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FALL 2013

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Malaysia's Diamond Malaysia Energy Commission HQ

The Building Already Built
Alliance Center, Denver

Wealth of Intent, Dearth of Data
IAQ in HPB Case Studies

Adapting to Climate
EcoCommercial Building, Noida, India

Competitive Edge
25 York Street, Toronto



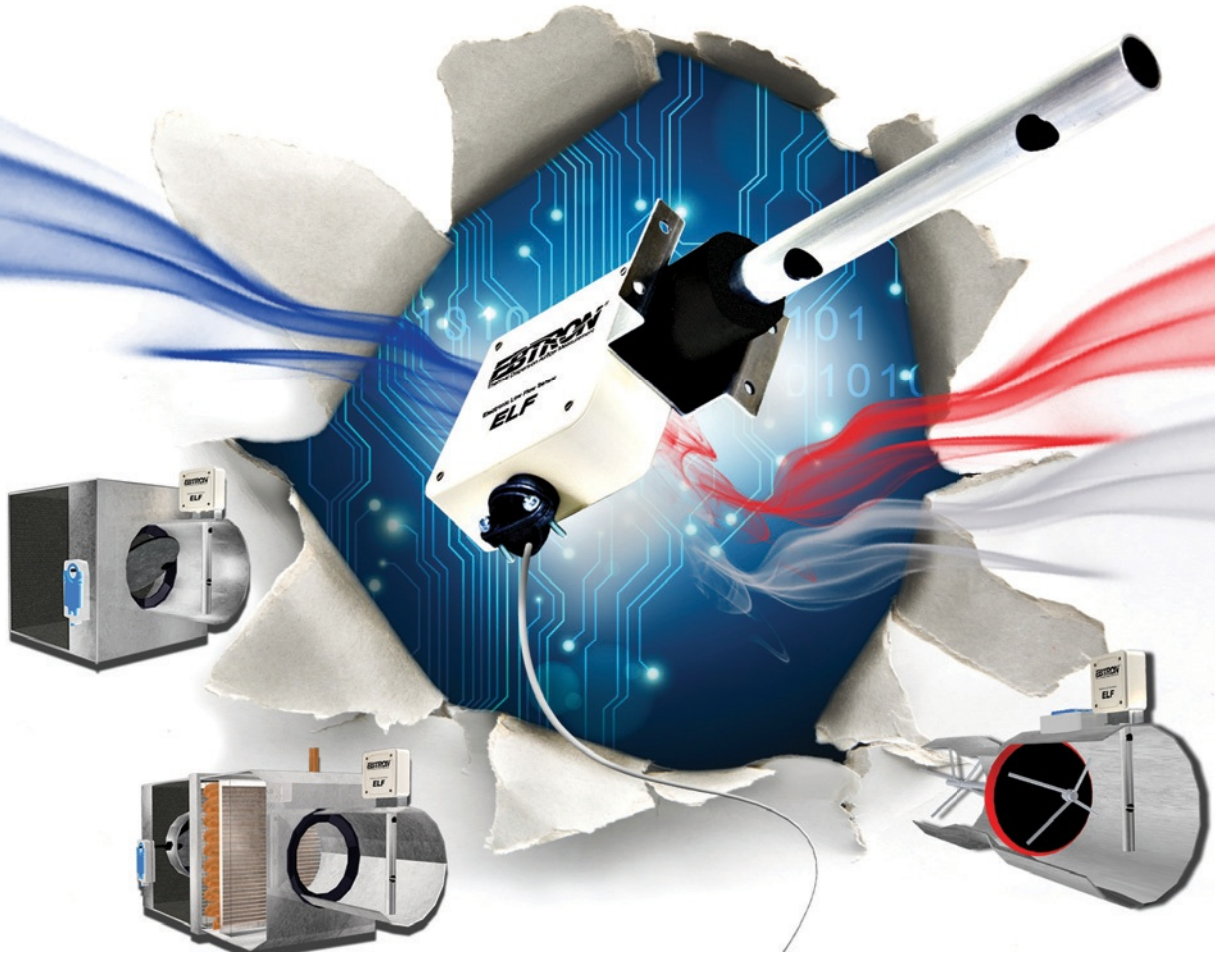
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Why Buildings Exist

Buildings are created for the people who use them, not to cover walls with energy performance plaques. When designing a building, losing sight of the human factor to achieve energy targets can come at a high cost to occupant health, comfort and productivity.

But the interactions between indoor air quality (IAQ) and energy can be complex. Dry air in an office may reduce natural defenses in the upper respiratory tract and contribute to a higher rate of upper respiratory tract infections. What will that cost in terms of productivity?

Well, we know from BOMA that tenants choose not to renew their leases in high-rise buildings because of thermal environment problems more often than any other reason. So, good IAQ can save money in terms of tenant turnover.

We also know that simply choosing to raise the temperature to save cooling energy can increase concentrations of VOCs and SVOCs and that peoples' response to these contaminants are stronger at higher temperatures. So, if the temperature needs to be reduced, what will that cost in terms of energy?

THE AUTOMATIC assumption often is that improving IAQ will cost additional energy. But, the authors of "Wealth of Intent, Dearth of Data"

(Page 34), assert that design, and operation and maintenance, strategies can support the yin-yang goals of energy efficiency and good IAQ.

We have learned that to reach the best balance of these twin goals, data is needed. So, authors Kevin Y. Teichman, Ph.D., Andrew K. Persily, Ph.D., Fellow ASHRAE, and Steven J. Emmerich, Member ASHRAE, dissected past HPB magazine case studies to discover how much IAQ performance is discussed. Their answer? Minimally.

THE AUTHORS recognize the case studies are not necessarily fully reflective of the IAQ in real-world buildings. However, the articles do skew toward metrics that show resources used (energy use intensity, gallons per flush, etc.). The authors say the only way to verify IAQ goals are being reached is by actual performance measurements, which the case studies lack.

Just two case studies included measurement data for common contaminants. Many shared creative strategies to provide good IAQ. But mostly, other aspects of building performance were more heavily emphasized.

"In our push to reduce energy consumption and negative environmental impacts associated with buildings, it is critical that we remember why buildings exist," says Persily.

Sarah Foster

High Performing Buildings describes measured performance of practices and technologies to promote better buildings, presenting case studies that feature integrated building design practices and improved operations and maintenance techniques.



HIGH PERFORMING BUILDINGS

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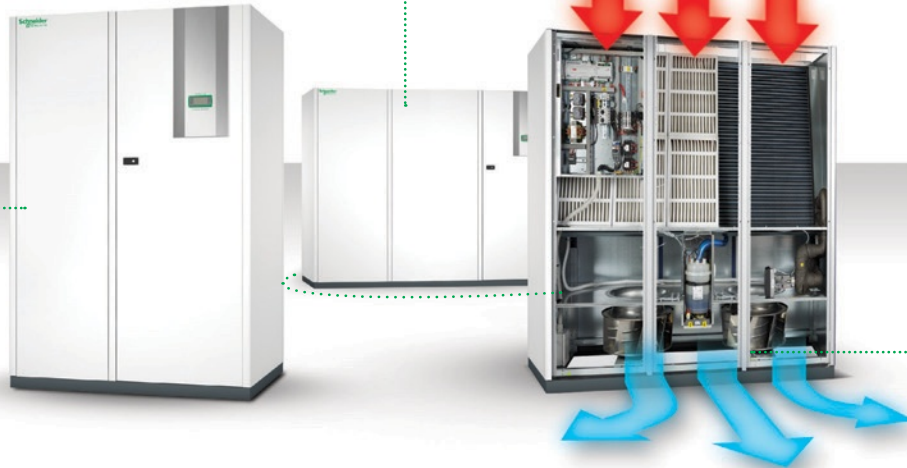
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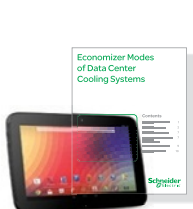
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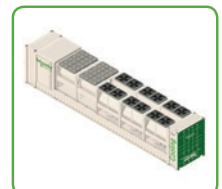
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Alliance Center

The Building Already Built

When the Alliance for Sustainable Colorado bought a century-old converted warehouse in 2004, the non-profit had barely moved in before it started tinkering to improve building performance. The organization, which seeks to advance sustainability, renovated the space into a multi-tenant nonprofit center, reducing energy use to 42 kBtu/ft², despite increased occupancy. The project provides examples of ongoing, cost-effective and relatively simple measures to reduce building energy consumption and reduce environmental impact. Several hundred visitors a year learn about the building's strategies during tours, and monthly "dine-a-logues" bring interested people together for talks and conversations on sustainability-related topics.

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Malaysia Energy Commission HQ (Diamond Building)

Malaysia's Green Diamond

The diamond shape of the Malaysia Energy Commission HQ reflects its status as a crown jewel of sustainability in that country. It incorporates self-shading to provide diffuse daylighting and views for occupants, while reducing energy use—a critical consideration in a tropical climate. The Diamond Building is one of the country's first buildings that goes beyond energy efficiency, incorporating sustainable design and strategies that reduce environmental impact. Examples include graywater recycling and on-site composting. The building uses nearly four times less energy than a typical Malaysia office building.



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IAQ in HPB Case Studies

Wealth of Intent, Dearth of Data

Good indoor environmental quality is a key goal of high performing buildings, but often is not factored into sustainable building discussions and programs. An analysis of 100 High Performing Buildings case studies reveals that most do not stress indoor air quality (IAQ). Neglecting IAQ while pursuing other goals can result in building environments that negatively impact occupant health, comfort and productivity, which defeats the overall goal of building design. It is critical to follow through on high performing designs with construction, commissioning, operation and maintenance, and IAQ performance measurements.





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Technology

NYC Metamorphosis

A roof leak repair project for a cond-op in New York's Upper East Side presented an unexpected opportunity for installing a green (vegetative) roof. Original plans called for repairing the leaks on the parking garage roof and repeating the previous limited landscaping. The committee overseeing the project instead decided to install a green roof that transformed the roof into an amenity for residents and added a system to detect any future leaks. The layout, inspired by the New York Harbor, includes trees that make up "sails" on the roof and LED pavers that change color from white to dark blue to create a feeling of waves.



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EcoCommercial Building, Noida

Adapting to Climate

An estimated 70% of India's building stock required for 2030 has not yet been built. Reducing the energy demands of this future growth can help reduce strain on the country's fossil fuel-reliant infrastructure, dependence on imported fuel and greenhouse gas emissions. The net zero EcoCommercial Building sets a benchmark for future sustainable design in India, proving that a building can deliver back to the climate rather than exploiting natural resources. Chilled beams provide radiant cooling that eliminates fan energy, while a zero water discharge system recycles and treats all sewage that is generated on site.



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25 York Street

Competitive Edge

In the competitive world of commercial real estate, why would an owner pursue sustainable design and its increased initial costs? For many developers, including the owner of 25 York Street in Toronto, the question is "why not"? High performing buildings often lease space faster and benefit owners and tenants in other ways. Building occupants at 25 York enjoy personal control of their environment through under-floor air diffusers, an abundance of daylight, rooftop garden patios and exterior views from 90% of the occupied spaces. Built on abandoned railway lands in the heart of downtown, the site provides access to alternative transportation and major attractions.

THE BUILDING ALREADY BUILT

BY PHILLIP SAIEG AND CHRIS WOLDUM

A Google search on “the greenest building is the one already built” yields about 700,000 hits. So, it seems fair to say that architect Carl Elefante’s idea resonates. The owners of the Alliance for Sustainable Colorado took his message to heart when they renovated the six-story 1908 warehouse that is home to nearly three dozen nonprofit organizations.

When the Alliance bought a century-old converted warehouse in 2004, the nonprofit had barely moved in before it started tinkering to improve building performance. The organization, which seeks to advance sustainability, renovated the space into a multi-tenant nonprofit center, reducing energy use to 42 kBtu/ft², despite increased occupancy. The project provides examples of ongoing, cost-effective and relatively simple measures to reduce building energy consumption and reduce environmental impact.

The Alliance Center began life in 1908 as a warehouse. Like many of

its neighbors in the area near Union Station in Denver’s Lower Downtown historic district, it was strictly utilitarian in character, with post-and-beam construction, plank floors, a brick façade and an elevated loading platform served by a rail spur.

More than a century later, bits of those old rail lines can still be seen peeking through the asphalt of the street out front, but the building has been transformed into an example of cost-effective high performance in existing buildings — and a

Top The original 1908 post-and-beam construction is visible throughout the building and is typical of the Lower Downtown Denver warehouse district.

Right Built in 1908, the Alliance Center’s building began as a warehouse for shipping companies using the nearby train station. It later served as the first official offices of the Wynkoop Brewing Company, Colorado’s first brewpub, founded by Gov. John Hickenlooper.

Opposite Denver’s Alliance Center is operated according to the belief that society cannot afford not to demand high performance in all buildings. The Alliance for a Sustainable Colorado aims to show how building owners can make their buildings high performance, benefiting their bottom line, the building’s occupants and the larger environment.



BUILDING AT A GLANCE

Name	Alliance Center
Location	Denver
Owner	Alliance for Sustainable Colorado
Principal Use	Office and meeting space
Occupants	Thirty-three nonprofit organizations (with about 130 people) all focused on some aspect of sustainability
Occupancy	95%
Gross Square Footage	38,000
Conditioned Space	38,000
Distinctions/Awards	LEED Gold-EB, 2006; LEED Silver-CI, 2006; LEED Gold-O&M, 2011 ENERGY STAR Leader (85 rating), 2006 USGBC National Leadership Award for Education by an Organization, 2006
When Built	1908 (Kennicott-Patterson Transfer and Storage Building)
Major Renovation	2005–06
Renovation Scope	Plumbing, lighting, build-out of individual office suites, cosmetic improvements including new carpet, paint, fixtures, furniture and equipment
Total Cost	\$867,000
Cost Per Square Foot	\$22.82
Substantial Completion/	
Occupancy	2006

All photos courtesy of The Alliance for Sustainable Colorado

testament to the truth of Carl Elefante's assertion.

When the Alliance purchased the building, its fourth and fifth floors already had been converted to office space and housed about 30 workers. The lower floors were used by the neighboring bookstore for storage. While the building was functional, it was not high performance—and high-performance buildings are crucial to sustainability, the essence of the Alliance's mission.

The renovation that followed reduced energy use, demonstrated resource efficiency and incorporated sustainable materials. The project received an ENERGY STAR rating of 85 and two LEED certifications in 2006: Gold for Existing Buildings and Silver for Commercial Interiors.



Above The Alliance Center is driven by its mission to promote sustainability and selects tenants with similar missions. This maximizes the benefits of co-location.

Left More than 1,000 people a year tour the Alliance Center to see green construction in a rehabilitated historic building. The purpose is to inspire adoption of resource-efficient measures in businesses and homes.

Bottom left Meeting rooms throughout the Alliance Center are available to tenant organizations and allied non-profit, for-profit and government groups.

The renovation, which took place from 2005–06, encompassed a range of strategies and improvements in several resource areas:

Energy and Atmosphere

The Center replaced over 1,000 40 W T-12 fluorescent lamps and magnetic ballasts with 32 W T-8 lamps and high efficiency electronic ballasts, reducing lighting energy use by over 40%. The new lamps contain 50% less mercury and phosphorus, eliminating the need to be disposed of as hazardous waste.

The lamps are dimmable, either manually or, in the case of the lights on the fifth floor, by automatic photo-sensors that adjust output according to daylight levels. Passive infrared occupancy sensors throughout the building turn lights on or off depending on human presence in the room.

The building's aging HVAC system consists of a 50-ton direct-expansion rooftop air-handling unit, two variable air volume units, diffusers, two exhaust fans, electric radiant heating panels and the associated controls. The control system was changed from pneumatic (air pressure) temperature controls to computerized direct digital controls (DDC) to set heating and cooling levels.

The DDC system allows customization of the temperature and airflow

in zones throughout the building, and monitors the internal climate, minimizing energy costs without sacrificing comfort. System managers can change settings online. The DDC

LOAD SHEDDING

Unless overridden by the operators, the Alliance's direct digital controls system will shed load by cutting out individual heating units according to a programmed sequence of operations. This feature helps reduce costs, as the local electric utility has a tiered rate system and per-kWh charges increase over a particular threshold.

Due to unseasonably cold weather (highs in the single digits), the demand limit was raised two times in 2011 to properly heat the building. While the Alliance views building performance as extremely important, building operators are not willing to sacrifice occupant comfort/productivity for energy gains. This experience further supports the planned replacement of the existing HVAC system with a highly efficient system that uses less energy.

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WATER AT A GLANCE

Annual Water Use 231,000 gallons (2011)

ENERGY AT A GLANCE

Annual Energy Use Intensity 42 kBtu/ft²*
Electricity 42 kBtu/ft²

Annual Source Energy 140 kBtu/ft²

Savings vs. CBECS 2003 55% below average for pre-1959 office buildings.

ENERGY STAR Rating 85

Heating Degree Days 5,942

Cooling Degree Days 777

Average Operating Hours per Week 60

*The Alliance has a single net meter, so any renewable generation from the 2.4 kW rooftop PV is built into the annual site EUI.

software has load-shedding capabilities (see Load Shedding) with zone-selective heating (via electric radiant ceiling panels) and cooling, allowing the system to adjust consumption to avoid exceeding a pre-established peak of 150 kW.

The system also monitors the difference between inside and outside temperatures, and, when appropriate (mainly in the summer), can circulate fresh, cool air instead of conditioned air. (The building's HVAC system is near, or even past, the end of its useful life and is slated for total replacement during an upcoming deep retrofit, slated to begin in September.)

The building's six refrigerated water fountains were replaced with unrefrigerated units, saving about 3,000 kWh a year. The front

entrance doors were replaced with units featuring 3/16 in. insulating glass with thermal edge spacers, heat mirror films suspended between the two panes, and krypton gas filling the voids. The film and the gas boost the R-value to 9.1, compared with 2.4 for traditional double-pane glass.

The doors allow the lobby to be naturally lit while blocking 99.5% of UV rays, protecting furnishings and carpeting. The lobby's windows are treated with bronze Mylar film that rejects 99% of incoming ultraviolet radiation and 60% of incoming heat.

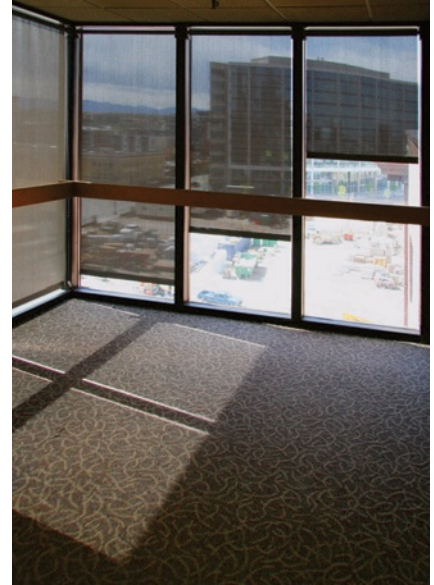
Windows on the sixth floor feature shade screens made from 100% recycled and recyclable, PVC free materials. The shade screens help control glare and heat gain or loss, while allowing outside views.

The combined savings from all these measures reduced the building's energy intensity from 56 kBtu/ft² in 2004 prior to the renovation, to 42 kBtu/ft² in 2006. The building's energy consumption dropped to 55% below the average for office buildings constructed before 1959, as determined in the Energy Information Administration's 2003 Commercial Buildings Energy Consumption Survey (CBECS).

Above left The Alliance Center provides below-market rent and operational support to over 30 nonprofit organizations all focused on some aspect of sustainable policies and practices.

Below The Alliance's historic building status creates some challenges in pursuing a high performing existing building. All exterior changes must match the historic nature of the building, creating additional considerations and constraints for improvements such as window replacements or treatments.





Clockwise from top left A 2.4 kW solar photovoltaic array on the roof supplies a small portion of the building's electricity. Its primary role is to demonstrate solar PV technology to visitors touring the building

The carpet tiles used throughout the building are glue-free, non-toxic and made from post-consumer recycled materials. They simplify maintenance by allowing undetectable replacement of individual tiles.

A bronze mylar window film rejects 99% of UV radiation, lowering the temperature by up to 15°F on sunny Colorado days and reducing heat loss during the winter.

Emission-free wheatboard (made of recycled wheat chaff) has been used for cabinets, countertops and shelving. This product is made from an agricultural waste product that is typically burned.

Recycled polycarbonate thermoplastic resin panels have been used to enable natural light to penetrate into interior offices.

Furnishings are reused or are made from recycled materials. Office partitions incorporating 80% recycled fabric over soft cores (as opposed to fabric over metal) were chosen for their sound absorptive quality to reduce noise in the building's open floor plans.

Calculating a simple payback period is not straightforward due to changing occupancy rates and electricity costs, but if electricity costs had remained at 2004 rates, the payback period would be just under 14 years. (In reality, electricity costs tend to rise over time, which would shorten the payback period.)

The Center is an all-electric building (no fuels are burned on site),

and 100% of purchased electricity is carbon offset by means of Green-e certified wind energy credits from Community Energy, Inc. The cost varies from year to year with changing energy market conditions; in 2011 the cost was \$5.50 per MWh.

A 2.4 kW solar photovoltaic array on the roof supplies a small portion of the building's electricity. Its primary role is to demonstrate solar PV technology to visitors touring the building.

Water Efficiency

In early 2006 all water fixtures were replaced with more efficient models, which reduced water consumption by 80% and saved more than \$4,500 per year—even though the number of workers in the building doubled and the number of visitors rose by a factor of 10. The new fixtures cost about \$22,000, yielding a payback time of less than five years.

