Going Rogue: Balancing High-Performance Design with Practical Applications

Logan Smith, Kerina Macariola, Abdul Qayyum Mohammed, Kevin Fisher, Mohamed Tatari, Go Sustainable Energy, LLC

ABSTRACT

Commercial and healthcare facilities, in central Ohio, are learning how to manage energy consumption in the wake of rising energy costs, while constructing new buildings to meet the growing population they serve. Energy efficient design for new construction is critical for organizations to maintain their sustainability efforts and bottom lines. However newer HVAC innovations might end up increasing energy consumption instead of reducing it due to added complexity and inexperience of teams implementing them.

HVAC loads comprise the lion's share of energy consumed in large (>10,000 ft^2) commercial and healthcare buildings. Beyond designing and procuring the most efficient HVAC systems, optimizing the sequences of operation is often the most cost-effective way to reduce energy consumption during operation. In high performance new construction, design engineers push for control strategies like demand-based resets on supply-air temperature, and dual maximum VAV controls. Additionally, more efficient equipment requires certain specifications or design criteria to operate effectively and efficiently.

This paper highlights case-studies from new construction projects in Central Ohio where these control strategies and efficient equipment were employed and resulted in higher energy use compared to simpler, more familiar technologies. We examine what went wrong, ranging from miscommunication to simple mistakes. We also explore the impact (that these mistakes have on the decision making of the facility and their design and construction partners. In summary, high-performance buildings are strongly dependent on the clarity of design documents, and the local workforce's expertise, staffing, and willingness to innovate. The working relationships between owners, architects, design engineers, general contractors, controls contractors, commissioning engineers, and maintenance personnel are where successful execution of high performance design either lives or dies.

Introduction

Design teams, construction vendors, and building owners in Central Ohio are pursuing construction of high-performance buildings that can minimize operational energy costs and meet an owner's sustainability goals. These intentions culminate in designers pushing for newer, more efficient equipment and controls. In theory, these newer equipment and controls will use the least amount of energy, but in practice it takes years of coordinated effort to implement them successfully. Conversely, simpler, more standard practices may be less efficient, in theory, but often have a higher likelihood of successful implementation. Finding a balance between newer and more established technologies is crucial as building energy performance has become increasingly important with the rise of energy costs. This paper focuses on examples from new construction projects of healthcare facilities and commercial buildings where implementation of newer equipment and more advanced controls led to higher energy consumption than planned.

Background

Our company has spent over 20 years working as a consultant with a broad range of clients providing accurate, unbiased information and recommendations on our clients' energy choices and their impact. Our role as a third-party consultant has allowed us to have a perspective into the unique challenges of each phase of a new construction project as well as the challenges faced by each involved party. Furthermore, our role has given us the opportunity to gain experience with energy performance at a variety of building types, ranging from small commercial buildings, like libraries or community centers, to large hospitals and manufacturers. We interact with new construction projects as commissioning agents or owner's advocates. We elaborate on our experience in the following sections for the different phases of a project, key areas of common missteps, along with an example for each. The intent is to highlight these areas so more professionals in the field can be aware and can help achieve the higher performance that is intended of our new building stock.

Survey of Common Missteps when Executing High Performance Buildings

Through our experience, we have found that communication is the main variable that overwhelmingly impacts energy performance of the building. More specifically communication between the teams designing, constructing, and operating the building. For example, if a designer assumes a construction vendor can correctly interpret their design drawings and specifications, or a construction vendor assumes that the building operator can successfully maintain a system without a manual, high performance design can easily turn into a game of telephone, as shown in Figure 1 below (Urban Green Council 2025).

