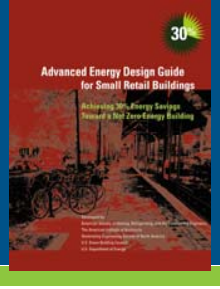

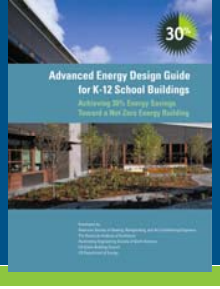

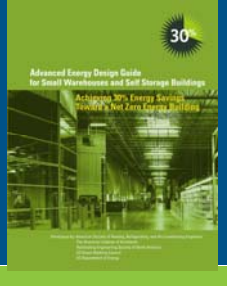

AEDG – Advanced Energy Design Guides:

Building Envelope

11 September 2008

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

Your Instructor

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  Seattle Dept of Planning & Development
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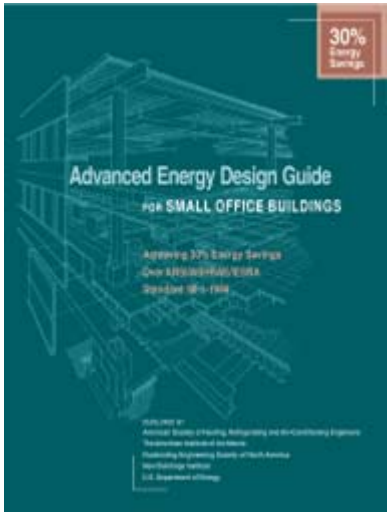
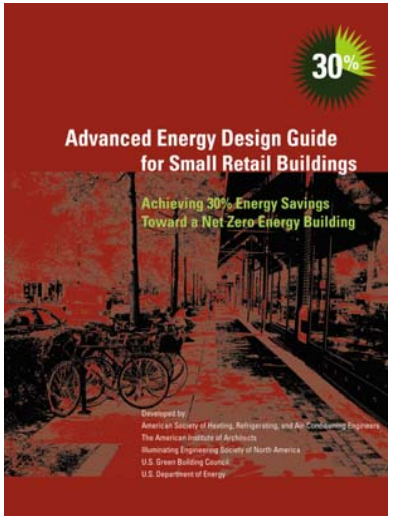
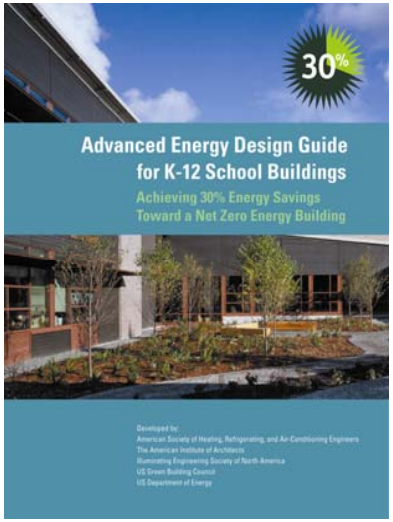
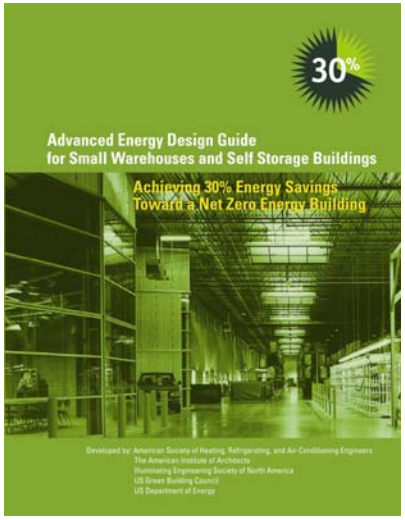
- Chair of ASHRAE SPC 189.1,
  Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
- Former chair of Envelope Subcommittee of ASHRAE SSPC 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*

