BUILD WITH STRENGTH

Zero Energy Schools:

How Innovative Concrete Systems Are Making It Possible

Lionel Lemay, PE, SE, LEED AP, NRMCA
Kenny Stanfield, AIA, LEED AP, Sherman Carter Barnhart

BUILD WITH STRENGTH

NRMCA®

Instructions

- Everyone is muted
- Webinar is being recorded
- Type questions in the question box
- Download the handouts in the GoToWebinar control panel
- Credit for course
  - Based on attendance
  - Survey (Quiz) – In follow-up e-mail 1 hour after webinar
  - Certificate – After passing quiz with 70% or higher
  - AIA members – We will register your attendance with AIA-CES if you provided AIA number

NRMCA Super Sponsors

BASF
We create chemistry

MASTER® BUILDERS SOLUTIONS

EUCLID CHEMICAL

gcp
applied technologies

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About the Course

Learning Units

- AIA-CES ZES101 (1LU/HSW or 1 PDH)

Learning Objectives

- Understand the principles and strategies behind zero-energy school design and construction.
- Understand how innovative concrete systems such as ICFs are being used to achieve zero-energy schools.
- Understand how a combination of energy-efficiency strategies, high-performance envelopes and solar power are used to meet zero-energy criteria.
- Understand the contribution concrete makes to safe and productive schools by providing energy-efficient, quiet and resilient structures.

Concrete Schools Across the Country

ZERO-ENERGY SCHOOLS THE NEW NORMAL ?

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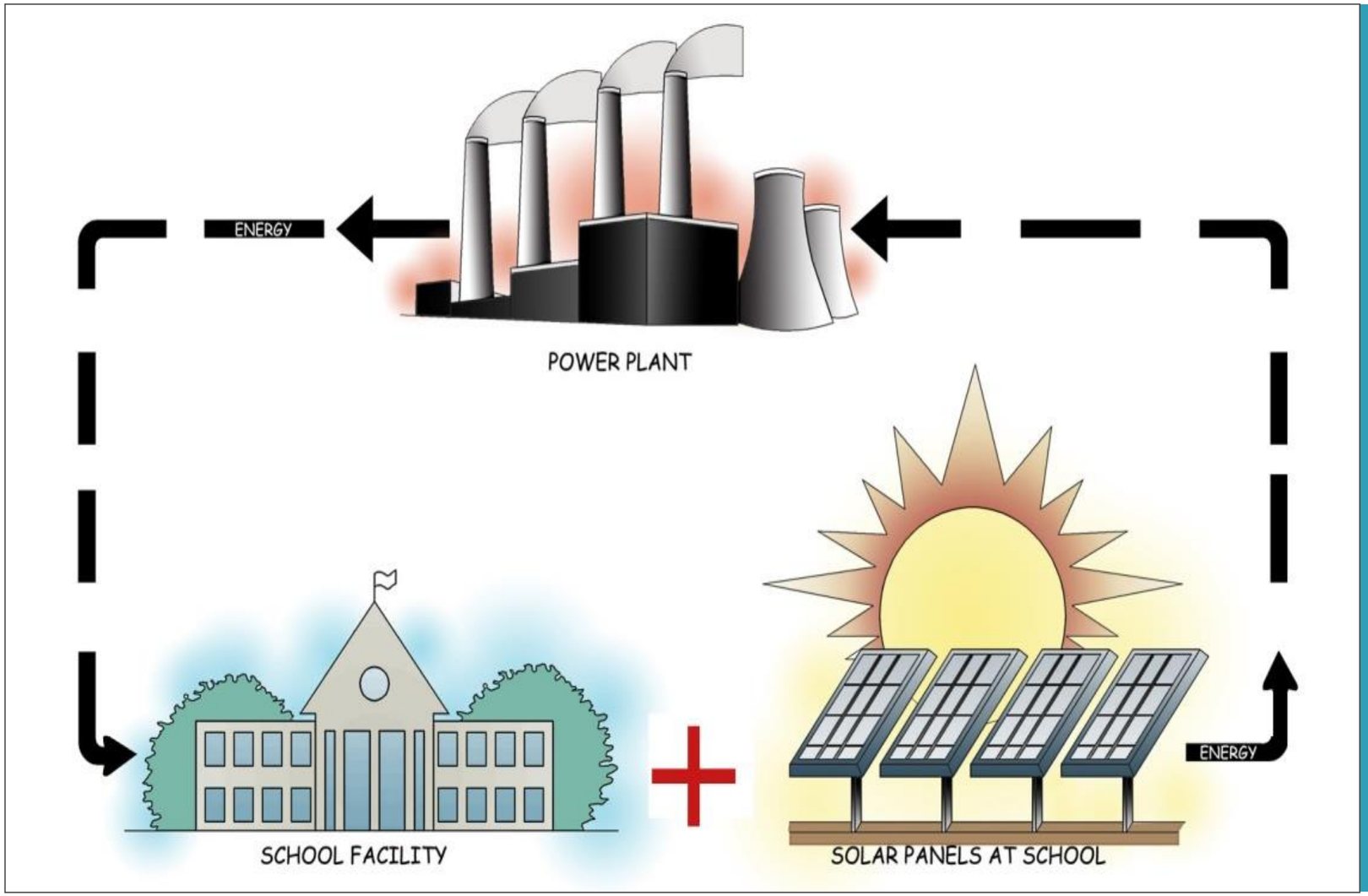
SHERMAN CARTER BARNHART ARCHITECTS

WHAT IS A ZERO-ENERGY BUILDING?

An ultra efficient new construction and/or deep energy retrofit project with a net site energy consumption of **ZERO** over a typical year of operation



THE DEFINITIONS

NET-ZERO OR ZERO-ENERGY

dramatic energy reduction
+ 100% renewables

ZERO-ENERGY EMERGING

dramatic energy reduction
+ a percentage of renewables

ZERO-READY OR “NEARLY” ZERO ENERGY

dramatic energy reduction

MEASURING ENERGY PERFORMANCE

A CAR'S PERFORMANCE IS MEASURED IN MILES PER GALLON (MPG) THE HIGHER THE MORE EFFICIENT

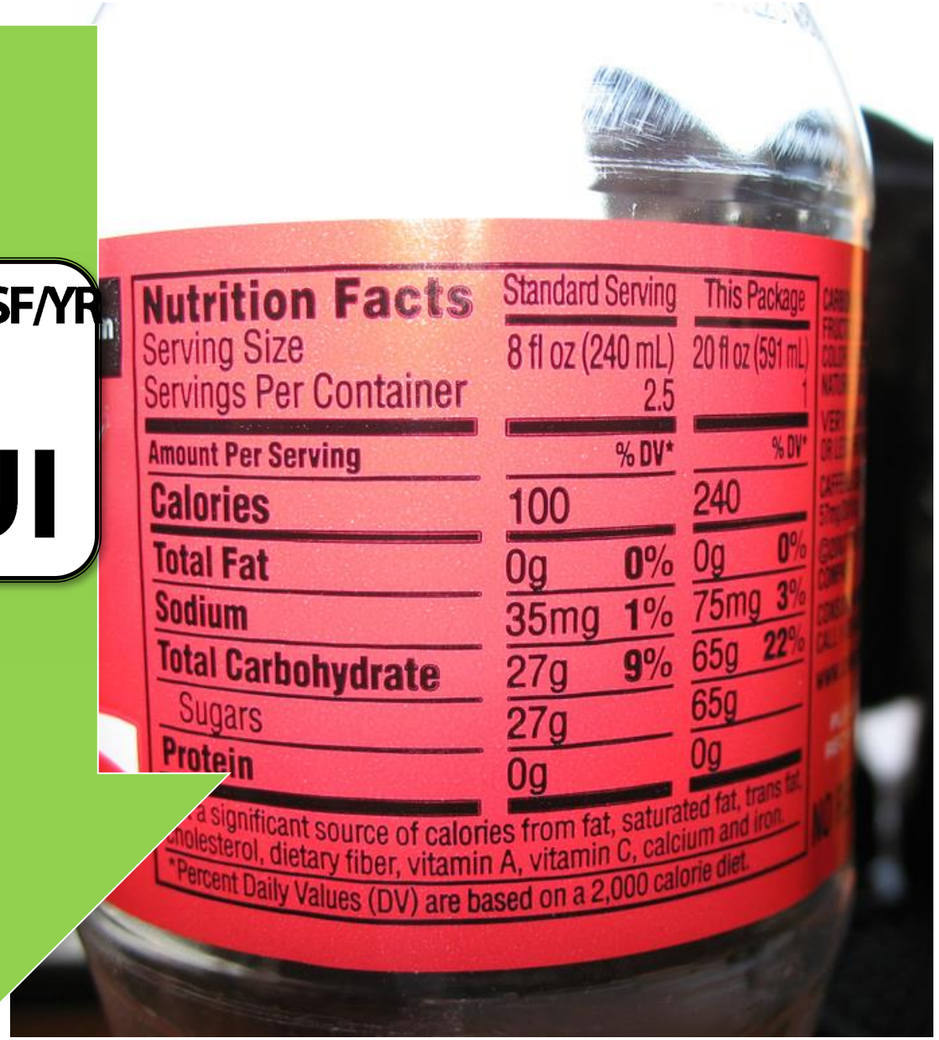
MEASURING ENERGY PERFORMANCE

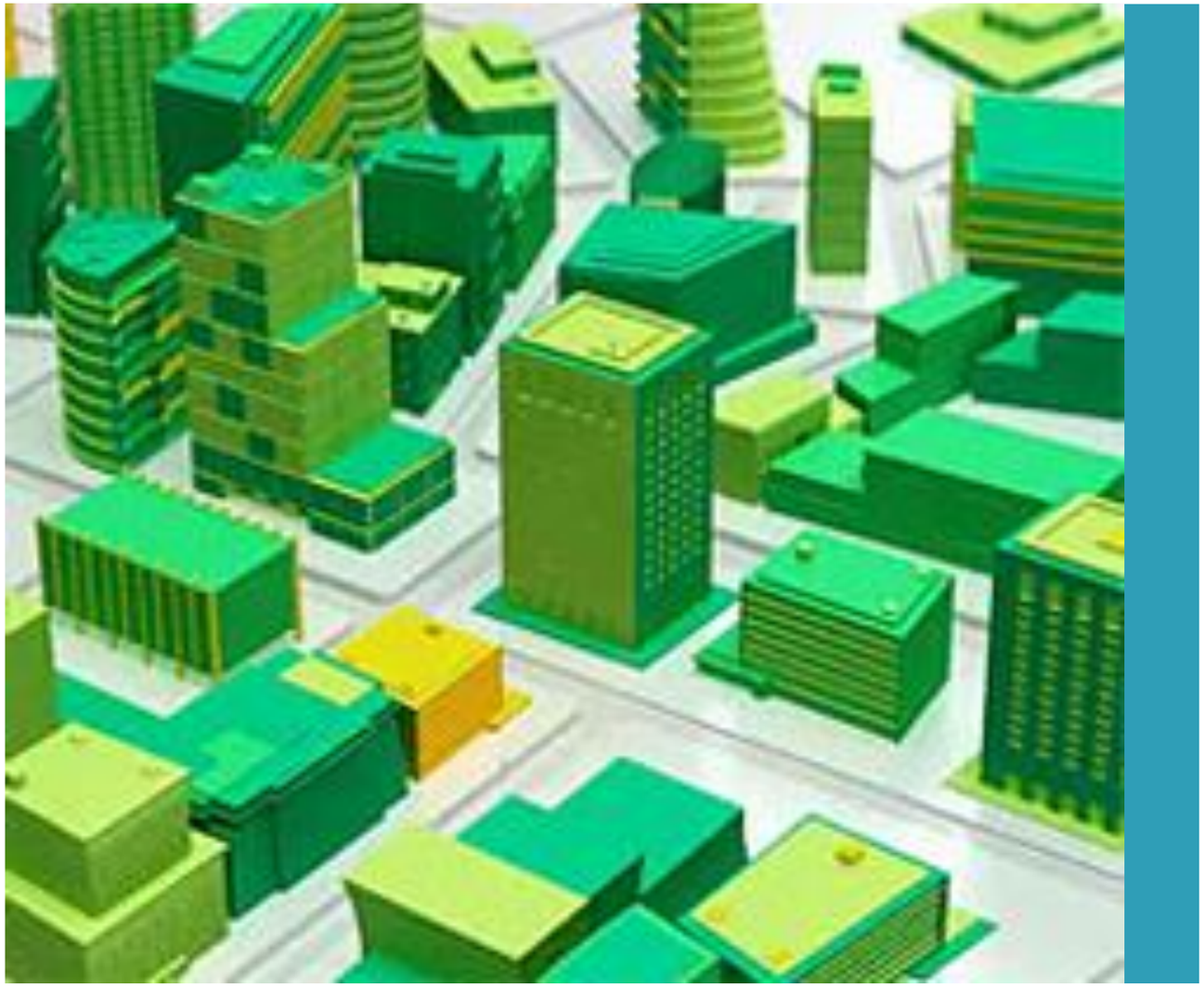
BUILDINGS ENERGY USE IS MEASURED IN 1,000 BRITISH THERMAL UNITS (KBTU) – THE LOWER THE BETTER

