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A River of Energy Solutions

Technologies for Net Zero Buildings

Dave Robau & Dr. Jennifer Languell

trifecta

Agenda

- Why We Do What We Do
  - Executive Orders, EPAct05, EISA07, and other fun stuff
  - Federal Requirements/Air Force Directives
- Key Components of a High-Performance Sustainable Building
  - Zero Energy Technologies
  - Renewable Energy Demonstration
- Introduction to Case Study Net Zero Energy Building
- Design Challenges & Features
- Discussion/Conclusions/Findings of Net Zero Energy Building

Dave Robau, LEED GA

Air Force Special Operations Command

Executive Director, Gulf Coast Energy Network
September 2005 - Present
Mr. Robau serves as the founder and Executive Director of the Gulf Coast Energy Network. He leads a network of scientist, engineers, architects, and planners from the various Gulf Coast states to expand the renewable energy market and promote energy conservation. The Network extends from southeast Texas to Tampa, Florida. He also serves on the Executive Steering Committee for the Power Up Energy Expo. Mr. Robau is a registered Green Associate with the U.S. Green Building Council and a member of the Association of Energy Engineers.

Environmental Scientist at US Air Force
December 2005 - Present
Mr. Robau serves as an Environmental Scientist with the U.S. Air Force. The concentration of his work involves developing Strategic Energy and Sustainability Plans and Environmental Management Systems for the Department of Defense, HQ Air Force Special Operations Command at Hurlburt Field, FL. In this capacity, he develops innovative solutions that enable military planners to reduce costs, conserve natural resources, streamline operations, and promote sustainability. He serves on the Hurlburt Field Energy Management Steering Group, Cross-Functional Team, Pollution Prevention Subcommittee, and the Recycling Subcommittee.

Dr. Jennifer Languell

UNIVERSITY OF FLORIDA
CIVIL ENGINEERING

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Trifecta - Sustainability

- Certified over 4 Million Square Feet of 3rd party certified single and multi-family residential
- Over 2 Million Square Feet of certified LEED Projects
- Over 1 Million Square Feet of Green Globes or FGBC Commercial
- Over 30,000 acres of certified Green Developments
- Active Board and Standard Committees
  - USGBC, FGBC, NAHB
- Host Discovery Channel's PROJECT EARTH
- Florida Contractor #1330049

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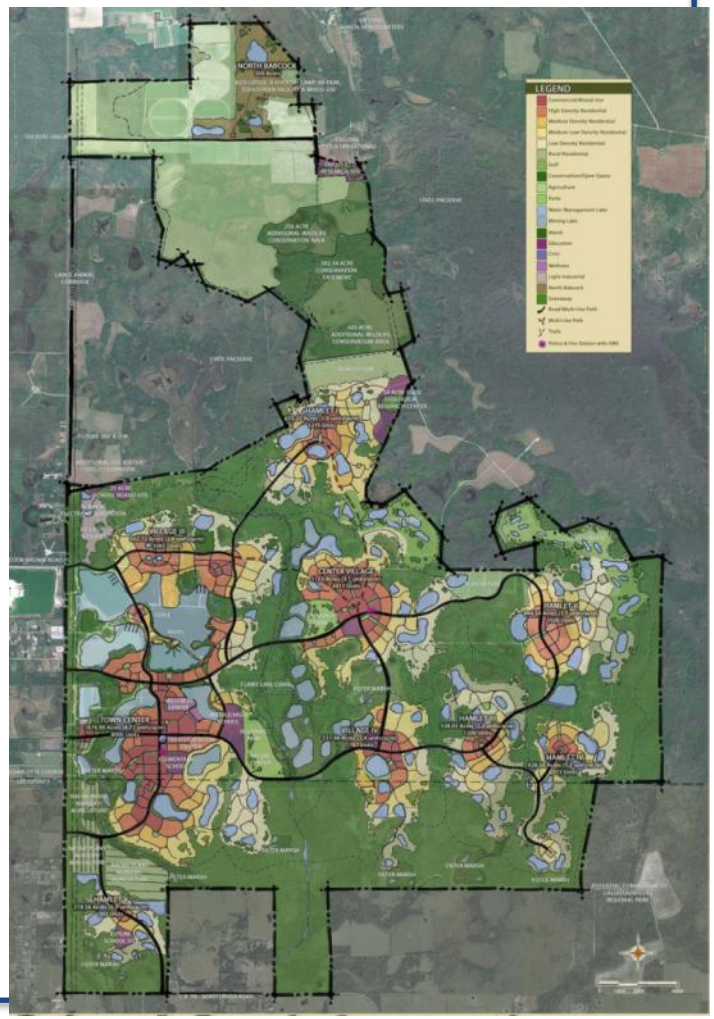

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Discovery CHANNEL

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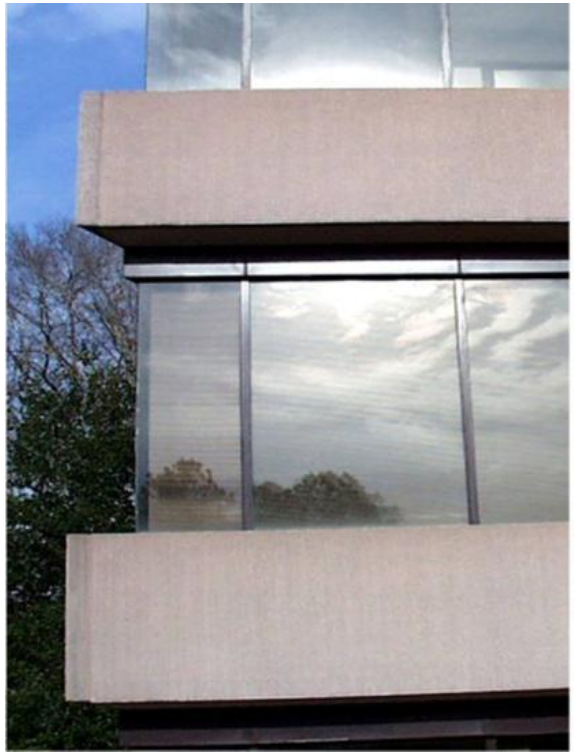
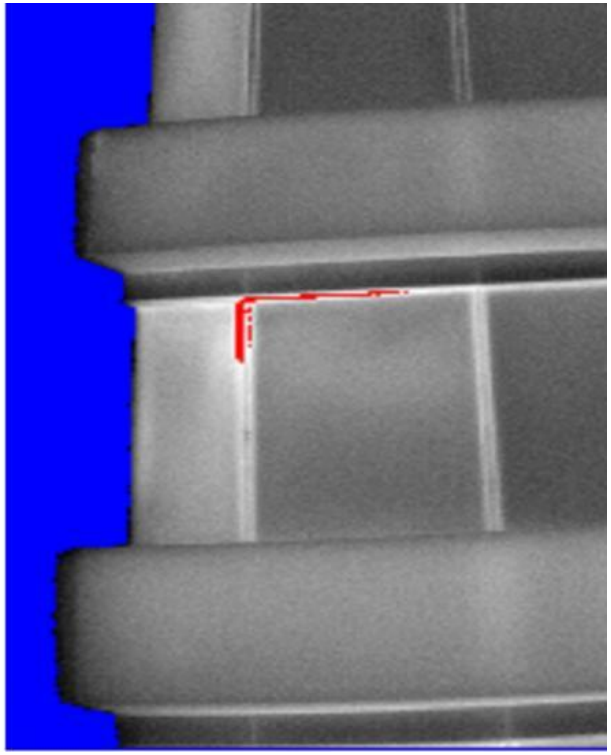
Beware of “Value Engineering”

Buildings have 3 Systems

1. Non – energized (envelope)
   - Windows
   - Doors
   - Roofs
   - Walls





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Buildings have 3 Systems

2. Energized
   - HVAC
   - Lighting
   - Water Heating
   - Plug Loads
   - Process Loads

Buildings have 3 Systems

3. Human
   - Come in building, turn things on
   - And sometimes off
   - Leave door and windows open
   - Require heat, light, air…

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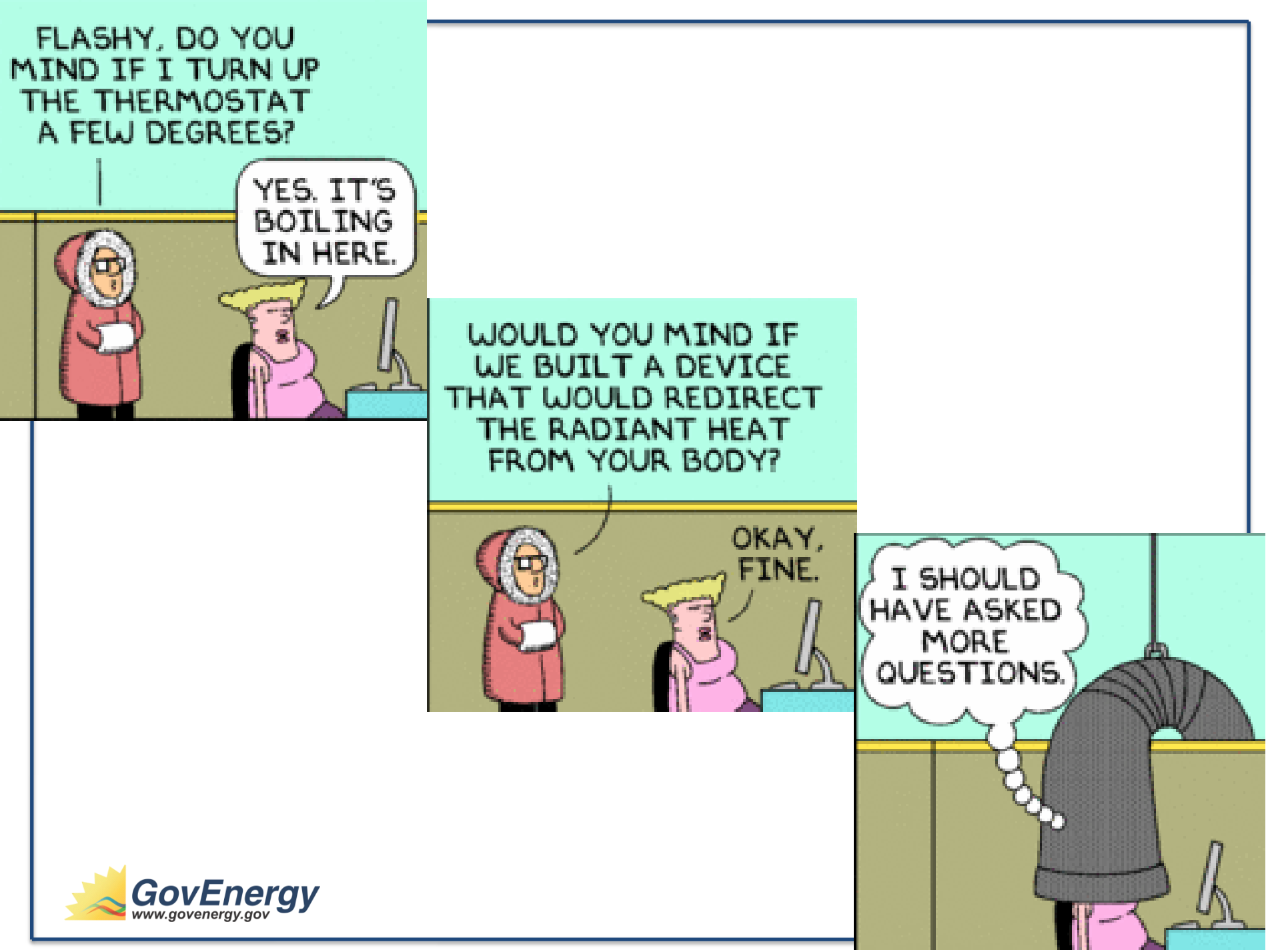
FLASHY, DO YOU MIND IF I TURN UP THE THERMOSTAT A FEW DEGREES?
YES. IT'S BOILING IN HERE.
WOULD YOU MIND IF WE BUILT A DEVICE THAT WOULD REDIRECT THE RADIANT HEAT FROM YOUR BODY?
OKAY, FINE.
I SHOULD HAVE ASKED MORE QUESTIONS.
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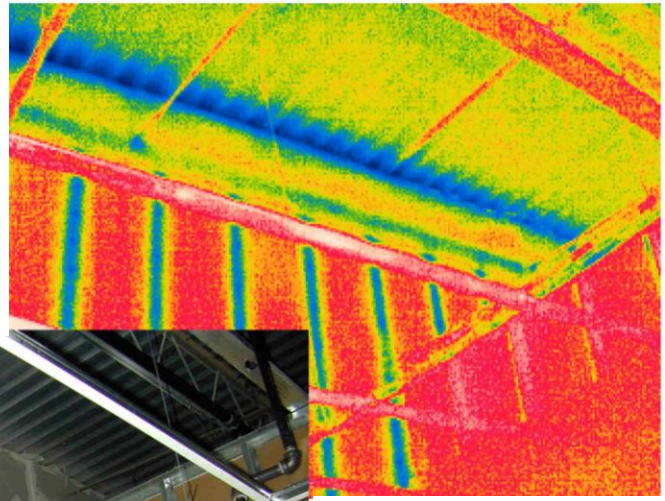
From Sieve to Silver