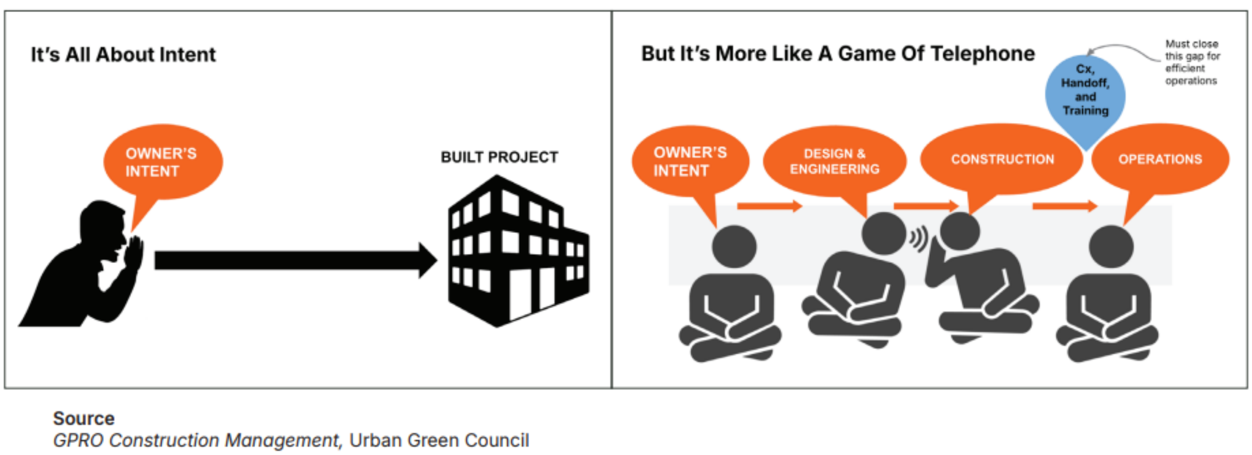

Figure 1. High performance design can become a game of telephone. *Source:* Urban Green Council 2025

Communication gets even more complicated when project teams get larger, timelines span multiple years, and when team staffing changes. To maximize the chance of success across large projects, each party must clearly document and communicate all the necessary information that the next party needs. Figure 2 below summarizes the most common missteps during different project phases that can ruin successful implementation and operation of high-performance design.

