TAYLOR ENGINEERING

Case Study: Efficient Lab Design

The University of California Santa Cruz (UCSC) Coastal Biology Building is a two-story, 40,000 square feet new marine biology laboratory on the Pacific Ocean coast. The building houses the Department of Ecology and Evolutionary Biology (EEB) and supports research and teaching on coastal conservation, ecology, habitat restoration, climate change impacts, and policy. The project contains 20 primary research labs, common analytical labs, 43 research offices, a core seawater laboratory, and a common seminar room and support administration. Additionally, there are over 8000 square feet of greenhouse and auxiliary buildings on site.

Photo courtesy EHDD

Innovation

The project is located directly on the coast and is exposed to year-round mild outdoor environmental conditions. UCSC has long had a directive of no air conditioning for non-critical spaces, but lab buildings are excluded. Because of the location of this building directly on the coast (~4 miles from central campus) and a relatively low-load research program, the design team determined it was possible to decentralize and severely limit compressor-based cooling in the project. The program was designed to concentrate/isolate high-load laboratory equipment into specialized equipment rooms and high-load lab spaces so that the vast majority of the building, including all but two research labs, could be served without compressor-based cooling. Both offices and laboratories in the main building are served by a single 45,000 cfm VAV air handler without a cooling coil. The high-load spaces (four equipment rooms, the server closet, and two high-load labs) are served by both this VAV air handler and a 14-ton cooling-only variable refrigerant flow system for supplemental cooling.

Project Type

New Construction

Services Provided

Plan and Spec Mechanical and Plumbing Design

Completion Date

2017

Innovation

Limited compressor-based cooling, BAS driven lab controls

Key Accomplishments

38% annual site energy savings relative to the Title 24 2018 Baseline

Because there is no cooling coil, the main air handler is always on economizer. This eliminates mechanical cooling energy use and eliminates zone reheat in mild and warm weather—one of the main energy sinks of traditional laboratory buildings. Additionally, combining lab and non-lab spaces onto a single air handler allows for lab exhaust makeup air heat recovery. Laboratories require 24x7 exhaust, which in turn requires 24x7 makeup air, which is generally provided as 100% outdoor air. With a single air handler that serves both non-lab and lab spaces, air from the non-lab zone airflows can be returned and used as makeup air for the labs, with its original heating energy recovered in the process.

The project's controls design is also innovative. Controls for variable air volume (VAV) laboratory supply and exhaust systems have

traditionally been separate from the rest of the Building Automation System (BAS). This project avoids the separate laboratory controls system and uses the BAS for the lab and non-lab controls, which reduces costs, eases contractor coordination, eliminates integration issues and reduces training required for building operators. Two key elements made this approach possible: (1) each lab with fume hoods uses a single controller to ensure fast-acting yet stable performance, and (2) detailed/proven control sequences were provided along with detailed functional performance tests and strong commissioning support.

Energy Efficiency

The building is designed to use 38% less annual energy than the Title 24 2008 baseline building and 29% less energy cost. A year of actual energy data is not yet available but will be by the summer of 2018. The project contains many energy-saving features in addition to minimizing compressor-based cooling explained in the *Innovation* section above:

- UCSC standards allow unoccupied setback on laboratory exhaust rates (6 ACH [1 cfm/sf] occupied and 4 ACH [0.67 cfm/sf] unoccupied exhaust rates). A scheduled unoccupied period combined with lab and hood area occupancy sensors (also used for lighting system) allowed for the safe 33% reduction in required airflow when labs are unoccupied. The building is served by two variable speed exhaust fans that are able to turn down safely to a fully unoccupied condition (all labs are unoccupied and at their exhaust minimums). Wind tunnel tests were completed to ensure safe dispersion of lab exhaust at these unoccupied exhaust rates below the ANSI/AIHA standard 3000 fpm stack discharge velocity requirement, eliminating the need for bypass air at the exhaust fans (a bypass damper was still included to maximize future flexibility).
- Hood automatic sash closers were included to minimize hood airflows when not in active use, eliminating one of the main energy drivers of laboratories. Trend data show the closers result in hoods being open only about 10% of the time, much lower than is typical without closers. They are also used to help ensure safe exiting during a supply system failure by forcing hood sashes to close, which reduces negative pressure in the room, reducing door opening forces.
- The main air handler has a supply fan array consisting of six fans and three variable speed drives, each serving two fans. This provides improved redundancy and allows fans to be staged off for more efficient operation at very low loads such as those that occur during unoccupied hours when airflow to non-lab spaces is shut off and lab ventilation rates are reduced to their unoccupied minimum.
- All conference rooms have CO_2 sensors, and all other spaces have occupancy sensors, with demand-controlled ventilation sequences to eliminate energy associated with excessive ventilation.
- All offices have operable windows with window switches to eliminate wasted heating energy while windows are open.
- Heating hot water is generated by two 750 KBH high efficiency condensing boilers with primary-only distribution with only 2-way valves and oversized heating coils, resulting in high ΔTs and thus low return water temperatures, ensuring condensing and high boiler efficiency.

Indoor Air Quality and Thermal Comfort

Given the constant requirement for outdoor air makeup in the laboratories and the combined lab/non-lab air handler, all zones will always see a very high percentage of outdoor air—higher than 30% above Standard 62.1. Nearly all cooling in the building is economizer cooling, so for most occupied hours, the building will be supplied with 100% outdoor air. All offices and conference rooms have operable windows as well as a ceiling fan, providing occupants with multiple methods of control over their thermal comfort in addition to the zone thermostat.

Cost Effectiveness

Taking advantage of the mild climate and limiting compressor-based cooling reduced first costs in cooling equipment. Because most of the labs use economizer-only cooling, there was no need for the typical expensive lab conditioning systems such as 4-pipe VAV or chilled beams. Early in the design phase, many typical lab energy conservation measures were studied and evaluated for life-cycle cost effectiveness. Some measures, such as exhaust air heat recovery, were found to not be life-cycle cost effective and thus not included in the design.

Environmental Impact

The project is LEED Gold certified, achieving many non-mechanical credits that help limit the environmental impact of the building, including daylighting, water-efficient fixtures (35% water use reduction), stormwater control, and certified, regional, recycled, and low-emissions materials. The mechanical design serves to reduce environmental impact chiefly through the energy efficiency measures described above.

Operation and Maintenance

UCSC facilities staff were involved in the design process from the beginning and reviewed all drawing sets for conformance with their facility standards and access requirements. All lab supply and exhaust air valves are accessible from a mechanical attic that is over 6’ tall and fully walkable. Because of the harsh marine air environment, special attention was paid to limit the potential of corrosion, including 316SS mist eliminators at air intakes to remove airborne salt-fog, 316SS or coated steel on any duct or equipment exposed to salt air, copper/copper coils in air handlers, and ASTM rated salt-spray coatings on outdoor equipment. The building underwent LEED enhanced commissioning with a 4-month trend review period, along with multiple building operator trainings.

More About Taylor Engineering: Founded in 1995, Taylor Engineering is a nationally recognized engineering firm specializing in mechanical systems design and construction, energy conservation, indoor air quality, controls, and system commissioning. Taylor Engineering specializes in cost-effective and innovative solutions that are designed from the start with construction and operation in mind. Complementing our engineering expertise, Taylor Engineering employees have extensive field experience including mechanical contracting; control system installation and operation; HVAC system monitoring, measurement and evaluation; and site auditing. Our cutting-edge design is informed through our involvement in energy and indoor air quality codes and standards, building science research, and the development of state-of-the-art simulation tools.