KEY SUSTAINABLE FEATURES

Water Conservation Low-flow faucets and showerheads, high-efficiency toilets and urinals.

Materials Recycled, recyclable, recovered and/or reused materials are used in tiled carpeting, lobby and meeting room furnishings and some furniture. Sustainably sourced materials are used in countertops, flooring and in wheatboard paneling.

Daylighting The building has windows on three sides. Daylight penetration on the fifth floor is facilitated by use of recycled translucent office partitions made from polycarbonate thermoplastic resin.

Transportation Mitigation Strategies

The building was chosen in part because of its accessibility by public transportation and rail. It hosts an eGo CarShare vehicle and provides bicycle parking and shower facilities to encourage cycle commuting.

On-Site Renewable Energy A 2.4 kW rooftop solar photovoltaic array provides a small portion of the building's electricity demand and serves as a demonstration project.

Recycling The Center offers single stream recycling via recycling bins in every office.

TRACKING AND REDUCING INDIVIDUALS' ENERGY USE

Over 100 plug load monitors have been installed in the Alliance Center to track energy use at an individual level. A study being led by a group of graduate students from Virginia Tech University involves using this data and evaluating how social networks can be used to reduce energy consumption.

The tenants have been divided into a variety of test groups, each with varying access to a software platform that compares their energy use data to others, and allows them to track and suggest specific actions to reduce energy use. The researchers will then evaluate whether access to this energy use information and the various social network interactions changed behavior and reduced energy consumption.

The initial study took place from May through mid-July. A detailed report is expected later this year with a second study likely next spring.

The Alliance Center encourages tenants to bike to work by providing convenient bike racks and showers for bikers. The building's location provides easy access to bus and light rail routes, while an on-site car sharing option provides transportation for those needing to commute to meetings.

Infrared Self-Generating Faucets.

These faucets save water and energy by generating hydroelectric power each time water under pressure flows through internal turbines. The electrical energy is stored in a rechargeable battery inside the faucet assembly. Water flows and turns off automatically. Combined with an aerator, each cycle uses less than 0.1 gallon of water.

Low-Flow Showerheads. Low-flow showerheads deliver less than 1.5 gallons per minute. A lever on the showerhead can regulate the flow, allowing even more water to be saved while soaping up and shaving.

Kitchenette Faucet Aerators.

Faucet aerators mix air with water to increase the shower-like spray, while reducing the amount of water used to 0.8 gallons per minute. A lever on the flow restrictor quickly and easily

cuts the flow to a trickle to save water while washing dishes, hands, etc.

High-Efficiency Toilets. Toilets are dual flush (0.9 gallons or 1.6 gallons) or 1 gallon units with air pressure-assisted flushing.

Waterless Urinals. All six urinals are waterless models with slick porcelain surfaces and cartridges containing a biodegradable sealing liquid; the urine passes through the cartridges and the liquid traps odors and sediments. The urinals save about 60,000 gallons of water per year.

Materials and Resources

The renovation used recycled, reclaimed and/or sustainably sourced materials wherever possible throughout the building.

Acoustics Materials. Many offices use open floor plans to increase interaction, natural light penetration and airflow. Sound-absorbing and sound-masking materials, such as ceiling tiles, reduce noise in these environments.

Office partitions with 80% recycled fabric over soft cores (as opposed to fabric over metal), were chosen for their sound absorptive quality. Sound deadening board (structural fiberboard) is made of 97% organic materials, including recovered wood or sugar cane fibers, and has a sound transmission class rating of at least 45. Tiled carpeting mutes footfalls.

Carpeting. Where carpeting is installed, the building uses bio-based polymers made from polylactic acid (PLA), a starch from corn and other plant material. It is



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The Alliance Center is a gathering place for leaders in sustainability from across the state. A monthly speaker series brings government and business leaders to the building to discuss Colorado's most pressing issues.

nontoxic, biodegradable and recyclable. The tiles are linked without using permanent glues by use of 3 × 3 in. squares, which adhere to the backing of intersecting carpet tiles, bonding carpet tiles together.

The carpet tiles and vinyl backing are made from 56% post-industrial and post-consumer recycled

materials, and are recyclable. The modular tile design reduces waste and cost, while the nondirectional patterns reduce installation waste; together, these features allow for undetectable replacement of damaged carpet squares.

Furnishings. Most of the furnishings are reused or are made from recycled materials. The lobby features a beautiful custom-built cabinet made

from samples of reclaimed materials. Every board, hinge and latch has been used before or has been diverted from the waste stream.

Countertops and Flooring.

Countertops and linoleum floors are made of a natural product, composed of linseed oil, wood flour, resin binders and dry pigments. These ingredients are mixed and pressed onto a natural jute backing. The product lasts 25 to 40 years, is biodegradable, gives off no volatile organic compounds (VOCs), and is easily cared for.

Wheatboard. Several places in the Center feature use of wheatboard, a replacement for particleboard, plywood or medium density fiberboard. Wheatboard is made from waste wheat straw fiber-bonded with a formaldehyde-free agent.

Indoor Environmental Quality

The Center minimizes VOCs through its choices of low- and no-VOC paint, wood sealers, adhesives, flooring, furniture, wall board and doors. Paper and cleaning products are acquired from environmentally friendly sources.

Commercial quality doormats at the entrances catch dirt and keep it from entering the building. The mats help keep the carpets and flooring cleaner, reduce the amount of maintenance and cleaning required, and lengthen the life of the flooring materials.

Daylight penetration on the fifth floor is facilitated by use of recycled translucent office partitions made from polycarbonate thermoplastic resin. The panels diffuse the

ENERGY USE (KWH)			
	2004 (Pre-renovation)	2006 (Post-renovation)	2012
Jan	67,680	40,800	52,258
Feb	54,240	37,920	46,715
Mar	43,680	38,080	38,542
Apr	50,240	25,280	25,764
May	43,680	33,920	23,410
Jun	50,240	28,800	25,572
Jul	63,200	36,480	31,773
Aug	53,600	40,160	30,474
Sep	29,920	33,600	26,997
Oct	35,360	36,800	25,269
Nov	39,520	51,360	29,745
Dec	58,400	62,240	42,795
Average	49,147	38,787	33,276
Total	589,760	465,440	399,314

BUILDING ENVELOPE

Roof

Type ballasted EPDM

Overall R-value 16 (estimated)

Reflectivity 0.2–0.3 (estimated)

Walls

Type Brick

Windows

R-value (Pane Only) 9.1

Location

Latitude 39° 44'

Orientation Northwest/southeast

daylight, reducing shadows and glare, while their honeycomb moldings provide a sound barrier.

Carbon dioxide levels are monitored by CO₂ sensors linked to the HVAC system. If levels rise beyond the limit, the system automatically adds more fresh air to the mix.

Sustainable Sites

The Center is located close to bus and light-rail mass transit facilities, and an electronic kiosk in the lobby

displays transit routes and schedules. Bike racks and showers in the building encourage commuting by bicycle. The Alliance Center also dedicates one parking spot to a car-sharing option provided by one of its tenants. This car is available for tenants to use for meetings and errands to minimize the number of car commuters.

Educational Features

The Alliance's mission includes using the Center as a tool to introduce various audiences to its sustainable features and to the potential for high performance in existing buildings. Several hundred students, policymakers, building professionals and interested citizens tour the Center each year.

A touch screen and extensive digital and passive signage throughout the building enables self-guided tours. The Alliance hosts special



Above The building is open to the public during business hours for self-guided tours, which provide information about green building and sustainability issues. The public is also welcome to work in shared areas throughout the building.

Below The building's close proximity to the state Capitol is a big asset. In a typical year, over 40 sustainability-related bills successfully pass into law as the direct result of Alliance Center tenants working together.

events and monthly “dine-a-logues” that bring interested people together for talks and conversations on sustainability-related topics. These events also serve to introduce attendees to the building.



BENEFITS OF RETROCOMMISSIONING

Like all complex systems, buildings need periodic assessment and adjustment to function at optimal efficiency. The Alliance hired a commissioning firm in late 2010 to check up on the performance of the Center's various systems, including the HVAC equipment, the domestic hot water system and the lighting and daylighting controls.

A number of things were amiss. For example, the HVAC system's economizer was not set up properly. Several of the building's air terminal units were not working because of faulty controls. One of the exhaust fans ran all of the time and the other wasn't working at all.

The electric water heater leaked. Thermostats were mounted on window frames rather than interior walls, which caused them to misread interior temperatures. On the fifth floor, where the electric light output is modulated by sensors that detect how much daylight is entering the space, several of the sensors were malfunctioning.

The commissioning firm also conducted a survey of the building's tenants, which exposed further problems. Some areas were too cold, others too warm. (The excessive warmth occurred in winter and summer, pointing to different reasons.)

Several tenants found the building to be noisy on occasion, mainly because of sound transmission through walls and floors. Over half complained of unpleasant odors, probably attributable to the inoperative exhaust fan.

A variety of complaints pertained to light levels in specific areas. The Alliance has added sound insulation in problem areas throughout the building and will address temperature control issues through controls and HVAC upgrades in its impending renovation.

Unhappy tenants raise churn rates. The retrocommissioning uncovered several areas that, once addressed, helped saved energy and money by reducing resource waste and tenant turnover.

Collaboration

The Alliance believes in partnerships and collaboration as ways of boosting mission effectiveness, but collaboration also has environmental impacts. Several features of the Center help achieve both goals.

For instance, the Center offers tenants shared services (phones, copiers and printers, Internet) that save money and energy. Shared conference rooms, coordinated via online scheduling software, reduce space waste and help to keep rents down.

The Alliance Center leases space to its nonprofit tenants at below-market rates as part of its mission to promote collaboration among sustainability-focused organizations. Doing so frees up funds for program-related work that tenants would otherwise spend on rent, thereby increasing mission effectiveness. The Center essentially breaks even on rental income versus operating expenses.

Pursuing Higher Performance

With the Center, the Alliance has sought to demonstrate what can be cost-effectively done to raise building performance with relatively simple measures. However, a great deal more potential is waiting to be



Above Well-behaved dogs are welcome and actually play an intentional and crucial role in breaking the ice and developing a sense of community among the 130 people across 30-plus tenant organizations.

Below Part of the Alliance Center's mission is to help organizations achieve greater efficiencies by providing stable, healthy, reduced-cost and secure office space. The Alliance also provides a shared phone system, internet service, printing and other services to lower tenant fees and minimize administrative overhead.

tapped. Consonant with the idea of a “living building,” the Alliance has not stopped tinkering.

No matter how green a building is constructed, most of the energy it consumes over its lifetime — embodied and consumed energy — is a function of its operations. So the payback of ongoing work and experimentation to improve efficiency increases the longer its life.

Since the original renovation, the Alliance Center has undergone retrocommissioning, LEED re-certification (Gold O&M), upgrades to the building automation systems and deep submetering to allow detailed analysis of electricity consumption by zone and activity. Data collection began in the summer of 2012 and is available at <http://tinyurl.com/kt666r2>.

Submetering has identified the building's biggest energy consumers as HVAC, plug loads and lighting. HVAC and lighting will be addressed in the upcoming

renovation described below, while the Alliance Center is aiming to reduce energy consumption by engaging tenants in projects to reduce plug loads and other tenant controlled energy uses. (See *Tracking and Reducing Individuals' Energy Use*.)

The Center also rewrote its purchasing policies to comply with LEED EB: O&M's materials and resources requirements. Affected supplies and materials include consumables such as printing and copier paper, toner cartridges, business cards, batteries and lamps, and durable goods such as copiers and furniture. Many of these purchasing policies have been incorporated into the building's new “green lease” and rules and regulations.



BUILDING TEAM DURING 2005-06 RENOVATION

Building Owner Alliance for Sustainable Colorado; John Powers, founder; Janna Six, co-founder; Aaron Nelson, Alliance Center manager

Energy Consultant Ambient Energy, Denver

Mechanical Engineer E Cube, Inc.

Architect Shears Adkins Architects

Contractor Sprung Construction



QuickFacts

- **Job Name:** Williston Northampton School upgrade with building automation controls
- **Address:** Easthampton, Massachusetts
- **iWorX Controls:** LCI, BLMC, BZU2
- **Equipment Controlled:** Gas fired 600 MBH boilers.
- **Type of Application:** Retrofit construction

Project challenge

Four of the largest buildings on the 115-acre campus were connected to a 60-year-old steam system. The school's management team, along with Taco's Eastern Commercial Regional Manager, Jeff Pitcairn, developed a phased plan to update the school's HVAC systems.

Project solution

The phased plan called for a total divestment of the steam system. The buildings are now heated by hot water, feeding a combination of fan coil units and convectors. Taco's LoadMatch® system was used to deliver hot water to the 42 zones. Choosing the system controls was a no-brainer. Taco's iWorX system installs so quickly and easily that hiring a controls company wasn't necessary. The capable Williston maintenance crew was able to handle the installation without any problems. The circulators are controlled by relays hooked to the iWorX modules and thermostats. "Until now, steam from the



boilers has run through a steam-to-water tube and-shell converter, and hot water circulated through a perimeter loop of fin tube baseboard, aided by fan-coil units throughout," said Jeff Tannatt, director of physical plant at Williston. This system remains, but the heat exchanger was replaced with a water-to-water unit. Like the library, Memorial Hall dormitory was updated with iWorX controls. The existing steam convectors are also being converted to hot water. Along with student dorms, the 35,000 sq./ft. facility has six faculty apartments. "There's no one temperature all the students can agree on," said Tannatt. Each dorm room gets a separate thermostat to keep everyone happy. "Long term, we hope to build additional geothermally heated and cooled dormitories," said Tannatt. "We are also installing natural gas condensing boilers in our smaller program buildings and faculty houses. No matter what kind of HVAC equipment we end up installing in the future, the iWorX system will easily adapt to it."

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The Alliance plans to begin a deep renovation this year that aims to improve the Center's performance to LEED Platinum levels and qualify for an even higher ENERGY STAR rating. The renovation is designed to address several of the 20 "imperatives" of the Living Building Challenge—while also showing how such improvements can improve tenant well-being and satisfaction, and the building's financial performance and asset value.

Renovation plans include upgrading the building's mechanical systems and eliminating the electric radiant heating panels. The renovation also will reconfigure floor plans to provide daylight and views to areas of the building that have lacked such amenities to-date. LED lighting will replace the existing T-8 fixtures. These changes, along with new "green leases" and other tenant engagement initiatives, are projected to reduce energy use by an additional 20%.

The Alliance plans to create an account of its experience and a kind of guide or how-to manual for other building owners and investors. The ultimate goal is to show and explain why society cannot afford not to demand high performance in all buildings.

Conclusion

The Alliance is acutely aware of the challenges and opportunities posed by the built environment with respect to achieving sustainability. Existing buildings account for nearly half of U.S. energy consumption and greenhouse gas emissions, and have long lives. Given the impossibility of razing current building stock and starting from scratch, addressing climate change and other sustainability problems demands upgrading existing buildings.

The Center's renovation demonstrates that a relatively low cost project can significantly improve a building's energy performance and sustainability. Strategies such as shared conference rooms and shared office services make efficient use of office space and financial resources. The Center's ongoing improvements and upcoming deep renovation will pay dividends in energy savings and reduced carbon emissions for decades to come—perhaps even into the next century. ●

LESSONS LEARNED

Tours Prompt Collaboration. Tours of the building introduce visitors to green building technologies and design, and, more importantly, collaboration in action. This experience often opens opportunities for collaboration with each other and with building tenants.

Seek Tenant Input to Create Buy-In. The Center's tenants are partners in making the building sustainable. Tenant buy-in for energy- and resource-saving measures is essential for getting their cooperation and is valuable in helping to create an "operating team" mentality that enhances the building's efficiency. With a high concentration of environmentally focused organizations, programming buy-in becomes a natural extension of their work.

Actively seeking tenant input into operational or space design changes helps boost tenant employee well-being, morale and productivity, which makes the building more valuable as an asset. Among several exercises conducted in laying the groundwork for the Center's planned deep retrofit was a tenant design charrette. Tenants gathered with Alliance staff to brainstorm ways to make the building work better for them.

The exercise yielded a number of measures, some of which—such as supplying the eGo Car Share option and setting up a building "green team"—have already been implemented. Others are slated for incorporation in the Center's planned retrofit.

Benefits of Canine Presence. The Alliance believes that dogs are good for morale and

encourage interaction. A prominent sign by the Center's front entrance announces that "well-behaved" dogs are welcome and lays out expectations.

Tenants and visitors are encouraged to bring their canine friends to work, and many do so regularly. This explicit policy no doubt discourages prospective tenants who dislike or are allergic to dogs, but nearly half of all Colorado households have dogs and the Center has had no trouble leasing its spaces. Office dogs often provide an "ice breaker" for new interactions between building occupants and help provide work-life balance.

Hire Experts, Involve Them Early. Building team members with LEED expertise are invaluable, and the project manager should be a LEED AP. A building commissioner should be involved in the project from the start.

The Alliance Center renovation might have avoided some corrective actions by taking such precautions. For example, not long after completion of the project, the building owner noticed excessive lighting in the entrance lobby. Many signs explaining the green features of the building hang on the lobby walls, and in addition to the overhead fluorescent fixtures, more than one dozen 250 W incandescent flood lamps illuminated the signs.

Several thousand watts of unnecessary photons were blasting the signs and actually heating the room to the point of requiring air conditioning year-round. Moreover, the lamps were not linked to a switch. These problems were rapidly addressed.

ABOUT THE AUTHORS

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Chris Woldum, LEED AP O+M, is formerly the Alliance Center Manager.



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Malaysia's GREEN DIAMOND

BY T.L. CHEN, P.E., C.ENG., FELLOW ASHRAE; AND AHMAD IZDIHAR, P.E.

INSPIRATION FOR THE “DIAMOND BUILDING” NAME

During one of the initial design workshops held in 2005, the building took its shape in response to the climatic design goals. The four slanting sides (which provide self shading), inverted pyramid form, and jagged corners led the principal architect to exclaim, “It looks like a diamond.” The name stuck, and the façade cladding was intentionally designed to emulate a diamond ring.

Gregers Reimann, IEN Consultants

The glimmering green façade of the Malaysia Energy Commission Headquarters known as the Diamond Building stands in stark contrast to the surrounding brown concrete government buildings. It stands apart in other ways, too: its sustainable design and building energy intensity of $20.6 \text{ kBtu/ft}^2 \cdot \text{year}$ mean it uses on average four times less energy than typical Malaysian office buildings. The building is designed to showcase technologies that reduce building energy and water consumption, promote use of sustainable building materials and provide enhanced indoor environmental quality.

Energy efficiency was a top priority in 2005 when the Energy Commission of Malaysia, Malaysia's regulatory body for energy policies, standards and safety, embarked on building its own headquarters building in the country's administrative capital of Putrajaya. However, the project team decided to venture beyond energy efficiency by going green, a relatively new term in Malaysia at the time. The resulting double Platinum-rated building is now a tourist attraction within the global sustainable community and serves as an example for private industry.

This building demonstrates that a Green Building Index Platinum rating (Malaysia's green building rating system) can be achieved with an additional cost of 6%. As a result, the number of green buildings in Malaysia has exploded since the Diamond Building's construction in 2010. (More than 50 million ft² [4.6 million m²] has been certified by Green Building Index [GBI] in the past four years.)



Photo by Lin Ho. Courtesy of Putra Perdana Development Sdn Bhd.

Diamond Shape

Climate and the solar path of equatorial Malaysia (3° north) helped shape the building's diamond design. Solar studies showed that 25° tilting façades would provide self shading on the north and south façades. To maximize daylighting, a central atrium was introduced, and the diamond shape was born.

The diamond symbolizes transparency, value and durability, characteristics that represent the Energy Commission's role and mission as a regulatory body. The shape also represents an optimal design approach to achieve energy efficiency.

The building includes seven floors above grade and two underground levels for parking. The seventh floor includes a small theater, board room and dining room.

Low-e glazing helps reduce direct solar heat gain for the east and west façades. The glazing's visual light transmittance (VLT) of more than 0.5 allows for effective natural lighting to the office interior in conjunction with lightshelves. The inverted diamond shape increases the ground space available for landscaping, which helps reduce the heat island effect.

Above The Diamond Building is the headquarters of Malaysia's Energy Commission. The building is designed to showcase technologies that reduce building energy and water consumption, promote use of sustainable building materials and provide enhanced indoor environmental quality. Strategies include self-shading façades, daylighting and floor slab radiant cooling.

Below The inverted pyramid shape increases ground space for landscaping while maximizing roof space for PV panels.

Opposite The atrium dome provides internal daylight throughout the building core.

BUILDING AT A GLANCE

Name Malaysia Energy Commission Headquarters (Diamond Building)

Location Putrajaya, Malaysia (15 miles south of Kuala Lumpur)

Owner Energy Commission of Malaysia

Principal Use Office

Employees/Occupants 400

Occupancy 100%

Gross Square Footage 158,075
Conditioned Space 123,450

Distinctions/Awards ASEAN Energy Award, 2012; ASHRAE Technology Award 2013 (Second Place, Category I); Green Mark Platinum, 2010 (Singapore); Green Building Index (GBI) Platinum, 2010 (Malaysia)

Total Cost USD\$21.5 million
Cost Per Square Foot \$136

Substantial Completion/Occupancy June 28, 2010

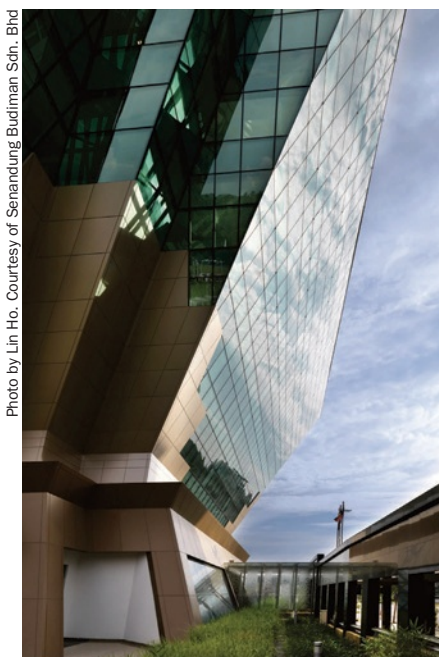


Photo by Lin Ho. Courtesy of Senandung Budiman Sdn. Bhd.

