Moving beyond Codes: Advanced Energy Design Guides and Zero Energy Buildings

Taller de Capacitación en Sistemas de Eficiencia Energética de Edificios y Etiquetado

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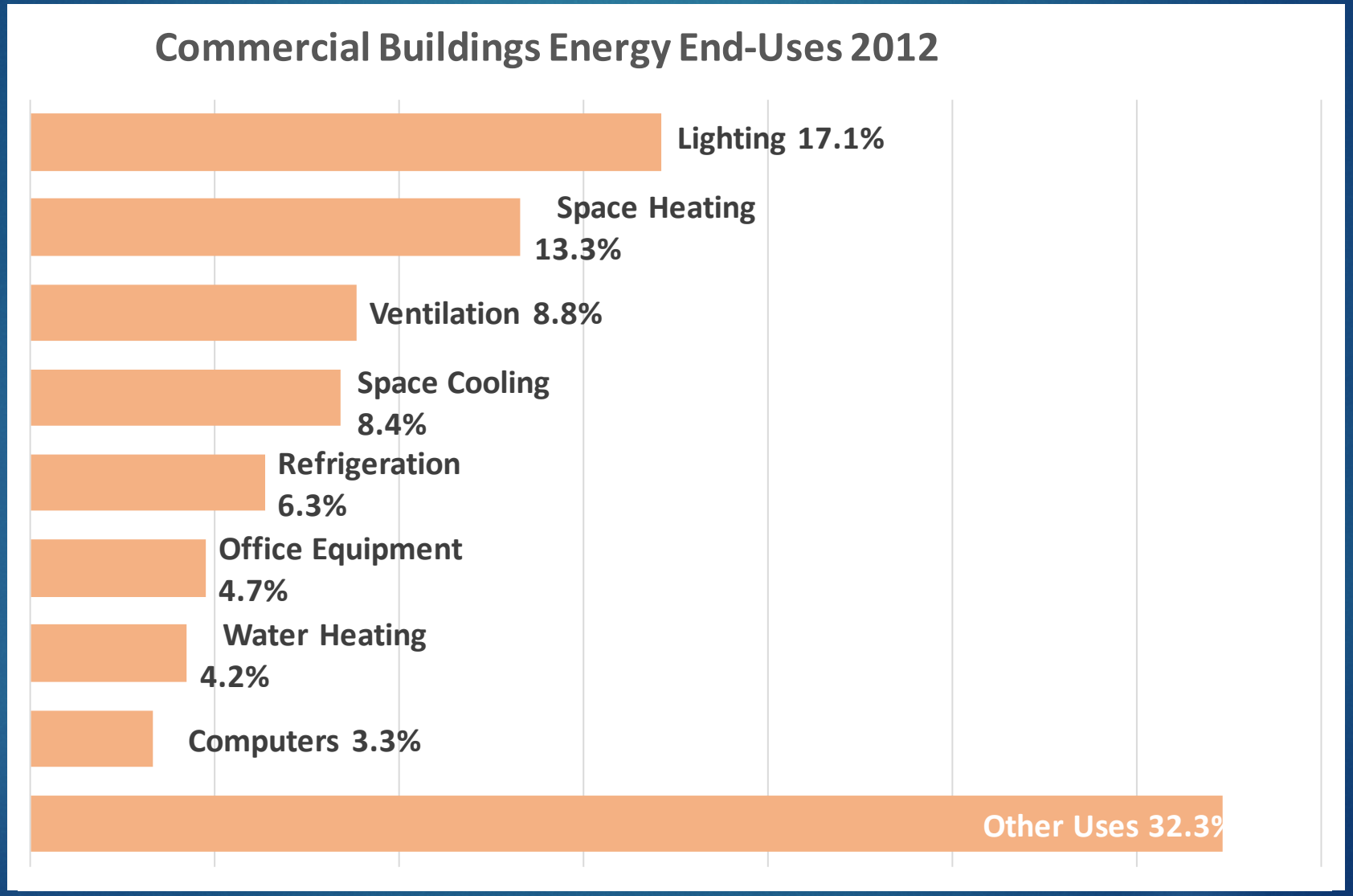
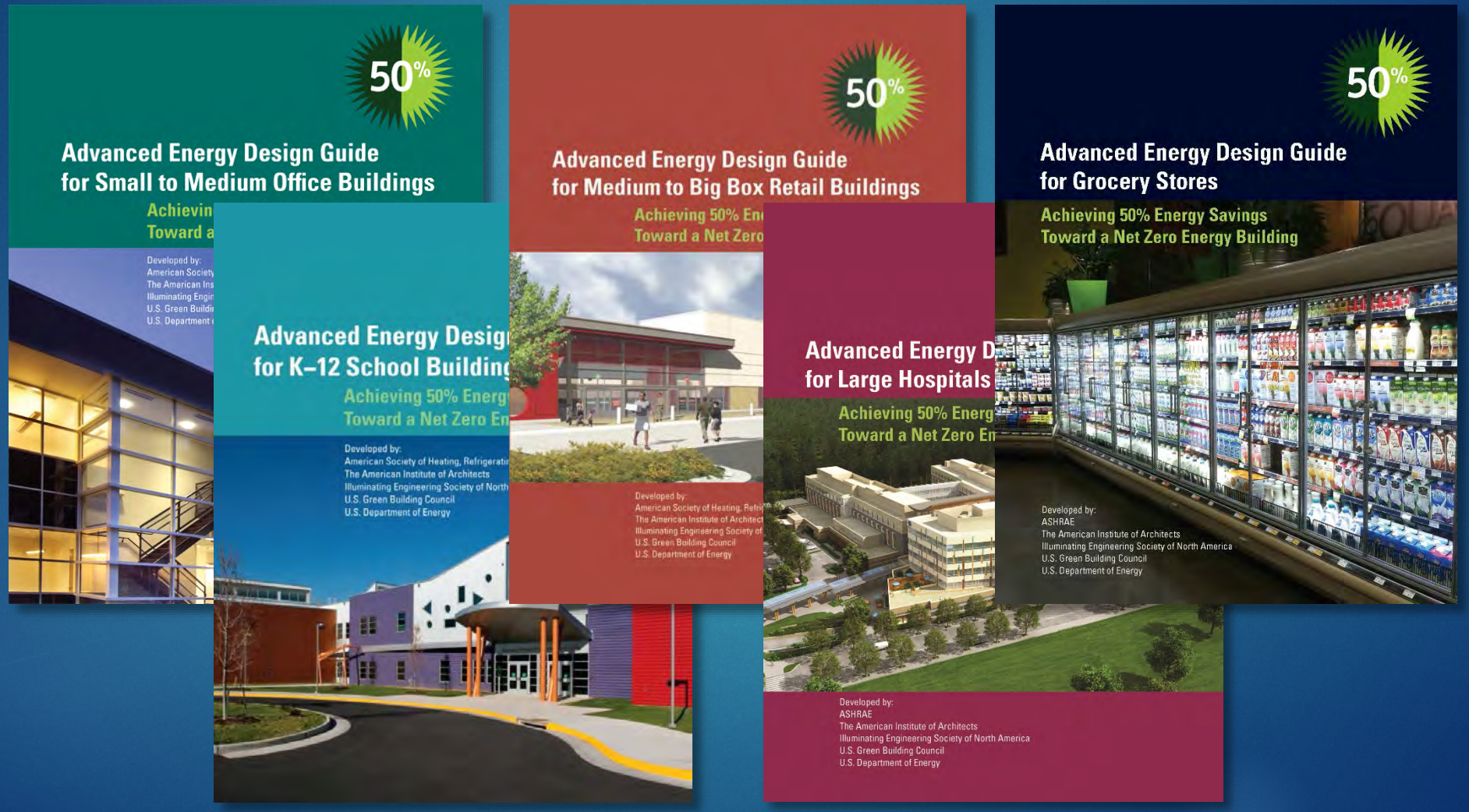
U.S. Buildings' Energy Use



