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Applying Energy-Efficient Strategies to Research

By Kevin D. Mussler
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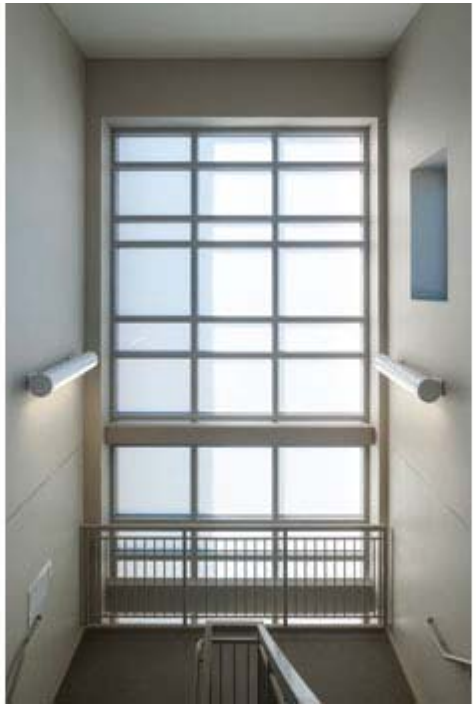

The purpose of the Center for Applied Energy Research (CAER) at the University of Kentucky-Lexington is to pursue new and beneficial energy strategies in the biofuels, solar energy and lithium battery research fields. This 43,156-square-foot LEED registered, and targeting LEED Gold, facility was created to promote and develop new energy efficiency strategies by focusing on those three distinct research areas. In addition to the

research laboratories, the building also has two Class 10,000 and one Class 1,000 Cleanrooms and a 0.5 percent RH Drylab for lithium battery manufacturing.

The design team focused on creating a state-of-the-art facility that embodied energy reduction principles. After 12 months of operation, the building is operating at 138.7 kBtu/sf/yr. Using the International Institute for Sustainable Laboratories (I2SL) benchmarking tool for comparison, the average energy usage for a similar facility is 321 kBtu/sf/yr, which is a 57 percent reduction in energy use.

The project received a competitive grant from the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) under the American Recovery and Reinvestment Act's (ARRA) NIST Construction Grant Program with cost share provided by the Commonwealth of Kentucky. The ARRA grant required that the building be built with U.S.-manufactured materials.

One of the goals of the project was to use it as an educational facility as well as a research facility. Guests are given the opportunity to watch ongoing research thanks to large windows and monitors offering views into the laboratories. An energy dashboard in the main lobby of the building educates visitors as to the environmental impact of the building by tracking (in real time) the amount of building energy used.

This is one of the first geothermal buildings designed for the University of Kentucky. The design team was challenged to make this building a test case implementing different energy strategies that could be used in future university buildings.

Center for Applied Energy Research Renewable Energy Laboratory

- *Location:* Lexington, Ky.
- *Owner:* University of Kentucky Center for Applied Energy Research
- *Principal Use:* Biomass and biofuels, solar energy and electrochemical power sources research. Includes 11 labs with support space, a .5 percent RH DryLab, three Clean Rooms, and four Controlled Environment Rooms
- *Employees/Occupants:* 35
- *Occupancy:* 100 percent
- *Gross Square Footage:* 43,156
- *Conditioned Space:* 100 percent
- *Distinctions/Awards:* LEED Gold (targeted)
- *Total Construction Cost:* $17,086,000
- *Cost Per Square Foot:* $397
- *Substantial Completion/Occupancy:* May 2012

Energy Efficiency Strategies

The design team focused on the building's orientation, envelope, lighting and HVAC systems to maximize energy reduction. To decrease the solar heat gain and enhance the use of daylight harvesting, the building was oriented on an east/west axis. Using energy modeling, the design team determined that the most cost-effective thermal envelope employed R-22.5 wall insulation with an R-35 high albedo white roof. Nanogel windows were used primarily in the stairwells to allow natural light to pass through the building in an open stairwell design while maintaining insulative integrity.

Energy for lighting was reduced by 13 percent in comparison to the ASHRAE baseline requirements. Reductions were obtained by "light level tuning," zone-level occupancy control, daylighting and a central control system that ensures lighting is turned off after business hours. The design team worked

Energy At A Glance

- Annual energy use intensity (EUI) (site): 138.7 kBtu/ft2
- Natural gas (process/HVAC): 27.8 kBtu/ft2

with users to set each individual office to the high limit of artificial lighting in each space. By tuning the lights, the lighting levels were reduced by as much as 30 percent in the offices. The laboratory spaces were designed with a zoned lighting system that allowed for reduced lighting levels in the spaces depending on usage of the labs. By zoning the lighting system in accordance with the bench layouts, researchers are able to turn on only the lights they need without lighting the entire lab.

HVAC systems consume a significant percentage of overall laboratory energy use due to the need to properly ventilate the building while maintaining proper pressurization in the labs. The traditional methodology for laboratory design uses 8 to 10 air changes per hour (ACH) using 100 percent outside air that would be exhausted through the fume hoods, maintaining a slightly negative pressure in each lab. The design team's approach was to reduce the amount of normal ventilation in the lab and to over-ventilate at a higher rate whenever a lab spill occurs. This resulted in a lab ventilation rate between 6 to 8 ACH in the occupied mode and between 4 to 6 ACH in the unoccupied mode. An air particulate sampling system was installed in the building which tests the air every 15 minutes. Whenever it senses a chemical occurrence, the system reacts and over-ventilates the space at 16 ACH, thus providing not only a safer lab but a much more energy-efficient building.

