



Award Category

HVAC Retrofit

System Features

Variable frequency drives

Air exchange rate reduced 30 to 40% to 10-12 air changes per hour

Hot and chilled water BTU metering and monitoring system

Annual Energy Savings

114,000 therms

1.74 million kWh

\$314,000

Annual CO₂ Emissions Avoided

1.38 million kg

Cost

\$655,000

Additional Awards

2004 San Diego Excellence in Energy Award (SANDEE)

Completion Date

Spring 2005

University of California, San Diego Laboratory Retrofit

Installing variable frequency drives and lowering the air change rate in two laboratory facilities enables UC San Diego to avoid producing 1.38 million kg of carbon dioxide emissions each year. Annual utility bill savings of \$314,000 will pay for the cost of implementation in just over two years.

As energy prices rise and commitment to sustainability heightens, universities across the nation are developing methods for reducing energy consumption. An analysis of facilities at UC San Diego revealed that retrofitting constant volume (CV) air supply and exhaust systems with variable frequency drives (VFDs) could achieve significant energy savings.

A comprehensive analysis conducted by engineering consultant Kuhn & Kuhn included a design review, spot checking of fan energy and flow readings, a lighting review, and an assessment of control system performance. Cost analysis was performed to determine the simple payback for installing variable frequency drives and upgrading building control systems to direct digital control.



View of Stein Clinical Research Facility. Photo © 2003 by Alan Nyiri, courtesy of the Atkinson Photographic Archive.

UC San Diego selected two of its largest and most energy-intensive laboratory buildings for the retrofitting project: Pacific Hall and the Stein Clinical Research Facility. Laboratory buildings require five to ten times more energy per square foot than a typical building due to rigorous ventilation requirements and other health and safety concerns. Additional energy is necessary to sustain the complex

research activities that continually take place inside. Both buildings chosen for the retrofit were equipped with constant volume ventilation systems which further contributed to high levels of energy consumption.

By focusing on energy-intensive laboratory buildings, the campus gained the most savings from its capital investment and reduced the payback time.

In a CV system, variations in thermal requirements are satisfied by varying the temperature of a constant volume of air being delivered to a space. This works well under uniform heating and cooling requirements. However, when heating and cooling loads vary, CV systems continually supply peak capacity even when the demand is not at peak level. This method consumes a great quantity of energy to maintain peak flow in the central system.



View of Pacific Hall. Photo: Reto Ambühler.

UC San Diego installed variable frequency drives to respond to the laboratory's varying load demands in a more efficient manner. Changing load requirements are now met by adjusting the volume, rather than the temperature, of supply air that enters a space. Variable frequency drives control the frequency of the electrical power supplied to HVAC motors,

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More Information

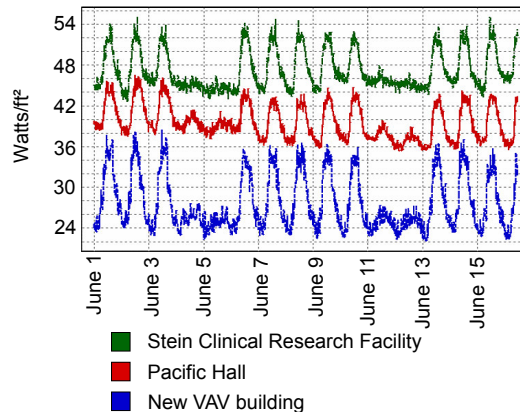
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which changes the motor speed, and subsequently the speed of fans and pumps in the system. Building owners can save significant amounts of energy by installing VFDs because the power required to drive a centrifugal fan or pump in an HVAC system is proportional to the cube of the fan or pump speed. Consequently, operating fans or pumps at a lower speed when demand is low can produce substantial energy and cost savings.

The U.S. EPA estimates that a 30% energy reduction in half of all American laboratories would save 84 trillion BTU per year. This equates to approximately \$1.25 billion in annual savings and 19 million tons of avoided carbon dioxide emissions.

A second important factor contributing to the considerable savings possible in retrofitting the laboratory facilities was the modification of the campus's air exchange rate standards. When the buildings were constructed, campus design criteria required 15-20 air changes per hour (ACH) in laboratories. Since then the university's Environmental, Health and Safety



Comparison of energy consumption between a newer VAV building and the two conventional CV laboratories after retrofitting. Image: John Dillriott.

department revised campus standards to 10-12 ACH, representing a 30 to 40 percent drop in air exchange rates. This adjustment had considerable implications for the supply air volume, and subsequently, the amount of fan energy required to supply it.

Together, Pacific Hall and Stein Clinical Research Facility require a combined air supply volume of 460,000 cfm over the course of a year. A large drop in the air exchange rate, multiplied by the massive volume of supply air moved over an entire year, yields huge horsepower savings at the fan motor. Rebalancing the buildings' HVAC systems and calibrating the VFDs to the new campus standards offered another opportunity to realize large energy savings.

The university saves 114,000 therms of natural gas and 1.74 million kWh annually since the completion of the retrofit in spring 2005. The resulting utility bill savings of \$314,000 each year will pay for the cost of implementation in just over two years.

The energy savings achieved in this project prevent 1.38 million kg of carbon dioxide emissions each year, which is equivalent to removing 299 cars from the road.

The retrofit included the installation of a 4-channel ultrasonic hot and chilled water BTU metering and monitoring system that provides real-time communication with the campus energy management system. This upgrade enables university staff to compare the energy performance of the laboratories before and after the retrofit, as well as analyze long-term energy use and demand profiling. The system will help ensure that the full benefits of the retrofit are realized, and provide comprehensive performance data that may reveal additional opportunities to improve energy efficiency.

Best Practices is written and produced 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.



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