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

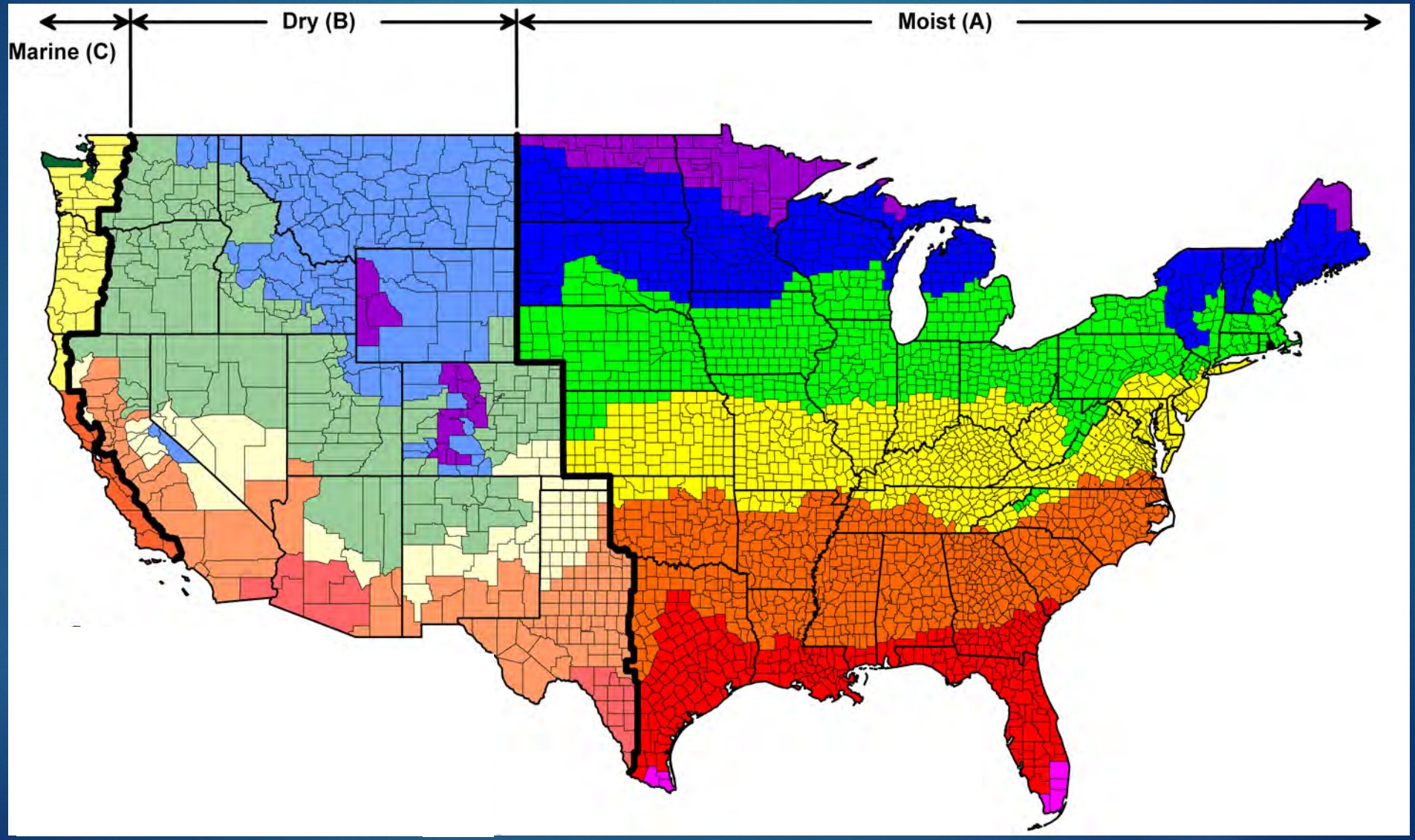
Five 50% Guides



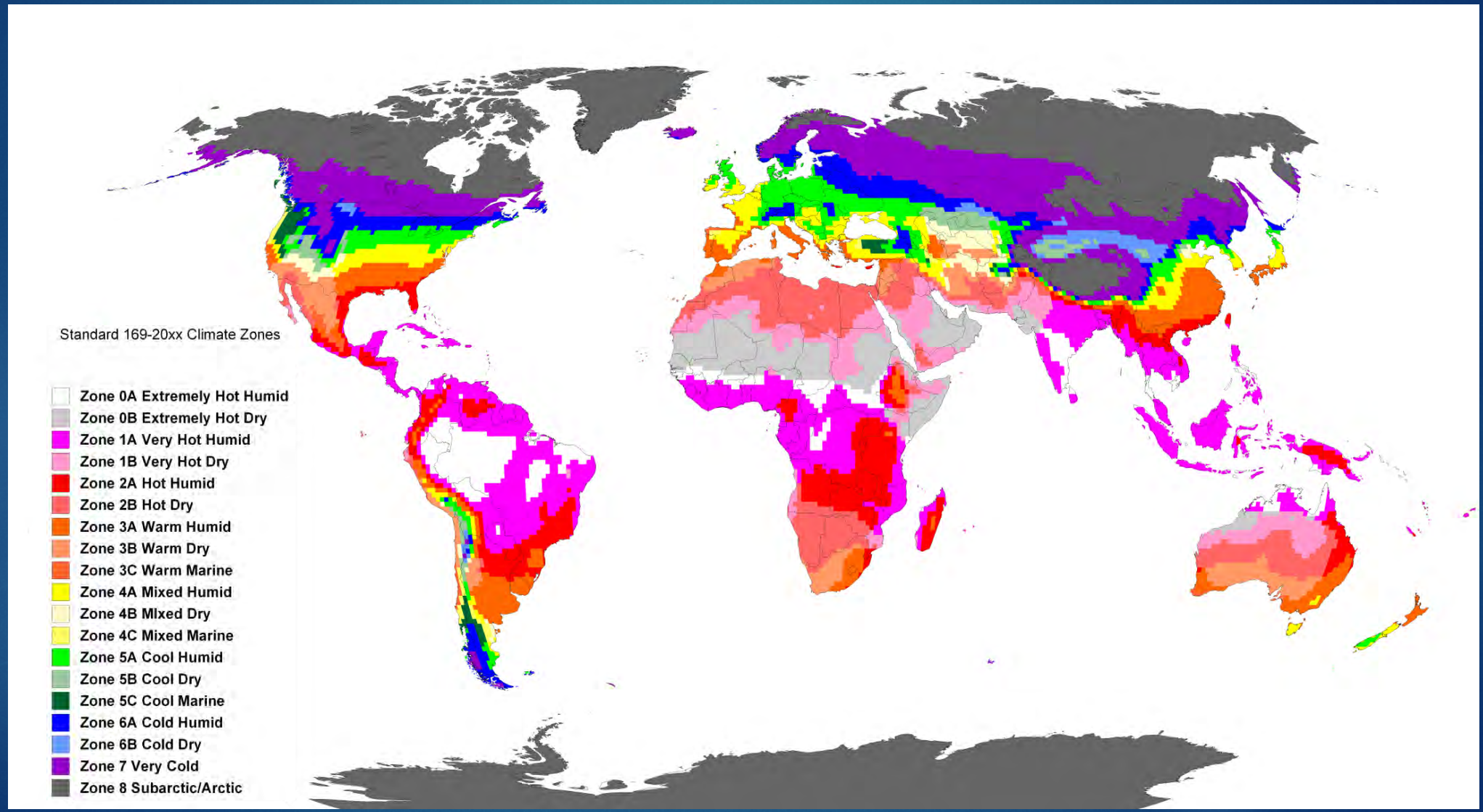
What are the 50% AEDGs?

- A way, but not the only way to build energy-efficient buildings that use significantly less energy than a minimum code-compliant building
- At least 50% energy savings as compared to ANSI/ASHRAE/IESNA Standard 90.1-2004
- 50% progress toward a net zero energy building

