Better Buildings
U.S. DEPARTMENT OF ENERGY

Getting to Zero: The How (and Why) of Net Zero Energy Buildings

Carolyn Sarno
Mason Cavell
Tom Hootman
Theresa Spurling-Wood

U.S. DEPARTMENT OF ENERGY

Agenda

- **Presentations**
  - **Mason Cavell,** Community Housing Partners
  - **Tom Hootman,** RNL
  - **Theresa Spurling-Wood,** Alachua County Public Schools
- **Additional Resources**
- **Discussion**

Mason Cavell
Community Housing Partners

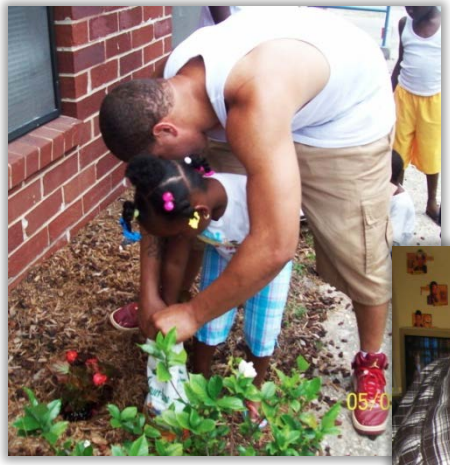
U.S. DEPARTMENT OF ENERGY

DESIGN STUDIO

Affordable Net Zero Housing

Mason Cavell, Community Housing Partners

Sustainable Approach



Environmental

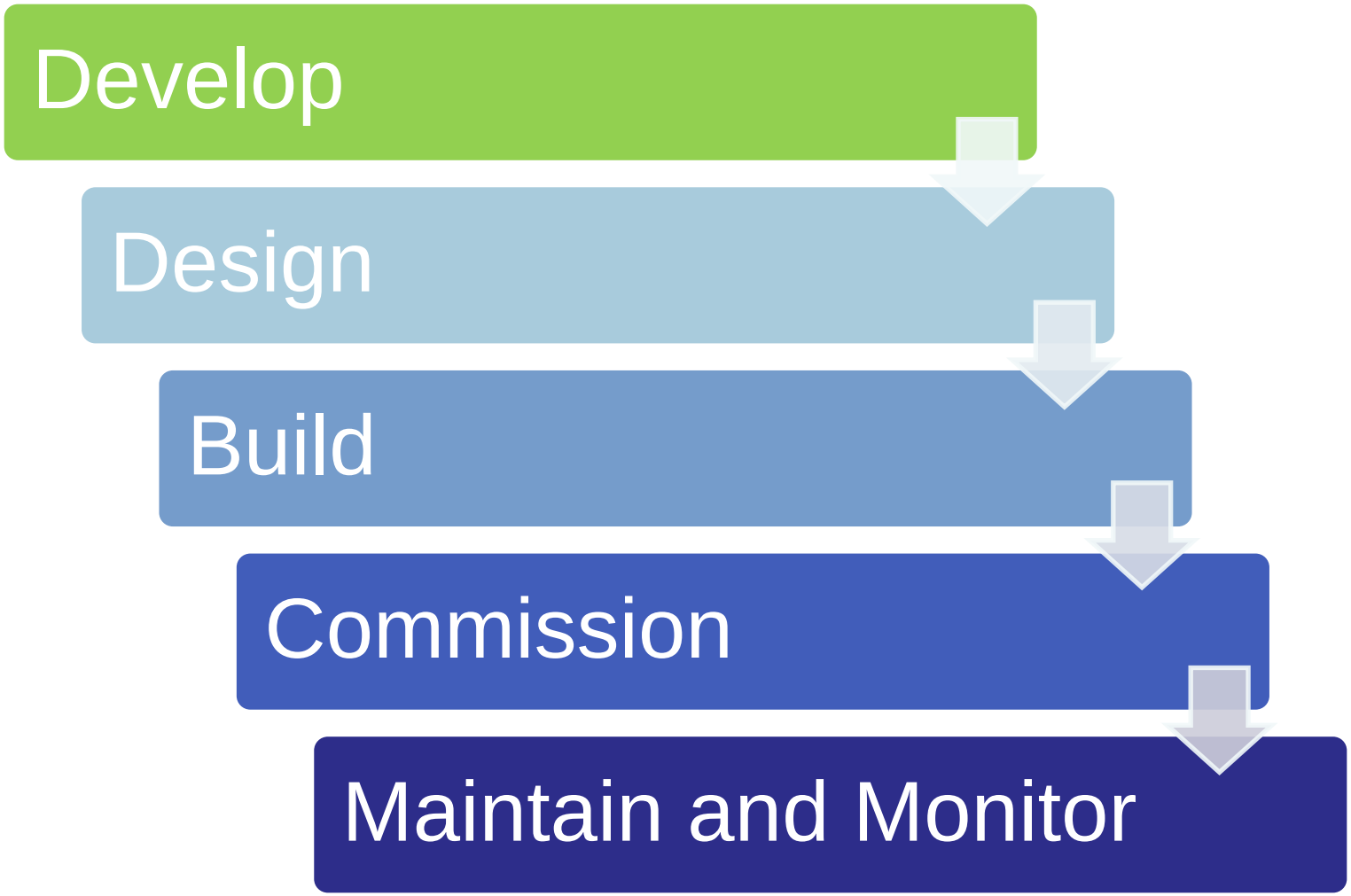
Economic

Social

Single-family Residential

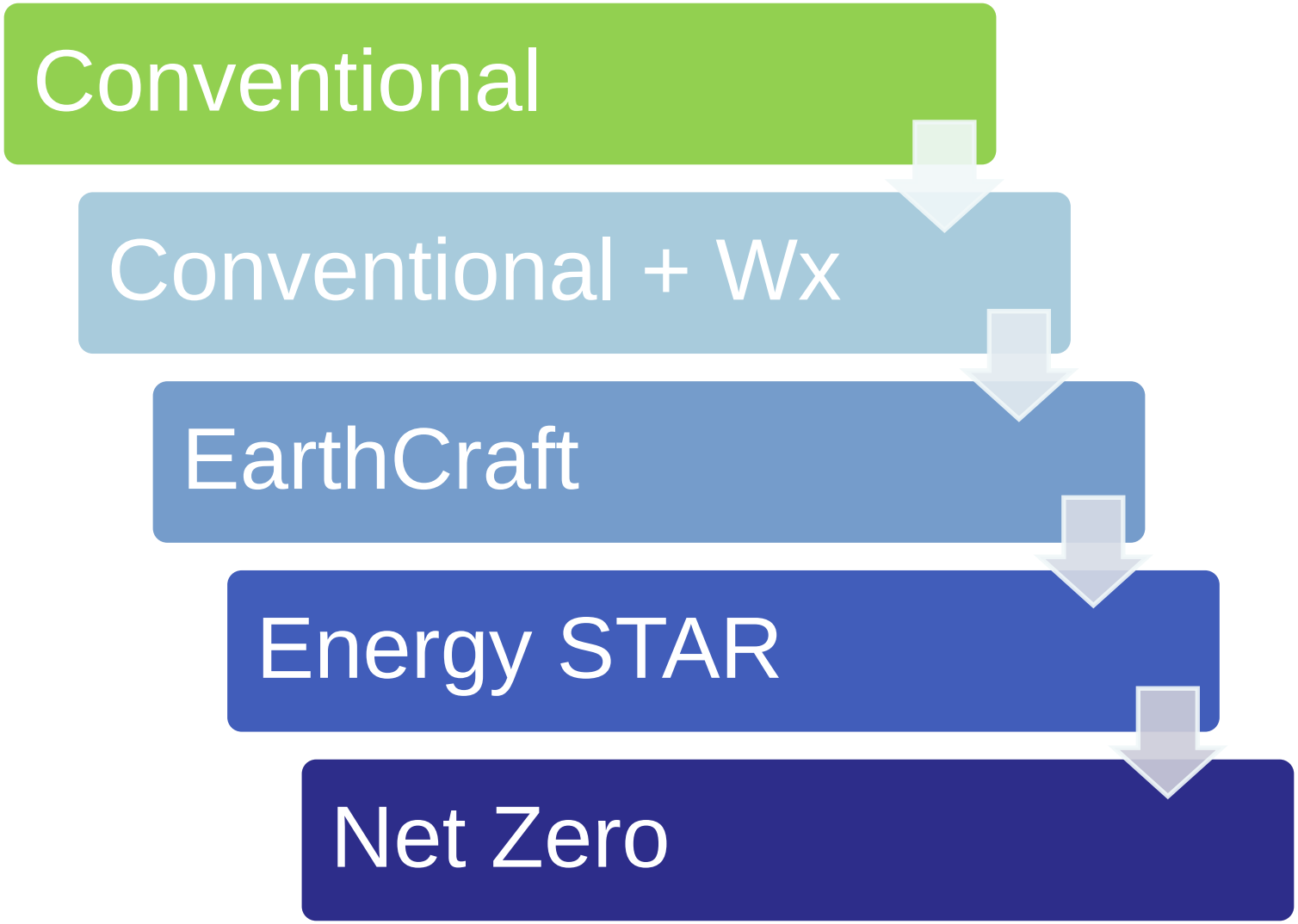
Multi-family Residential

Vertical Integration



Collaborative Process

Building Evolution



Grissom Lane

8-unit property in Blacksburg, VA

Universal design, exclusively for seniors

First affordable net-zero housing in Virginia

For DOE and EarthCraft Net Zero Standards, we must achieve…

- HERS index of <50 (pre-solar)
  - Target: HERS 35 pre-solar
- Infiltration <1.5 ACH50
- Lighting: minimum 75% CFL/LED
- Appliances: Energy STAR / WaterSense
- Windows: U-Value < 0.30
- Ventilation: ASHRAE 62.2 2010
- Code: IECC 2012 or better

Elements of Net Zero

Envelope

- Thermal and pressure boundaries
- Windows and doors

Systems

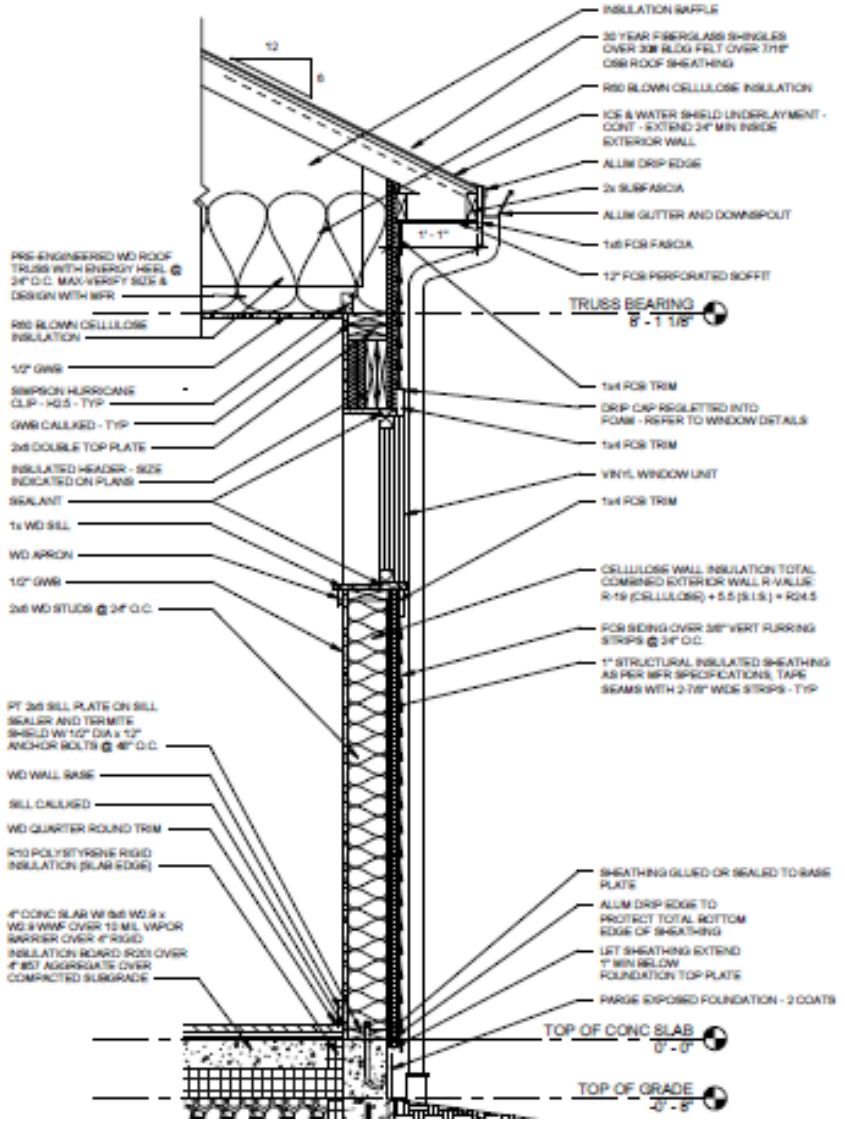
- HVAC
- Appliances
- Water heating
- Lighting

