Getting to Zero-Energy Buildings: AEDGs to ZEBs

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U S Department of Energy

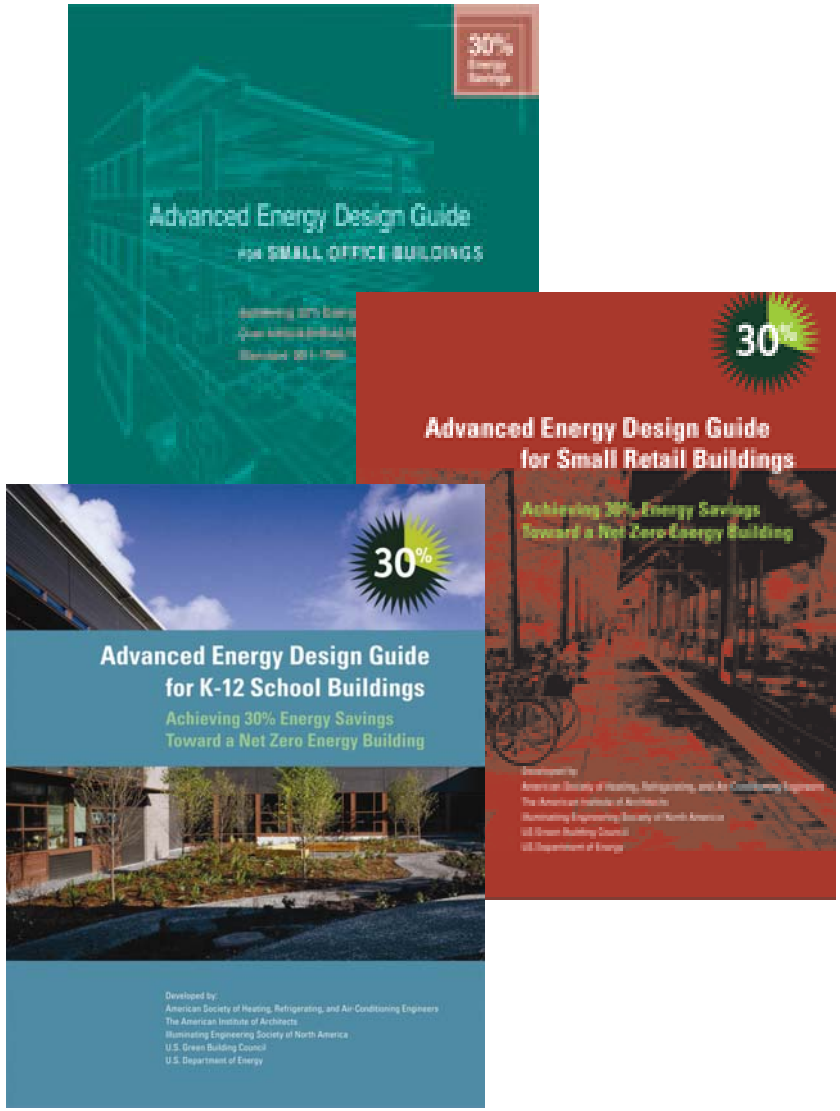
Energy Efficiency and Renewable Energy

30% Advanced Energy Design Guides

- ASHRAE, IESNA, AIA, USGBC, and DOE developing series of energy design guides for achieving 30% lower energy than 90.1
- Prescriptive tabular approach
- Small office guide published 2005, retail guide in late 2006, and K-12 schools in early 2008.
- ***LEED points without simulation!***

- Warehouse guide released in April 2008, followed by highway lodging and healthcare guides in late 2009.

- www.ashrae.org/aedg



Development Objectives

- Provide *a way, but not the only way* to achieve 30% energy savings relative to 90.1-1999
- Provide recommendations (prescriptive measures) and design strategies ("how to implement" tips)
- Energy savings as the independent variable - Use of practical, off-the-shelf technology
- Provide user-friendly document targeting contractors, design/build firms and designers involved in smaller buildings (< 20K ft^2)
- LEED points: 4 E&A credits

Recommendation Tables

Climate Zone 5 Recommendation Table

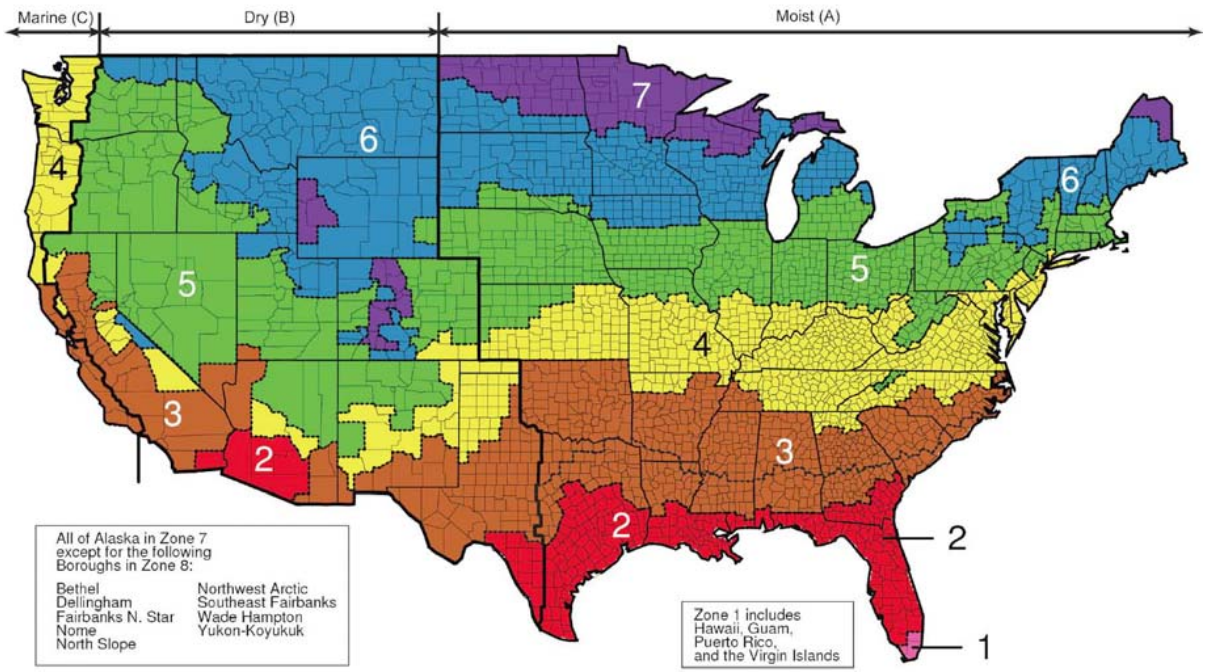
	Item	Component	Recommendation	How-To's in Chapter 4
Envelope	Roof	Insulation entirely above deck	R-20 c.i.	EN2, 17, 20-21
		Metal building	R-13 + R-19	EN3, 17, 20-21
		Attic and other	R-38	EN4, 17-18, 20-21
		Single rafter	R-38 + R-5 c.i.	EN5, 17, 20-21
		Surface reflectance/emittance	No recommendation	
	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
- References to "how-to" section

