CHALLENGING CONVENTIONAL

BY JON WIENER, AIA

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Faced with a growing allied health program and a shortage of space, Chemeketa Community College sought a sustainable renovation and addition to its existing health sciences building. The design team proposed an unconventional and potentially risky approach for the 72,000 ft^2 addition: eliminate mechanical air conditioning and use passive cooling strategies to provide a comfortable, healthy building. The resulting addition uses 60% less energy than code, costs the same as conventional design and saves nearly $35,000 per year in operational costs compared to a code baseline building.

The Health Sciences Classroom Building renovation and addition provides additional classroom, training and faculty space. The two-story facility allows the college to expand its science and allied health programs that train health professionals, particularly nurses and dental hygienists. while also upgrading existing facilities to improve educational quality and boost enrollment.

The existing 61,000 ft^2 building was renovated in 2011 at a cost of $10 million. The interior renovation included remodeling, plus new building spaces including labs, classrooms and restrooms. The project also involved enclosing the second-floor breezeway, adding insulated window systems, new mechanical systems and selective system upgrades.

The addition was completed in 2010 at a cost of $20 million. It joins the existing building on a single spine that was originally a corridor and is now a daylit two story circulation and student interaction area (pictured right).

The entire building, which houses dedicated health programs and general purpose classrooms, is highly trafficked and already at capacity, accommodating nearly 1,700 people. It features 22 classrooms, each of which can hold 20 to 60 students, plus 56 private faculty offices and space for 20 adjunct professors.

While designing a building without mechanical air conditioning was a first for the design team and posed a risk for the college, design tools demonstrated that the building would be comfortable year-round. These tools played a critical role in convincing the college to opt for a sustainable building free of air conditioning. As "insurance," the design included space and basic provisions to accommodate future air conditioning if it were ever deemed necessary.

BUILDING AT A GLANCE

Name Chemeketa Community College Health Sciences Complex Addition (aka Building #8)

Location Salem, Ore.

Owner Chemeketa Community College

Principal Use Higher education
Includes
Science labs (biology, chemistry, anatomy)
Classroom, training and faculty space for health professions (dental hygiene, nursing and pharmacy technology)

Employees/Occupants
1,672 (existing building and addition)

Occupancy 100%

Gross Square Footage 72,000
Conditioned Space 72,000

Distinctions/Awards
2013 Sustainable Buildings Industry Council Beyond Green Award of Merit for a High-Performance Building

Total Cost $20 million
Cost per Square Foot $285

Substantial Completion/Occupancy 2010

Design Strategies

The building uses a range of diverse passive and energy-saving active strategies. The primary passive strategy is night flush, which removes heat from the building during the summer. Active systems include mechanical heat, radiant heating system with heat recovery units and mechanical ventilation.

These strategies work in concert to produce an energy use intensity of 31.9 $kBtu/ft^2 \cdot yr$ for the addition.

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Above The juncture of the existing Chemeketa Community College Health Sciences Complex, the new classroom/clinic/lab wing and the faculty office wing serves as a gathering area for students. The addition does not include mechanical air conditioning, but instead relies on alternative strategies such as ceiling fans, which help reduce the perceived temperature.

Opposite This two-story space in the faculty office wing distributes daylight and provides a path for natural ventilation. Glass panels allow the collaboration space (left) to also receive daylight.

This number drops even lower—to 28.9 $kBtu/ft^2 \cdot yr$—with the contributions of 155 kW of rooftop photovoltaic panels.

The same building designed to meet code would have an energy use intensity of 45 $kBtu/ft^2 \cdot yr$. Compared to the average existing building on campus, it will save more than $54,000 per year in energy costs, and meets the projected annual operating savings of $35,000 compared to an Oregon code baseline building.

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A wall of windows creates a bright, open student collaboration and study area near the dental clinic. The school fulfills its mission to serve the community by training much-needed health professionals, particularly nurses and dental hygienists.

Comfort Levels. The design approach relied upon research that shows that an inside temperature of 80°F to 82°F is comfortable if the surrounding building mass is cool and air movement is present. These conditions result in a perceived temperature of 76°F, which is within the acceptable design temperature range for conventional buildings.

