General Services Administration
Public Buildings Service

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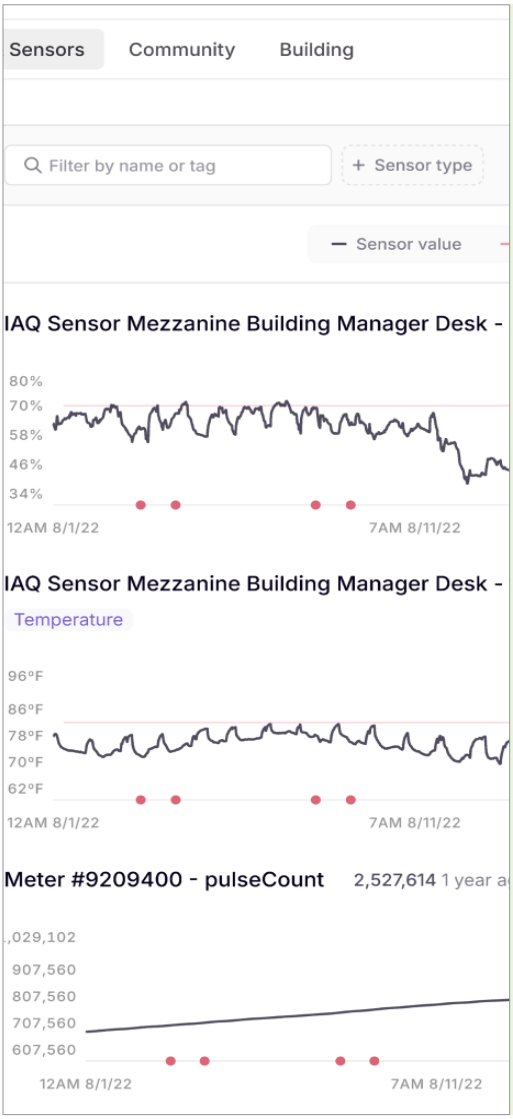
OPERATOR IN THE LOOP GRID-INTERACTIVE EFFICIENT BUILDING



Machine-Learning Software Predicts Peak Demand and Capacity Charges to Reduce Utility Costs

Buildings can act as "responsive assets" to the grid, flexing energy use depending on fluctuating utility costs and the carbon intensity of electrical generation.[1] A grid-interactive efficient building (GEB) acts as an intelligent interface between building operations and the grid, actively responding to grid conditions to capitalize on lower costs and reduce energy use. Utility cost structures are becoming increasingly complex.[2] GEB technologies, combined with integrated operational strategies, can achieve previously unattainable utility savings while reducing carbon emissions and increasing overall efficiency.

In collaboration with Pacific Northwest National Laboratory (PNNL), GSA evaluated a GEB operator-in-the-loop technology that predicts peak demand to achieve utility cost savings. Building operators choose whether and how to implement reduction actions. There are three key strategies to reduce costs based on demand: predicting installed capacity (ICAP) charges, participating in demand response (DR) programs, and reducing monthly peak building demand.

The GEB operator-in-the-loop technology successfully predicted when ICAP charges would be calculated. ICAP charges help ensure grid reliability during the year's highest demand days and are calculated based on the building's energy use during peak periods and the overall grid demand. Building managers were able to respond to all day-ahead ICAP DR alerts, achieving a simple payback of less than one year. While the software accurately predicted monthly peak demand, building managers were unable to respond to the alerts in time.

INTRODUCTION

21 states (served by PJM, ISO New England and ISO New York) have ICAP charges[3]

"The technology's dashboard helped us visualize building performance and refine strategies to reduce demand and costs. Our team had not previously known when ICAP charges would occur."

– Michael Diggs, Building Manager
20 Washington Place
Newark, New Jersey
U.S. General Services Administration

What Is This Technology

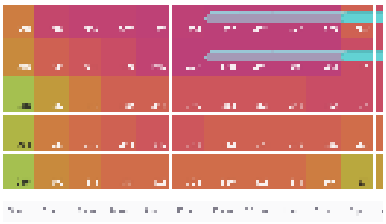
DATA-DRIVEN PEAK DEMAND PREDICTIONS AND OPERATIONAL GUIDANCE

A software-as-a-service (SaaS) technology, the GEB operator-in-the-loop software employs machine learning to predict load shedding events using real-time and historical data from load monitoring, the utility/ISO, and weather data. Events are called based on cost signals for demand reduction and/or according to load management strategies, including tracking and responding to monthly billing peak demand cycles. The operations and management (O&M) team is alerted by text and email when an event will occur. Facility managers decide how to act, choosing an action from the vendor-developed protocol specific to the building. The technology features a dashboard that displays real-time building data. While the vendor offers an automated GEB solution, the operator-in-the-loop system was selected because it simplified GSA cybersecurity mitigation requirements. A three-year commitment is required with an annual subscription fee. The GEB technology was provided by Logical Buildings. The effectiveness of LoRaWAN, used to enhance wireless signaling, was not the focus of this evaluation but was secondarily considered.

What We Did

EVALUATED LOAD SHED AND LOAD MANAGEMENT CAPABILITIES

The evaluation was conducted at 20 Washington Place in Newark, NJ. GSA authorized the utility to share data with the vendor. The utility installed a pulse-drop meter, which provided real-time data to the vendor's dashboard by reading the meter's electrical signal in 15-minute intervals. A wireless LoRaWAN transmitter, which required no FedRAMP authorization, was connected to the pulse-drop meter for data-sharing capabilities. An electrician installed two current transducers (CTs) on the building's two chillers. The chillers were selected because they are the largest single loads in the building and are compatible with GEB protocols. The CTs measure current, which was used to calculate the power draw of the chillers. The evaluation was conducted between August 2021 and November 2022, monitoring the technology for demand reduction and continuous load management.