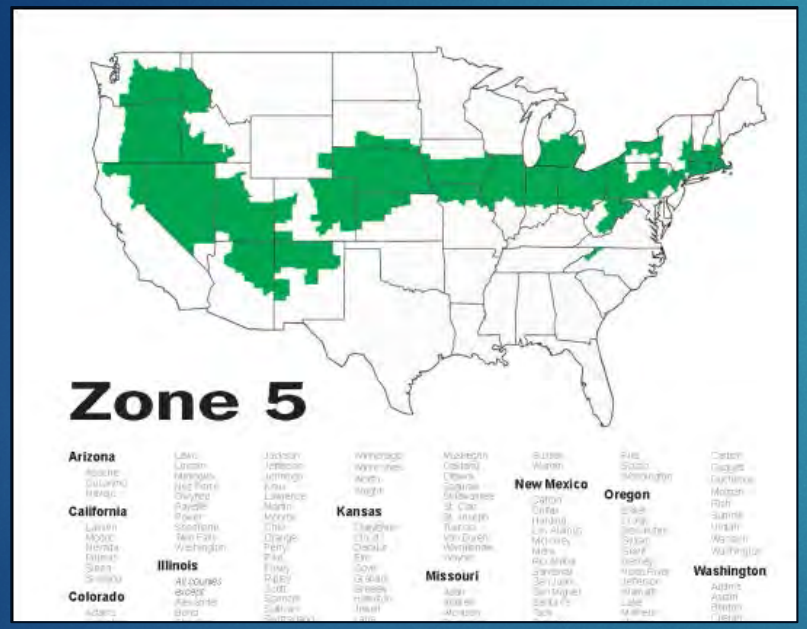
Recommendations by Climate Zones



World Climate Zones -- Standard 169-2013



Recommendations Tables



Climate Zone 5 Recommendation Table for Small to Medium Office Buildings

	Item	Component	Recommendation	How-To Tips	✓
Envelope	Roofs	Insulation entirely above deck	R-30.0 c.i.	EN2, 17, 19, 21–22	
		Attic and other	R-49.0	EN3, 17, 19, 20–21	
		Metal building	R-19.0 + R-11.0 Ls	EN4, 17, 19, 21	
		SRI	No recommendation	None	
	Walls	Mass (HC > 7 Btu/ft^2)	R-13.3 c.i.	EN5, 17, 19, 21	
		Steel framed	R-13.0 + R-15.6 c.i.	EN6, 17, 19, 21	
		Wood framed and other	R-13.0 + R-10.0 c.i.	EN7, 17, 19, 21	
		Metal building	R-0.0 + R-19.0 c.i.	EN8, 17, 19, 21	
		Below-grade walls	R-7.5 c.i.	EN9, 17, 19, 21–22	
	Floors	Mass	R-14.6 c.i.	EN10, 17, 19, 21	
		Steel joint	R-38.0	EN11, 17, 19, 21	
		Wood framed and other	R-38.0	EN11, 17, 19, 21	
	Slabs	Unheated	R-15.0 for 24 in.	EN12, 14, 17, 19, 21–22	
		Heated	R-20.0 for 24 in.	EN13–14, 17, 19, 21–22	
	Doors	Swinging	U-0.50	EN15, 17–18	
		Nonswinging	U-0.50	EN16–17	
	Vestibules	At building entrance	Yes	EN18	
	Continuous Air Barriers	Continuous air barrier	Entire building envelope	EN17	
	Vertical Fenestration	WWR	20% to 40%	EN25; DL6	
		Window orientation	Area of W and E windows each less than area of S windows (N in southern hemisphere)	EN30–31	
		Exterior sun control (S, E, and W only)	PF-0.5	EN26	
		Thermal transmittance	Nonmetal framing windows = U-0.35 Metal framing windows = U-0.39	EN23–24	
		SHGC	Nonmetal framing windows = 0.26 Metal framing windows = 0.38	EN24, 32–33, DL12	
Daylighting / Lighting	Daylighting	Light-to-solar-gain ratio	Minimum VT/SHGC = 1.10	EN34–42	
		Vertical fenestration EA	0.12	DL7–11	
	Interior Finishes	Interior surface average reflectance	Ceilings = 80% Wall surfaces = 70% Open office partitions = 50%	DL14–15; EL4	
		Open office partitions parallel to window walls	Total partition height = 36 in. maximum - or - Partition above desk height = min 50% translucent	DL4, 10; EL2, 4	
	Interior Lighting	LPD	0.75 W/ft^2	DL1–5; EL2–3, 5, 12–19	
		24-hour lighting LPD	0.075 W/ft^2	EL20	
		Light source lamp efficacy (mean LPW)	T8 and T5 lamps > 2 ft = 92 T8 and T5 lamps ≤ 2 ft = 85 All other > 50	EL6–8	
		Ballasts	4 ft T8 lamp nondimming applications = NEMA Premium instant start 4 ft T8 lamp dimming applications = NEMA Premium program start Fluorescent and HID sources = electronic	EL8	
		Controls for daylight harvesting in open offices—locate on N and S sides of bldg	Dim all general fluorescent lights within primary and secondary daylight zones of open offices	DL16–20, EL1, 11	
		Automatic controls	Auto ON to 50% = private offices, conference and meeting rooms, lounge and break rooms, copy rooms, storage rooms Auto ON occupancy sensors = restrooms, electrical/mechanical rooms, open and private office task lighting Time switch control = all other spaces	DL13; EL1, 5, 9–10	

High Performance Buildings Examples

