set as a new monthly peak. This 15-minute period is a function of the utility and the GEB operator-in-the-loop platform. For GSA staff to address a load management alert from the GEB operator-in-the-loop software, staff must be located within the building; in space that can receive an alert; and not involved in a consuming task/able to respond to the alert. The likelihood of all of those conditions being met every time an alert is received are low. Therefore, operator-in-the-loop alerts as a means to address load management are expected to have a low success rate. However, a review of the vendor's dashboard as well as the tracking and reviewing the alerts could allow GSA to discern patterns for better operations (e.g., softer building starts on Mondays).

Demand reduction was successful at 20 Washington Place. However, the building was already engaged in a demand response program, so this was not entirely new for the building operations. From 2016 - 2022, the building was enrolled in a demand response program and annually shed load in a test event to demonstrate capability necessary to participate in the program. In contrast to the traditional demand response program, during this evaluation, the GEB operator-in-the-loop vendor created seven demand response events for 20 Washington Place in both 2021 and 2022. The building staff were able to meet each of the demand response events. The building staff achieved 0.27 kW/ft^2 (or 0.35 kW/ft^2 when weather adjusted) average from the demand response events.

The GEB operator-in-the-loop software was cost effective, but the cost effectiveness is complicated for GSA operations. 20 Washington Place's annual participation in the traditional demand response program yield a rebate check to GSA. This rebate is not part of the traditional GSA budget and, thus, GSA regions have flexibility for use of these funds. Region 2 has used the demand response rebate funds to invest in other energy efficiency measures in Region 2 buildings. Because these funds are separate from the budgetary process, Region 2 has flexibility and can deploy these funds differently. GSA staff raised concerns if these demand response rebate funds were reduced or were lost to the region.

Separate from the demand response rebate funds, the cost effectiveness of the technology is complex because it was from predicting ICAP events and savings from ICAP events. These ICAP savings are not fixed and the GEB operator-in-the-loop predicts when the ICAP events may be determined. The GEB operator-in-the-loop vendor effectively predicted the ICAP events in 2022, but did not predict all the ICAP events in 2021 (i.e., August 26, 2021). It is unknown the success rate of ICAP predictions.

Another complexity with the cost effectiveness is the ICAP savings determination. Widget-based savings can be determined in a lab and verified in the field. As a result, the savings can be found in energy bills relatively easily. In contrast, GEB savings can only be determined in the field. The ICAP savings calculation is more complex in that the utility and ISO determine the ICAP events after the period, so the ICAP savings cannot be quickly determined. The ICAP calculations also require a fair amount of tracking to determine the savings. Finally, once the savings are determined, the bills need to be scrutinized to confirm the savings are occurring for the building. The GEB operator-in-the-loop vendor does provide an annual summary report where the savings are calculated (see Manufacturer Data in Appendix). However, GSA may want a secondary internal analysis to confirm ICAP savings. Secondary ICAP analysis will require some training and tracking that may not be easily automated and will require a lengthy analysis per GSA building.

The GSA staff preferred the operator-in-the-loop aspects of the technology over an automated option. The technology was quick and easy to deploy with no cyber mitigation. The operator-in-the-loop technology did enable demand response savings; however, the long-term method of valuing the demand response costs is uncertain.

Lessons Learned and Best Practices

The following lessons learned and best practices were gathered from this evaluation.

Variability and Energy Performance Service Contracts

A challenge with GEB technologies is that the predictive performance of the GEB measures is unknown. In 2021, 20 Washington Place shed across 7 events, an average of 116 kW. In contrast, in 2022 across a different 7 events, only shed an average of 37 kW. Finally, as shown in Table 9, when 20 Washington Place shed load as part of its participation in its other demand response program, 20 Washington Place shed 101 kW in the single 4-hour test event.

Each ISO has their own methodology to calculate the customer baseline load (CBL) to calculate the demand reduction. This analysis calculated the CBL for both NYISO and ISO PJM. 20 Washington Place is < 20 miles from NYISO territory. The load reduction in PJM was an average of 76 kW. In contrast, using the NYISO methodology, the load reduction was 33 kW (CBL normal) and 48 kW (weather adjusted).

Therefore it is important to treat the load reductions as relative to the building location. The building did result in reduced load, but the magnitude of the load may depend on the methodology used to calculate the baseline.

Although not part of this evaluation, GSA often uses an energy performance service contract (ESPC) in many regions and projects for energy efficiency projects. ESPCs guarantee savings and recoup the initial costs as part of the process. The variability in demand response reductions may limit the use of GEB measures in ESPCs. Until methods of better predictions on future performance of demand response or methods of addressing variability of performance in the contracting, GEB measures may struggle to be incorporated into ESPCs. GSA's blueprint for integrating GEB technologies into performance contracts recommends "GEB measures associated with traditional utility-sponsored demand response should be included where they can, and the terms of the incentive and specific number of demand response days should be pre-negotiated to reduce the potential savings uncertainty (NREL, 2021)."

