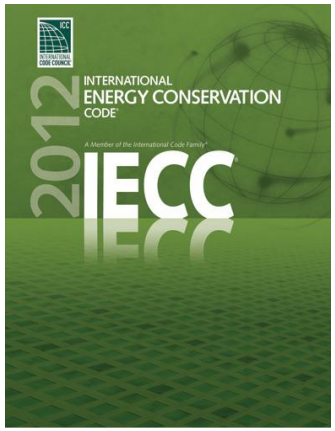
Montana Commercial Energy Code Update - 2014

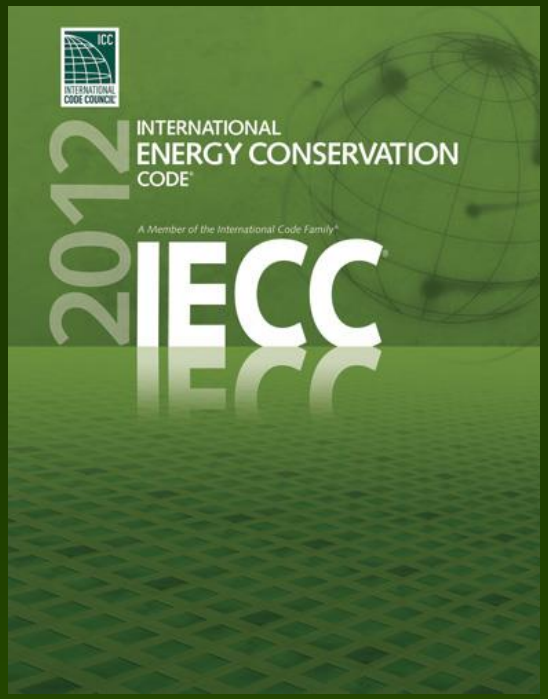
Funded By: NorthWestern Energy | Efficiency Plus

Presented By Dale Horton Architect
NCAT NATIONAL CENTER FOR APPROPRIATE TECHNOLOGY






- ✓ International Building Code
- ✓ International Mechanical Code
- ✓ International Fuel Gas Code
- ✓ International Property Maintenance Code
- ✓ International Fire Code
- ✓ International Zoning Code
- ✓ International Plumbing Code
- ✓ International Existing Building Code
- ✓ International Private Sewage Disposal Code
- ✓ International Performance Code
- ✓ International Residential Code
- ✓ **International Energy Conservation Code**
- ✓ International Wildlife-Urban Interface Code



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Source: Yellowstone NP Photo Archives

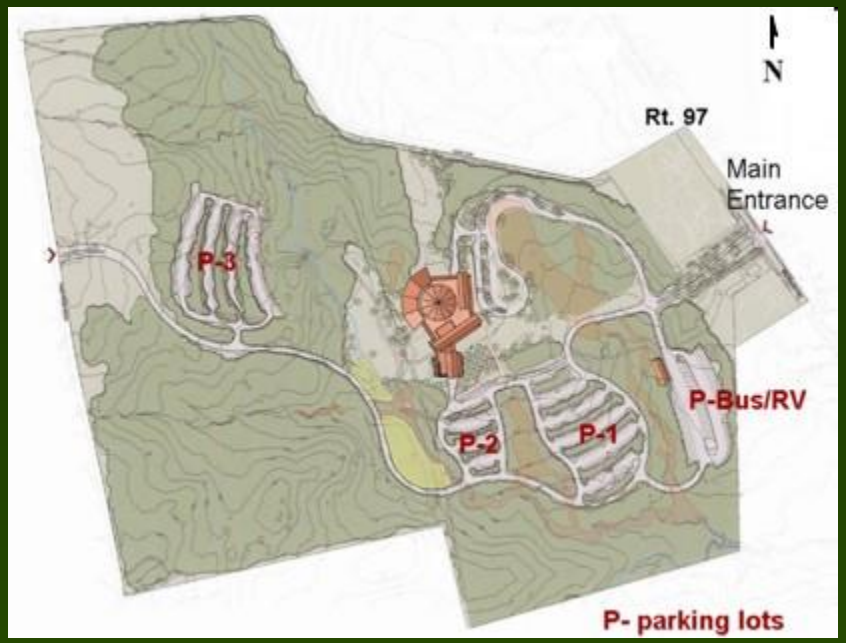
Organization of 2012 IECC

Commercial Section		Residential Section	
1	Scope and Administration	1	Scope and Administration
2	Definitions	2	Definitions
3	General Requirements	3	General Requirements
4	Commercial Energy Efficiency	4	Residential Energy Efficiency
5	Referenced Standards	5	Referenced Standards

Scope: Buildings and Sites

R101.2

This code applies to *commercial buildings* and the building sites and associated systems and equipment.

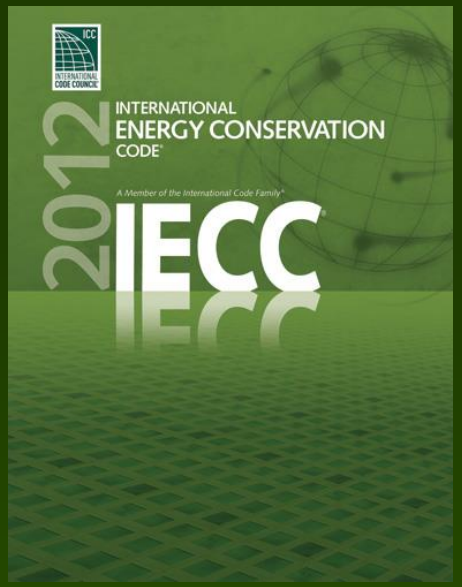


Source: National Park Service

BUILDING SITE. A contiguous area of land that is under the ownership or control of one entity.

R101.3

"…shall regulate the design and construction of buildings for the effective use and conservation of energy over the life of each building."



First Question:

Does My Project Need to Comply with Commercial or Residential Provisions?

Commercial Building Definition

"Not Residential"

Source: Going Beyond Code USDOE Building Energy Codes Program

IECC Residential Provisions Applicability

R-1: Transient uses. (hotels, motels, boarding houses)

R-2 <= 3 stories **:** Occupants primarily permanent. (apartments, dormitories, fraternities and sororities, convents, monasteries)

R-3: Catchall. (single detached houses and duplexes Adult facilities and child care facilities that provide accommodation for <= 5 occupants

R-4 <= 3 stories **:** Residential care/assisted living facilities 6-15 occupants

Application to Existing Buildings R101.4

C101.4.1 Not Retroactive

C101.4.2 Historic Buildings….Exempt

C101.4.3 Additions, alterations & repairs to existing buildings "Whatever is new has to comply."

C101.4.4 Change in occupancy – full compliance.

C101.4.5 Unconditioned to conditioned - full compliance.

C101.4.6 Mixed occupancy - *Residential* and *commercial* separately considered

Application to Existing Buildings

C101.4.3 Additions, alterations & repairs to existing buildings
"Whatever is new has to comply."

Exceptions:

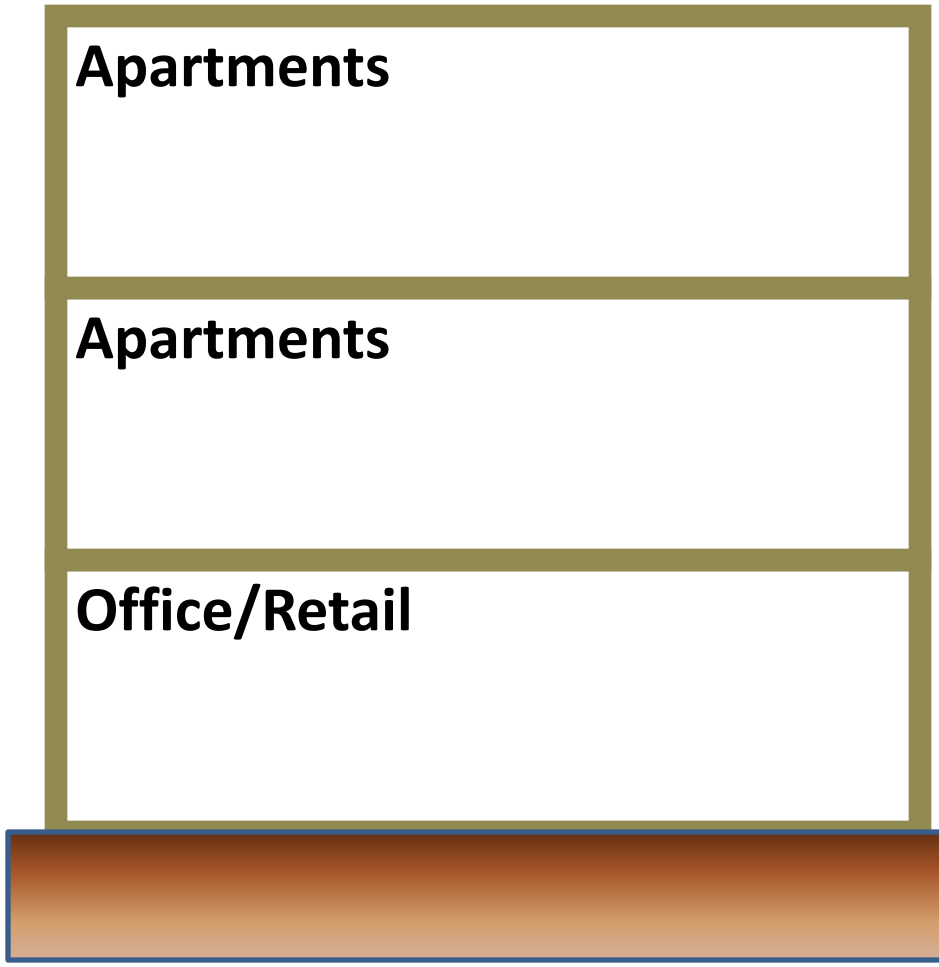
1. Storm window installation.
2. Glass only replacements.
3. If exposed cavities are filled with insulation.
4. If roof, wall or floor cavity is not exposed.
5. If reroofing (insulation adjacent to roof deck), can be required to install insulation to code.
6. Replacement of existing doors, new vestibule not required.
7. If < 50% luminaires in space replaced, no greater LPD.
8. Bulb/ballast replacement, no greater LPD.

Application to Existing Buildings

C101.4.6 Mixed occupancy.

Both *residential* and *commercial* occupancies, each separately considered

Does Residential or Commercial Apply?

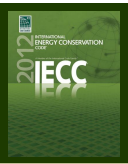


In this 3-story mixed occupancy building would the commercial or residential sections apply to each floor?

Does Residential or Commercial Apply?

In this 4-story mixed occupancy building would the commercial or residential sections apply to each floor?

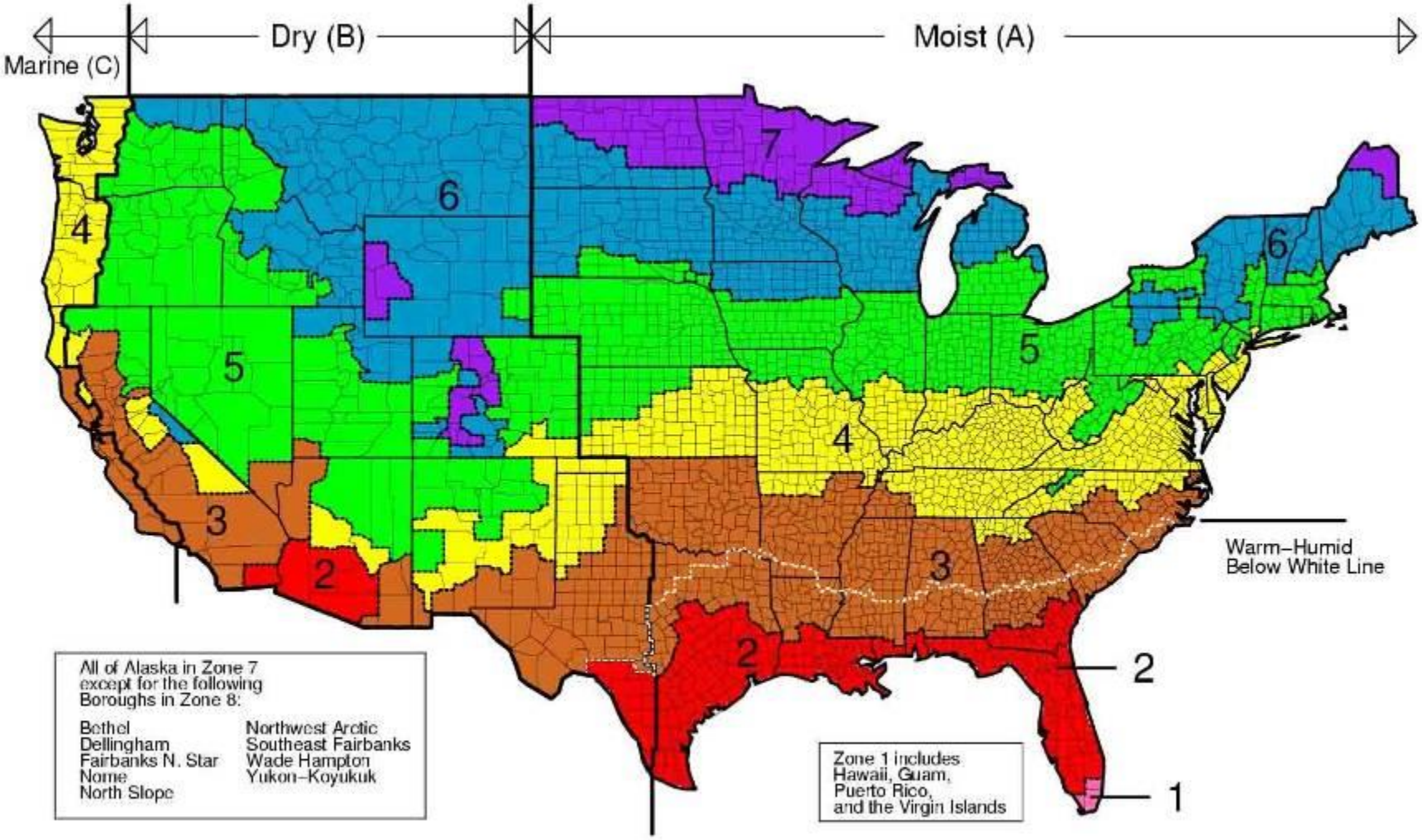
Commercial Organization Overview Chapter 4

