MEP Technologies

For Eco-Effective Buildings

PHOTO: DON F. WONG, COURTESY PERKINS+WILL

Conference room at the LEED Platinum Great River Energy building in Maple Grove, Minn. Note the underfloor air diffusers in the floor and high windows for daylighting.

Learning Objectives

After reading this article, you should be able to:

- ✔ List mechanical, electrical, and plumbing (MEP) system approaches that offer savings in energy and resources.
- ✔ Describe why buildings using underfloor air distribution (UFAD) must be different from those employing standard ducted systems.
- ✔ Discuss how power monitoring and metering support green building.
- ✔ Explain how integrated daylighting-and-dimming systems work.

By C.C. Sullivan and Barbara Horwitz-Bennett

Sustainable building trends are gaining steam, even in the current economic downturn. More than five billion square feet of commercial space has either been certified by the U.S. Green Building Council under its Leadership in Energy and Environmental Design program or is registered with LEED. It is projected that the green building market's dollar value could more than double by 2013, to as much as $140 billion.

This interest in sustainability is sparking technological innovation, too, as Building Teams and manufacturers work together to make systems that use resources more efficiently. This is evident in the steadily growing number of sustainable mechanical, electrical, and plumbing (MEP) technologies—notably displacement ventilation, power metering and monitoring, integrated daylighting and dimming systems, and hands-free, low-flow plumbing fixtures.

A review of recent work and thinking from a number of building experts shows how Building Teams are benefiting from these key MEP technologies. The findings show how a new way of thinking about green building is emerging, one that is more systems-focused than in the past, for both renovation projects and new construction.

INNOVATIVE VENTILATION—NOT JUST HOT AIR

ILLUSTRATION: ENVIRONMENTAL SYSTEMS DESIGN

Chicago's Dearborn Center was one of the first high-rise buildings in the U.S. designed with a positive displacement ventilation supply air plenum floor system. This figure illustrates how the sustainable mechanical/electrical systems were integrated by the MEP engineering consultant.

Displacement ventilation refers to systems where low-velocity supply air introduced at the floor level "displaces" the warmer room air, thereby creating a fresh, cool air zone at the occupied level. It has been used in Scandinavian buildings since the 1970s, yet it is only recently that this concept has attracted wide interest in the United States for commercial heating, ventilation, and air-conditioning (HVAC) systems design.

Displacement ventilation's popularity is growing, especially for conference rooms, office spaces, and classrooms. "There is increased demand to construct and renovate buildings that are more resource efficient, sustainable, and have improved learning and health benefits," says Michael McDermott, LEED AP and senior associate, Environmental Systems Design, Chicago. "As this demand increases, the displacement ventilation concept may rise to the top in HVAC system selection."

Delineating the system's main benefits, McDermott lists:

• **Flexibility.** As loads change, the system compensates. For example, a space that changes use, and as a result has loads concentrated in one floor area, will cause buoyant forces to drive supply air toward the new loads.

• **Indoor air quality.** Because fresh supply air pools at the floor level, personal thermal plumes draw fresh air upward, where the warm, polluted air is extracted at the high return.

• **Energy savings.** The lower pressure drop often reduces fan energy and equipment requirements. Economizer operating hours can also be increased to take advantage of free cooling because supply air temperatures are higher than with overhead air distribution systems. In addition, chiller efficiency may be increased when the system is not dehumidifying due to a lower supply air temperature and higher return air temperature.

• **Improved acoustics.** Low-velocity air supply generates less noise than a typical supply diffuser.

According to Don Jones, AIA, LEED AP, a principal and senior designer, and Eric Joesten, PE, LEED AP, principal, director of mechanical engineering, their firm, EwingCole, Philadelphia, has discussed how displacement ventilation can reduce the amount of ductwork needed, thus possibly allowing lower floor-to-floor heights. Displacement ventilation may also make it unnecessary to have such energy-consuming and expensive components as variable-air-volume (VAV) boxes and reheat coils. Jones and Joesten also contend that buildings with displacement ventilation can offer building occupants enhanced control of their environment.

But displacement ventilation is not ideal in all environments. For example, settings with high cooling loads may require uncomfortably cold supply air, explaining why displacement schemes are rarely employed in very warm climates. In addition, with system performance dependent on ceiling height, spaces with low ceilings are usually not suited to the use of displacement HVAC, says McDermott.