TABLE 1 ENERGY USE
MODELED ENERGY
SAVINGS

	Energy Savings (%)
Lighting	53.6
Air-Conditioning Plant	47.1
Air-Side Fans	90.9
Mechanical Ventilation	10
Elevators	10
Domestic Water System	30.3
Garage Lighting	60.2
Total Building Energy Consumption (with PV)	46.1

Note: Energy savings derived from reference model based on compliance with Malaysian Standard 1525:2007 with building energy intensity (BEI) of 64 kBtu/ft²·year instead of a typical office BEI of 79 kBtu/ft²·year. See note in *Energy at a Glance* (right) for definition of building energy intensity.

While the building may appear to be fully glazed, metal cladding replaces the exterior glazing for the first meter of each floor. Using glazing for this lower wall section does not serve any notable purpose in terms of energy efficiency and daylighting.

Extensive computer simulation of the diamond form was conducted to ensure that the building performed as designed in regard to daylight levels and energy use. To maintain

the occupants' visual comfort, various daylight simulation exercises were conducted to verify that daylighting would be adequate and well distributed.

Energy Efficiency

The design building energy intensity (BEI) was 27 kBtu/ft²·year (85 kWh/m²·year), representing a 65% reduction compared to a typical office building in Malaysia with a BEI of 79 kBtu/ft²·year (249 kWh/m²·year). Energy simulation was performed with IES Virtual Environment software conforming to ASHRAE Standard 140-2004 and Standard 90.1-2007 (*Tables 1* and 2).

Energy efficiency performance of the building recorded for the period from October 2010 to November 2011 is depicted in *Figure 1*. The actual BEI of 20.6 kBtu/ft²·year (65 kWh/m²·year) has surpassed the design target to achieve an annual energy savings of more than 70%.

HVAC System

The Diamond Building is designed to provide thermal comfort using the following strategies:

- Floor slab radiant cooling addressing the sensible load of the air-conditioned space; and

TABLE 2 COMPARISON OF ENERGY CONSUMPTION
AND COOLING LOAD, OCT 2010–SEPT 2011

	Total Electricity (kBtu/yr)	Total Electricity with PV (kBtu/yr)	Total Cooling Load (kBtu/yr)
Proposed Model	3,746,738	3,479,977	7,514,732
Reference Model	6,462,342	6,462,342	11,536,040
Total Savings	42%	46.1%	34.9%
Actual Performance	2,753,709	2,409,254	6,258,911

Note: Reference model based on compliance with Malaysian Standard 1525:2007.



Landscaping surrounding the building helps reduce the urban heat island effect. On-site composting provides nutrients for plants, reduces the need for fertilizers and reduces waste.

WATER AT A GLANCE

Annual Water Use 896,000 gallons

ENERGY AT A GLANCE

Annual Building Energy Intensity (BEI) (Site) 20.6 kBtu/ft²

Electricity (From Grid) 20.6 kBtu/ft²

Renewable Energy 2 kBtu/ft²

(connected to the national grid to receive a higher feed-in tariff rate)

Annual Source Energy 61 kBtu/ft²

Annual On-Site Renewable Energy Exported 2 kBtu/ft²

Annual Net Energy Use Intensity 18.6 kBtu/ft²

Savings vs. Standard 90.1-2004 Design Building 54.9%

Average Operating Hours per Week 52

Note: BEI is the total energy consumption, excluding parking garage, divided by the total gross floor area (GFA), excluding parking garage GFA, and rationalized for 2,704 hours operation per year (or 52 hours/week, the standard office working hours in Malaysia). It is also corrected for vacancy space if the building is not 100% occupied. See FAQ 9.5 at www.greenbuildingindex.org/FAQs-9.html for the formula for BEI.

- Air-side system addressing the latent load, air movement and air filtration. Primary chilled water is supplied by a district cooling system (DCS) plant. While the facility is called a gas district cooling plant, in reality the existing plant has more

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When Missouri’s Hazelwood School District needed to update the HVAC systems in a number of buildings, Steve Limas of KAI Design & Build in St. Louis proposed Daikin VRV. “Daikin is at the forefront of efficiency and design flexibility,” Limas said. “The modulating compressor results in a more efficient refrigerant system, matching the load exactly and saving energy.”

A Daikin air-cooled VRV Heat Recovery system replaced an old 200-ton two-pipe chiller system in Northwest Middle School.

The decision to use Heat Recovery VRV allowed Limas to take advantage of building diversity to maximize energy savings.

The district has realized substantial HVAC energy savings, according to facilities director, Tom Mangogna. Limas isn’t surprised. “Daikin systems actually change the electrical demand performance of a building.” Daikin’s minimal maintenance requirements and low noise levels also appealed to Mangogna. “My teachers appreciate the reduction in noise level. You can barely hear these systems”.

Flexibility, efficiency and energy savings — just a few of the reasons why both Hazelwood School District and KAI Design & Build are Likin’ Daikin.



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Photo by Lin Ho. Courtesy of Senandung Budiman Sdn. Bhd

The east and west façades receive morning and afternoon sun, but low-e glazing and blinds help reduce heat gain and prevent glare.

electric-driven chillers than gas-fired chillers. The building chilled water plant primarily consists of two heat exchangers, one duty and one standby, each of 4,197 kBtu (1230 kW) capacity.

Two distinct control strategies are used for office operating hours (cooling is provided via air-handling

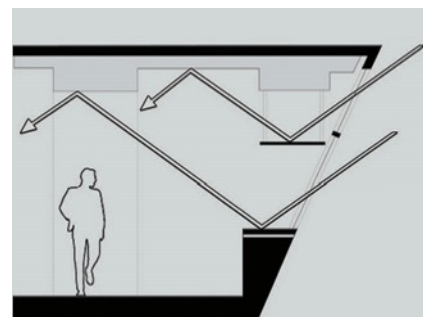
units) and for thermal mass charging mode. During the six to eight hours of thermal mass charging mode, chilled water from the building plant is directed to the concrete slab to achieve a slab temperature of 64.4°F (18°C) to 68°F (20°C) to provide radiant cooling during office hours. The slab-cooled concrete floors act as a cooling rechargeable battery, or thermal mass storage, being charged daily from 10 p.m. to 6 a.m. (during the off-peak tariff period).

Lighting Systems

The Diamond Building is designed to be at least 50% daylit, without glare and with minimal heat entry. The energy-efficient artificial lighting system is daylight responsive. The lighting load is 2.5 Btu/ft² (8 W/m²) with an illumination level of 27.9 fc (300 lux) to 37.16 fc (400 lux), conforming to Malaysian Standard 1525-2007, *Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings*.



Photography by Lin Ho. Courtesy of Senandung Budiman Sdn. Bhd



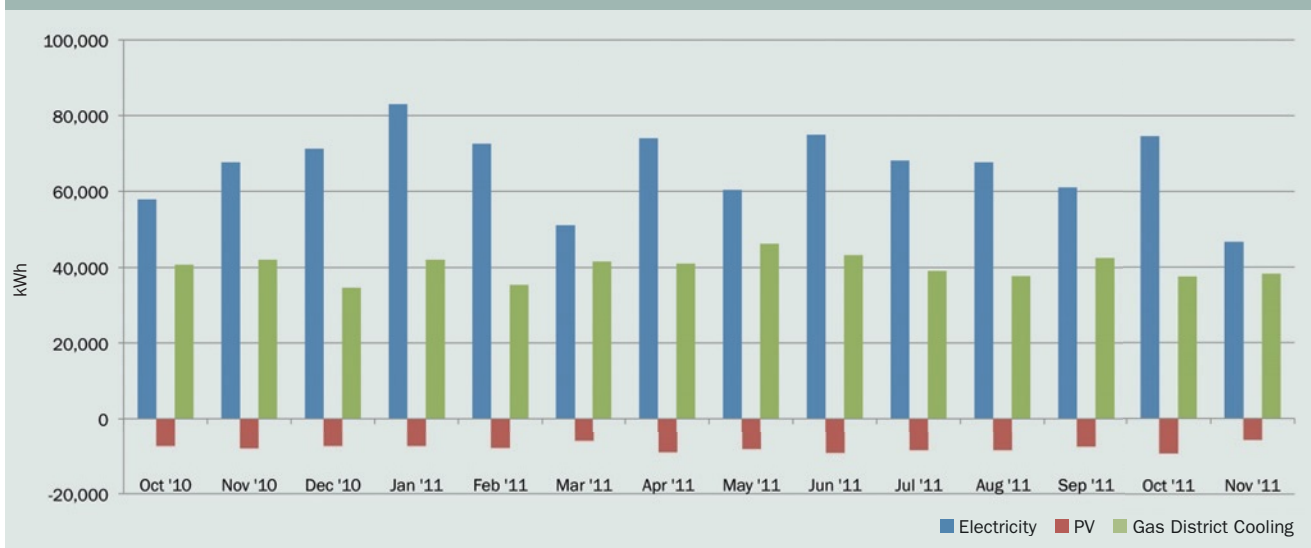
Source: Greening Asia—Emerging Principles for Sustainable Architecture

Diffuse light is deflected deep into the room by the mirror lightshelf and window sill.

Daylight Strategies

Façade Daylighting. Daylight is reflected off the mirror lightshelf and window sill, and cast onto the ceiling, deflecting it deep into the room. This design, along with fixed blinds, help prevent glare.

FIGURE 1 ENERGY USE, PV GENERATION, OCT 2010–NOV 2011 (KWH)



Note: While the facility district cooling system plant is called a gas district cooling plant, in reality the existing plant has more electric driven chillers than gas fired chillers.



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Photo by Lin Ho. Courtesy of Senandung Budiman Sdn. Bhd

Graywater from the building is recycled in a mini wetland area, reducing potable water demand for irrigation. Microorganisms living on the root of the reed bed cleanse the water before it is released.

Atrium Daylighting. The daylight design of the atrium consists of three key design elements:

- An automated blind that regulates light penetration into the atrium;
- Different window sizes for each floor; and
- Reflective aluminum panels.

The automated atrium glazing roller blind consists of 24 individual blinds that can form six configurations depending on the outdoor light levels. The blinds allow 30% of the light through to ensure daylighting for the offices facing the atrium even when the atrium blinds are fully engaged.

Two light sensors on the atrium glazing control the blind operation. The principal control strategy aims to block direct sunlight penetration into the offices and to moderate the light level in the atrium, so it is “just right” throughout the day.

Daylight availability decreases deeper into the atrium. For the upper floors, windows are replaced

with white walls (to reflect light deeper down the atrium), while floor-to-ceiling windows are used for the lower floors. Aluminum panels mounted on the fourth and fifth floor of the atrium walls reflect light to the first and second floors.

Skylight. At the lounge area outside the small theater on level seven is a skylight that takes in mostly diffuse light from the southern part of the sky. The skylight brings in sufficient light to illuminate the lounge area, eliminating the need for electric lights during the day.

Lighting System and Control Daylight Responsive Lighting

Control. To maximize daylighting, the artificial lighting system is daylight responsive. Two light sensors are installed on each façade with one additional sensor on the first floor to measure the atrium light level.

A building automation system (BAS) centrally controls electric lights in the daylight zones via light sensors. All work tables have individual task



Photo by Lin Ho. Courtesy of Senandung Budiman Sdn. Bhd



Photo by Lin Ho. Courtesy of Putra Perdana Development Sdn. Bhd

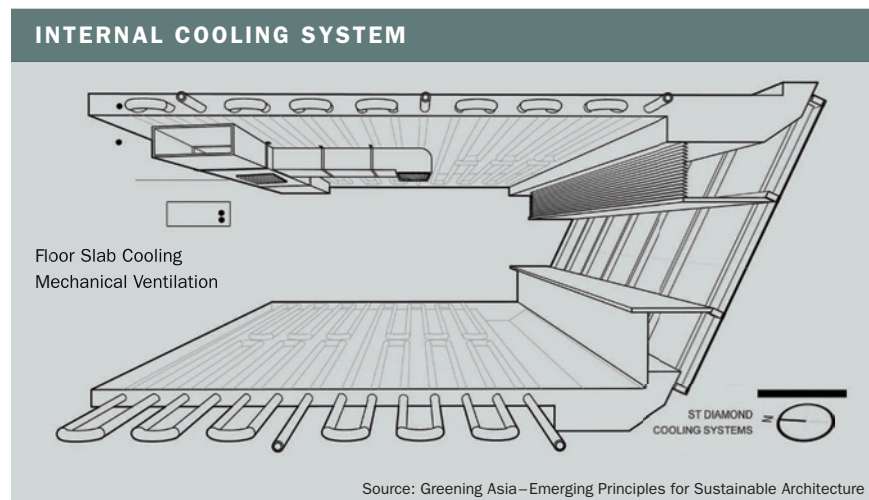
Top An automated roller blind controls lighting in the atrium. Its various configurations help prevent direct sun while still illuminating the space. In this image, it is fully engaged.

Above The blinds open completely when conditions allow. White walls and aluminum panels deflect light into the lower floors.

lights, providing flexibility and comfort of individual light control.

Energy-Efficient Electric Lights.

General office lighting is ceiling suspended with electronic ballasts and T5 tubes of 104 lumen/W efficacy. Compact fluorescent downlights are used in the common areas and T5 light fittings are used in the garage.



Source: Greening Asia—Emerging Principles for Sustainable Architecture

Floor slab radiant cooling and a mechanical air-side system provide conditioning and ventilation. The concrete floors are charged each night, acting as a rechargeable battery as they release cooling throughout the day.



3 Ways to Win

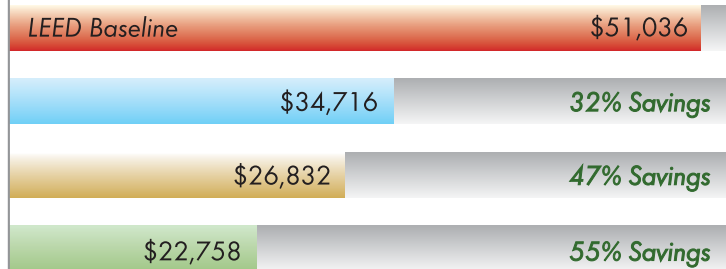
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Above Ample glazing connects lobby occupants to the outdoors. Low-VOC paints and carpets help maintain good indoor air quality.

Right A skylight illuminates this internal lounge area on the seventh floor, eliminating the need for artificial lighting during daylight hours.

KEY SUSTAINABLE FEATURES

Water Conservation Water-efficient fittings save more than 67% of potable water compared to conventional water fittings.

Recycled Materials Represent 31% of material cost. Recycled contents in dry walls, ceiling boards, carpet and floor finishes.

Daylighting Façade daylighting, atrium daylighting (automated blinds, different window size on each floor and reflective aluminum panels), and reflected roof light.

Carbon Reduction Strategies Energy-efficient strategies such as daylighting, radiant floor cooling and efficient artificial lighting reduce CO₂ by 1,673 metric tons per year.

Transportation Mitigation Strategies Ten percent of parking garage spaces are designated for green/fuel-efficient vehicles and carpool vehicles; secure bicycle racks; location served by public transportation; and shaded walkways for pedestrians (linking with master development).

Other Major Sustainable Features Rainwater harvesting, graywater recycling via mini wetland, solar photovoltaic array, atrium stratification control, heat pipes, on-site composting, advanced air filtration, condensate harvesting, thermal mass storage, heat recovery from shower drain, and recycling of test water from fire sprinkler system.

Occupancy sensors are installed in the bathrooms to control lighting and exhaust fans. In the open office area, lighting is zoned so it can be limited to only the areas needing it.

The total lighting energy is reduced substantially from the baseline annual building load of 1,781 MBtu (522 MWh) to 1,160 MBtu (340 MWh), up to a 35% savings. In addition, the energy-efficient artificial lighting reduces the cooling load by 5.4%. The use of daylight helps to further reduce the total lighting energy from 1,160 MBtu/yr (340 MWh/yr) to 788 MBtu/yr (231 MWh/yr) which represents an additional 32% reduction from the base building.

IAQ, Thermal Comfort

The Diamond Building is designed to create a pleasant, healthy and comfortable working environment for occupants. Low volatile organic compound (VOC) paints (certified under the Carpet and Rug Institute Green Label) are used throughout the building. Likewise, only low VOC carpets (Green Label Plus certified) are used.

Ventilation air is provided via a primary air-handling unit located at the roof, which precools the air to 68°F (20°C). Heat pipes are installed for the primary air-handling unit to aid in relative humidity control without energy penalty.



Photo by Lin Ho. Courtesy of Putra Perdana Development Sdn Bhd

The precooled air is distributed through floor air-handling units except at the ground floor where it is introduced directly into the conditioned space. The ventilation rate complies with ASHRAE Standard 62.1-2007.

The primary air-handling unit also is designed for space dehumidification. Demand-control ventilation is regulated by CO₂ sensors. This system is designed to provide good IAQ and energy-efficient operation, which is critical in an equatorial climate where ventilation air is hot and humid throughout the year.

The variable air volume (VAV) system with a default minimum airflow setting also helps maintain good IAQ. Following construction, a pre-occupation air flush out was performed by supplying outdoor air to provide 10 ach for at least 30 minutes for the whole building. A permanent air flush-out system, which also meets fire code requirements for a smoke spill system, is provided.

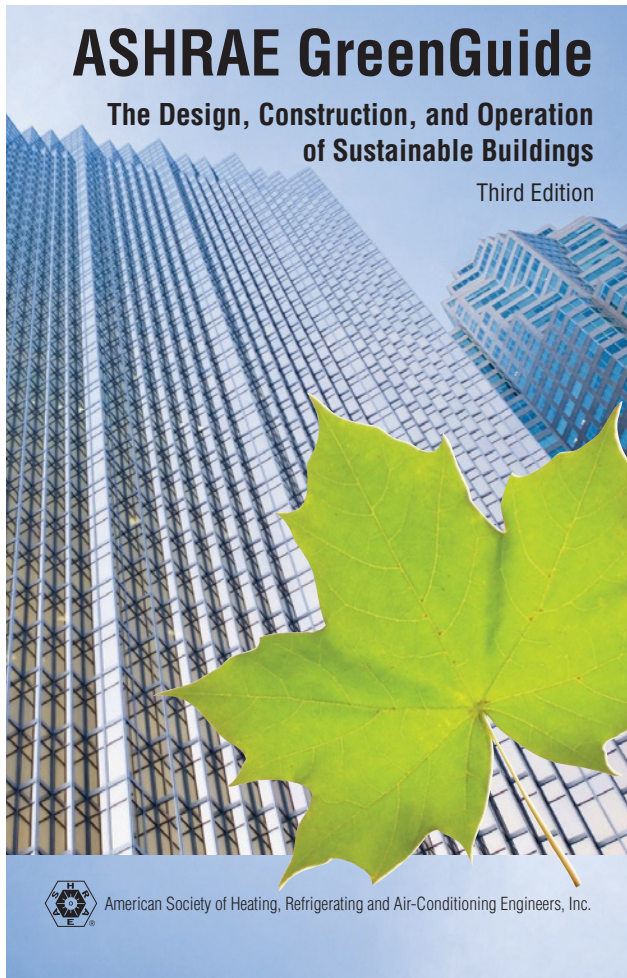
The dehumidified ventilation system also keeps the air dry to obviate the possibility of condensation on the surface of the chilled floor slab, which is maintained at 64.4°F to 68°F (18°C to 20°C) to be sufficiently above the dew-point temperature of 60.8°F (16°C).

A 12-month post-occupancy comfort survey was carried out to collect occupants' responses regarding thermal comfort, visual comfort, acoustic comfort, glare comfort and odor problems. Over 80% of the occupants expressed satisfaction. The

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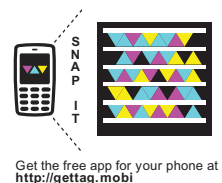
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- Updates on teaming strategies
- Information on how issues related to carbon emissions affect building design and operational decisions
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Roof

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Overall R-value 24 (bare) and 25 (green roof)

Solar Reflectance Index (SRI) >29

Walls

Type*	Opaque Glass Curtain Wall	Metal Clad Wall	Brick Wall
Overall R-value	13.9	13.2	1.9

Glazing Percentage 40%

Windows

East/West Orientation

U-value 0.072

Solar Heat Gain Coefficient (SHGC) 0.37

Shading Coefficient (SC) 0.43

Visual Transmittance 52%

North/South Orientation

U-value 0.956

Solar Heat Gain Coefficient (SHGC) 0.46

Shading Coefficient (SC) 0.53

Visual Transmittance 55.9%

Location

Latitude 2.93° N

Orientation 101.7° E

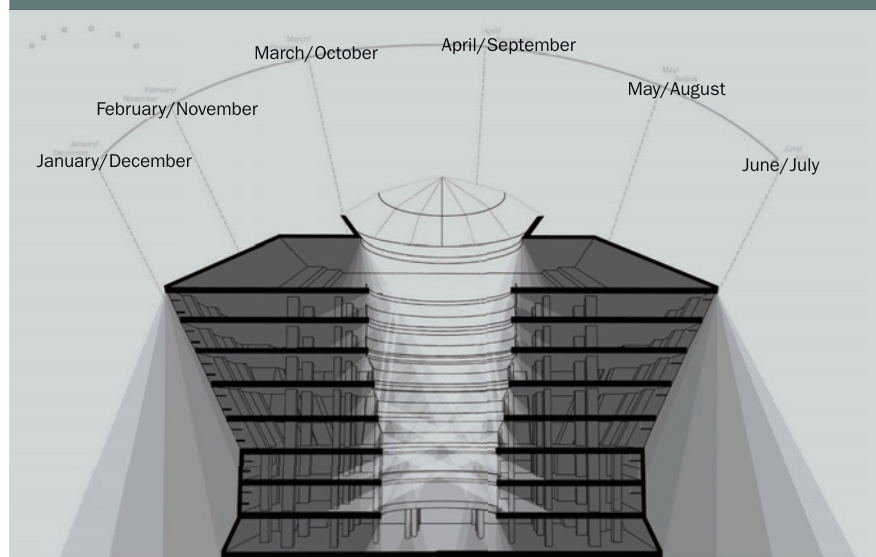
*Curtain wall and metal clad wall are insulated, while the brick wall is not insulated.

only complaint identified a lack of air movement in two stagnant areas, which has since been addressed.