What the Design Guides Provide

- Explains integrated design
  - Checklists
  - Suggested targets
- Savings by climate zone
  - 8 climate zones
  - Prescriptive path
  - *No modeling required*
  - Helps earn CHP, LEED, or other credits



How Do I Get the Advanced Energy Design Guides?

- Free download at ashrae.org/freeaedg
  - 50,000 downloads already
- ASHRAE sent out 15,000 free hard copies to U S school districts



What's Next for the AEDGs?

Additional Advanced Energy Design Guides Planned or in Process

- **30% for Highway Lodging (due early 2009)**
- **30% for Healthcare (due spring 2009)**
- **30% for Existing Buildings (2008, 2009)**

- **50% and Beyond towards Net Zero Energy Buildings (2009→)**

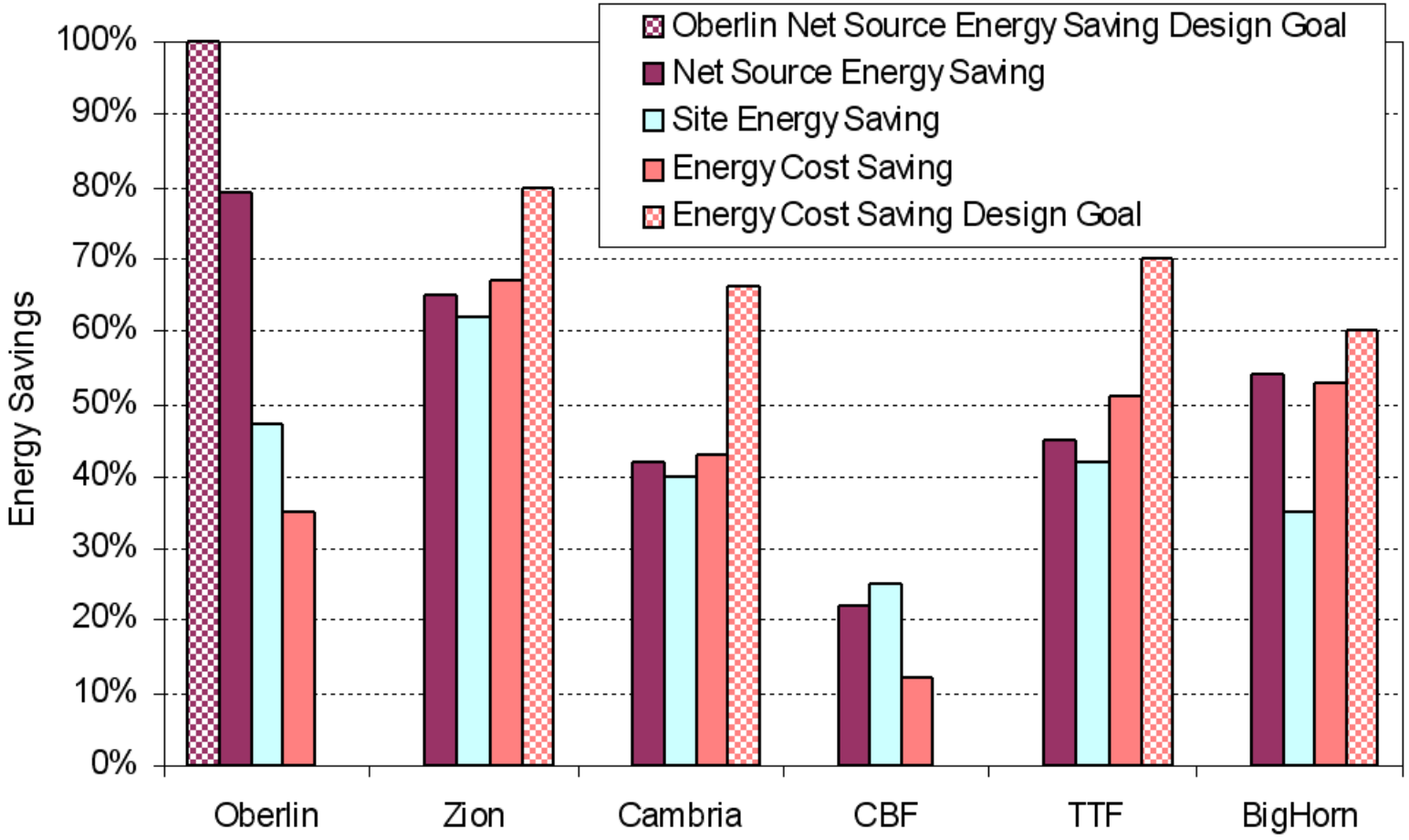
Real Low-Energy Buildings

Case Study Buildings

- Oberlin College Lewis Center
  - Oberlin, Ohio
  - goal: zero net site energy use (79%)
- Zion Visitor Center
  - Springdale, UT
  - goal: 70% energy cost savings (65%)
- Cambria Office Building
  - Ebensburg, PA
  - goal: 66% energy cost savings (43%)
- Chesapeake Bay Foundation (CBF)
  - Annapolis, MD
  - goal: LEED 1.0 Platinum Rating (25%)
- Thermal Test Facility (TTF)
  - Golden, CO
  - goal: 70% energy savings (51%)
- BigHorn Home Improvement
  - Silverthorne, CO
  - goal: 60% energy cost savings (53%)

