Lean, Mean and Green

An Affordable Net Zero School

By Kenneth Stanfield

From its conception, Richardsville Elementary was designed to be an affordable net zero facility. The design team explored numerous energy saving strategies to dramatically reduce energy consumption. By reducing energy use to 19.31 kBtus annually, the net zero goal could be realized through the implementation of a solar array capable of producing enough energy to meet the school's operating demands. Coupled with the goal of a LEED certified facility, the building's components were identified and implemented to affordably attain a facility that demonstrates a sustainable site, net zero energy, water efficiency, materials and resources conservation, and an indoor/outdoor environment that promotes a healthy, progressive learning atmosphere while reducing life cycle maintenance costs and zeroing out electricity costs.

Richardsville Elementary

What is a "net zero" building?

By definition, a "net zero" or "zero energy building" (ZEB) uses the same amount of energy, measured annually, as it produces using on-site renewable energy sources – i.e. it generates as much energy as it consumes. Any building – existing or new – can achieve net zero by harnessing sufficient renewable energy sources, like solar panels or wind turbines, that collectively offset the building's annual energy consumption.

The issue is that energy derived from renewable sources today is not necessarily considered "cheap energy," or typically not nearly as cost competitive as energy pulled from the fossil-fueled grid. For example, while advances in technology have led to some remarkable increases in the performance and efficiency of solar panels, it still requires, even with government incentives, a significant investment from an owner, resulting in lengthy payback schedules.

Richardsville Elementary Exterior Front View

Richardsville Elementary Exterior Rear View

Can a school afford to "go zero"?

In planning a net zero building, the renewable energy really is the easy part. The real challenge, and significant achievement, is to profoundly reduce the energy consumption of the building through its design and operation. This in turn reduces the renewable energy required, resulting in a reduced investment and shorter payback.

Those in the school business – boards of education or administrators, architects or engineers – understand the complexities and constraints of school finance and limited construction spending.

So the question is: Can a school facility – a building that includes a gymnasium, library, kitchen, cafeteria and classrooms – be designed to reduce energy significantly enough that a typical public school district can afford to "go net zero?"

To answer that question, one must first determine to what level energy consumption can be reduced without sacrificing human comfort and a healthy learning environment. In Kentucky, the average school building consumes 73 kBtus of energy per square foot annually.

Scheduled to open in August, 2010, as a net zero school, Richardsville Elementary, is designed and modeled to consume 19.31 kBtus per square foot per year. That's 73% more efficient than the average school. The 77,466 square foot building bid in December 2008, at a total construction cost, including site development of $12,160,000.00, or $156.97 per square foot. The solar panel array – consisting of a 207kw roof-applied amorphous thin film system and a 139kw mono-crystalline shade structure in the parking lot – was bid separately, for an additional cost of $2,753,124.00.

With the solar panels included, the total per square foot cost for construction was $195.50. At the time of bid, the Kentucky Department of Education was estimating the cost of a typical elementary school at $203.00 per square foot – "typical" being a 73 kBtu, non-LEED certified building with the same program requirements as Richardsville.

What are the design strategies for a "net zero" school?

At the beginning, the design team, lead by Sherman Carter Barnhart Architects and CMTA Engineering, working together with the Warren County Board of Education, identified three essential goals for Richardsville to be a net zero school: To reduce energy – "go lean"; to implement a strict operations and maintenance plan – "get mean"; and achieve LEED certification – "go green".

Going "lean" to reduce energy consumption –

HIGH PERFORMANCE BUILDING ENVELOPE/SITE ORIENTATION

The high performance envelope began with a compact design, both in plan and volume. The reduced perimeter wall characteristic of the resulting plan aided in reducing HVAC load. This load was further reduced by: eliminating attic space; situating the high bay areas of the building – the gymnasium, cafeteria, and media center – in the center of the "doughnut" plan; and incorporating the heat pumps in mechanical closets between classrooms. This in turn reduced the first cost of the building shell, "shifting" construction dollars to pay for the more expensive, yet more efficient, geothermal system.

Super insulated ICF walls and an R-32 roof provide an efficient building envelope, requiring much less energy to heat and cool the facility. And, due to the efficiency of the building envelope, the heat pumps were downsized. The building is oriented north-south to optimize the classroom daylighting strategies and maximize the electrical output of the roof mounted solar panels.

GEOTHERMAL HVAC/MONITORING CONTROLS

A geothermal heating and cooling system, coupled with a distributive pumping strategy, will reduce the building's energy consumption and reduce the area needed for the mechanical spaces. In addition, several geothermal units in the facility will be used solely for hot water generation, eliminating the need for water heaters. Occupancy and motion sensors, as well as CO2 monitoring, maintain an optimum learning environment and reduce the system's power demands.

