Cultivating the Next Generation of Analytics Software: Field Results and Commercialization Successes

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ABSTRACT

Energy management and information systems (EMIS) with fault detection and diagnostic tools are achieving energy savings of 9% on average, with two-year paybacks. They are being incorporated into energy management processes, commissioning services, and utility programs. As effective as they are, the Department of Energy estimates even greater savings are possible, with a national study revealing a potential of 29% savings from improved control and operations. Two key barriers prevent these deeper savings - limited personnel to fix problems once they are identified, and the time and expense to manually implement changes in the existing automation systems. In partnership with the research community, the EMIS industry is beginning to bridge this performance gap by developing new capabilities to push *corrective action and control improvements* to buildings via analytics software. Many of these capabilities have been folded into market-available product offerings and are commonly included in development roadmaps.

In this paper we document our EMIS partners' field implementations of a suite of control enhancements spanning; 1) 'one-time' corrections of setpoints; 2) short-term active testing for automated loop tuning and functional testing; and 3) continuous supervisory control for demand flexibility and year-round efficiency. We present 10 field tests integrating these enhancements in managed buildings across the country and offer insights into operator acceptance and integration into operations and maintenance practices. Taken together, the implemented strategies have the potential to yield energy savings of 12-18%, and their deployment through EMIS provides a scalable path to narrowing the building energy performance gap.

Introduction

In 2025, buildings consumed approximately 37% of all energy used in the United States (EIA 2026). It is commonly accepted that a significant fraction of this was wasted due to inefficient operation caused by operational faults. A comprehensive simulation study by Fernandez et al. (2017) estimated average energy savings from improved control and operations of 29% across a broad cross section of buildings in the U.S. Traditional commissioning services have been shown to yield energy savings of 6% (Crowe et al. 2020) and, when combined with smart building analytics technologies, savings can reach 9% with two-year paybacks (Kramer et al. 2020). Thus, a significant gap exists between the 29% opportunity and the savings being achieved by state-of-the-art processes and technologies for achieving energy efficiency.

To address this energy performance gap, the U.S. Department of Energy and Lawrence Berkeley National Laboratory have partnered with leading providers of smart building analytics to pilot fault-free optimal control (FFOC) strategies in real building conditions and document best practices for their successful implementation. FFOC refers to a suite of capabilities to streamline and automate the correction of common heating, ventilating, and air-conditioning (HVAC) faults, and the implementation of advanced HVAC control strategies. These capabilities are implemented using energy management and information system (EMIS) software integrated with the building automation system (BAS). The spectrum of strategies ranges from one-time fixes to recurrent active testing, to continuous supervisory updates of control parameters. Exemplifying the next generation of smart building capabilities, the FFOC strategies include:

- Correction of zone temperature setback setpoints
- Correction of economizer high limit temperature setpoint
- Correction of incorrectly programmed HVAC schedules
- Release of unnecessary control overrides
- Automated loop tuning
- Supply air temperature reset with rogue zone suppression
- Supply air static pressure reset with rogue zone suppression
- Demand flexibility strategies via:
  - Zone temperature adjustment
  - Zone temperature adjustment for precooling
  - Chilled water temperature setpoint reset
- Automated commissioning via:
  - Open-loop functional tests implemented through overrides of control outputs
  - Closed-loop functional tests implemented through adjustments of setpoints

Significant operational improvements and energy savings can be realized through the implementation of these strategies. In the Fernandez et al. (2017) study, energy efficiency measures (EEMs) corresponding to the three correction strategies and two reset strategies were estimated individually to have achievable site energy savings ranging from 0.11% to 7.5%. Combining the energy savings of the individual strategies results in an upper bound on the savings potential of 18.01%; however, this does not account for their interactions. To account for interactions, we use simulation results that combine 37 EEMS (including the five FFOC strategies) in packages (groups of EEMS simulated together). From the simulation packages, Fernandez et al. (2017) estimated the national annual building energy savings to be 29%. This is 32% less than the 42.5% savings estimated by summing the contribution from individual EEMS. Thus, to determine a conservative estimate of the energy savings of two or more FFOC strategies that accounts for interactions, the savings of individual FFOC strategies are added and scaled by a factor of 29/42.5. As a result, the upper bound on the potential energy savings of the five FFOC strategies of 18% is scaled to yield a conservative estimate of 12.3% savings.

In this work we document field implementations of FFOC by EMIS partners. The outline for the paper is as follows. We first describe how FFOC strategies are implemented and how their capabilities can help close the energy savings gap. We then present a summary of the implementation of FFOC in 44 buildings with 12 EMIS providers. Next, results illustrating 10 successful field tests of FFOC strategies are presented and key considerations for its successful use are documented. Finally, we present a summary of the work and plans for further advancements of FFOC.

Benefits of FFOC

FFOC strategies reside in EMIS and are enabled by two-way connectivity between the EMIS and BAS. Operational data are read from the BAS (and other sources, e.g., energy meters, or weather data) and the analytics in the EMIS determine the presence of faults and/or the opportunity for corrective actions or supervisory control updates. Depending on the strategy and frequency of updates, the user can then authorize the push of fault corrections and advanced control sequences from the EMIS to the BAS. The benefits of FFOC include the following:

- It enables rapid resolution of problems and control improvements through user-friendly analytics software and removes the need for time-consuming manual changes to the BAS that characterize today's operations and maintenance (O&M) workflow. FFOC does not prevent recurrence of faults; however, it will expedite the correction of certain types of faults no matter their frequency.
- Deployment of FFOC through EMIS facilitates the delivery at scale of significant HVAC energy savings and peak demand reductions. The 12-18% site energy savings estimated in the previous section is consistent with results from Zhang et al (2022), who found median HVAC energy savings on the order of 30% from simulations of advanced control sequences (ASHRAE, 2024) that are among the FFOC strategies. Granderson et al. (2025) reported peak reductions of 10% from EMIS-based demand flexibility strategies.
- The capabilities of FFOC empower owners to maximize the value of their BAS and reserve O&M staff for the most challenging problems.

A recognition of these benefits has resulted in field deployments of FFOC capabilities by more than a dozen providers of analytics software. Those deployments are summarized next.

FFOC Implementations

FFOC solutions have been implemented by more than a dozen technology providers in 44 buildings across the U.S., Canada, and Australia. Five providers have fully commercialized offerings of specific FFOC strategies. The implementation sites include a number of different building types, with retail and office being the most prevalent as illustrated in Figure 1.