Therefore, the goal was to make sure the mass temperature was sufficient so the indoor temperature was 82°F or less. To promote air movement, every occupiable room is equipped with ceiling fans, with six fans in every 30-seat classroom, also reducing the perceived temperature by 2°F or 3°F.

While computer modeling projected that the addition would be warmer than 82°F just 30 hours in an average year, it has outperformed the model, and indoor temperatures are never expected to exceed 82°F given an average year. No complaints of discomfort have surfaced.

INCENTIVE PROGRAM BOOSTS ENERGY EFFICIENCY, PROJECT SAVINGS

The building team participated in the Energy Trust of Oregon's Path to Net Zero pilot, which required the project to use 60% less energy than code requirement. The college received more than $130,000 in incentives for energy modeling and installing energy-efficient systems and equipment.

The project's capital project manager said enrolling in the pilot enabled the addition to be built to a standard that wouldn't have been attainable before. They received technical support, earned incentives and discovered ways to cut costs.

For example, energy modeling revealed that 36 turbine ventilators included in the original design were not necessary to meet cooling needs, saving thousands of dollars in building costs.

Added Mass for Passive Cooling. Building mass absorbs heat during the day and releases it at night when the building is unoccupied. The cooler surface of the mass reduces the perceived temperature by 1°F to 2°F.

The rule of thumb is that a room needs to have at least two times the floor area of exposed mass to achieve the desired perceived thermal comfort conditions; a concrete floor and ceiling typically provide this. For this building, computer studies were performed to ensure that each exposure has enough mass to achieve this effect. The design team used floor slab and roof slab, as well as additional interior concrete masonry unit (CMU) block walls in a few locations to achieve success with this strategy.

Energy-Efficient Heating. A variety of strategies were used to minimize the energy needed to heat the building. First, heating and ventilation were designed as separate systems, a more cost-effective, efficient approach allowing for greater user control.

Heat distribution occurs via radiant wall base convectors, an efficient, cost-effective solution providing

WATER AT A GLANCE

Annual Water Use Not available since the building's (existing and addition) water use is not metered separately.

ENERGY AT A GLANCE

Annual Energy Use Intensity (EUI) (Site) 31.9 kBtu/ft^2
- Natural Gas 13.5 kBtu/ft^2
- Electricity (From Grid) 15.4 kBtu/ft^2
- Renewable Energy (On-Site PV) 3 kBtu/ft^2

Annual Source Energy 56 kBtu/ft^2

Annual Energy Cost Index (ECI) $0.24/ft^2

Annual Net Energy Use Intensity 28.9 kBtu/ft^2

Savings vs. 2004 Oregon Structural Specialty Code 60%

Carbon Footprint 5.9 lb $CO_2e/ft^2 \cdot yr$

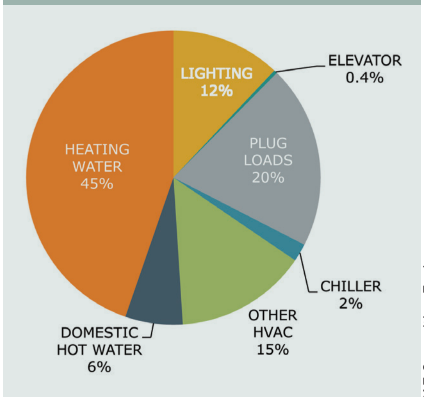
Heating Degree Days (Base 65˚F) 4,617

Cooling Degree Days (Base 65˚F) 699

Annual Hours Occupied 2,640 hr (approx. 12 hours/day × five days/week × 10 months/year)

Note: Energy data only represent the Health Sciences Complex Addition.

FIGURE 1
ENERGY USE BREAKDOWN, OCT. 2012 – SEPT. 2013



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heat at the perimeter, where needed. Finally, two old boilers in the existing building were replaced through state cash incentives with three high-efficiency boilers, accommodating the existing building and addition.

Ventilation. The ventilation design, which includes a passive system to achieve night flush, results in a building full of fresh air. Code-compliant ventilation in the office areas occurs via automated operable windows in the curtain wall, while classrooms meet ventilation code requirements via a heat recovery ventilator (HRV) controlled by a CO_2 occupancy sensor.