KBTU's/SF/YR

or

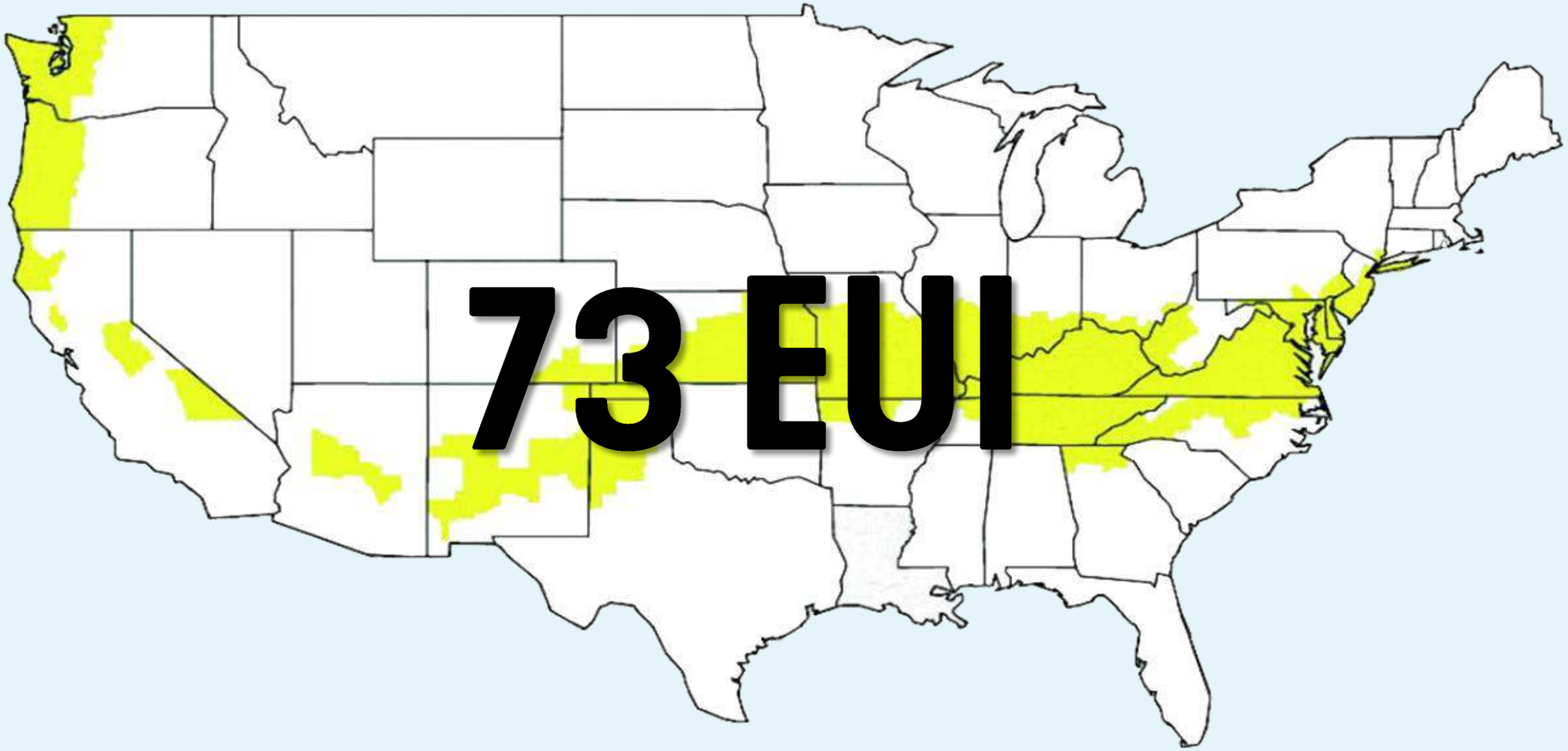
EUI





QUANTIFY ENERGY USE – CLIMATE ZONE 4

A TYPICAL 72,000 SF SCHOOL, ON AVERAGE CONSUMES 73 EUI/SF/YEAR



21E 21ST CENTURY EDUCATION + ENERGY

SHERMAN CARTER BARNHART ARCHITECTS

SETTING A BENCHMARK

SETTING A BENCHMARK

INSULATED CONCRETE FORM

- Load Bearing Walls
- Insulation
- Thermal Mass
- Air Barrier
- Sound Isolation
- Storm Resistance
- Speed of Construction

CHANGING DESIGN STRATEGIES: BUILDING ENVELOPE

ALVATON ELEMENTARY – KY'S FIRST ICF SCHOOL - 2006

SETTING A BENCHMARK

CLIMATE ZONE 4

73 EUI/SF/YR

ENERGY STAR

51 EUI/SF/YR

LEED® /AEDG – 50%

36 EUI/SF/YR

34 EUI/SF/YR

ALVATON ELEMENTARY

ARRA GRANT CRITERIA FOR KY ZERO-ENERGY SCHOOLS

25 EUI/SF/YR

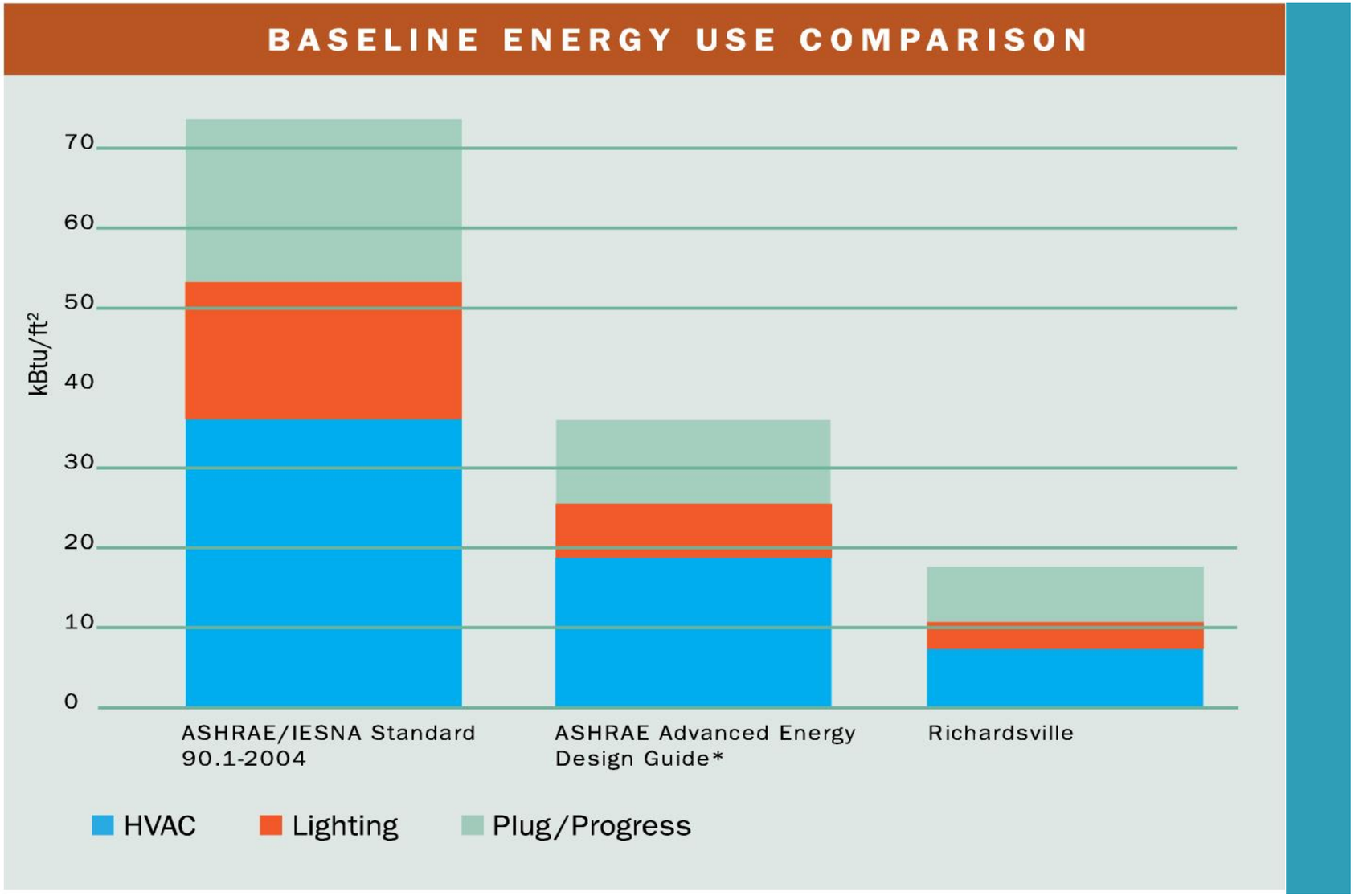
21E 21ST CENTURY EDUCATION + ENERGY

SHERMAN CARTER BARNHART ARCHITECTS

THE MOST COST EFFECTIVE WAY TO CONSERVE ENERGY…

" IS TO NOT USE IT."

