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/ft², similar to or less than the cost of a comparable conventional building.

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 first year of energy data shows site energy use intensity at 32.6 kBtu/ft². While that performance resulted in a preliminary ENERGY STAR rating for the first year of 93, operations can be improved in the second year.

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 building is in the sight line of the entry area, and visual distractions from disrupt quiet contemplation. The colors and mechanical systems are virtu-ally indistinguishable, and internal visual distractions are eliminated. Emphasis was given to external views overlooking lakes, woods and the restored prairie.

Holy Wisdom Monastery

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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 stormwater management.

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.

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

**KEY SUSTAINABLE FEATURES**

**Water Conservation** Low flow fixtures throughout including waterless urinals and 3-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. CO2 control is not recognized by Wisconsin code as a viable method to control air quality.

**Energy at a Glance**

- **Annual Energy Use Intensity (Site)** 32.8 kBtu/ft²
- **Natural Gas** 2.7 kBtu/ft²
- **Electricity** 27.4 kBtu/ft²
- **Renewable Energy (Produced)** 2.5 kBtu/ft²
- **Annual Source Energy** 94 kBtu/ft²
- **Annual Energy Cost Index (ECI)** $/ft² (including renewable electricity purchase premium, 100% of purchased electricity is renewable)
- **Annual Net Energy Use Intensity** 30.1 kBtu/ft²
- **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 excluding 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 49% 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
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/ft² (construction cost) or $296/ft² (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 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, multi-level 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/ft².

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

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<th>Building Envelope</th>
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<td><strong>Walls</strong></td>
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<td><strong>Foundation</strong></td>
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<td><strong>Windows</strong></td>
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<td>Orientation</td>
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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/ft², a cost lower than all of the 60 LEED certified and non-certified buildings included in the study.

Before you choose a building comfort solution, you need to look at the whole picture – and that means total installed costs. From equipment purchase through initial power-up of the system, you’ll discover our Variable Refrigerant Flow zoning solutions offer numerous upfront cost and long-term cost of ownership advantages over traditional HVAC. Let us show you a smarter way to create the ultimate in building comfort. Visit www.totalinstalledcosts.com or call 1-800-433-4822.

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Wide variety of ducted and ductless fan coils save labor and material costs.

Compact condensing units significantly reduce structural costs.

No 100% secondary heat source for most climates; low ambient condition capabilities.

Fits in elevators, reducing costly rigging.

ENERGY USE, GENERATION; PEAK POWER

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<td>Total Energy Use</td>
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<td>Peak kW</td>
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A VRF zoning solution with lower total installed costs than traditional HVAC alternatives? No problem.
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 but would require more piano tuning. If supplemental heat within the piano is sufficient, 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/ft²·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 the 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.

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Balancing Cost, Sustainability

In pursuing beauty yet simplicity within a Benedictine aesthetic, one might wonder whether the Spartan approach results in cost savings. The natural ventilation question has two parts. One part involves determining the other part involves deter-

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.