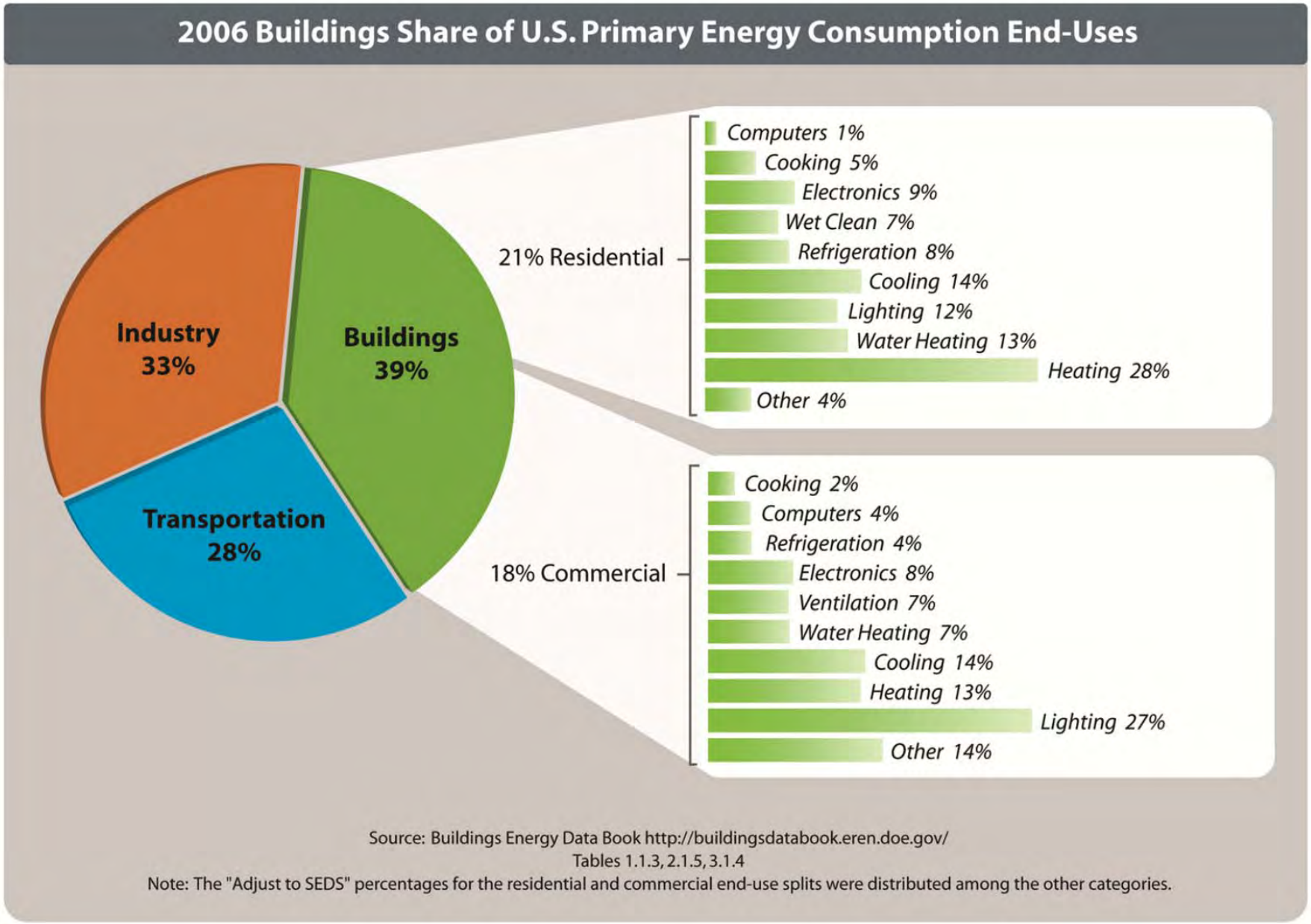
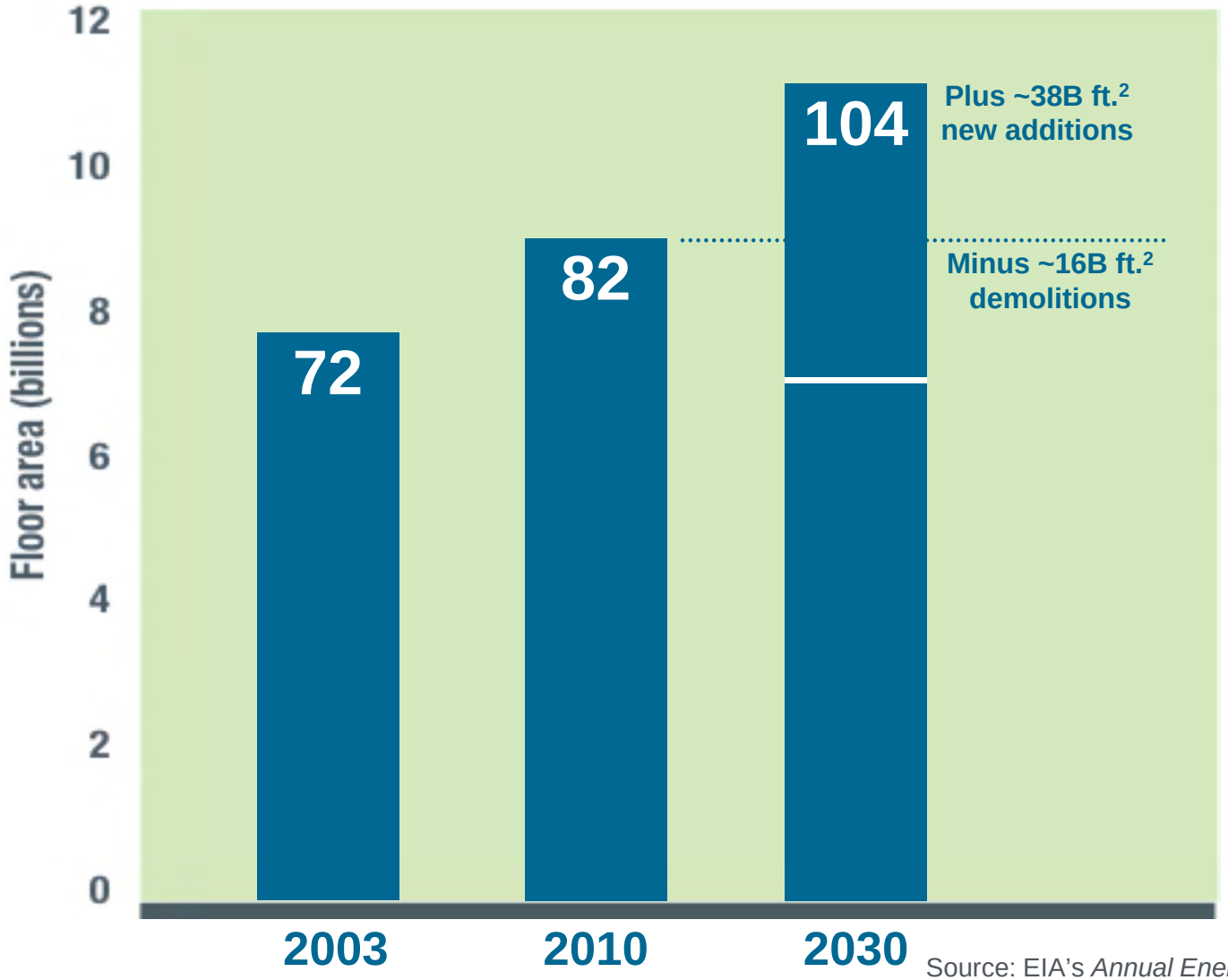
Are High-Performance Buildings Really Performing?

Drury B. Crawley, Ph.D.
ASHRAE
Pikes Peak Chapter
April 9, 2010

Buildings' Energy Use



Commercial Square Footage Projections



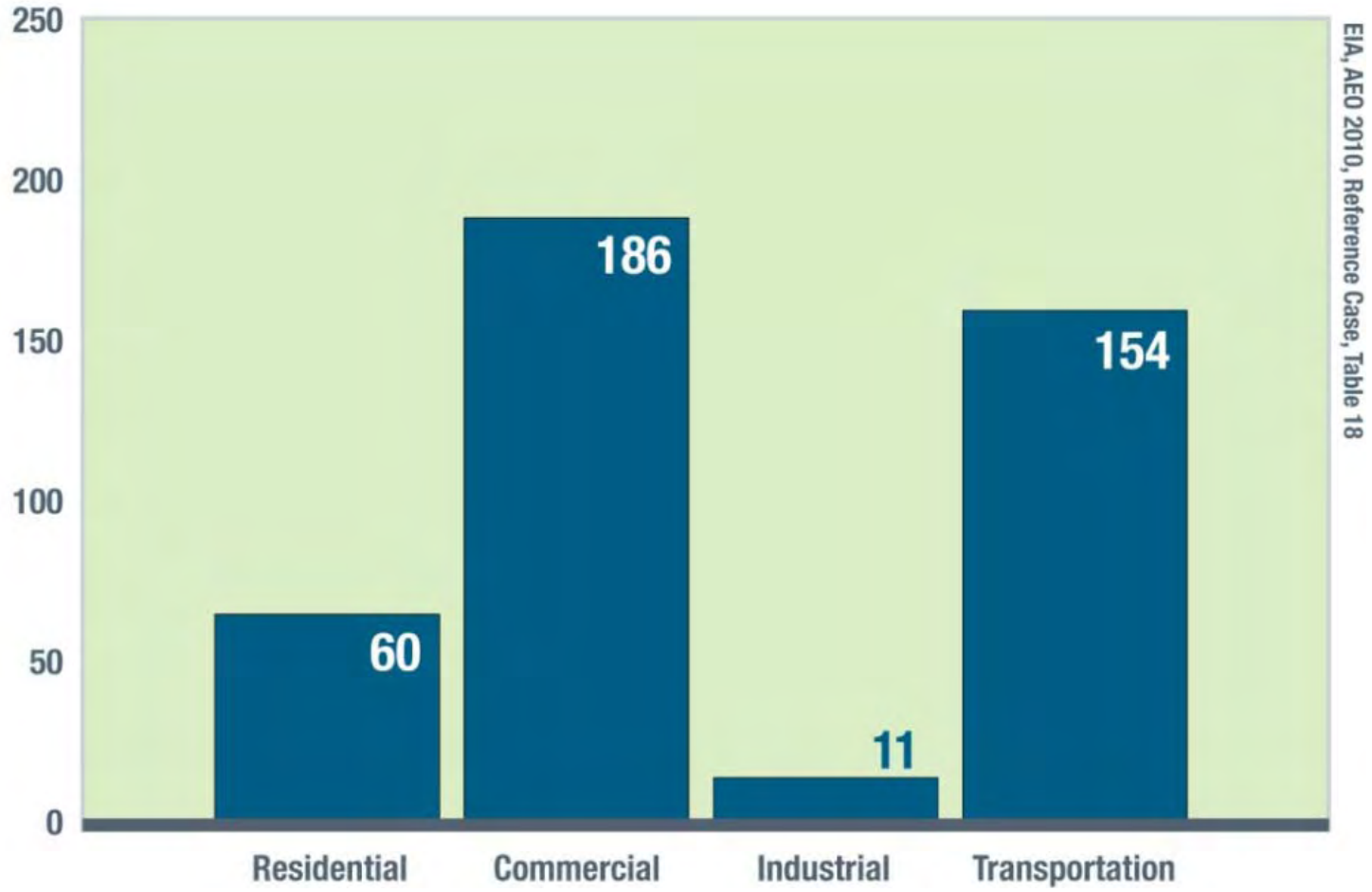
Source: EIA's *Annual Energy Outlook 2009*, Table 5.

Projected Electricity Growth

2010 to 2025, by End-Use Sector *(site quad)*

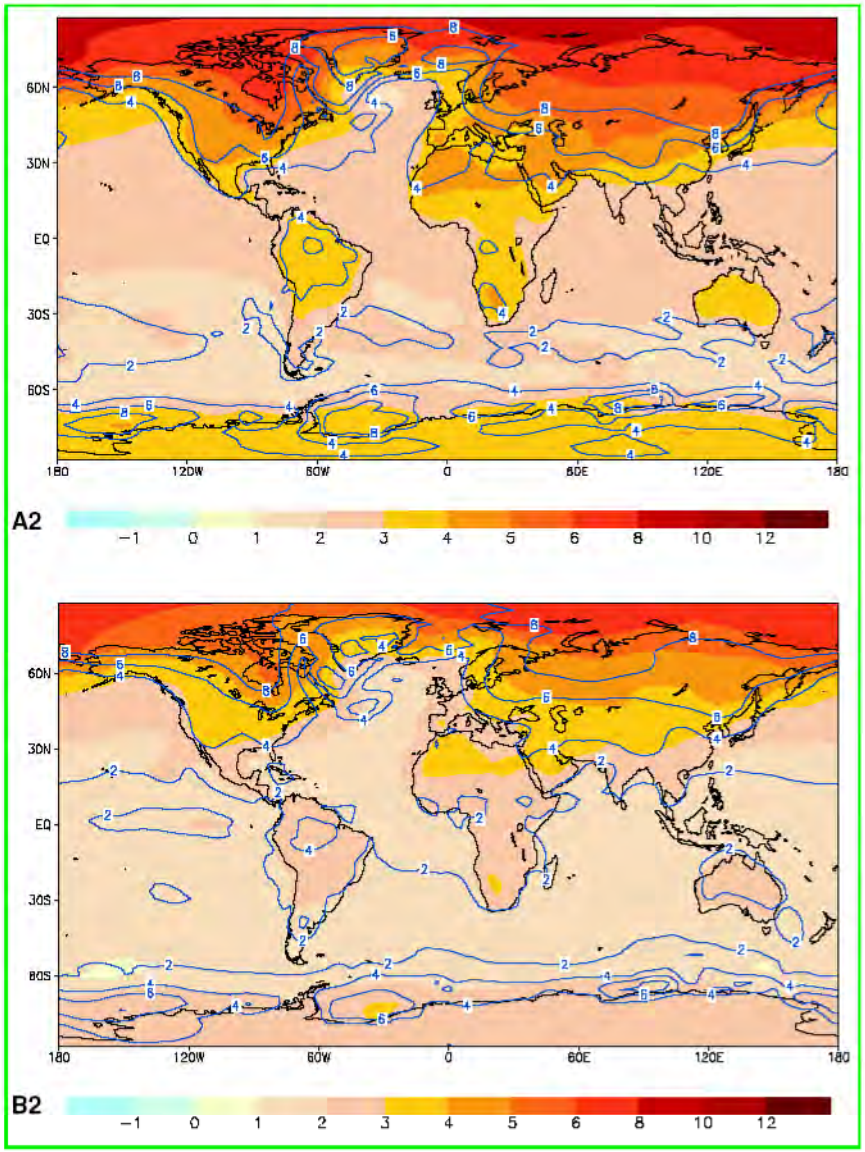
Projected Increase in Carbon Dioxide Emissions

