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STUDENT REMEDY

BY STEVEN GUTTMANN, P.E., ASSOCIATE MEMBER ASHRAE; TED M. TIFFANY, MEMBER ASHRAE; NADIA SABEH, PH.D., P.E.

Sex, lack of sleep and stress rank as some of the top health concerns among college students, and University of California, Davis's rebuilt and reimagined Health & Wellness Center is there to help. Services extend beyond primary medical care and pharmaceuticals to free contraception from the "Love Lab," to napping kits from the Stress & Wellness clinic.

The 2012 LEED-NC Gold facility replaced an aging 1950s-era student health center. Ample windows provide daylighting and views, which are associated with healing benefits. The 75,303 ft^2 center offers primary care services for the university's 30,000 students with clinical exam and treatment spaces, specialty clinics such as acupuncture, dermatology and neurology, women's health and counseling services, health promotion and education, and laboratory services and office support areas.

BUILDING AT A GLANCE

Name	University of California, Davis Health & Wellness Center
Location	Davis, Calif.
Owner	University of California, Davis
Principal Use	Student health care
Includes	Exam, treatment, education and office spaces; laboratory
Employees/Occupants	80 full-time employees, 42 visitors (students)/day
Occupancy	100%
Gross Square Footage	75,303
Conditioned Space	73,112
Distinctions/Awards	LEED-NC Gold, 2012
Total Cost	$33,358,000
Cost Per Square Foot	$445
Substantial Completion/Occupancy	Oct. 2009/March 2010

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Above The physical therapy department on the third floor includes six private treatment rooms and a large gym space. Most patients are treated for orthopedic problems, sports injuries, work injuries or neurological conditions.

Below Bike racks at the northeast corner of the building encourage the use of alternative transportation and reflect the campus' high rate of bicycle use.

Opposite The UC Davis Health & Wellness Center serves 30,000 students, offering primary medical care and specialty health services. The high window-to-wall ratio on the north façade maximizes daylighting, which is associated with healing benefits.

Countering the perception that green buildings are more expensive to design and construct, the UC Davis Health & Wellness Center (H&WC) ultimately came in under budget and ahead of schedule, and performs better than the energy models predicted. In a post-occupancy survey, the building was rated by the occupants as "exceptional" with respect to thermal comfort, air quality, lighting, acoustics, and general satisfaction with the building and its design and operation.

Initial budget was a concern, but the UC Davis campus has a successful history of including design elements that could lead to long-term savings in the building's operation and life-cycle costs. A university system-wide mandate requires that all new construction perform at least 20% better than the California Energy Code. As this project began, the university was defining its sustainable development priorities in a more comprehensive way, and this project was seen as an opportunity to test ideas.

One key element of the building's energy savings is chilled beams, a technology that has not been widely used in the U.S. Chilled beams bring cooling to the zone level, virtually eliminating reheat and allowing the amount of air delivered to be reduced to only what is required for ventilation. They also reduce the fan energy associated with heating, cooling and ventilation, resulting in greatly reduced energy needs compared to a traditional HVAC system.

The characteristics of the chilled beam system in the H&WC allowed for many cost savings to be incorporated into the design, making this strategy energy efficient and cost effective. Three years into its operation, its actual energy use savings are 47.4% better than the weather-calibrated LEED baseline building with an energy use intensity of 84.9 kBtu/ft^2. For a building with minimum air change rates more similar to a hospital than an office building, this performance is exceptional.

Project Description

The flexible design of the new three-story H&WC allows future expansion of programs such as employee health and sports medicine. The building sits on La Rue Road, one of the main

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Above **Students approach the main entrance to the building from the west. The building's east-west axis maximizes north and south exposures, while minimizing east and west exposures.**

Right **The Health Education and Promotion department waiting area on the third floor provides a view of the green roof over the main entry pavilion. Student representatives on the building committee strongly advocated for this project element. This is the campus' first green roof, and it gives the campus O&M staff an opportunity to experiment with this technology on a small scale.**

roads through campus, that forms the east boundary of the site. The main entry is on the northeast corner of the building, reaching out to bicycle riders and pedestrians who make their way onto the site off the sidewalk along La Rue.