Classrooms also feature operable windows for night flush, passive cooling and additional ventilation. But, the classrooms can function adequately with the windows closed for the purposes of thermal separation and acoustic privacy.

Insulated doors at the roof in lieu of traditional and potentially leaky dampers contribute to a tight exterior building envelope with minimal air infiltration. In addition, a myriad of rooftop wind-powered turbine ventilators allow the building to "breathe" by allowing fresh air to move through the building and vent out the roof.

The building's warm air naturally rises and that warm air, when combined with a "chimney"—the turbine ventilator—creates a stack effect, which draws air through the building, lowering its temperature. Modeling determined that the original design featured more ventilators than were necessary, so some were eliminated.

All of these features are central to the fully integrated design concept that eliminated the need for air conditioning; these features in the building envelope essentially play the role of the mechanical system. The night flush that draws

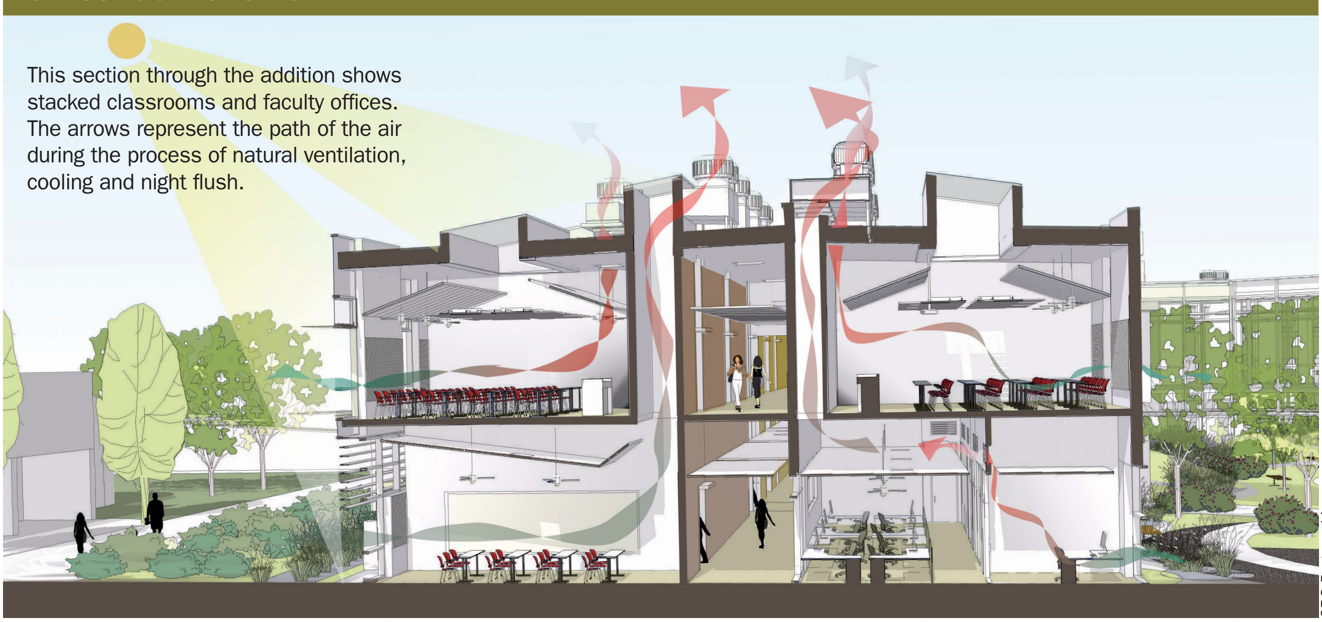
SOLAR PANEL FINANCING

The project's 155 kW of rooftop photovoltaic panels were installed under a third-party power purchase agreement. An independent company installed and maintains the panels at no cost to the college.

This company sells the power produced to the local utility at an agreed upon feed-in-tariff rate, and the college receives a small percent of their payments. The renewable energy certificates associated with the solar power are sold to the utility, so the college cannot claim them. The college inherits ownership of the panels after 15 years, or can buy them sooner if mutually agreeable.