2008 to 2030, by End-Use Sector *(MMTCO$_2$-e)*

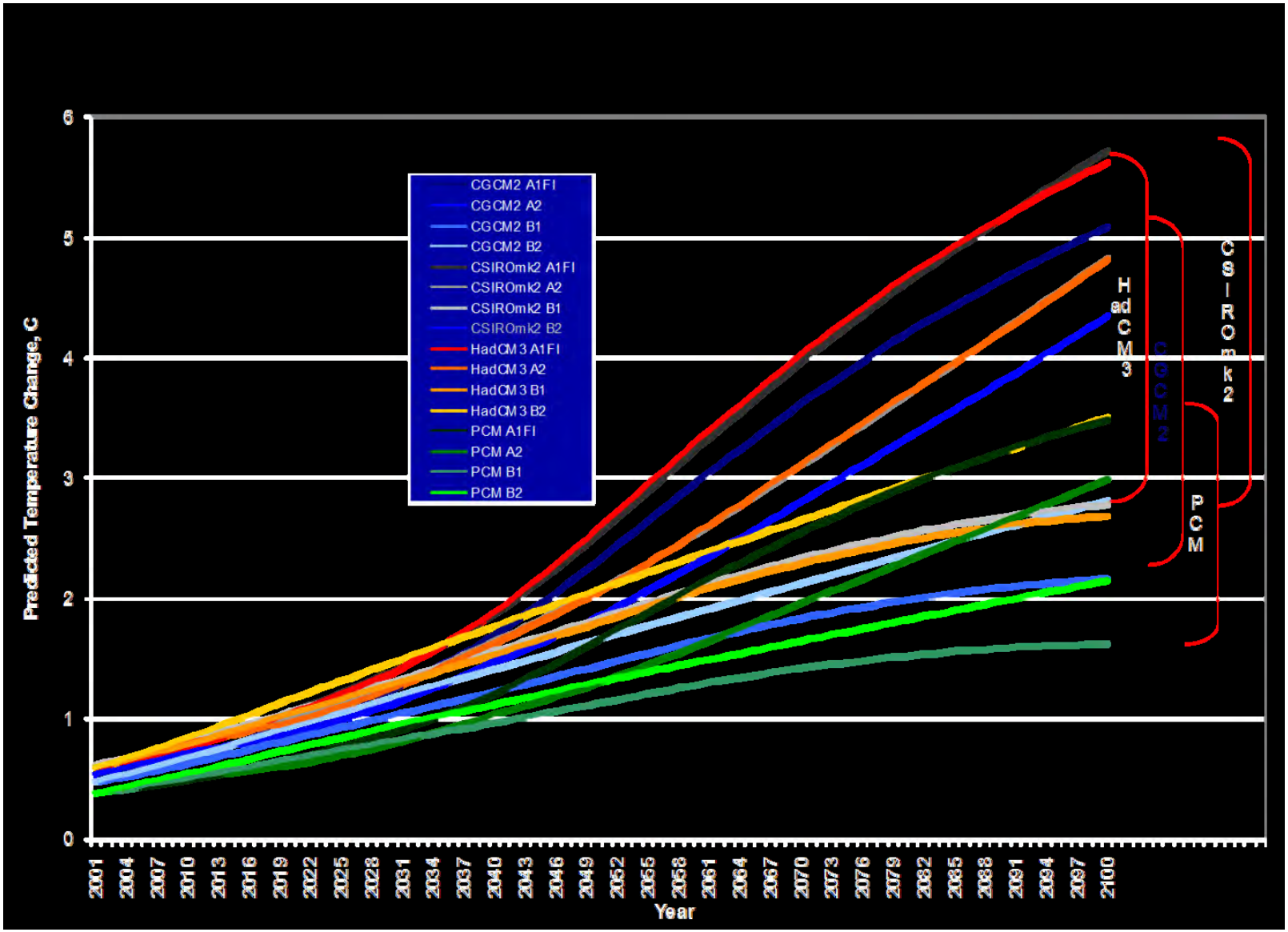


Global Warming?

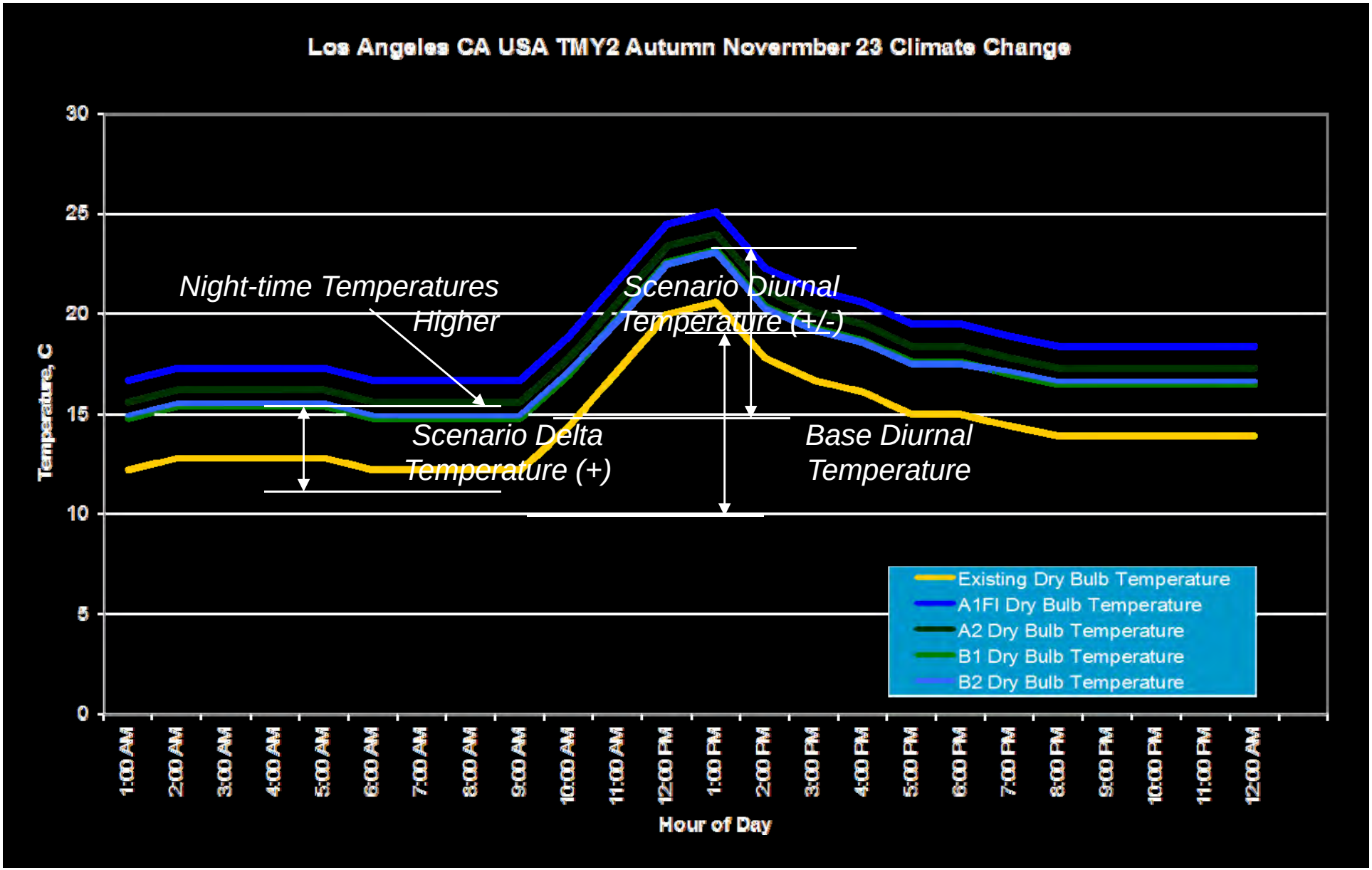
At least climate change



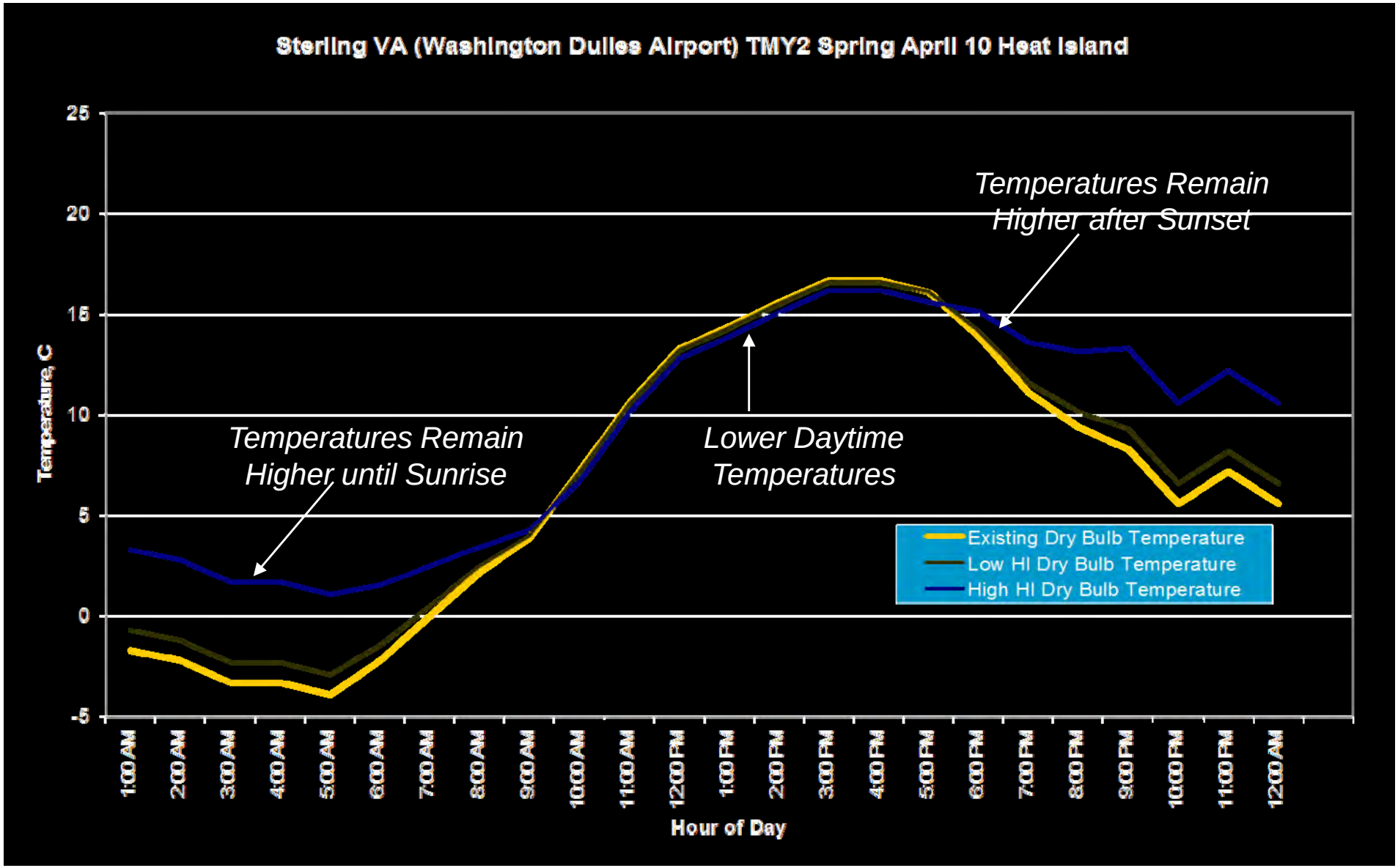
Range of Annual Average Temperature Change Predicted



What do Climate Change Scenarios look like?