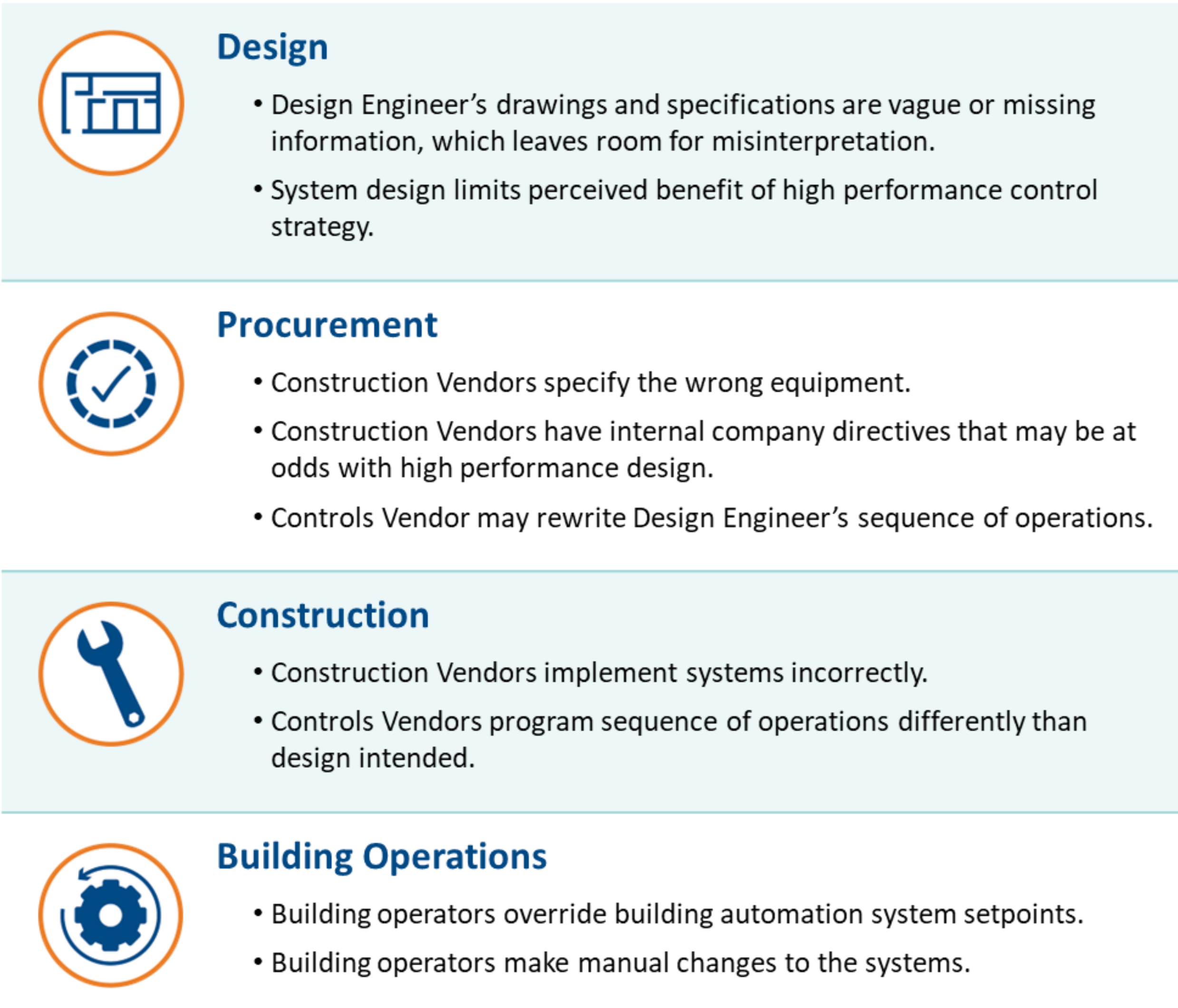

Figure 2. Phases of a new construction project and what causes high building performance to fall short.

Each of these critical points where high-performance design falters are rooted in miscommunication and inexperience with efficient technologies and/or advanced control strategies. If parties during design and construction do not help one another maximize the chance of successful implementation, the building will fail to achieve high energy performance. In turn, the operational energy costs may be significantly higher than promised, and the owner may face additional costs and time spent resolving the incorrect implementation. The following sections dive into and discuss each phase in more detail along with examples from active projects.

Design Phase

Design documents must clearly document all the necessary elements without leaving any room for misinterpretation from the construction and operations teams. Clear documentation and communication become especially important when the design team is trying to "push the envelope" of typical design. While the design team may have gotten out of the "doing it the old way" mind set, that may not be true of the construction and operations teams. So, a new piece of equipment or a new controls sequence is ripe for misinterpretation by the construction and operations teams. Issues during design can be divided into two main categories:

- Design documents are vague
- Design missing key elements for high performance

Design documents are vague: Dual maximum control is a control strategy that may be implemented for VAV reheat systems. This control strategy is theoretically more efficient than traditional VAV control strategies. The diagram shown in Figure 3 illustrates dual maximum VAV control.

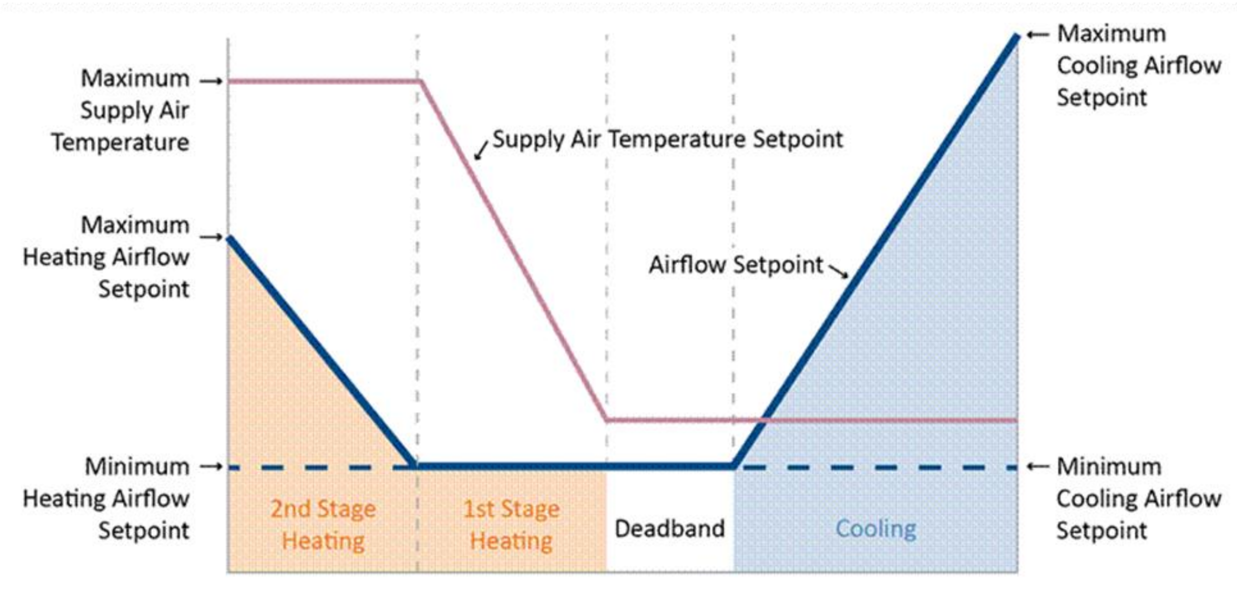

Figure 3. Dual maximum VAV control diagram.