Demand Response Programs and Revenue

GSA has produced documents advising staff on GEB measures. Staff at 20 Washington Place mentioned during their focus group surveys that some of the recommendations from the vendor were not new and consistent with past guidance. Despite having the knowledge base of GEB measures, the likelihood for GEB events appears low for some GSA buildings. As noted in this report, although already enrolled in a demand response program, a demand response event had not been called for 20 Washington Place since 2014. Between 1991 and 2022, PJM initiated 61 load management events across the entire PJM territory. An event called by PJM, may not apply to all zones in PJM.[10] During this 30-year period, roughly ⅓ of the events were applicable to buildings served by PSEG (where 20 Washington Place is located). The two most recent PJM events applicable occurred in March 2014 and December 2022. This evaluation period was July 2021 - November 2022. Having the tools for GEB measures is necessary, but based on data, the likelihood of a demand response event being called by either the utilities or the ISO/RTOs seems low. However, funds from participation in the demand response programs have yielded benefits to buildings in the region. This

[10] https://www.pjm.com/-/media/planning/res-adeq/load-forecast/alm-history.ashx

BA-63 revenue can be used by the building and region for upgrades and other improvements. Once enrolled, the building will have at least one test event annually and GEB measures (and possibly technology) will be needed to comply with the test. If buildings meet the program parameters during the test or an actual event, the building is eligible to receive the demand response revenue.

Buildings should enroll in demand response programs and receive the rebates for participation. These rebates allow flexibility for other energy-related projects.

ICAP (Capacity and Transmission)

The GEB operator-in-the-loop in this evaluation induced demand response events in an attempt to lower the building's operating load when the predicted ICAP events were expected to occur. The vendor in this report is not the only vendor providing speculative data to when ICAP dates would be assessed to GSA buildings in the PJM territory.

The 2022 ICAP savings in this evaluation resulted in the technology being cost effective. Tracking the costs of ICAP events is more complex than typical energy efficiency measures. An ICAP strategy is not guaranteed, as the vendor is predicting when the events may occur. The vendor in this evaluation predicted well in 2022, but was less successful in 2021 for 20 Washington Place. The ICAP valuation approach is not viable across the country, as not all locations are subject to capacity markets. Further, ISO and utilities may develop different methods for determining the ICAP events/calculations negating the approach in this evaluation that made the GEB operator-in-the-loop technology cost effective.

Another challenge with reducing load during ICAP events is that it reduces the overall potential of a true demand response event. For example, 20 Washington Place successfully reduced loads in 2022 reducing their costs in 2023 for everyday transmission and capacity. In the process, 20 Washington Place's load is considered lower and thus 20 Washington Place has less potential load to shed in a PJM demand response event. 20 Washington Place would still receive payments for participating in the PJM demand response program, but the overall value for participation is lower in 2023 because of the lower load values when the ICAP charges were being assessed. 20 Washington Place pays less for energy in 2023 (but that only is realized in an analysis of the bills) from ICAP reductions and receives a rebate for participation in PJM demand response. However, the PJM results in tangible funds that allows the site to use those funds on other energy-related projects. The ICAP strategy is challenging in that it is based on predicting when the ICAP calculation dates will occur, calculating the savings from the bills, and potentially affecting the magnitude of demand response funds. GSA staff may be resistant to losing (or reducing in size) the demand response funding if other GEB strategies are pursued.

Distributed Energy Resources

Distributed energy resources (DERs) were not an active part of this evaluation. On-site PV as well as battery storage were briefly discussed, but did not exist at this facility. As GSA increases the amount of DERs across the GSA portfolio, flexible and dynamic building operation is going to be necessary. GSA will move away from a "set and forget" building operation to more active and dynamic building operations. As GSA shifts to this more active building and load management, GSA staff will need more real-time data about the building. The GEB operator-in-the-loop platform did provide real-time data as well as a post review of the frequency of load management alerts allowed staff to consider softening the building start-up on Mondays after the window has been offline for the weekend.

There is a growing need for GEB operations to incorporate DERs and meet GSA goals. GSA staff have a knowledge base and examples of GEB measures. The GEB operator-in-the-loop technology can be deployed and scaled quickly because of the low need for cyber mitigation. But until either the correct valuation or incentive structure is created, GEB solutions may have low use in GSA buildings.

Utility Meters

This project relied upon a relatively standard meter, a pulse-drop meter, to track the building power in real time. The pulse-drop meter uses the utility metering apparatus and conveys the same data to the building. Building power (as well as the power of certain components in the building) will be necessary in most GEB scenarios.

Using the same metering equipment as the utility allows the building operator to track the same building-level data that the utility uses. The pulse-drop meter reduces costs and data inaccuracy by reusing the same data as the utility.

Deployment Recommendations

The top seven deployment priorities for operator-in-the-loop GEB technology are listed as follows.

1. **Existing buildings should be prioritized for operator-in-the-loop GEB technology.** The operator-in-the loop design and quick deployment of limited equipment makes retrofit applications possible. New construction projects can install equipment, meters, and control during construction that allow for GEB operations. This technology should be included in the options for GEB operations in GSA buildings. Existing buildings should be prioritized as they outnumber new construction projects and this technology is easier to deploy in existing buildings than some other GEB systems.
2. **Buildings with on-site or site adjacent staff should be prioritized for operator-in-the-loop GEB technology.** Operator-in-the-loop requires staff to initiate actions. Therefore, staff need to be located on site or adjacent to the building to initiate the necessary GEB actions.
3. **Buildings with >40 kBtu/ft^2-yr EUIs should be prioritized for GEB measures.** Buildings with high EUIs will have more loads that can be managed as well as loads that can be monetized to offset the cost of the technology. The likelihood that staff are monitoring devices and available to act in a timely manner when the load management alerts are received is low. In contrast, staff had advanced notice when the demand reduction events were expected to occur.
4. **Buildings with flat (or near) flat load profiles should be avoided for GEB technology.** Flat load profiles indicate the same operation across the day and limit the potential for many GEB measures.
5. **Buildings in locations with installed capacity markets should be prioritized for operator-in-the-loop GEB technology.** The technology was only cost effective because of installed capacity (ICAP) savings. Although the site had been enrolled in a demand response program, the building had not been called upon for a demand response event since 2014. Installed capacity markets allow for other revenue streams.
6. **Avoid load management/continuous demand reduction strategies with operator-in-the-loop technology.** Active load management requires a rapid response from alert to action to reduce the building load appropriately. The likelihood that staff are monitoring devices and available to act in a timely manner when the load management alerts are received is low. In contrast, staff had advanced notice when the demand reduction events were expected to occur.
7. **Buildings with dense material construction work with LoRaWAN wireless technology.** Historic buildings (which is ⅓ of the GSA portfolio) and other buildings have dense walls and other material construction. The denser walls attenuate many wireless signals. LoRaWAN can effectively pass through dense materials.

