HIGHER EDUCATION PARTNER

UNIVERSITY OF CALIFORNIA IRVINE

Implementation Model: Smart Labs

ORGANIZATION TYPE
Public University

BARRIER
Laboratories consume the majority of building energy on the UCI campus; however, lab retrofits face restrictive requirements to maintain safety and adhere to stringent building and fire codes

SOLUTION
Develop an integrated "Smart Lab" program to improve lab energy efficiency through an array of control and sensor technologies without compromising safety

OUTCOME
UC Irvine has demonstrated a paradigm shift in lab energy management, achieving energy savings of up to 60% in Smart Lab buildings while lowering maintenance costs

Overview

UC Irvine recognized that laboratories—which consume approximately two-thirds of total campus energy—are crucial for achieving energy reduction goals. However, the stringent safety requirements, building codes, and fire codes in these buildings make efficiency retrofits difficult. To overcome this barrier, UC Irvine developed an integrated "Smart Lab" approach that combines a suite of occupancy and air quality sensors with variable air volume features and digital controls. Smart Lab retrofits have dramatically reduced energy consumption and cut maintenance costs, while also improving equipment lifetime, correcting deferred maintenance problems, and improving safety.

UC Irvine's Playbook

Policies

UC Irvine identified energy efficiency as an important pathway to meeting its sizeable greenhouse gas (GHG) reduction goals. These include the University of California's system-wide goal of reducing GHG emissions to 2000 levels by 2014 and to 1990 levels by 2020, as required by AB 32 (the California Global Warming Solutions Act) and UC's Sustainable Practices Policy. In 2008, the UC Irvine Sustainability Committee drafted the first campus climate action and sustainability plan, which outlines guiding principles, goals and metrics, and specific projects to aid UCI in achieving its environmental goals. UCI chose to accelerate its energy-savings program and challenged campus staff to cut laboratory energy use in half – essentially doubling the performance required under California Title 24 energy efficiency standards. The university adopted the goal of beating Title 24 standards by 30% in new construction in 1991, and has continued its focus on energy savings ever since.

Process

UC Irvine first issued a challenge for Facilities staff to identify aggressive opportunities for efficiency improvements in laboratories. Based on these findings, a more formal process for Smart Lab retrofits was developed, along with staff training materials. Smart Lab retrofits are designed not only to improve building performance, but also to provide a rich "information layer" to enable smarter building management and data tracking. To roll out the Smart Labs program, UCI secured buy-in from several key stakeholder groups, including researchers, other laboratory staff, environmental health and safety staff and the fire marshal, and used each retrofit as a learning experience to make improvements during subsequent retrofits.

An Energy Management Challenge – When Facilities staff were given the task of identifying aggressive approaches to energy reduction, they found a significant opportunity in air ventilation. Laboratory buildings use 100% outside air ventilation, with no recirculation of return air. Thus, the entire internal air volume of a typical lab building is exhausted to the atmosphere via high-velocity exhaust stacks every 5-8 minutes. An enormous amount of energy is required to supply, heat, cool, humidify, dehumidify, filter, distribute, and exhaust this air, and this process takes place whether the laboratory is fully occupied, partially occupied, or vacant.

In new and retrofitted labs, engineers found that they could integrate airflow systems with sophisticated occupancy and air-quality sensors. The goal was to tailor the air-changes-per-hour (ACH) rate to lab usage. When the facility is empty, for example, the rate is half what it would normally be. As staff started implementing the new approach they found that:

- Many laboratories were actually operating with higher air-changes than desired or required by code. The average was 8.2 ACH prior to retrofit
- Reducing air-changes cut reheat almost to zero
- The retrofit process uncovered many known, and some unknown, system issues and malfunctioning parts. Thus, Smart Lab projects funded a multitude of deferred maintenance problems and design deficiencies though their energy savings

Technical Guidance – As the initiative matured, UC Irvine developed guidance to lay out a seven-step process for completing a Smart Lab retrofit or new construction. This list formalizes the technical approach for each project – including baseline features that must be installed beforehand, upfront analysis to assess opportunities for improvements, and the technologies to be installed. For whole-building retrofits requiring extensive construction, 3-6 months should be allocated prior to formal engineering to ensure project success. Outreach to all parties affected should be part of the project planning. The seven steps are as follows:

1. ***Baseline Features:*** The building must begin with direct-digital controls, variable-air volume, manifolded exhaust fans, differential pressure control of heating hot water, and known problems fixed. If needed, installation of these baseline features would occur under this step.
2. ***Control Installation:*** Installation of real-time demand-based ventilation controls for ACH based on occupancy and measured air quality. Zone-by-zone ACH varies from 2 ACH unoccupied to 10-12 ACH when threshold levels of VOCs, CO2, or particulates are detected. Carbon monoxide sensing is added as needed.
3. ***Lighting Improvements:*** Laboratory lighting efficiency is improved and associated heat load is reduced, thus enabling lower air changes. UCI's typical retrofit protocol includes switching T8 32 watt to T8 25 watt bulbs, changing normal light output ballast to reduced light output ballast, sequencing lighting to auto-on at 50%, manual on to 100% and auto off, and recircuiting lab bays.
4. ***Exhaust Fan Optimization:*** Exhaust fan energy is sharply reduced via a three-step process. First an exhaust dispersion study is performed, typically taking three months once the contract is in place. Second, based on this study, exhaust stack discharge airspeeds are reduced by (a) closing bypass dampers and/or (b) extending stack heights and/or (c) running manifolded fans in parallel. Third, if the dispersion study indicates re-entrainment problems under specific wind conditions, exhaust stack discharge airspeed may be anemometer-controlled.
5. ***Noise Attenuator Removal:*** Because lower fan speeds and duct airspeeds reduce HVAC noise significantly, duct noise attenuators are removed where feasible. Attenuators are often found upstream of exhaust fans and both upstream and downstream of supply fans. Sometimes it is feasible to remove resistive elements while leaving their exterior casings intact. If resultant noise is higher than acceptable, duct liner can be installed with a minor energy penalty compared to that of a typical duct attenuator.
6. ***Fume Hood Ventilation Adjustment:*** Fume hood standby ventilation is reduced to conform to the new AIHA/ANSIZ9.5 standard. Following a hazard evaluation, qualifying hoods may be reduced from approximately 375 to 200-250 internal air-changes per hour.
7. ***Final Commissioning:*** Final commissioning is performed to ensure that all improvements are working, integrated, and meeting performance specifications – including the IT functions of the "information layer." Initial commissioning may also be required prior to steps 1 or 2 (above) if there is uncertainty about existing system conditions and what needs to be included in the retrofit program.

