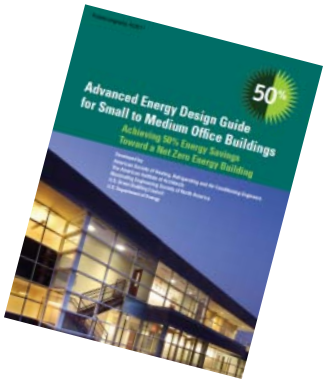
Welcome to the Webcast

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Overview of the 50% Advanced Energy Design Guide for Small to Medium Office Buildings



Start Time: 12:00 Noon Eastern Time

Handout: http://www.energycodes.gov/events/doe/aedg_small_medium_bldgs.stm

Audio: Will be over the phone, not the computer. Dial into the phone number provided when you registered (and sent again in the reminder email message)

Questions: To submit questions 1) select “Q&A” from the top menu, 2) click in the top box, 3) type your question, and 4) click “Ask” (questions will be answered at the end)

Today's Speakers

Jeremy Williams is currently on fellowship with the U.S. Department of Energy Building Technologies Program. His educational background includes: Business, Education, Construction Management. He was a Senior Graduate Research Assistant at *Center for Construction Project Performance, Assessment and Improvement* (c2p2ai) at Michigan State University, with a research focus on energy code compliance. He coordinated the Michigan Energy Code Training and Implementation Program in Michigan – a joint effort between the State of Michigan and MSU.

Bing Liu, P.E., is a Senior Research Engineer at Pacific Northwest National Laboratory (PNNL) with more than 16 years of experience in sustainable building design and analysis, energy efficiency analysis and simulation, and high-performance building metering and measurement. Ms. Liu leads the PNNL Commercial Building Simulation Team supporting the next generation of codes and standards (ASHRAE Standard 90.1 and 189.1). She also chaired the project committee to develop the first Advanced Energy Design Guide book targeting 50% energy savings for small to medium offices**.**

Dr. Merle McBride is employed by Owens Corning and works at their Center of Science and Technology in Granville, Ohio. He has served on all the 30% and 50% AEDG project committees.

Michael Lane joined Puget Sound Energy in May of 2011 as Sr. Energy Management Engineer working in the Business Energy Management division. Previously he was Project Manager and Lead Lighting Specialist at the Lighting Design Lab. Michael is a member of the IES and serves on the IES Outdoor Environmental Lighting & IES Energy Management Committees, the ASHRAE 90.1 Energy Committee as Co-Vice Chair and has served on six AEDG project committees. In 2004, and 2010 Michael received the IES Presidential Award.

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The Parker Ranch installation in Hawaii

Advanced Energy Design Guides

for 50% Energy Savings in Buildings

Jeremy Williams

AEDG Steering Committee

Building Technologies Program

September 15, 2011

Presentation Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

What are the *Advanced Energy Design Guides* (AEDGs)?

Who develops the AEDGs?

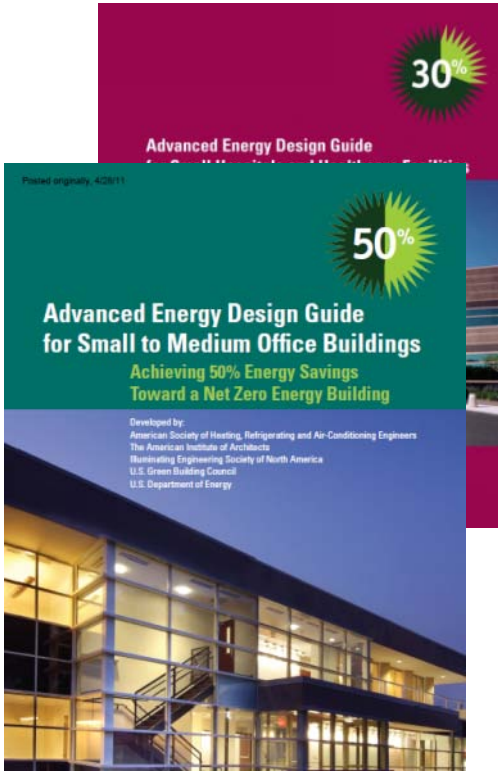
- Introduction to the guides
- Background information
- Impact and distribution
- Future AEDGs

The AEDG Series

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

How do I achieve these energy savings targets (i.e., 50%) in my *real* building?

- Guidance and recommendations by building type and geographic location
- Collection of experts and combined experience
- In-line with DOE energy savings targets
- Apply to new commercial construction
- Educational guidance—*not* a code or standard



AEDG Partnership

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Collaboration of professional organizations and DOE
- Specialized Project Committee for each guide
- Oversight is provided via AEDG Steering Committee
- Backed by DOE national laboratory leadership, energy simulation, technical analysis and support
- Open peer review and commentary process

The AEDG Series

Two AEDG series:

- 30% energy savings
- 50% energy savings

30% AEDG Series

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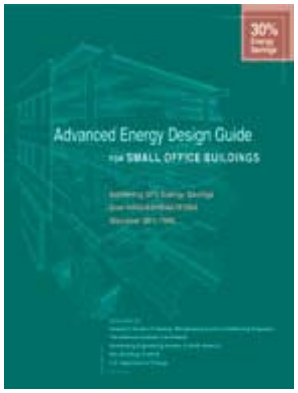
Two AEDG series:

- **30% energy savings**
- 50% energy savings

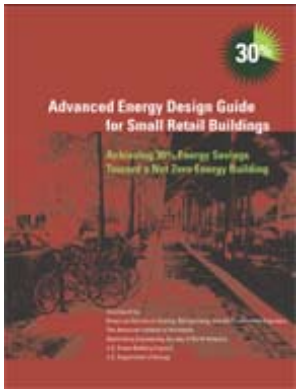
Advanced Energy Design Guides with recommendations to achieve 30% energy savings over *ASHRAE Standard 90.1—1999*

Free download:

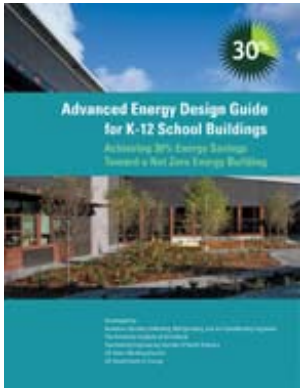
www.ashrae.org/technology/page/938



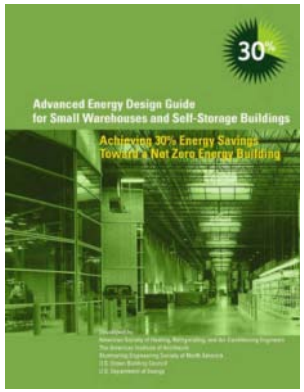
Small Office



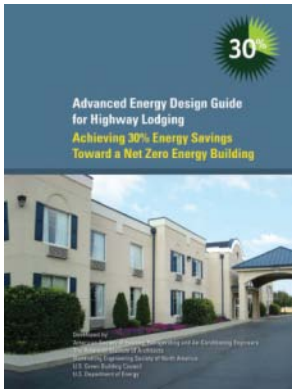
Small Retail



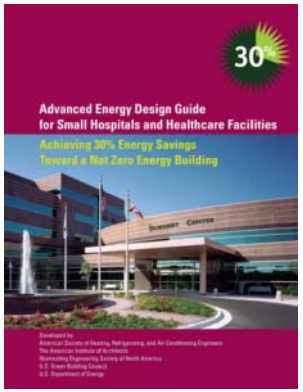
K-12 School



Warehouse



Highway Lodging



Small Hospital

50% AEDG Series

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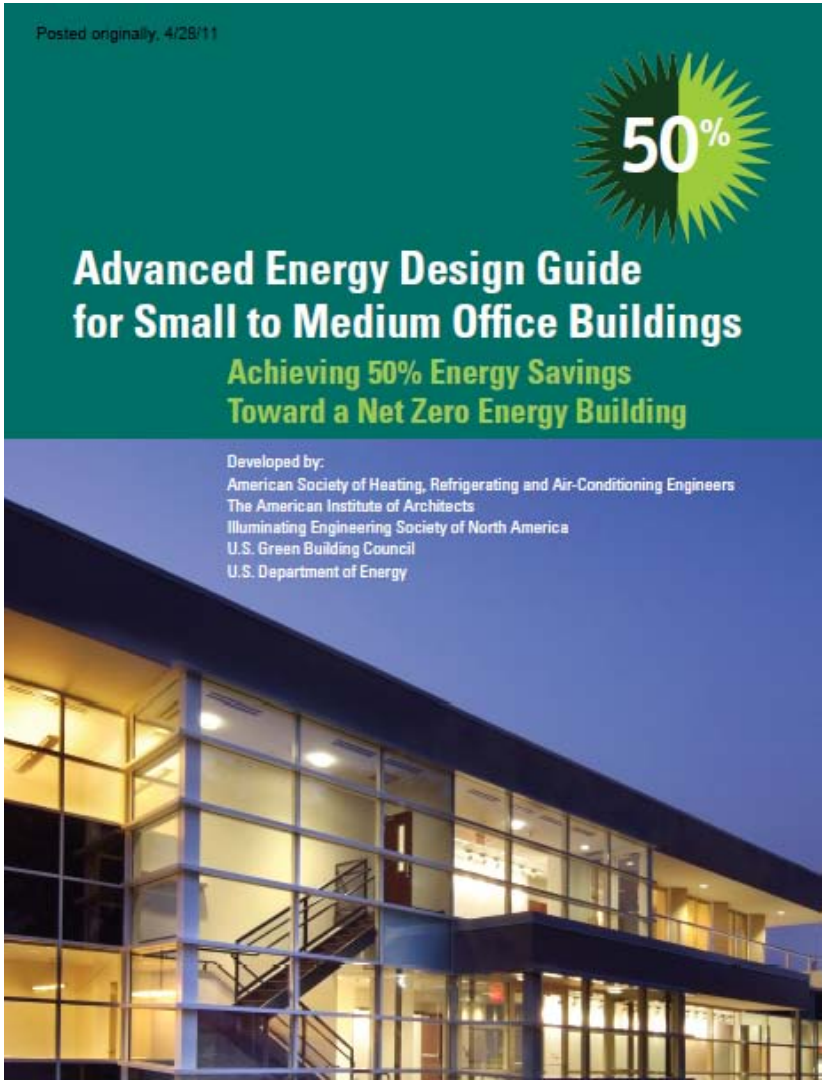
Two AEDG series:

- 30% energy savings
- **50% energy savings**

50% energy savings over *ASHRAE Standard 90.1—2004*

50% AEDG Building Types:

1. Small to Medium Office Buildings
2. K-12 Schools
3. Medium to Big Box Retail
4. Large Hospitals



50% AEDG Background

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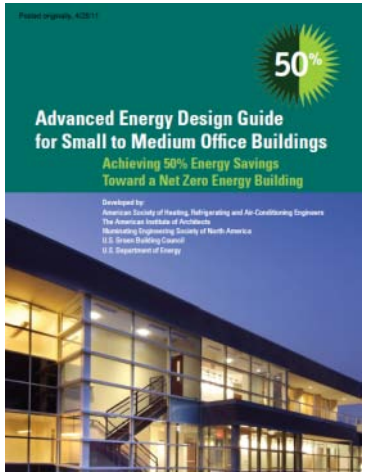
- Described as a ‘cookbook’ approach to building energy efficiency
- Provide design packages and strategies to help owners and designers achieve 50% site energy savings over ASHRAE 90.1–2004
- Present climate specific recommendations for prominent building types
- Offer both prescriptive and performance solutions

- Whole building approach:
  - Opaque envelope and fenestration
  - Lighting and Daylighting
  - HVAC and service hot water
  - Plug and process loads



50% AEDG Background

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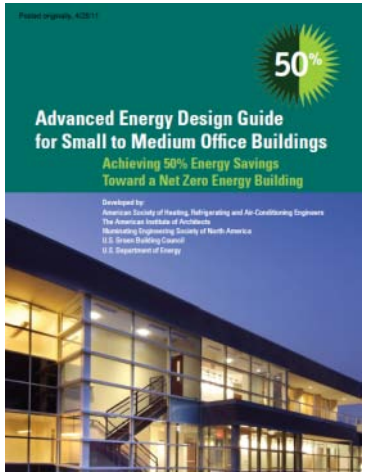
- Most commonly used by architects and engineers, but useful to building owners, developers, or anyone interested in energy efficiency applications and high-performance buildings

- Primarily new commercial construction, also applicable to:
  - Complete or major Renovations
  - Building additions
  - Remodeling and modernization projects
  - Systems upgrades



50% Technical Support Documents (TSDs)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Detailed documentation of 50% savings strategies by building type:
  - ✓ Small Office
  - ✓ Medium Office
  - ✓ Large Office
  - ✓ Large Hospital
  - ✓ Medium Retail
  - ✓ Grocery Stores
  - ✓ Highway Lodging
  - ✓ Quick-service Restaurant

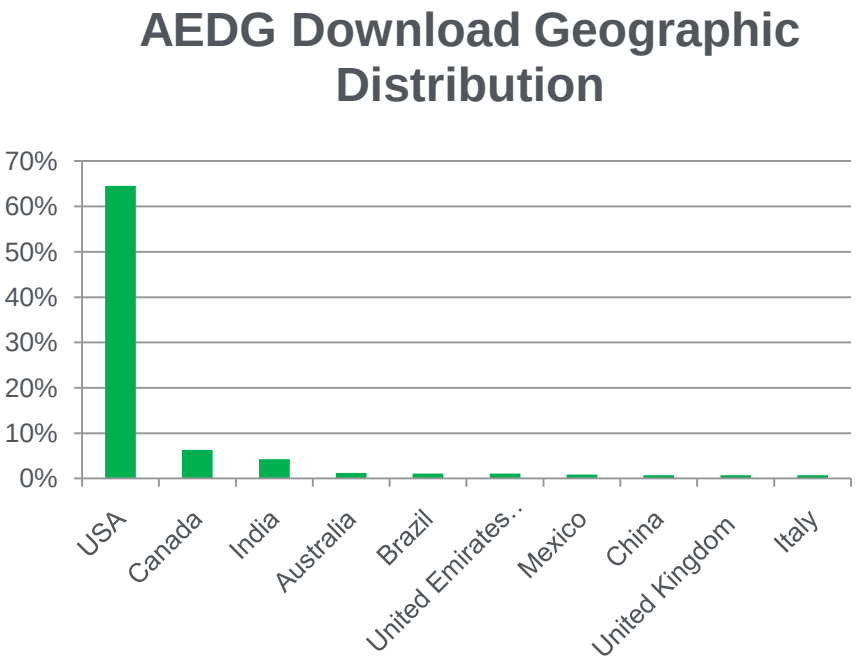
- Cost-effectiveness analysis

- *Free* Download: http://www.ashrae.org/technology/page/1402

Impact and Distribution

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

- Over 329,000 copies in circulation (as of 9/2/2011)
- Promote worldwide building energy efficiency
- Referenced in RFP specifications
- ASHRAE Standard 90.1
- ASHRAE/USGBC/IES Standard 189.1
- LEED rating system



50% AEDG Series in Progress

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

AEDG Building Type	Scheduled
Small to Medium Office	*AVAILABLE NOW*
K-12 Schools	Oct 2011
Medium to Big Box Retail	Jan 2012
Large Hospital	May 2012

What is New?

