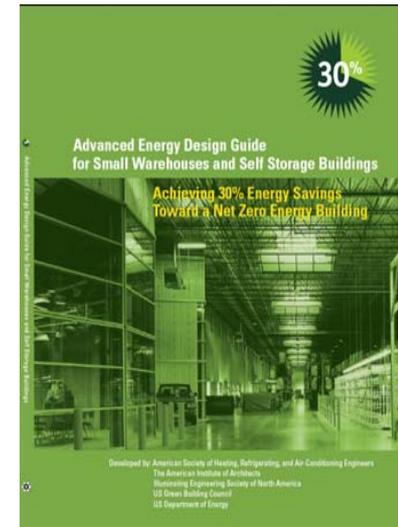
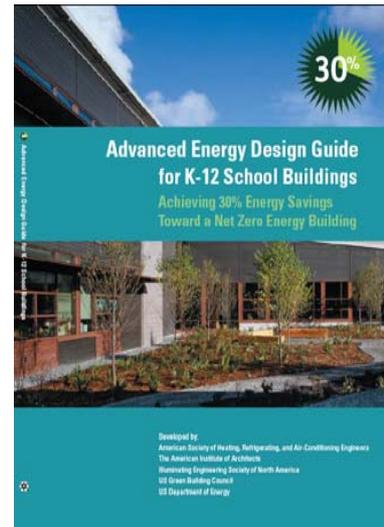
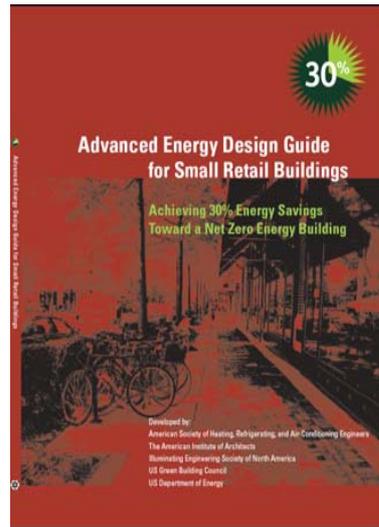
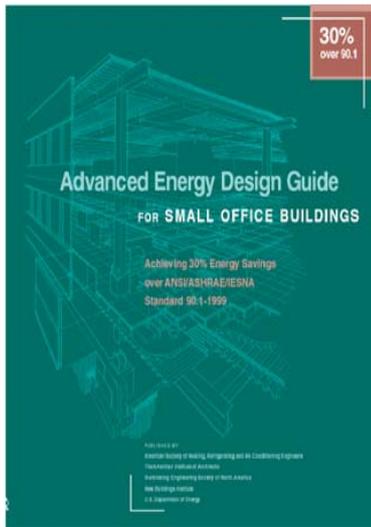




[www.ashrae.org/aedg](http://www.ashrae.org/aedg)

# AEDG Advanced Energy Design Guides



[lightingdesignlab.com](http://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.

- » [michael@lightingdesignlab.com](mailto:michael@lightingdesignlab.com)
- » 1-800-354-3864 x26
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lighting design lab



# 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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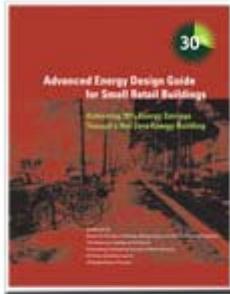
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### Overview/Purpose

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 ANSVASHRAE/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.

ANSVASHRAE/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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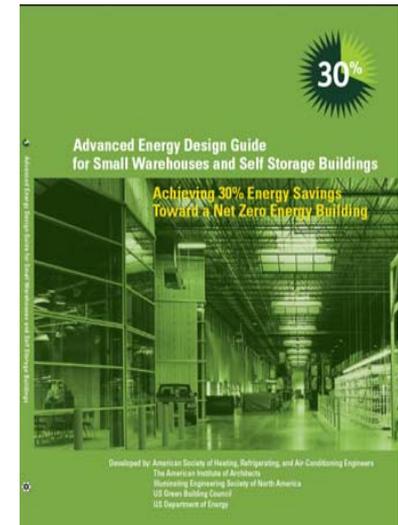
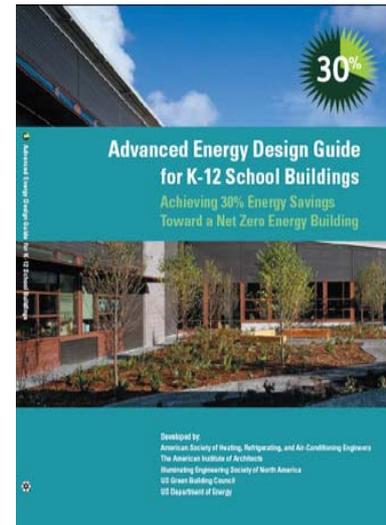
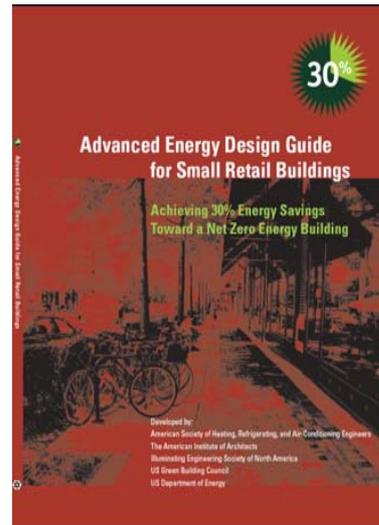
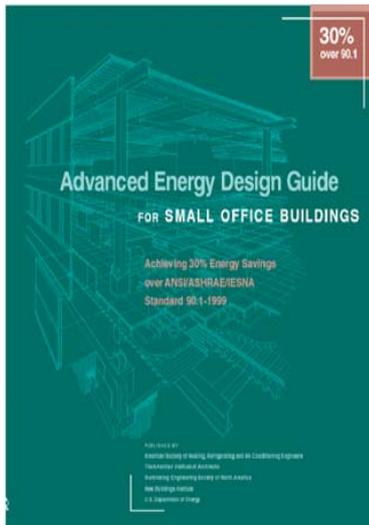
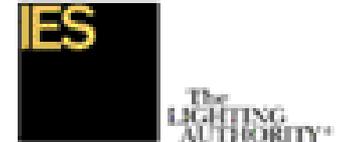
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# Timeline & Goals