An often-repeated example of design drawings being too vague is when a design team tries to implement this more efficient dual maximum control logic for their VAV reheat system while specifying only two airflows (a maximum and a minimum). In these cases, the design team is assuming a high level of competence from the audience. The design team's assumptions result in vague design documents which force the controls contractor to make their own assumptions based on their past experiences; however, the controls contractor's assumptions may be incorrect. In this example, the design team assumes that the controls vendor knows that that dual maximum control is different from traditional VAV control whereas the controls vendor's perspective is "we have done this hundreds of times". Consequently, the vague design documentation led to poor implementation of what should be a highly efficient control strategy, resulting in higher energy use than expected.

Design documents need to be clear and specific and leave no room for misinterpretation from implementation and operations teams. Successful implementation of this logic has been accomplished when a design team included a graphic similar to Figure 3 in their sequence of operation and specified the four airflows in the VAV schedule: heating minimum and maximum, cooling minimum and maximum. An example of a VAV schedule that resulted in successful dual maximum VAV control logic implementation is shown below in Table 1.

Table 1. Recommended VAV Box Design Schedule

PRIMARY AIRFLOW		HEATING COIL	
MAX	MIN	AIRFLOW MAX	AIRFLOW MIN
685 CFM	140 CFM	275 CFM	140 CFM
400 CFM	80 CFM	160 CFM	80 CFM
725 CFM	145 CFM	290 CFM	145 CFM
375 CFM	75 CFM	150 CFM	75 CFM
600 CFM	120 CFM	240 CFM	120 CFM

Recreated VAV design schedule specifying four airflow setpoints resulting in successful implementation of dual max VAV control.

Design missing key elements for high performance: Demand-based supply air temperature (SAT) reset is an advanced SAT reset strategy for air handling units (AHUs) and is detailed in ASHRAE Guideline 36. A less advanced form of SAT reset logic is an outside air temperature-based reset. Outside air temperature-based SAT reset logic references outside air temperature to determine SAT set-point. In this newer, advanced logic, the SAT set-point is determined based on the loads within the building. Theoretically, the demand-based strategy uses the least amount of energy for heating and cooling (Elehwany et al. 2024) i.e. it is expected to be a more aggressive temperature reset compared to the typical outside air-based sequence.

There are often issues implementing demand-based AHU SAT reset, and these issues may stem from the design documents missing key elements for high performance. These key pieces of information may be obvious to fellow engineers but may not be obvious to a construction team, controls vendor, or building operator. Additionally, design teams may specify advanced technologies or strategies without appropriately considering additional steps that need to be taken during the design phase to successfully implement these technologies.

Rogue zones, in the case of demand-based SAT resets, are zones that always request for cooling and drive the AHU SAT to its minimum setpoint. Zones with high internal heat gains or on the interior should be designed such that the zone's cooling setpoint can be met with the maximum AHU SAT the reset allows (ASHRAE Guideline 36 - 2024). Consequentially, VAVs serving these zones with high internal heat gains must be larger and have higher airflows, which then requires larger ductwork and AHUs. If a designer does not account for these zones in their VAV box design, these zones will "go rogue" if a demand-based AHU SAT reset strategy is implemented, resulting in increased energy use.

At a hospital, the design team did not appropriately account for each zone's cooling load when sizing VAVs. Therefore, zones with high internal heat gains became rogue zones when the controls vendor implemented a demand-based AHU SAT reset strategy. This misstep led to operational issues and increased energy use compared to if a theoretically less efficient but simpler SAT reset strategy based on outside air temperature was implemented. Figure 4 below illustrates how this control strategy went awry. Figure 4 shows an hourly bin analysis comparing demand-based AHU SAT reset setpoints against the outdoor air temperature and a typical linear outdoor air-based SAT reset as a reference. For reference the design SAT temperature for design loads is 55°F.

