Plucking Dollar$ From The Sky

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Executive Summary

Laboratories are generally the most expensive spaces to build and operate on a college campus. Their furnishings are costly, they require a larger and more complex infrastructure, and they require greater and more technically demanding design. These things all contribute to higher construction costs, but it is the huge demand for energy, year after year, that has the greatest fiscal impact.

The single greatest user of energy in most laboratory rooms is almost always the chemical fume hood, but normally the room itself requires a high ventilation rate (4 to 8 air exchanges per hour). This is due to the fact that the air being exhausted from the room is outdoor air that has been heated or cooled to provide a comfortable environment for the occupants. This exhaust air, along with the energy used to condition it, is blown out the roof and disappears into the sky.

The large energy requirements of lab rooms makes them a high value target in our overall efforts to reduce energy costs and, at the same time, reduce our footprint on the environment.

To this effort, we set about redesigning the way we control the operation of laboratories and similar rooms with high ventilation requirements and at the same time maintain safe working conditions for laboratory personnel. We created a framework whereby the lab user could select whether the room needed to operate as a fully functioning laboratory, or if air flows could be reduced because the room was unoccupied or active processes are not occurring.

This operational change was implemented on an experimental basis in one of our buildings. The energy savings were immediately evident and have been substantial. This design feature is now a required component of all laboratory remodeling projects and new building construction.

Introduction of the Organization

The University of Nebraska–Lincoln Building Systems Maintenance, a department of the Facilities Management and Planning under the Vice-Chancellor of Business and Finance, is responsible for the maintenance of more than 150 buildings on two campuses.

The University of Nebraska, chartered in 1869, is a land-grant university and is a member of the Association of Public and Land-grant Universities (APLU). It is one of the nation's leading teaching institutions, and a research leader with a wide array of grant-funded projects aimed at broadening knowledge in the sciences and humanities.

UNL Building Systems Maintenance (BSM) has an annual budget of approximately $6.3 million and has 65 employees to care for more than 8 million gross square feet (gsf) of space serving more than 24,000 students and 6,100 faculty and staff. Its work is spread across two campuses, separated by about 1-1/2 miles with residential neighborhoods between. Buildings range in age from a few built in the 1890’s to facilities that have just completed construction. They vary from large multi-story laboratory buildings, to classrooms or offices, to animal research facilities.

BSM management consists of the Director, Associate Director, and a team of Managers and Zone Managers who provide budgetary, strategic, and managerial guidance to the organization.

Problem Statement

Energy costs continue to escalate, and even though Nebraska enjoys fairly low utility rates when compared to the rest of the country, those costs are a very significant portion of the Facilities budget. As every college or university is painfully aware, laboratory buildings are the most expensive to operate and maintain. The problem we all face is how to manage and reduce those expenses, and, at the same time, provide a safe and comfortable working environment for learning and discovery. We saw energy being used to condition air for the laboratory spaces, and saw all of that air in each room being blown out room being blown out the roof six to eight times every hour. Our problem was how to pluck those dollars back out of the sky.

Design

The goal of the design was to reduce the demand on the HVAC system for laboratories when the facilities were not being used in a manner that would not cause fugitive emissions or when it was unoccupied. Our controls engineers decided on installing an occupancy switch inside the doorway to the lab which would allow the lab occupant to indicate whether the HVAC controller needed to be providing full, design ventilation or if something less would be sufficient.

The idea to reduce air flow to under-used or unoccupied spaces grew out of UNL's success with a similar improvement in which electronic motion sensors were used to reduce minimum ventilation and thermostat sensitivity in unoccupied offices and classrooms.

Our Chemistry building was chosen as the building most likely to pay the greatest dividends, but new factors had to be taken into consideration. For lab spaces, the controls engineers were unwilling to risk using an automatic sensor, so we designed a lighted toggle switch to allow users to command the control system to provide HVAC conditions that matched the use of the room.

In addition to the installation of the toggle switch, each lab controller (a microprocessor with a thermostat having ventilation control capabilities) had to be reprogrammed to implement the correct HVAC operational changes as the lab user changed the switch between required operational statuses.

The toggle switch is installed next to each laboratory door (multi-door labs have a switch next to each door so they all show the same state), and connected to the lab controller. The lab controller is configured to calculate the required air changes in both occupied and unoccupied modes. Other lab-specific requirements such as temperature, humidity, and volatile organic compounds (VOC's) can be entered into the calculation, as well. Regulatory minimums were respected no matter what control status was commanded.

All of the design work was done by UNL control engineers in collaboration with UNL's office of Environmental Health and Safety, and the Chemistry Department.

Implementation

Installation was accomplished in phases. This was to allow for initial testing and because of budget constraints. The first rooms retrofitted were the undergraduate laboratories in the Chemistry building because those were most likely to have significant unoccupied periods and least likely to have dangerous chemical present.

A significant and crucial part of the implementation was the engagement of the laboratory users. After the hardware was installed and programming was completed, training sessions developed by our controls engineers, the Chemistry Department, and EHS and were held for all of the users. They were given a sense of how important their contribution to the effort was and were instructed on the proper operation of the controls. Signs were placed on the outside of each laboratory door notifying users that this control capability had been installed and that they should verify that the lab was in its proper operating mode before beginning any lab work.

After initial tests had proved the concept to be effective and valuable, it was expanded to the rest of the Chemistry building and to other laboratories across the two campuses. It is now the design standard for construction of laboratories and animal care facilities across both campuses and all properties of the UNL system.

Benefits

The primary benefit of this operational change has been in reduced energy use because most of the HVAC controlled laboratory and animal care spaces require 100% outdoor air to be provided throughout those areas. Even with UNL's relatively low energy costs, this is expensive due to extreme swings in temperature and humidity. The utility costs for the Chemistry building were reduced by 30%, or $250,000, in the first year after this program was installed. Most of the savings were from fan and heat energy. The average ventilation rate for the entire building was reduced from 8.0 to 4.5 air exchanges per hour. In animal care areas, room air exchanges can be reduced from 15 to 20 per hour to 2 to 4 per hour when no animals are present.

In addition to energy savings, the fact that not all labs are running at maximum ventilation demand at all times increases system diversity, reduces wear on the HVAC equipment, and decreased filter loading. This means that the unexpected loss of an exhaust fan will have a lesser impact on system operation, and preventive maintenance cycles of the central HVAC system can be lengthened.

Retrospect

While this method of laboratory control has become the UNL design standard, it is important to note that it is not the ideal for every installation. If a facility is expected to be very heavily used, a waiver of the design standard may be appropriate. The best savings will be realized by making sure the lab users close their fume hood sashes and shut off unnecessary equipment whenever possible.

We have also discovered it is important to consult with HVAC designers, when possible, to be sure supply valves are not over-sized. Over-sized valves are difficult to control and limit the amount of exhaust ventilation that can be reduced.

Also, while we were pleased with the initial results and are confident we put in place a successful program, we do not know how well the departments are keeping up with the training of the lab users. Training and Standard Operating Procedures are administered by EHS, and it is important to assure that operation of the occupancy controls are part of an ongoing program.

Finally, there are many, and sometimes conflicting, codes for design and operation of HVAC systems. It was our intent to reduce costs by reducing ventilation and still keep the people using those spaces safe and healthy. We have not taken it upon ourselves to interpret these codes ourselves and have found it valuable to look to our EHS group for direction in compliance.