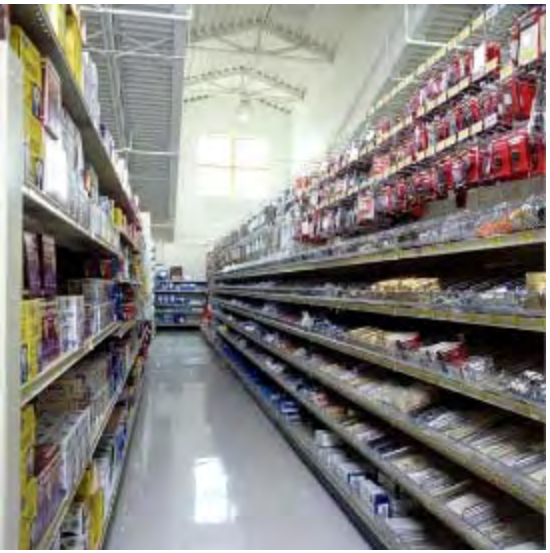


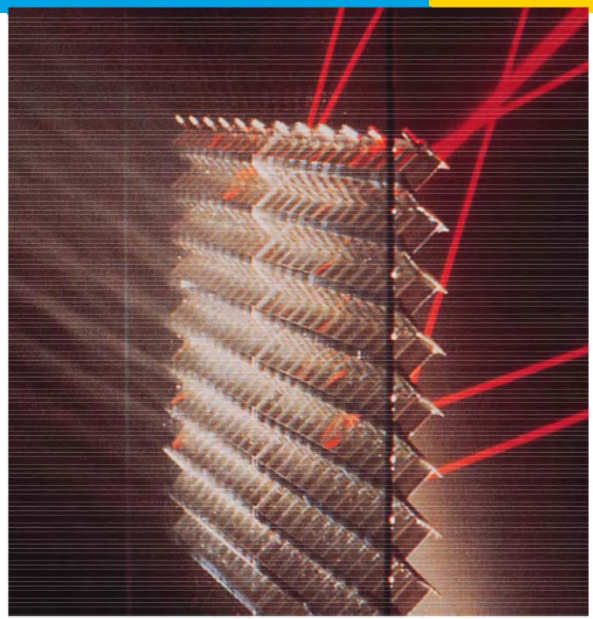
Heat Island

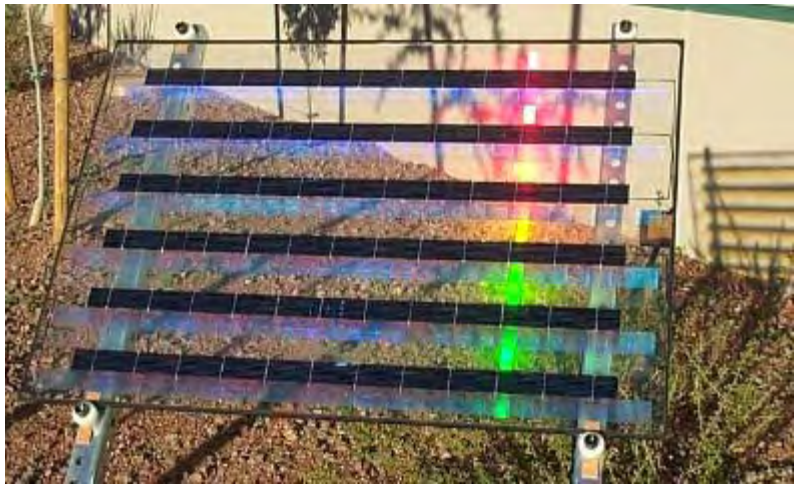

Sterling VA (Washington Dulles Airport) TMY2 Spring April 10 Heat Island
Temperature, C
25
20
15
10
5
0
-5
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
9:00 PM
10:00 PM
11:00 PM
12:00 AM
Hour of Day
Temperatures Remain Higher after Sunset
Temperatures Remain Higher until Sunrise
Lower Daytime Temperatures
Existing Dry Bulb Temperature
Low HI Dry Bulb Temperature
High HI Dry Bulb Temperature

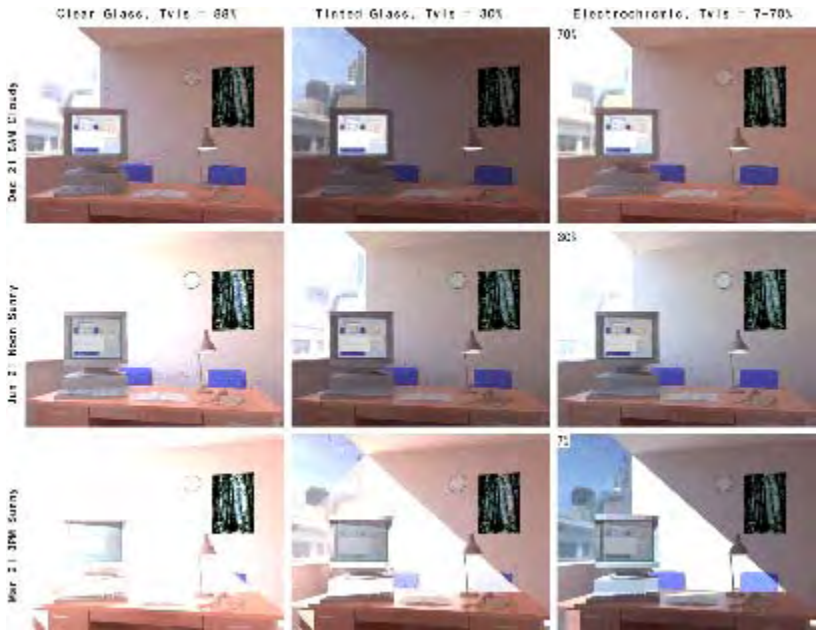
Current Technologies: The Cool Stuff Out There

Daylighting

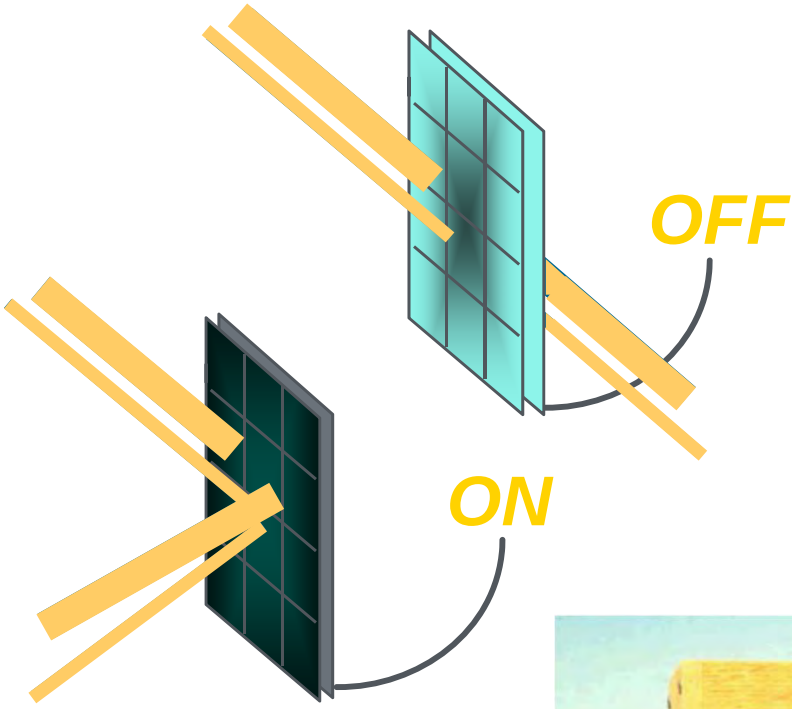




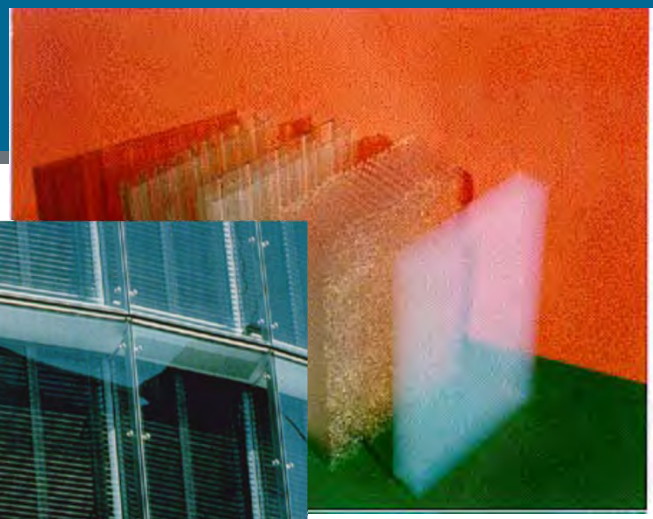




Electro-
Photo-chromic Windows
Thermo-



Super Envelopes

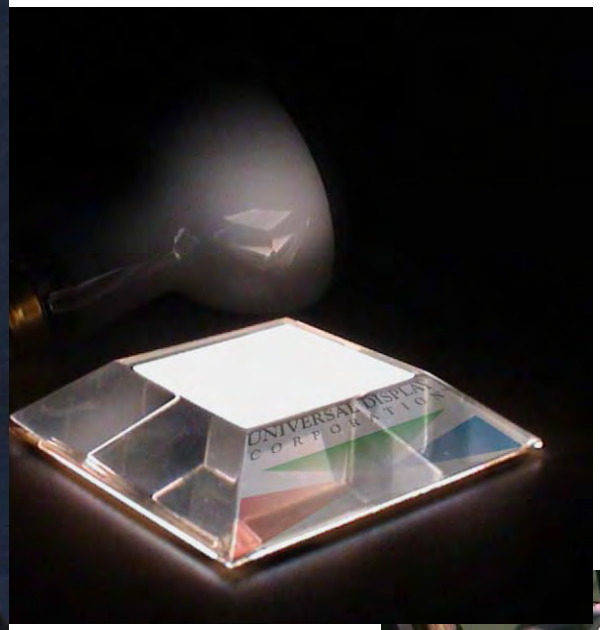


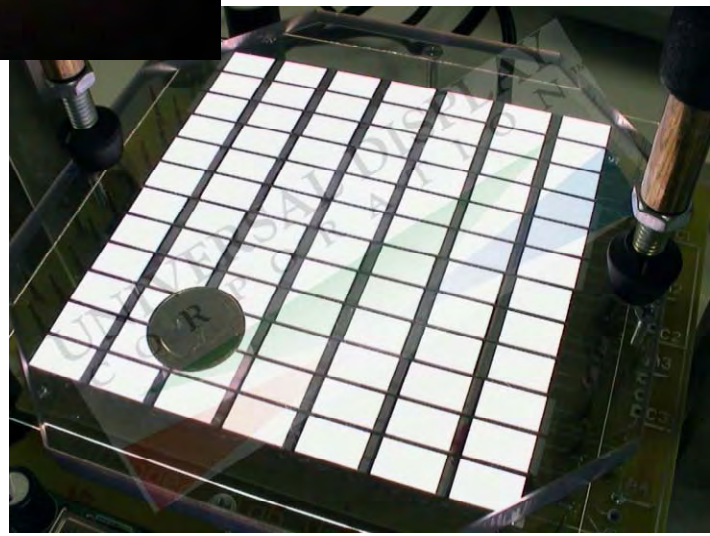
Lighting: Moving from incandescent and fluorescent to LED and OLED

LED Lighting Sources

Subcompact Fluorescent Lighting

SSL and OLED






Lunch Meat
Cheese

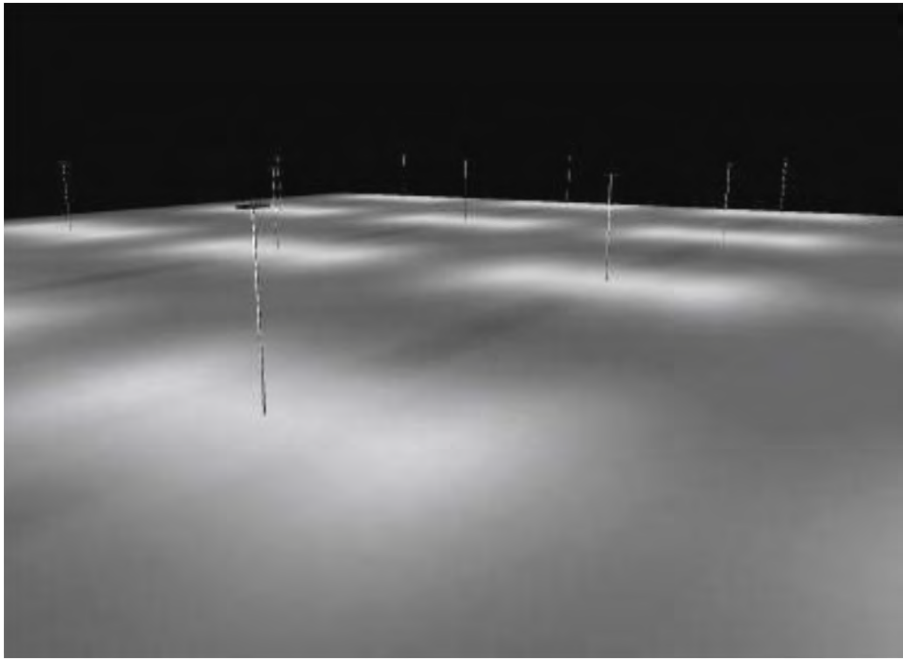
Why LEDs?

- Potential for impressive energy-efficiency improvements and large savings on maintenance
- Directional control and uniformity
- Fully dimmable
- Reduced glare, long life and durability projections
- Low lumen depreciation comparable to traditional metal halide and high-pressure sodium technology

LED Site (Parking Lot) Lighting Specification

- Retailer Energy Alliance completed specification in early 2009
- Installed at Walmart test site (Leavenworth, Kansas) July 2009

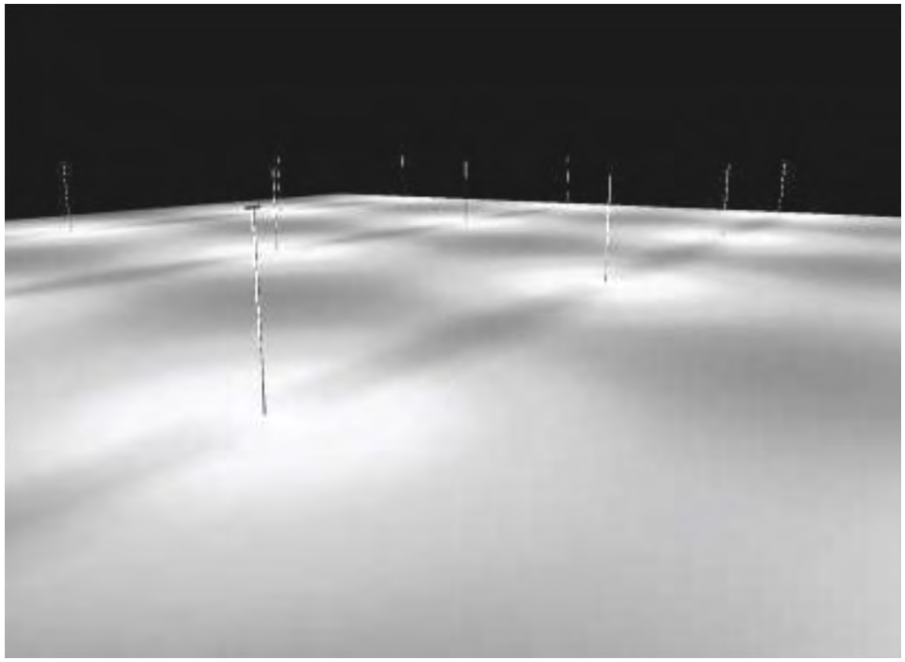
Metal Halide Parking Lot



Average: 3.5
Maximum: 9.0
Minimum: 0.9
Max : Min: 10.0

455 W MH

LED Parking Lot



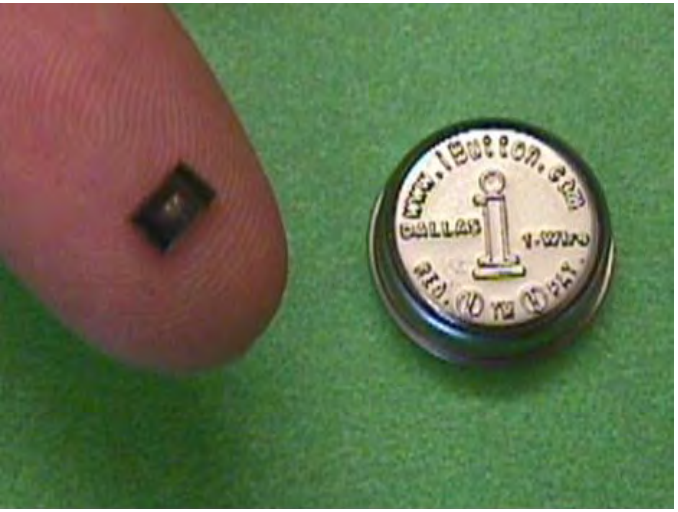
Average: 2.8
Maximum: 5.2
Minimum: 1.2
Max : Min: 4.3

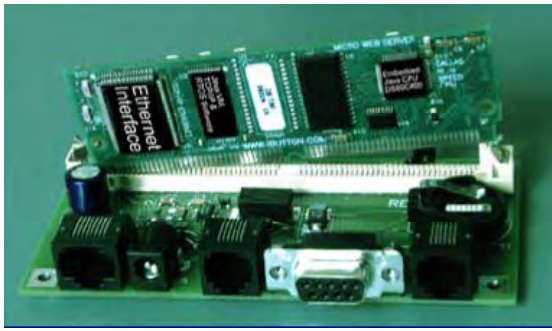
218 W LED

What it looks like

SUPERVALU
Tradition, excellence and future promise.