		Minor Changes	Significant Changes	New Section
C401	General			
C402	Envelope			
C403	Mechanical			
C404	Service Water Heating			
C405	Power and Lighting			
C406	Additional Efficiency Packages			
C407	Total Building Performance		C401 85%	
C408	System Commissioning			

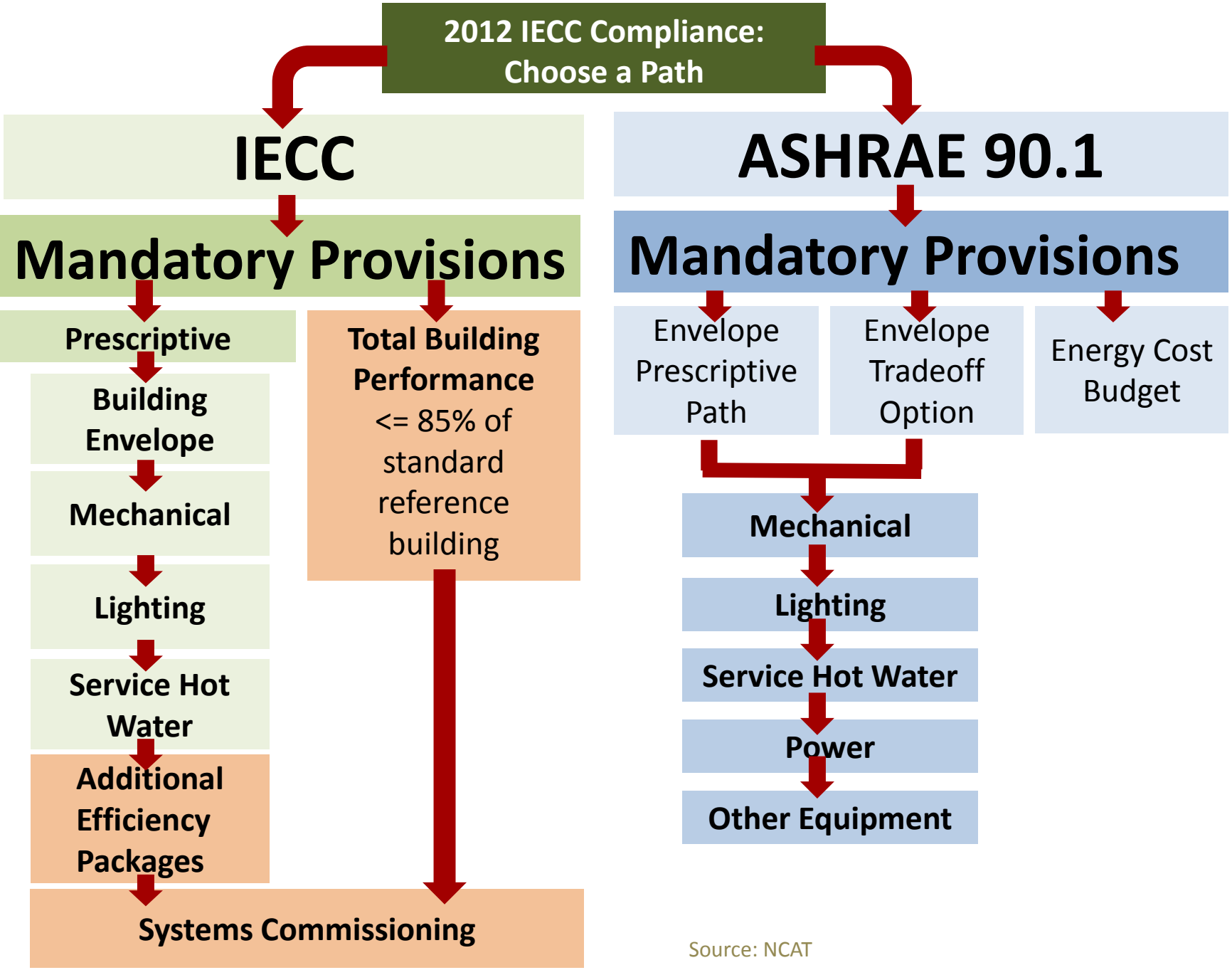
2012 IECC Commercial - Major Changes

Envelope	Thermal Envelope Requirements
	Window Wall Ratio (40% to 30%)
	Redefined Fenestration Categories
	Air Barriers and Sealing
Mechanical	Automatic Start Capabilities
	Demand Controlled Ventilation
	Energy Recovery Ventilation Systems
	Economizers
Lighting	Space by Space LPD
	Modified Controls Requirements (Daylight Zones, Specific Applications)
■	Additional Efficiency Package Options
■	Commissioning

Climate Zones 2012 IECC - Chapter 3

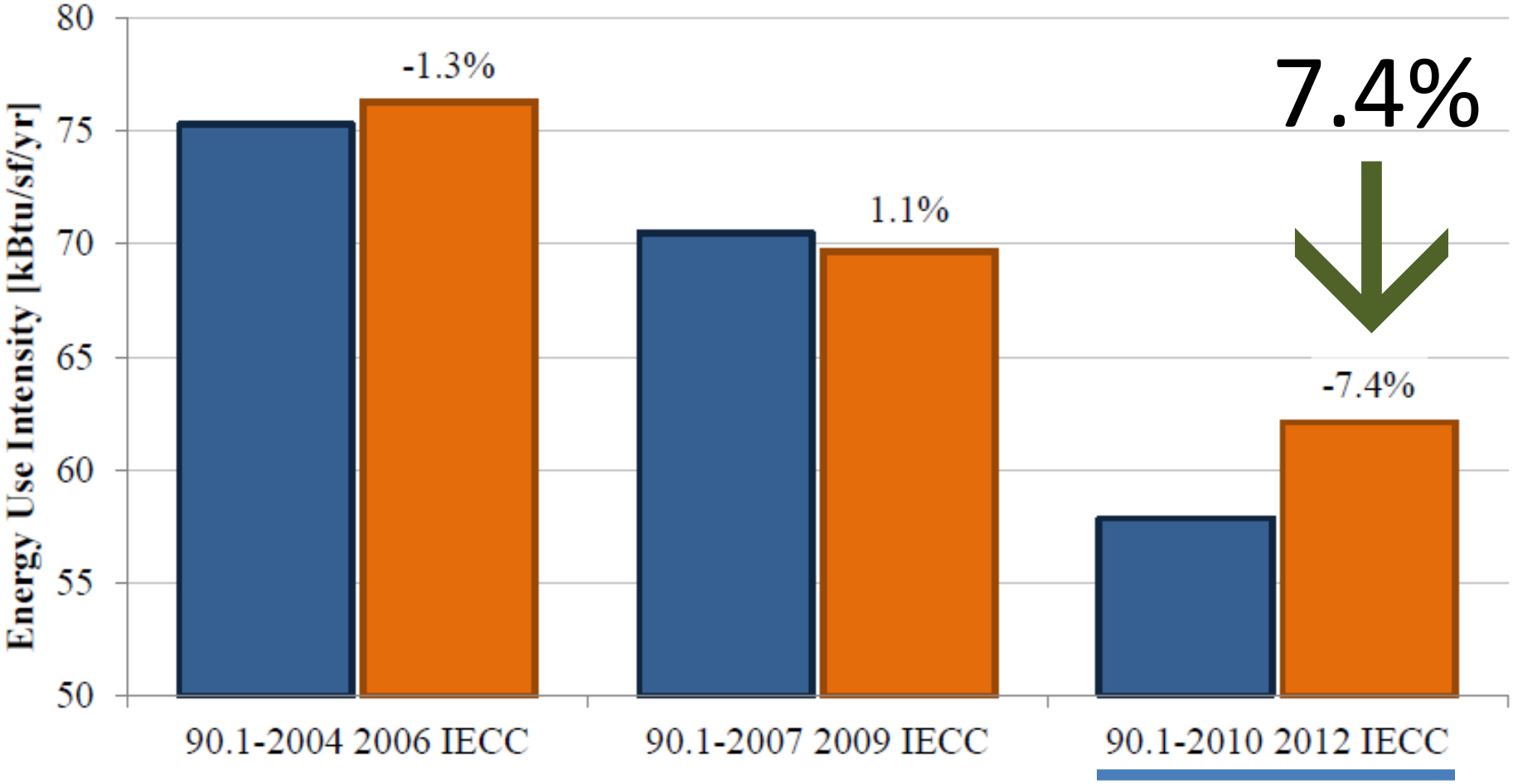


Determining Your Climate Zone is the First Step in the Process


2012 IECC Compliance:
Choose a Path
IECC
Mandatory Provisions
Prescriptive
Building Envelope
Mechanical
Lighting
Service Hot Water
Additional Efficiency Packages
Total Building Performance
<= 85% of standard reference building
Systems Commissioning
ASHRAE 90.1
Mandatory Provisions
Envelope Prescriptive Path
Envelope Tradeoff Option
Energy Cost Budget
Mechanical
Lighting
Service Hot Water
Power
Other Equipment

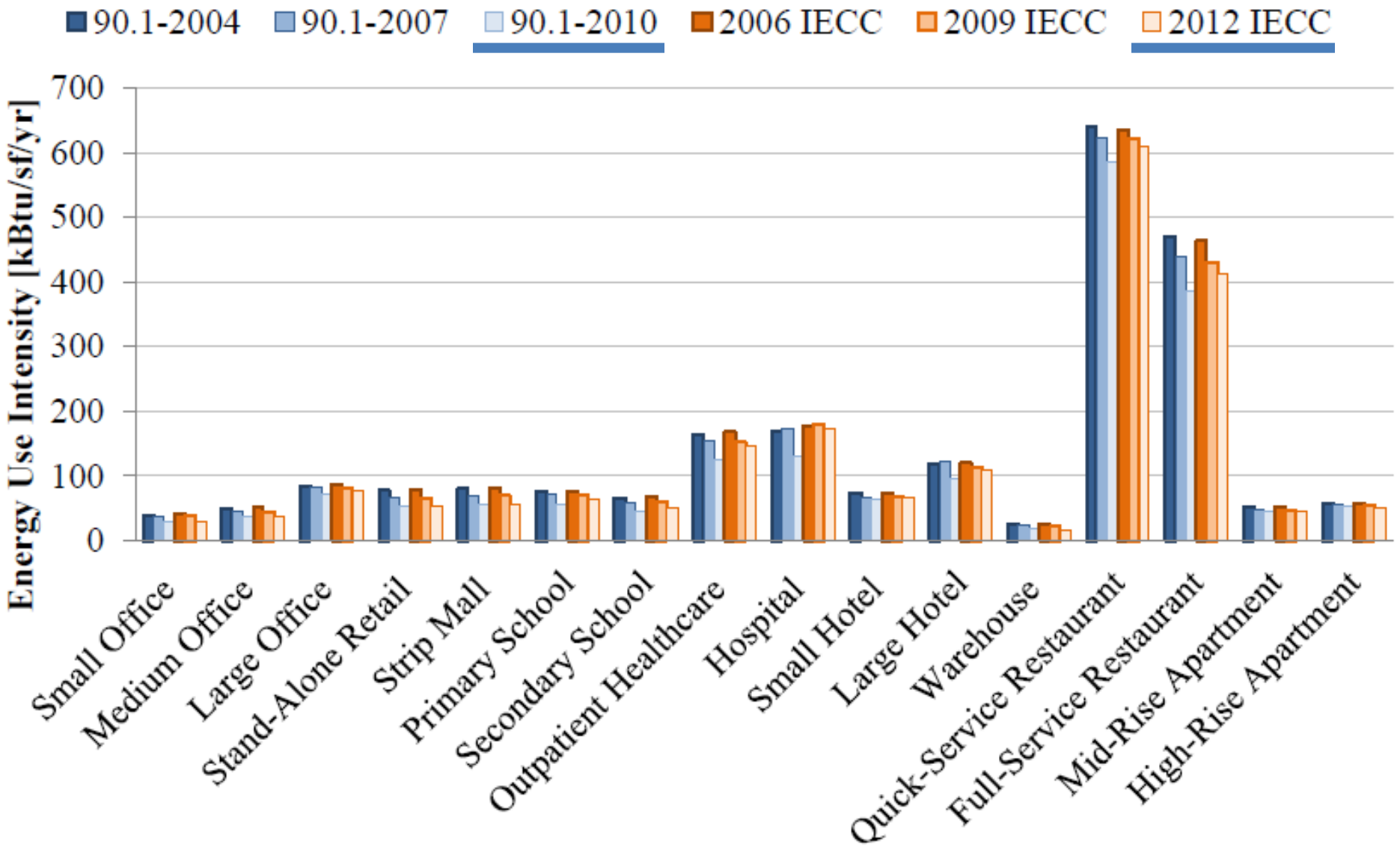
Source: NCAT

Site Energy Savings for the IECC and Corresponding Standard 90.1



PNNL-22760 Prepared for the USDOE, **Energy and Energy Cost Savings Analysis of the IECC for Commercial Buildings,** August 2013