"You can get heating and cooling savings of 30% by using air barriers only, or by using a whole slew of other things."

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Thermal Comfort?

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What is above those drop ceilings?

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Smoke Test QA/QC

Current Directives

2005

Aug 2005, Energy Policy Act of 2005 (EPAct05)
- New facilities, 30% more efficient than ASHRAE 90.1
- Use of advanced meters

2006

Jan 2006, Federal Leadership in High Performance and Sustainable Buildings MOU (HPSB)
- Establish *Guiding Principles* for new construction
- DoD was first voluntary signatory

2007

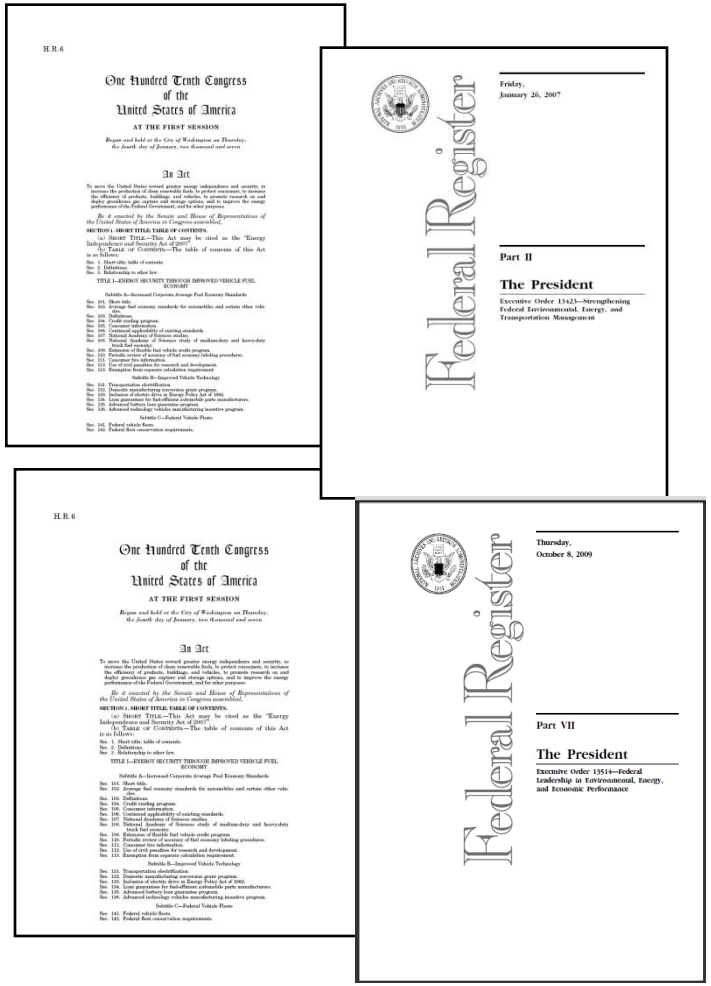
Jan 2007, Executive Order 13423: Strengthening Federal Environmental, Energy and Transportation Management
- Reduce energy consumption 30% by 2015
- Reduce water use 16% by 2015
- All new construction must incorporate HPSB principles
- 15% of existing buildings must be HPSB by 2015

2008

Energy Independence and Security Act (EISA 2007)
- New facilities reduce fossil fuel generated energy, 55% by 2010 – 100% by 2030
- 30% hot water supplied by solar water heaters
- Restore predevelopment hydrology
- Identification and use of a green building rating system

2009

Oct 2009, Executive Order 13514: Federal Leadership in Environmental, Energy and Economic Performance
- GHG reporting requirements for Scope 1, 2, 3
- Each agency shall develop, implement, and annually update an integrated Strategic Sustainability Performance Plan



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Current Directives

- EO 13514, Leadership in Environ
  and Economic Performance (Oct
  - Reinforces and expands requirements of EO 13423
  - GHG reporting requirements for Scope 1, 2, & 3
  - Federal facilities planned after 2020 shall be zero-net-
  - Allows flexibility for compliance (8)
    - Each agency shall develop, implement, and annu
      Strategic Sustainability Performance Plan and wi
      on lifecycle return on investment

Sec. 8. *Agency Strategic Sustainability Performance Plan.* Each agency shall develop, implement, and annually update an integrated Strategic Sustainability Performance Plan that will prioritize agency actions based on lifecycle return on investment. Each agency Plan and update shall be subject to approval by the OMB Director under section 4 of this order. With respect to the period beginning in fiscal year 2011 and continuing through the end of fiscal year 2021, each agency Plan shall:

(a) include a policy statement committing the agency to compliance with environmental and energy statutes, regulations, and Executive Orders;

(b) achieve the sustainability goals and targets, including greenhouse gas reduction targets, established under section 2 of this order;

(c) be integrated into the agency's strategic planning and budget process, including the agency's strategic plan under section 3 of the Government Performance and Results Act of 1993, as amended (5 U.S.C. 306);

(d) identify agency activities, policies, plans, procedures, and practices that are relevant to the agency's implementation of this order, and where necessary, provide for development and implementation of new or revised policies, plans, procedures, and practices;

(e) identify specific agency goals, a schedule, milestones, and approaches for achieving results, and quantifiable metrics for agency implementation of this order;

(f) take into consideration environmental measures as well as economic and social benefits and costs in evaluating projects and activities based on lifecycle return on investment;

(g) outline planned actions to provide information about agency progress and performance with respect to achieving the goals of this order on a publicly available Federal website;

(h) incorporate actions for achieving progress metrics identified by the OMB Director and the CEQ Chair;

(i) evaluate agency climate-change risks and vulnerabilities to manage the effects of climate change on the agency's operations and mission in both the short and long term; and

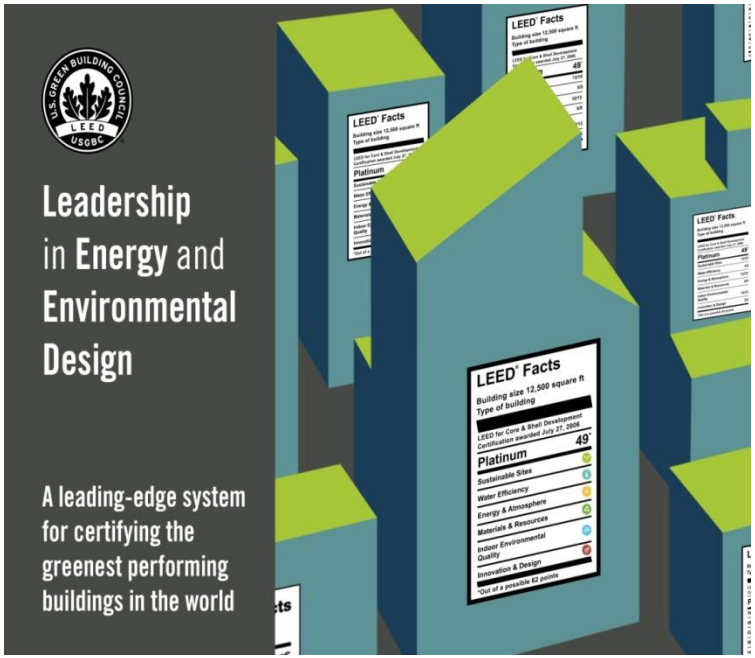
(j) identify in annual updates opportunities for improvement and evaluation of past performance in order to extend or expand projects that have net lifecycle benefits, and reassess or discontinue under-performing projects.

Current Directives

- Revision of policy memorandum nearing final draft
  - All construction that meets the USGBC LEED 2009 Minimum Program Requirements (MPRs) *will receive formal LEED Silver Certification* as the minimum certification level
    - Incorporates requirements of DoD Infrastructure Sustainability Policy memo (draft) – minimum of 20 points in energy and water
  - Incorporates Federal High Performance and Sustainable Building (HPSB) requirements of EPAct 05, EO 13423, EISA 07, and EO 13514
  - Requires life-cycle cost analysis
  - Provides sustainable benchmarks for other project types – Horizontal, Utility, and Industrial
  - Installations shall use AF MILCON Requirements Scoresheet to track and report HPSB and LEED status at four key milestones

High-Performance Buildings

- Key Components of a High-Performance Sustainable Building
- Places the Focus On:
  - Integrated Design
  - Energy Performance
  - Protect & Conserve Water
  - Enhance IEQ
  - Resource Conservation



Remember: A LEED Certified Building is not *always* a HPSB

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Why LEED?