Results

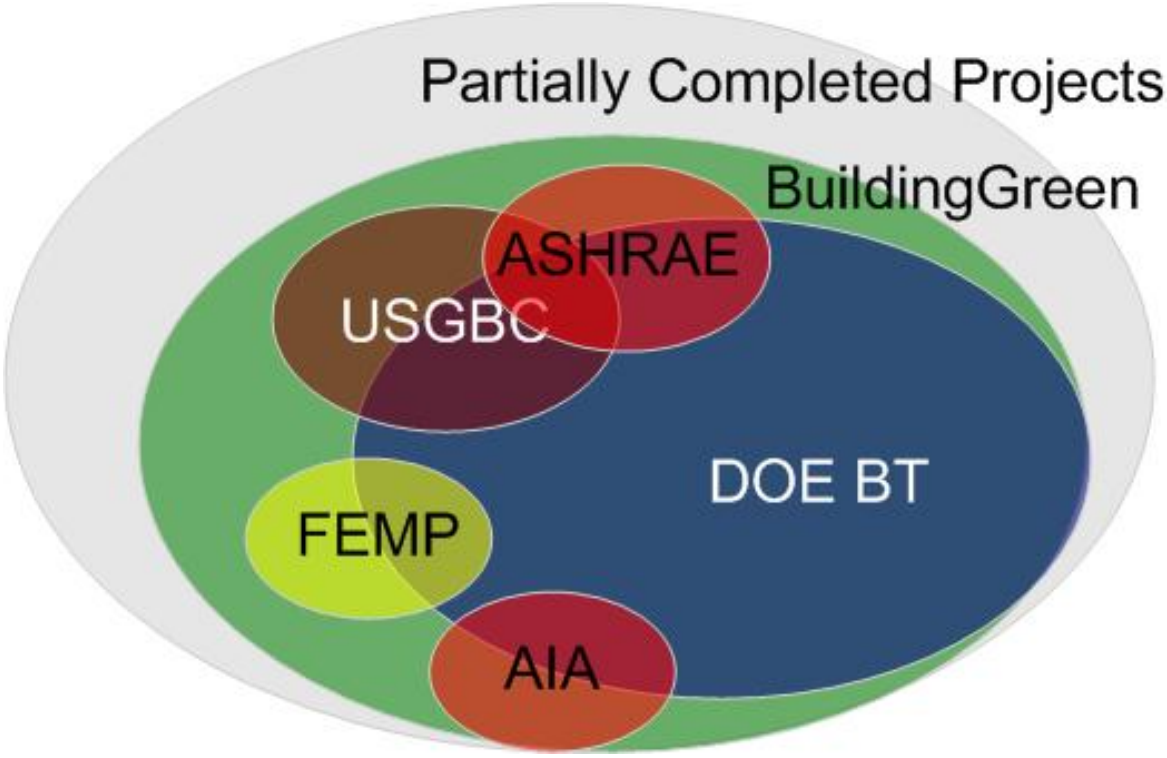
Measured Energy Savings vs. Design Goals



Database of Information on High Performance Buildings

High-Performance Buildings Database

- Share successes and lessons learned about projects
- Public database
- www.highperformancebuildings.gov



Database Partners

- USGBC
- Federal Energy Management Program
  - New Federal buildings must be entered by Executive Order 14123
- AIA Top Ten Winners
- USGBC LEED™ case studies
- Massachusetts Technology Collaborative
- Efficiency Vermont
- USGBC Cascadia Chapter
- Department of Energy
- ASHRAE/IESNA/AIA Advanced Energy Design Guide case studies
- New Buildings Institute (links data from Getting to 50 database)

