lighting design lab

Originally aired on July 31, 2008

Today's event (10/16/08) is a rebroadcast of three previous webcasts which originally aired on 7/31/08, 8/14/08, and 9/11/08

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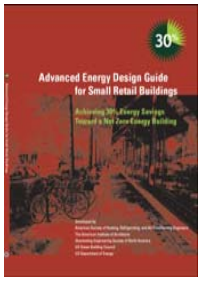
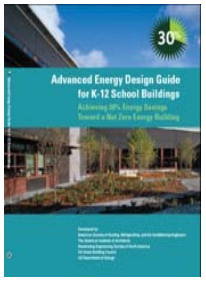
AEDG
Advanced Energy Design Guides





lightingdesignlab.com

Michael Lane, LC

- Project Manager at the Lighting Design Lab and has been with the Lab since its inception in 1989.
- Received Bachelor of Architecture from Washington State University in 1982, and has specialized in the lighting field for over 26 years.
- Is a member of the IESNA and was in the first class to be Lighting Certified (LC) by NCQLP.
- Serves on the IESNA Sustainable Lighting & Energy Management Committees, the ASHRAE 90.1 Energy Committee and the LEED Sustainable Sites Committee.

lighting design lab

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AEDG

The ASHRAE *Advanced Energy Design Guides* are a series of publications designed to provide recommendations for achieving energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999.

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Advanced Energy Design Guides

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Overview/Purpose | Published/Completed Guides | Additional Information
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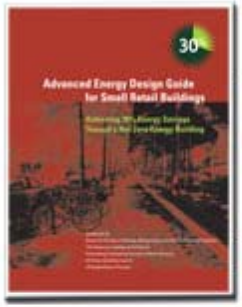
Overview/Purpose

The ASHRAE *Advanced Energy Design Guides* (AEDG) are a series of publications designed to provide recommendations for achieving energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999. The guides have been developed in collaboration with these partnering organizations: The American Institute of Architects (AIA), the Illuminating Engineering Society of North America (IESNA), the U.S. Green Building Council (USGBC), and the U.S. Department of Energy (DOE). The New Building Institute (NBI) participated only in the development of the *Advanced Energy Design Guide for Small Office Buildings*.



The initial series of guides have an energy savings target of 30% which is the first step in the process toward achieving a net zero energy building - defined as a building that, on an annual basis, draws from outside resources equal or less energy than it provides using on-site renewable energy sources. Each 30% Guide addresses a specific building type. Additional guides for existing buildings and at 50% energy savings towards a net zero energy building are also planned.

ANSI/ASHRAE/IESNA Standard 90.1-1999, the energy conservation standard published at the turn of the millennium, provides the fixed reference point for all of the 30% Guides in this series. The primary reason for this choice as a reference point is to maintain a consistent baseline and scale for all of the 30% AEDG series documents.

The recommendations in the 30% Guides will allow those involved in designing or constructing the various building types to easily achieve advanced levels of energy savings without having to resort to

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The American Society of Heating, Refrigerating and Air-Conditioning Engineers advances technology to serve humanity and promote a sustainable world. Membership is open to any person associated with the field. **Click here to join ASHRAE**

ASHRAE Satellite Broadcast

ASHRAE will present a free satellite broadcast and simultaneous Webcast, "Integrated Building Design: Bringing the Pieces Together to Unleash the Power of Teamwork," on April 16, 2008. Learn More

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To promote building energy efficiency, ASHRAE and its partners are making the Advanced Energy Design Guides available for free download (PDF). Learn More

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Looking to build performance in your career? Or maybe you're seeking to improve performance of the buildings you design, operate and maintain. Either way, ASHRAE's 2008 Annual Meeting in Salt Lake City is for you. Learn More

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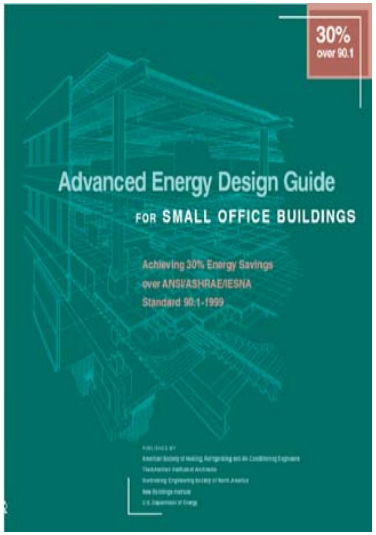
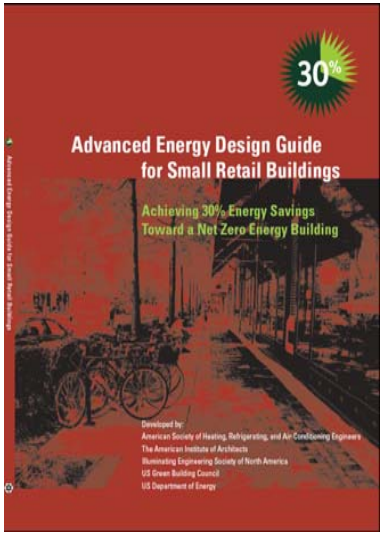
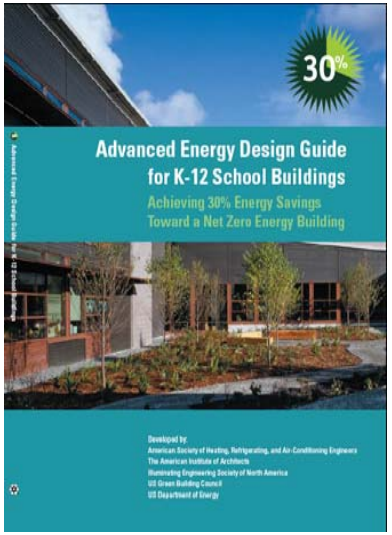
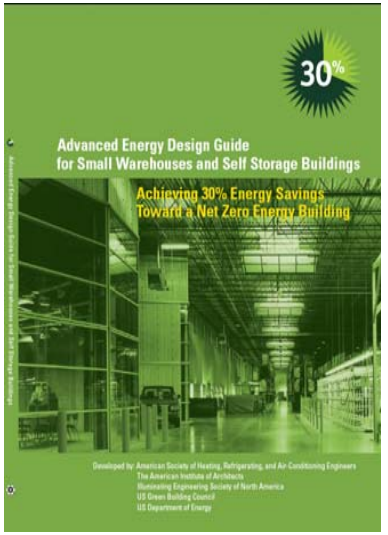








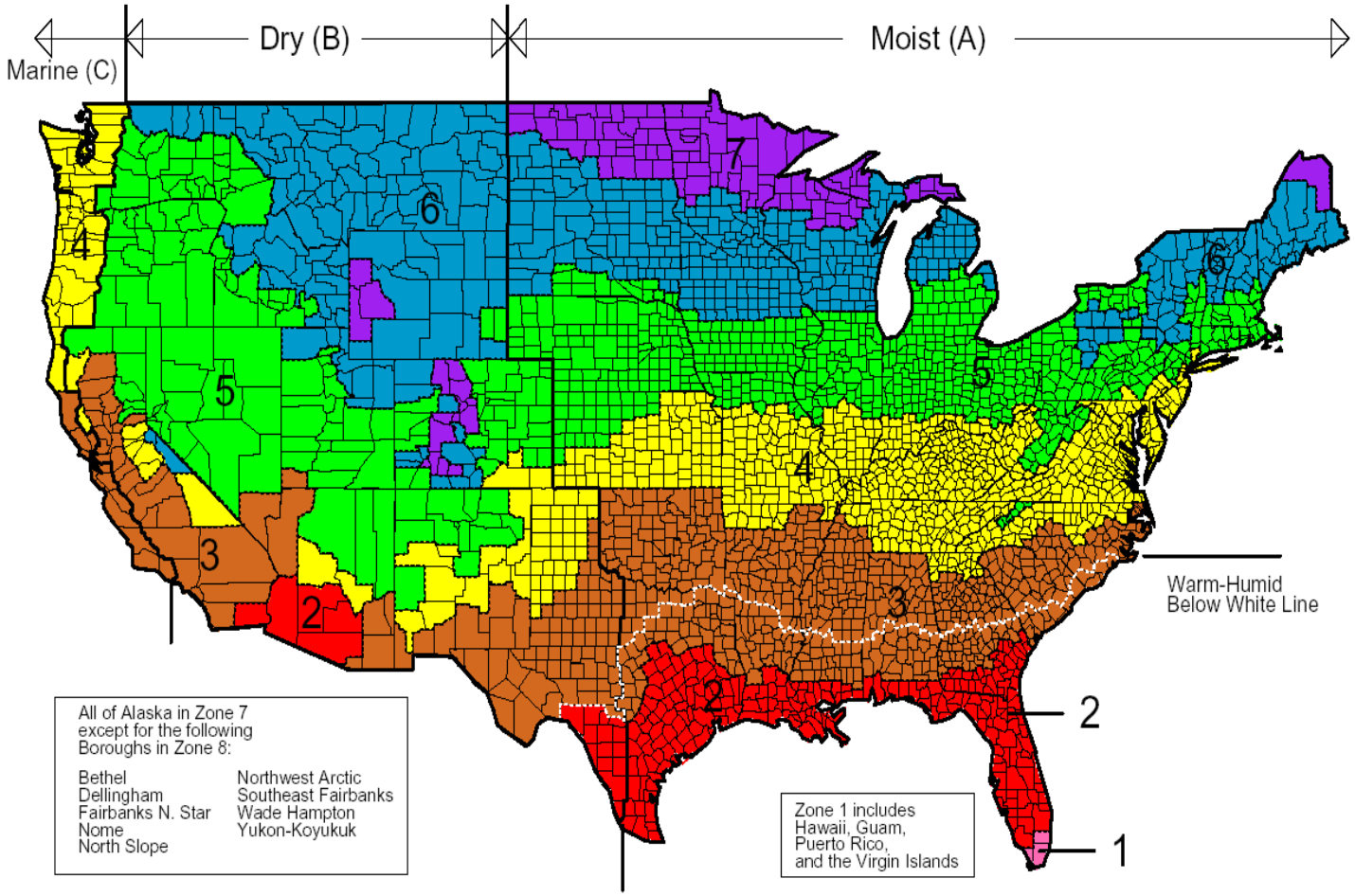
Timeline & Goals

- **Complete document in 1 year**
- **30% energy savings relative to buildings constructed to meet the energy requirements of Standard 90.1-1999**
- **Savings to be achieved in each climate location (not simply an average)**
- **Hard goal of 30% to be consistent with LEED® rating system**
- **Attain energy savings through packages of design measures**

Contents

US DOE - Climate Zones

All of the energy saving recommendations for each of the eight U.S. climate zones are contained on a single page, thus facilitating the 30% Guide's use.



Climate Zone 4 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	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	EN7, 17, 20-21
		Steel framed	R-13 + R-7.5 c.i.	EN8, 17, 20-21
		Wood framed and other	R-13	EN9, 17, 20-21
		Below-grade walls	No recommendation	EN10, 17, 20-21
	Floors	Mass	R-8.3 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-7.5 for 24 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
		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)	0.34	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)	80% 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.

AEDG for Small Office Buildings...

- **is the first in a series designed to provide recommendations for achieving 30% energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999.**
- **This Guide focuses on small office buildings, and are limited to 20,000 ft^2 in size.**
- **The recommendations in this Guide will allow those involved in designing or constructing small office buildings to easily achieve advanced levels of energy savings without having to resort to detailed calculations or analyses.**
- **For more information on the entire Advanced Energy Design Guide series, please visit the AEDG web page at www.ashrae.org/aedg.**

Where is the Energy Used?

Annual Energy Use in MBTU - 5000 SF Office Building (Round 4)

	Location	Climate Zone	Lighting	Cooling	Heating	Fans	SWH	Plugs	Aux	Total	Savings w/ Plug	Savings wo Plug
Base	Duluth MN	Zone 7	77.7	11.1	224.5	40.7	14.6	38.9	1.0	408.5	-	-
Advanced	Duluth MN	Zone 7	49.3	5.3	102.9	28.1	6.3	38.9	1.0	231.8	43.3%	47.8%
	Savings over Base		*28.4*	*5.8*	*121.6*	*12.6*	*8.3*	*0.0*	*0.0*	*176.7*		
	Savings % over Base		*36.6%*	*52.3%*	*54.2%*	*31.0%*	*56.8%*	*0.0%*	*0.0%*	*43.3%*		
	% savings		*16.1%*	*3.3%*	*68.8%*	*7.1%*	*4.7%*	*0.0%*	*0.0%*			
Base	Miami FL	Zone 1	77.7	75.5	0.0	32.3	10.3	38.9	0.0	234.7	-	-
Advanced	Miami FL	Zone 1	49.3	47.7	0.0	25.2	3.4	38.9	0.0	164.5	29.9%	35.9%
	Savings over Base		*28.4*	*27.8*	*0.0*	*7.1*	*6.9*	*0.0*	*0.0*	*70.2*		
	Savings % over Base		*36.6%*	*36.8%*	*0.0%*	*22.0%*	*67.0%*	*0.0%*	*0.0%*	*29.9%*		
	% savings		*40.5%*	*39.6%*	*0.0%*	*10.1%*	*9.8%*	*0.0%*	*0.0%*			
Base	Phoenix AZ	Zone 2	77.7	74.7	1.1	41.5	10.8	38.9	0.2	244.9	-	-
Advanced	Phoenix AZ	Zone 2	49.3	44.4	1.0	33.0	3.6	38.9	0.2	170.4	30.4%	36.2%
	Savings over Base		*28.4*	*30.3*	*0.1*	*8.5*	*7.2*	*0.0*	*0.0*	*74.5*		
	Savings % over Base		*36.6%*	*40.6%*	*9.1%*	*20.5%*	*66.7%*	*0.0%*	*0.0%*	*30.4%*		
	% savings		*38.1%*	*40.7%*	*0.1%*	*11.4%*	*9.7%*	*0.0%*	*0.0%*			
Base	Seattle WA	Zone 4	77.7	12.5	39.5	24.3	13.3	38.9	0.7	206.9	-	-
Advanced	Seattle WA	Zone 4	49.3	5.8	33.4	20.7	5.2	38.9	0.7	154.0	25.6%	31.5%
	Savings over Base		*28.4*	*6.7*	*6.1*	*3.6*	*8.1*	*0.0*	*0.0*	*52.9*		
	Savings % over Base		*36.6%*	*53.6%*	*15.4%*	*14.8%*	*60.9%*	*0.0%*	*0.0%*	*25.6%*		
	% savings		*53.7%*	*12.7%*	*11.5%*	*6.8%*	*15.3%*	*0.0%*	*0.0%*			

Lighting and Daylighting Technologies

- **Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2004) as the advanced case**
  - *1999 Standard = 1.3 w/ft^2*
  - *2004 Standard = 1.0 w/ft^2*
- **Recommendation for high performance lamps, which reduced the LPD to 0.9 w/ft^2**
- **Occupancy sensors to turn off lights during unoccupied hours**
- **Daylighting controls recommended for fixtures within 12 ft of north or south window walls and within 8 ft of skylight edges**

High-Performance T8 lamps

- **“Premium / Super / Enhanced”:**
  - *Initial lumens 3,100*
  - *Maintained lumens 2,915 Slightly higher L/W than standard T8 (91 vs 88)*
  - *Provide 85 or greater Color Rendering Index*
  - *Achieve a rated life of 24,000 hours or greater (under standard testing procedures)*

Lighting Recommendations

Climate Zone 4 Recommendation Table

	Item	Component	Recommendation
Lighting	Interior Lighting	Lighting power density (LPD)	0.9 W/ft^2
		Light source (linear fluorescent)	90 mean lumens/watt
		Ballast	Electronic ballast
		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
		Occupancy controls	Auto-off all unoccupied rooms
		Interior room surface reflectances	80%+ on ceilings, 70%+ on walls and vertical partitions

T8 lamps and lumens

	Lamp Wattage	Initial Lumens	Mean Lumens	CRI	mean Lumens per watt
F34/CW/RS	34	2650	2300	62	67.6
F32T8/8xx/ 25 watt	25	2400	2280	85	91.2
F32T8/8xx/ 28 watt	28	2738	2574	83.5	91.9
F32T8/8xx/ 30 watt	30	2850	2685	84	89.5
F32T8/7xx	32	2817	2660	78	83.1
F32T8/8xx	32	2950	2770	85	86.6
F32T8/8xx/ High Performance	32	3100	2948	85	92.1
F28T5	28	2900	2750	85	98.2
F54T5HO	54	5000	4750	85	88.0

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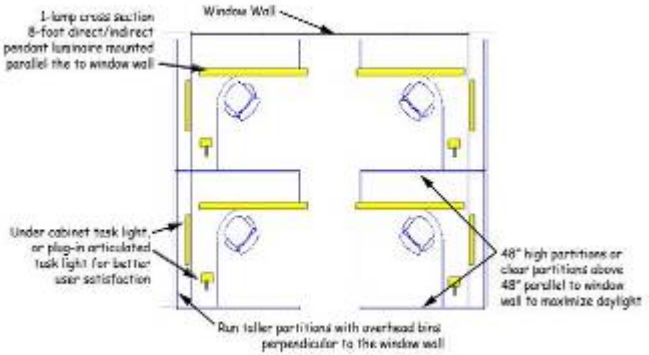


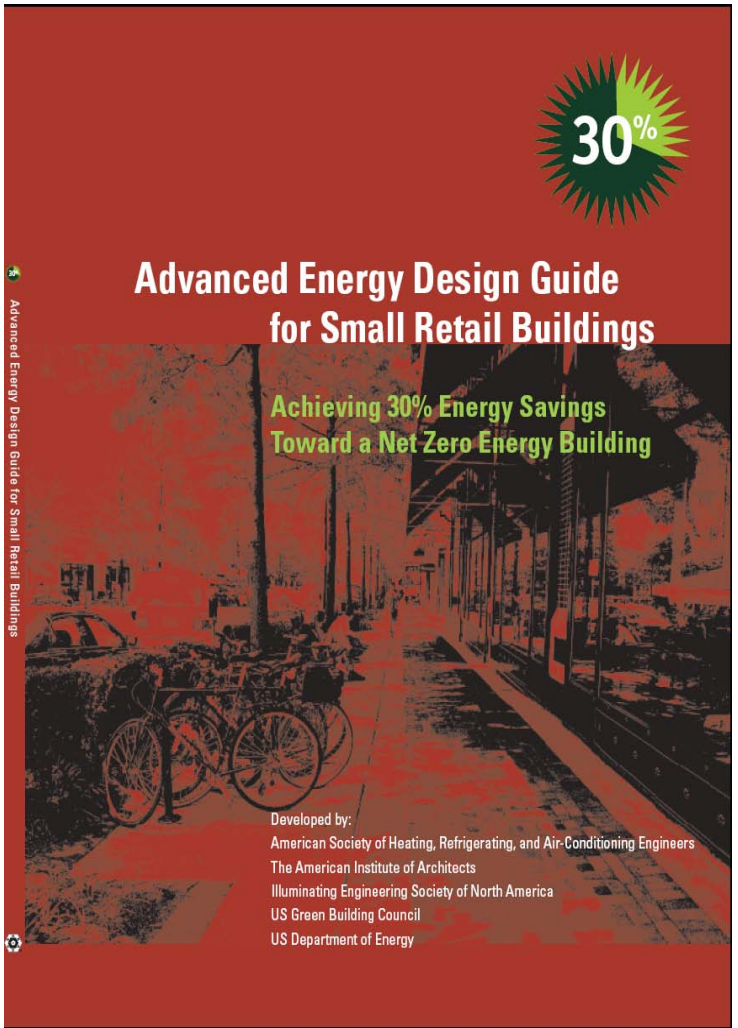
Space Type	Floor space allocation	LPD	LPD*area
Corridor/Transition	10%	0.55	0.055
Other Areas	10%	0.75	0.075
Lobby	10%	1.09	0.109
Office - enclosed	25%	0.94	0.235
Office - open plan	20%	1.03	0.206
Conference Meeting/Multipurpose	10%	1.02	0.102
Active storage	15%	0.78	0.117
	100.0%		0.899

The target lighting in open offices is 30 average maintained footcandles for ambient lighting with a total of at least 50 footcandles provided on the desktop.

LEED-NC EAc1 Optimize Energy Performance

- **OPTION 2 — PRESCRIPTIVE COMPLIANCE PATH (4 Points)**
- **Comply with the prescriptive measures of the ASHRAE Advanced Energy Design Guide for Small Office Buildings.**
- **The following restrictions apply:**
  - *Buildings must be under 20,000 square feet*
  - *Buildings must be office occupancy*
  - *Project teams must fully comply with all applicable criteria as established in the Advanced Energy Design Guide for the climate zone in which the building is located*

AEDG for Small Retail Buildings...



