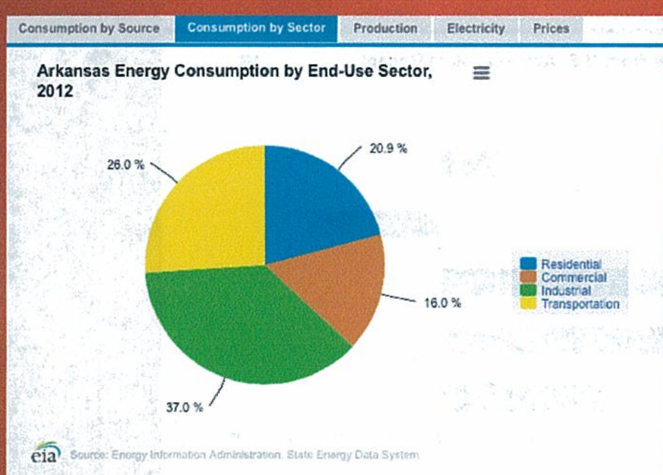
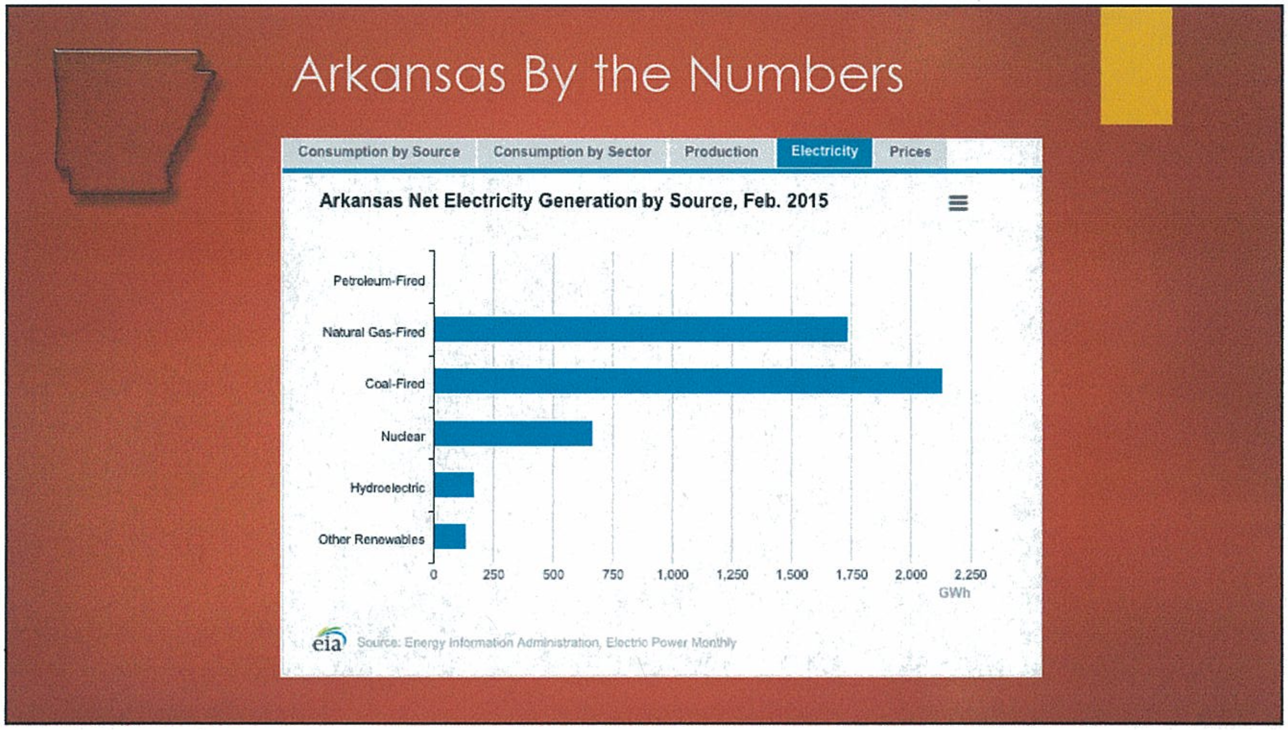
Getting To Zero

COST EFFECTIVE METHODS OF ACHIEVING NET-ZERO READY BUILDING DESIGN

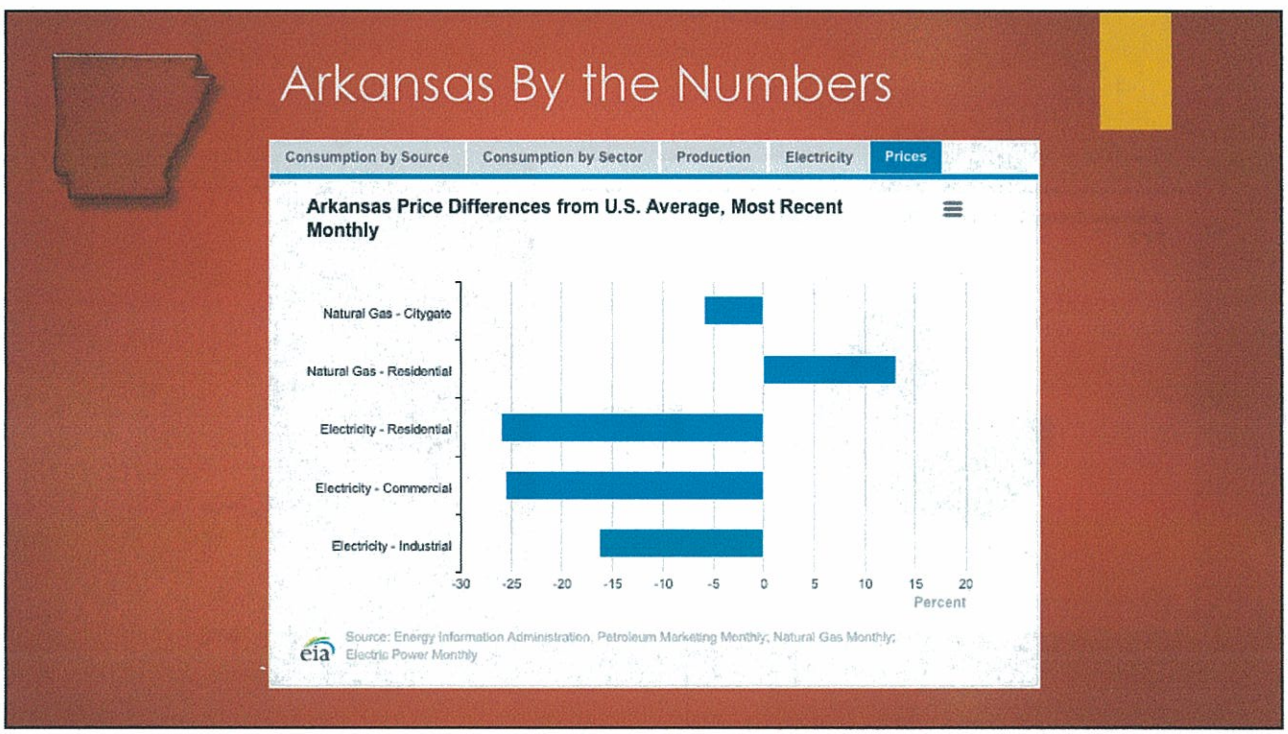
Residential and Commercial Energy Use



- According to the DOE commercial buildings including offices, schools, hospitals, restaurants, hotels and stores consume nearly 20% of all energy used in the U.S.
- That translates into more than $200 Billion spent each year to power millions of square feet that is often designed or operated inefficiently.
- **Why am I here today? To tell you it doesn't have to be that way!**



Arkansas By the Numbers
Consumption by Source
Consumption by Sector
Production
Electricity
Prices
Arkansas Net Electricity Generation by Source, Feb. 2015
Petroleum-Fired
Natural Gas-Fired
Coal-Fired
Nuclear
Hydroelectric
Other Renewables
0
250
500
750
1,000
1,250
1,500
1,750
2,000
2,250
GWh
Source: Energy Information Administration, Electric Power Monthly



Arkansas By the Numbers
Consumption by Source
Consumption by Sector
Production
Electricity
Prices
Arkansas Price Differences from U.S. Average, Most Recent Monthly
Natural Gas - Citygate
Natural Gas - Residential
Electricity - Residential
Electricity - Commercial
Electricity - Industrial
-30
-25
-20
-15
-10
-5
0
5
10
15
20
Percent
Source: Energy Information Administration, Petroleum Marketing Monthly; Natural Gas Monthly; Electric Power Monthly

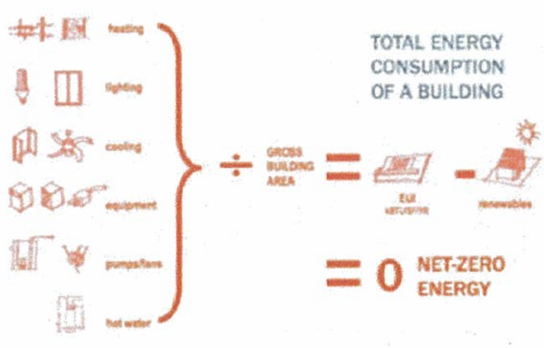
Arkansas By the Numbers

- As of 2014 Coal-fired electric power plants in Arkansas supplied over half (53%) of the state's electricity.
- With increased legislation driving power providers away from building new coal-fired electric power plants, I think many Arkansans have no clue the effect this could have on the price of electricity for our residents.
- We have become accustomed to paying roughly 25% less than the national average for residential and commercial electricity. Many people in our region will have a very difficult time absorbing the increased cost of power that we will see in the coming years.

WHAT IS NET-ZERO ENERGY (NZE)?

NZE buildings have a fully off-set carbon footprint. A building is a Net-Zero annual user of energy if:

The amount of power generated by on-site renewables (wind, solar, etc.) = The amount of energy consumed by the building.