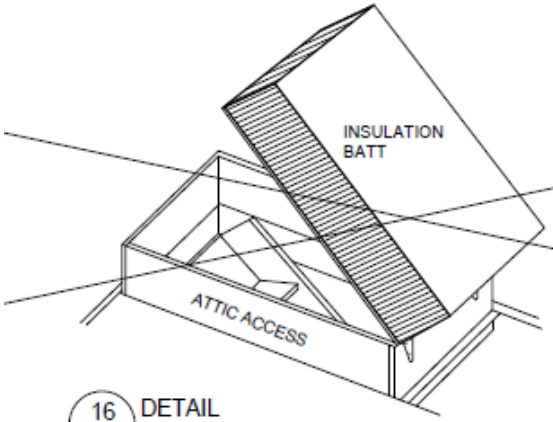
Renewable Energy

- Solar PV

Envelope

Insulation	• R-60 attic (blown cellulose) • R-24.5 walls (dense-pack cellulose)
Air Barrier	• Continuous air barrier • 1.5 ACH @ CFM50
Windows	• Ply-Gem 3-pane, vinyl trim • U-0.21
Construction	• 2x4 cellulose plus Structural Insulated Sheathing





AN INSULATED ATTIC HATCH SHALL BE BUILT TO OPEN TO THE ATTIC AND FORM AN AIRTIGHT SEAL WHEN CLOSED.THE ATTIC HATCH MUST ACCOMMODATE THE "HIDEAWAY STAIRS" AND BE INSULATED TO AT LEAST R-5. ADDITIONAL POINTS MAY BE EARNED IF THE ATTIC HATCH IS INSULATED TO R-19.

16/EC101 DETAIL
SCALE:NOT TO SCALE

Systems

HVAC (all electric)	• 21 SEER Mini-Split Heat Pump • Continuous 15cfm ventilation • Ducts inside building envelope
Appliances	• Energy STAR refrigerators, front-load W/D • EPA WaterSense toilets and plumbing fixtures
Water Heating	• Heat pump hybrid water heater (1 per 2 units)
Lighting	• LED bulbs in incandescent fixtures

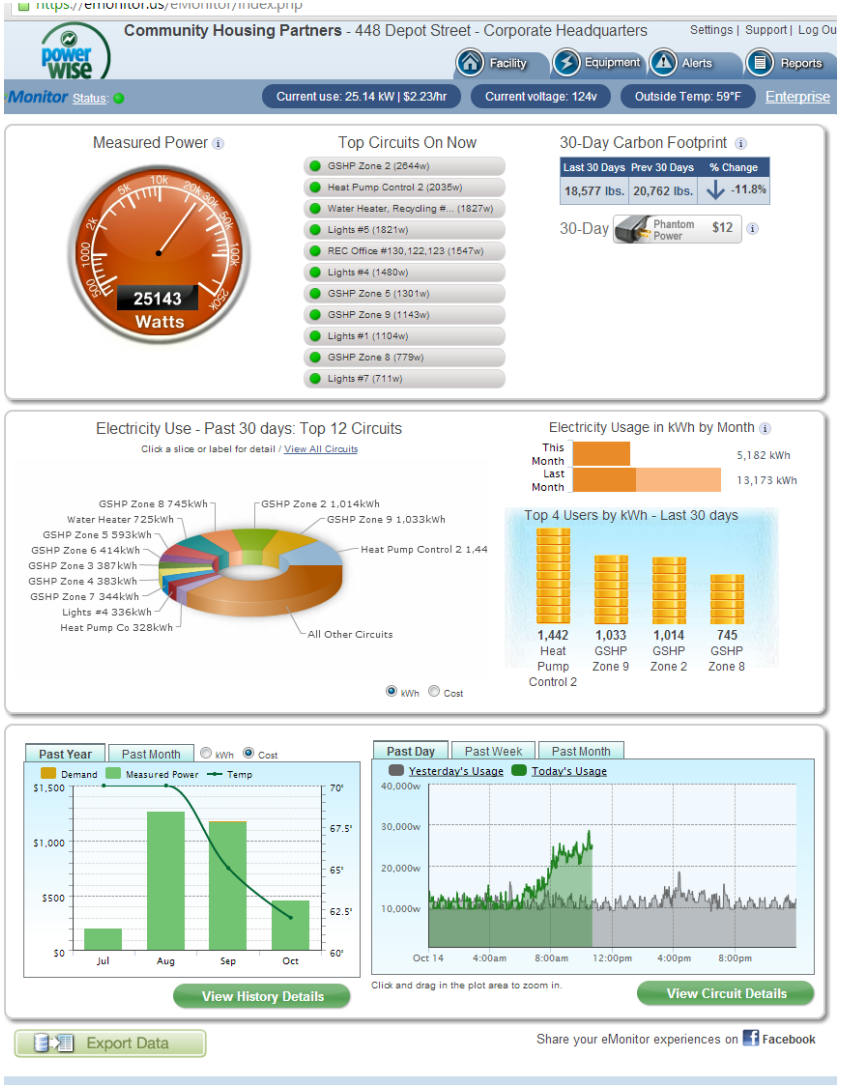

A.O.Smith


FRIGIDAIRE
FRIGIDAIRE


PHILIPS

Renewable Energy

Measurement and Verification



Major Challenges

Tenant Behavior (X-factor)

- Education and feedback

Cost

- Long payback, low cash flows

Utility Cooperation

- Solar net-metering uncertainty
- Dependent on state-by-state policies

Thanks!

Mason Cavell
Director, Energy Programs
Community Housing Partners

Tom Hootman
RNL

U.S. DEPARTMENT OF ENERGY

NET ZERO ENERGY BEST PRACTICES

Tom Hootman, AIA, LEED AP BD+C
RNL, Director of Sustainability

RESEARCH SUPPORT FACILITY

Federal Office Building

222,000 SF

822 Occupants

$64M Firm Fixed Price

$57.4M Construction

Complete June 2010

NREL – RESEARCH SUPPORT FACILITY II

BUCKLEY ANNEX NET ZERO ENERGY COMMUNITY

SMUD – EAST CAMPUS OPERATIONS CENTER

SINGAPORE – NET ZERO PROTOTYPE

OWNER BEST PRACTICES

01 Put it in writing.

02 Integrated delivery for cost control.

03 Invest in architecture.

04 LEED energy modeling is not enough.

05 Follow through.

01 Put it in writing.

OBJECTIVES

1. Mission Critical

Safety
LEED Platinum
Energy Star

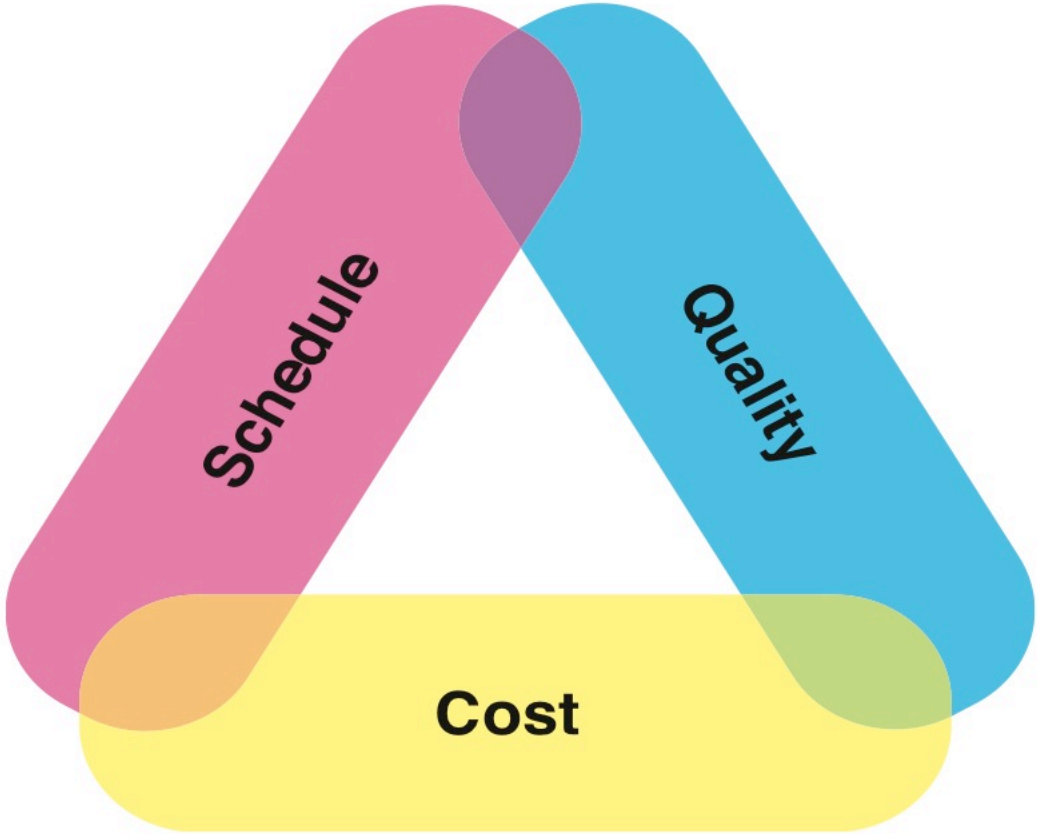
2. Highly Desirable

800 staff Capacity
25kBTU/ft^2/year
Substantial Completion by 2010

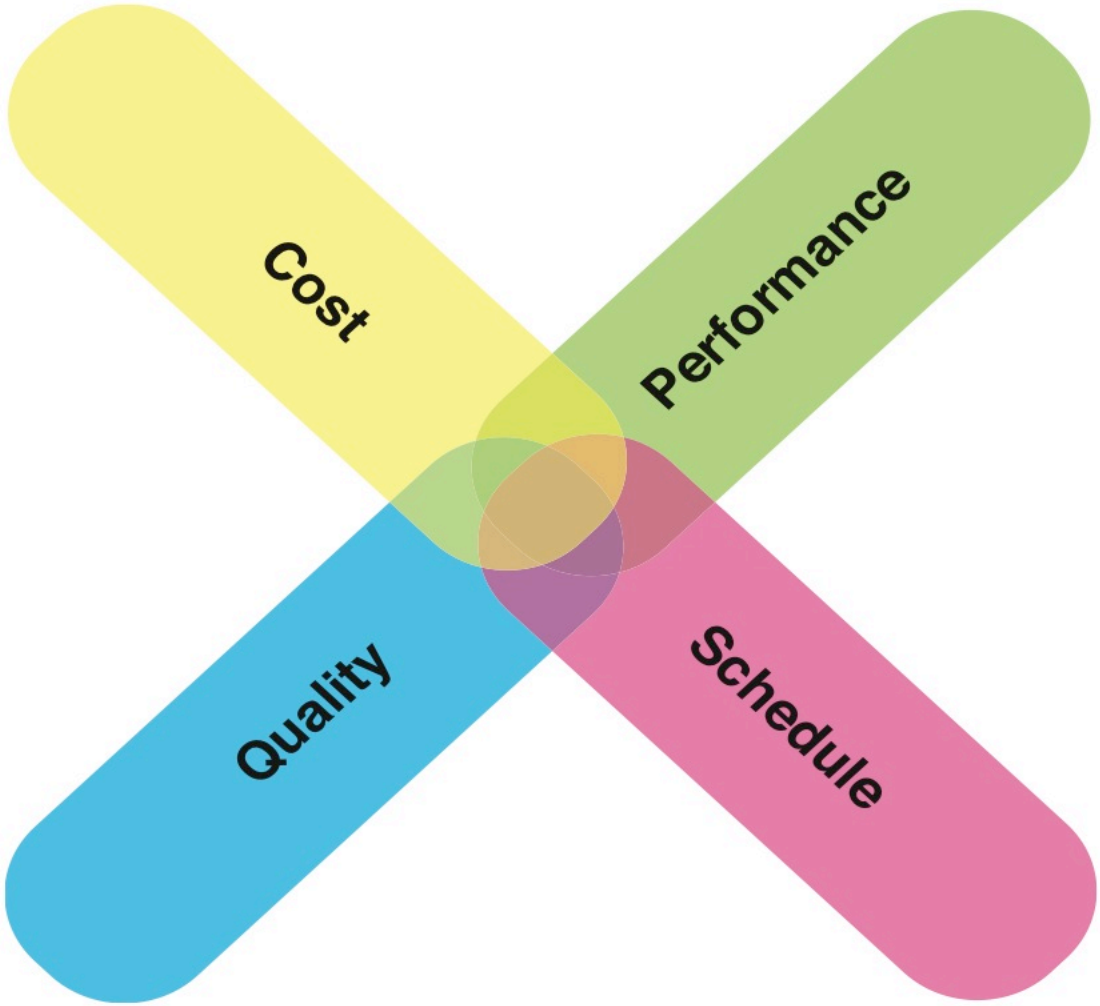
3. If Possible

Net zero design approach
Visual displays of current energy efficiency
National and global recognition and awards