Publications Available



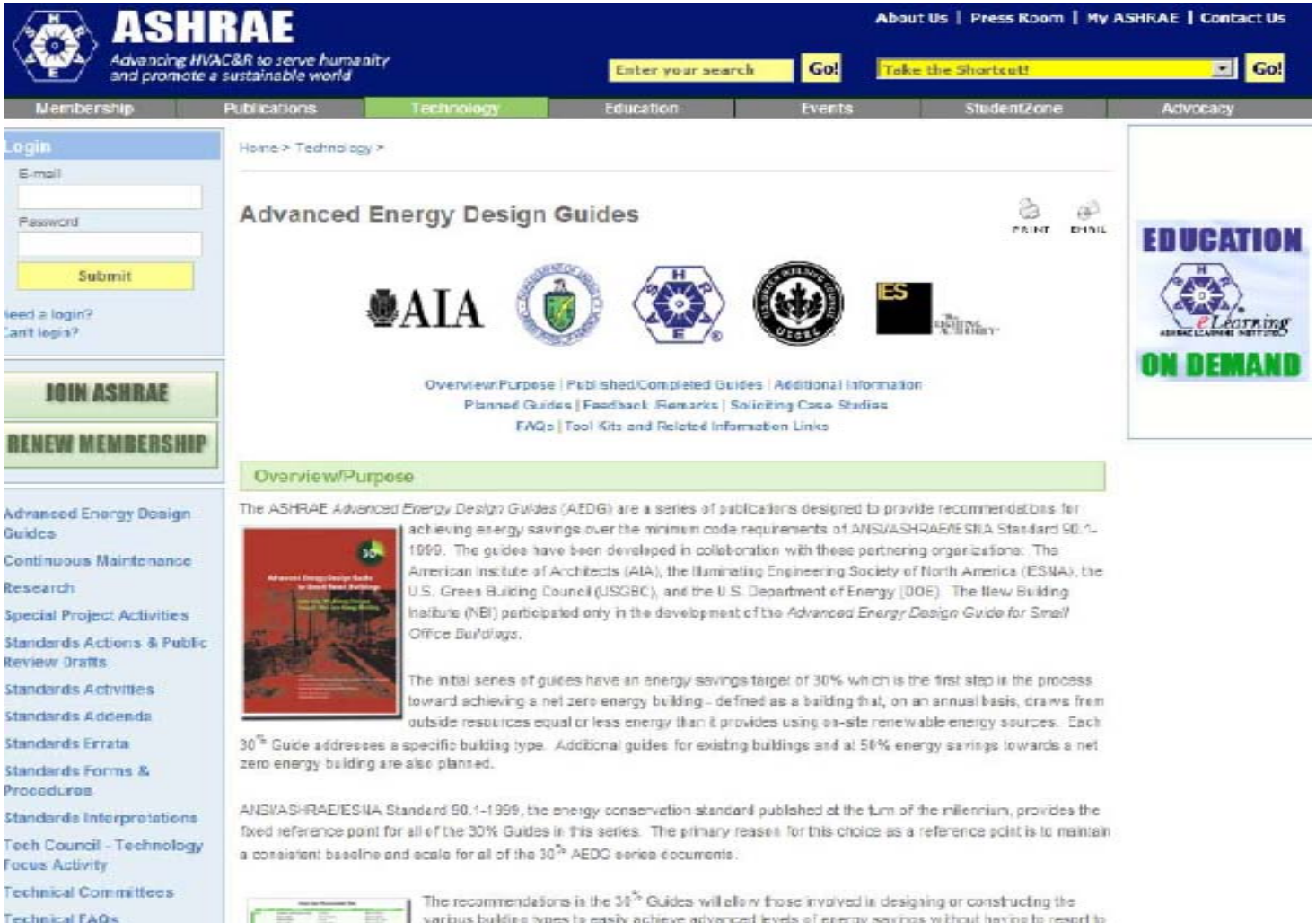






Homepage

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



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

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**

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

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

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

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

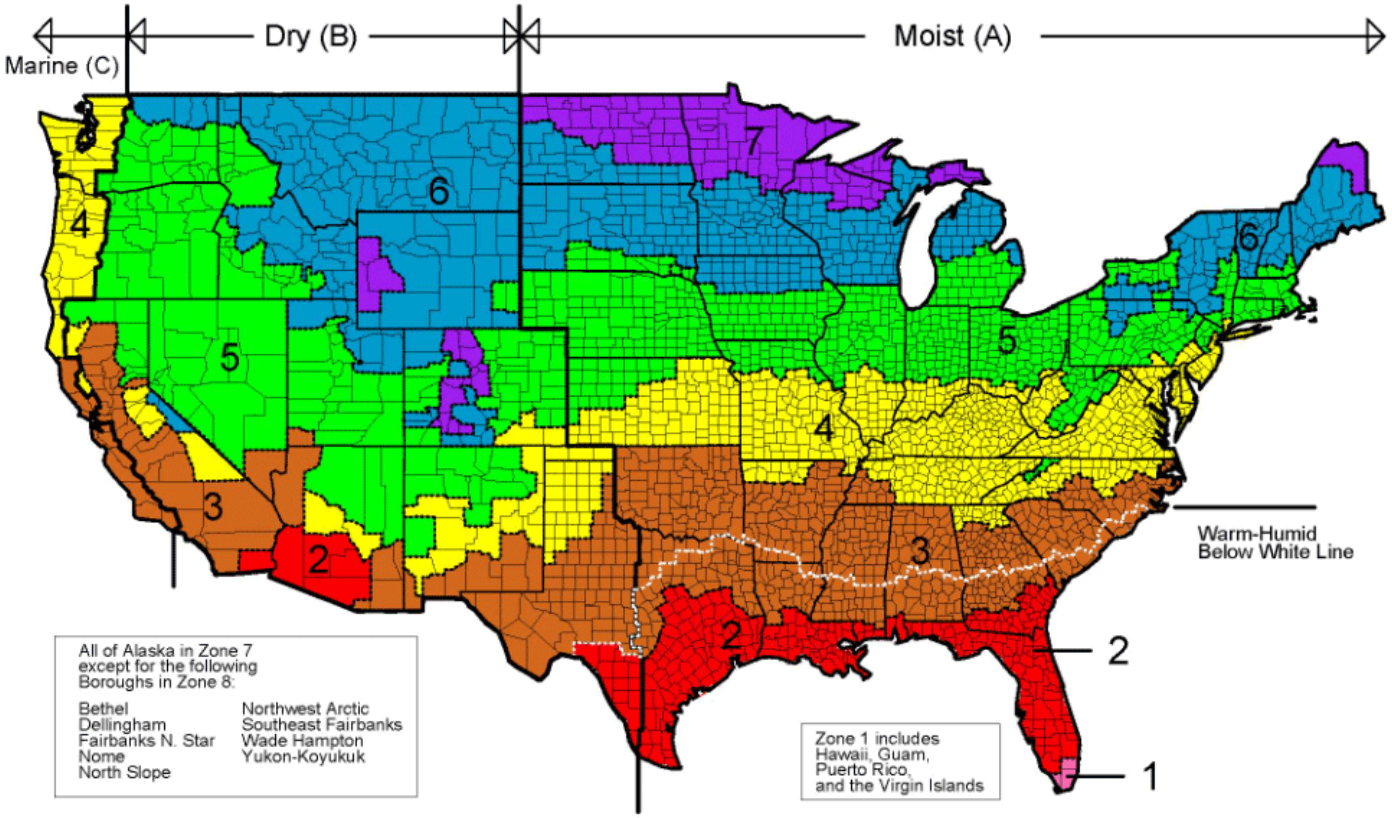
Chapter 3: Recommendations by Climate

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.