Controls


www.iButton.com

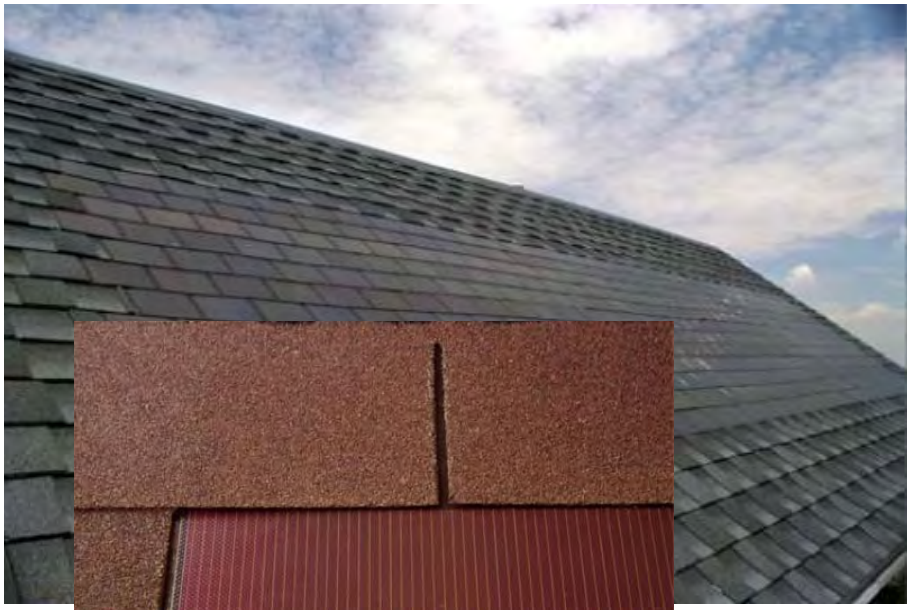

Ethernet Interface

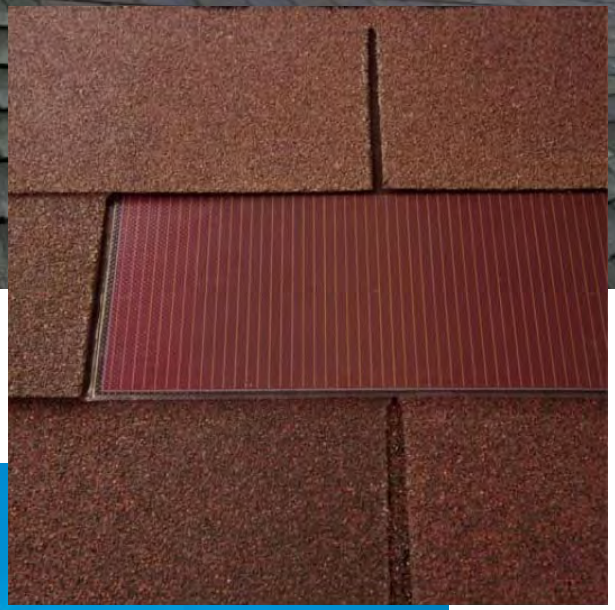

0-10 V
IBECS
0-10 Volt
Interface
Network

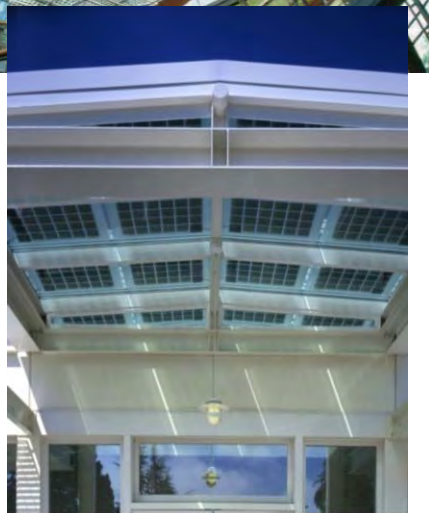

1-Wire®.net
DATA
DS2890
DS9502
J2
GND
U1
Gray
ADDRESSABLE DIMMER


1-Wire®.net
DS2890
DS9502
GND
U1
Gray
ADDRESSABLE DIMMER
GE Electronic Ballast
Total
Performance
Systems

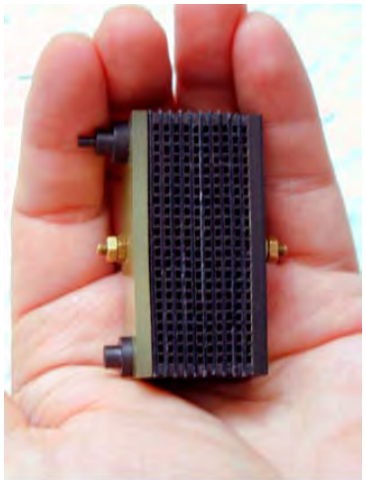
Photovoltaic Power



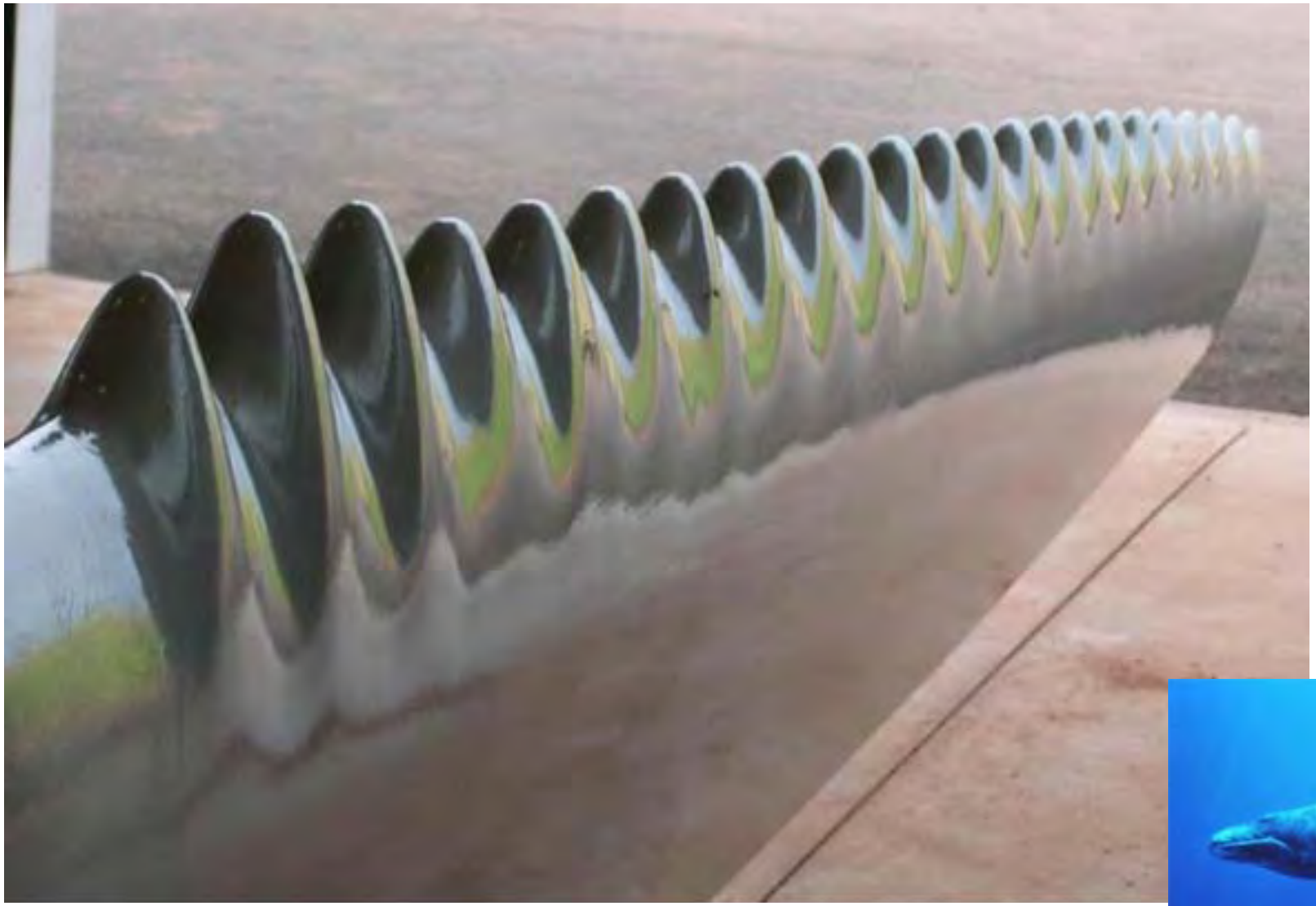




Fuel Cells, Microturbines, DHCP



Emulating Biological Solutions



Barriers to Progress

- High first costs for energy-efficient technologies
- Consumer concerns about quality and reliability
- Lack of a detailed business case for energy efficiency investments
- Dearth of customizable strategies for design, installation, control and commissioning
- Workforce capabilities: A&E firms, construction crews and O&M teams unfamiliar with latest tech

OK, Low Energy, Zero Energy…
lots of definitions

ZEB Renewable Hierarchy

1. Energy Efficiency
   – daylighting, CHP, passive solar
2. Footprint supply options
   – building mounted PV or wind
3. Site supply options
   – parking lot PV or wind
4. Imported supply options
   – wood chips, ethanol
5. Renewable credits

ZEB Definitions

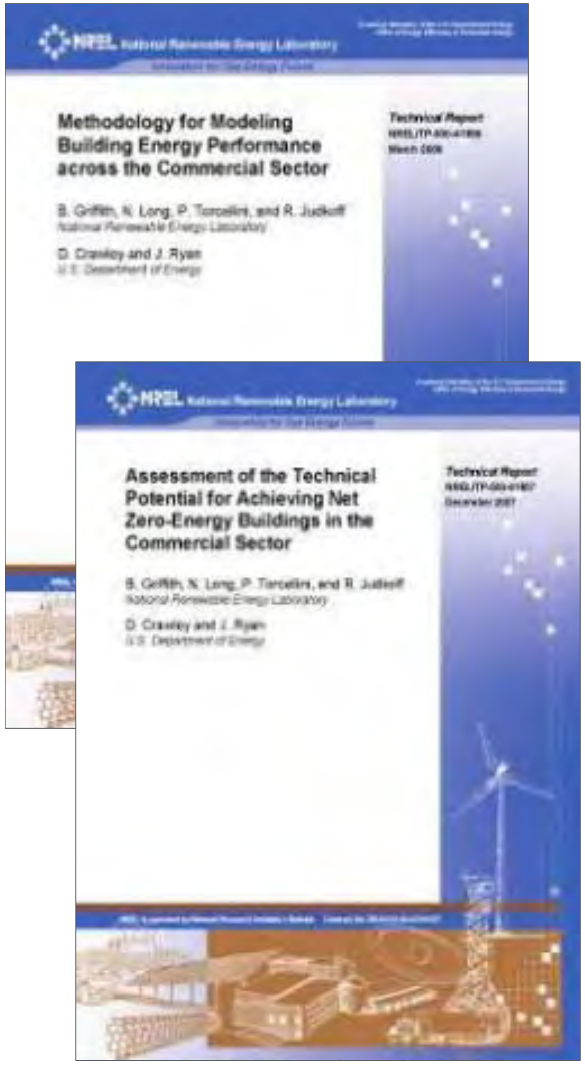
- **Net-Zero Site Energy:** produces as much renewable energy as it uses annually, when accounted for at site.
- **Net-Zero Source Energy:** produces (or purchases) as much renewable energy as it uses annually, when accounted for at source. Source energy refers to primary energy used to extract, process, generate, and deliver energy to the site.
- **Net-Zero Energy Costs:** building in which money the utility pays the building owner for the renewable energy the building exports to the grid is at least equal to the amount the owner pays the utility for energy services and energy used annually.
- **Net-Zero Energy Emissions:** produces (or purchases) enough emissions-free renewable energy to offset emissions from all energy used in the building annually. Carbon, nitrogen oxides, and sulfur oxides are common emissions that ZEBs offset.

Can we get to Net-Zero Energy?