02 Integrated delivery for cost control.



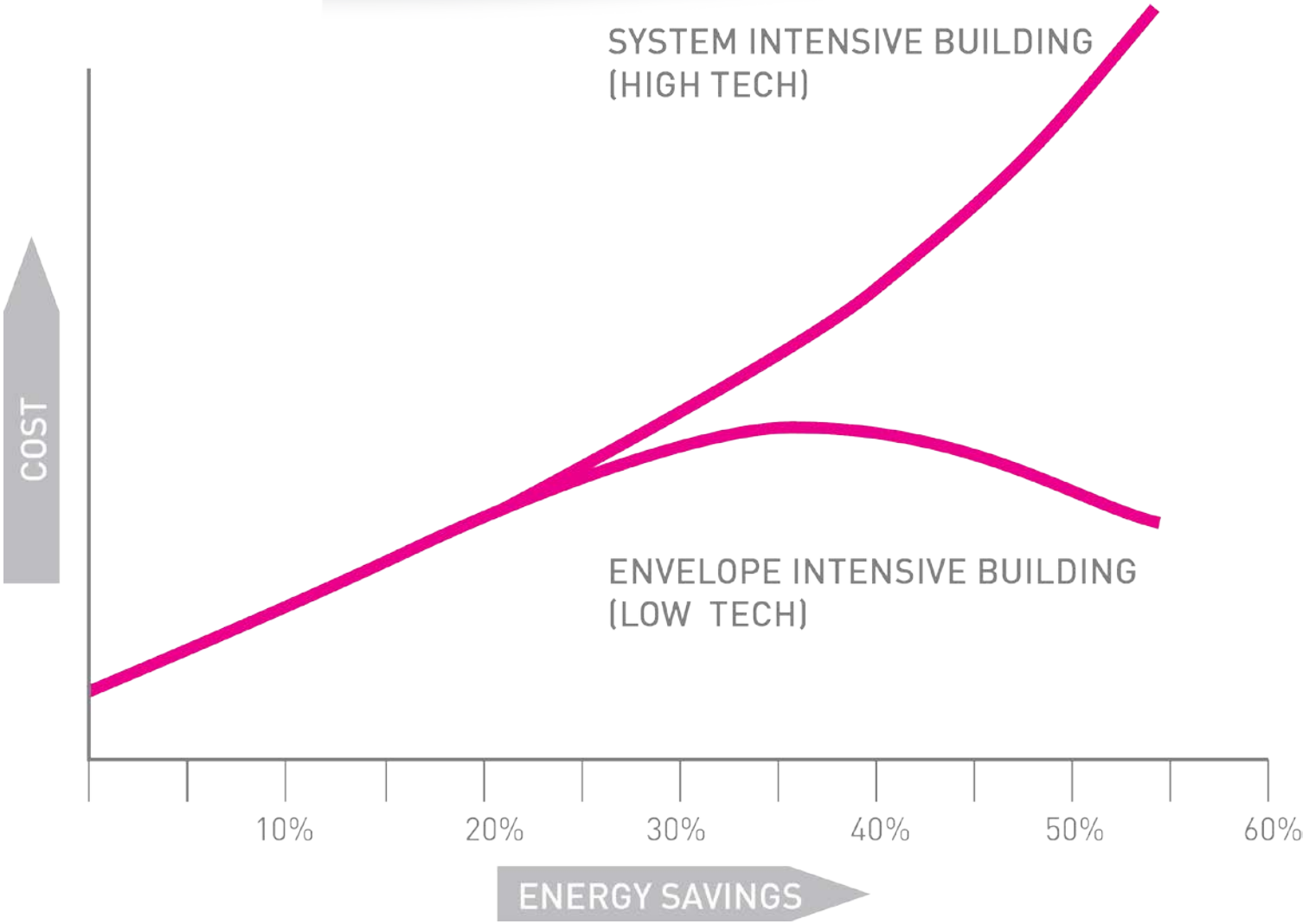
CONVENTIONAL DELIVERY

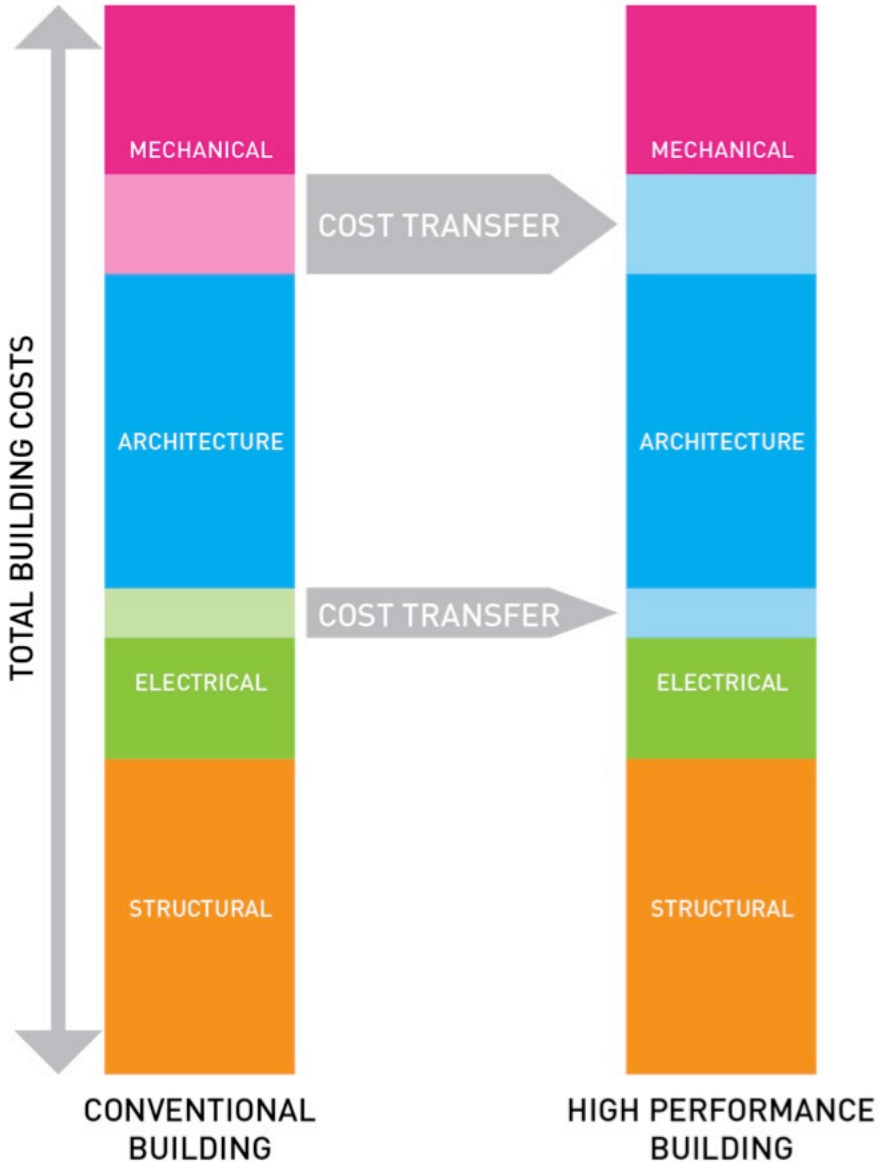


INTEGRATED DELIVERY


$259/SF
35 kBtu/SF
FAST TRACK

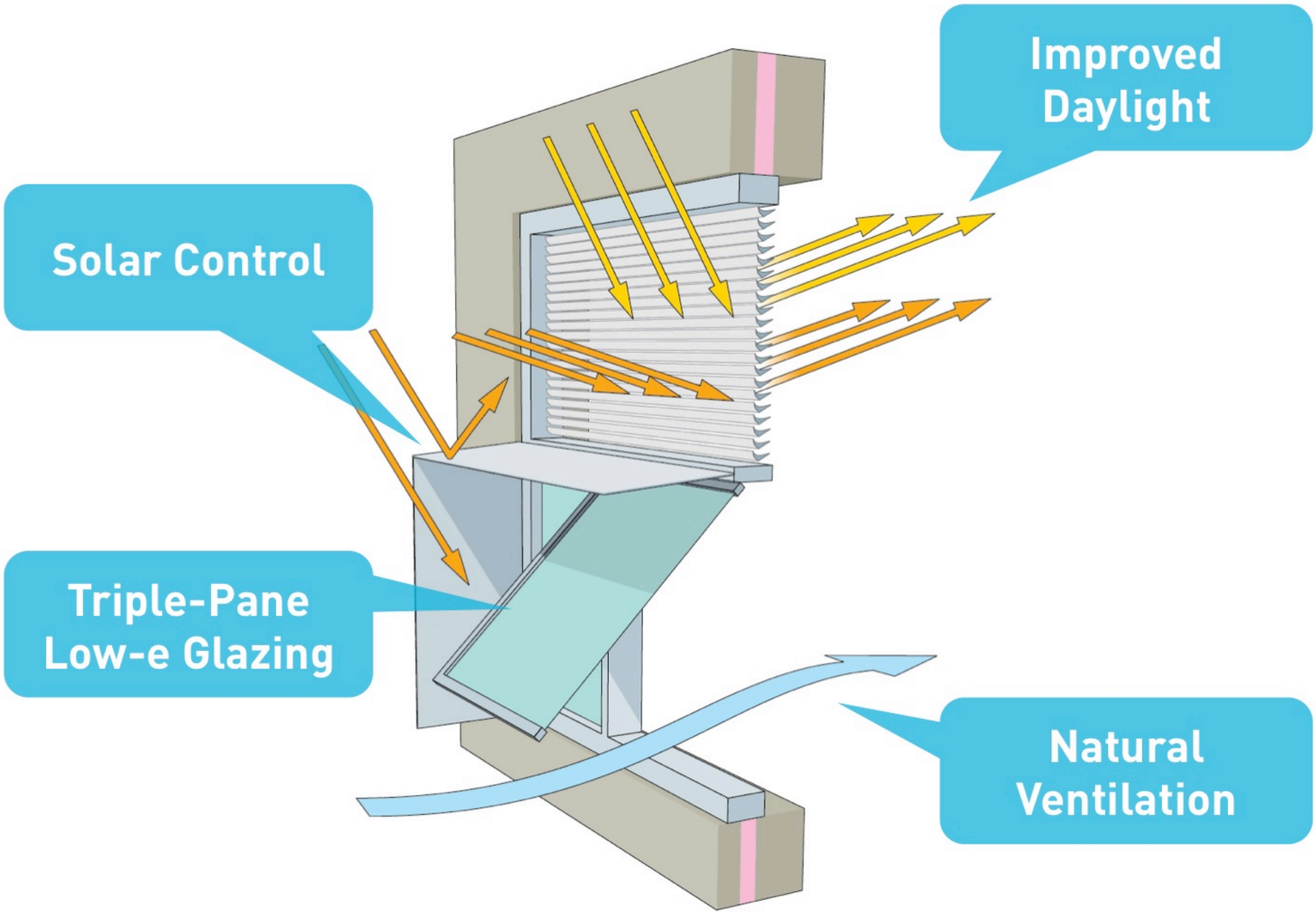
03 Invest in architecture.