Advanced Energy Design Guide for Small to Medium Office Buildings

Bing Liu, PE, CEM, LEED AP
Chair, AEDG SMO Project Committee

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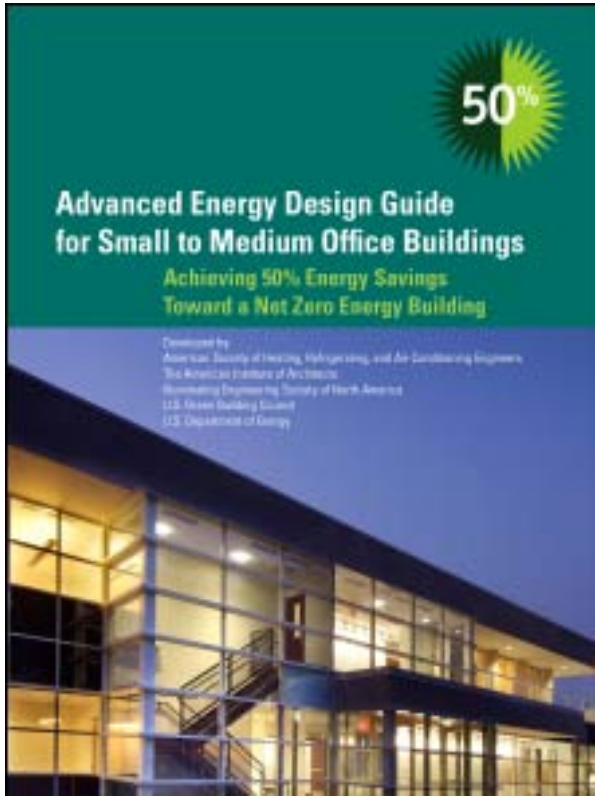
AEDG-SMO Project Committee

Bing Liu **Chair** Pacific Northwest National Laboratory	
Merle McBride *Vice-chair* Owens Corning	Don Colliver *AEDG Steering Committee Chair* University of Kentucky
Daniel Nall *AIA/USGBC Representative* WSP Flack + Kurtz	Erin McConahey *Member at Large* Arup
Mick Schwedler *ASHRAE Representative* Trane	Lilas Pratt *Staff Liaison* ASHRAE
Michael Lane *IES Representative* Lighting Design Lab	Brian Thornton *Analysis Support* PNNL
Mathew Tanteri *IES Representative* Tanteri + Associates	Weimin Wang *Analysis Support* PNNL

AEDG SMO Buildings
Scope

- Small to medium office buildings up to 100,000 ft² in gross floor area.
- Covers administrative, professional, government, bank/financial services, and medical offices (without medical diagnostic equipment)
- The Guide does not cover specialty spaces such as data centers, which are more typical in large office buildings.



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AEDG SMO Buildings
Contents

Foreword: Make a business case to building owners and developers

Chapter 1: Introduction

Chapter 2: Expanded guidance on integrated design

Chapter 3: Integrated Design Strategies

- Performance strategies for those not using the prescriptive recommendations
- Whole building case studies

Chapter 4: Recommendation Tables

- General strategies by climate zone
- Prescriptive recommendations by climate zone

Chapter 5: How To Implement Recommendations

- Good design practices (how-to tips)
- Technical examples
- Additional bonus savings (top-lighting, natural ventilation, renewable energy)

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Chapter 2 and 3
Integrated Design Process and Strategies

- Integrated Project Delivery process
- Multidisciplinary Recommendations
- Major Energy Saving Focus
  - Building envelope
  - Lighting
  - Plug loads
  - HVAC systems
  - Service water heating

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Chapter 3
Case Studies

The Terry Thomas—A Case Study

The building team for The Terry Thomas, a 40,000 ft^2 Class A commercial office building in Seattle, used an advanced approach to energy-efficient design with the use of natural ventilation and daylighting. Extensive thermal and energy modeling was used to determine the most effective strategies and balance the trade-offs needed to design a building with passive cooling, natural ventilation, and daylighting while maintaining a comfortable work environment for the occupants. The LEED Gold-CS, LEED Platinum-CI building was measured as 42% more efficient than a baseline building designed to ASHRAE/IESNA Standard 90.1-2004. Moreover, through the integrated design process, the project achieved significant energy efficiency within the initial construction cost budget.

The building is designed as a "square doughnut" form that enhances the natural ventilation and daylighting while providing communal space for the tenants via the center courtyard. The passive cooling strategies employed are complemented by automated louvers and a combination of dynamic and fixed external shading.

Shading and Daylighting

The optimal designs required that two goals be balanced: the need to remove solar heat and glare that might hinder natural ventilation and the need to provide adequate daylight to interior spaces. Eliminating solar gain also allows for the elimination of the mechanical cooling system while still maintaining thermal comfort. Effective external shading was the key to controlling solar gain and thus reducing cooling peak load. The project optimized the shading strategy for each façade at each floor:

- Fixed exterior tinted-glass shades ("sunglasses"), angled to provide the required shading and optimum levels of daylight, are used on the east and west external façades.
- Dynamic external venetian blinds that are automatically adjusted based on light level and sun angle are used on the northeast, south, and some east façades.
- The building shape and courtyard allow for uniform daylighting in each open office space. The high ceilings and narrow floor plates allow natural light to penetrate the interior.
- Daylighting is further enhanced with high internal reflectance, exposed ceilings with no ductwork, and low open office partitions.

Building Data	
Steel deck roof with gypsum sheathing	Overall R-value = R-30 Reflectivity = 95
Metal-framed walls with gypsum sheathing, batt insulation, and corrugated metal cladding	Overall R-value = R-21 Glazing = 45%
Windows	U-factor = 0.4 SHGC = 0.36 VT = 68%
Sunshades	SHGC = 0.52
EUI	37 $kBtu/ft^2$
Annual cost index	$0.53/$ft^2 \cdot yr$
Total construction cost	$10.2 million
Cost per square foot	$160/$ft^2$

Natural Ventilation

The building uses passive cooling and natural ventilation, and heating is provided for the building perimeter by radiant hydronic baseboards. Internal heat gains are reduced by the use of less artificial light as a result of the maximized use of natural light. The following characteristics are the key components of the natural ventilation system.

- The internal courtyard allows for cross-ventilation, which is enhanced by the narrow floor plate and open office plan. Other features that help to optimize the natural ventilation system include the open ceilings and castellated beams.
- Motorized louvers are located near the ceiling on each floor and are used in conjunction with occupant-controlled operable windows along the building perimeter.
- The passive cooling design and use of natural ventilation allowed for the elimination of the mechanical cooling system and reduced the HVAC equipment cost. Louvers are controlled with CO_2 sensors. This use of this DCV strategy contributes to the reduction of unnecessary outdoor ventilation air and the accompanying heating energy use.

Additional information on The Terry Thomas and the extensive modeling that was used in the design process can be found in the Summer 2010 issue of *High Performing* Buildings (Sethi and Marseille 2010).

Second Floor Office on the South Façade with Castellated Beams*

Exterior Tinted-Glass Shades Used on the East and West Façades†

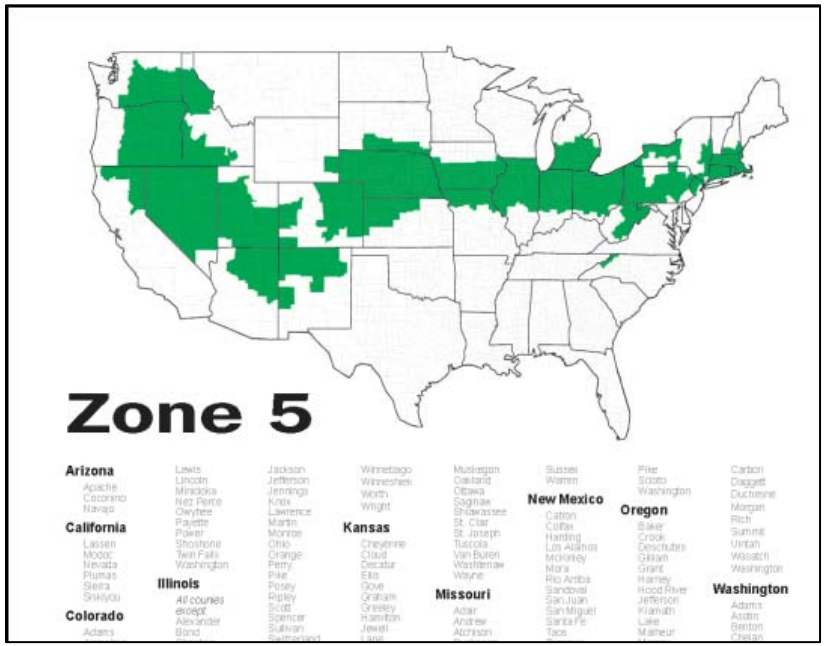
External Venetian Blinds*

Internal Courtyard*

*Photographs reprinted with permission of Chris Meek and Kevin Van Den Wymelenberg

†Photograph reprinted with permission of High Performing Buildings

Chapter 4
Recommendation 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	

Chapter 5
Technology Examples

Additional Benefits of Daylighting

Daylight and View Windows
Source: Cody Andresen, Arup

At the Kirsch Center for Environmental Studies, 100% of the normally occupied areas have access to daylight and views outside. Providing this access can help to improve the indoor working environment and may lead to improved worker performance.

Recessed High-Performance Lensed Fluorescent Fixtures

Fixture Example #1
Source: Michael Lane, Lighting Design Lab

Fixture Example #2
Source: Michael Lane, Lighting Design Lab

Recessed high-performance lensed fluorescent fixtures are available from more than six lighting manufacturers. The distinguishing feature of these fixtures is an optical lens (or lenses) that direct the light to the workstation. This lens is *not* the flat prismatic lens common to the old lensed fluorescent troffer.

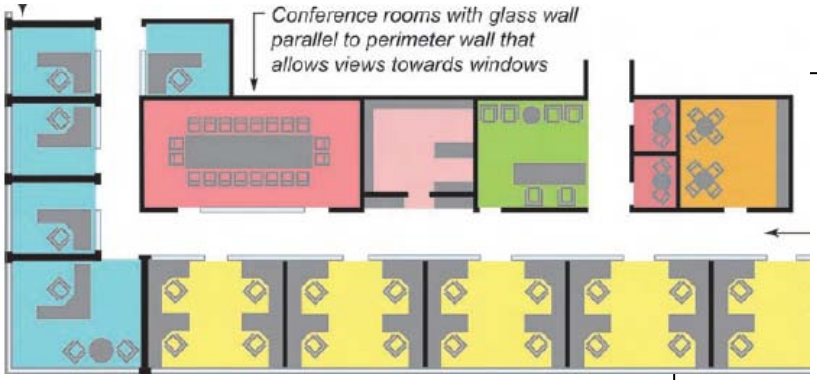
Energy-Use Dashboards at ASHRAE Headquarters

Makeup Air Unit Schematic
Source: Michael Lane

PV Power Monitoring
Source: Michael Lane

When ASHRAE renovated their headquarters building in 2008, one of the features that was added was real-time monitoring of the building subsystems, which is displayed continuously on screens in the building's lobby. The systems monitored include the makeup air unit and the PV power.

Chapter 5
How-to Tips



Warm Climates

EN28 ***Building Form and Window Orientation*** **(Climate Zones: 0 2 3)**

In warm climates, south-facing glass can be more easily shielded and can result in less solar heat gain and glare than can east- and west-facing glass. During early building configuration studies and predesign, preference should be given to site layouts that permit elongating the building in the east-west direction and that permit orienting more windows to the north and south. A good design strategy avoids areas of glass that do not contribute to the view from the building or to the daylighting of the space. If possible, configure the building to maximize north- and south-facing walls and glass by elongating the floor plan. Since sun control devices are less effective on the east and west façades, the solar penetration through the east- and west-facing glazing should be minimized. This can be done by reducing the area of glazing or, if the glass is needed for view or egress, by reducing the SHGC, or by utilizing automated operable shading systems. For buildings where a predominantly east-west exposure is unavoidable, more aggressive energy conservation measures will be required in other building components to achieve an overall 50% energy savings. See DL5 and DL6 for more information on building orientation and shape as they relate to daylighting strategies.

Table 5-2 Vertical Fenestration Descriptions

CZ	U-Factor	SHGC	VT	Glass and Coating	Gas	Spacer	Frame
1-3	0.46	0.23	0.51	Double clear, highly selective low-e coating		Standard	Broken aluminum
1-3	0.47	0.24	0.32	Double clear, low-e reflective coating		Standard	Broken aluminum
1-3	0.32	0.20	0.29	Double clear, low-e reflective coating		Standard	Foam-filled vinyl c pultruded fiberglas
4-5	0.34	0.25	0.51	Double clear, highly selective low-e coating	Argon	Insulated	Broken aluminum
4-5	0.35	0.22	0.32	Double clear, low-e reflective coating	Argon	Insulated	Broken aluminum
4-5	0.32	0.20	0.29	Double clear, low-e reflective coating		Standard	Foam-filled vinyl c pultruded fiberglas
6-7	0.31	0.39	0.50	Triple clear, low-e coating for outer light only	Argon	Insulated	Broken aluminum
6-7	0.26	0.31	0.54	Double clear, low-e selective coating	Argon	Insulated	Foam-filled vinyl c pultruded fiberglas
8	0.25	0.39	0.53	Triple clear, low-e coating for outer and second lights	Argon	Insulated	Aluminum thermall isolated frame
8	0.22	0.36	0.53	Triple clear, low-e coating for outer light only	Argon fill both spaces	Insulated	Foam-filled vinyl c pultruded fiberglas

CZ = climate zone

Table 5-4 4 ft T8 Lamp Efficacy

T8 Lamp Description	Watts	Lumens		Mean LPW	Color Temperature, K
		Initial	Mean		
F32T8/RE70	32	2800	2613	82	300, 3500, 4100
F32T8/RE70	32	2717	2535	79	5000
F32T8/RE80	32	2950	2807	88	3000, 3500, 4100
F32T8/RE80	32	2800	2660	83	5000
F32T8/RE80/HP	32	3100	2937	92	3000, 3500, 4100
F32T8/RE80/HP	32	3008	2848	89	5000
F32T8/25W/RE80	25	2458	2344	94	3000, 3500, 4100
F32T8/25W/RE80	25	2350	2241	90	5000
F32T8/28W/RE80	28	2725	2599	93	3000, 3500, 4100
F32T8/28W/RE80	28	2633	2509	90	5000
F32T8/30W/RE80	30	2850	2717	91	3000, 3500, 4100
F32T8/30W/RE80	30	2783	2653	88	5000

Note: Yellow-shaded lines indicate lamps that comply with the recommended 90+ mean lumens per watt (LPW).