IMPACTS OF U.S. BUILDINGS ON RESOURCES

40% primary energy use*

72% electricity consumption*

39% CO_2 emissions*

13.6% potable water consumption**

- Global CO_2 Emissions By Sector:
  - #1 Buildings
  - #2 Transportation
  - #3 Industry

Sources:
*Environmental Information Administration (2008). EIA Annual Energy Outlook.
** U.S. Geological Survey (2000). 2000 data.

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Net Zero Energy Buildings

- Executive Order 13514, Leadership in Environmental, Energy, and Economic Performance (Oct 09)
  - Reinforces and expands requirements of EO 13423
  - Advanced Metering (EPAct 2005, EISA 2007)
  - Energy Intensity Reduction Mandates (Btu/ft2)
  - Federal facilities planned after 2020 shall be zero-net-energy
  - Each agency shall develop, implement, and annually update an integrated Strategic Sustainability Performance Plan and will prioritize agency actions based on lifecycle return on investment

ZEB Definitions

- In concept, a net ZEB is a building with greatly reduced energy needs through efficiency gains such that the balance of the energy needs can be supplied by renewable technologies[1]
- Over a 12-month period, a ZEB produces all of its required energy and oftentimes provides excess power to the electrical grid
- A smart ZEB should first encourage energy efficiency, and then use renewable energy sources available on site (or off site)
- A building that buys all its energy from a wind farm or other central location has little incentive to reduce building loads

Zero Energy Buildings: A Critical Look at the Definition[1]

Paul Torcellini, Shanti Pless, and Michael Deru, USDOE, National Renewable Energy Laboratory

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Renewable Energy Supply

ZEB Renewable Energy Supply Option Hierarchy

Option Number	ZEB Supply-Side Options	Examples
0	Reduce site energy use through low-energy building technologies	Daylighting, high-efficiency HVAC equipment, natural ventilation, evaporative cooling, etc.
	On-Site Supply Options	
1	Use renewable energy sources available within the building's footprint	PV, solar hot water, and wind located on the building
2	Use renewable energy sources available at the site	PV, solar hot water, low-impact hydro, and wind located on-site, but not on the building
	Off-Site Supply Options	
3	Use renewable energy sources available off site to generate energy on site	Biomass, wood pellets, ethanol, or biodiesel that can be imported from off site, or waste streams from on-site processes that can be used on-site to generate electricity and heat
4	Purchase off-site renewable energy sources	Utility-based wind, PV, emissions credits, or other "green" purchasing options. Hydroelectric is sometimes considered

Why Go ZEB?

- Minimize overall environmental impacts by encouraging energy-efficient building design and construction (i.e. LEED/HPSB)
- Meet the Federal/State mandates associated with energy/carbon
- Provide Energy Security for critical infrastructure
- Reduce carbon emissions and environmental permitted requirements
- Eliminate our dependence of volatile/finite sources of energy
- Better forecasting for long-term strategic energy planning
- Ensure that power will be available over the lifetime of the building
- Eliminate line loss from the electrical grid (improve efficiency)
- Reduce external costs (transportation and conversion losses)
- Make best use of taxpayer dollars

Zero Energy Technologies

Among other important areas, Design Teams should focus on:

- Building Envelope
- HVAC Equipment/Delivery System
- Building Automation Systems
- Lighting Controls & Sensors

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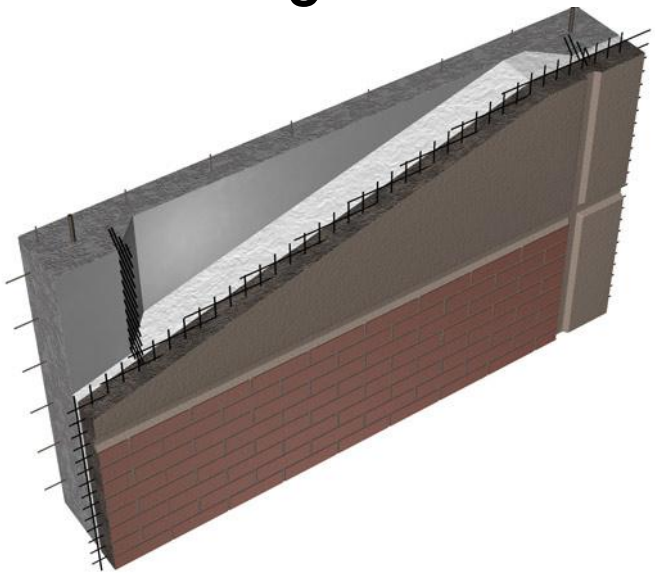
Zero Energy Technologies

Building Envelope

- Increase Efficiency
- AT/FP Setbacks
- Windload Ratings



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Zero Energy Technologies

HVAC Equipment/Delivery System

- Advanced High-Performance Equip
- Ground Source Heat Pumps*
- Enhanced Commissioning
- Goal Setting (Surpass ASHRAE 90

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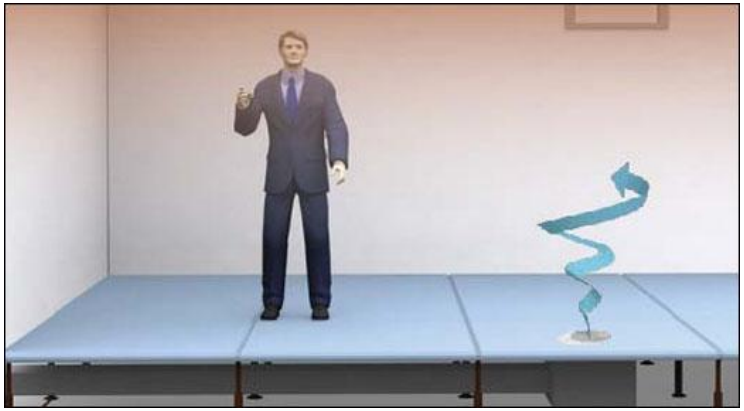
Zero Energy Technologies

HVAC Delivery System

Underfloor Air Distribution System

- Raised Access Floor System
- Very Efficient Passive Design
- Conditions “Breathing Zone”
- Provides Occupant Control



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Zero Energy Technologies

Building Automation Systems

- Monitors/Controls HVAC & Lighting Systems
- Continuous Logging of IAQ
- Schedules Setpoints and setbacks

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Zero Energy Technologies

Lighting Controls & Sensors

- Light Level Tuning
- Occupancy/Vacancy Sensors
- Dashboards (Real-time data)

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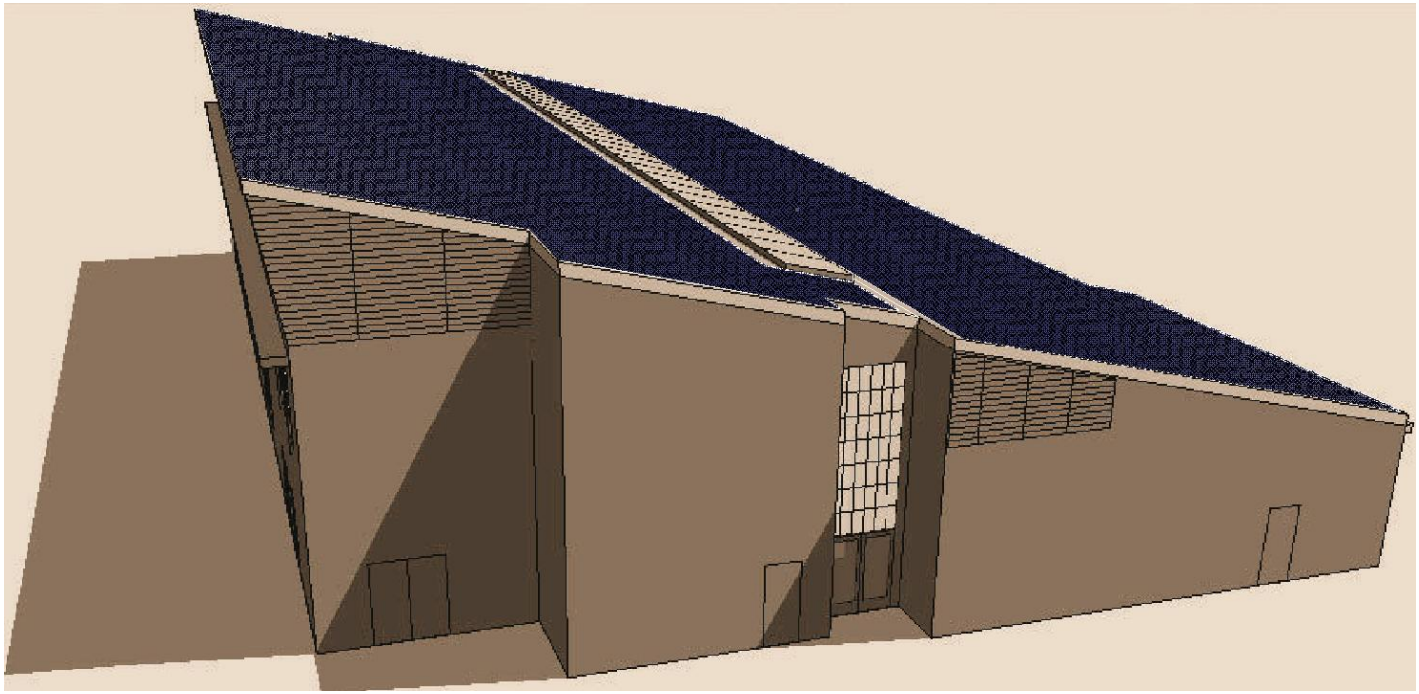
AFCEE Zero-Net Energy Demonstration Study