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

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

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

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

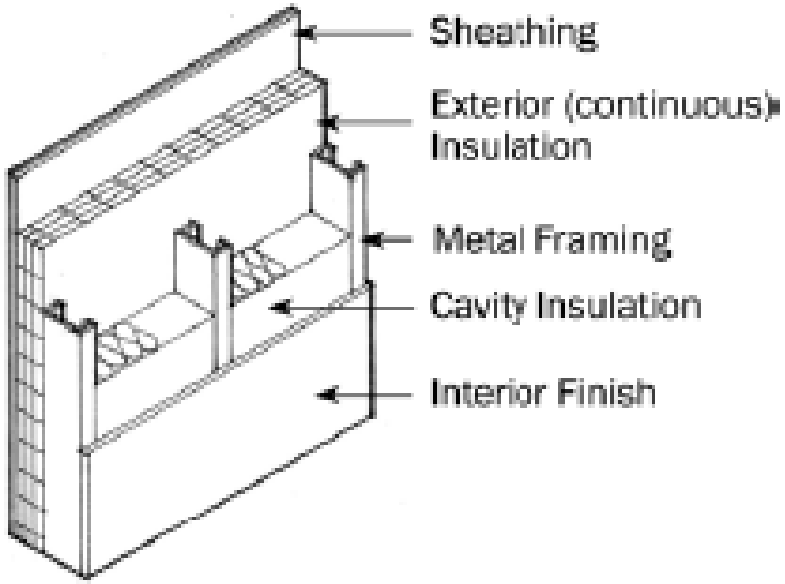
Roofs	Insulation entirely above deck	R-25 c.i.
	Attic and other	R-38
	Metal building	R-13 + R-13
	SRI	0.78
Walls	Mass (HC > 7 Btu/ft^2·°F)	R-7.6 c.i.
	Steel framed	R-13 + R-3.8 c.i.
	Wood framed and other	R-13
	Metal building	R-16
	Below-grade walls	Comply with Standard 90.1*
Floors	Mass	R-8.3 c.i.
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