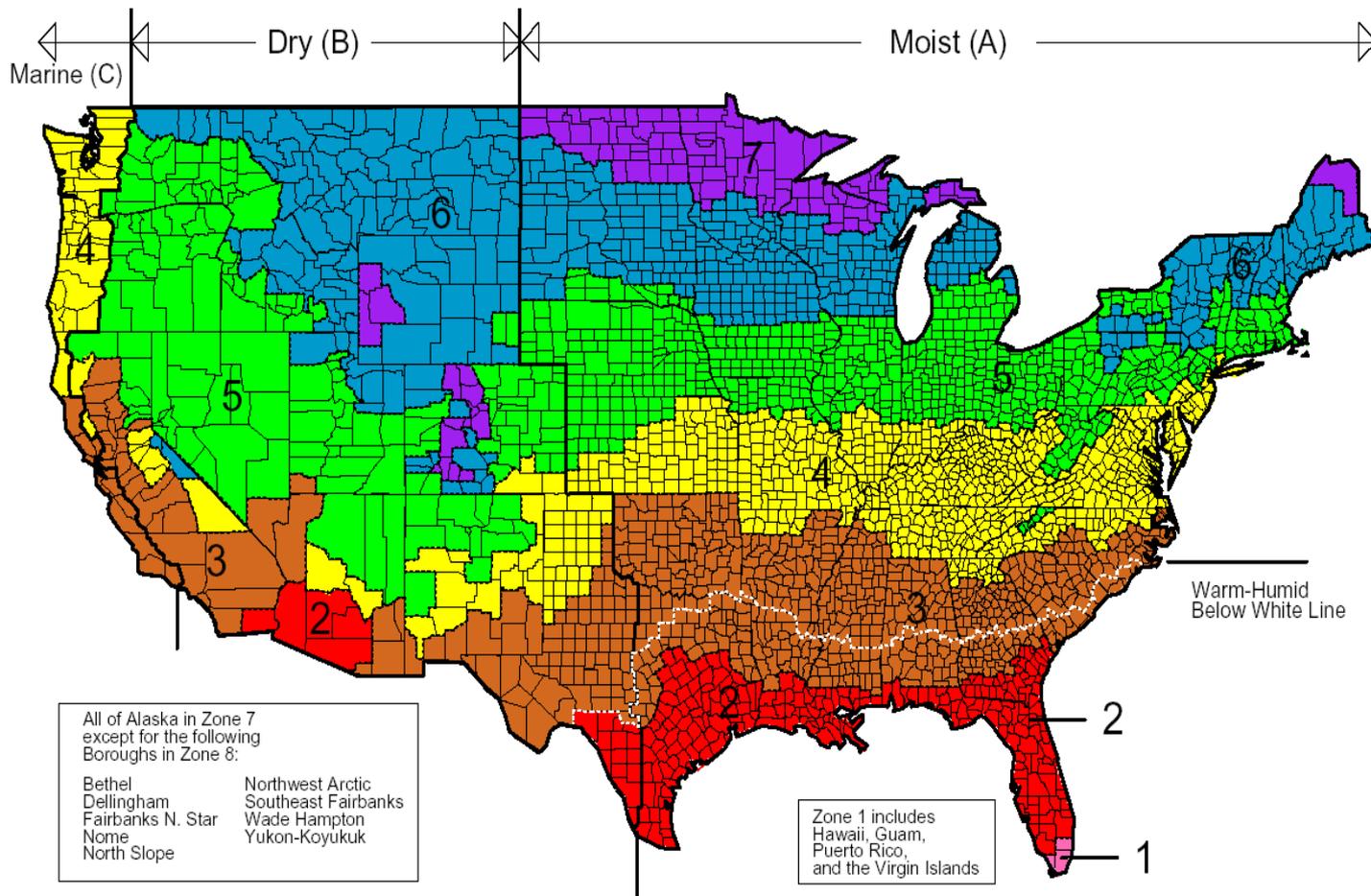
- » **Complete document in 1 year**
- » **30% energy savings relative to buildings constructed to meet the energy requirements of Standard 90.1-1999**
- » **Savings to be achieved in each climate location (not simply an average)**
- » **Hard goal of 30% to be consistent with LEED® rating system**
- »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

# Contents

- » **Chapter 1 Introduction**
- » **Chapter 2 Process for Achieving Energy Savings**
- » **Chapter 3 Recommendations by Climate**
- » **Chapter 4 Technology Examples and Case Studies**
- » **Chapter 5 How to Implement Recommendations**
  - » *Quality Assurance*
  - » *Envelope*
  - » *Lighting*
  - » *HVAC*
  - » *Service Water Heating*
  - » *Bonus Savings*

# USDOE - 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

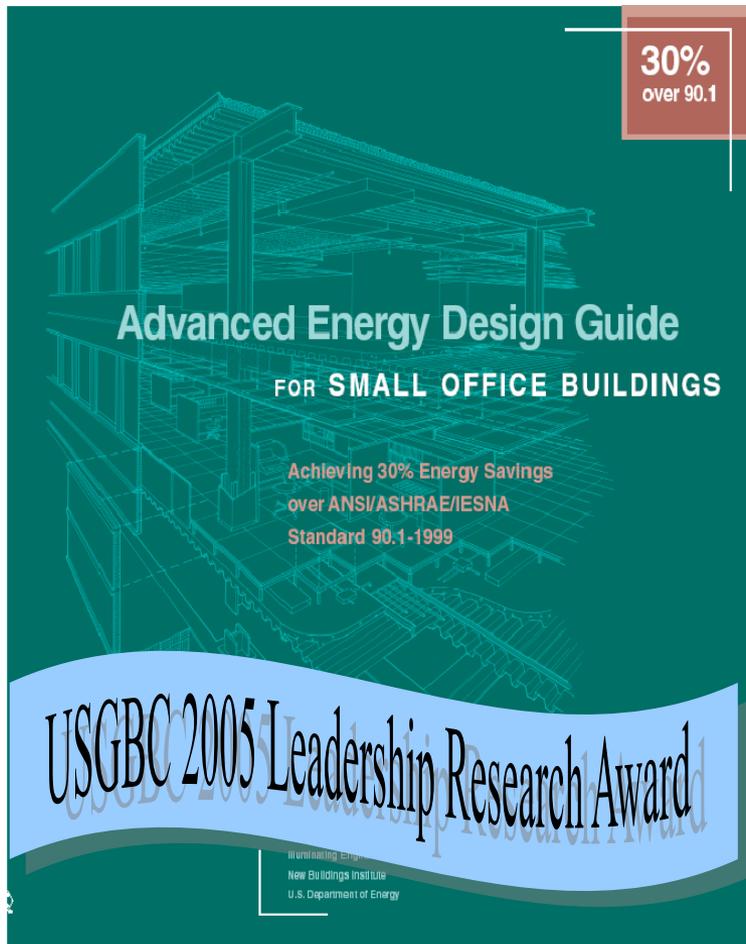
Item	Component	Recommendation	How-To's in Chapter 4
Roof	Insulation entirely above deck	R-20 c.i.	EN2, 17, 20-21
	Metal building	R-13 + R-19	EN3, 17, 20-21
	Attic and other	R-38	EN4, 17-18, 20-21
	Single rafter	R-38	EN5, 17, 20-21
	Surface reflectance/emittance	No recommendation	
Walls	Mass (HC > 7 Btu/ft <sup>2</sup> )	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 <sub>x</sub> —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