Professional Development and Education Center

Hurlburt Field, FL



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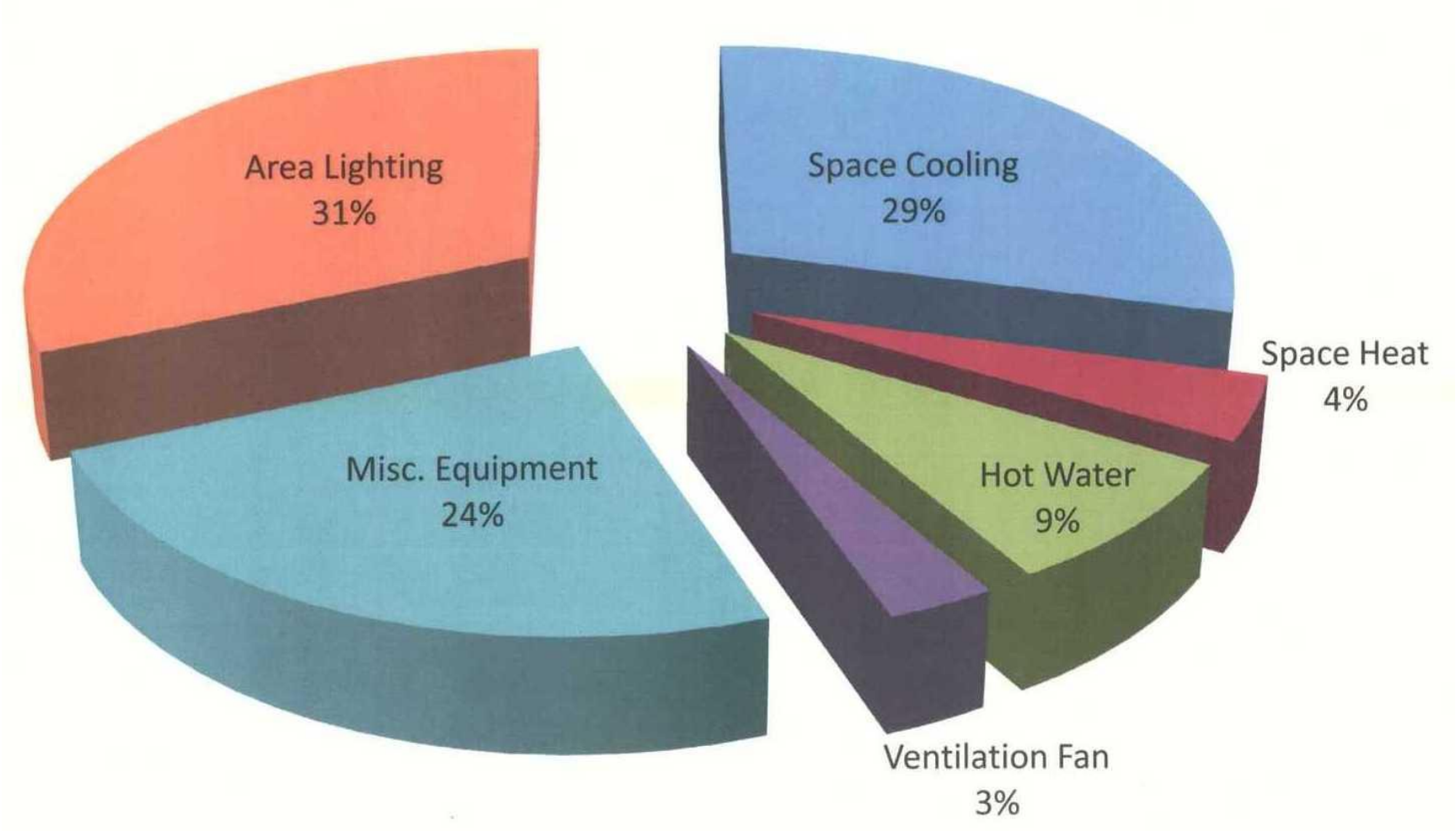
AFCEE ZNE Pilot Project

Generic Energy Consumption - Commercial Buildings



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AFCEE ZNE Pilot Project

Net-Zero Site Energy:

- Produces Renewable Annually ≥ non-renewable used (at site)

Design Approach:

- Lowest Life Cycle Cost.
- 5' Line…Low Maintenance & Off-the-Shelf +
- Optimize Building &System Efficiency
- Renewables to Achieve Zero-Net.

Studies / Analysis:

- Life Cycle Cost Analyses
- DoE Building Life Cycle Cost (BLCC5 .3-10)
- Energy Trane TRACE 700.
- Water efficiency In-House

Department of Air Force

- June 2, 2011
- Memorandum
- Air Force Sustainable Design and Development (SDD) Implementing Guidance
- Timothy A Byers, Maj Gen, USAF

Air Force SDD Implementing Guidance

- As it relates to LEED
- Registered
- Formally Certified
- Achieve LEED Silver minimum (50 points)
- 20 points MUST come from ENERGY & WATER
- Requires life-cycle cost analysis

U.S. GREEN BUILDING COUNCIL

LEED™

LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

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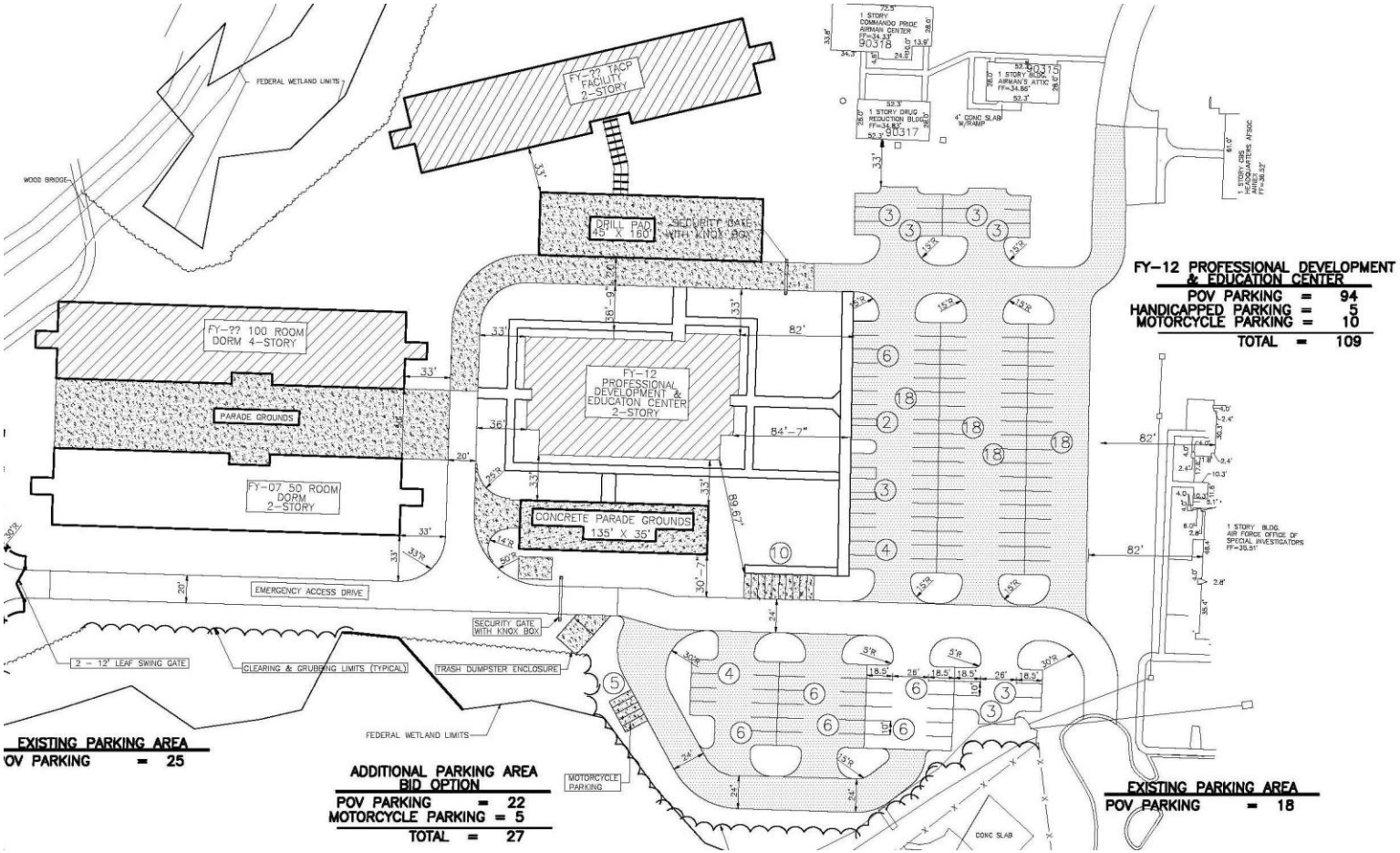
AFCEE Zero-Net Energy Pilot Project

Professional Development & Educational Center – Hurlburt Field, FL



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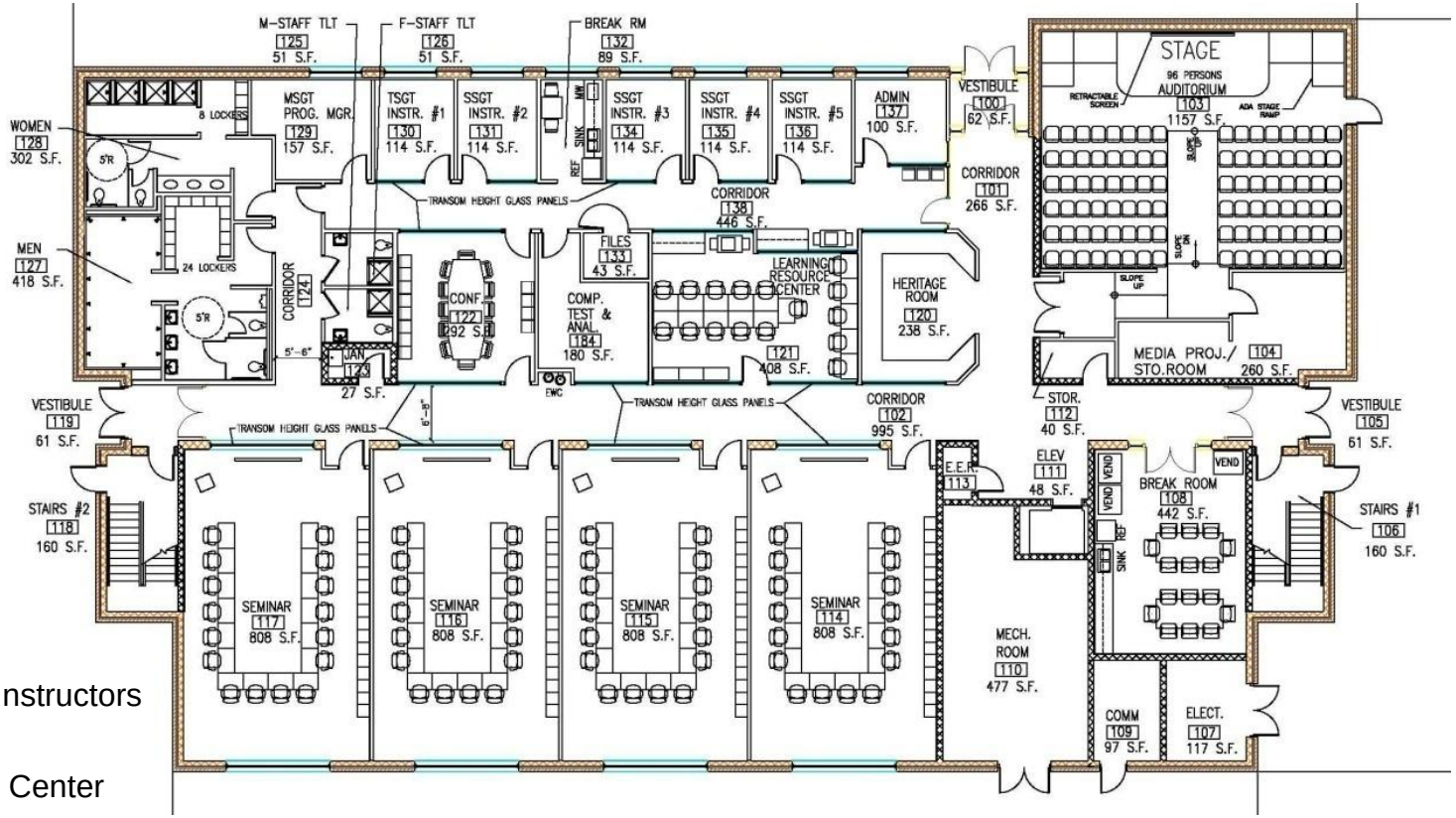
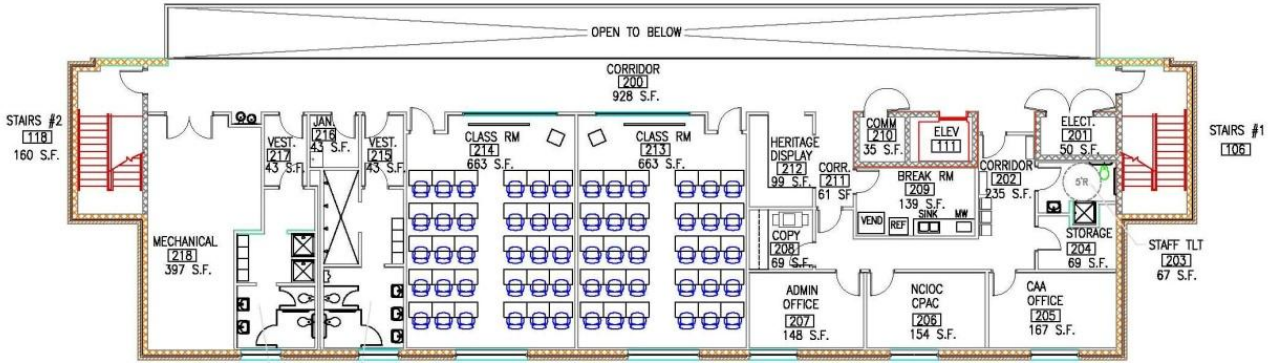
Site Plan