National Average Energy Use Intensity for all Standard 90.1 and IECC Prototypes



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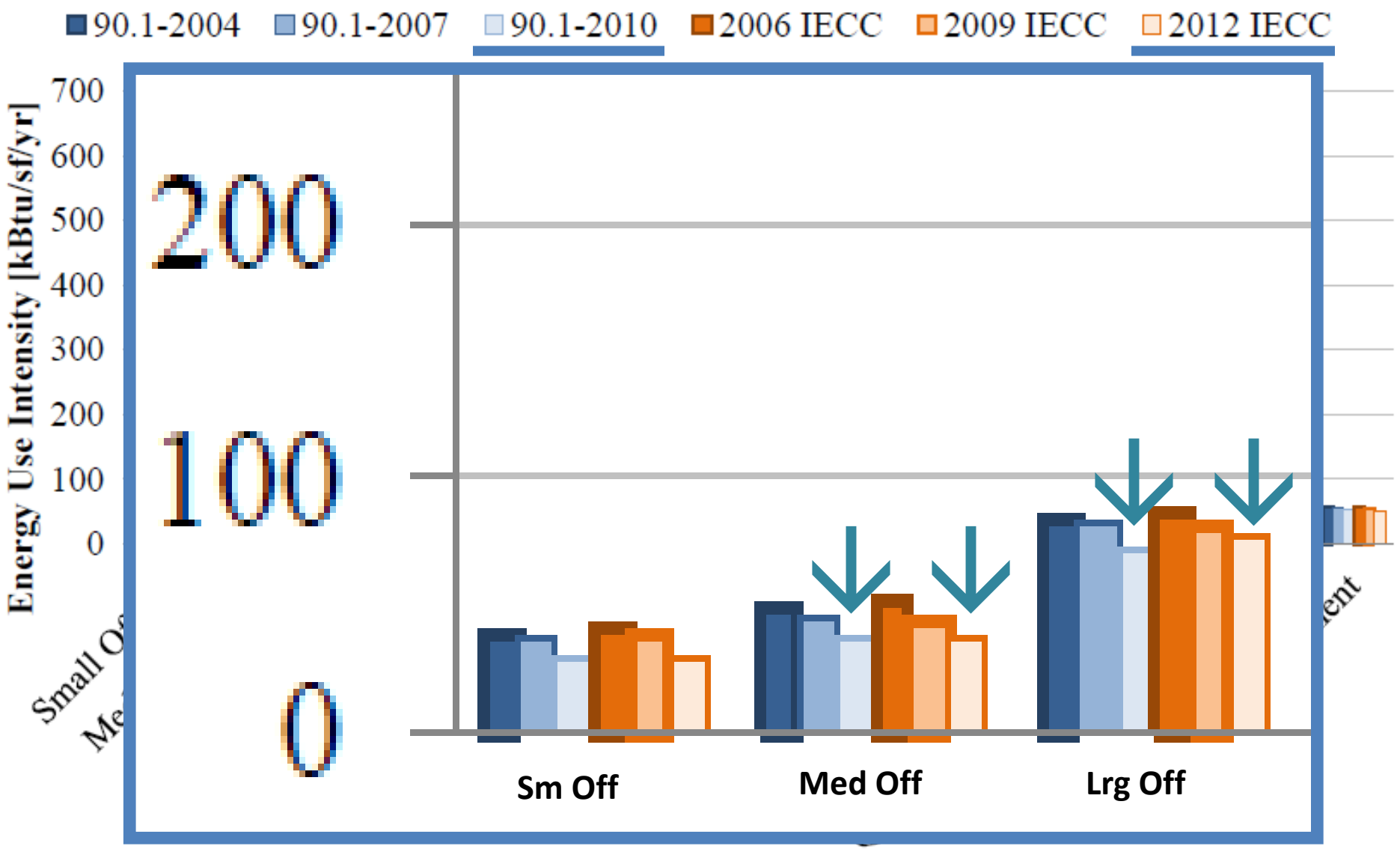


PNNL-22760 Prepared for the USDOE, **Energy and Energy Cost Savings Analysis of the IECC for Commercial Buildings,** August 2013

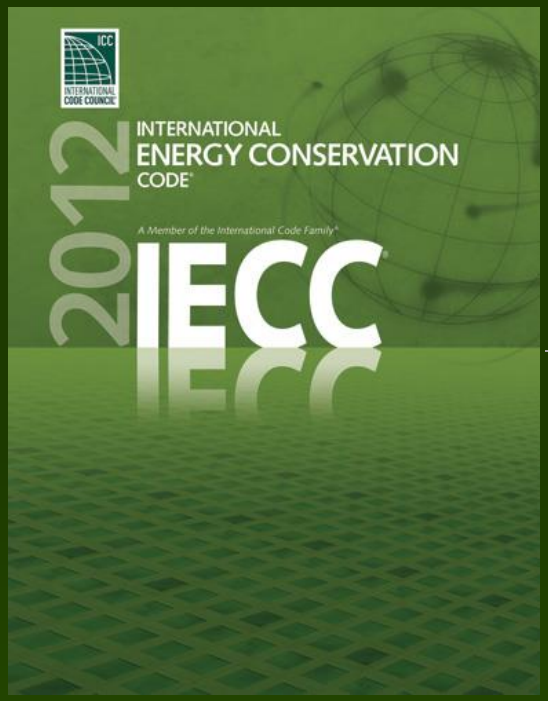
Total Building Performance C401.2

Proposed building must have an annual cost less than the standard reference design.

The building energy cost must be <= 85% of the standard reference design. Plus……

- **C402.4 – Air Leakage**
- **C403.2 - Mandatory General Mech Provisions**
- **C404 - All Service Water Heating Provisions**
- **C405.2 – Lighting Controls**
- **C405.3 – Tandem Wiring**
- **C405.4 – Exit Signs**
- **C405.6 - Exterior Building Lighting Controls**
- **C405.7 – Residential Separate Electric Metering**

Source: NREL Image Gallergy; NASA Marshall Space Flight Center; Photographer: Marshall Space Flight Ctr.



Section C402

Building Envelope Requirements

Table C402.2

TABLE C402.2 OPAQUE THERMAL ENVELOPE REQUIREMENTS[a]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs																
Insulation entirely above deck	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings (with R-5 thermal blocks)[a, b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49
Walls, Above Grade																
Mass	R-5.7ci	R-5.7ci	R-5.7ci	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-19.5ci	R-13 + R-13ci	R-13+ R-19.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13+ R17.5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-15.6ci or R-20 + R-10ci	R-13 + R-15.6ci or R-20 + R-10ci
Walls, Below Grade																
Below-grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-12.5ci
Floors																
Mass	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-10ci	R-10.4ci	R-10ci	R-12.5ci	R-12.5ci	R-12.5ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci
Joist/framing	NR	NR	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30[e]	R-30[e]	R-30[e]	R-30[e]	R-30[e]
Slab-on-Grade Floors																
Unheated slabs	NR	NR	NR	NR	NR	NR	R-10 for 24 below	R-10 for 24 below	R-10 for 24 below	R-10 for 24 below	R-10 for 24 below	R-15 for 24 below	R-15 for 24 below	R-15 for 24 below	R-15 for 24 below	R-20 for 24 below
Heated slabs[d]	R-7.5 for 12 below	R-7.5 for 12 below	R-7.5 for 12 below	R-7.5 for 12 below	R-10 for 24 below	R-10 for 24 below	R-15 for 24 below	R-15 for 24 below	R-15 for 36 below	R-15 for 36 below	R-15 for 36 below	R-20 for 48 below	R-20 for 24 below	R-20 for 48 below	R-20 for 48 below	R-20 for 48 below
Opaque Doors																
Swinging	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Roll-up or sliding	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75

For SI: 1 inch = 25.4 mm. ci = Continuous insulation. NR = No requirement.

LS = Liner System—A continuous membrane installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the r

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA Appendix A.

b. Where using R-value compliance method, a thermal spacer block shall be provided, otherwise use the U-factor compliance method in Table C402.1.2.

c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C 90, ungrouted or partially grouted at 32 inches or less on center vertically and 4 of 0.44 Btu-in/h-f^2 °F.

d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.

e. Steel floor joist systems shall be insulated to R-38.

TABLE C402.2 OPAQUE THERMAL ENVELOPE REQUIREMENTS[a]

	2012 IECC		2009 IECC	
	Climate Zone 6		Climate Zone 6	
	All Other	Group R	All Other	Group R
Walls, Above Grade				
Mass	R-13.3ci	R-15.2ci	R-13.3ci	R-15.2ci
Metal building	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-5.6ci	R-13 + R-5.6ci
Metal framed	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci
Wood framed and other	R-13 + R-7.5 or R-20 + R-3.8ci	R-13 + R-7.5 or R-20 + R-3.8ci	R-13 + R-7.5ci or R-21	R-13 + R-7.5ci or R-21
Walls, Below Grade				
Below-grade wall	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci

Source: NCAT

TABLE C402.2 OPAQUE THERMAL ENVELOPE REQUIREMENTS[a]

	2012 IECC		2009 IECC	
	Climate Zone 6		Climate Zone 6	
	All Other	Group R	All Other	Group R
Walls, Above Grade				
Mass	R-13.3ci	R-15.2ci	R-13.3ci	R-15.2ci
Metal building	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-5.6ci	R-13 + R-5.6ci
Metal framed	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci
Wood framed and other	R-13 + R-7.5 or R-20 + R-3.8ci	R-13 + R-7.5 or R-20 + R-3.8ci	R-13 + R-7.5ci or R-21	R-13 + R-7.5ci or R-21
Walls, Below Grade				
Below-grade wall	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci

TABLE C402.2 OPAQUE THERMAL ENVELOPE REQUIREMENTS[a]

	2012 IECC		2009 IECC	
	Climate Zone 6		Climate Zone 6	
	All Other	Group R	All Other	Group R
Roofs				
Insulation above deck	R-30ci	R-30ci	R-20ci	R-20ci
Metal buildings (with R-5 thermal blocks) [a, b]	R-25 + R-11 LS	R-25 + R-11 LS	R-13 + R-19	R-19
Attic and other	R-49	R-49	R-49	R-49

Compressed

Between Purlins

"Liner System"

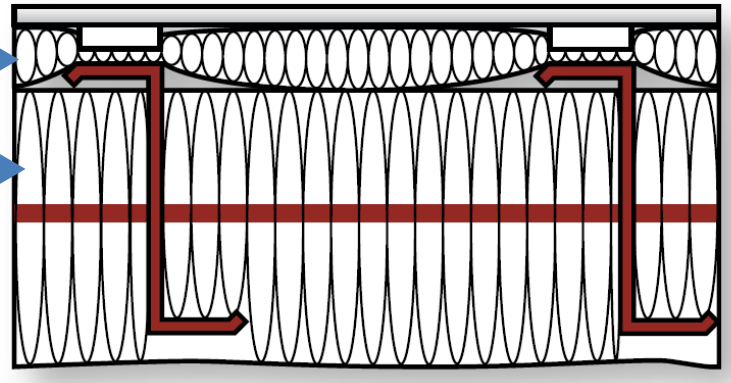


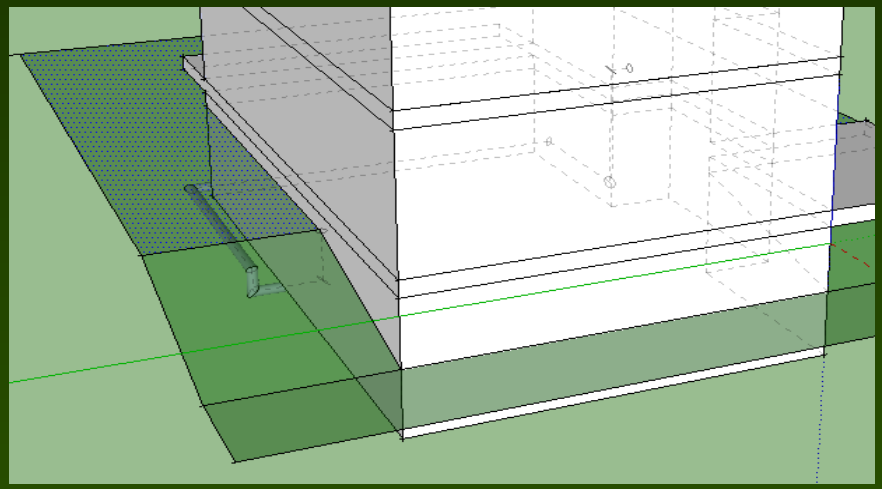
TABLE C402.2 OPAQUE THERMAL ENVELOPE REQUIREMENTS[a]

	2012 IECC		2009 IECC	
	Climate Zone 6		Climate Zone 6	
	All Other	Group R	All Other	Group R
Floors				
Mass	R-12.5ci	R-12.5ci	R-12.5ci	R-14.6ci
Joist/framing	R-30	R-30[e]	R-30	R-30[e]
Slab-on-Grade Floors				
Unheated slabs	R-10 for 24 below	R-15 for 24 below	R-10 for 24 below	R-15 for 24 below
Heated slabs[d]	R-15 for 36 below	R-20 for 48 below	R-15 for 24 below	R-20 for 48 below
Opaque Doors				
Swinging	U-0.37	U-0.37	U-0.7	U-0.5
Roll-up or sliding	R-4.75	R-4.75	U-0.5	U-0.5

Definition Clarification C402.2.2

~~Above-Grade Wall: C202 Definition > 50% above grade.~~
~~Basement Wall: C202 Definition >= 50% below grade.~~

C402.2.2.1
Above-grade-wall > 15% above grade.
Basement wall >= 85% below grade.