Scott Kesler, director of MEP engineering for the healthcare sector at OWP/P, Chicago, cautions that "most important, these systems require valuable floor space, and many codes haven't yet been modified to allow for this ventilation strategy." On the other hand, he sees strides being made in the area of market acceptance, by both Building Teams and end-users. "More vendors are providing displacement equipment, making it more competitive and cost effective," he says. "Improved control systems are offering better comfort and energy efficiency, and heat recovery devices are making humidity control easier to accomplish."

Underfloor air distribution, or UFAD, is a subset of displacement HVAC that has been experiencing growth due to end-user preferences, availability of products, and overall

PHOTO: DON F. WONG, COURTESY PERKINS+WILL

Public area at Great River Energy show how advanced HVAC technology and abundant daylighting can dramatically improve indoor air quality, energy savings, and workplace productivity.

PHOTO: COURTESY TATE ACCESS FLOORING

Installation of the UFAD system at Great River Energy. The UFAD provides 30% additional fresh air delivery to occupants and 50% energy savings.

system efficiencies.

"The biggest advantage of UFAD is savings from reduced fan and cooling energy, as most of these systems supply air to the underfloor plenum at low pressure—0.5 inches of water pressure—and relatively high cooling temperatures—65ºF vs. 55ºF," says Dale Holland, PE, LEED AP, executive vice president of the electromechanical engineering firm Dunham Associates, Minneapolis.

Holland's firm recently designed a UFAD system for the Great River Energy headquarters building, Maple Grove, Minn., a LEED Platinum project that was one of the 2009 Top 10 green projects of the AIA Committee on the Environment (AIA/COTE). To make it work, the Dunham Associates' team designed a low-velocity, underfloor displacement ventilation system with a lake-source geothermal system. The air-delivery concept and natural heat rejection resulted in 30% more fresh air delivered to the "breathing zone" and 50% energy savings.

Another benefit of UFAD, of course, is the underfloor air-supply plenum, which obviates the need for horizontal distribution ductwork and can be utilized to run wiring systems, says Chris Schaffner, PE, LEED AP, with The Green Engineer, a Concord, Mass.-based sustainable design consulting firm. Raised floors improve access to below-floor spaces. In addition, concrete floor slabs can double as a thermal storage system, absorbing the cool nighttime air and offsetting the room's heat the next day.

It should be noted, however, that UFAD systems need to be designed well and even then may not be suitable for all buildings and occupancies. Charles B. Kensky, PE, LEED AP, a principal with Bala Consulting Engineers, King of Prussia, Pa., outlines a number of concerns that require special attention:

- Humidity control is a constant problem, as are high internal equipment loads and perimeter cooling/heating.
- The raised floor, acting as a supply air plenum, must be sealed at all joints to walls, columns, and cutouts.
- The concrete floor below the raised floor must be thoroughly cleaned and sealed to prevent dust.
- The building height cannot be reduced significantly due to the ceiling return and outside air path requirements.
- A conventional air-conditioning system may be required for perimeter areas and conference rooms.
- UFAD systems are difficult to retrofit into existing buildings due to ramps.

In Holland's opinion, "The largest challenge is having the right tools to design the underfloor temperature to be uniform and provide the right volume above the floor to maintain stratification without discomfort." To address this issue, Holland's firm recommends utilizing computational fluid dynamics (CFD) software to visualize system performance during the design phase.

While UFAD systems work well in office settings, Kesler points out they are not appropriate for applications such as acute-care settings in hospitals, due to issues of infection control for plenums that must be open to multiple spaces. In fact, he explains, "Many codes do not and may never be changed to allow this type of ventilation strategy in healthcare occupancies."

Natural ventilation and mixed-mode. Mechanical cooling and fan energy account for approximately 20% of commercial building electrical consumption in the United States, according to the Lawrence Berkeley National Laboratory (LBNL). That is the main reason why passive natural ventilation, although more common in Europe and Japan, is gaining interest among Building Teams for sustainable building projects in the U.S.

Researchers at the Center for the Built Environment (CBE) at the University of California, Berkeley, offer a mixed-mode informational portal with case studies and project data. According to the group's analysis, there are five different design approaches to natural/mixed-mode ventilation:

• **Concurrent mixed-mode operation.** The most prevalent design strategy, this system utilizes air-conditioning and operable windows in the same space, at the same time.

• **Changeover designs.** Becoming more common, this approach programs building "changeovers" between natural ventilation and air-conditioning on a seasonal or even daily basis.