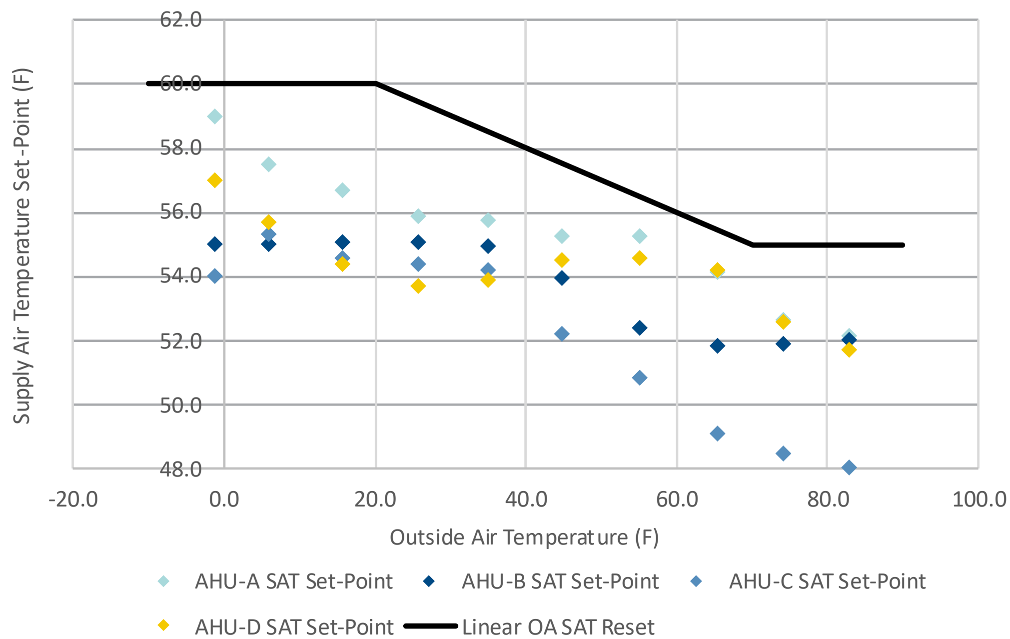

Figure 4. Comparison of implemented SAT resets to typical linear outdoor air-based SAT reset.

Advanced technologies may be theoretically more efficient, but they are often more complicated and more difficult to implement. Design teams that pursue advanced technologies must carefully consider what additional steps and considerations must be taken during design to successfully implement the technology. In this example, design was lacking critical guidance and details to support a successful implementation of a complex efficiency strategy.

Procurement Phase

During the procurement phase, construction partners will solicit multiple manufacturers to provide equipment that meets the basis of design of the design of the project to ensure competitive pricing for the client. There may also be a value engineering step during this phase, adding yet another variable to the procurement process. Equipment submitted by manufacturers may lack certain features necessary for high performance or the equipment may not work at all within the building design. Additionally, the controls vendor may rewrite elements of the design documents, specifically the sequences of operation to work with the equipment procured. To avoid these issues all parties should be vigilant towards any changes during the procurement phase. Furthermore, these changes should be communicated across all parties to ensure that all changes are acceptable from each party's standpoint. Issues during the procurement phase can be divided into a couple main categories:

- Vendors specify wrong equipment
- Vendor's internal rule of thumb

Vendors specify wrong equipment: Heat recovery chillers (HRCHs) absorb waste heat from return chilled water (CHW) cooling the return CHW and rejecting the heat into return heating hot water (HHW) to heat the HHW. For a HRCH to simultaneously cool and heat the two water streams, those two streams' temperatures must be within the HRCH's specified operating temperature ranges.

During one project, a high-performance building was designed with a heat recovery chiller (HRCH); however, due to decisions made during procurement, the HRCH was installed but cannot be used. Ensuring vendors specify the correct equipment during procurement is another crucial step in building a high-performance facility.

During procurement, vendors and construction teams may make changes to equipment for cost savings or other reasons. On this project, there was a lack of technical oversight to ensure critical equipment was procured to allow for the efficient design to operate. Condensing boilers got "valued out" for cheaper, non-condensing hot water boilers. The HHW temperature that the non-condensing boilers provided was above the operating range of the HRCH, rendering the HRCH unusable. Therefore, the changes made during procurement resulted in the owner paying a premium for a high-performance system that cannot be used.

Vendors and construction teams must carefully review design schedules and specifications to ensure all necessary equipment is procured to allow systems to meet design intent. Additionally, any changes made during procurement must be carefully reviewed and discussed by all parties to ensure that design intent can still be met with the changes. In this case, designers and others should specify their CHW return temperatures and HHW return temperatures on their respective design days, and they should specify a make/model of a HRCH and list its cold-side and hot-side acceptable operating temperature ranges.