CHANGE BEHAVIOR

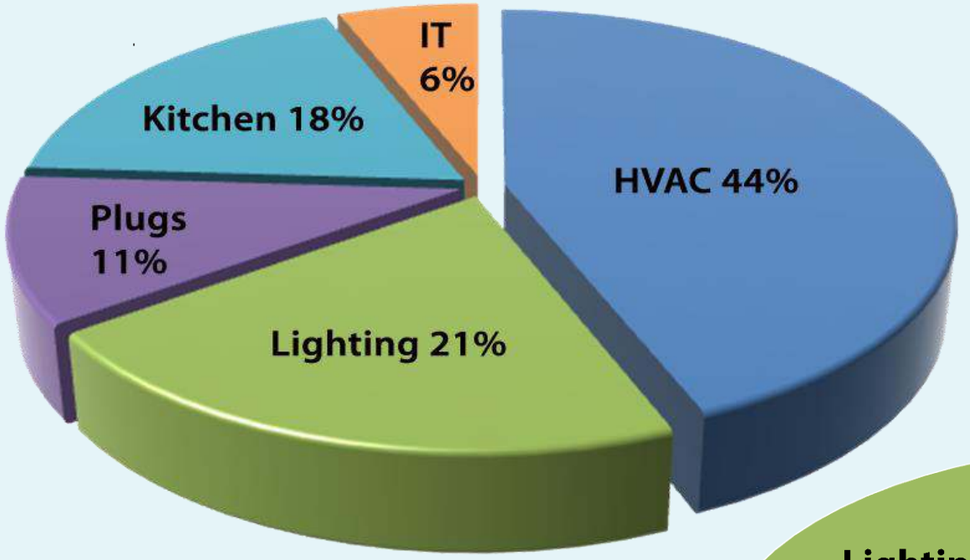


* 50% AEDG for K-12 school buildings

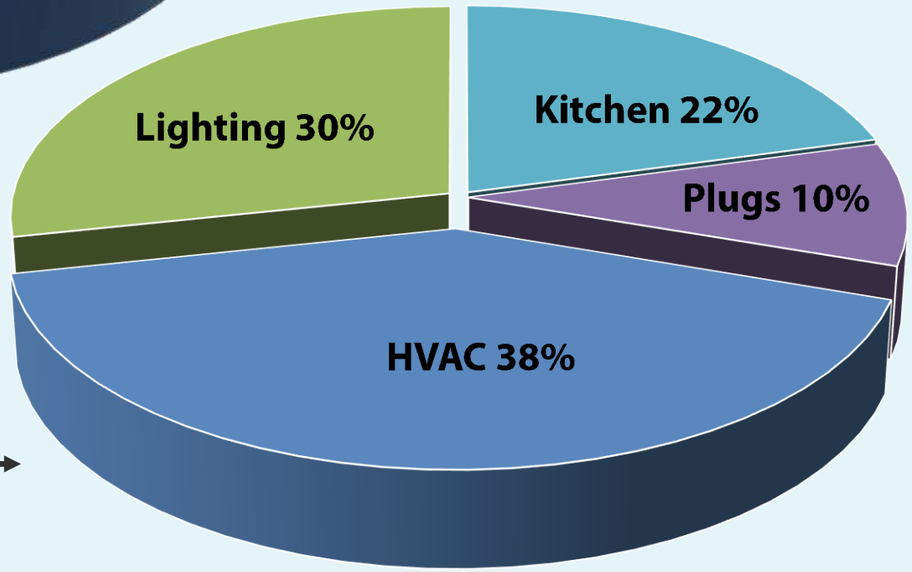
THE MOST COST EFFECTIVE WAY TO CONSERVE ENERGY…

" IS TO NOT NEED IT."

CHANGE DESIGN



Richardsville Elementary
Actual Use: 18.2 EUI/SF/YR



Average School
73EUI/SF/YR

RICHARDSVILLE ELEMENTARY SCHOOL

NATION'S FIRST ZERO-ENERGY PUBLIC SCHOOL

SIZE

72,285SF| 550 Students

PreK - 5th Grade

CONSTRUCTION COST

Building: $12, 160,000

Solar Array: $2,766,664

$206.50 SF

ENERGY USE

18.2 EUI

RICHARDSVILLE ELEMENTARY SCHOOL

NATION'S FIRST ZERO-ENERGY PUBLIC SCHOOL

CLASSROOM DAYLIGHTING

ENERGY "DASHBOARD" | GREEN SCREENS

21E 21ST CENTURY EDUCATION + ENERGY

SHERMAN CARTER BARNHART ARCHITECTS

RICHARDSVILLE ELEMENTARY SCHOOL

NATION'S FIRST ZERO-ENERGY PUBLIC SCHOOL

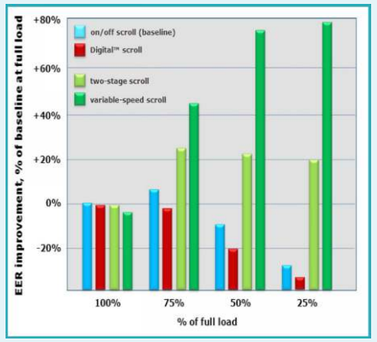
CLERESTORY "SPINE"

346 KW SOLAR ARRAY

CHANGING DESIGN TO REDUCE ENERGY CONSUMPTION

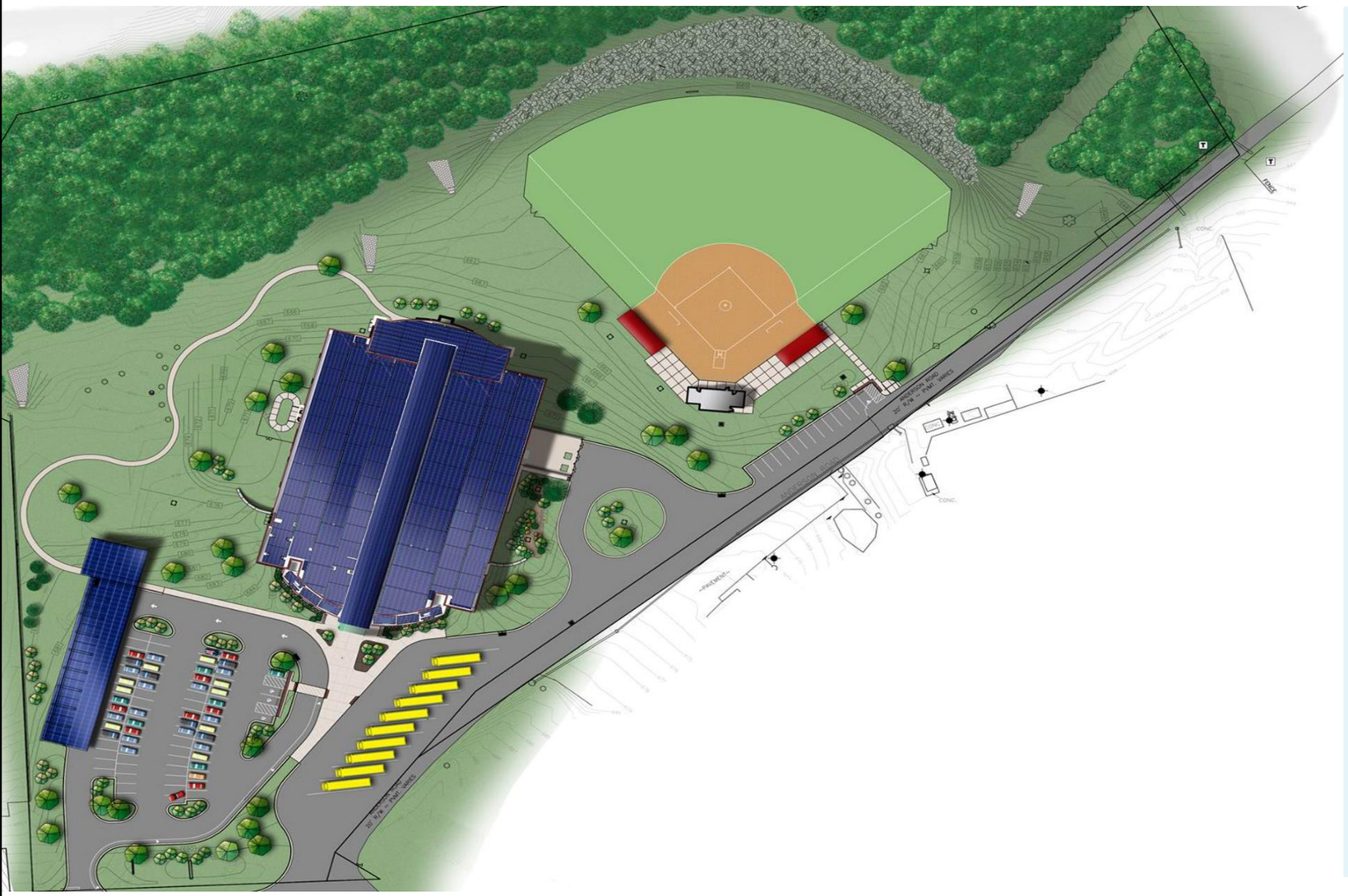
THE STRATEGIES

- SITE ORIENTATION
- HIGH PERFORMANCE THERMAL ENVELOPE
- MAXIMIZE BUILDING SYSTEM PERFORMANCE
- BUILDING SIZE
- RENEWABLE ENERGY SOURCE
- “ENERGIZE” CURRICULUM



THE STRATEGIES

SITE DESIGN & BUILDING ORIENTATION



- North/south building orientation provides active daylighting in academic spaces.
- Filter storm water run off.
- Utilize native, drought resistant landscaping to reduce irrigation demands.
- Reduce or eliminate detention basins.
- Permeable paving reduces storm water run-off.
- Outdoor recreational opportunities for students and faculty.

THE STRATEGIES

HIGH PERFORMANCE THERMAL ENVELOPE – INSULATED CONCRETER FORM (ICF)

- Compact building volume reduces areas of exposed exterior surfaces.
- Super insulated exterior wall & roof systems.
- Reduce external air infiltration.
- Reduce or eliminate large mechanical platforms.
- Superior acoustics.
- Faster construction.
- Disaster resiliency.

THE STRATEGIES

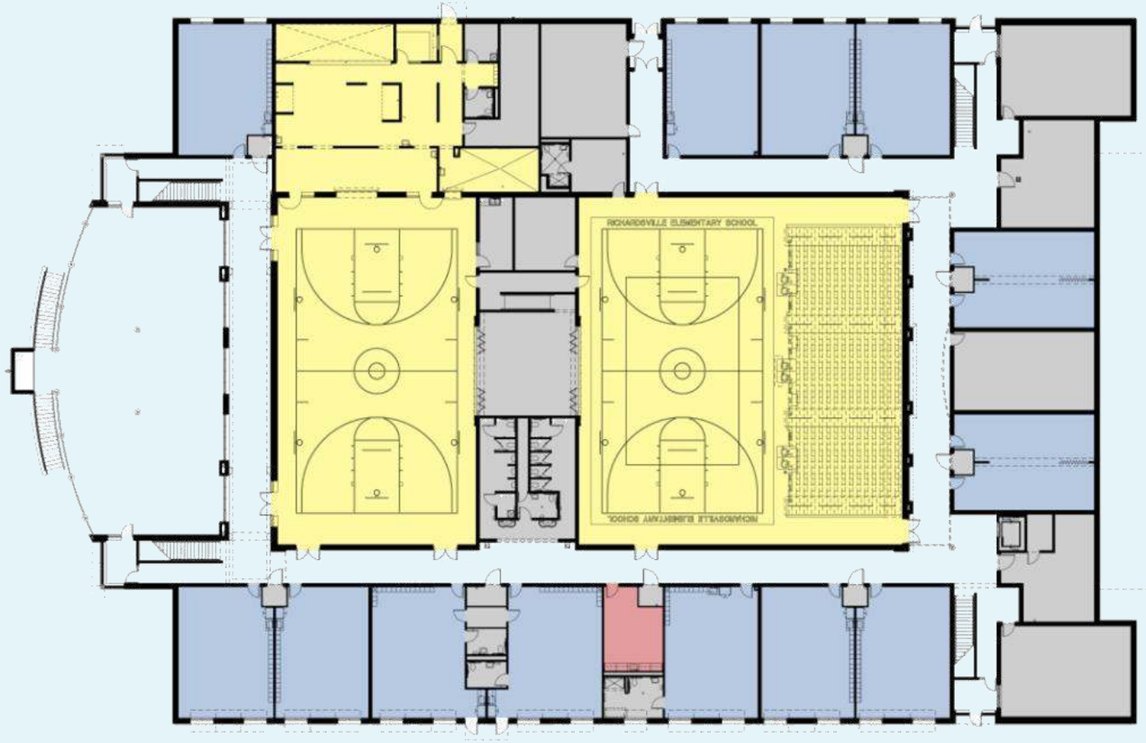
BUILDING SIZE MATTERS: ASHRAE 50% ADVANCED ENERGY DESIGN GUIDE FOR PROTOTYPE K-12 SCHOOL