• **Zoned systems.** Also common, these assign different building zones with different conditioning strategies.

• **Alternate designs.** These run indefinitely in one mode until manually switched.

• **Contingency schemes.** Designed with provisions for change in the future, contingency schemes fully set up a building with either mechanical ventilation or natural ventilation.

In terms of applications, Bala's Kensky explains, "Natural ventilation can be very energy efficient in stable climates, but it is most effective in temperate or dry climates." However, in order to be successful, natural ventilation and mixed-mode systems must be considered early in the schematic design phase, as their operational effectiveness is very much dependent on such variables as ceiling and building height, floor plate size and depth, and window size and location.

While harnessing and utilizing nature's fresh air breezes sounds great in theory, Kesler warns against what he calls "elaborate and potentially expensive controls and actuators" that may be required for switchover from natural to mechanical ventilation modes and back.

Experts at UC Berkeley's Center for the Built Environment also acknowledge that mixed-mode strategies can potentially add to a building's cost and complexity. Moreover, the AEC industry's general lack of familiarity with such systems may imply a steeper learning curve for many Building Teams. In addition, the potential for smoke migration during fire events may be at odds with local building codes, not to mention the security and safety concerns associated with operable windows.

ENERGY-SAVING ELECTRICAL TECHNOLOGIES

On the electrical side of the MEP equation, a number of discrete systems and components are improving building performance. One surprisingly important ally for green building to emerge over the last few years has been submetering and monitoring systems. These tools are an important part of any sustainable design package, offering invaluable energy usage information.

"The biggest advantages to monitoring building loads," says Ryan Fryman, PE, LEED AP, CxA, a principal and senior electrical project engineer with TLC Engineering for Architecture, Jacksonville, Fla., "is the opportunity to determine where the biggest energy-using systems are, so that we can target them for ways to save energy."

Bala's Kensky explains further that "the more you meter, measure, and trend, the more you can improve on your buildings operations, thus optimizing the systems and reducing operating costs." Although first cost has traditionally been a deterrent to the use of submetering, meters are becoming less expensive, he says, and "virtual meters," such as data loggers that track system efficiency (in the form of chilled water exiting an HVAC system compared to energy consumed) are also being used more widely.

"First cost can be a challenge, but the return on investment can be real if the proper actions are taken when anomalies are found," says Kensky. He warns that this is also dependent on properly training building operators on how to utilize these sophisticated building management systems and helping them understand the overall system operations and how slight changes can improve or degrade operations.

According to A. (Tom) Papademos, PE, LEED AP, director of electrical engineering with Albert Kahn Associates, Detroit, the primary benefits of monitoring and metering technologies are to:

- **Provide information** to monitor energy expenses on a daily or weekly basis.
- **Allocate energy costs** to different segments of production processes.
- **Identify operational changes** that result from malfunctioning equipment.
- **Direct energy consumption reduction** by readily identifying current usage compared to a baseline number.

In addition, while these systems have been available for many years, some newer features make submetering and monitoring easier to use and richer in useful information. For example, several products now on the market provide data on kilowatt-hours (kWh) in dollars, current demand load in kilowatts, and cost per hour based on current load. Other products can report on estimated CO_2 emissions in pounds based on U.S. Department of Energy standards, as well as net metering with utility-delivered vs. user-received power and net usage.

Motorized systems. It may seem paradoxical, but the use of motorized systems can sometimes enhance sustainable design, even while adding some upfront cost and incremental power load.

For example, while the use of window shades and blinds—a long-standing solar shading strategy—may be routine these days, the integration of controls with such products is quickly catching on. "Motorized shades, when used correctly, can decrease the heat load significantly on a building's spaces that may see large fluctuations in direct sun heat loads," says TLC Engineering's Fryman. "With more competition, the upfront cost has come down, making these systems more viable."

Furthermore, sophisticated control systems offer additional capabilities for motorized solar control, as Kensky explains: "Central systems can automate the controls for responding to sunlight exposure changes throughout the day and through seasonal changes. For example, nighttime winter operation lowers the shades to provide additional insulation, if desired, and nighttime summer operation raises the shades to assist in nighttime cooling."

