



Best in Class: Successful High Performance Building Automation System Upgrades

Building automation systems are a fundamental component of most commercial HVAC systems. Proper design, installation, and operation of these systems is critical for achieving efficient performance while producing acceptable thermal comfort and indoor air quality. Both new construction and retrofits of existing buildings can benefit from the performance upgrades that the best building automation systems offer.



ASHRAE Guideline 36 is a proven, cost-effective opportunity to achieve massive reductions in energy consumption.

Introduction

The Best in Class large-scale demonstration study implemented high-performance building automation system upgrades in existing buildings based on ASHRAE Guideline 36: High Performance Sequences of Operation for HVAC Systems.

Building automation system upgrades achieved:



12-60% HVAC energy savings



<8-year simple payback



Improved indoor air quality

Two Types of Demonstration Retrofits

1. Full retrofit of control hardware and software included full replacement of automation system infrastructure at air handlers and zone level and addressing deferred maintenance issues. Some full retrofit projects included end-of-service life replacements of HVAC equipment.

2. Software-only. For buildings with existing, modern digital direct control systems, upgrades were limited to programming new control sequences. Software-only projects were dedicated to energy efficiency upgrades.

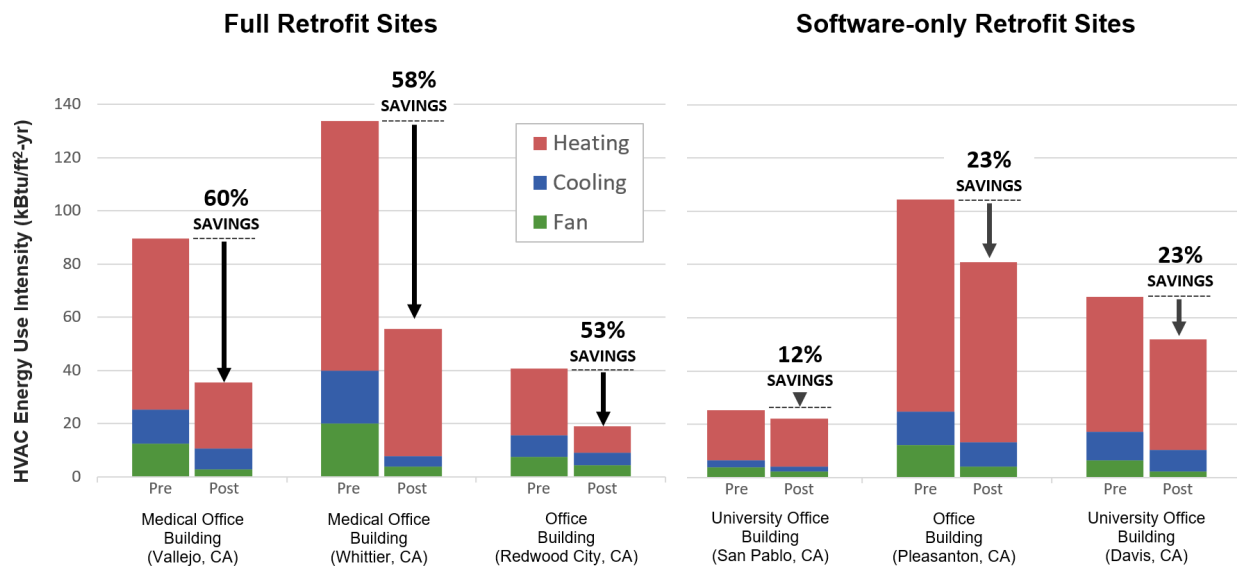
The study included two reference projects that pre-date the publication of Guideline 36 but included the same fundamental control sequences.



Energy Results

The **full retrofit projects** achieved **50 to 60% HVAC energy savings**, with **simple paybacks ranging from 6 to 8 years**. The **software-only retrofit projects** achieved **HVAC energy savings range from 10 to 25%**, with **simple paybacks ranging from 2 to 7 years**. The consistency in overall savings across the sites illustrates the opportunity across the existing building stock. At all sites, the savings are primarily attributed to the following measures:

- Change in zone airflow control to dual maximum VAV logic, with low minimums
- Implementation of demand-based duct static pressure and supply air temperature resets
- Refinement of HVAC operating schedules
- Full retrofit sites only: Resolution of deferred maintenance issues



Thermal Comfort

Retrofit projects achieved energy savings while maintaining or slightly improving thermal comfort.