EMIS providers have implemented subsets of the full suite of FFOC strategies in different combinations based on their company-specific priorities and the interests of their clients. As shown in Figure 2, the most frequently implemented strategy is zone temperature setpoint correction, which has been demonstrated in 33 buildings. Implementation of advanced

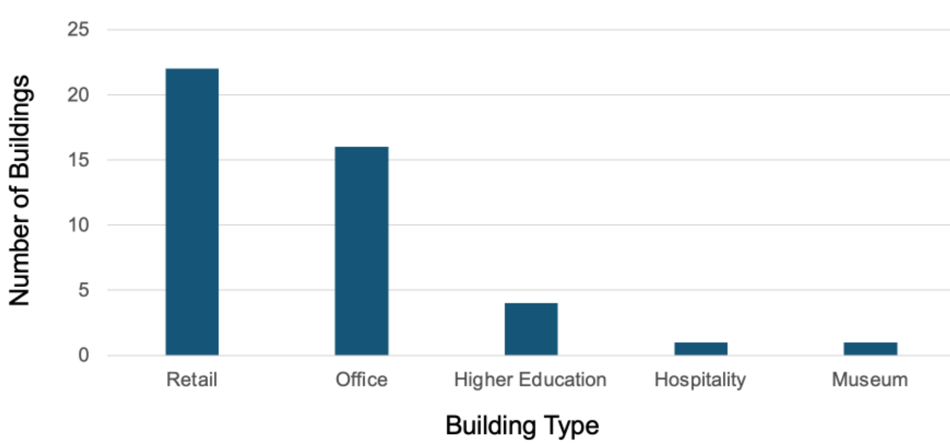

Figure 1. Distribution of FFOC implementations by building type.

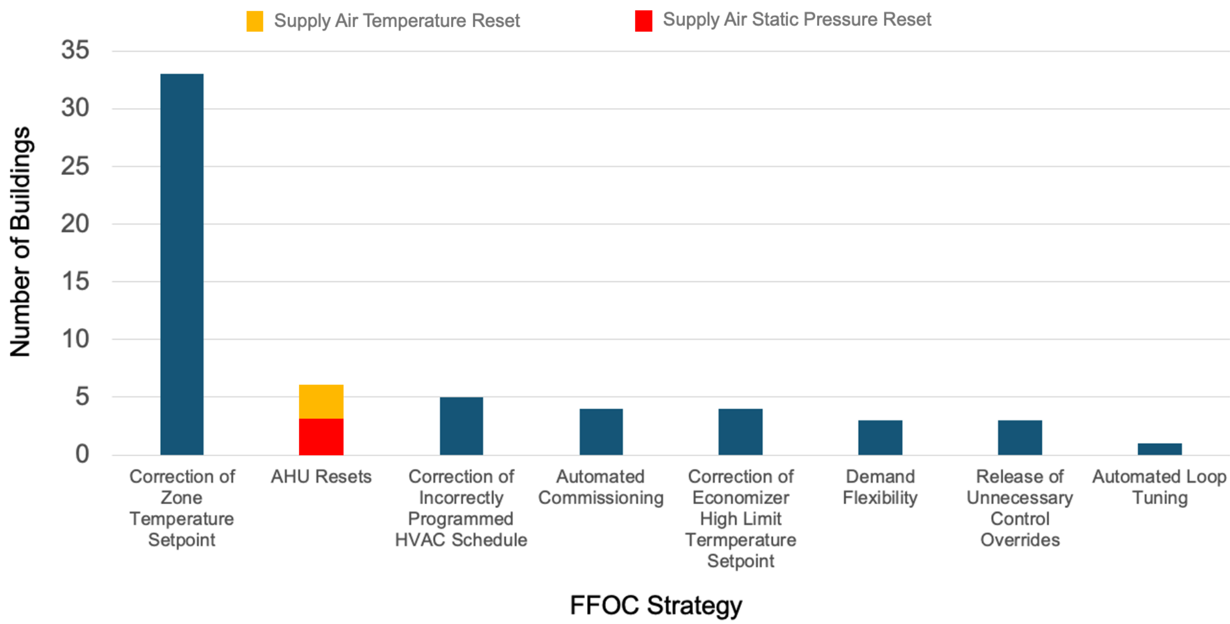

Figure 2. Distribution of FFOC implementations among the individual FFOC strategies. AHU Resets consist of static pressure reset (red) and supply air temperature reset (yellow).

reset strategies and correction of incorrectly programmed schedules were the next most frequently implemented. Automated commissioning (functional testing of the control sequences) and demand flexibility strategies were developed more recently and interest in these applications is growing quickly. Automated loop tuning is the least tested strategy in the suite, but it is a highly promising area undergoing active development.

FFOC strategies broadly fall into three categories:

- *One-time fix* strategies consist of automatic identification and resolution of common faults upon user approval. These include incorrect zone temperature and economizer high limit setpoints, HVAC schedules, and control overrides.
- *Continuous supervisory* optimization strategies involve calculating control setpoints within the EMIS and continuously pushing them back to the BAS. The reset and demand flexibility strategies fall into this category.
- *Active testing* strategies fall between the one-time fix and continuous optimization approaches, as they involve taking control of components or systems for a short period of time to facilitate data collection under specific operating conditions. Data collected during the test are then processed, either to determine new control parameters that are pushed to the BAS (automated loop tuning), or to assess the performance of the component or system under test (automated commissioning).

To date, continuous supervisory control has accounted for 60% of the implemented FFOC strategies, one-time corrections for 32%, and active tests for 8%. The distribution is somewhat skewed by the fact that one EMIS provider implemented zone temperature setpoint correction in a continuous manner in a large number of buildings. Most providers have implemented this strategy as a ‘one-time’ intervention that executes only when a departure from the desired setpoint is detected. Automated commissioning (ACx) accounts for all but one of the active testing implementations.

Figure 3 shows the distribution of the FFOC implementations by BAS platform and illustrates that FFOC strategies have been successfully integrated with over a dozen major BAS platforms that are well represented in the commercial stock. FFOC strategies rely on two-way communication between the EMIS and BAS, typically using the BACnet protocol. Despite being an international standard, manufacturers are given some latitude in how certain features of the protocol are implemented. Thus, it has been important to demonstrate that the EMIS platforms are able to successfully execute write-backs to a diversity of BAS products and associated controllers.

FFOC Field Tests

This section provides examples of 10 field tests of FFOC strategies, including five from what are now fully commercial offerings. Because the tests were typically implemented over a period of hours or days, energy and demand savings are not reported. Instead, we use descriptions of the implemented strategies and their qualitative change to operations to convey their value.

Figure 4 illustrates a commercialized zone temperature setpoint correction strategy in which the corrected setpoint used to control a packaged air-conditioning unit is updated at 15 minute intervals based on outdoor air conditions. The top panel of Figure 4 shows that prior to activating the correction strategy, the zone setpoint was a constant value of 23°C. After activating the correction strategy, the setpoint was reduced to 21°C and stayed at this value for most of the remaining operation illustrated by the data. Throughout the period shown, the equipment operated in heating mode, and it is evident from the second panel that the lower setpoint results in reduced heating demand. The third panel shows the compressor cycling off for significant lengths of time after the setpoint is reduced.