When specifying such products, Papademos advises choosing the appropriate type of shade, selecting a shade with compatible aesthetics, and specifying a system that can easily be integrated into the building management system (BMS). In fact, says Fryman, motorized shade systems need to be carefully integrated into the overall building design in early schematics. "The building orientation to the sun, interior lighting and glare possibilities, and power and controls for the shades and lighting must be incorporated to achieve the best results for the space application," he says.

Kesler warns, however, that proprietary shade and motor control packages can add to installed costs and may lead to ongoing maintenance problems.

Photovoltaics. It's impossible to discuss building electrical efficiencies without discussing solar power, which is why so many Building Teams at least consider the use of photovoltaic (PV) arrays or building-integrated PV (BIPV) materials for green projects. And while R&D into PV systems is progressing, with more efficient and larger aesthetic variety coming to the market, "First cost still remains at a point where the PV systems that do get installed are justified for reasons other than straight economics," says Steven Eich, PE, LEED AP, vice president, Environmental Systems Design, Chicago. These include grants and incentives to offset the first costs. Moreover, the use of PVs in a project makes a powerful environmental statement that remains associated with the building.

On a technical level, other benefits of photovoltaics include the following:

- PV energy is generated and consumed at the same location, **eliminating transmission line losses**.
- PV systems **offset pollutants** such as nitrogen oxide, CO2, sulfur dioxide, and nuclear waste.
- BIPV systems can **replace** other building elements like **glazing or spandrel panels**.
- BIPV and roof-mounted solar-power systems can **provide shade** that will reduce a building's cooling load.
- PV modules can be used as window shades or fins to **reduce solar heat gain**.

Still, PV first costs are high, and the typical payback is very unattractive at 20-25 years. However, some experts say that government incentives will change this. In fact, according to Brandy A. Chambers, LEED AP, an engineer with R.G. Vanderweil Engineers, Boston, a 30% federal tax credit is available to virtually all photovoltaic projects, and many states have additional incentives. For example, the Massachusetts Technology Collaborative offers additional rebates on systems up to 500kW in size, and the New York State Energy Research and Development Authority offers rebates on systems up to 50kW in size, in addition to a state-offered tax credit, according to Chambers.

In addition, more and more building owners are availing themselves of power purchase agreements. “Through this arrangement, an independent third party installs an array on to the interested party’s property, but retains ownership,” explains Chambers. “The property owner then agrees to buy the electricity that the array produces at a fixed cost per watt, which is typically lower than utility-supplied electricity. The owner also benefits by avoiding the potential headaches involved in financing and maintaining the array.”

Building product manufacturers are also offering new products and services for solar energy projects. For example, Tecta America, a Skokie, Ill.-based roofing contractor, recently launched a solar division offering a comprehensive turnkey package, including design, engineering, financing, installation, maintenance, warranty, and monitoring performance of solar installations.

Power-generating switches. At a large scale, photovoltaics are a compelling way to return power to the grid. At a much smaller, more local scale, new electrical gadgets are helping end-users save energy and even return some to their own buildings through smart product design.

Among the more unusual offerings of this type is a new light switch that actually generates power through the act of switching it on. Capturing the kinetic energy created by this motion, one device powers its wireless signal (which can be transmitted up to 300 feet) to dim, turn on, or shut off incandescent and dimmable compact fluorescent lights. “It is a great solution that delivers truly green lighting projects,” attests Alan L. Bravo, principal and project director, FBA Engineering, Newport Beach, Calif., who has specified the light switches for a number of projects.

Bravo also likes the fact that the wireless product eliminates the problem of routing new conduit for retrofits. “This solution allows for the easy placement and relocation of wireless light switches and solar powered photosensors on any surface, which solves a lot of problems,” he says. The product also offers greater flexibility for the future, and does not require batteries. “This makes it very appealing from a maintenance standpoint,” he adds.

A related product developed by researchers at the LBNL’s Environmental Energy Technologies Division, called WiLight, also harvests the mechanical energy created when the user clicks on the switch. This energy then powers a wireless signal either when the occupant desires to change the light setting or in response to building-wide demand.

According to LBNL spokesman Allan Chen, the WiLight system can also be integrated with another LBNL technology, the client logic integrated relay (CLIR), which enables buildings to monitor the status of the electricity grid over the Internet, via signals from utility servers. “If the grid nears an overloaded emergency state, the CLIR box uses the WiLight radio bridge to send a radio frequency signal to the building indicating the seriousness of the crisis. Nonessential energy uses are reduced—for example, building lighting levels—as WiLight reads the signals and lowers the lighting to preset levels,” Chen explains.