GREENSBURG K-12 SCHOOL

Greensburg K-12, a 120,000 ft^2, two-story facility located in Greensburg, KS, accommodates 375 students from pre-kindergarten through high school. The campus includes a library, a cafeteria, a kitchen, science labs, two gymnasiums, an art/music wing, courtyards, playgrounds, and a football stadium. After 95% of the town was destroyed by an EF5 tornado in May of 2007, the school was rebuilt as part of Greensburg's plan for a model "eco-community." Ground was broken on the facility in October of 2008, and the school's grand opening was held in August of 2010.

Designed to achieve the U.S. Green Building Council's LEED for Schools Platinum designation, Greensburg K-12 anticipates a 60% energy-use cost savings. Energy analysis modeling of this school versus an ASHRAE/IESNA Standard 90.1-compliant building of the same size and shape indicates a reduction of more than 50% before adding savings gained from the 50 kW on-site wind turbine, which could provide an additional 10% in annual electricity savings.

As part of Greensburg's overall plan of efficiency and sustainability, Greensburg K-12 was designed from the ground up to be an environmentally responsible model school. Many techniques were used to make the most efficient use of materials and energy.

Thermal Envelope

The walls and parts of the roof are insulated with R-30 to R-40 rated structural insulated panels in order to eliminate heat/cold migration through the exterior building envelope that can occur with more traditional metal stud framing. Overhangs on the south-facing windows reduce summer solar gains and allow winter passive solar tempering for more energy efficiency.

Lighting

The school was built facing east-west to make use of abundant daylight from north and south for both lighting and winter heating. Daylighting is used in all regularly occupied spaces:

- The classrooms and hallways are naturally lit to diminish the need for electric lighting and to improve student performance.
- Electronic timer light switches, indoor occupancy switches, and photoelectric switches are used to manage lighting levels and power usage.

Greensburg School Building Exterior

- Skylights are used to reduce the use of electricity during daylight hours and to provide plenty of light to corridors and other common areas.

HVAC

Heating and cooling are supplied by a hybrid closed-loop GSHP system, combined with a fluid cooler, through almost one hundred 410 ft deep vertical wells. A sensor-controlled outdoor air system lets in outdoor air as needed. The heating and hot-water system are electric to best utilize both the on-site wind turbine as well as the abundant energy produced by the Greensburg wind farm. Carbon dioxide sensors control a dedicated outdoor air system with energy recovery ventilators to provide outdoor air ventilation as needed. All classrooms and most of the offices have operable windows in order to allow natural ventilation.