Figure 5 illustrates a commercialized demand flexibility strategy implemented via zone temperature adjustments. The top panel shows that a demand reduction (compared to the

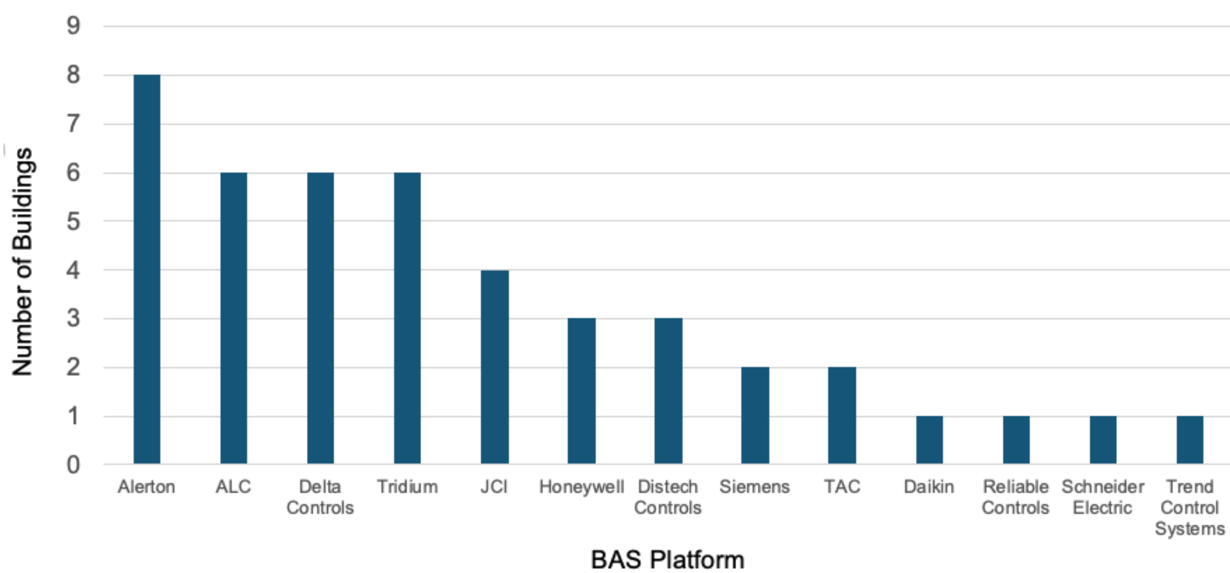

Figure 3. Distribution of building automation systems integrated with FFOC implementations.

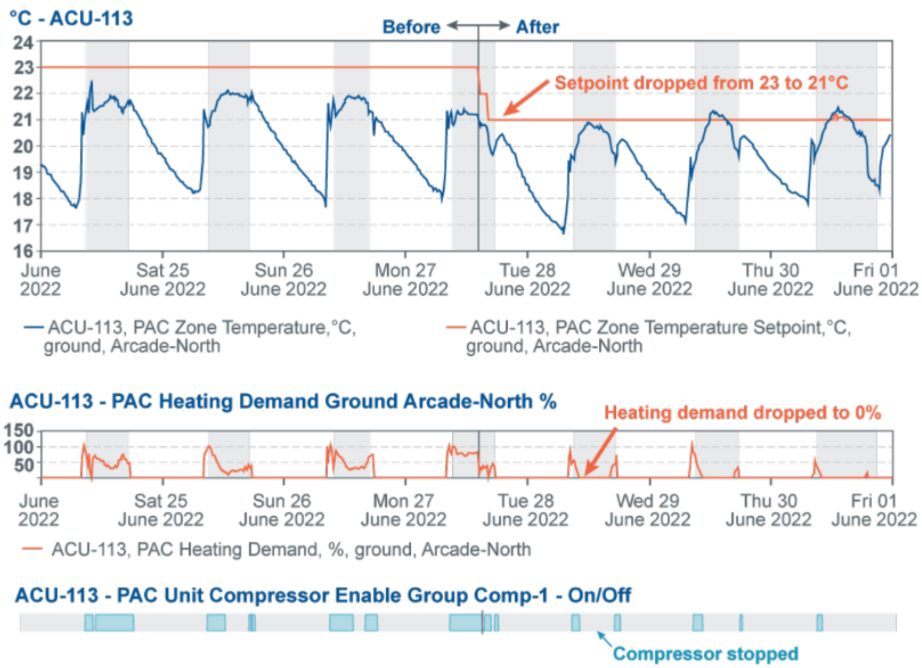

Figure 4. Field test of a commercialized continuous zone temperature setpoint correction strategy.

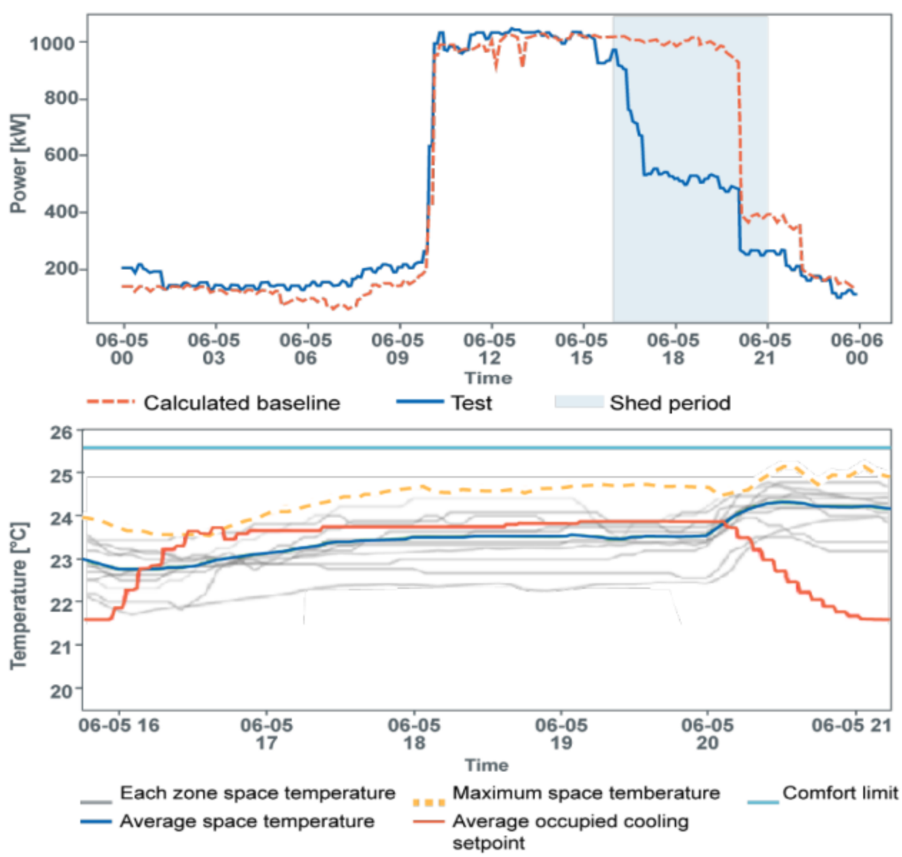

Figure 5. Field test of a commercialized demand flexibility strategy via zone temperature setpoint adjustment.

calculated baseline) of approximately 500 kW is achieved during a large portion of the shed period. The bottom panel shows the details of the zone cooling setpoint adjustments that cause this reduction. The strategy is implemented by gradually increasing individual zone cooling setpoints for about 45 minutes beginning shortly before 4:00 PM. During this time the average zone cooling setpoint increases from approximately 21.5°C to slightly less than 24°C. Throughout the test, the maximum space temperature is maintained below the comfort limit of 25.6°C. The gradual reduction of the average zone cooling setpoint that begins at 8:00 PM is done to avoid a rebound spike in demand. Further details of the strategy and its implementation can be found in Granderson et al. (2025).