BEF-P Calculation

From a lamp catalog it is known that a two-lamp ballast with 32 W lamps uses 55 W and has a BF of 0.87. With this information, calculate the BEF and BEF-P as follows.

$$BEF = (0.87 \cdot 100)/55 = 1.58$$

$$BEF\text{-}P = 1.58 \cdot 2 = 3.16$$

A BEF-P of 3.16 passes the required minimum of 3.0.

RY

Integrated Design Approach

- AEDG presents “A Way Not The Only Way…” through the prescriptive tables.
- AEDG presents a tutorial on the elements of Integrated Design for Energy Conservation.
- AEDG presents a description of required design tasks for energy conservation by design phase.
- AEDG stresses the importance of energy modeling for design of building not amenable to tables.

Multi-Disciplinary Design Teams

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Entire Building Configuration Determines Energy Performance

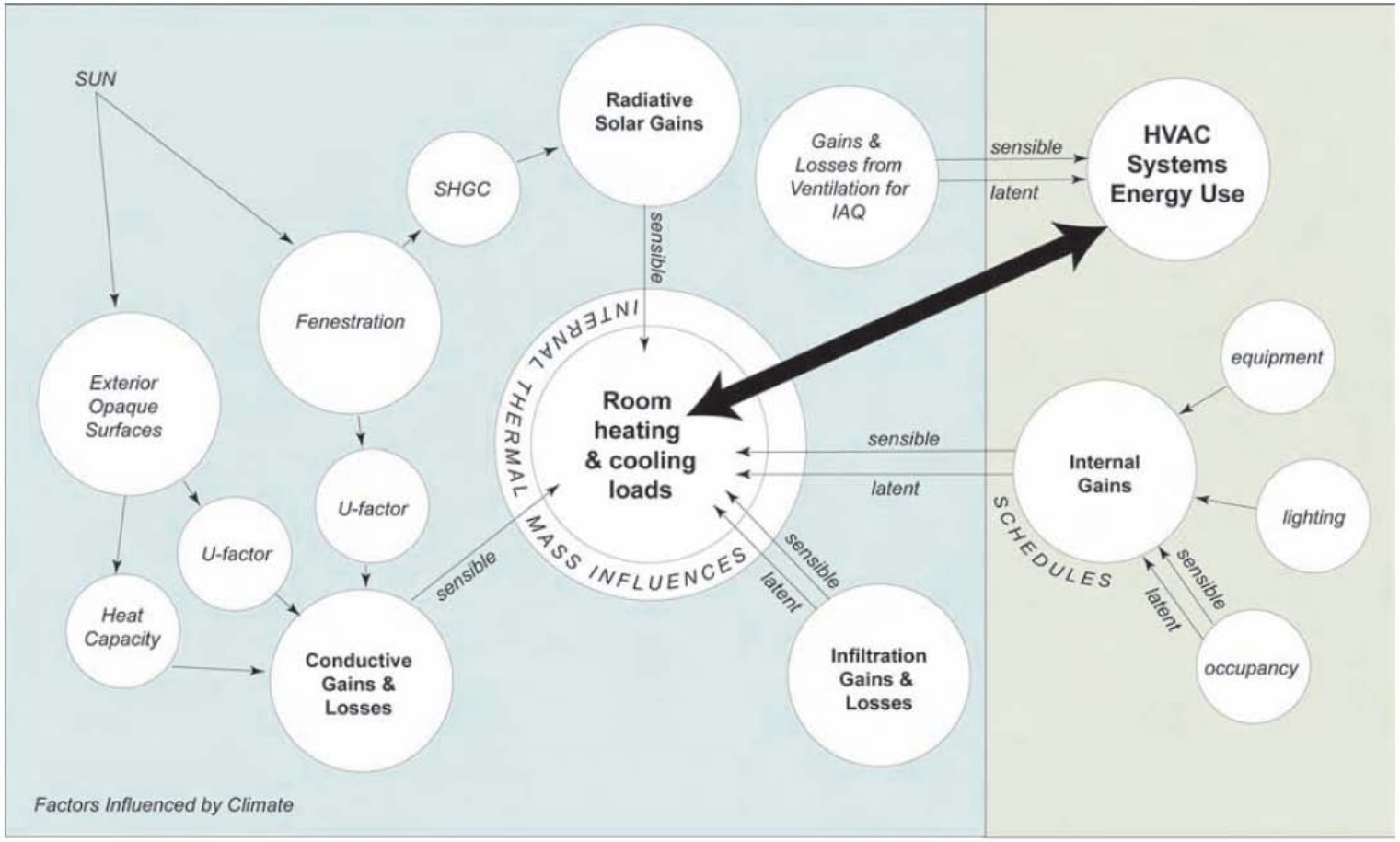

Figure 3-2 Heating and Cooling Influence

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Savings Opportunities Vary with Climate

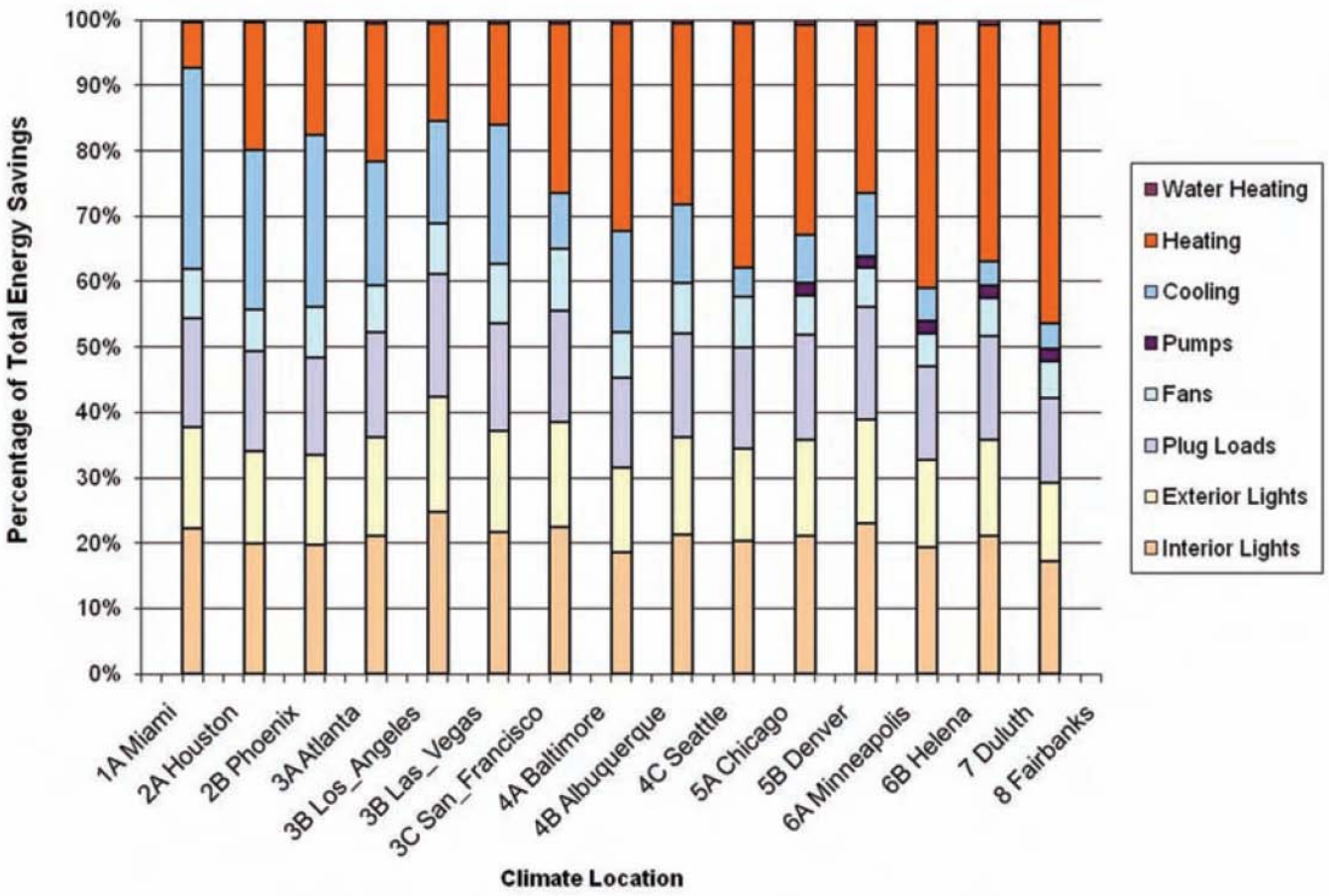

Figure 3-14 Percentage of Total Energy Savings arising from Each End-Use System
Source: Thornton et al. (2009)

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Cumulative Impact of Integrated Approach

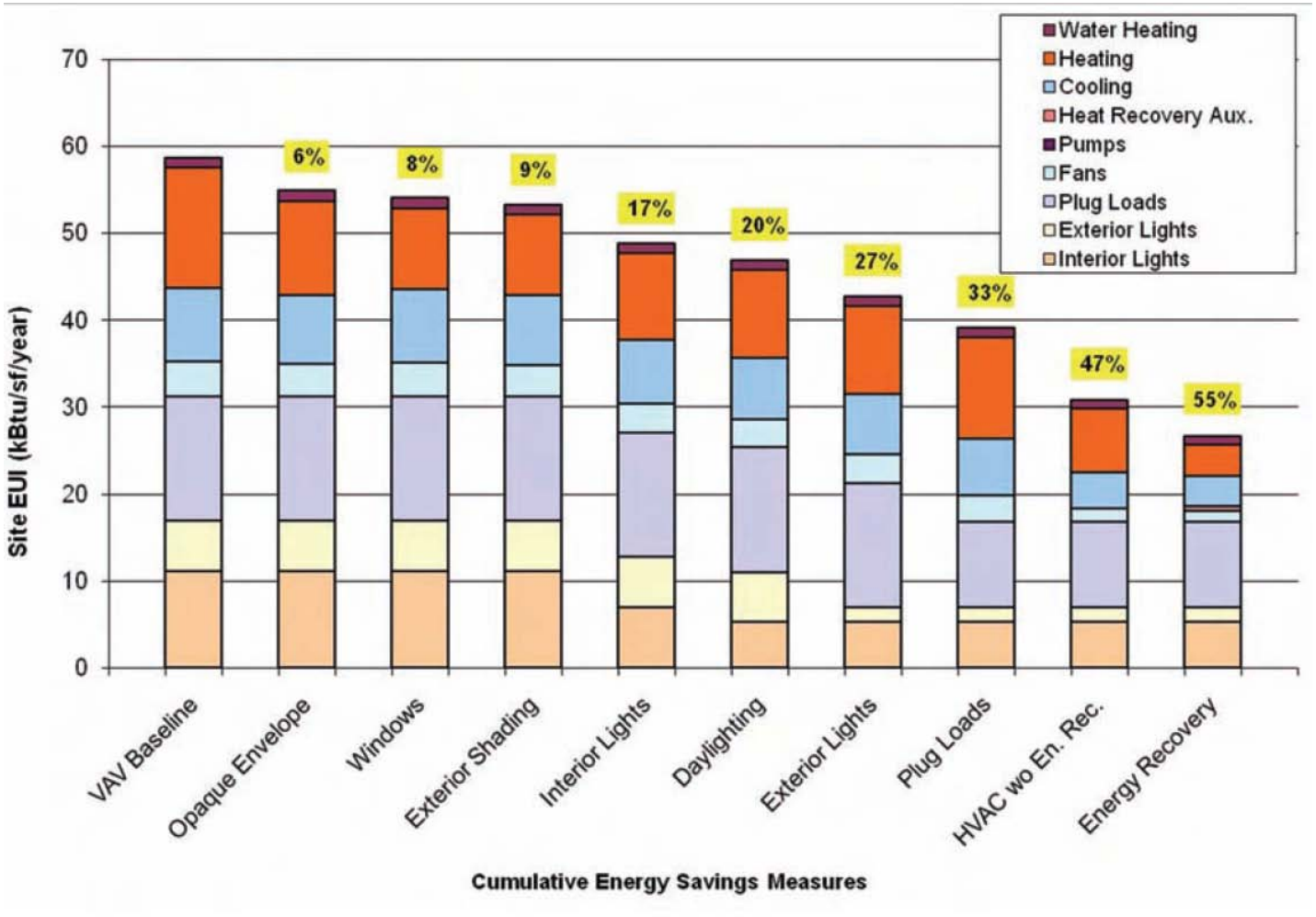

Figure 3-15 Relative Impact of Energy Savings Strategies

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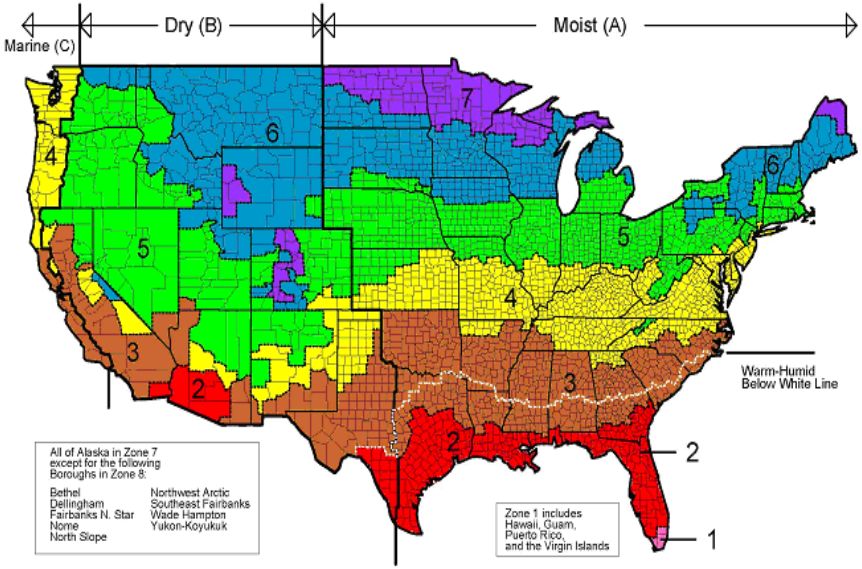
Grounds Rules for Prescriptive Path

- Products must be available from at least 2 manufacturers
- Systems must be within first cost range of conventional systems
- Savings are determined based on modeling with ASHRAE 90.1-2004 as the Base Case.
- All systems and products must be compliant with ASHRAE 90.1-2010
- Systems must provide compliance with ASHRAE 62.1-2010 and ASHRAE 55-2010

Technical Analysis Approach

- Two representative prototypes:
  - 20,000 ft² small office
  - 53,000 ft² medium office
- Recommendations by all 8 DOE climate zones plus moist/dry for 16 total locations
- Energy Savings:
  - 50-61% relative to 90.1-2004
  - 46% relative to 90.1-2007
  - 31% relative to 90.1-2010
  - 55% relative to 90.1-1999



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Technical Analysis Approach

Documented in PNNL technical reports

Available for free download

- Detailed documentations of 50% savings strategies and cost effectiveness analysis
- Small offices: http://tinyurl.com/3pn5oyq
- Medium offices: http://tinyurl.com/3klsybn

ENERGY

PNNL-19004

Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830

Technical Support Document: 50% Energy Savings Design Technology Packages for Medium Office Buildings

BA Thornton
W Wang
MD Lane
MI Rosenberg
B Liu, Project Manager

September 2009

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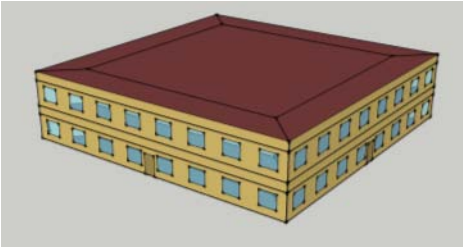

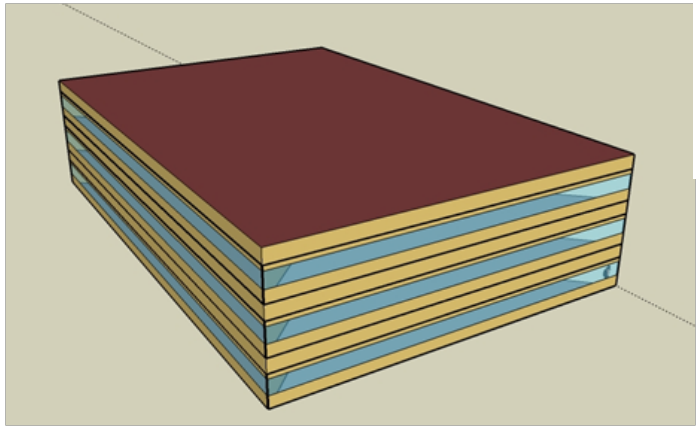

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Building Envelope Strategies for the 50% AEDG SMO

Merle McBride, Ph.D., P.E.
Senior Research Associate

Owens Corning
Center of Science and Technology
Granville, Ohio

General Design Strategy

1 - Minimize the envelope heating and cooling loads, both sensible and latent (conduction, solar, infiltration, water vapor diffusion and thermal mass).