Innovation and Green Features

Rainwater Harvesting. Using rainwater for toilet flushing and irrigation has reduced annual potable water consumption by 35% compared to potable water otherwise used for industry standard water fittings and irrigation as defined by the Green Building Index. Rainwater is collected from the 7,530 ft² (700 m²) catchment area dome and stored in four 2,600 gallon (10,000 L) rooftop tanks.

ANNUAL LIGHT-RAY TRACING



As daylight angles shift throughout the year, the building design still allows for ample internal daylighting via the atrium and self shading on the north and south façades.

Wastewater Recycling. Wastewater (graywater) is collected and discharged to a mini on-site wetland area that incorporates a reed bed planting system. The graywater irrigates the plants within the wetland via a subsoil soaker hose.

Microorganisms living on the root system of the reed bed cleanse the graywater. The wastewater is stored for no more than 24 hours, and any excess is channeled to the town sewage system.

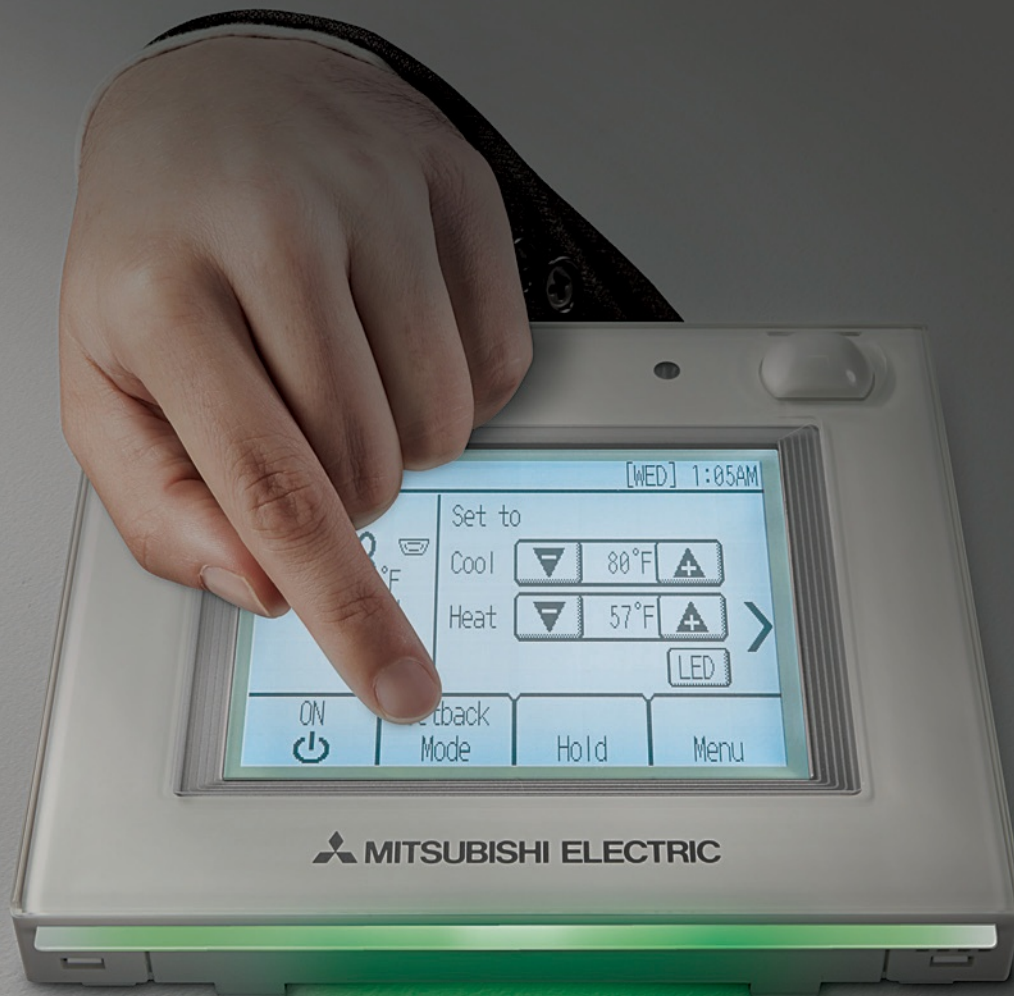
Water-Efficient Fittings. These reduce potable water use by more than 67% compared to conventional plumbing fittings. These fittings include toilets with dual flush systems; faucet aerators; showerhead aerators; and urinals modified to provide a small amount of water, making them suitable for Muslim use.

Muslim practice requires males to use water to clean up after using a restroom. A water flush with limited cleansing water of 0.03 L/s (0.475

TABLE 3 IAQ MEASUREMENT

COP limit	<3,000	<1,000	<10	22 to 26	40 to 70	<100	<150
	Total Volatile Organic Compounds ppb	CO ₂ ppm	CO ppm	Temp. °F	RH %	Formaldehyde (HCHO) ppb	Particulate Matter 10 µg/m ³
Level 2	786	470	0.5	72.9	63	30	14.3
Level 3	609	414	0.4	71.8	65	45	12.5
Level 4	706	455	0.5	72.9	60	50	15.1
Level 5	370	453	0.4	72.0	57	45	10.5
Level 6	435	433	0.4	71.6	59	30	11.2
Level 7	609	400	0.3	71.6	65	90	9.6

Source: Greening Asia – Emerging Principles for Sustainable Architecture



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Photo by Lin Ho. Courtesy of Putra Perdana Development Sdn Bhd

The building is designed to be at least 50% daylight. The building automation system controls the energy-efficient artificial lighting via daylight sensors.

BUILDING TEAM

Building Owner/Representative
Energy Commission of Malaysia

Architect NR Architect

General Contractor
Putra Perdana Construction Sdn Bhd

Mechanical, Electrical Engineer
Primetech Engineers Sdn Bhd

Energy Modeler IEN Consultants Sdn Bhd

Structural, Civil Engineer
Perunding SM Cekap

Landscape Architect
KRB Enviro Design Sdn Bhd

Lighting Design Primetech Engineers Sdn Bhd, Megaman (Malaysia)

Green Building Index (GBI) Consultant
Exergy Malaysia Sdn Bhd

gpm) per flush is incorporated for their use. Non-Muslims do not need to press the flush button to clean up. In Malaysia, such modified urinals are referred to as “less water” (water-less) urinals, rather than “no water” (waterless) urinals.

Energy-Efficient Office Equipment.

A procurement policy allows for the purchase of only energy-efficient labeled equipment and appliances with five-star ENERGY STAR ratings. Centralizing and networking printers also increases efficiency.

Renewable Energy. A 244 kBTu (71.4 kW) photovoltaic installation consisting of 1,112 rooftop panels provides 10% of the building’s energy needs. The generated

energy is now connected to the national utility’s grid under the Feed-in Tariff scheme (2012). The panels have generated a monthly average of 28,320 kBTu (8,300 kWh) and 341,200 kBTu (100,000 kWh) annually.

Atrium Stratification Control. An elevated 137 ft (41.8 m) atrium contains the hot air pocket (about 104°F [40°C]) below the atrium glazing. Only the circulation space on the ground floor level of the atrium is air conditioned.

Advanced Air Filtration (Electrostatic Precipitator). This air cleaner ensures good IAQ, especially during the time open burning in Indonesia causes haze.

On-Site Composting. Landscaping and food waste is composted, and the end product is used on site for landscaping. This strategy reduces fertilizer costs and recycles resources rather than increasing the waste stream.

Condensate Water Harvesting.

Especially productive for Malaysia’s year-round humid climate conditions, plans in the near future include using the harvested cool water to provide evaporative cooling around the external walkway paths.

Operation and Maintenance

The Diamond Building was the first building in Malaysia to engage the services of a GBI registered commissioning specialist, whose services helped improve building operating efficiency.

LESSONS LEARNED

Overcoming Skepticism. Convincing clients to adopt new concepts and emerging technologies in a developing country is often more challenging than the design itself. Stories of failures or unsatisfactory performance, especially within the region, had not helped, although such failures are often traced to such technologies not being “tropicalized” to suit the local climate and environment.

Prior to the Diamond Building’s construction, a government demonstration building adopted slab cooling, which required various modifications for over two years before it could finally achieve acceptable occupant comfort.

Fortunately, two favorable factors convinced the client to pursue sustainable strategies for this project. The developer/contractor is a leading proponent of sustainable construction and had been involved in government funded demonstration projects to showcase energy efficiency. In addition, the MEP engineer successfully implemented emerging technologies in the Malaysia Securities Commission Headquarters, an award winning energy-efficient building built a decade earlier.

Slab Cooling. Minor condensation was spotted at the chilled water pipe manifold riser cupboards. With a congested piping manifold, proper pipe insulation is difficult and a

risk of cold spots on the slab exists due to the looped pipe bottleneck area at the riser. Future designs should consider smaller zones served by each riser, since more risers would allow adequate spacing for proper pipe insulation to mitigate such problems.

The slab charging strategy involves presetting a fixed charging duration based on the best estimated calculations. To achieve uniformity of slab temperature during chilled water charging and eliminate the risk of overcharging, temperature sensors to control the duration of charging should be installed. These sensors can have set-points to allow for dynamic control of the charging process.

Air Movement. Recognizing that air handlers sized to remove only the latent load will provide insufficient air movement for a year-round hot and humid climate application, higher air movement was originally addressed by incorporating fan-assisted VAV units. However, due to the extremely high escalated metal costs (when the project was bid out in 2008–09 at the height of the world metal price crisis), these were replaced with normal VAV units. The redesign uses enlarged ringed ducts to maintain a minimum of 4 ach. Unfortunately, due to space constraints, the compromised ringed ducts did not achieve the desired minimum airflow, resulting in a few “stagnant” areas.

District Cooling Commercial Charge Rates.

The Diamond Building has prompted the district cooling plant operator to consider storing cooling thermal energy generated during the off-peak tariff period in buildings rather than investing in costly thermal storage plants.

Owners of projects that incorporate charging thermal mass with chilled water and that are served by a district cooling system (DCS) should negotiate the after-hours chilled water cost. Negotiations for lower rates can be based on the cost-effective higher charging temperature (46°F–48°F for the DCS versus 60°F for the Diamond Building) and the capital cost savings to the DCS operator who can use the building slab for thermal mass storage rather than construct additional thermal storage plants.

Integrated Design. Early integrated design is key to achieving successful sustainable building design and operation. The planning process began with trips to visit other green projects in Singapore and Thailand, and design workshops/brainstorming sessions, which included all of the key consultants. Any “crazy idea” to advance the goals of energy efficiency and sustainable design was welcome during this session. The energy efficiency consultant created building simulations quantifying performance (energy, daylight, thermal comfort, etc.), iteratively aiding the building design development.

Cost-Effectiveness

The building’s eco-friendly measures cost USD\$1 million, representing about 6% of the total construction cost. Savings of almost USD\$333,000 annually in operating costs from energy efficiency (USD\$317,000) and solar power generation (USD\$15,000) result in an estimated payback of 3.5 years despite Malaysia’s subsidized utility tariff rates.

Environmental Impact

The operational carbon (CO₂) reduction achieved by the Diamond Building (as verified by the GBI Assessor) amounts to 1,673 metric tons per year, which is akin to

taking 900 cars off the road (assuming each car travels 7,500 miles/year). This reduction is derived from savings of electricity energy alone and does not include reduction due to water savings, waste discharge, refuse recycling and embodied carbon.

Conclusion

The Diamond Building represents a new approach toward climate responsive building design in Malaysia. Energy savings of four times that of typical office buildings demonstrate the environmental and financial benefits of strategies such as climatic design, daylighting

and in-slab radiant cooling. Good indoor air quality access to sunlight provides a pleasant working environment. Practices such as on-site composting and graywater recycling reduce demand for resources while also reducing the waste stream. ●

ABOUT THE AUTHORS

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Ahmad Izdihar, P.E., is the CEO of Exergy Malaysia and Associate of Primetech Engineers.



WEALTH OF INTENT, DEARTH OF DATA



© Opposite, clockwise from top left: Halkin Photography; Anne Hansen, Weber Thompson; Jamie Forsyth; Chris Meek, UW Integrated Design Lab

BY KEVIN Y. TEICHMAN, PH.D.,
ANDREW K. PERSILY, PH.D., FELLOW ASHRAE,
STEVEN J. EMMERICH, MEMBER ASHRAE

GOOD INDOOR ENVIRONMENTAL QUALITY (IEQ) is a key goal of high performing buildings, but often is not factored into sustainable building discussions and programs.¹ Buildings exist to support occupant activities and needs. Therefore, efforts to reduce energy use or other environmental impacts that degrade IEQ can have potentially significant negative impacts on health, comfort and productivity.² While critically important, energy is only one aspect of building performance and should not be pursued to the neglect of IEQ.

As part of its activities to support the design and construction of sustainable buildings, ASHRAE began publishing *High Performing Buildings* (HPB) in winter 2008. In recent years, the magazine has sought to present key building information, including energy and water consumption data, in a consistent format that enables comparisons across buildings of different size and function in different climatic zones. Grumman and Hinge recently summarized energy data from 60 buildings and more detailed characteristics from eight buildings featured in HPB (*What Makes Buildings High Performing*, Spring 2012).*

However, indoor air quality (IAQ) is often given minimal attention in high-performing buildings, as evidenced by our review of 100 case studies published in HPB, relative to energy, water, and waste considerations. We hasten to add that this is not uniformly true, citing two

notable examples to the contrary that concluded: (1) “The highest return on the construction dollar [is] human productivity in the designed space” (*Resourceful By Nature*, Spring 2012) and (2) “Indoor air quality measurements of the building confirm that

careful design of the HVAC systems, proper building material selection, implementation of green building cleaning practices, and regularly scheduled HVAC maintenance can result in excellent IAQ and energy efficiency” (*Proving Performance*, Winter 2012).

These two articles were exceptions among the case studies we reviewed, because they provided measurement information on indoor pollutants other than carbon dioxide (CO₂). Readers may find the recent paper of Newsham, et al., informative, because the authors took physical measurements and used a post-occupancy questionnaire to compare 12 green and 12 conventional office buildings.³

Methodology

We examined all of the case studies included in HPB from Winter 2008 through Winter 2013, a total of 100 buildings. We focused primarily on those building design characteristics that are intended to promote good IAQ (e.g., dedicated outdoor air

Opposite, clockwise from top left

The Natural Resources Defense Council Building (NRDC) in New York cites human productivity as the highest return on the construction dollar. Measurements were made of formaldehyde, particulate matter, total VOC, and carbon monoxide. All were measured well below values specified in the air testing option under the LEED credit for a Construction Indoor Air Quality Management Plan.

The Terry Thomas building in Seattle uses glass shades and CO₂ sensors to control motorized window louvers for natural ventilation and occupant comfort.

The Oregon Health and Science University Center for Health and Healing features an atrium open to the public, café, and day spa. The building features night-flush precooling with outside air until one hour before occupancy.

External shades outside a break room in the Terry Thomas building retract as the sun moves overhead or when it's overcast. The Northwestern climate allows for natural ventilation to be coupled with shading strategies to replace an HVAC system entirely.

*David Grumman and Adam Hinge are members of High Performing Buildings magazine's Editorial Advisory Board.



Photo © Pat Corkery/PIX 15164

The outdoor air intakes of the U.S. Department of Energy's National Renewable Energy Laboratory in Golden, Colo., were placed according to modeled exhaust emissions.

systems, low volatile organic compound [VOC] emitting building materials and high efficiency filtration). We also recorded, among other characteristics, the energy consumption data for the building, its source(s) of energy, features intended to reduce water consumption (e.g., rainwater harvesting for irrigation and other non-potable purposes), and construction waste diverted from landfills. We noted when the performance of the building was compared to a building standard such as ASHRAE Standard 62.1-2010, *Ventilation for Acceptable Indoor Air Quality*, and ASHRAE/IES 90.1-2010, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.

Results

Before we discuss the results of our review of the HPB case studies, it is important to mention some of the

potential limitations of our analyses. First, we limited our review to only the information contained in the articles. While the editors deserve credit for trying to standardize the information presented in each case study (e.g., sidebars on energy performance, key sustainable features, and lessons learned), due to understandable space limitations, the authors may have been limited in their description of some building attributes and performance.

Also, in preparing this article, we had to interpret the information in the magazine articles and could have misinterpreted some of the provided details. Last, and most important, it should be emphasized that the case studies included in HPB are likely among the best examples of high-performing buildings and not representative of current new and retrofit construction practice.

Table 1 shows the prevalence of several IAQ-impacting features in decreasing order of their mention in the 100 HPB case studies.

It has long been recognized that the primary options available to control indoor air contaminant concentrations are contaminant source removal or reduction, ventilation, and air cleaning. Besides being fundamental approaches to improving IAQ, high performance building standards or programs typically include requirements and/or offer credit for these features.¹ As such, it is no surprise that many of the items in Table 1 relate to one of these three approaches.

Specifically, four items are related to source control (low-VOC-emitting materials, low-emitting cleaning materials, formaldehyde-free materials, and carbon monoxide sensors). Eight are ventilation-related (carbon dioxide sensors for demand control ventilation, hybrid ventilation, dedicated outdoor air system, displacement ventilation, reference to ASHRAE Standard 62.1, nighttime outdoor air purge, post-construction building flush out, and monitoring outdoor air intake

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rates). Two relate to air cleaning (filtration efficiency cited and gaseous air cleaning).

Most other items may be considered either general claims related to the achievement of good IAQ (claim of good IAQ, anecdotal mention of IAQ improvements, and claim of healthy IAQ) or specific actions taken to verify achievement of acceptable IAQ after construction (post-occupancy IAQ survey, IAQ monitoring program, and indoor contaminant data provided). The general claims show a positive level of awareness of the importance of good IAQ, but data are typically not provided to support that acceptable IAQ was actually achieved.

Some people automatically assume improving IAQ will cost

The tight building envelope of the Heifer International headquarters in Little Rock, Ark., allows for an air change rate that exceeded the target. The building's narrow arc gives every workstation outdoor views and daylight.



Photo © Timothy Hursley

additional energy (e.g., by increasing ventilation rates). However, as discussed by Levin and Teichman⁴ and Persily and Emmerich,¹ many of the *Table 1* features can be part of strategies that can support *both* the energy efficiency and IAQ objectives of high-performance building design and operation.

Examples of such strategies include demand-controlled ventilation, dedicated outdoor air systems, displacement ventilation, natural/hybrid ventilation, and construction practices that increase envelope tightness. Source control and air cleaning measures may indirectly be considered energy-related if they

BUILDING FEATURES

During our review of 100 HPB case studies, we also came across many noteworthy building features and/or interesting observations. Inclusion of these statements does not imply we checked their veracity.

Ventilation

- In one of the few buildings in which an envelope airtightness measurement was made, the actual building air change rate ($>0.5 \text{ h}^{-1}$) significantly exceeded the target (0.1 h^{-1}) (*Passing on the Gift*, Winter 2008). (Note that the reference pressure for the measurement and target were not provided.)
- Composting toilet exhaust systems were designed to draw air down through the toilets instead of at the ceiling thereby removing odors. (*Conservation Gateway*, Winter 2008).
- Exhaust emissions were modeled to determine the optimal location of outdoor air intakes (*Walking the Walk*, Summer 2008).
- Many buildings employing hybrid ventilation send a signal to building occupants that natural ventilation has become optimal; others interlock the opening of windows with the shutting off of mechanical ventilation systems (*Green Show-And-Tell*, Fall 2012).
- Lab-quality, central CO_2 sensors were determined to be better than room CO_2 sensors, only 27% of which were determined to be accurate within $\pm 20\%$ (*The Right Fit*, Winter 2011).

Water

- Energy costs make up 80% of a typical water bill; 7% to 8% of U.S. energy is used to move and treat water (*Rainwater: The Untapped Resource*, Summer 2008).
- Municipal water systems typically use 4 ppm of chlorine to treat water; rainwater systems for non-potable use can be chlo-

minated to just 0.25 ppm (*Rainwater: The Untapped Resource*, Summer 2008).

- One building used a self-contained biological filtration system that collected rainwater, used fish to fertilize the water, and then filtered the water through greenhouse plants (*A Building That Teaches*, Winter 2013).