Envelope

Lighting	Interior Lighting	Lighting power density (LPD)	0.9 W/ft <sup>2</sup>	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 <sub>t</sub>	HV1- 2, 6, 16, 20
		Gas furnace (0-225 KBtuh - Split)	80% AFUE or E <sub>t</sub>	HV1- 2, 6, 16, 20
		Gas furnace (>225 KBtuh)	80% E <sub>c</sub>	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 <sub>2</sub> 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 <sub>t</sub>	WH1-4
		Gas instantaneous	0.81 EF or 81% E <sub>t</sub>	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<sup>2</sup> 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](http://www.ashrae.org/aedg).**

# Where is the Energy Used?

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

	<i>Location</i>	<i>Climate Zone</i>	<i>Lighting</i>	<i>Cooling</i>	<i>Heating</i>	<i>Fans</i>	<i>SWH</i>	<i>Plugs</i>	<i>Aux</i>	<i>Total</i>	<i>Savings w/ Plug</i>	<i>Savings wo Plug</i>
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%
	<i>Savings over Base</i>		28.4	5.8	121.6	12.6	8.3	0.0	0.0	176.7		
	<i>Savings % over Base</i>		36.6%	52.3%	54.2%	31.0%	56.8%	0.0%	0.0%	43.3%		
	<i>% savings</i>		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%
	<i>Savings over Base</i>		28.4	27.8	0.0	7.1	6.9	0.0	0.0	70.2		
	<i>Savings % over Base</i>		36.6%	36.8%	0.0%	22.0%	67.0%	0.0%	0.0%	29.9%		
	<i>% savings</i>		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%
	<i>Savings over Base</i>		28.4	30.3	0.1	8.5	7.2	0.0	0.0	74.5		
	<i>Savings % over Base</i>		36.6%	40.6%	9.1%	20.5%	66.7%	0.0%	0.0%	30.4%		
	<i>% savings</i>		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%
	<i>Savings over Base</i>		28.4	6.7	6.1	3.6	8.1	0.0	0.0	52.9		
	<i>Savings % over Base</i>		36.6%	53.6%	15.4%	14.8%	60.9%	0.0%	0.0%	25.6%		
	<i>% savings</i>		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<sup>2</sup>*
  - » *2004 Standard = 1.0 w/ft<sup>2</sup>*
- » **Recommendation for high performance lamps, which reduced the LPD to 0.9 w/ft<sup>2</sup>**
- » **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

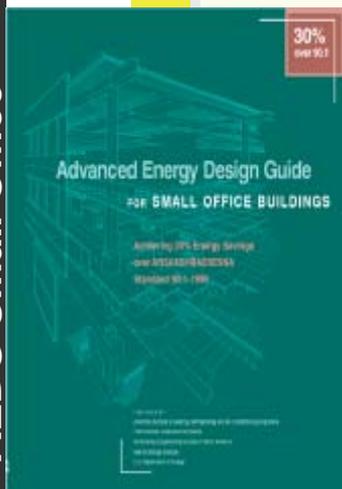
- » **“Premium / Super / Enhanced”:**
  - » *Initial lumens 3,100*
  - » *Maintained lumens 2,915*  
*Slightly higher L/W than standard T8 (91 vs 88)*
  - » *Provide 85 or greater Color Rendering Index*
  - » *Achieve a rated life of 24,000 hours or greater (under standard testing procedures)*



# Lighting Recommendations

## Climate Zone 4 Recommendation Table

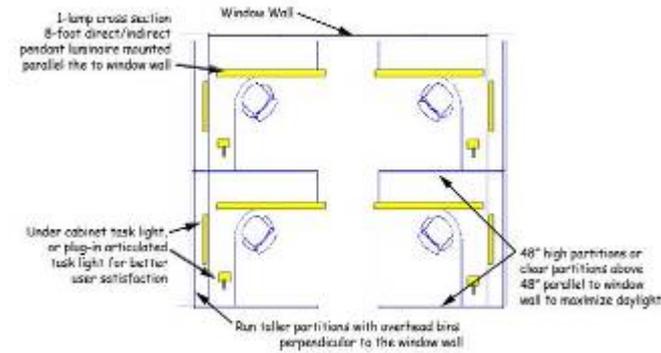
Item	Component	Recommendation
Lighting	Lighting power density (LPD)	0.9 W/ft <sup>2</sup>
	Light source (linear fluorescent)	90 mean lumens/watt
	Ballast	Electronic ballast
	Dimming controls for daylight Harvesting for WWR 25% or higher	Dim fixtures within 12 ft of N/S window wall or within 8 ft of skylight 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

# AEDG - Spaces



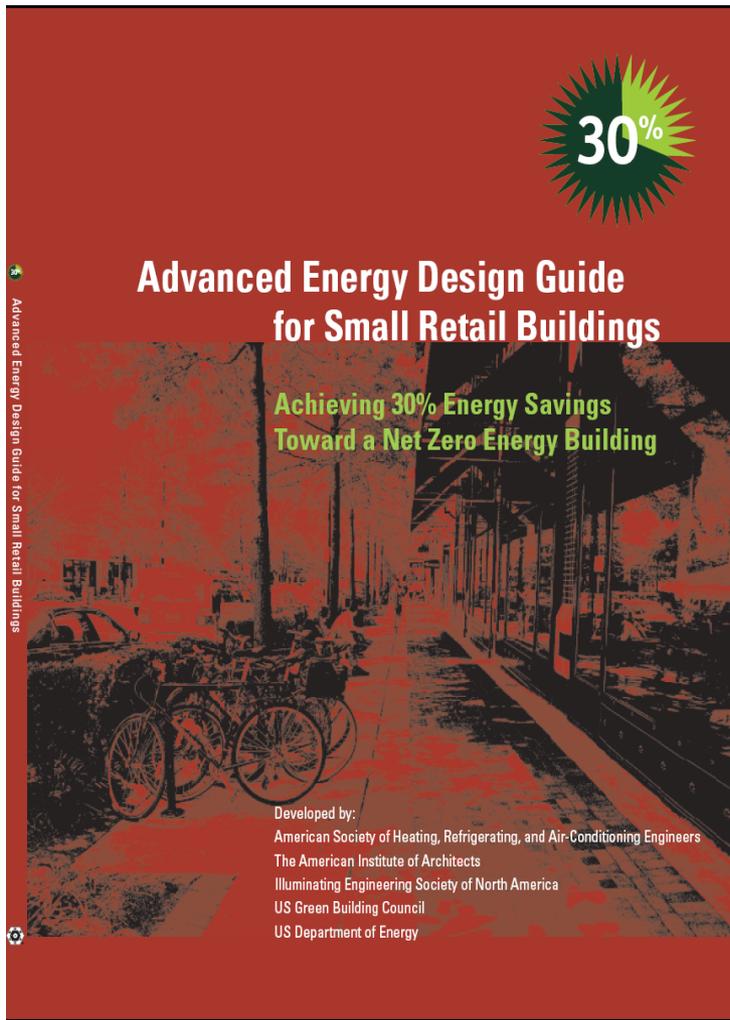
Space Type	Floor space allocation	LPD	LPD*area
Corridor/Transition	10%	0.55	0.055
Other Areas	10%	0.75	0.075
Lobby	10%	1.09	0.109
Office - enclosed	25%	0.94	0.235
Office - open plan	20%	1.03	0.206
Conference Meeting/Multipurpose	10%	1.02	0.102
Active storage	15%	0.78	0.117
	100.0%		0.899

**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<sup>2</sup> 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](http://www.ashrae.org/aedg).