Figure 6 shows an automated commissioning (ACx) test being performed on a group of nine variable air volume (VAV) terminal units. In this open-loop functional test, the damper of each terminal unit is overridden to three separate positions - (1) fully open, (2) fully closed, and (3) 50% open. Test data are processed through a set of four pass-fail rules that assess if damper operation and airflow rates are consistent with expected operation. As an example, one rule compares the terminal unit airflow rate with the damper fully closed to a damper leakage threshold. An airflow rate above this threshold is flagged for further review and is likely a damper leakage issue, an airflow sensor issue, or a point configuration issue.

Figure 7 shows field data demonstrating a commercialized zone temperature setpoint correction strategy. In this particular case, the strategy was applied to 250 terminal units and identified instances where zone temperature setpoints did not conform to the site operational policy. The policy stipulates a zone cooling setpoint of 72-80°F, and a zone heating setpoint of 65-72°F. The analytics detected 30 cases in which setpoints exceeded the high or low limits. Figure 7 illustrates two zones with cooling setpoints operating below the lower limit for cooling in the early morning hours of May 31, 2024. By 7:30 AM, the setpoints had been automatically corrected to the target setpoint of 72°F.

Figure 8 shows a commercialized ACx tool being used to perform closed-loop automated functional tests and analysis on terminal equipment. In this case the closed-loop test drives a

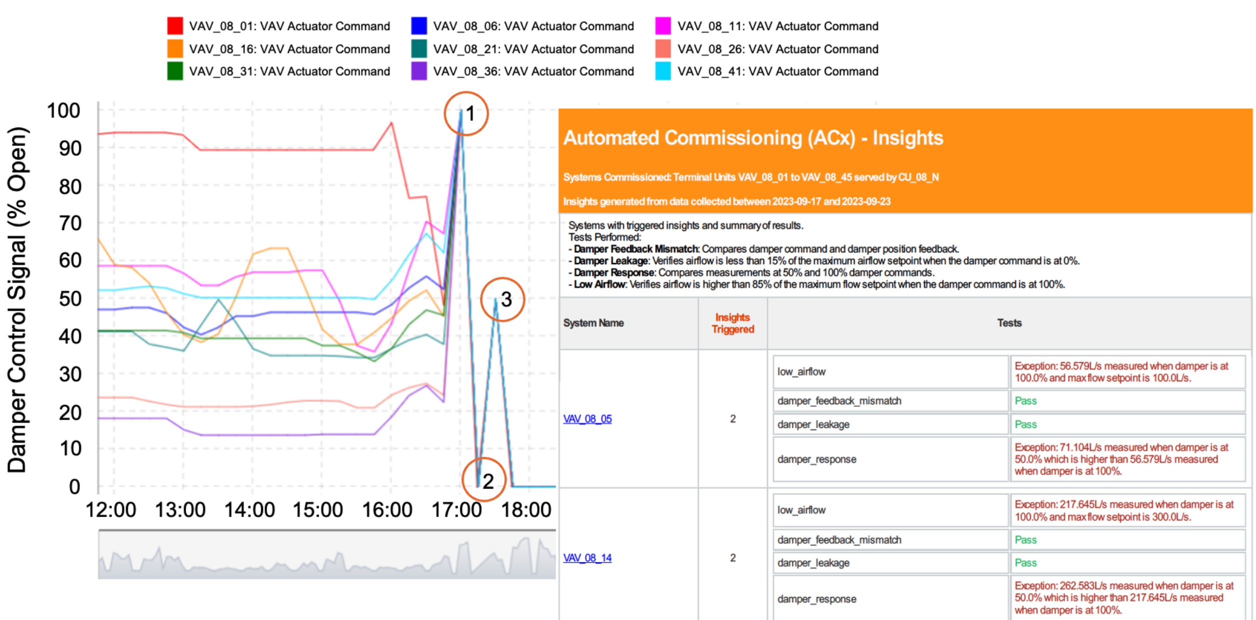

Figure 6. Field test of a commercialized open-loop ACx test for VAV terminal units.

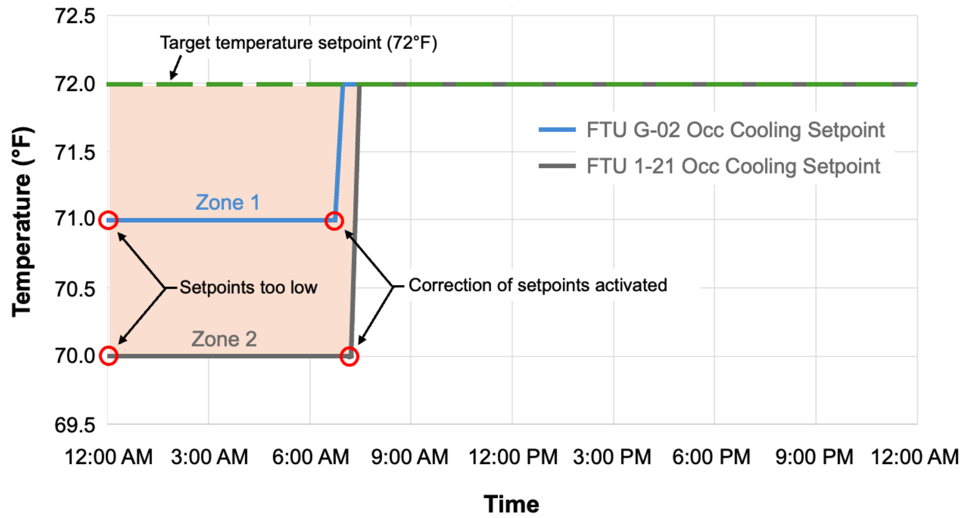

Figure 7. Field test of a commercialized zone temperature setpoint correction strategy.