Energy

- A swimming pool was used for load shifting of excess heat (*Rx for Platinum*, Winter 2009).
- In one building, biodiesel fuel was made from recycled fry oil, and a glycerin by-product was used for shower gel (*Golden Arches Green Performance*, Fall 2009).
- Laptop computers (25 kW to 50 kW) were used to replace computer stations (150 kW to 175 kW) (*Small Steps, Big Savings*, Fall 2009).
- Energy use intensity comparisons should be made on an energy/person/hour $\times$ climate factor basis, as opposed to energy/area/year (*Resourceful By Nature*, Spring 2012).

Building Operation

- In one building, it was agreed that the owner would pay for capital expenses (e.g., a new boiler), the property manager for operation and maintenance expenses (e.g., a lighting retrofit), and the tenant for sustainability initiatives (e.g., photovoltaics and storm water management) (*Cooperative Solutions*, Fall 2009).
- Employees were allowed to wear shorts in one building when the interior temperature exceeded about 27°C (81°F) (*Old Concepts, New Tools*, Summer 2010).
- The public display of building data led to suggestions from people who had never been in the building (*Early Adopter*, Winter 2011).



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The Oregon Health and Science University Center for Health and Healing demonstrates in bricks and mortar that a healthy built environment is integral to healthy living.

are used to justify lower ventilation rates; however, some high-performance standards and programs may not allow these approaches.

Eight of the 10 most prevalent IAQ-impacting features in *Table 1* are design measures intended to achieve good IAQ. However, good design alone is not sufficient to achieve good IAQ; building operation and maintenance are also key to realizing the intended level of IAQ performance. Measures that directly relate to IAQ performance, e.g., monitoring, occupant surveys and measured contaminant levels, are much less common. Several of the measures, primarily those related to ventilation (e.g., dedicated outdoor air and displacement ventilation), could be viewed as being motivated by energy considerations as well as IAQ.

Table 2 shows the prevalence of the IAQ features compared to energy-, water-, and waste-related features in decreasing order of their mention in the 100 case studies. This table shows the high prevalence of energy features relative to the other three categories. Our analysis did not focus on energy, and therefore, only the highest-level energy features are identified. An unusually large number of energy features are not included in the table (e.g., increased insulation and daylighting). For comparison, if one averages the highest three prevalence features in each category, the results are 81 for energy, 51 for IAQ, 50 for waste and 47 for water.

Additional Results Discussion

Earlier, we discussed quotes from two of the case studies that provided measured IAQ data other than references to CO₂ monitoring for demand control ventilation. In the Natural Resources Defense Council Building in New York City (*Resourceful by Nature*, Spring 2012), measurements were made of formaldehyde, particulate matter, total VOC, and carbon monoxide, all of which were measured well below values specified in the air testing option under the LEED credit for a Construction Indoor Air Quality Management Plan.⁵ In addition, screening measurements were made for ethylene dichloride (plastic

TABLE 1 PREVALENCE OF IAQ-IMPACTING FEATURES MENTIONED IN THE 100 HPB CASE STUDIES

Feature	Prevalence (# of Case Studies)
Low-VOC-Emitting Materials	60
Carbon Dioxide Sensors (for demand control ventilation)	51
Hybrid Ventilation (i.e., for extended periods, the building is naturally ventilated)	42
Claim of Good IAQ	36
Dedicated Outdoor Air System	31
Displacement Ventilation (e.g., underfloor air distribution)	31
Reference to ASHRAE Standard 62.1	25
Filtration Efficiency Cited (e.g., MERV)	22
Low-Emitting Cleaning Materials	16
Formaldehyde-Free Materials	14
Post-Occupancy IAQ Survey	12
IAQ Monitoring Program	12
Anecdotal Mention of IAQ Improvements (e.g., perceived increased productivity)	10
Nighttime Outdoor Air Purge	10
Claim of Healthy IAQ	9
IAQ Considered During Construction (e.g., ductwork sealed)	8
Gaseous Air Cleaning	6
Air Leakage or Air Change Measurement	5
Carbon Monoxide Sensors (for controlling garage exhaust ventilation)	4
Post Construction Building Flush Out	4
Monitoring of Outdoor Air Intake Rates	1
Indoor Contaminant Data Provided	1

TABLE 2 PREVALENCE OF FEATURES

IAQ FEATURES	Prevalence (# of Case Studies)
Low-VOC-Emitting Materials	60
Carbon Dioxide Sensors	51
Hybrid Ventilation	42
Claim of Good IAQ	36
Dedicated Outdoor Air System	31
Displacement Ventilation (e.g., underfloor air distribution)	31
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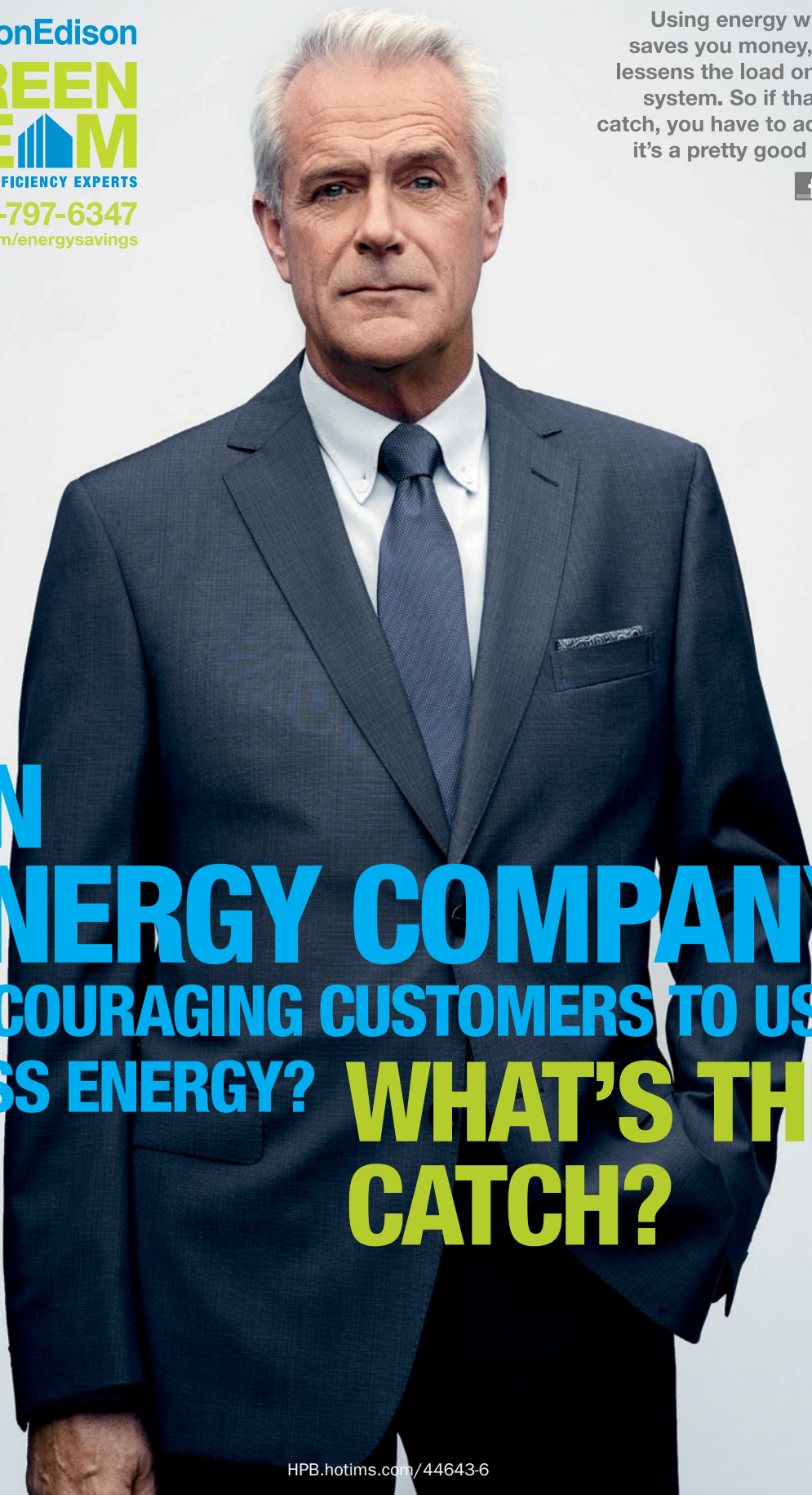
The elimination of destructive demolition and reconstruction and spackle/painting/sanding (crystalline silica in pre-existing core walls, respirable particles, etc.) during renovation of the 8th floor of the Natural Resources Defense Council's New York office improves the environmental quality of the floor.

welding adhesive),^{1,2} dichlorobenzene (plastic foam insulation), crystalline silica (joint compound), and chromated copper arsenate (pressure-treated wood).

Similarly, in the California Department of Health Building P (*Proving Performance*, Winter 2012), pre-occupancy testing was performed for individual VOCs (including formaldehyde and acetaldehyde), particulate matter, carbon monoxide, and CO₂. All of the concentrations measured were below the California Office of Environmental Health Hazard Assessment chronic recommended exposure levels and below 1% of the Occupational Safety and Health Administration's permissible exposure limits.^{6,7}

Conclusion

This case study analysis highlights many of the creative approaches used in sustainable buildings, which will hopefully inspire others to continue making progress in this critical area. In addition, integrated design, from the perspective of IAQ, is discussed in the ASHRAE IAQ Design Guide.⁸

A man with grey hair, wearing a dark blue suit, white shirt, and blue tie, stands against a light blue background. He has a serious expression.

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However, these case studies, at least as they are presented in HPB, do not stress all aspects of building sustainability, in particular IAQ. Neglecting IAQ, while pursuing other goals, can result in building environments that negatively impact occupant health, comfort, and productivity, which defeats the overall goal of building design, including reduced costs.

In addition, while building design is key to achieving a high-performing building, it is critical to follow these good intentions through construction, commissioning, operation, and maintenance. Only in this way, will high-performing buildings actually perform as designed.

Finally, the only way to verify that these goals are being reached is by performing actual performance measurements, which is particularly

lacking for IAQ as shown in these case study reports. In the words of W. Edwards Demming: “In God we trust; all others bring data.”⁹ ●

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ADAPTING TO CLIMATE

BY ASHISH RAKHEJA, MEMBER ASHRAE

“Adapting a building to the climate is better than adapting the climate to a building” is an apt slogan of Bayer Material Science’s EcoCommercial Building Program. Its initiative to develop India’s EcoCommercial Building (ECB) as a part of the Bayer Climate Program has set up a benchmark of sustainability for the Indian construction industry. India’s EcoCommercial Building, located in Greater Noida, India (near New Delhi), exceeds the existing standards for high performance buildings and ensures that a building can deliver back to the climate rather than exploiting the resources.

The EcoCommercial Building is part of the Bayer Climate Program, which seeks to reduce the company's greenhouse gas emissions, and improve energy and resource efficiency.

Part of this effort involves designing and constructing net zero energy buildings around the world. So, the building, which became India's first net zero energy building, was conceived by Bayer as a prototype with plans to build several such buildings to establish new benchmarks for future sustainable developments.

Project teams discussed and brainstormed ideas from conception as part of an integrated project delivery approach. Some of the project's highlights include:

- A 40% reduction in energy use (compared with the ASHRAE/IESNA Standard 90.1-2004 baseline) through high performance envelope insulation, improved protection against sunlight via high performance double glazed windows with integrated motorized blinds, and the use of energy-saving technologies associated with the electrical power supply system/building management system;
- Emission-free, on-site energy generation through the use of a 57 kW photovoltaic system;
- Chilled beams for radiant cooling that eliminate fan energy; and
- A zero water discharge system that recycles and treats all sewage that is generated on site. The sewage treatment plant is compact, odor-free and uses a sequential batch reactor system to provide high efficiency aerobic treatment. The treated effluent is used for makeup in cooling towers and flushing.



Sankalpan Infrastructure Pvt Ltd

BUILDING AT A GLANCE

Name	EcoCommercial Building (ECB), Noida
Location	Greater Noida, Uttar Pradesh, India (25 miles SE of New Delhi)
Owner	Bayer
Principal Use	Office
Includes	Offices, meeting rooms and some product exhibition spaces
Employees/Occupants	50
Occupancy	90% to 100%
Gross Square Footage	9,600
Conditioned Space	7,151
Distinctions/Awards	LEED-NC Platinum (64 of 69 points), 2012
Total Cost	\$6,799,020
Cost Per Square Foot	\$ 708
Substantial Completion/Occupancy	January 2011

Top The building façade is optimized through active and passive design features to ensure its climate responsiveness. For example, the roof extends beyond the building on all four sides, protecting the walls from direct sun and reducing heat gain. The additional area on the roof provides adequate space for the photovoltaic cells.

Opposite The EcoCommercial Building's exterior lighting is designed to minimize night sky pollution while maximizing energy efficiency.

Environmental Footprint

The EcoCommercial Building achieved its net zero energy objective by targeting the following parameters that optimize its air-conditioning load and environmental footprint:

- Efficient building envelope design;
- Climatically responsive façade concepts, including a roof that extends beyond all four sides of the building, protecting it from direct sun and reducing heat gain;
- Efficient glazing balancing low thermal conductivity and shading coefficient;
- Thermal mass and insulation materials;
- Lighting and daylighting controls;
- Energy recovery opportunities;
- HVAC system equipment selection at highest full-load and part-load efficiency points; and
- Commissioning.

Table 1 depicts the 2011 actual annual energy consumption and amount of carbon emitted. When compared to the Standard 90.1-2004's calibrated baseline, this translates into CO₂ emission reduction of approximately 40 tons. The building's actual on-site electricity generation for 2011 was 72,023 kWh, which is 8,113 kWh over the 63,910 kWh consumed that year, resulting in net zero energy status.

Design Condition Analysis

A year-round air-conditioning load profile was created using ISHRAE data file Weather Data and Design Conditions (WeDCo) to size equipment. A conventional building may be designed for peak ambient conditions, but in this project's system design, annual building

TABLE 1 ENERGY CONSUMPTION AND CARBON EMISSIONS

	ASHRAE/IESNA Standard 90.1-2004 Calibrated Baseline Case	Proposed Case (Energy Simulation)	One Year Actual Consumption*
Air-Conditioning Load	54 ton	24 ton	24 ton
Annual Energy Consumed (kWh/yr)	105,685	54,540	63,910
Energy Use Intensity (kBtu/ft ² ·yr)	37.5	19.1	22.73
Lighting Power Density (W/ft ²)	1	0.67	0.67
Carbon Emitted (kg/yr)	99,661	51,431	60,267

*Actual energy consumption metered from Jan. 10, 2011, to Jan. 11, 2012.

performance was evaluated along with the detailed study of environmental conditions such as wind speed and solar orientation to optimize the building performance.

This evaluation enabled the design team to move away from the traditional practice of low internal temperatures. *Table 2* outlines the indoor design conditions adopted for the project.

All external surfaces, including the walls, roof and foundation, are insulated (using polyurethane panels) on the exterior. This design helps reduce heat gain or loss inside the building. The rectangular building includes a two-story glazed lobby, which faces north.

Envelope

Typically in internal-loads dominated buildings, properly specified fenestrations result in energy efficiency savings of 10% to 40% in lighting and HVAC. To explore this potential, the building envelope design was evaluated to analyze its effect on cooling loads and daylighting. Through several iterations, envelope specifications were identified that yielded the highest resistance and minimum payback period.

Insulation materials for exterior walls are 150 mm (6 in.) autoclaved aerated concrete (AAC), fly-ash block work and 75 mm (3 in.)

TABLE 2 INDOOR DESIGN CONDITIONS

Dry Bulb Temperature	75°F ±1°
Relative Humidity	Not Exceeding 55%
Dust Filtration Efficiency	Combination of MERV 8 Prefilter and MERV 13 Bag Filter

polyurethane foam (PUF). Roof insulation materials are 75 mm (3 in.) rigid polyurethane insulation and a 50 mm (2 in.) layer of mineral wool. In addition, a window-to-wall ratio (WWR) of 33.8% helps ensure maximum daylighting potential with minimum solar heat gains.

The envelope design minimizes the energy demand and operating power. It also reduced the size and cost of the HVAC system needed to maintain adequate building pressurization, good indoor air quality and a comfortable thermal environment for building occupants.

Lighting

Since the EcoCommercial Building is a day-use building, daylighting is maximized in all occupied spaces. Simulation software was used to evaluate the impact of various shading devices to minimize glare indoors. The main objective of simulation was to ensure that the use of blinds/curtains on windows not compromise occupants' visual comfort. Integrated motorized blinds are achieving these goals, and no problems have been reported regarding their operation.

An energy-efficient lighting system with daylighting controls provides additional light when daylighting is not sufficient.



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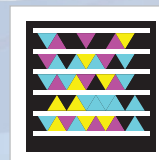
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Energy-efficient lighting fixtures with daylight controls contribute to the building's low energy use. Window integrated motorized blinds minimize glare while maximizing daylighting.

Energy-efficient fixtures and ballasts contribute to a 37% reduction in lighting energy compared to Standard 90.1-2004. Other benefits include enhanced lighting quality in the space and a healthy and productive work environment. Lighting equipment selection sought to balance the design requirements and

WATER AT A GLANCE

Annual Water Use 96,240 gallons

ENERGY AT A GLANCE

Annual Energy Use Intensity (EUI) (Site) 22.73 kBtu/ft²

Electricity (From Grid) 2.15 kBtu/ft²
Renewable Energy 20.57 kBtu/ft²

Annual Source Energy -63 kBtu/ft²

Annual Energy Cost Index (ECI) \$0.059/ft²

Annual On-Site Renewable Energy Exported 5.02 kBtu/ft²

Annual Net Energy Use Intensity -2.86 kBtu/ft²

Savings vs. Standard 90.1-2004 Design Building 40%

Heating Degree Days (base 65°F) 848

Cooling Degree Days (base 65°F) 5,091

Average Operating Hours per Week 40

limit the number of fixture types and lamp selection in order to have reasonable inventories.

The building uses a combination of energy-efficient T5 linear fluorescent and compact fluorescent lamps, which have good color rendering properties and long life and are readily available, easily controllable and affordable. Eyestrain and fatigue due to excessive lighting levels are reduced by high frequency electronic ballasts linked to daylight sensors.

Occupancy sensors in normally unoccupied areas like storage areas, toilets and mechanical rooms minimize lighting use. Lighting controls ensure minimum internal heat gain and reduced air-conditioning load in those spaces.

Approximately 87% of total regularly occupied spaces in the building have a minimum daylight factor of 2%. A lighting power density (LPD) of 7.2 W/m² (0.67 W/ft²) in all occupied spaces is significantly lower than the Standard 90.1-2004 baseline of 11.8 W/m² (1.1 W/ft²).

Energy Modeling

It is a conventional practice to compute air-conditioning loads using peak ambient conditions that occur 0.4% or 1% of the year. This leads to oversized equipment selection, which introduces inefficiency

DEFINING DAYLIGHT FACTOR

Daylight Factor (DF) is a ratio of internal light level to external light level and is defined as $DF = (E_i/E_o) \times 100\%$, wherein E_i is illuminance due to daylight at a point on the indoor working plane and E_o is simultaneous outdoor illuminance on the horizontal plane from an unobstructed hemisphere of overcast sky.

in the system due to part-load operation most of the year. For the EcoCommercial Building, computer simulation tools were used to create a year-round AC load profile that helped improve understanding of operating conditions.

Building thermal performance calculations were made for two primary reasons: to size and select mechanical equipment and to predict the performance of each component that contributes to heat gain in the space. After several iterations, the calculations resulted in a final breakdown of space sensible and latent loads.

The careful planning of passive and active design features resulted in a total diversified AC load of 84 kW for 891 m² (24 tons for 9,600 ft²). The project achieved 37 m²/kW (1,401 ft²/ton) for the overall built-up area and 28 m²/kW (1060 ft²/ton) for the conditioned spaces. Further comparison is made with Standard 90.1-2004 (for calibrated baseline case) to study the benefit of each strategy (*2011 Actual Energy Use Vs. Calibrated Baseline*).

DOAS and DCV

As a design strategy, the room sensible and latent heat gains were computed separately. A dedicated outdoor air system (DOAS) was



The building team selected low-VOC protective coatings, paints and flooring materials and placed a priority on regional building materials with recycled content.

selected for the project that accommodated the building's entire latent loads.

Dry outdoor ventilation air is supplied through an externally mounted unit that dehumidifies the air before it is supplied to occupied space. This dry outdoor air acts as primary air to the chilled beams.

A design ventilation rate of 30% additional outdoor air over ASHRAE Standard 62.1-2004 enhances the indoor air quality within the building and provides occupant comfort. The air quality is monitored inside the entire building with help of CO₂ sensors located 1.8 m (6 ft) above the floor level in various spaces.

These sensors provide an audible alarm to the operator when the difference between outdoor and indoor CO₂ levels exceeds 530 ppm. The DOAS system starts at 7 a.m. to remove moisture that builds up during unoccupied hours and brings down the temperature to desired level before office start-up.

The DOAS provides heat recovery from the building's exhaust. Dehumidified cold exhaust air from the bathrooms and office space is

collected in each service core. This air enters one side of the rotating heat wheel, chilling the wheel and drying the desiccant coating.

This cool and dry part of the wheel then rotates into the outdoor air-stream where it absorbs heat and gains humidity from the incoming ventilation air before it is cooled to room temperature in the air-handling unit (AHU) room. The energy recovery wheel reduces the ventilation AC load by 80%, minimizing operating energy and the size of air-conditioning equipment. Dedicated floor-mounted AHUs are located on the ground floor and the first floor.

Chilled Beams

Chilled beams provide cooling and offer several advantages, including reducing operation costs due to savings in AHU fan energy and simultaneous reduction in chiller energy. The beams receive incoming chilled water at 15°C (59°F) rather than at the conventional 7°C (45°F).