CLASSROOM SECTION

This section through the addition shows stacked classrooms and faculty offices. The arrows represent the path of the air during the process of natural ventilation, cooling and night flush.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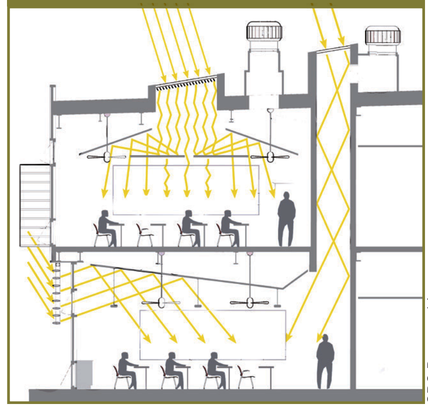
in cool outside air also is key to precooling the building. The automated night flush, operable windows and ducted mechanical ventilation system controlled by CO_2 sensors with heat recovery ventilators all contribute to the building meeting ventilation code.

Automated Controls. The night flush occurs automatically and is controlled through the building energy management system. Windows open automatically based on the temperature difference between inside and outside, and are programmed to avoid operation during classroom hours to minimize disturbance.

DAYLIGHTING DESIGN



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Above In the upper classroom, daylight is distributed by light bouncing off reflectors onto the sloping ceiling and then to desktops. In the lower classroom, the perimeter clerestory and a light shaft combine to provide daylight.

Above left Basket weaving patterns of local Native Americans inspired this paving design outside of faculty offices.

KEY SUSTAINABLE FEATURES

Storm Water Management Lighted "cauldrons" highlight the transfer of runoff from downspouts to rain gardens.

Daylighting Skylights, custom daylight reflectors, integrated light shafts/natural ventilation shafts, vision glazing and daylight glazing, exterior vertical shades for east and west exposures, horizontal exterior shades for southern oriented exposures, interior automated shades for glare reduction, electrochromic glazing for lighting intensity control in the skylights, bright interior surfaces for reduction of contrast and better daylight distribution.

Controls Individual wall dimmers in private offices, preset wall controls in classrooms to enhance energy conservation by preprogramming efficient settings for general use occupants. Podium controls integrated into an A/V touch screen that allow more discrete and override controls by the teacher. Classroom lighting controls are integrated with shades, electrochromic glazing, window operators and A/V equipment through the podium touch screen. Daylight harvesting controls in corridors and public spaces. Smaller control zones in large areas for discrete control of the space.

Super-Insulated Skin. Reducing energy loads is the most cost-effective way to achieve a high performance building. A critical part of this strategy is the innovative, super-insulated exterior. The project uses a new insulated wall panel system comprised of rigid insulation bonded to a light metallic skin, which performs as a moisture barrier.

The structure of the panels allows the avoidance of metal "z" connections that are normally used, making the walls more thermally effective and allowing them to achieve an effective R-27. These walls, combined with an R-60 roof composed of rigid insulation over a concrete and metal deck, contribute to the most highly insulated enclosure the design team has ever done.

Exterior Window Shading. Projecting window sunshades are the most visible environmental strategy on the exterior. To address the variety of orientations, each required a slightly different approach for shading and functionality. Since the upper floor has skylights, the windows just needed shading; on the lower floor, horizontal louvers shade and act as lightshelves to bounce the daylight further inside.

Daylighting. Daylight permeates the structure throughout. Almost all spaces on the upper floor have skylights, and light shafts channel daylight throughout the ground level.

Daylighting strategies strongly impacted the interior architecture, encouraging sloped ceilings, two-story spaces, and the choice of finish materials. Desktop, flooring and wall colors meet specific light reflectivity criteria.

Daylight harvesting was incorporated wherever possible. This control strategy minimizes the energy needed for lighting and reduces the internal heat gain from light fixtures.

One design challenge was to balance the daylight from exterior windows with the light from the shafts so that it was evenly distributed throughout each room. The goal was to have a daylight factor between 2% and 4% across the entire floor area. Excessive variation of daylight was minimized by eliminating visual hot spots.