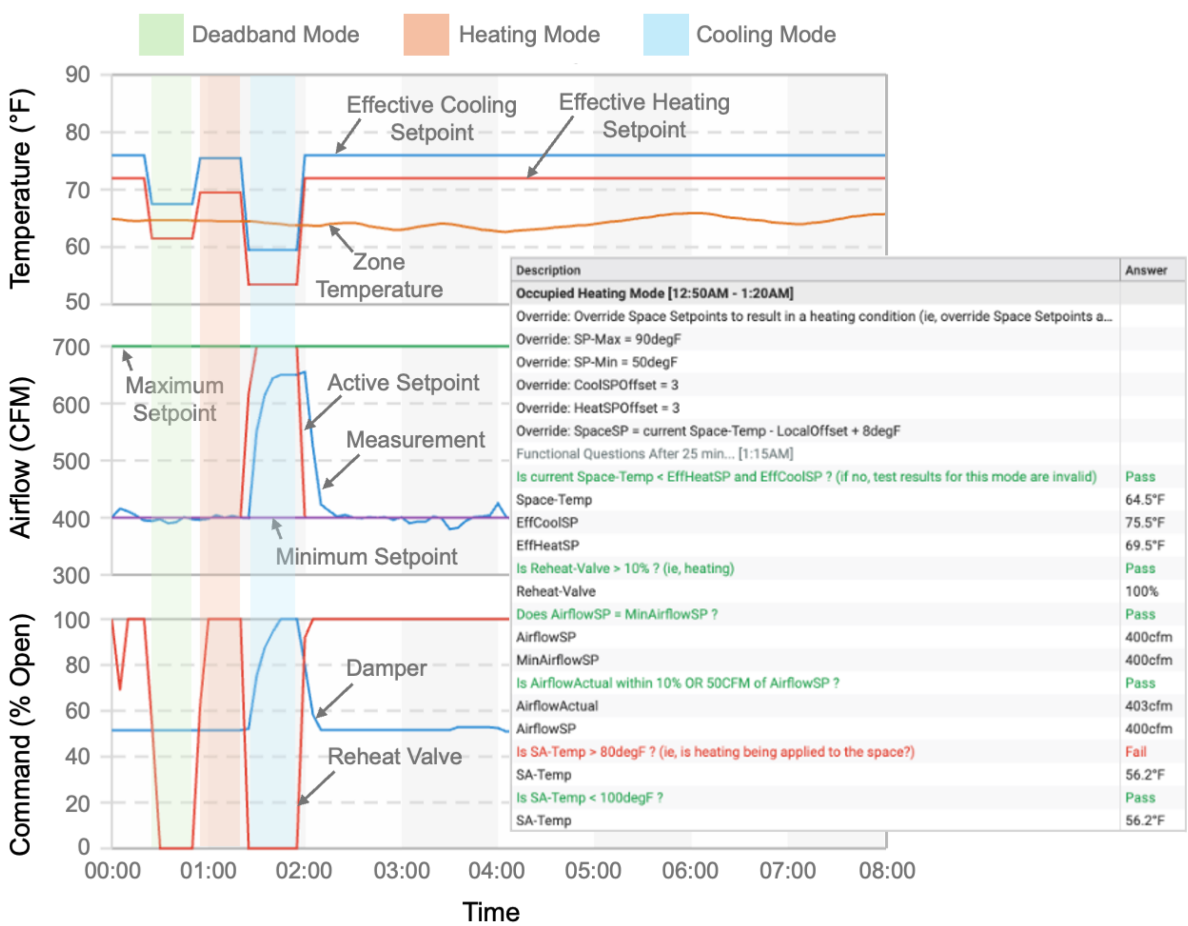

Figure 8. Field test of a commercialized closed-loop ACx test for VAV terminal units.

VAV terminal unit to different operating modes by overriding the effective cooling and heating setpoints. The test is performed in the early morning hours and begins with setpoint adjustments that drive the terminal unit into a deadband mode of operation. The trend data in Figure 8 shows the expected behavior for the deadband mode, with the zone temperature between the two setpoint temperatures (top panel), the active airflow setpoint set to its minimum value (middle panel), and the reheat valve command driven to the closed position (bottom panel). After 30 minutes in the deadband mode, the setpoints are adjusted to force operation in the heating mode, where it can be seen that the reheat valve command is driven to 100% open in response to the significant zone temperature error. After another 30 minutes, the setpoints are adjusted again to force operation in the cooling mode. In the cooling mode, the active airflow setpoint is driven to its maximum value, resulting in the damper being driven wide open, and the reheat valve command is driven to the closed position. The data generated in the test are processed through a suite of pass-fail questions to assess operation. A sample of typical questions pertaining to heating mode operation is shown on the right side of Figure 8.

Figure 9 shows results from a test of the economizer high limit setpoint correction strategy applied to a single-zone rooftop unit (RTU). The correction strategy compares the actual fixed dry-bulb economizer high limit setpoint from the BAS to the minimum of two values: 1) the high limit setpoint based on the best practice engineering reference (ASHRAE 2022); and 2) the lowest cooling setpoint for all zones served by the AHU. If the high limit setpoint from the BAS is lower than the minimum of these values, the high limit setpoint is corrected (increased) to that minimum.

For the test, the recommended economizer high limit setpoint and the occupied cooling setpoint for the zone served by the RTU were set to 68°F. Initially, the actual economizer high limit setpoint is equal to 55°F. At mid-day on Sept. 5, the corrective strategy is initiated and automatically raises the high limit setpoint temperature to 68°F. On Sept. 7 the test is completed and the high limit setpoint is automatically restored to its initial value. The green shaded area represents the additional temperature range for which economizing was enabled due to the

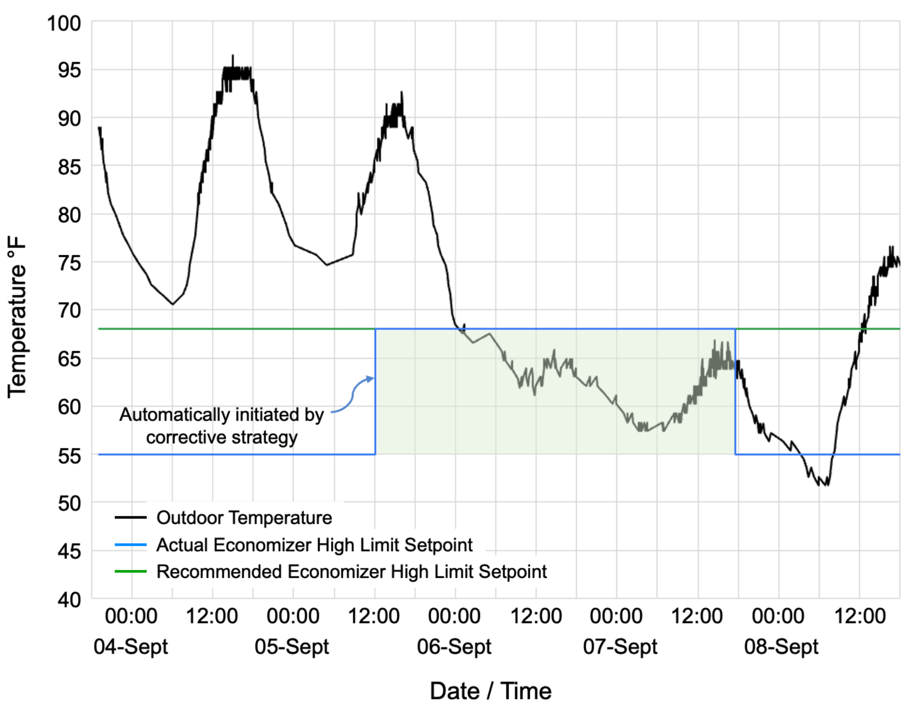

Figure 9. Field test of the economizer high limit setpoint correction strategy.

corrected high limit setpoint. In this particular test, the outdoor air temperature is below the corrected economizer high limit setpoint (68°F) and above the initial high limit setpoint (55°F) for almost all of Sept. 6 and the first 18 hours of Sept. 7. The energy savings achieved from the correction will depend on equipment runtime during the expanded economizing conditions.