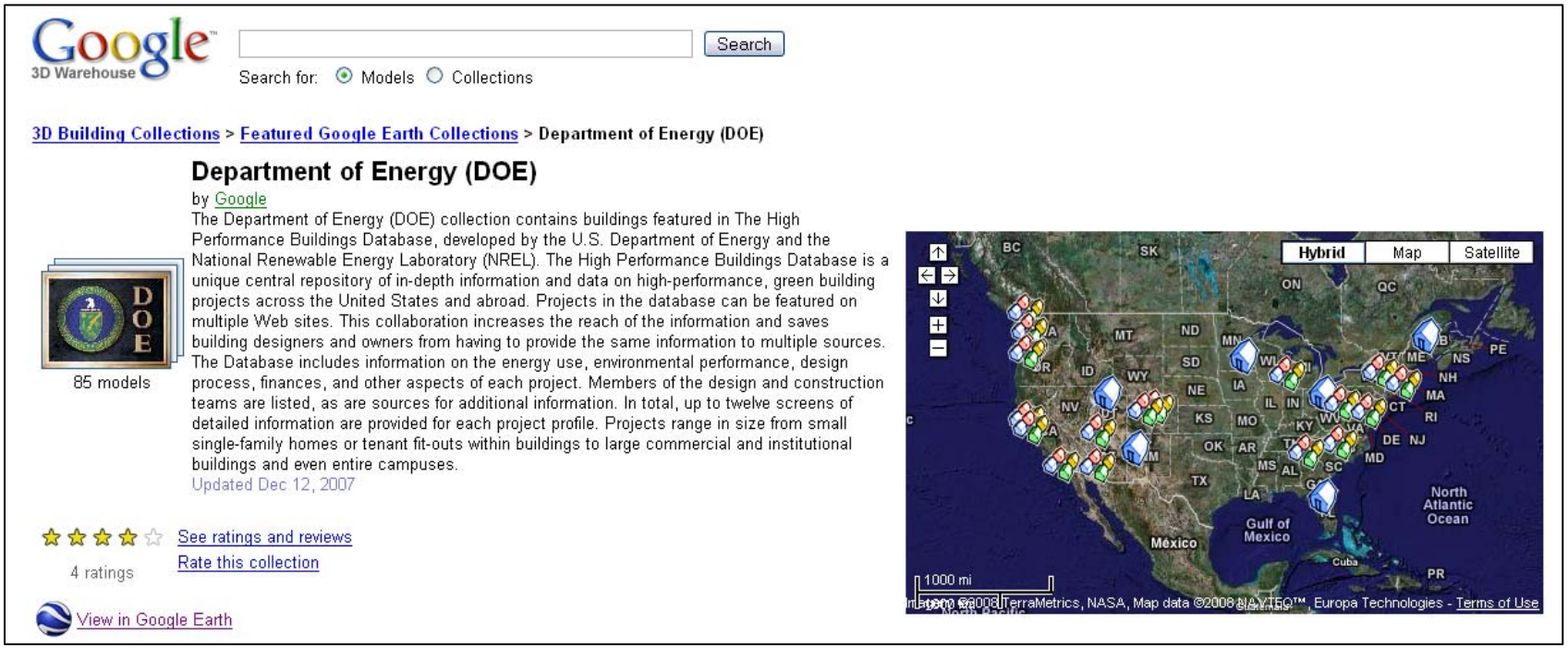
- We know of others that are linking the data
- 3-D models (SketchUp) available for many of the buildings in a new Google Earth layer

Google Earth Layer for High Performance Buildings

- Lives on Google Server
- Can “fly” to any of the featured High Performance Buildings
- Displays buildings in 3D with textures
  - Models can be downloaded into Google SketchUp (not full geometry!)
- Links to HPB Database to show detailed information of building

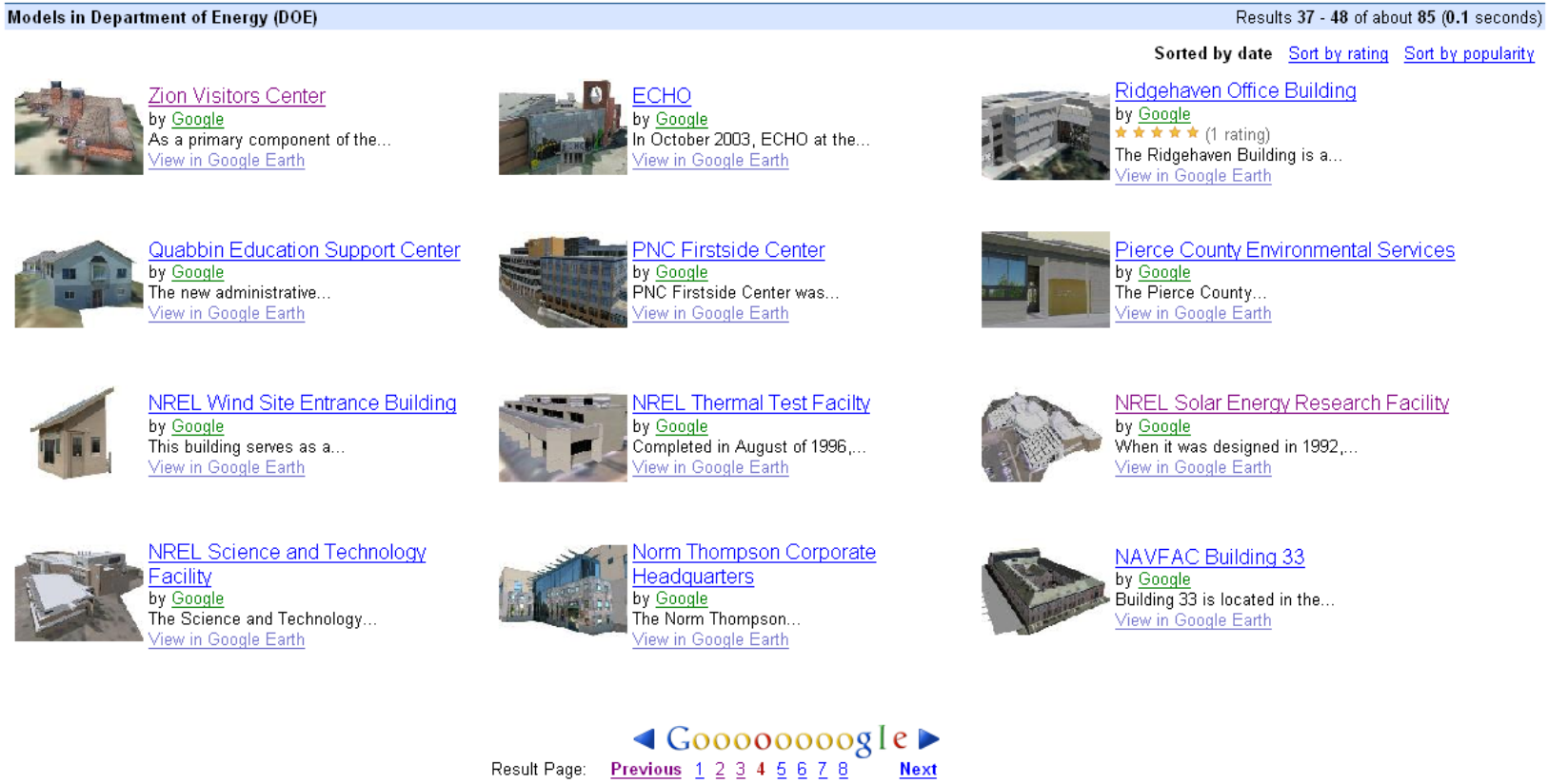
DOE Building Collections in Google 3D Warehouse