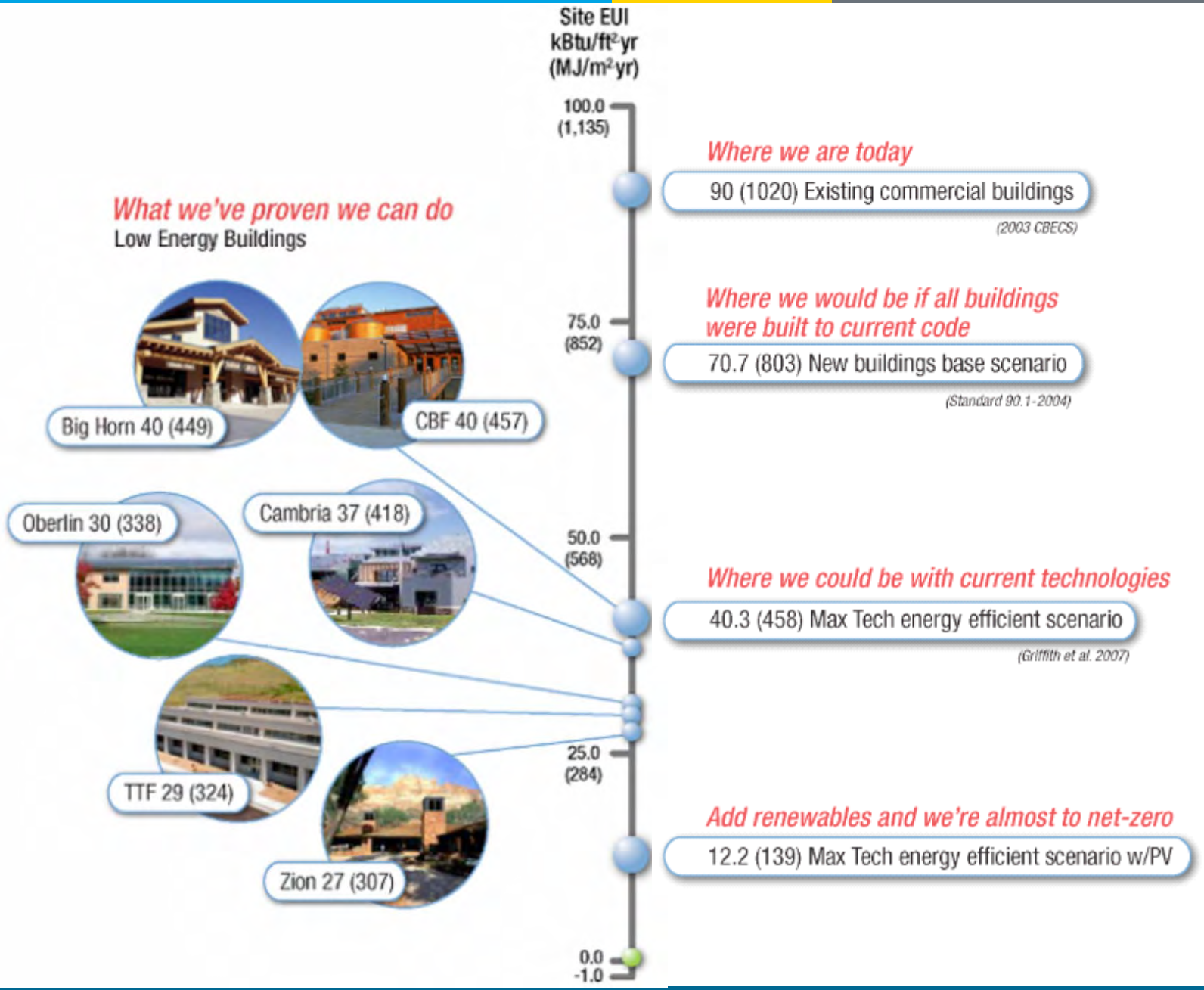
Technical Potential

- Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector
  www.nrel.gov/docs/fy08osti/41957.pdf

- Methodology for Analyzing the Technical Potential for Energy Performance Across the Commercial Sector
  www.nrel.gov/docs/fy08osti/41956.pdf

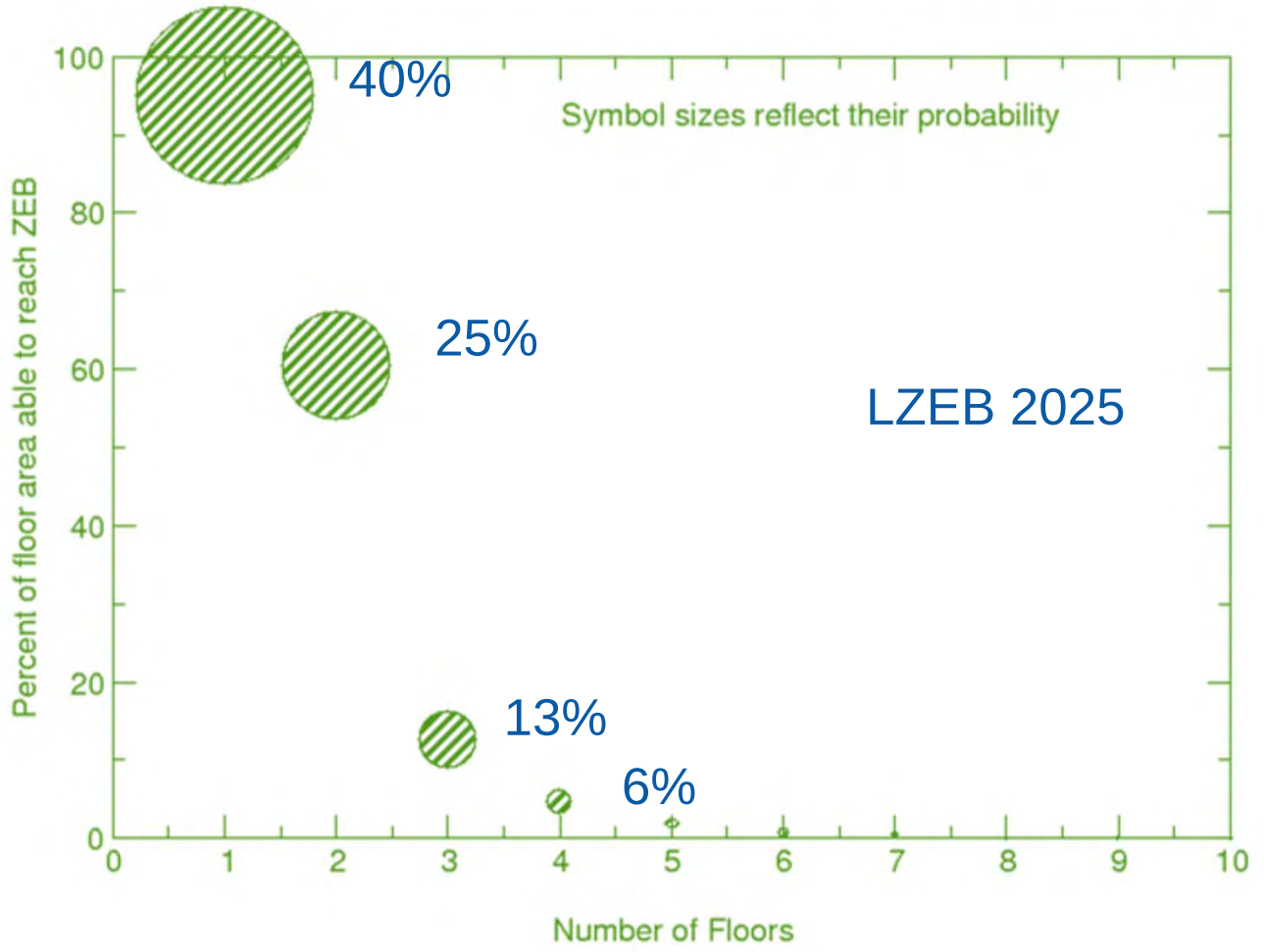


Great Potential in Commercial Buildings



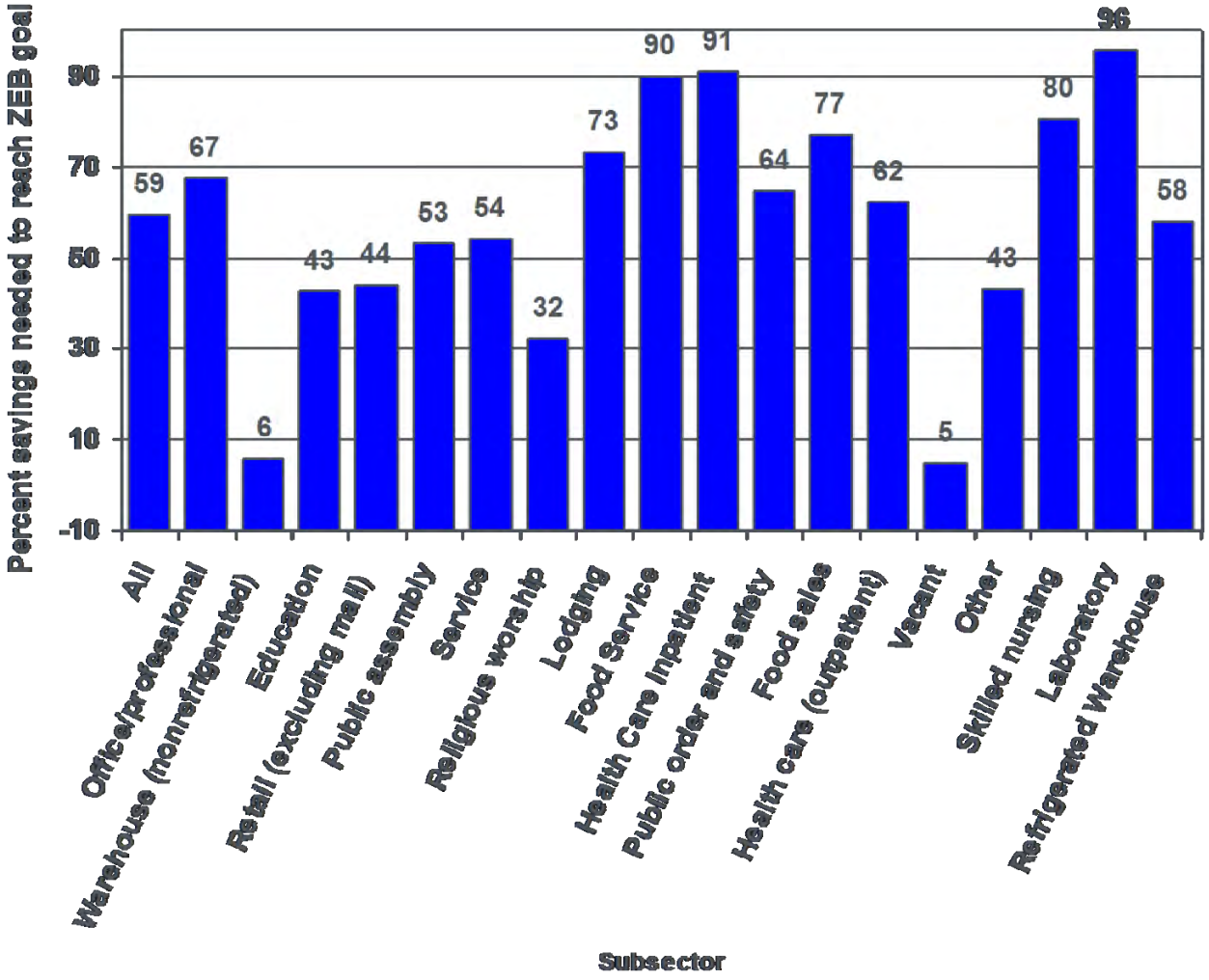
ZEB Characteristics

- Number of floors impacts ability to reach ZEB goal
- Roof area
- Daylighting



Energy Efficiency

Need 60% to 70% decrease in energy consumption of commercial buildings



Low-Energy Case Study Buildings

- **Oberlin College Lewis Center—Ohio**
  Goal: zero net site energy use (79%)
- **Zion Visitor Center—Utah**
  Goal: 70% energy cost savings (65%)
- **Cambria Office Building—Pennsylvania**
  Goal: 66% energy cost savings (43%)
- **Chesapeake Bay Foundation—Maryland**
  Goal: LEED 1.0 Platinum Rating (25%)
- **Thermal Test Facility—Colorado**
  Goal: 70% energy savings (51%)
- **BigHorn Home Improvement Center—Colorado**
  Goal: 60% energy cost savings (53%)

Six Buildings

- Each had committed owners
- Each set aggressive energy goals
- Each was monitored for at least one year
- Each building was successful
- Each had some problems
- Many of the problems were similar

Study Questions

- How do low-energy buildings perform?
- Where are the gaps between design goals and actual performance?
- What are (technical) issues for creating low-energy buildings?
- Can we reach “net-zero energy buildings”?