- **is the second in a series designed to provide recommendations for achieving 30% energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999.**
- **This Guide focuses on small retail buildings, and are limited to 20,000 ft^2 in size.**
- **The recommendations in this Guide will allow those involved in designing or constructing small retail buildings to easily achieve advanced levels of energy savings without having to resort to detailed calculations or analyses.**
- **For more information on the entire Advanced Energy Design Guide series, please visit the AEDG web page at www.ashrae.org/aedg.**

Lighting Technologies

- **Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2004) as the advanced case**
  - *1999 Standard = 1.9 w/ft^2*
  - *2004 Standard = 1.7 w/ft^2*
- **Recommendation for high performance lamps and high-performance ballasts**
- **Ceramic Metal Halide accent lighting**
- **Occupancy sensors in back of house**

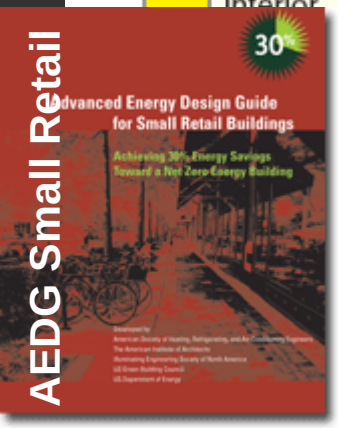
High-Performance Electronic Ballasts

	2	F32T8								
	Standard ballasts		**Optanium**		**Ultra Max/Start**		**QHE / QTP**		**ULTim8**	
	Watts	**BF**	**Watts**	**BF**	**Watts**	**BF**	**Watts**	**BF**	**Watts**	**BF**
low	50	0.77	48	0.78	48	0.77	48	0.78	47	0.77
lpw	90		96		95		96		97	
normal	58	0.88	55	0.88	54	0.87	55	0.88	54	0.87
lpw	89		94		95		94		95	
high	77	1.16	73	1.18	74	1.15	74	1.20	NA	-
lpw	89		95		92		96			

AEDG Small Retail
AEDG Small Retail

Lighting Recommendation

	Item	Component	Recommendation (Minimum or Maximum)
Lighting	Interior Lighting	Lighting power density (LPD)	1.3 W/ft^2
		Linear fluorescent with high-performance electronic ballast	91 mean lm/W
		All other sources	50 mean lm/W
		Dimming controls for daylight harvesting under skylights	Dim fixtures within 10 ft of skylight edge
		Occupancy controls	Auto-off all non-sales rooms
		Interior room surface reflectances	80%+ on ceilings, 70%+ on walls in locations with daylighting
	Additional Interior or or	Additional LPD for adjustable lighting equipment that is specifically designed and directed to highlight merchandise and is automatically controlled separately from the general lighting	0.4 W/ft^2 (spaces not listed below) 0.6 W/ft^2 (sporting goods, small electronics) 0.9 W/ft^2 (furniture, clothing, cosmetics, and artwork) 1.5 W/ft^2 (jewelry, crystal, china)
		Sources	Halogen IR or CMH
		Façade and externally illuminated signage	0.2 W/ft^2



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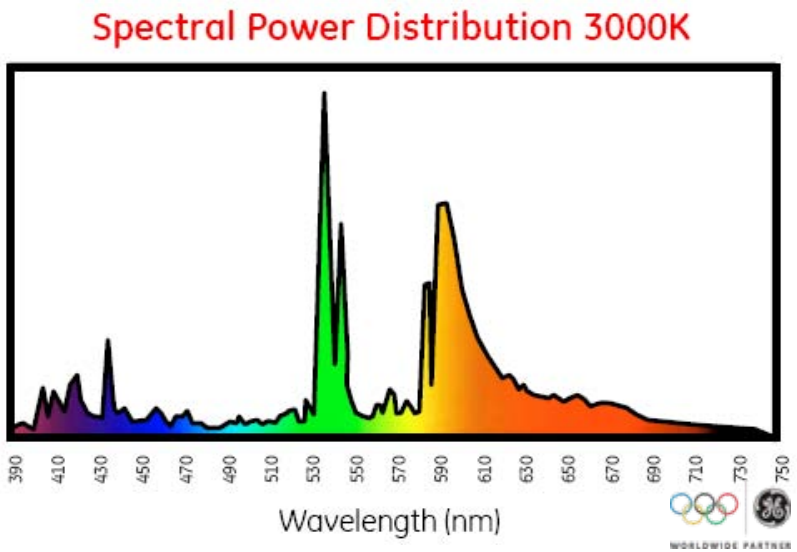
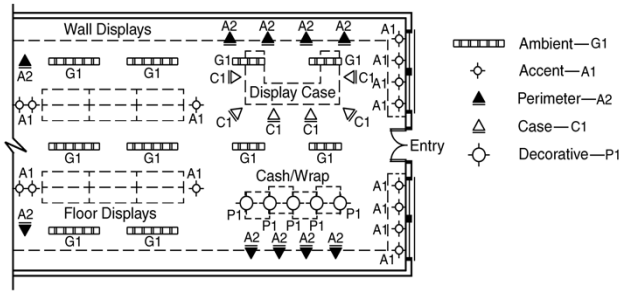
Ceramic Metal Halide



		Life	CBCP	Lumens
Philips	CDM35/PAR30L/M/FL	9000	7400	2200
GE	CMH39PARL/FL25	10000	11000	2400
Sylvania	MCP39PAR30LN/U/830/FL	9000	7400	2300

AEDG - Spaces



Base Lighting LPD (1999 Standard)	Space allocation		50% accent at 1.6	
Merchandising Sales Area	70%		2.1	1.47
Active storage	20%		1.1	0.22
Office	5%		1.5	0.08
Other spaces	5%		1.125	0.06
				1.82
Feature lighting	70%		**0.8**	0.56
				2.38

Additional Interior Lighting Power

For lighting equipment installed in retail spaces that is specifically designed and directed to highlight merchandise, provided that the additional lighting power shall not exceed

(1) 1.6 W/ft^2 or

(2) 3.9 W/ft^2 for displaying and selling fine merchandise (such as jewelry, fine apparel and accessories, china and silver) and in art galleries and similar spaces where detailed display and examination of merchandise is important.

Optional configurations

50% accent at 1.6	
2.1	1.47
1.1	0.22
1.5	0.08
1.125	0.06
	1.82
0.8	0.56
	2.38

accent at 1.6	
2.1	1.47
1.1	0.22
1.5	0.08
1.125	0.06
	1.82
1.6	1.12
	2.94

50% accent at 1.6 + 50% accent at 3.9	
2.1	1.47
1.1	0.22
1.5	0.08
1.125	0.06
	1.82
2.75	1.93
	3.75

accent at 3.9	
2.1	1.47
1.1	0.22
1.5	0.08
1.125	0.06
	1.82
3.9	2.73
	4.55

Use your computer to ask a question at any time during the rebroadcast

Base Lighting LPD (2004 Standard)	Space allocation		50% accent at 1.6	
Merchandising Sales Area	70%		1.7	1.19
Active storage	20%		0.8	0.16
Office	5%		1.1	0.06
Other spaces	5%		1	0.05
				1.46
Feature lighting	70%		**0.8**	0.56
				2.02

Additional Interior Lighting Power

For lighting equipment installed in retail spaces that is specifically designed and directed to highlight merchandise, provided that the additional lighting power shall not exceed

(1) 1.6 W/ft^2 **times the area of specific display** or

(2) 3.9 W/ft^2 **times the area of specific display** for valuable merchandise, such as jewelry, fine apparel and accessories, china and silver, art, and similar items, where detailed display and examination of merchandise are important.

AEDG model

Advanced Lighting LPD (AEDG)	Space allocation		50% accent at 0.58	
Merchandising Sales Area	70%		1.51	1.06
Active storage	20%		0.65	0.13
Office	5%		0.95	0.05
Other spaces	5%		1	0.05
				1.28
Feature lighting	70%		**0.29**	0.20
				1.49

50% accent at 0.58	
1.51	1.06
0.65	0.13
0.95	0.05
1	0.05
	1.28
0.29	0.20
	1.49

accent at 0.58	
1.51	1.06
0.65	0.13
0.95	0.05
1	0.05
	1.28
0.58	0.41
	1.69

50% accent at 0.58 + 50% accent at 1.42	
1.51	1.06
0.65	0.13
0.95	0.05
1	0.05
	1.28
1.0	0.70
	1.98

accent at 1.42	
1.51	1.06
0.65	0.13
0.95	0.05
1	0.05
	1.28
1.42	0.99
	2.27

IESNA RP-2 Table 2

RP-2 Table 2: Lighting Design Guide for Merchandising ans Associated areas				
	Circulation	**General**	**Perimeter**	**Feature Display**
Grocery and Supermarket / Warehouse Store / Discount / Drug and Convenience / Mass Merchant - ***Low***	20 - 25	50 - 75	50 - 75	200 - 375
Grocery and Supermarket / Warehouse Store / Discount / Drug and Convenience / Mass Merchant - ***High***	30	60 - 100	85 - 100	500 - 850 (300)
Department / Speciality Retailer / Home and Bath Bedding - ***Low***	20	40	50	200
Department / Speciality Retailer / Home and Bath Bedding - ***High***	25	50	75	350
Upscale Department / Upscale Specialty - ***Low***	15	30	40	150
Upscale Department / Upscale Specialty - ***High***	20	40	80	400 (200)
Designer Shop or Boutique / Furniture / Fine and Precious Jewlery / Upscale Crystal, China or Silver - ***Low***	8	20	20	100
Designer Shop or Boutique / Furniture / Fine and Precious Jewlery / Upscale Crystal, China or Silver - ***High***	12	30 - 60	60	300 - 600 (300)

ASHRAE 90.1-2007

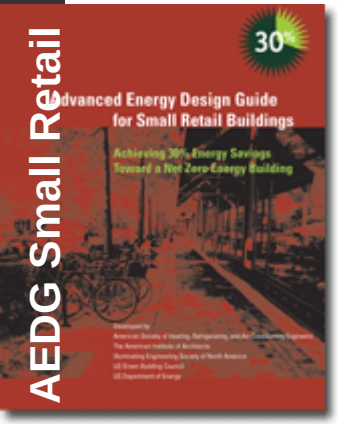
- **9.6.3 (c) For lighting equipment installed in retail spaces that is and specifically designed and directed to highlight merchandise, calculate the additional lighting power as follows:**
  - *1.0 W/ft^2 (the floor area for all products not listed below)*
  - *1.7 W/ft^2 (the floor area used for the sale of vehicles, sporting goods and small electronics)*
  - *2.6 W/ft^2 (the floor area used for the sale of furniture, clothing, cosmetics and artwork)*
  - *4.2 W/ft^2 (the floor area used for the sale of jewelry, crystal, and china)*

90.1 2004 Additional Interior Lighting Power

(1) 1.6 W/ft^2 **times the area of specific display** or
(2) 3.9 W/ft^2 **times the area of specific display** for valuable merchandise,

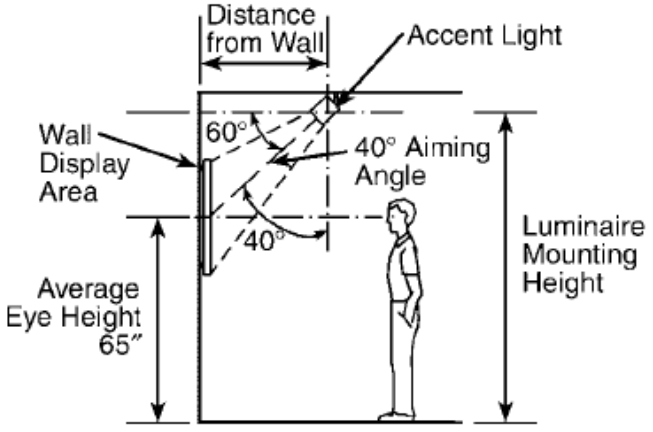
Additional Interior Lighting/Accent Lighting

- **The following additional lighting power densities (LPDs), from the Recommendation Tables in Chapter 3, are available for adjustable lighting equipment that is specifically designed and directed to highlight merchandise (accent lighting) above and beyond the base 1.3 W/ft^2 allowance.**
  - *0.4 W/ft^2 (spaces not listed below)*
  - *0.6 W/ft^2 (sporting goods, small electronics)*
  - *0.9 W/ft^2 (furniture, clothing, cosmetics, and artwork)*
  - *1.5 W/ft^2 (jewelry, crystal, china)*



CMH	51.67	lpw
Halogen	18.75	lpw
Halogen/CMH	0.36	

Courtesy ASHRAE

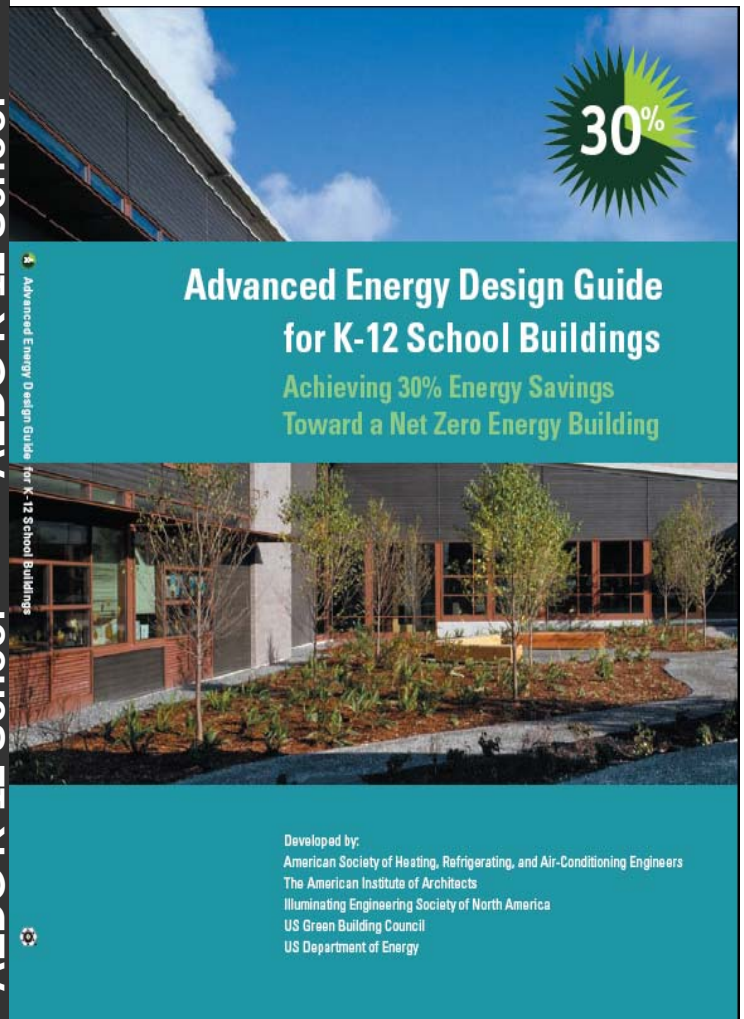


Distance from wall determined by mounting height, eye height, and 40° aiming angle.

LEED-R EAc1 Optimize Energy Performance

- **OPTION 2 — PRESCRIPTIVE COMPLIANCE PATH (4 Points)**
- **Comply with the prescriptive measures of the ASHRAE Advanced Energy Design Guide for Small Retail Buildings.**
- **The following restrictions apply:**
  - *Buildings must be under 20,000 square feet*
  - *Buildings must be retail occupancy*
  - *Project teams must fully comply with all applicable criteria as established in the Advanced Energy Design Guide for the climate zone in which the building is located*

AEDG for K-12 School Buildings



- **is the third in a series designed to provide recommendations for achieving 30% energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999.**
- **This Guide focuses on K-12 school buildings, which include elementary, middle, and high school buildings.**
- **The recommendations in this guide will allow Contractors, Consulting Engineers, Architects and Designers to easily achieve advanced levels of energy savings without having to resort to detailed calculations or analyses.**
- **For more information on the entire Advanced Energy Design Guide series, please visit the AEDG web page at www.ashrae.org/aedg.**

Lighting and Daylighting Technologies

- **Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2004) as the advanced case**
  - *1999 Standard = 1.5 w/ft^2*
  - *2004 Standard = 0.9 to 1.2 w/ft^2*
- **Manual ON occupancy sensors to turn off lights during unoccupied hours**
- **Daylighting controls recommended for fixtures within 15 ft of north or south window walls and within 10 ft of skylight edges**

Climate Zones 1 & 2

Lighting	Interior Finishes	Interior room surface average reflectance	70%+ on ceilings and walls above 7 ft 50%+ on walls below 7 ft	DL14, EL1	
	Interior Lighting—Daylighted Option	Classroom daylighting (daylighting fenestration to floor area ratio)	Toplighted— South-facing roof monitors: 8%–11% North-facing roof monitors: 12%–15%	DL1–19, DL28–35	
			Sidelighted— South-facing: 8%–11% North-facing: 15%–20%	DL1–19, DL20–27	
			Combined toplighted and sidelighted— South-facing sidelighted: 6%–8% Toplighted: 2%–3% North-facing sidelighted: 9%–13% Toplighted: 3%–5%	DL1–19, DL20–35	
		Gym toplighting (daylighting fenestration to floor area ratio)	South-facing roof monitors: 5%–8% North-facing roof monitors: 7%–10%	DL1–19, DL36–37	
		LPD	1.2 W/ft² maximum	EL9–16	
		Light source system efficacy (linear fluorescent)	75 mean lm/W minimum	EL2, EL3, EL5	
		Light source system efficacy (all other sources)	50 mean lm/W minimum	EL4, EL5	
		Occupancy controls	Manual on, auto off all zones	EL6, EL8, DL16	
		Dimming controls daylight harvesting	Dim all fixtures in classrooms and gym and other fixtures within 15 ft of sidelighting edge and within 10 ft of toplighting edge	DL16	
	Interior Lighting—Non-Daylighted Option	LPD	1.1 W/ft²	EL9–16	
		Light source system efficacy (linear fluorescent)	85 mean lm/W minimum	EL2, EL3, EL5	
		Light source system efficacy (all other sources)	50 mean lm/W minimum	EL4, EL5	
		Occupancy controls—general	Manual on, auto off all zones	EL6, EL8, DL16	
		Dimming controls daylight harvesting	Dim fixtures within 15 ft of sidelighting edge and within 10 ft of toplighting edge	DL16	

Climate Zones 3 & 4

Lighting	Interior Finishes	Interior room surface average reflectance	70%+ on ceilings and walls above 7 ft 50%+ on walls below 7 ft	DL14, EL1	
	Interior Lighting—Daylighted Option	Classroom daylighting (daylighting fenestration to floor area ratio)	Toplighted— South-facing roof monitors: 8%–11% North-facing roof monitors: 12%–15%	DL1–19, DL28–35	
			Sidelighted— South-facing: 8%–11% North-facing: 15%–20%	DL1–19, DL20–27	
			Combined toplighted and sidelighted— South-facing sidelighted: 6%–8% Toplighted: 2%–3% North-facing sidelighted: 9%–13% Toplighted: 3%–5%	DL1–19, DL20–35	
		Gym toplighting (daylighting fenestration to floor area ratio)	South-facing roof monitors: 5%–8% North-facing roof monitors: 7%–10% Only skylights: 2%–4%	DL1–19, DL36–37	
		LPD	1.2 W/ft² maximum	EL9–16	
		Light source system efficacy (linear fluorescent)	75 mean lm/W minimum	EL2–3, EL5	
		Light source system efficacy (all other sources)	50 mean lm/W minimum	EL4–5	
		Occupancy controls	Manual on, auto-off all zones	EL6, EL8, DL16	
		Dimming controls daylight harvesting	Dim all fixtures in classrooms and gym and other fixtures within 15 ft of sidelighting edge and within 10 ft of toplighting edge	DL16	
	Interior Lighting—Non-Daylighted Option	LPD	0.9 W/ft²	EL9–16	
		Light source system efficacy (linear fluorescent)	85 mean lm/W minimum	EL2–3, EL5	
		Light source system efficacy (all other sources)	50 mean lm/W minimum	EL4–5	
		Occupancy controls—general	Manual on, auto off all zones	EL6, EL8, DL16	
		Dimming controls daylight harvesting	Dim fixtures within 15 ft of sidelighting edge and within 10 ft of toplighting edge	DL16	

Climate Zones 5, 6, 7 & 8

Lighting	Interior Finishes	Interior room surface average reflectance	70%+ on ceilings and walls above 7 ft 50%+ on walls below 7 ft	DL14, EL1	
	Interior Lighting—Daylighted Option	Classroom daylighting (daylighting fenestration to floor area ratio)	Toplighted— South-facing roof monitors: 8%–11% North-facing roof monitors: 12%–15%	DL1–19, DL28–35	
			Sidelighted— South-facing: 8%–11% North-facing: 15%–20%	DL1–19, DL20–27	
			Combined toplighted and sidelighted— South-facing sidelighted: 6%–8% Toplighted: 2%–3% North-facing sidelighted: 9%–13% Toplighted: 3%–5%	DL1–19, DL20–35	
		Gym toplighting (daylighting fenestration to floor area ratio)	South-facing roof monitors: 5%–8% North-facing roof monitors 7%–10%	DL1–19, DL36–37	
		LPD	1.2 W/ft² maximum	EL9–16	
		Light source system efficacy (linear fluorescent)	75 mean lm/W minimum	EL2–3, EL5	
		Light source system efficacy (all other sources)	50 mean lm/W minimum	EL4–5	
		Occupancy controls	Manual on, auto off all zones	EL6, EL8, DL16	
		Dimming controls daylight harvesting	Dim all fixtures in classrooms and gym and other fixtures within 15 ft of sidelighting edge and within 10 ft of toplighting edge	DL16	
	Interior Lighting—Nondaylighted Option	LPD	1.1 W/ft²	EL9–16	
		Light source system efficacy (linear fluorescent)	85 mean lm/W minimum	EL2–3, EL5	
		Light source system efficacy (all other sources)	50 mean lm/W minimum	EL4–5	
		Occupancy controls—general	Manual on, auto off all zones	EL6, EL8, DL16	
		Dimming controls daylight harvesting	Dim fixtures within 15 ft of sidelighting edge and within 10 ft of toplighting edge	DL16	