# Lighting Technologies

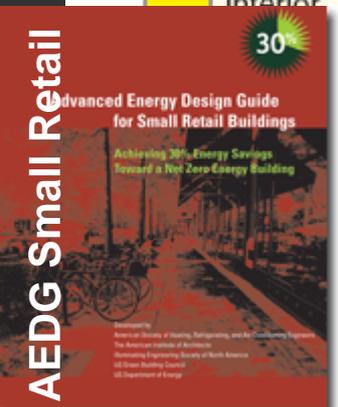
- » **Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2004) as the advanced case**
  - » *1999 Standard = 1.9 w/ft<sup>2</sup>*
  - » *2004 Standard = 1.7 w/ft<sup>2</sup>*
- » **Recommendation for high performance lamps and high-performance ballasts**
- » **Ceramic Metal Halide accent lighting**
- » **Occupancy 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			

# Lighting Recommendation

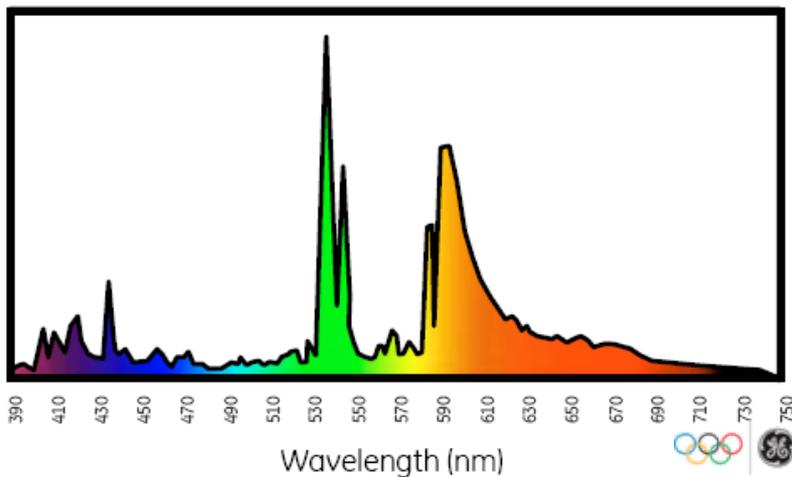
Item	Component	Recommendation (Minimum or Maximum)
Lighting	Interior Lighting	Lighting power density (LPD)
		1.3 W/ft <sup>2</sup>
		Linear fluorescent with high-performance electronic ballast
		91 mean lm/W
		All other sources
		50 mean lm/W
	Dimming controls for daylight harvesting under skylights	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 Lighting	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 <sup>2</sup> (spaces not listed below)
		0.6 W/ft <sup>2</sup> (sporting goods, small electronics)
		0.9 W/ft <sup>2</sup> (furniture, clothing, cosmetics, and artwork)
		1.5 W/ft <sup>2</sup> (jewelry, crystal, china)
Sources	Halogen IR or CMH	
	Façade and externally illuminated signage	0.2 W/ft <sup>2</sup>



Courtesy ASHRAE

# Ceramic Metal Halide

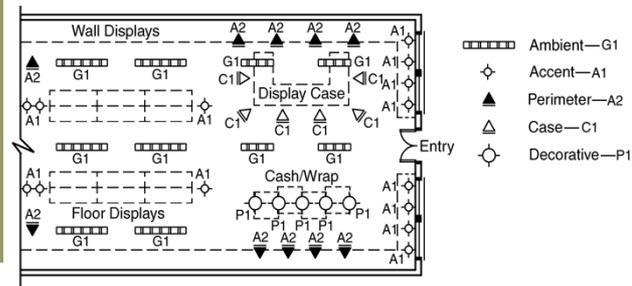
Spectral Power Distribution 3000K



**PHILIPS**

		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<sup>2</sup> or
- (2) 3.9 W/ft<sup>2</sup> 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
<b>0.8</b>	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
<b>1.6</b>	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
<b>2.75</b>	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
<b>3.9</b>	2.73
	4.55

<b>Base Lighting LPD (2004 Standard)</b>	<b>Space allocation</b>	<b>50% accent at 1.6</b>	
<b>Merchandising Sales Area</b>	70%	1.7	1.19
<b>Active storage</b>	20%	0.8	0.16
<b>Office</b>	5%	1.1	0.06
<b>Other spaces</b>	5%	1	0.05
			1.46
<b>Feature lighting</b>	70%	<b>0.8</b>	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<sup>2</sup> **times the area of specific display** or
- (2) 3.9 W/ft<sup>2</sup> **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

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

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

<b>accent at 0.58</b>	
1.51	1.06
0.65	0.13
0.95	0.05
1	0.05
	1.28
<b>0.58</b>	0.41
	1.69

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

<b>accent at 1.42</b>	
1.51	1.06
0.65	0.13
0.95	0.05
1	0.05
	1.28
<b>1.42</b>	0.99
	2.27

# IESNA RP-2 Table 2

RP-2 Table 2: Lighting Design Guide for Merchandising and Associated areas				
	Circulation	General	Perimeter	Feature Display
Grocery and Supermarket / Warehouse Store / Discount / Drug and Convenience / Mass Merchant - <b>Low</b>	20 - 25	50 - 75	50 - 75	200 - 375
Grocery and Supermarket / Warehouse Store / Discount / Drug and Convenience / Mass Merchant - <b>High</b>	30	60 - 100	85 - 100	500 - 850 (300)
Department / Speciality Retailer / Home and Bath Bedding - <b>Low</b>	20	40	50	200
Department / Speciality Retailer / Home and Bath Bedding - <b>High</b>	25	50	75	350
Upscale Department / Upscale Specialty - <b>Low</b>	15	30	40	150
Upscale Department / Upscale Specialty - <b>High</b>	20	40	80	400 (200)
Designer Shop or Boutique / Furniture / Fine and Precious Jewellery / Upscale Crystal, China or Silver - <b>Low</b>	8	20	20	100
Designer Shop or Boutique / Furniture / Fine and Precious Jewellery / Upscale Crystal, China or Silver - <b>High</b>	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<sup>2</sup> (the floor area for all products not listed below)*
- » *1.7 W/ft<sup>2</sup> (the floor area used for the sale of vehicles, sporting goods and small electronics)*
- » *2.6 W/ft<sup>2</sup> (the floor area used for the sale of furniture, clothing, cosmetics and artwork)*
- » *4.2 W/ft<sup>2</sup> (the floor area used for the sale of jewelry, crystal, and china)*