Appendices

A. Indoor Air Quality / Wireless Building Communication

Indoor air quality (IAQ) sensors, wireless building communication, alerts, and user experience aspects of the operator-in-the-loop platform were qualitatively evaluated.

A large portion of GSA buildings are historic with dense walls and floors that limit wireless communications. One of the reasons the technology was selected was to evaluate the LoRAWAN wireless protocol's success in communicating in existing buildings through these dense materials.

A wireless gateway was placed on the ground floor of 20 Washington Place. This gateway communicated to the vendor's cloud. The pulse-drop sensor connected to the main utility meter was located two floors below the lobby. The pulse-drop monitored the building electricity power usage in real-time and shared that data wirelessly to the vendor's cloud.

IAQ sensors were placed in the GSA office located in the mezzanine of 20 Washington Place. The vendor's platform not only provides GEB solutions, but provides other non-GEB technologies including IAQ, security, and other monitoring options. The IAQ sensors were included in the evaluation as proof of concept.

During the evaluation period, the software provided multiple alerts related to the IAQ in the building. Table A1 lists the number of IAQ-related alerts staff received.

Table A1. Number of IAQ Alerts

Type of Alert	Humidity	Temperature	Particulate Matter
Quantity	200+	17	5

Building staff received alerts via text message, email, and the application on a mobile device. Users of the software could select the type of alert received but could not select a window for when the alerts could be received nor the frequency of alerts.

Besides alerts, users who had access to the vendor software could log in and see the humidity (or other metrics) values both as a snapshot of the current value as well as the values over the day. Figure A1 shows examples from the vendor's platform and the humidity information provided.

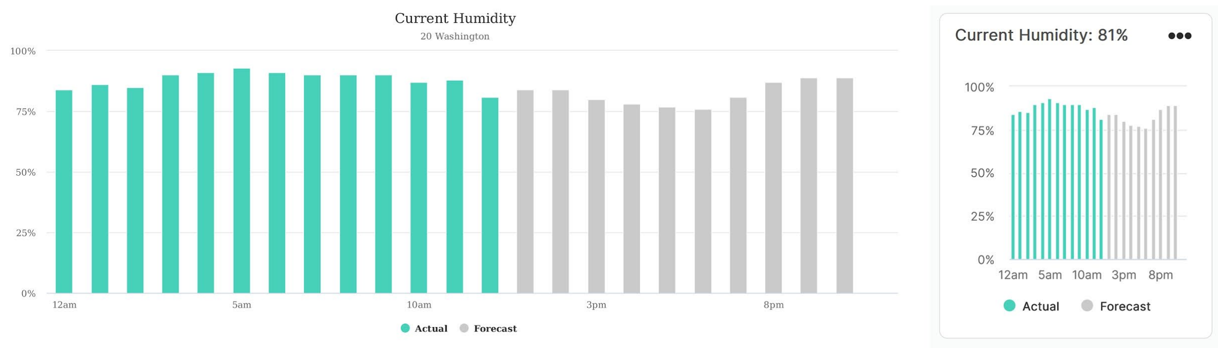


Figure A1. User Software Humidity Information

Humidity

During the evaluation period, building staff received more than 200 alerts related to humidity. Over 90% of the time, these humidity alerts were received after hours or on weekends when the building was closed. GSA staff allow the humidity to drift (not be managed as tightly) when the building is not occupied. Table A2 depicts a period where building staff received text messages frequently in the middle of the night over a weekend when the building was closed, and the humidity was allowed to drift.

Table A2. Example Humidity Alerts

Date	Time	Alert	Action Taken
12/18/2022 Sunday	12:20 am	Humidity of 28 is too low at IAQ Sensor Mezzanine Building Manager Desk - humidity in 20 Washington. Humidity should be between 29 and 70.	No action taken
12/18/2022 Sunday	2:24 am	Humidity of 71 is too high at IAQ Sensor Mezzanine Building Manager Desk - humidity in 20 Washington. Humidity should be between 29 and 70.	No action taken
12/18/2022 Sunday	2:44 am	Humidity of 72 is too high at IAQ Sensor Mezzanine Building Manager Desk - humidity in 20 Washington. Humidity should be between 29 and 70.	No action taken
12/18/2022 Sunday	4:50 am	Humidity of 26 is too low at IAQ Sensor Mezzanine Building Manager Desk - humidity in 20 Washington. Humidity should be between 29 and 70.	No action taken

The building staff allowed humidity to drift during these periods. Also, the sensors were located in the mezzanine office, which was not a representative space in the building. GSA P-100 specifies a humidity criteria for occupied periods as well as a different criteria for unoccupied periods. GSA P-100 additionally has HVAC design criteria for U.S. Courts and the humidity values differ for summer and winter (GSA, 2024). The vendor did not ask nor did their software allow for the user (e.g., GSA staff) to establish the time periods, seasons, or acceptable range for the humidity alerts.