Figure 10 illustrates an implementation of the schedule correction strategy for an RTU. The diagnostic strategy compares the RTU fan status to the reference schedule and accumulates the amount of time the two differ over a two-day sliding window. If the cumulative difference over a two-day period exceeds five hours, a fault is indicated and the reference schedule for each day of the week is written to the BAS to correct the schedule. The reference schedule for the RTU is the same each day with the unit turning on at 6:00 AM and turning off at 8:00 PM. To test the HVAC schedule correction strategy, the schedule was altered to cause the RTU to turn on at 7:00 AM on Sunday, 7:30 AM on Monday, 2:00 AM on Thursday, and 12:00 AM on Friday, and turn off at 6:00 PM on Wednesday.

The plots in Figure 10 show time series traces of the RTU fan status and the reference schedule. The top panel shows a three day period (Wednesday through Friday) of Week 26 (June 23-29, 2024). This is before the RTU schedule was altered and it can be seen that the RTU fan status and reference schedule are perfectly aligned. The schedule is altered on Friday, June 28, and the resulting operation is shown in the middle panel for Wednesday through Friday of Week 27 (June 30 - July 6, 2024). Periods of misalignment between the RTU fan status and reference schedule are indicated with yellow shading. The cumulative time of misalignment exceeds five hours on Thursday morning at 5:00 AM; however, the schedule correction is only made on Friday after two days of data have been processed. The lower panel of Figure 10 shows

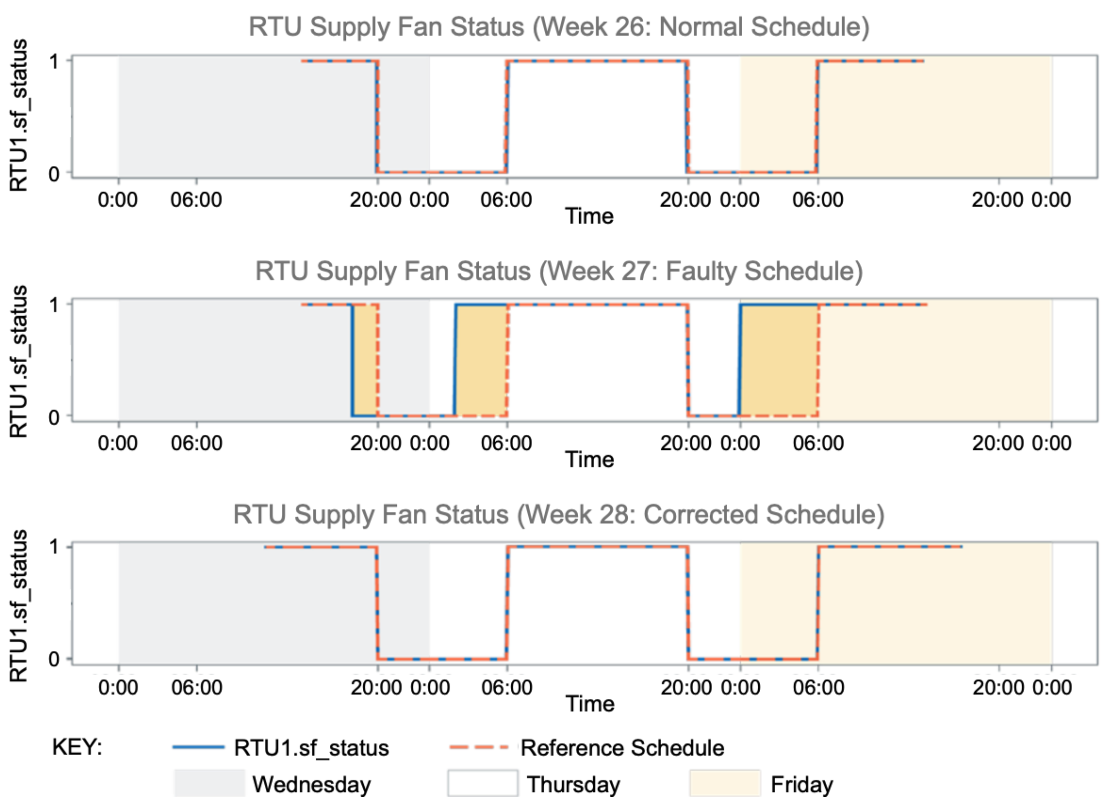

Figure 10. Field test of the HVAC schedule correction strategy.

scheduling for Wednesday through Friday of Week 28 (July 7-13, 2024) and shows that after the schedule correction, the RTU fan status and the reference schedule are again aligned.

Figure 11 illustrates the strategy for correcting unnecessary control overrides. The top panel shows operational data on August 1. Shortly after 2:00 PM, a chilled water valve is overridden to a partially open position. Prior to the override the valve had been fully open and still unable to meet the supply air temperature setpoint. The override exacerbated the temperature control problem. The bottom panel shows that at about 9:00 AM the following day the fault has been diagnosed, and an operator-authorized autocorrection of the override occurs. Following the release of the override, the valve returns to the fully open position, resulting in the supply air temperature of the unit being lowered.

Figure 12 illustrates the performance of the automated loop tuning corrective strategy (Lin et al. 2023). Trend data for the first day of operation shows that the reheat coil valve of a VAV terminal unit is hunting between the fully open and fully closed position for several hours beginning just before 6:00 AM (top panel). As a result, the discharge air temperature from the terminal unit cycles rapidly between approximately 80°F and 115°F (bottom panel). During the afternoon hours of the first day, an active test is performed in which the control signal of the reheat valve is stepped from 0% open to 10% open, and then to 40% open. The response of the discharge air temperature during the test is used to compute new tuning parameters for the proportional-integral controller that controls the valve. The new control parameters are written back to the controller, and trend data on the second day of operation shows that the valve is no longer hunting.