First Floor

- Class Rooms
- Private Offices for Instructors
- Auditorium
- Learning Resource Center
- Conference Room
- Break Room
- Showers



Second Floor

- Class Rooms
- Private Offices for Instructors
- Break Room
- Showers.

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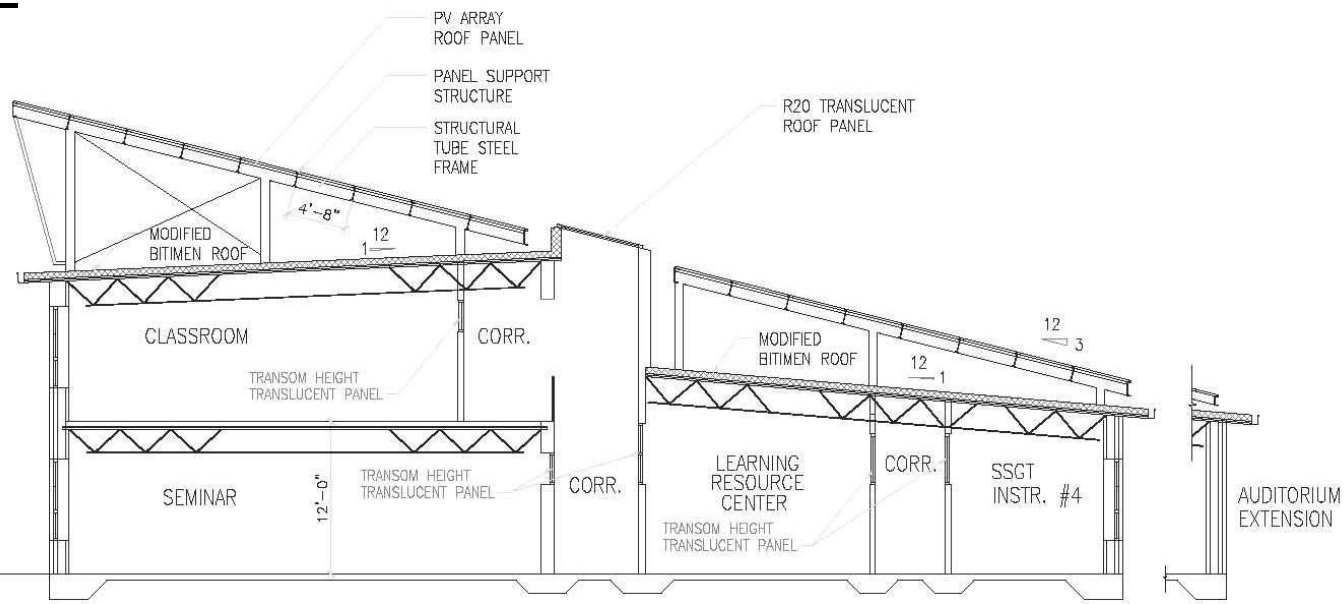
West Elevation



Section

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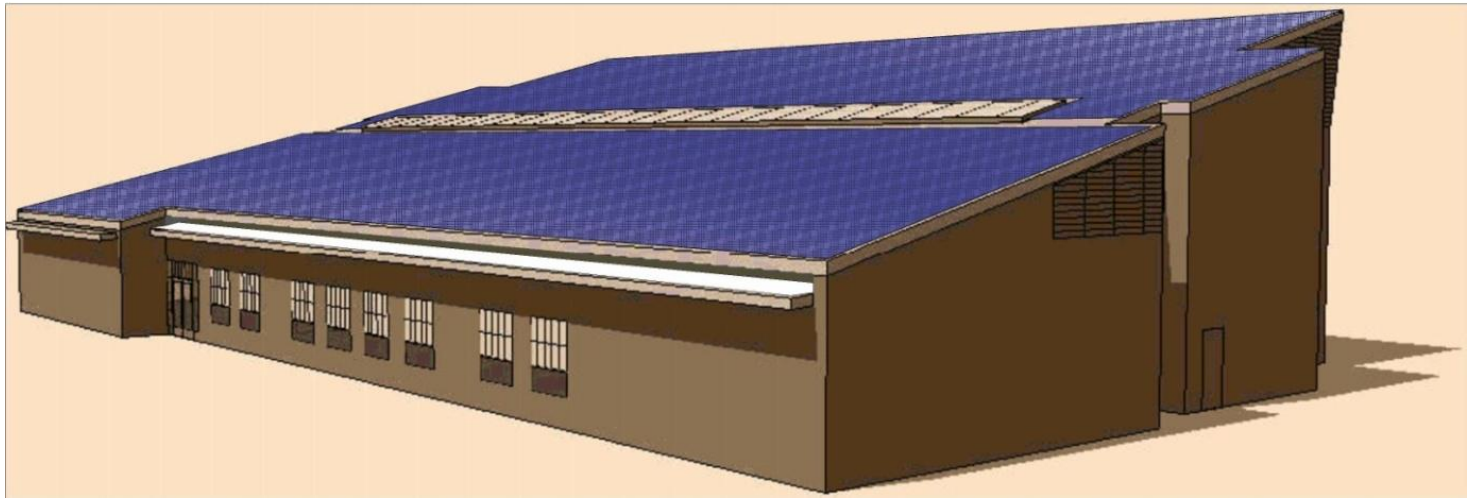
Roof Sensitivity Study

	First Cost	Energy Cost ($/yr)	Energy Savings ($/yr)
PDEC Built Up Roof R-15	$144,928	$32,806	$(166.20)
ASHRAE Baseline Roof, R-24.5	$176,988	$32,640	BASE
PDEC Built Up Roof R-30	$192,924	$32,685	$(44.65)
PDEC Built Up Roof R-38	$206,755	$32,701	$(60.68)
PDEC BUILT UP ROOF R-50	$222,690	$32,621	$ 18.98



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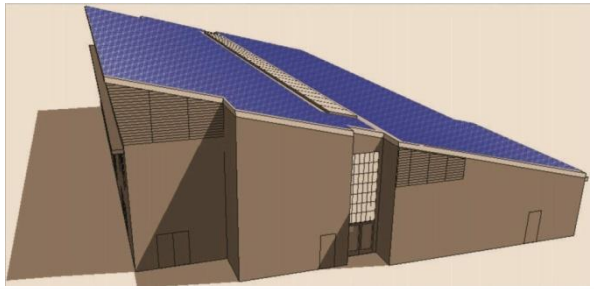
PDEC ZNE Study Model Elevation - South East Corner

Wall Sensitivity Study

	First Cost	Energy Cost ($/yr)	Energy Savings ($/yr)	Square Footage Losses
ASHRAE BASELINE WALL R8	$77,109	$32,011		Base
PDEC Wall-2" Polystyrene btwn wythes	$195,032	$31,613	$397	
PDEC Wall-2" Poly Btwn wythes + R13	$197,917	$31,532	$479	69
PDEC Wall-2" Poly Btwn wythes + R19	$201,112	$31,448	$563	241
PDEC Wall-2" Poly Btwn wythes + R30	$204,815	$31,413	$598	446
PDEC Wall-2" Poly Btwn wythes + R38	$208,502	$31,402	$609	616
PDEC Wall - 2" Poly Btwn wythes + 6" Spray Foam	$232,990	$31,432	$580	241
Split Face Block over R-20 ICF	$298,473	$31,435	$577	244
Split Face Block over R-49 ICF	$333,944	$31,351	$660	520
Metal Siding, 4" Insulation	$75,602	$31,704	$307	n/a
6" Exterior Insulation, 12" Concrete	$204,410	$31,474	$537	310



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HVAC System Alternatives

System	MBTU	Energy Cost per Year	% Energy Savings from Base	Annual Cost Savings	EPAct 2005
BASE CASE	1086	$30,437			
Model 1- VAV	951	$26,680	12.4%	$3,757	
Model 2-VAV with Total Energy Wheel heat recovery	879	$24,704	19.0%	$5,733	
Model 3-Reduced Lighting Power	746	$20,700	31.3%	$9,737	yes
Model 4- Improved Walls, Windows, and Skylights	694	$19,328	35.6%	$10,956	yes
Model 5- Under-floor Air Distribution	731	$20,413	32.2%	$9,871	yes
Model 6- Chilled Beam	775	$21,745	28.1%	$8,539	
Model 7-Water Source Heat Pumps	787	$21,541	27.1%	$8,743	
Model 8-Ground-Coupled Water Source Heat Pumps	743	$20,804	31.1%	$9,480	yes
Model 9- VAV w/DOAS	704	$19,659	34.7%	$10,625	yes
Model 10-Radiant Floor Heating/Cooling	709	$19,740	34.3%	$10,544	yes
Model 11 – Model 4 with high eff heat pump chiller, boiler and HW	635	$18,605	41.5%	$11,832	yes
Model 15 – DX/Gas Package with lo lgt, kallwall, glazing walls	882	$24,509	18.7%	$5,928	

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Not all designs achieved EPAct