2 - Minimize the internal loads (lighting and plug loads).

3 - Maximize the mechanical systems performance (ventilation loads and the HVAC and SWH equipment efficiencies).

Building Envelope Strategies

1 – Upgrade the Envelope Thermal Efficiency

2 – Make Fundamental Changes to the Building Basic Structure and Form

3 – Incorporate New Features

1 - Upgrading Envelope Thermal Efficiency

Roofs

Walls

Floors

Slabs

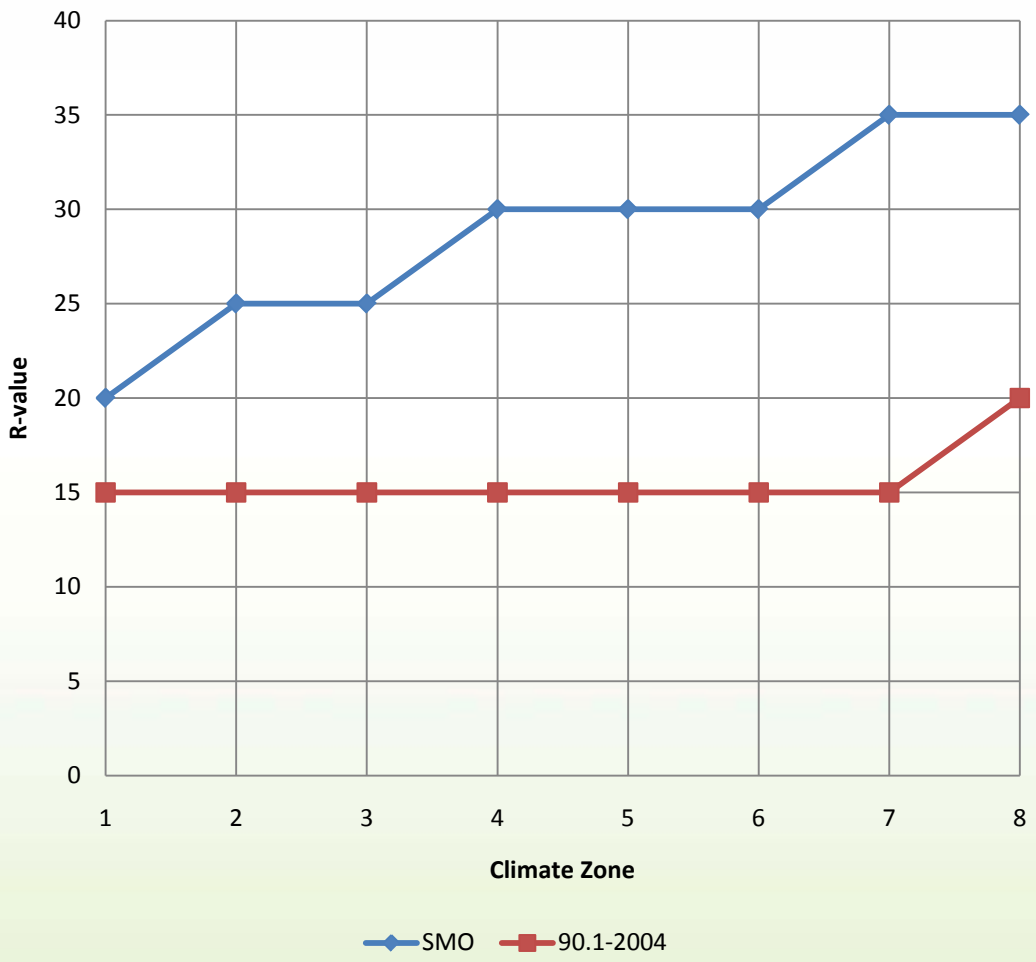
Doors

Vestibules

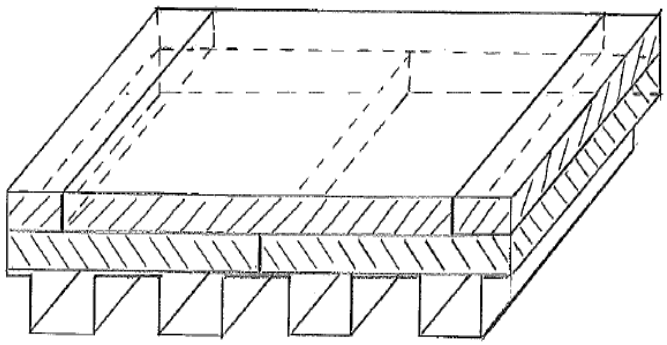
Fenestration

Daylighting

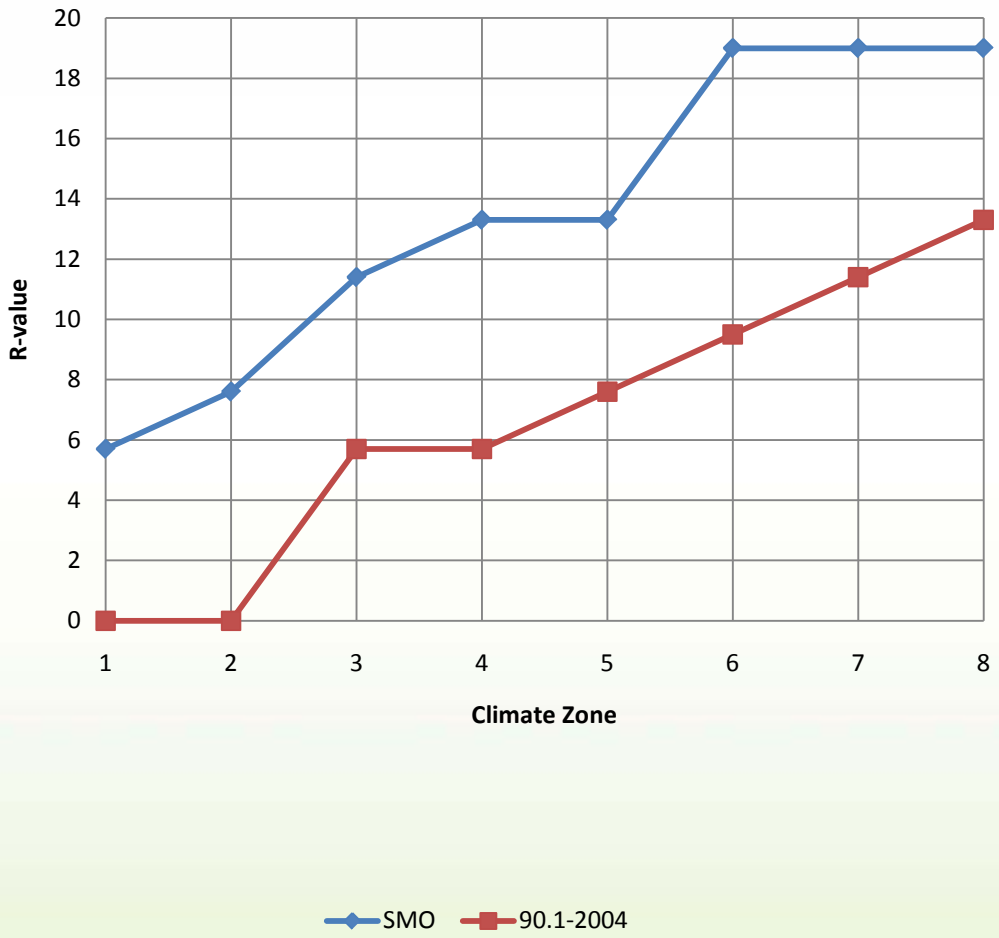
Insulation Above Deck

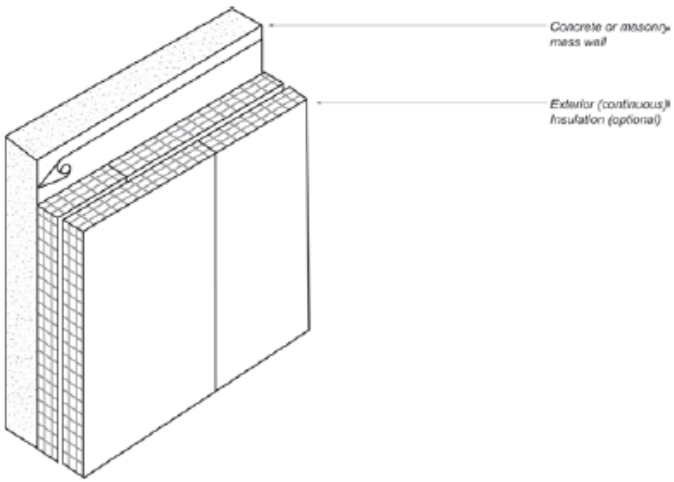


- No Thermal Bridges
- Stagger edges of multiple layers

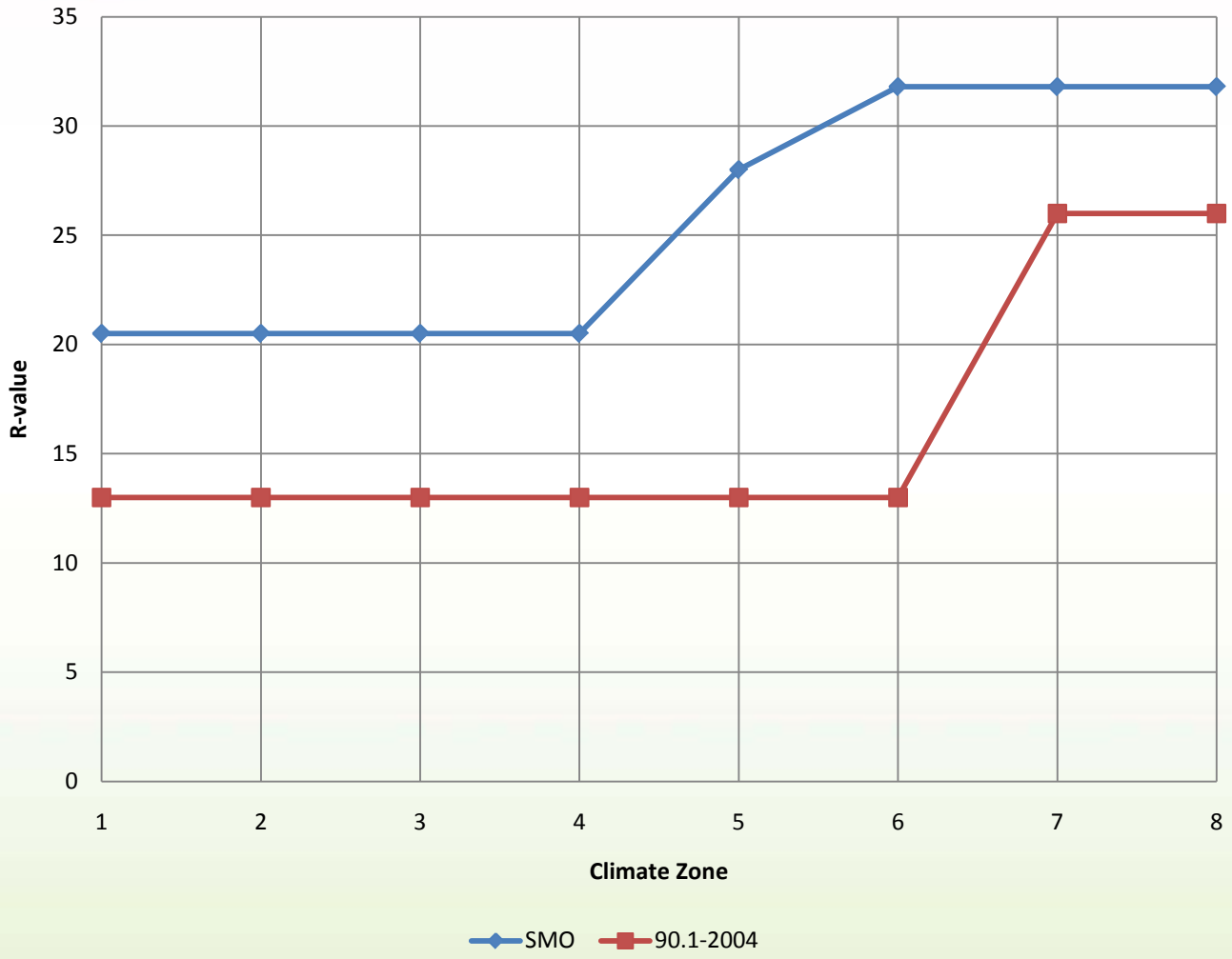


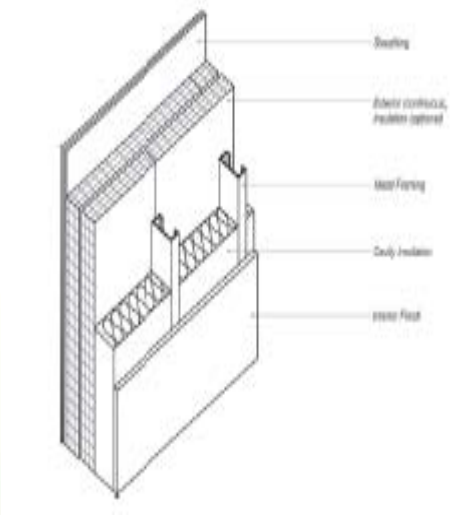
Mass Walls


20
18
16
14
12
10
8
6
4
2
0
R-value
1
2
3
4
5
6
7
8
Climate Zone
SMO
90.1-2004

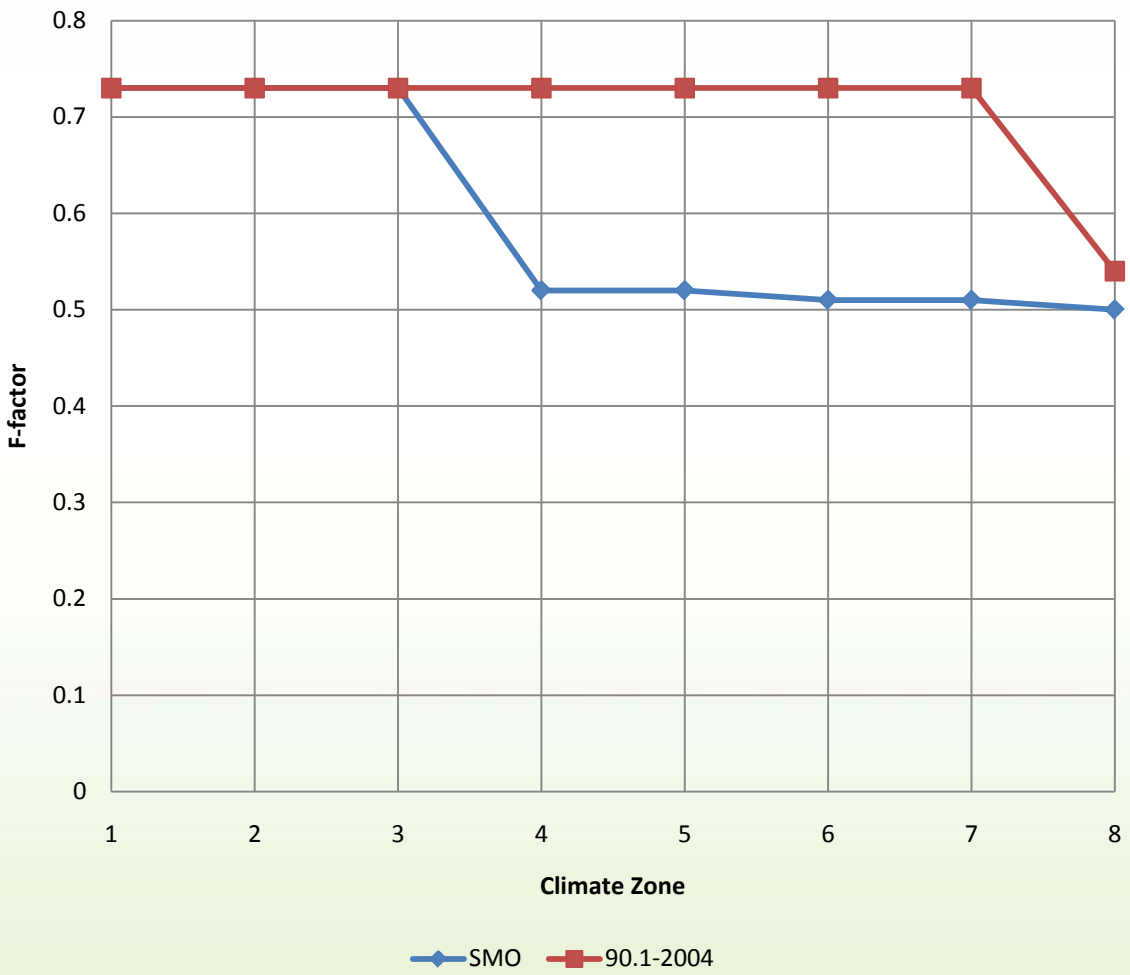

Concrete or masonry mass wall
Exterior (continuous) insulation (optional)

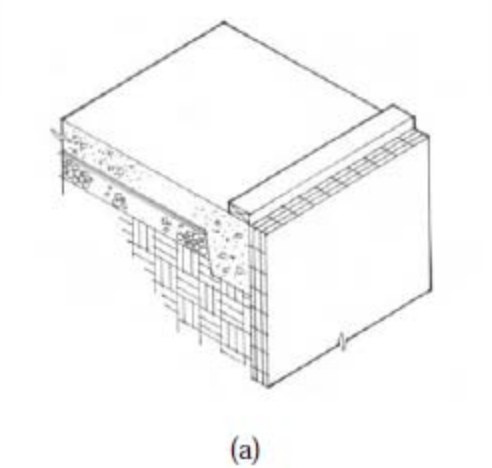
Steel Framed Walls

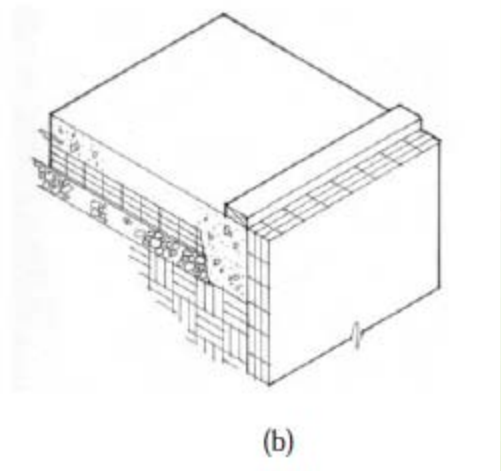




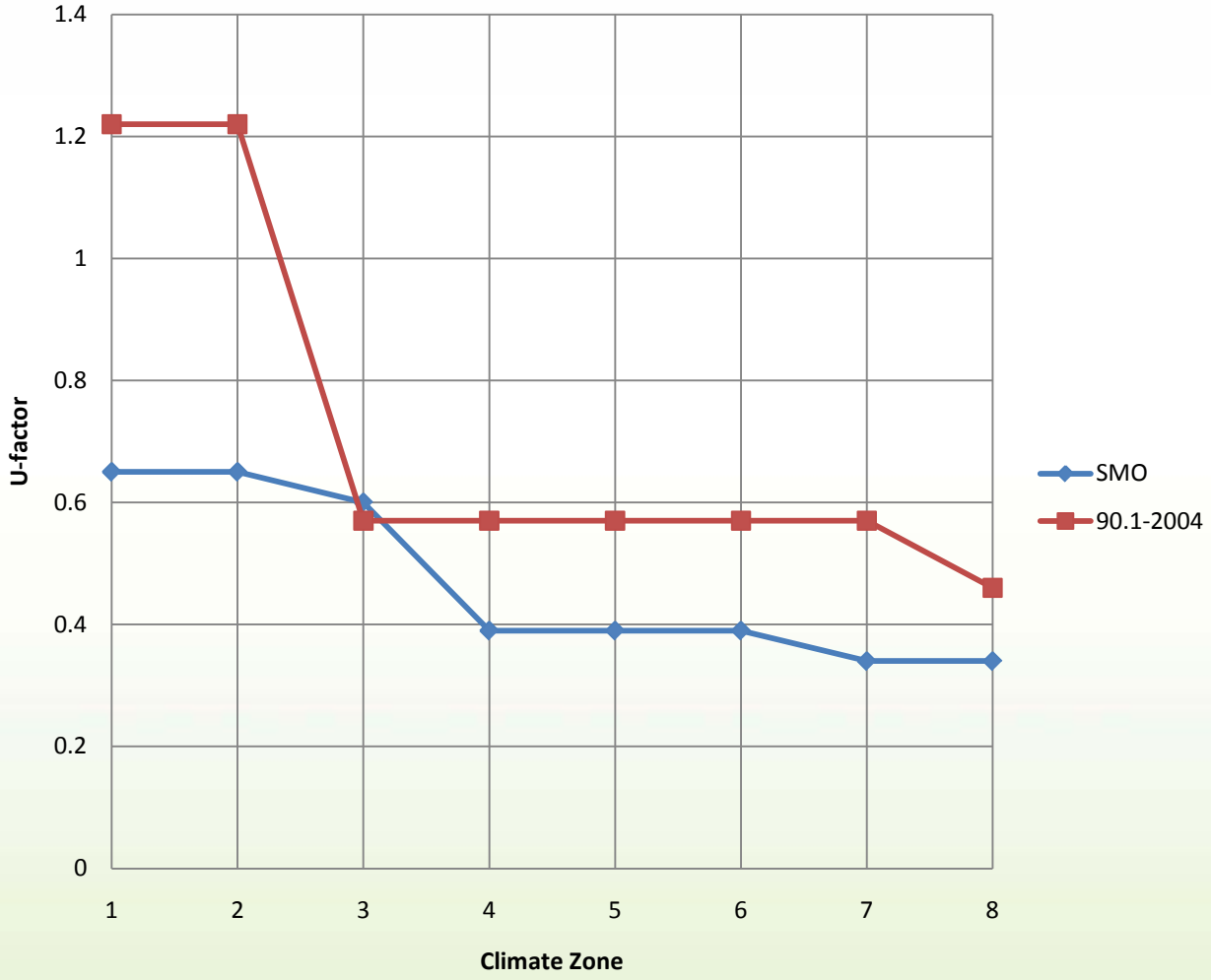
Unheated Slabs



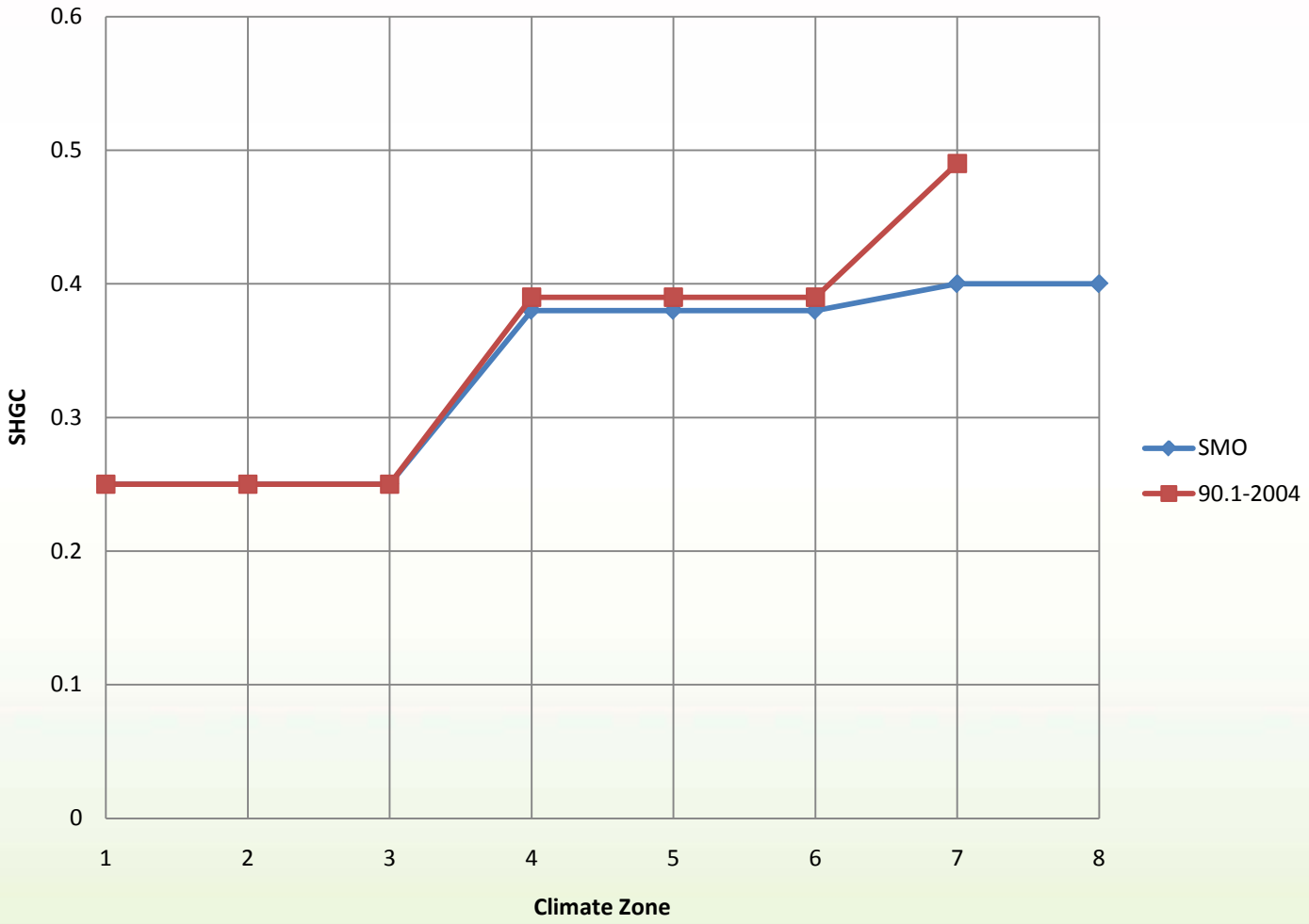




Vertical Fenestration – U-factor