Based on indoor design conditions of 24°C (75°F) and 55% relative humidity, the room dew-point temperature is 14°C (57°F) and chilled water is supplied at a temperature 1°C (0.6°F) higher (at 15°C [59°F]) to avoid any condensation on

BUILDING ENVELOPE

Roof

Type Reinforced cement concrete (RCC) slab with 3 in. thick polyurethane foam and 2 in. of additional mineral wool with waterproofing

Overall U-value 0.03 Btu/h·ft²·°F

Walls

Type 6 in. thick autoclaved aerated concrete (AAC) fly-ash block work and 3 in. thick polyurethane foam (PUF)

Overall U-value 0.04 Btu/h·ft²·°F

Glazing Percentage 33.8%

Windows

Effective U-factor for Assembly 0.27 Btu/h·ft²·°F

Solar Heat Gain Coefficient (SHGC) 0.31

Visual Transmittance 50%

Location

Latitude 30.44 N

Orientation Northeast

BUILDING TEAM

Building Owner/Representative Bayer

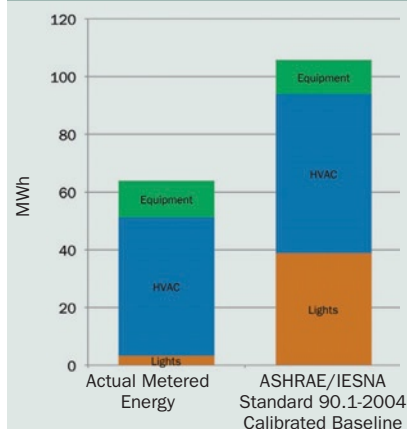
Architect, Structural Engineer, Landscape Architect Sankalpan

General Contractor Shobha Developers

Mechanical, Electrical Engineer; Energy Modeler; Environmental Consultant; LEED Consultant AECOM India Pvt. Ltd.

Commissioning Agent Measurement & Verification Services Pvt. Ltd. (MVSPL)

2011 ACTUAL ENERGY USE VS. CALIBRATED BASELINE



KEY SUSTAINABLE FEATURES

Water Conservation Zero water discharge system treats all sewage generated on site. Recycled and treated water is used for makeup in cooling towers and flushing.

Daylighting Eighty-seven percent of total regularly occupied spaces in the building have a minimum daylight factor of 2%.

Carbon Reduction Strategies On-site PV array provides emission-free energy, exceeding building demand.

Transportation Mitigation Strategies Campus bus facilities used by more than 75% of occupants.

Other Major Sustainable Features Chilled beams, efficient lighting design, dedicated outdoor air system with demand control ventilation.

surfaces. In addition, dry fresh air is injected into chilled beams (after passing through the DOAS), enhancing the sensible load handling capability and minimizing the number of beams inside.

Double entry doors with an air lock help prevent hot humid outdoor air from entering the building. Additionally, a drip tray is provided for beams in the reception area to minimize the possibility of condensation.



Using chilled beams to provide air conditioning is a new concept in India. The system is a major contributor to this building's HVAC energy savings. It also reduces operating costs due to savings in AHU fan energy and a reduction in chiller energy.

Commissioning

Despite superior standards of design solutions and exposure to new technologies and products, a significant gap exists in the quality of execution due to poorly trained labor and conventional operation methodology. The project incorporated ASHRAE-recommended commissioning methodology, using a third-party commissioning agent and energy auditor to carry out the following activities:

Design phase commissioning that provided early input for incorporating monitoring mechanisms to facilitate successful operation and maintenance by building staff.

Construction phase commissioning to ensure the proper implementation of mechanical and electrical systems.

Acceptance phase commissioning, which required contractors to demonstrate the operation of the equipment as per design intent.

Occupancy phase commissioning, which focused on proper operation of the systems by the operation and maintenance (O&M) staff.

Ongoing commissioning, which will be done at a later stage to periodically verify operational methods and equipment performance.

Energy meters monitor equipment performance and continuously log data. This data is compared with the baseline data to determine the savings.

The monthly consumption of the whole building and the individual

TABLE 3 2011 ENERGY PRODUCTION, USE (KWH)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
PV Production	4,149	4,743	6,776	7,438	7,852	7,210	6,064	5,706	6,759	6,616	4,427	4,281	72,023
Building Consumption	2,666	1,231	3,198	5,261	8,271	8,698	7,337	7,474	7,883	5,419	4,106	2,365	63,910
Lighting	684	349	297	180	178	152	148	244	220	152	211	413	3,227
Air Conditioning	1,042	171	2,106	4,091	6,911	7,257	6,028	6,023	6,206	4,136	3,312	758	48,045
Equipment	940	710	795	990	1,181	1,289	1,161	1,207	1,456	1,131	584	1,194	12,638
Monthly Net Energy Production/Use	1,483	3,513	3,577	2,177	-418	-1,488	-1,273	-1,768	-1,124	1,197	321	1,916	8,113

Note: Equipment includes laptops, printers, copiers, coffee maker, refrigerator, etc.



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The EcoCommercial Building is one of only a few net zero energy buildings in India. While initial project costs were significantly higher than typical commercial construction costs, the investment is providing reduced operating expenses for the long term.

consumption of HVAC, lighting and other related areas were compared with the monthly baseline consumption figures provided through energy modeling (see *2011 Actual Energy Use Vs. Calibrated Baseline*).

Metered systems include the main incoming power supply, chillers, internal lighting, external lighting, air-handling units, the water supply system, the sewage treatment plant and the solar PV system.

The commissioning team did not identify any aspects of the project that needed improvement. This project's innovative design and its high performance that meets design goals demonstrate the effectiveness of integrated project delivery.

Solar PV

The project's 57 kW crystal-line silicon grid-connected solar system is expected to generate 88.9 MWh/year. It produced 72 MWh during 2011 due to mutual shading of the panels in a few

locations, but still exceeded the building's consumption. The excess energy is fed into the existing adjacent building within the campus.

Other Sustainable Features

Site Selection. The EcoCommercial Building is a part of Bayer's factory campus located in an industrial

for International Development (USAID) launched a five-year program in July 2012 in partnership with India's Ministry of Power and the Ministry of New and Renewable Energy that aims to accelerate India's transition to a high performing, low emissions and energy secure economy.

In the building sector, the program involves promoting energy efficiency and net zero energy goals. Activities include technical resource development, capacity building, demonstration projects, Energy Conservation Building Code (ECBC) implementation support and updating the ECBC 2007 with provision for NZEB components.

Source: The Partnership to Advance Clean Energy-Deployment (PACE-D) Technical Assistance Program

park. The site is supported by well-connected public transportation. Bayer also provides buses to transport employees to various parts of Delhi and its satellite cities.

Water. Rainwater harvesting pits 3 m (10 ft) in diameter and 5 m (16 ft) deep are located in all four

LESSONS LEARNED

Integrated Project Delivery. This method was a key to developing this building. All of the stakeholders were included in the design process from the beginning. The basic intent of the EcoCommercial Building's design is to reduce the energy demand through implementing highly efficient energy conservation measures. This reduced energy demand enabled the owner to make an early decision to implement a photovoltaic system and pursue net zero energy status.

Higher Initial Costs, Lower Operating Costs. The cost of the building is relatively high compared to typical commercial building in this region. The material and the technology used such as photovoltaic cells for power generation, chiller plant and chilled beams, sewage treatment plant, rainwater harvesting system, additional insulation, energy-efficient windows, cladding materials and LEED-certified office furniture increased the project cost significantly. This initial

investment has considerably decreased the operating cost of this building.

Integrating Services Without Hampering Design. An exposed ceiling is designed to showcase the chilled beams, a new concept for providing air conditioning in India. Making the exposed ceiling aesthetically pleasing and fully functional presented a challenge. Each service element, including chilled water pipes, conduit, light fittings, chilled beams, speakers, smoke detectors, motion sensors, etc., was meticulously coordinated by the designer, project manager, and electrical and HVAC vendors to achieve the desired result.

Grand Opening Activities May Explain Higher Energy Use. The building's first year EUI of 22.73 kBtu/ft²-yr is slightly higher than the modeled EUI of 19.1 kBtu/ft²-yr. The model did not account for the grand opening presentations and tours, which may explain the higher than expected EUI.

corners of the ECB site and have a total volume of 141 321 L (37,333) gallons. The rainwater is primarily used to recharge the underground aquifer.

Storm water pipes empty into 500 mm × 450 mm (20 in. × 18 in.) water retention tanks/catch basins, and overflow passes through oil and silt traps before reaching the rainwater harvesting pits. The additional overflow water from the harvesting pits is discharged in the municipal drain. In addition to the on-site sewage treatment system, which recycles the building's wastewater, low-flow plumbing fixtures help reduce water use.

Landscaping. Native and indigenous species were selected for landscaping, eliminating the need for regular irrigation. To help establish

the new landscaping, plants were watered twice a day for the first two years.

Material Selection. The building team placed a priority on regional building materials with recycled content. The team also selected low-VOC paints, sealants, coatings and adhesives whenever possible.

Conclusion

The EcoCommercial Building exceeds the existing standards for high performance buildings and ensures that a building can deliver back to the climate rather than exploiting resources. It illustrates the potential energy savings that can be achieved via early collaboration to design an efficient building envelope and building systems. ●



The project team researched and explored the environmental sustainability of various building materials. The insulating materials contribute to the building's reduced energy use and net zero energy status. On-site PV panels generate more electricity than the building consumes.

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COMPETITIVE EDGE

BY JON W. DOUGLAS AND VICTOR HALDER

AFrame Studio

Environmental benefits and long-term operations cost savings have traditionally been the main drivers of sustainable design. But building owners—including the owner of one of Toronto’s newest office towers—are also viewing high performing buildings as a competitive edge in leasing and managing office space. The strategy has worked for 25 York Street, which leased 90% of its space in the first year and 100% in the second year, outpacing the market’s average lease-out rate.

Located on once-abandoned railway lands, this \$250 million project revitalized this site on Toronto's waterfront. The first major office development south of the railway tracks in more than a decade, 25 York includes 30 stories with a five-level podium and three levels of parking. The building is located in the heart of the Toronto downtown core, just south of the financial district.

The AAA office building includes a gourmet kitchen for employees to prepare food, rooftop garden patios, ground floor retail, a fitness center, a prayer room, and massage rooms. Linking directly to the major attractions of the downtown core, the Toronto underground PATH walkway through 25 York provides direct indoor access to Union Station and in-building bicycle storage and showers. This building is steps from the waterfront, the Air Canada Centre (home to three Toronto professional sports teams), the entertainment district, and the financial core, plus many major restaurants and retail chains.

The building features large floor plates and a state-of-the-art building technology platform for the distribution of air, voice, data and power cabling. Building occupants enjoy personal control over their temperature and airflow volume through underfloor air distribution, an abundance of daylight with incorporated daylight sensors for indirect/direct lighting, and exterior views from 90% of the occupied spaces in the building.

The property management team received LEED for Existing

Buildings: Operations & Maintenance Platinum certification in 2012. The team identified and implemented best practices that would continue the sustainable commitment to occupant comfort and environmental responsibility.

Tenant organizations are increasingly seeking green building space in the Toronto market and across North America (see *For More Information on the Economic Benefits of Green Buildings*). Whether it's for keeping and attracting employees, reducing long-term operating costs, or part of a broader corporate sustainability initiative, tenants are putting sustainability on the "must-have list."

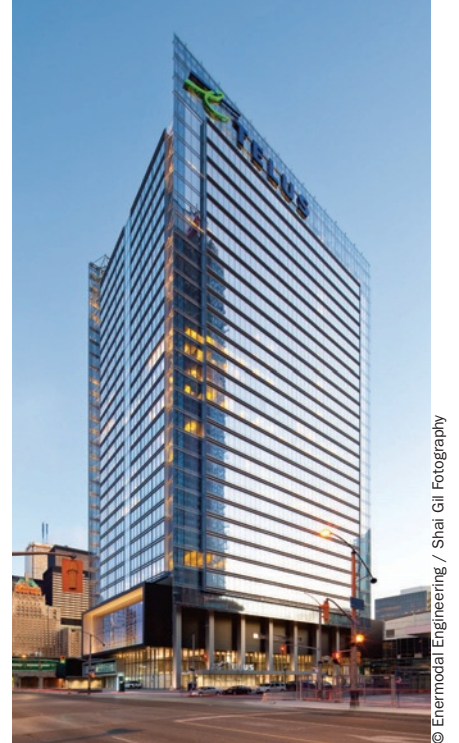
On the opposite side, developers and property managers are seeing increased competition. By focusing on energy management, managers can reduce the impact of rising utility costs on their tenants.

Though a green certification might not increase rent, not having it for a new development is a bigger risk; this could lead to not being able to attract tenants to a space quickly. Sustainable building certification has progressed from "why" to "why not" certify.

Water and Site

Despite its location in the downtown core, 25 York Street incorporates green space in a variety of ways. The building's green and white reflective roof helps minimize the urban heat island effect. Occupants enjoy a podium level rooftop green space that can be used at lunch or for entertainment events.

A combination of measures, including dual-flush toilets, low flow



© Enermodal Engineering / Shai Gil Photography

Above The building team viewed sustainability as an important element in designing a competitive, AAA office tower in the Toronto rental market. Conservation measures reduce long-term operating costs, while green certification helps attract tenants.

Opposite The building is set back from the street, providing ample space for pedestrians. Its location next to Toronto's Union Station provides convenient access to alternative transportation.

BUILDING AT A GLANCE

Name	25 York Street
Location	Toronto
Owner	Menkes Union Tower Inc.
Principal Use	Office, podium level retail
Employees/Occupants	3,281
Expected (Design) Occupancy	100%
Percent Occupied	100%
Gross Square Footage	853,266
Conditioned Space	775,368
Distinctions/Awards	LEED-C&S Gold, 2011; LEED-EB O&M Platinum, 2012; BOMA Canada Earth Award, 2012; BOMA BEST (Building Environmental Standards) Level 4, 2012
Construction Cost	CAN\$185 million
Cost Per Square Foot	CAN\$217
Project Cost	CAN\$250 million (includes site work, consultant costs)
Substantial Completion/Occupancy	June 2010

**FOR MORE INFORMATION ON
THE ECONOMIC BENEFITS
OF GREEN BUILDINGS**

Doug Gatlin. 2008. **"The Green Building Advantage Won't Last Long."** *The Sustainable Enterprise Report: Turning Awareness into Action.* <http://tinyurl.com/kk8st4r>

S. Michael Brooks. 2012. **"The Value of Green Buildings."** *Property Biz Canada.* <http://tinyurl.com/l6tpbwc>

Kristena Hansen. 2013. **"Real Estate: 'Greener' Buildings Showing High Prices, Easier Sales."** *Phoenix Business Journal.* <http://tinyurl.com/m2t5wlp>

faucets and rainwater reuse, reduce water use. Rainwater is collected from the roof, stored in an underground 29,000 gallon cistern and used to flush the toilets and urinals on floors three through five.

Limiting the reclaimed water use to three floors reduces the cost of dual plumbing and doesn't hinder the water savings. This design also allows the fixtures to run off of city water pressure, eliminating any need for a connection to the tower booster pumps, saving energy and reducing costs.

Landscaping consists of native adaptive vegetation species, reducing watering demands. A highly efficient drip irrigation system is fed from the rainwater cistern.

Based on actual metered data for 2012 and assuming 252 working days per year and 3,281 occupants in the building, the building's water use is 37% lower than a typical office building.

Landscaping on the rooftop patio and elsewhere consists of native adaptive vegetation, reducing watering demands. A highly efficient drip irrigation system is fed from the rainwater cistern.

Energy

Recognizing the environmental impacts associated with energy used by office buildings, the owner charged the design team with creating a high performance building. These systems help protect tenants from rising utility costs while providing occupants with a superior space.

The project team hired an independent commissioning agent to peer review the design, provide recommendations for new technologies, ensure installation of systems was correctly done and provides operational support during the first year of operations. This commissioning process included functional testing, confirming that all system components operated in an integrated

manner resulting in expected energy efficiency and occupant comfort.

The property manager also hired an energy management consultant to monitor performance and identify opportunities to further push energy performance, which has resulted in an ENERGY STAR score of 88. Building energy conservation measures include an airtight, well-insulated envelope, high performance windows, automated solar tracking interior shades in addition to lighting and HVAC strategies.

Energy monitoring identified that the building was using 35% more electricity for lighting and power panels compared to the energy model prediction. This higher than expected energy use was due to approximately



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- Building Performance Modeling
- Building Performance Measurement
- Case Studies and Lessons Learned
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- Indoor Environmental Quality Strategies
- Low Energy Techniques
- Market Value (return on investment)
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- Plug Load Reduction Strategies
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~ Kent Peterson, Conference Chair



Located on once-abandoned railway lands, this \$250-million project revitalized this area on Toronto's waterfront. Nearby attractions include a professional sports venue, the entertainment district and the financial core, plus restaurants and retail chains.

50% of the total load being on during unoccupied hours, when it was expected that only 20% of the total load should have been operating.

Building management worked with tenants to identify the source of the excess energy use and determined strategies to ensure equipment and lighting only operate when required. Reductions in airflow rates through the compartmental units also increased energy savings.

Actual annual energy use intensity decreased by 2% from 2011 (71.3 kBtu/ft²) to 2012 (70.1 kBtu/ft²), despite increases in cooling degree days and tenant

occupancy. Continued monitoring will safeguard the building from falling out of "energy calibration" and will result in continued savings into the future.

Lighting

Electronic ballasts, an automatic lighting control system comprising of a Digital Addressable Lighting Interface (DALI), and extensive use of occupancy sensors and daylight sensors contribute to a low lighting power density (LPD). This design reduces the cooling load and energy consumption by eliminating unnecessary artificial lighting.

Efficient T8 lamps are used in the washrooms, storage/service areas, parking garage and stairwells. T5HO lamps and task lights with a LPD of 0.1 W/ft² are used in office areas. Exterior lighting includes low level flood lights and recessed high-intensity discharge lamps, while LED exit signs provide additional lighting savings. The effective LPD (0.76 W/ft²) was estimated as 41% lower than ASHRAE/IESNA Standard 90.1-1999 for office buildings (25% and 15% lower than Standard 90.1-2007 and Standard 90.1-2010 respectively).

WATER AT A GLANCE

Annual Water Use 7,933,369 gallons

ENERGY AT A GLANCE

Annual Energy Use Intensity (EUI) (Site) 70.1 kBtu/ft²

Electricity (From Grid) 46.1 kBtu/ft²

Deep Lake Cooling Energy 3 kBtu/ft²

District Steam Energy 21 kBtu/ft²

Annual Source Energy 189.5 kBtu/ft²*

Annual Energy Cost Index (ECI) CAN\$3.23/ft²

Annual Load Factor 64%

Average Monthly Peak Demand 2,068 kW

Savings vs. Calibrated MNECB 1997 Reference building 21%**

ENERGY STAR Rating 88

Carbon Footprint 7.2 lb CO₂e/ft²·yr

Renewable Energy Certificates 21,857 MWh (valid until August 2014)

Number of Years Contracted to Purchase RECs 2

Heating Degree Days (base 65°F) 5,565

Cooling Degree Days (base 65°F) 957

Annual Hours Occupied 2,340

* Deep lake cooling energy is converted to equivalent electrical input power by using 0.29 kW/ton and then multiplied by electricity source-site ratio of 3.34.

** According to LEED Canada-NC Version 1.0, a reduction of more than 21% compared to the MNECB reference building equals a reduction of more than 11% energy compared to ASHRAE/IESNA Standard 90.1-1999.

FIGURE 1 TYPICAL ENERGY END USE

- Lighting and Receptacles
- Parking Garage and Ancillary
- Mechanical
- Ventilation Fan
- Computer Room
- Retail
- Heating
- Cooling

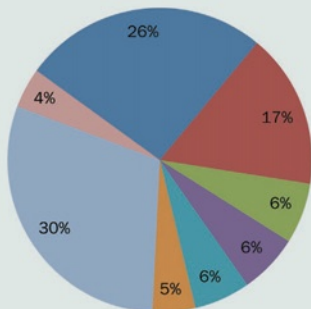
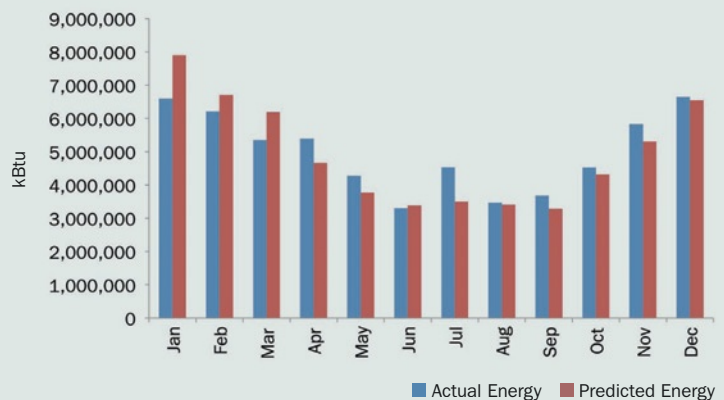


FIGURE 2 2012 MONTHLY ENERGY CONSUMPTION



OCCUPANT COMFORT SURVEY

Building management conducted a survey of all building occupants to determine overall satisfaction with comfort in the building. The survey was developed and administered through the Center for the Built Environment at the University of California, Berkeley.

Areas of the survey included: office layout, office furnishings, thermal comfort, air quality, lighting, acoustics, building cleanliness and maintenance, recycling systems, and daylighting controls. Occupant responses were collected anonymously via an internet hyperlink, which was emailed to all occupants.