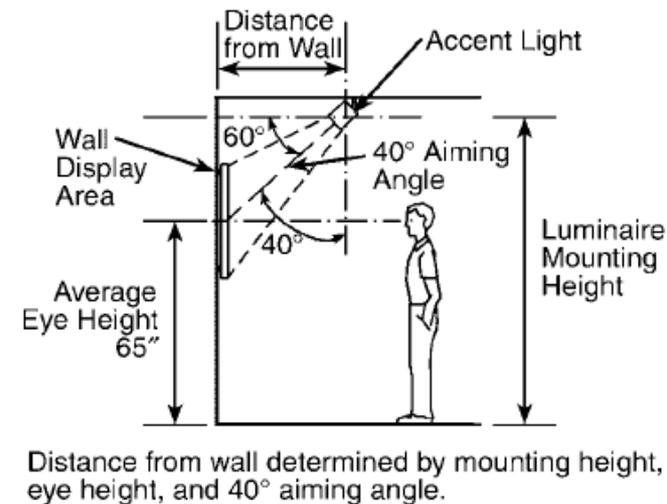
## 90.1 2004 Additional Interior Lighting Power

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

# Additional Interior Lighting/Accent Lighting

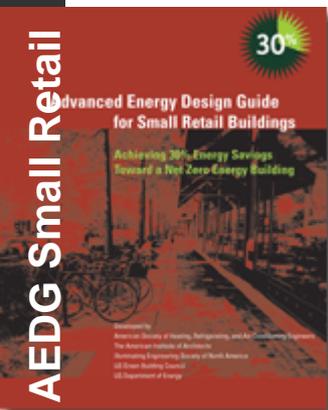
» The following additional lighting power densities (LPDs), from the Recommendation Tables in Chapter 3, are available for adjustable lighting equipment that is specifically designed and directed to highlight merchandise (accent lighting) above and beyond the base 1.3 W/ft<sup>2</sup> allowance.

- » 0.4 W/ft<sup>2</sup> (spaces not listed below)
- » 0.6 W/ft<sup>2</sup> (sporting goods, small electronics)
- » 0.9 W/ft<sup>2</sup> (furniture, clothing, cosmetics, and artwork)
- » 1.5 W/ft<sup>2</sup> (jewelry, crystal, china)



CMH	51.67	lpw
Halogen	18.75	lpw
Halogen/CMH	0.36	

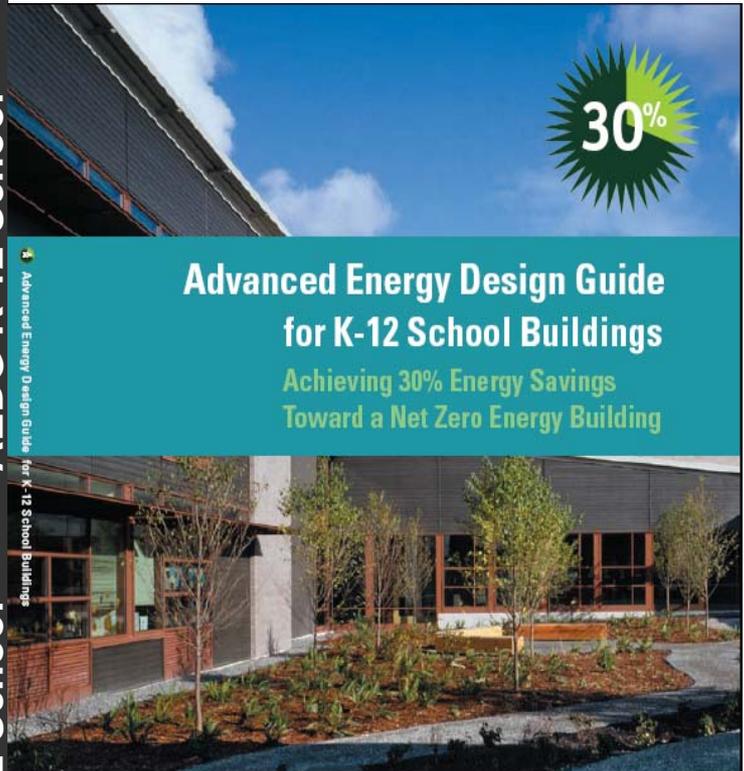
Courtesy ASHRAE



# 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

A green sunburst graphic with the text "30%" in white, indicating energy savings.The cover of the "Advanced Energy Design Guide for K-12 School Buildings" features a photograph of a modern school building with large windows and a landscaped courtyard. A teal banner across the middle contains the title and subtitle. A green sunburst graphic with "30%" is in the top right corner.

**Advanced Energy Design Guide  
for K-12 School Buildings**  
Achieving 30% Energy Savings  
Toward a Net Zero Energy Building

Developed by:  
American Society of Heating, Refrigerating, and Air-Conditioning Engineers  
The American Institute of Architects  
Illuminating Engineering Society of North America  
US Green Building Council  
US Department of Energy

- » **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](http://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<sup>2</sup>*
  - » *2004 Standard = 0.9 to 1.2 w/ft<sup>2</sup>*
- » **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/ft <sup>2</sup> 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/ft <sup>2</sup>	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 Zone 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/ft <sup>2</sup> 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/ft <sup>2</sup>	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 Zone 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/ft <sup>2</sup> 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/ft <sup>2</sup>	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	

# 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



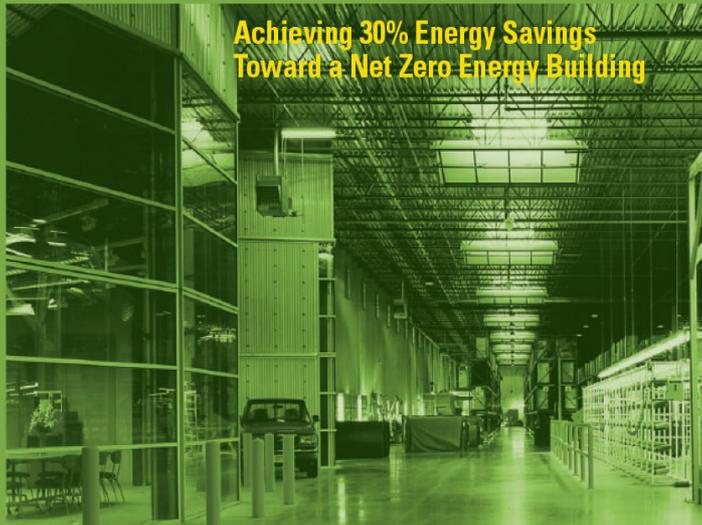
Meets 75 and 85 MLPW efficacy

# AEDG for Small Warehouses Buildings

30%

Advanced Energy Design Guide  
for Small Warehouses and Self Storage Buildings

Achieving 30% Energy Savings  
Toward a Net Zero Energy Building



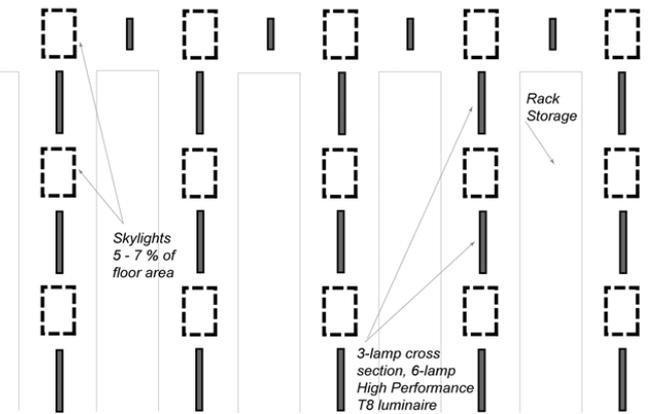
Developed by: American Society of Heating, Refrigerating, and Air-Conditioning Engineers  
The American Institute of Architects  
Illuminating Engineering Society of North America  
US Green Building Council  
US Department of Energy