Vertical Fenestration - SHGC



Alternative Opaque Constructions

Roof Assemblies	
R	U
Insulation Above Deck	
20	0.048
25	0.039
30	0.032
35	0.028
Attic and Other	
38	0.027
49	0.021
60	0.017
Metal Building	
19 + 10 FC	0.057
19 + 11 Ls	0.035
25 + 11 Ls	0.031
30 + 11 Ls	0.029
25+11+11 Ls	0.026

Slabs	
R - in.	F
Unheated	
10 - 24	0.54
20 - 24	0.51
Heated	
7.5 - 12	1.02
10 - 24	0.90
15 - 24	0.86
20 - 24	0.843
20 - 48	0.688
25 - 48	0.671
20 full slab	0.373

Walls, Above Grade	
R	U
Mass Walls	
5.7	0.151
7.6	0.123
11.4	0.090
13.3	0.080
19.0	0.066
Steel Framed	
13 + 7.5 c.i.	0.064
13 + 15.6 c.i.	0.042
13 + 18.8 c.i.	0.037
Wood Framed and Other	
13	0.089
13 + 3.8 c.i.	0.064
13 + 7.5 c.i.	0.051
13 + 10.0 c.i.	0.045
13 + 12.5 c.i.	0.040
13 + 15.0 c.i.	0.037
13 + 18.9 c.i.	0.032
Metal Building	
0 + 9.8 c.i.	0.094
0 + 13.0 c.i.	0.072
0 + 15.8 c.i.	0.060
0 + 19.0 c.i.	0.050
0 + 22.1 c.i.	0.044
0 + 25.0 c.i.	0.039

Walls, Below Grade	
R	C
7.5 c.i.	0.119
10.0 c.i.	0.092
15.0 c.i.	0.067

Floors	
R	C
Mass	
4.2 c.i.	0.137
10.4 c.i.	0.074
12.5 c.i.	0.064
14.6 c.i.	0.056
16.7 c.i.	0.051
20.9 c.i.	0.042
23.0 c.i.	0.038
Steel Framed	
19	0.052
13 + 7.5 c.i.	0.045
30	0.038
38	0.032
49	0.027
60	0.024
Wood Framed and Other	
19	0.051
30	0.033
38	0.027
49	0.022
60	0.018