	PROTOTYPE	RICHARDSVILLE
Exterior Wall to Floor Area Ratio	49%	38.9%
Window to Floor Area Ratio	34%	26.9%
Roof to Floor Area Ratio	100%	62.7%

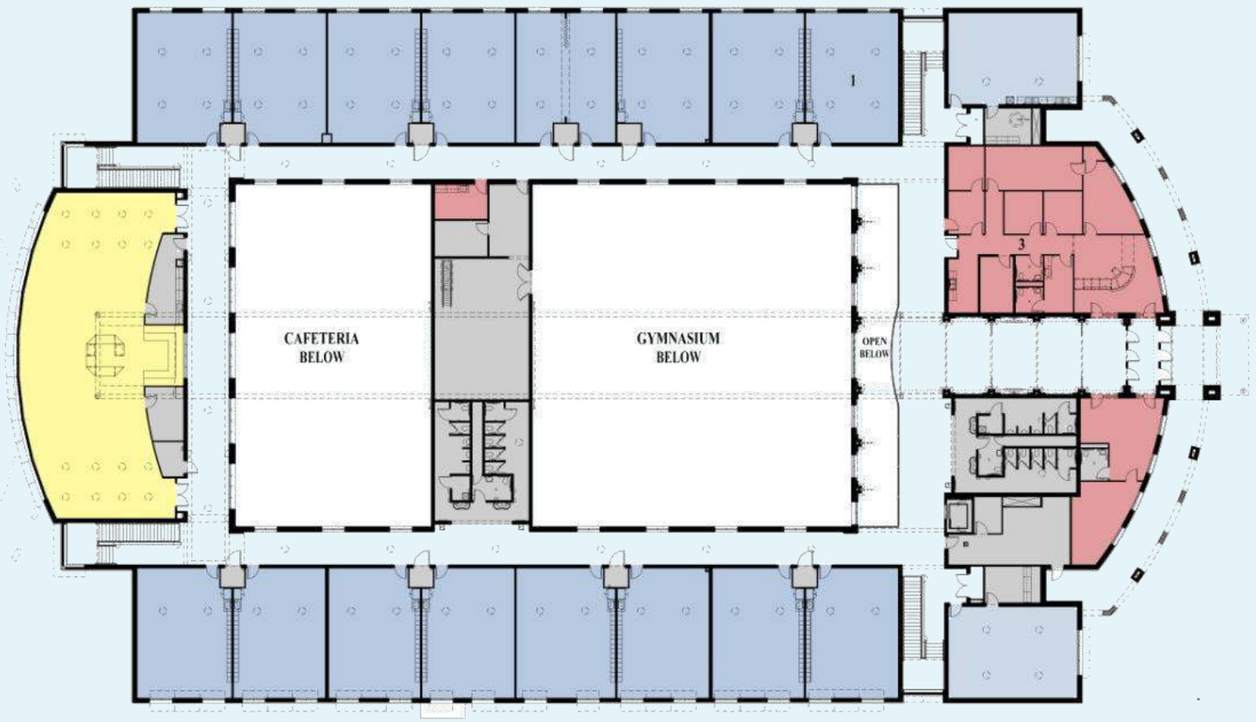
THE STRATEGIES

BUILDING SIZE MATTERS: ASHRAE 50% ADVANCED ENERGY DESIGN GUIDE FOR PROTOTYPE K-12 SCHOOL

first floor



second floor



THE STRATEGIES

GEOTHERMAL HVAC

- Reduce mechanical loads.
- Reduce or eliminate large mechanical platforms.
- Dual compressor heat pumps & distributive pumping systems reduce energy demand.
- Reduce make-up air in unoccupied/partially occupied spaces.

THE STRATEGIES

OUTSIDE AIR VENTILATION

- Dedicated outside air systems (DOAS).
- Heat recovery wheel.
- Demand control ventilation based on Co_2 and occupancy.
- Occupant diversity.
- Displacement ventilation.

THE STRATEGIES

HEALTHY KITCHEN DESIGN

- Test kitchen evaluation & recommendations.
- ENERGY STAR appliances.
- Eliminate type I hood – Type II hoods.
- Healthy foods & locally grown.

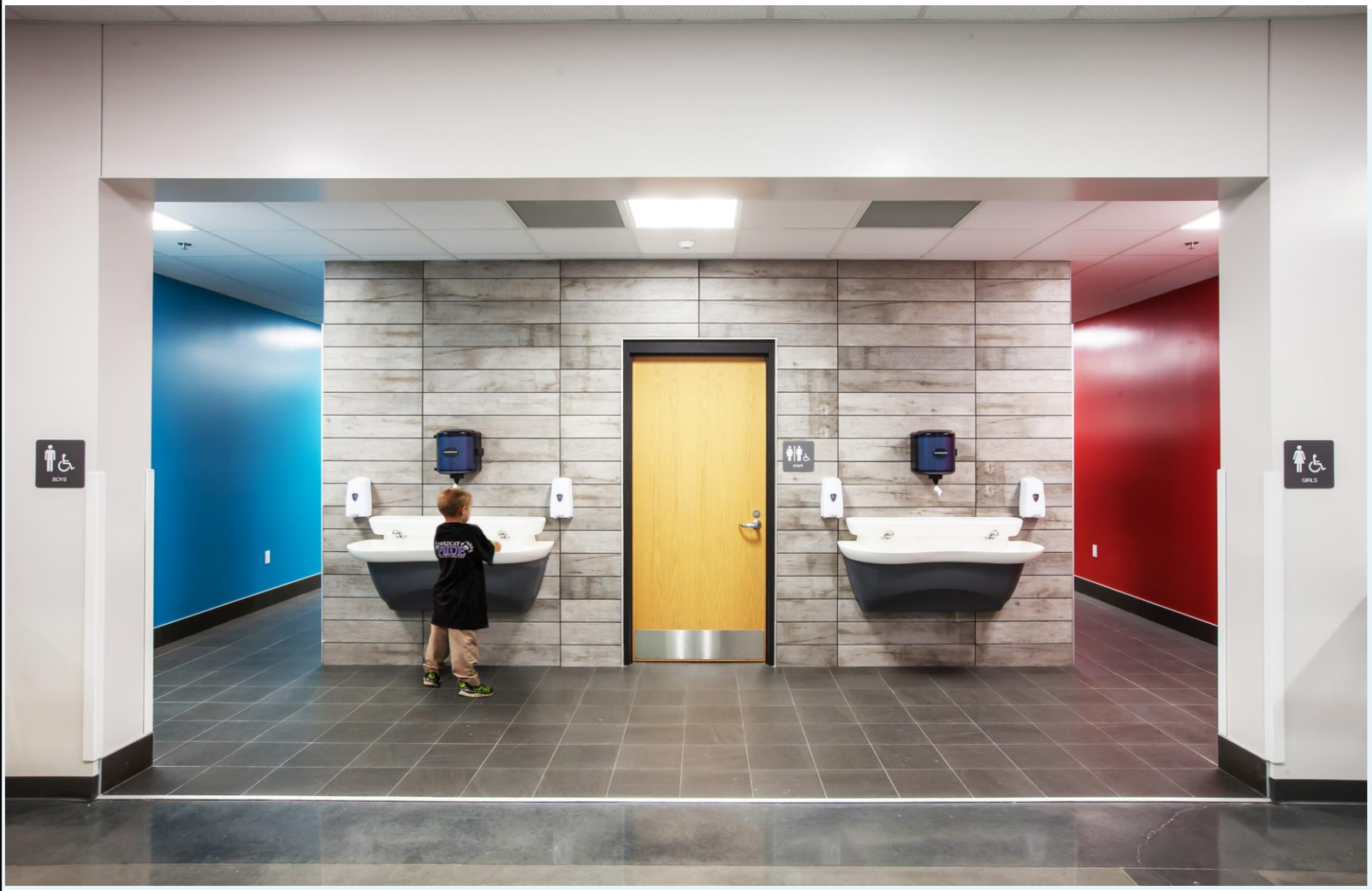
THE STRATEGIES

COMPUTERS

- TVA test case.
- 7.5% of energy “tested” school was consumed by computers.
- Wireless technology throughout.
- Laptop carts in lieu of computer labs.
- Equipment off at night.
- Reduce power consumption by 50%.

THE STRATEGIES

LIVING BUILDING STRATEGIES & LIFE CYCLE EVALUATION



- 24/7 Building operation plan.
- User-friendly automated building control system.
- Security lighting with motion detection minimizes energy consumption.
- Recycling program for students, faculty & the community.
- Life cycle cost evaluations on materials, finishes, and equipment.

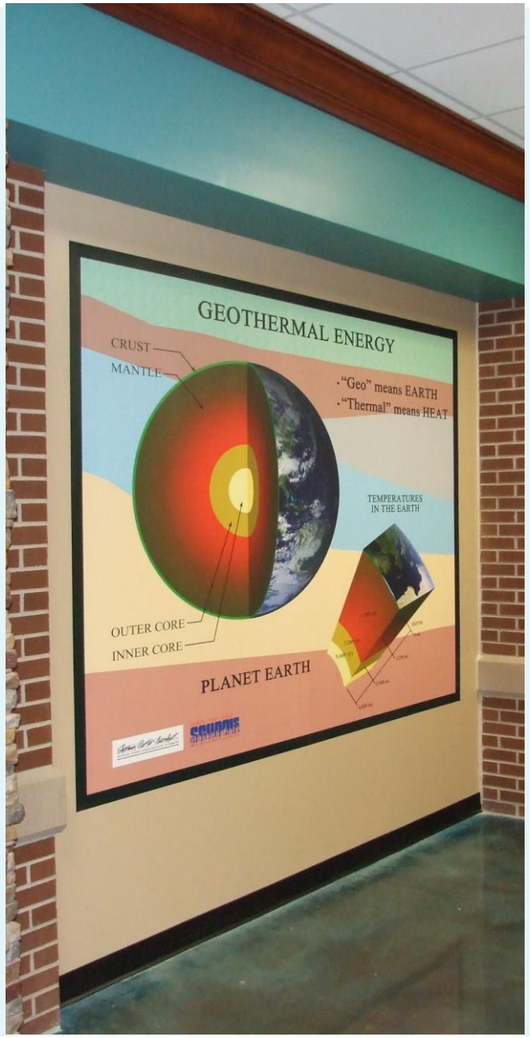
THE STRATEGIES

RENEWABLE ENERGY SOURCE

- 100% Required generation.
- Grid tied.
- Two meters – one for usage & one for generation.
- School district receives annual refund check from excess energy produced.

THE STRATEGIES

ENERGIZE THE CURRICULUM : THREE DIMENSIONAL TEACHING TOOL



- Every hallway has an energy related theme.
- Energy "dashboards"/green screens demonstrate the school's daily energy use.

THE STRATEGIES

ENERGIZE THE CURRICULUM : GROWING MINDS…ENERGY TEAMS

- Energy initiative spread District wide.
- Each school has an energy team with energy kit to monitor energy consumption & to perform energy audits.
- Teams focus on energy awareness, student achievement (STEM) & building energy leaders.