Table A2 demonstrates that the vendor's platform was capable of sending humidity-related alerts. However, being able to specify the site's specified acceptable values and when those values can occur is just as important to being capable of sending alerts.

Temperature

The IAQ sensors also track when the temperature in the space may be undesirable. During the evaluation period, the building received 17 temperature alerts. The building took no action related to the temperature alerts. The sensors were in the mezzanine office and at times the temperature in that space was abnormal compared to other spaces in the building. Table A3 is an example set of temperature alerts. This table demonstrates how the platform sent alerts within multiple minutes of each other and when the building was closed. In this table, the staff received four alerts (examples within one minute of each other) over six hours when the building was closed.

Table A3. Example Temperature Alerts

Date	Time	Alert	Action Taken
9/13/2022 Tuesday	5:45 am	Temperature of 82 is too hot at IAQ Sensor Mezzanine Building Manager Desk - temperature in 20 Washington. Temperature should be between 58 and 82	No action taken
9/13/2022 Tuesday	5:44 am	Temperature of 82 is too hot at IAQ Sensor Mezzanine Building Manager Desk - temperature in 20 Washington. Temperature should be between 58 and 82	No action taken
9/12/2022 Monday	11:24 pm	Temperature of 82 is too hot at IAQ Sensor Mezzanine Building Manager Desk - temperature in 20 Washington. Temperature should be between 58 and 82	No action taken
9/12/2022 Monday	11: 23 pm	Temperature of 82 is too hot at IAQ Sensor Mezzanine Building Manager Desk - temperature in 20 Washington. Temperature should be between 58 and 82	No action taken

The alerts Table A3 were pre-programmed by the vendor. All of the 17 temperature alerts received indicated a temperature of either 82 or 83 and stated temperature is too hot at IAQ Sensor Mezzanine Building Manager Desk - temperature in 20 Washington. Temperature should be between 58 and 82." The GEB vendor did not ask nor did their software allow for the user to establish the temperature range to be specified. GSA P-100 states "Allowance for unoccupied hour setup and setback optimized with re-occupancy pick-up and pull-down energy demands within a range of 13°C to 28°C (55°F to 83°F) (GSA, 2024). Had the vendor established their range to comply with GSA P-100, these alerts should never have been issued.

Table A3 demonstrates that the vendor's platform was capable of sending temperature-related alerts. However, being able to specify the site's specified acceptable tolerance range is just as important to being capable of sending alerts.

Particulate Matter

In early June 2023, smoke from Canadian wildfires filtered down to the eastern U.S. During this period, the air quality index in New Jersey was at times well over 100. The building staff received alerts that the particulate matter 2.5 values in the building were too high. These alerts corresponded to readings from the vendor's software related to particulate matter.

Summary

The IAQ, temperature, and particulate matter examples alerts demonstrate that the GEB vendor's platform can monitor and share secondary (non-power) information with occupants. Temperature and humidity both can affect occupant comfort. These alerts could inform building staff if the comfort related metrics are out of range during a GEB action (e.g., demand response, load management, etc.). That almost all of the alerts came during unoccupied periods indicates the occupant comfort aspects were not affected during the 14 demand response events that occurred during the evaluation period.

The alerts also demonstrated that the wireless communication technology worked. The GEB-related sensors (*i.e.,* CTs monitoring the chillers, pulse-drop on the utility meter) were located multiple floors below the vendor's cellular modem. The IAQ sensors were located more than a floor above the vendor's cellular modem. The building materials (walls, floors) are dense as typical of an older building. Although the IAQ alerts were non-actionable because they occurred when the building was closed or the alerts were within acceptable GSA parameters, it does not diminish that the sensors could communicate through dense building materials.

B. Load Shed / Demand Response

Table B1 and Table B2 details the day, time, and content of each demand response alert. The table lists the temperature the day the alert was received as well as the time of the alert.

Table B1. 2021 Demand Response Alerts

Date	Time	Alert	Temp
7/22/2021	-	Test event	73°
7/26/2021	6:00 pm	PJM Peak Demand Event Alert TODAY - July 26 - 3 pm to 6 pm ENDED	82°
7/26/2021	6:00 pm	STARTING NOW: PJM Peak Demand Event Alert TODAY - July 26 - 3 pm to 6 pm ENDED	82°
7/26/2021	3:00 pm	PJM Peak Demand Event TODAY- 7/26 from 3PM to 6PM Building Managers: ACTIVATE DEMAND MANAGEMENT PROTOCOLS AT YOUR DISCRETION TODAY from 3pm to 6pm TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile	82°