TARGETING LIGHTING SYSTEMS

Lighting experts at Lawrence Berkeley National Laboratory suggest that lighting controls, which can dim or turn off lights automatically, could actually reduce lighting in commercial buildings by almost one-half. In fact, LBNL researcher Francis Rubinsten goes so far as to predict that if 30% of commercial buildings adopted lighting control systems by 2025, the nation could reduce its energy use by 700 billion kilowatt-hours, saving about $50 billion.

Starting with the occupancy sensor, Craig DiLouie, education director for the Lighting Controls Association, Arlington, Va., reports that the technology is “a proven, reliable method of automatic lighting control” that can deliver significant energy savings—35% to 45% in offices, according to the New Buildings Institute—while complying with the automatic shutoff requirements of most commercial building energy codes.

Manufacturers are steadily improving their products and now offer systems that offer both reliability and flexible design options. For example, OWP/P’s Kesler lists such technological advances as improved lens technology, wireless sensors with built-in transmitters and receivers, and dual-technology components with a combination of ultrasonic, passive infrared, and microphonic sensors to minimize nuisance operations. Craig DiLouie, of the Lighting Controls Association, points out that the dual-technology sensors are ideal for spaces where occupants move very little, such as office environments or classrooms in which students are taking tests.

Other newer product options, according to DiLouie, include “manual-on” sensor switches, which maximize energy savings by requiring the user to turn the lights on manually while it turns them off automatically. Even more efficient is the bilevel switching sensor, which combines manual-on/auto-off or auto-on to 50%/auto-off.

Do these lighting controls reduce energy usage? A comparative study of eight office spaces, recently conducted by California Lighting Technology Center, revealed the following energy savings as compared to baseline performance:

- An auto-on to 100% bilevel occupancy sensor: 34% savings.
- An auto-on to 50% bilevel occupancy sensor: 52% savings.
- A manual-on bilevel occupancy sensor: 46% savings.

However, even with all these capabilities and potential savings, the systems must be properly specified in order to work effectively. “Poorly designed systems can actually waste energy by turning on lights needlessly,” says Eich. This can happen when occupants walk down a corridor of unoccupied offices, causing the lights to turn on in each office as they go by.

DiLouie further cautions that, while occupancy sensors are a safe, reliable, proven method of occupant detection and automatic shutoff, they "must be properly applied, installed, and calibrated to be most effective. If misapplied, nuisance switching may result, which could irritate occupants and jeopardize savings."

System commissioning to ensure proper operation, settings, and adjustments are made at the time of occupancy is also advised, says Kesler. To this end, a newer technology, self-calibrating sensors, can be helpful to automate commissioning, thereby maximizing energy savings.

Integrated daylighting and dimming. As desirable as natural light is, many experts actually claim that, in and of itself, it does not save energy and is therefore not inherently sustainable. Rather, a well-designed daylighting control system is essential to properly harvest natural light, says the LCA's DiLouie.

Moreover, says DiLouie, daylighting control systems are integral to energy standards like the International Energy Conservation Code (IECC) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards. "The latest generation of energy codes, such as IECC 2009 and Title 24—and likely ASHRAE 90.1-2010 and ASHRAE 189.1—are beginning to require daylighting control, and it is particularly favored in LEED projects where designers attempt to exceed 90.1 for energy points," he says.

According to Kensky, LEED for Commercial Interiors (LEED-CI) awards a credit for daylight-responsive controls within 15 feet of all windows.

But in terms of tweaking the design, the Bala engineer explains, "The better systems are integrated with photosensor and dimming ballasts that will match a specified light level for the space by dimming the lights. The space can be set up so that the fixtures farther away from the natural light source will dim less and the light levels will be uniform and consistent throughout the space."

For what he calls the "ultimate in performance," DiLouie recommends a *digital dimming system*, which he sees as ideally suited for daylighting control because control zones can be set up and reconfigured over time without hardwiring. However, "If the dimming system is not properly designed and commissioned—for example, if the photosensor is improperly placed—occupants may respond negatively to improper operation and the owner may disable it, negating the benefit of the investment."

In addition, says Kesler, higher installed costs, more complicated systems to operate and maintain, and contractors who are less familiar with such products can add to the complexity of using such systems in building projects.