HVAC System Alternatives

System	MBTU	Cost per Year	% Energy Savings from Base	Annual Cost Savings	EPAct 2005	LEED Point
BASE CASE	1352	$36,420				
Model 11 - Heat Pump Boiler/Chiller	844	$24,742	37.5%	$12,085	yes	13
Model 12 - Model 11 with Economizer	838	$24,555	38.0%	$12,272	yes	13
Model 13 - R-160 Walls & Roof	838	$24,538	38.1%	$12,289	yes	13
Model 14 - Model 11 with Gas Boiler	959	$25,596	29.0%	$11,231		9

Envelope and equipment optimization topped out a
41%better than ASHRAE '07

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NPV of HVAC Alternatives

Alternative	Initial Cost (PV)	Life Cycle Cost (PV)	ZNEB LCC Cost
ASHRAE BASE *	$305,665	$911,787	$3,018,827
Model 1 - VAV, Term Ht, Chlr, Blr	$701,225	$1,383,943	$3,229,568
Model 3 - VAV, TEW, Low Lgt Pwr	$711,635	$1,324,435	$2,772,212
Model 2 - VAV, Add Total Energy Wheel (TEW)	$719,584	$1,431,945	$3,138,032
Model 4 - VAV, Lo Lgt, Kalwall, Glass upgr	$740,239	$1,330,995	$2,679,019
Model 9 - VAV W/DOAS	$770,730	$1,372,151	$2,739,000
Model 7 - Water Source Heat Pumps	$778,897	$1,379,014	$2,905,973
Model 6 - Chilled Beam System, DOAS	$805,902	$1,401,298	$2,905,744
Model 10 - VAV, TEW, Undrflr Air Radiant Heat	$808,790	$1,408,114	$2,783,696
Model 11a – Model 4 w/Ht Pump Clr, Blr DHW	$815,613	$1,397,220	$2,629,577
Model 8 - Ground Coupled Heat Pumps	$1,083,520	$1,641,205	$3,082,966
Model 5 - Underfloor w/Baseboard Radiant-DOAS	$1,521,338	$2,128,018	$3,547,461

Grey – not 30%
PV cost to achieve ZEB $1.2M - $2.2M

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NPV of HVAC Alternatives

Alternative	Initial Cost (PV)	Life Cycle Cost (PV)	ZNEB LCC Cost
ASHRAE BASE *	$305,665	$911,787	$3,018,827
Model 3 – 31.3%	$711,635	$1,324,435	$2,772,212
Model 4 – 35.6%	$740,239	$1,330,995	$2,679,019
Model 9 – 34.7%	$770,730	$1,372,151	$2,739,000
Model 11a – 37.5%	$815,613	$1,397,220	$2,629,577

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Not 41.5% - due to adjusting plug load

LCC Water Heating Alternatives

System	Cost Per Year	% Cost Savings From Base	Annual Cost Savings	Initial Cost($)	Life Cycle Cost ($)
Model 1 - Electric Water Heater on Grid Power	$2,780			$19,355	$62,726
Model 2 - Heat Pump WH on Grid Power	$1,059	61.9%	$1,721	$21,300	$40,103
Model 3 - Gas WH @ 85% Efficiency	$1,057	62.0%	$1,723	$19,296	$37,026
Model 4 - 30% Solar Thermal WH w/ Heat Pump Backup	$842	69.7%	$1,938	$71,749	$116,078
Model 5 - Heat Pump WH on PV-Only Power	$1,918	31.0%	$861	$99,079	$109,779
Model 6 - 100% Solar Thermal-No Backup	$720	74.1%	$2,059	$100,989	$134,930
Model 7 - 100% Solar Thermal Heat Pump Backup	$2	99.9%	$2,778	$103,654	$138,295

3 – lowest LCC – but gas, EISA and more complicated clacs
2 – low LCC – easy to offset with PV's
4 – EISA – NOT lowest LCC…

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Hot Water Recommendation

- Compared to heat pump on grid power or gas water heating (from local utility)
- None of the solar water heating options are cost effective, based on LCCA.
- From a ZNE perspective
- If primary goal is ZNE
- Recommended system = water source heat pump on photovoltaic power.

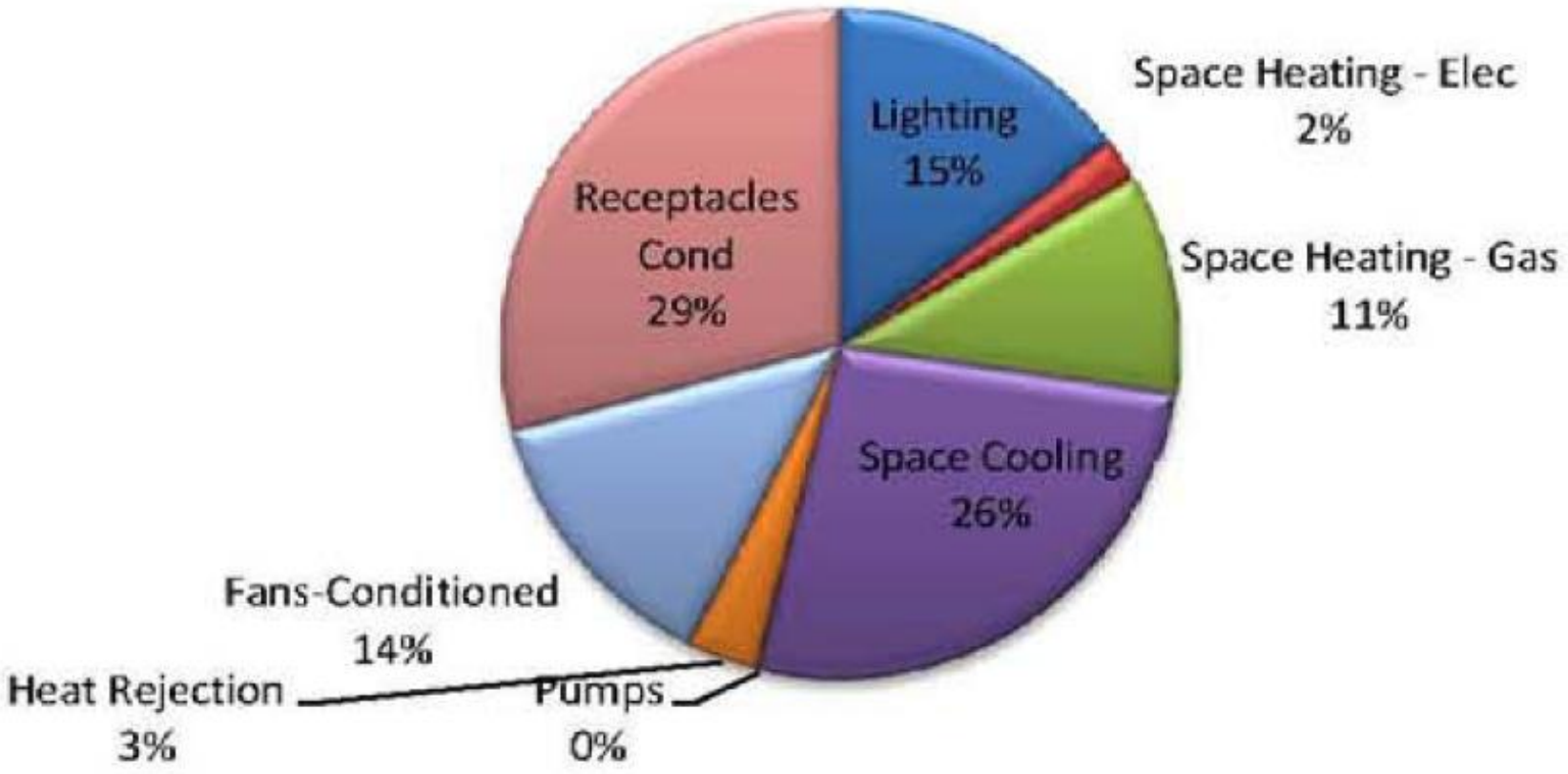
Lighting and Electrical

Lighting:

- Lighting Reduced to 9.6% of Total Building Energy
- Site Lighting:
  - Baseline – ASH RAE 90.1 0.15 watts/sf
  - Design - 0.0256 watts/sf
- Interior Lighting:
  - Baseline - 1.2 watts/sf.
  - Design - T-5 (majority), LED (auditorium) 0.47 watts/sf
- Lighting Control:
  - Classrooms, Offices, and Break areas to have dual technology occupancy sensors.
  - Daylighting Controls not recommended due to small size and large number of hard walled rooms…and not a lot of windows

AFCEE ZNE Pilot Project

ASHRAE 90.1 BASE CASE Energy Usage



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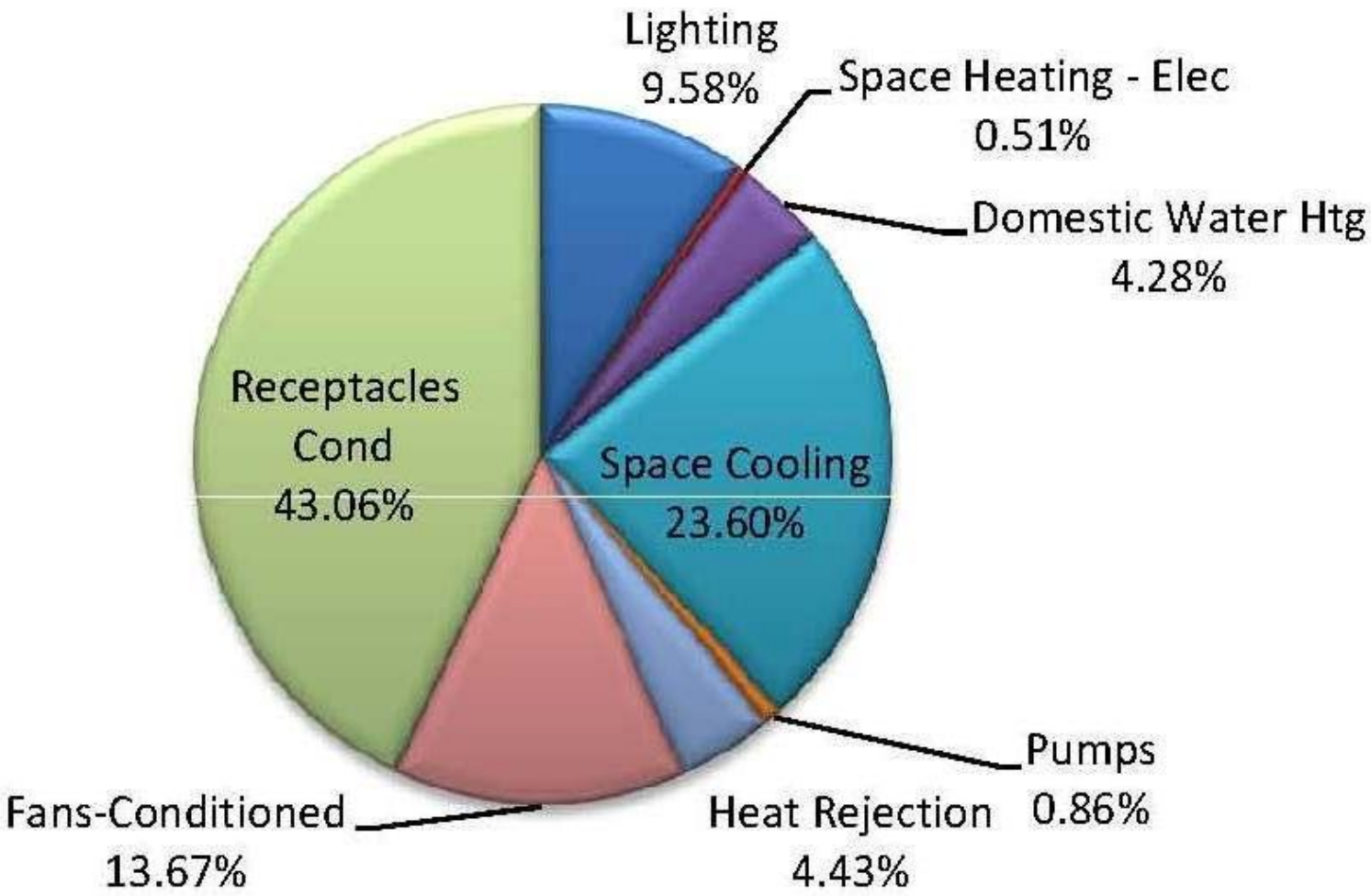
AFCEE ZNE Pilot Project

