Field Validation of Lighting Retrofit with HVAC Integration and Plug Load Controls at Hennepin County Building, Minnesota

CASE STUDY

Background

Hennepin County, the most populated county in Minnesota, operates a massive portfolio of buildings covering most building types. They also have an ambitious goal of reducing greenhouse gas emissions from their operations by 25 percent by 2025. Over the past decade, they have undertaken significant energy retrofits focused on lighting and smart building controls.

Project Summary

The county partnered with Slipstream–a non-profit focused on energy efficiency and climate solutions–to integrate light-emitting diode (LED) lighting with luminaire-level lighting controls (LLLCs), automatic receptacle (plug load) controls, and zoned heating, ventilation, and air conditioning (HVAC) controls in one floor of a multi-story building in downtown Minneapolis. The floor is occupied by an outpatient clinic and a fitness center; both are served by a common variable air volume (VAV) system, covering a total of 7,300 ft^2.

In the outpatient clinic, the different exam rooms, nurses' stations, pharmacy, and reception area all had highly variable occupancy—making it an excellent candidate for control of lighting, HVAC services, and a few select receptacles. The fitness center was open 24/7, so lighting, HVAC, and plug loads were running all day long even though there were significant periods when no one was using the center.

The backbone of the new hardware for the retrofit was a networked lighting control system. The existing fixtures were all replaced on a one-for-one basis. Sensors communicate wirelessly with each other to create a flexible, granular mesh sensing network throughout the building which can be used for individual receptacle control, HVAC zone control, and lighting control. In addition to the new lighting fixtures and controls, wirelessly controlled receptacles were installed

The project was funded by U.S. Department of Energy (DOE) via the Scaling Up the Next Generation of Building Efficiency Packages Funding Opportunity Announcement (FOA), which "supports high-impact real building demonstrations led by strategically structured teams who will identify and verify the cost and energy performance of multisystem energy efficiency packages." The goal of the field validation was to test the performance of plug load integration and identify potential challenges and future opportunities. Members of this project team members include Slipstream (formerly Seventhwave); Cree Lighting; Legrand/ Wattstopper; Xcel Energy; and Pacific Northwest National Laboratory (PNNL).

PROJECT QUICK FACTS

- **Location:** 701 South 4th Avenue Minneapolis, MN 55415
- **Building Size:** ~7,300 ft^2
- **Building Sector Type:** Outpatient medical and fitness center in a high rise multi-functional office building
- **HVAC Unit Type:** One very large, variable air volume (VAV) air handling unit (AHU) that serves several zones in this area, plus many zones in other areas of the building that were not being retrofitted (a significant measurement and verification consideration). Most VAV boxes are hot water reheat boxes. Building has a hot and chilled water system for heating and cooling the AHU.
- **Building Automation System (BAS) Type:** Automatrix system with JACE
- **Occupancy Description:** Fitness area is open 24/7, with highly variable occupancy. The outpatient clinic has regular occupancy during 6 a.m.–6 p.m. CT, Monday–Friday.
- **Utility Incentives:** $8,700
- **Project Completion Year:** 2021

and became a critical piece in the entire project. The building's designated controls contractor implemented new HVAC sequences using occupancy data from the lighting network that allowed the systems to shut down during periods of no occupancy; this was especially important in the case of the fitness center.

Energy Saving Control Strategies

- LED with networked lighting controls (task tuned, occupancy sensors, and some daylight sensors)
- Plug load controls in exam rooms, in common area equipment, like printers and chargers, and on fitness center exercise equipment
- Thermostat setback based on occupancy
- VAV box shutoff based on occupancy
- Supply Air Temperature (SAT) reset static pressure reset based on VAV box position (which is based on occupancy)

Project Cost Considerations

Project used networked lighting controls which requires a certain amount of equipment independent of space size. Meaning that cost per square foot may be higher for small buildings, such as Hennepin's outpatient building.

- Field validations target a small building or portion of the building for scheduling and budget purposes. This site was only 7,300 ft^2. As a result, the lighting material and labor costs are higher per square foot compared to a larger, full-sized project.

Project Cost			
	Material (/ft^2)	Labor (/ft^2)	Payback (years)
Lighting	$4.41	$4.52	55.9
Lighting w/ Incentives	$2.38	$2.44	30.1
Plug Load	$0.33	$0.11	40.5
HVAC	—	$1.60	6.6
Subtotal	$4.82	$6.26	—
Subtotal w/ Incentives	$2.79	$4.18	—
Total	$10.97		26.6
Total w/ Incentives	$9.97		23.7

- The pharmacy in the outpatient clinic required a pharmacist to be on-site while electricians were in space – contributing to additional labor costs.
- Lighting equipment is responsible for the long payback.
- Savings from mechanical integration reduced the simple payback time by 1/3.

Lessons Learned

For both Hennepin County and the lighting vendor, the concept of integrating controls across systems was relatively new and resulted in a number of lessons learned:

- **Lighting and mechanical integration requires coordination with many more parties than a standard project with stand-alone systems.** The project required close coordination between the County, the building's property management firm, clinic staff, the lighting control vendor, and the

contractor; this presented some challenges. For example, mapping control points between lighting and HVAC zones involved advanced planning and coordination between the electricians, lighting controls specialists, mechanical contractors, and building staff.

- **Lighting software needs to be current and contain compatible firmware for successful integration.** Originally expected to be plug and play, the lighting system required updates to integrate with HVAC system. The lighting vendor had to push current versions of software and firmware to devices. Plan for recurring updates and schedule them in advance.
- **Occupants can unknowingly bypass automatic receptacle controls.** Even though the plug load integration was successful, the 22 automatic receptacle controls that were installed did not yield any data. It was determined that users may have bypassed the controlled receptacles or may have been confused on which was the controlled receptacle versus the standard constant-on receptacle. The values in the savings facts are based on modeled results.
- **Spaces lighted primarily by decorative fixtures are harder to integrate.** The large exercise floor with treadmills in the fitness center had decorative fixtures that were harder to integrate into the platform. The solution was to use a tubular LED retrofit coupled to an independent control module.
- **Occupant education is essential.** Lack of energy savings data revealed that occupants may have bypassed the controlled receptacles or may have been confused on which receptacles were controlled versus constant-on. Training occupants on how the lighting controls work is key to adoption, which would yield better energy savings results. Automatic receptacle controls are a new concept for some and informational sheet explaining how it worked and which loads/devices were ideal for controlled usage were shared with the occupants however, additional guidance may have helped.
- **Large buildings or spaces allow for more occupant response HVAC sequences.** This field evaluation only involved a portion of the first (7,300 ft^2) of a 15-story office tower. This hindered overall HVAC energy performance at the system level. Many potential AHU-level control improvements were omitted or constrained because the HVAC systems served many floors that did not include the new zone controls.
- **Train building owner/operator staff during commissioning.** Once the commissioning is completed by the vendor, it is beneficial to have local onsite staff who can make necessary adjustments as appropriate.

Potential Energy Savings		
Lighting Savings	1.5 kWh/ft^2	68%
Plug Load Savings*	Average 42 kWh/ receptacle/yr	53%
HVAC Savings	2.8 kWh/ft^2 6 kBtu/ft^2	—
Total Cost Savings	$0.41/$ft^2$	

*** Modeled**

Published August 2023 | DOE/EE-2752