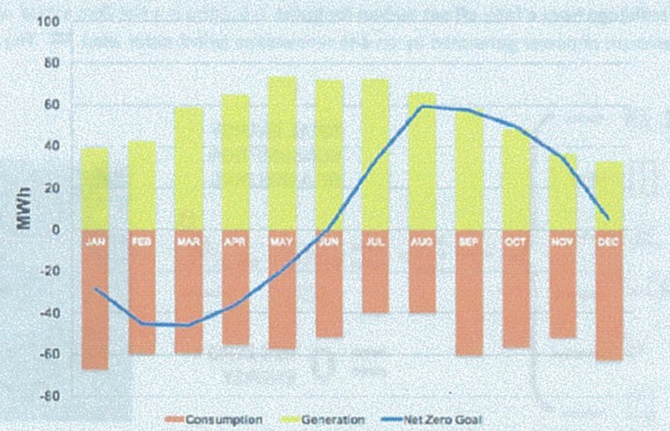


Any Building can be NET ZERO if you have enough ZEROs in your checkbook!

- The trick is lowering the overall consumption of your building first before making the determination if renewable power generation products make economic sense.
- Don't just throw a lot of money at Solar PV or Wind products to generate the amount of power you are using. Reduce consumption first because this will translate to a linear reduction in the amount of generation equipment required.

WHY ARE SCHOOLS IDEAL CANDIDATES FOR NET-ZERO ENERGY?

Photovoltaic solar panels generate the most amount of electricity during the summer months, when the school building is consuming the least amount of energy – even with ongoing summertime programs. Electricity prices are also highest in the summertime, so more revenue is generated. Schools' operating dollars are some of the most precious of all public tax dollars – and are increasingly under strain. Beyond dollars, the benefits of environmental and energy stewardship enrich the curriculum and the community.



How are Buildings Compared?

HOW IS ENERGY USE MEASURED?

All of the power consumed in Discovery Elementary School – whether electricity, natural gas, or propane – is converted into BTUs. An **Energy Use Intensity (EUI)** number is the total number of BTUs (in thousands) consumed over one year and then divided by the total square footage of the building.

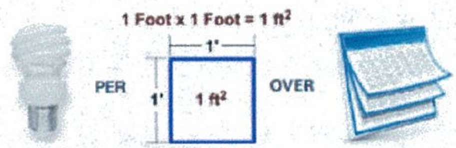
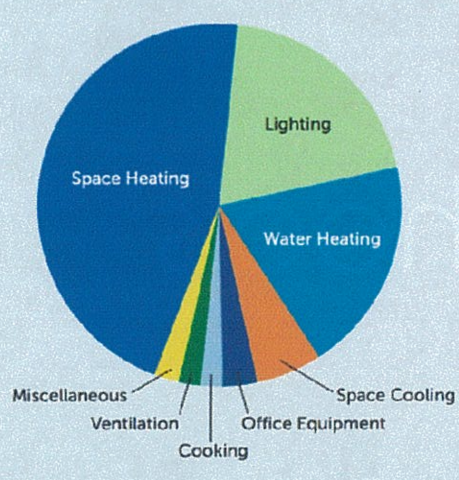


FIGURE 1 BREAKDOWN OF ENERGY USE IN K-12 SCHOOLS



Source: U.S. DOE, 2006b.

- In the average US School Heating, Cooling and Hot Water Generation make up roughly 75% of the total energy used by the school.
- Knowing that, where do you think the largest opportunity for improving energy consumption in a school might be?
- With our patented Hot Water Generation System we can essentially eliminate the water heating portion of this pie.
- In the average Net Zero or Net Zero Ready school this pie looks much different.

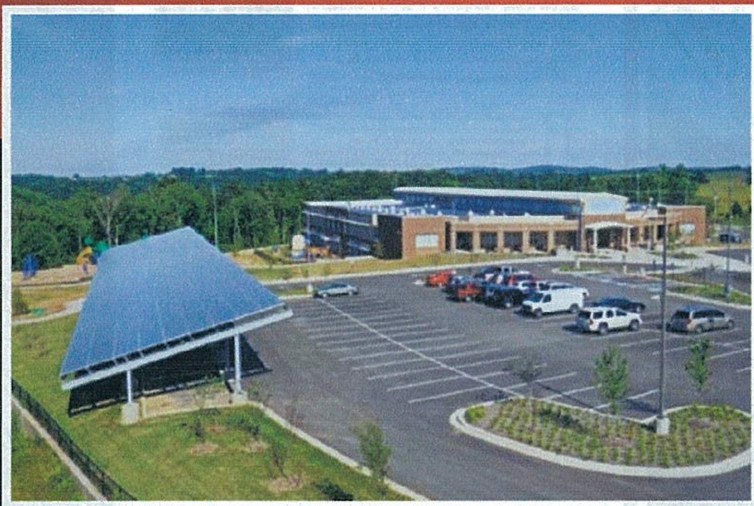
Benefits of Energy Efficiency in Schools

- Reduce energy costs.
- Improve indoor air quality
- Increase attendance.
- Improve student performance
- Demonstrate leadership.
- Reduce greenhouse gas (GHG) emissions and other environmental impacts.
- Enhance educational opportunities.
- Increase economic benefits through job creation and market development.
- Increase security and safety.
- Other benefits.

K-12 Schools

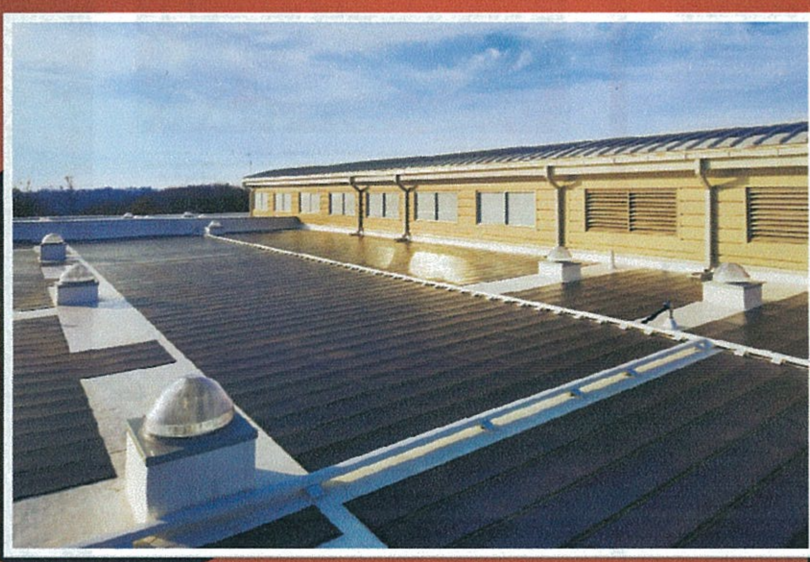
Richardsville Elementary School

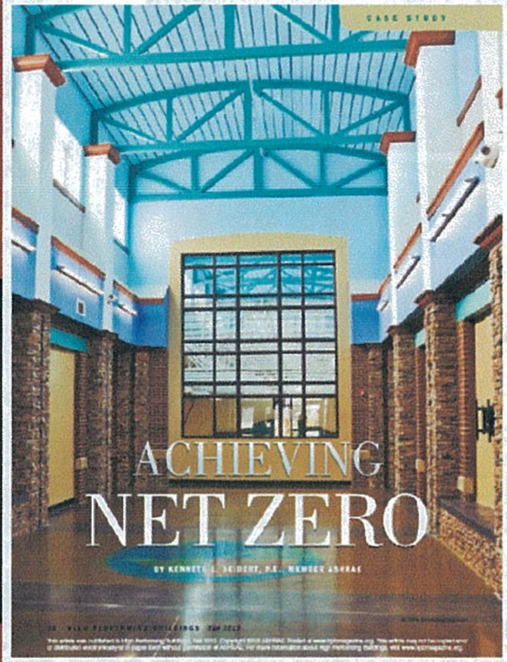
(Richardsville, KY)



Richardsville Elementary School

(Richardsville, KY)





"How would one design a net zero energy school and how much would it cost?" Mark Ryles, AIA, then facilities director for the Kentucky Department of Education, asked this question in fall 2007, right after Plano Elementary became the state's most energy efficient school. This question launched a collaboration involving MEP engineers, architects, state regulators, utility companies, school board members, school facility managers and school staff to design the first full-scale net zero energy school in the United States.

Richardsville Elementary, originally built in 1946, is located in the Warren County Public School District (WCPS) in south central Kentucky. The district has a long history of energy management, being one of the first school districts in the state to hire a full-time energy manager. WCPS had five ENERGY STAR schools when Plano Elementary opened in 2007. Plano was rated at 99 and had an annual energy use intensity (EUI) of 26.8 kBtu/ft².

After such an achievement, investigating net zero seemed the next logical step. During preparations to replace Richardsville's aging building, designers researched current technologies, performed energy modeling and discussed building envelope and site orientation. They decided photovoltaics were the best way to make Plano's exemplary design work as net zero.

However, a PV system with enough capacity to produce Plano's 26.8 kBtu/ft²·yr was too expensive for Warren County's construction budget. Therefore, the team designated a new EUI target of 17 kBtu/ft²·yr as the basis for a financial model that indicated a 15-year simple return on investment (ROI) (See 2009 Financial Model sidebar, Page 43).

Setting the EUI and ROI goals were a critical first step in the collaboration process. The collaborating partners realized that they had to change their design paradigms and usual building construction techniques to reach the goal, as well as ask for waivers of agency regulations.

This project demanded innovative energy reduction strategies such as dedicated outdoor air systems (DOAS) with dynamic reset, new IT systems, and even alternative methods to prepare lunches.

The architect supported the project with a building massing model

Opposite: Visitors coming into the main entrance of Richardsville Elementary look down the central hallway toward a large window overlooking the gymnasium/cafeteria. This forms the central spine of the building and has clerestory windows to admit natural light. The floors are made of concrete that does not require waxing.

The south side of the building has exterior lightshelves to direct sunlight further into the classroom.

BUILDING AT A GLANCE

Name: Richardsville Elementary School
Location: Richardsville, Ky. (7.3 miles north of Bowling Green, Ky.)
Owner: Warren County Public Schools
Principal Use: Elementary school
Includes: Gymnasium and cafeteria
Employees/Occupants: 860 students, 35 staff
Occupancy: 84%
Gross Square Footage: 72,285
Conditioned Space: 72,285
Distinctions/Awards: First Net Zero Energy School in the United States; American School and University Magazine, Special Citation, 2009 and 2011; and Andromeda Award, Alliance to Save Energy (Warren County Public Schools), 2009
Total Cost: $14,317,200
Cost Per Square Foot: $198.50
Substantial Completion/Occupancy: September 2010

For more details on Plano Elementary, see the Fall 2009 issue of High Performing Buildings magazine or go to http://tinyurl.com/[illegible]

...aimed to reduce heat transfer from the outdoors. The engineer developed energy reduction strategies and energy modeled the project, beginning at the schematic phase to ensure the targeted energy performance would be achieved.