AEDG K-12 School
AEDG K-12 School
AEDG K-12 School

Mean Lumens per Watt

Table 5.4. Efficacy Values for Different Lamp/Ballast Combinations

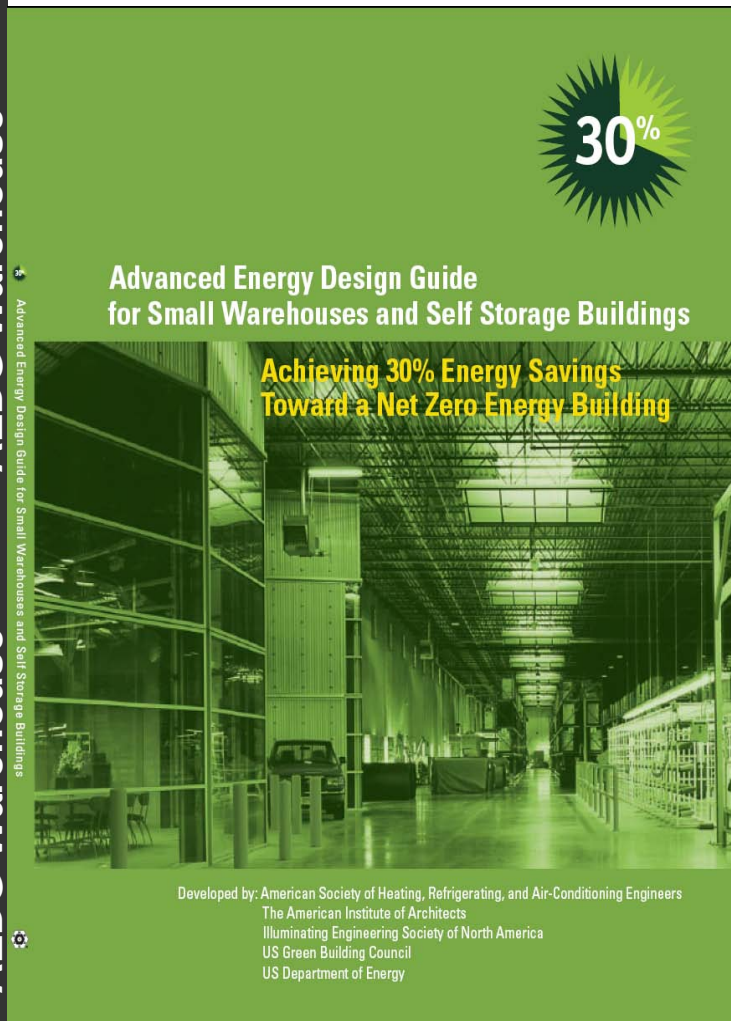
Ballasts	Lamps					AEDG-SO 90mlpw	AEDG-SR 91mlpw
	F32T8 Generic Standard	F32T8 Efficient Standard	F32T8 Premium Standard	F32T8 Efficient Premium	F32T8 High Efficiency		
Generic Standard Instant Start (59 W, 0.87 BF)	74	77	80	84	87	87	NA
Low Light Level Instant Start (54 W, 0.78 BF)	73	75	78	82	85	85	NA
High Light Level Instant Start (74 W, 1.15 BF)	78	81	84	89	92	92	NA
Program Start (61 W, 0.87 BF)	72	74	77	81	84	84	NA
Low Light Level Program Start (56 W, 0.78 BF)	70	73	75	79	82	82	NA
Dimming Rapid Start (64 W max, 0.88 BF max)	69	72	75	78	81	81	NA
Efficient Instant Start Normal Light Level (54 W, 0.87 BF)	81	84	87	92	95	95	95
Efficient Instant Start Low Light Level (48 W, 0.78)	82	85	88	93	96	96	96
Efficient Instant Start High Light Level (70 W, 1.15 BF)	83	86	89	94	97	97	97
Efficient Dimming (58 W, 0.87 BF max)	76	78	81	86	88	88	88

Does not meet efficacy criteria

Meets 75 MLPW efficacy criteria

Meets 75 and 85 MLPW efficacy

AEDG for Small Warehouses Buildings



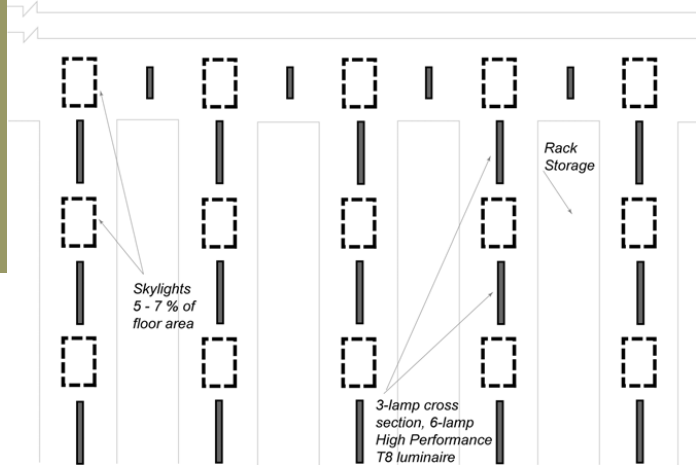
- **is the fourth in a series designed to provide recommendations for achieving 30% energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999.**
- **This Guide focuses on warehouses up to 50,000 ft^2 and self storage buildings.**
- **The recommendations in this guide will allow Contractors, Consulting Engineers, Architects and Designers to easily achieve advanced levels of energy savings without having to resort to detailed calculations or analyses.**
- **For more information on the entire Advanced Energy Design Guide series, please visit the AEDG web page at www.ashrae.org/aedg.**

AEDG Warehouse
AEDG Warehouse
AEDG Warehouse

Lighting and Daylighting Technologies

- **Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2004) as the advanced case**
  - *1999 Standard = 1.2 w/ft^2*
  - *2004 Standard = 0.8 w/ft^2*
- **Skylights required 5 – 7%**
- **Automatic daylight controls on electric lighting**
- **Occupancy sensors to turn off lights during unoccupied hours**
- **High-performance T8 ”system”, or T5**

AEDG - Spaces



Space Type	Floor space allocation	LPD	LPD*area
General Warehouse	75%	0.60	0.45
Fine Storage	20%	0.85	0.17
Office	5%	0.90	0.05
	100.0%		0.67

The target lighting in general warehouse is 10 average maintained vertical footcandles on the face of the product.

Lighting Recommendations

	Item	Component	Conditioned	Semi-heated	How-To Tips in Cha
	Skylights	Area (percent of gross roof)	5%–7% prismatic diffusing skylights required in warehouse areas (except in self-storage areas)		EN1, 18–20
		Thermal transmittance	U-1.36	U-1.36	EN1, 19
		Solar heat gain coefficient (SHGC)	0.19	No recommendation	EN1, 19
		Visible light transmittance (VLT)	0.45		EN1, 19
Lighting	Interior Lighting	Lighting power density (LPD)	Warehouse (bulky and self storage) = 0.6 W/ft^2 Warehouse (fine storage) = 0.85 W/ft^2 Office area = 0.9 W/ft^2		EL12–18
		Linear fluorescent lamps	T-5HO or T-8 high-performance with high-performance electronic ballast		EL3–7
		Controls for daylight harvesting	Automatic dimming or switching of all luminaires in daylighted areas		DL1–10, EL9, 10
		Occupancy controls	Auto-on/off for all luminaires in the warehouse and self-storage areas, manual-on/auto-off for all office areas		EL8
		Ceiling surface reflectances	80%		EL2
	Exterior Lighting	Canopied areas	0.5 W/ft^2		EL19–21

SkyCalc: Miami

SkyCalc: Skylight Design Assistant - Tabular Results

Company Name: AEDG - Warehouse
Project Description: Skylighting Project - Miami

Electric Lighting Usage	kWh/yr		
Ltg. Energy without Skylights	83,212	Lighting Fraction Saved	63%
Lighting Energy w/ Skylights	30,802	Full daylighting (h/yr)	3,359

	Savings from Design Skylighting System		
Savings		Annual Energy Savings (kWh/yr)	Annual Cost Savings ($/yr)
Lighting		52,411	$6,289
Cooling			
Heating			
Total		**52,411**	**$6,289**

Skylighting System Description

Skylight unit size (ft^2)	32.0
Number of Skylights	65
Total Skylight Area (ft^2)	2,080
Skylight to Floor Ratio (SFR)	5.9%

Site Description

Climate Location	Miami.wea3	
Climate Zone	CZ1 (very hot, 9,000 <	
Building Type	Warehouse	
Building Area	35,100	(ft^2)

SkyCalc: Phoenix

SkyCalc: Skylight Design Assistant - Tabular Results

Company Name: AEDG - Warehouse
Project Description: Skylighting Project - Phoenix

Electric Lighting Usage	kWh/yr		
Ltg. Energy without Skylights	83,212	Lighting Fraction Saved	62%
Lighting Energy w/ Skylights	31,215	Full daylighting (h/yr)	3,377

	Savings from Design Skylighting System		
Savings		Annual Energy Savings (kWh/yr)	Annual Cost Savings ($/yr)
Lighting		51,997	$6,240
Cooling			
Heating			
Total		**51,997**	**$6,240**

Skylighting System Description

Skylight unit size (ft^2)	32.0
Number of Skylights	65
Total Skylight Area (ft^2)	2,080
Skylight to Floor Ratio (SFR)	5.9%

Site Description

Climate Location	Phoenix.wea3	
Climate Zone	CZ2 (hot, 6,300 < CDI	
Building Type	Warehouse	
Building Area	35,100	(ft^2)

SkyCalc: Seattle

SkyCalc: Skylight Design Assistant - Tabular Results

Company Name: AEDG - Warehouse
Project Description: Skylighting Project - Seattle

Electric Lighting Usage	kWh/yr		
Ltg. Energy without Skylights	83,212	Lighting Fraction Saved	50%
Lighting Energy w/ Skylights	41,357	Full daylighting (h/yr)	2,515

Savings from Design Skylighting System

Savings		Annual Energy Savings (kWh/yr)	Annual Cost Savings ($/yr)
Lighting		41,856	$5,023
Cooling			
Heating			
Total		**41,856**	**$5,023**

Skylighting System Description

Skylight unit size (ft^2)	32.0
Number of Skylights	65
Total Skylight Area (ft^2)	2,080
Skylight to Floor Ratio (SFR)	5.9%

Site Description

Climate Location	Seattle.wea3	
Climate Zone	CZ4 (mixed, 3,600 < H	
Building Type	Warehouse	
Building Area	35,100	(ft^2)

SkyCalc: Duluth

SkyCalc: Skylight Design Assistant - Tabular Results

Company Name: AEDG - Warehouse
Project Description: Skylighting Project - Duluth

Electric Lighting Usage	kWh/yr		
Ltg. Energy without Skylights	83,212	Lighting Fraction Saved	57%
Lighting Energy w/ Skylights	35,791	Full daylighting (h/yr)	2,964

	Savings from Design Skylighting System		
Savings		Annual Energy Savings (kWh/yr)	Annual Cost Savings ($/yr)
Lighting		47,421	$5,691
Cooling			
Heating			
Total		**47,421**	**$5,691**

Skylighting System Description

Skylight unit size (ft^2)	32.0
Number of Skylights	65
Total Skylight Area (ft^2)	2,080
Skylight to Floor Ratio (SFR)	5.9%

Site Description

Climate Location	Duluth.wea3	
Climate Zone	CZ7 (very cold, 9,000	
Building Type	Warehouse	
Building Area	35,100	(ft^2)

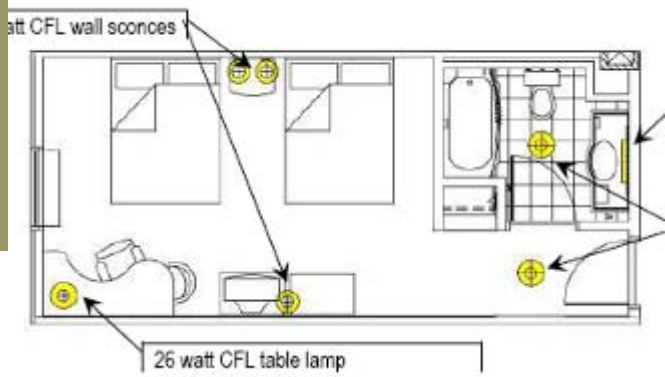
Additional AEDG Guides

- **The ASHRAE 30% Advanced Energy Design Guide for Highway Lodging**
  - *Publication date to be determined.*
- **The ASHRAE 30% Advanced Energy Design Guide for Existing Buildings**
  - *Publication date to be determined.*
- **The ASHRAE 50% Advanced Energy Design Guide for Big Box Retail**
  - *Publication date to be determined.*
- **Additional 50% Advanced Energy Design Guides planned for**
  - *K-12 School Buildings*
  - *Small Office Buildings*
  - *Small Retail Buildings*
  - *Publication dates to be determined.*

Lighting and Daylighting Technologies

- **Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2004) as the advanced case**
  - *1999 Standard = 2.0 w/ft^2*
  - *2004 Standard = 1.0 w/ft^2*
- **Compact Fluorescent (CFL) with electronic ballast**
- **Master control and entry and vacancy control in bathroom**
- **Bi-level control in stairs**
- **Manual-on/auto-off occupancy sensors for all laundry, office, exercise, business center, meeting rooms, and non-public spaces**

AEDG - Spaces



Space Type	Floor space allocation	LPD	LPD*area
Guest Room	70%	0.74	0.52
Corridor	13%	0.50	0.07
Lobby	11%	1.10	0.12
Laundry	6%	0.60	0.04
	100.0%		0.74

AEDG Lodging

Lighting	Interior Lighting	Lighting power density (LPD), W/ft^2	Guest Rooms = 0.74	Office = 0.9
			Corridors = 0.5	Lobbies = 1.1
			Exercise = 0.9	Laundry = 0.6
			Meeting Rooms = 1.1	Stairs= 0.6
		Fluorescent lamps	Compact Fluorescent (CFL) with electronic ballast, T5HO or T8 high-performance with high-performance electronic ballast	
		Occupancy controls	Bi-level in stairs, manual-on/auto-off for all laundry, office, exercise, business center, meeting rooms, and non-public spaces	
		Guest Room Controls	Master control and entry and vacancy control in bathroom	
		Plug load lighting	Compact Fluorescent (CFL) with electronic ballast	
	Exterior Lighting Power Density (LPD)	Lighting Zone 2 = Residential Mixed-use Areas and Neighborhood Business Districts Lighting Zone 3 = All other areas		
			Lighting Zone 2	Lighting Zone 3
		Base Allowance	600 watts	750 watts
		Parking areas and drives	0.06 W/ft^2	0.10 W/ft^2
		Walkways less than 10 feet wide	0.7 W/lf	0.8 W/lf
		Walkways 10 feet wide or greater	0.14 W/ft^2	0.16 W/ft^2
		Entry Canopies	0.25 W/ft^2	0.4 W/ft^2
		Façade (use wattage only for façade)	0.10 W/ft^2	0.15 W/ft^2

AEDG Lodging

- **2004 = 9286 watts**
  - *AEDG Zone 3 = 5650 watts*
  - *AEDG Zone 2 = 3500 watts*
  - *AEDG Zone 1 = 2550 watts*
- **with façade lighting - 2004 = 13850 watts**
  - *AEDG Zone 3 = 9070 watts*
  - *AEDG Zone 2 = 5780 watts*
  - *AEDG Zone 1 = 2550 watts*

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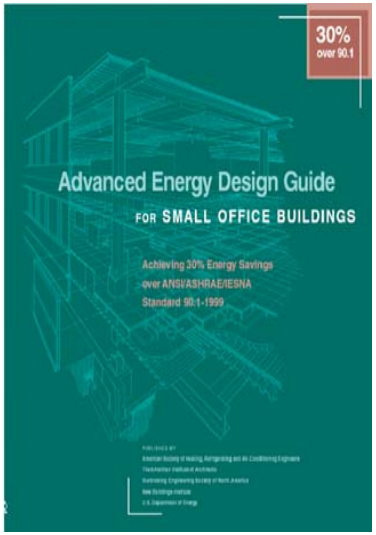

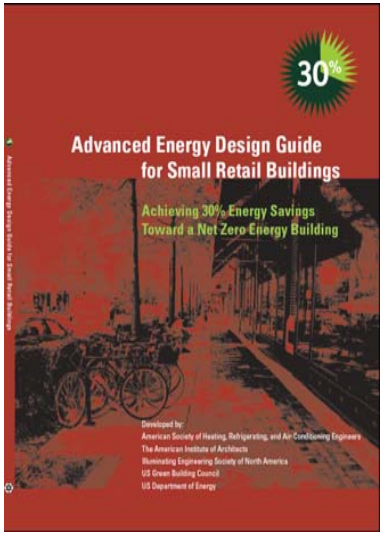

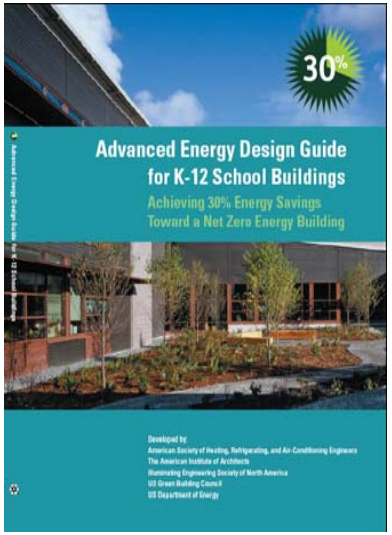

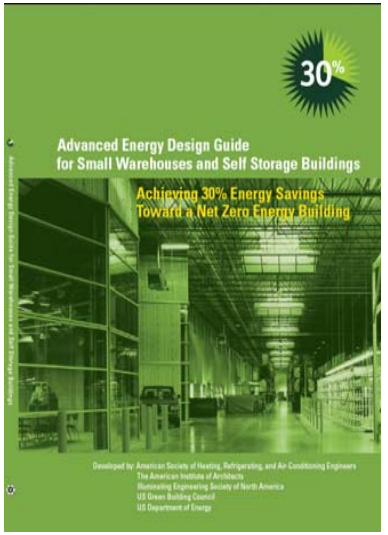

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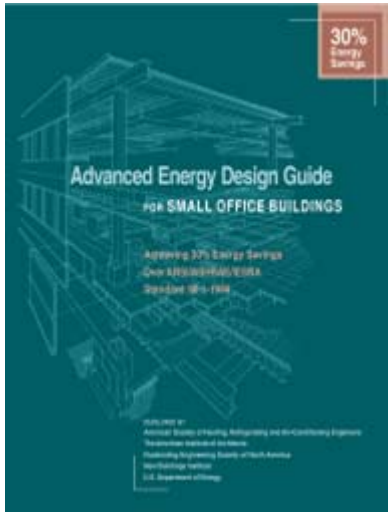
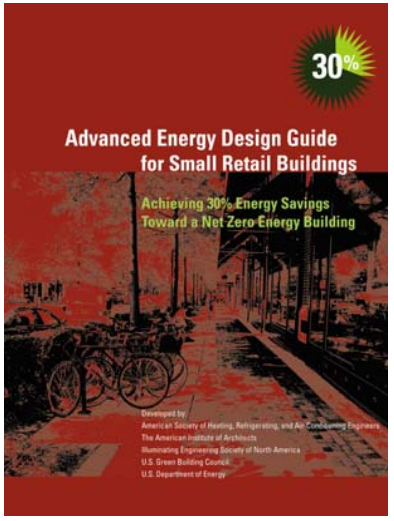
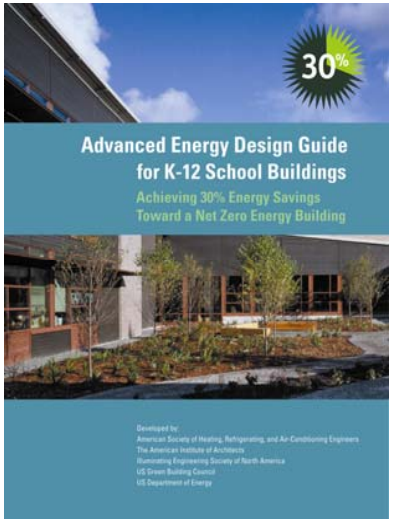
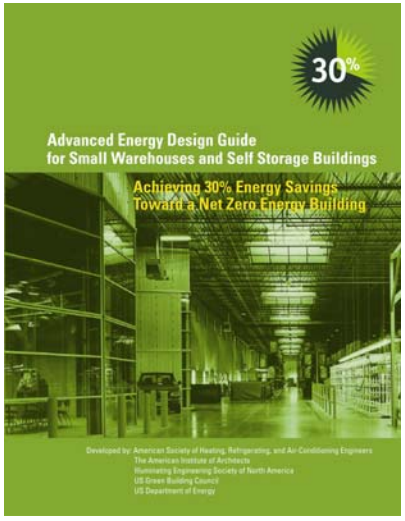
Advanced Energy Design Guides: HVAC Recommendations









Originally aired on August 14, 2008

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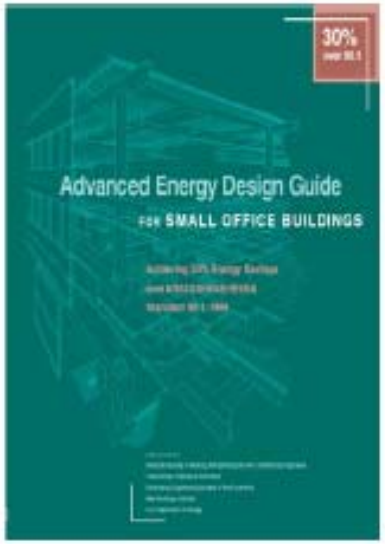

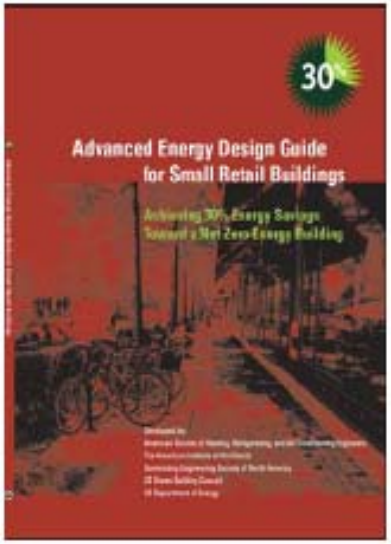

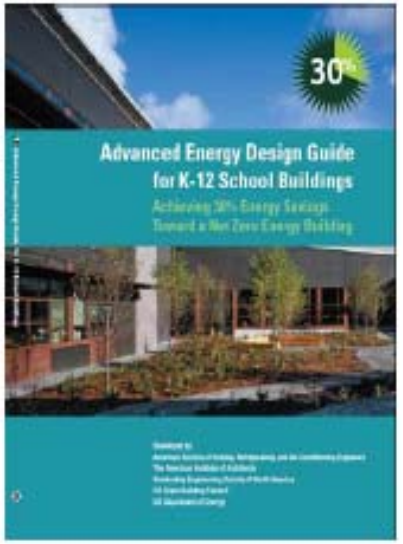

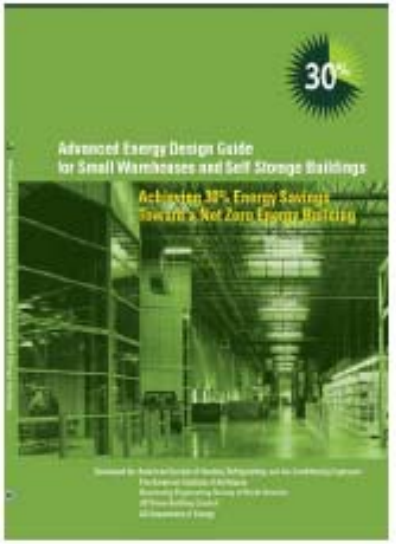

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Overview/Purpose

The ASHRAE *Advanced Energy Design Guides* (AEDG) are a series of publications designed to provide recommendations for achieving energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999. The guides have been developed in collaboration with these partnering organizations: The American Institute of Architects (AIA), the Illuminating Engineering Society of North America (IESNA), the U.S. Green Building Council (USGBC), and the U.S. Department of Energy (DOE). The New Building Institute (NBI) participated only in the development of the *Advanced Energy Design Guide for Small Office Buildings*.