COST TRANSFER


SOLAR WALL
60’ WIDE
SUPER
WINDOW


Improved Daylight
Solar Control
Triple-Pane Low-e Glazing
Natural Ventilation


Radiant Heating
+ Cooling
Occupant
Comfort
Eliminate
Perimeter Heat

04 LEED energy modeling is not enough.

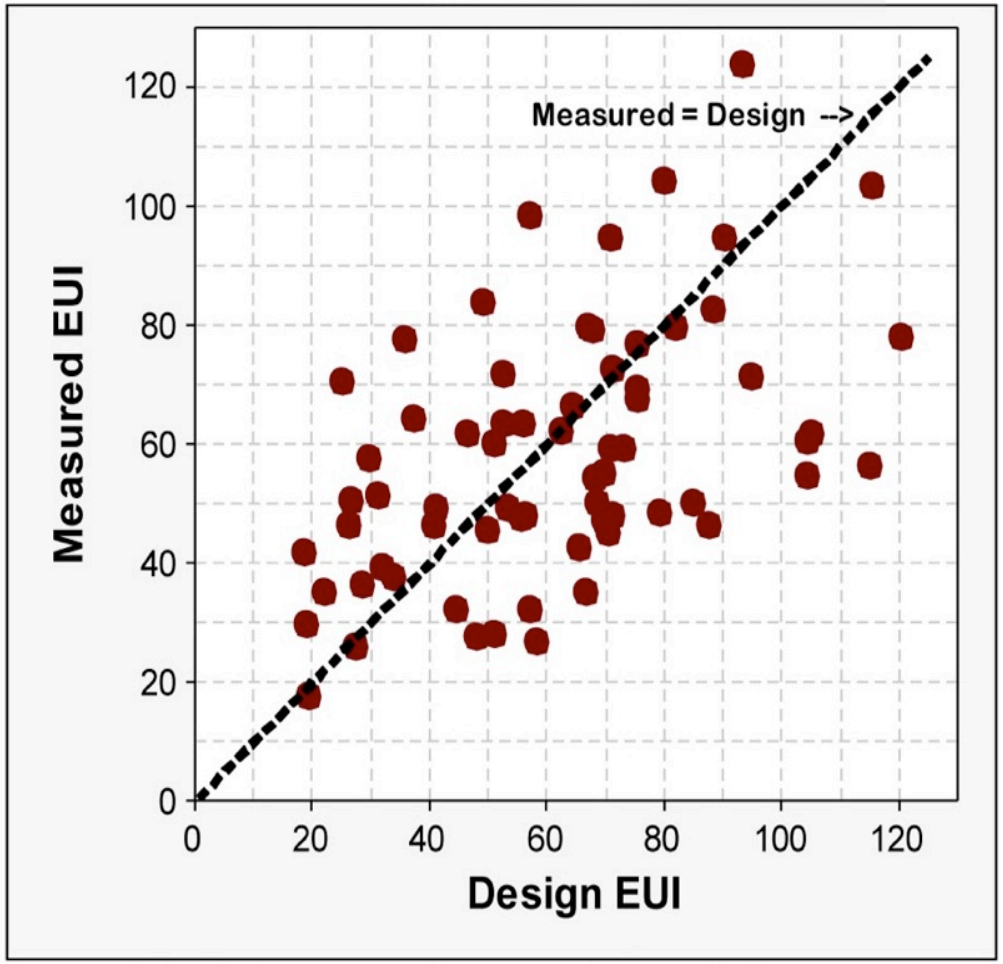


Figure ES- 4: Measured versus Design EUIs
All EUIs in kBtu/sf

New Buildings Institute
Energy Performance of LEED for New Construction Buildings (March 2008)