Utility Bills Don't Lie…

WARREN RURAL ELECTRIC COOPERATIVE CORPORATION
www.wrecc.com

A Touchstone Energy® Cooperative

Bowling Green	Franklin	Leitchfield	Morgantown	Pay by Phone
(270) 842-6541	(270) 586-3443 (800) 844-1664	(270) 259-3161	(270) 526-3384 (800) 844-1707	(270) 842-3234 (866) 319-3234

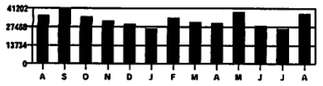
ACCOUNT NUMBER	397917042	METER LOCATION	RICHARDSVILLE RD 1775

SERVICE FROM	SERVICE TO	NO. DAYS	READING PREVIOUS	READING PRESENT	MULT	KWH USAGE	CHARGES
07/16/12	08/16/12	31	0	0	1	36894	2,056.30
DEMAND:			READING ACTUAL	BILLED			
			210.780 210.780	210.780			2,199.47
TVA FUEL COST			0.024300			36894	886.02
DISTRIBUTION CHARGE							40.00
POWER GENERATION CREDIT							-11,901.51
SCHOOL TAX							155.45
CURRENT CHARGES FOR SERVICE							-6,564.27
PREVIOUS BALANCE							-27,009.71

Current Bill Due Date Does Not Apply To The Previous Balance — CR BAL DO NOT PAY

Customer Name	BILLING DATE	PAYMENT DUE DATE	TOTAL DUE NOW:	-33573.98
WARREN CO BD OF ED	08/22/12	09/05/12	AFTER DUE DATE PAY:	-33573.98

HISTORY GRAPH - COMPARE YOUR USAGE



MESSAGES

- Failure to receive bill does not relieve customer's payment obligations.
- Any previous unpaid balance is subject to disconnect without further notice.

RETAIN THIS COPY FOR YOUR RECORDS

PLEASE DETACH AND RETURN THIS PORTION WITH PAYMENT — KY053350R

Warren Rural Electric Cooperative Corporation
951 Fairview Avenue, P.O. Box 1118
Bowling Green, Kentucky 42102
ADDRESS SERVICE REQUESTED

Address
City State Zip
Telephone Email
Please indicate change of address or telephone number here
Charge to: MasterCard ☐ VISA ☐
Account No
Exp Date
Signature

Account Number
397917042
Date Due
09/05/12
Total Due Now
-33573.98
After Due Date Pay
-33573.98

WARREN CO BD OF ED
NEW RICHARDSVILLE SCHOOL
PO BOX 51810
BOWLING GREEN KY 42102-6810

WRECC
PO Box 3200
Hopkinsville, KY 42241-3200

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Peter Kelly-Detwiler, Contributor
I write about energy technologies and policies.
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ENERGY | 12/10/2012 @ 8:05AM | 2,423 views

Net Zero Schools in Kentucky: Models for the Future Come from Surprising Places

+ Comment Now + Follow Comments

This week, I asked a close friend to guess which state boasted the nation's first net zero public elementary school. "California?" he ventured. "Vermont?" "Massachusetts?" No, no, and no. How about Kentucky, the nation's third largest coal producer, with $5 bn in annual coal revenues and the nation's fourth lowest electricity costs (at just over 7 cents per kilowatt-hour)?

(Richardsville School - Architect: Sherman Carter Barnhart Architects; Photo courtesy of CMTA, Inc.)

21E 21ST CENTURY EDUCATION + ENERGY

SHERMAN CARTER BARNHART ARCHITECTS

SETTING A BENCHMARK

CLIMATE ZONE 4 — 73 EUI/SF/YR

ENERGY STAR — 51 EUI/SF/YR

LEED® /AEDG – 50% — 36 EUI/SF/YR

34 EUI/SF/YR — ALVATON ELEMENTARY

ARRA GRANT CRITERIA FOR KY ZERO-ENERGY SCHOOLS — 25 EUI/SF/YR

18.2 EUI/SF/YR — RICHARDSVILLE ELEMENTARY

SETTING A BENCHMARK

SINCE RICHARDSVILLE 18 ICF SCHOOLS DESIGNED FOR ZERO ENERGY

2 ZERO ENERGY schools

6 ZERO ENERGY EMERGING schools

10 ZERO ENERGY READY schools

	ENERGY	EUI
Richardsville Elementary	Zero Energy	18.2
Jennings Creek Elementary	Zero Energy	17.5
South Warren Middle & High	Zero Emerging	24
Bristow Elementary	Zero Emerging	23.6
Flaherty Primary	Zero Ready	21.7
Elkhorn Crossing	Zero Ready	28.9
Jody Richards Elementary	Zero Emerging	20
Ezra Sparrow Early Learning	Zero Ready	24.5
Hardin Early College & Career Center	Zero Ready	23
Irvington Elementary	Zero Ready	24

	ENERGY	EUI
Meade County College & Career Center	Zero Emerging	23.5
Cecilia Valley Elementary	Zero Ready	23
Taylorsville Elementary	Zero Ready	24
Hardinsburg Elementary	Zero Ready	24
Lone Oak Middle School	Zero Ready	19.5 *
Cumberland Trace Elementary	Zero Emerging	17.5 *
Bardstown Ind. Elementary	Zero Emerging	17.5 *
Hanson Elementary	Zero Ready	20 *

* projected energy use

SETTING A BENCHMARK

SINCE RICHARDSVILLE 18 ICF SCHOOLS DESIGNED FOR ZERO ENERGY

23.6 EUI

24 EUI

SETTING A BENCHMARK

SINCE RICHARDSVILLE 18 ICF SCHOOLS DESIGNED FOR ZERO ENERGY

23 EUI

24 EUI

SETTING A BENCHMARK

SINCE RICHARDSVILLE 18 ICF SCHOOLS DESIGNED FOR ZERO ENERGY

23 EUI

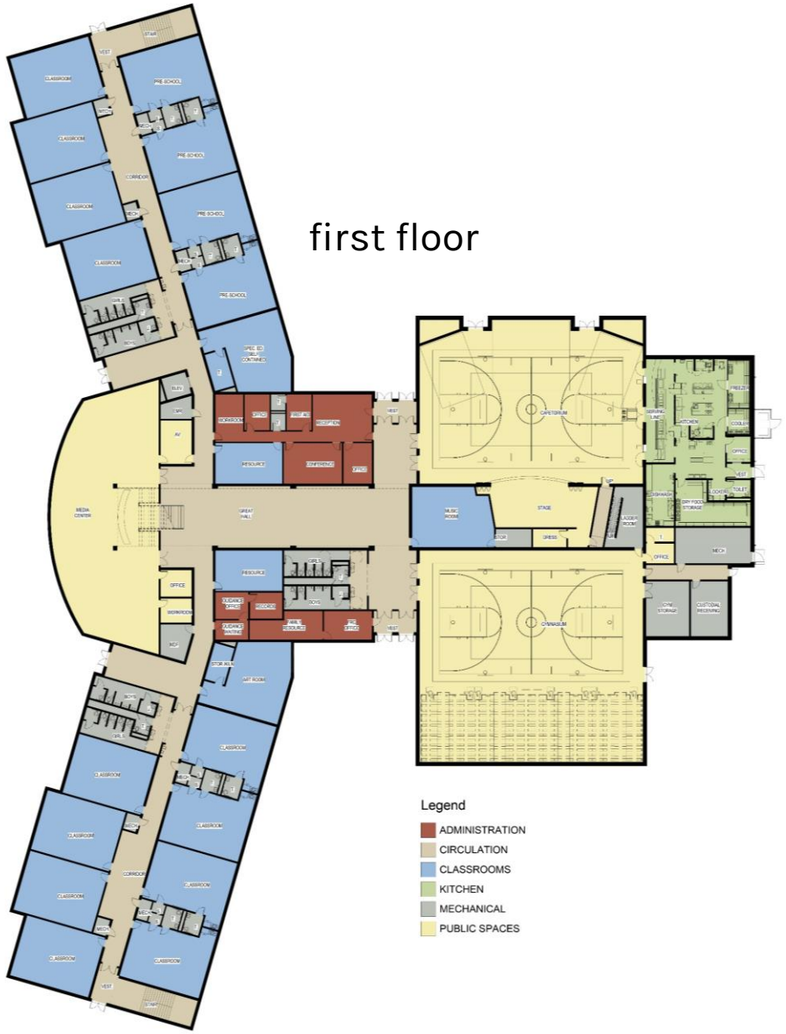
PROJECTED 17.5 EUI

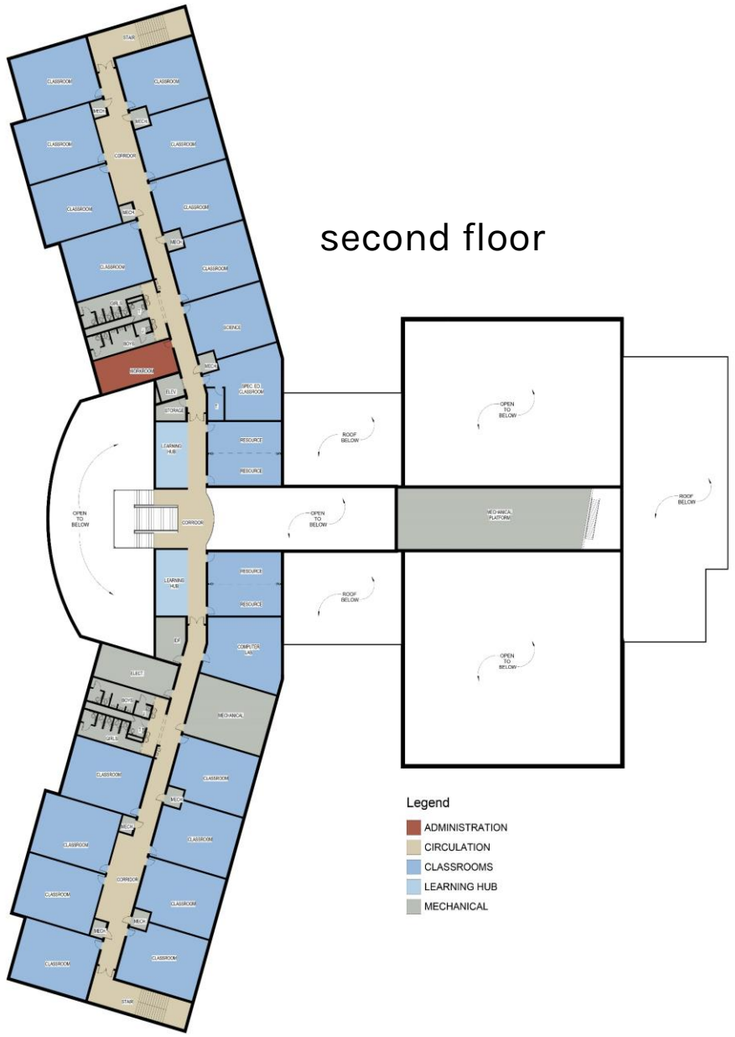
JENNINGS CREEK ELEMETNARY

KENTUCKY'S 2ND ZERO ENERGY SCHOOL

JENNINGS CREEK ELEMETNARY

KENTUCKY'S 2ND ZERO ENERGY SCHOOL





SIZE

88,469 SF| 750 Students

PreK - 5th Grade

CONSTRUCTION COST

Building: $17,708,463

Solar Array: $392,251

$204.6 SF

ENERGY USE

17.5 EUI

JENNINGS CREEK ELEMENTARY

	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**		

IT'S NOT JUST ABOUT ENERGY

21ST CENTURY LEARNING

ALLOW — 24/7 Access To Student Learning Tools & Teacher Resources.