The initial series of guides have an energy savings target of 30% which is the first step in the process toward achieving a net zero energy building - defined as a building that, on an annual basis, draws from outside resources equal or less energy than it provides using on-site renewable energy sources. Each 30% Guide addresses a specific building type. Additional guides for existing buildings and at 50% energy savings towards a net zero energy building are also planned.

ANSI/ASHRAE/IESNA Standard 90.1-1999, the energy conservation standard published at the turn of the millennium, provides the fixed reference point for all of the 30% Guides in this series. The primary reason for this choice as a reference point is to maintain a consistent baseline and scale for all of the 30% AEDG series documents.

The recommendations in the 30% Guides will allow those involved in designing or constructing the various building types to easily achieve advanced levels of energy savings without having to resort to

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To promote building energy efficiency, ASHRAE and its partners are making the Advanced Energy Design Guides available for free download (PDF). Learn More

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ASHRAE

Development of the AEDGs

Collaboration of Partner Organizations

Management via a Steering Committee

Volunteer team effort over a year

Focus group for conceptual review

65% and 90% public reviews

Guide Goal

- Packages of recommendations that result in at least 30% energy savings when compared to ANSI/ASHRAE/IESNA Std. 90.1-1999
- Present recommendations for *some ways, but not all ways or the only way* to build energy efficient buildings
  - Provide climate specific recommendations
  - Not a code or Standard
- 30% progress toward a net zero energy building

Use your computer to ask a question at any time during the rebroadcast

Guide Contents

Development of Recommendations

- Recommendations for envelope, lighting, HVAC, and Service Hot Water that achieve at least 30% whole building energy savings
  - Additional Savings Strategies included, but not needed for 30%
- Energy is independent variable & cost-effectiveness (e.g. payback) is dependent variable
- Recommendations modeled to verify 30% savings over ASHRAE 90.1-1999 in each climate zone
  - Site Energy Use
  - Includes “typical” plug loads (whole building energy savings)

Development of Recommendations- HVAC

Use practical off-the-shelf technologies and strategies available from multiple manufacturers

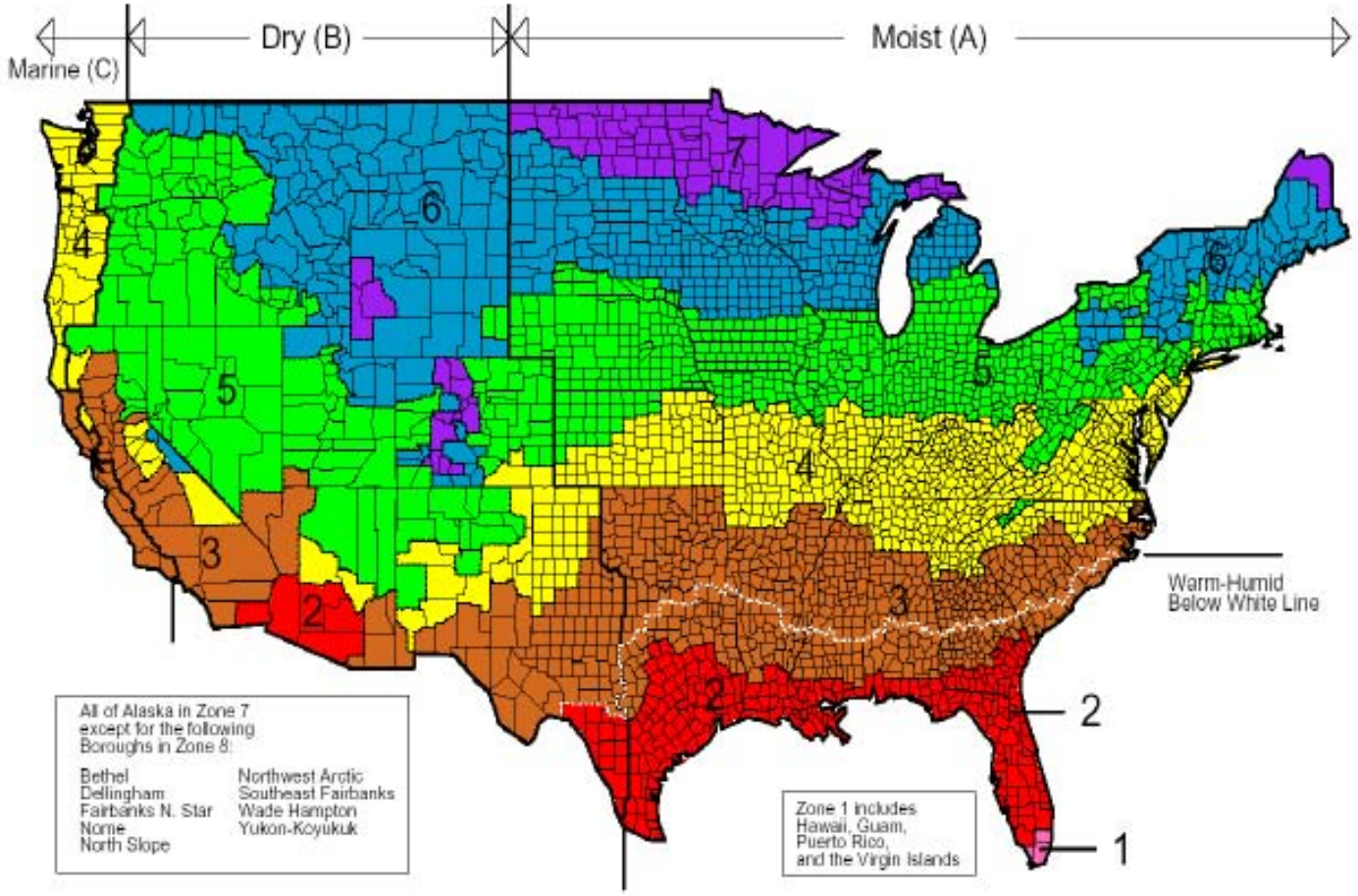
Provide climate specific HVAC recommendations for typical system types

HVAC Recommendation types:

- Heating and cooling system type
- Heating and cooling efficiency (SEER, EER, COP, AFUE, etc)
- Ventilation control and preconditioning
- Economizer use
- Fan efficiency
- Duct design

US Climate Zones

All of the HVAC recommendations for each of the 8 climate zones are contained on a single page



Climate Zone 4 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	EN5, 17, 20-21
		Surface reflectance/emittance	No recommendation	
	Walls	Mass (HC > 7 Btu/ft^4)	R-11.4 c.i.	EN6, 17, 20-21
		Metal building	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	EN9, 17, 20-21
		Below-grade walls	No recommendation	EN10, 17, 20-21
	Floors	Mass	R-8.3 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-7.5 for 24 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
		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)	0.34	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)	80% 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.

Integrated Design Concepts and HVAC

First, reduce the load:

- Siting and orientation
- Glazing
- Envelope
- Lighting/daylighting
- Plug loads

…then design an efficient HVAC system to meet *any* remaining loads

AEDGs provide a Chapter to help implement this concept

Guide Scope

- SO AEDG
  - Office Buildings up to 20,000 ft^2
- SR AEDG
  - Retail Buildings up to 20,000 ft^2
- K-12 AEDG
  - Elementary, Middle, and High Schools
- WH AEDG
  - Warehouse and Self Storage Facilities up to 50,000 ft^2

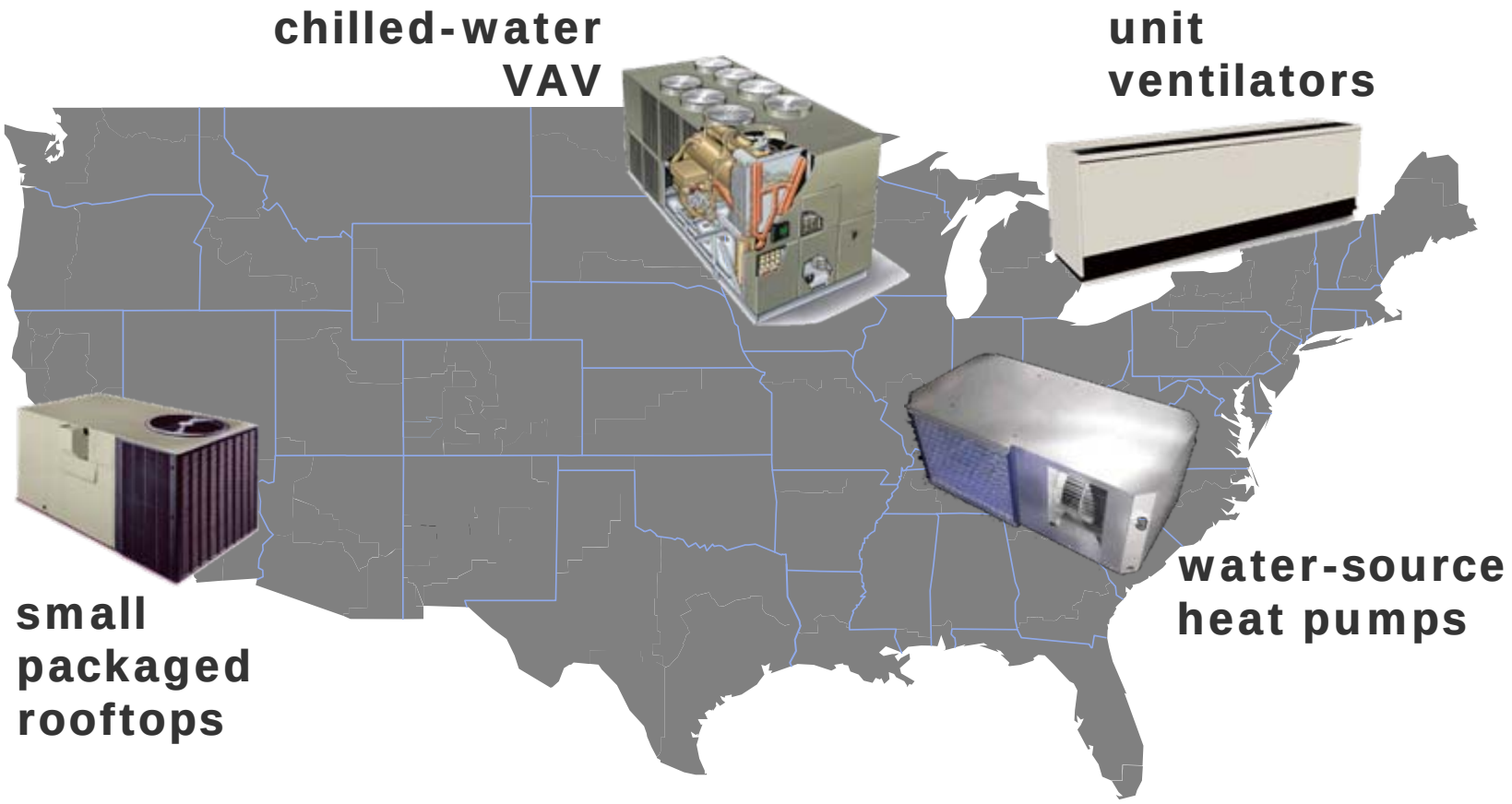
- HVAC recommendations based typical system types

prescriptive HVAC recommendations for

Small Office, Small Retail, Warehouse

prescriptive HVAC recommendations for K-12

What Type of HVAC System Typical?



AEDG for Small Office Buildings

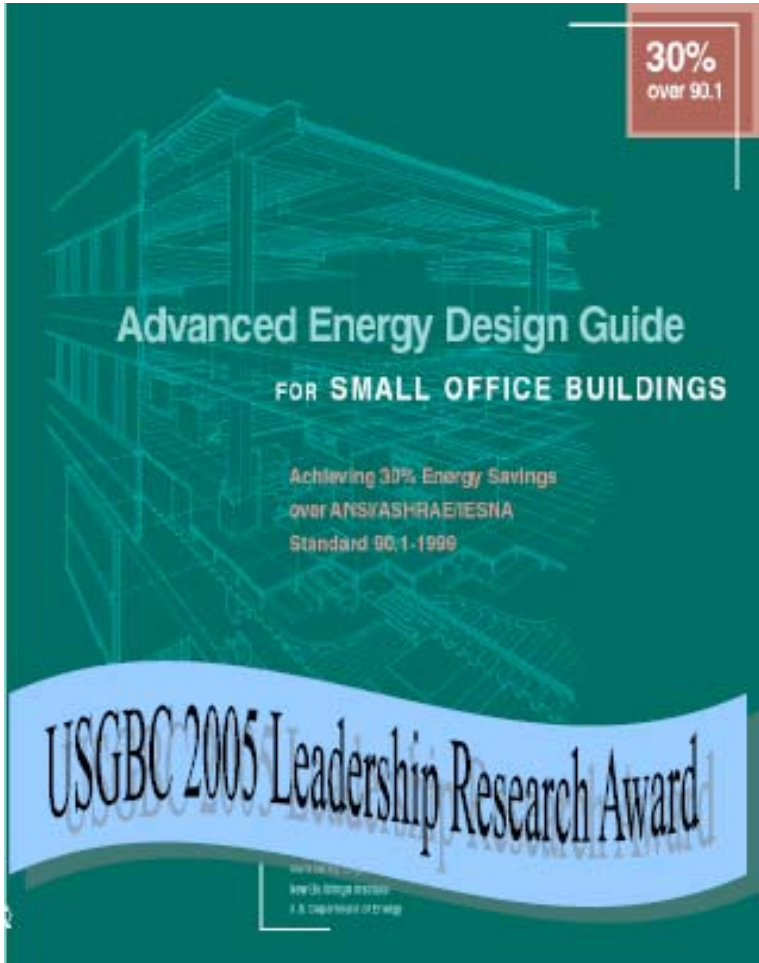
First in the AEDG series

Focuses on small offices up to 20,000 ft^2

Split or single package roof top DX system types

Does not apply to central plant systems

Alternative path for 4 EA LEED credits



AEDG for Small Retail Buildings

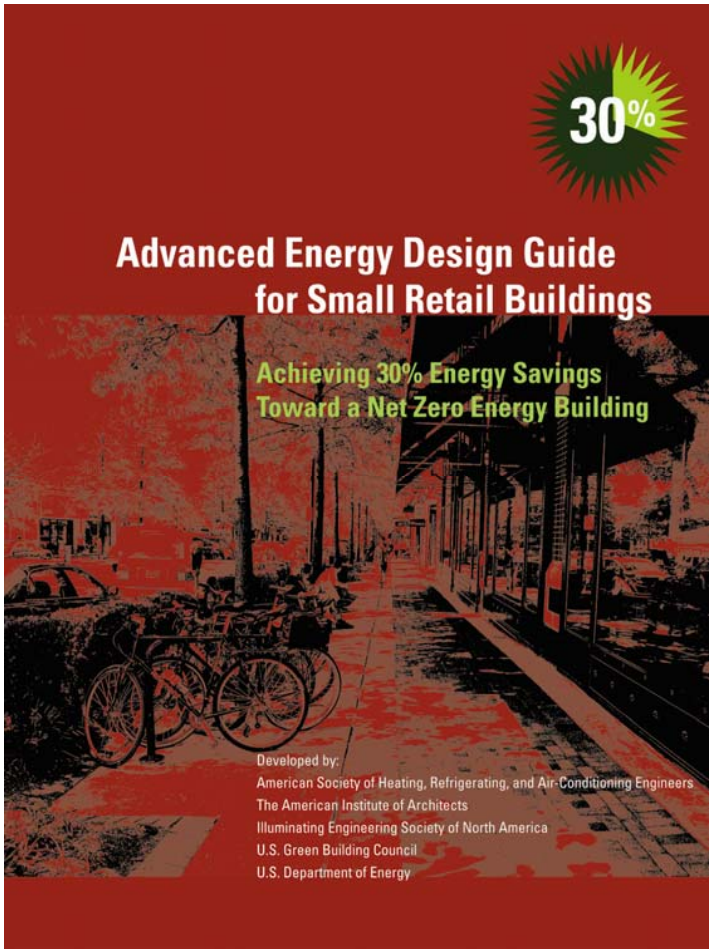
Second in the AEDG series

Focuses on small retail
up to 20,000 ft^2

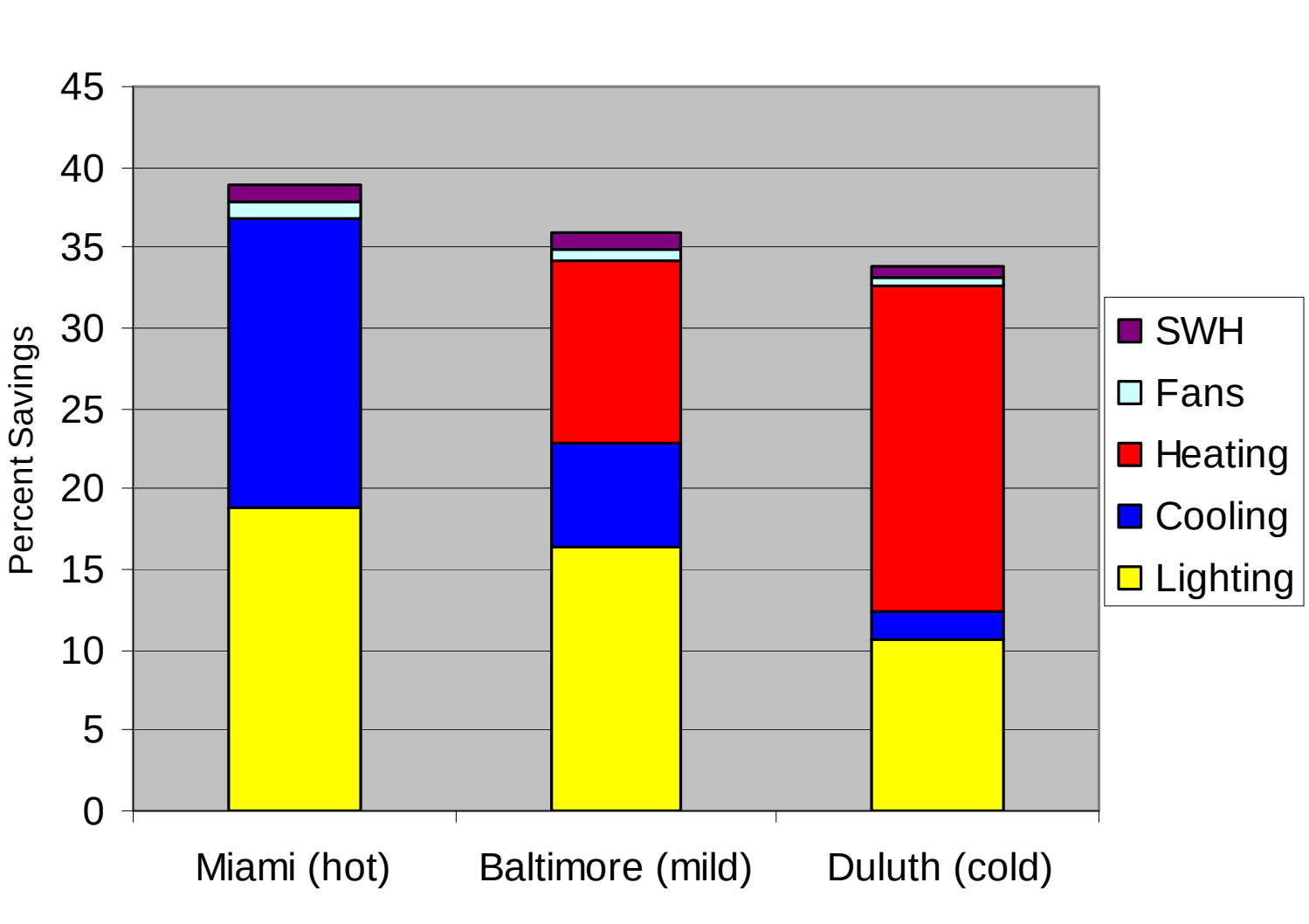
Split or single package roof top
DX system types

Does not apply to central
plant systems

Same HVAC recommendations
as Small Office AEDG, with retail
specific how to's

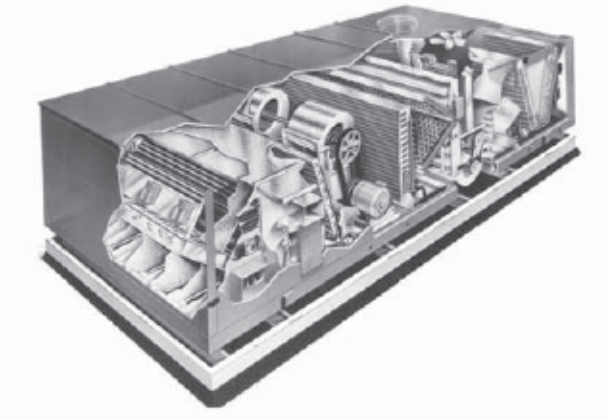


Where is the Energy Saved?