- » **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<sup>2</sup> 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](http://www.ashrae.org/aedg).**

# Lighting and Daylighting Technologies

- » **Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2004) as the advanced case**
  - » *1999 Standard = 1.2 w/ft<sup>2</sup>*
  - » *2004 Standard = 0.8 w/ft<sup>2</sup>*
- » **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 <sup>2</sup> Warehouse (fine storage) = 0.85 W/ft <sup>2</sup> Office area = 0.9 W/ft <sup>2</sup>		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 <sup>2</sup>		EL19–21

**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			
<b>Total</b>		<b>52,411</b>	<b>\$6,289</b>

**Skylighting System Description**

Skylight unit size (ft <sup>2</sup> )	32.0
Number of Skylights	65
Total Skylight Area (ft <sup>2</sup> )	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 <sup>2</sup> )

**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			
<b>Total</b>		<b>51,997</b>	<b>\$6,240</b>

**Skylighting System Description**

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

**Site Description**

Climate Location	Phoenix.wea3
Climate Zone	CZ2 (hot, 6,300 < CDE
Building Type	Warehouse
Building Area	35,100 (ft <sup>2</sup> )

## 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			
<b>Total</b>		<b>41,856</b>	<b>\$5,023</b>

**Skylighting System Description**

Skylight unit size (ft <sup>2</sup> )	32.0
Number of Skylights	65
Total Skylight Area (ft <sup>2</sup> )	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 <sup>2</sup> )

## 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			
<b>Total</b>		<b>47,421</b>	<b>\$5,691</b>

**Skylighting System Description**

Skylight unit size (ft <sup>2</sup> )	32.0
Number of Skylights	65
Total Skylight Area (ft <sup>2</sup> )	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 <sup>2</sup> )

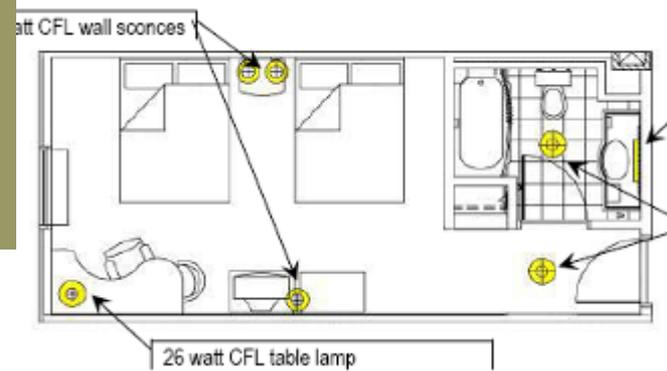
# Additional AEDG Guides

- » **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<sup>2</sup>*
  - » *2004 Standard = 1.0 w/ft<sup>2</sup>*
- » **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 <sup>2</sup>	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 <sup>2</sup>	0.10 W/ft <sup>2</sup>
		Walkways less than 10 feet wide	0.7 W/lf	0.8 W/lf
		Walkways 10 feet wide or greater	0.14 W/ft <sup>2</sup>	0.16 W/ft <sup>2</sup>
Entry Canopies		0.25 W/ft <sup>2</sup>	0.4 W/ft <sup>2</sup>	
Façade (use wattage only for façade)	0.10 W/ft <sup>2</sup>	0.15 W/ft <sup>2</sup>		

# AEDG Lodging

» **2004 = 9286 watts**

» *AEDG Zone 3 = 5650 watts*

» *AEDG Zone 2 = 3500 watts*

» *AEDG Zone 1 = 2550 watts*

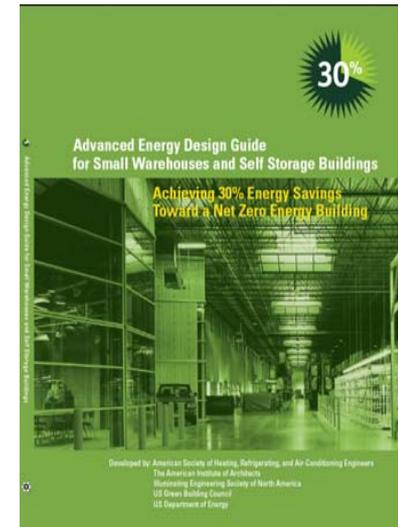
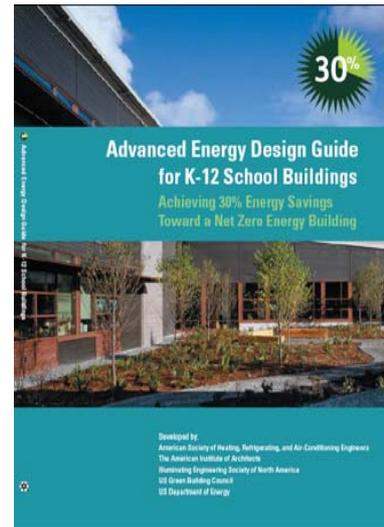
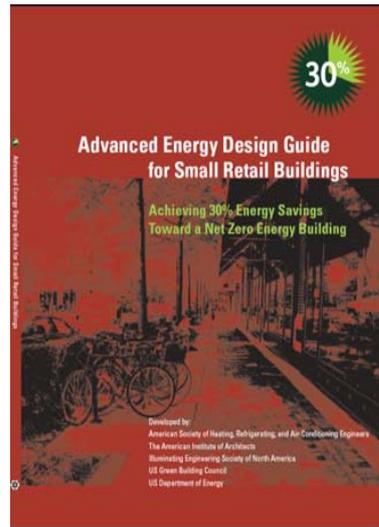
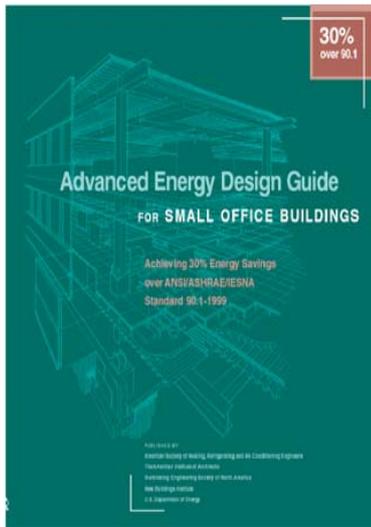
» **with façade lighting - 2004 = 13850 watts**