Energy Profile for ZNE PDEC



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Lighting and Electrical

Miscellaneous Equipment (Plug Load):

- Minimize Plug Load
  - Work With / Educate Owner to Make Operational / Energy Trade-Offs.
  - Laptops in Learning Resource Center and Instructor Offices.

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Renewable Energy

Alternatives Studied:

- Purchase Green Energy Credits
- Wind Turbine Energy
- Wood Pellet Heating
- …Drive Steam Turbine.
  - Equipment First Cost Prohibitive Factor. 75 kW Self Contained Turbine Greater Than $1M Before Cost of Fuel.
- Photovoltaic (PV).
  - Studied Thin Film and Polycrystalline Panels.
  - Thin Film Less Efficient Requiring Greater Square Footage.

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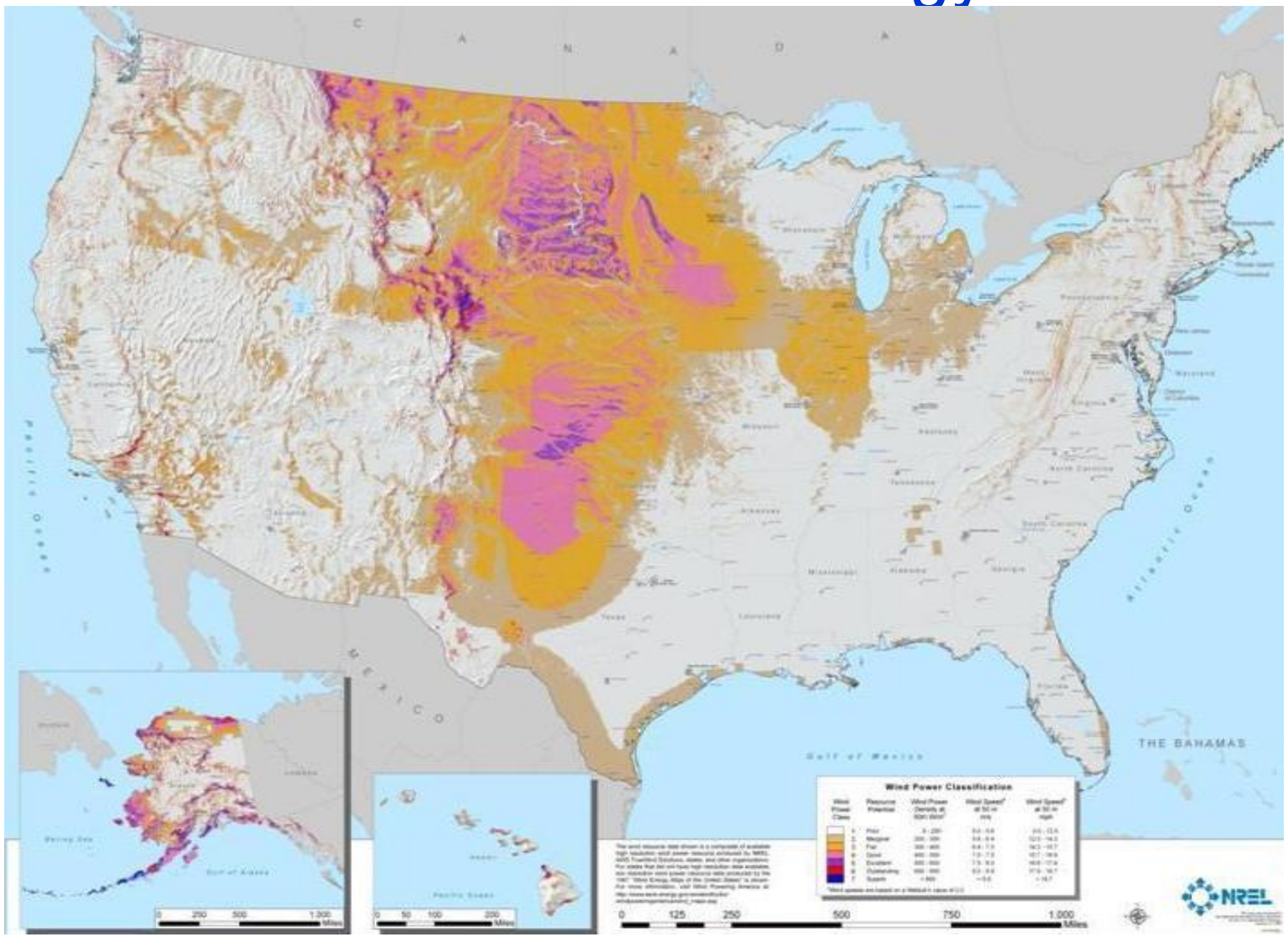
Renewable Energy



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50 Meter Wind Power Resource

Wind – Not So Much for Florida

	Available % of State	% of Total Windy Land Excluded	Installed Capacity[3] (MW)	Annual Generation (GWh)
Alabama	0.02%	70.6%	118.2	333
Arizona	0.74%	52.0%	10,904.1	30,616
Arkansas	1.34%	60.5%	9,200.3	26,906
California	1.67%	74.6%	34,110.2	105,646
Colorado	28.73%	19.2%	387,219.5	1,288,490
Connecticut	0.04%	83.1%	26.5	73
Delaware	0.04%	94.8%	9.5	26
Florida	0.00%	99.2%	0.4	1
Georgia	0.02%	90.7%	130.1	380

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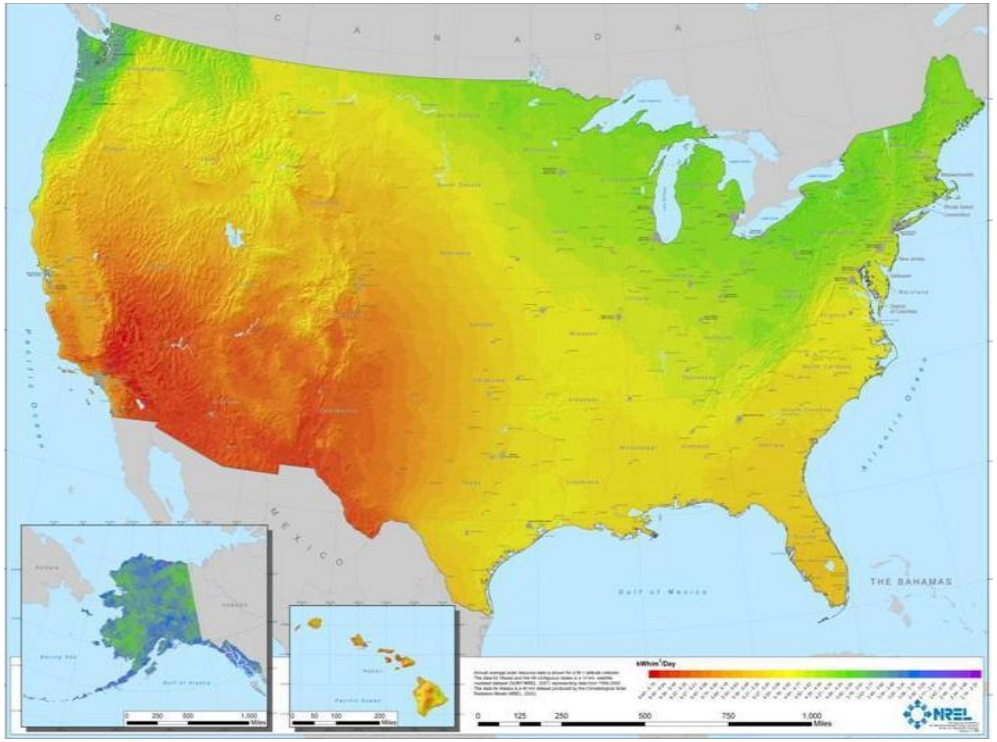
Renewable Energy

Photovoltaic (PV):

- Most Viable and Cost Effective of Alternatives.
- 220 kW Polycrystalline Panel System
- 19,000sf Required Covering Roof & Parade Grounds
- Panels and Structure - $1.7M.



Photovoltaic Solar Resource

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PVs

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Renewable Energy

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Plumbing / Irrigation

Low Flow Fixtures:

- Dual-Volume Flush Valves for Water Closets (1.6 gpf solids & 1.1 gpf liquids)
- 1-pint Flush Urinals
- Lavatories (0.5 gpm)
- Showers (1.5 gpm)

Drip or No Irrigation:

- Xeriscape Plantings.
- Minimize Groundcover.