PREDICTIVE MODELING

1 CONCEPT

2 DESIGN

3 CONSTRUCTION

4 OPERATIONS

CHARRETTE MODEL

AS-DESIGNED MODEL

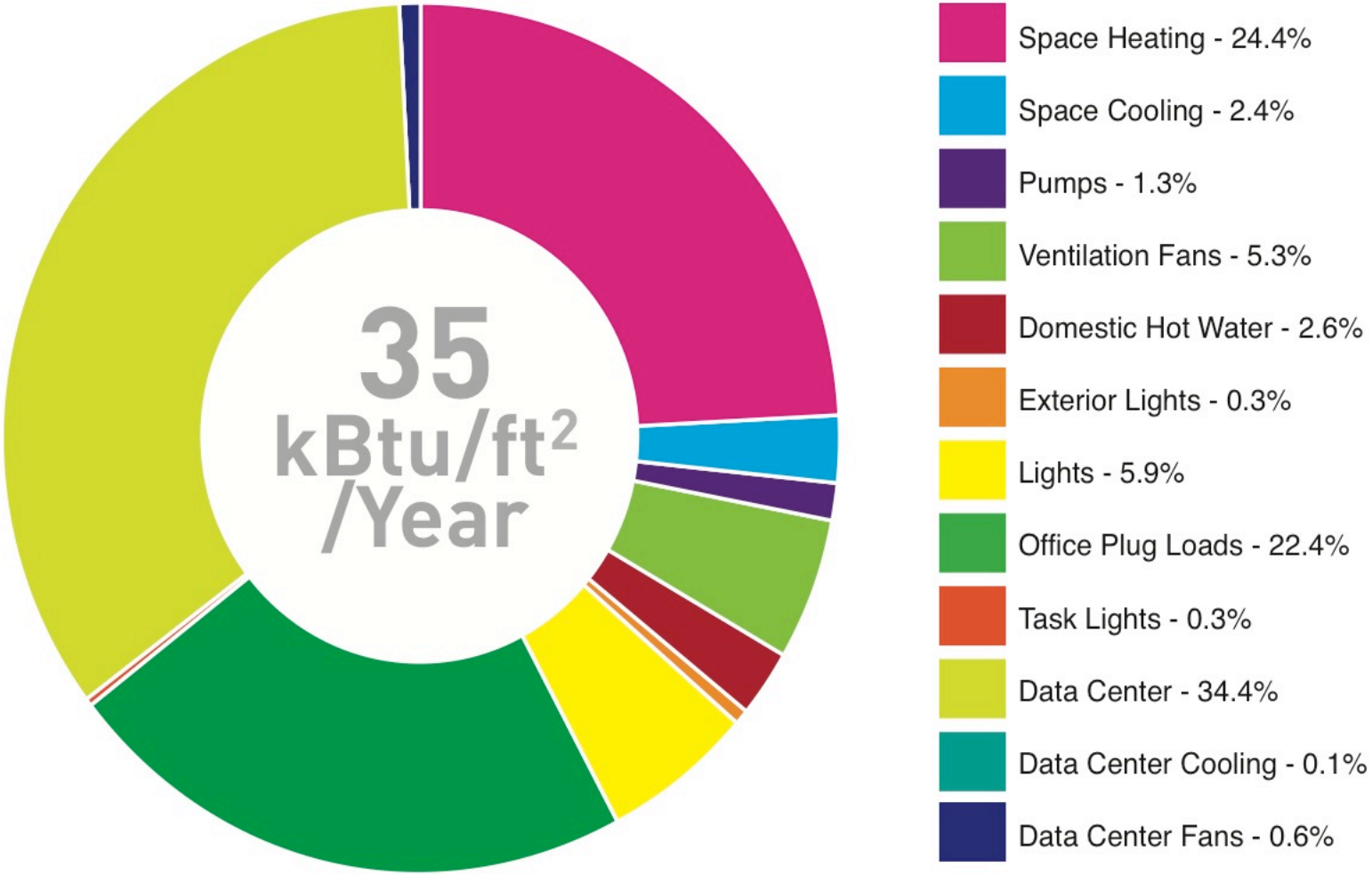
LEED MODEL + BASELINE

AS-BUILT MODEL

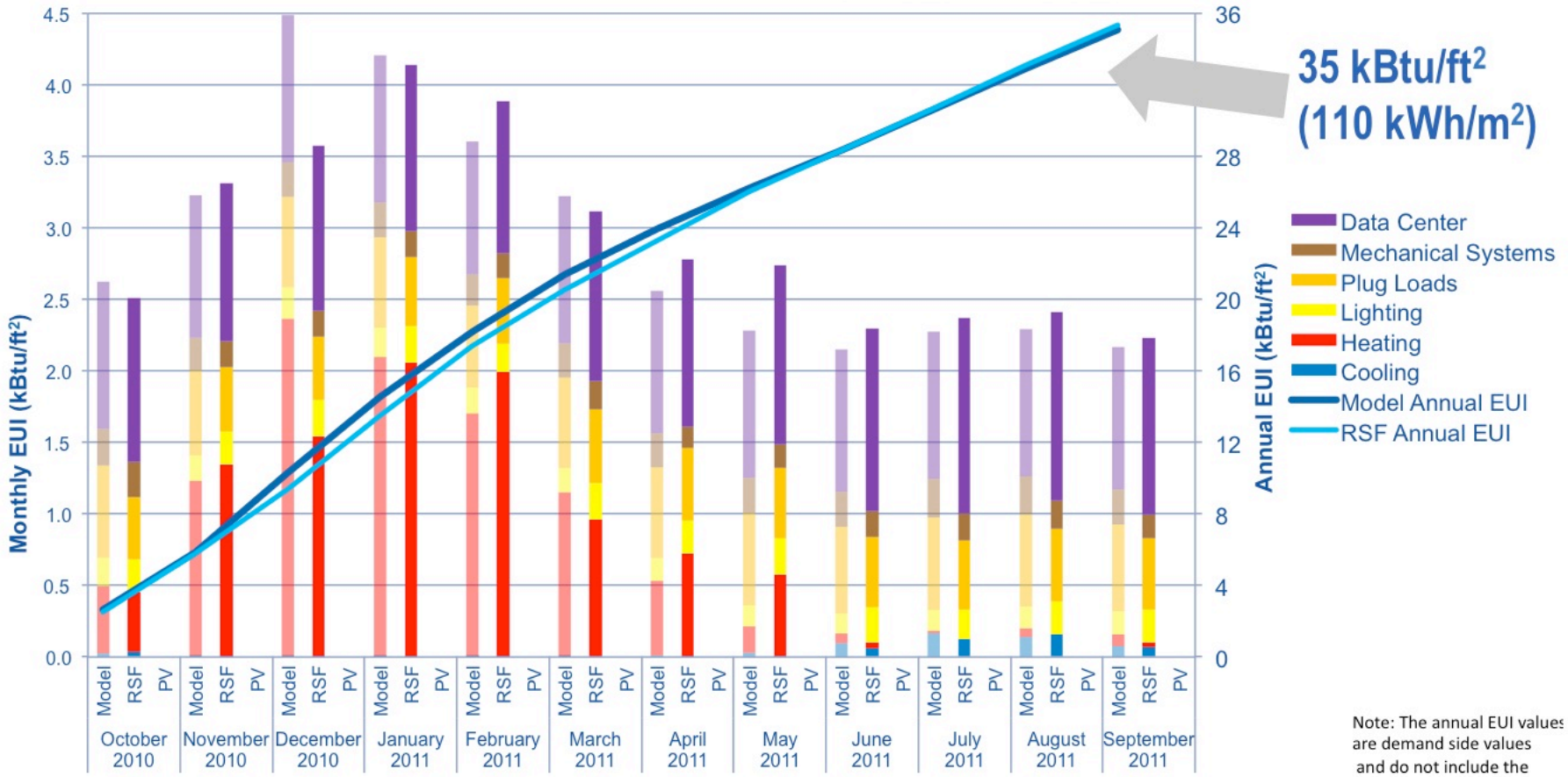
OPERATIONS MODEL

ZERO

RSF END USE

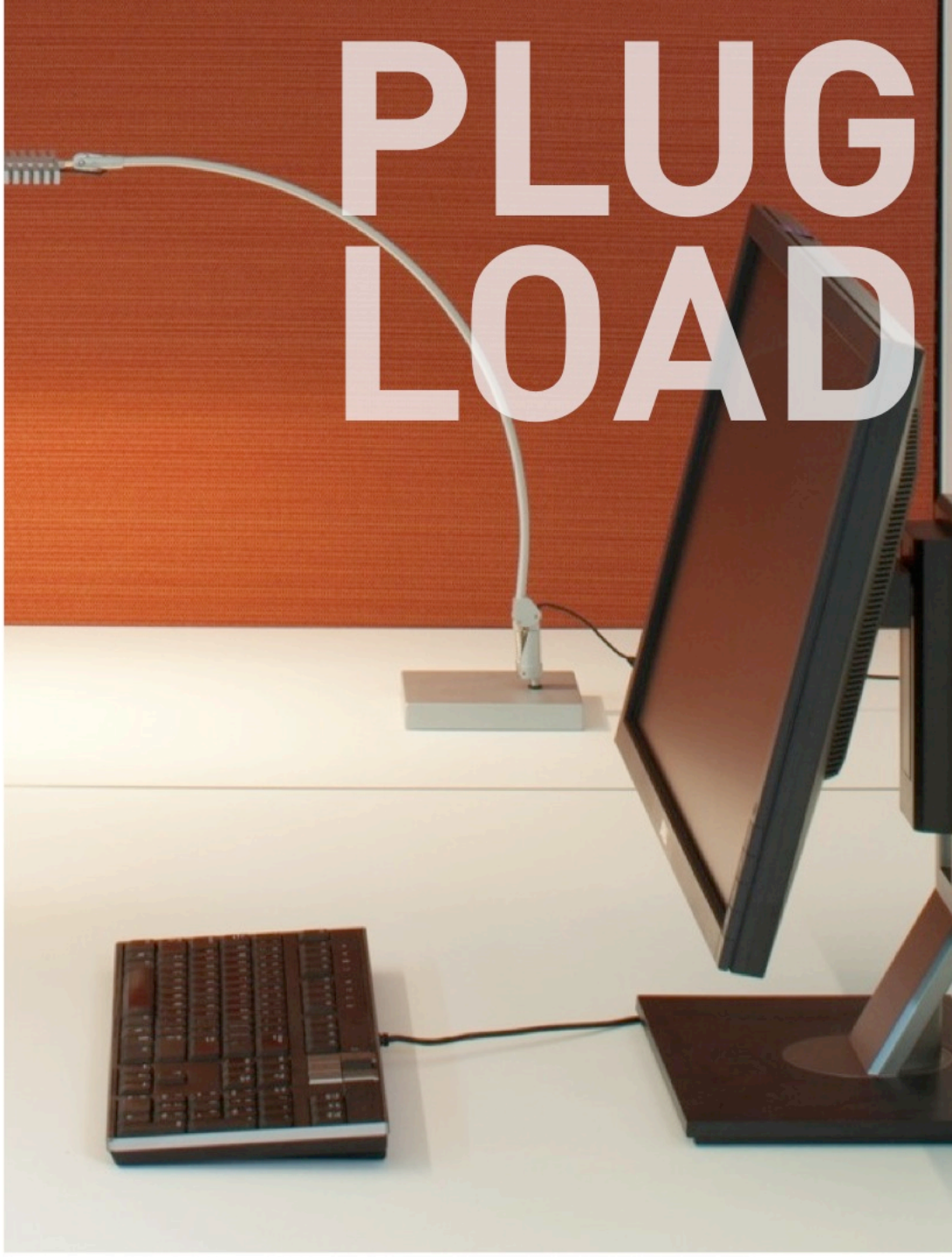

35
kBtu/ft²
/Year
Space Heating - 24.4%
Space Cooling - 2.4%
Pumps - 1.3%
Ventilation Fans - 5.3%
Domestic Hot Water - 2.6%
Exterior Lights - 0.3%
Lights - 5.9%
Office Plug Loads - 22.4%
Task Lights - 0.3%
Data Center - 34.4%
Data Center Cooling - 0.1%
Data Center Fans - 0.6%

05 Follow through.



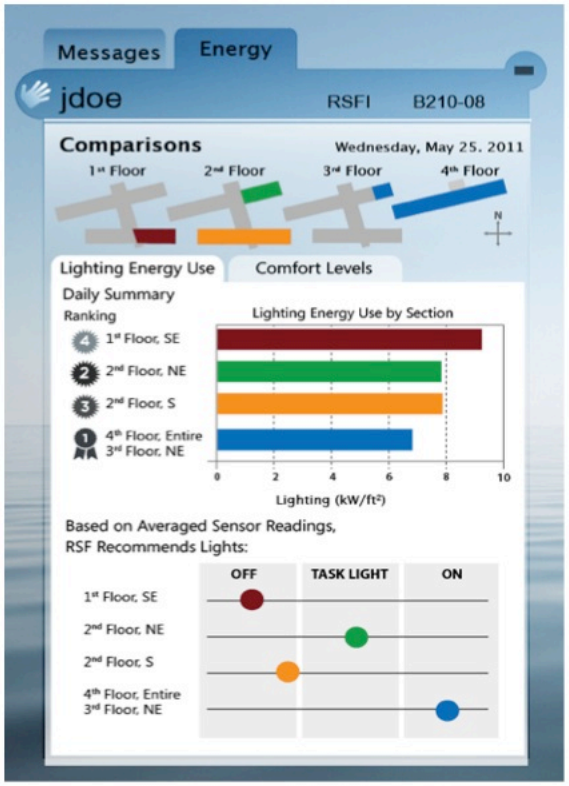
MODELED VS. MEASURED

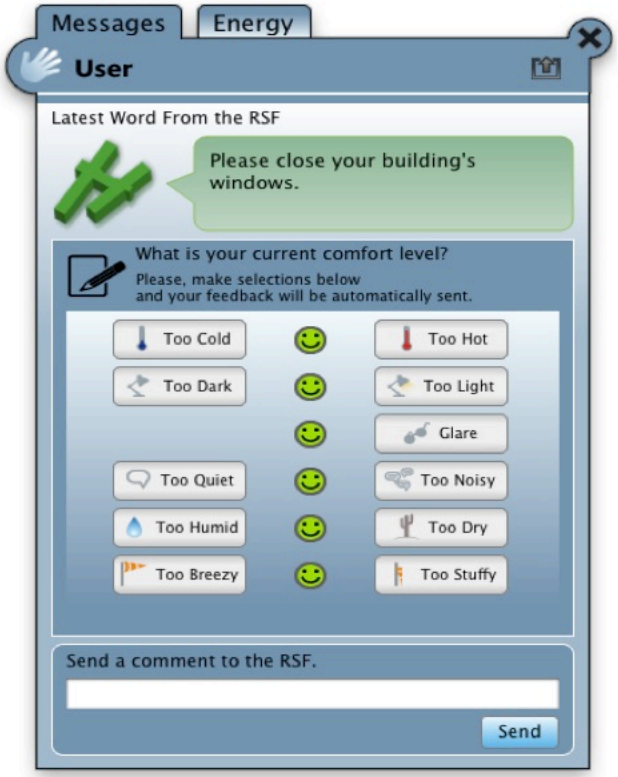
VOIP Phones 2 Watts	VOIP Phones 15 Watts
LED Task Light 6 Watts	Fluorescent Task Light 35 Watts
24” LCD Monitor 18 Watts	24” LCD Monitor 50 Watts
Laptop Computer 30 Watts	Desktop Computer 300 Watts
Shared Printers 100 Watts	Personal Printer 460 Watts
Load Sensing Power Strip	Personal Space Heater 1500 Watts

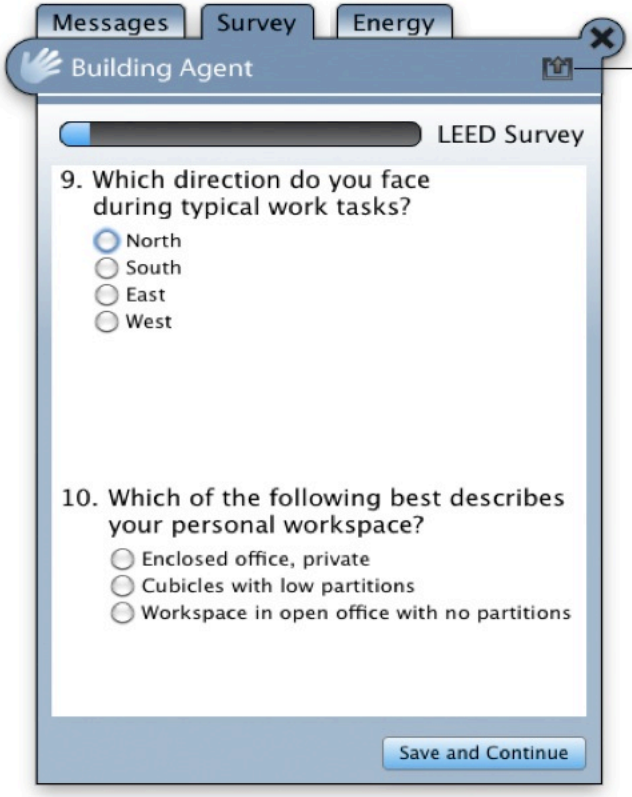



NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Research Support Facility
Energy Tracker
5:00 PM
23.5° F
69.4 % Outside Realtive Humidity
1.4 mph Wind Speed out of Northwest
Plug Loads
65 kW
Mechanical
35 kW
Lighting
30 kW
Energy Demand Target
Whole
Building
-300 kW
Photovoltaics
600 kW
Data Center
115 kW
Heating
1.5 kW
Cooling
15 kW
Update Timer
Home
Whole Building
Photovoltaics
Plug Loads
Mechanical
Lighting
Data Center
Heating
Cooling

BUILDING AGENT APP







OWNER BEST PRACTICES

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05 Follow through.

Theresa Spurling-Wood
Alachua County Public Schools

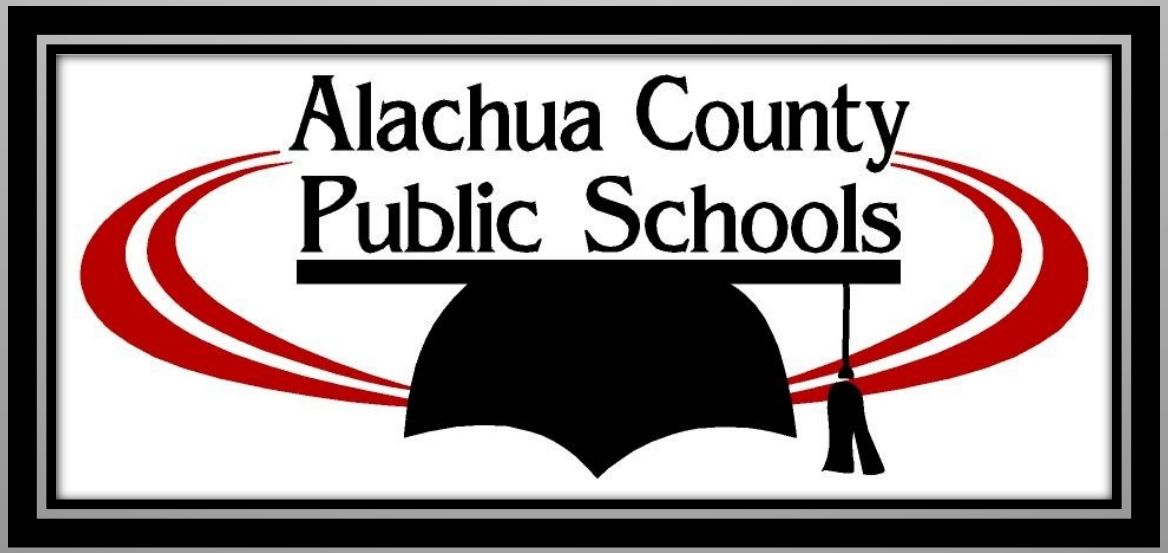
U.S. DEPARTMENT OF ENERGY

Getting to Zero:

The How (and Why) of Net Zero Energy For K-12 Schools

Better Buildings Summit 2014

Theresa Spurling-Wood CIE,GGP,LEED AP



Energy Independence and Security Act

- The EISA of 2007 set a goal of net-zero energy use for commercial buildings by 2030. EISA 2007 further specified a net-zero energy target of 50% of U.S. commercial buildings by 2040 and a net-zero standard for 100% of new and existing commercial buildings by 2050. When does it apply to schools?

- According to US DOE, nationally K-12 schools spend more than $6 billion each year on energy, more than on books and computers.