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

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)



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

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)

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

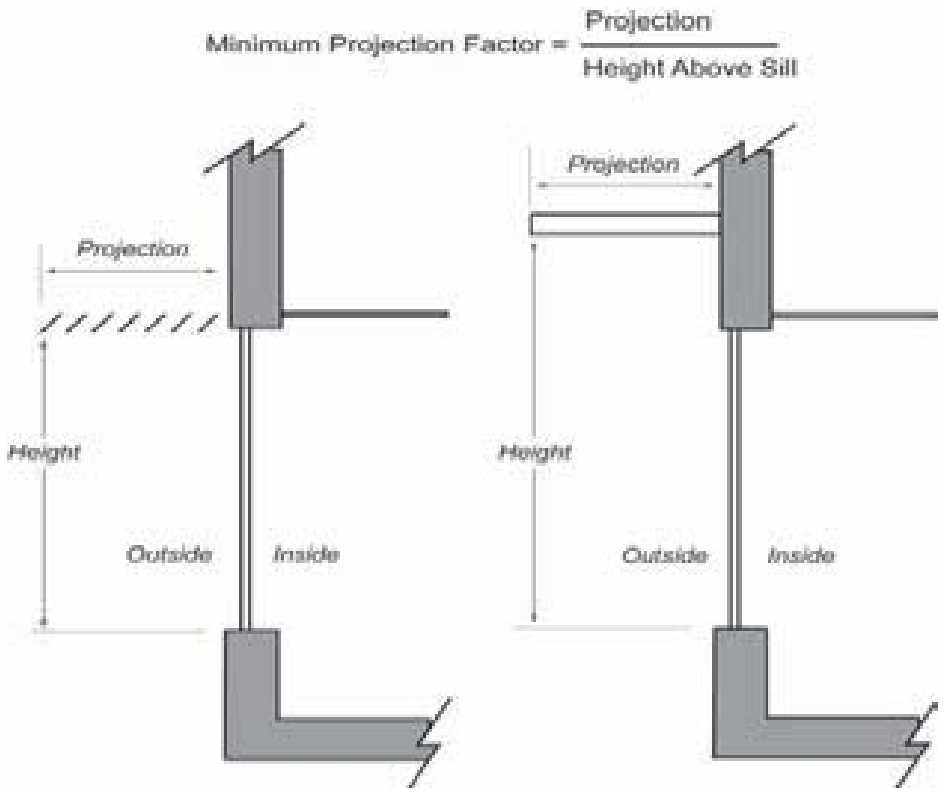
Independent Certification & Inspection Agency (IA): _____

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.