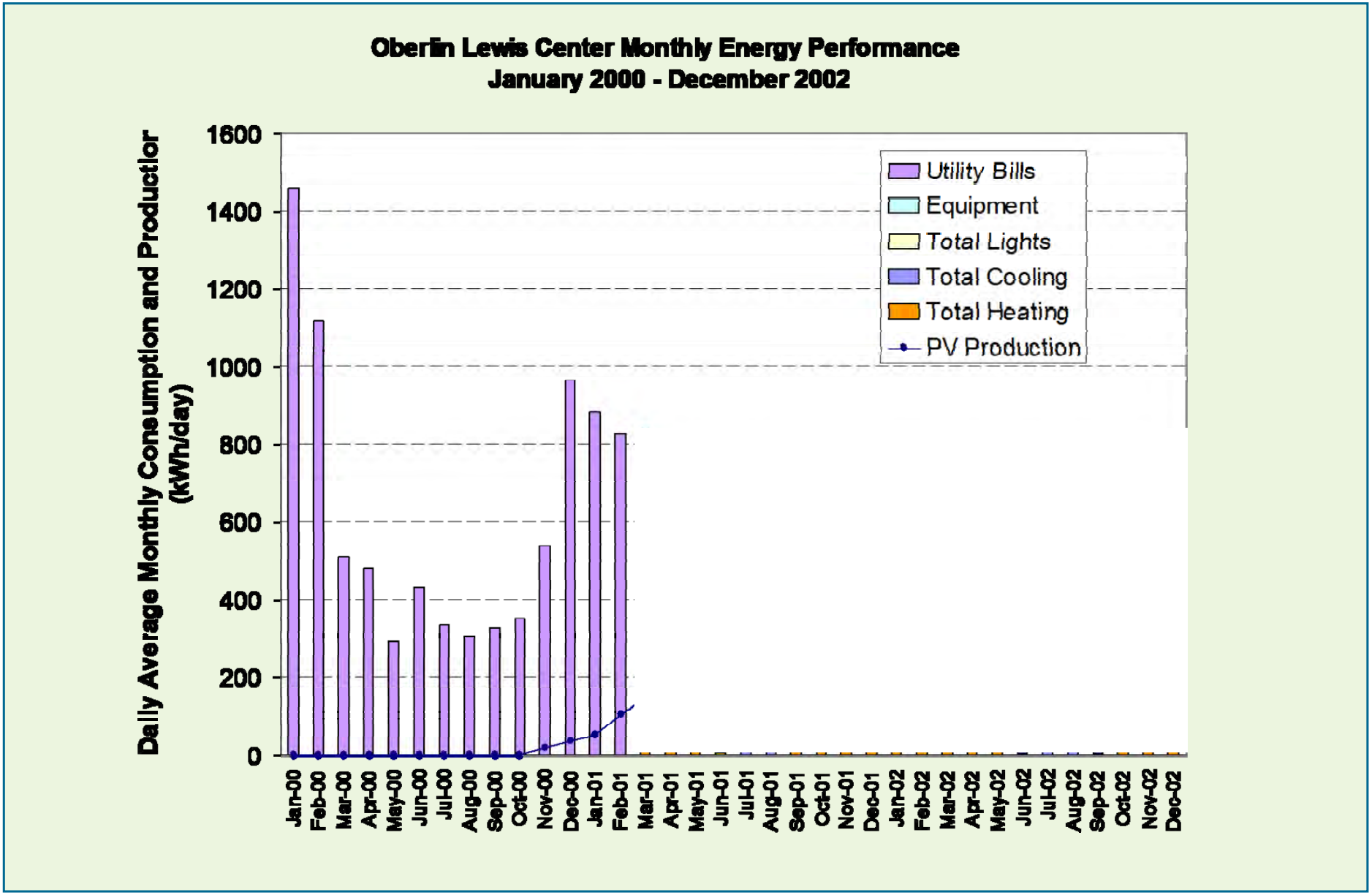
Lewis Center for Environmental Studies

- 13,600 ft^2 classroom and offices
- 60 kW PV system
- Daylighting
- Ground-source heat pumps
- Water treatment
- Natural ventilation

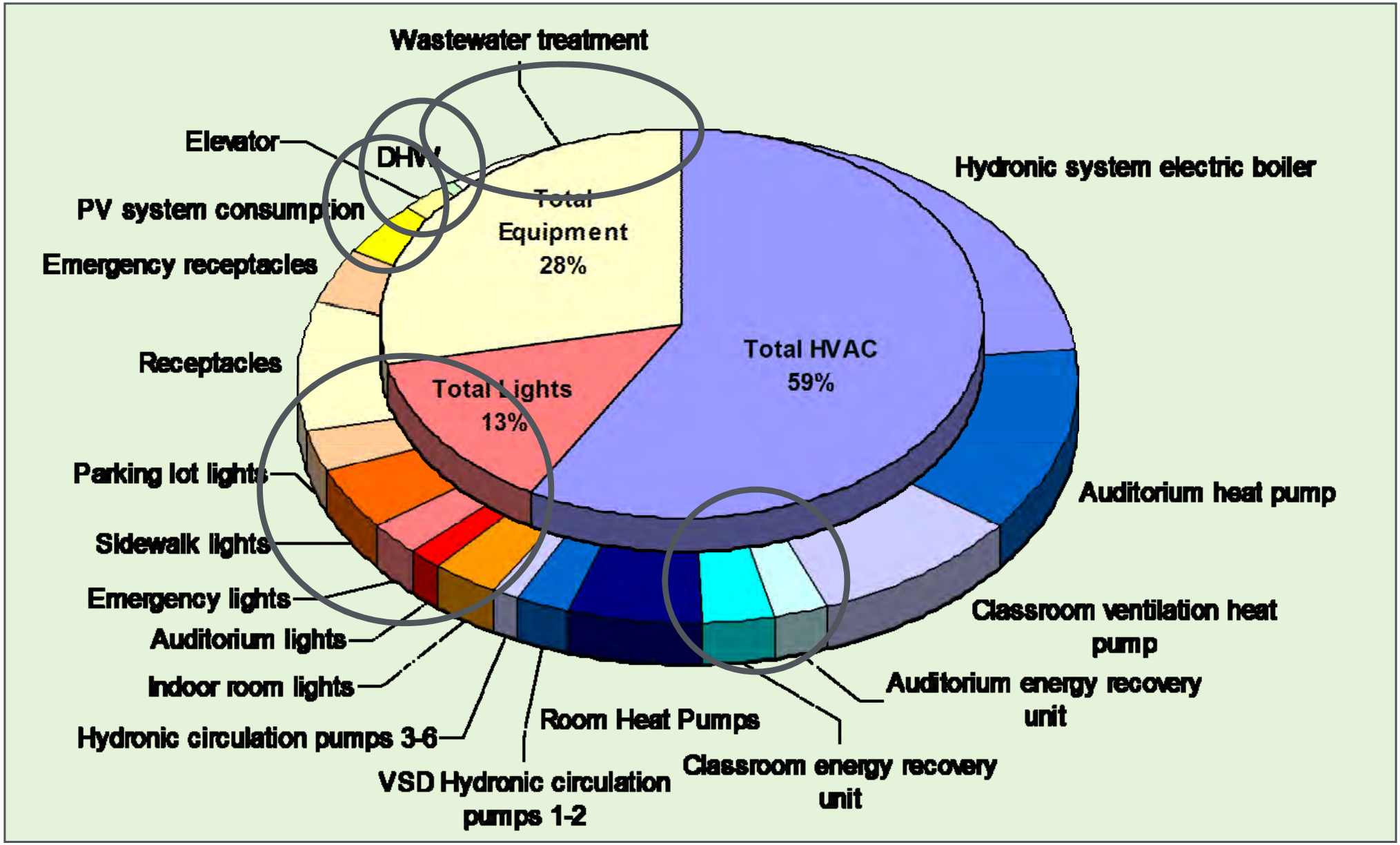
Lewis Center—Oberlin College

- Geothermal wells
- BIPV
- Daylighting
- Energy-efficient, integrated design—40% less than code
- Indoor air quality (low-VOC materials)
- Material selection (durability, recycled content, certified products)
- Living machine
- Landscape (indigenous, aquatic)

Monthly Energy Totals—Oberlin



End-Use Energy



Zion Visitor Center

- 7.2 kW PV system (UPS)
- Passive evaporative cooling
- Excellent thermal envelope
- Trombe walls
- Overhangs
- Daylighting

BigHorn Home Improvement Center

- 18,400 ft^2 retail store and 24,000 ft^2 warehouse
- Daylighting
- Natural ventilation (no mechanical cooling)
- Transpired solar collector
- Radiant floors
- PV

NREL Thermal Test Facility (TTF)

- 10,000 ft^2 laboratory and office
- Typical steel frame building
- Good insulation package
- Simple daylighting design
- 2-stage evaporative cooling
- Instantaneous hot water

Cambria Office Building

- 34,500 ft^2 spec office for PA DEP
- 18.2 kW PV system
- Ground-source heat pumps
- Under-floor air distribution
- Heat recovery ventilators
- Daylighting

Chesapeake Bay Foundation
Merrill Center

- 31,000 ft^2
- Ground-source heat pumps
- Daylighting
- Passive solar heating
- Solar DHW
- Natural ventilation
- PV
- 1st Platinum LEED building

Lighting Systems

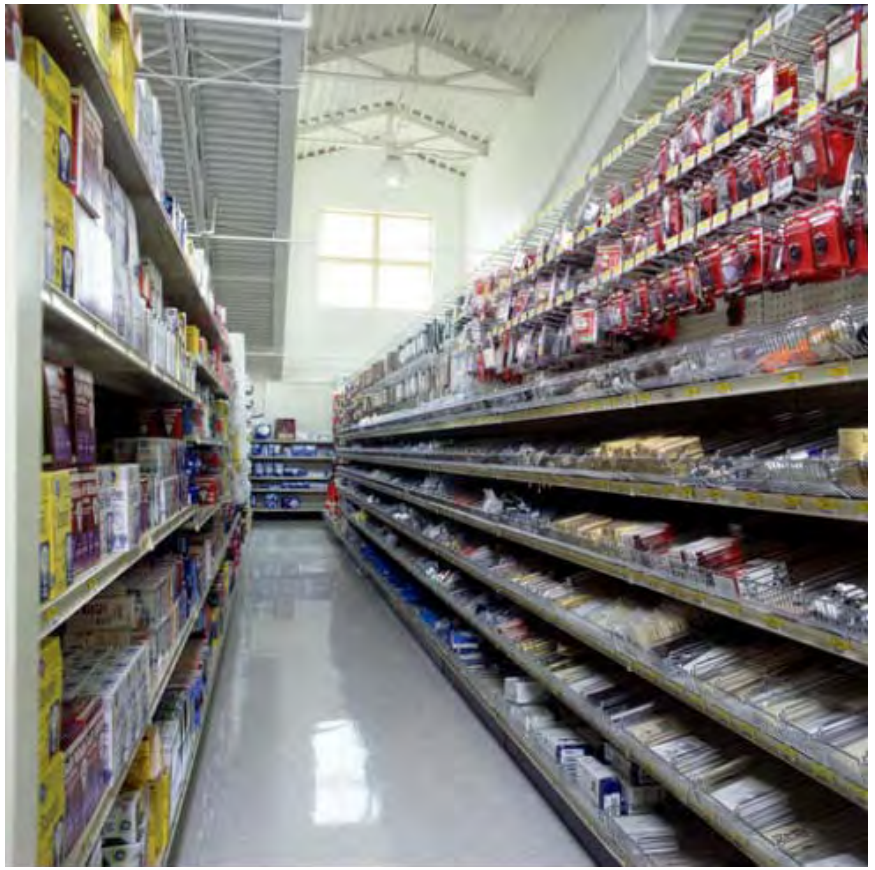
- TTF: clerestories, auto on/off control
- Oberlin: high glass, manual dimming control
- Cambria: clerestories, indirect lighting, lower lighting levels
- BigHorn: clerestories, translucent panels, stepped CF lighting
- Zion: clerestories, high glass, on/off control
- CBF: clerestories, high glass, on/off semi-automatic control

Daylighting Design

- Slight over design needed
  - Never as bright as predicted
  - Darker colors common issue
  - Occupant perception
  - Do not over glaze (especially lower windows)
- Screens on operable windows
- Frame areas
- Glass type—errors?
- Glare control

Lighting Design

- Lower levels acceptable in most cases
  - Effective task lighting allowed lower ambient levels
  - Daylighting augmented spaces; allowed for lower levels at night
  - Circuiting

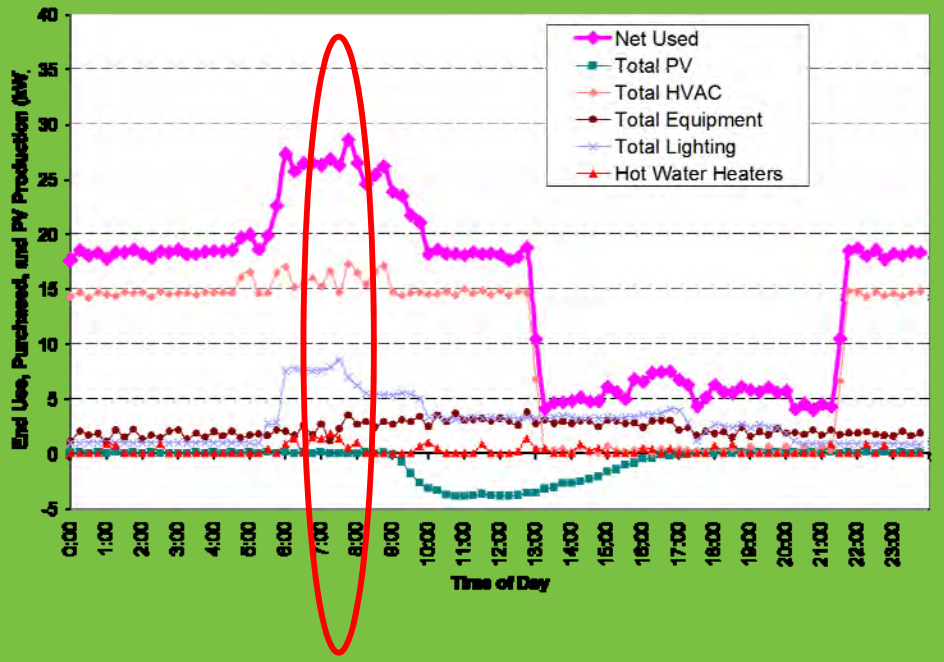


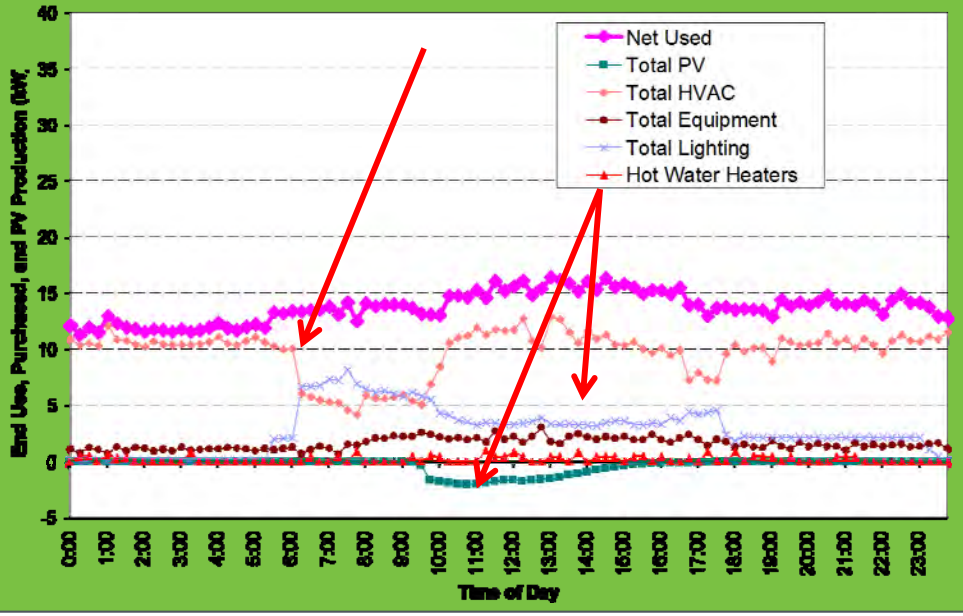
HVAC Systems-Natural Ventilation

- Natural ventilation (3 buildings)
  - Occupants don’t want to interact with building (somewhat different than residential)
  - Automatic windows worked well
    - Set-up issues
    - Interface with EMS
    - Open area (screens, window distance)
    - Hardware failures
    - May be better to use relief dampers
- Control strategies
- More limited than economizer