PHOTO: LUCIE MARUSIN, COURTESY PERKINS+WILL

Dimming ballasts, daylight sensors, and motion sensors reduce artificial lighting needs at Great River Energy. The new headquarters harvests daylight through narrow office floorplates and multiple light-filled atriums. With reduced lighting requirements, less heat is generated, lowering the need for air conditioning. The building uses 40% less energy for lighting than similarly sized buildings that use standard technology.

To address some of these obstacles, LBNL's daylighting group is working on an integrated building-equipment communications network, or IBECS. This novel system is intended to better enable building lighting and envelope systems to respond automatically to changes in occupancy, daylight levels, and energy costs. They also give occupants more control over their environment, says LBNL's Chen.

Essentially, the research team is taking a networking technology called embedded-device networks and integrating it with lighting and envelope controls. The ultimate goal, says Chen, is to achieve lighting-related savings on electricity consumption of 59% in new construction and 43% for retrofits by 2015.

Light-emitting diodes. Another pocket of promising research is in the area of light-emitting diodes, or LEDs. Although the technology is generally associated with decorative and specialty applications, it is being considered more and more for general, white-light illumination. "LED lighting is very in vogue and is featured by almost all manufacturers for its energy-saving capabilities," relates Kensky. "With low wattage, no mercury, and extremely long life, it is touted as the future of lighting." According to Kahn's Papademos, other benefits of LEDs include:

- LED point sources can easily be controlled.
- LEDs introduce less heat into the building's envelope as compared to other lighting sources.
- LEDs offer infinite color combinations, when properly specified and designed.
- The LED's illuminated surface is not hot to the touch.

On the other hand, LEDs have their own problems, says Peter Levasseur, AIA, LEED AP, director of sustainable design,

PHOTO: EWINGCOLE

This skylight system at the North Shore Long Island Jewish Health Monter Cancer Center, Lake Success, N.Y., brings natural light into the space.

and Mary Alcaraz, PE, LC, LEED AP, a principal and director of lighting design, with EwingCole, Philadelphia. For example, LEDs generally cost more than other lighting options and sometimes have limited light output.

There is also the unresolved question of what to do with the lamp at the end of its life. Papademos explains that the current philosophy is to design a fixture around the LED, so that when the light source eventually needs to be replaced—perhaps 10 or 15 years down the road—it may follow that the fixture would need to be replaced as well. Papademos also mentions a lack of common definitions and terms among LED manufacturers, and a need for more standardized tests and measurements to back up manufacturer performance claims. "Quite often, if it sounds too good to be true, it is," he says.

At the same time, researchers are diligently working to bring the technology to a point where it can be competitive with halogen, fluorescent, and metal halide lamps. For example, organic light-emitting diodes (OLEDs) are reported to offer power-conversion efficiencies close to those required for energy-efficient operation, although at this point, only for green and red light, and with insufficient luminances for interior building lighting, according to the Washington, D.C.-based Optoelectronics Industry Development Association.

A related recent achievement, reports the U.S. Department of Energy, is a white OLED that surpasses the power efficacy of incandescent bulbs through the utilization of a high-efficiency phosphorescent technology.

OTHER WAYS TO SAVE LIGHTING ENERGY

Light-reflecting materials and light shelves. Whether it's with light shelves or light-reflecting materials such as extruded aluminum or composite aluminum panels, another way to save on electrical lighting costs is by maximizing daylight penetration.

"Light shelves reflect and direct daylight onto the ceiling and deeper into the space and reflective materials can increase daylight penetration by as much as four times the distance from the floor to the top of the windows," Kesler explains.

Although light shelves do add to first cost, they have become more affordable in recent years, according to Alcaraz and Levasseur. They can also be integrated into wall systems and are available in multiple material types and options.

EwingCole designers point out, however, that their appearance may be somewhat jarring to occupants, occasional maintenance problems may arise, and the exterior shelves might create unwanted sites for bird habitats.

In terms of design, their effective use is very much dependent on such factors as 1) the size of shelf, 2) horizontal or vertical placement, 3) interior versus exterior installation, and 4) building orientation, says Kesler, who warns that "they are not appropriate in tropical or arid climates due to intense solar heat gain."

Papademos adds that designs should also be careful to allocate sufficient building height for proper design and placement, and aesthetically blend any exterior shelves into the building façade.

Prismatic glazing. Another effective way to improve natural light distribution and illumination is by using prismatic glass, acrylics, and polycarbonates. Offering a higher quality of daylight within a space than clear or typical obscuring material, translucent prismatic materials are being used more and more as the fenestration material in lieu of other more traditional materials.