An existing parking lot to the north serves the building, so no new parking was needed; however, preferred parking spaces are designated for electric vehicles. Combining a welcoming outdoor space and storm water management strategies, the southern portion of the site is dedicated to a wellness garden that acts as a storm water retention area and bioswale.

The region's climate consists of hot, dry summers and cool, rainy winters. The H&WC is oriented along an east-west axis to maximize north and south exposures and minimize east and west exposures. The north elevation is almost all curtain wall glazing, which maximizes the introduction of soft natural light into the band of waiting areas located along the north perimeter of the floor plan.

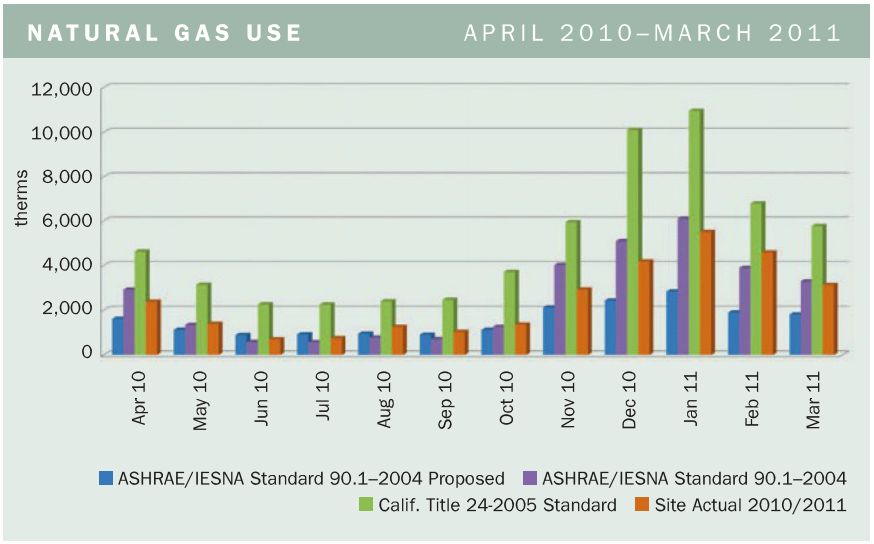
On the south elevation, punched windows with integral sunshade devices control the intense southern sun. The east and west elevations have vertical sunshade devices to control glare and address the rising and setting sun.

Energy Efficiency

Building Envelope. Even with a window-to-wall ratio of 41.2%, the building envelope includes features that contribute to energy efficiency and, in the case of its green roof, add a unique design element among campus buildings. Wall construction consists of 2 × 6 metal stud-framed walls with R-19 insulation. Thermal bridging through the walls occurs due to the use of conductive metal studs, and the resulting effective U-value is 0.18.

A built-up roof with 4 in. rigid insulation sits on top of the metal deck. Outside, the campus's first green roof helps reduce the heat island effect. Its effective U-value is 0.04.

Total glazing area for the building is approximately 11,700 ft^2. A combination of fritted and non-fritted glass helps balance performance and cost, with the solar heat gain coefficient (SHGC) ranging



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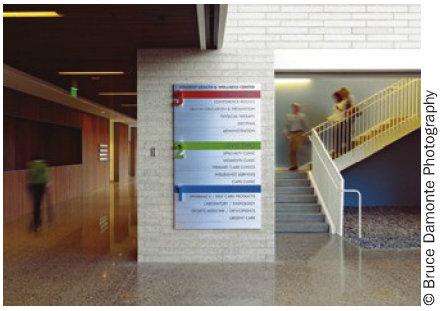