Source: NCAT

The conflicting definitions in Chapter 2 for "Above-grade-wall" and "Basement wall" have been deleted by errata.

Insulation of Radiant Heating Systems C402.2.8

Radiant Panels to be insulated with R-3.5

Radiant Panel for Sensible Heating of Indoor Space	Must Comply with U and R-Value Tables	Must Comply with R-3.5
Slab in contact with ground <=24" Below Grade	Yes	Yes
Slab in contact with ground >24" Below Grade	No	Yes
Slab not in contact with ground	No	Yes
Not a slab	No	Yes

Fenestration Update

TABLE C402.3 BUILDING ENVELOPE REQUIREMENTS: FENESTRATION			
2012 Categories	Climate Zone 6		2009 Categories
Vertical fenestration	2012 IECC	2009 IECC	Vertical fenestration
U- factor			
Fixed fenestration	0.36		
Operable fenestration	0.43		
		0.35	Non-Metal Frame
		0.45	Metal Frame Curtain Wall/Storefront
		0.55	Metal Frame - All Other
Entrance doors	0.77	0.80	
SHGC			
SHGC	0.40	0.40	
Skylights			
U- factor	0.50	0.60	
SHGC	0.40	0.40	

Area-Weighted U-Factor C402.3.4

Allowed to meet requirements in Table C402.3

Can’t combine fenestration types from different categories when calculating the area-weighted average U-factor

Fenestration U-Factor 303.1.3

How Do You Meet the Requirement?

Fenestration product rating in accordance to NFRC 100, tested by independent laboratory, labeled and certified by the manufacturer. If not then use default Glazed Fenestration U-factor Table C303.1.3(1)

NFRC
National Fenestration Rating Council®
CERTIFIED

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
Condensation Resistance	
51	—

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information. www.nfrc.org

NFRC Product Certification Program

NFRC Label Certificate for Site-Built Products

World's Best Window Co.
Millennium 2000+

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:

Default U-Factors Tables C303.1.3(1) and (2)

DEFAULT GLAZED FENESTRATION U-FACTOR

TABLE C303.1.3(1)

DEFAULT GLAZED FENESTRATION U-FACTOR				
FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKYLIGHT	
			Single	Double
Metal	1.2	0.8	2	1.3
Metal with Thermal Break	1.1	0.65	1.9	1.1
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.6			

TABLE C303.1.3(2)

DEFAULT DOOR U-FACTORS	
DOOR TYPE	U-FACTOR
Uninsulated Metal	1.2
Insulated Metal	0.6
Wood	0.5
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

Fenestration SHGC and VT Product Rating Requirements Table C303.1.3(3)

Two Options for Meeting the SHGC and VT Requirements

Fenestration product rated and labeled to NFRC 200, or

TABLE C303.1.3(3)

DEFAULT GLAZED FENESTRATION SHGC AND VT

	SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
	Clear	Tinted	Clear	Tinted	
SHGC	0.8	0.7	0.7	0.6	0.6
VT	0.6	0.3	0.6	0.3	0.6

Maximum Vertical Fenestration Area C402.3.1

Percentage of Vertical Fenestration Area to Gross Wall Area

Allows up to 30% maximum of above grade wall

Up to 40% vertical fenestration area allowed in Climate Zones 1-6, provided:

At least 50% conditioned floor area within daylight zone

Automatic daylighting controls; and

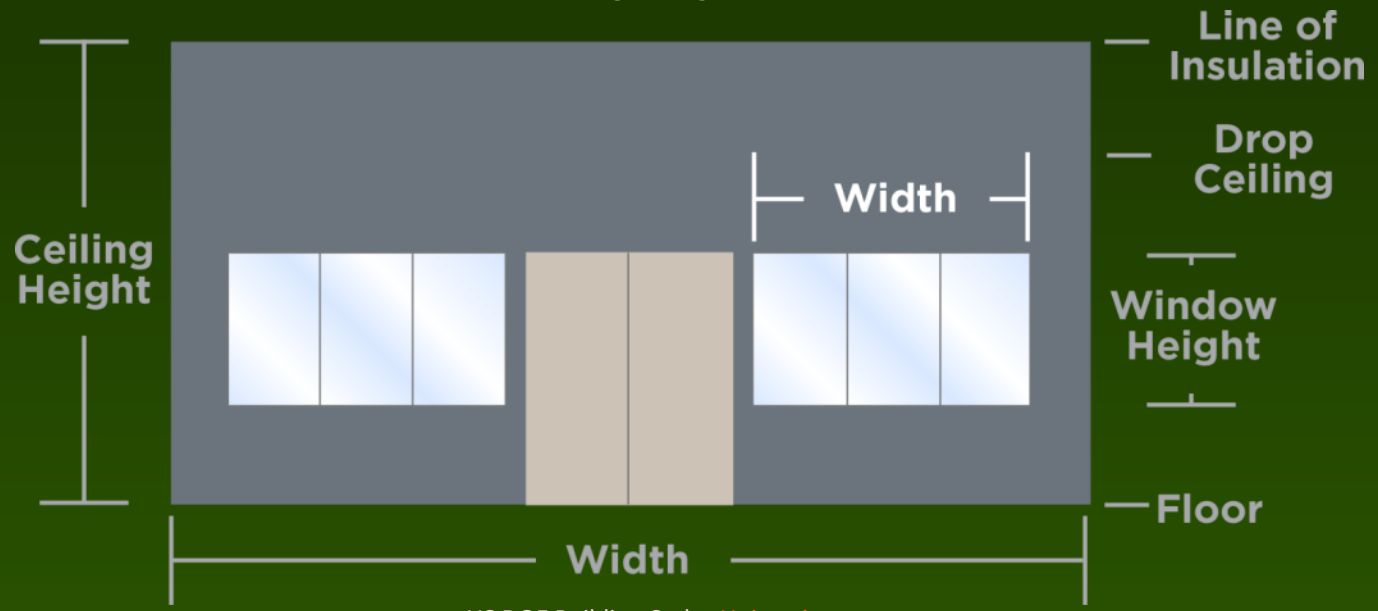
VT of vertical fenestration is ≥ 1.1 times SHGC

Vertical Fenestration Requirement C402.3.1

Based on above-grade wall area *(gross)*

- **Includes walls between conditioned space and unconditioned space or outdoors.**
- **Includes walls that are > 15% above grade.**

Total fenestration area *(includes frame and glazing)* but not opaque door area



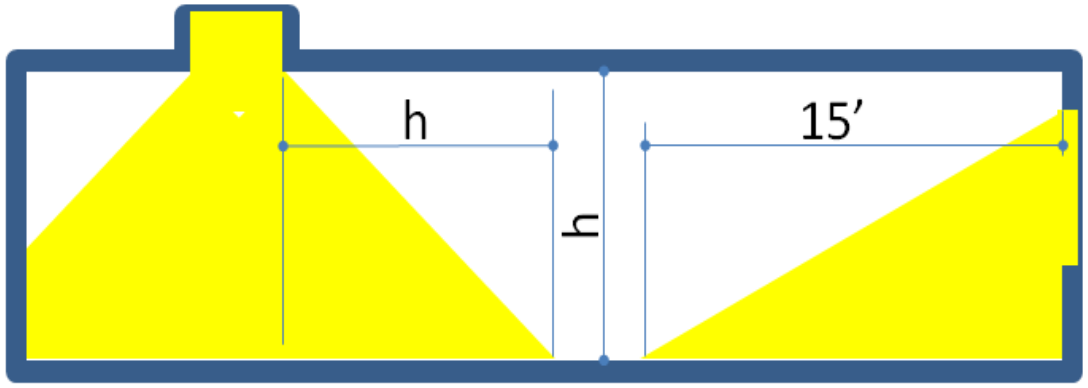
Skylight Minimum Fenestration Area *C402.3.1*

Limited to ≤ 3% of Roof Area

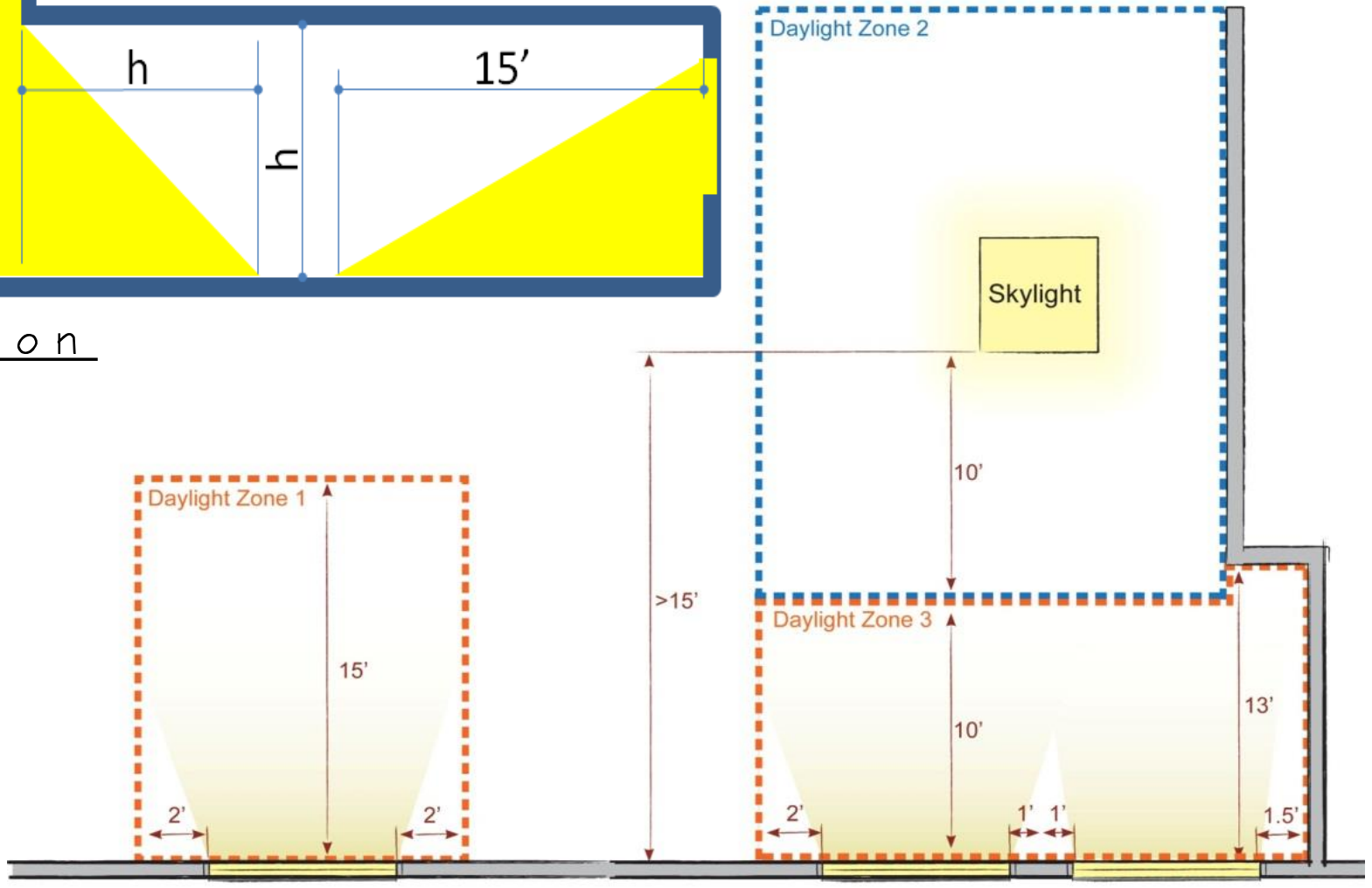
Up to 5% allowed if automatic daylighting controls installed in daylight zones under skylights

