BUILDING ON BELIEFS

BY MARK HANSON, PH.D.

The Benedictine Sisters at Holy Wisdom Monastery never set out to prove that green buildings can be constructed at the same cost of a conventional building. Their mission of prayer, hospitality, justice and care for the earth guided the design of energy-efficient systems and selection of sustainable materials for their new monastery near Madison, Wis. The result is a LEED Platinum-NC facility that uses significantly less energy than average and was built at a total project cost of $246/ft^2, similar to or less than the cost of a comparable conventional building.

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Above **Large windows in the 400-seat assembly room (chapel) ensure that all areas receive ample natural light during the daytime. The four triangles cut into the southeast wall echo the Sisters' logo and are backlit by skylights during the day and fluorescent lights at night.**

Opposite **A dramatic skylight illuminates the baptismal font located at the entrance to the assembly room (chapel) at Holy Wisdom Monastery in Middleton, Wis.**

A theme of unadorned simplicity and beauty characterizes the monastery, which is used for worship, concerts, meetings, dining, reading, reflection and administration. In addition to the Sisters and their coworkers, oblates and members of the Sunday Assembly, other building users include individuals and groups on retreats, volunteers who work in the prairie, and other visitors.

Structural elements are concealed and mechanical systems are virtually inaudible to prevent visual or auditory distractions from disrupting quiet contemplation. The colors are uniform throughout and internal visual distractions are eliminated. Emphasis was given to external views overlooking lakes, woods and the restored prairie.

Holy Wisdom Monastery's spaces consist of offices, conference rooms, library, IT, large and small assembly/worship spaces, dining rooms, and a commercial kitchen. With no residential areas, the mix of space uses is similar to those of office buildings.

The first year of energy data shows site energy use intensity at 32.6 kBtu/ft^2. While that performance resulted in a preliminary ENERGY STAR rating for the first year of 93, operations can be improved in the second year.

Building Envelope, HVAC

The high performance design starts with a thermally efficient building envelope and continues with a highly efficient HVAC system and minimum lighting power density and miscellaneous loads. Building envelope includes an R-30 roof, R-16 walls and wood windows with an assembly value of R-2.9.

The HVAC design features a closed-loop ground-source heat pump system combined with a dedicated outdoor air delivery system with energy recovery. To provide a quiet environment, a central heat pump system was located in a separate maintenance building that is adjacent to and part of the monastery building project.

The maintenance building structure reuses the subbasement of the old Benedict House, the Sisters' former retreat and conference center that was deconstructed. A green roof and patio covers the maintenance building for aesthetics, as it is in the sight line of the entry area, some offices and the board room in the new monastery building. The green roof also plays a role in storm

BUILDING AT A GLANCE

Name Holy Wisdom Monastery

Location Middleton, Wis. (90 miles west of Milwaukee)

Owner Benedictine Women of Madison

Principal Use Office
Includes Offices, conference rooms, library, IT, dining rooms, commercial kitchen, workshop, large and small assembly rooms

Employees/Occupants 20 Sisters and employees, up to 600 during events

Occupancy 25% (weighted average for operating hours)

Gross Square Footage 34,383

Distinctions/Awards LEED-NC Platinum (highest rated LEED-NC Platinum building in the U.S. at time of certification); 2010 Aon Build America Merit Award (The Associated General Contractors of America); 2010 Design-Build Award of Merit (Design Build Institute of America); 2010 Top Ten LEED project (#5), Interiors & Sources magazine

Construction Cost $7,182,191 (includes demolition and site preparation).

Total Cost $8,457,211 (includes construction cost plus design fee, pipe organ, bells, font, LEED certification, and food service equipment)
Cost Per Square Foot $246 (total cost), $209 (construction cost)

Substantial Completion/Occupancy September 2009

KEY SUSTAINABLE FEATURES

Water Conservation Low flow fixtures throughout including waterless urinals and 1 gallon/flush toilets

Recycled Materials All gypsum board, asphalt, steel and glass; total recycled content is 21% of material cost

Daylighting 85% of regularly occupied spaces meet LEED daylighting minimum of 25 footcandles; chapel/assembly (largest space) does not use electric lights during daytime events

Individual Controls BCS system provides room by room temperature control, operable windows, multilevel/dimmable lighting controls

Other Major Sustainable Features

- Ground source heat pump system connected to 39 closed loop wells; outside air supplied via a dedicated system with energy recovery ventilation with economizer operation during moderate temperatures
- Native landscaping that requires no irrigation
- Green roofs on garage and maintenance building

water management (Photos, p. 44). The same factors drove the decision to install a green roof on the four-stall attached garage.

Heat is delivered by a combination of hydronic in-floor and coil units located in the air delivery system. Cooling also is provided using the heat pumps and coil units. The shell design provides for natural ventilation in most rooms, including the 400 seat assembly room (chapel).