Vendor's internal rule of thumb: Silicon controlled rectifier (SCR) reheat is a premium reheat coil option for most electric VAV reheat boxes. There are many HVAC manufacturers that advertise SCR as a modulating control, meaning it can provide outputs of 1-100% (Nailor Industries Inc. 2026), whereas older electric reheat elements can only operate in on/off mode.

Vendors may override the design to comply with their own internal directives by applying their own rules of thumb when submitting equipment for a project. In one example, the HVAC vendor did not follow the minimum heating VAV airflow setpoints specified in the design schedule. Instead, the vendor programmed the minimum heating airflow setpoints that were higher than specified in the design schedule based on their own internal rule of thumb.

Vendors may use outdated internal directives that do not account for more advanced technologies. In this case, the vendor was ultimately unaware of the procured equipment's operational limits and abilities. SCR reheat VAV boxes do not need a minimum airflow of 70 cfm/kW of electric heater size required of older reheat elements. However, on this project the vendor did not have any internal documentation for their sales and installation teams on minimum heating airflow, so they simply overrode design and utilized their rule of thumb for minimum heating airflow. When this issue was caught during commissioning, it then took the vendor months to reach out to their factory to confirm that the original design was compatible with the equipment.

Construction vendors may limit the owner and designers' ambition for high performance design. In this case, ambitions were hindered through the vendor's enforcement of outdated directives. It is crucial that owners and design teams communicate early with vendors to understand if they have any internal directives that may prohibit the implementation of design intent.

Construction Phase

Even if design documents are clear and concise, the construction vendors provide the correct equipment, and the controls vendors simply copies and pastes the design engineers' sequences of operation in their submittal, there is still room for error during construction. These errors stem from misinterpretation and miscommunication, and can potentially lead to accidental redesign of certain elements of a building's systems. This phase is where commissioning agents need to be extra vigilant to avoid issues. Two examples of this are:

- Controls vendor deviates from sequence in a subtle way that is detrimental
- Sequence of operations are incorrectly implemented

Controls vendor programs sequences of operation slightly different: A controls vendor can potentially program the sequences of operation in a way that strays from the design engineer's intent. This often occurs in the implementation of demand-based AHU SAT resets. A controls vendor may not effectively communicate with the design team changes made to the sequence that may affect the original design intent.

We have seen multiple ways controls vendors have improperly programmed demand-based AHU SAT resets. In a few cases, we have seen design engineer's write demand based resets with reference to ASHRAE Guideline 36, calling for the reset based on zone's calls for cooling, and have seen the controls vendor copy and paste this sequence into their submittal. In contrast, the controls vendors program the reset based on VAV box damper positions, zone temperature deviation from setpoint, or they include zone's calls for heating as a negative vote. While these three variations at face value may seem similar, they are all fundamentally different than the design engineer's intent. It is critical that design engineers and commissioning agents review the sequences of operation a controls vendor includes in their submittal and in their implementation plans.

Improper implementation of design sequences of operations: Energy recovery ventilators (ERVs) with fixed plate enthalpy heat exchangers transfer both heat and moisture. ERVs save energy by pre-conditioning ventilation air through the exchange of heat and humidity between the outside air and the exhaust air streams during appropriate air temperature conditions. ERVs are most beneficial at very high or very low outdoor air temperatures. At the outdoor air temperature extremes, a building still requires a certain amount of ventilation air to be brought in. The ERV pre-cools and dehumidifies this ventilation air in the summer and pre-heats and humidifies the air in the winter.

Poor implementation of the design sequences of operation can lead to a project straying from the design intent. One example of this was at a local community center. The owner and design team had goals to make the center a high efficiency building and invested in an ERV with a fixed plate enthalpic plate heat exchanger for the building's main AHU. We observed during functional testing that the ERV's heat exchanger was not controlled according to the sequence of operations. The ERV was being bypassed at high outdoor air temperatures. Figure 5 below is a screen shot of the building automation system for the facility; the unit is shown in 100% bypass on a warm summer day with an outdoor temperature of 82.1°F.