2 – Building Structure and Form

Windows

Exterior Sun Control

Vestibules

Daylighting Glass

Building Orientation and Daylighting

Building Shape and Daylight

Correct Lighting Levels

Windows

- Orientation

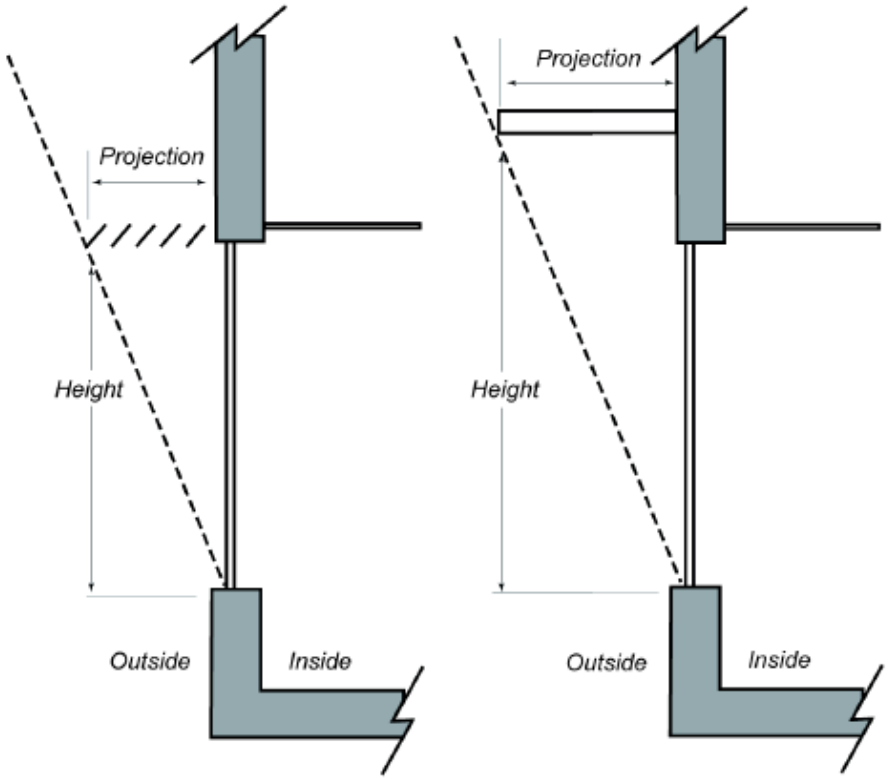
  A_w and A_e each < A_s

- Window-to-Wall Ratios

  20% to 40%

Exterior Sun Control
(South, East and West)

$$\text{Projection Factor} = \frac{\text{Horizontal Projection}}{\text{Height Above Sill}}$$



PF = 0.5

Vestibules

Primary Occupant Entrances

(Excluded: Emergency Exits, Maintenance Doors, Loading Docks and Specialty Entrances)

CZ 1-2 = No recommendation

CZ 3 = Buildings > 10,000 ft^2

CZ 4-8 = All Offices

Daylighting Glass

- VT = 0.6 to 0.7
- Minimum VT/SHGC =1.10 in all CZ
- Vertical Fenestration EA = 0.12 in all CZ

Building Orientation and Daylighting

Vertical facades that provide daylighting should be oriented within 15° of north and south directions.

Building Shape and Daylight

- Locate occupied spaces within a minimum distance from the perimeter.
  - Shape building footprint so all occupants are within 30 ft of perimeter fenestration.
  - Shape building footprint so regularly occupied spaces are within 15 ft of the perimeter.
  - Ensure that 75% of the occupied spaces are within 20 ft of the perimeter wall.

Correct Lighting Levels

- In clear sky conditions illuminance levels should be 25 fc to 250 fc.
- In overcast conditions achieve a daylight factor of 2% but no more than 20%.

3 – New Features

Mitigation of Thermal Bridges

Continuous Air Barriers

Thermal Mass to Reduce Loads

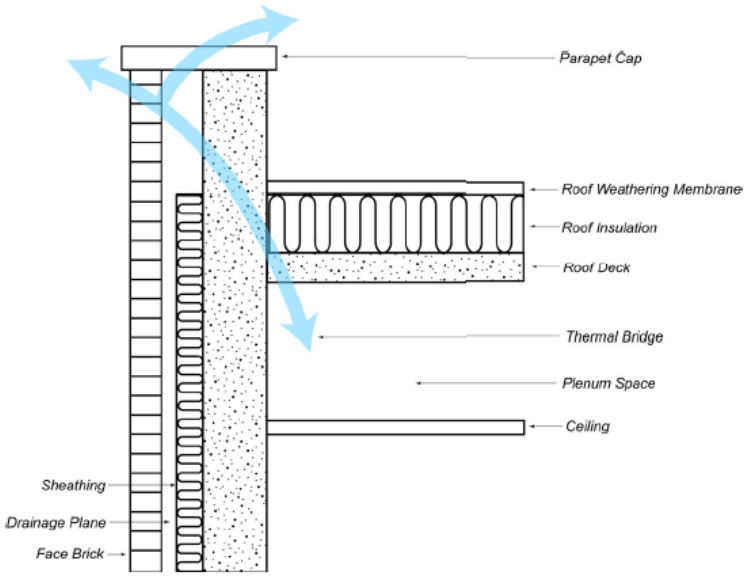
Mitigation of Thermal Bridges

Roofs

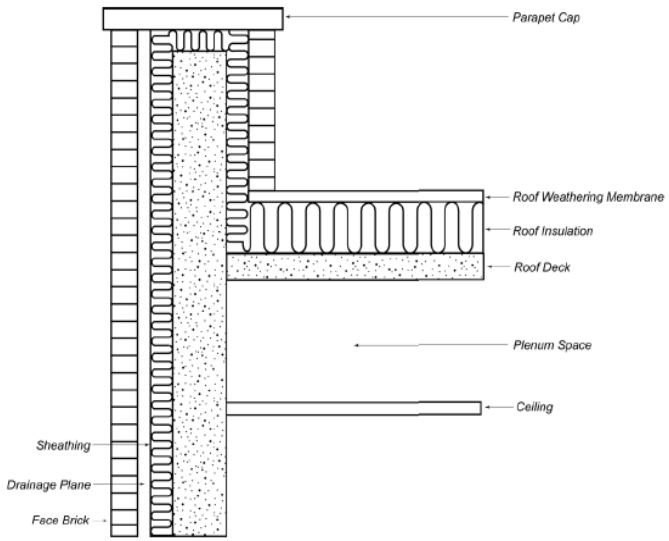
Windows

Foundations

Roof Parapet

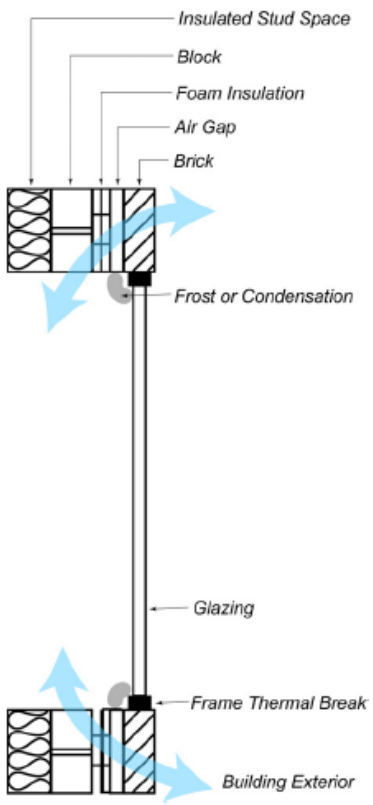


(a) Problem

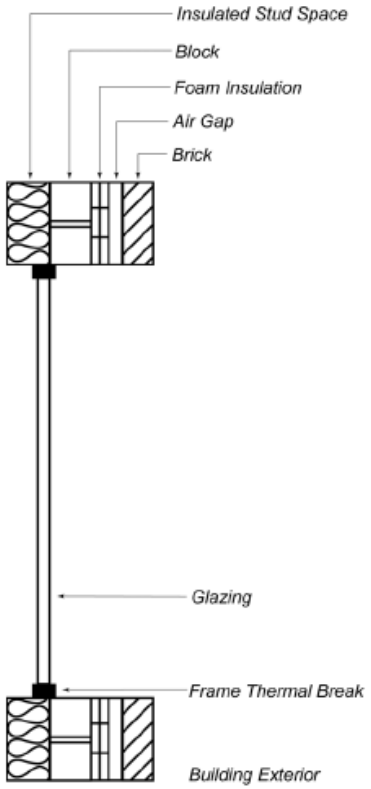


(b) Solution

Windows

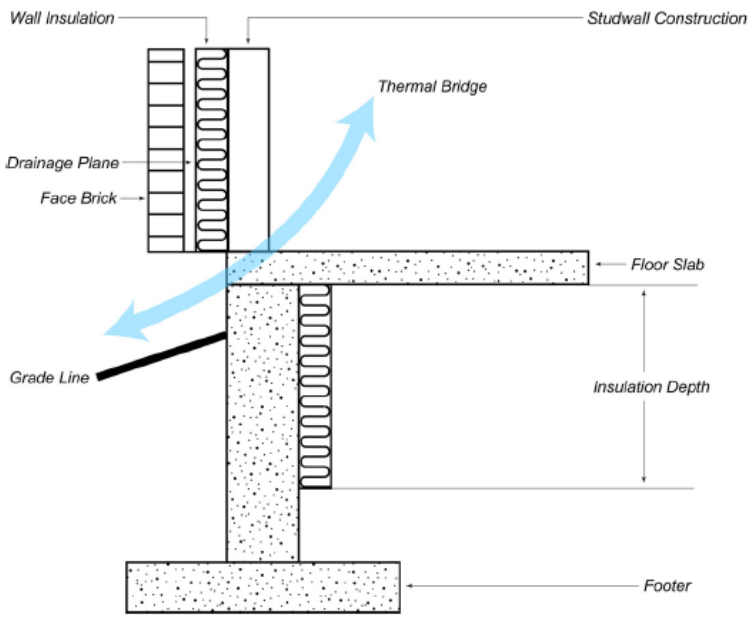


(a) Problem

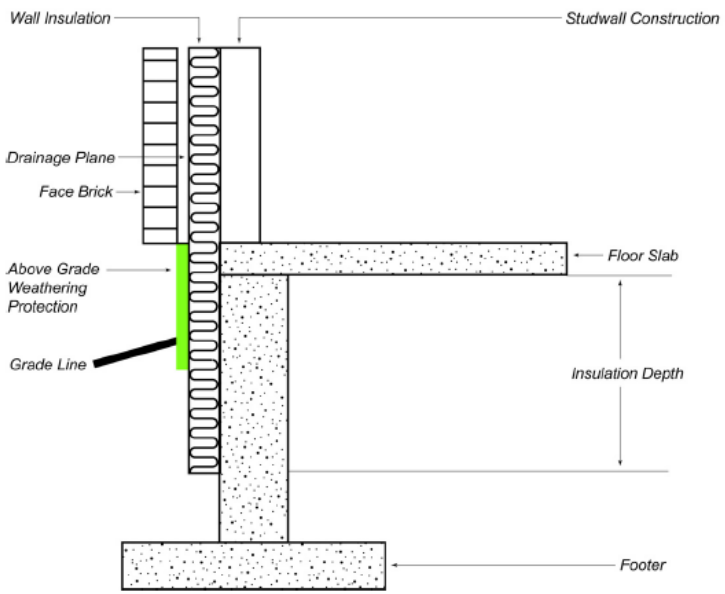


(b) Solution

Foundations



(a) Problem



(b) Solution

Continuous Air Barriers

Entire Building Envelope for all Offices
in All Climate Zones

Thermal Mass

Reduce Thermal Loads Improve Thermal Comfort Passive Solar Designs

(Lobbies, Corridors, Etc…)

Conclusions

- Minimizing the envelope heating and cooling loads is the first step in achieving 50% energy savings.
- The strategy is:
  - Upgrade the Thermal Envelope Efficiency
  - Make Fundamental Changes to the Building Basic Structure and Form
  - Incorporate New Features

Lighting and Daylighting Strategies For the 50% AEDG SMO

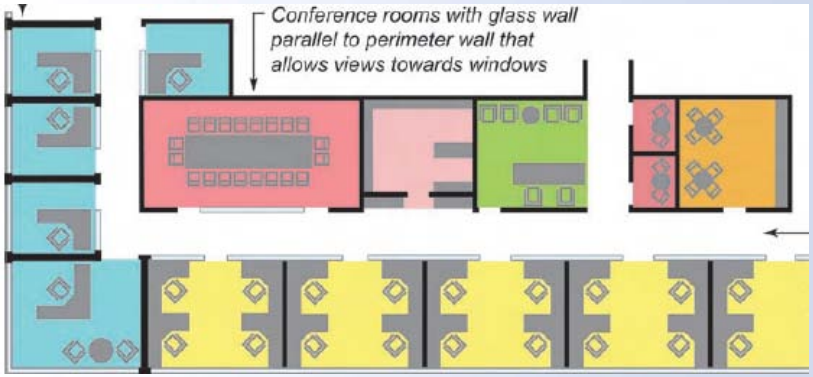
Michael Lane, LC
Senior Energy Management Engineer

PUGET SOUND ENERGY

Climate Zone Recommendations

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	
	Exterior Lighting	Façade and landscape lighting	LPD = 0.075 W/ft^2 in LZ3 and LZ4, 0.05 W/ft^2 in LZ2 Controls = auto OFF between 12 am and 6 am	EL23	
		Parking lots and drives	LPD = 0.1 W/ft^2 in LZ3 and LZ4, 0.06 W/ft^2 in LZ2 Controls = auto reduce to 25% (12 am to 6 am)	EL21, 24–25	
		Walkways, plazas, and special feature areas	LPD = 0.16 W/ft^2 LZ3 and LZ4, 0.14 W/ft^2 in LZ2 Controls = auto reduce to 25% (12 am to 6 am)	EL22, 24–25	
		All other exterior lighting	LPD = follow Standard 90.1-2010 Controls = auto reduce to 25% (12 am to 6 am)	EL24–25	

Daylighting Recommendations



- Use a shallow floor plate
- Locate workstations next to North or South windows
- Use low partitions with translucent materials
- Locate private offices on east and west perimeters
- Use light-colored matte finishes
- For controls
  - daylight dimming in open offices
  - occupancy sensing in private offices and conference rooms w/ daylight override