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

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

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

Window Orientation: all climate zones

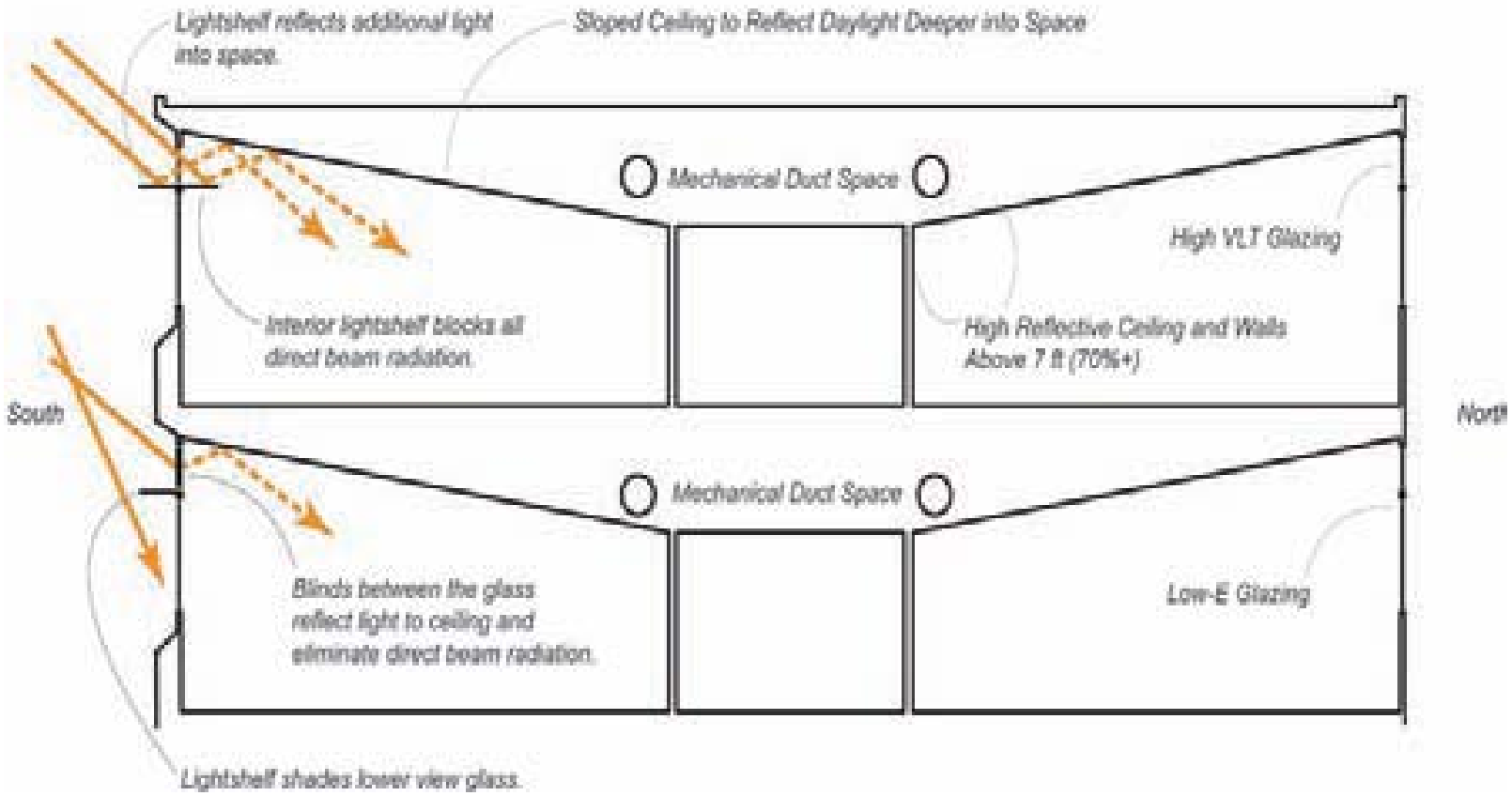
$$(A_N * SHGC_N + A_S * SHGC_S) > (A_E * SHGC_E + A_W * SHGC_W)$$

- 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)