Heat maps visualize building energy use, indicating day, time, and the impact of load shed during demand response events.

FINDINGS

ACCURATELY PREDICTED ICAP CHARGES Alerted the night before, the O&M team was able to act on all 14 DR events (7 events each summer between June and September), achieving a 20% reduction (shed intensity 0.56 kW/SF). ICAP savings were approximately $20,000 in 2022.

FACILITATES PARTICIPATION IN DR PROGRAMS While no actual utility demand events occurred, participants are required to successfully respond to an annual simulated DR event to maintain eligibility. In September, the building successfully demonstrated a test load shed, with demand reductions comparable to those achieved during the ICAP events.

ACCURATELY PREDICTED MONTHLY PEAK DEMAND Despite the accuracy of the predictions, building management was unable to respond within the required 15-minute window. Because the O&M team oversees several buildings on the site, they were either too far away to respond to alerts or occupied with other tasks. During the 122-day evaluation period for continuous demand management, 29 alerts were issued, but none were acted upon.

SINGLE-DAY INSTALLATION The software required minimal cybersecurity mitigation and can provide stand-alone control without integration into the building automation system.

BUILDING MANAGEMENT APPROVED The O&M team preferred the operator-in-the-loop technology over an automatic system. Staff found the real-time data and predictive recommendations useful. They appreciated how the intuitive dashboards enhanced data visualization but expressed a desire for customization to address issues related to alert frequency.

POSITIVE RETURN ON INVESTMENT Based on ICAP savings, the technology had a simple payback of less than one year, accounting for the required three-year subscription. Unrealized savings for the simulated event were not factored into the cost analysis because the building was engaged in the DR program prior to the start of the evaluation.

PRIORITIZE BUILDINGS WITH ONSITE STAFF Staff will be more able to act quickly on continuous demand management alerts. Buildings with 24-hour operations, an energy use intensity of >40 kBtu/SF/year, and uneven load profiles should also be prioritized.

Positive Return on Investment

Payback less than 1 year based on ICAP savings and 3-year subscription

Initial Site Engineering Study ($15K over 3 years)	$5,000
Installation ($4K for on-site metering equipment and electrician, over 3 years)	$1,333
Annual Subscription (3-year subscription required)	$6,000
Monthly Peak Demand Reduction (not realized)	$0
ICAP Capacity Reduction (115 kW/yr)	$7,847
ICAP Transmission Reduction (91 kW/yr)	$12,662
Simple Payback	**< 1 year**

CONCLUSIONS

For more information, contact GSA's Center for Emerging Building Technologies
cebt@gsa.gov

Footnotes

[1] https://rmi.org/our-work/buildings/pathways-to-zero/grid-interactive-energy-efficient-buildings/

[2] https://www.energy.gov/femp/evaluating-your-utility-rate-options

Technology for testbed measurement and verification provided by Logical Buildings.

What We Concluded

REDUCED CAPACITY CHARGES, UNCHANGED MONTHLY PEAK DEMAND

The GEB operator-in-the-loop technology accurately predicts building peaks and grid-initiated DR events. The dashboard's correlation of real-time, historical and external data allowed the O&M team to optimize building operations with informed decision-making. The timing for ICAP charges is determined by the ISO at the end of the season, long after the peak has occurred, and is impossible for the O&M team to predict manually. The software guided the team to achieve savings the building had not previously attained, but value assessments are complex. ICAP savings are not realized until the following year, which requires annual cost comparisons to verify, and the charges are not relevant across the GSA portfolio. The operator-in-the-loop aspect was less useful for reducing monthly peak demand, although predictions were accurate. The 15-minute response time required building operators to be in the building and able to act on the alert. Load management data can inform building operations to reduce energy use, such as implementing softer building openings, even if alerts are not acted on.

Lessons Learned and Best Practices

- Real-time data aid in establishing flexible operational strategies as GSA moves away from a "set and forget" approach to energy management and incorporates more distributed energy resources (DERs).
- Case studies show that the highest savings come from lowering ICAP charges, followed by participating in DR programs, and lastly, by reducing monthly peak building demand.
- ICAP savings are not guaranteed. Some locations are not subject to capacity markets. Tracking savings will require internal analysis per building, which is not easily automated.
- Other ISOs and utilities may have different methods for calculating ICAP events and charges. Load reductions are relative to building location, and the magnitude of reductions depends on the calculation method.
- ICAP savings are not directly realized and may impact regional budgets participating in DR programs. Strategies can be explored for regions to retain savings and implement comparable rebate structures to utilize ICAP savings.
- Similar services may be available in some regions. The added value of the GEB technology includes correlated insights, data visualization and user interface, building-specific predictions, and continuous demand management functionality.
- GEB technology can be integrated into ESPC and UESC projects with careful planning and strong collaboration. However, ESCOs may be risk-averse to GEB technologies because GEB events are unpredictable, with variable load shed intensity and no set pattern.
- GEB technologies can help buildings optimize carbon efficiency by delivering real-time data on both building and grid carbon usage.
- GEB operator-in-the-loop technologies are easier to deploy in retrofits than some other GEB systems.
- If continuous load management (reducing monthly peak demand) is the primary objective, an automated GEB technology may be more successful. The vendor offers an automated solution, but it was not tested in this evaluation.