Other Sustainable Features

- Operable windows provide natural ventilation in classrooms, offices, and other spaces.
- An on-site wind generator provides 50 kW of power that supplements the 12.5 MW generated from the community wind farm.
- Rainwater is captured and stored, and bioswales are used to filter parking lot runoff. Waterless urinals and low-flow fixtures, faucets, and toilets minimize water usage.

(Right) Interior Hallway and (Left) Daylighted Classroom

Pump for Closed Loop Hybrid Heat Pump System

Prescriptive Recommendations:

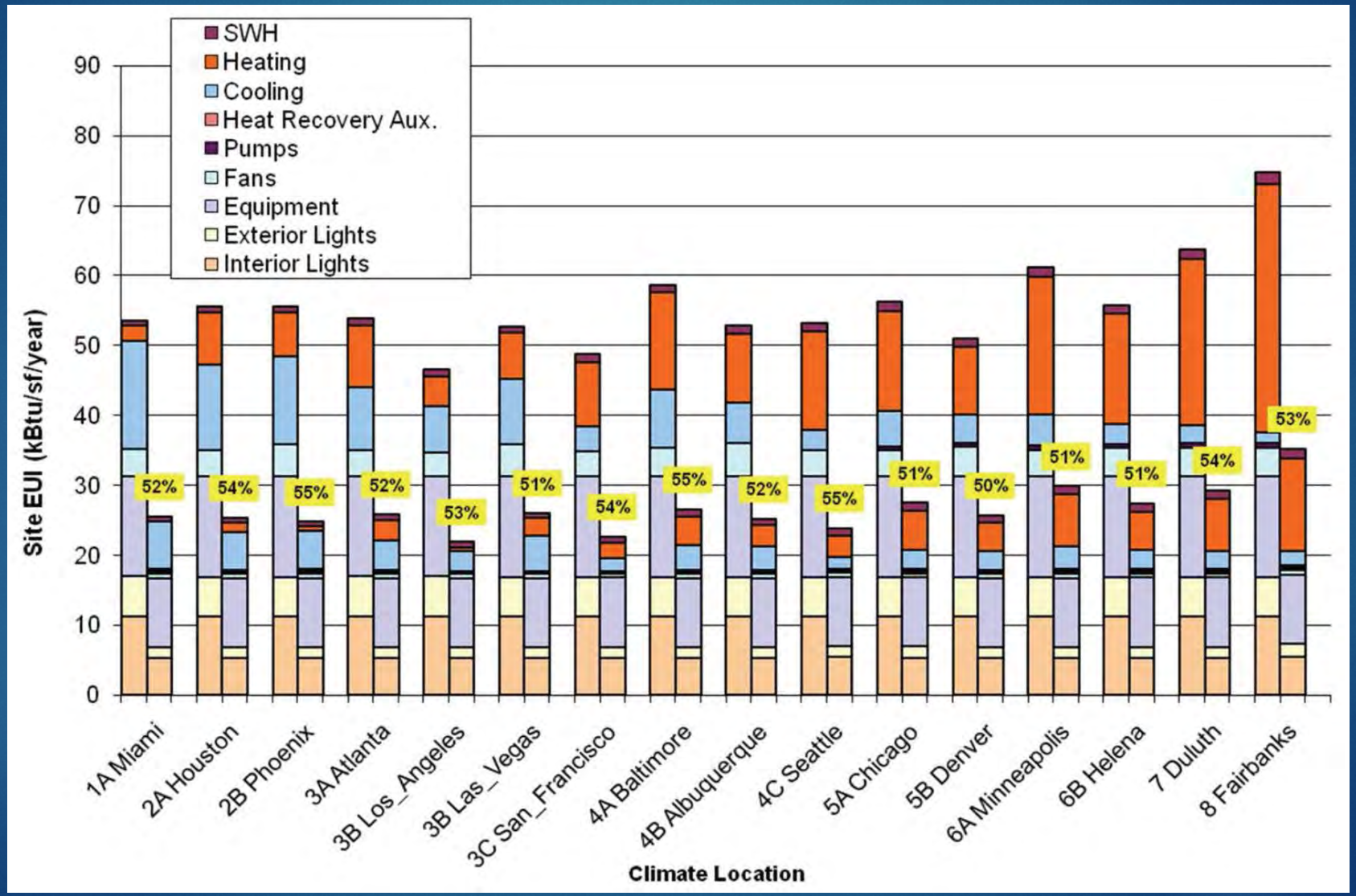
- Envelope – insulation, vestibules
- Fenestration – FFR, SHGC, VT, sun control
- Daylighting – % of floor area
- Interior Lighting – LPD, ballasts, controls
- Exterior Lighting – facades, parking lots
- Plug Loads – equipment, controls, kitchen
- SWH/ HVAC systems
  - VAV-DOAS, FCU-DOAS, GSHP-DOAS
- Quality Assurance – Cx, M&V, benchmarking