PV totaling 2.03 Megawatts on 21 sites

School	Phase 1	Phase 2	Phase 3	Total kW Installed
Buchholz High School	156	52	104	313
Duval			54	54
Eastside High School		26	78	104
Ft. Clarke Middle School	156		52	208
GlenSprings Elementary School		79		79
Howard Bishop			31	31
Kanapaha Middle School	52	157		209
Lincoln Middle School	52	53		105
Littlewood Elementary School		57		57
Loften High School	105			105
Meadowbrook Elementary School			183	183
Sidney Lanier Center	52			52
Terwilliger Elementary School			103	103
Westwood Middle School	126			126
Wiles Elementary School			52	52
Williams Elementary School	50	104		155
Gainesville High School			52	52
Lake Forest Elementary School			26	26
Hawthorne HS				5
High Springs Community				10
Waldo Community				5
Total	**750**	**528**	**736**	**2,034**

2003

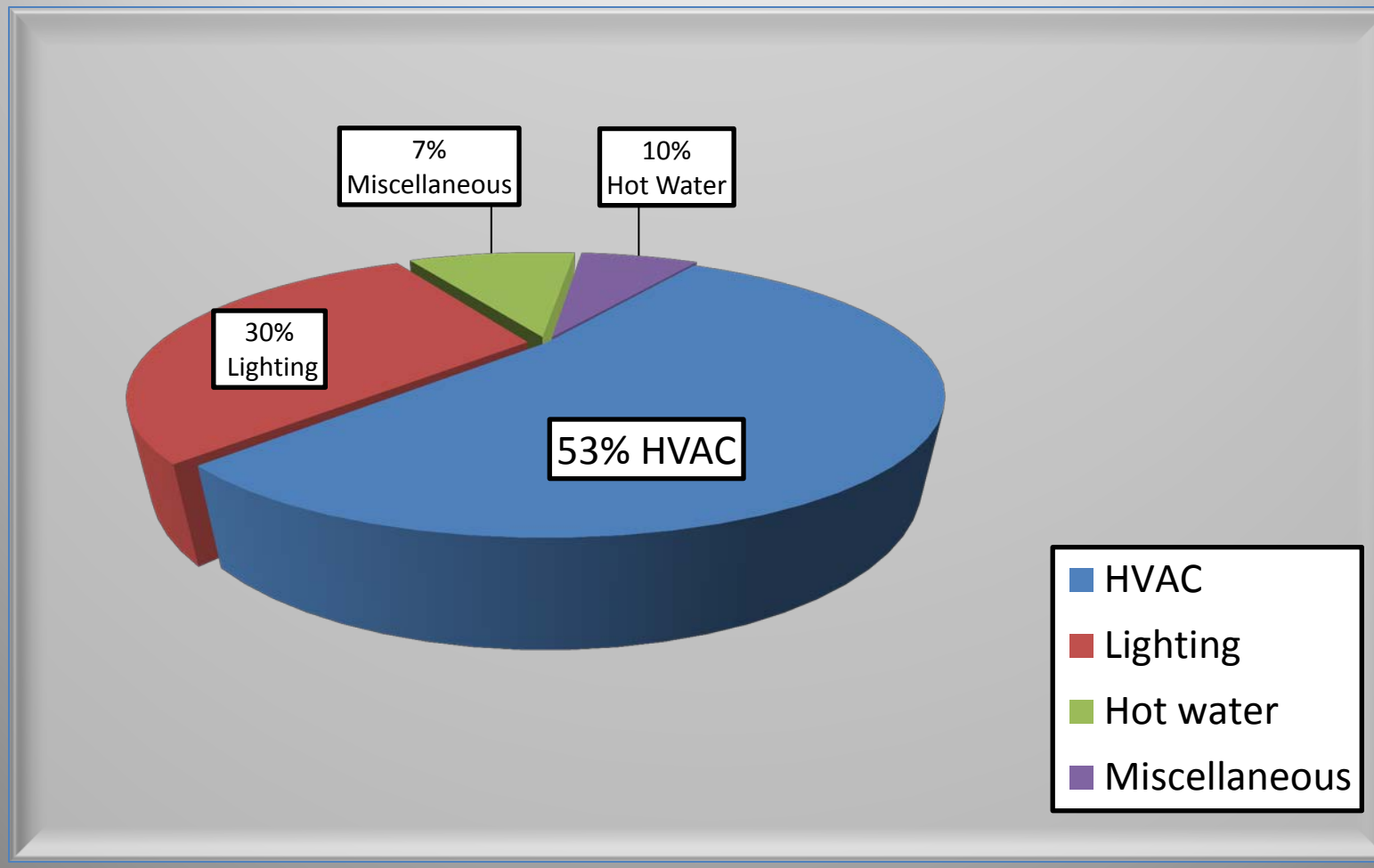
The path to getting there started with a partnership project between the City of Gainesville and School Board of Alachua County which included installation of two 1.8 kW PV arrays at two middle school locations.

CITY OF GAINESVILLE
every path starts with passion
FLORIDA

WHEREAS, both the City of Gainesville and the SBAC believe that a solar awareness program at schools is an important first step to increasing the use of solar energy in the community and that schools are an excellent showcase for the benefits of solar energy

Typical Hot & Humid School

2002 Energy Consumption Profile



2008 - 2009

- Started a district wide energy reduction program due to increasing utility costs

- FY 07/08 annual usage was 57,563,967 kWh*

*These numbers are for the schools involved in the annual conservation incentive program and only uses kWh reduction for rewards data.

2009 - 2011

- FY 08/09 51,956,668 kWh
- FY 09/10 53,578,536 kWh
- FY 10/11 53,175,367 kWh

- Consumption trending upward
- School Board requested more energy savings
- Going backward on “Path to Net Zero” possibilities

2011

Alachua County Public Schools begins PV Feed In Tariff Program

- No installation or maintenance cost to School Board
- Provides roof rental income to the District for 20 years
- 750kW of FIT PV installed on schools,
  program sponsored by Gainesville Regional Utilities
- Roof leases will expire in 20 years and PV system ownership including revenue or net metering deductions will be turned over to ACPS
- To ensure current roof warranties not voided, some manufacturers required additional protection from PV array installations

2012

Lessons learned and energy consumption decreases

- FY 11/12 48,966,737 kWh
- 528kW of FIT PV added to school roofs
- While selecting sites to mount PV arrays, always check the condition of every site roof because sometimes locations will need to be shifted
- Inspect all building electrical tie-ins and it should be noted permitting process needs to be streamlined for renewables
- Ownership of a school building does not change and is appealing to investors
- It is a long term relationship with installation contractor and investors

2013

- FY 12/13 46,183,508 kWh
- New school usage 815,121 kWh*
- Reducing load everywhere involves everyone
- 736 kW of FIT PV on school sites includes *Meadowbrook ES
- 10 Percent district wide total energy reduction

Analysis of Meadowbrook Elementary School Performance:

Towards Net Zero Energy

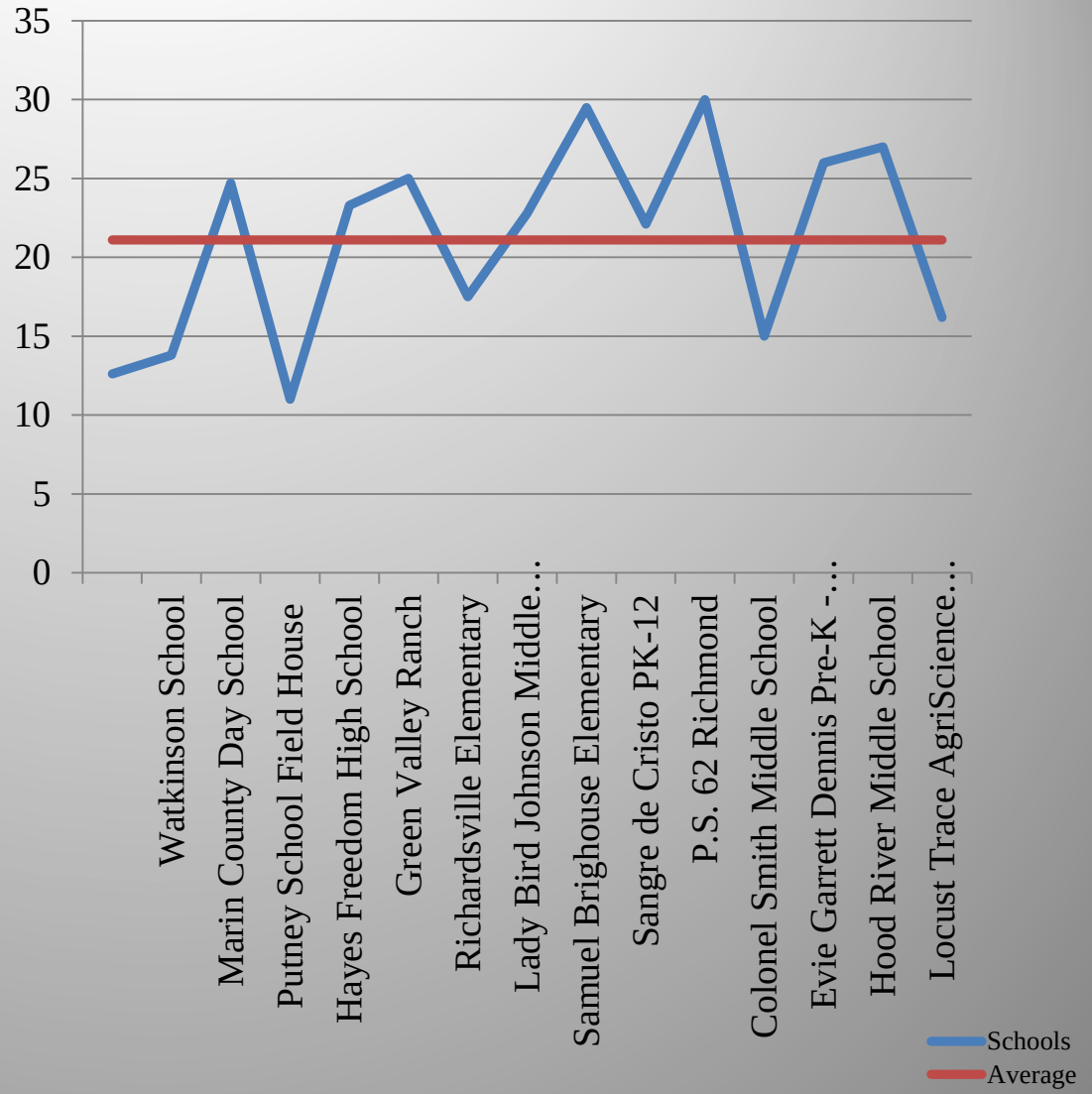
Presented by

Hamed Hakim
Ruthwik Pasunuru
Arati Sakhalkar

Net Zero Energy Schools – An Introduction

Why Net Zero schools?