ENABLE — Students To Learn At Their Individual Pace In Real World Context.

SUPPORT — Teachers To Collaborate, Share, and Integrate 21st Century Skills Into The Learning Environment.

PROVIDE — Flexible Spaces Designed To Accommodate Large and Small Group Teams and Integrated Learning.

CREATE — An Exciting Environment To Inspire Learning and Support 21st Century Skills Proficiency.

ENCOURAGE — Family and Community Interaction, Involvement, and Collaboration.

21E 21ST CENTURY EDUCATION + ENERGY

SHERMAN CARTER BARNHART ARCHITECTS

21ST CENTURY LEARNING OBJECTIVES

ALLOW — 24/7 Access To Student Learning Tools & Teacher Resources.

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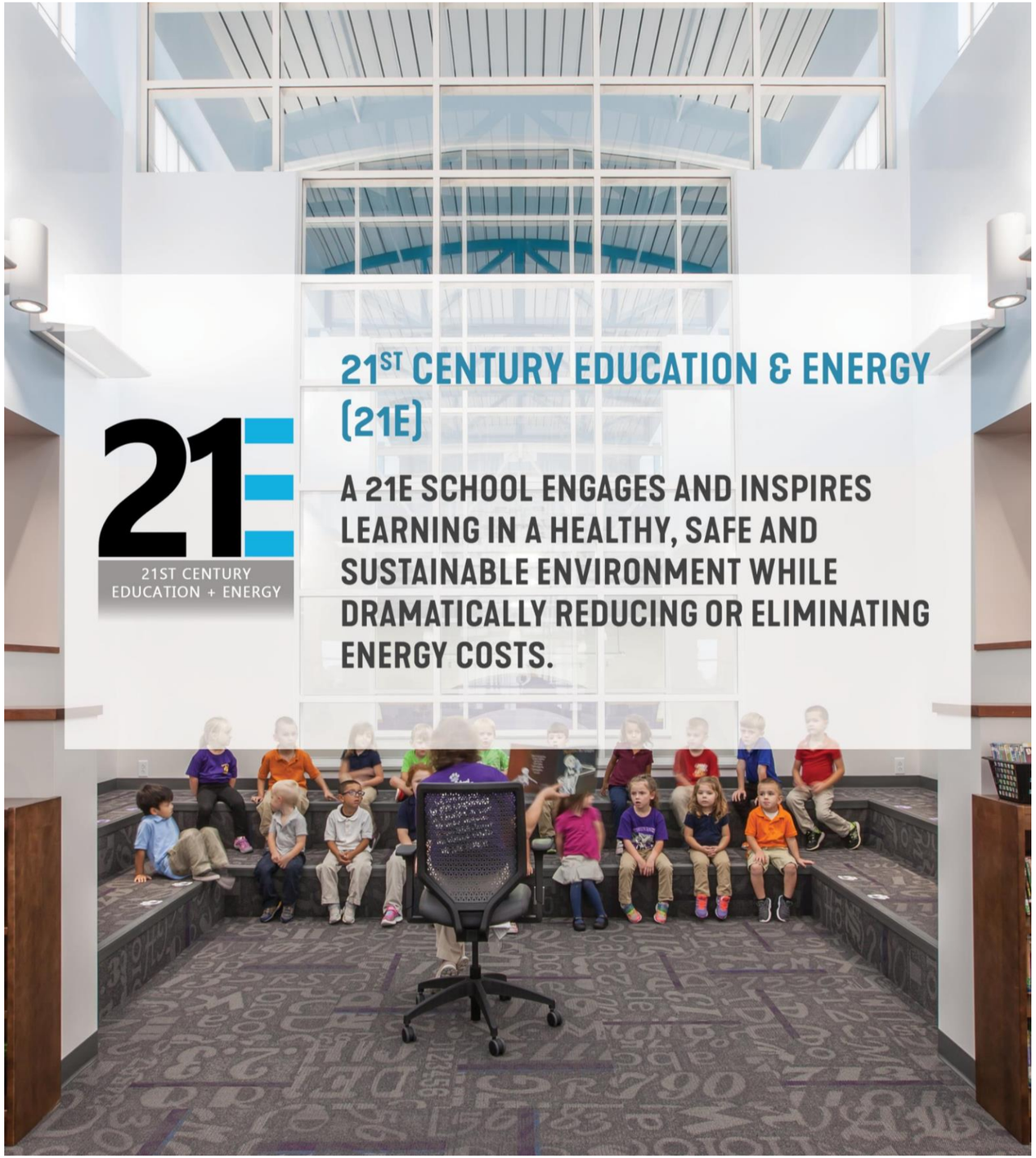
+

THE 2030 CHALLENGE

- Carbon neutral buildings.
- Water reduction targets for consumption and CO_2 emissions reductions from transportation.
- Reduction targets for embodied carbon emissions from materials manufactured and transported for building construction.



21ST CENTURY EDUCATION & ENERGY (21E)

A 21E SCHOOL ENGAGES AND INSPIRES LEARNING IN A HEALTHY, SAFE AND SUSTAINABLE ENVIRONMENT WHILE DRAMATICALLY REDUCING OR ELIMINATING ENERGY COSTS.

21E
21ST CENTURY EDUCATION + ENERGY

SAFE & SECURE

SECURE VESTIBULE: FIRST LAYER OF DEFENSE • ACCESS CONTROL • WELCOMING

Blu-Hawk
Advanced Sentry Alert System

SHERMAN CARTER BARNHART ARCHITECTS

SUPPORT EVERY STUDENT

LEARNING STREETS • COLLABORATIVE LEARNING SPACES • NON-TRADITIONAL LEARNING AREAS

CREATIVE & INNOVATIVE

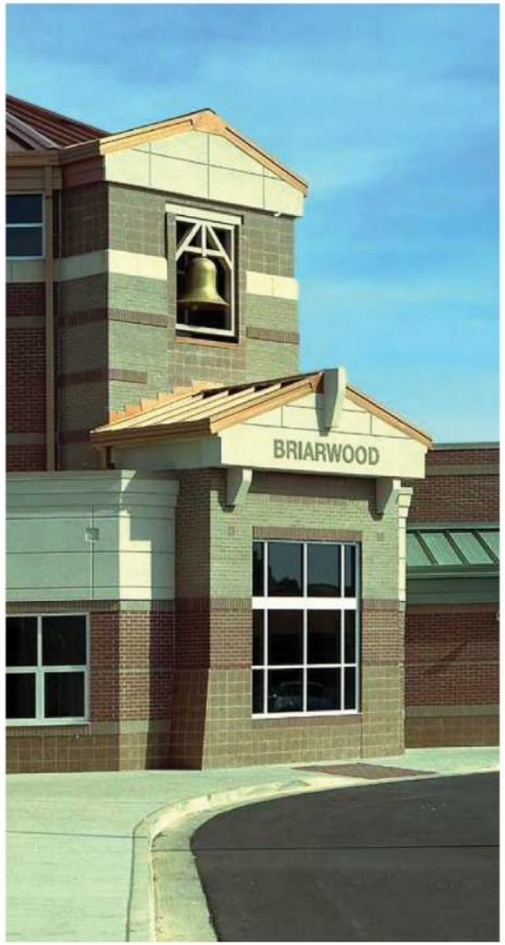
ANYTIME, ANYWHERE LEARNING

SPACES DESIGNED FOR MAXIMUM FLEXIBILITY

COMMUNITY CONNECTED

THE "HEART & SOUL" OF THE COMMUNITY

21E
21ST CENTURY EDUCATION + ENERGY



COST EFFICIENT TO BUILD & OPERATE

A LEADER IN RESILIENT BUILDING DESIGN – INSULATED CONCRETE FORM (ICF)

DISASTER RESILIENT/STORM SHELTER

A LEADER IN RESILIENT BUILDING DESIGN – INSULATED CONCRETE FORM (ICF)

- Hold occupants for up to two hours with temporary ventilation, power, plumbing and water (generator required).
- Design for usable clear area of 5 SF/ Person.
- Capable of withstanding 250 mph winds and pressure of a direct tornado strike.
- Must include restrooms.
- Two-hour fire barrier, all doors rated for 90 minutes plus ICC-500 impact resistance rating.
- Third party peer review and quality assurance plan.