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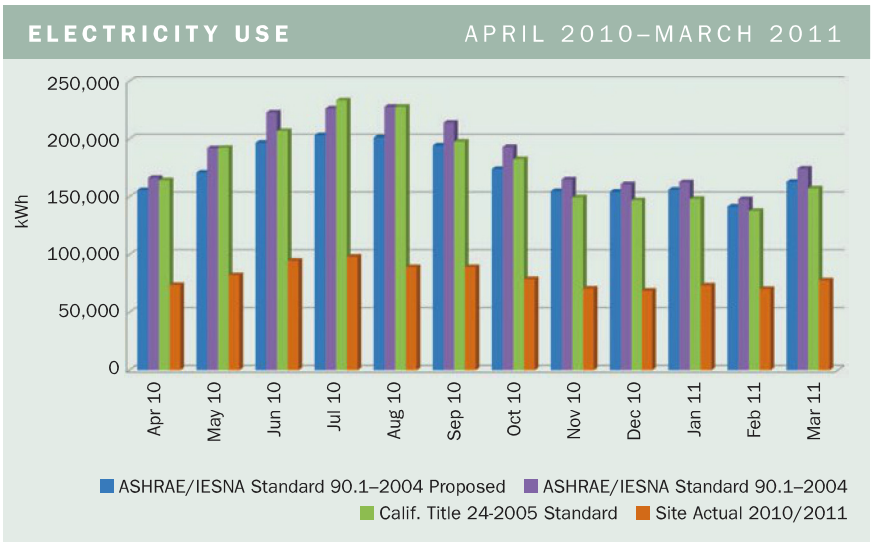
Above Stairs off the main entry have clear signage for easy way finding. Low-emission indoor building materials such as paints and sealants promote good indoor air quality.

Below left Daylight floods the main entry into the building on the north façade. The thermal load impact of the building's 41.2% window-to-wall ratio is managed by maximizing north facing curtain wall, minimizing east and west facing curtain wall, and by providing effective shading of south facing punched window openings.



from 0.29 (fritted glass) to 0.37 (non-fritted). The fenestration has a U-factor of 0.45.

Lighting. The lighting design of the H&WC integrates occupancy sensors and daylight harvesting. Occupancy sensors are used in all exam rooms, offices, restrooms and other applicable areas. The design of the facility on an east-west axis enhances daylighting, especially along the north elevation. Daylight sensors in the north waiting areas adjust electric lighting levels as needed.

The interior lighting uses mainly third-generation T-8 linear fluorescent ECO lamps in recessed fixtures and CFL downlights, with some T-5HO lamps at fixtures in open areas. A few lobbies have decorative MR16 halogen spotlighting for artwork.

When lighting controls credits (based on use of occupancy sensors and daylight controls) are factored into the lighting design, the overall effective lighting power density (LPD) is 0.98 W/ft^2. This is a reduction of 11% in LPD from a California Energy Code-compliant lighting system.

HVAC: Chilled Beams. Chilled beams, still relatively unknown in the U.S., are used more widely in the United Kingdom and Europe.

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ENERGY AT A GLANCE

Annual Energy Use Intensity (Site)
84.9 kBtu/ft^2
Natural Gas 39.85 kBtu/ft^2
Electricity 45.05 kBtu/ft^2

Annual Source Energy 192 kBtu/ft^2

Annual Energy Cost Index (ECI) $1.84/ft^2

Savings vs. Standard 90.1-2004 Design Building 35.1% (energy), 28.1% (cost)

Heating Degree Days 2,853

Cooling Degree Days 1,127

WATER AT A GLANCE

Annual Water Use 124,000 gallons

KEY SUSTAINABLE FEATURES

Water Conservation
Low-flow toilets (1.25 gpf), ultra low-flow urinals (0.125 gpf) and low-flow lavatories (0.5 gpm) reduce indoor water use by more than 35% relative to LEED standard fixtures.

Indoor Air Quality Low-emission paints, carpet systems, glues and sealants.

Daylighting Natural light in waiting rooms provide 30% of lighting needs.

Controls Daylight controls in waiting room; occupancy sensors with dimmers in offices.

Other Major Sustainable Features
Bike racks.

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Above **Chilled beam systems are used throughout the building and can be easily spotted in the ceiling of this northeast corner seminar room. These seminar rooms required more chilled beams than the typical spaces to accommodate the brief morning peak loads. However, the use of chilled beams allowed the peak load to be accommodated without the major oversizing of duct and fans that would be required in a conventional all-air system.**

Below right **A laboratory on the first floor supports clinical services. Interior lighting mainly consists of third-generation T-8 linear fluorescent ECO lamps in recessed fixtures and CFL downlights.**

Roadblocks to their greater use in the U.S. include perceptions about their cost and the normal tendency for designers, engineers and contractors to work with what they know.