» *AEDG Zone 3 = 9070 watts*

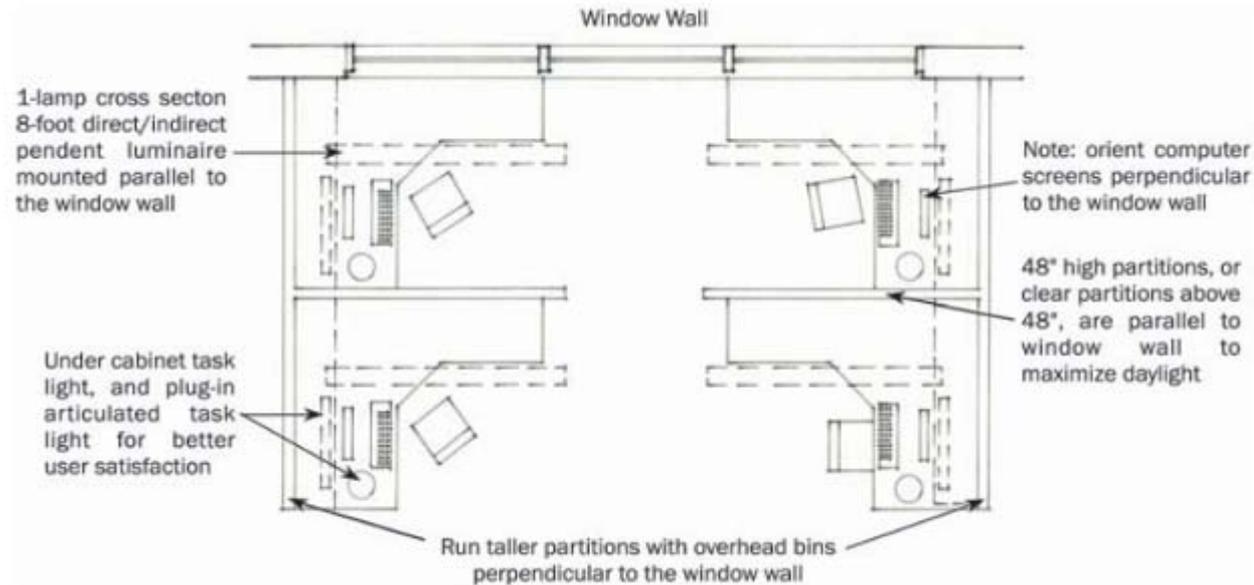
» *AEDG Zone 2 = 5780 watts*

» *AEDG Zone 1 = 2550 watts*

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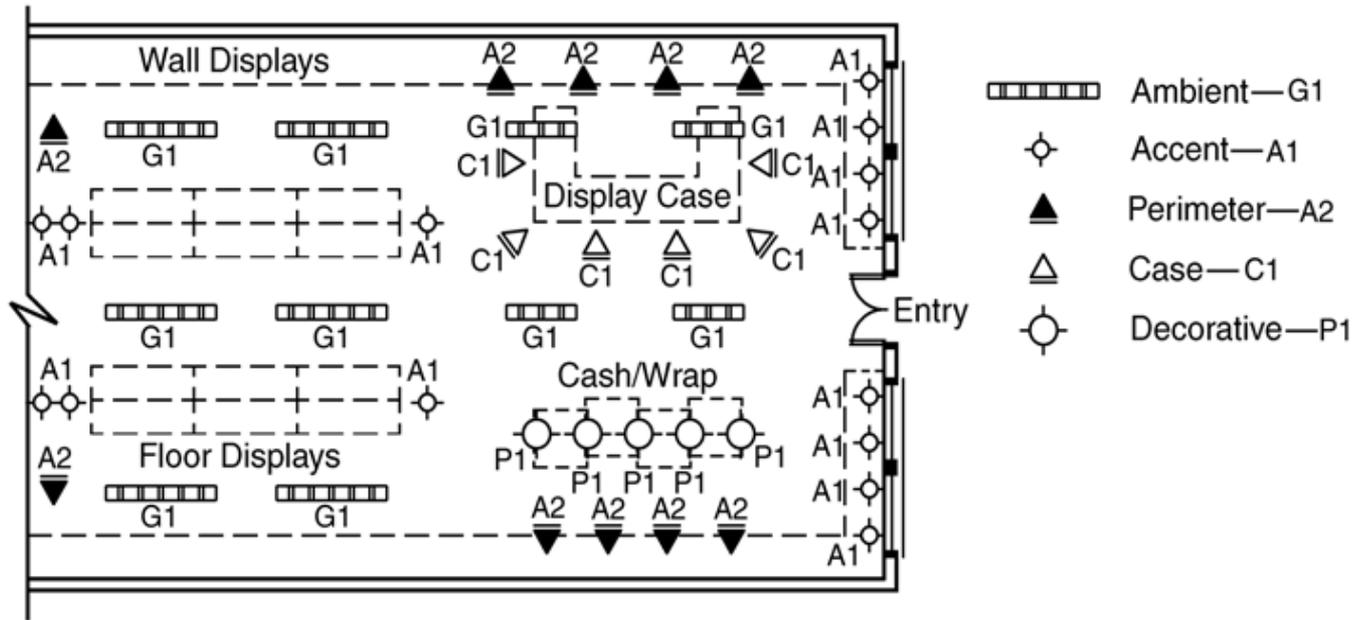
# EL11 Open Plan Office



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 by a combination of the ambient and supplemental task lighting.

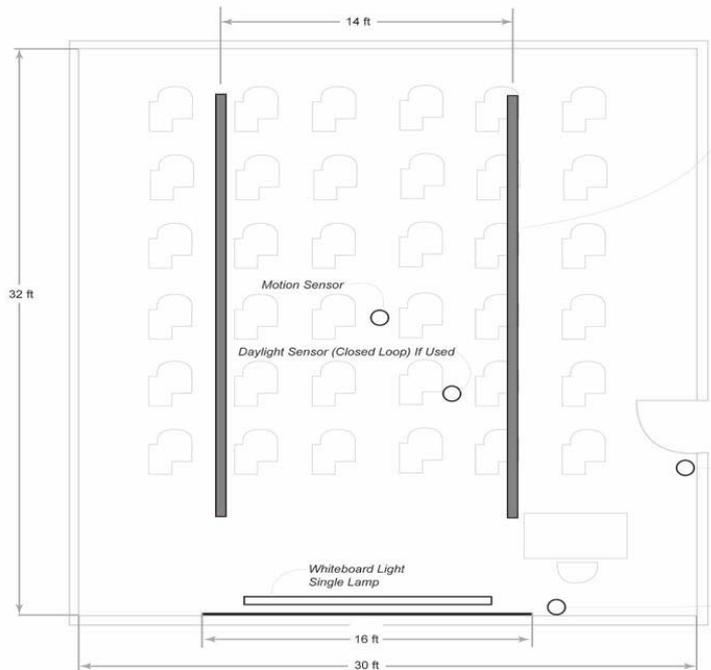
Open plan offices account for approximately 20% of the floor area. Assuming an 8 foot by 8 foot work station and a 4 foot center aisle, this layout is about 1.03 W/ft<sup>2</sup> including task lighting wattage. Use daylight dimming ballasts and photocell control in daylight zone (within 12 feet of window wall) if WWR is greater than 25% in this area. Use occupancy sensor local control or scheduling on all luminaires.