Figure 13 illustrates the operation of the static pressure reset with rogue zone suppression strategy over a one-day period (Lin et al. 2021). The strategy is implemented using trim and respond reset logic (Taylor 2015). The top panel shows the number of pressure requests (red) and the number of ignored requests (blue). The difference is the number of net requests, denoted R*. When R* is greater than 0, the static pressure setpoint (black trace in bottom panel) is increased

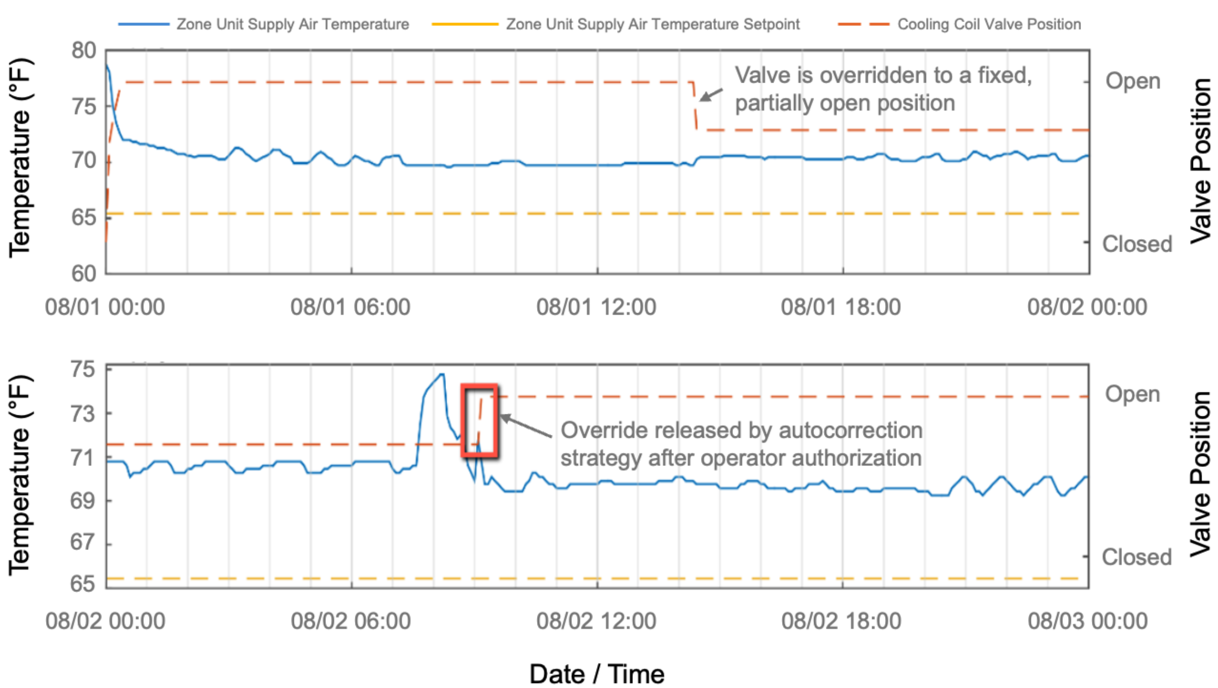

Figure 11. Field test of the override correction strategy.

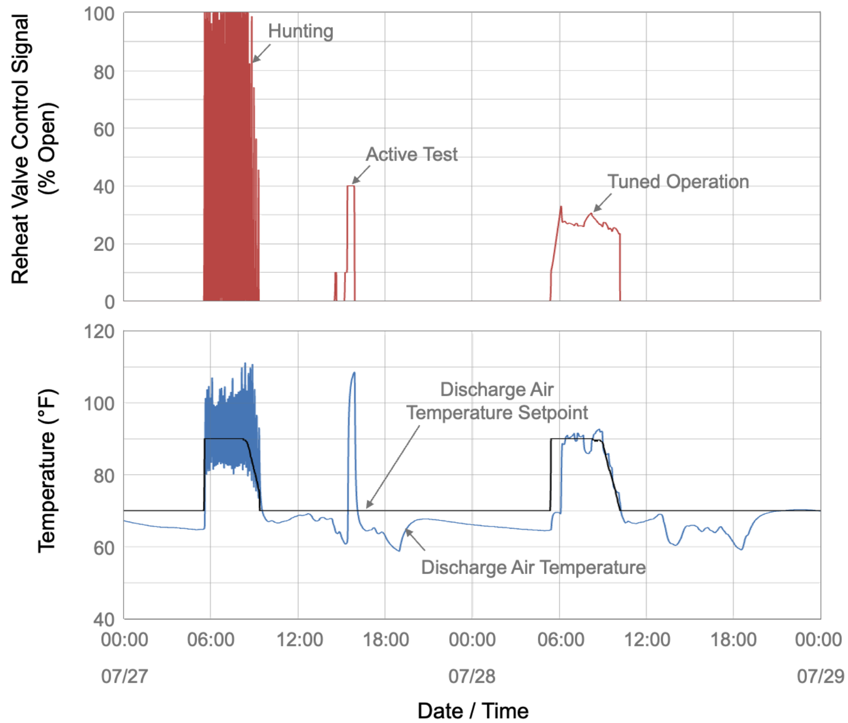

Figure 12. Field test of the automated loop tuning strategy.

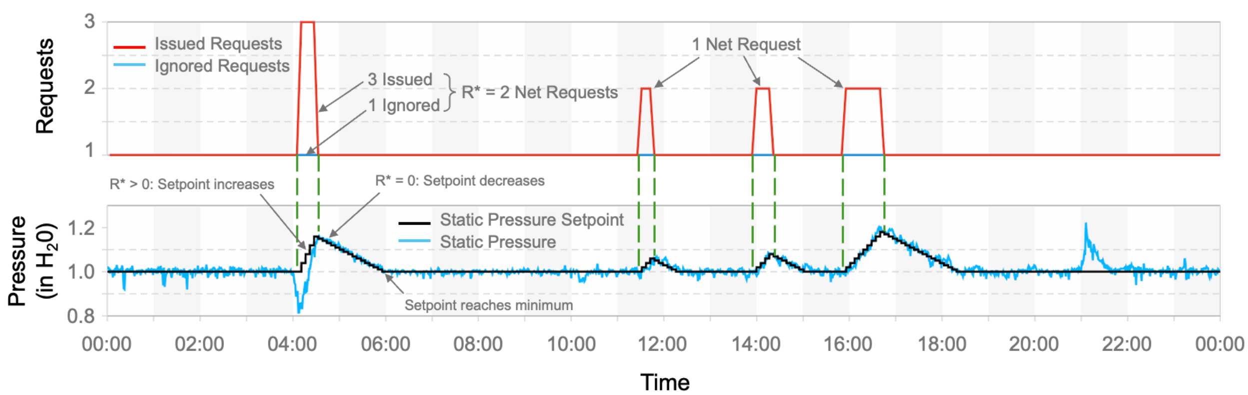

Figure 13. Field test of the static pressure reset with rogue zone suppression strategy.

(the setpoint responds), and when R* is less than or equal to 0, the static pressure setpoint is decreased (the setpoint is trimmed). The strategy prevents the setpoint from exceeding its minimum and maximum limits. In this particular example, the setpoint operates for much of the day at its minimum allowable value.

