BEST PRACTICES 2014

UC Davis Plant and Environmental Science Lab Energy Retrofit

UC Davis took advantage of newly installed lighting occupancy sensors, and conducted wind tunnel analysis to optimize ventilation, reducing energy use by 36 percent. The project combined reduced airflow rates, variable frequency drives, direct digital controls, and advanced control strategies.

UC Davis has been making significant strides toward energy efficiency in recent years. Since joining UC's Statewide Energy Partnership program in 2009, the university has completed over 120 projects in 75 buildings, with a net cost of $55 million, including incentives from PG&E. These projects have reduced electricity and gas usage on campus by 13 and 17 percent respectively, compared to a 2009 baseline, yielding $3.1 million in net energy cost savings (excluding debt service payments). In 2014, planning for energy efficiency projects began in eight of the ten largest laboratory buildings on campus, including the Plant and Environmental Sciences (PES) laboratory energy retrofit.

The HVAC retrofit of the PES lab will yield significant energy savings. Image: UC Davis.

Completed in 2001, the PES building was a significant addition to the extensive lab facilities on campus, providing state-of-the-art facilities for plant and environmental science research. Laboratories make up almost 80 percent of the building's floor area, and as with any lab, ventilation requirements are high due to safety concerns associated with the chemicals involved in the research. Significant fan power is required to maintain high airflow rates, and air must be reheated at the zone level to maintain comfortable temperatures. Both of these factors result in significant energy consumption, however this can often be reduced through careful analysis.

The laboratory HVAC system in the PES building consists of five air handling units (AHUs) which were originally designed to supply air to the laboratory spaces at a constant rate of ten air changes per hour (ACH). Five dual exhaust fans, 40 exhaust hoods and several dedicated perchloric and hydrochloric acid exhaust fans remove contaminated air from the lab spaces.

The primary energy savings resulted from measures to reduce total airflow rates while ensuring sufficient ventilation when needed.

The system was designed to operate constantly even though the building is largely unoccupied during the night and weekends, offering large opportunities for savings. However, the researchers often carry out experiments at irregular times, so it was essential to monitor occupancy, ensuring that lower flow rates are only used when spaces are in fact unoccupied. The facilities team found a way to cost-effectively monitor occupancy for the HVAC control by integrating the occupancy sensors that had been previously installed with a lighting retrofit.

Laboratory systems must maintain safe conditions not only within the building, but also in the surrounding environment, so it was essential to perform detailed analysis before reducing exhaust stack velocities for energy savings. The project team determined chemical inventories for each lab and surveyed occupants to evaluate how labs and fume hoods are typically used.

Following this survey, CPP Wind Engineering performed a fan optimization study to verify that laboratory exhaust flow rates and velocities are safe, while being as energy efficient as

Award Category

HVAC Design/Retrofit

Green Features

Occupancy-based HVAC control

Temperature setback and ventilation rate reduced during unoccupied hours

Occupancy control for spaces and fume hoods

Reduced exhaust velocities established through wind tunnel studies

VFDs on exhaust fans

Direct digital controls

Estimated Annual Energy and Cost Savings

1,446 MWh

48,900 therms

$138,000

36% total energy savings

Size

140,000 ft^2

Cost

$1.3 million

$396,000 PG&E incentives

Completion Date

Fall 2014

2014

BEST PRACTICES

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Project Team

Energy Engineering: Mark Goldberg EnerNOC

Mechanical Engineer: Dave Weston, Weston and Associates

Wind Tunnel Testing: CPP Wind Engineering

Wind Tunnel Testing (preliminary, in-house): Bruce White, UC Davis Aeronautical Wind Tunnel Facility

More Information

http://daviswiki.org/Plant_and_Environmental_Sciences_Building

http://labs21.lbl.gov/workshop/AdvCourse-ExhDisp-3.pdf

http://www.cppwind.com/portfolio/cpp-helps-lawrence-berkeley-national-lab-save-energy-protect-air-quality

possible. They built a 1:180 scale model of the PES building and the surrounding environment, and then tested it in a “boundary layer” wind tunnel by releasing a neutrally buoyant plume (nitrogen gas with ethane tracer) and measuring concentrations at surrounding air intakes and other areas of concern. They evaluated the model under a wide range of wind conditions and used this information to create a fan reduction matrix, characterizing the minimum allowable flow rate for each fan, for all possible wind speeds and directions. They incorporated this information into the building automation system, which takes into account current wind conditions and controls exhaust fans accordingly.

A lab retrofit requires close collaboration with research staff to ensure smooth implementation and safe operation.

Once the design was finalized, the project team installed variable frequency drives (VFDs) on laboratory supply fans and building exhaust fans, reduced airflow rates and balanced the room airflows. After thoroughly assessing safety requirements, the laboratory airflow requirements were reduced from ten to six ACH when occupied, and down to four ACH when unoccupied. They also performed several other energy efficiency measures, such as replacing ten existing exhaust fan motors with high-efficiency motors, and upgrades for new relays and direct digital controls (DDC) which allowed wider zone temperature ranges and reduced ventilation flow rates during unoccupied periods.

The UC Davis facilities engineers estimate that these combined retrofits will avoid almost 1,446 MWh of electricity use and 48,900 therms of gas use each year, corresponding to 34 and 38 percent respectively of whole building energy use. This is estimated to save $138,000 per year, and $1.3 million, resulting in a simple payback of seven years, after accounting for $396,000 of incentives from PG&E. As an additional benefit, these retrofit measures will reduce the peak power consumption of the building by 120kW.

Wind tunnel model used to establish minimum safe stack exhaust velocities. Image courtesy of CPP Wind Engineering.

LESSONS LEARNED

It’s often the case that several stand-alone retrofit projects in a building can be integrated to have a larger impact and to be more cost effective than if they were performed individually. The staff at UC Davis capitalized on an opportunity to do exactly this when they used occupancy sensors installed as part of a recent lighting retrofit to control the HVAC system. As Joshua Morejohn, Energy Manager at UC Davis explains, “This project is noteworthy because it leverages the campus’ Smart Lighting Initiative to turn a lighting energy retrofit into a whole-laboratory energy retrofit, in short, to turn a smart lighting project into a smart lab project.” Through this approach the project resulted in substantial energy savings with a reduced first cost.

Best Practices case studies are coordinated by the Green Building Research Center, at the University of California, Berkeley.

The Best Practices Competition showcases successful projects on UC and CSU campuses to assist campuses in achieving energy efficiency and sustainability goals. Funding for *Best Practices* is provided by the UC/CSU/IOU Energy Efficiency Partnership.