However, chilled beams can be a key part of an energy-efficiency strategy for buildings with high ventilation requirements, effectively decoupling ventilation and zone conditioning. This type of strategy allows for deep energy savings from reductions in reheat and fan energy use. Reheat is prevalent in systems where high air changes for infection control are used, but it is virtually eliminated in this system because more than 50% of the zone cooling is met at the zone level.

In addition, if facilities do not require chilled water for dehumidification uses, the warmer chilled water supply temperature needed by the chilled beams can significantly improve cooling plant performance. "Active" chilled beams, which introduce ventilation air directly to the beam to enhance performance compared to "passive" beams, are used in the H&WC to meet the sensible loads of the spaces.

As compared to a conventional all-air HVAC system, the chilled beam system for this facility uses 70% less air volume, with only a small penalty in additional pump energy required to deliver water to the chilled beams. Because pumping water is a more efficient means of heating and cooling than blowing air, the system reduces overall energy transport costs.

Additional reductions in fan energy use are achieved by reducing the face velocity across the air-handling unit coils to 350 fpm from the more common 500 fpm. This 30% reduction in velocity provides a 50% reduction in airflow resistance, leading to a 65% reduction in energy use for this component of the constant-volume ventilation system.

The duct system also is designed for low-pressure drops. Chilled beams

OVERCOMING UNFAMILIARITY OF CHILLED BEAMS

Chilled beams work particularly well in a medical environment by supporting the use of 100% outdoor air, eliminating the significant reheat energy that such buildings require and reducing energy transport costs. Those characteristics would also benefit buildings with many other functions, giving the technology potentially great application throughout the building industry.

Unfortunately, the lack of familiarity with this technology in the industry can still result in increased costs for a chilled-beam solution, partially from "risk-based" pricing by contractors and a lack of recognition of cost-saving opportunities such as reductions in floor-to-floor height. However, clear and strong communication of the benefits and a strong desire by the design team to deliver high performance building solutions make overcoming initial objections possible—and the results can be exceptional.

BUILDING ENVELOPE

Roof
Type Built-up roofing
Overall R-value 23.3
Reflectivity
Cool Roof Rating Council Certified
Aged Solar Reflectance 0.75
Thermal Emittance 0.85

Walls
Type Metal stud wall with R-19 batt insulation in cavity
Overall R-value 5.5
Glazing Percentage 41.2%

Basement/Foundation
Slab Edge Insulation R-value
R-0 perimeter slab on grade

Windows
U-value Center of Glass (COG) 0.29
Solar Heat Gain Coefficient (SHGC)
0.29 COG east, south and west;
0.37 COG north
Visual Transmittance 60%

Location
Latitude 38.5° N
Orientation East-west axis
(front orientation: north)

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Above **Small fins on the north façade provide shading for late afternoon summer sun. Extensive use of glass on the north façade maximizes daylight opportunities without significantly impacting peak loads.**

Below **The punched windows with integrated sunshades on the south façade minimize heat gain. Fritted glass can be seen on portions of the east façade.**

BICYCLE CAPITAL OF THE U.S.

Davis, Calif., has earned the name "Bicycle Capital of the U.S." because of the efforts to provide thousands of residents and students with a bicycle friendly environment. Wide streets, an extensive bikeway network, gentle terrain, mild climate, supportive public policies, and an attitude of mutual respect between cyclists and motorists all contribute to the high rate of bike use. The University of California, Davis's Health & Wellness Center provides a bounty of bike racks.

—http://tinyurl.com/bike-capital

were selected at the lower end of their operating pressure range—all chilled beam selections were made at 0.25 in. w.g. pressure drop, which is half the industry chilled beam average of 0.5 in. w.g. and similar to the pressure drop of a variable air volume (VAV) terminal box.

The chilled beam system allowed for a reduction of building height by 3 ft due to the need for much smaller ducts, while still providing adequate interstitial space for low-pressure-drop duct design. The overall shaft footprint was reduced by 75% compared to the requirements of a traditional VAV system, providing more assignable square footage for the building.

Overall Performance

The building was projected during the design phase to perform 35.1% better (based on energy consumption) than the LEED baseline building. Metered data show that as a result of the implemented energy-saving strategies, the building is performing even better than that prediction; the total measured annual energy use intensity (84.9 kBtu/ft^2) is 31% less than the predicted annual energy use intensity (123 kBtu/ft^2).