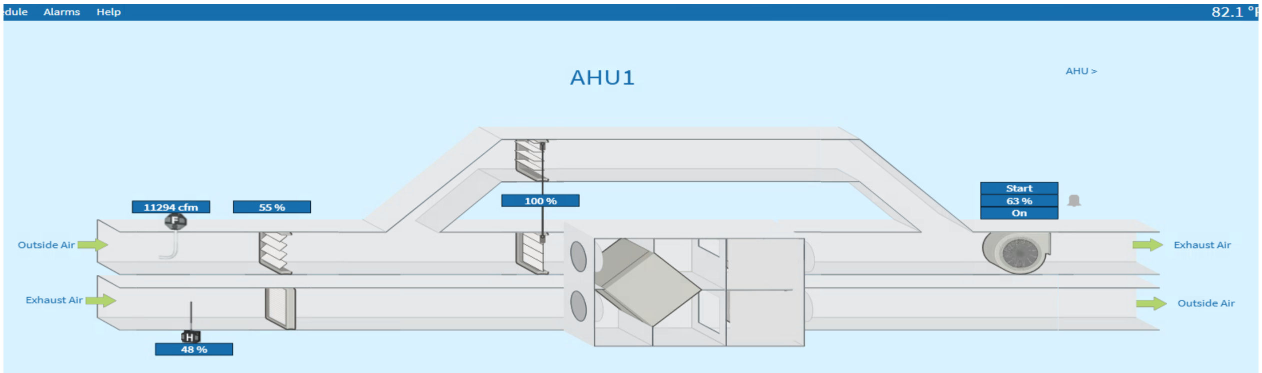

Figure 5. BAS observations, bypass dampers 100% open when it is beneficial to utilize the ERV.

Even if design teams provide a well-written sequence of operations, it is up to controls vendors to implement it correctly. In this case, significant investment was made to design a high-performance building. The upfront cost for the ERV added an additional $200,000 to the project but was still pursued because of the owner's goals around efficiency. Despite extra efforts during the design process for a high-performance building, poor implementation may lead to under-utilization of efficiency features, such as an ERV. These efficiency features may come with high upfront costs yet are implemented in the hopes that the features will pay back over a few years or to meet energy efficiency goals of an organization.

To help promote proper implementation of high-performance design, commissioning agents should follow controls implementation closely to ensure significant investments in energy efficiency are fully utilized and design sequences are met.

Building Operation

Regardless of how a high-performance project is completed, facilities staff are ultimately the ones who must operate and maintain the building over its lifetime. Building end-users may change building performance through manual changes and building automation system overrides. The building operators are rarely engineers. In most cases they are facility technicians with experience and background in running existing facilities, but those may not necessarily be high-performance facilities. The building operators are tasked with ensuring their facilities function and maintain comfort for its occupants. Energy efficiency may or may not be part of a facility's culture. Facilities teams may view high-performance building's controls and features as complicated and new. Therefore, proper documentation, education and training of more advanced efficiency features become crucial. Without adequate documentation and education, the building will not reach its energy performance potential. To avoid these types of issues the design team should keep the building operators, their training and capabilities at the top of their minds as they design systems. Ideally, the design team communicates with the building operators to take their feedback into account. A couple examples of issues during operation are:

- BAS overrides lead to deviation from design intent
- Manual changes compromise efficiency features

BAS overrides lead to deviation from design intent: Overrides are a useful tool for building operators that allow them to troubleshoot equipment and while keeping the building operational. However, operators may use overrides to disable an advanced control strategy, like demand-based AHU SAT reset.

In a healthcare facility, where demand-based AHU SAT reset was implemented, a facilities team faced numerous “hot” maintenance requests, where occupants filed complaints that their work areas were simply too hot. To resolve this maintenance issue, the facilities team overrode the controls to operate their AHUs at fixed SAT setpoints, effectively disabling the demand-based reset altogether. This quick fix resolved their maintenance requests but at the cost of increased reheat energy.

Facilities teams may use the most straightforward solution to solve a problem rather than engaging with complex controls logic to troubleshoot issues. In this example, the issue could have likely been resolved without disabling the demand-based AHU SAT rest. However, this would require facilities staff to spend time they often do not have to determine how the logic may be modified to resolve the issue.

Maintenance staff will manage the HVAC systems for the lifetime of the building. Proper training and ongoing resources for this team are vital for sustained success when implementing more advanced control strategy. Otherwise, a facilities team may troubleshoot issues using the most straightforward path which may not maintain optimal efficiency.

Manual changes compromise efficiency features: ERVs with enthalpy wheels transfer both heat and humidity similar to the fixed plate ERVs described in a previous section. They are effective at pre conditioning outside ventilation air when outside air conditions are hot or cold.