Information Layer – A Smart Lab creates a rich "information layer" that facilitates active building management and allows for granular data tracking. This layer:

- Makes the working environment safer by providing air quality data to users
- Sends text messages to technical staff whenever a zone triggers high ACH
- Provides a detailed, zone-specific record of air quality and system performance
- Enables reports and dashboards with which staff can identify failed components and single out the aspect of the operation that is driving energy use

Thus, a Smart Lab with these essential features is significantly safer than prior designs. Although a Smart Lab includes many sensors and controls that require sophisticated maintenance, these same features provide self-diagnostics that enable ongoing monitoring, maintenance, and performance. A few laboratories, such as biocontainment facilities, employ selected Smart Lab features on a case-by-case basis.

***Staff Training* –** Smart Lab retrofits also have a staff training component. Training tools have been created and are posted online. In addition to these tools, training for the Environmental Health and Safety staff, building facility managers, and lab workers was conducted as the Smart Labs program was rolled out across campus. This training helps facilitate the use of the Smart Lab information layer to save energy while maintaining safe working environments.

***Smart Labs Program Rollout* –** Implementing the Smart Labs program required buy-in from management, research, and operations; this relies on the insight and approval of senior management, and the cost is not insignificant. Identifying and modifying existing policies and procedures from other successful retrofits saves a great deal of time and money in this process. UCI has also hired a third-party consultant to review proposed changes to the lab air circulation system to ensure safety.

Continuous improvement is the core of the Smart Labs concept. Smart Labs are not just controls and sensors; the dashboards associated with these sensors provide real-time feedback as well as monthly reporting data that are actionable. Return on investment is directly affected by lab practices, and facility managers are expected to modify operations, such as fume hood sash management, and make active use of the building management system. The system automatically adjusts for efficiency including control run times of office areas, reset of static pressure to minimum required, and locating simultaneous heating and cooling.

Tools:

- Smart Labs Website
- Reports and Dashboards

Outreach

UC Irvine maintains a website devoted to the Smart Labs program where students, faculty, and staff can learn about various aspects of this initiative. The workflow process for determining the air change rate of a laboratory is documented to provide everyone with more information about how and why the labs are operated in this manner. In addition, lab users can review how to access much of the information that is being collected from the various systems monitoring and controlling their lab environment.

Additionally, UC Irvine senior management and Facilities Management staff have been proactive in sharing the information with other institutions through workshops and conference presentations, both nationally and internationally. UCI has hosted a number of outside groups that come to the campus to learn about the Smart Labs program.

Tools:

- Smart Labs Website

Measuring Success

UC Irvine uses a mix of energy, maintenance, and air quality metrics for tracking the success of a Smart Lab retrofit.

> ***Energy Savings*** – Electricity savings (kWh/year) and natural gas savings (therms/year) are tracked. Energy data is collected and analyzed using metering from MelRok and the EnergiStream software package, in addition to the monitoring and review of the campus overall energy use. The data is recorded and reported in monthly and yearly reports.
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> ***Maintenance Metrics*** – UCI also suggests that trouble calls and maintenance savings are tracked, as a Smart Lab retrofit should generate a reduction in maintenance issues in addition to energy savings. Trouble calls and maintenance requests are tracked as part of the Facilities Service system.
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> ***Air Quality and Ventilation*** – Smart Lab ventilation systems also allow for tracking of indoor air quality in the lab zones, which can trigger an environmental health and safety response to high levels of CO2, TVOC's, CO, and particulate. Lab ventilation reports are provided monthly from the Aircuity system.

Outcomes

UC Irvine has demonstrated that the Smart Labs approach can drive a paradigm shift for laboratory energy use, demonstrating that energy savings of as much as 60% are possible on an annual basis. In addition to energy savings, a number of malfunctioning and deferred maintenance problems are uncovered and corrected by a comprehensive Smart Lab retrofit. The expense of monitoring-based commissioning or retro-commissioning can be greatly reduced or eliminated completely using the rich information layer that the Smart Lab program provides. Finally, the moving parts of the HVAC system in retrofitted buildings are slowed down, resulting in reduced maintenance and increased life expectancy for these components.

Tools:

- Smart Laboratories Cut Energy Consumption More Than Half – an overview paper with a list of labs included, and their associated energy savings
- Smart Labs Before and After Energy Usage