Renewable Energy

Solar photovoltaics were selected as the renewable energy source to offset the energy used by the school. The solar PV system did not bid until later stages of construction to obtain the lowest cost.

A 208 kW thin film PV system was located on the roof, and a shade structure built in the parking area accommodates 140 kW of crystalline panels. The full PV system became operational in January 2012.

Figure 1 shows that the building has been operating at net zero energy since January 2012. From September to December 2011, only 60% of the solar PV system was operational, resulting in a net EUI of 0.26 kBtu/ft² for the last 12 months. However, since the PV system became fully operational, power generation has exceeded consumption by 26.5%.

The PV system was designed for a 20-year life-cycle, and it was expected that surplus power would be generated in the initial years.

Above left: A 140 kW crystalline array mounted on a parking shade structure and a 208 kW thin-film array mounted on the roof provide the school's renewable energy. Above right: The roof is covered with a thin-film solar array. This 208 kW array has been operational since February 2012.

FIGURE 1 NET ZERO ENERGY MWH SUMMARY

Read Date	MWh Consumed	MWh Generated	MWh Difference
8/16/2012	36.4	54.8	(18.4)
7/15/2012	26.0	56.0	(30)
6/11/2012	28.0	51.5	(23.5)
5/16/2012	38.2	45.0	(6.8)
4/16/2012	29.8	35.3	(5.5)
3/16/2012	30.6	31.8	(1.2)
2/14/2012	33.8	18.6	14.3
1/18/2012	26.0	14.9	11.1
Subtotal (100%PV)	238.8	327.0	(88.1)
12/14/2011	29.2	1.6	27.7
11/17/2011	31.4	12.2	19.6
10/17/2011	34.0	18.9	15.2
9/15/2011	41.2	22.5	18.7
Subtotal (60%PV)	136.0	62.1	74.3
Total	385.0	371.4	6.2

MWh summary documenting eight months of operation with the power generation system at 100% and four months at 60% operation.

AUTHOR'S NOTE ON MZEB

Due to of the groundbreaking nature of this project, this article has been published prior to having one year of full data on the power generation system. Because the school opened in September 2010, more than 12 months of energy consumption data is available; however the full renewable energy system did not become operational until January 2012.

Figure 1 shows the MWh summary documenting eight months of operation with the power generation system at 100% and four months at 60% operation. Since the power generation system began full output, generation has exceeded consumption by 26.5%.

Looking at the previous 12 months, consumption exceeded generation by only 1.2%, which included the four months with only 60% capacity. Using this data, even without the full 12 months of 100% solar PV output, it is clearly evident this building is operating as a net zero energy building.

ENERGY AT A GLANCE

Annual Energy Use Intensity (EUI) (Site): 18.2 kBtu/ft²
Electricity (from Grid): 18.2 kBtu/ft²
Annual Source Energy: 60.5 kBtu/ft²
Annual Energy Cost Index (ECI): $0.70/ft²·year
Annual On-Site Renewable Energy Exported (from PV): 17.8 kBtu/ft²
Annual Net Energy Use Intensity: 0.26 kBtu/ft²
Savings vs. Standard 90.1-2004 Design Building: 72.8%
ENERGY STAR Rating: 100
Heating Degree Days (base 65°F): 3,710
Cooling Degree Days (base 65°F): 2,660
Average Operating Hours per Week: 45

WATER AT A GLANCE

Annual Water Use: 421,200 gallons

The gymnasium serves as gym and cafeteria. The cafeteria setup is pictured here. The clerestory windows that form the spine of the building and admit daylight into the main hall and gymnasium/cafeteria can be seen at the top of the photo. None of the overhead lights were on when this picture was taken.

Because the output of the panels deteriorates over time, the system was designed so at year 10, generation would match consumption. *Figure 2* graphs the production of each PV system over the last 12 months.

Energy Consumption

The net zero operation has grabbed public attention, but the low energy consumption is a source of pride for the design team. During the past 12 months, actual building energy consumption has been 18.2 kBtu/ft², while the design energy goal was 17 kBtu/ft².

The school is equipped with a power monitoring system that can measure and trend HVAC, lighting, kitchen, plug load, and IT power consumption individually (*Figure 3*). *Figure 4* compares Richardsville's energy consumption to baseline energy use according to ASHRAE/IESNA Standard 90.1-2004 and data from ASHRAE's *Advanced Energy Design Guide (AEDG) for K–12 School Buildings: Achieving 50% Energy Savings Toward a Net Zero Energy Building.*

Energy Reduction Strategies

Envelope. Energy benchmarking data from past projects provided clear evidence that an efficient thermal envelope can have a substantial impact on energy performance.

Richardsville Elementary was constructed with insulated concrete form (ICF) walls. The district had first used ICF walls in the construction of Alvaton Elementary, and the thermal performance, along with the thermal mass it provided, is a proven strategy to reduce HVAC energy.

A rectangular shape was chosen early to minimize heat transfer surface areas. The ratio of exterior wall-to-floor area is 38.9%, window-to-floor area is 26.9% and roof-to-floor area is 62.7%. The same ratios for the prototypical school modeled in ASHRAE's 50% school buildings AEDG, by comparison, are 49%, 34% and 100%, respectively. The architects' building design minimized the exterior heat transfer surfaces, which helped achieve the energy performance goals.

Lighting Strategies. The lighting energy consumption is 3.0 kBtu/ft²·yr. The primary strategies to reduce this energy use were minimizing the lighting energy intensity and

NEW VS. OLD VIDEO

New vs. Old Richardsville Elementary School is a fun video [illegible]. The video is a parody of the "Get a Mac" PC vs. Mac ad campaign that ran from 2006 to 2009 (http://tinyurl.com/[illegible]).

The New Richardsville Elementary School constantly tells Old Richardsville Elementary School by touting all of the sustainable features of the new school including its being built to be net zero energy.

In the end, Old Richardsville School decides he wants to attend the new school, too.

View the New vs. Old Richardsville Elementary School video at http://tinyurl.com/[illegible]

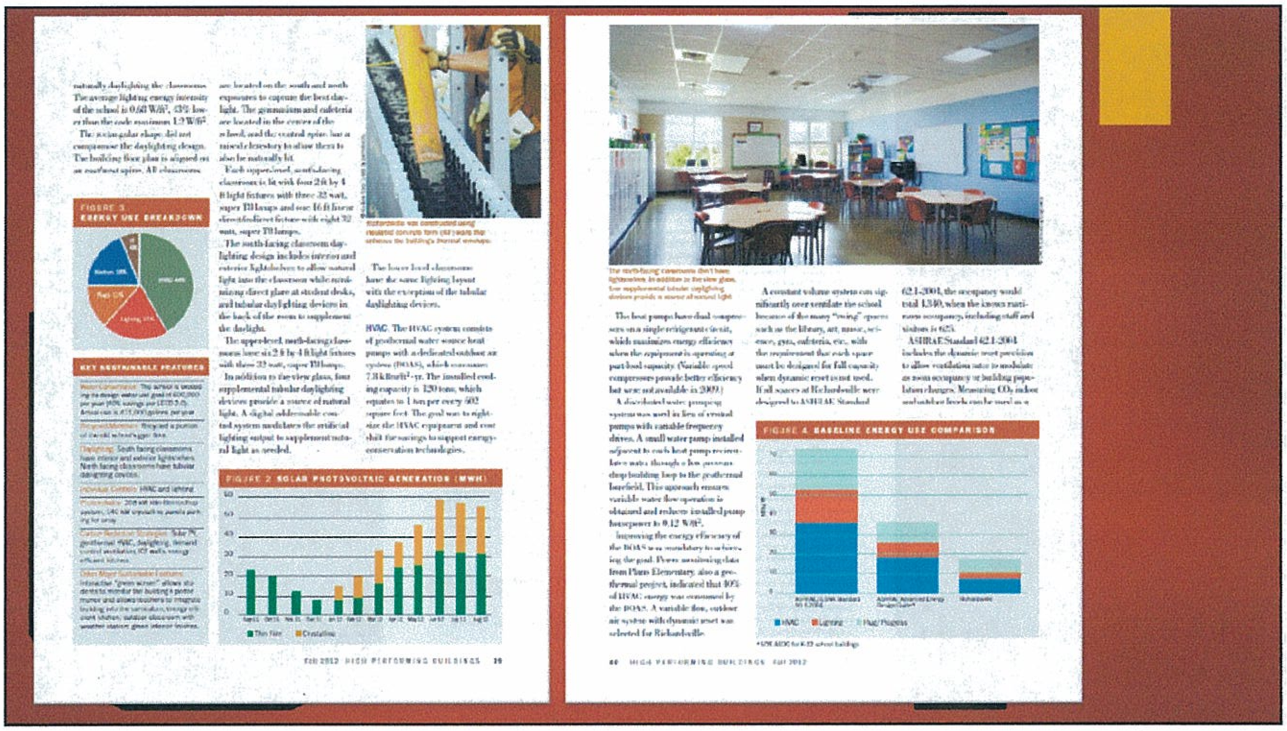


FIGURE 3 ENERGY USE BREAKDOWN
KEY SUSTAINABLE FEATURES
FIGURE 2 SOLAR PHOTOVOLTAIC GENERATION (MWH)
Thin Film
Crystalline
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HVAC
Lighting
Plug/Process
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BUILDING TEAM
Other Green Strategies
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Behavior Changes
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Marion Junior High School

MOST ENERGY EFFICIENT SCHOOL IN STATE OF ARKANSAS

BUILT AT NEAR CONVENTIONAL CONSTRUCTION COSTS **($133/SQ. FT / 2009)** ($175/ SQ. FT / 2015)

ENERGY USAGE: (22 KBTU/SQ. FT/YEAR @ $133/SQ. FT.)