Additional Bonus Savings

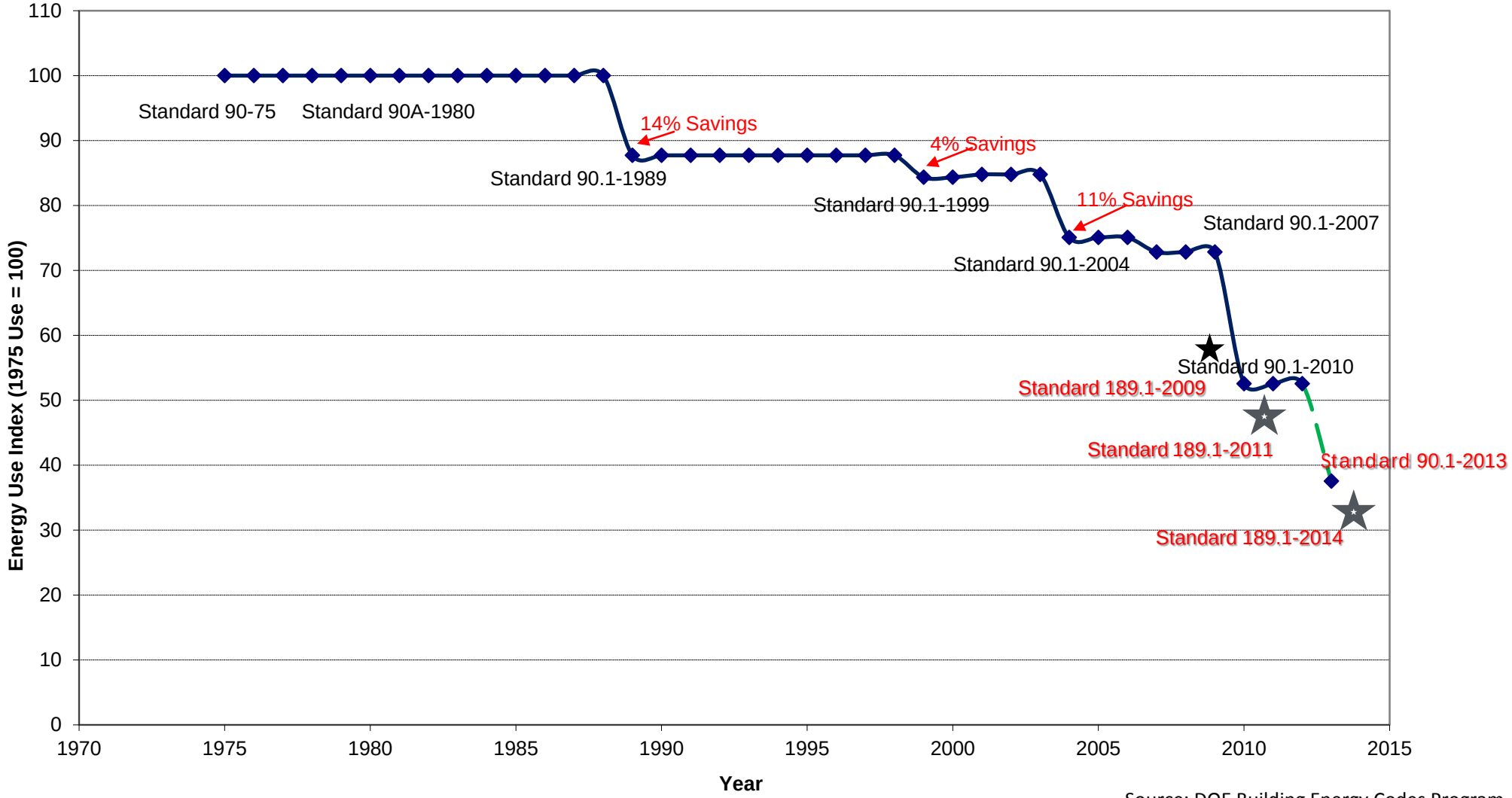
- Additional HVAC Systems
  - Natural Ventilation, Evaporative Cooling, IAQP
  - Thermal Storage, Thermal Mass
  - Thermal Displacement Ventilation

- Renewable Energy
  - Photovoltaic, Wind Turbine
  - Transpired Solar Collector
  - Power Purchase Agreements

Medium Office with Radiant Heating & Cooling System



Increased Stringency Standards 90.1/189.1



Source: DOE Building Energy Codes Program

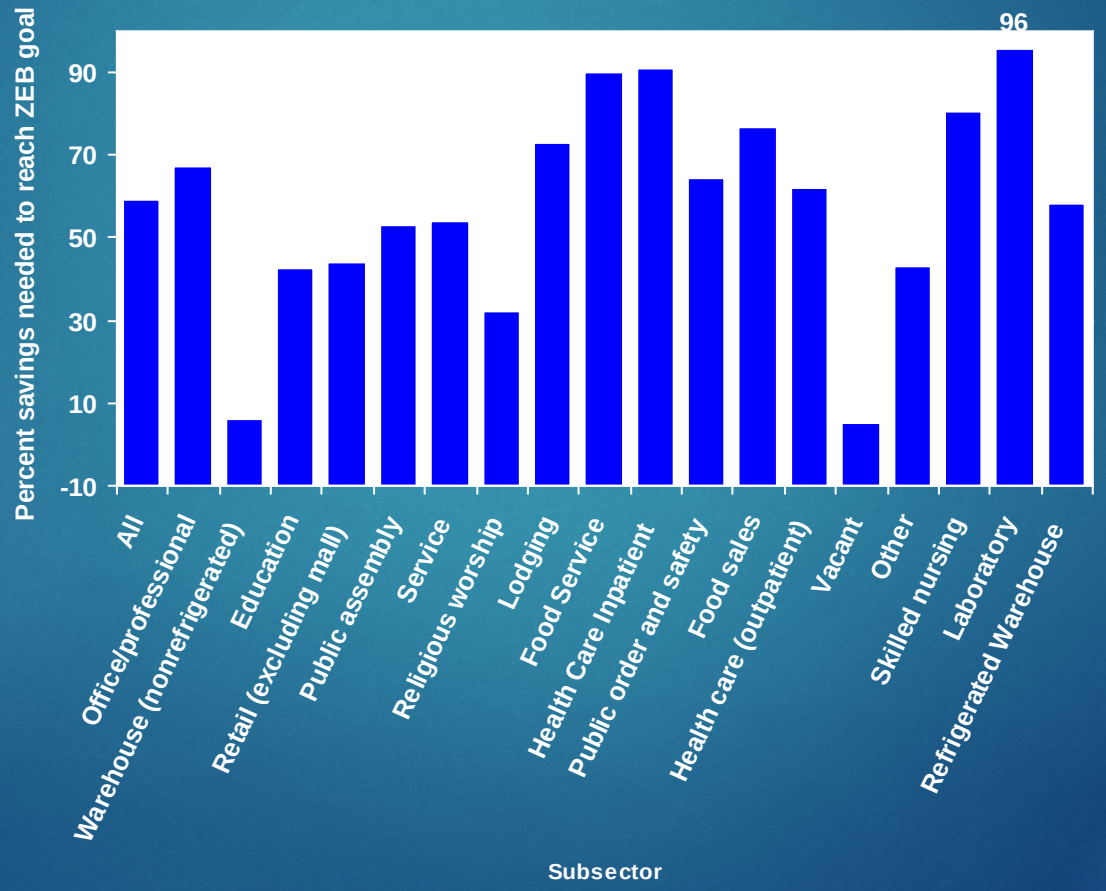
Can we get to Net Zero Energy Buildings?