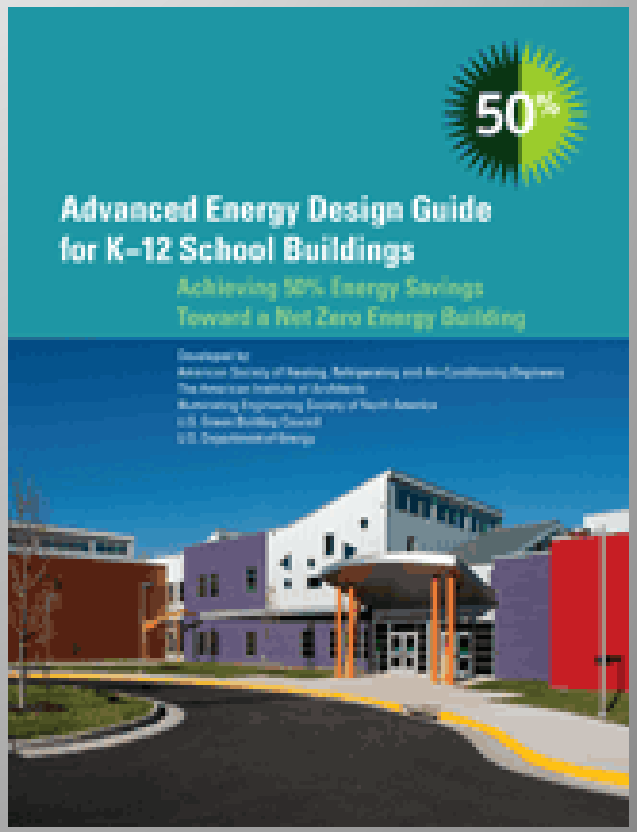
- Schools consume 17% of non-residential energy in US
- According to U.S.DOE (2006), $ 2 billion can be saved by improving energy strategies in schools
- Easy to make Net Zero since
  - Less operation hours
  - Seasonal Occupation
  - Long holiday break periods
  - Large site and roof areas
- 15 Net Zero schools in US
  none in Florida
- Based on studies
  average EUI of existing NZE school:
  21.1 kBtu/sf/yr



Net Zero School Projects' EUI(KBtu/sf-yr),
Source: Hutton; Doo Consulting Firm

ASHRAE Advanced Energy Design Guide for K-12 School Buildings

- Developed by collaboration of ASHRAE, American Institute of Architects (AIA), Illuminating Engineering Society of North America (IESNA), US Green Building Council with support from Department of Energy (DOE)
- Guidelines to achieving 50% energy savings for a building complying with ASHRAE/IESNA 90.1-2004 standard
- Recommendations for 8 primary climate zones in USA and highlights various steps involved to design a NetZero Energy School
- Outlines requirements for design criteria for Envelope, Daylighting, Electric Lighting, HVAC, Plug loads, Quality Assurance, Kitchen Equipment, Commissioning



Meadowbrook Elementary School Data

SCHOOL AT GLANCE	
Owner	Alachua County Public Schools
Designer	Schenkel Shultz Architectural Firm
Contractor	Parrish-McCall Constructors
Principal Use	Elementary K-12 school
Occupants	Approximately 600 students, 50 employees
Gross Area	95,620 SF
Conditioned Area	Approximately 85,000 SF
Distinctions/Awards	4-Globes
Total Cost	$16.5 M
Completion	July 2012

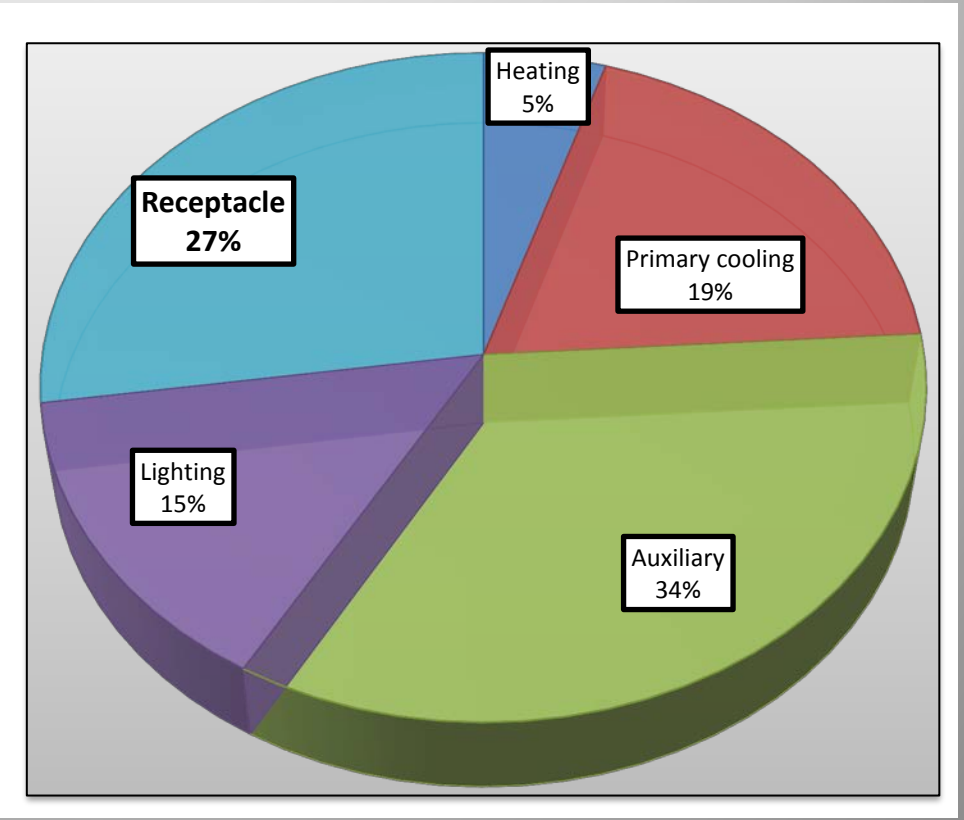
Meadowbrook Elementary School Design Data

- Integrated design approach used
- East/West axis building orientation optimum for daylight harvesting
- Good lighting design and with local light controls
- Two 150 ton chillers outfitted with Bipolar Ionization modules
- Low-emission and non-toxic paints, sealers, coatings, and adhesives used in construction phase
- Green Globes certified (4 Green Globes)
- Can be considered as Net Zero ready school

Meadowbrook Elementary School

Actual modeling consumption

- Software used for modelling Trane Trace 700
- End Energy Use breakdown
- EUI : 27.68 kBtu/sf/yr



Results

Energy Use Intensity (EUI) in kBtu/sf/yr

Actual Model	ASHRAE 90.1, 2007	ASHRAE AEDG 50%Savings	Proposed Model
27.68	35.83	25.7	**22.71**

Close to average EUI of Net Zero Schools in US ie 21.1 kBtu/sf/yr

Calibration of simulated model

Calibration Standards & Techniques used-

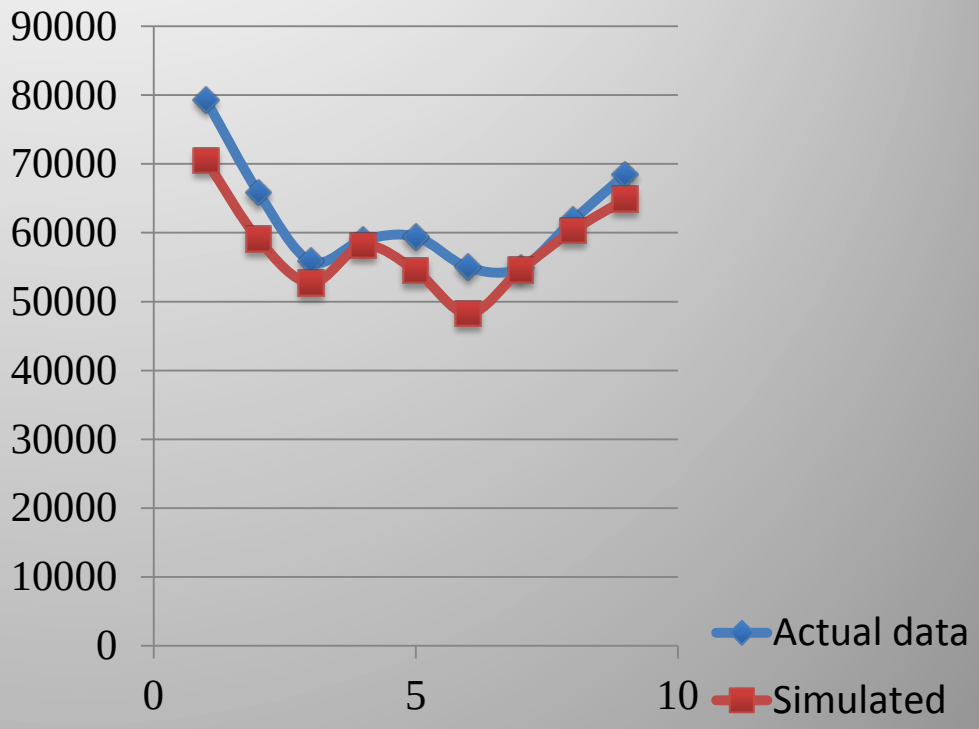
- IPMVP (2002)
- FEMP (2008)
- ASHRAE (2002)

Coefficient of Variance –

$$RMSE_{MONTH} = \left[\frac{(M_{Month} - S_{Month})]^2}{N_{Month}}\right]^{\frac{1}{2}}$$

$$CV(RMSE_{MONTH})\% = \frac{RMSE_{MONTH}}{A_{MONTH}} \times 100$$

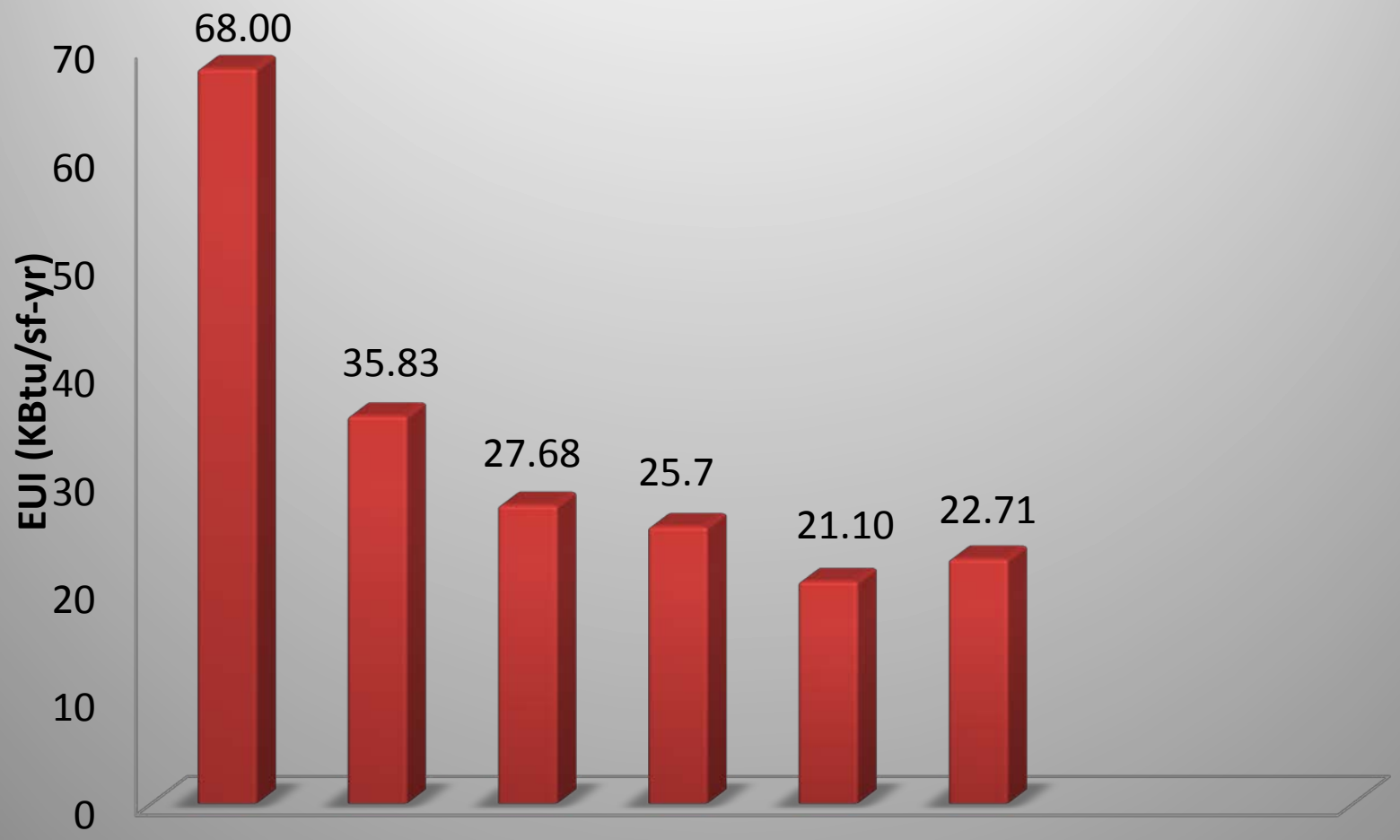
CV ($RMSE_{Month}$) = 8%



Therefore, FEMP (±10%) & ASHRAE (±15%) compliant !