Marion School District Project Team

PKM ARCHITECTS

Pat Kelley Magruder – Project Architect
Located: West Memphis, AR

HALTOM ENGINEERING
MECHANICAL ENGINEERS

Jeff Haltom– Mechanical Engineer
Located: Downtown Memphis, TN

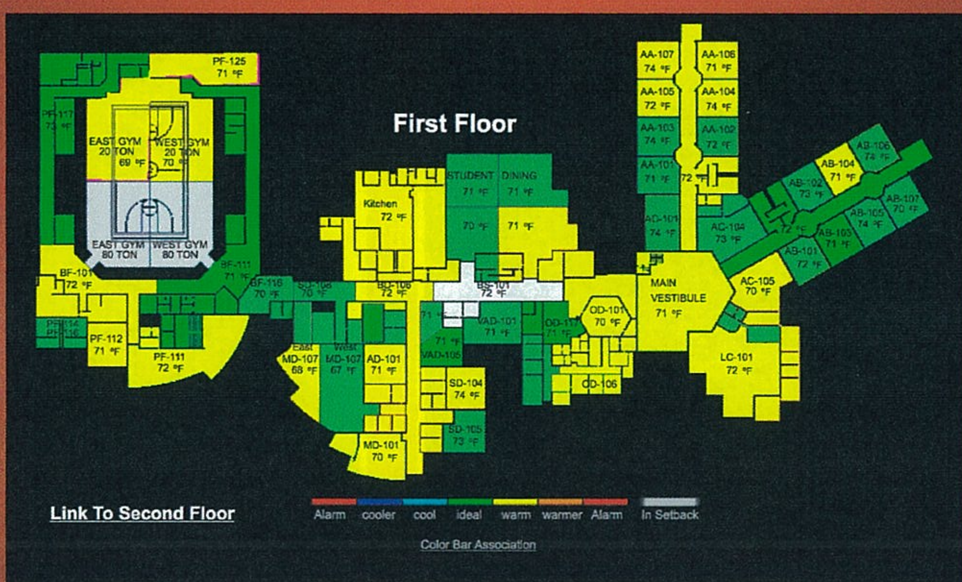
BALDWIN & SHELL CONSTRUCTION COMPANY

Baldwin & Shell– Project Architect
Located: Little Rock, AR

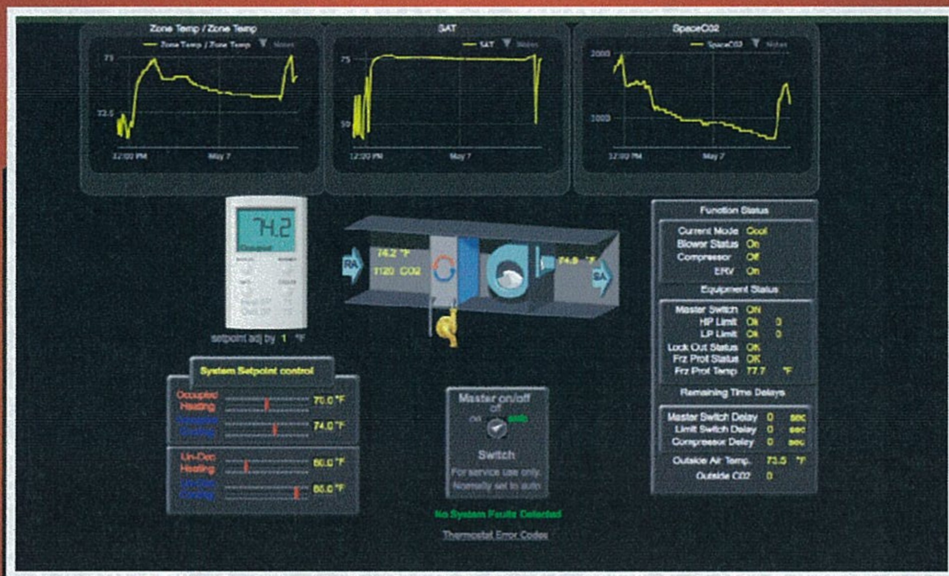
Hydro-Temp

Hydro-Temp– HVAC Equipment Manufacturer
Located: Pocahontas, AR

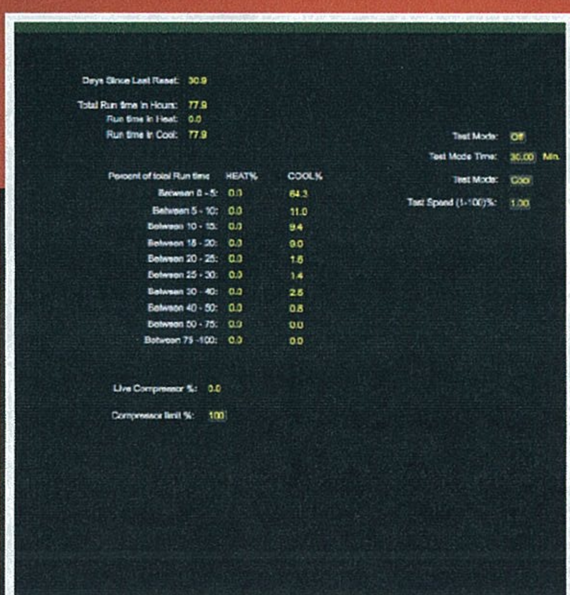
Marion Junior High School



Marion Junior High School



Marion Junior High School



Lets Compare Marion Jr High School to a similar Arkansas High School

GREENE COUNTY TECH HIGH SCHOOL COMPLETED: **2011**	MARION JUNIOR HIGH SCHOOL COMPLETED: **2009**
GCT HS FINISHED COST: **$ 37,100,000**	MJHS FINISHED COST: **$ 26,000,000**
GCT HS TOTAL SQUARE FOOTAGE: **240,000 SQ. FT.**	MJHS TOTAL SQUARE FOOTAGE: **196,000 SQ. FT.**
COST PER SQ. FT. : **$155**	COST PER SQ. FT. : **$133**

ARLINGTON PUBLIC SCHOOLS

DISCOVERY ELEMENTARY SCHOOL

PROJECT DATA

Grades:	**Pre-K-5**	**Budget:**	**$36,257,611**
Students:	**630 (max capacity: 684)**	**Low Bid:**	**$32,305,807**
Square Footage:	**97,588 GSF**	**Average Bid:**	**$33,390,872**
Limits of Disturbance:	**15.5 acres**	**Building Cost/SF:**	**$273**
		Building + PV Cost/SF:	**$289**

SETTING A NEW STANDARD FOR A NEW CENTURY

Arlington Public Schools' Discovery Elementary School is one of a series of school projects that will help strategically transform 21st century education in Arlington County, Virginia. As the first new elementary school in the County in 11 years, and the first new project as part of a 10 year Capital Improvements Program, the project's primary objective is to set a new standard for the new century – in sustainability, efficiency, flexibility, and in the design of learning environments. Net-Zero Energy (NZE) design was a primary contributor to all of these goals.

Considerations for site footprint, solar orientation, building construction, and energy use were given top priority in the iterative design process. With a capacity of 650 students in grades Pre-K through 5, the 98,000 GSF building is designed for an Energy Use Index (EUI) of 23 kBTU/sf/year – one third of the energy use of a typical County elementary school. This ultra-low EUI makes on-site photovoltaic energy generation possible within a traditional school budget.

MASSING & MATERIALS

The mass of the two-story building is broken down into smaller components, which help minimize the visual impact of the building's volume. The east and west ends of the building are articulated as multiple, two story masses, reflecting the scale of neighborhood homes. On the south side, the early childhood classrooms are grouped into "kinder-houses," and the building's public space is defined by a large roof canopy with a cedar soffit – serving as the school's "front porch" with covered outdoor dining and play spaces. These massing strategies have been balanced with the need to provide enough roof area to contain all of the photovoltaic panels required for Net-Zero Energy operation. Exterior materials are residential in nature and scale, with select color accents on factory-finished metal.

Discovery Elementary is anticipated to become the first Net-Zero Energy school in the Mid-Atlantic, and the largest in the United States.

23 kBtu/sq.ft/year @ $273/sq.ft

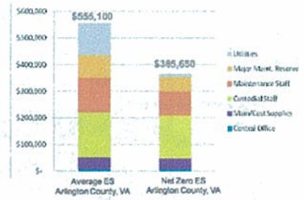
CASH FLOW

The full cost of the photovoltaic (PV) system is $1.6M, which requires about $100K of the yearly bond payment. PV revenue will cover this payment by year 7 and provide a 6.3% annualized return over 20 years. When this is added to other energy conservation savings, **the new school will cost $47K less to operate than an average APS school in Year One.** Money is returned to the system's operating budget, while allowing school inhabitants and community members to enjoy the environmental benefit of a fully offset carbon footprint!

Year	Energy Conservation Savings		Solar PV Income Generated		Annual Cash Flow	
1	$	51,986	$	(4,639)	$	47,347
2	$	53,546	$	(4,116)	$	49,430
3	$	55,152	$	(3,479)	$	51,673
4	$	56,807	$	(2,732)	$	54,075
5	$	58,511	$	(1,876)	$	56,635
6	$	60,266	$	(913)	$	59,353
7	$	62,074	$	154	$	62,228
8	$	63,937	$	1,323	$	65,259
9	$	65,855	$	2,593	$	68,448
10	$	67,830	$	3,962	$	71,793
11	$	69,865	$	5,430	$	75,296
12	$	71,961	$	6,995	$	78,956
13	$	74,120	$	8,656	$	82,776
14	$	76,344	$	10,413	$	86,756
15	$	78,634	$	12,264	$	90,898
16	$	80,993	$	14,210	$	95,203
17	$	83,423	$	16,250	$	99,673
18	$	85,926	$	18,384	$	104,309
19	$	88,503	$	20,612	$	109,115
20	$	91,158	$	22,933	$	114,092
Total	$	1,396,893	$	126,423	$	1,523,316

TOTAL COST OF OWNERSHIP

The school has no boiler or chiller to maintain, no mechanical equipment above ceilings or on the roof, and no complicated lighting control systems. The residential-style heat pumps can be serviced by a maintenance staff with a diversity of skill sets and are floor-mounted for ease of access and filter-changing. LED lights typically do not require changing for up to 20 years. The flooring systems do not require stripping and waxing, and all high-traffic exterior play areas have artificial surfaces, reducing the cost of landscape maintenance. Combined with zero energy costs, the total annual cost of ownership with these savings drops by approximately $200K!