Key Considerations for Successful Use of FFOC

FFOC strategies have been shown to work reliably and safely in a large and diverse number of sites, without compromising existing operational practices, BAS functionality, or occupant comfort. O&M teams have been found to be receptive to the benefits of using EMIS-based analytics and supervisory control to maximize the value of BAS infrastructure.

These implementations have provided insights as to how owners can be most successful when integrating these new technology capabilities into their facility management and O&M processes. A summary of these insights follows.

Common to All FFOC Strategies

Organizations must establish their operational procedures for the fault correction process, clearly identifying who is authorized to execute the corrective action and when action will be taken. Starting slowly with O&M staff, communicating how the strategies work, and utilizing user interfaces to provide clear recommendations for action and authorization prior to initiating action, are key to building trust with the system. Since FFOC strategies are new to the market, it may be necessary to expose the required control and analytics points over BACnet and configure them to be writeable. While several implementation sites had legacy controllers that were successfully written to by the selected EMIS platform, there was one case in which the older device was not able to 'take' the FFOC control commands. In that case, the control device that was being written to used a computer chip with erasable programmable read-only memory (EPROM). EPROM chips have a limited number of erasure cycles before the chip becomes unreliable, and we suspect that writebacks at lower priorities had been disabled to maximize the life of the chip/controller.

One-time Correction Strategies

When implementing zone temperature setpoint corrections a best practice is to document an institutional policy for occupied and unoccupied setpoints. This policy will provide EMIS systems with clear reference points when pushing zone temperature corrections.

Manual overrides of control signals are often used for troubleshooting and as a temporary remedy for operational issues. FFOC providers can monitor the BACnet priority array of the control signal to determine whether a manual override is in place. The FFOC logic can be configured to identify cases where an override has been in place for a length of time that exceeds a defined threshold, and O&M staff should be given final authority to release those that do.

Correcting economizer high limit temperature setpoints requires knowledge of the existing control sequence (fixed/differential dry bulb or enthalpy). This FFOC strategy is based on reference setpoints (ASHRAE 2022) defined by climate zone which can be adopted as an institutional practice. If the high limit temperature setpoint is accessible over BACnet, it is recommended to update it directly as a one-time fix. If it is not accessible, the alternative is to continuously control other available points such as the economizer enable or mode points.

Correction of incorrectly programmed HVAC schedules can be accomplished by comparing properties of schedule objects from the BAS with operational policy schedules. If the schedule objects are not readable, equipment runtime can be analyzed to estimate a schedule.

Active Testing: Automated Loop Tuning Strategy

There are a number of reasons a feedback control loop may be unstable or hunting. It may be due to a mechanical problem with an actuator (e.g., sticking), an instability upstream in the system that cascades to downstream loops, or to poor tuning. If the cause of the hunting behavior has been isolated to poor tuning parameters, automated tuning may be applied. Feedback control loops in HVAC systems are overwhelmingly controlled by proportional-integral (PI) control laws; however, how those PI control laws are implemented differs among BAS manufacturers. To implement automated tuning, an FFOC provider must know the equations that implement the controller's PI loop. This documentation may be easy to find for some controller models, but not for others. The FFOC loop tuning strategies are not recommended if the site is already using solutions that automatically correct or adapt to loop tuning issues.

Active Testing: Auto-commissioning

Functional testing to verify the correct operation of control sequences can be conducted by changing setpoints to drive systems into different operational modes (closed-loop testing), or by overriding control outputs (open-loop testing). Setpoint adjustments may be lower risk, as they provide assurance that BAS logic continues to control the HVAC equipment. The absolute level of risk depends on the system in question and the testing being conducted. FFOC implementations have safely demonstrated both closed-loop and open-loop approaches.

Supervisory Control Optimization Strategies: AHU Resets and Demand Flexibility

The supervisory control logic runs in the EMIS, and the resulting setpoint updates are pushed to the BAS. The associated two-way data communication with the BAS (reading from and writing to) should occur at fixed intervals. Five minutes was most commonly used in the FFOC implementations. To maintain control continuity in the case of communications losses, a 'heartbeat' signal should be sent from the EMIS to the BAS at each sampling instance to verify the two-way communication is active and synchronized. If the heartbeat signal is not received at the BAS, control is programmed to revert back to the sequences programmed in the BAS.

To gain the full energy benefits of the Guideline 36 reset strategies, it is important to identify and suppress rogue zones. Rogue zones can be identified using analytics that calculate zone-level request hours, and total system run hours and compare them to a rule-of-thumb threshold. They can also be identified using equipment analytics, for example, those that identify leaking reheat valves, unmet supply airflow setpoints, and excessively low cooling setpoints.

The FFOC demand flexibility strategies harness the analytics capabilities of the EMIS to offer more nuanced sequences than those typically implemented exclusively using BAS infrastructure. Meter data can be incorporated to enable meeting a flexibility target, zones can be dynamically pre-qualified and prioritized throughout the flexibility period, and site-specific comfort and service delivery requirements can be continuously included in the control logic. There are many types of demand flexibility programs available across the country, with different event durations, frequencies, and incentive designs that can be aligned with the particular FFOC demand flexibility approach that is implemented. It is recommended to test demand flexibility control sequences in your facility prior to responding to actual grid events.

Summary and Future Work

This paper presents field tests of 10 FFOC strategies, including five that are now included in commercial offerings from EMIS providers. FFOC has been implemented in a range of building types, with retail and office being the most common, and successfully integrated with control systems from 13 BAS manufacturers. The work reported here illustrates the growing interest in utilizing platforms external to the BAS to implement strategies that deliver energyefficient and demand-flexible services to buildings. This interest began with EMIS vendors, and more recently has expanded to BAS manufacturers, who are starting to use their own cloud platforms to implement FFOC.

Among the suite of strategies that have been implemented, AHU reset strategies are garnering considerable attention due to significant energy savings achievable through their use. Implementation through EMIS offers a scalable deployment path for this and other FFOC strategies that is particularly compelling for existing buildings with older infrastructure. More work remains, including developing and disseminating guidance on how to determine if Guideline 36 strategies are a good fit for your building.

ACx is also beginning to get a foothold in practice. Commissioning (Cx) providers are increasingly turning to it as an alternative to manual commissioning of terminal equipment. Software tools implementing ACx are being developed by EMIS providers and Cx firms. Future work will focus on raising awareness around the value proposition of ACx, how ACx integrates with traditional Cx processes, and prospects for its use on a broader array of HVAC equipment.

The need for demand flexibility in commercial buildings is rapidly growing, as evidenced by the recent uptick in virtual power plant program offerings across the U.S. (ASE 2025). Scaled deployment of EMIS-based demand flexibility solutions would enable more consistency and reliability in demand flexibility performance all while ensuring a higher degree of thermal comfort. The strategies shown in this study are zone-based, however there is great potential in leveraging strategies for AHU systems as well as chiller plant systems.

Acknowledgements

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