Control Systems

- Mixed results: Controls only as smart as the building operator
- Probably the biggest success factor
- Flexibility and well thought out control algorithms important for tuning building
- Demand management
  - Set points, setback, control to goals and comfort
- Staff must be able to program
  - All systems were reprogrammed from original sequencing


Net Used
Total PV
Total HVAC
Total Equipment
Total Lighting
Hot Water Heaters
End Use, Purchased, and PV Production (kW)
Time of Day


Net Used
Total PV
Total HVAC
Total Equipment
Total Lighting
Hot Water Heaters
End Use, Purchased, and PV Production (kW)
Time of Day

PV Systems (5 of 6 projects)

- Excellent for UPS systems
- Roughly 1 kWh/watt installed capacity
- Issues:
  - Parasitic loads (isolation transformers)
  - Inverter trips
  - Inverter programming

Feedback

- To make better buildings, designers need feedback (both positive and negative)
- Measuring building performance
  - how the building is being operated
  - understand the culture of the organization
  - where the energy is going

Monitoring

- Dedicated monitoring systems work better
- Develop detailed monitoring plans with questions to answer
- Strive toward common results
  (not always possible)
- Energy performance improves with monitoring

ZEB Database

First Database of Net-Zero Energy Buildings:
http://commercialbuildings.energy.gov/

Building	Location	Floor Area (ft^2)	Annual Purchased Energy ($kBtu/ft^2$)
Aldo Leopold Legacy Center	Baraboo, WI	11,900	-2.02
Audubon Center at Debs Park	Los Angeles, CA	5,020	
Challengers Tennis Club	Los Angeles, CA	3,500	-0.0955
Environmental Tech. Center, Sonoma State	Rohnert Park, CA	2,200	-1.47
Hawaii Gateway Energy Center	Kailua-Kona, HI	3,600	-3.46
IDeAs Z2 Design Facility	San Jose, CA	6,560	-0.00052
Oberlin College Lewis Center	Oberlin, OH	13,600	-4.23
Science House	St. Paul, MN	1,530	0

System Details

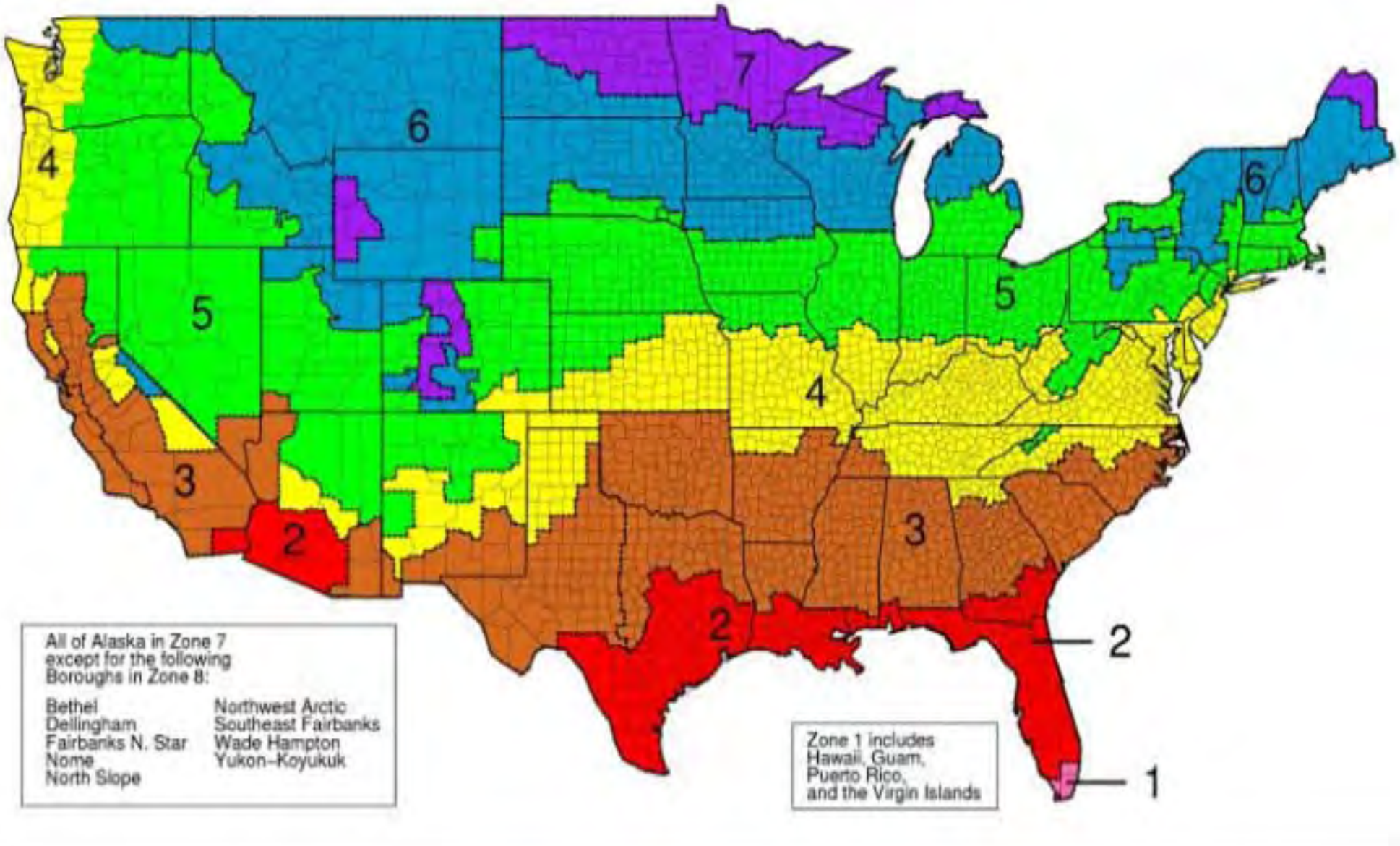
Building	Building Use	PV System Size	% Savings w/o PV	Floors	HVAC System Type
Aldo Leopold	Commercial office	406	70%	1	GSHP; Radiant Slab; Earth-Tube; Natural Ventilation
Audubon Center	Recreation; Park	25	?	1	Solar Hot Water; Absorption Chiller; Natural Ventilation
Challengers Tennis Club	Recreation	6	60%	2	Natural Ventilation
Environmental Tech. Center, Sonoma State	Higher education; Laboratory	3	80%	1	Natural Ventilation; Passive Solar Heating/Cooling; Thermal Mass; Radiant Heating
Hawaii Gateway	Commercial office	20	80%	1	Natural Ventilation; Cold Sea Water to Cool Air
IDeAs Z2	Commercial office	30	60%	2	GSHP; Radiant Slab
Oberlin College	Higher education; Library; Assembly	160	54%	2	GSHP; Radiant Slab
Science House	Interpretive Center	8.8	60%	1	GSHP; Natural Ventilation; Passive Solar Heating

First Steps to Zero — Advanced Energy Design Guides (AEDGs)

30% Advanced Energy Design Guides

- ASHRAE, IES, AIA, USGBC, and DOE developing series of energy design guides for achieving 30% lower energy than 90.1
- Prescriptive tabular approach
- Small office, small retail, K–12 schools, small warehouses and self-storage, highway lodging, and small healthcare
- LEED points without simulation!
- Next up:
  - 50% technical analysis completed for medium office, highway lodging, medium box retail, grocery store
  - www.ashrae.org/aedg

Recommendations by Climate Zone



Tables with Recommendation by Climate Zone

Climate Zone 5 Recommendation Table

	Item	Component	Recommendation	How-to's in Chapter 4
Envelope	Roof	Insulation entirely above deck	R-20 c.i.	EN2, 17, 20-21
		Metal building	R-13 + R-19	EN3, 17, 20-21
		Attic and other	R-38	EN4, 17-18, 20-21
		Single rafter	R-38 + R-5 c.i.	EN5, 17, 20-21
		Surface reflectance/emittance	No recommendation	
	Walls	Mass (HC > 7 Btu/ft^2)	R-11.4 c.i.	EN6, 17, 20-21
		Metal building	R-13 + R-13	EN7, 17, 20-21
		Steel framed	R-13 + R-7.5 c.i.	EN8, 17, 20-21
		Wood framed and other	R-13 + R-3.8 c.i.	EN9, 17, 20-21
		Below-grade walls	R-7.5 c.i.	EN10, 17, 20-21
	Floors	Mass	R-10.4 c.i.	EN11, 17, 20-21
		Steel framed	R-30	EN12, 17, 20-21
		Wood framed and other	R-30	EN12, 17, 20-21
	Slabs	Unheated	No recommendation	EN17, 19-21
		Heated	R-10 for 36 in.	EN14, 17, 19-21
	Doors	Swinging	U-0.70	EN15, 20-21
		Non-swinging	U-0.50	EN16, 20-21
	Vertical Glazing	Window to wall ratio (WWR)	20% to 40% maximum	EN23, 36-37
		Thermal transmittance	U-0.42	EN25, 31
		Solar heat gain coefficient (SHGC)	N, S, E, W - 0.46 N only - 0.46	EN27-28
		Window orientation	(A_N * $SHGC_N$ + A_S * $SHGC_S$) > (A_E * $SHGC_E$ + A_W * $SHGC_W$)	A_x–Window area for orientation x EN26-32
		Exterior sun control (S, E, W only)	Projection factor 0.5	EN24, 28, 30, 36, 40, 42 DL5-6
	Skylights	Maximum percent of roof area	3%	DL5-7, DL8, DL13
		Thermal transmittance	U-0.69	DL7, DL8, DL13
		Solar heat gain coefficient (SHGC)	0.39	DL8, DL13
Lighting	Interior Lighting	Lighting power density (LPD)	0.9 W/ft^2	EL1-2, 4, 8, 10-16
		Light source (linear fluorescent)	90 mean lumens/watt	EL4, 9, 17
		Ballast	Electronic ballast	EL4
		Dimming controls for daylight harvesting for WWR 25% or higher	Dim fixtures within 12 ft of N/S window wall or within 8 ft of skylight edge	DL1, 9-11, EL6-7
		Occupancy controls	Auto-off all unoccupied rooms	DL2, EL5, 6
		Interior room surface reflectances	80%+ on ceilings, 70%+ on walls and vertical partitions	DL3-4, EL3
HVAC	HVAC	Air conditioner (0-65 KBtuh)	13.0 SEER	HV1- 2, 4, 6, 12, 16-17, 20
		Air conditioner (>65-135 KBtuh)	11.0 EER/11.4 IPLV	HV1- 2, 4, 6, 12, 16-17, 20
		Air conditioner (>135-240 KBtuh)	10.8 EER/11.2 IPLV	HV1- 2, 4, 6, 12, 16-17, 20
		Air conditioner (>240 KBtuh)	10.0 EER/10.4 IPLV	HV1- 2, 4, 6, 12, 16-17, 20
		Gas furnace (0-225 KBtuh - SP)	80% AFUE or E_t	HV1- 2, 6, 16, 20
		Gas furnace (0-225 KBtuh - Split)	90% AFUE or E_t	HV1- 2, 6, 16, 20
		Gas furnace (>225 KBtuh)	80% E_c	HV1- 2, 6, 16, 20
		Heat pump (0-65 KBtuh)	13.0 SEER/7.7 HSPF	HV1- 2, 4, 6, 12, 16-17, 20
		Heat pump (>65-135 KBtuh)	10.6 EER/11.0 IPLV/3.2 COP	HV1- 2, 4, 6, 12, 16-17, 20
		Heat pump (>135 KBtuh)	10.1 EER/11.0 IPLV/3.1 COP	HV1- 2, 4, 6, 12, 16-17, 20
	Economizer	Air conditioners & heat pumps - SP	Cooling capacity > 54 KBtuh	HV23
	Ventilation	Outdoor air damper	Motorized control	HV7-8
		Demand control	CO_2 sensors	HV7, 22
	Ducts	Friction rate	0.08 in. w.c./100 feet	HV9, 18
		Sealing	Seal class B	HV11
		Location	Interior only	HV9
		Insulation level	R-6	HV10
SWH	Service Water Heating	Gas storage	90% E_t	WH1-4
		Gas instantaneous	0.81 EF or 81% E_t	WH1-4
		Electric storage 12 kW	EF > 0.99 – 0.0012xVolume	WH1-4
		Pipe insulation (d<1½ in./ d≥1½ in.)	1 in./ 1½ in.	WH6

Note: If the table contains "No recommendation" for a component, the user must meet the more stringent of either Standard 90.1 or the local code requirements in order to reach the 30% savings target.