Daylight Zone Definition C202

Source: Kenergy



Section

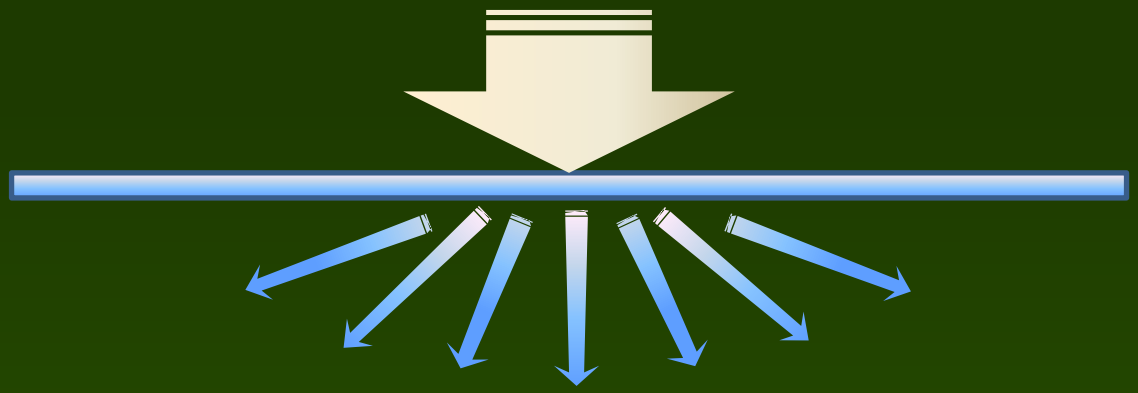


Plan

Haze Factor C402.3.2.2

- **Skylights in certain space types to have a glazing material or diffuser with a measured haze factor > 90%**

  Office, storage, automotive service, manufacturing, non-refrigerated warehouse, retail store, and distribution/sorting area

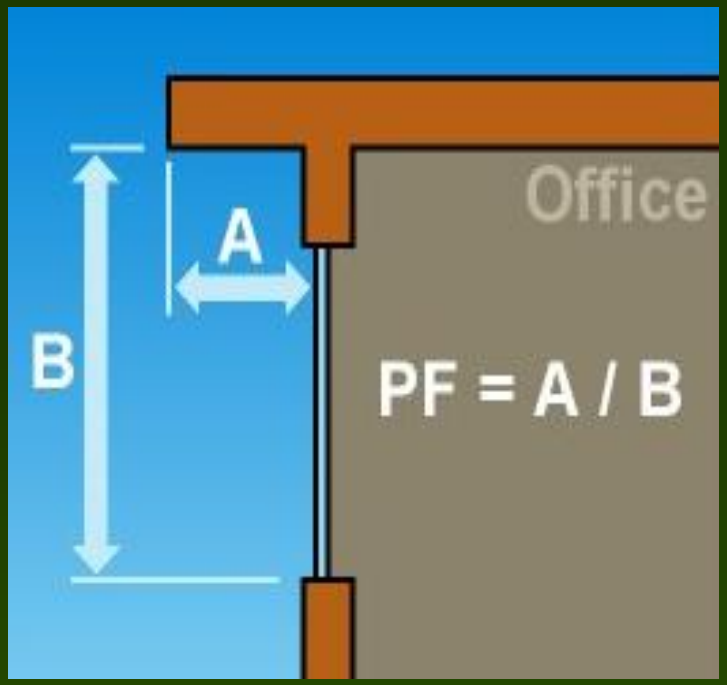


- **<u>Exception</u>**

  Skylights designed to exclude direct *sunlight* entering the occupied space by use of fixed or automated baffles, or the geometry of skylight and light well

Fenestration SHGC Requirements

The Effect of Overhangs on Fenestration SHGC



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Overhangs allow a higher SHGC product to be installed

Projection factor must be calculated

When different windows or glass doors have different PFs Evaluate separately

SHGC Adjustment C402.3.3.1

When PF ≥ 0.2, the required maximum SHGC may be adjusted by multiplying the required maximum SHGC by the multiplier in Table C402.3.3.1

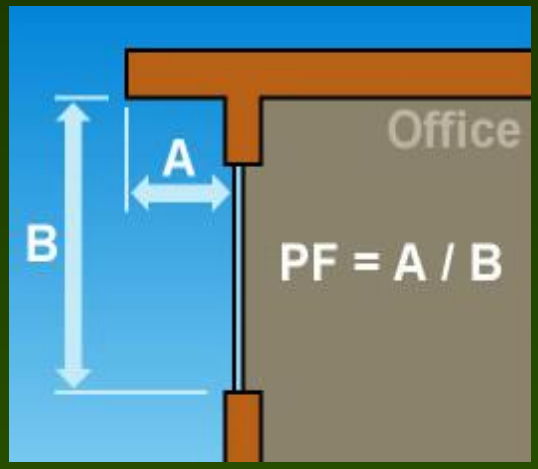

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TABLE C402.3.3.1 SHGC ADJUSTMENT MULTIPLIERS		
PROJECTION FACTOR	ORIENTED WITHIN 45 DEGREES OF TRUE NORTH	ALL OTHER ORIENTATION
0.2 ≤ PF < 0.5	1.1	1.2
PF ≤ 0.5	1.2	1.6

Increased Skylight SHGC C402.3.3.3

In Climate Zone 6, skylights above daylight zones with automated daylight controls are permitted a maximum SHGC of 0.60

Increased Skylight U-Factor C402.3.3.4

Skylights above daylight zones with automated daylight controls are permitted a maximum U-factor of 0.75 in Climate Zones 4-8

Skylights Requirements

Skylight Requirements Summary			
	% of Roof Area*	U-factor	SHGC
Zone 6 Provisions	**3%**	**0.5**	**0.4**
with Auto Daylighting Controls	**5%**	**0.75**	**0.6**
	* - Gross roof area		

Vertical Fenestration Requirements

Vertical Fenestration Requrements Summery								
		U-factor			SHGC		VT	
	% of Wall Area*	Fixed	Operable	Entrance Doors	Within 45° of North	Other Orient.	Within 45° of North	Other Orient.
Zone 6 Provisions								
PF<0.2	30%	0.36	0.43	0.77	0.40	0.40	N/A	N/A
0.2<=PF<0.5	30%	0.36	0.43	0.77	0.44	0.48	N/A	N/A
PF>=0.5	30%	0.36	0.43	0.77	0.48	0.64	N/A	N/A
>=50% floor area in Daylight Zones with Auto Controls								
PF<0.2	40%	0.36	0.43	0.77	0.40	0.40	0.44	0.44
0.2<=PF<0.5	40%	0.36	0.43	0.77	0.44	0.48	0.48	0.528
PF>=0.5	40%	0.36	0.43	0.77	0.48	0.64	0.53	0.704

* - Gross above grade wall area

Dynamic Glazing C402.3.3.5

SHGC determined using manufacturer's lowest-rated SHGC

Considered separately from other fenestration

- Area-weighted averaging isn't allowed

Source: Solar Innovations

Air Barriers & Construction C402.4.1 and C402.4.1.1

Air barrier requirements:

- Placement allowed
  - On inside of building envelope
  - On outside of building envelope
  - Located within assemblies composing envelope OR
  - Any combination thereof

1. **Continuous for all assemblies that are a part of the thermal envelope and across joints and assemblies***
2. Joints and seams to be sealed per C402.4.2
3. **Recessed lighting to comply with C404.2.8. Where objects are installed that penetrate the air barrier, make provisions to maintain the air barrier's integrity***

*** - Items 1 and 3 not required if tightness is tested.**

Air Barrier C402.4.1.2

Air Barrier Compliance Paths

1. Materials
   Assemblies
2. Building Testing

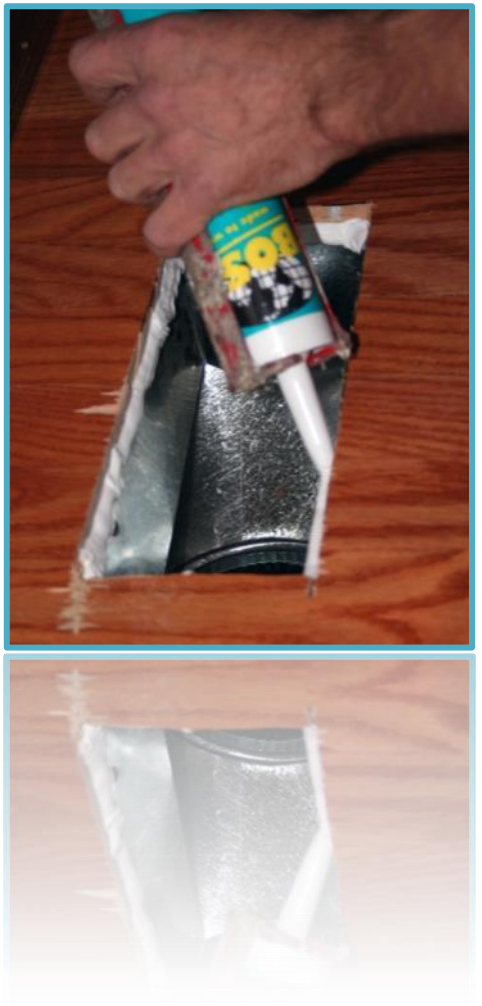
Air Barrier Materials *C402.4.1.2.1*

Materials with air permeance ≤ 0.004 cfm/ft² under pressure differential of 0.3 in. w.g. tested in accordance with ASTM E 2178

C402.4.1.2.1 Materials Deemed to Comply as Air Barrier	
1	3/8 inch plywood
2	3/8 inch oriented strand board
3	1/2 inch extruded polystyrene insulation board
4	1/2 inch foil-back polyisocyanurate insulation board
5	1 1/2 inch 1.5 pcf closed cell spray foam
6	4.5 inch (0.4 and 1.5 pcf) open cell spray foam
7	1/2 inch exterior or interior gypsum board
8	1/2 inch cement board
9	Built up roofing membrane
10	Modified bituminous roof membrane
11	Fully adhered single-ply roof membrane
12	5/8 inch Portland cement/sand parge, or gypsum plaster
13	Cast-in-place and precast concrete.
14	Fully grouted concrete block masonry.
15	Sheet steel or aluminum.

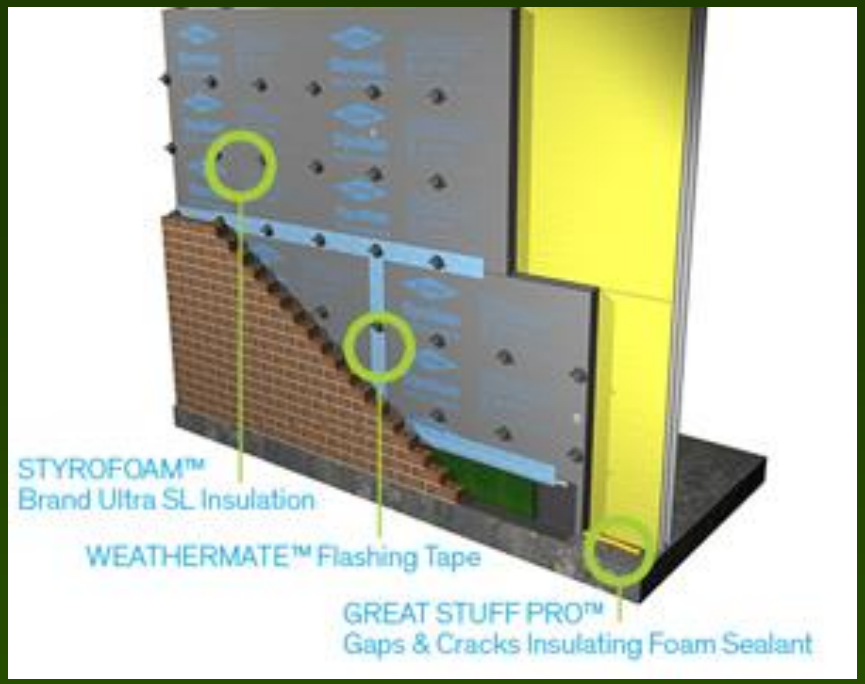
Air Barrier Penetrations C402.4.2

- **Penetrations of air barrier and air leakage paths to be caulked, gasketed, or otherwise sealed**
- **Joints and seals**
  - Sealed in same manner or taped or covered with a moisture vapor-permeable wrapping material
  - Securely installed in or on the joint for the entire length
    - To resist positive and negative pressure from wind, stack effect and mechanical ventilation
  - Sealing materials appropriate to construction materials



Air Barrier Assemblies *C402.4.1.2.2*

Assemblies of materials and components (sealants, tapes, etc.) with average air leakage ≤ 0.04 cfm/ft² at 0.3 in. w.g.



air barrier
abaa
association of
america

Source: building dow.com

Air Barrier Building Test *C402.4.1.2.3*

Air leakage rate of completed building tested and confirmed to not exceed 0.40 cfm/ft^2 at a pressure differential of 0.3 inches water (75 Pa).

