Designing a high performing building is challenging enough when it is optimally sited and the building envelope is driven by performance considerations. This office building meets its energy and financial goals while adhering to the strict architectural requirements of its neighborhood, which is designed to reflect the federal style of the older areas of Louisville, Ky.

When CMTA outgrew its office space, the firm considered where the majority of its employees lived—east Jefferson County—in selecting a site for its new office. The firm picked a 600-acre residential, commercial and retail development outside of Louisville in Prospect, Ky. The firm was attracted to the sustainable principles of the community’s walkable live-work design.
CMTA outgrew its existing office space in 2008 and used the opportunity to design and build a new corporate headquarters. Plans called for the new facility to function as a laboratory to test new technologies and demonstrate their cost effectiveness to clients.

Goals
Plans included additional meeting space in anticipation of hosting more client meetings to showcase the design and green features. All partners agreed the new building should:

- Be designed as a measurement and performance speaks loudest);
- Earn LEED Gold certification with-testing lab for green systems;
- Be designed to clients.

Ensure green features complement the new sustainable development where the building is located;

Consume minimal energy and be awarded an ENERGY STAR rating of 100 (Models are important predictors, but benchmarking actual performance speaks loudest);

Be designed as a measurement and testing lab for green systems;

Earn LEED Gold certification without exceeding a 3% construction premium; and

Take the first step toward becoming a net zero energy facility.

Thermal Envelope
Designing a high performance thermal envelope that met the neighborhood’s architectural guidelines was a challenge. The development guidelines required structures to be built to the property lines, which did not allow optimum orientation for daylighting.

The building exterior is designed to appear as three separate buildings, but is actually one. The first façade is a Victorian storefront and the other two are federal townhouses.

The building walls are constructed of insulated concrete forms (ICF). ICF provides an excellent thermal barrier, reduces air infiltration and is a structural wall system. The added wall depth visually reinforces the look of a historic building. Roof insulation and high performance glass contribute to the thermal envelope that exceeds ASHRAE/IESNA Standard 90.1-2004 by 20%.

The building front faces west and includes large windows in the Victorian storefront for the first-floor conference rooms. Awnings that project 7 ft from the building provide solar and glare control.

The second floor’s two separate work areas are daylit. Natural light is enhanced with six supplemental tubular devices that convey daylight from the flat roof to the second floor space. Where exterior offices are adjacent to the daylit work areas, both exterior and interior windows are provided to convey more natural light to the work areas.

The daylit areas primarily have west and north exposures. These areas operate well in summer because the impact of the sun is later in the day. Interior blinds reduce glare during winter when the angle of the sun is lower.

Lighting
The lighting system uses three strategies for reducing its electrical consumption: minimize lighting energy intensity; provide excellent lighting controls; and use daylight for the second floor work areas. The first strategy is largely responsible for the system’s low energy consumption.

The lighting system is designed for 0.65 W/ft², which exceeds the current energy code by 40%. The goal was to “right size” the lighting systems by designing them to meet ASHRAE/IESNA 90.1-2007, but not over light. During design meetings staff indicated a preference for lighting systems that provide a contrast with the computer monitors. Task lights help ensure that workstation lighting levels are adequate; however, the task lights are rarely needed.

Active daylighting systems modulate artificial light outputs in the two separate 2,500 ft² work areas. The original analog/mechanical type
lighting control system was removed after six months because it did not provide sufficient control.

Each of the large work areas was refitted with a digital addressable daylight control system. Two different manufacturers’ systems were chosen because plans called for each to be installed in several high performance projects engineered by CMTA that were beginning construction. This allowed CMTA to field test these systems in their building prior to installation in their clients’ buildings.

Both functioned better than the previous system, but one daylight system still had difficulty reducing lighting intensity to desired levels. These systems are factory programmed, and CMTA found that it was difficult to adjust the systems to respond to lower light levels than their factory settings. Start-up was a slow process with each. These systems are so new that service technicians do not yet have adequate training nor do they understand the software programming.

Energy Performance

The all-electric building’s energy consumption from the utility grid for the first year (ending July 2010) was 13.6 kBtu/ft²·yr, earning an ENERGY STAR rating of 100. The first-year’s energy use is actually one-half of a similar building with an ENERGY STAR rating of 95 (A 95 rated building can consume 28 kBtu/ft²·yr.)

CMTA has benchmarked annual energy consumption of its designs for many years. Its benchmarking philosophy follows the adage attributed to W. Edwards Demming, “In
If the server room HVAC unit were relocated from the previous office. The server operates 24/7, and it consumes 15% of the building’s energy. Even higher. Total building energy use would be included, the IT room’s percent of the percentage of total energy consumed because high performance systems reduce the energy use of the HVAC and lighting systems. Figure 2 (Page 52) segregates the energy use by major categories. Almost one-third of the annual energy use is consumed by loads normally referenced as “plug,” as shown in Figure 2. The plug loads are relatively high compared to the percentage of total energy consumed because high-performance systems reduce the energy use of the HVAC and lighting systems. Further analysis of the plug loads shows that the 80 ft² IT room consumes 15% of the building’s energy. The server operates 24/7, and it uses existing equipment that was relocated from the previous office. If the server room HVAC unit were included, the IT room’s percent of total building energy use would be even higher.