- Energy-saving recommendations for each climate zone on single page
- Tables color-coded to maps
- Prescriptive recommendations identify energy savings without costly calculations
- Tied to "how-to" section

Building Simulation – Key to Improving Building Performance

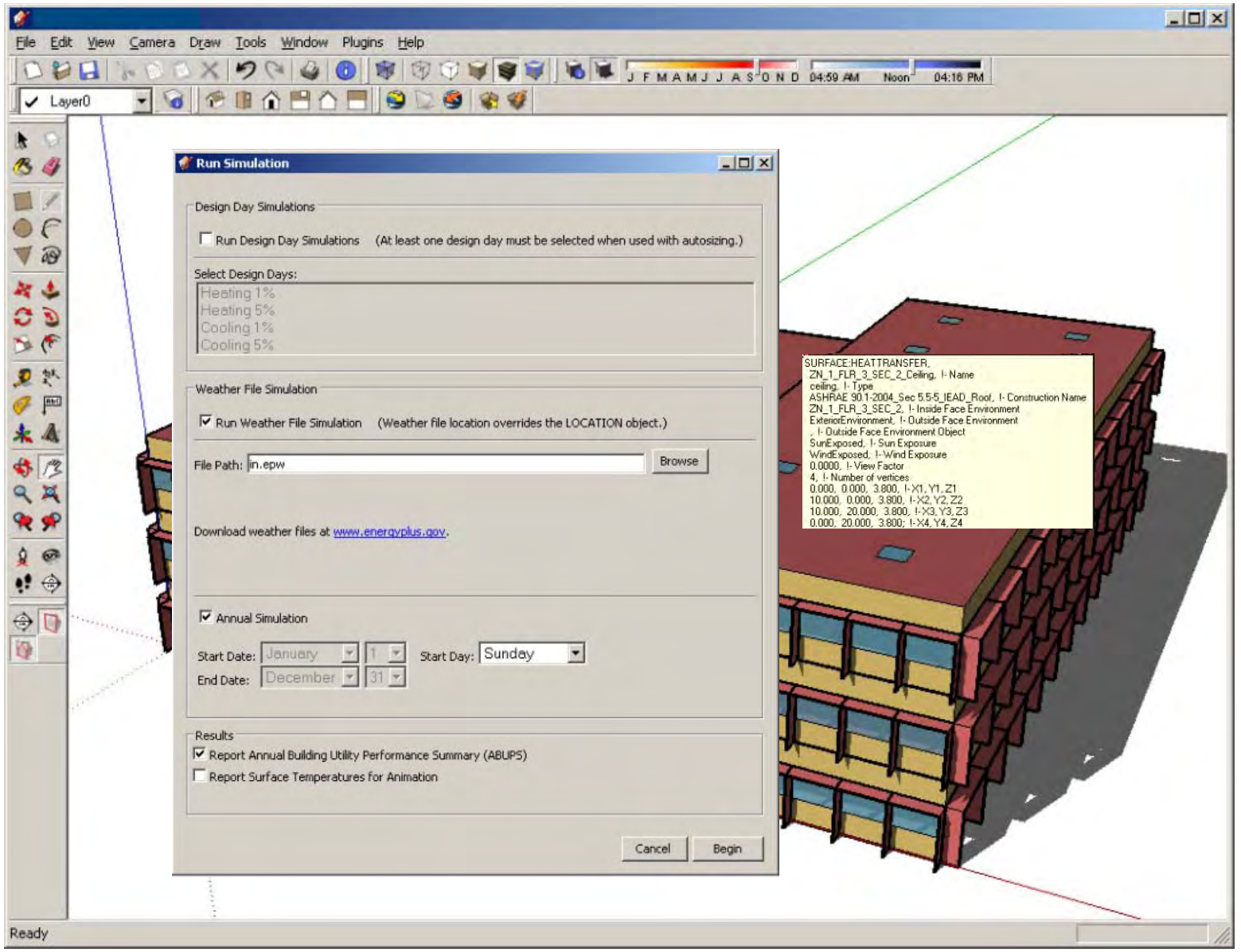
Simulation Drivers/Trends

- Simulation is still more art than science
- Major Issues:
  - Building data maintenance/storage throughout building life-cycle
  - Training...must train users in simulation methods not tools!
  - Tools must enable and encourage new technologies
  - Too many technologies/systems that many tools cannot simulate
- Code Compliance
- Points for Building Ratings
- Qualify for Utility or Government Rebates/Incentives
- Green/sustainable design and policy are driving simulation more than energy costs

Simulation Trends

- New tools/capabilities in established tools
  - Interoperability—IAI IFC, XML, BIM Standards
  - Visualization/VR
  - Integration—thermal, CFD, electrical, IEQ, visual
  - Risk assessment (insurance)
  - Embodied energy, LCI/LCA
  - Toxicity of built environment
- More tools, not fewer, customized to user needs
- Users continue to want more at lower effort

BIM – Integrating Energy and Environmental Performance, Code Compliance



Simulation vs. Operating Energy

- Simulation is primarily a comparative tool rather than an absolute energy tool
- Simulation has been shown to be critical for designing buildings and making decisions
- BUT real buildings
  - Use more energy than simulations
  - Produce less power than simulations
  - Have worse controls than simulations
  - Have more occupant complaints than simulations
- Why?
  - Schedules differ from what was modeled
  - Installed vs. modeled components/system
  - Sub-optimal operation of HVAC systems
  - Disabling of control systems
  - Typical vs. actual weather year can differ significantly

Recent and Pending Legislation Significant to Buildings

Relevant Policy and Legislation

American Recovery and Reinvestment Act of 2009

- set aside $16.8 billion for energy efficiency and renewable energy
- $2.5 billion of that allocated to Applied Research, Development, Demonstration, and Deployment

Executive Order 13514

- requires federal buildings to meet sustainability targets

American Clean Energy and Security Act *(in Senate)*

- would require increased stringency of ASHRAE 90.1: 30% now; 50% by 2016
- would establish incentive-based retrofit program for energy savings

Executive Order 13514

Federal Leadership in Environmental, Energy, and Economic Performance *(signed Oct. 5)*

- Establishes numerous goals for federal agencies
- Represents a transformative shift in the way the government operates by:
  - establishing GHGs as the integrating metric for tracking progress in federal sustainability
  - requiring a deliberative planning process
  - linking to budget allocations and OMB scorecards to ensure goal achievement

Executive Order 13514 *(cont.)*

Requires agencies to meet sustainability targets, including:

- achieve 30% reduction in vehicle fleet petroleum use by 2020
- achieve 26% reduction in potable & 20% reduction in industrial, landscaping, & agricultural water consumption by 2020
- comply with new EPA stormwater management guidance
- achieve 50% recycling & waste diversion by 2015
- requires that 95% of all applicable procurement contracts will meet sustainability requirements
- requires 15% of buildings meet the Guiding Principles for High Performance and Sustainable Buildings by 2015
- design all new federal buildings that begin the planning process by 2020 to achieve net-zero energy by 2030

American Clean Energy and Security Act *(pending Senate approval)*

H.R.2454: Contains broad-reaching policies aimed at establishing a cap-and-trade system for greenhouse gases and new energy policies to provide reductions in energy use.

Energy Use

- Requires increased stringency of ASHRAE 90.1
  - 30% now
  - 50% by 2016
- Establishes incentive-based retrofit program for energy savings
- Establishes voluntary building energy labeling program for new construction
  - mandatory for DOE and EPA buildings
  - requires significant improvements to CBECS and RECS

American Clean Energy and Security Act *(cont.)*

Codes

- Provides grants to state and local building code departments to assist in enforcement
  - for training, equipment, increased staffing, and certifications and accreditations

Cap-and-Trade

- Establishes trading scheme of allowances for GHGs
  - begins at 90% of baseline in 2012; goes down to 15% after 2032
  - 80% to producers/importers; 20% to secondary users
  - 10% of producer/importer allowances subject to auction
  - offset credits available for destruction of CFCs

American Clean Energy and Security Act *(cont.)*

Reporting Requirements

- Stationary sources emitting more than 25k metric tons of CO_2 equivalent per year
- Facilities with on-site power plant or landfill must also report emissions
- Emitters must report emissions in 2011 for 2007–2010, and quarterly thereafter

American Recovery and Reinvestment Act of 2009

- Set aside $16.8 billion for energy efficiency and renewable energy
- $2.5 billion of that allocated to Applied Research, Development, Demonstration, and Deployment

RECOVERY.GOV

DOE's Commercial Building Initiative

Enabling significant improvements in the energy performance of new and existing commercial buildings throughout the U.S.

- Mandates: Energy Independence and Security Act of 2007
  U.S. GHG Targets

- Strategy: Public-private partnerships to accelerate widespread adoption of advanced building technologies and best practices

- Activities: Market Outreach, Engagement and Demonstration
  High Performance Building Package R&D

Energy Independence and Security Act of 2007

- Called for development of Net-Zero Energy Commercial Building Initiative [EISA Section 422]:
  - commercial buildings newly constructed by 2030
  - 50% of commercial building stock by 2040
  - all commercial buildings by 2050
- Authorized DOE to collaborate with national labs, private sector, other federal agencies, non-governmental organizations to advance high-performance commercial buildings
- Directed DOE to recognize High-Performance Green Building Partnership Consortia and competitively select Consortium

Market Outreach and Demonstration Critical to Reaching Goals

Commercial Building Partnerships

- DOE has partnered with more than 20 companies who have agreed to:
  - ***build one new building at 50% less energy*** than Standard 90.1
  - ***retrofit a building that uses 30% less energy*** than the CBECS baseline or 30% less than the mean of their building portfolio
- Labs provide technical assistance
- Recovery Act provides funding for second solicitation
- Funding should allow selection of 50–75 new CBPs

Commercial Building Energy Alliances (CBEAs)

Informal associations among building owners and operators who want to reduce energy consumption

Current CBEAs	Future CBEAs
– Retailer Energy Alliance (launched February 2008) – Commercial Real Estate Energy Alliance (launched April 2009) – Hospital Energy Alliance (launched April 2009)	– Higher Education Energy Alliance (launching 2010) – Government Energy Alliance (launch TBD)

Market Share of Alliance Members (as of April 2010)

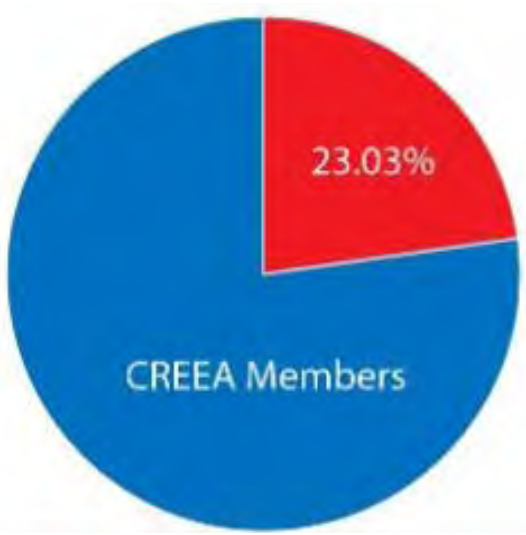
Retailer Energy Alliance

- 48 member companies
- 2.548 billion sq. ft.

Hospital Energy Alliance

- 35 member companies
- 323 million sq. ft.

Commercial Real Estate Energy Alliance



- 52 member companies
- 5.856 billion sq. ft.

Key Alliance Activities

- Commercial Technology Solutions: Targeting 50% Energy Savings at the System Level
  - Commercial Lighting Solutions (www.lighting-solutions.org)
  - In development:
    - Packaged HVAC Systems Solutions
    - Supermarket Refrigeration Solutions
    - Daylighting Solutions

- Supplier Summits
  - Dialogue between commercial building owners and operators and suppliers
  - Summits this year

HVAC &Refrigeration	Renewables	Lighting	Envelope
Orlando, Jan. 28, ASHRAE/AHR Expo	Austin, Feb. 23, Renewable Energy World Expo	Las Vegas, May 11, IES/LIGHTFAIR®	Miami, June, AIA National Convention

Key Alliance Activities *(cont.)*

- Technology Identification and Screening
  - Nominated, promising energy-efficient technologies are evaluated by DOE and national laboratories
  - Speeds application of “proven” technologies in commercial buildings
  - Supports identification of suitable technologies for possible Technology Specifications
- Technology Specifications
  - *1st* project: LED Outdoor Area Lighting
  - LEDs for Refrigerated Display Cases
  - Rooftop HVAC
  - High-Efficiency Parking Garage Lighting

CBEA Technology Specifications: LED Outdoor Area (Parking Lot) Lighting

- Why LEDs make sense for commercial parking lots
  - save energy
    - enhanced luminaire optical efficiency
    - better total system efficacy (lumens per watt)
    - control capability (e.g., dimming)
  - reduced maintenance costs
  - improved uniformity
  - environmentally friendly
- Timing
  - REA working group established April 2008
  - specifications completed early 2009
  - installed at test site July 2009

Summary

- We can do 30% (or more) energy savings cost-effectively today
- Creating design guides today (for 30%) → technology packages (for 50%) for tomorrow and beyond
- It’s not one technology but how the technologies are integrated
- To get to zero, it will take improvements in technologies, cost reductions, and supporting policies

Thanks!

Questions?

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Think about Metrics

Energy

Demand

Cost

Water

IEQ

Carbon

Business
(student, occupied room, sales)

Technical Support Documents or AEDGs

30% Energy Savings

Small Retail
www.pnl.gov/main/publications/external/technical_reports/PNNL-16031.pdf
Small Office
www.pnl.gov/main/publications/external/technical_reports/PNNL-16250.pdf
Highway Lodging
www.pnl.gov/main/publications/external/technical_reports/PNNL-17875.pdf
Small Warehouse
www.pnl.gov/main/publications/external/technical_reports/PNNL-17056.pdf
K–12 Schools
www.nrel.gov/docs/fy07osti/42114.pdf

50% Energy Savings

Medium Box Retail
www.nrel.gov/docs/fy08osti/42828.pdf
Grocery Stores
www.nrel.gov/docs/fy08osti/42829.pdf
Highway Lodging
www.pnl.gov/main/publications/external/technical_reports/PNNL-18773.pdf
Medium Office Buildings
www.pnl.gov/main/publications/external/technical_reports/PNNL-18774.pdf

Technical Reports on Net-Zero Energy Buildings

- Assessment of the Technical Potential for Achieving Zero-Energy Commercial Buildings
  www.nrel.gov/docs/fy06osti/39830.pdf

- Federal Research and Development Agenda for Net-Zero Energy, High-Performance Green Buildings
  ostp.gov/galleries/NSTC%20Reports/FederalRDAgendaforNetZeroEnergyHighPerformanceGreenBuildings.pdf

- Zero Energy Buildings: A Critical Look at the Definition
  www.nrel.gov/docs/fy06osti/39833.pdf