HVAC Recommendations

- Efficiency Recommendations
  - Recommendations by air conditioner size
    - 0-65 kBtuh, 65-135 kBtuh, 135-240 kBtuh, >240 kBtuh
  - Recommendations by gas furnace size and type
    - 0-225 kBtuh single package, 0-225 kBtuh split
  - Recommendations by heat pump size
    - 0-65 kBtuh, 65-135 kBtuh, >135 kBtuh



Efficiency Recommendations

Cooling efficiencies generally higher in the hotter climates and lower in the colder climates

Smallest equipment:

- 13 SEER for all climate zones
- Highest efficiencies available from multiple manufacturers

Component	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Air conditioner (0-65 KBtuh)	13.0 SEER	13.0 SEER	13.0 SEER	13.0 SEER	13.0 SEER	13.0 SEER	13.0 SEER	13.0 SEER
Air conditioner (>65-135 KBtuh)	11.3 EER 11.5 IPLV	11.3 EER 11.5 IPLV	11.0 EER 11.4 IPLV	11.0 EER 11.4 IPLV	11.0 EER 11.4 IPLV	NR	NR	NR
Air conditioner (>135-240 KBtuh)	11.0 EER 11.5 IPLV	11.0 EER 11.5 IPLV	10.8 EER 11.2 IPLV	10.8 EER 11.2 IPLV	10.8 EER 11.2 IPLV	NR	NR	NR
Air conditioner (>240 KBtuh)	10.6 EER 11.2 IPLV	10.6 EER 11.2 IPLV	10.0 EER 10.4 IPLV	10.0 EER 10.4 IPLV	10.0 EER 10.4 IPLV	NR	NR	NR

Efficiency Recommendations

Heating efficiencies generally higher in the colder climates and lower in the warmer climates

Split systems (Split) higher heating efficiency because these systems available from multiple manufacturers

Single Package limited to 80% because of condensation/freezing concerns

Component	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Gas furnace (0-225 KBtuh - SP)	80% AFUE or Et	80% AFUE or Et	80% AFUE or Et	80% AFUE or Et	80% AFUE or Et	80% AFUE or Et	80% AFUE or Et	80% AFUE or Et
Gas furnace (0-225 KBtuh - Split)	80% AFUE or Et	80% AFUE or Et	80% AFUE or Et	80% AFUE or Et	90% AFUE or Et	90% AFUE or Et	90% AFUE or Et	90% AFUE or Et
Gas furnace (>225 KBtuh)	80% Ec	80% Ec	80% Ec	80% Ec	80% Ec	80% Ec	80% Ec	80% Ec
Heat pump (0-65 KBtuh)	13.0 SEER 7.7 HSPF	13.0 SEER 7.7 HSPF	13.0 SEER 7.7 HSPF	13.0 SEER 7.7 HSPF	13.0 SEER 7.7 HSPF	13.0 SEER 7.7 HSPF	13.0 SEER 7.7 HSPF	13.0 SEER 7.7 HSPF
Heat pump (>65-135 KBtuh)	10.6 EER 11.0 IPLV 3.2 COP	10.6 EER 11.0 IPLV 3.2 COP	10.6 EER 11.0 IPLV 3.2 COP	10.6 EER 11.0 IPLV 3.2 COP	10.6 EER 11.0 IPLV 3.2 COP	NR	NR	NR
Heat pump (>135 KBtuh)	10.1 EER 11.5 IPLV 3.1 COP	10.1 EER 11.5 IPLV 3.1 COP	10.1 EER 11.0 IPLV 3.1 COP	10.1 EER 11.0 IPLV 3.1 COP	10.1 EER 11.0 IPLV 3.1 COP	NR	NR	NR

Outdoor Air Recommendations

Economizers in zones 3-6 with cooling capacity above 54 kBtuh

Item	Component	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Economizer	Air conditioners & heat pumps- SP	NR	NR	Cooling capacity > 54 KBtuh	Cooling capacity > 54 KBtuh	Cooling capacity > 54 KBtuh	Cooling capacity > 54 KBtuh	NR	NR

Demand controlled ventilation in all zones

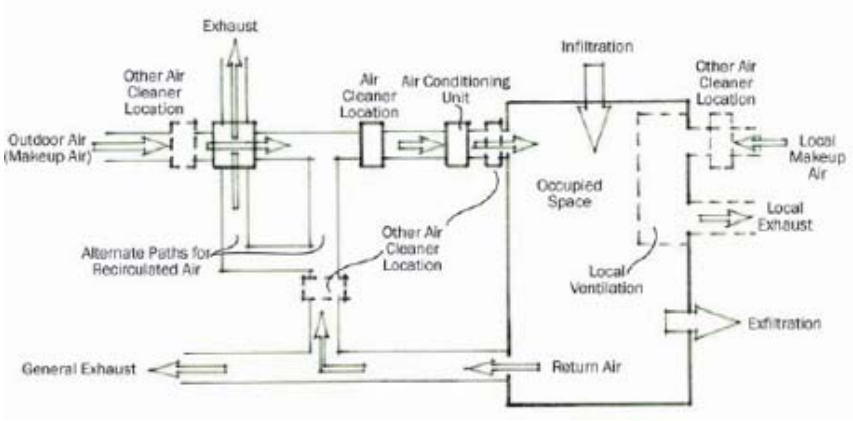
Interior only ducts with 0.08” w.c./100 ft in all zones

Ventilation	Outdoor air damper	Motorized control
	Demand control	CO_2 sensors
Ducts	Friction rate	0.08 in. w.c./100 feet
	Sealing	Seal class B
	Location	Interior only
	Insulation level	R-6

How to Implement (Chapter 5)

Good Design Practice for office and retail spaces:

- Humidity control at part load
- Energy recovery
  - Bypass dampers
- Ventilation air configuration
- Ductwork distribution
- Duct insulation and sealing
- Control strategies to turn equipment off when not needed



Cautions for office and retail spaces:

- Relief fans or dampers rather than return fans
- Noise control
- Carbon dioxide sensor location

LEED-NC and LEED-R EAc1 Optimize Energy Performance

Option 2 – Prescriptive Compliance Path (4 credits)

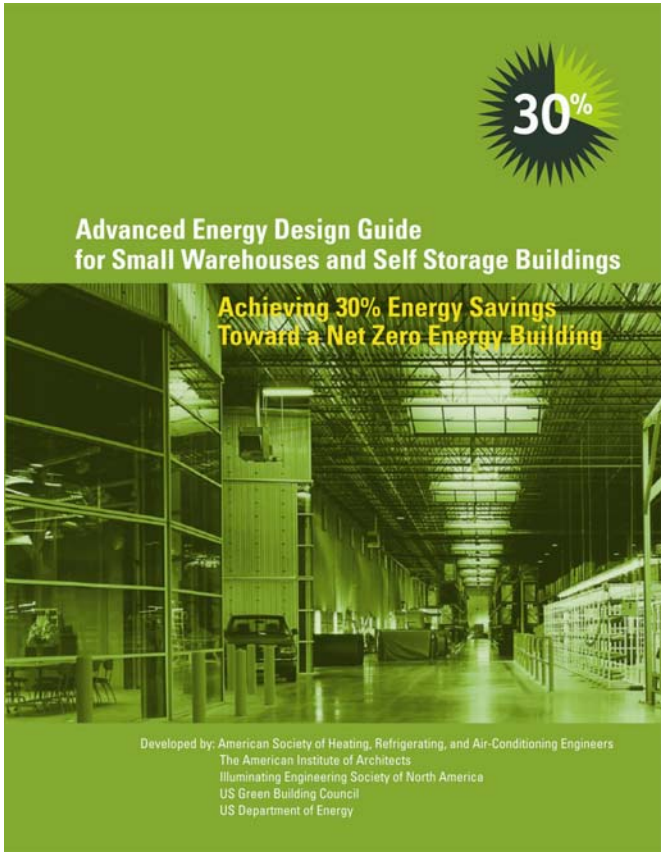
Comply with the prescriptive measures of the Advanced Energy Design Guide for Small Office or Small Retail Buildings

The following restrictions apply:

- Buildings must be under 20,000 ft^2
- Buildings must be office (or retail) occupancy
- Project teams must fully comply with all applicable recommendations as established in the Advanced Energy Design Guide for the climate zone in which the building is located

AEDG for Warehouse and Self Storage

- Fourth in the AEDG series
- Focuses on small warehouse up to 50,000 ft^2 and self storage
- Split or single package roof top DX system types
- Does not apply to central plant systems
- Similar HVAC recommendations as Small Office AEDG, with some warehouse specific additions



AEDG WAREHOUSE

AEDG Warehouse: Additional Recommendations

AEDG WAREHOUSE

Cooling system type in Conditioned Storage spaces

- Variable speed fan and compressor heat pump in zones 1-5
- Maintain humidity control at part load

Higher efficiency large furnace in zones 5-8

Destratification fans for high bay spaces in zones 5-8

No demand controlled ventilation recommendations

Component	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Cooling System (Conditioned Storage all)	Heat Pump packaged systems for low sensible load spaces, Variable speed supply fan; inverter compressor					NR		
Gas furnace (>225 KBtuh)	80% Ec	80% Ec	80% Ec	80% Ec	82% Ec or 81% Et	82% Ec or 81% Et	82% Ec or 81% Et	82% Ec or 81% Et
Destratification	NR				Destratification fans for high bay spaces			

AEDG Warehouse: Additional How to Implement

AEDG WAREHOUSE

In addition to the general good design practices and cautions in the Small Office AEDG:

- Indirect gas-fired unit heaters
- Radiant slab in high infiltration spaces such as loading docks
- Ventilation rates based on product storage off-gassing
- Low leakage automatic louver dampers on exhaust fans to minimize heating season infiltration

Use your computer to ask a question at any time during the rebroadcast

AEDG for K-12 Schools

AEDG K-12 SCHOOLS

Third in the AEDG series

Focuses on elementary, middle, and high schools

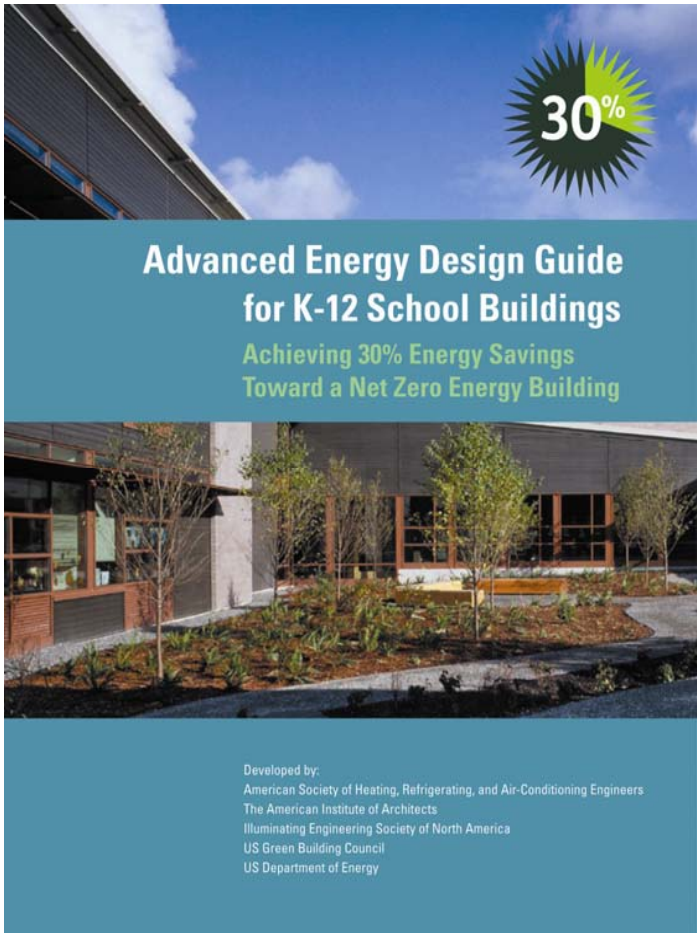
Multiple types of HVAC systems

Typical Space types

- Classrooms
- Administrative
- Corridors
- Restrooms
- Gyms
- Assembly
- Kitchen
- Media Centers

Space types not covered

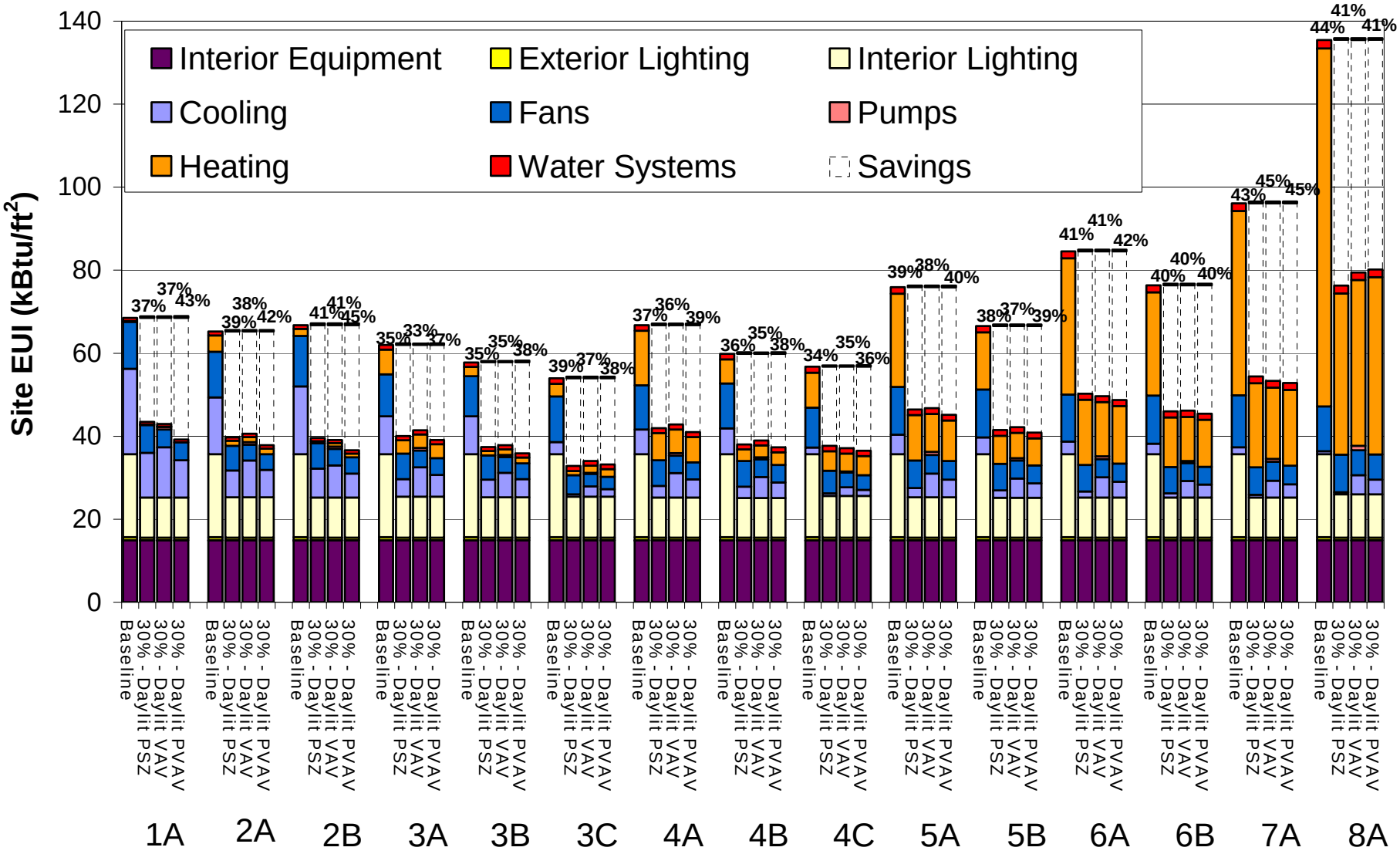
- Pools
- Wet Labs
- Wood working or Auto shop
- Field Lighting



Energy Modeling Results- Daylit Elementary School

AEDG K-12 SCHOOLS

AEDG K-12 SCHOOLS



prescriptive recommendations for
Six HVAC System Types

HV-1: Single-zone, packaged DX units (or split DX systems)

HV-2: Water-source (or ground-source) heat pumps with dedicated OA system

HV-3: Unit ventilators with water chiller and boiler

HV-4: Fan coils with water chiller and boiler and dedicated OA system

HV-5: Multiple-zone, VAV packaged DX rooftop units

HV-6: Multiple-zone, VAV air handlers with water chiller

AEDG K-12 SCHOOLS

climate-specific and system-specific

Recommendation Tables

Climate Zone 2 Recommendation Table for K-12 Schools

	Item	Component	Recommendation		How-To Tip	✓
HVAC	Packaged DX Rooftops (or DX Split Systems)	Heat pump (≥65 and <135 kBtu/h)	10.6 EER/3.2 COP		HV1, HV7–8, HV10	
		Heat pump (≥135 kBtu/h)	10.1 EER/11.5 IPLV/3.1 COP			
		Gas furnace (<225 kBtu/h)	80% AFUE or E_t			
		Gas furnace (≥225 kBtu/h)	80% E_c			
		Economizer	Comply with Standard 90.1*		HV13	
		Ventilation	Energy recovery or demand control		HV9, HV11–12, HV14	
		Fans	Constant volume: 1 hp/1000 cfm Variable volume: 1.3 hp/1000 cfm		HV19	
	WSHP System	Water-source heat pump (<65 kBtu/h)	Cooling: 12.0 EER at 86°F Heating: 4.5 COP at 68°F		HV2, HV7–8, HV10	
		Water-source heat pump (≥65 kBtu/h)	Cooling: 12.0 EER at 86°F Heating: 4.2 COP at 68°F			
		GSHP (<65 kBtu/h)	Cooling: 14.1 EER at 77°F and 17.0 EER at 59°F Heating: 3.5 COP at 32°F and 4.0 COP at 50°F		HV2, HV7–8, V10, AS4	
		GSHP (≥65 kBtu/h)	Cooling: 13.0 EER at 77°F and 16.0 EER at 59°F Heating: 3.1 COP at 32°F and 3.5 COP at 50°F			
		Gas boiler	85% E_c		HV2, HV7, HV10	
		Economizer	Comply with Standard 90.1*		HV13	
		Ventilation	DOAS with either energy recovery or demand control		HV9, HV11–12, HV14	
		WSHP duct pressure drop	Total ESP < 0.2 in. H_2O		HV19	
			A (humid) zones:	B (dry) zones:		
	Unit Ventilator and Chiller System	Air-cooled chiller efficiency		10.0 EER and 11.5 IPLV	HV3, HV7–8, HV10, HV25	
		Water-cooled chiller efficiency		No recommendation	HV3, HV7–8, HV10, HV25	
		Gas boiler				
		Economizer				
		Ventilation				
		Pressure drop				
	Fan Coil and Chiller System	Air-cooled chiller efficiency				
		Water-cooled chiller efficiency				
		Gas boiler				
		Economizer				
		Ventilation				
		Pressure drop	Total ESP < 0.2 in. H_2O		HV19	

Unique recommendations are included for each HVAC system type in the climate-specific tables (Chapter 3)

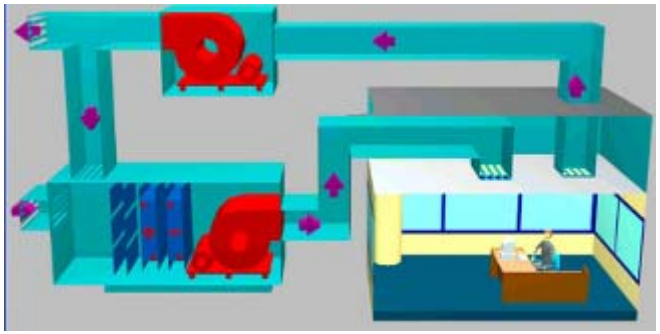
AEDG K-12 SCHOOLS

AEDG K-12 SCHOOLS

HVAC Equipment Efficiencies

Recommended efficiencies based on:

- Climate zone
- HVAC system type
- System size (capacity)
- Fuel type (electricity or natural gas)



Item	Component	Recommendation	How-To Tip	✓
Packaged DX Rooftops (or DX Split Systems)	Air conditioner (<65 kBtu/h)	13.0 SEER	HV1, HV7–8, HV10	
	Air conditioner (≥65 and <135 kBtu/h)	11.0 EER		
	Air conditioner (≥135 and <240 kBtu/h)	10.8 EER		
	Air conditioner (≥240 kBtu/h)	10.0 EER and 10.4 IPLV		
	Heat pump (<65 kBtu/h)	13.0 SEER/7.7 HPSF		
	Heat pump (≥65 and <135 kBtu/h)	10.6 EER/3.2 COP	HV1, HV7–8, HV10	
	Heat pump (≥135 kBtu/h)	10.1 EER and 11.0 IPLV/3.1 COP		
	Gas furnace (<225 kBtu/h)	80% AFUE or E_t		
	Gas furnace (≥225 kBtu/h)	80% E_c		
	Economizer	>54 kBtu/h	HV13	
	Ventilation	Energy recovery or demand control	HV9, HV11–12, HV14	
	Fans	Constant volume: 1 hp/1000 cfm Variable volume: 1.3 hp/1000 cfm	HV19	

for climate zone 5

AEDG K-12 SCHOOLS

Chapter 5
Good Design Practice

Load calculations

Dehumidification

Energy recovery

Equipment efficiencies

Ventilation air

Dedicated OA systems

Economizer

Demand ventilation

Exhaust air systems

Fan motor efficiencies

System-level controls

Chilled-water system

Hot-water heating

Thermal zoning

Filters

Duct design, construction

Duct insulation

Duct sealing, leak testing

Air balancing

Commissioning

Relief versus return fans

Heating sources

Noise control

Proper maintenance

Zone temperature control

Operable windows

HV-11
Ventilation Air

Determine based on ASHRAE 62.1

- Use actual occupancy for calculations, not egress (exit) population
- Use population diversity (D) when using multiple-zone recirculating systems
- Use time-of-day schedules to introduce ventilation air only when a zone is expected to be occupied

AEDG K-12 SCHOOLS

HV9 or HV14

Energy Used to Condition OA

Climate Zone 2 Recommendation Table for K-12 Schools

	Item	Component	Recommendation	How-To Tip	✓
HVAC	Packaged DX Rooftops (or D	Heat pump (≥65 and <135 kBtu/h)	10.6 EER/3.2 COP	HV1, HV7–8, HV10	
		Heat pump (≥135 kBtu/h)	10.1 EER/11.5 IPLV/3.1 COP		
		Gas furnace (<225 kBtu/h)	80% AFUE or E_t		
		Gas furnace (≥225 kBtu/h)	80% E_c		
		Economizer	Comply with Standard 90.1*	HV13	
		Ventilation	Energy recovery or demand control	HV9, HV11–12, HV14	
		Fans	Constant volume: 1 hp/1000 cfm Variable volume: 1.3 hp/1000 cfm	HV19	
	WSHP System	Water-source heat pump (<65 kBtu/h)	Cooling: 12.0 EER at 86°F Heating: 4.5 COP at 68°F	HV2, HV7–8, HV10	
		Water-source heat pump (≥65 kBtu/h)	Cooling: 12.0 EER at 86°F Heating: 4.2 COP at 68°F		
		GSHP (<65 kBtu/h)			
		GSHP (≥65 kBtu/h)			
		Gas boiler			
		Economizer			
		Ventilation			
		WSHP duct pressure drop			
	Unit Ventilator and Chiller System				
		Air-cooled chiller efficiency			
		Water-cooled chiller efficiency			
		Gas boiler			
		Economizer			
		Ventilation			
		Pressure drop			
	Fan Coil and Chiller System	Air-cooled chiller efficiency			
		Water-cooled chiller efficiency			
		Gas boiler			
		Economizer	Comply with Standard 90.1*	HV13	
		Ventilation	DOAS with either energy recovery or demand control	HV9, HV11–12, HV14	
		Pressure drop	Total ESP < 0.2 in. H_2O	HV19	

Because conditioning OA for ventilation is such a big contributor to energy use in K-12 schools, either exhaust-air energy recovery or demand-controlled ventilation (DCV) is recommended

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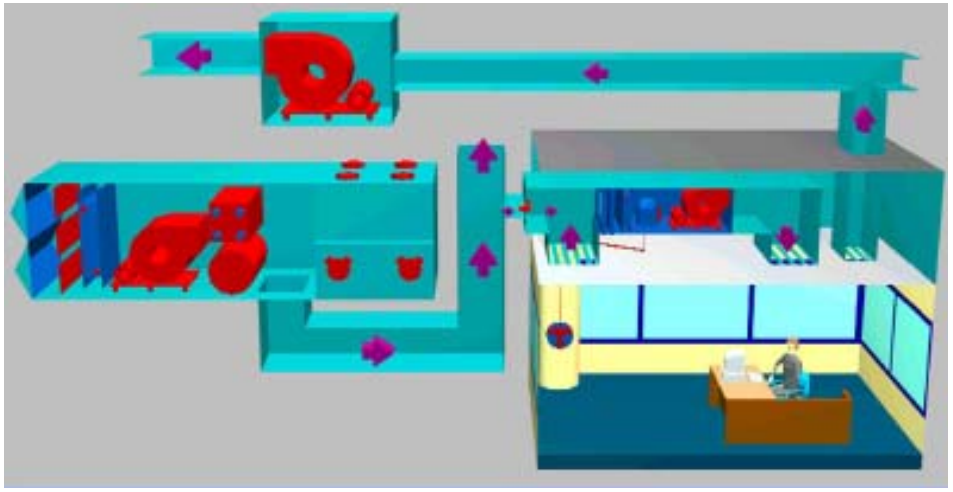
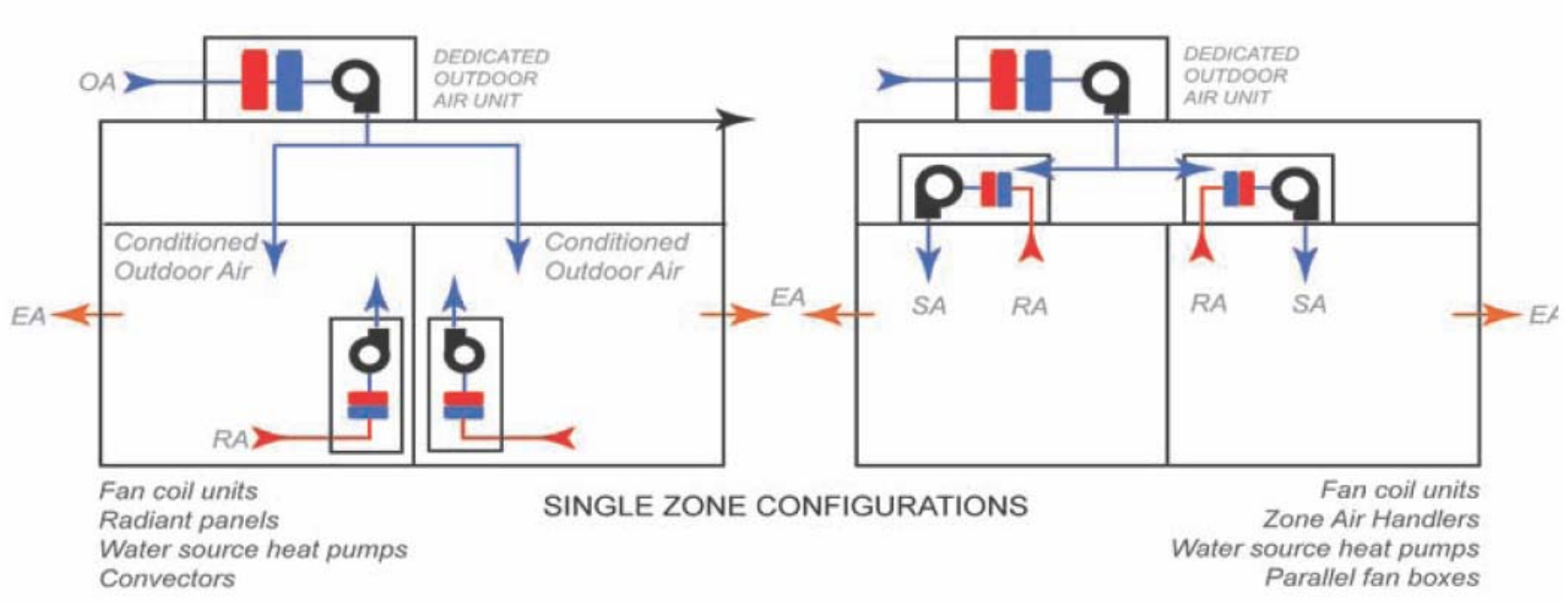
Part-Load Dehumidification

AEDG K-12 SCHOOLS

- Strategies to minimize cycling of constant speed fans
- Design system to minimize number of hours that space relative humidity remains above 60%
- Recommends methods for improving part-load dehumidification
  --refers to several strategies (by HVAC system type)



HV-12
Dedicated OA Systems



DOAS with energy recovery recommended for WSHP, fan coil, and as an option for unit ventilators

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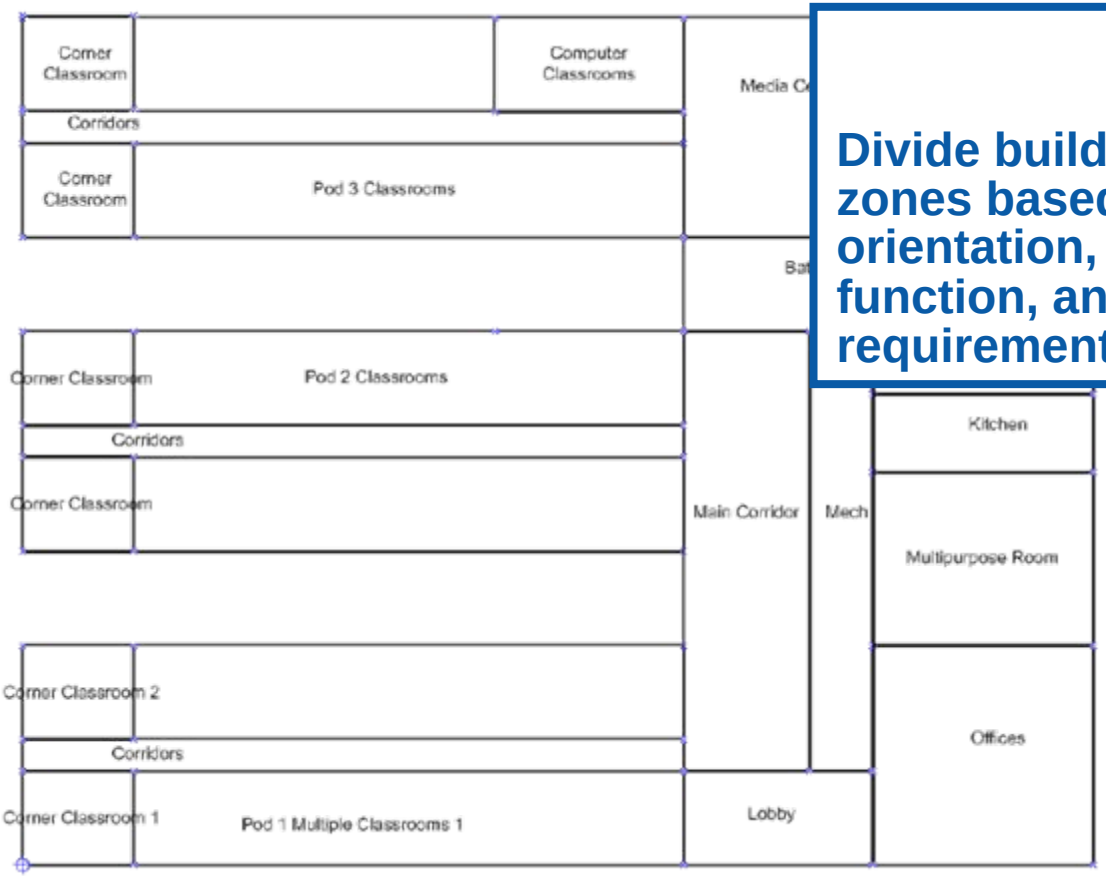
HV-20
Thermal Zoning



Divide building into thermal zones based on building size, orientation, space layout and function, and after-hours use requirements

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Thermal Zoning (continued)

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For multiple-zone systems, avoid using a single air handler to serve zones with significantly different occupancy patterns

- Use multiple air handlers so those serving unused areas of the building can be shut off when not in use

  or

- Use BAS to define separate operating schedules for different areas of the building, and shut off airflow to unused areas

Proper Maintenance

Neglecting preventive maintenance practices can quickly negate any energy savings expected

- Filters should be replaced regularly
- ERVs need to be cleaned periodically
- Dampers, valves, louvers, and sensors must all be periodically inspected and calibrated
- Need asset management strategies

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LEED-Schools EAc1 Optimize Energy Performance

AEDG K-12 SCHOOLS

Option 2 – Prescriptive Compliance Path (4 credits)

Comply with the prescriptive measures of the Advanced Energy Design Guide for K-12 School Buildings

The following restrictions apply:

- Buildings must be under 100,000 ft^2
- Buildings must be include the typical spaces covered under the scope
- Project teams must fully comply with all applicable recommendations as established in the Advanced Energy Design Guide for the climate zone in which the building is located

Future Guides

Advanced Energy Design Guide for Highway Lodging – 30% savings

- Just completed 90% review

Advanced Energy Design Guide for Healthcare Facilities – 30% savings

- Just starting

Advanced Energy Design Guides for 50% savings – Planned:

- K-12 Schools
- Big Box Retail
- Small Office
- Small Retail

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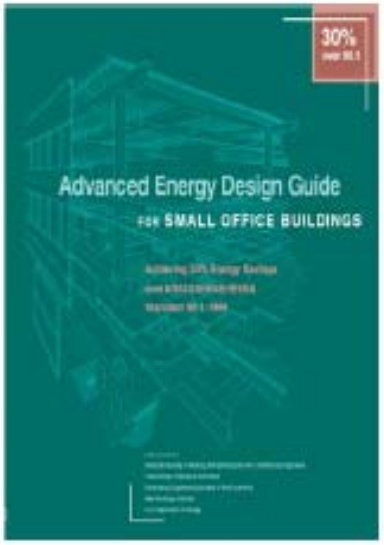

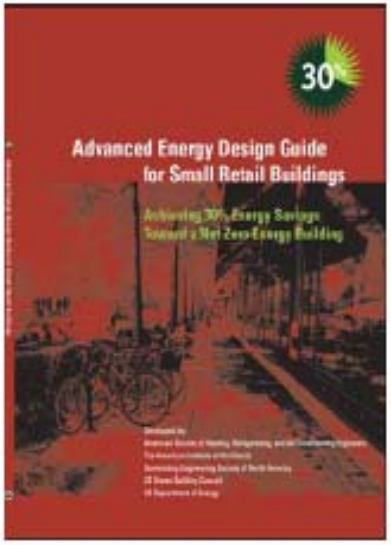

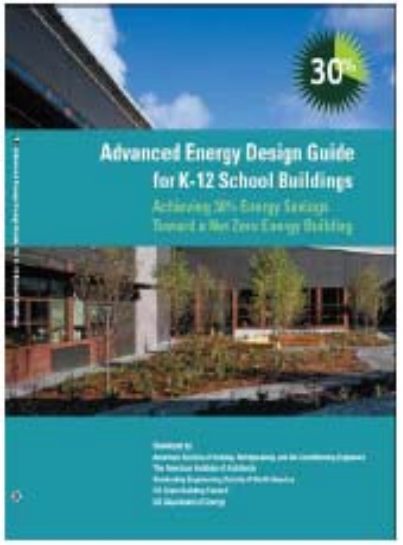

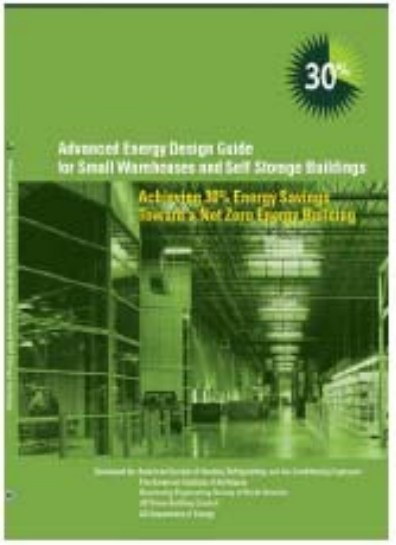

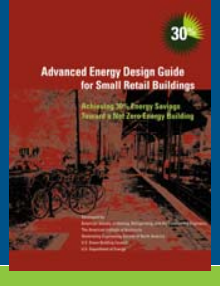

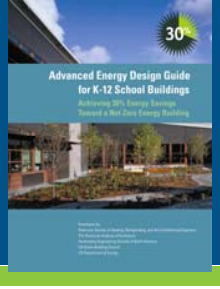

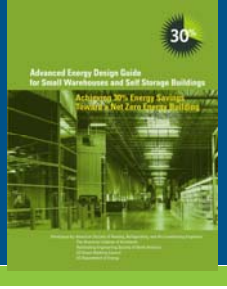

AEDG – Advanced Energy Design Guides:

Building Envelope

Originally aired: September 11, 2008

John Hogan, PE, AIA
Seattle Dept of Planning & Development

Your Instructor

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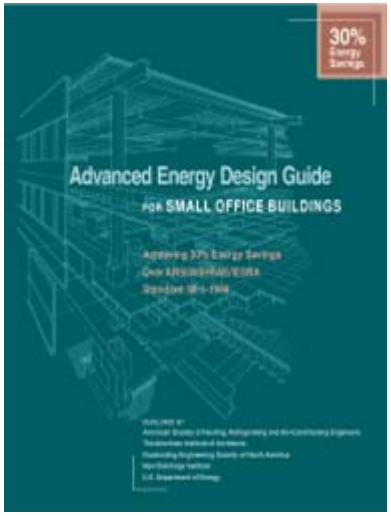
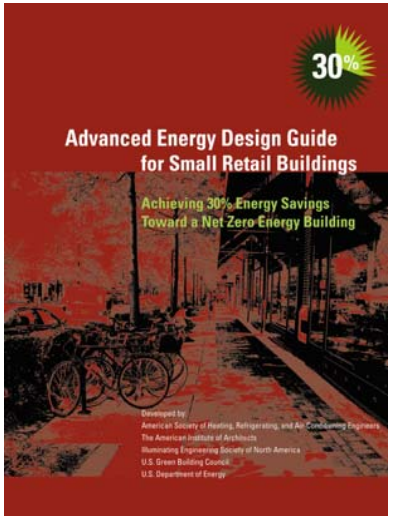
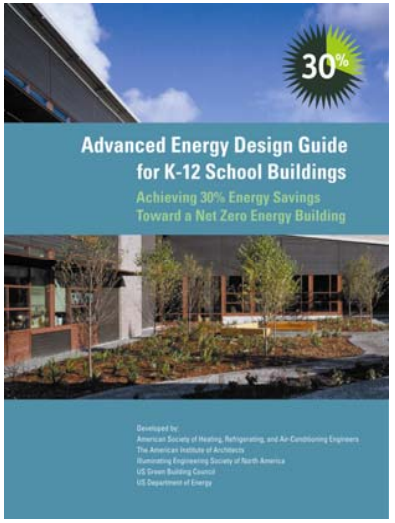
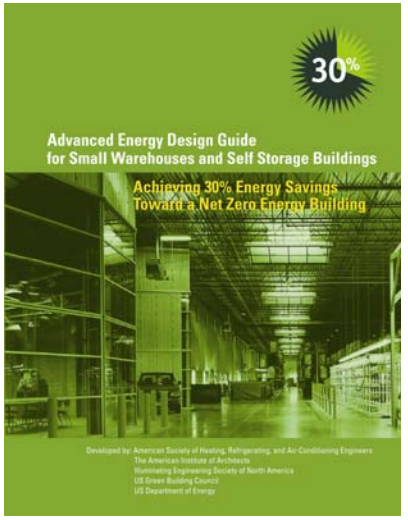
- Consultant to the AEDG Steering Committee
- Chair of ASHRAE SPC 189.1,
  Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
- Former chair of Envelope Subcommittee of ASHRAE SSPC 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*