Utility power consumption is reduced by the photovoltaic system, which produced about 15% of the building’s total energy use (15.7 kBtu/ft²) during its first year of operation.

Hvac System
The building’s HVAC system uses high-efficiency, geothermal water source heat pump units. The installed capacity of the heat pump units is 600 kBtu/ton and the geothermal well field capacity is 780 kBtu/ton. The well field consists of 12 vertical bores, which are each 400 ft deep. All heat pump units three tons and larger have dual refrigerant compressors piped into a common refrigerant circuit to increase efficiency to approximately 23 SEER during part-load conditions. Part-load operation hours dominate the heat pump units’ runtime.

The distributive water pumping system consists of individual water pumps that are sized for each heat pump and recirculate water through the entire geothermal loop without the aid of central pumps. This type of variable flow pumping system reduces pumping energy use because the individual water pumps operate only when their respective heat pump compressor is on. Purging air from the piping of distributive pumping systems is much more difficult than doing so in a central pump system. The piping system in a distributive pumping system should be designed to facilitate air venting.

A single rooftop unit serves as a dedicated outdoor air unit (DOAS). The unit is equipped with a supply fan, exhaust fan, heat recovery wheel and variable frequency drives (VFDs) for each fan. A demand control ventilation system supplements the DOAS to modulate the outside air introduced into the building in response to the actual space air quality. A system that provides central testing of CO₂ will be needed.

Measurement and Testing
Another goal is to use the building to measure and test green systems. As discussed previously, measuring the energy consumption independently for each building system (HVAC, lighting, plug loads and PV) allows for the comparison of actual energy data with the predicted energy model. Each month when utility invoices are received, energy usage from the building’s digital electric metering system is read to compare data, trend results and ensure performance.

Sustainable Features

<table>
<thead>
<tr>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal HVAC with distributive pumping</td>
</tr>
<tr>
<td>Demand control ventilation</td>
</tr>
<tr>
<td>Active daylighting</td>
</tr>
<tr>
<td>Thin film solar PV</td>
</tr>
<tr>
<td>Occupancy controls</td>
</tr>
<tr>
<td>Insulated concrete form walls</td>
</tr>
</tbody>
</table>

God we trust, all others bring data.” This long-term tracking program has provided a wealth of data to measure success and improve quality.

The building’s Ethernet-based digital electric metering system measures the energy consumed by the HVAC, lighting and plug loads. It also tracks the energy generated by the solar photovoltaic system. Figure 1 (Page 52) shows the monthly energy consumption of each system. Figure 2 (Page 52) segregates the energy use by major categories. Almost one-third of the annual energy use is consumed by loads normally referenced as “plug,” as shown in Figure 2. The plug loads are relatively high compared to the percentage of total energy consumed because high-performance systems reduce the energy use of the HVAC and lighting systems.

Further analysis of the plug loads shows that the 80 ft² IT room consumes 15% of the building’s energy. The server operates 24/7, and it uses existing equipment that was relocated from the previous office. If the server room HVAC unit were included, the IT room’s percent of total building energy use would be even higher.

Utility power consumption is reduced by the photovoltaic system, which produced about 15% of the building’s total energy use (15.7 kBtu/ft²) during its first year of operation.

Hvac System
The building’s HVAC system uses high-efficiency, geothermal water source heat pump units. The installed capacity of the heat pump units is 600 kBtu/ton and the geothermal well field capacity is 780 kBtu/ton. The well field consists of 12 vertical bores, which are each 400 ft deep. All heat pump units three tons and larger have dual refrigerant compressors piped into a common refrigerant circuit to increase efficiency to approximately 23 SEER during part-load conditions. Part-load operation hours dominate the heat pump units’ runtime.

The distributive water pumping system consists of individual water pumps that are sized for each heat pump and recirculate water through the entire geothermal loop without the aid of central pumps. This type of variable flow pumping system reduces pumping energy use because the individual water pumps operate only when their respective heat pump compressor is on. Purging air from the piping of distributive pumping systems is much more difficult than doing so in a central pump system. The piping system in a distributive pumping system should be designed to facilitate air venting.

A single rooftop unit serves as a dedicated outdoor air unit (DOAS). The unit is equipped with a supply fan, exhaust fan, heat recovery wheel and variable frequency drives (VFDs) for each fan. A demand control ventilation system supplements the DOAS to modulate the outside air introduced into the building in response to the actual space air quality. A system that provides central testing of CO₂ will be needed.
when federal and state tax credits were received, the solar renewable energy credits (SRECs) were sold and the value of the generated energy was included, the ROI timeframe was significantly reduced. A simple payback of eight years is shown in Table 1 (Page 58).

The original financial plan did not include selling the SRECs because there is not a market in Kentucky; however, these credits were sold to a utility company in another state at an annual value of $375/kWh generated. Finding a buyer of the SRECs was a learning experience for firm engineers and the chief financial officer, but now the firm can walk clients through the process.

