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GEB SOFTWARE WITH SUPERVISORY CONTROL

GEB Software with Supervisory Control Shows Promise In Early Days of GEBs

A grid-interactive efficient building (GEB) uses smart technologies to continuously optimize for energy efficiency and demand flexibility.[1] GEBs actively respond to real-time grid fluctuations, flexing loads to reduce demand, lower costs, and enhance resilience. The promise of GEBs to shift the paradigm of energy management has been widely discussed,[2,3] but few studies have been conducted to fully understand GEB implementation in the real-world setting of an individual building.

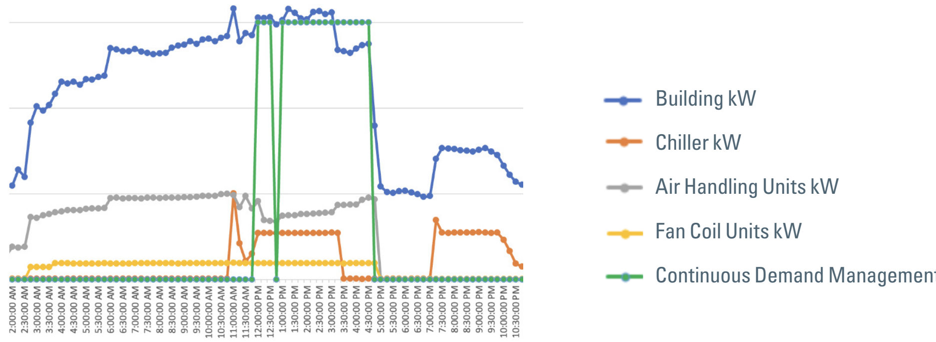
In collaboration with the National Laboratory of the Rockies, CEBT tested a GEB software with supervisory control that uses machine learning and automated system optimization (ASO) to enhance building performance, respond to grid signals, and manage peak demand. The study followed a 2020 CEBT evaluation of the same technology,[4] where the software achieved energy savings with supervisory control of HVAC systems based on real-time occupancy data and accurately predicted daily peak demand. The current evaluation's expanded scope tested the software's capabilities within the more complex context of a GEB.

This evaluation is one of the first of its kind, and results correlate with some known issues related to GEB implementation, including challenges maintaining occupant comfort. The evaluation considered three primary objectives: energy efficiency, utility-driven automated demand response (ADR), and managing daily peak demand through continuous demand management (CDM). Results reflected previous findings, including 4% energy savings in an already-efficient building and accurate predictions to support the GEB software's CDM functionality. ADR events were enacted successfully, but results for CDM were inconclusive due to insufficient data.

INTRODUCTION

Software engagement visualized

The green line depicts the software activating continuous demand management in response to peak



"The GEB software performed well as a proof of concept. With these lessons learned, there is potential to make refinements and improve future GEB deployments."

— Joshua Banis
Program Manager
Center for Emerging Building Technologies
U.S. General Services Administration

What Is This Technology

AI PREDICTIONS WITH CUSTOMIZED, RULE-BASED RESPONSES

The GEB software with supervisory control is an energy management information system with ASO. AI and machine learning algorithms analyze data from the building automation system (BAS), third-party sensors, and external sources, including weather and advanced metering, to predict peak demand. The software uses a customized, rule-based algorithm to deploy demand response in stages, flexing loads following a defined protocol. For this evaluation, initial pre-cooling was enacted followed by two stages of increasing air handler units (AHU) supply air temperature setpoints. Stages 3–5 reduced static pressure setpoints to lower fan speeds. CDM and ADR events followed the same protocol, with three additional stages for ADR that increased chilled water setpoints. The sequence of stages remained static, but setpoints were adjusted as necessary. Events concluded when the target load reduction was achieved. Occupancy sensors placed at each entrance provided data to optimize AHUs, including start/stop and duct static pressure ramps. The GEB software for this evaluation was provided by Nantum AI.

What We Did

EVALUATED GEB INTEROPERABILITY, GRID ALIGNMENT, AND SUPERVISORY CONTROL CAPABILITY

The GEB software's impact on CDM, ADR, and energy efficiency was evaluated at the Foley Federal Building and U.S. Courthouse in Las Vegas, Nevada. The 209,000 SF courthouse is high performing, with an energy use intensity (EUI) of 28.8 kBtu/SF, and is managed by an engaged facilities team. After the original site became unavailable, Foley was selected because the building's non-critical loads allowed for setpoint and schedule customization and because the building's multiple AHUs allowed for zone control. The response protocol was co-developed by the project team, which the vendor programmed into the BAS controls. Simulated events were conducted to test ADR because the utility had recently changed DR events to begin after 5 pm when building operations were ramping down and occupancy was reduced. The simulated events reflected the utility's historical pattern for DR events between 3 and 5 pm on weekdays. Baseline data from 2021 was used to determine savings.

FINDINGS

VALUABLE AS PROOF OF CONCEPT The software demonstrated accurate predictive capability, initiated supervisory control, responded to simulated ADR events, and increased energy efficiency.