- Provides enhanced display of High Performance Buildings
- Currently contains 85 models (in SketchUp)
- Linked to the HPB Database for additional information



DOE Building Collections in Google 3D Warehouse (cont)

Review building information online



DOE Building Collections in Google 3D Warehouse (cont)

Detailed view contains link to HPB database

Google Earth Layer

Display detailed information
on the featured buildings

High Performance Buildings

NREL Solar Energy Research Facility

- Location: Golden, CO
- Annual Purchased Energy: 359 kBtu/ft²
- Building type(s): Laboratory
- New construction
- 115,000 sq. feet (10,700 sq. meters)
- Project scope: 3-story building
- Suburban setting
- Completed October 1993

Read the full in-depth case study from the Department of Energy

This case study is also available at
BuildingGreen.com High Performance Federal Buildings

Photo credit: Warren Gretz

View 3D model in Google Earth

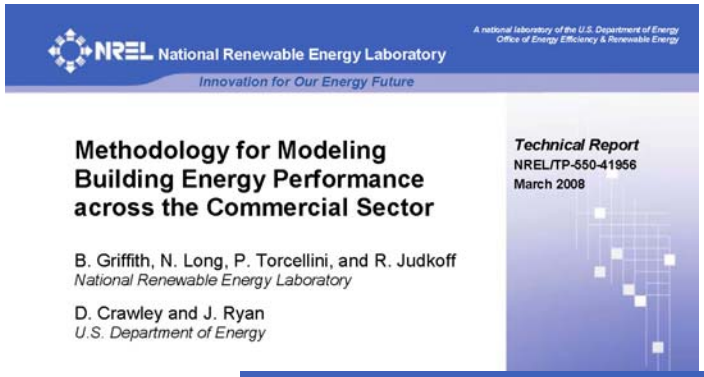
Can We Get to Zero-Energy?

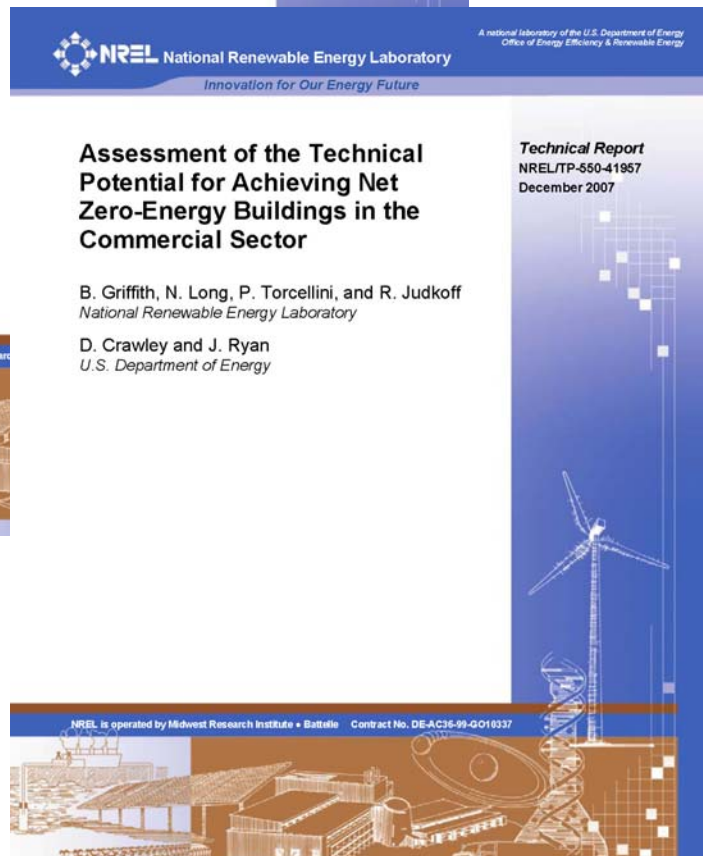
Assessment of Technical Potential

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

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

- Scenario Analysis Using EnergyPlus Models for 4,820 Samples
  - Forward modeling allows modeling "what if" scenarios
  - Annual, 15-minute modeling with historical weather files for 2003
  - Detail developed from probability, literature, engineering design, codes, and standards.