It was challenging to determine just the right width (and resulting light) of the light shafts, which also provide the exhaust path for the night flush, while taking up valuable classroom square footage. The configuration of the lightshelves also required careful experimentation in a quest to achieve appropriate daylighting balance.

The resulting design provides an ideal quantity and even distribution of daylight. The shafts bringing daylight into the back of first-floor classrooms effectively balance the light from the exterior windows.

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Electrochromic skylights and a daylight reflector combine to provide even daylighting throughout this nursing classroom. The degree of tint in the electrochromic glass determines the light level reaching the room.

The college required light levels of 35 lumens, which is achieved by natural light in all of the classrooms. During a typical day the electric light fixtures are not necessary.

The first-floor classrooms receive natural light via shafts with skylights, windows with lightshelves and sloped ceilings. Second-floor classrooms have skylights with reflectors and windows with lightshelves.

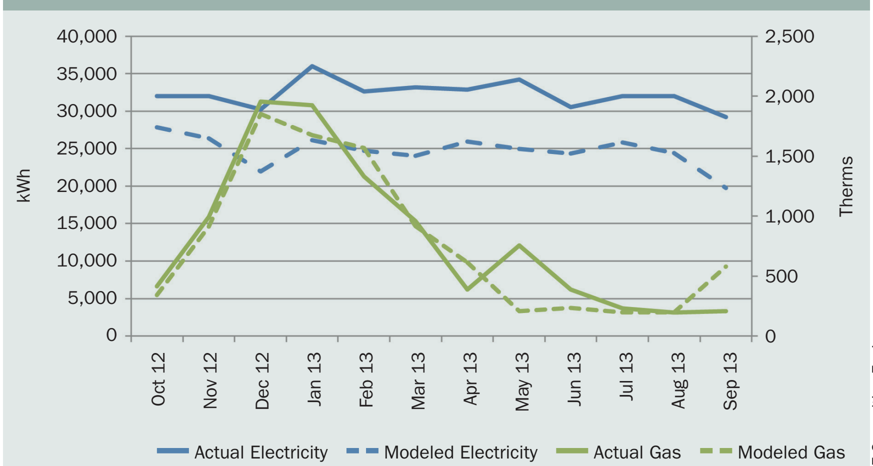
The skylights are glazed with electrochromic glass that changes light transmission properties when voltage is applied to respond to the amount of light outside. A sensor automatically adjusts the amount of light transmitted so that it's not too bright in the classroom. A switch in the room allows the instructor to darken the glazing for a projected presentation.

Artificial light, when needed, is provided through the most energy-efficient fixtures available at the time of construction, mostly T-8 fluorescent fixtures. Daylight and occupancy sensors help minimize lighting energy use.

Integrated Design

When used effectively and wholeheartedly, integrated design can be a means to avoiding cost premiums associated with sustainable design. Integrated design was central to this project's approach, and called for extensive and detailed studies addressing daylighting, temperature and comfort.

FIGURE 2 MODELED, ACTUAL ELECTRICITY AND NATURAL GAS USE, OCT. 2012 – SEPT. 2013



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Note: Gas use data includes estimated values for October 2012 to December 2012, July 2013 and August 2013 due to unavailbility of utility bills and gaps in the energy monitoring software. The new addition of the Health Sciences Complex is separately metered for electricity consumption, but a single gas meter serves the existing and new portions of the building. However, the water heaters are submetered, providing an effective method of proportioning the gas for the boilers that serve multiple buildings.

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External louvers combine with a deeply recessed glass plane to reduce heat gain at the entrance on the western elevation. Multiple daylighting studies helped determine the design of exterior shading devices.

BUILDING ENVELOPE

Roof
Type Elastomeric
Overall R-value R-60
Reflectivity 0.82

Walls
Type Masonry or metal siding over 3 in. insulated metal panel
Overall R-value R-27
Glazing Percentage 35%

Windows
Effective U-factor for Assembly 0.34
Solar Heat Gain Coefficient (SHGC) 0.27
Visual Transmittance 63%

Location
Latitude 45°
Orientation Varies; primarily south and southeast, north and northwest

The mechanical engineer, lighting designer and energy analyst were responsible for these studies. A study using airflow analysis software allowed for each of the classroom variables; room airflow, mass, lighting and solar loads were analyzed and adapted to achieve the best room performance.