Technical Potential

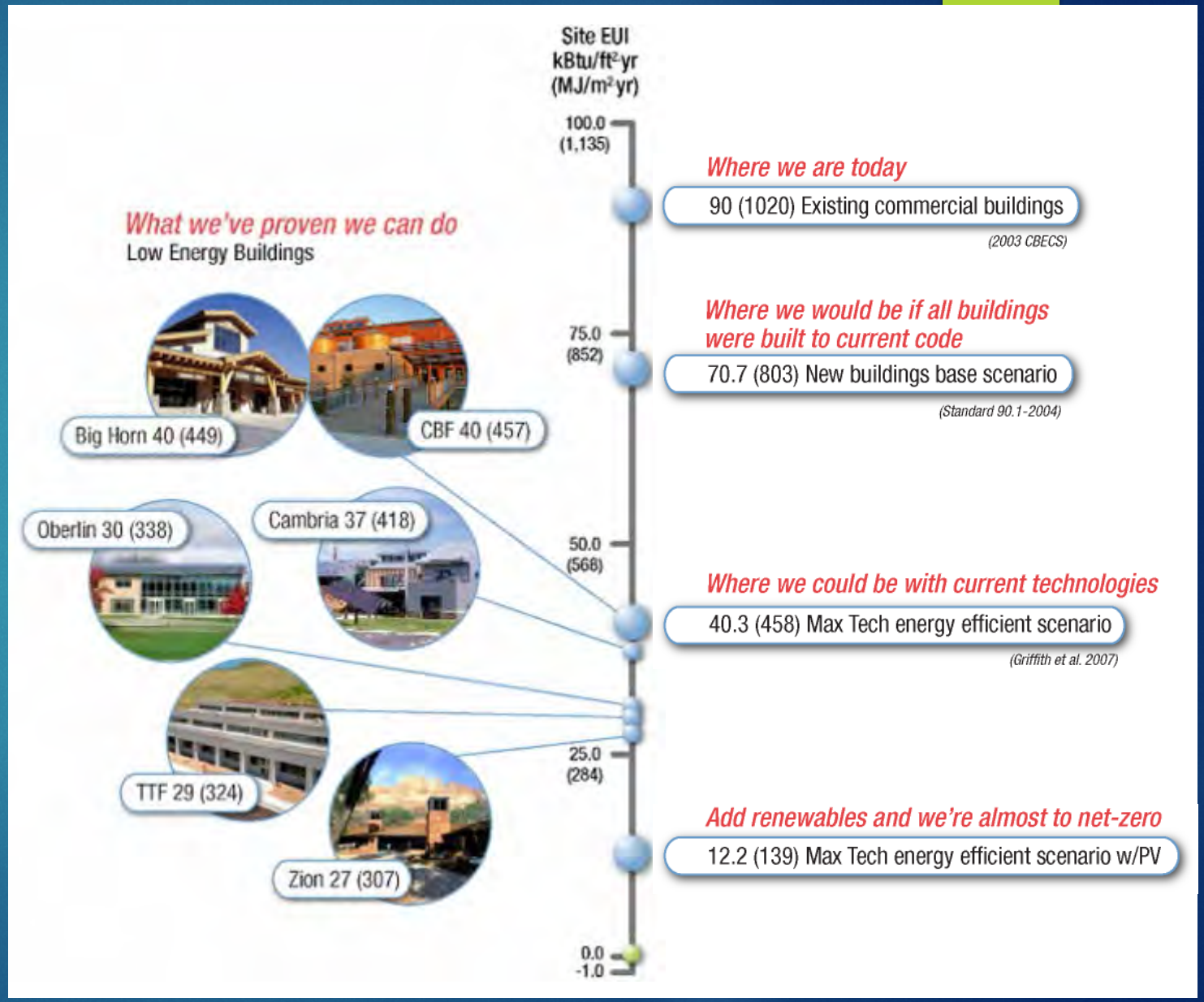
- Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector
  www.nrel.gov/docs/fy08osti/41957.pdf
- Methodology for Analyzing the Technical Potential for Energy Performance Across the Commercial Sector
  www.nrel.gov/docs/fy08osti/41956.pdf
- ASHRAE initiated a new research project (1651-RP) in 2013 to update this analysis and produce new results for future ASHRAE Standards development. Results due in 2016. Initial savings of another 45+% over 90.1-2010

Energy Efficiency

Need 60% to 70% decrease in energy consumption of commercial buildings in order for renewables to supply the balance



Great Potential in Commercial Buildings



Great Potential: Real ZEB Commercial Buildings

NREL RSF → LARGE ZEB!