ENERGY EFFICIENT

THE FIRST ZERO-ENERGY SCHOOL IN THE UNITED STATES

BARDSTOWN INDEPENDENT ELEMENTARY

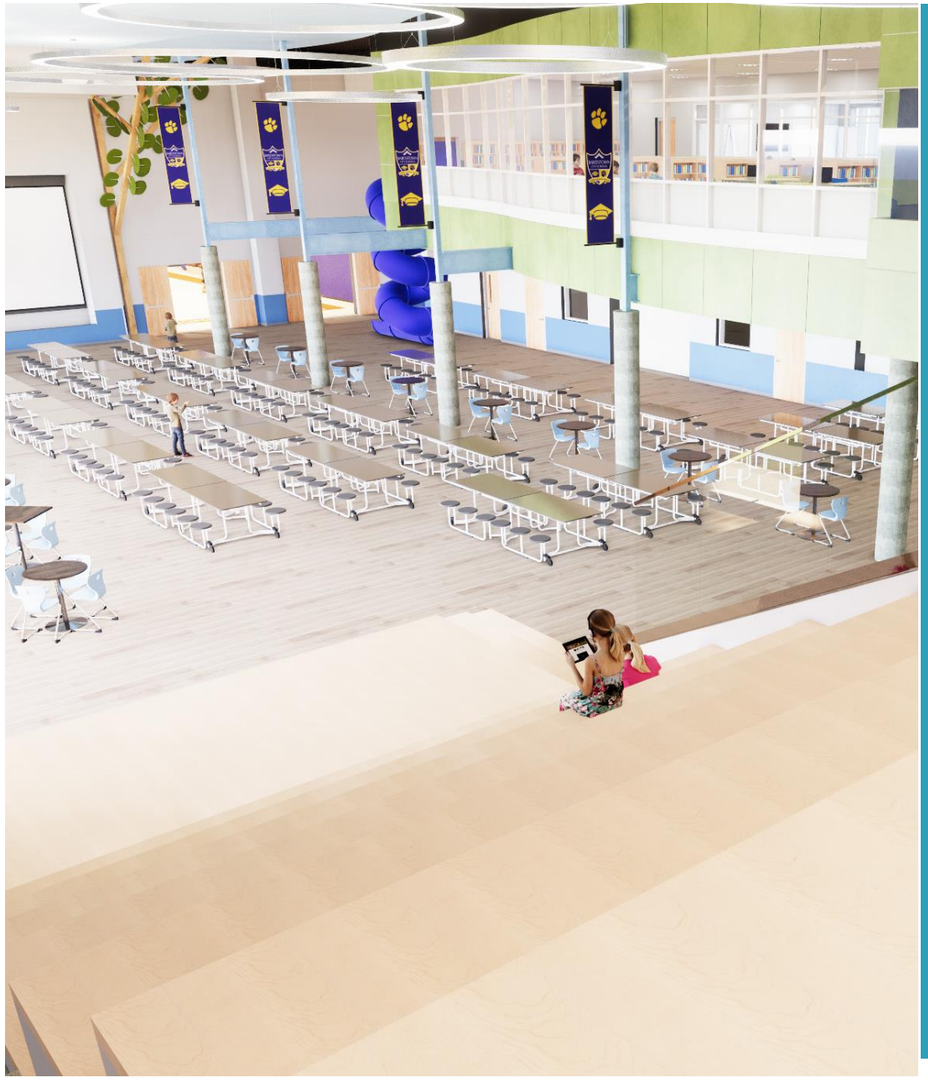
KY'S FIRST ZERO ENERGY | DISASTER RESILIENT SCHOOL

21E 21ST CENTURY EDUCATION + ENERGY

SHERMAN CARTER BARNHART ARCHITECTS

BARDSTOWN INDEPENDENT ELEMENTARY

KY'S FIRST ZERO ENERGY | DISASTER RESILIENT SCHOOL



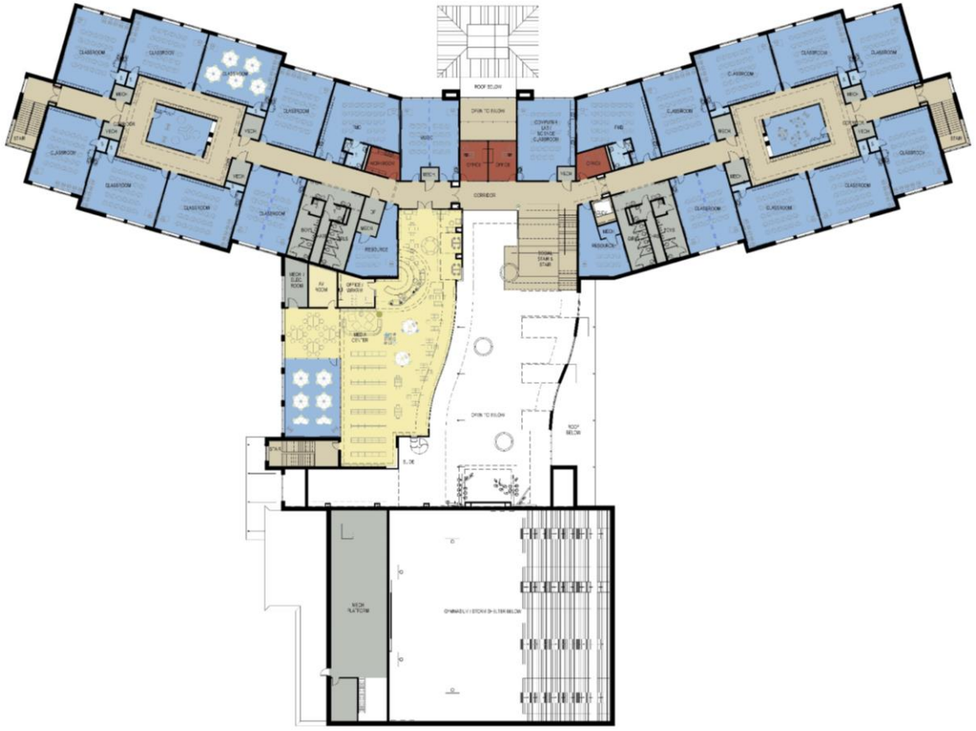
21E 21ST CENTURY EDUCATION + ENERGY

SHERMAN CARTER BARNHART ARCHITECTS

BARDSTOWN INDEPENDENT ELEMETNARY

KY'S FIRST ZERO ENERGY | DISASTER RESILIENT SCHOOL

first floor



second floor

Department Legend

- ADMINISTRATION MAIN
- ADMINISTRATION SUPPORT
- CIRCULATION MAIN
- CLASSROOMS MAIN
- CLASSROOMS SUPPORT
- MECHANICAL MAIN
- MECHANICAL SUPPORT
- PUBLIC SPACES MAIN
- PUBLIC SPACES SUPPORT

SIZE

89,911 SF | 850 Students

2nd - 5th Grade

CONSTRUCTION COST

Est. $18.2 Million

ENERGY USE

Estimated Energy Use 17.5 EUI

ZERO-ENERGY SCHOOLS THE NEW NORMAL ?

KENNY STANFIELD, AIA, LEED AP

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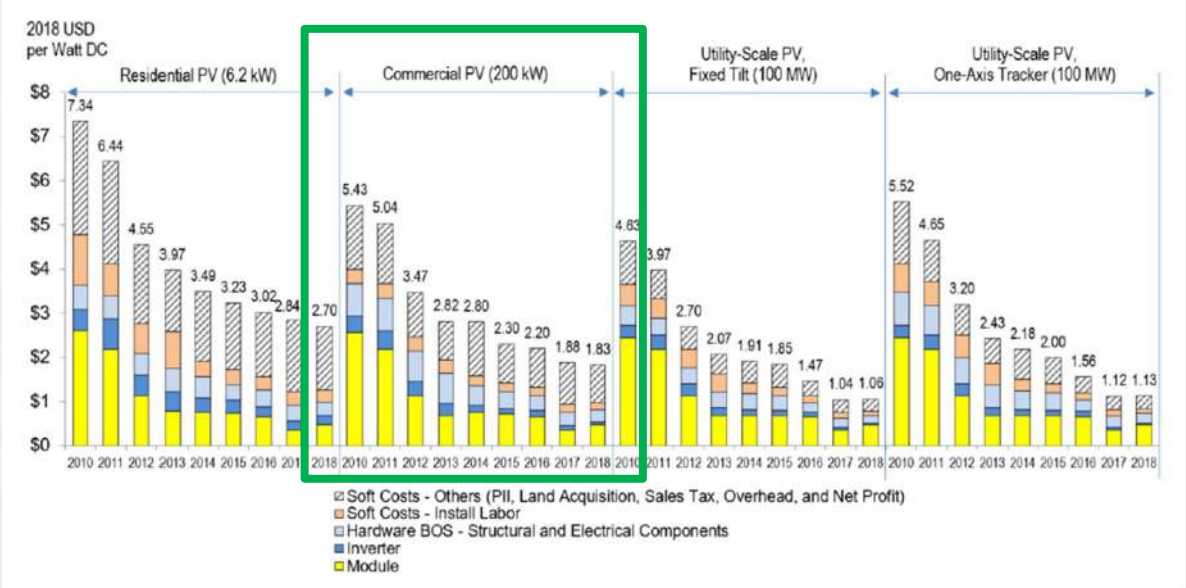
SHERMAN CARTER BARNHART ARCHITECTS

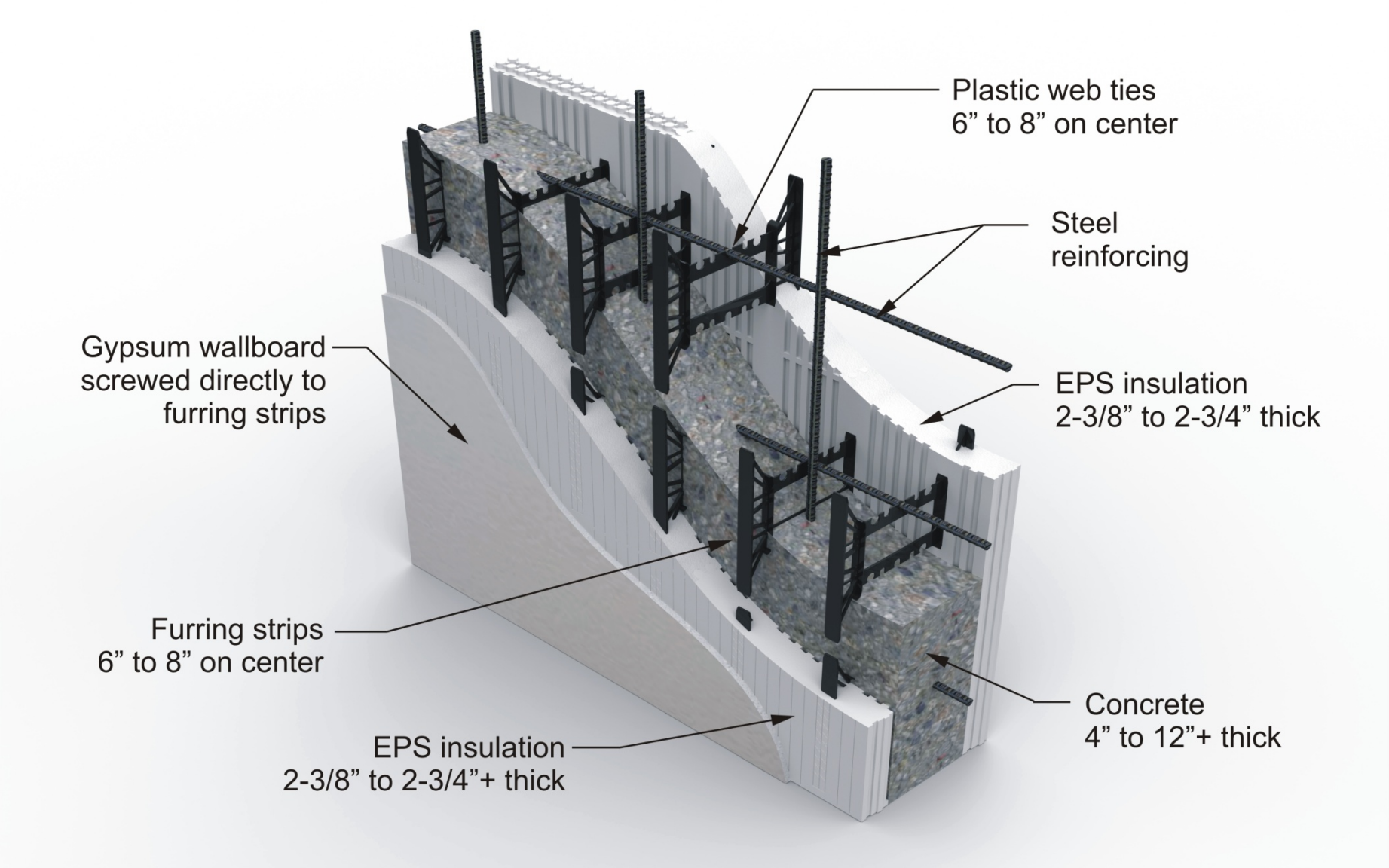
On-site Power Generation

- PV panels most common
- 5,500 K-12 schools w/ PV
- Decline in first costs
  - 66% reduction
- To be effective:
  - Minimize EUI to 20-24 kBtu/ft^2/yr or lower

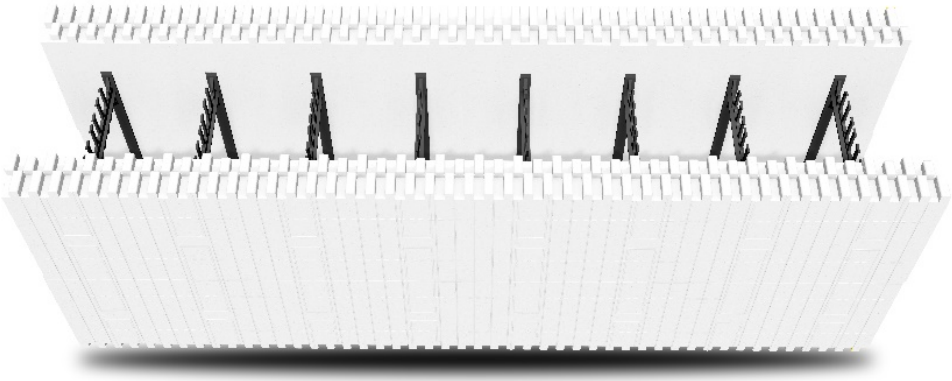


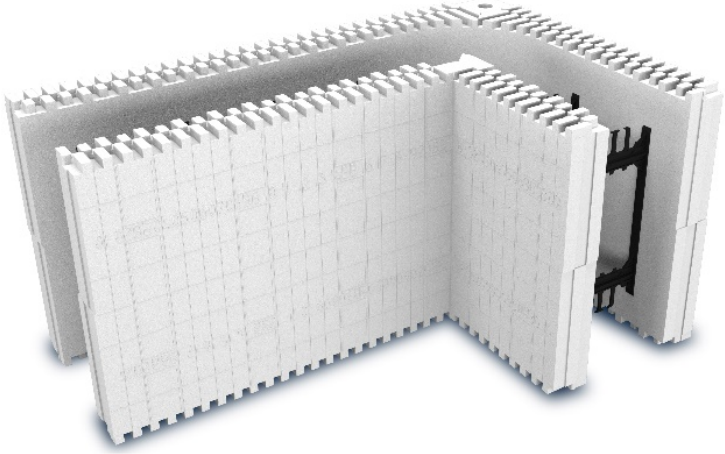
Source: National Renewable Energy Laboratory