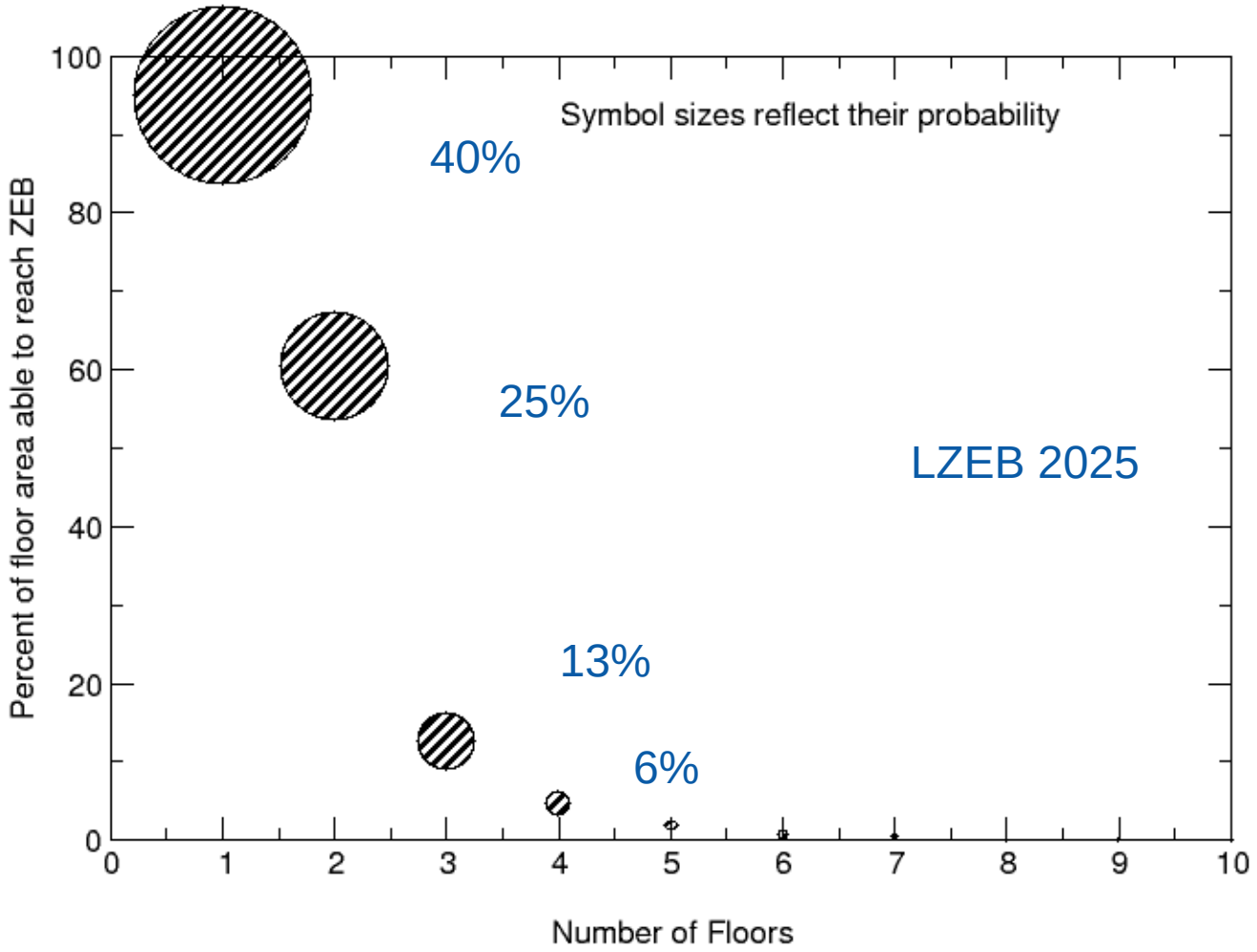




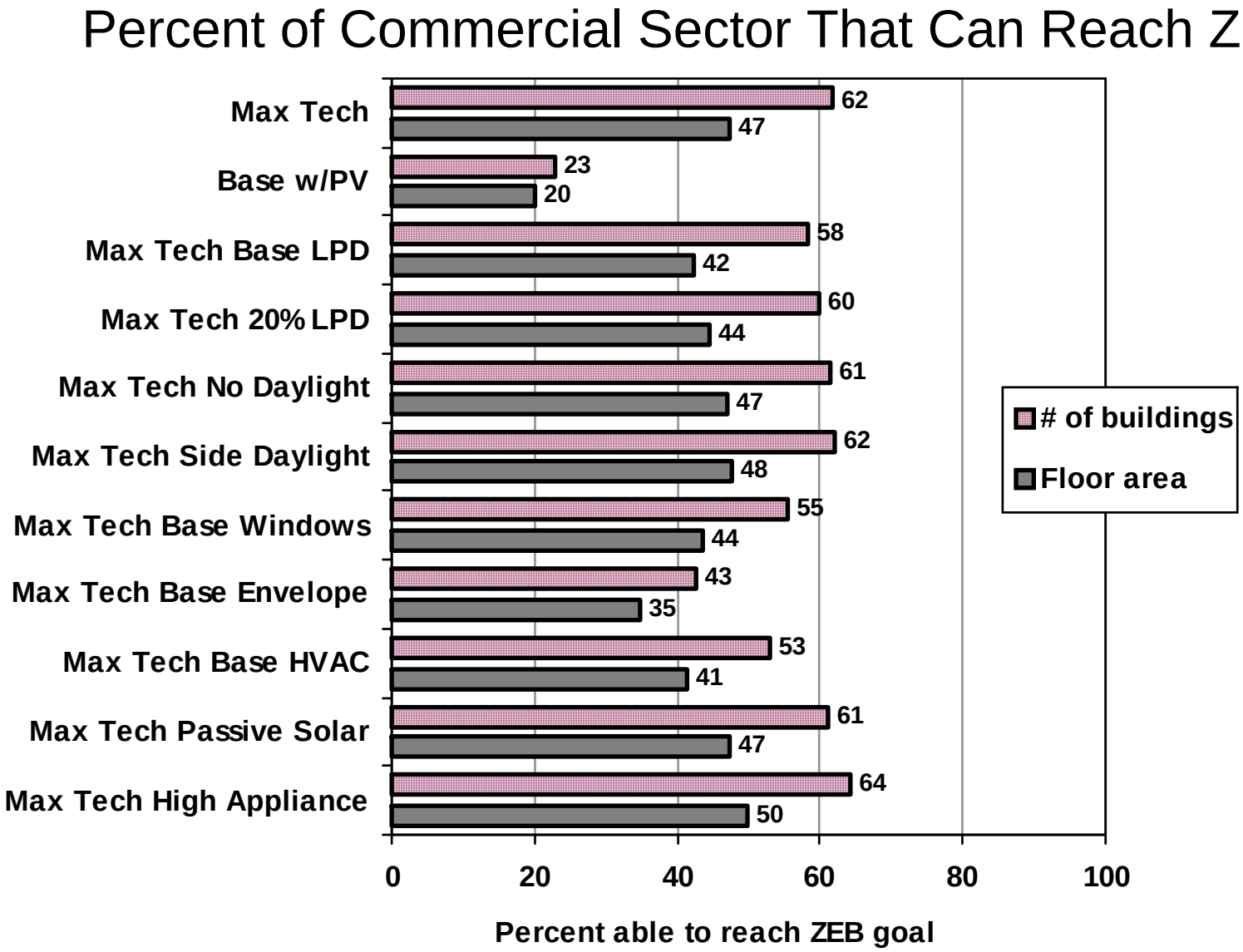
ZEB Characteristics

Number of floors impacts ability to reach ZEB goal

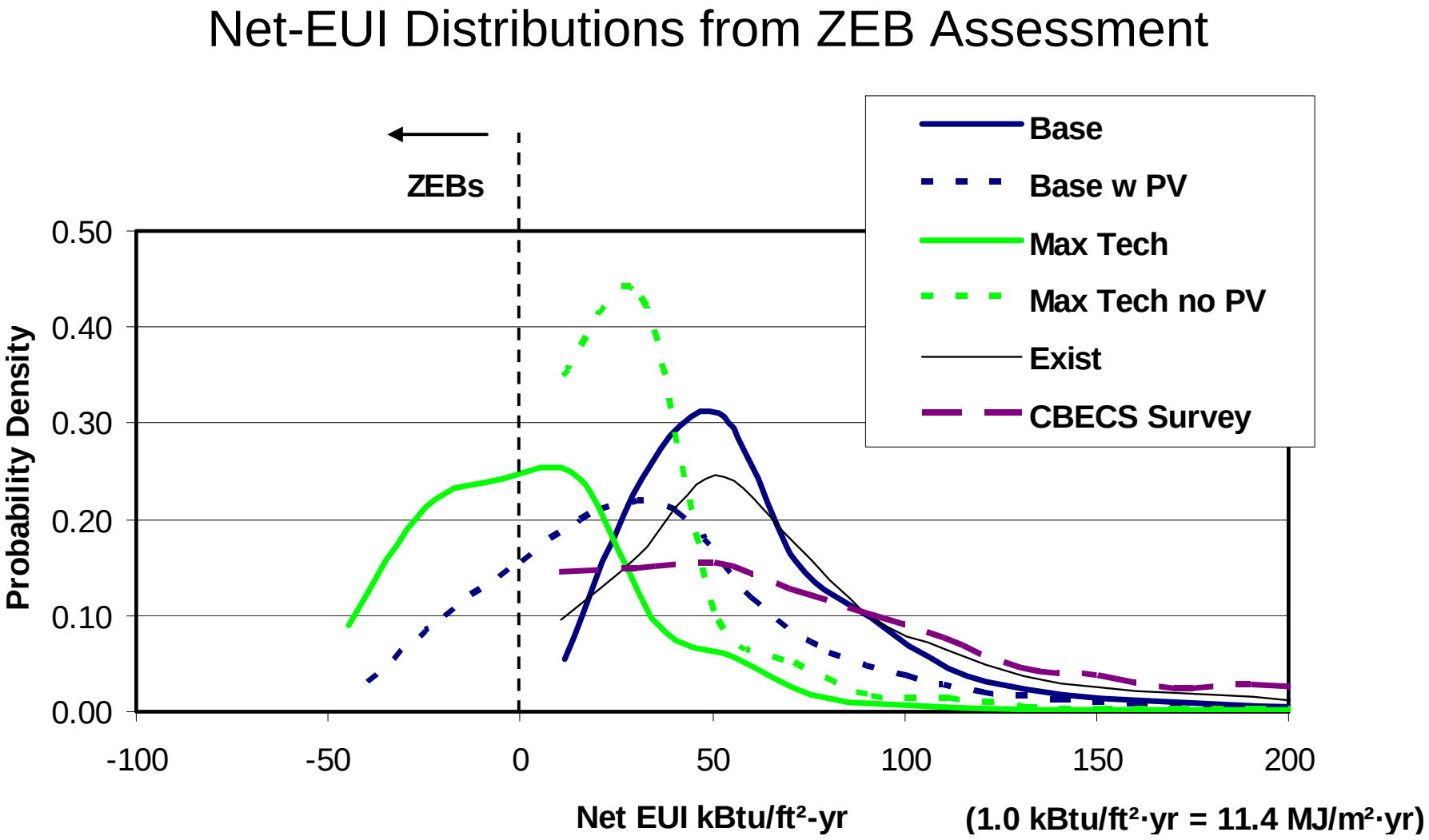
- Roof area
- Daylighting



Results


Percent of Commercial Sector That Can Reach ZEB
Max Tech
62
47
Base w/PV
23
20
Max Tech Base LPD
58
42
Max Tech 20% LPD
60
44
Max Tech No Daylight
61
47
Max Tech Side Daylight
62
48
Max Tech Base Windows
55
44
Max Tech Base Envelope
43
35
Max Tech Base HVAC
53
41
Max Tech Passive Solar
61
47
Max Tech High Appliance
64
50
# of buildings
Floor area
0
20
40
60
80
100
Percent able to reach ZEB goal

Results


Net-EUI Distributions from ZEB Assessment
ZEBs
Base
Base w PV
Max Tech
Max Tech no PV
Exist
CBECS Survey
Probability Density
0.50
0.40
0.30
0.20
0.10
0.00
-100
-50
0
50
100
150
200
Net EUI kBtu/ft²-yr
(1.0 kBtu/ft²·yr = 11.4 MJ/m²·yr)

Target EUIs for 30% Savings

- Developed targets by climate zone and principal building activity
- Cited in DOE order 430.2B (Feb. 27, 2008) for federal buildings