The design team met over a six-week period, adjusting the model and brainstorming ideas for rerunning it, then reviewing the results. The study successfully determined the number of air turbines needed, room mass, solar shading and daylighting for optimal comfort.

Multiple daylight studies using lighting analysis software also were developed to evaluate the optimal spacing and dimension of the exterior shading devices. Additional daylight studies looked at the shape and configuration of the diffuser/reflectors incorporated into the upper classrooms under the skylights.

Daylight studies evaluated the spaces under direct sun and overcast sky conditions on multiple dates throughout the year to verify proper spacing of reflector components and optimal shading dimensions. Several interior studies looked at glare potential on white boards to minimize window reflections and optimize teaching conditions, while minimizing the need for interior blinds or shades. The daylight studies helped the design team shape the daylight control elements to aesthetically and functionally fit the building, maximize the daylight potential, and minimize the need for electric illumination.

To control cost, redundant systems were avoided. For example, rather than invest in mechanical air conditioning when the building was going to rely on passive ventilation and night flush for cooling, the design team opted to allot these funds toward the exterior skin and controls.

Operational Strategies

Since occupants generate heat, the design team recognized the importance of reducing the occupant load in the event of extended periods of hot weather. In the Willamette Valley, these heat waves only occur once or twice during a typical summer.

Given that community colleges typically have fewer classes in the summer, the college agreed to avoid using the most vulnerable classrooms (six south-facing classrooms on the second floor) during the hottest hours of the day. Since the building includes 22 classrooms, it was an easy concession. This strategy avoided the need for air conditioning, a key tactic to meeting the construction budget, and the occupants have reported being comfortable year-round.

Resource Efficiency

While LEED certification was not pursued, sustainability was an important consideration, influencing materials choices and sourcing. The major exterior skin materials are brick and steel. Both are recyclable and are derived from plentiful materials.

The metal wall panel provider is one of the first companies in the

Advertisement formerly in this space.

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country to offer Cradle to Cradle certified building envelope products. This certification process evaluates product components for safe environmental health impacts throughout their life cycle and their potential for being recycled or safely composted.

The most prominent, expensive and complex pieces of equipment in the building are the 28 dental chairs, built and provided by a local company in Newberg, Ore. The PV wafers were also manufactured locally, in Salem, Ore.

Environmental Awareness

Because this is a health and science building, the occupants were interested in expressing the relationship between the built environment and natural systems. In response to these desires, the design highlights how storm water runoff is collected and transferred to the ground. The downspouts from the roof terminate in lighted "cauldrons," which contain the splash of the water and call attention to the rain gardens of native plantings surrounding the building.

Other water management strategies include settlement ponds adjacent to the building, designed and planted to enhance the landscape character.

The landscape design also incorporates a healing garden. Indigenous plants used by local Native Americans (the Confederated Tribes of Grand Ronde) for medicinal purposes surround a special courtyard and feature instructional signage.

To help make occupants more environmentally aware and to show them how to understand and operate their building properly, the design team produced a user manual. The 45-page booklet explains the importance of energy efficiency, and how occupants' actions play a significant role in reducing the energy use of the building.

For example, the manual instructs users on how to use daylight, fans and automated windows in specific classrooms or offices, depending on their specific lighting and temperature conditions. Occupants are reportedly comfortable and are knowledgeable about how to operate their building.

BUILDING TEAM

Building Owner/Representative
Chemeketa Community College

Architect SRG Partnership

General Contractor Lease Crutcher Lewis

Mechanical, Electrical and Plumbing Engineer PAE Consulting Engineers

Environmental Consultant
SOLARC Architecture and Engineering

Structural Engineer
KPFF Consulting Engineers

Civil Engineer Westech Engineering

Landscape Architect
Lango Hansen Landscape Architects

Lighting Design Luma Lighting

High Performance Building Consultant
Energy Studies in Buildings Laboratory

Commissioning Agent
Environmental & Engineering Services, Inc. (Ron Anderson)

Cost Estimator Rider Levett Bucknall

Laboratory Planning
Research Facilities Design

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Above North-facing windows provide indirect natural light for the dental clinic, which provides free services for low-income children. The dental chairs were locally sourced from a company in Newberg, Ore.