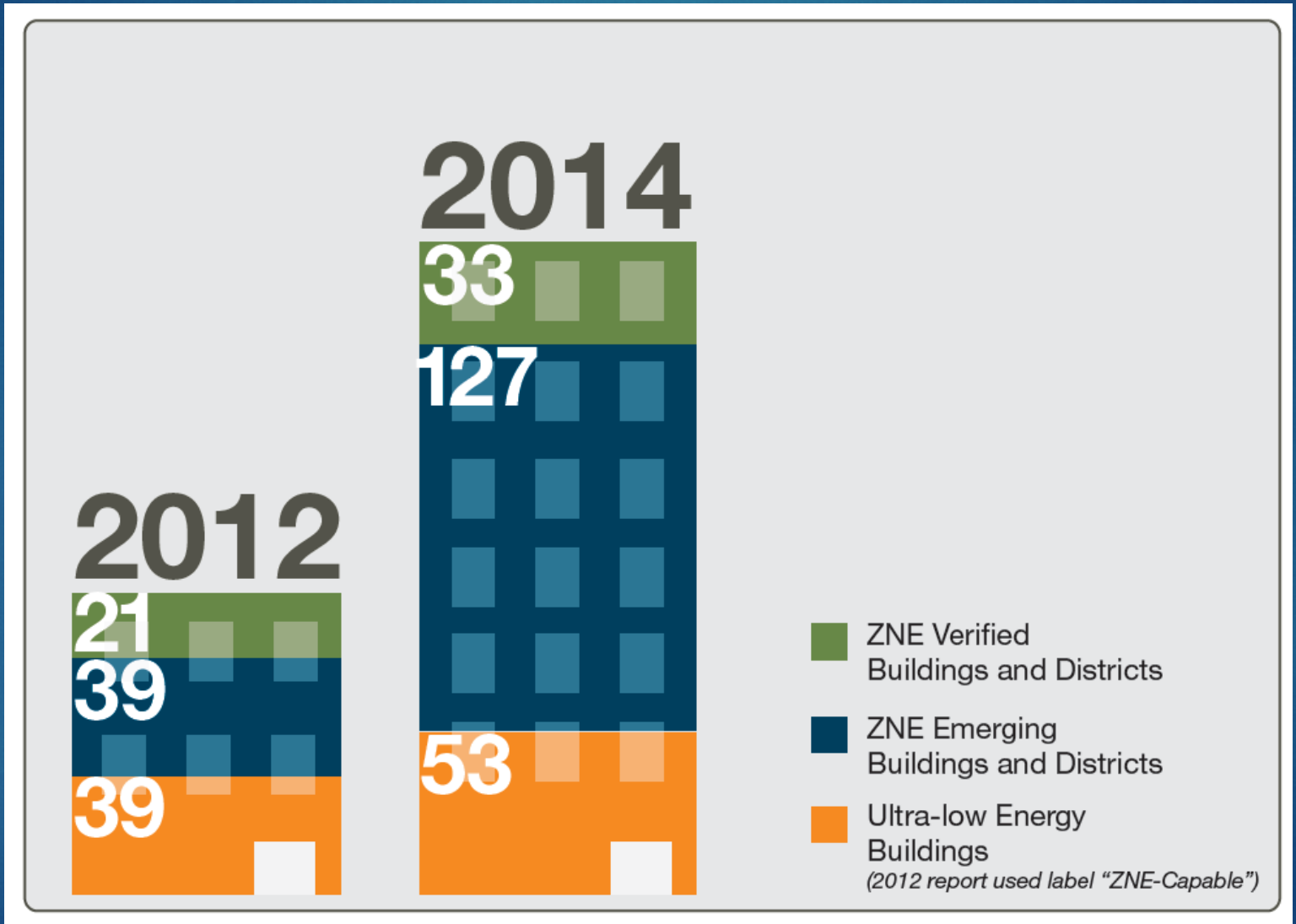
Objectives

- Critical
  - Safety
  - LEED Platinum
  - Energy Star
- Goal
  - 220,000 ft^2
  - 800 people
  - 35 kBtu/ft^2-yr
  - 100 kW data center
  - Flexible
  - BIM / energy model
  - Complete in 2010
- Stretch
  - Net zero energy
  - Most energy efficient building in world
  - LEED Platinum Plus
  - ASHRAE 90.1 + 50%

What did they achieve?

- LEED Platinum 58 of 69 LEED-NC points
- Operating at net zero-energy including roof and site mounted PV
- Energy use: 35.4 kBtu/ft^2-yr
- vs predicted 35.1 kBtu/ft^2-yr
- Peak plug loads of 0.35 W/ft^2 vs predicted 0.55 W/ft^2
- 100% of workstations are daylit
- Peak LPD of 0.3 W/ft^2
- PV meeting load since July 2011
- Workspace for 1300 staff, 360,000 ft^2
- http://www.nrel.gov/sustainable_nrel/rsf.html

Many new ZEBs and ZECs!



New Buildings Institute. 2014. Getting to Zero Status Update, Vancouver, WA. www.newbuildings.org/zero-energy

NZEB of the Future?
Probably More Like NREL RSF

Or These Recent NZE Buildings

Summary

- Today's energy standards are pushing buildings to use 60% less energy than buildings 40 years ago
- Beyond those energy standards and codes:
  - Possible today to cost-effectively construct buildings that use substantially less energy
  - Guidelines exist to help designers those savings another 50%
- Low and net zero energy buildings are being constructed and operated today

No Single Metric Tells the Story of Building Performance

- **Energy**
- **Demand**
- **Cost**
- Water
- IEQ
- Carbon
- Business
  (student, occupied room, sales, beer)

Thank you

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50% AEDGs Available

- Small to Medium Offices
- K-12 Schools
- Medium to Big Box Retail
- Large Hospitals
- Supermarkets

- All the AEDGs available as free PDF download from: www.ashrae.org/aedg

- Technical support documents describing the process and results are available here: http://energy.gov/eere/buildings/advanced-energy-design-guides

More on the NZEB NREL Research Support Facility

- NREL RSF web site:
- http://www.nrel.gov/sustainable_nrel/rsf.html

- "The Design-Build Process for the Research Support Facility"
- http://www.nrel.gov/docs/fy12osti/51387.pdf

- Energy Performance Update
- http://www.nrel.gov/sustainable_nrel/pdfs/rsf_operations.pdf

- Reducing Data Center Loads for a Large-Scale, Net Zero Office Building
- http://www.nrel.gov/sustainable_nrel/pdfs/52785.pdf