Electric Lighting Recommendations

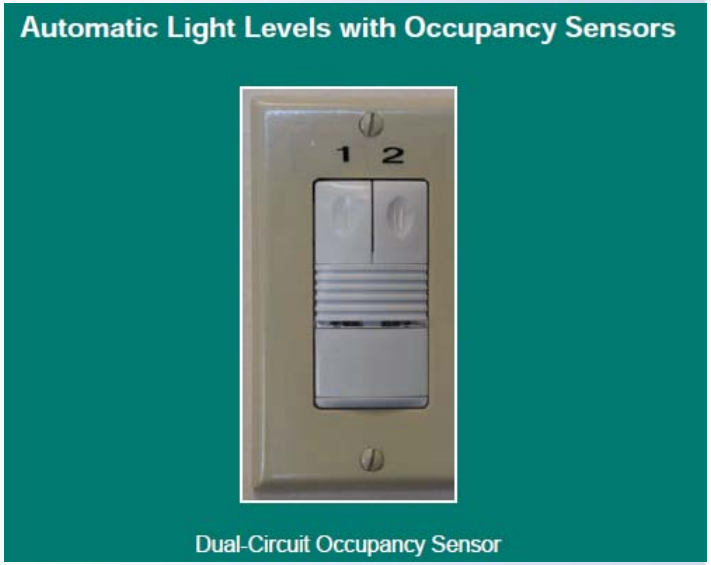
- Reduce Lighting Power Densities

Table 3-3 Standard Percentage Assumptions by Space Type (Thornton et al. 2010)

Space Type	Percentage of Floor Area	Standard Baseline LPD, W/ft^2	Adjusted Baseline LPD, W/ft^2
Office—open plan	15%	1.1	0.68
Office—private	29%	1.1	0.8
Conference/meeting room	8%	1.3	0.77
Corridor/transition space	12%	0.5	0.5
Active storage area	14%	0.8	0.64
Restroom	4%	0.8	0.82
Lounge/recreation area	2%	1.2	0.73
Electrical/mechanical room	2%	1.5	1.24
Stairway	3%	0.6	0.6
Lobby	6%	1.3	1.09
Other	5%	1.0	0.82
Weighted LPD for the whole building	100%	1.0	0.75

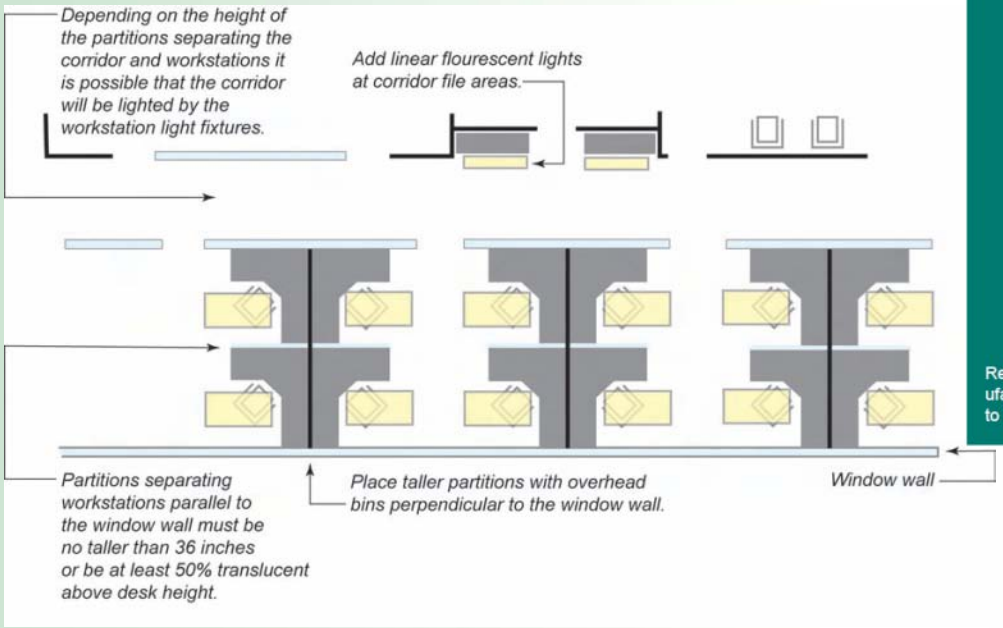
Electric Lighting Recommendations

- Reduce Lighting Power Densities
  - High Performance lensed fluorescent fixtures
  - 90+ lpw fluorescent lamps
  - NEMA Premium ballasts
- Dim general lighting in Open Offices
- Use dual circuit occupancy sensors in Private Offices
- Night lighting (10% max)



EL14 Open-Plan Offices (Climate Zones: all)

The target lighting in open offices is 30 average maintained footcandles for ambient lighting, with approximately 50 fc provided on the desktop by a combination of the ambient light and daylight. Supplemental task lighting is only required during nondaylight hours. Open-plan office areas account for approximately 16% of the floor area and are designed to 0.68 W/ft^2……



Recessed High-Performance Lensed Fluorescent Fixtures

Fixture Example #1
Source: Michael Lane, Lighting Design Lab

Fixture Example #2
Source: Michael Lane, Lighting Design Lab

Recessed high-performance lensed fluorescent fixtures are available from more than six lighting manufacturers. The distinguishing feature of these fixtures is an optical lens (or lenses) that direct the light to the workstation. This lens is *not* the flat prismatic lens common to the old lensed fluorescent troffer.

Electric Lighting Recommendations

- Exterior Lighting
  - calculate LPD only for areas intended to be lighted.
  - areas that are lighted to less than 0.1 fc are assumed to not be lighted
  - design with a maximum to minimum ratio of illuminance no greater than 30 to 1 (if the minimum light level is 0.1, then the maximum level in that area should be no greater than 3 fc)
  - reduce power between 12:00 p.m. and 6:00 a.m. to no more than 50%
  - turn façade lighting OFF after midnight
  - use 90.1-2010 lighting zone 3 or lower recommendations

HVAC Strategies for the 50% AEDG SMO

Bing Liu, PE, CEM, LEED AP
Daniel Nall, WSP Flack + Kurtz
Mick Schwedler, Trane
Erin McConahey, Arup

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Principles for HVAC Efficiency

- High full load efficiency and maximized part load efficiency (units rarely operate at full load)
- Humidity control and ventilation maintenance without reheat
  - Vary airflow for load modulation with constant maximum apparatus dew point
  - Separate ventilation airflow from sensible conditioning and maintain constant maximum apparatus dewpoint in ventilation airflow
- Move only as much air as necessary
  - Vary airflow with sensible load
  - Disable conditioning air flow when possible
- Independent controls for ventilation and sensible cooling
- Heat or energy recovery in almost all climate zones

System types for 50% savings

- Constant volume air-source heat pumps with DOAS
- Water source heat pumps with DOAS
- VAV Fan coils with DOAS
- Radiant heating/cooling with DOAS
- Air-cooled VAV DX units with indirect gas-fired heat or with electric baseboards
- Chilled water VAV with air-cooled chiller and with hydronic distribution and condensing boiler or electric baseboards
- Others may work, but weren't tested for this study

30% AEDG solutions that don't work for 50% savings

- Constant volume systems without Dedicated Outdoor Air System (DOAS)
- Constant Volume DX cooling only systems even with DOAS
- Constant outdoor air ventilation

Air Source Heat Pump With DOAS

- Premium DX heating/cooling efficiency
- Very low exterior temperature heating performance (-4°F)
- DOAS with energy recovery and humidity control
- Unit fan and compressors cycle with load
- Low pressure drop ductwork design
- Demand controlled ventilation (DCV)
  - Motorized damper control
  - Ventilation Airflow monitoring per 62.1-2010

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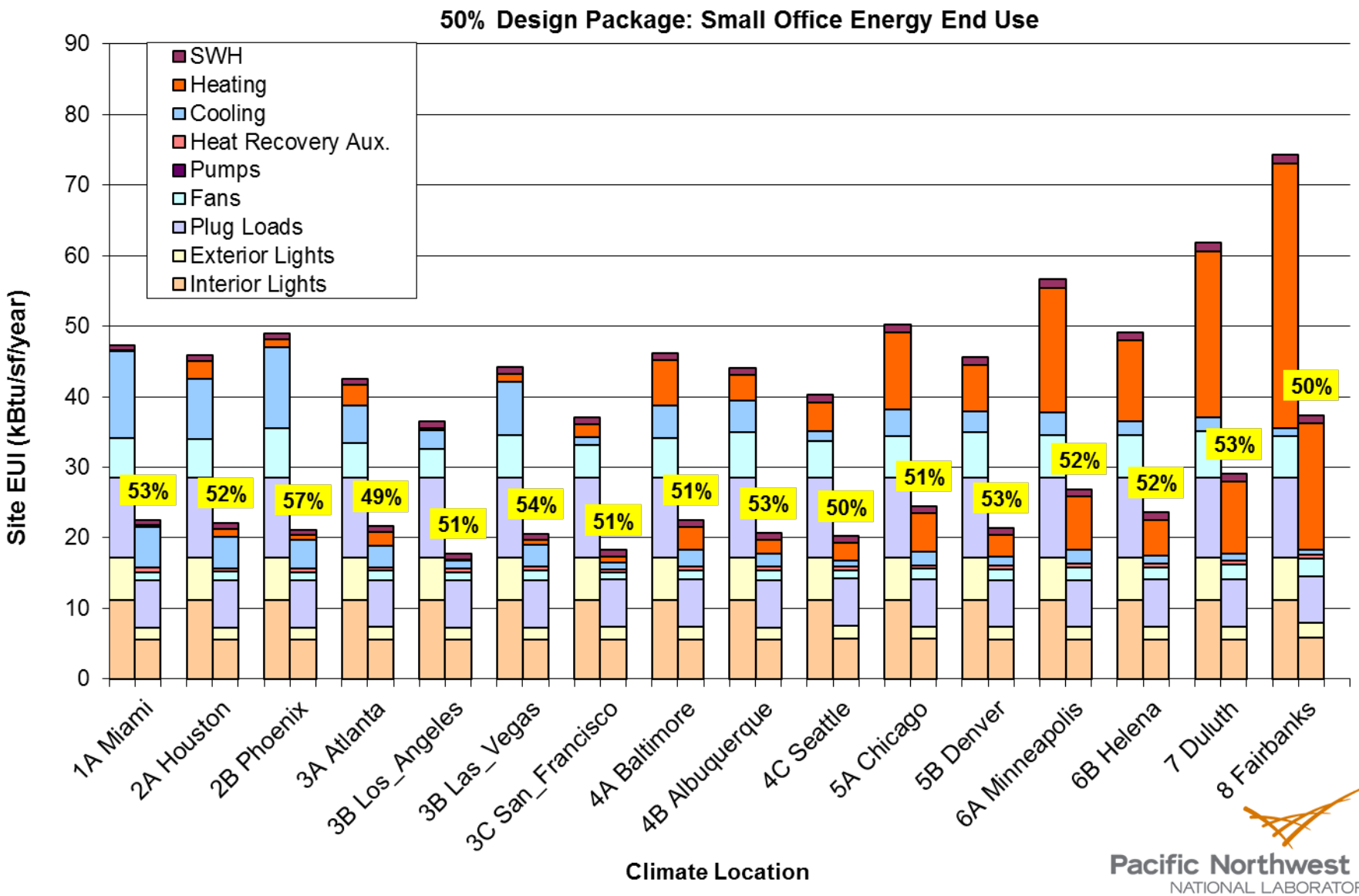
Air Source Heat Pump System Results



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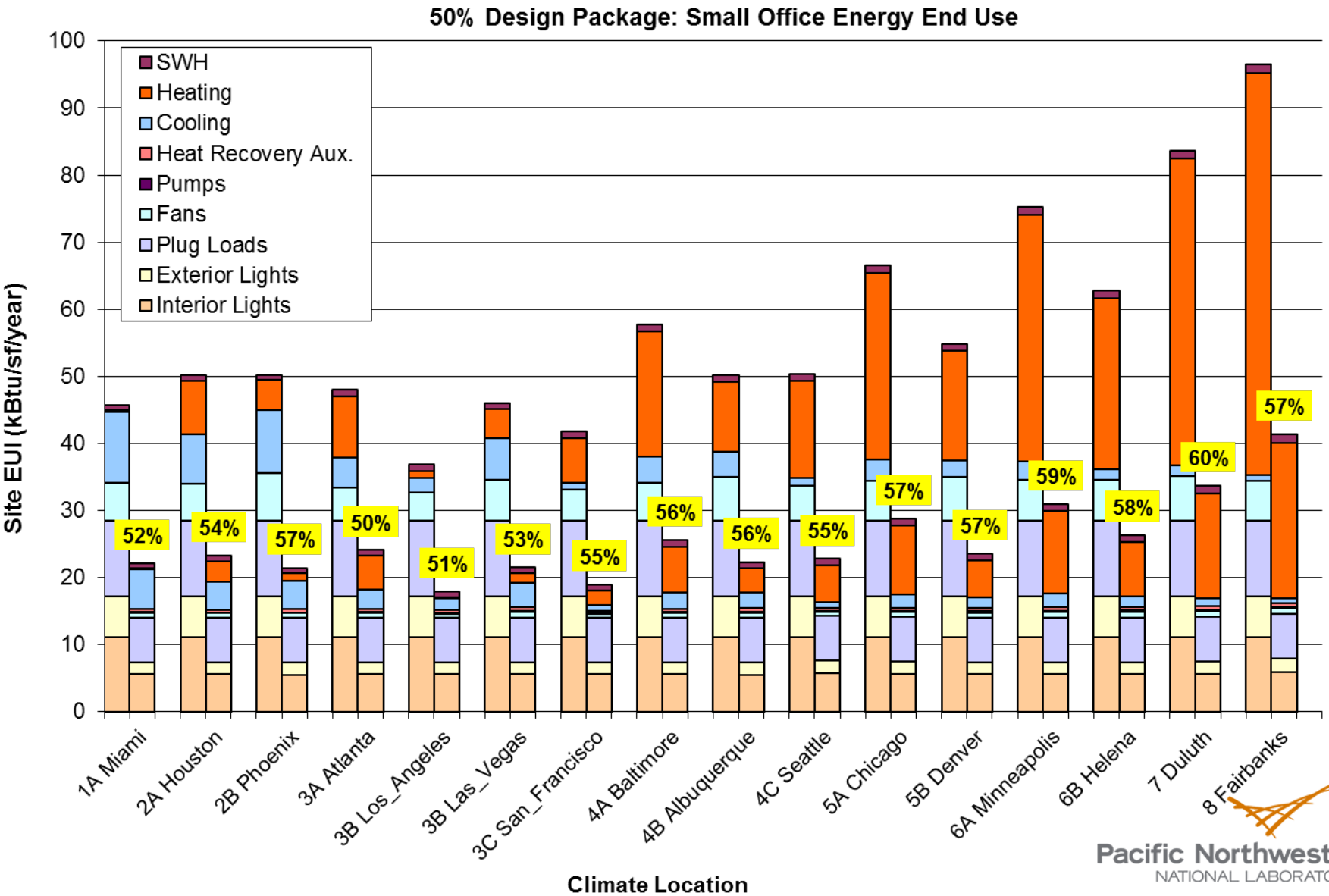
Water Source Heat Pump System with DOAS

- Heat pump units -in 5 ton size range
  - Single stage, EER 16.4, COP 5.2
  - Two-stage part load/full load EER 17.6/15.0, - COP 5.7/5.0
  - ECM fan motors
- Loop heating and cooling
  - Cooling tower, variable speed or two speed fan
  - Condensing boiler
  - Optimize loop cooling temperature
- DOAS with energy recovery and humidity control