Wisconsin code requires the operation of mechanical ventilation during occupancy, so the air handlers operate during all occupied hours. CO_2 control is not recognized by Wisconsin code as a viable method to control air quality.

While the number of occupied hours is extensive, heating and cooling are turned off to the fan coil units during periods of moderate temperature and occupants have the option of using the operable windows in their spaces to supplement mechanically supplied air.

Top **Photovoltaic panels on the southwest slope of the assembly room (chapel) roof provide 8% of the monastery's energy needs. The system is designed to be expanded to eventually provide all energy requirements (on a net basis) for the facility from on-site renewable energy.**

Below **By earning 63 out of 69 possible points under LEED-NC v2.2, Holy Wisdom Monastery became the highest-rated LEED-NC building in the U.S. at the time of certification.**

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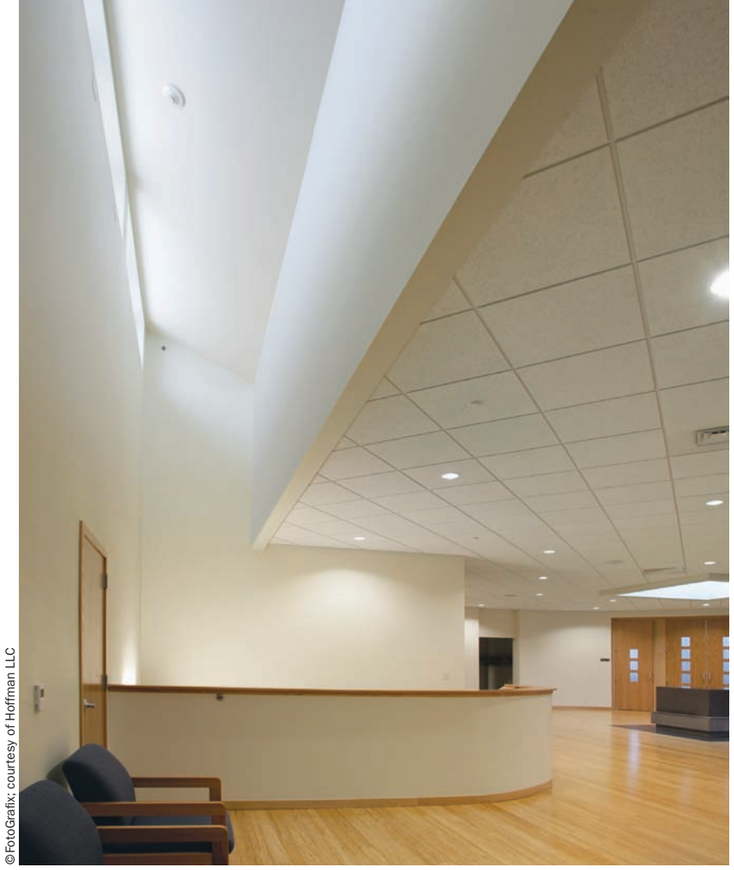

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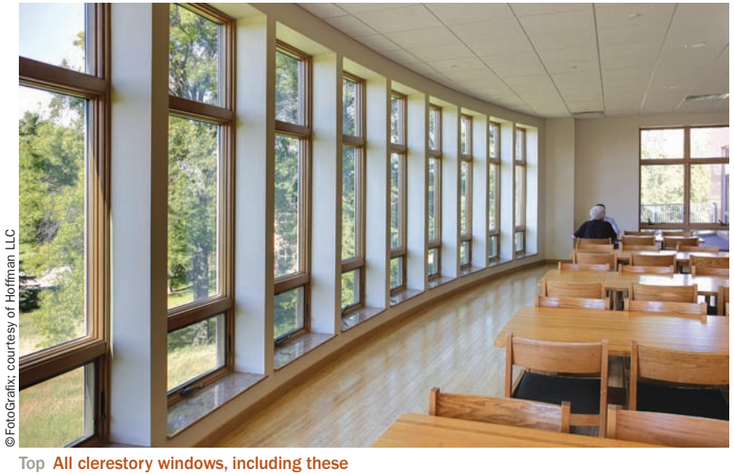

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Top **All clerestory windows, including these in the gathering area (top left of photo), are operable to exhaust warm air as part of the natural ventilation design.**

Below **These windows in the guest dining room are just some of the many that provide daylight to 85% of regularly occupied spaces in the monastery. Each was customized based upon its location and orientation to the sun to provide views, reduce glare and minimize unwanted solar heat gain.**

Each space is furnished with multiple level or manual dimming lighting controls and HVAC temperature controls intended to be easy to use and provide considerable control of conditions in each space.