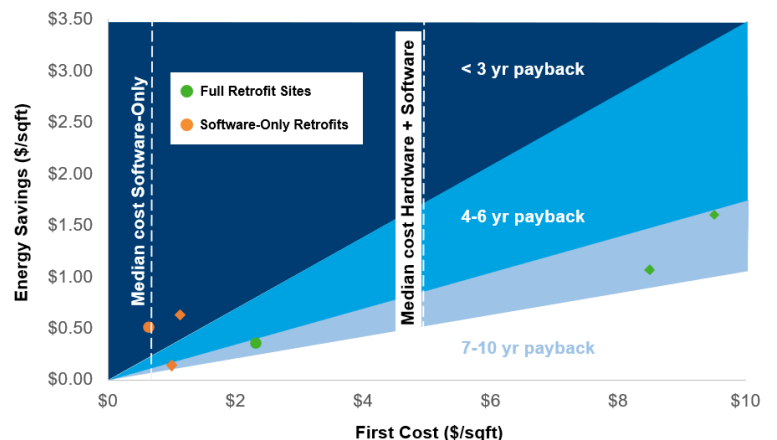
Project Economics

The savings at the full retrofit sites are partly attributed to the resolution of deferred maintenance issues. The savings at the software-only retrofits are a strong indication of the energy saving potential associated with the Guideline 36 (high-performance) sequences.

Control retrofits can be very cost effective.

Median costs for full retrofits were \$4.90/ft² with simple paybacks within 6 to 10 years. Median costs for software-only retrofits were \$0.65/ft² with simple paybacks ranging from 2 to 7 years.

Simple Payback





Opportunity

ASHRAE Guideline 36 is a proven, cost-effective opportunity to achieve massive reductions in building energy consumption. The rapid increase in industry awareness and attention to ASHRAE Guideline 36 since its initial 2018 publication is evidence of its potential and momentum. As of 2021, most of the leading building automation system manufacturers have publicly indicated they are developing Guideline 36 programming libraries, and several have released partial libraries.

Implementing ASHRAE Guideline 36 in building automation systems in new and existing buildings is an opportunity for significant energy savings and successful long-term performance. These approaches also offer a market-ready opportunity to rapidly decarbonize existing buildings by significantly reducing heating energy consumption (up to 60% at some sites). In addition to the energy savings, the projects improved indoor air quality and provide a potential for improving occupant thermal comfort. BAS front-end interface updates can also improve system operational performance by more clearly communicating system conditions, enhancing functionality, and streamlining navigation for operators.

Many of the featured energy measures are already required by building energy standards (California Title 24, International Energy Conservation Code, and ASHRAE Standard 90.1). However, the team's observation of low adoption rates of these strategies in existing buildings, even in recent construction, suggests that there is a significant opportunity to improve energy performance among the existing building stock and a need for educating designers on best practices.

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Publication Date: December 2021

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		Full Retrofit			Software-Only Retrofit		
Background	Building Type	Medical office building	Medical office building	Office building	University office building	Office building	University office building
	Location	Vallejo, CA	Whittier, CA	Redwood City, CA	San Pablo, CA	Pleasanton, CA	Davis, CA
	Floor Area	200,000 ft ²	34,000 ft ²	140,000 ft ²	50,000 ft ²	24,000 ft ²	144,000 ft ²
	ASHRAE Climate Zone	3B	3B	3C	3B	3C	3B
	CA Climate Zone	3	9	3	3	12	12
	Demonstration Site	Yes	Yes	No	Yes	Yes	No
HVAC System	Air Handling Units	12 VAV and 1 CAV with reheat	2 VAV with reheat	2 VAV with reheat	4 VAV with reheat; 2 SZVAV	1 VAV with reheat	11 VAV with reheat
	Economizer	Yes	Yes	Yes	Yes	Yes	Yes
	Cooling	Central utility plant	Direct Expansion	Direct Expansion	Chiller plant	Chiller plant	Central utility plant
	Heating	Central utility plant	Boiler plant	Boiler plant	Boiler plant	Boiler plant	Central utility plant
Existing Control Strategy	Duct static pressure control	Fixed setpoint	Fixed setpoint	Fixed setpoint	Fixed setpoint	Fixed setpoint	Fixed setpoint
	Supply air temperature control	Limited reset	Limited reset	Limited reset	Limited reset	Limited reset	Fixed setpoint
	VAV terminal control	Single maximum	Single maximum	Single maximum	Single maximum	Single maximum	Single maximum
Maintenance	Deferred maintenance	Yes	Yes	Yes	-	-	-
Retrofit	Retrofit scope	Full hardware and software DDC retrofit, including replacing pneumatic zone controls, control valves and economizer dampers.			Revise controller programming and graphics.		