# EL19 General Lighting in Merchandise Sales Areas



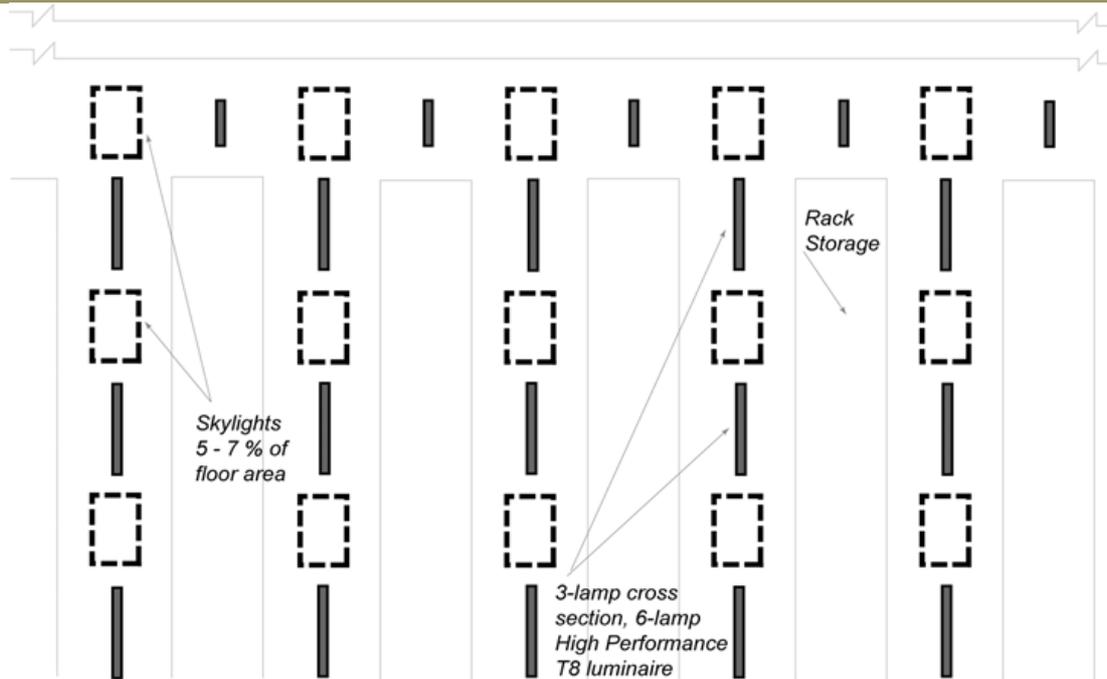
The general lighting (fixture type G1 in Figure 5-23) at 1.5 W/ft<sup>2</sup> provides the base level of lighting for the merchandise. The spill light from the merchandise will provide adequate lighting for the circulation paths. Also included in the base allowances is decorative/focus lighting at the sales transaction counter—this may be provided by pendants over (fixture type P1 in Figure 5-23) and wall lighting behind (fixture type A2 in Figure 5-23) the counter.

# EL10 Classroom Lighting



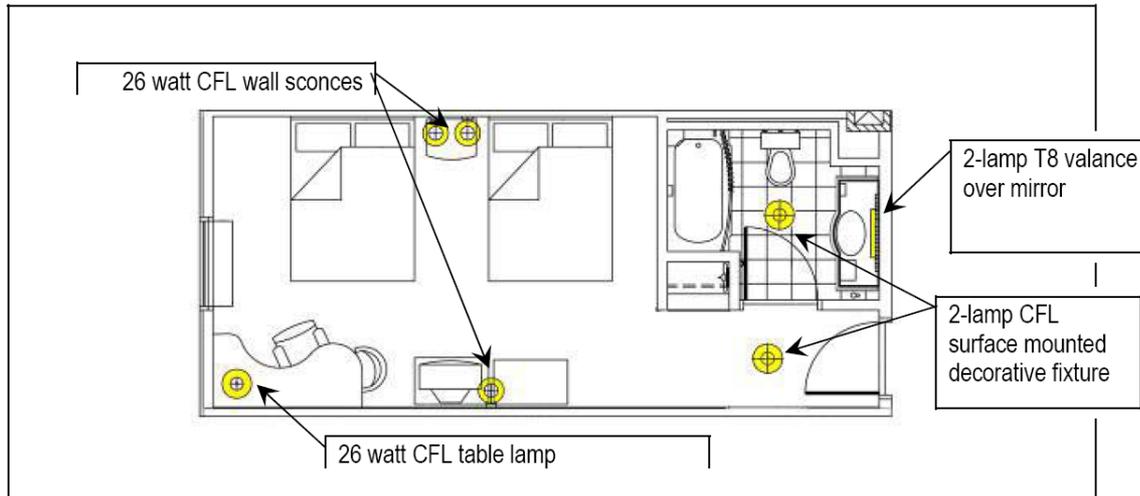
For best results, provide a flat, white acoustical tile or gypsum board ceiling at least 9 ft 6 in. above the finished floor with a direct/indirect suspended lighting system. By using a classroom lighting system designed for this application, including energy efficient ballasts and controls (see EL2), the lighting system can operate at an LPD lower than 1.0 W/ft<sup>2</sup>, including supplemental whiteboard lighting. Choosing among the many options includes consideration of the grade level, teaching technology, budget, and whiteboard relevance.

# EL14 General Lighting in Bulky Storage Areas



The target lighting in the warehouse area is 10 average maintained *vertical* footcandles. To achieve the 10 average recommended vertical footcandles, design to 15 average maintained horizontal footcandles in the stack areas. Lay out skylights centered in the aisles to meet 5%–7% skylight-to-floor area (see EN19 for recommendations and DL4 for skylight layout recommendations). The typical layout shown in Figure 5-16 uses three-lamp cross section six-lamp high-performance T-8 luminaires spaced equally between the skylights (see DL7 for recommendations of photocell controls).

# EL13 General Lighting in Guest Rooms



The target LPD of 0.74 W/ft<sup>2</sup> in the guest room assumes a typical room of 350 sf and the lighting providing approximately 35 average maintained footcandles at the desk area and bedside table. The typical layout in Figure 5-14 uses 2-lamp 26 watt CFL surface decorative at the entry, two 26 watt CFL wall sconces at the bedside table plus one 26 watt CFL wall sconce near dresser/TV, and a 26 watt CFL table lamp on the desk. See HV14 for additional control recommendations.

Bathroom lighting is provided by a two lamp CFL surface decorative fixture for general area lighting and 2-lamp 3-foot T8 fluorescent valance over the mirror. See EL9 for information on vacancy sensor in the bathroom.

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