ENERGY AT A GLANCE

Annual Energy Use Intensity (Site)
32.6 kBtu/ft^2
Natural Gas 2.7 kBtu/ft^2
Electricity 27.4 kBtu/ft^2
Renewable Energy (Produced) 2.5 kBtu/ft^2

Annual Source Energy 94 kBtu/ft^2

Annual Energy Cost Index (ECI) $1/ft^2 (including renewable electricity purchase premium, 100% of purchased electricity is renewable)

Annual Net Energy Use Intensity
30.1 kBtu/ft^2

Annual Load Factor 33%

Savings vs. Standard 90.1-2004 Design Building 47.8% energy use/53.7% cost (before considering renewable energy)

ENERGY STAR Rating 93 (preliminary; for office category including solar)

Heating Degree Days 5,553

Cooling Degree Days 1,432

WATER AT A GLANCE

Annual Water Use Private well supplies water for campus; use is not metered

Lighting, Other Power Use

Daylighting and exterior views are critical features of the project, and a new window jointly developed between Andersen® Corporation and Hoffman LLC was used to manage glare. That window provides a visible transmittance at the center of glass of 20% and is used on the east, west and south facing windows.

The north facing windows have a 40% visible transmittance. The windows also are highly effective in reducing unwanted solar gain with a solar heat gain coefficient of 0.23 at the center of glass. The glass choice eliminated the need for exterior

BUILDING ENVELOPE

Roof
Type Sloped asphalt shingle above chapel with the rest a fully adhered roof
Overall R-value R-30
Reflectivity Except for shingle section, very high

Walls
Type Steel studs with exterior insulation and additional foam for sealing and between studs; outside wall is brick
Overall R-value R-16 (for assembly)
Glazing percentage 16%

Foundation
Slab edge insulation R-value
R-10 for 48 inches

Windows
U-value 0.35 for assembly
Solar Heat Gain Coefficient (SHGC)
W/S/E = 0.23 center of glass (COG); N = 0.26 COG
Visual Transmittance W/S/E = 0.2 COG; N = 0.4 COG

Location
Latitude 43° N
Orientation Essentially on N/S axis

COMPARING GREEN BUILDING COSTS

One study that rejects the notion of a cost premium is "Cost of Green Revisited: Reexamining the Feasibility and Cost Impact of Sustainable Design in the Light of Increased Market Acceptance," by Peter Morris and Lisa Faye Matthiessen of Davis Langdon (http://tinyurl.com/greenrevisited).

Because the monastery's spaces are also similar to those in the academic buildings included in the Morris and Matthiessen study, it can be compared to those 60 buildings (17 LEED certified buildings and 43 non-LEED buildings). As that study adjusted costs to Sacramento in 2007, we adjusted Holy Wisdom's costs to the Sacramento market using RSMeans Regional Cost Factors and to 2007 prices using a BLS (U.S. Bureau of Labor Statistics: Materials and Components of Construction) Index.

Holy Wisdom's resulting construction cost was $220/ft^2, a cost lower than all of the 60 LEED certified and noncertified buildings included in the study.

window shades to control glare or heat gain, preserving views and allowing for daylight.

The large assembly room/chapel does not use any lights during daytime events. Lighting controls are manual, multilevel on/off. Wood-framed windows provide a distinct advantage over aluminum frame windows in terms of higher R-values to retain heat.

Because of the extensive daylight in the monastery, electric lighting was designed to supplement daylight.

Direct/indirect T5 and other fluorescent lighting using T8 and CFLs serve internal areas while exterior lighting uses a limited number of LEDs. The parking lot fixtures are powered by their own PV systems. The internal lighting power density is only 0.7 W/ft^2.

Other power use is associated with the monastery's IT systems including servers, work stations, printers and a copier. In addition, a commercial kitchen is used to prepare at least 14 meals per week. Several coolers and freezers store fruit and vegetables harvested from the monastery gardens.

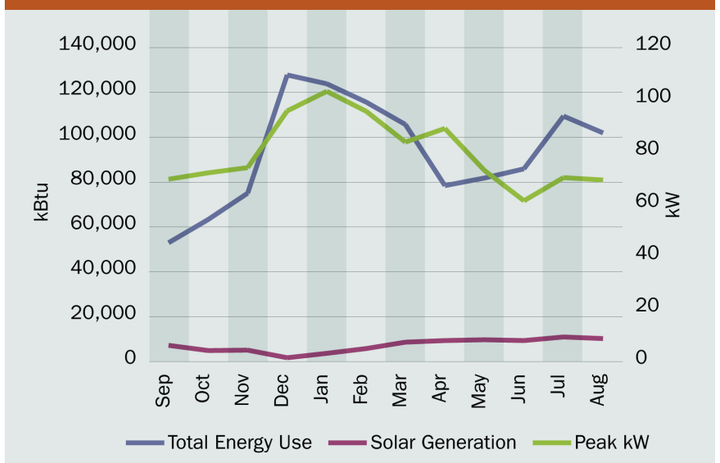
Conserving Energy, Water

The monastery's cost includes an initial renewable energy system (20 kW photovoltaic roof-mounted array), with a provision for expanding the PV system to reach net zero energy consumption in the future. Had funding been available when the project was built and assuming the rest of the system would have cost the same per kW, a net zero energy project could have been provided at $258/ft^2 (construction cost) or $296/ft^2 (total project cost).