Building operators may make manual changes to parts of a system that reduce impact of premium efficiency features. At a library, a gravity relief damper was manually adjusted by the facility team leading to lowered exhaust airflow.

Often building operators make manual changes in an effort to alleviate an observed issue; however, these changes may cause operation to stray from the design intent and may even cause additional issues. This was the case for the library described in this example. Facility staff indicated that a unit equipped with an ERV struggled to meet its supply air temperature setpoint during the coldest outside air conditions. The lowered exhaust airflow led to inadequate heat exchange between exhaust air and ventilation air which caused low supply air temperatures for the unit. The facilities staff were aware that the unit had issues maintaining its supply air temperature setpoint but were not aware that issues stemmed from manually adjusting the gravity relief damper which impacted the exhaust airflow through the ERV. The manual changes resulted in not only an increase in energy consumption but also impacted climate control and occupant comfort.

This example illustrates how ongoing equipment maintenance and technical expertise play a role in ensuring efficiency features are maximized long after the building is completed and design teams have left. The building end-users are the people that ensure a building has high energy performance. To maintain energy performance, a facility team may need to rely on a technical or engineering resource when troubleshooting issues to ensure root problems are addressed and efficient operation is maintained.

Summary: The Balance

The industry is moving towards high performance buildings, an imperative to mitigate climate change. However, it is important to reflect on the range of issues that can cause a high-performance building to fall short of its expected performance. These issues range from a lack of building operator training to lack of foresight into the potential issues. This paper is intended to provide a simple guiding framework based on real world examples of new construction projects where high-performance design falls short. With each project, our team and the fellow designers, construction vendors, owners, facilities personnel, and commissioning agents learn what can be done differently to make the next project better. We reflect on the communication gaps during each phase and on whether pushing for more advanced strategies and systems was worth it.

The building types that we observed to be impacted by obstacles to reach high-performance during each phase of a new construction project are shown in Table 2 below. In summary these issues are not isolated to a single building type and can impact any building.

Table 2. High Performance Obstacles During New Construction and Buildings Impacted

Phase	What Goes Wrong	Building Type Impacted
Design	Design Documents Too Vague	• Hospitals • Medical Centers • Medical Office Buildings • Primary Care Offices
	Design Missing Key Elements for High Performance	• Hospitals • Libraries
Procurement	Specifying Wrong Equipment	• Hospital • Medical Research Facilities
	Outdated Rule's of Thumb	• Medical Centers • Primary Care Offices
	Rewriting Elements of Design	• Hospitals • Medical Office Buildings
Construction	Improper Implementation	• Municipal Buildings • Primary Care Offices
Building Operation	Building Automation System Overrides or Manual Changes	• Hospitals • Libraries

Building types impacted by high building performance falling short at various project phases.

Solutions

During new construction projects aiming for high performance, we often see a disconnect between a designer's expectations and the application by construction vendors or operation by facilities. Additionally, even if communication channels are open early, there may still be misinterpretation during procurement, construction, and implementation. Below is a summary of actions that may be taken throughout a new construction project to help increase the likelihood of successful implementation of high-performance design.

- Encourage designers to engage with construction vendors prior to procuring a submittal. This engagement allows both parties to work through any perceived issues before it is too late. This step is extremely important for the controls vendor who programs all HVAC systems' sequence of operation.
- Encourage designers to engage facilities staff, who are the building end-users, for feedback on their design documents and to learn about how they currently operate other buildings.
- Stress that designers provide all necessary detailed information on their design documents and specifications, and in some cases list information on both deliverables. To some designers this may feel redundant, but this gives owners a better chance of holding vendors accountable if something goes wrong. In addition, detailed design documentation prevents the loss of institutionalized project knowledge caused by turnover of employees at construction and controls vendors.
- Encourage commissioning agents and other energy consultants to review submittals to ensure the right equipment is specified, and to make sure that the controls vendor is not steering the sequences of operation away from the designer's intent.

Conclusion

Theoretically, advanced strategies and systems achieve the best building performance; however, they often have more room for error compared to simpler options that are also capable of achieving substantial energy efficiency. These top-of-the-line options are costlier, and if implemented incorrectly may require significant additional troubleshooting costs during building operation; moreover, these advanced strategies and systems risk never working correctly. In the pursuit of high energy performance, it is important that a balance is struck between pursuing the newest technologies and what can actually be implemented successfully. Communication is ultimately the key to striking this balance and ensuring that a high performance design meets its full potential.

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