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%

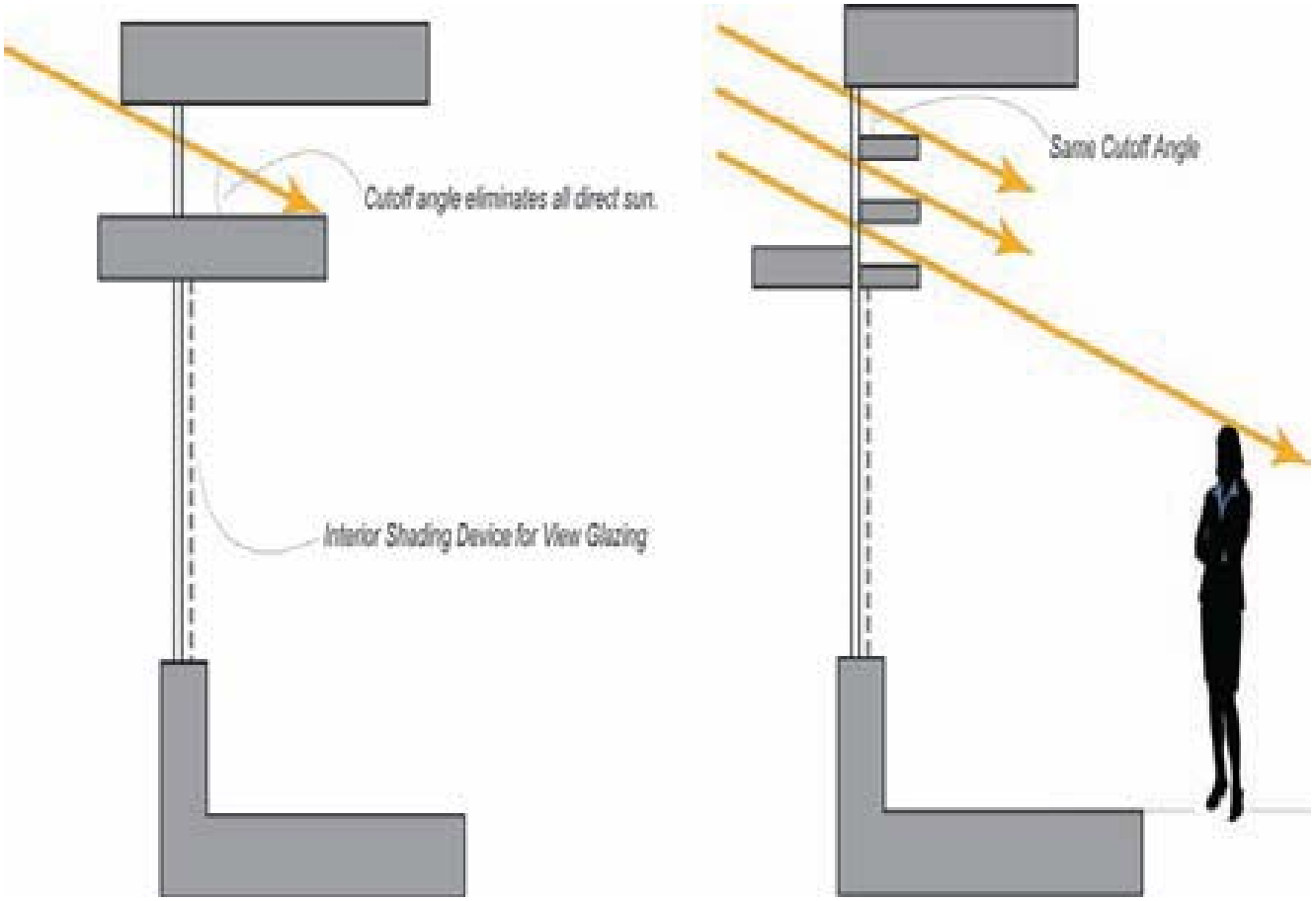
Classroom sidelighting: all climate zones