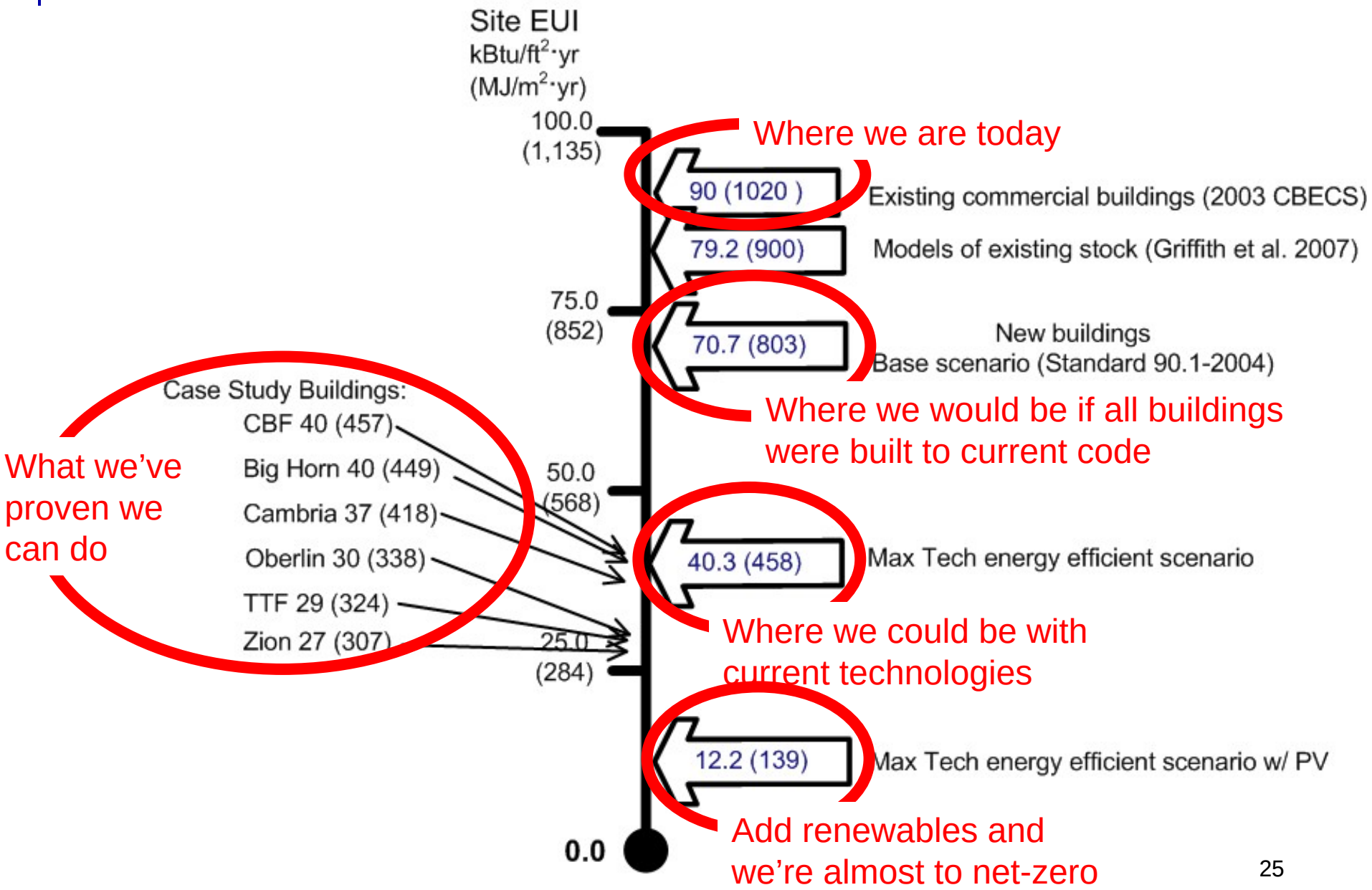
Table 1. Target Energy Use Intensities[1] for 30% savings relative to ANSI/ASHRAE/IESNA Standard 90.1-2004[2] by Subsector and Climate Zone[3]: IP Units kBtu/ft^2-yr

Subsectors	Climate Zones															
	All	1A	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7	8
All	49	58	47	51	54	40	44	49	39	39	52	45	53	51	52	52
Office/professional	40	39	42	45	37	32	31	42	41	37	42	33	43	43	47	47
Nonrefrigerated warehouse	29	19	21	21	26	21	21	29	35	21	33	35	35	33	32	32
Education	36	36	34	40	29	29	38	42	24	30	37	31	42	45	45	45
Retail (except malls)	47	47	46	46	44	38	38	48	40	40	51	50	53	64	70	70
Public assembly	43	46	46	46	50	37	37	38	33	54	48	35	46	36	49	49
Service	58	58	55	55	42	44	44	55	36	36	64	53	72	60	76	76
Religious worship	31	28	28	28	20	21	21	31	41	41	36	24	40	27	31	31
Lodging	38	45	36	36	37	28	28	40	43	43	39	36	42	45	44	44
Food services	248	248	248	248	266	262	262	257	257	257	235	198	239	239	248	248
Inpatient health care	77	75	75	75	83	69	68	74	74	74	81	74	79	81	81	81
Public order and safety	47	38	38	38	47	47	47	42	42	42	55	54	51	61	61	61
Food sales	127	140	140	140	133	105	105	132	132	132	121	127	146	146	127	127
Outpatient health care	53	53	56	56	45	55	55	46	46	46	63	53	57	55	75	75
Vacant	21	21	16	16	21	14	14	29	29	29	15	15	28	28	28	28
Other	40	51	51	51	40	40	40	40	40	40	43	43	44	44	44	44
Skilled nursing	92	92	92	92	79	72	72	102	102	102	99	74	93	93	93	93
Laboratory	226	226	226	226	226	258	258	191	191	191	219	219	226	226	226	226
Refrigerated warehouse	60	60	60	60	60	60	60	62	60	60	60	60	60	60	60	60

[1] EUIs are site (delivered) energy use for the whole building.
[2] 30% Targets were developed from modeling results for Standard 90.1-2004 multiplied by 0.7 (listed in Table 2).
[3] Climate zones are defined in ANSI/ASHRAE Standard 169-2006.

http://buildings.energy.gov/highperformance/pdfs/energy_use_intensity_targets.pdf

Great Potential for Commercial Building Energy Efficiency



More information

- Office of Building Technologies
  buildings.energy.gov
- EnergyPlus
  www.energyplus.gov
- High Performance Buildings
  www.highperformancebuildings.gov

'Every building is a forecast. Every forecast is wrong.'

Steward Brand