The building scored well overall; only three categories resulted in rates of more than 20% occupant dissatisfaction. These

areas included acoustics and office layout, which are outside the control of the property manager. However, the property manager shared this information with the individual tenant groups, and suggested how they could address these concerns of their occupants, including white noise to address the acoustics concerns.

Thermal comfort was the final area of concern. Occupants were not aware of the underfloor air distribution system's individual controls, since they were accustomed to traditional office space where they had no control over the ventilation or temperature of individual workstations. The property manager addressed these concerns by providing education on operating the system's controls.

HVAC

The heating and cooling systems are served by the local district energy system (DES) piped through heat exchangers and circulating pumps. The DES generates and distributes thermal energy at the community level, rather than generating it on site at buildings. This system avoids the use of on-site infrastructure and boilers, while also eliminating costly maintenance and operating concerns.

Heating for office spaces is provided via perimeter hydronic finned elements, which are recessed into the raised floor plenum. The building entrance and the high glazed areas are heated via fan coil units located below the glazed surface or over the revolving door.

The perimeter hydronic finned elements have underfloor air diffusers that stratify heat effectively and increase occupant comfort. The fan coils have finned tube coils and fans, which are compact in design to provide heating at the entrance and high glazed areas where individual zone control is required.

District cooling from the DES also eliminates the on-site chiller plant, cooling tower and concern for maintenance and operation of this plant. The DES uses deep lake cooling to provide cooling energy that already has a very high coefficient of performance (COP), which is not possible for an on-site chiller and cooling tower plant. This cooling technology significantly reduces the need for electricity use.

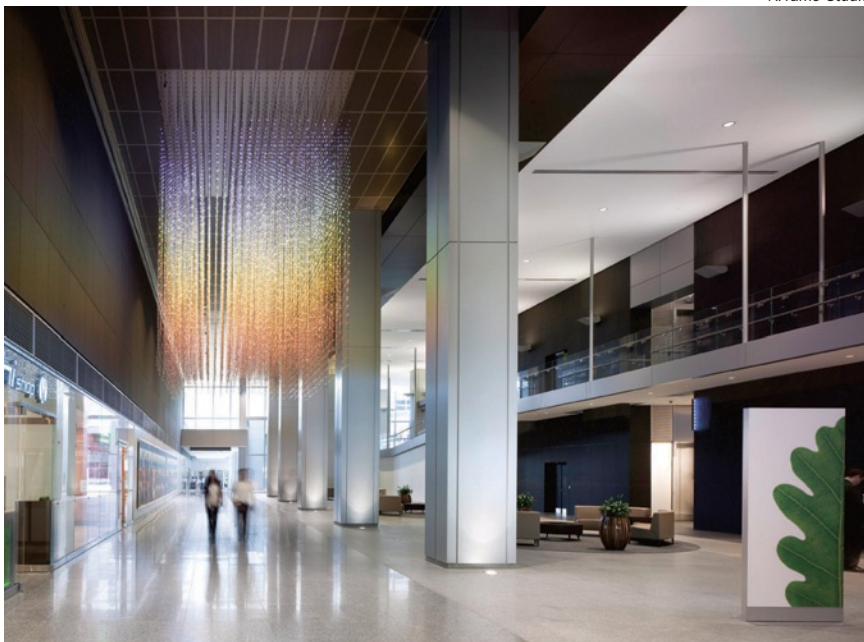
Cooling is primarily provided via down discharge VAV compartmental units on each floor. Chilled water is available to meet process equipment cooling requirements in local area network (LAN) rooms, elevators, machine rooms and telephone rooms via dedicated terminal units to limit space temperatures.

Ventilation air is provided to the office area (floors 4–30) via a common

Below The ground floor, mezzanine floor and the third floor are served by three dedicated air-handling units with demand-control ventilation. CO₂ sensors are located on the return duct and multiple CO₂ sensors are located in densely populated areas.

Bottom Building occupants enjoy personal control over their temperature and airflow volume via floor air diffusers.

AFrame Studio



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Steelcase ©2013



Top Left These work spaces provide mobile workers access to phones, power and ample work surfaces.

Top Right The building's design offers abundant daylighting with incorporated daylight sensors for indirect/direct lighting. Ninety percent of occupied spaces have exterior views.

Above Meeting rooms and offices in this tenant space have glass fronts, providing transparency, privacy and daylighting. Over 75% of wood used in the building is from Forest Stewardship Council certified sources.

KEY SUSTAINABLE FEATURES

Water Conservation Low flow fixtures, native species landscaping and rain collecting cistern for urinal/toilet flushing and irrigation.

Materials Construction waste diversion: 93%; one-fifth of materials regionally sourced; one-third of materials recycled.

Daylighting Automated interior shades reduce glare and optimize daylight; 90% of spaces have an exterior view.

Individual Controls Adjustable floor diffusers for ventilation air.

Transportation Mitigation Strategies Located next to Union Station, a major public transportation hub. On-site bike rental provides convenient bicycle access for use throughout the downtown core.

Other Major Sustainable Features Green roof terrace, green tenant guidelines, green housekeeping program.

air shaft served by two central makeup air units. Compartment VAV units located on each floor mix return air with outdoor air. Supply air is provided through floor diffusers via an underfloor distribution network.

The ventilation air is controlled by CO₂ sensors located in the return duct of each floor, four CO₂ sensors located in the open office space and additional CO₂ sensors in high density areas such as meeting rooms. Occupancy sensors also control ventilation supply, which is distributed through underfloor air diffusers that direct fresh air to the occupants.

The ground floor, mezzanine floor and the third floor are served by three dedicated air-handling units with demand-control ventilation. CO₂ sensors are located on the return duct and multiple CO₂ sensors are located in densely populated areas.

An independent direct digital control (DDC) system works as a

building automation system (BAS) for monitoring and controlling HVAC equipment, energy consumption and environmental comfort.

Envelope and Glazing

The envelope primarily consists of curtain wall and spandrel panel with some masonry walls on the ground floor and mezzanine floor. The windows are insulated double glazed units (IGU), low e-coated, 0.75 in. argon (90%) filled gaps with thermal breaks.

Automatic solar tracking interior blinds control solar gain and glare in the building. They also reduce heat loss in winter and heat gain in summer, saving energy.

The U-value for windows is 0.34, while the spandrel panel has an effective insulation R-value of 4.5. The roof is type III, built-up roofing on concrete deck with an overall roof insulation of R-20. The foundation is comprised of a 26 in. concrete wall.

Measuring and Verifying

A microprocessor based electronic metering system is installed for tenant and base building sub-metering. It monitors lighting, receptacle and

DISTRICT STEAM HEATING SYSTEM

Toronto's district steam heating system supplies in excess of 626 MW of steam to more than 140 downtown institutional, commercial (including 25 York Street) and governmental buildings (representing over 40 million ft²). The system, operated by Enwave Energy Corporation, is powered by three steam plants, which can switch between natural gas or oil, depending on which is most available and cost effective.

The oldest known district heating system dates back to the 1300s in Chaudes-Aigues Cantal, a village in France. The

townsfolk devised a method of distributing warm water through wooden pipes that is still in use today. The first commercial district heating system was created by Birdsill Holly in Lockport, N.Y., in 1877.

Today, approximately 150 district energy systems of varying sizes operate in Canada. According to the International District Energy Association, some 5,000 district energy systems operate in the United States, heating and cooling roughly 8% of all commercial office space.

Source: Enwave Energy Corporation

DEEP LAKE WATER COOLING SYSTEM

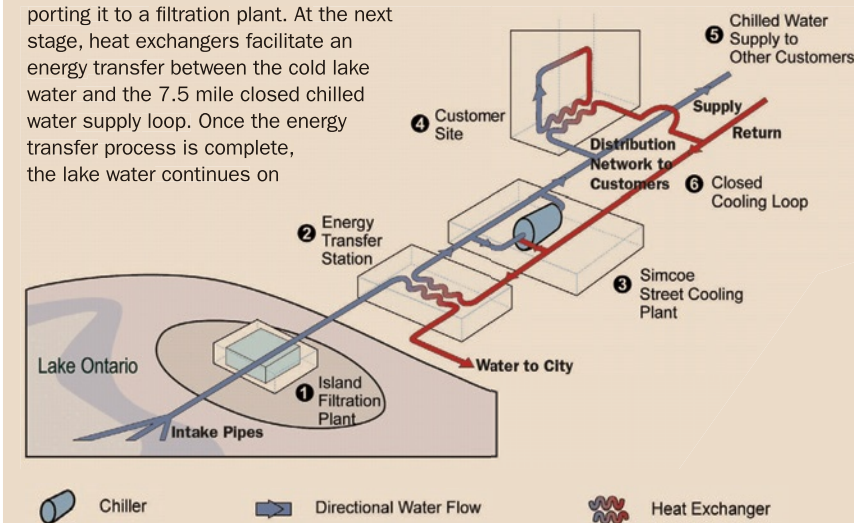
A deep lake water cooling system operated by Enwave Energy Corporation takes advantage of Lake Ontario's icy waters to provide cooling to 64 Toronto buildings, including 25 York Street. During winter, the surface of Lake Ontario cools to about 39°F. This cold water sinks to the lake's bottom during the summer, and remains very cold despite the summer heat.

Three high-density polyethylene pipes draw water from a depth of 272 ft, transporting it to a filtration plant. At the next stage, heat exchangers facilitate an energy transfer between the cold lake water and the 7.5 mile closed chilled water supply loop. Once the energy transfer process is complete, the lake water continues on

its path to the city's potable water system and is not returned to the lake.

If necessary, district cooling water can be further chilled by two 4,700 ton steam-driven centrifugal chillers. Heat exchangers at the customer buildings cool the internal building loop, providing chilled water for the building cooling systems.

Source: Enwave Energy Corporation



mechanical energy consumption on each floor in addition to the other energy end uses included in *Figure 1*.

The electrical meter data are integrated to the building automation system for automated data trending and archiving. The steam meter and chilled water energy meter provide the heating and cooling energy consumption.

The design stage energy simulation predicted an annual energy reduction of 25.4% relative to Canada's 1997 Model National Energy Code for Buildings (MNECB) baseline. Based on measured data the actual energy savings were 21% below the calibrated reference building based on the MNECB 1997.

The building has been in operation for more than three years, and 2012 monthly energy consumption is shown in *Figure 2*. The 2012 annual energy consumption was 70 kBtu/ft²·yr, with an energy cost index of CAN\$3.23/ft²·yr. Actual annual energy consumption is 1% higher than predicted due to minor operational issues associated with optimizing control sequences of various mechanical equipment.

The building uses 70.1 kBtu/ft²·yr, 34% less than the typical Canadian commercial office building average of 105.6 kBtu/ft²·yr. The typical office building energy data is derived from the Natural Resources Canada's *Survey of Commercial and*

BUILDING ENVELOPE

Roof

Type Type III, built-up roofing on concrete deck

Overall R-value R-20

Walls

Type Spandrel panel and curtain wall with some masonry wall on the ground floor and mezzanine floor

Overall R-value R-4.5

Glazing Percentage 77%

Windows

Effective U-factor for Assembly 0.34

Solar Heat Gain Coefficient (SHGC) 0.22

Visual Transmittance 0.36

Location

Latitude 43.64 N

Longitude 79.4 W

Orientation True north is at 160 47' 30" of west

Institutional Energy Use—Building SCIEU-2009, published in December 2012.

The HVAC system uses non-CFC refrigerant, R-410A, which meets LEED requirements. The annual energy consumption has been reduced by 16 million kBtu as compared to MNECB reference building, reducing equivalent CO₂ emissions by 726 tons based on Ontario electricity generation and greenhouse gas (GHG) emission factor.

Material Choices

During the design process, the project team sought sustainable materials, which were sourced from local manufacturers, made from recycled materials, or came from certified forests (over 75% of the wood used is Forest Stewardship Council certified). Ninety-three percent of construction waste was salvaged or recycled and diverted from the landfill. To ensure good indoor air quality, all



sealants, adhesives, paints, coatings, laminates, composites, and carpet are low off-gassing varieties.

Sustainable Operations

The facility has implemented policies for housekeeping, site management and pest management to



reduce the environmental impacts of maintenance and upkeep. For facilities in a northern climate, snow maintenance, which can involve the overuse of salt, can have a significant environmental impact.

However, the implementation of best practices, such as removing

Left The building uses 70.1 kBtu/ft² • yr, 34% less than a typical Canadian commercial office building. Heating and cooling systems are served by the local district energy system.

Above An automatic lighting control system comprising of a digital addressable lighting interface, efficient lighting and daylight/occupancy sensors contribute to a low lighting power density.

LESSONS LEARNED

Education. The building management team worked with tenant groups after the occupant comfort survey identified areas of occupant dissatisfaction or confusion regarding how to use building systems. Main areas of concern were acoustic quality, office layout and general operations.

One response by the building team involved explaining to occupants the reasoning behind some of the changes, such as the automatic blinds that track the sun to reduce glare and heat load. Tenants expressed concerns about the blinds moving throughout the day and questioned the reasoning for their automation. The team allayed concerns by explaining that the blinds are designed to keep occupants comfortable and increase energy efficiency.

The building team also informed tenants that the building audio system could be used to provide white noise to the open office areas to address acoustic concerns from the occupants. The minimal mechanical equipment results in little background sound.

Water Submeters. Water submetering can be an important tool to provide valve information for performance and diagnostic purposes. In the LEED for New Construction rating system, points are only awarded for the installation of energy meters, and often water submetering is cut to save costs. However, it is next to impossible to determine why water use is high or how much water a rain harvesting system is saving without these meters. Installing water meters in a live system postconstruction can

quadruple the cost. Installing these meters during construction saves money in the long run and can provide valuable information to the property team during operations.

Motivated Team. A motivated site team is key to pursuing and obtaining LEED EB: O&M. It is important that the site team is not only committed to the effort, but also is excited to work on the project. Everyone on the property team already has a full-time job and has a full plate of tasks to be completed, so adding a LEED certification can be overwhelming. Keys to motivating a team include a high commitment level from the property management company, tenant willingness to participate, and an explanation of how the process will improve building operations. A team that is motivated and passionate about sustainability is more likely to develop innovative strategies, streamline documentation efforts and maintain new programs.

Tenant Education. While implementing green operation programs as part of LEED EB: O&M certification, the property manager discovered that tenant education was a critical element. Informing occupants in advance of the program's implementation and explaining its rationale greatly improved the program's success. These programs included the zero waste target and energy conservation. Explaining objectives and how the programs would benefit occupants helped make the implementation process go smoothly and allowed for tenant input.

accumulated snow before applying deicer, ensuring deicing application devices are calibrated to the width of the path, and applying deicer before the ice has bonded to the surface can dramatically reduce the use of salt. These practices have resulted in reducing the quantity of deicer used, which means less chemical residue making its way into the water system.

A building waste management program has resulted in a diversion

BUILDING TEAM

Building Owner/Representative Menkes Property Management Services Ltd.

Architect Adamson Associates Architects

General Contractor Menkes Construction Ltd.

Mechanical Engineer, Commissioning Agent TMP Consulting Engineers

Electrical Engineer, Lighting Design Mulvey & Banani

Energy Consultant, Sustainability/LEED Consultant Enermodal Engineering

Structural Engineer Stephenson

Civil Engineer MMM

Environmental Consultant Theakston

Landscape Architect MBTW

rate of more than 85%. The building team is targeting the ultimate goal of eliminating waste sent to the landfill.

The building features multiple collection bins for various types of waste to ensure materials like paper aren't compromised from liquid left over in glass bottle or cans. Less frequent waste items like electronics and furniture are donated for reuse or sent to recycling facilities. Building management seeks to engage occupants by making them aware of programs like the waste diversion efforts and broader sustainability issues.

The building team provides green tenant guidelines to new tenants (who may not be pursuing LEED certification) to address sustainability in their fit-out and coordinate with the base building efforts.

These guidelines also can provide guidance on sustainable construction practices for smaller alterations in the building. Following these guidelines is voluntary; however, they have been well received by tenants, and widely used in the building.

Conclusion

As one of Toronto's premier new office towers, 25 York Street demonstrates the benefits of energy efficiency and sustainability. The AAA office tower meets tenant expectations for a modern office, while still achieving multiple LEED certifications. When combined with sustainable operations and tenant involvement, green building design can positively impact occupants and the owner's bottom line. ●



David Whittaker

The AAA office building includes a gourmet kitchen for employees to prepare food, rooftop garden patios, ground floor retail, a fitness center, a prayer room and massage rooms.

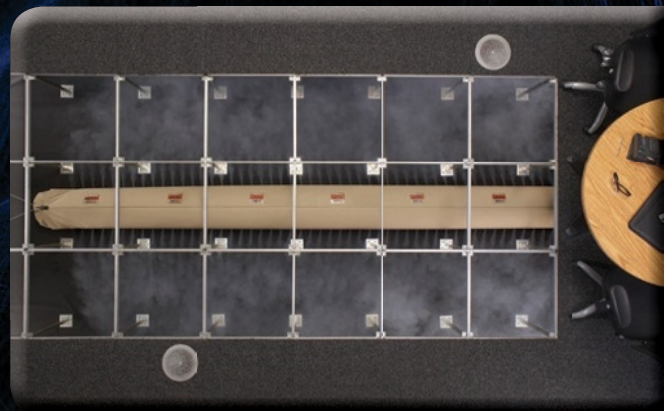
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NYC METAMORPHOSIS



Above and Below Views of the green roof from above during the day and at night. Because many of the buildings' residents look down on the space, it was important that the green roof have visual interest from above as well as within the garden.



Owners want green (vegetative) roofs because they provide connection to nature, absorb storm water, lower energy costs and reduce the heat island effect.

However, in the case of the Royal York cond-op in New York's Upper East Side, no one thought about a green roof when major leak repairs needed to be done on the roofs of a two-level parking garage between the two 12-story buildings.

A committee made up of the building manager, managing agent and board had planned on repeating the previous ho-hum combination of boxwood and brick planters. Although the existing public roof space could be accessed from each building, the roofs weren't intended to be an amenity for residents.

Michael Franco and his team at Town and Gardens had to think outside of the box to sell the committee on doing more with this space. They needed a strong concept to drive the metamorphosis from plain roof to residential garden.

"We couldn't figure out what to do with such a large space that had no other feature except the doorways," says Franco. "Then, we looked at a map of the New York harbor and started to look at its lines and translate them to the roof."

The concept of navigation included moving people through the space and connecting the two buildings through the design. Other maritime themes included trees in planters that provide screening and also make up the "sails" on the roof, and LED pavers that change color from white to dark blue to give a feeling of waves.

The harbor concept was so strong that it sold the project to the committee and also provided solutions to fulfilling the program. Privacy was an important component for the project, and the strong lines inspired by the harbor redirect, drawing the eye away from the residences.

More information about the Royal York green roof is available at <http://tinyurl.com/cu92mso>.

Reported by Sarah Foster

Products Used for Vegetative Roofs

GeoEdge™ by **Permaloc** is a flexible, multi-height, durable aluminum edge restraint and component system for landscaped roof systems and permeable pavement applications. GeoEdge has a sturdy L-shaped profile, and is available in several heights with a choice of a solid wall, or a slotted wall to allow for water runoff.

LightWild Tiles deliver accent lighting effects from ground levels. They are available in squares, linear rectangles, and circles. Standard sizes range from narrow 2x12 in. rectangles to 12x12 in. squares. Stainless steel housings, frosted tempered glass lenses, and high slip ratings (co-efficient of friction) ensure that every size tile can endure pedestrian foot traffic.

The Enkadrain 3000R series is **Colbond's** family of environmentally conscious composites made of post-industrial recycled polypropylene drainage core and a geocomposite fabric bonded to one or both sides. The entangled filaments are molded into a square waffle pattern that maintains the flexible design of other Enkadrain products. This product, because it exceeds 40% post-industrial recycled content, can help contribute up to 2 LEED points when used in conjunction with other recycled content products.

Toro's Evolution™ controller's user interface was designed with shortcut buttons that provide quick access to basic functions while the advanced menu leverages the experience and knowledge of the irrigation professional, all shown on a graphics display.

Hanover® Pedestal® Pavers are an alternative to the polyethylene pedestal support system. The Pedestal® Pavers incorporate the idea of an elevated paver drainage system with the use of an integrally footed, concrete paver of the highest quality. The waterproofing assembly is protected from weather and UV light and pedestrian access is permitted.



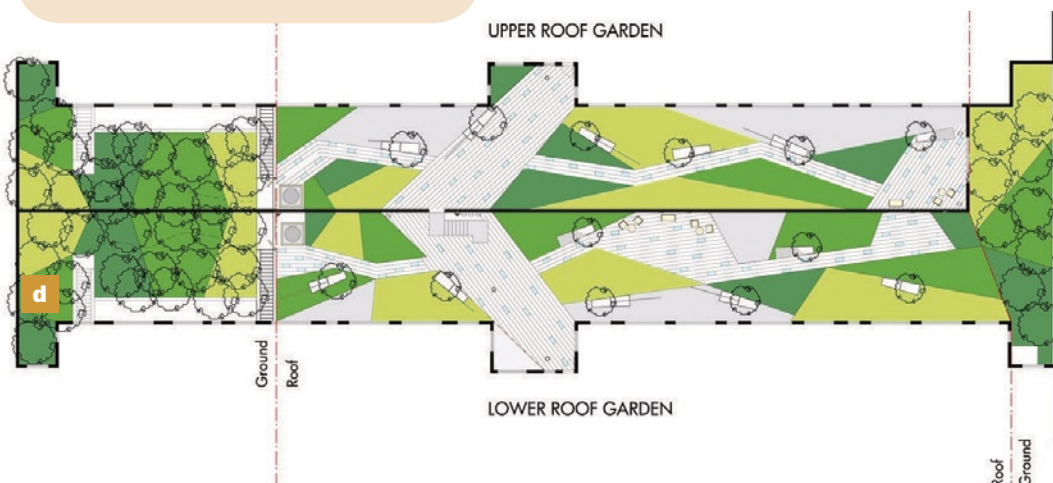
a The space presented several challenges for design, one of which was the multilevel roof. The geometric design visually joined the two spaces.

b The nautical theme was carried through to the trellis structures. The shape was inspired by the sails of a ship.

c The “sails” serve a dual purpose in the garden. They are structures onto which climbing plants can grow, and they screen the residences from the garden, providing privacy.

d A plan of the green roof clearly illustrates the concept of intersecting lines and the unified design across the upper and lower roofs.

e The specialty lighting ensures the garden is just as interesting at night as it is during the day. The LED pavers change color from white to blue for a wave-like appearance.





