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# LEARNING BY DESIGN

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# NET ZERO SCHOOLS
## THE NEW NORMAL?

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In the last decade, the concept of designing educational buildings to be net zero, (buildings that generate as much energy as they consume) has gone from possibility to reality. In fact, the number of net zero school verified buildings in the United States grows each year. However, there is still considerable skepticism about net zero buildings becoming the norm, instead of the exception for the design and construction of new school buildings. The reasons are the scarcity of hard data proving the results: Are the energy reduction strategies proven and viable for most school design applications? Are the strategies affordable compared to similar code compliant buildings? Does the renewable energy source offer a realistic payback for the initial investment?

The first hurdle in discussing the viability of a net zero school is understanding a typical schools' energy use characteristics and recognizing the essential decisions required to dramatically reduce the energy consumption. A clear baseline for comparison must first be established to accurately measure results. ASRAE 90.1 has documented climate zones for the United States and assigned the average energy performance of school buildings in each zone. In Climate Zone 4, for example, the energy consumption for the average school is 73 EUI annually. While there is still some variance in the energy performance criteria necessary to achieve net zero, all sources at least agree that the first step is to dramatically reduce energy consumption. ASHREA also has a K-12 Design Guide that advocates a "50% energy reduction towards net zero". The target goal is to reduce consumption so that the solar array (or other renewable energy source) required to offset the energy use is as small as possible to make a reasonable payback on the investment realistic and attainable. For our net zero projects, the target was set at a 75% energy reduction; where we project the buildings to operate on less than 25 EUI annually. With this magnitude of energy reduction, the entire solar array necessary to offset 100% of the energy use can be contained to the roof area of an 80,000 s.f. school. By comparison, if you attempted to place a solar array capable of achieving net zero for the average school using 73 EUI, you would need an extra football field of solar panels! The same logic applies to the initial cost of the renewable coupled with the anticipated payback – the smaller the better.

So what are the design strategies necessary to achieve a 75% reduction in energy use?

Our strategies for energy reduction can be summed up as follows:

- **Site Orientation:** Provide north/south building orientation to maximize daylighting opportunities and to incorporate thermal mass/passive solar strategies.
- **Building Envelope:** Compact building footprint (perimeter wall and height) with high R-value and high-thermal mass materials such as ICF (insulated concrete forms).
- **HVAC and Electrical Systems:** Energy-efficient HVAC system (geothermal) with occupant diversity, CO2 array quality sensors, and LED lighting and wireless technology for reduced energy demand.
- **Kitchen and Operations:** Eliminate Type 1 hood, steam and convection cooking only, energy star appliances, and 24/7 building operation plan.
- **Technology and Plug Loads:** Eliminate traditional computer lab with wireless technology throughout building, limit use of classroom appliances.
- **Curriculum Integration:** Student energy teams monitor building performance and conduct energy audits, curriculum incorporates energy awareness and sustainable practices.

With each of these strategies integrated, an EUI of 25 or less is attainable.

PHOTOGRAPHY: SHERMAN CARTER BARNHART ARCHITECTS

In 2011, Warren County Schools, in Bowling Green, KY, opened Richardsville Elementary School, considered to be the first verified Net Zero Public School in the nation. Since that time, it has consistently operated at an annual energy consumption of 18.2 EUI, a 75% reduction compared to the average school in Climate Zone 4 operating at 73 EUI. The 75,000 s.f. school was constructed for $203.00 per sq. ft., which included a $2.7 million dollar, 348 KW solar array. The cost of the solar equated to $7.90 per watt. The school is 100% grid-tied, and energy is measured with two meters, one for consumption and another for solar electricity generation. Every watt generated for the solar array is put back on the grid. The reason for this arrangement is that the energy provider, TVA (Tennessee Valley Authority) is paying .10 cents more per watt for the renewable green energy than its retail selling price to the school. Because

the school produces more energy than it consumes (and is essentially selling the renewable energy at a profit), Richardsville Elementary operates as a revenue stream for the District, earning approximately $40,000 annually.

Following Richardsville, the Warren County School district enacted a policy that would require all future new building be classified as "Net Zero Ready". This would require the energy saving strategies designed at Richardsville to be adapted and incorporated for any new school to achieve an energy reduction strategy of 25 EUI or less. Two elementary schools have since come on line – Jody Richards Elementary has a verified EUI of 20.3 and Bristow Elementary has a verified EUI of 24.2. A new high school / middle school (currently the largest school in Kentucky with 332,000 square feet) operates on 23.7 EUI annually.

The precedent for mainstream net zero and net zero ready schools has been established in KY and continues to grow nationally.

Today, in Warren County, Kentucky's next net zero school is currently under construction and scheduled to open in August 2018. Employing similar energy saving strategies which have now become standard elements of design for Warren County Schools, the new Jennings Creek Elementary is projected to operate at 19.2 EUI annually. A 325 KW solar array mounted on the roof will generate 100% of the required energy to operate the school. The arrangement with TVA (the energy provider) is different than their first net zero school. At this site, there is no premium paid for the solar generated electricity, just a selling rate equal to the retail buying rate (per Kentucky's net metering laws). The cost of solar has come down significantly in the last several years. It is currently around $3.00 per watt, so the payback for the initial investment is 7.57 years. For both Jennings Creek and Richardsville, we have assumed that the criteria for achieving net zero is both energy use and energy cost. In some areas of the country, the owners of solar arrays receive only partial credit for the energy generated. In these instances, the payback can vary greatly, and a school could potentially achieve net zero in usage long before it achieved net zero in energy cost.

Nevertheless, it is important to understand the significance of the energy reduction magnitude first. For Jennings Creek, we are reducing the annual energy bill from an anticipated $225,000 to $51,000. Now, to reach net zero, we provide enough solar energy to offset the remaining demand. By zeroing out energy use and its associated costs, Warren County has saved the equivalent of four teachers' salaries. (See Jennings Creek Cost Table).

Any new school in the planning stages can be designed with similar energy saving strategies and with comparable results. Many school districts stop there and reap the benefits of a significantly reduced energy bill.

In states that recognize and promote the value of renewable energy sources, the net zero school strategy can continue to grow and profoundly change the way we design the built environment. As demonstrated by the policies put in place by the Warren County School District, energy efficient, net zero school buildings attainable today. LBD

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| | A Typical Kentucky Elementary (No Photovoltaics) | B Jennings Creek Elem. (42.84 kw Photovoltaics) | SAVINGS | Jennings Creek Phase II Solar (284.24 kw Photovoltaics) | SAVINGS (NET ZERO) |
|---|---|---|---|---|---|
| COST PER SQUARE FOOT | $221.00 | **$201.17** | $19.83 | **$4.43** | $15.40 |
| TOTAL CONSTRUCTION COST | $19,551,870.00 | **$17,708,464.00** | $1,843,406.00 | **$392,251.00** | $1,451,155.00 |
| PROJECTED ENERGY USE | 73 EUI | **19.2 EUI** | 53.8 EUI (74%) | **19.2 EUI** | 0 |
| PROJECTED ANNUAL ENERGY COST | $194,632.00 | **$51,773.00** | $142,859.00 | **$51,773.00 (PAYBACK IN 7.57 YEARS)** | 0 |
| **TOTAL SAVINGS OVER 20 YEAR BOND** | | | **$3,041,526.00** | **TOTAL PHOTOVOLTAICS REVENUE** | **$643,538.00** |
| **TOTAL CUMULATIVE SAVINGS (NET ZERO) (OVER 20 YEAR BOND)** | | | **$3,685,064.00** | | |

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