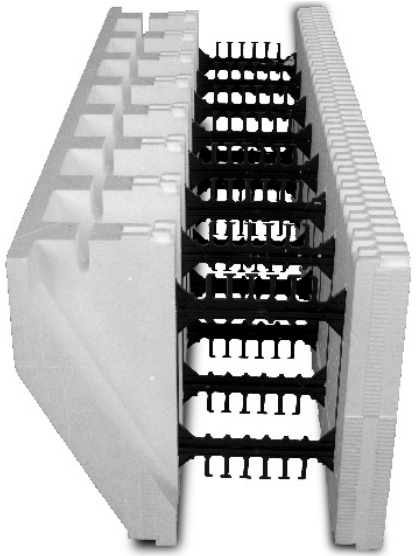
Insulating Concrete Forms (ICFs)

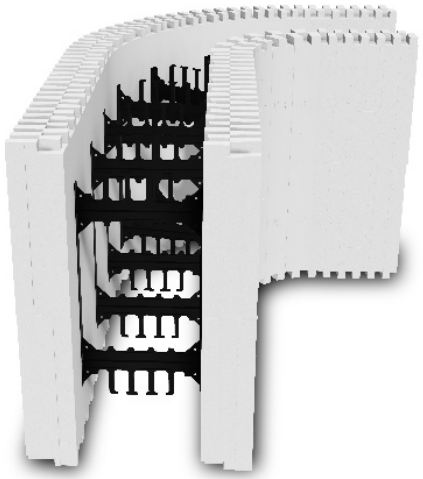


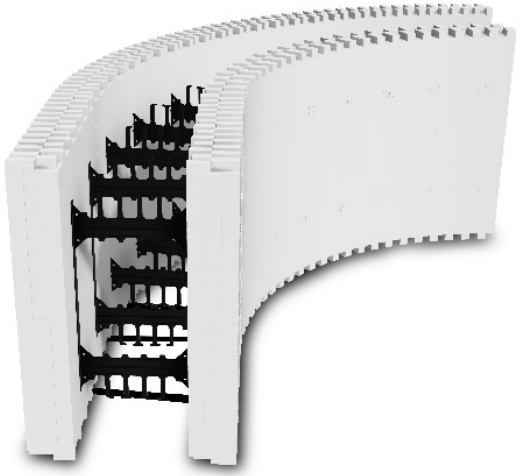
Form Types

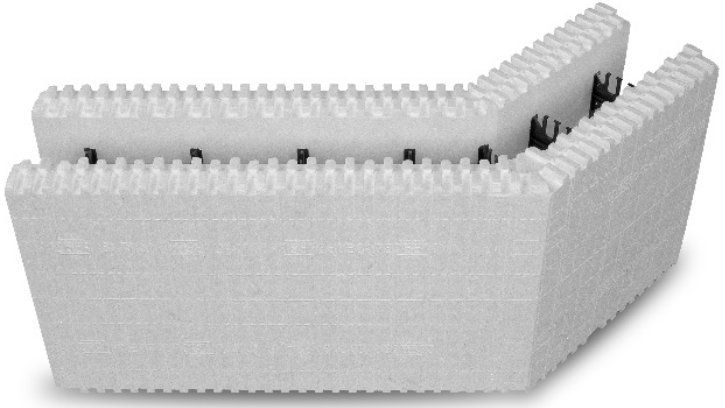




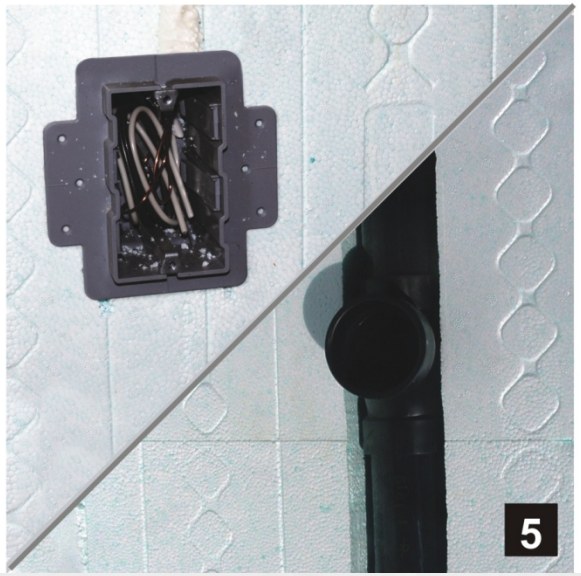




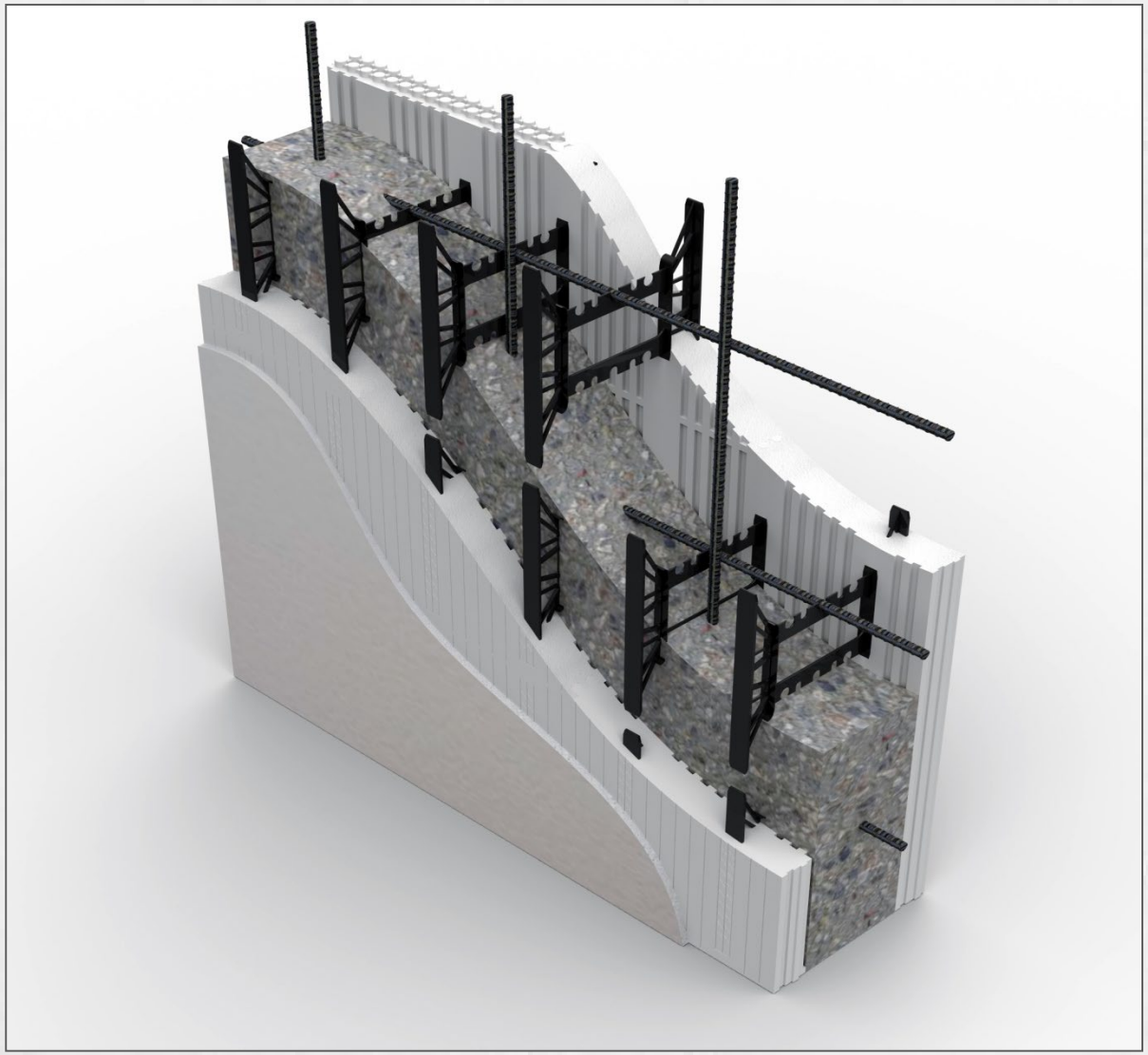




Construction Steps



Any Finish



ICF: 9 Functions in 1

1. Concrete form (that stays in place)
2. Thermal barrier
3. Air barrier
4. Moisture barrier
5. Fire barrier
6. Sound barrier
7. Substrate for running utilities
8. Substrate for attaching finish materials
9. Reinforced concrete structure

ICF: High Performance Envelope

- R-30+ (Performance) Wall Insulation
- Thermal Mass
- Reduced Air Infiltration

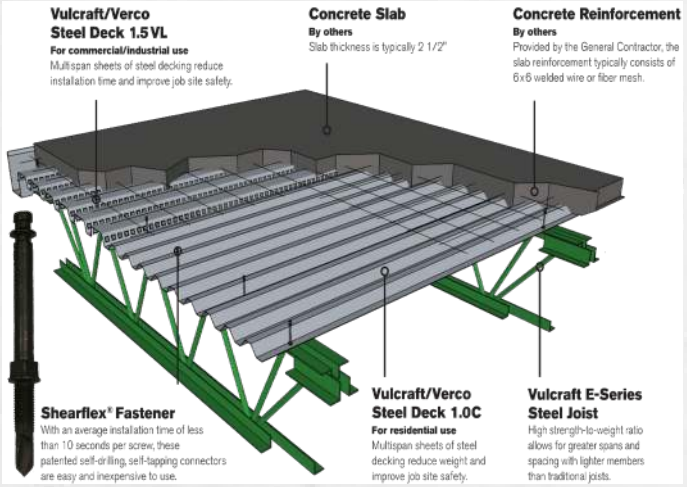
ICF: Safer & Quieter

- Fire-rated Walls
  - 2 hrs for 4” wall
  - 3 hrs for 6” wall
  - 4 hrs for 8” wall
- Fire-rated Floors
  - 2 to 3 hrs (system based)
- High Impact Resistance
  - (200 mph+)
- Sound Transmission
  - STC: 50+ up to 70

ICF: Construction Advantages

- Faster Installation (expedites other trades)
- Reduced Construction Schedules
- Reduce worker fatigue (fewer injuries)
- Minimal Heavy Equipment/Machinery
- Efficient Design (less material waste)
- Superior Weather Protection

Typical Floor Systems



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- Structural system recommendations
- Cost comparisons
- Specification review
- Design/construction team collaboration

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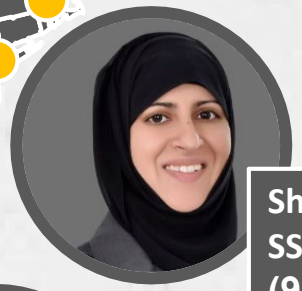

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  - June 17: Economical Design of Insulating Concrete Forms
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Thank you
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