Discovery Elementary School is all-electric, including the kitchen and hot water systems. By offsetting all of its energy costs through photovoltaic generation, the building hedges against future energy inflation. In fact, the more electricity prices go up, the higher the return on the investment for the school.

PROJECT TEAM

VMDO Architects
Architect-of-Record

CMTA Engineers
Mechanical & Lighting Engineering / Net-Zero Engineering

2rw Consultants
Power, Plumbing & Fire Protection Engineering

Bowman Consulting
Civil Engineering

Fox & Associates
Structural Engineering

Oculus
Landscape Architecture

EIS, Inc.
Food Services

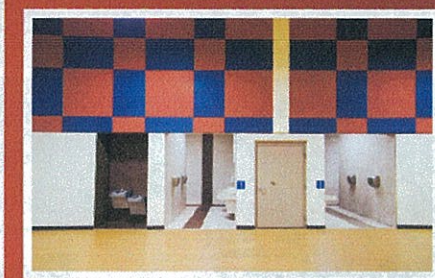
Downey & Scott
Cost Estimating

Toole Design Group
Transportation Consultant

A new school building is a massive investment for any community. Discovery Elementary will provide an effective return on investment for the life of the building – in tax dollars; in ease-of-operation; in teacher recruitment; and most importantly, in the lives of students.

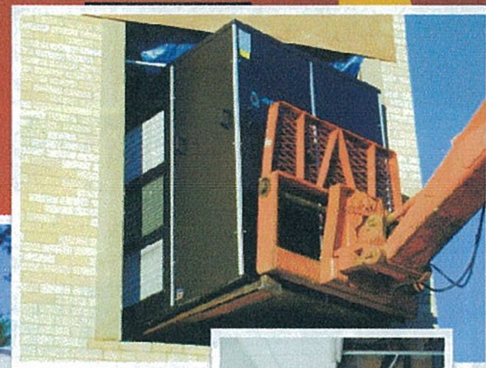
Avondale Elementary – FEMA Safe Room

Avondale Elementary – FEMA Safe Room

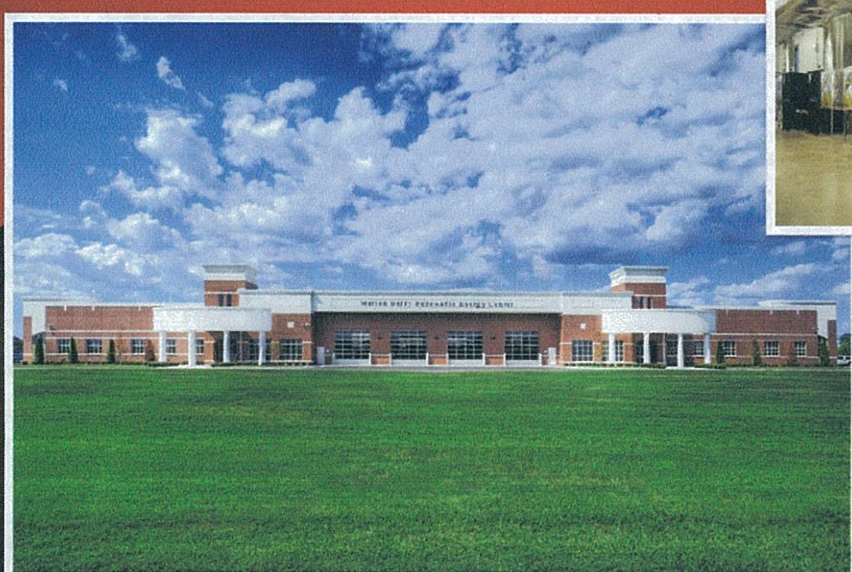


Post Secondary

Black River Technical College



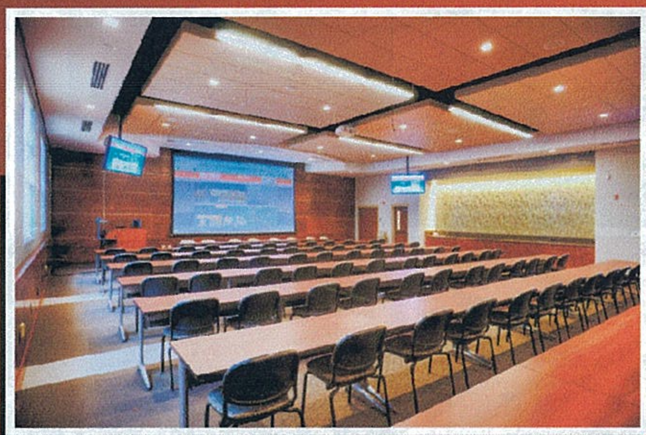

Marion Berry Renewable Energy Center

U.S. GREEN BUILDING COUNCIL LEED SILVER USGBC

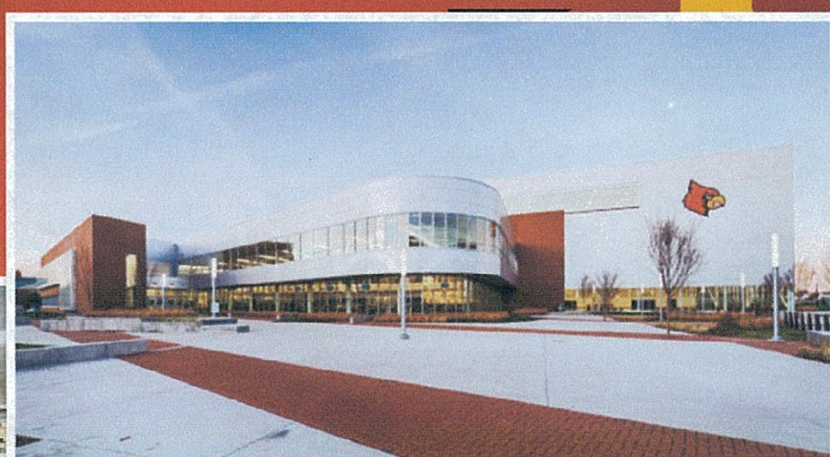
Marion Berry Renewable Energy Center

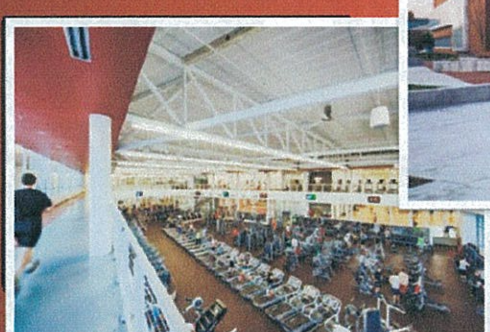
U.S. GREEN BUILDING COUNCIL
LEED SILVER
USGBC