For CAER, the team designed a geothermal central utility plant to be a heating and cooling source for the traditional 100 percent outside air system required to maintain a safe environment. Another advantage of installing a geothermal infrastructure is the ability to heat and cool non-laboratory spaces with low-cost, high-efficiency geothermal water-source heat pumps. Significant savings came on the heating side with a heat pump design that is 300 percent more efficient than a high efficiency hot water boiler. A heat recovery chiller captures the heat rejected from the chilled water system and uses it for reheat in the building.

In addition to these energy saving strategies, a 3-angstrom enthalpy energy recovery wheel was integrated with the air particulate sampling system; if any chemicals migrate through the wheel, the system will react and bypass the wheel.

- Electricity (from grid): 110.9 kBtu/ft2
- Annual source energy: 400 kBtu/ft2
- Annual energy cost index (ECI): $2.57/ft2
- Savings vs. Standard 90.1-2004 design building: 54.3 percent
- Carbon footprint: 37.5 lb CO2e/ft2/yr
- Heating degree days (base 65 F): 4,783
- Cooling degree days (base 65 F): 3,754
- Average operating hours per week: 55

Water at a Glance

- Annual water use: 1,605,168 gallons

Building Envelope

- Roof type: high albedo white roof
- (R-35 overall insulated value)
- Reflectivity/emittance: 0.1
- Glazing percentage: 15.6 percent
- Slab edge insulation F-factor: 0.73
- Walls type: mass wall (this is steel framed with mass wall but it is not ICF)
- Walls overall R-value: R-22.5

Windows

- Windows U-factor for assembly: 0.4
- Visual transmittance: 0.35
- Windows solar heat gain coefficient (SHGC): 0.34
- Gel-filled window U-factor: 0.10
- Gel-filled window visual transmittance: 0.58
- Location: Latitude: 38.0 degrees N, 84.5 degrees W
- Orientation: east/west

Other Sustainable Strategies

Water

A process water loop utilizes the geothermal system for water-cooled equipment. This equipment had previously been cooled by domestic water that was spilled directly to the drain after a single pass. The estimated water savings from the process loop is 60,600 gallons per year. Low-flow fixtures were installed, which reduced domestic water usage by 24 percent.

Site

The geothermal wellfield for the CAER lab is located beneath an existing parking lot to prevent further site disturbance. The rainwater from the site is diverted to a bioswale. The landscaping chosen for the bioswale are native species that eliminate the need for irrigation.

Materials

Based on requirements of the funding source, all materials were to be U.S.-assembled goods. Finishes such as flooring, paints and adhesives were selected for their compliance with LEED low-emitting limitations for TVOCs. The concrete used for the building slab and sidewalks includes 20 percent fly ash which is a byproduct of local power plants. Throughout the construction process, 77 percent of construction waste was recycled and diverted from landfills

Building Team

- *Building Owner/Representative:* Courtney Fisk, University of Kentucky/Center for Applied Energy Research
- *Architect of Record:* Timothy Murphy, AIA, LEED AP, Murphy + Graves + Trimble, PLLC
- *Design Consultant:* Jim Gabel, AIA, LEED AP, Hastings+Chivetta
- *Laboratory Consultant:* John Lewis, LEED AP BD+C, Research Facilities Design
- *Construction Manager:* Turner Construction Company
- *MEP Engineer:* CMTA Inc.: Kevin Mussler, PE, LEED AP, CxA, Principal in Charge; Chris Reeves, PE, LEED AP, CEM, Project Manager and Mechanical Engineer; Alan Kellum, PE, RCDD, LEED AP, Electrical Engineer; Carrie Kelty, PE, LEED AP, Energy Modeler
- *Structural Engineer:* S. Craig Brown, PE, SECB, Brown + Kubican, PSC
- *Civil Engineer:* Jihad Hallany, PE, Vision Engineering, LLC
- *Landscape Architect:* Anthony Barrett, ASLA, LEED AP, Barrett Partners Inc.
- *Commissioning Agent:* Richard T. Burks, PE, CCP, Paladin Inc.

Conclusion

This project had many challenges from the “Buy American” requirement to the high energy efficiency goals to the fast-paced design and construction schedule. While being at the forefront of design is challenging, the results have far exceeded the expectations of the entire team. The annual utility savings of more than $120,000 will be used for future energy research, fulfilling the mission of the Center for Applied Energy Research to develop new and innovative technologies.

Environmentally Friendly Features

Transportation

- Dedicated parking for low-E and fuel-efficient vehicles
- Access to the Legacy Trail, a 12-mile walking and biking trail which begins in downtown Lexington and runs through the research farm

Light

- Oriented on an east/west axis
- Nanogel windows
- Dimmable T-5 fixtures
- Natural daylight for offices

Energy

- Geothermal ground source heat pumps
- Heat recovery chiller
- Energy recovery while

Water

- Low-flow fixtures
- Geothermal process water loop

Kevin D. Mussler, PE, LEED AP, CxA, is the managing partner of CMTA Inc.'s Lexington, Ky. office. He was the principal-in-charge for this project. Mussler has been employed with CMTA since 1994. He is a graduate of the University of Kentucky with a Bachelor of Science degree in Mechanical Engineering.