Source: Energy Conservatory

Source: Retrotec

Air Leakage of Fenestration *C402.4.3*

Fenestration Assembly	cfm/ft^2	Test Procedure
Windows, sliding glass doors, and swinging doors	0.20	AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400
Skylights - with condensation weepage openings	0.30	
Skylights – all other	0.20	
Curtain walls and storefront glazing	0.06	NFRC 400 or ASTM E283 at 1.57 psf
Commercial glazed swinging entrance doors	1.00	
Revolving doors	1.00	
Garage doors	0.4	ANSI/DASMA 105, NFRC 400, or ASTM E283 at 1.57 psf
Rolling doors	1.00	

Exceptions

– Field-fabricated fenestration assemblies

– Fenestration in buildings that meet the building test for air barrier compliance option

Mandatory Requirements C402.4.5.1

Stairway and Shaft Vents

- **To have Class I motorized dampers with maximum leakage rate of 4 cfm/ft^2 at 1.0 inch water gauge**
- **Dampers to be installed with controls to be able to open automatically upon**
  - Activation of any fire alarm initiating device of building's fire alarm system or
  - Interruption of power to the damper

Mandatory Requirements *C402.4.5.2*

Outdoor Air Intakes and Exhausts

Buildings ≥ 3 stories in height above grade

Class IA motorized leakage-rated damper

- Maximum leakage rate ≤ 4cfm /ft^2 @ 1.0 inch w.g.

Buildings < 3 stories in height

- ✓ Gravity (nonmotorized) with maximum leakage rate of 20 cfm/ft^2 at 1.0 inch water gauge allowed
  - ✓ For exhaust and relief dampers
  - ✓ For ventilation air intakes and exhaust and relief dampers in buildings of any height in CZ 1-3
  - ✓ Where design outdoor air intake or exhaust capacity is < 300 cfm
- ✓ Dampers < 24 inches in either dimension may have a leakage of 40 cfm/ft^2 at 1.0 inch water gauge

Mandatory Requirements C402.4.7 Vestibules Clarification

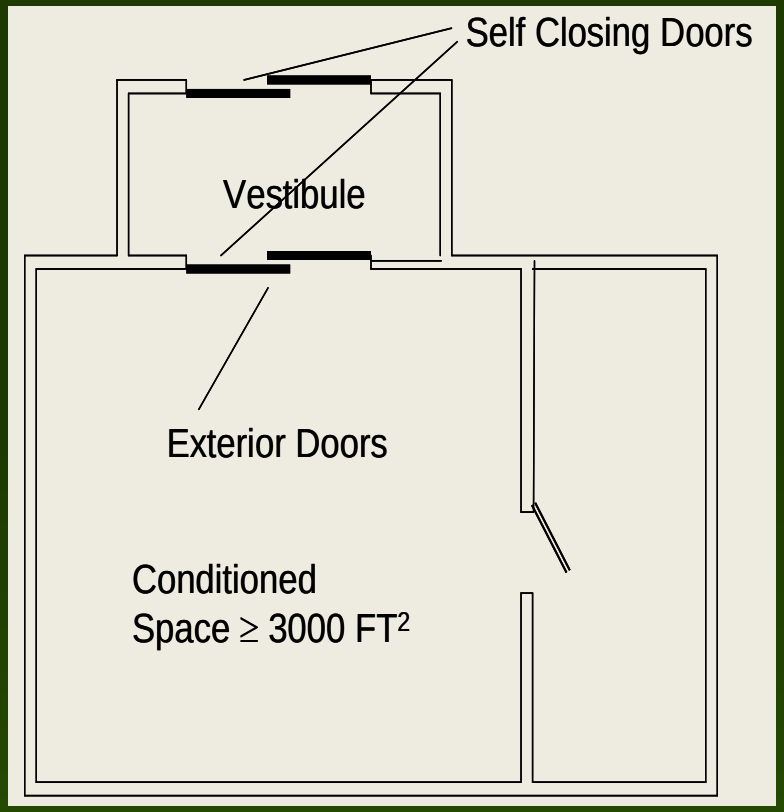
Required to reduce infiltration into spaces

Required on entrance doors leading into spaces ≥ 3,000 ft²

Doors must have self-closing devices

Exceptions

- Buildings in Climate Zones 1 and 2
- Doors from a sleeping unit or dwelling unit
- Revolving doors
- Doors not intended for public use or intended solely for employee use



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Mandatory Requirements C402.4.8 Recessed Lighting

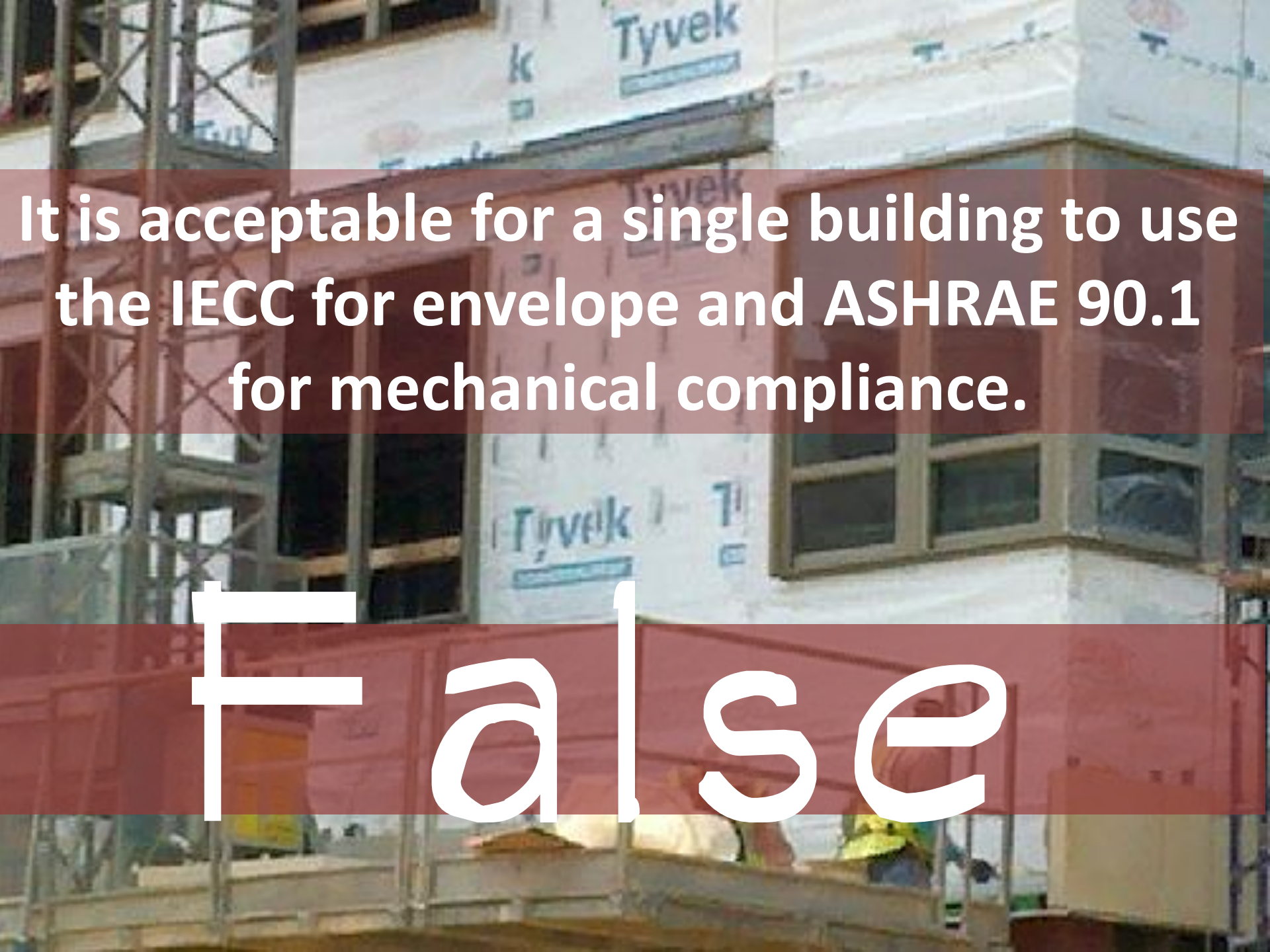
All recessed luminaires installed in the building envelope

Type IC rated and sealed with gasket or caulk between housing and interior wall or ceiling covering

Type IC rated and labeled in accordance with ASTM E 283 to allow ≤ 2.0 cfm of air movement between conditioned and unconditioned spaces

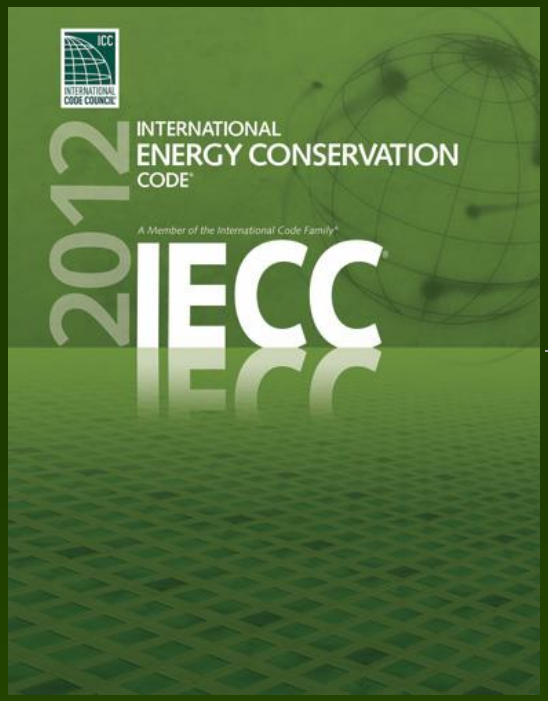
It is acceptable for a single building to use the IECC for envelope and ASHRAE 90.1 for mechanical compliance.

T / F



It is acceptable for a single building to use the IECC for envelope and ASHRAE 90.1 for mechanical compliance.

False



Section C403

Building Mechanical Systems

C403.1 General

C403.2 Mandatory Provisions (11 provisions)

C403.3 Simple HVAC System Requirements

C403.4 Complex HVAC System Requirements

Mandatory Provisions Overview C403.2

	C403.2	Minor Changes	Significant Changes	Remarks
1	HVAC Load Calculations	Minor		
2	Equipment and System Sizing	Minor		
3	HVAC Equipment Performance			Many Changes to Tables
4	HVAC System Controls			Auto Start Expanded
5	Ventilation			Demand Control Expanded
6	Energy Recovery Ventilation			Energy Recovery Expanded
7	Duct/Plenum Insul. & Sealing			
8	Piping Insulation			Modified Table, Protection
9	HVAC System Commissioning			Refers to C408
10	Air System Design and Control			
11	Heating Outside a Building			

TABLE C403.2.3(1) MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

"Heating Section Type"
New Column Differentiates Electric Resistance From Other Heating Types

"Electric Resistance (or None)"

"All Other"

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE				URE[a]
Air conditioners, air cooled	< 65,000 Btu/h[b]	All				
Through-the-wall (air cooled)	≤ 30,000 Btu/h[b]	All				
Small-duct high-velocity (air cooled)	< 65,000 Btu/h[b]	All				
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)				
		All other				
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	10.8 EER 11.0 IEER	AHRI
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package			
		All other	Split System and Single Package			
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package			
		All other	Split System and Single Package			
Air conditioners, water cooled	< 65,000 Btu/h[b]	All	Split System and Single Package	12.3 IEER	12.3 IEER	210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	AHRI 340/360
		All other	Split System and Single Package	11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	12.5 EER 12.7 IEER	
		All other	Split System and Single Package	10.8 EER 11.0 IEER	12.3 EER 12.5 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.4 EER 12.6 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.2 EER 12.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.0 EER 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.0 EER 12.2 IEER	

TABLE C403.2.3(1) MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 6/1/2011	As of 6/1/2011	
Air conditioners, air cooled	< 65,000 Btu/h[b]	All	Split System	13.0 SEER	13.0 SEER	AHRI 210/240
				13.0 SEER	13.0 SEER	
Through-the-wall (air cooled)	≤ 30,000 Btu/h[b]			12.0 SEER	12.0 SEER	
				12.0 SEER	12.0 SEER	
Small-duct high-velocity (air cooled)	< 65,000 Btu/h[b]			10.0 SEER	10.0 SEER	
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Elec		11.2 EER 11.4 IEER	11.2 EER 11.4 IEER	AHRI 340/360
				11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Elec		11.0 EER 11.2 IEER	11.0 EER 11.2 IEER	
				10.8 EER 11.0 IEER	10.8 EER 11.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Elec		10.0 EER 10.1 IEER	10.0 EER 10.1 IEER	
				9.8 EER 9.9 IEER	9.8 EER 9.9 IEER	
	≥ 760,000 Btu/h	Elec		9.7 EER 9.8 IEER	9.7 EER 9.8 IEER	
				9.5 EER 9.6 IEER	9.5 EER 9.6 IEER	
Air conditioners, water cooled	< 65,000 Btu/h[b]			12.1 EER 12.3 IEER	12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Elec		11.5 EER 11.7 IEER	12.1 EER 12.3 IEER	AHRI 340/360
				11.3 EER 11.5 IEER	11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Elec		11.0 EER 11.2 IEER	12.5 EER 12.7 IEER	
				10.8 EER 11.0 IEER	12.3 EER 12.5 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.4 EER 12.6 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.2 EER 12.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.0 EER 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.0 EER 12.2 IEER	

Integrated Energy Efficiency Ratio (IEER) has been added for some equipment.