The design team learned a lot of lessons from this unusual project completed in 2009, says Franco.

Before beginning the project, a leak detection system was installed on the roof. We wanted to make sure we were starting with an installation with no problems. We found two leaks that were fixed. The leak detection system is permanent, so only the part of the roof that has a problem needs to be fixed.

The innovative lighting system LED light tiles added \$100,000 to the budget. We made it an option to do it or not. The concept was strong enough to convince the committee to go ahead.

We learned a lot about lighting systems and protections that need to be put into them. The system got hit by lightning at one point. We learned about safety issues after that, says Franco.

The paving system has a specific pattern. It turns out that when the pedestal pavers are offset and put on an angle, the angle and movement of traffic puts a lot of pressure on the paving system. A year later, we found the pavers were shifting because of the movement of traffic and because of the way people stepped off the stairway. We

needed to incorporate a system that binds the pavers, and we needed to come up with a method to control the pavers' movement. Blue board was used to secure the pavers.

Young kids tend to reach for things that are loose. There were minor incidents of rock throwing. So we installed a buffer between the gravel and the beds to limit access to the gravel.

We were able to come up with green roof vegetation (heuchera, liriopi and pachysandra) that worked in a shallow space rather than expensive, raised planters that aren't very attractive. Also, the extensive green roof is relatively easy to dismantle when there is need for access. Extensive green roofs are designed to be low maintenance, requiring only minimal weeding and fertilizing.

We consider the gardens to be a shady space. However, at one time of the year for a few weeks, the light reflects off a building and fries the plants in one section. So we added pebbles to that area so that the plants don't get the direct impact. Photo studies might have helped with that.

f The glass light tiles were constructed to the exact specification of the roof pavers. This allowed the tiles to fit directly into the paving system. A stainless steel edge was used on the glass tiles for protection.

g Sweeps of textures help to create bold contrasting patterns with delicate planting accents.

h The east boundary of the ground-level garden is shared with a neighboring building. Using the colors and simplicity of lines, this patterned fence creates a visual pop through the birch tree grove, providing four season interest.



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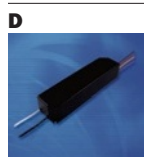
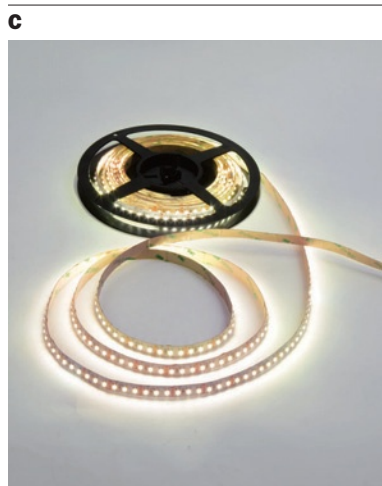
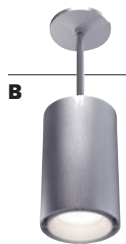
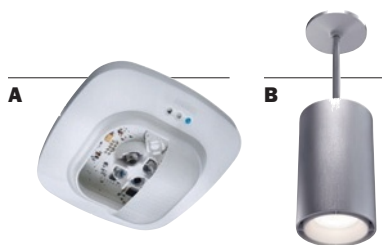
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The growing importance of energy efficiency and sustainability has given birth to new generations of products and technologies available in the marketplace. A sampling is included here.

To have your product considered for a future issue of HPB, send a product description to hpbmagazine@ashrae.org.



A Presence Detector

The new IR Quattro HD presence detector from *Steinel* is a passive infrared sensor featuring mechanically scalable square detection zone, which enables coverage zones to be delineated without overlapping or gapping and with no detection in neighboring passageways. Mounted on a ceiling, the Quattro will turn lights on and off automatically in response to occupancy and changes in light levels and features a square design that offers a coverage zone using four digital pyroelectric sensors. HPB.hotims.com/44643-174

B Pendant LED

USA Lighting announces the BeveLED 2.0 LED pendant light. Available in 12 W, 16 W, 24 W, or 33 W, the lamps feature color curve dimming which allows a customizable color palette range between 2200 K and 3500 K, as well as brightness dimming. The 6-inch diameter BeveLED offers a 10° to 80° beam spread, delivering a 10° optic with a center beam candlepower rating of more than 26,000. HPB.hotims.com/44643-180

C Strip Lighting

Edge Lighting offers the SS2P Soft Strip lighting for applications such as indoor, under/above cabinet, closet, or work station lighting. Available in 1 foot increments up to 25 feet, these strip lights feature 36 warm-white, 3097 K LEDs per foot with a color rendering index of 80+. Available power supply is a 60 W, 120 V input, 12 V dc output supply that is compatible with electronic low-voltage dimmers. HPB.hotims.com/44643-184

D Waterproof LED Drivers

PhiHong introduces the PDA040 series of waterproof LED drivers for use in residential or commercial applications. The waterproof design and wide operating temperature range add to the versatility. The PDA040 series is Class 2 per UL1310 and compliant with UL8750 and UL60950. Standard features on the drivers include over-voltage protection, over-current protection, short-circuit protection, brownout and brownout recovery. Additionally, the power supplies have a power factor correction greater than 0.9 and a total harmonic distortion of less than 20%. HPB.hotims.com/44643-167

E Colored LEDs

Osram Opto Semiconductors announces five new colored LEDs of the Duris P 5 module. The five color versions of are deep blue (450 nm),

blue (470 nm), true green (528 nm), yellow (590 nm) and red (615 to 625 nm). Based on either the InGaN (Indium Gallium Nitride) material system or InGaAlP (Indium Gallium Aluminum Phosphide) depending on the wavelength, the 2.6 × 2.2 mm LEDs use low forward voltage to achieve high efficiency of the amount of light produced to power consumed. HPB.hotims.com/44643-182

F ESL Light Bulb

Vu1 offers the R30, an electron-stimulated luminescence bulb (ESL). Designed as a mercury-free alternative to compact fluorescent bulbs, the R30 contain no toxic materials and resembles traditional incandescent bulbs. The bulb features fully linear dimming with ordinary household Triac-based dimmers and a color temperature of 3200 K. Fits standard 5 and 6 inch recessed cans and R30/R40 luminaires. HPB.hotims.com/44643-168

G LED Wall Pack

Cooper Lighting offers the Lumark Crosstour MAXX LED Wall pack luminaire series. A patent pending architectural design integrates high output LEDs available in full cutoff and refractive lens models. The series' reflector technology, optical components and thermal management outputs up to 7,416 lumens. Offered in 3500 K and 5000 K CCT (correlated color temperature), the series is available with optional dimming drivers, occupancy sensors, 90-minute emergency battery back-up, and pole mount arm configurations. Applications include pedestrian walkways, building entrances, industrial facilities, perimeter parking areas, storage facilities, and loading docks. HPB.hotims.com/44643-173

H Wireless Lighting Control

The Pico wireless remote control from *Lutron* now features a continuously glowing LED nightlight to make it easy to locate the control and turn on the lights in the dark. The remote provides control of lights from anywhere within the lighting space and is compatible with a wide variety of Lutron lighting controls. Available in 2-button and 3-button models with raise/lower configurations, the Pico features a three-year battery life and can be configured for use as a handheld control, car visor control, wall-mount control, or table-top control. HPB.hotims.com/44643-161

I Indoor/Outdoor Floodlight

EcoSense Lighting offers the Floodlight Bullet, an architectural and landscape luminaire. Featuring a high-output 6 inch fixture with 2048 delivered lumens at 4000 K—75.9 lumens per W, 150° vertical aiming and 358° horizontal rotation, and a Gore Vent feature that protects electronic components from harmful moisture. The field-interchangeable optical lenses allow for simple optical design modifications and the direct line voltage connections eliminate the need for external transformers. Also available in a smaller 4 inch fixture version. HPB.hotims.com/44643-175

J Dispensable Thermal Pads

The new line of dispensable thermal pads from *Dow Corning* enable LED lamp manufacturers to quickly and precisely print a layer of thermally conductive silicone compound in controllable thicknesses on complex substrate shapes. This is done while ensuring thermal management properties and reduced manufacturing cost. The product line encompasses four grades distinguished by varying levels of thermal conductivity with or without controlled bond line thicknesses that offer thermal conductivity of 1.5 W/mK or 2.5 W/mK thermal conductivity. Two grades, TC-4016 and TC-4026, incorporate glass beads to offer improved control over bond line thickness. HPB.hotims.com/44643-172

K Occupancy Sensors

The PerfectSense line of occupancy sensors from *NexLight* includes ceiling and wall-mount models, a wall switch, and a power pack. All models feature a daylight sensor that will turn lights off when natural light exceeds the selected lux level. The daylight sensor can be turned off and the sensor can be configured to use passive infrared or ultrasonic occupancy detection only. HPB.hotims.com/44643-166

L LED Drivers

eldoLED introduces the SOLOdrive 565 and 566. These 50 W LED drivers are for DALI and 0-10 V based, high-power LED lighting applications that require active cooling. Both drivers feature built-in auxiliary power output for a 12 V fan or cooling device, removing the need for additional power supply for the fan. All drivers come with a proprietary LEDcode feature, allowing fine-tuning of the driver configuration for specific lighting applications and extension of its feature set with sensors to create a complete and integrated sensor-operated lighting solution. HPB.hotims.com/44643-165

M Handrail Lighting

The LED V-Rail System from *Intense Lighting* now includes the IVR2-SPI, a slim post model with integral power supply. The new 24V DC model features 120 V through 277 V input, and is made from extruded 6061-T6 aluminum alloy with an external rail jacket available in 304 stainless steel. The closely packed array of

small LEDs ensure uniform illumination. Color temperature options include 3000 K, 3500 K, or 4000 K. HPB.hotims.com/44643-169

N Scalable Area Lights

GE announces their new Evolve LED scalable area lights designed with retailers, auto dealers, commercial property owners, mall operators, and other businesses in mind. A heat sink is incorporated directly into the die-cast aluminum housing and is available with three mounting options. The Evolve lamp uses high brightness LEDs rated 70 CRI at 4000 K and 5700 K. HPB.hotims.com/44643-178

O Cobra Head Streetlamp

Evolucia presents its LED cobra head luminaire for 70–250 W HID lamp replacement. These Dark Sky-compliant streetlamps offer up to 90 lumens per W and feature patented Aimed Optics to keep light on the roadway with minimal light glare and spillage. The input voltage operating range is 110-277 VAC and 347 VAC. An input voltage option of 480 VAC is available with a step-down transformer. dc and solar options are also available for off-grid applications. HPB.hotims.com/44643-185

Coastal Light Luminaire

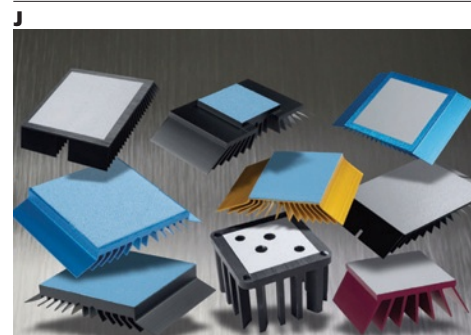
Lighting Science presents the Coastal Light luminaires designed with amber-colored lights that will not interfere with sea turtle hatching migration to the sea. Studies show that common lighting with wavelengths in the ultraviolet, blue, or green spectrum are most disruptive to turtles. Available in a variety of configurations and mountings, the luminaires offer optional full cutoff shielding attachable in the field without tools. The Coastal Light meets Florida Wildlife Conservation standards and International Dark Sky Association requirements. HPB.hotims.com/44643-150

LED Upgrade Kit

Cree introduces the UR Series kit, a 102 lumens per W linear LED upgrade kit to replace fluorescent lamps. The UR Series is designed to fit into existing T8/T12 linear fluorescent fixtures—allowing end users to easily upgrade to LED lighting. The LED lightbars deliver 4500 lumens for a 2x4 fixture and 3600 lumens for a 2x2 fixture and feature a seven year warranty. HPB.hotims.com/44643-153

Outdoor LED Luminaires

Five new LED luminaires from *Lithonia Lighting* resemble the classic appearance of traditional light source predecessors, but deliver up to 86% in energy savings compared to metal halide. Models include canopy light designed to replace up to 250 W metal halide fixtures, wall packs to replace up to 70 W high-pressure sodium wall packs, and area lighting that replaces up to 100 W metal halide. HPB.hotims.com/44643-154



Tear Drop LED Streetlight

Holophane offers a new series of pedestrian streetlight luminaire that combines classic and elegant outdoor lighting design with modern, long-life LEDs that reduce energy consumption, promote sustainability and minimize maintenance costs. Available in two housing styles with four LED lumen packages and asymmetric and symmetric distributions, these lights are CSA listed as suitable for wet locations up to 30°C (86°F) and 40°C (104°F) ambient temperature, depending on wattage. HPB.hotims.com/44643-155

White LEDs

The BLANCA 700 series LED luminaires from Winona offer spot, flood, linear surface, and linear cove white lighting to wash or graze applications such as commercial building facades, architectural details, and landmarks. IP66 rated to weather the elements, the luminaires are available in color temperatures of 2700 K, 3000 K, 3500 K, or 4000 K with multiple distribution patterns, making this series versatile in many lighting applications. HPB.hotims.com/44643-157

Luminaire Series

Peerless expands its Mino series of LED luminaires to now include a 1 x 4 ft recessed luminaire and nominal 1 x 1 foot recessed, surface/wall and pendant models. The product line has been upgraded to high-transmission lenses and is now available in a 3000 K warm white color temperature option. Featuring a dimmable, modular, and upgradeable LED light engine, the Mino series achieves uniform color consistency within 2.5 MacAdam ellipses while delivering L80 performance for 50,000 hours (12 to 15 years for normal use). HPB.hotims.com/44643-158

Downlights

Cree adds the Full Definition CR4 and CR6 LED lights to its CR Series. These two models are designed to replace incandescent four- and six-inch recessed downlights in residential and commercial applications. Light output is a warm-white 2700 K color temperature and features dimmable operation. HPB.hotims.com/44643-159

Personal Wireless Lighting

Philips launches Hue v1.1, a smart phone/tablet application that allows users to control their lighting environment with their mobile devices. The new Philips Hue channel on IFTTT.com (If This Then That) enables the Hue system

access to any application programming interface (API) on the Internet, allowing the product's smart bulbs to act as informational gateways and visual cues for updates on weather, stock quotes, sports scores, email, social media and more. HPB.hotims.com/44643-160

Retrofit Downlight Housing

Dasal Architectural Lighting announces the release of its new DLR-R round and DLR-Q square LED remodel housings for residential, hospitality, retail and light commercial retrofit applications. The new 4-inch (nominal) housings offer designers and contractors the option to upgrade existing small-aperture halogen installations to energy-efficient LED. Dasal's compatible LED trims can reduce power consumption by 60% to 70% compared to halogen MR16s. HPB.hotims.com/44643-162

Hybrid Path Light

Auroralight expands its Telluride Hybrid series of luminaires with the HUL-16 model. Designed for use with fully dimmable, interchangeable LED modules up to 12 W, the HUL-16 will also accept all MR16 halogen lamps in its standard GU5.3 socket. The product line comes with 12 different LED module choices, 12 different halogen lamp options and 12 different AMS mount options. HPB.hotims.com/44643-164

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Light Sensory Network

Sensity presents the Light Sensory Network (LSN), which operates using their NetSense platform. Designed to be installed along with an LED upgrade, the LSN connects LED luminaires in a virtual network, adding sensors that enable data collection. Possibilities include retail analytics with data gathered from luminaires, tracking the movement of people and goods in and out of buildings, or monitoring an area for CO₂ emissions, seismic activity, carbon monoxide, pollutants, humidity, or UV radiation. HPB.hotims.com/44643-170

Solar Light Poles

Sapa Pole Products introduces a new model of stand-alone light poles, the Flexsol Soluxio. Designed for use in areas lacking power grids or lighting infrastructure, these light poles store solar energy gathered through cylindrical solar panels in an enclosed lithium battery. The stored energy can also be used for other applications, such as a surveillance camera, weather station, or a GPS system. Light output automatically adjusts to deliver the desired amount of energy even in cases of cloudy weather, low yield, or indirect sunlight. HPB.hotims.com/44643-171

Interchangeable LED Module Downlight

The TLS-DMT6 from Toshiba is a complete lighting unit designed with interchangeable LED modules for easy color temperature changes or upgrades. The LED modules are available in two output levels of 1100 lumens at 20 W, and 1500 lumens at 26 W in color temperatures of 3000 K, 3500 K, and 4000 K. The model features an integral driver, LED array, built-in heat sink, and is mounted with bar hangers and brackets. HPB.hotims.com/44643-176

Puck Lights

Light Puckz from American Illumination are low profile LED engines designed for uplighting or ceiling, cove, or furniture downlighting. The compact array consists of three high brightness LEDs available in white, red, blue, green, amber, RGB, or RGBA colors, and the field-interchangeable optics allow for spot, narrow flood, or flood lighting patterns. Easily integrates into existing sockets and fixtures with G5.3 bi-pins, hard wire, or RJ25 connections. HPB.hotims.com/44643-177

Motorized Track Head

NSPEC Architectural Lighting, a division of Nora Lighting, offers the REVO motorized universal track head. The track head accepts LED, halogen, CFL, R, BR, and PAR light bulbs and is available J, L, or H-style track systems. A single REVO remote can control any head independently and the clutch-backed motors allow for hand adjustment. Motors will function even when the track is dimmed. Heads can be rotated 340° horizontally and vertically rotated up to 200°. HPB.hotims.com/44643-181

Light Controller

The Luxon Light Controller (LLC) is a local Web-enabled light controlling unit of a larger light management system. Application software is embedded in the Web server, eliminating the need for additional devices. The LLC features a two-way wireless communication interface for connection with individual luminaires and sensors. Controls up to 200 lamps, switches, or sensors via time clock, motion sensor, and daylight harvesting methods. The unit is designed for DIN rail mounts. HPB.hotims.com/44643-183

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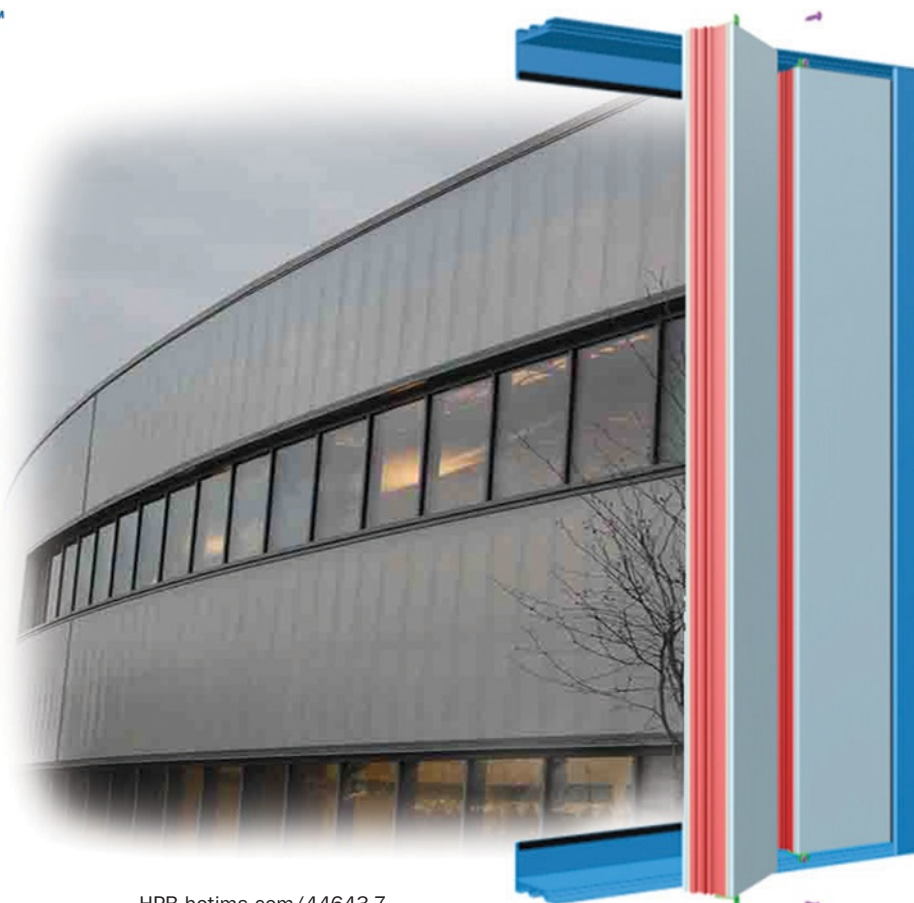
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