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Plumbing / Irrigation

Rainwater Harvesting Using UG Storage Cistern

- Potable Water Backup
- Flushing and Irrigation.
- Collects Water from Roof
- Conserves Energy to Treat, Distribute, and Pump Back to WWTP (OUTSIDE 5' Line)

	Potable Water Wastewater Conveyance (annual gallons)	% Reduction From Base	Initial Cost ($)	Life Cycle Costs ($)
Base Design	123,500		$30,935	$1,777
Low Flow Design	88,075	71%	$30,935	$1,777
Low Flow with Cistern	0	100%	$79,535	$4,568

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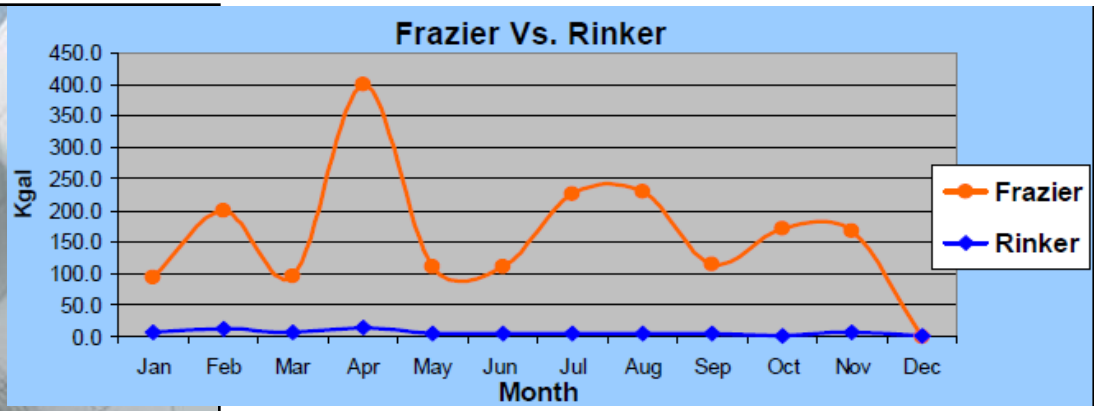

Cister

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Energy Usage Verification

PER EO's

Energy Monitoring, Metering, and Verification.

- Required for LEED and for ZNE.
- Sub-Metering all Electrical, HVAC, and Hot Water Systems

DDC Controls"

- Monitor/Control
  - All HVAC and Renewable Energy Systems, Including Rainwater Harvesting (as applicable).
  - Metering for Energy Usage/Verification on Water, Electrical, Gas
  - Sub-metering for Chiller Plant, Boiler Plant, and Water Heating.
- Metering and Verification Information Handled by / Stored on building DDC; Transmitted to Base Wide Host.

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Cost Impact to Achieve ZEB

Overall Cost Estimate

- Total Rounded Request $10.4M; Increase of $1.7 M.

Primary Facilities:

- Increased from $4.841M (17,760 sf at $272/sf) to $6.988M (17,940 sf at $389 / sf).
- Additional materials (structural steel framing for support of photovoltaic systems, Kalwal-type translucent panels, etc.) and systems (water storage cistern and associated piping, solar hot-water heating, etc.).
- Some saving in overall building structure was realized due to the building being modified from a two story “stacked” to a story and a half “lean-to” structure.

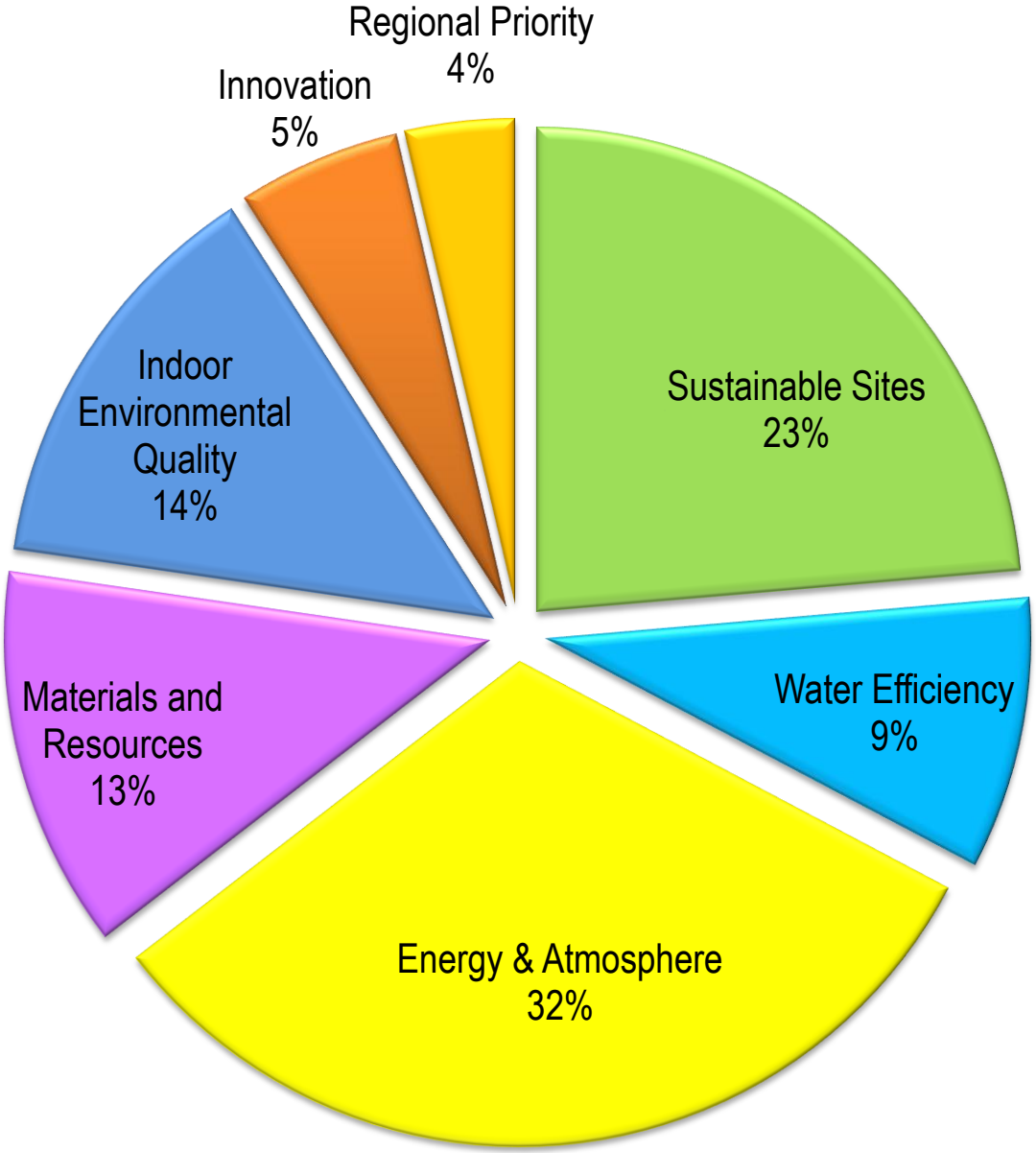
Supporting Facilities:

- Decreased from $2.666M to $1.975M
- Decrease in pavements and exterior communications infrastructure.

US Green Building Council

LEED LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN	Points Available	Points Targeted	Additional Possible Points	NA
Sustainable Sites	26	12		14
Water Efficiency	10	6	4	
Energy & Atmosphere	35	27	6	2
Materials & Resources	14	3	5	6
Indoor Environmental Quality	15	11	1	3
Innovation Credits	6	2	4	
Regional Priority Credits	4	3	1	
TOTAL LEED POINTS	110	64	21	25

LEED Credit Breakdown



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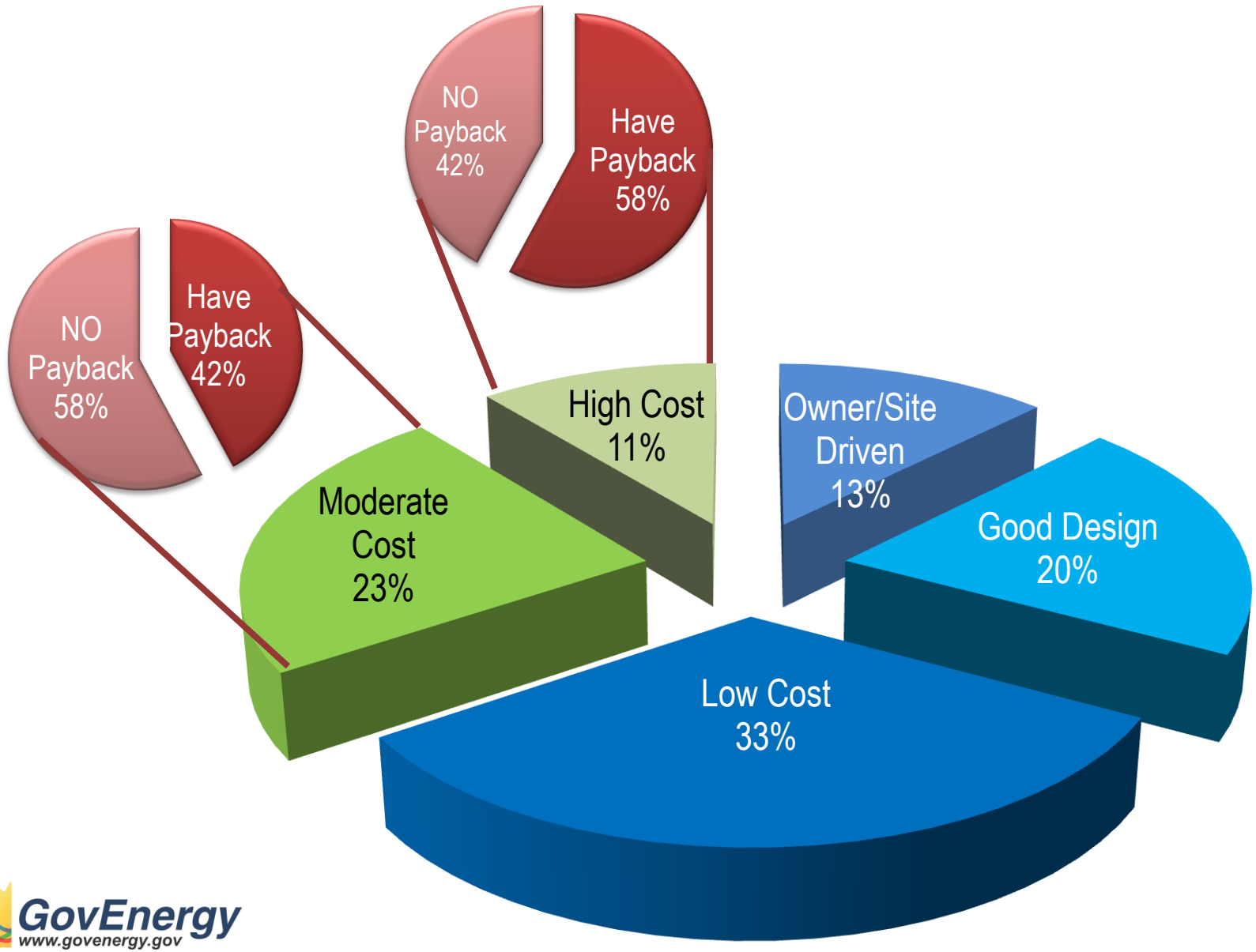
LEED Credit Cost



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Thoughts

- In this climate, optimized design, based on LCC, does not comply with EPAct and EISA
- Achieving EPAct and EISA does not comply with LCC requirements
- Once the building was optimized the plug loads drove the energy consumption
- Max energy reduction through design 37.5%
- Buy the rest in PV's (only option at this location)
- How many projects are buying LEED credits

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