Integrated Part-Load Values no longer included

TABLE C403.2.3(1) MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
				Before 6/1/2011	As of 6/1/2011	
Air conditioners, air cooled	< 65,000 Btu/h[b]		Split System	13.0 SEER	13.0 SEER	AHRI 210/240
					13.0 SEER	
Through-the-wall (air cooled)	≤ 30,000 Btu/h[b]				12.0 SEER	
					12.0 SEER	
Small-duct high-velocity (air cooled)	< 65,000 Btu/h[b]				10.0 SEER	
Air conditioners, air cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric R			11.2 EER 11.4 IEER	AHRI 340/360
		All			11.0 EER 11.2 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric R			11.0 EER 11.2 IEER	
		All			10.8 EER 11.0 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h	Electric R			10.0 EER 10.1 IEER	
		All other	Split System and Single Package	9.8 EER 9.9 IEER	9.8 EER 9.9 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER 9.8 IEER	9.7 EER 9.8 IEER	
		All other	Split System and Single Package	9.5 EER 9.6 IEER	9.5 EER 9.6 IEER	
Air conditioners, water cooled	< 65,000 Btu/h[b]				12.1 EER 12.3 IEER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h				12.1 EER 12.3 IEER	AHRI 340/360
					11.9 EER 12.1 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h				12.5 EER 12.7 IEER	
					12.3 EER 12.5 IEER	
	≥ 240,000 Btu/h and < 760,000 Btu/h				12.4 EER 12.6 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.2 EER 12.4 IEER	
	≥ 760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.1 IEER	12.0 EER 12.4 IEER	
		All other	Split System and Single Package	10.8 EER 10.9 IEER	12.0 EER 12.2 IEER	

Size categories have been significantly changed.

Many minimum efficiency ratings have been changed

Table C403.2.3(2) MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

Higher SEER Ratings for Through-the-Wall Units

Added IEER Values

New Heating Rating for Small-Duct High-Velocity Heat Pumps (air-cooled) – 6.8 HSPF

TABLE C403.2.3(2) MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Air cooled (cooling mode)			Split System	.0 SEER	AHRI2 10/240
			Single Packaged	0 SEER	
Through-the-wall, air cooled			Split System	13.0 SEER	
			Packaged	13.0 SEER	
Single-duct high-velocity air cooled			Split System	10.0 SEER	
Air cooled (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER	AHRI 340/360
		All other	Split System and Single Package	10.8 EER 11.0 IEER	
				10.6 EER 10.7 IEER	
				10.4 EER 10.5 IEER	
				9.5 EER 9.6 IEER	
				9.3 EER 9.4 IEER	
Water source (cooling mode)	< 135,000 Btu/h			11.2 EER	ISO 13256-1
				12.0 EER	
				12.0 EER	
Ground water source (cooling mode)	< 135,000 Btu/h	All	59°F entering water	16.2 EER	
		All	77°F entering water	13.4 EER	
Water-source water to water (cooling mode)	< 135,000 Btu/h	All	86°F entering water	10.6 EER	ISO 13256-2
			59°F entering water	16.3 EER	
Ground water source Brine to water (cooling mode)	< 135,000 Btu/h	All	77°F entering fluid	12.1 EER	
Air cooled (heating mode)	< 65,000 Btu/h[b]	—	Split System	7.7 HSPF	AHRI 210/240
		—	Single Package	7.7 HSPF	
Through-the-wall, (air cooled, heating mode)	≥ 30,000 Btu/h[b] (cooling capacity)	—	Split System	7.4 HSPF	
		—	Single Package	7.4 HSPF	
Small-duct high velocity (air cooled, heating mode)	< 65,000 Btu/h[b]	—	Split System	6.8 HSPF	

Table C403.2.3(2) MINIMUM EFFICIENCY REQUIREMENTS: ELECTRICALLY OPERATED UNITARY AND APPLIED HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY	HEATING SECTION TYPE	SUB-CATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
			°F wb Air	3.3 COP	AHRI 340/360
			°F wb Air	2.25 COP	
			°F wb Air	3.2 COP	
	(cooling capacity)		17°F db/15°F wb Outdoor Air	2.05 COP	
Water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water	4.2 COP	
Ground water source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	50°F entering water		
Ground source (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid		
Water-source water to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	68°F entering water		
		—	50°F entering water		
Ground source brine to water (heating mode)	< 135,000 Btu/h (cooling capacity)	—	32°F entering fluid	2.5 COP	

Replaced HSPF Factor for Heat Pumps in Heating Mode with COP Values

Added New Categories for Water Source (water to water) and Ground Source (brine to water) Heat Pumps

Table C403.2.3(3) MINIMUM EFFICIENCY REQUIREMENTS: PTACs, PACKAGED TERMINAL HEAT PUMPS, ETC.

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY		TEST PROCEDURE[a]
			Before 10/08/2012	As of 10/08/2012	
PTAC (cooling mode) new construction	All Capacities	95°F db outdoor air	5 - (0.213 × Cap/1000) EER	8 - (0.300 × Cap/1000) EER	AHRI 310/380
PTAC (cooling mode) replacements	All Capacities	95°F db outdoor air	9 - (0.213 × Cap/1000) EER	10.9 - (0.213 × Cap/1000) EER	
PTHP (cooling mode) new construction	All Capacities	95°F db outdoor air	3 - (0.213 × Cap/1000) EER	14.0 - (0.300 × Cap/1000) EER	
PTHP (cooling mode) replacements[b]	All Capacities	95°F db outdoor air	10.8 - (0.213 × Cap/1000) EER	10.8 - (0.213 × Cap/1000) EER	
PTHP (heating mode) new construction	All Capacities	—	3.2 - (0.26 × Cap/1000) COP	3.2 - (0.26 × Cap/1000) COP	
PTH			/1000)	2.9 - (0.26 × Cap/1000) COP	
				9.0 EER	AHRI 390
				8.9 EER	
				8.6 EER	
SPVHP (cooling mode)	< 65,000 Btu/h	outdoor air		9.0 EER	
	≥65,000 Btu/h and < 135,000 Btu/h	95°F db/ 75°F wb outdoor air	8.9 EER	8.9 EER	
				8.6 EER	
				3.0 COP	AHRI 390
(heating mode)				3.0 COP	
	≥ 135,000 Btu/h and < 240,000 Btu/h	47°F db/ 75°F wb outdoor air	2.9 COP	2.9 COP	

Higher EER Values for PTAC and PTHP Units

Added New Categories and Ratings for SPVAC and SPVHP Units

Added Categories and Ratings for Room Air Conditioners

TABLE C403.2.3(5) MINIMUM EFFICIENCY REQUIREMENTS: GAS- AND OIL-FIRED BOILER

EQUIPMENT TYPE[a]	SUBCATEGORY OR RATING CONDITION	SIZE CATEGORY (INPUT)	MINIMUM EFFICIENCY	TEST PROCEDURE
Boilers, hot water		Btu/h	80% AFUE	10 CFR Part 430
		tu/h and Btu/h[b]	80% E_t	10CFR Part 431
		Btu/h[a]	82% E_c	
	Oil-fired[c]	Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	82% E_t	10 CFR Part 431
		2,500,000 Btu/h[a]	84% E_c	
Boilers, steam		< 300,000 Btu/h	75% AFUE	10 CFR Part 430
	Gas	2,500,000 Btu/h[b]	79% E_t	10CFR Part 431
		2,500,000 Btu/h[a]	79% E_t	
	Gas-fired-natural draft	300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	77% E_t	
		> 2,500,000 Btu/h[a]	77% E_t	
	Oil-fired[c]	< 300,000 Btu/h	80% AFUE	10 CFR Part 430
		≥ 300,000 Btu/h and ≤ 2,500,000 Btu/h[b]	81% E_t	10CFR Part 431
		> 2,500,000 Btu/h[a]	81% E_t	

Category Reorganization

Modest Efficiency Increases

TABLE C403.2.3(8) MINIMUM EFFICIENCY REQUIREMENTS: HEAT REJECTION EQUIPMENT

EQUIPMENT TYPE[a]	TOTAL SYSTEM HEAT REJECTION CAPACITY AT RATED CONDITIONS	SUBCATEGORY OR RATING CONDITION	PERFORMANCE REQUIRED[b, c, d]	TEST PROCEDURE[e, f]
Propeller or axial fan open circuit cooling towers	All	95°F Entering Water 85°F Leaving Water 75°F Entering wb	≥ 38.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal fan open circuit cooling towers	All	95°F Entering Water [illegible] wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Propeller or axial fan closed circuit cooling towers	All	[illegible] Water 90°F Leaving Water 75°F Entering wb	≥ 14.0 gpm/hp	CTI ATC-105S and CTI STD-201
Centrifugal closed circuit cooling towers	All	102°F Entering Water 90°F Leaving Water [illegible] wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201
Air-cooled condensers	All	[illegible] 15°F Subcooling 95°F Entering db	≥ 176,000 Btu/h•hp	ARI 460

New Tables!

TABLE C403.2.3(9) HEAT TRANSFER EQUIPMENT

EQUIPMENT TYPE	SUBCATEGORY	MINIMUM EFFICIENCY	TEST PROCEDURE[a]
Liquid-to-liquid heat exchangers	Plate type	NR	AHRI 400

Off-Hour Controls C403.2.4.3 Mandatory

1. **Thermostatic Setback (55° to 85°)**
2. **Automatic Setback and Shutdown – Auto timeclock or programmable controls with daily scheduling capabilities**
3. **Automatic Start Capabilities**

Exceptions:
1. Continuously operated zones.
2. Zones with <=6,800 Btu/h & readily accessible manual shutoff

Automatic Start Capabilities C403.2.4.3.3 Mandatory

Automatic start controls for each HVAC system

Capable of automatically adjusting daily start time to bring each space to desired occupied temperature immediately prior to scheduled occupancy

Demand Controlled Ventilation C403.2.5.1 Mandatory

DCV **must be provided for spaces > 500 ft² and with an average occupant load > 25 people/1000 ft² of floor area where the HVAC system has:**

- An air-side economizer, or
- Automatic modulating control of the outdoor air damper, or
- A design outdoor airflow > 3,000 cfm

US DOE Building Codes University

(Trigger was 40 people/1000 ft²)

Demand Controlled Ventilation C403.2.5.1

Mandatory

Exceptions:

- Systems with energy recovery
- Multiple zone systems without direct digital control of single zones communicating with central control panel
- Systems with design outdoor airflow < 1,200 cfm
- Spaces where supply airflow rate minus any makeup or outgoing transfer air requirement < 1,200 cfm
- Ventilation provided for process loads only

Energy Recovery Ventilation Systems C403.2.6

Mandatory

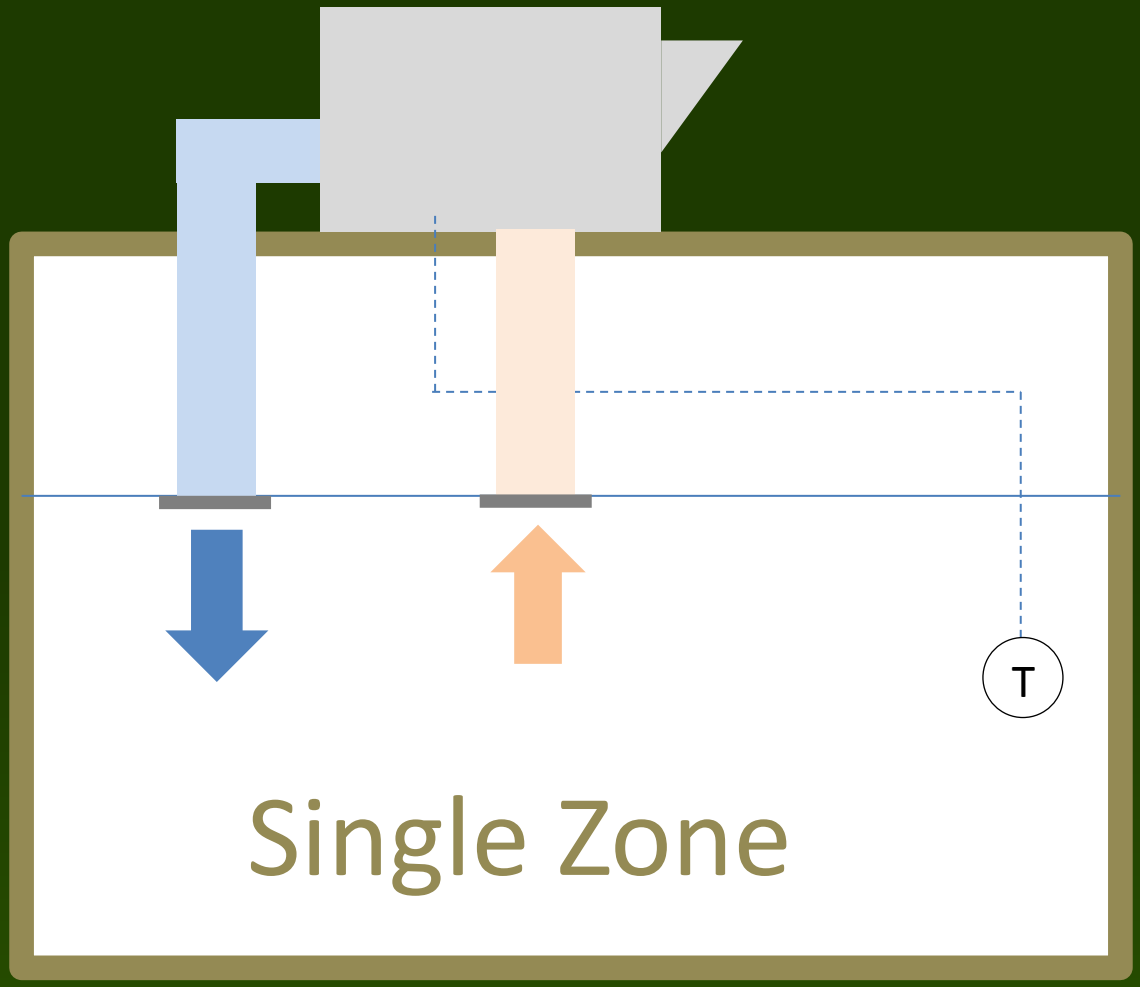
- Applies to fan systems with supply airflow rates > values in Table C403.2.6