ENERGY EFFICIENCY Whole-building energy savings were 4.3%, including electricity savings of 4.2% and natural gas savings of 5%.

LIMITED DATA, INCONCLUSIVE RESULTS FOR CONTINUOUS DEMAND MANAGEMENT The software successfully engaged for 75% of peak days. Troubleshooting for supervisory control led to a small sample size, limiting the usable data needed to determine savings. Inconsistent engagement may have been related to the building's thermal load reacting to setpoint changes and energy efficiency measures. The software was decommissioned before sufficient data could be collected.

THREE SUCCESSFUL ADR EVENTS All simulated ADR events were successfully executed, resulting in an average kW reduction of 8% from baseline and average savings of 0.14 W/SF.

OCCUPANCY COMFORT ISSUES Temperatures drifted too far from comfort levels and there were humidity issues. Early in the evaluation, the software needed to be overridden because static pressure (an adjustable parameter) was too low, causing reduced airflow and complaints of mugginess. The issue was resolved by the end of the study. The O&M team received an increase in hot and cold calls during the evaluation.

ONGOING COMMISSIONING Installation and integration lasted 17 weeks. Continuous setpoint adjustments were made throughout the evaluation. Testing times and locations were sometimes restricted due to court proceedings.

BUILDING MANAGEMENT FEEDBACK The O&M team found the optimal start for warmups to be beneficial. Facility managers preferred the GEB software's trending features over the current BAS's, which showed where an existing issue related to excessively running pumps could be remediated. Impacts on occupant comfort resulted in generally negative feedback and the O&M team ultimately requested the software be disabled.

CYBERSECURITY COMPLIANCE The GEB software operated in full compliance with GSA's stringent requirements.

CONCLUSIONS

These Findings are based on the report, “Field Validation of Grid-Interactive Efficient Building Software Solution,” which is available from the CEBT website www.gsa.gov/cebt

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

What We Concluded

HIGH VALUE POTENTIAL, NEEDS REFINEMENT AND RESOLUTION OF INCONSISTENCIES

Buildings are dynamic. Altering operations according to grid signals can negatively impact building functionality in other ways, including temperature, humidity control, and efficiency. There is potential for the GEB software to further GEB implementation, but there are inconsistencies to resolve prior to deployment. Supervisory control functionality needs refinement to find a better balance between GEB objectives and their potential impacts. New technologies often require adjustments. Deployment will require an extended commissioning process, including adjustments according to building response and recommissioning. Maintaining occupant comfort has been highlighted as one of the most critical and unresolved challenges when implementing GEB strategies.[5] Despite initial optimism for the site’s suitability, results suggest that courtrooms are not fit for technology of this nature due to strict air conditioning requirements. Additional testing in buildings with more flexible conditioning standards and longer schedules is recommended.

Best Practices and Lessons Learned

Known challenges First-generation automated GEB software has not yet resolved challenges with occupant comfort and fluctuating building performance. Additional evaluations are recommended.

Human-in-the-loop First-generation GEBs likely require a human-in-the-loop approach until automated AI strategies are perfected.

Strategic goal setting Balance objectives (cost, comfort, energy) and adapt automation strategies over time.

Comprehensive commissioning Test across seasons and times of day. Complete commissioning could take one year.

Iterative implementation Plan for ongoing testing and adjustments, particularly for DR strategies.

Energy storage Incorporating onsite storage and renewables can minimize impact on occupant comfort and strengthen resilience.

Site priorities Best for buildings with flexible temperature control requirements.

Empower O&M team Provide appropriate training and time to ensure building managers are comfortable with the software. Operators can turn the system, ramps, and demand management on and off and adjust static pressure minimum and maximum setpoints.

Granular data Use 5-minute data intervals for automated demand management for faster response times to changing demand. This evaluation used 15-minute data.

Maximize occupancy tracking Ensure sensors are installed at all egress points and verify proper orientation.

BAS programming Use a BAS subcontractor familiar with government standards and BAS mapping to install GEB software. A more sophisticated BAS may offer better control, customization, and simplify commissioning.

Footnotes

[1] Grid-interactive Efficient Buildings Technical Report Series: Overview of Research Challenges and Gaps. https://www1.eere.energy.gov/buildings/pdfs/75470.pdf

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

[3] Value Potential for Grid-interactive Efficient Buildings in the GSA Portfolio. https://rmi.org/wp-content/uploads/2019/07/value-potential-grid-integrated-buldings-gsa-portfolio.pdf

[2] https://www.gsa.gov/climate-action-and-sustainability/center-for-emerging-building-technologies/completed-assessments/energy-management/energy-management-information-system-with-automated-system-optimization

[5] Grid-interactive Efficient Buildings Technical Report Series: Whole-building Controls, Sensors, Modeling, and Analytics. https://www1.eere.energy.gov/buildings/pdfs/75478.pdf

Technology for test-bed measurement and verification provided by Nantum AI