For example, more than 2,000 pieces of prismatic glass were installed in the base of the high-profile One World Trade Center project. The SOM-designed Freedom Tower utilizes the reflective, refractive, and light transmission properties of the glass to create a dynamic, shimmering façade.

Other typical applications include installing prismatic glass on the top third of a window to refract sunlight toward the ceiling, or in roof lights to keep out radiation while letting in sunlight.

Translucent materials. Another interesting daylight-enhancing choice is the use of translucent materials. In addition to letting in sunlight, many translucent panels and wall/roof

PHOTO: EWINGCOLE

An innovative LED fixture at the Cooper University Hospital lobby in Camden, N.J. LEDs have low wattage and use no mercury.

PHOTO: EWINGCOLE

Light shelves at the Olympus Headquarters, Center Valley, Pa., help maximize daylighting opportunities.

assemblies offer higher R-values than conventional windows. While more commonly used for exterior wall construction, the materials can also be fitted with light fixtures to control brightness, Papademos explains.

As for the latest technological advances in this realm, Alcaraz and Levasseur report more affordable glazing, tinting, frit, and, color options. Also, many Building Teams are using 3D modeling and daylighting visualization tools, which enable building owners and end-users to see designs prior to construction.

Perhaps one of the most exciting developments is a new translucent panel product on the market that utilizes aerogels, among the world's lightest solid materials and a material formerly used exclusively for extreme environmental conditions such as the body of the space shuttle.

Claimed to deliver thermal insulating and light transmitting factors two to four times better than comparable products, aerogel-filled translucent panels were recently specified for the new Yale Sculpture Gallery, an AIA/COTE 2008 Top 10 Green Project, designed by KieranTimberlake Associates. Integrated with a triple-glazed curtain wall and exterior sunshading system, the panels are so effective on their own at reducing solar heat gain and cold-weather heat loss that they are successfully balancing the overall performance losses from the glass areas.

SAVING WATER

Although fresh water is very much taken for granted, the fact is that supply is declining. "Some experts are even more concerned with the supply of fresh water than the supply of energy," says Andrew P. Simpson, LEED AP, a mechanical engineer with R.G. Vanderweil, Boston. He notes that considerable energy is used to pump and treat water, too.

Cost savings is strong motivator. "One of the least costly ways to conserve water—low-flow and no-flow fixtures—has amazing saving potential, reducing water usage by a staggering amount," says Simpson. "In fact, the payback period for efficient fixtures is typically measured in months, and water savings can amount to hundreds of thousands of gallons a year."

Not only do low-flow fixtures save a great deal of water, but they are required by the National Plumbing Codes. Consequently, they are quite widely used at this point, says Kensky.

While high-efficiency toilets—which use 1.28 gallons per flush and urinals at just 1/8th gpf—have succeeded in raising the bar on water savings, vacuum-waste systems are now coming out, making it possible to flush a toilet with less than 0.5 gpf, according to David E. DeBord, CPD, LEED AP, a senior associate with Environmental Systems Design, Chicago.

At the same time, Kesler points out that, in general, some of the "extremely low-flow" fixtures on the market may not perform well and might skew the public and owner perception regarding the efficacy of low-flow fixtures in general." And the same goes for waterless fixtures, which aren't even legal is some states, including Illinois and Minnesota.

"We rarely use these because most of our clients and owners are concerned about the extra expense and maintenance required, and the public is still a bit wary of the waterless [products]," relates Donia Bessa, PE, CPD, LEED AP, a mechanical engineer in the healthcare division of TLC Engineering for Architecture. "You also have to be careful what drain piping you use because undiluted urine will eat away metal piping."

To address this last issue, DeBord suggests providing either a manual flush valve for maintenance staff to periodically operate to wash out the piping, or a valve actuated by a timer. "This would still keep water usage at a minimum, yet provide some protection for the piping systems."

Dual-flush systems. These low-flow systems made their debut on the U.S. market only in recent years, even though they have been pretty much standard in Europe, Israel, and Australia for years. These units save water by using a lower flush rate for liquid waste disposal and a higher flow rate for solid waste disposal. Easy to retrofit, an existing flush valve can be replaced with a dual-flush handle.