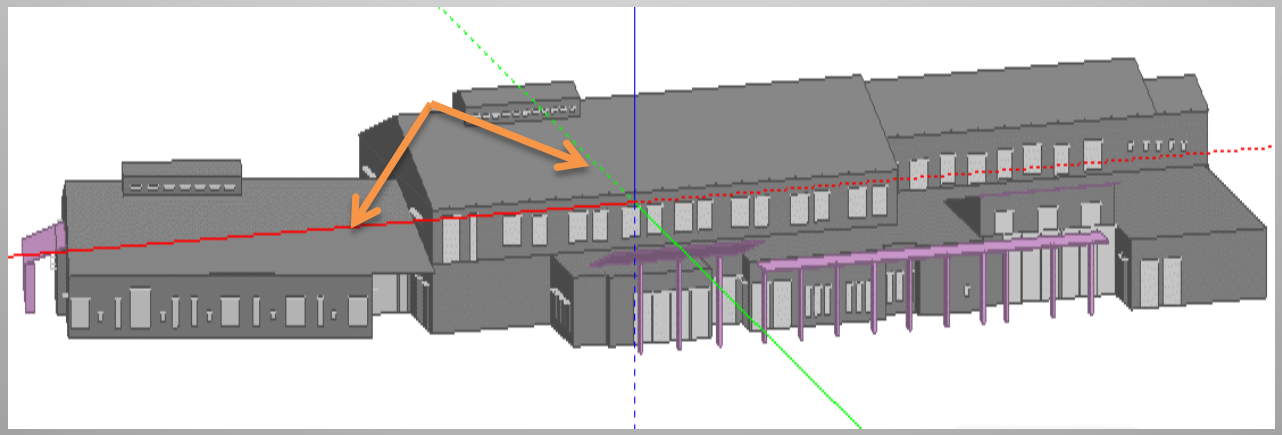
Energy Use Intensity

Path to NET ZERO energy



Other recommendations based on AEDG

- HVAC : Strategies like Energy Recovery, Dedicated Outdoor Air Systems (DOAS), Demand Control Ventilation
- Plug Loads : 0.7 W/sf, Use of ENERGY STAR equipment, 2/3 laptops of total computers
- Lighting : Use of LEDs, additional 20% savings in lighting energy by daylighting strategies such solar tubes, sky lights, roof monitors



- Using VFD demand based exhaust, highly efficient refrigeration systems for kitchens
- **Regular auditing, operation & maintenance, educating occupants**

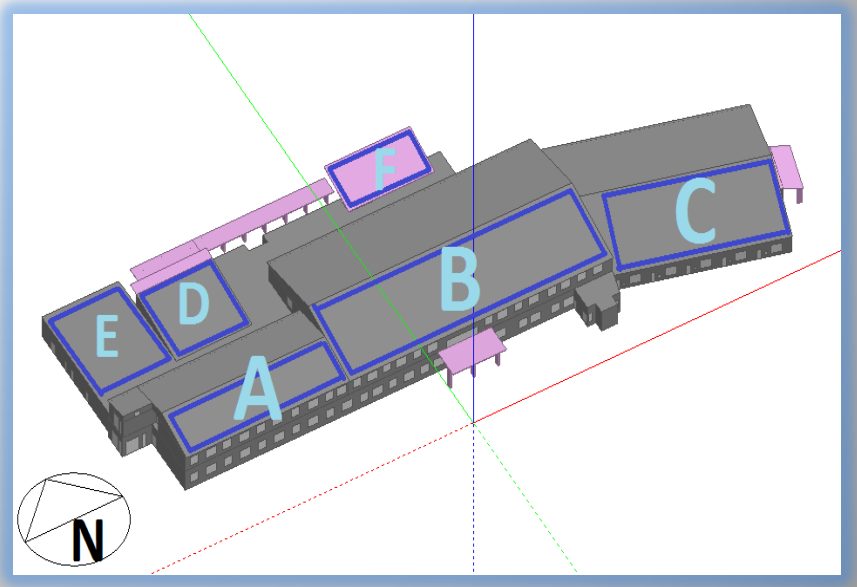
Scope of PV panels to offset energy consumption

- EUI of Proposed Model : 22.71 kBtu/sf/yr
- NREL's PV Watts Calculator: 500 kW array required to completely offset Energy Consumption
- Current PV System: 183 kW, 609 Hanwha Panels, 14 – 15 % efficient
- Additional array required to achieve net zero status : 317 kW (approx.)

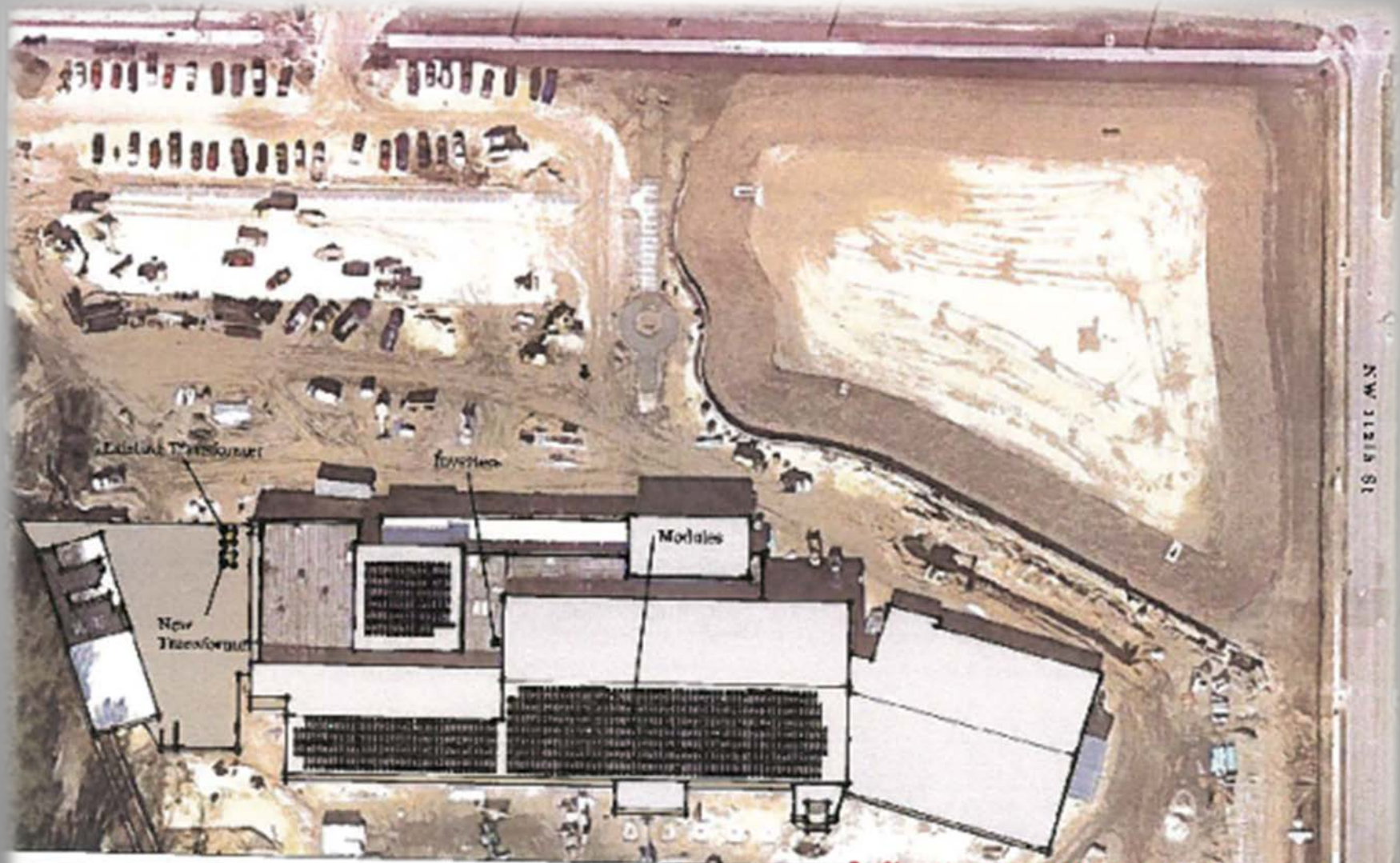
Potential areas for PV installation

- Area available on roof -

A	**4400**	**SF**
B	11700	SF
C	7000	SF
D	3100	SF
E	4500	SF
F	2300	SF
Total:	33000	SF
PV Panel Area = (85%)(33000)= 28050 SF		



- Current PV occupies 18,000 sf.
- Therefore, area available 10,050 sf.
- Cannot achieve Net Zero status on footprint, if existing panels used.



Meadowbrook Solar 1,2,4&5
182.7kW Total
609 Hanwha 300W Modules
11 SMA TriPower Inverters

solar impact

AS-BUILT DRAWING

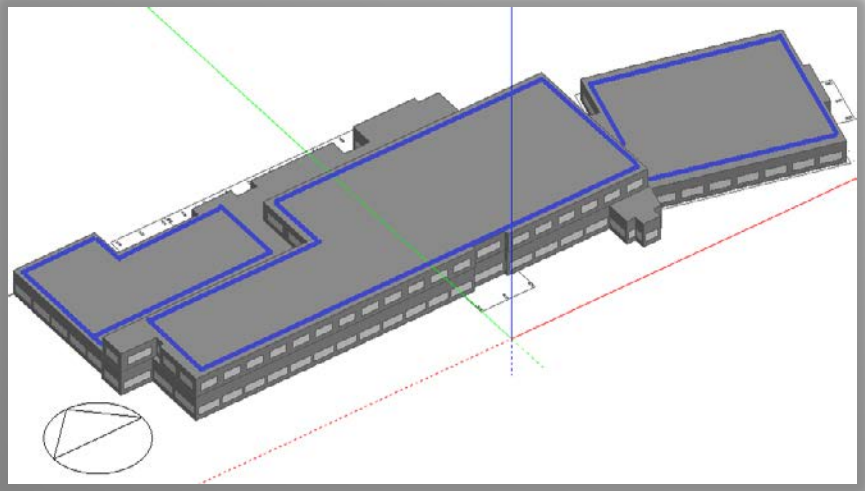
Site Plan
AS BUILT

07 October 2013

Potential areas for PV installation

Solar carport system for parking lot

- PV system support
- Shade for parking
- Minimize radiant heat transfer



- 53,000 sf of roof area is available if flat roof is considered.
- Flat roof increases the PV installation area by 50%

Limitations

- Economics of energy efficiency designs is not discussed in this work
- All the results are based on estimated inputs
- We recommend more detailed research on integrating energy and economic policies for schools in Florida which can motivate them to achieve net zero energy status.

Summary & Conclusions

- NetZero Concept is moving towards next “normal” in the Construction Industry.
- Net Zero Schools are serving as test platforms for adopting technical and financial aspects of NetZero.
- If designed and implemented all NetZero strategies well, Florida is not far away in getting its First Net Zero School.
- Most importantly, making students stewards of NetZero Energy concept is the biggest achievement.

Moving forward

- The cost of existing system was $525K
- An additional 100kW could be added on the roof of Meadowbrook for additional $300K
- Contractor stated almost no issues with the existing building design for installing the solar modules, racking, DC wiring, and inverters since all of the conduits ran on the exterior of the building and
- Based on current marginal cost of electricity of $0.132/kWh, would be approximately a 15-year payback for district which is longer than usual because there are no tax benefits for a school district and assuming 4% electricity inflation.

Meadowbrook Elementary

Installation completed

Total Net Zero

- Would require a total of system total of 500 kW
- Would require an additional ground mounted system of 217 kW to reach Net Zero using existing PV panel arrays
- Ground options could be a covered parking area or the existing roof of the covered play court.
- Additional electrical infrastructure would be needed.

Could District go to NET ZERO?

How many kW would you need to provide 45,000,000 kWh of electrical energy from a PV system? What would be the payback?

Current annual electricity total $7 million

http://www.earthday.org/footprint-calculator

Special Thanks goes to
Charles J. Kibert, Ph.D., P.E.
Holland Professor
Powell Center for Construction & Environment
University of Florida
PO Box 115703
Gainesville, Florida 32611-5703 USA
t: +1 352 273 1189

ACPS Link to all solar projects:
http://www.sbac.edu/pages/ACPS/Departments_Programs/DepartmentsAF/D_thru_F/FacilitiesMainConstr/Energy_Conservation/Solar_Projects

Questions and comments:
Theresa Spurling-Wood, LEED AP, CIE
Spurlita@gm.sbac.edu
352-955-7400 ext 1430

Resources

U.S. DEPARTMENT OF ENERGY

NZE Resources

Commercial Building Consortium

http://www.zeroenergycbc.org/

SEE Action

http://www1.eere.energy.gov/seeaction/

NEEP ZNE Roadmap

http://neep.org/public-policy/energy-efficient-buildings/high-performance-public-buildings/zero-net-energy-buildings

New Buildings Institute

http://newbuildings.org/zero-energy

Discussion

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