Indoor Air Quality

The chilled beam system operates close to the fresh air requirements for occupancy, allowing the design to use a dedicated 100% outdoor air system (DOAS). The DOAS provides ventilation air volumes that exceed the requirements of ASHRAE Standard 62.1-2004 by 30%.

Large and reliable quantities of outside air are particularly suited to health-care facilities, and 100% outdoor air systems provide operational flexibility for managing outbreaks of infectious airborne diseases. Chilled beams maintain high overall air changes in occupied spaces through the induction characteristics of the device, allowing for total air changes of at least three times greater than the air changes due to outside air alone. This helps ensure good mixing of air in a space, preventing buildup of indoor irritants due to stratification.

In addition to the mechanical ventilation system, operable windows

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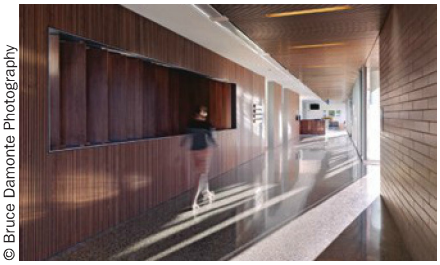

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Above The location of the main entrance on a major campus circulation route reaches out to bicycle riders and pedestrians. An existing parking lot to the north serves the building, so no new parking was needed; however, preferred parking spaces are designated for electric vehicles.

Left Daylighting helps illuminate this hallway and many other spaces in the Health & Wellness Center. Electric lighting levels are automatically adjusted based on occupancy and daylight levels.

are provided in the large waiting areas located on the north side of the building. These windows provide occupants with a direct connection to the outdoor environment to enhance perceptions of well-being.

Chilled beams, by their nature, are more compatible with operable windows than many other types of systems. In cooling mode, as a space temperature gets closer to the fluid temperature in the beam (normally at 57°F to 60°F), the cooling effect of the coil drops off logarithmically.

If windows are opened during days when natural ventilation meets the load, the zone cooling essentially turns off, and the tempered ventilation air neither heats nor cools the space. This eliminates the need for the operable windows to be connected to the HVAC system through window sensors or switches, resulting in significant cost savings. Areas with operable windows have dew-point monitors to ensure that HVAC system operational parameters are adjusted as necessary to avoid condensation on the chilled beams.

Occupant Comfort

A post-occupancy evaluation was performed using the Occupant Indoor Environmental Quality (IEQ) Survey and Building Benchmarking tool developed by the Center for the Built Environment (CBE) at UC Berkeley. The results of the survey placed the building in the 91st percentile in overall satisfaction and indoor air quality, and in the 92nd percentile for thermal comfort compared to all buildings in the CBE database.

Environmental Impact

The H&WC's energy efficiency is particularly notable given that the building taps into the university's campus steam and chilled water systems. This means that chiller and boiler performance makes only a small contribution to energy efficiency.

The chilled beam system is the key component in reducing energy consumption through its efficient

BUILDING TEAM

Building Owner/Representative
Rick Welsh/Jill Tomczyk

Architect Brian Shiles, John Ruffo, Mitch Fine, Brian Milman; WRNS Studio

General Contractor
McCarthy Construction

Mechanical Engineer
Steve Guttmann, Guttmann & Blaevoet

Electrical Engineer
Charles Silverman, Silverman & Light

Energy Modeler
Ted Tiffany, Guttmann & Blaevoet

Structural Engineer
Patrick Ryan, Rutherford & Chekene

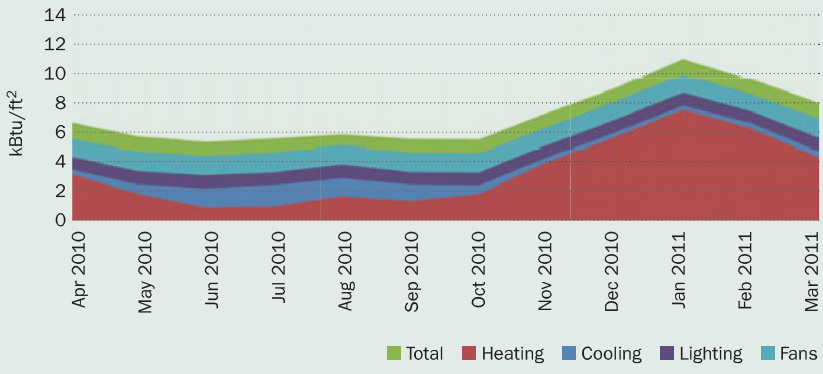
Civil Engineer
Evelyn Chan, Sandis Civil Engineers