TECHNOLOGY

The use of wireless computer technology will reduce plug load and aid in the efficiency and performance of the building. This wireless technology helps reduce the building's footprint and overall area by eliminating a computer lab from the school's program. Any space, indoor or outdoor, can be utilized for laptop computers, thus saving an estimated 1000 square feet. The benefits extend beyond not having to condition the extra space. The use of laptops in lieu of large desktop computers further decreases energy use and the additional cooling loads associated with the internal heat gains from numerous desktop units.

Getting "mean" with operations management –

OPERATIONS AND MAINTENANCE PLAN

During the development of the operations manual, a plan for building security, after-hours use, and maintenance was implemented. Environmentally friendly "green" finishes such as soy-based stained concrete and porcelain pavers reduce maintenance labor and secondary energy consumption.

As a testament to the school district's commitment to energy-reducing policies, it should be noted that a school principal's evaluation in Warren County includes a component for measuring the operational efficiency of their facility against a district baseline. This policy makes building administrators aware of the importance placed on efficient operations, and includes them in leading the cause to save energy.

EFFICIENT KITCHEN STRATEGIES

The kitchen energy management strategy involves several areas of concentration. First, using ENERGY STAR-rated equipment helps reduce energy consumption. Second, by employing combi-ovens in lieu of fryers and tilting skillets, eliminating the Class I hood necessary for grease-laden vapors, make-up air will be significantly reduced or possibly eliminated. Moreover, the combi-ovens provide a healthier cooking alternative, improving the nutritional quality of the school meal plan. Preparing and implementing an energy-conscious business operations strategy for the kitchen will further aid in energy conservation.

Going "green" to ahieve LEED certification –

DAYLIGHTING SYSTEMS

All classrooms utilize daylighting principles to achieve LEED credits. The windows specified on the project are oriented to face north/south. They have been individually analyzed and modeled to converge on insulating and tinting requirements so that glare and direct beam light is controlled. The energy needed to counteract heat gains is minimized while the lighting for the classroom environment is properly provided. Light fixtures in classrooms have automated daylight dimming controls, and it is anticipated that the fixtures will be off during 70% of the school hours.

Exterior light shelves on south facing walls reflect light into the classroom, eliminating direct beam light and thereby making the environment comfortable to occupants, decreasing the need for additional cooling loads. Interior light shelves are used to reduce glare. The classrooms on the north side of the building have roof-mounted "solar tubes" that spread light into the classrooms through vertical chases. A central "spine" light monitor harvests daylight and distributes it into the high volume spaces of the gymnasium, cafeteria, and media center.

ALTERNATE RENEWABLE ENERGY SOURCE

The solar photovoltaic (PV) system at Richardsville Elementary is grid-tied, using energy from the utility grid when on-site generation is inadequate. During periods of low demand, such as after school, weekends or summer, electrical power is returned to the grid, providing an alternate fuel source to the area.

The PV system is comprised of a 207 kW roof applied amorphous thin-film system and a 139 kW mono-crystalline shade structure in the parking area. These technologies were selected for their high-energy production relative to costs. Mono-crystalline systems are mounted at an optimum angle to the sun using a steel structure engineered for the high wind forces and specified to contain a high recycled content. The amorphous thin-film system was selected for the roof due to its inherent ability to operate efficiently on the near flat roof surface. The electrical output from the PV field is a direct current (DC), similar to a battery, but the electrical systems in the building are designed for three phase alternating currents (AC). Two (2) 95% energy efficient inverters are used at the school to convert the DC input from the PV panels to an AC output. In addition to using efficient inverters, the wiring and connection systems have been designed to minimize transmission losses and allow maintenance.

BUILDING AS A TEACHING TOOL

The facility will involve students in monitoring the performance of the net zero design, earning "Innovation" LEED points and teaching environmental stewardship to future generations. A "geothermal hallway" exposes the piping manifolds and equips the pipes coming to and from the well field with a temperature gauge, so students can monitor the performance of the system. The "solar hallway" has a battery charging station where students can see the energy transferred from the solar panels to the laptop computer batteries. The "water conservation hallway" allows students to monitor the amount of rainwater collected and filtered through the site's bioswales. The "recycling hallway" provides bins for all recyclable products and allows students to monitor the quantities of materials collected. Outside, a compact weather station gathers information 24/7, enabling students and teachers to evaluate the building's performance throughout Kentucky's four distinct seasons.

Richardsville Elementary Media Center

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A school design veteran, Kenny now heads the education studio at the Louisville, Kentucky, office of Sherman Carter Barnhart, and leads the firm's efforts in green and sustainable school design.