Date	Time	Alert	Temp
		app/desktop platform for your property specific Kilowatt Crush protocols checklist TAKE ACTION TO SAVE ON ENERGY COSTS! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols Please confirm receipt of this message If you have any questions/comments please reach out to us at: Concierge@logicalbuildings.com (908) 517-3730	
7/26/2021	2:52 pm	STARTING NOW: PJM Peak Demand Event Alert TODAY - July 26 - 3pm to 6pm	82°
7/26/2021	10:38 am	PJM Peak Event TODAY - July 26th - From 3pm to 6pm	82°
7/26/2021	10:13 am	PJM Peak Demand Event Alert TODAY - July 26 - 3pm to 6pm	82°
7/27/2021	6:00 pm	STARTING NOW: PJM Peak Demand Event Alert TODAY - July 27 - 3 pm to 6 pm ENDED	81°
7/27/2021	3:00 pm	STARTING NOW: PJM Peak Demand Event Alert TODAY - July 26 - 3pm to 6pm	81°
8/11/2021	9:44 am	-	81°
8/12/2021	11:26 am	DOUBLE HEADER: PJM Peak Demand Event Alert TODAY - August 12 - 3pm to 6pm PJM Peak Demand Event TODAY - 8/12 from 3pm to 6pm Building Managers: ACTIVATE DEMAND MANAGEMENT PROTOCOLS AT YOUR DISCRETION TODAY from 3pm to 6pm TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist TAKE ACTION TO SAVE ON ENERGY COSTS! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols Please confirm receipt of this message If you have any questions/comments please reach out to us at: Concierge@logicalbuildings.com (908) 517-3730	84°F
8/12/2021	10:40 am	-	-
8/13/2021	10:19 am	TRIPLE PLAY: PJM Peak Demand Event Alert TODAY - August 13 - 3pm to 6pm PJM Peak Demand Event TODAY - 8/13 from 3PM to 6PM Building Managers: ACTIVATE DEMAND MANAGEMENT PROTOCOLS AT YOUR DISCRETION TODAY from 3pm to 6pm TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist TAKE ACTION TO SAVE ON ENERGY COSTS! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols Please confirm receipt of this message If you have any questions/comments please reach out to us at: Concierge@logicalbuildings.com (908) 517-3730	86°F
8/24/2021	-	PJM Peak Demand Event Alert TODAY - August 24 - 3pm to 6pm PJM Peak Demand Event TODAY- 8/24 from 3pm to 6pm Building Managers: ACTIVATE DEMAND MANAGEMENT PROTOCOLS AT YOUR DISCRETION TODAY from 3pm to 6pm TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist TAKE ACTION TO SAVE ON ENERGY COSTS! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols Please confirm receipt of this message If you have any questions/comments please	81°F

Date	Time	Alert	Temp
		reach out to us at: Concierge@logicalbuildings.com (908) 517-3730	
8/25/2021	2:52 pm	STARTING NOW: PJM Peak Demand Event Alert TODAY - August 25 - 3pm to 6pm PJM Peak Demand Event TODAY- 8/25 from 3PM to 6PM Building Managers: ACTIVATE DEMAND MANAGEMENT PROTOCOLS AT YOUR DISCRETION TODAY from 3PM to 6PM TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist	81°F
8/25/2021	-	DOUBLE HEADER: PJM Peak Demand Event Alert TODAY - August 25 - 3pm to 6pm PJM Peak Demand Event TODAY- 8/25 from 3PM to 6PM Building Managers: ACTIVATE DEMAND MANAGEMENT PROTOCOLS AT YOUR DISCRETION TODAY from 3PM to 6PM TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist TAKE ACTION TO SAVE ON ENERGY COSTS! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols Please confirm receipt of this message If you have any questions/comments please reach out to us at: Concierge@logicalbuildings.com (908) 517-3730	81°F
8/26-8/27/2021	-	no alert issued - yet energy consumption is high and temperature outside is higher than previous two alerts that were issued.	83°F

Table B2. 2022 Demand Response Alerts

Date	Time	Alert	Temp
5/30/2022	7:55 pm	Hottest Day in May - Shift the power during tomorrow's heat! Be sure to adjust your building controls accordingly and save money! Building Managers: Demand Response events are possible. Logical Buildings will notify you of any events called. This is a great time to test your Demand Management skills! Below are some energy-saving tips and best practices: • Pre-cool: pre-cool hallways and common spaces in the morning and return thermostats to their normal setpoint in the evening • Thermostat/BMS: raise setpoints by 4-5 degrees in amenity spaces after pre-cooling • Lighting: flip off all non-essential lighting throughout the building • Doorways: keep doorways, especially to the outdoors, closed and use revolving doors • Elevator: do not shut off, but lock out a service elevator if possible • Maintenance: reschedule any maintenance routines to early morning hours • Residents: encourage residents to keep their blinds closed if possible Small change adds up! If you have any questions about how to best operate your buildings to save money and earn cash using less energy, get in touch! concierge@logicalbuildings.com (908) 517-3730	83°F
7/18/2022	1:00 pm	Shift the power during the forecasted heat wave this week! Be sure to adjust your building controls accordingly and save money! Building Managers: Demand Response events are likely in the Northeast. Logical Buildings will notify you of any events called. This is a great time to test your Demand Management skills!	80°F

Date	Time	Alert	Temp
7/19/2022	3:28 pm	PJM Peak Demand Event Alert TOMORROW - July 20 - 3pm to 6pm Attention Building Managers: TOMORROW is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TOMORROW from 3PM to 6PM TOMORROW is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Shift the power during the heat wave this week! Small change adds up! More Reduction = More Rewards	82°F
7/20/2022	11:08 am	REMINDER: PJM Peak Demand Event Alert TODAY- July 20 - 3pm to 6pm Attention Building Managers: TODAY is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TODAY from 3PM to 6PM TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist	87°F
7/20/2022 **7/21/2022**	6:12 pm	DOUBLE HEADER: PJM Peak Demand Event Alert TOMORROW - July 21 - 3pm to 6pm Attention Building Managers: TOMORROW is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TOMORROW from 3PM to 6PM TOMORROW is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist	88°F
7/21/2022	10:58 am	REMINDER: PJM Peak Demand Event Alert TODAY- July 21 - 3pm to 6pm Attention Building Managers: TODAY is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TODAY from 3PM to 6PM TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist	88°F
7/21/2022 **7/22/2022**	8:26 pm	TRIPLE HEADER: PJM Peak Demand Event Alert TOMORROW - July 22 - 3pm to 6pm Attention Building Managers: TOMORROW is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TOMORROW from 3PM to 6PM TOMORROW is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Shift the power during the heat wave this week! Small change adds up!	88°F