University of Louisville – New Student Recreation Center

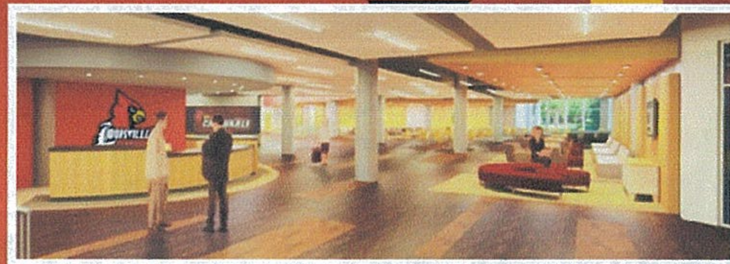
UNIVERSITY OF LOUISVILLE

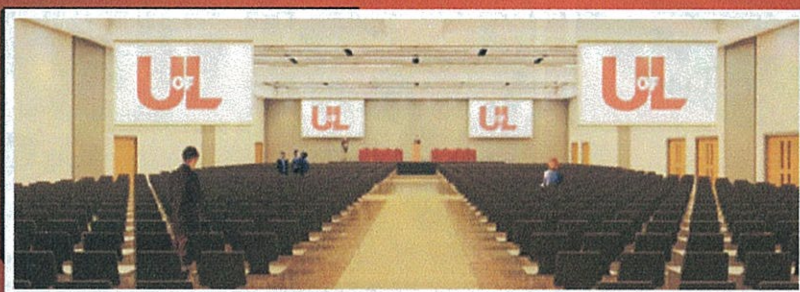




University of Louisville – Future SAC East Renovation

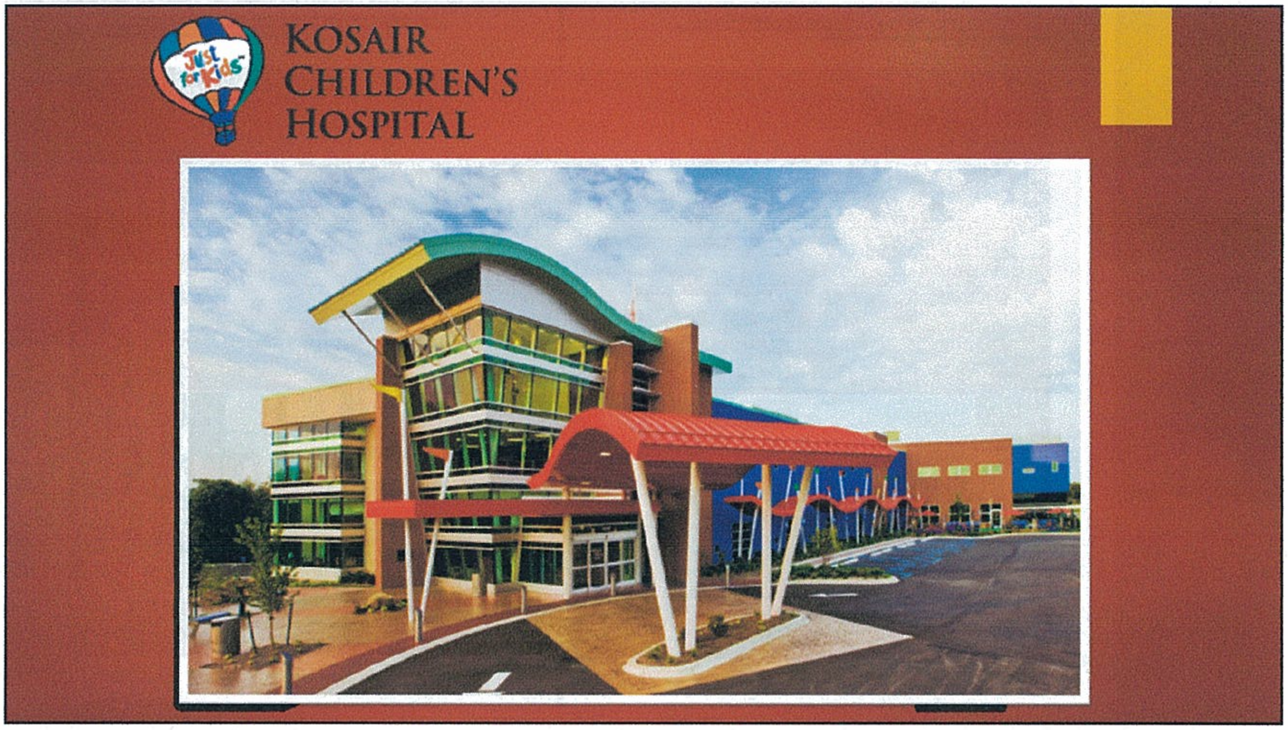
UNIVERSITY OF LOUISVILLE

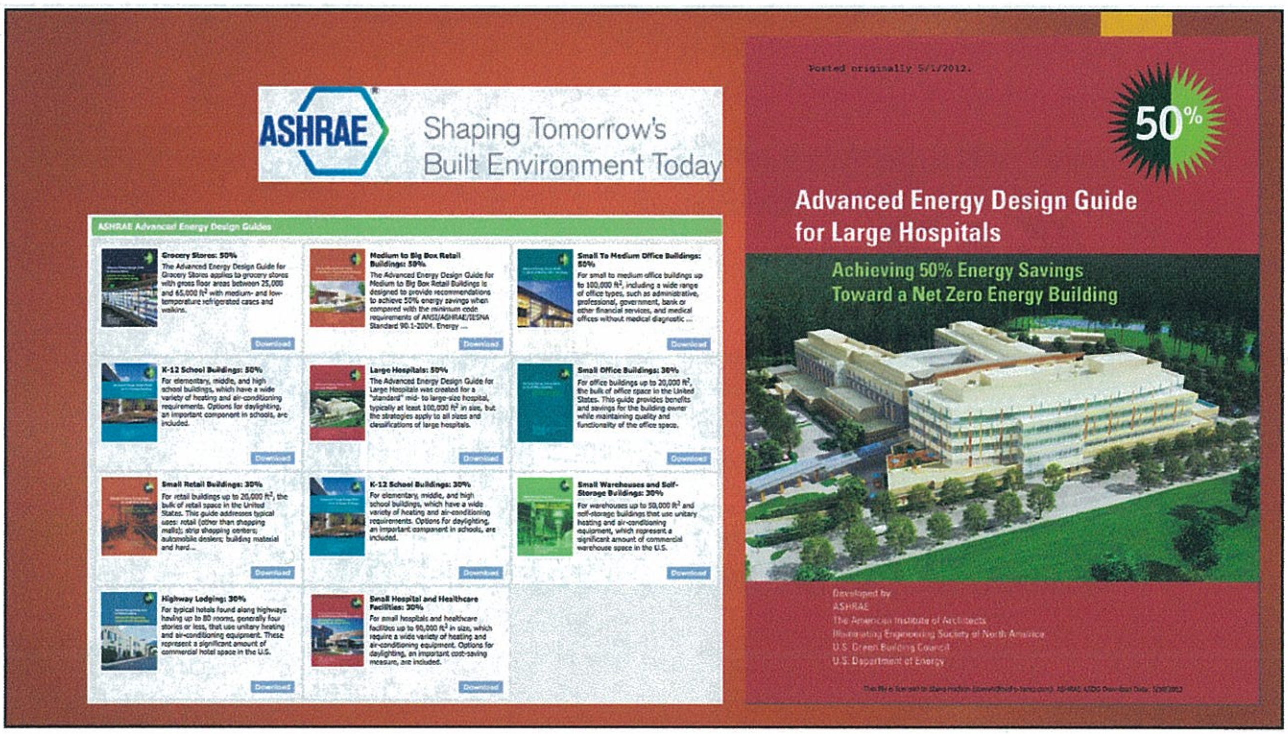




Beginning Summer 2015, the east first floor of the Student Activities Center will begin renovations as Intramurals moves to the new Student Recreation Center. When completed the renovated east first floor of the Student Center will serve as a significant meeting area for the University Community.

HealthCare


KOSAIR
CHILDREN'S
HOSPITAL
Just for Kids


ASHRAE
Shaping Tomorrow's
Built Environment Today
ASHRAE Advanced Energy Design Guides
Grocery Stores: 50%
The Advanced Energy Design Guide for Grocery Stores applies to grocery stores with gross floor areas between 25,000 and 65,000 ft² with medium- and low-temperature refrigerated cases and walkins.
Download
Medium to Big Box Retail Buildings: 50%
The Advanced Energy Design Guide for Medium to Big Box Retail Buildings is designed to provide recommendations to achieve 50% energy savings when compared with the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-2004. Energy ...
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Small To Medium Office Buildings: 50%
For small to medium office buildings up to 100,000 ft², including a wide range of office types, such as administrative, professional, government, bank or other financial services, and medical offices without medical diagnostic ...
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K-12 School Buildings: 50%
For elementary, middle, and high school buildings, which have a wide variety of heating and air-conditioning requirements. Options for daylighting, an important component in schools, are included.
Download
Large Hospitals: 50%
The Advanced Energy Design Guide for Large Hospitals was created for a "standard" mid- to large-size hospital, typically at least 100,000 ft² in size, but the strategies apply to all sizes and classifications of large hospitals.
Download
Small Office Buildings: 30%
For office buildings up to 20,000 ft², the bulk of office space in the United States. This guide provides benefits and savings for the building owner while maintaining quality and functionality of the office space.
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Small Retail Buildings: 30%
For retail buildings up to 20,000 ft², the bulk of retail space in the United States. This guide addresses typical uses: retail (other than shopping malls); strip shopping centers; automobile dealers; building material and hard...
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Small Warehouses and Self-Storage Buildings: 30%
For warehouses up to 50,000 ft² and self-storage buildings that use unitary heating and air-conditioning equipment, which represent a significant amount of commercial warehouse space in the U.S.
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Highway Lodging: 30%
For typical hotels found along highways having up to 80 rooms, generally four stories or less, that use unitary heating and air-conditioning equipment. These represent a significant amount of commercial hotel space in the U.S.
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Small Hospital and Healthcare Facilities: 30%
For small hospitals and healthcare facilities up to 90,000 ft² in size, which require a wide variety of heating and air-conditioning equipment. Options for daylighting, an important cost-saving measure, are included.
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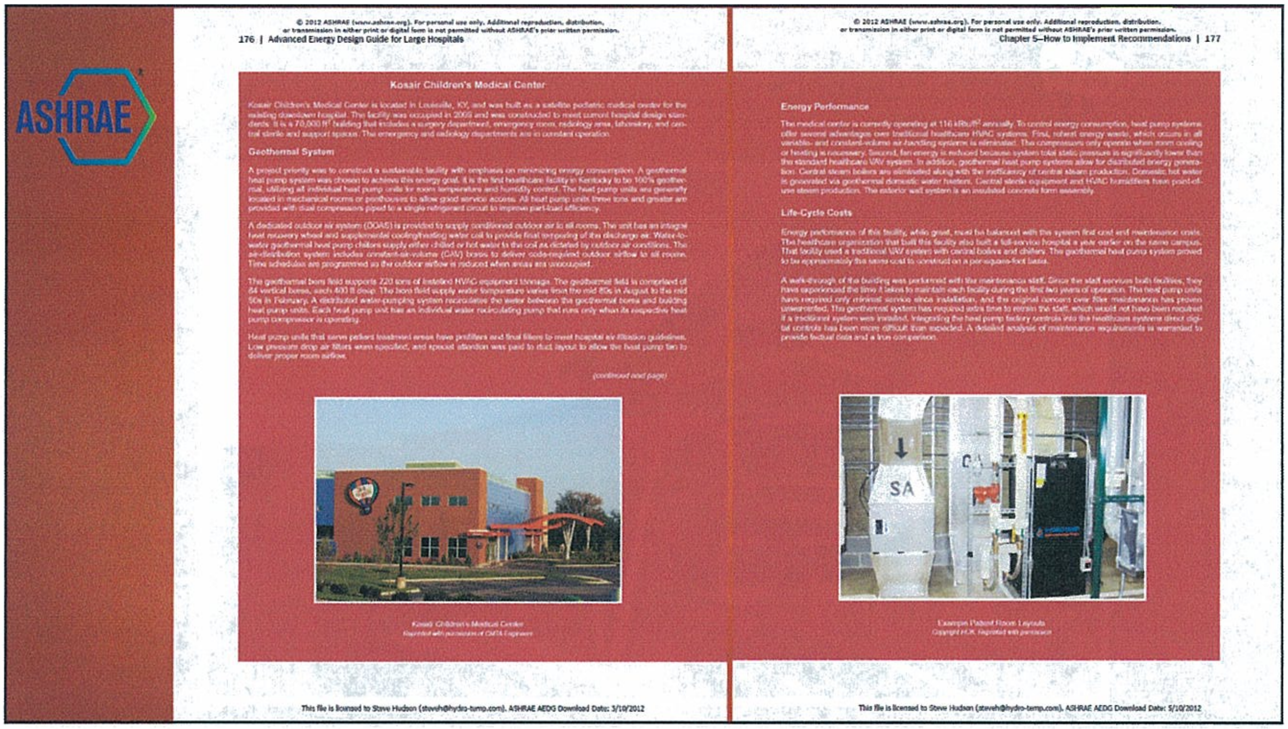
Posted originally 5/1/2012.
50%
Advanced Energy Design Guide
for Large Hospitals
Achieving 50% Energy Savings
Toward a Net Zero Energy Building
Developed by
ASHRAE
The American Institute of Architects
Illuminating Engineering Society of North America
U.S. Green Building Council
U.S. Department of Energy



Kosair Children's Medical Center

Kosair Children's Medical Center is located in Louisville, KY, and was built as a satellite pediatric medical center for the existing downtown hospital. The facility was occupied in 2005 and was constructed to meet current hospital design standards. It is a 70,000 ft² building that includes a surgery department, emergency room, radiology area, laboratory, and central sterile and support spaces. The emergency and radiology departments are in constant operation.