Below The major exterior skin materials are brick and steel. Both are recyclable and are derived from plentiful materials.

Social Responsibility

The college "values access and diversity, which is affirmed by how we care, collaborate, and innovate

with each other and the community," according to its mission. These values are incorporated into the project, which is designed for serving and reaching out to the community. Its core reason for existence achieves this by training much-needed health professionals, particularly nurses and dental hygienists. In addition, a dental clinic provides free services to low-income children.

The surrounding community was also impacted. In designing the Native American healing garden, the college reached out to the Confederated Tribes of Grand Ronde to confirm that its design appropriately reflected their culture.

Finally, the project's Portland-based contractor placed a priority on involving subcontractors from the Salem area. Because funding for the building came in part from a local bond, the college sought to keep that money in the local economy.

LESSONS LEARNED

Water Heating Energy Use Is Higher Than Expected. The building is using more energy than projected in heating water for the radiant heating system and in the operation of the heat recovery ventilator (HRV) units. It seems the occupancy sensors are triggering the HRVs to run at unoccupied times. The design team is looking into whether this is an error or a setting adjustment needed on the occupancy sensors.

Reflector Positioning Could Be Higher to Maximize Daylighting. The classroom skylights with reflectors below work well, but would be even better with increased ceiling heights. In the larger classrooms, the flat reflectors make the space feel too constricted.

Electrochromic Glass Does Not Adjust Quickly Enough for Pedagogical Needs. The time it takes for the electrochromic glass to change from light to dark is too long for classroom use when a presentation is being given. The college has compensated by keeping the skylights at a slightly dark tint to minimize the transition time; plans involve eventually transitioning away from projectors to LED screens, which will be much brighter and allow the electrochromic glass to be acceptable at a wider range.

Integrating Lighting, Window Shades and Skylight Glazing Controls Into One System Challenging. Classroom podiums often have a digital touch screen so faculty can turn off the lights and close window shades when they want to use the A/V system for a presentation. Since each system has its own computerized controls and different software, the college's IT staff has been challenged to try to integrate them into a single system operating from the podium panel. Keeping these elements separate may be a better solution.

Post-Occupancy Performance

Three years after its completion, the building continues to perform exceptionally well. Faculty members enjoy teaching in it, and its comfort has been reported as better than expected.

Commissioning high performance buildings with passive strategies needs to extend for several years so subtle adjustments to seasonal variations can be made. In the interest of making sure the building performs as designed, the design team has collected performance data and analyzed any shortcomings.

Upon performing a detailed measurement and verification study, the mechanical engineer found that the new construction portion of the building is using slightly more energy than projected: 31.9 kBtu/ft^2·yr (actual) vs. 27 kBtu/ft^2·yr (projected). The higher than expected energy use is due to the heat recovery units running more than anticipated (see *Lessons Learned*).

However, the building has outperformed projections in terms of temperature and comfort. An occupant survey is planned to ensure that the building's passive ventilation strategies are functioning properly.

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Rainwater travels down a downspout to a COR-TEN steel cauldron with a gravel bed before cascading into a bioswale. The LED lights inside the cauldron shine into the splashing water, creating a flame-like glow and highlighting the water's transition to the groundwater table.

Conclusion

The Health Sciences Complex addition stands as a successful example of how, given all of the correct ingredients—including client trust and a true integrated design process—it is possible to design a high performance/low-energy building without increased construction cost. It is evidence that challenging the conventional and pushing for innovative solutions can save money and resources. Functioning examples of high performance design can also educate the public to advocate for high performance design, promoting healthy environments well into the next century. ●

ABOUT THE AUTHOR

Jon Wiener, AIA, is a principal at SRG Partnership in Portland, Ore.