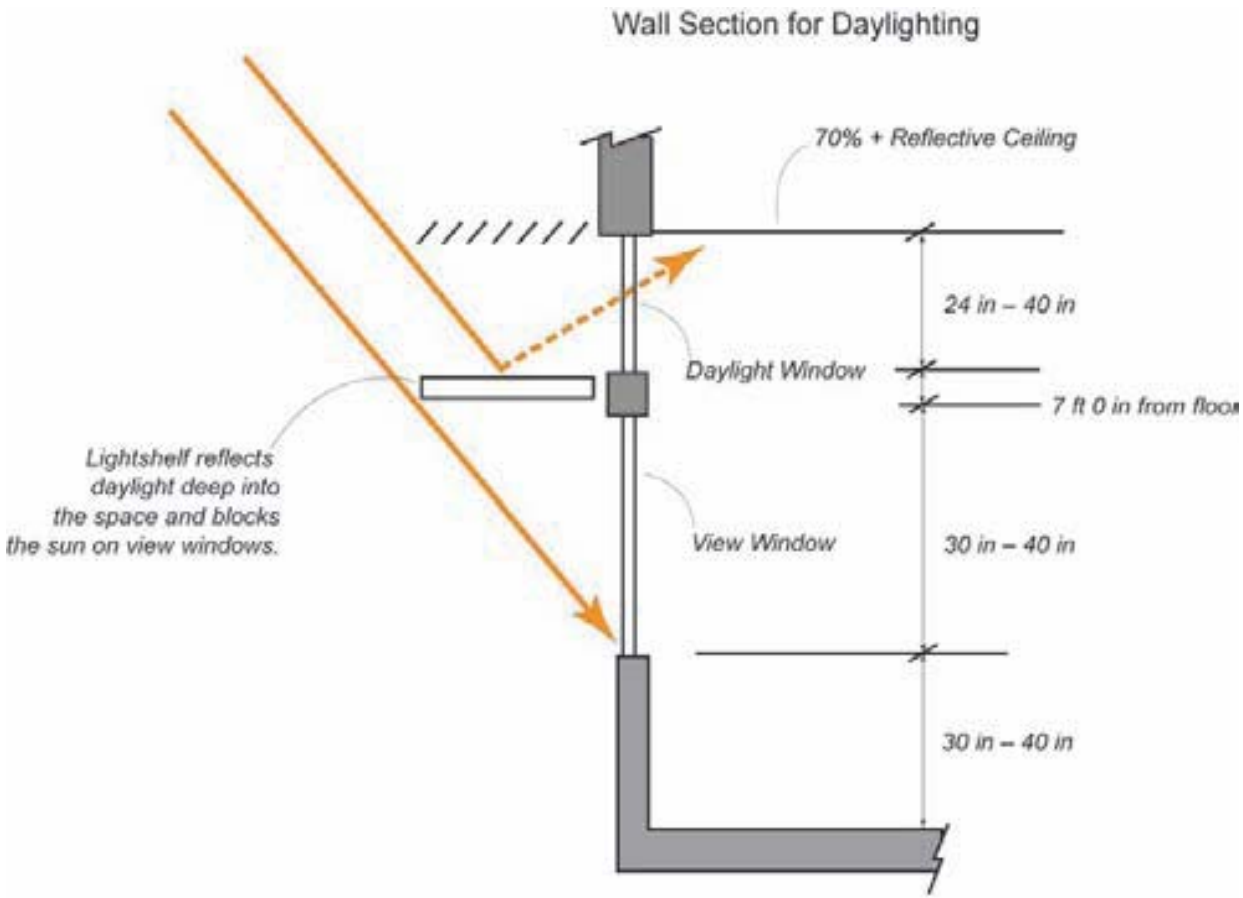
Chapter 3: Recommendations by Climate

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

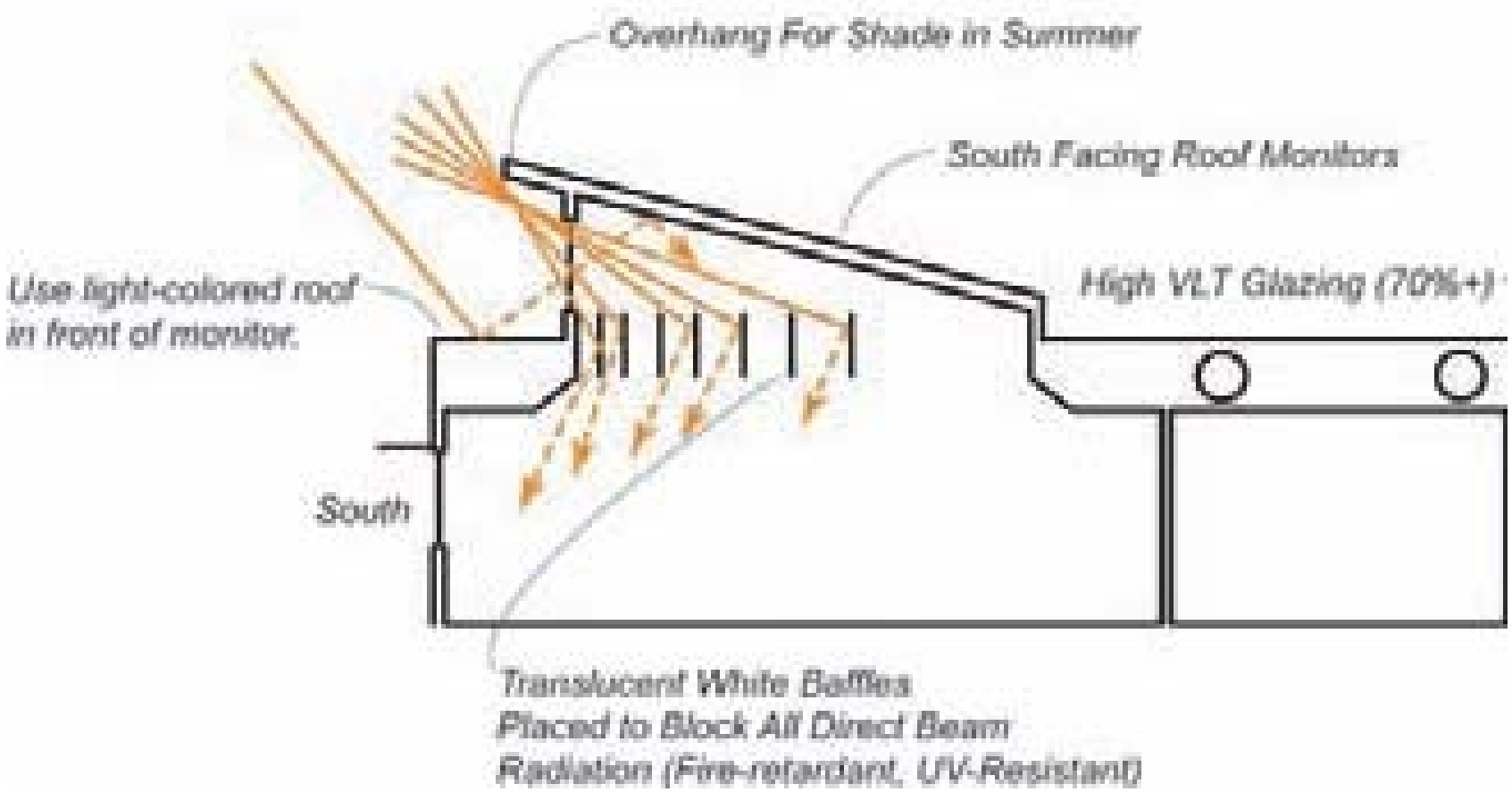
Overhang cut-off angle



Lightshelf detail



Classroom toplighting alternate



Chapter 3: Recommendations by Climate