Publications Available









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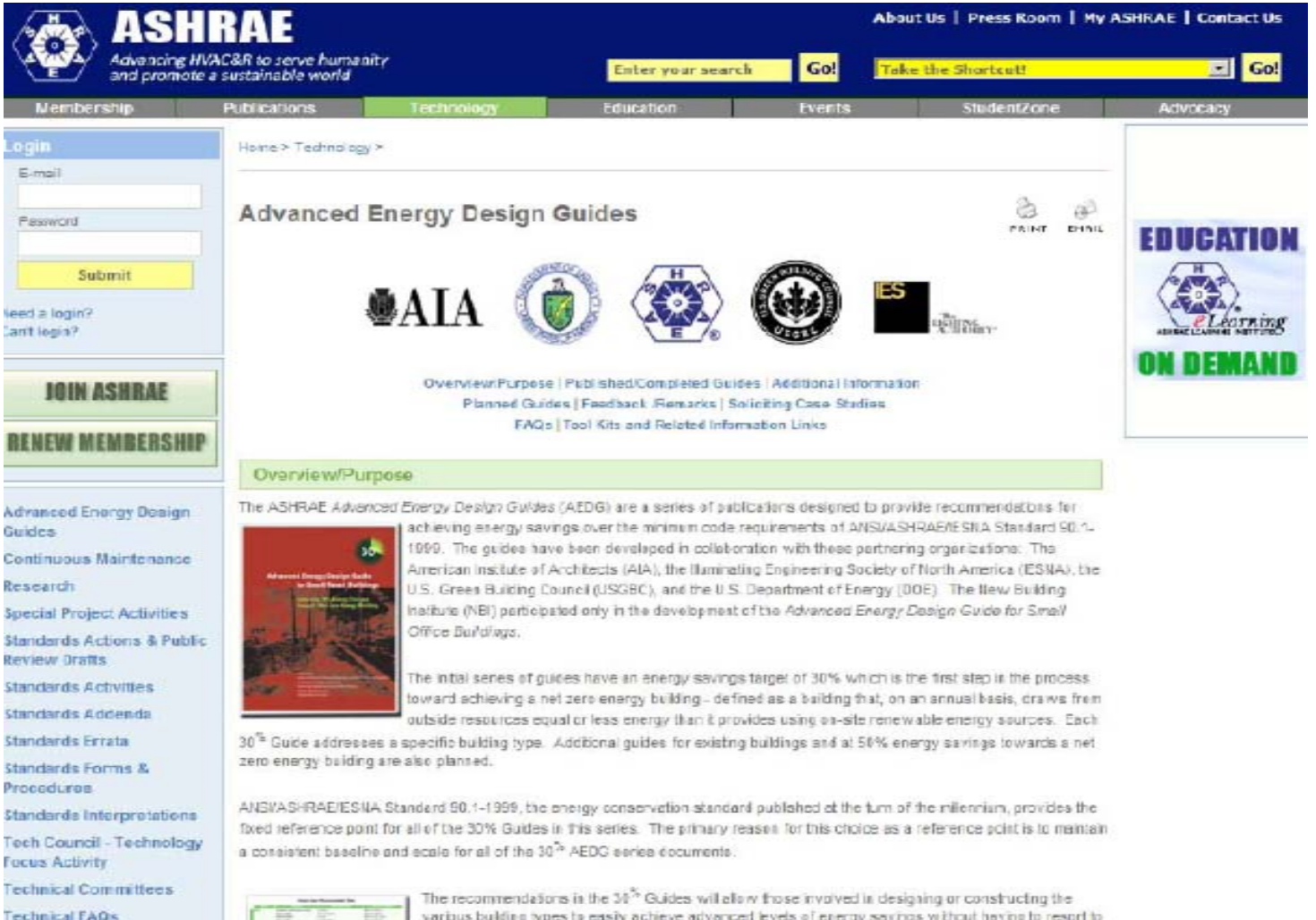


Overview: General Goal

- **The ASHRAE *Advanced Energy Design Guides* are a series of publications designed to provide recommendations for achieving energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1-1999**
- **Intended for contractors and designers who create small buildings**
- **Provides a simple approach to achieve energy savings without having to resort to detailed calculations or analysis**

Overview: Available Guides

- **Published Guides for 30% energy savings (compared to Standard 90.1-1999):**
  - Small offices, up to 20,000 ft^2
  - Small retail, up to 20,000 ft^2
  - Schools, elementary through high school
  - Warehouse & self-storage, up to 50,000 ft^2
- **Guides being developed for 30% savings:**
  - Highway lodging
- **Future Guides:**
  - 50% energy savings

Overview: Outline of Guides

- **Chapter 1:** Introduction
- **Chapter 2:** Integrated Process for Achieving Energy Savings
- **Chapter 3:** Recommendations by Climate
- **Chapter 4:** Technology Example and Case Studies
- **Chapter 5:** How-to-Tips Implement Recommendations
- **Appendix A:** Envelope Thermal Performance Factors

Chapter 2: Integrated Design Process

Design choices should be in order as follows:

- **1. Optimize on-site resources, especially daylighting**
- **2. Reduce loads on energy-using systems**
- **3. Size systems properly for reduced loads**
- **4. Incorporate efficient equipment and systems**
- **5. Refine systems integration**

Chapter 2: Integrated Design Process

1. Assess the site:

- Evaluate centrality to the community
- Evaluate access to public transportation
- Identify on-site energy opportunities
- Identify best building orientation

Chapter 2: Integrated Design Process

Identify on-site energy opportunities:

- **Integrated design begins with site assessment and selection**
- **Site selection is an opportunity to obtain free energy resources**

Chapter 2: Integrated Design Process

- **Daylighting can provide most lighting needs in many locations**

Chapter 2: Integrated Design Process

- **Passive solar heat can reduce heating loads**

Chapter 2: Integrated Design Process

- **External overhangs can reduce cooling loads**

Chapter 2: Integrated Design Process

- **Photovoltaic (PV) panels can reduce the amount of electricity that needs to be produced by fossil fuels**

Chapter 2: Integrated Design Process

2. Reduce loads on energy-using systems:

- **Reduce internal loads:**
  - more efficient equipment/appliances/lighting
- **Reduce heat gain/loss through the building envelope:** many options, see next slides
- **Reduce thermal loads:**
  - utilize passive solar design, thermal storage
- **Refine building to suit local conditions:**
  - operable windows, cross-ventilation

Chapter 2: Integrated Design Process

Reduce heat gain/loss through building envelope:

Building Envelope: Control solar gain to reduce cooling load through windows	Use beneficial building form and orientation
	Minimize windows east and west, maximize north and south
	Use glazing with low solar heat gain coefficient (SHGC)
	External shade glazing to reduce solar heat gain and glare

Chapter 2: Integrated Design Process

Reduce heat gain/loss through building envelope:

Control solar gain to reduce cooling load through windows	Use vegetation on S/E/W to control solar heat gain (and glare)
Reduce solar gain through opaque surfaces to reduce cooling load	Increase insulation of opaque surfaces
	Increase roof surface reflectance and emittance
	Shade building surfaces with deciduous or coniferous trees as appropriate for surface orientation

Chapter 2: Integrated Design Process

Reduce heat gain/loss through building envelope:

Reduce conductive heat gain and loss through building envelope	Increase insulation on roof, walls, floor, slabs, and doors and decrease window U-factor
Reduce air infiltration	Provide continuous air barrier
Reduce heat gain or loss from ventilation exhaust air	Use energy recovery to precondition outdoor air

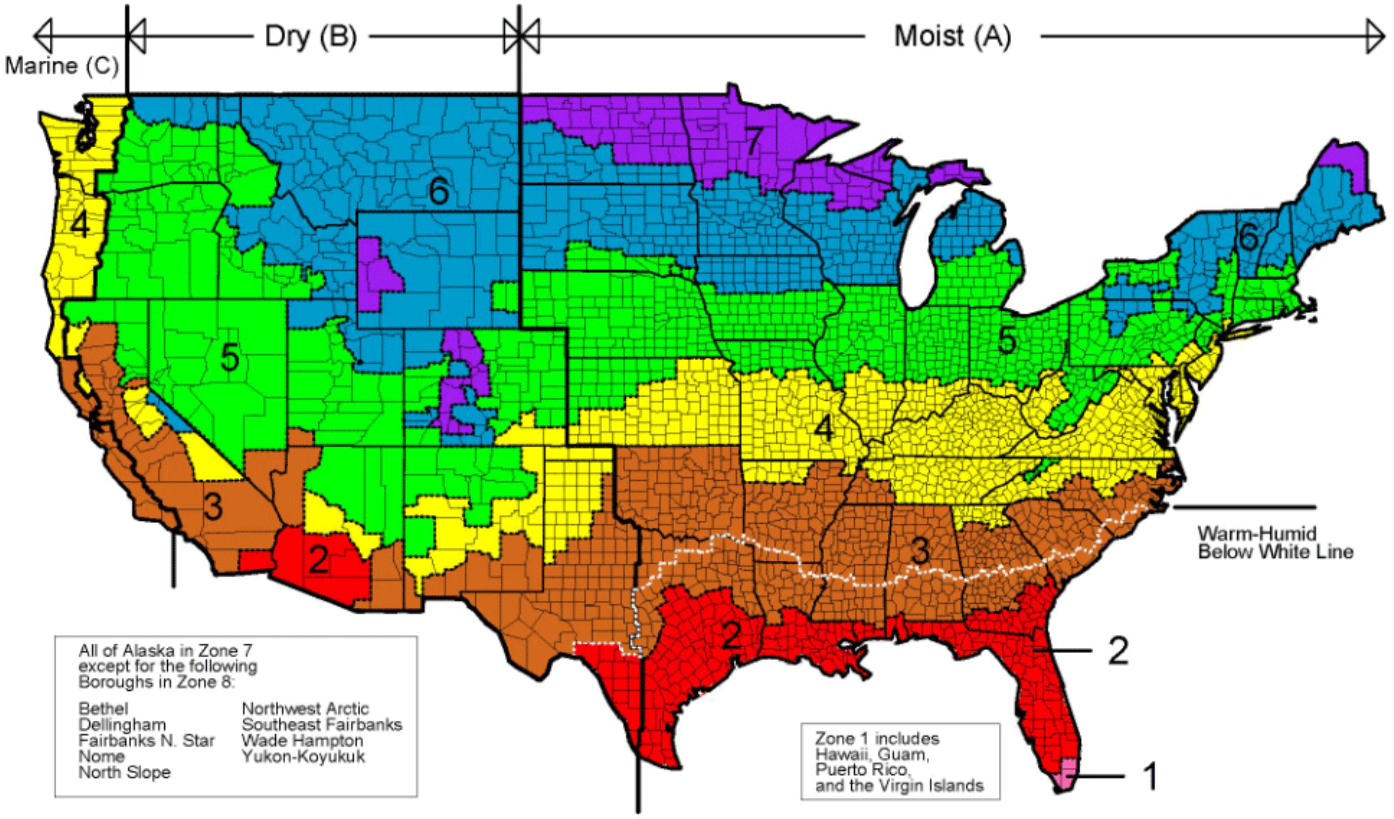
Chapter 3: Recommendations by Climate

Background info & underlying assumptions:

- Additional information is contained in ASHRAE's base documents:
  - "Standard 90.1-2007" (definitions, other criteria)
  - "Standard 90.1 User's Manual" (examples)
- For components where recommendations are <u>not</u> listed in the AEDG:
  - the energy analysis presumes that all the other components are built to the criteria in Standards 90.1 and 62.1

Chapter 3: Recommendations by Climate

Climate Zone Map for U.S.



Chapter 3: Recommendations by Climate

Roof/Wall/Floor (min. R-value): Climate Zone 1 (Miami, Honolulu, San Juan P.R.)

Roofs	Insulation entirely above deck	R-25 c.i.
	Attic and other	R-30
	Metal building	R-19
	SRI	0.78
Walls	Mass (HC > 7 Btu/ft^2·°F)	R-5.7 c.i.
	Steel framed	R-13
	Wood framed and other	R-13
	Metal building	R-16
	Below-grade walls	Comply with Standard 90.1*
Floors	Mass	R-4.2 c.i.
	Steel framed	R-19
	Wood framed and other	R-19

Chapter 3: Recommendations by Climate

Insulation R-value (Std.90.1-2007, §5.5.3)

- **R-value of insulation alone:**
  "R-values of insulation for the thermal resistance of the added insulation in framing cavities and continuous insulation only"
  - does not include air films or building materials
  - sometimes only continuous insulation (ci)
- **U-factor, C-factor, or F-factor for the entire assembly:**
  AEDG Appendix A has Envelope Performance Factors for overall assembly alternates

Chapter 3: Recommendations by Climate

Cool Roof (SRI - solar reflectance index)

- Solar reflectance and emittance values from a lab accredited by the Cool Roof Rating Council

Category	Product	Reflectance	Emissivity	SRI
Single-ply	White polyvinyl chloride (PVC)	0.86	0.86	107
Single-ply	White chlorinated polyethylene (CPE)	0.86	0.88	108
Single-ply	White chlorosulfonated polyethylene (CPSE), e.g., Hypalon	0.85	0.87	106
Single-ply	White thermoplastic polyolefin (TSO)	0.77	0.87	95
Liquid-applied	White elastomeric, polyurethane, acrylic coating	0.71	0.86	86
Liquid-applied	White paint (on metal or concrete)	0.71	0.85	86
Metal panels	Factory-coated white finish	0.70	0.87	85

Chapter 3: Recommendations by Climate

Roof/Wall/Floor (min. R-value): Climate Zone 3 (Memphis, Atlanta, El Paso, Las Vegas, L.A.)

Roofs	Insulation entirely above deck	R-25 c.i.
	Attic and other	R-38
	Metal building	R-13 + R-13
	SRI	0.78
Walls	Mass (HC > 7 Btu/ft^2·°F)	R-7.6 c.i.
	Steel framed	R-13 + R-3.8 c.i.
	Wood framed and other	R-13
	Metal building	R-16
	Below-grade walls	Comply with Standard 90.1*
Floors	Mass	R-8.3 c.i.
	Steel framed	R-19
	Wood framed and other	R-30

AEDG K-12
Chapter 3: Recommendations by Climate

Roof/Wall/Floor (min. R-value): Climate Zone 5 (Chicago, Boise, Boston, Vancouver BC)

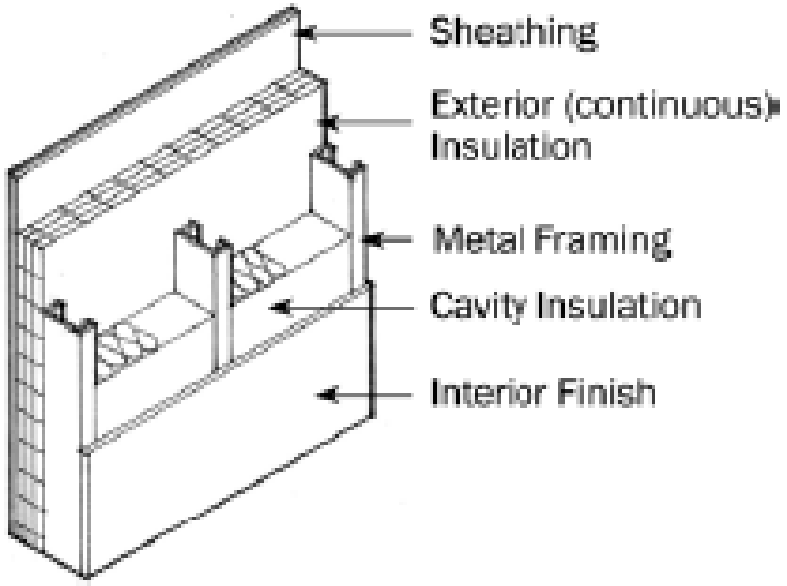
Roofs	Insulation entirely above deck	R-25 c.i.
	Attic and other	R-38
	Metal building	R-13 + R-19
	SRI	Comply with Standard 90.1*
Walls	Mass (HC > 7 Btu/ft^2·°F)	R-11.4 c.i.
	Steel framed	R-13 + R-7.5 c.i.
	Wood framed and other	R-13 + R-3.8 c.i.
	Metal building	R-19 + R-5.6 c.i.
	Below-grade walls	R-7.5 c.i.
Floors	Mass	R-10.4 c.i.
	Steel framed	R-30
	Wood framed and other	R-30

Use your computer to ask a question at any time during the rebroadcast

Chapter 3: Recommendations by Climate

Cavity insulation plus continuous insulation

Adding exterior foam sheathing as continuous insulation is the preferred method to upgrade the wall because it tends to minimize the impact of the thermal bridging. (AEDG Warehouse – EN8)



Chapter 3: Recommendations by Climate

Roof/Wall/Floor (min. R-value): Climate Zone 7 (Duluth, Anchorage, Caribou ME)

Roofs	Insulation entirely above deck	R-25 c.i.
	Attic and other	R-60
	Metal building	R-13 + R-19
	SRI	Comply with Standard 90.1*
Walls	Mass (HC > 7 Btu/ft^2·°F)	R-15.2 c.i.
	Steel framed	R-13 + R-7.5 c.i.
	Wood framed and other	R-13 + R-7.5 c.i.
	Metal building	R-19 + R-5.6 c.i.
	Below-grade walls	R-7.5 c.i.
Floors	Mass	R-12.5 c.i.
	Steel framed	R-38
	Wood framed and other	R-30

Chapter 3: Recommendations by Climate

Loading Dock Weatherseals: all climate zones

Vehicular/dock infiltration—door closed	0.28 cfm/ft^2 of door area
Vehicular/dock infiltration—door open with truck in place	Weatherseals for dock levelers and trailer hinges

- Dock levelers should be furnished with brush-type seals to reduce the effective leakage crack width of the operating clearance from approximately 1.125 in. to less than 0.25 in. Inflatable or foam-type hinge seals should be utilized to minimize infiltration through this gap. (AEDG Warehouse – EN13)

Chapter 3: Recommendations by Climate

Fenestration (max. U/SHGC): Climate Zone 1 (Miami, Honolulu, San Juan P.R.)

Total fenestration to gross wall area ratio	35% max
Thermal transmittance—all types and orientations	U-0.56
SHGC—all types and orientations	SHGC—0.25
Exterior sun control (S, E, W only)	Projection factor > 0.5

Chapter 3: Recommendations by Climate

Fenestration area (Std.90.1-2007, §3.2)

- **Fenestration area:**
  "total area of the fenestration measured using the rough opening and including the glazing, sash, and frame."
- **Comments:**
  - must use rough opening, not glass area

Chapter 3: Recommendations by Climate

U-factor rating (Std.90.1-2007, §5.8.2.4)

- **U-factor** (§5.8.2.4)
  "U-factors shall be determined in accordance with NFRC 100.
- **Comments:**
  - ratings are for overall product including glass, sash, and frame (not center of glass)
  - the overall product U-factor w/frame can be twice as high as the center-of-glass U-factor
  - higher U-factor for products at a slope

Chapter 3: Recommendations by Climate

SHGC rating (Std.90.1-2007, §5.8.2.5)

- **Solar Heat Gain Coefficient** (§5.8.2.5)
  "SHGC for the overall fenestration area shall be determined in accordance with NFRC 200."

- **NFRC labeling for inspectors** (§5.8.2.2)
  - manufactured products, 4" x 4" label at factory
  - site-built products, 8-1/2" x 11" label certificate

Chapter 3: Recommendations by Climate

Chapter 3: Recommendations by Climate

NFRC PRODUCT CERTIFICATION PROGRAM

NFRC Label Certificate for Site-Built Products

World's Best Window Co.
Millennium 2000
Vinyl Clad Wood Frame
Double Glazing • Argon Fill – Low E
Product Type: Vertical Slider

ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.35	0.32
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance	Air Leakage (U.S./I-P)
0.51	0.2

Project Location

Street Address: _____

City: _____ State: _____ Zip Code: _____

Project Name (Optional): _____ Designer (Optional): _____

Product Line Information

Operator Type (per Table 4-3 of NFRC 100) _____

Product Line ID No. _____ Individual Product ID No. _____

How many of this individual product _____ Location in building _____

Elevation drawing page _____ Fenestration (window & door) schedule page _____

Frame Material Supplier Company name: _____

City: _____ State: _____ Zip Code: _____

Street Address: _____

Contact: _____ Phone: _____ Fax: _____

Glazing Material Supplier Company name: _____

City: _____ State: _____ Zip Code: _____

Street Address: _____

Contact: _____ Phone: _____ Fax: _____

Glazing Contractor/Installer Comp. name: _____

City: _____ State: _____ Zip Code: _____

Street Address: _____

Contact: _____ Phone: _____ Fax: _____

Certification Authorization

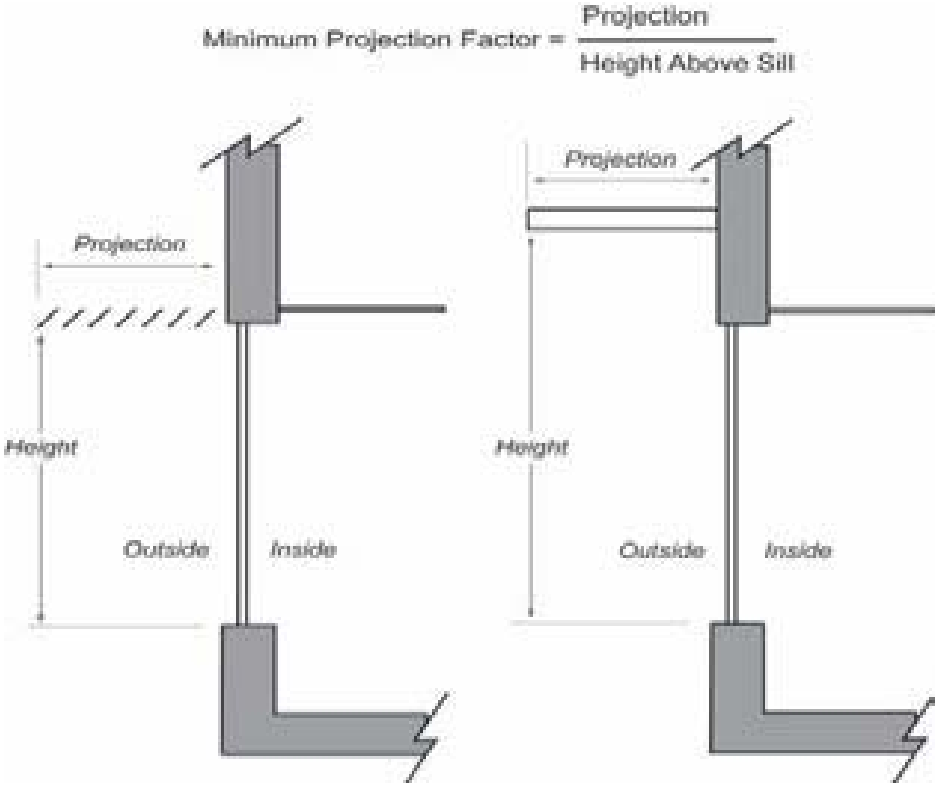
Independent Certification & Inspection Agency (IA): _____

Date Certification Authorization Issued: _____

Chapter 3: Recommendations by Climate

Projection factor (Std.90.1-2007, §3.2)

- Projection factor is the ratio of the horizontal depth of the overhang divided by the height above the window sill.