The catch is that the toilet's effectiveness is dependent on the user. Consequently, occupants must be instructed how to flush the units—and the learning curve isn't always so smooth. "Our feedback from owners indicates that it's difficult to change people's habits," confirms Bessa. In fact, TLC has actually found it easier to specify the 1.28-gpf toilets, both for this reason and to earn points more easily using the LEED template.

One way around this challenge is to install a time sensor, which automatically selects the flush mode depending on the amount of time the toilet is in use.

Hands-free systems. Hands-free fixtures are almost commonplace for public buildings, as well as commercial and institutional facilities. In addition to flush valves and faucets, end-users are now also opting for touchless soap dispensers and hand dryers. Not only are they hygienic and able to save significant volumes of water, according to Dunham's Holland, but some of the newer fixtures also have temperature adjustments, the lack of which was, in the past, a drawback for many clients.

Another improvement making these products more attractive is longer-lasting batteries. "The newer models incorporate tiny water-powered turbines that trickle charge the batteries, vastly increasing their life span and reducing maintenance," explains Bessa. A/C-powered sensors are another choice, requiring even less maintenance, although they won't function during power outages unless put on emergency power. They also require periodic adjustment of the sensor angles and distances to ensure optimal operation, according to Kesler. BD+C

GREEN MEP EDUCATION QUIZ

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1. Which is an important benefit or feature of displacement ventilation systems?
   - A. They provide a single, consistent supply of air, regardless of load.
   - B. Fresh supply air pools at the floor level, and exhaust is extracted upward.
   - C. Higher pressures are required, increasing equipment sizes.
   - D. Air is supplied at a higher velocity than with standard HVAC systems.

2. A significant advantage of underfloor air distribution (UFAD), in addition to the reduction in fan and cooling energy, is the relatively high supply-air temperature for cooling. What is the typical temperature of this supply air in UFAD systems?
   - A. 45ºF
   - B. 55ºF
   - C. 65ºF
   - D. 75ºF

3. Which of the following considerations must be made in the design of underfloor air-distribution (UFAD) systems?
   - A. The raised floor of the supply-air plenum must be sealed at all joints.
   - B. Ceiling returns and outside-air path requirements may limit reductions in building heights.
   - C. Conventional air-conditioning may be required for perimeter spaces.
   - D. All of the above.

4. Passive natural ventilation can be used to reduce mechanical cooling and fan use, which account for approximately what percentage of commercial building electrical consumption in the United States?
   - A. Less than 1%
   - B. 4%
   - C. 20%
   - D. 55%

5. Natural ventilation is most effective in:
   - A. Temperate or dry climates.
   - B. Wet and humid climates.
   - C. Healthcare facilities, such as acute-care facilities.
   - D. Buildings with limited occupancies.

6. True or false: The 30% federal tax credit for the use of photovoltaic (PV) systems is available only to owners of detached single-family homes.
   - A. True.
   - B. False.

7. Power monitoring and metering technologies:
   - A. Can provide information to monitor energy expenses and help identify operational changes that result from malfunctioning equipment.
   - B. Do not allow end-users to determine how much energy specific facilities, processes, or types of equipment use.
   - C. Are only able to track energy expenditures on an hourly basis.
   - D. Are required by law.

8. Which is NOT a feature of power purchase agreements?
   - A. An independent third party installs a solar array on the interested party's property.
   - B. The third party retains ownership of the solar array.
   - C. The property owner agrees to buy the electricity produced by the array at a fixed cost per watt.
   - D. The property owner pays for the installation and maintenance of the solar array.

9. According to research by Lawrence Berkeley National Laboratory (LBNL), the use of integrated dimming and daylighting can affect the energy requirements and costs of operating buildings. According to LBNL researchers, which of the following statements is NOT true?
   - A. If 30% of commercial buildings used lighting controls by 2025, U.S. energy costs would drop by about $50 billion.
   - B. If 30% of commercial buildings used lighting controls by 2025, U.S. energy use would drop by 700 billion kilowatt-hours.
   - C. Automatic dimming and on/off controls can reduce thermal gain from daylighting by almost one-half.
   - D. Automatic dimming and on/off controls can reduce commercial building lighting costs by almost one-half.

10. Daylighting controls are now required in some codes and standards, including:
   - A. The Florida Building Code and ASHRAE 90.1
   - B. The International Energy Conservation Code and ASHRAE 90.1
   - C. The International Energy Conservation Code and the International Building Code.
   - D. The International Building Code and the NFPA Life Safety Code.