Date	Time	Alert	Temp
7/22/2022		REMINDER: PJM Peak Demand Event Alert TODAY - July 22 - 3pm to 6pm Attention Building Managers: TODAY is a PJM Peak Demand Event between 3pm and 6pm This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TODAY from 3PM to 6PM TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Shift the power during the heat wave this week! Small change adds up! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols Please confirm receipt of this message If you have any questions/comments please reach out to us at: Concierge@logicalbuildings.com (908) 517-3730	86°F
7/28/2022		no event alert or reminder issued in building History	79°F
8/2/2022	12:02 pm	PJM Peak Demand Event Alert TOMORROW - August 3rd - 3pm to 6pm Attention Building Managers: TOMORROW is a PJM Peak Demand Event between 3pm and 6pm This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TOMORROW from 3PM to 6PM Please confirm receipt of this message TOMORROW is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Be on alert for a Double-Header event during this week's heatwave. Shift the power during the heat wave this week! Small change adds up! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols	80°F
8/3/2022	11:26 am	Logical Buildings: I hope everyone is doing well. Just wanted to make sure site team received notifications for PJM Peak Demand Event for TODAY – AUG 3rd - 3pm to 6pm (and likely Thursday 8/4) for 20 Washington. Alerts have been sent out via SmartKit AI app/email/text – if anyone is having issues accessing the platform/getting alerts please let us know. Please check your SmartKit mobile app/desktop platform for your specific Kilowatt Crush protocols checklist and implement them from 3-6pm today. Appreciate if the site team can confirm receipt of this email and happy to jump on a call to discuss if the site team has any questions.	81°F
8/3/2022	11:38 am	GSA communication: Yes, I received the notification for a event today from 3-6 and informed the O&M contractor.	-
8/3/2022	11:51 am	Logical Communication: Thanks Michael. Appreciate the confirmation.	-
8/3/2022	-	PJM Peak Demand Event Alert TOMORROW - August 3rd - 3pm to 6pm Attention Building Managers: TOMORROW is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TOMORROW from 3PM to 6PM Please confirm receipt of this message TOMORROW is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Be on	81°F

Date	Time	Alert	Temp
		alert for a Double-Header event during this week's heatwave. Shift the power during the heat wave this week! Small change adds up! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols If you have any questions/comments please reach out to us at: Concierge@logicalbuildings.com (908) 517-3730	
8/3/2022	12:06 pm	REMINDER: PJM Peak Demand Event Alert TODAY - August 3rd - 3pm to 6pm Attention Building Managers: TODAY is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TODAY from 3PM to 6PM TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Shift the power during the heat wave this week! Small change adds up! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols	81°F
8/4/2022	8:03 am	DOUBLE HEADER: PJM Peak Demand Event Alert TODAY - August 4th - 3pm to 6pm Attention Building Managers: TODAY is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TODAY from 3PM to 6PM TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Shift the power during the heat wave this week! Small change adds up!	82°F
8/4/2022	10:41 am	Communication from Logical Buildings: Hi Michael, We have another PJM Peak demand event from 3-6pm today. Just wanted to make sure O&M staff is notified. Also, would it be possible to get input from O&M on what protocols they are implementing during the event. We are seeing reductions from the data but not big as last year. We wanted to make sure they are implementing the chiller protocols (pre-cool chilled water loop & increase setpoint). Happy to get on a call with them to discuss if they have any questions.	-
8/4/2022	12:40 pm	Communication from GSA: Good afternoon Gowthamram, I did coordinate with O&M staff this morning about today's event. I will get exactly the changes their making for the next meeting.	-
8/4/2022	12:46 pm	Communication from GSA: Great. Thank you Michael!	-
8/7/2022	4:01 pm	PJM Peak Demand Event Alert TOMORROW - August 8th - 3pm to 6pm Attention Building Managers: TOMORROW is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TOMORROW from 3PM to 6PM Please confirm receipt of this message	86°F

Date	Time	Alert	Temp
		TOMORROW is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Be on alert for a Double-Header event during this week's heatwave. Shift the power during the heat wave this week! Small change adds up! More Reduction = More Rewards	
8/8/2022	10:52 am	REMINDER: PJM Peak Demand Event Alert TODAY - August 8th - 3pm to 6pm Attention Building Managers: TODAY is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TODAY from 3PM to 6PM Please confirm receipt of this message TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Be on alert for a Double-Header event during this week's heatwave. Shift the power during the heat wave this week! Small change adds up! More Reduction = More Rewards 4 total alerts: alert and reminder sent at 3pm alert and reminder sent at 6pm	87°F
8/8/2022	7:53 pm	DOUBLE HEADER: PJM Peak Demand Event Alert TOMORROW - August 9th - 3pm to 6pm Attention Building Managers: TOMORROW is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TOMORROW from 3PM to 6PM Please confirm receipt of this message TOMORROW is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Be on alert for a Double-Header event during this week's heatwave. Shift the power during the heat wave this week! Small change adds up!	87°F
8/9/2022	11:55 am	REMINDER: PJM Peak Demand Event Alert TODAY - August 9th - 3pm to 6pm Attention Building Managers: TODAY is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TODAY from 3PM to 6PM Please confirm receipt of this message TODAY is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Shift the power during the heat wave this week! Small change adds up! More Reduction = More Rewards	89°F
8/9/2022		Attention Building Managers: TOMORROW is a PJM Peak Demand Event between 3PM and 6PM This is a key opportunity to manage and reduce both electricity costs and carbon emissions! ACTIVATE DEMAND MANAGEMENT PROTOCOLS TO REDUCE ELECTRICITY AT YOUR DISCRETION TOMORROW from 3PM to 6PM Please confirm receipt of this message TOMORROW is a Kilowatt Crush Checklist protocol day - Please check your SmartKit mobile app/desktop platform for your property specific Kilowatt Crush protocols checklist Be on	89°F