Geothermal System

A project priority was to construct a sustainable facility with emphasis on minimizing energy consumption. A geothermal heat pump system was chosen to achieve this energy goal. It is the first healthcare facility in Kentucky to be 100% geothermal, utilizing all individual heat pump units for room temperature and humidity control. The heat pump units are generally located in mechanical rooms or penthouses to allow good service access. All heat pump units three tons and greater are provided with dual compressors piped to a single refrigerant circuit to improve part-load efficiency.

A dedicated outdoor air system (DOAS) is provided to supply conditioned outdoor air to all rooms. The unit has an integral heat recovery wheel and supplemental cooling/heating water coil to provide final tempering of the discharge air. Water-to-water geothermal heat pump chillers supply either chilled or hot water to the coil as dictated by outdoor air conditions. The air-distribution system includes constant-air-volume (CAV) boxes to deliver code-required outdoor airflow to all rooms. Time schedules are programmed so the outdoor airflow is reduced when areas are unoccupied.

The geothermal bore field supports 220 tons of installed HVAC equipment tonnage. The geothermal field is comprised of 84 vertical bores, each 400 ft deep. The bore field supply water temperature varies from the mid 80s in August to the mid 50s in February. A distributed water-pumping system recirculates the water between the geothermal bores and building heat pump units. Each heat pump unit has an individual water recirculating pump that runs only when its respective heat pump compressor is operating.

Heat pump units that serve patient treatment areas have prefilters and final filters to meet hospital air filtration guidelines. Low pressure drop air filters were specified, and special attention was paid to duct layout to allow the heat pump fan to deliver proper room airflow.

(continued next page)

Kosair Children's Medical Center
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Energy Performance

The medical center is currently operating at 116 kBtu/ft² annually. To control energy consumption, heat pump systems offer several advantages over traditional healthcare HVAC systems. First, reheat energy waste, which occurs in all variable- and constant-volume air-handling systems is eliminated. The compressors only operate when room cooling or heating is necessary. Second, fan energy is reduced because system total static pressure is significantly lower than the standard healthcare VAV system. In addition, geothermal heat pump systems allow for distributed energy generation. Central steam boilers are eliminated along with the inefficiency of central steam production. Domestic hot water is generated via geothermal domestic water heaters. Central sterile equipment and HVAC humidifiers have point-of-use steam production. The exterior wall system is an insulated concrete form assembly.

Life-Cycle Costs

Energy performance of this facility, while great, must be balanced with the system first cost and maintenance costs. The healthcare organization that built this facility also built a full-service hospital a year earlier on the same campus. That facility used a traditional VAV system with central boilers and chillers. The geothermal heat pump system proved to be approximately the same cost to construct on a per-square-foot basis.

A walk-through of the building was performed with the maintenance staff. Since the staff services both facilities, they have experienced the time it takes to maintain each facility during the first two years of operation. The heat pump units have required only minimal service since installation, and the original concern over filter maintenance has proven unwarranted. The geothermal system has required extra time to retrain the staff, which would not have been required if a traditional system was installed. Integrating the heat pump factory controls into the healthcare systems direct digital controls has been more difficult than expected. A detailed analysis of maintenance requirements is warranted to provide factual data and a true comparison.

Example Patient Room Layouts
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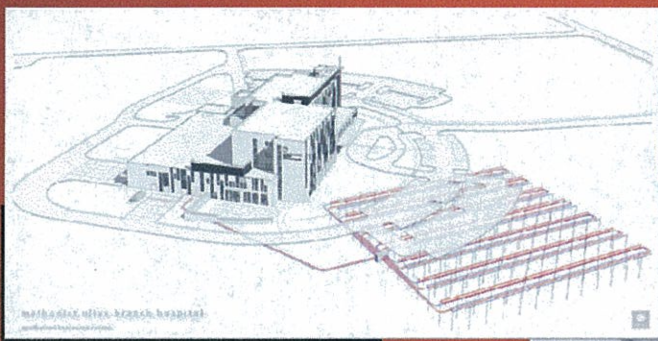
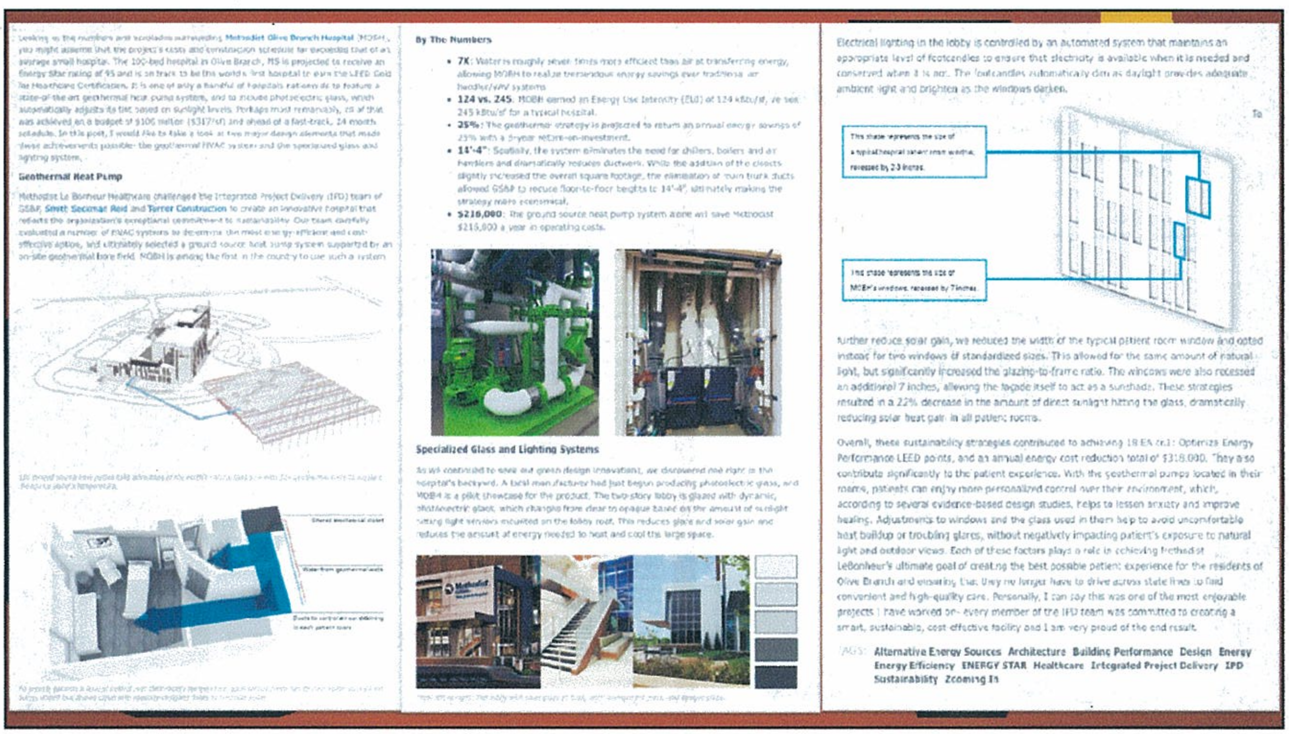
Methodist Olive Branch Hospital

First in-patient healthcare facility in the U.S. to attain LEED for Healthcare Gold Certification.

Methodist Olive Branch Hospital





Looking at the numbers and accolades surrounding **Methodist Olive Branch Hospital** (MOBH), you might assume that the project's costs and construction schedule far exceeded that of an average small hospital. The 100-bed hospital in Olive Branch, MS is projected to receive an Energy Star rating of 95 and is on track to be the world's first hospital to earn the LEED Gold for Healthcare Certification. It is one of only a handful of hospitals nationwide to feature a state-of-the-art geothermal heat pump system, and to include photoelectric glass, which automatically adjusts its tint based on sunlight levels. Perhaps most remarkably, all of this was achieved on a budget of $106 million ($317/sf) and ahead of a fast-track, 24 month schedule. In this post, I would like to take a look at two major design elements that made these achievements possible- the geothermal HVAC system and the specialized glass and lighting system.

Geothermal Heat Pump

Methodist Le Bonheur Healthcare challenged the Integrated Project Delivery (IPD) team of GS&P, **Smith Seckman Reid** and **Turner Construction** to create an innovative hospital that reflects the organization's exceptional commitment to sustainability. Our team carefully evaluated a number of HVAC systems to determine the most energy-efficient and cost-effective option, and ultimately selected a ground source heat pump system supported by an on-site geothermal bore field. MOBH is among the first in the country to use such a system

By The Numbers

- **7X**: Water is roughly seven times more efficient than air at transferring energy, allowing MOBH to realize tremendous energy savings over traditional air handler/VAV systems.
- **124 vs. 245**: MOBH earned an Energy Use Intensity (EUI) of 124 kBtu/sf, vs. 245 kBtu/sf for a typical hospital.
- **25%**: The geothermal strategy is projected to return an annual energy savings of 25% with a 5-year return-on-investment.
- **14'-4"**: Spatially, the system eliminates the need for chillers, boilers and air handlers and dramatically reduces ductwork. While the addition of the closets slightly increased the overall square footage, the elimination of main trunk ducts allowed GS&P to reduce floor-to-floor heights to 14'-4", ultimately making the strategy more economical.
- **$216,000**: The ground source heat pump system alone will save Methodist $216,000 a year in operating costs.

Specialized Glass and Lighting Systems

As we continued to seek out green design innovations, we discovered one right in the hospital's backyard. A local manufacturer had just begun producing photoelectric glass, and MOBH is a pilot showcase for the product. The two-story lobby is glazed with dynamic, photoelectric glass, which changes from clear to opaque based on the amount of sunlight hitting light sensors mounted on the lobby roof. This reduces glare and solar gain and reduces the amount of energy needed to heat and cool the large space.

Electrical lighting in the lobby is controlled by an automated system that maintains an appropriate level of footcandles to ensure that electricity is available when it is needed and conserved when it is not. The footcandles automatically dim as daylight provides adequate ambient light and brighten as the windows darken.

This shape represents the size of a typical hospital patient room window, recessed by 2-3 inches.

This shape represents the size of MOBH's windows, recessed by 7 inches.