Operation

Because CMTA is an MEP engineering firm, it is in a unique position as a building owner to understand the systems and operate each system at peak efficiencies regardless of the

Eight sensors are embedded in the ICF wall system at different locations on each exterior wall exposure to record the temperature gradient. The sensors were installed with the goal of determining whether the mass of the wall system delays peak wall cooling loads to later hours when the building is unoccupied.

Solar Photovoltaics

The firm’s long term goal is a net zero-energy building (NZEB). As a first step toward the NZEB goal, the firm selected a thin film amorphous silicon solar photovoltaic system. CMTA’s past project data indicated that the thin film can generate the most annual kilowatt-hours for the least installed cost. The installed system is rated for 11 kW, and the cost was $85,000.

Figure 3 (Page 52) shows monthly energy generation versus predicted energy generation. The system exceeded the first year expectations, but produced more electricity in the summer and less in the winter than expected. It generated approximately 15% of the first year’s building energy consumption.

When CMTA first designed the solar PV system, the firm planned to expand it later. The phase II expansion will include crystalline panels mounted on the south wall elevation. Besides generating electricity, the panels will provide a shade structure for south-facing windows.

The solar PV system was originally selected as a project goal because it aligned with CMTA’s vision. A long financial return on investment (ROI) was expected, but when federal and state tax credits were received, the solar renewable energy credits (SRECs) were sold and the value of the generated energy was included, the ROI timeframe was significantly reduced.

A simple payback of eight years is shown in Table 1 (Page 58).

The original financial plan did not include selling the SRECs because there is not a market in Kentucky; however, these credits were sold to a utility company in another state at an annual value of $375/kWh generated. Finding a buyer of the SRECs was a learning experience for firm engineers and the chief financial officer, but now the firm can walk clients through the process.

Operation

Because CMTA is an MEP engineering firm, it is in a unique position as a building owner to understand the systems and operate each system at peak efficiencies regardless of the
LEED ceremony. which slows the process. too long, frustrating clients. Submitting the in which the LEED submittal process took LEED can be obtained in a timely manner. Enhanced Commissioning. Materials, Indoor Pollutant Control and including Certified Wood, Low-Emitting missed points had been documented cor- 10 points and Platinum was missed by LEED Gold certification was exceeded by 10 points and Platinum was missed by three points. Platinum could have been obtained with minimal extra cost if two missing points had been documented cor- rectly. Four other credits could have been reasonably pursued if prioritized early, including Certified Wood, Low-Emitting Materials, Indoor Pollutant Control and Enhanced Commissioning. LEED can be obtained in a timely manner. CMFA has been a team member on projects in which the LEED submittal process took too long, frustrating clients. Submitting the design credits during construction speeds the process. Many teams that CMFA has worked with prefer to submit all at once, which slows the process. The construction points for the CMFA headquarters were awarded four months after project completion. This allowed CMFA to combine a grand opening with the LEED ceremony. complexity. Firm engineers concentra- the occupied/unoccupied operation of the geothermal system, unoccupied control of plug loads and proper operation of the lighting control system. The geothermal heat pump units are scheduled to operate from 7 a.m. to 5:30 p.m., Monday through Friday. They maintain a 60°F set- point during winter unoccupied hours. Tending of unoccupied run- down hours shows that only a couple of zones ever operate because of the high quality thermal envelope. In the summer the heat pump units are always off during unoccupied periods. Occupied temperature setpoints are 72°F, summer and 73.5°F, winter. Occupants can adjust temperature within a range of ±2°F. Employees working outside of the regular hours can adjust thermostat settings by using the override button, which resets a control zone’s setpoint to the occupied mode for two hours. Control of plug loads was con- sidered during design. The power to printers, plotters, vending and the coffee maker is deactivated on the same occupancy schedule as the HVAC system. This eliminates some of the phantom plug loads. A 30-minute override button is provided to allow operation during unoccupied hours. Hindsight shows the building should have been on a similar schedule because it is con- suming a significant phantom load 24/7 and is rarely used. Staff is asked to turn off worksta- tions at night. The “computer police” periodically check workstations after hours to help change past routines into new habits. The lighting control system is active between 7:30 a.m. and 5:30 p.m. During occupied hours, the occupancy sensors control most lights, and the dimming system modulates lighting output in the open work areas. Lighting in the stairs, lobby and corridors operates continuously in the occupied mode.

Conclusion The new facility accomplished all goals set at the beginning of the project and exceeded expectations. The building has met the first prior- ity, consuming minimal energy and operating as planned. Employees are proud to be working in the building, and it has proven to be an unexpected boost in recruiting employees. The building is a real- life training tool for employees and clients regarding high performance systems. The measurement systems provide data to improve the efficien- cies of future project designs. The solar photovoltaic system has proven to be a good investment, and the second phase is planned for 2011. CMFA will evaluate the performance and the payback period of the south-facing panels. Many factors, such as performance, the cost of PV panels or film, and the availability of tax credits, will affect future steps toward the net zero goal. The firm hopes to continue adding to its PV system every two years, with the goal of reaching net zero energy after 10 years.

To comment on this article, go to www.HPBmagazine.org.

To comment on this article, go to www.HPBmagazine.org.