Landscape Architect
Marq Truscott, Quadriga

Lighting Design
Mary-Jane Lawless, Silverman & Light

LEED Consultant
Pauline Souza, WRNS Studio

ENERGY USE BREAKDOWN APRIL 2010–MARCH 2011



LESSONS LEARNED

Throughout the project, the team focused on controlling costs and keeping the project on schedule These efforts were especially important given the inclusion of the new technology of chilled beams that had not been widely accepted yet.

Introducing a New Technology. Chilled beam HVAC systems are still relatively unfamiliar to most building owners in the U.S. For this reason, it took some convincing for the clients to believe that this system could be reliably delivered, and that the project could be built on time and on budget. Areas of concern were addressed during the design phase through educational meetings with potential bidders, through the use of highly detailed installation methods in the bid documents, and by locking in a price with the supplier early and requiring all subcontractors to use that unit price. Ultimately, energy efficiency, thermal comfort and indoor air quality goals prevailed over risk-management concerns.

Integrating a Construction Manager into the Process. A construction manager (CM) on board during the design phases was invaluable in receiving preconstruction constructability and cost feedback prior to bidding. The team was able to directly solicit feedback from the trades, allowing the architect/engineer team to develop a tighter set of construction documents. This process also helped the team develop a rapport with the contractor and build a positive relationship before construction began, fostering a team attitude. The contractor's understanding of the reasons behind the design concepts helped preserve the design during construction. In hindsight, the only improvement to this process would have been to bring the CM on board earlier in the design phase.

Taking Advantage of Strong Client Involvement. Strong client leadership on the H&WC's building committee helped decisions to be made efficiently, allowing the design to be delivered on schedule. Also, student representation on the building committee gave students a voice in the process and ensured their needs and concerns were represented.

heating, ventilation and cooling methods. The building envelope's high window-to-wall ratio (41%) allows for plenty of natural daylight, which, along with an efficient lighting design, results in electricity savings.

Materials-use savings from the reduction in building height reduced the environmental impacts of the materials' mining, fabrication and transportation. The climate-change impact of the building's energy use, measured in carbon dioxide equivalent (CO_2e) emissions, is 473 metric tons of CO_2e/year compared to 872 metric tons of CO_2e/year for the Standard 90.1-2004 building—a 46% reduction.

Project Finance

The design team incorporated several cost control measures throughout the project to come in under budget. The client retained an independent cost reviewer who reviewed the construction manager's cost estimates, and an early site improvement package allowed the contractor to begin construction early and minimize escalation.

To control the cost of the initial purchase of the chilled beams, the team locked in a material cost with the supplier and required all subcontractors to use that unit cost. Use of the chilled beam system also resulted in many other cost reductions. The smaller sizes of the ductwork associated with the chilled beam system allowed the team to lower the floor-to-floor height of the building from 15 ft to 14 ft, saving 3 ft of overall building height. This translated into significant savings in the steel and cladding systems for the perimeter of the building.

The project participated in the statewide Savings by Design utility incentive program run by PG&E and other utilities in California, which contributed more than $183,000 in owner incentives for energy-efficient design. After the incentives, the net additional cost to the project for the use of chilled beams was $169,000.

Based on a 2010 projected annual energy savings of $25,500, the actual payback period for the chilled beams was predicted to be 6.6 years. Since actual performance has been so much better than projected, the actual payback period will be shorter.

Conclusion

College is the first time that most students make their own decisions about medical care. The Health and Wellness Center guides them through that process with a building organized to make it easier for the students to seek care. The sustainable attributes of the center add to the healing environment for the students and save energy, reducing costs and enhancing public health by reducing the overall environmental impact of this new campus facility. ●

ABOUT THE AUTHORS

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