Date	Time	Alert	Temp
		alert for a Double-Header event during this week's heatwave. Shift the power during the heat wave this week! Small change adds up! More Reduction = More Rewards If you are not on-site please contact your next in command to follow through with these protocols If you have any questions/comments please reach out to us at: Concierge@logicalbuildings.com (908) 517-3730	

B. Load Management

Table B1 details the day, time, and content of each load management alert. The table lists the temperature the day the alert was received as well as the load at the time of event; billing peak; and last year's peak.

Table B1. Load Management Alerts

Date	Time	Alert	Temp	Load	Bill Peak	Last Year	Action Taken
8/9/2022 Tuesday	10:35 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	89	359	435		No action taken
8/22/2022 Monday	7:36 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	74	415	435		No action taken
8/22/2022 Monday	11:06 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	74	426	435		No action taken
8/22/2022 Monday	12:21 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	74	498	435	498	No action taken
8/24/2022 Wednesday	6:51 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	79	374	435	498	No action taken
8/24/2022 Wednesday	8:51 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	79	376	435	498	No action taken

Date	Time	Alert	Temp	Load	Bill Peak	Last Year	Action Taken
8/24/2022 Wednesday	2:22 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	79	429	498	-	No action taken
8/25/2022 Thursday	8:23 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	80	365	498	-	No action taken
8/25/2022 Thursday	11:22 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	80	420	498	-	No action taken
8/25/2022 Thursday	12:08 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	80	364	498	-	No action taken
8/26/2022 Friday	3:37 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	80	468	498	-	No action taken
8/27/2022 Saturday	3:21 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	79	333	498	-	No action taken
8/29/2022 Monday	12:52 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	78	372	500	498	No action taken
8/29/2022 Monday	3:52 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	78	373	500	498	No action taken
8/30/2022 Tuesday	10:07 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	79	380	500	498	No action taken
8/31/2022 Wednesday	10:07 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce	79	361	495	423	No action

Date	Time	Alert	Temp	Load	Bill Peak	Last Year	Action Taken
		energy usage.					taken
9/2/2022 Friday	12:51 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	69	308	495	423	No action taken
9/12/2022 Monday	9:37 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	73	401	495	423	No action taken
9/13/2022 Tuesday	10:22 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	75	347	495	423	No action taken
9/19/2022 Monday	9:21 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	73	341	495	423	No action taken
9/19/2022 Monday	11:52 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	73	395	495	423	No action taken
9/20/2022 Tuesday	9:37 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	65	343	495	423	No action taken
9/22/2022 Thursday	9:07 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	71	344	495	423	No action taken
9/22/2022 Thursday	10:52 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	71	346	495	423	No action taken
9/27/2022 Tuesday	4:51 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	63	419	495	423	No action taken
10/18/2022 Tuesday	12:08 pm	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	50	266	266	410	No action taken

Date	Time	Alert	Temp	Load	Bill Peak	Last Year	Action Taken
11/7/2022 Monday	8:52 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	69	347	360	423	No action taken
11/7/2022 Monday	9:38 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	69	170	360	423	No action taken
11/7/2022 Monday	11:38 am	Live sensor readings show that 20 Washington is close to setting a new billing period peak. Take actions from the Daily Events checklist to reduce energy usage.	69	307	360	423	No action taken

References

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PJM. 2020b "PJM Manual 11: Energy & Ancillary Services Market Operations" Revision: 111. Effective November 19, 2020. https://www.pjm.com/-/media/documents/manuals/archive/m11/m11v111-energy-and-ancillary-services-market-operations-11-19-2020.ashx

RMI. 2019. "Value Potential for Grid-Interactive Efficient Buildings in the GSA Portfolio. A cost-benefit analysis." Rocky Mountain Institute.

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Manufacturer Data

Vendor 2022 Performance Review

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20 Washington Snapshot: 2022 ESG Achievements and Cost

- Electricity Usage Savings: **$25K**
- Electricity Usage Reduction: **14%**
- Capacity/Transmission Reduction Savings: **$20K**
- Total Annual Energy Savings: **$45.5K**
- Carbon Reduction: **45 MT CO2**

20 Washington's ESG Solutions with smartkit ai

Logical Buildings' SmartKit AI Software monitored the following electric loads at 20 Washington:

- Common area electric
- Chiller 1
- Chiller 2

SmartKit AI sent notifications to the 20 Washington staff when there was a capacity tag management event (May – September, from 2-6pm). There can be up to 10 events throughout the summer.

SmartKit AI tracked real-time event electricity consumption for measurement and verification of electricity cost savings.

SmartKit AI – Energy Monitoring & ICAP Management

smartkit ai

Actionable data, HVAC setpoint management, and training

Secure cloud integrations with utility smart meters, building controls, and IoT networks to provide real-time insights and fault detection. Ongoing energy management and HVAC setpoint training to lower costs and carbon emissions.