Water Source Heat Pump System with DOAS



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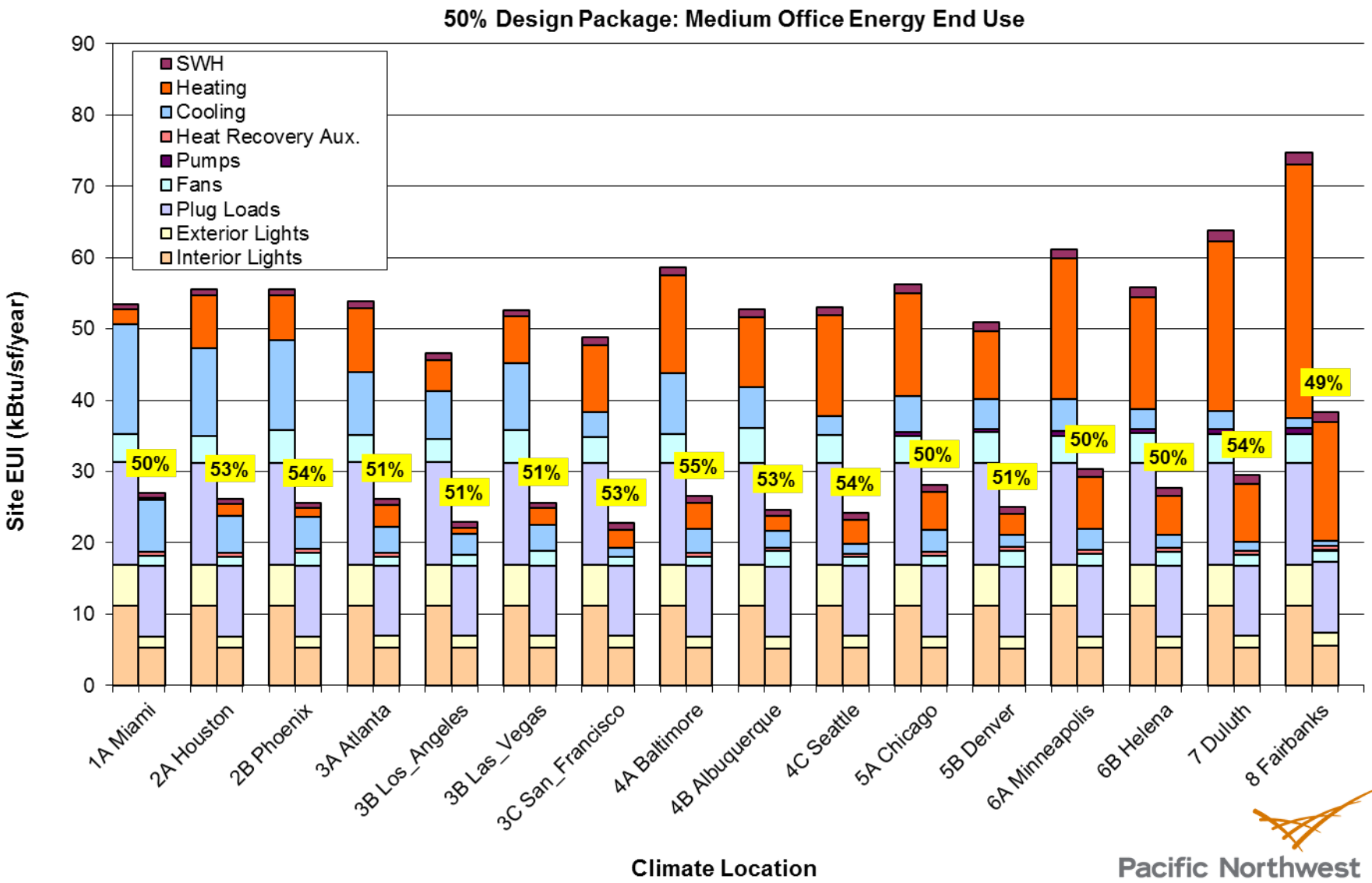
Advanced VAV System

- Premium DX cooling efficiency
- Energy recovery ventilator
  - All except 3B-CA, 3B other, 3C
- Supply air temperature reset
  - Previously excluded 3A and 4a
- Indirect evaporative cooling
  - 2B, 3B-CA, 3B other, 4B, 5B
- Demand controlled ventilation (DCV)
  - Motorized damper control
  - Ventilation Airflow monitoring per 62.1-2010

Advanced VAV System Results



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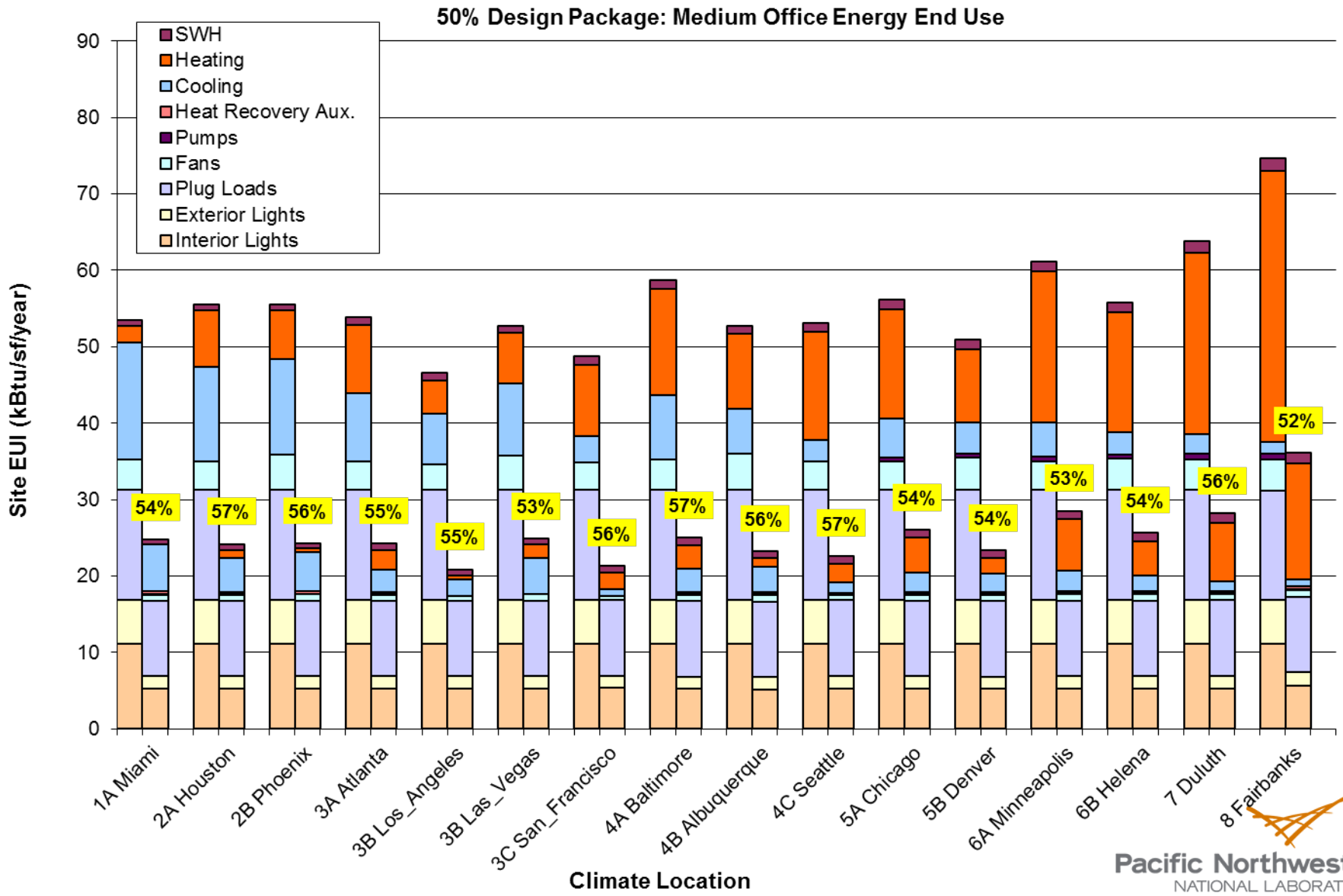
Advanced Fan Coil System with DOAS

- Fan Coil Systems –chilled and hot water coils
  - ECM fan motors
  - Fan coils cycle when no space loads
- Variable flow pumping
- DOAS with energy recovery and humidity control
- Chilled water supply
  - Efficient air-cooled chiller as described for VAV
  - 42°F for DOAS
  - Variable flow with pressure reset
- Hot water
  - Condensing boiler 140°F supply, 120°F return

Advanced Fan Coil Results



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Advanced Radiant System with DOAS

- Radiant cooling/heating ceiling panels or floor slab
- Variable flow pumping
- DOAS with energy recovery and humidity control
- Chilled water supply
  - Efficient air-cooled chiller as described for VAV
  - 42°F for DOAS
  - 58°F for radiant system
  - Variable flow with pressure reset
- Hot water
  - Condensing boiler 120°F supply, 100°F return

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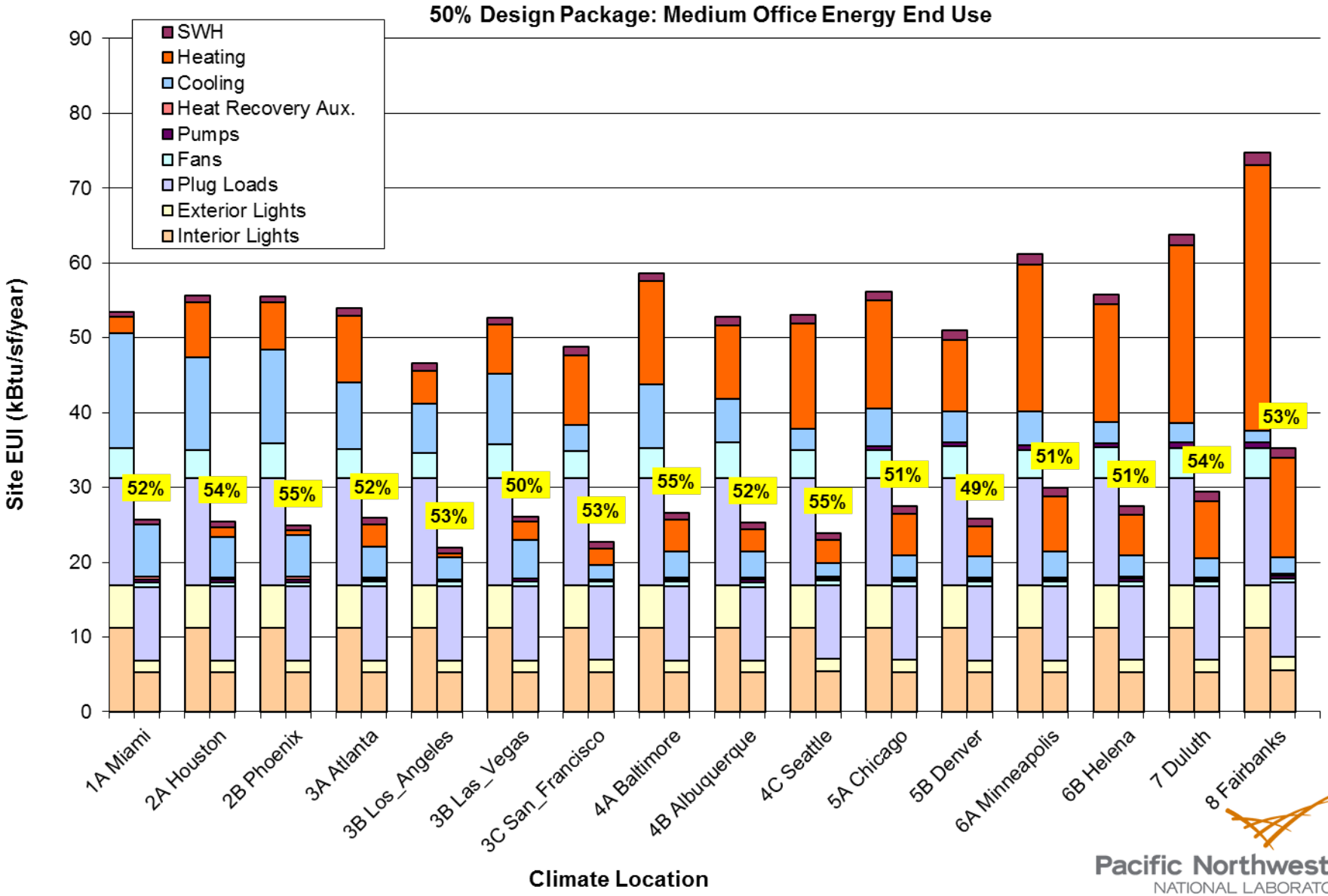
Advanced Radiant System Results



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Other Information in the AEDG

- Plug loads peak reduction and off-hour control management
- How-To Tips
- Cautions
- References and Resources
- Detailed Discussion of Quality Assurance and Commissioning

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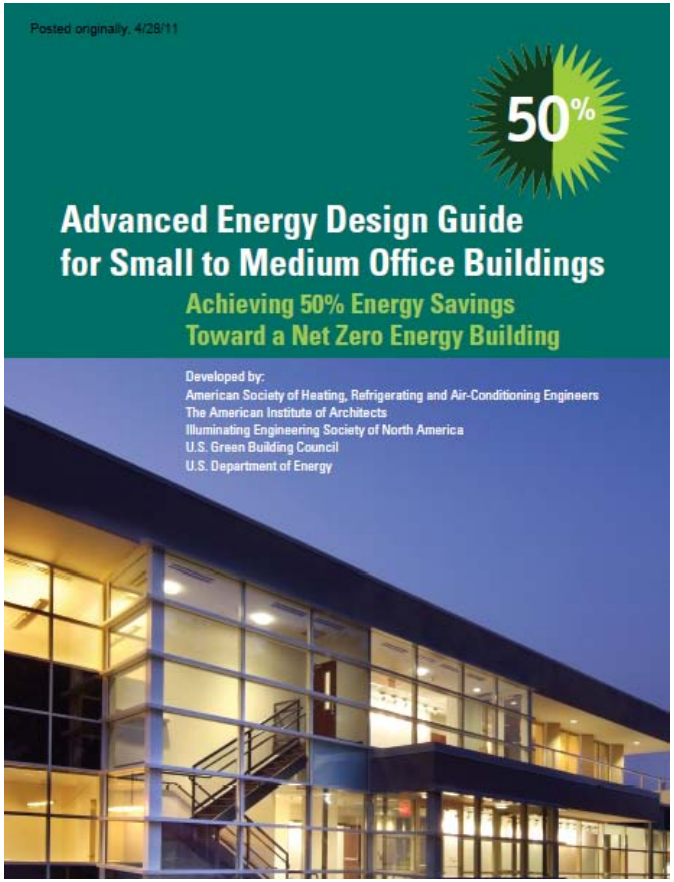

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