To further reduce solar gain, we reduced the width of the typical patient room window and opted instead for two windows of standardized sizes. This allowed for the same amount of natural light, but significantly increased the glazing-to-frame ratio. The windows were also recessed an additional 7 inches, allowing the façade itself to act as a sunshade. These strategies resulted in a 22% decrease in the amount of direct sunlight hitting the glass, dramatically reducing solar heat gain in all patient rooms.

Overall, these sustainability strategies contributed to achieving 18 EA cr.1: Optimize Energy Performance LEED points, and an annual energy cost reduction total of $318,000. They also contribute significantly to the patient experience. With the geothermal pumps located in their rooms, patients can enjoy more personalized control over their environment, which, according to several evidence-based design studies, helps to lessen anxiety and improve healing. Adjustments to windows and the glass used in them help to avoid uncomfortable heat buildup or troubling glares, without negatively impacting patient's exposure to natural light and outdoor views. Each of these factors plays a role in achieving Methodist LeBonheur's ultimate goal of creating the best possible patient experience for the residents of Olive Branch and ensuring that they no longer have to drive across state lines to find convenient and high-quality care. Personally, I can say this was one of the most enjoyable projects I have worked on- every member of the IPD team was committed to creating a smart, sustainable, cost-effective facility and I am very proud of the end result.

TAGS: **Alternative Energy Sources** **Architecture** **Building Performance** **Design** **Energy** **Energy Efficiency** **ENERGY STAR** **Healthcare** **Integrated Project Delivery** **IPD** **Sustainability** **Zooming In**

Nov. 2014 Air Conditioning, Heating, and Refrigeration News

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Alternative HVAC Systems Popular in Hospital Applications

Health Care Facilities Embrace Nontraditional Equipment

By Joanna R. Turpin

November 3, 2014 No Comments

KEYWORDS air curtains / energy management / geothermal system / VRF system

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Geothermal systems make sense for hospitals as they offer impressive energy savings and increased levels of comfort. (Photo courtesy of Hydro-Temp)

From the Ground Up

When decision makers at Methodist LeBonheur Health embarked on the development of a new facility to serve the growing area of Olive Branch, Mississippi, they identified a number of guiding principles to which every element of the project needed to support. These included a focus on the healing environment, patient safety, efficiency in delivering care and operating the facility, flexibility for future growth and changes in modalities, and an overall concentration on patient satisfaction.

In order to meet those goals, a design team consisting of Gresham, Smith, and Partners; Smith Seckman Reid, and Turner Construction, along with Methodist Le Bonheur Healthcare, conducted an in-depth life-cycle cost analysis of several HVAC systems and concluded a geothermal heat pump system from Hydro-Temp would be the most sustainable — as well as the most cost-effective — choice for the 200,000-square-foot Methodist Olive Branch Hospital.

Once the determination was made to go with geothermal, installing a large bore field with existing site restrictions proved to be a challenge. The required bore field size was reduced nearly one-third by going with a hybrid geothermal system, which includes a combination dry/wet fluid cooler, along with a pumping package and predictive bore field temperature controls by Greensleeves Energy Solutions. The fluid cooler operates primarily during off-peak hours, as required, based on bore field temperatures.

Ultimately, 196 geothermal wells were installed in a bore field on the hospital site, supporting 211 geothermal heat pumps throughout the hospital with outside air provided by dedicated outside air system (DOAS) units. The DX DOAS units have energy recovery with sensible/enthalpy wheels or plate exchangers, which provide filtered, dehumidified, and thermally neutral air. Energy efficiency was optimized using variable-speed compressors in the heat pumps. Split DX HVAC systems were provided for critical equipment room environments.

This hybrid arrangement just goes to show that geothermal systems can make sense for just about any health care facility, said Henry Gross, managing partner, Hydro-Temp. "It is very rewarding to be able to work closely with specifying engineers who are open to working through new design possibilities. It's all mindset — even though ground loops are not complicated, it is important for the engineers to understand the nuances of a ground loop."

Geothermal comes with significant benefits, including impressive energy savings and increased levels of comfort, said Gross. "The system does not work against a high temperature, so the compressor runs more efficiently. That usually means the discharge air temperatures can be a lot cooler, and you can get more dehumidification in air conditioning mode. With our variable speed equipment, we can set the discharge air temperature for about 53?F in the cooling mode, which will really wring out the air and increase comfort in the space. In the heating mode, we set the discharge air temperature for around 100?F, so that it doesn't feel too cool or too hot."

For those who think geothermal systems cost significantly more than traditional boiler/chiller systems, think again, said Gross. "The first cost is almost a wash. Obviously, with geothermal, you do need to have space, but, typically, the piping can go under a hospital's parking lot. And life-cycle cost is much lower with geothermal because the ground-loop temperatures keep the compressor discharge pressures much lower, so the compressor doesn't have to work as hard as it does on an air-source unit. Maintenance is much easier, as well."

Most hospital administrators are always looking for ways to improve energy savings without sacrificing patient comfort, and, as can be seen here, there are many HVAC solutions available that will help them achieve those goals.

Publication date: 11/3/2014

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Future Shriners Hospital

Next Target: Correctional Facilities – Why?

Because we can change the economics model of how correctional facilities operate. Designed properly we can almost eliminate the largest component of many correctional facilities monthly utility bills, Hot Water Production.

With our PATENTED Hot water generation system, as a by-product of air conditioning we have a tremendous quantity of hot water available to us at little or no cost.

My understanding is this is one of the big ticket costs in operating a jail. We could potentially take an area that has all of the control electronics for monitoring inmates, cool that area 24/7 as it already is, and as a byproduct of this daily cooling we will produce a tremendous amount of hot water at little to no cost.

Where does Arkansas Stand in terms of leading energy efficient design

- #1 Most Efficient HVAC unit is manufactured in Arkansas.
- Advances in Solar PV technology advancing in Northwest Arkansas
- School in Marion Arkansas without any special assistance is performing at Net-Zero levels and is likely the most energy efficient school of its type in the State of Arkansas.
- #1 Most efficient safe room in the country is likely in West Memphis Arkansas (Avondale Elementary – Marion School District)
- Marion Berry Renewable Energy Center is likely most energy efficient building of its type in the country. (ASU – Mid South / MSCC)
- Future Marion Performing Arts Center is modeling to become the most efficient building of its type in the country.

Marion School District is building some of the most energy efficient buildings in the state with the leadership from:

- School Administration
- PKM Architects
- Haltom Engineering
- Baldwin & Shell Construction
- Hydro-Temp

PKM ARCHITECTS

HALTOM ENGINEERING
MECHANICAL ENGINEERS

BALDWIN & SHELL CONSTRUCTION COMPANY

Hydro-Temp

DUKE ENERGY.

SunSense Schools

The SunSense® schools program helps schools in the Duke Energy service territory to manage energy costs while promoting energy education. The program:

- Provides new solar photovoltaic (PV) systems to schools designated as Enhanced Hurricane Protection Area (EHPA) shelters, at no cost to the school.
- Supports renewable energy education, energy efficiency and environmental stewardship by providing teachers and students with interactive learning experiences and training materials.

Applications are available! To enter your school for the opportunity to receive a free PV system, see the "Apply" tab below.

See a complete list of all SunSense Schools recipients.

How It Works | Energy Education | Apply | FAQ

Free PV systems for schools

Each year Duke Energy will select up to 11 schools to receive fully installed PV systems. Selection is competitive with priority given to EHPA-designated schools; however, all public schools that are current Duke Energy customers may submit an application. Refer to the Apply tab for a list of Key Dates for 2015.

K-12 public schools

- Up to 10 schools each year can receive a system of up to 10 kW with battery backup option.
- Selection will favor schools that demonstrate a commitment to energy efficiency and renewable energy education.

Public post-secondary schools

- One school each year can receive a system of up to 100 kW.
- Selection will be based on attendance, energy consumption, energy education plans and other criteria.

Minimum Requirements

To be eligible to receive a PV system through the SunSense schools program, schools must:

- Be a public educational facility.
- Be a current Duke Energy customer with a metered account.
- Have an appropriate site available at the school for a ground-mounted PV system and must have facilities that meet the requirements for the interconnection of the PV system to the Duke Energy power system.

Among K-12 schools, priority will be given to schools designated as Enhanced Hurricane Protection Area (EHPA) shelters. Based on Florida statutes, EPHA shelters are determined by the Florida Division of Emergency Management.

Selection Criteria
Applications will be evaluated and scores awarded using the following key categories:

Elementary through High Schools (K-12)

- 40% – Commitment to energy efficiency and renewable energy education
- 20% – Location that maximizes geographic distribution throughout Duke Energy service territory
- 20% – Number of students
- 20% – Shelter capacity

Post-Secondary Schools (Colleges, universities, trade schools)

Post-secondary schools will be selected based on criteria such as attendance, energy consumption on main campus and plans to use the solar array as an educational and research tool.

DUKE ENERGY.

How It Works | Energy Education | Apply | FAQ

Energy education at schools with solar PV systems

The solar PV systems are installed at selected schools with the goal of enhancing understanding and awareness of renewable energy among students, faculty and school administration.

Hands-on learning using the included data collection systems will provide the selected schools with the opportunity to become the centerpiece of a strong focus on renewable energy and energy-efficiency that can be expanded into the community.

Energy education at K-12 schools

Schools in the Duke Energy service area that are not eligible or selected to receive solar PV systems can still benefit from the SunSense schools program. By using educational materials available through the program you'll have access to:

- Classroom materials that support hands-on learning
- Curriculum aligned with Sunshine state standards
- Teacher training to help you include energy efficiency and renewable energy in the classroom.

Educators: If you'd like to participate in the energy education program, email us at sunsenseschools@duke-energy.com. Please include information about your school and about the type of educational support that you would find most useful.

Community funding for energy education

Duke Energy residential customers can help fund energy education in their community schools by enrolling in the SunSense Schools Residential program when they sign up for our EnergyWise Home[SM] program.

To learn more, visit the SunSense schools residential program Web page.

My goal is for the world to come to Arkansas to see how common folks come up with uncommon solutions to issues we are faced with each and every day.

QUESTIONS?

THANK YOU

FOR HAVING US!

-Slides available upon request

Contact Info:

Steve Hudson
Managing Partner – Hydro-Temp Corporation
(870) 892-8343

NOTABLE PROJECTS