Measurable ROI

Smart building software that creates layers of energy savings, allowing building operators to manage their building systems and achieve ESG goals. Maximize revenue and energy costs savings with peak demand management alerts and HVAC setpoint guidance.

SmartKit AI™ is a product of Logical Buildings. To learn more about how Logical Buildings helps building owners and home owners save money and reduce emissions, contact learn@logicalbuildings.com or visit logicalbuildings.com

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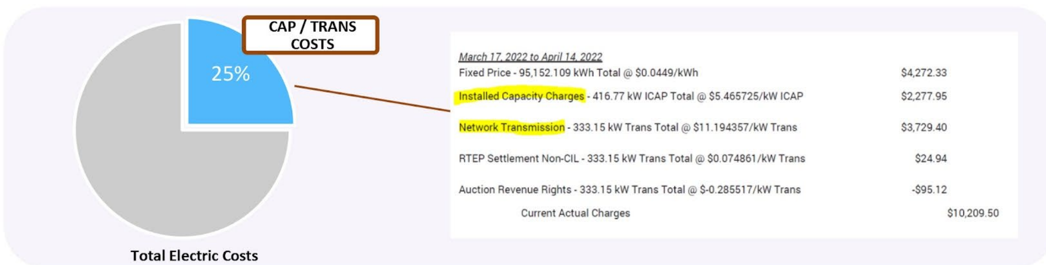
Capacity Tag Management at 20 Washington

Each year every building in PJM is assigned Generation Capacity and Transmission “tag” values by the utility company, which dictate monthly charges on the supply side of the electric bill. These values are based on a building’s electricity usage during the entire electric system’s 5 peak consumption hours in the calendar year (most often occurring during the hottest days of the summer).Thus, each building pays for its “contribution” to the amount of capacity/transmission required for the grid to operate effectively during those peak hours.

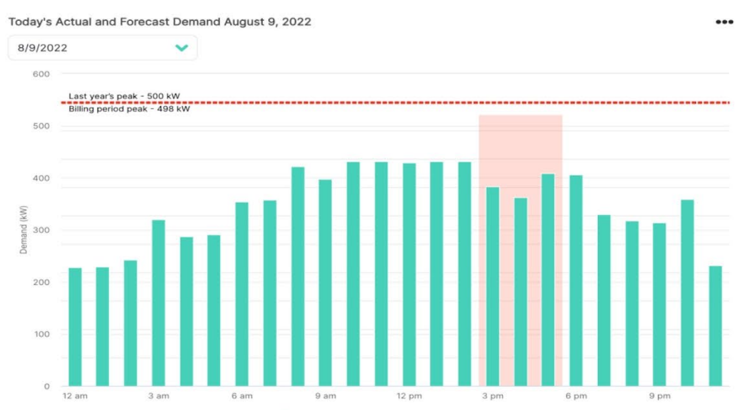


Saving Energy and Reducing Costs with Data-Driven Insights

20 Washington used SmartKit AI to monitor electricity consumption and receive peak-demand management alerts to generate revenue and lower electricity costs.

Logical Buildings notified 20 Washington when the grid was peaking so that the property could reduce their demand for a specific 3-hour window (3:00-6:00pm).

From June-September, 20 Washington’s peak KW was 449. As a result of actions like these, 20 Washington **reduced their usage to an average of 346 KW** during the top 5 hours for PJM and PSEG and **saved $20,509 in capacity and transmissions cost savings.**



On August 9, 2023, 20 Washington reduced their demand from 432 kW to 363 kW.

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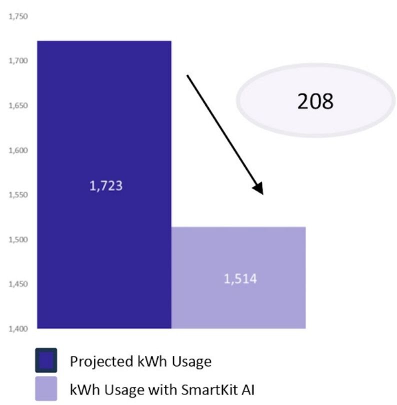
kWh Savings and Carbon Emissions Reduction

Logical Buildings performed a baseline analysis of 20 Washington's utility data in 2021 and used the International Performance Measurement and Verification Protocol (IPMVP) to calculate energy savings.

In 2022, 20 Washington reduced their kWh usage from 1,722,676 in 2021 to 1,514,277 in 2022 by reducing energy consumption throughout the year.

This **14% reduction of 208,399 kWh** allowed them to save **$25,008.**

Kilowatt Hours Reduced
in thousands



	Baseline kWh Usage	Actual kWh Usage	Reduction
Jan	130,055	106,791	23,264
Feb	116,165	94,947	21,218
Mar	127,459	95,726	31,733
Apr	123,135	107,137	15,998
May	139,700	115,216	24,484
Jun	154,701	149,890	4,811
Jul	206,745	189,559	17,186
Aug	198,192	187,559	10,633
Sep	147,189	129,246	17,943
Oct	126,070	108,089	17,981
Nov	124,799	111,026	13,773
Dec	128,466	119,091	9,375
Total	**1,722,676**	**1,514,277**	**208,399**

20 Washington Summary

- Electricity Usage Savings: **$25K**
- Capacity/Transmission Reduction Savings: **$20K**
- Total Electricity Usage Savings: **$45.5K**
- Electricity Usage Reduction: **14%**

CO2

45

Metric tons

Emissions Reduction

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