Chapter 3: Recommendations by Climate

Fenestration (max. U/SHGC): Climate Zone 3 (Memphis, Atlanta, El Paso, Las Vegas, L.A.)

Total fenestration to gross wall area ratio	35% max
Thermal transmittance—all types and orientations	U-0.45
SHGC—all types and orientations	SHGC—0.25
Exterior sun control (S, E, W only)	Projection factor > 0.5

Chapter 3: Recommendations by Climate

Fenestration (max. U/SHGC): Climate Zone 5 (Chicago, Boise, Boston, Vancouver BC)

Total fenestration to gross wall area ratio	35% Max
Thermal transmittance—all types and orientations	U-0.42
SHGC—all types and orientations	SHGC-0.40
Exterior sun control (S, E, W only)	Projection factor > 0.5

Chapter 3: Recommendations by Climate

Fenestration (max. U/SHGC): Climate Zone 7 (Duluth, Anchorage, Caribou ME)

Total fenestration to gross wall area ratio	35% Max
Thermal transmittance—all types and orientations	U-0.33
SHGC—all types and orientations	SHGC-0.45
Exterior sun control (S, E, W only)	Projection factor > 0.5

Chapter 3: Recommendations by Climate

Vertical fenestration descriptions

U-Factor	SHGC	VLT	Description
0.56	0.25	0.30	Double glazing; clear glass; metal frame; high-performance tint; medium-performance reflective
0.45	0.25	0.32	Double glazing; clear glass; metal frame with a thermal break; high-performance tint; medium-performance reflective
0.42	0.40	0.55	Double glazing; clear glass; metal frame with a thermal break; super sputter low-e (e = 0.05) on both panes
0.33	0.45	0.60	Double glazing; clear glass; vinyl/insulated frame; super sputter low-e (e = 0.05) on both panes

Chapter 3: Recommendations by Climate

Window Orientation: all climate zones

$$(A_N * SHGC_N + A_S * SHGC_S) > (A_E * SHGC_E + A_W * SHGC_W)$$

- the area of glazing on the east and west façades, times their respective SHGCs, should be less than the area of glazing on the north and south façades times their respective SHGCs (AEDG Office - EN26)

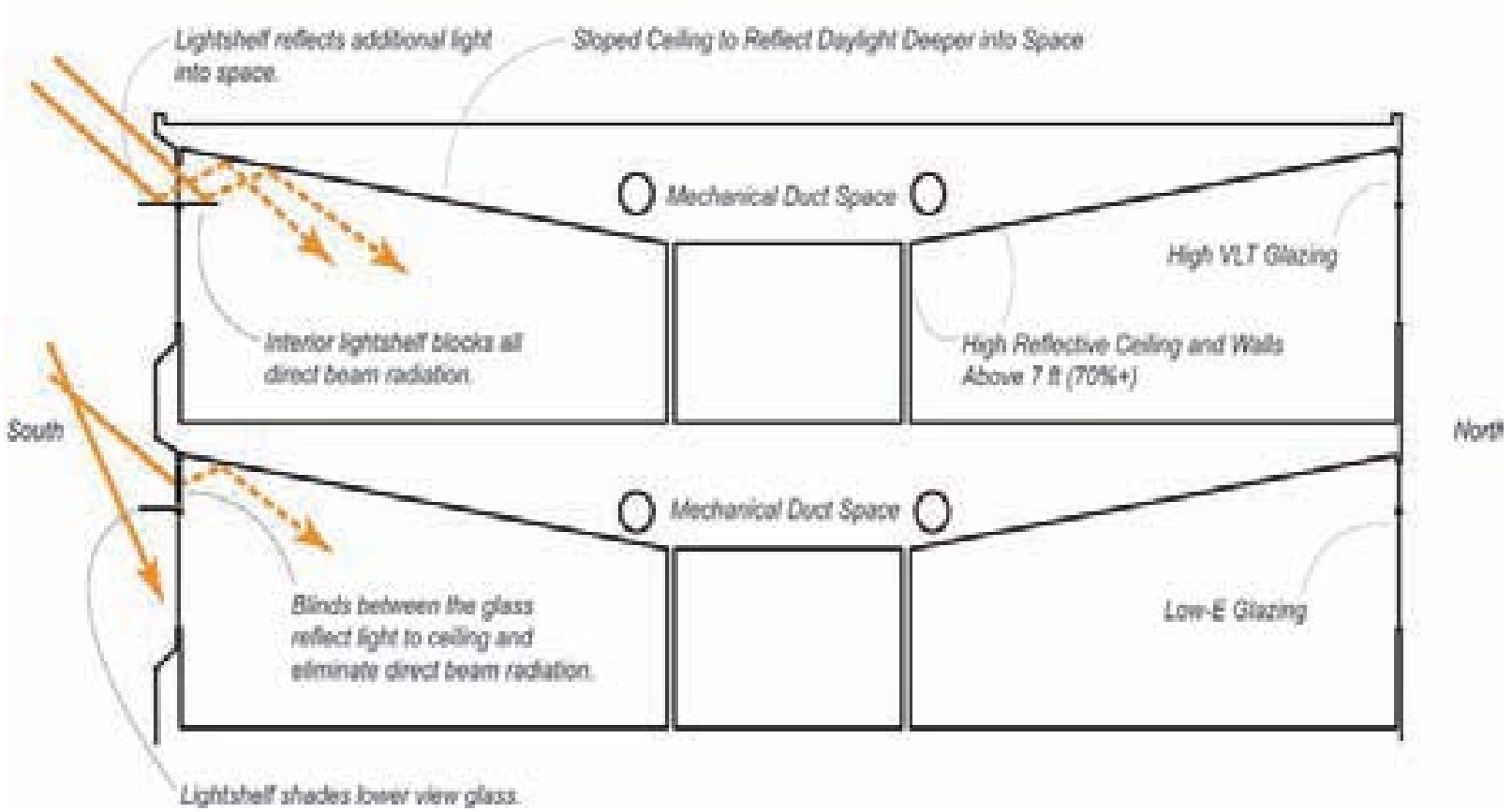
Chapter 3: Recommendations by Climate

Daylighting: all climate zones

Classroom daylighting (daylighting fenestration to floor area ratio)	Toplighted— South-facing roof monitors: 8%–11% North-facing roof monitors: 12%–15%
	Sidelighted— South-facing: 8%–11% North-facing: 15%–20%
	Combined toplighted and sidelighted— South-facing sidelighted: 6%–8% Toplighted: 2%–3% North-facing sidelighted: 9%–13% Toplighted: 3%–5%

Chapter 3: Recommendations by Climate

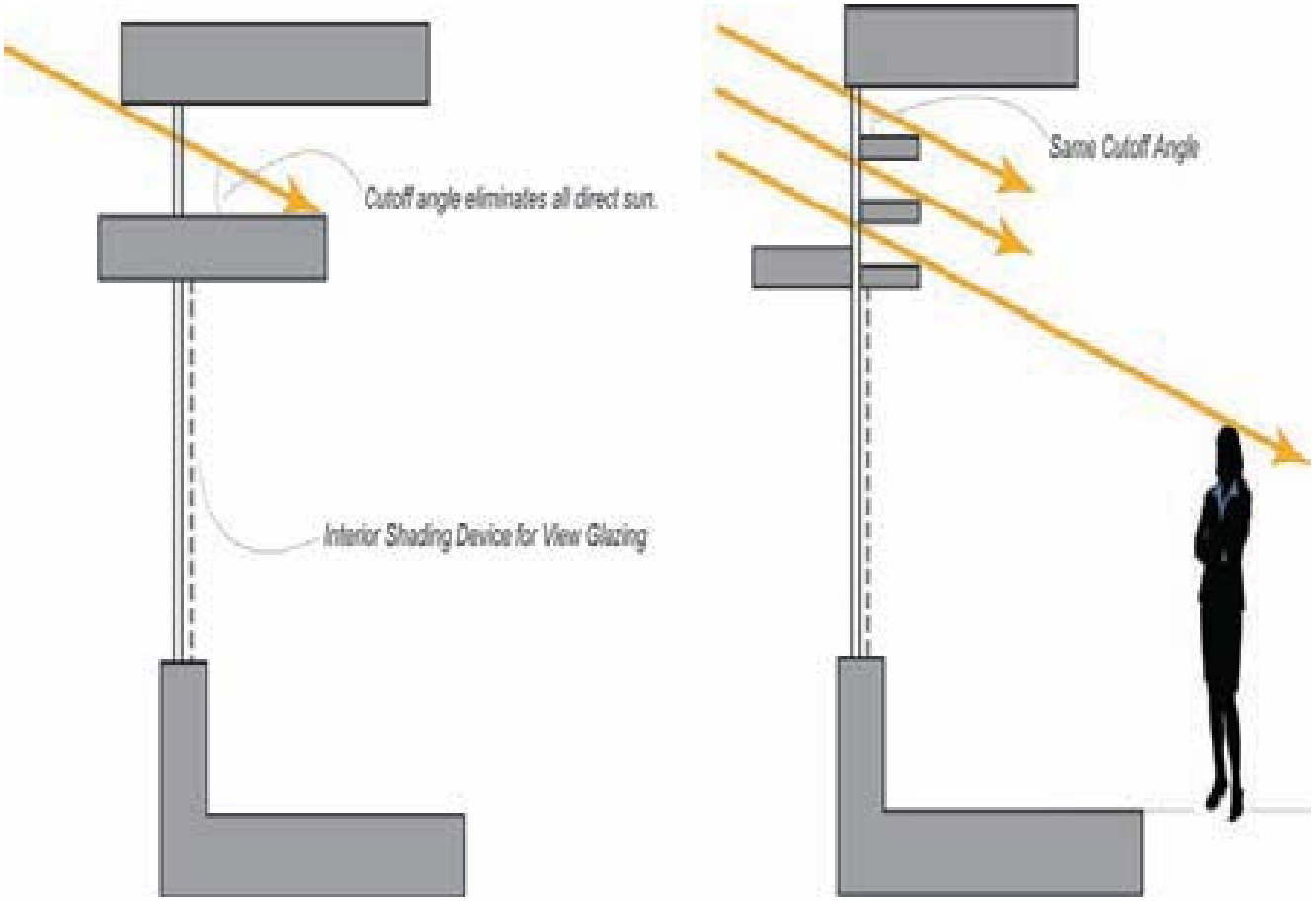
Classroom sidelighting: all climate zones



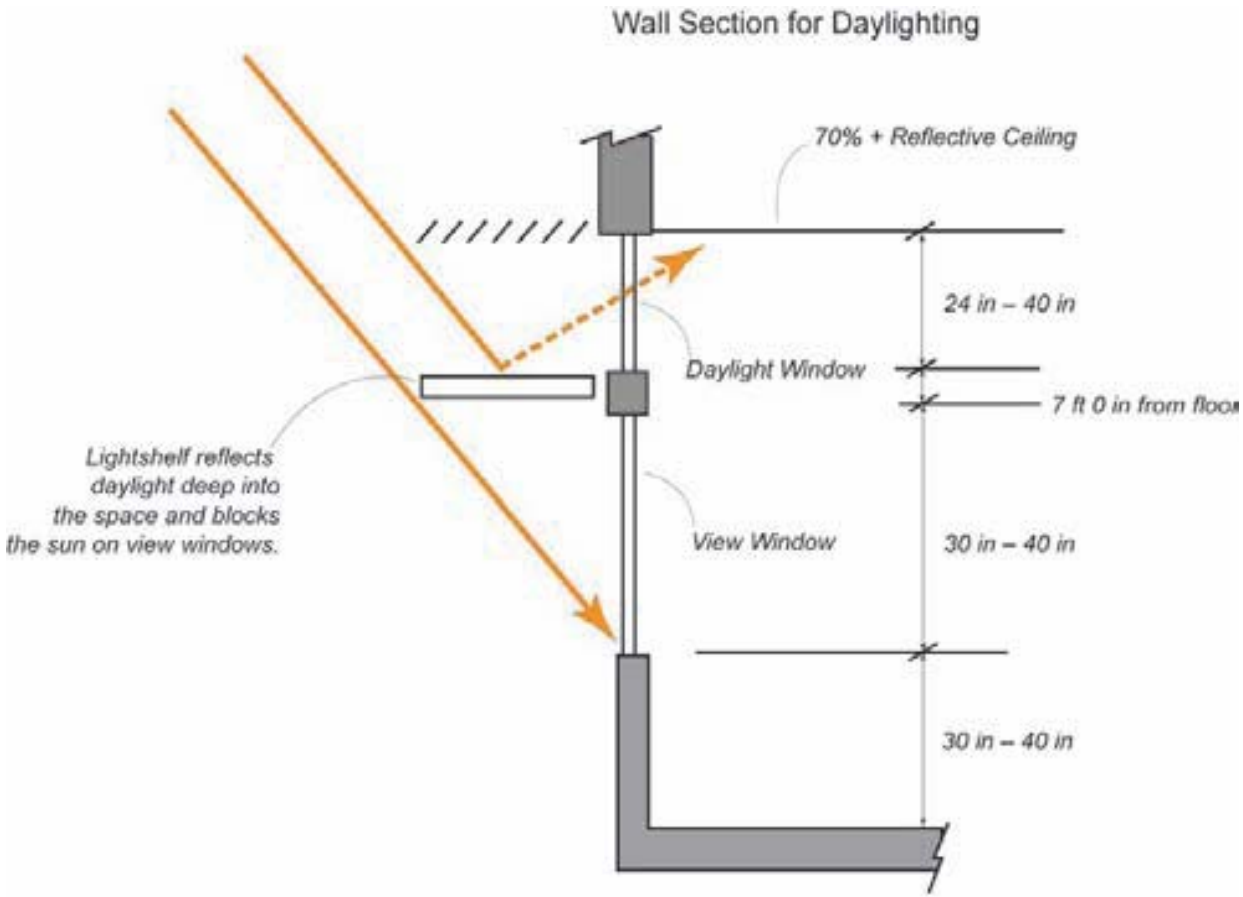
AEDG K-12
Chapter 3: Recommendations by Climate

- **North-facing classroom with daylighting and sloped ceilings**

Overhang cut-off angle

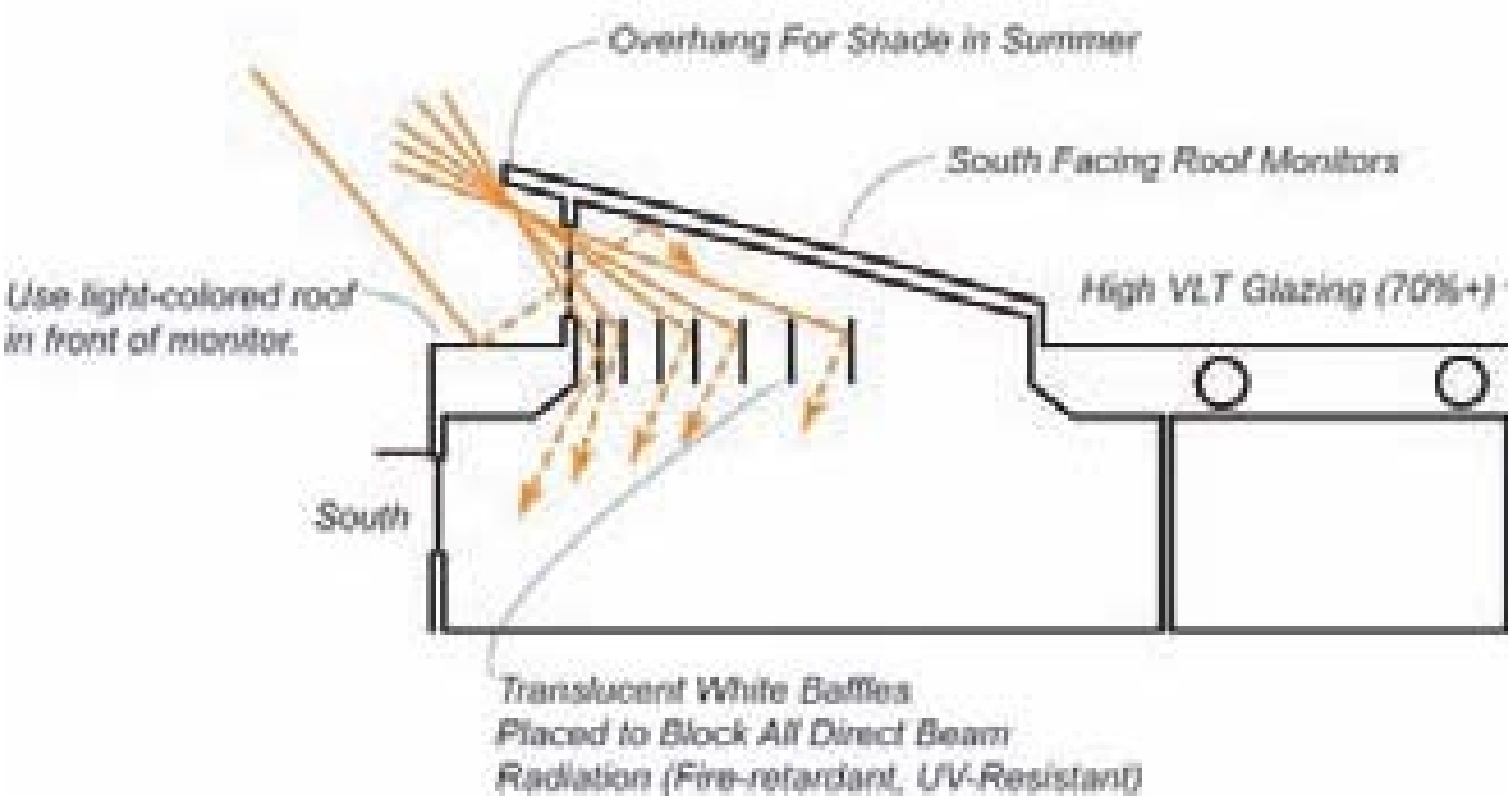


Lightshelf detail



Chapter 3: Recommendations by Climate

Classroom toplighting alternate



Chapter 3: Recommendations by Climate

- **Gym with toplighting**

Chapter 4-5: Examples and How-to Tips

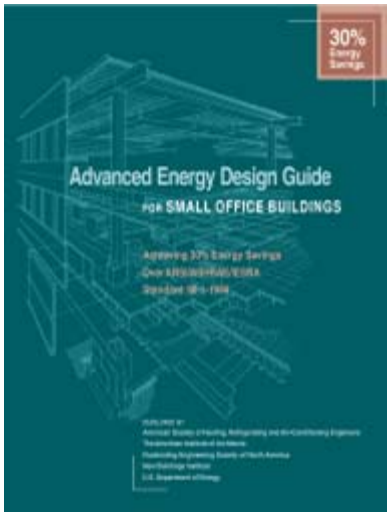
For more examples and more how-to tips:

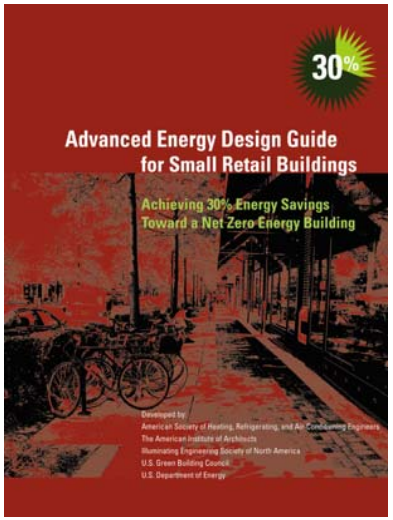
- **Chapter 4:**
  Technology Examples and Case Studies

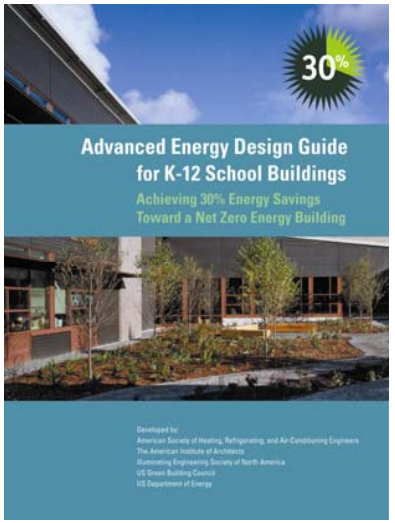
- **Chapter 5:**
  How-to Tips to Implement Recommendations

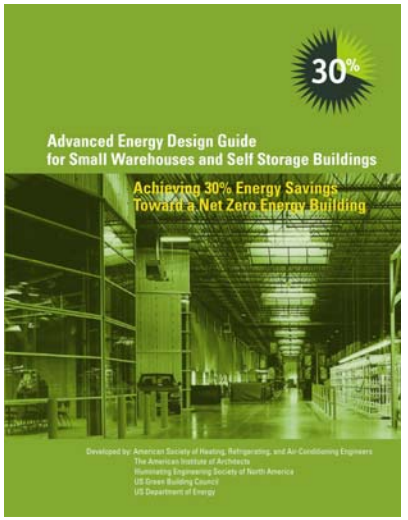
Downloads

- **www.ashrae.org/aedg**









Questions

- If you have a question and you haven’t submitted it yet, please do so now using your computer