Other renewable energy options were considered, but rejected except for PV powered parking lot lights. The PV production has been flawless, and output has exceeded model estimates by 10%.

A private well system serves as the monastery's water source. Water is conserved by a portfolio of efficiency measures including one gallon per

ENERGY USE, GENERATION; PEAK POWER
SEPT. 2009 — AUG. 2010



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Above **Two green roofs on the garage and maintenance buildings with reflective white pavers reduce the heat island effect, add aesthetic value and provide usable outdoor spaces.**

Right, above **This green roof is located on top of what was the sub-basement of the Sisters' previous retreat and conference center and now serves as the maintenance building. The Sisters requested 8" deep trays so the two green roofs could be planted with prairie forbs and grasses from their own seeds rather than sedum.**

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Right, below **The commercial kitchen features ENERGY STAR appliances and other efficiency measures. It also provides workers with views, daylight, and natural ventilation as they prepare at least 14 meals per week.**

LESSONS LEARNED

The monastery building team is exploring two questions related to the facility's operation:

- What are the optimal control settings for comfort and energy performance during natural ventilation operation when the air handlers are operating, but no heating or cooling is provided?
- What is the optimal way to control humidity in the assembly room (chapel) for the pipe organ and concert piano?

The natural ventilation question has two parts. One part involves determining the lower and upper outside temperature setpoints between which no heating or cooling is provided. The other part involves determining when during this period to run the heat recovery wheels and when to bypass them to save additional energy.

Due to high humidity conditions that are common during moderate summer temperatures (between 60°F and 75°F), the building team has decided with the facility manager that it is better to lower the temperature setpoints and run the heat wheels in the assembly room (chapel) at all times for additional humidity control.

The heat wheels are enthalpy wheels, which help provide humidity control. The experimentation with the setpoints and use of the heat wheels is ongoing and will be adjusted over time based on occupant comfort feedback and energy costs.

The second question relates to balancing energy use associated with humidity control and management of the piano. The assembly room (chapel) where the concert piano is located seats up to 400 people and has a high peak in the ceiling.

The maximum humidity level for the piano is 55% relative humidity in the summer. Allowing a wider range of humidity would save energy, but would require more piano tuning. If supplemental heat within the piano is sufficient to control humidity, the owner can then allow the space humidity to increase with minimal impact on tuning needs.

While the first year energy performance was strong at 32.6 kBtu/ft^2 · yr, efficiency is expected to improve as the owner addresses these questions.

Other energy reduction measures already taken include adjusting pump pressures for the hot and cold fluid loops from the central heat pumps and modifying two control settings for the in-floor heating in two areas of the monastery. An 11-month commissioning check discovered the incorrect in-floor heating settings.

flush toilets, waterless urinals, low flow lavatories and sinks, rain barrel water capture for limited plant watering, and an ENERGY STAR-rated commercial dishwasher.

Balancing Cost, Sustainability

In pursuing beauty yet simplicity within a Benedictine aesthetic, one might wonder whether the Spartan approach results in cost savings. The materials selections were based on sustainability and costs, but also quality. The wood windows, wood casework and trim, extensive bamboo floors, in-floor heating, brick exterior, direct/indirect light fixtures, and the pipe organ all indicate high quality.

The project provides a high performance building that meets the owner's mission and needs, and comes without a first cost premium. A cost-conscious owner and the use of an integrated design and delivery method with design and construction management were key contributors to effective cost management.

The response of the Benedictine community, including oblates, the Sunday assembly, and the broader community has been enthusiastic. More than 3,000 visitors from the U.S. and other countries have visited the monastery for tours and educational events related to building design, construction, and performance. The monastery is serving the mission of the Benedictine Women of Madison and other needs not originally imagined, such as a venue for green weddings. ●

BUILDING TEAM

Building Owner/Representative
Holy Wisdom Monastery/Neal Smith, executive director

Architect Hoffman LLC

General Contractor, Landscape Architect
Hoffman LLC (construction manager)

Mechanical Engineer
Fredericksen Engineering

Electrical Engineer, Lighting Design
Czarnecki Engineering

Energy Modeler CDH Energy

Structural Engineer Larson Engineering

Civil Engineer Mayo Corporation

LEED Consultant Vertegy

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