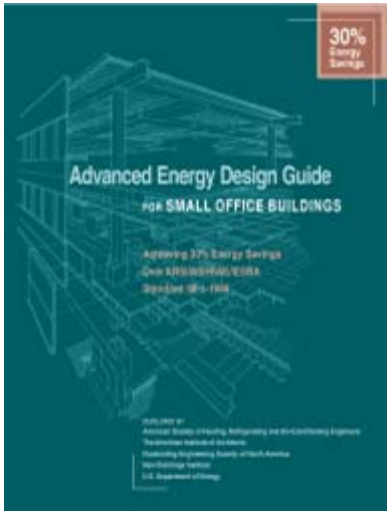
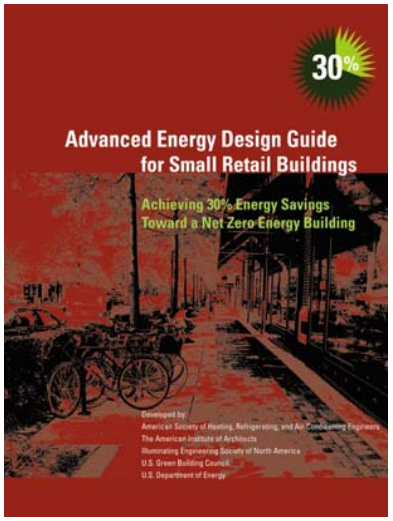
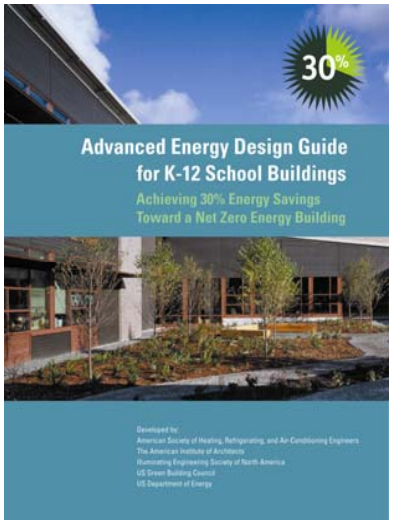
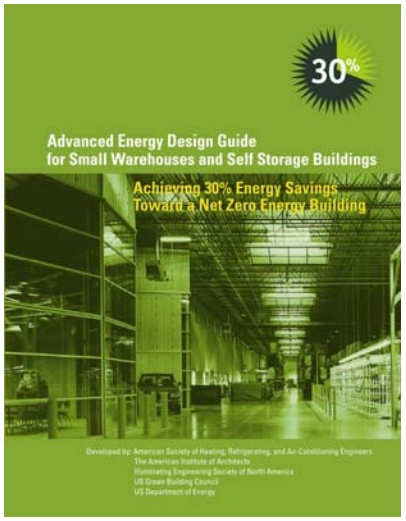
- **Gym with toplighting**

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

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