TABLE C403.2.6 ENERGY RECOVERY REQUIREMENT

	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE					
	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
	DESIGN SUPPLY FAN AIRFLOW RATE (cfm)					
Climate Zone 6B	≥ 11000	≥ 5500	≥ 4500	≥ 3500	≥ 2500	≥ 1500

Replaces a single fixed trigger point of 5,000 cfm and 70% outside air.

Simple HVAC Systems *C403.3*

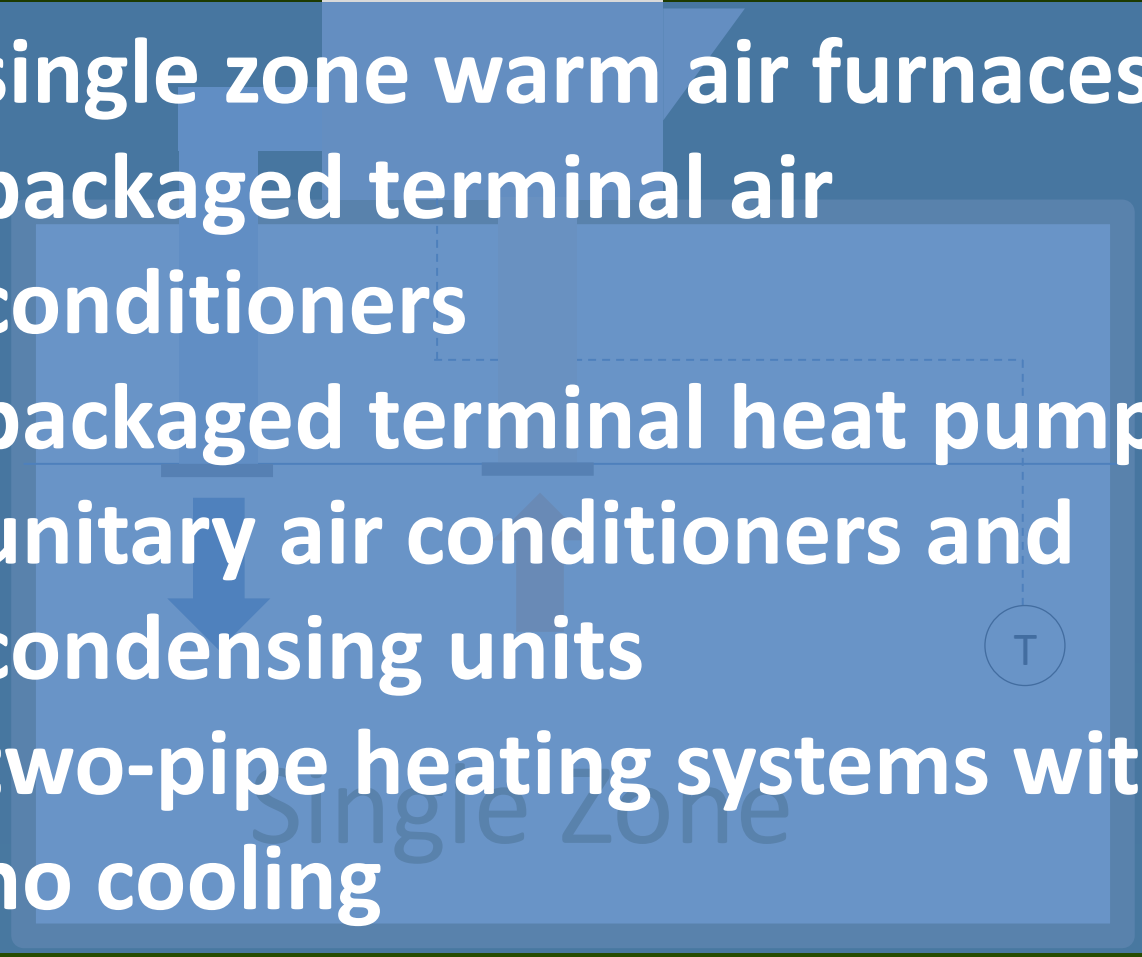


Source: NCAT

All systems that do not qualify as simple HVAC systems fall under the complex system requirements.

Simple HVAC Systems *C403.3*

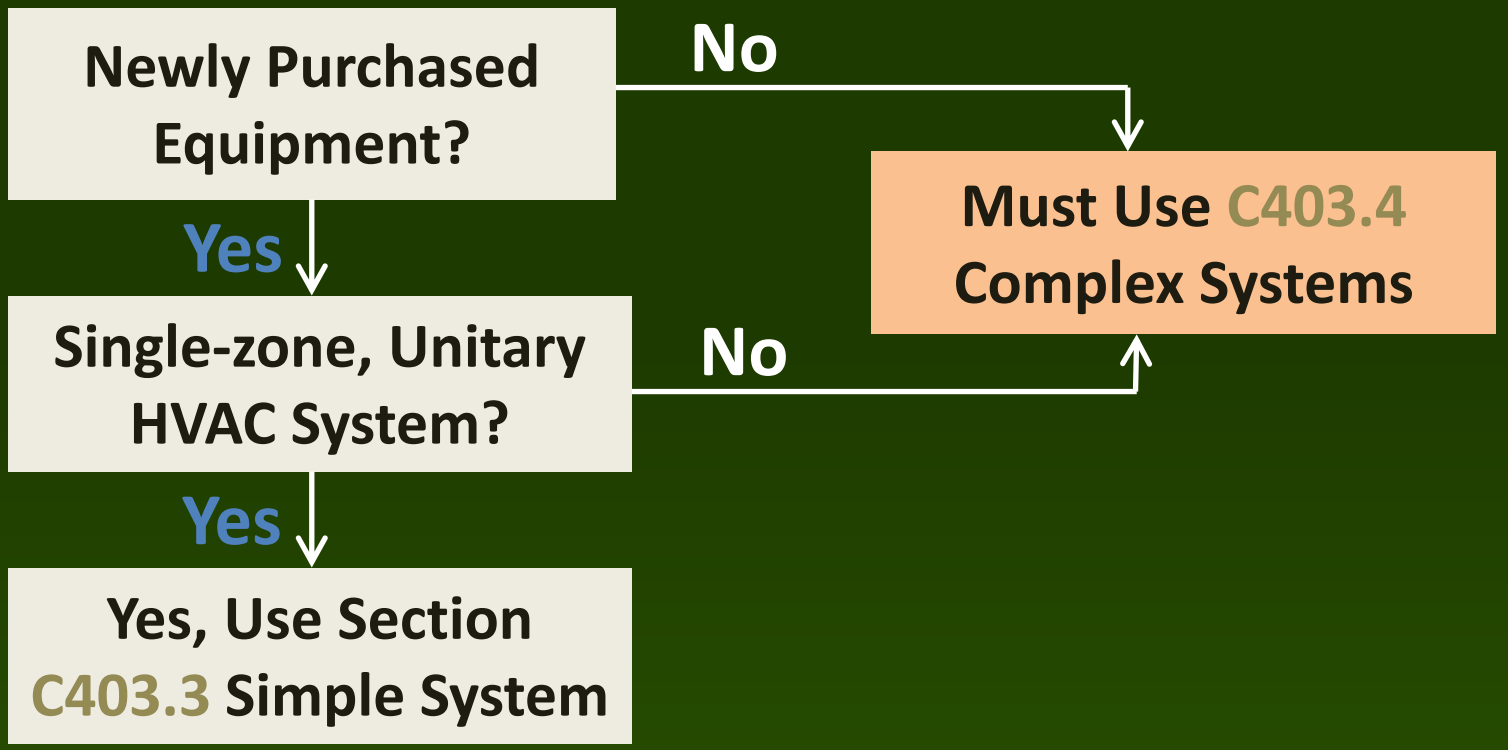
- single zone warm air furnaces
- packaged terminal air conditioners
- packaged terminal heat pumps
- unitary air conditioners and condensing units
- two-pipe heating systems with no cooling



Source: NCAT

All systems that do not qualify as simple HVAC systems fall under the complex system requirements.

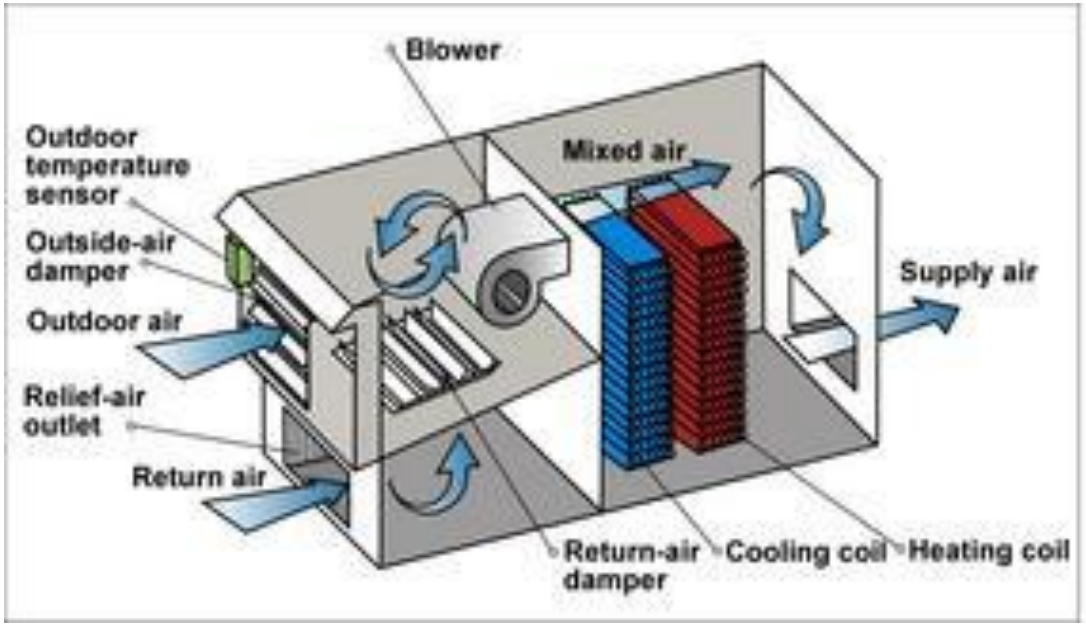
Compliance for Simple HVAC Systems and Equipment



Simple HVAC Systems & Equipment

C403.3

- ✓ Must include economizers dependent on climate zone
- ✓ Capable of providing 100-percent outdoor air even if additional mechanical cooling is required *(integrated economizer)*
- ✓ Must provide a means to relieve excess outdoor air



Simple HVAC System Economizers C403.3

TABLE C403.3.1(1) ECONOMIZER REQUIREMENTS	
	ECONOMIZER REQUIREMENT
Climate Zone 6	Economizers on all cooling systems ≥ 33,000 Btu/h[a]

[a] The total capacity of all systems without economizers shall not exceed 300,000 Btu/h per building, or 20 percent of its air economizer capacity, whichever is greater.

Exceptions (economizers not required)

- Individual fan-cooling units with supply capacity < 33,000 Btu/Hr
- Where > 25% of air designed to be supplied by the system is to spaces that are designed to be humidified > 35°F dew-point temperature to satisfy process needs
- Systems that serve residential spaces where system capacity is < 5 times requirement in Table C403.3.1(1)
- Systems expected to operate < 20 hours/week
- Where use of outdoor air for cooling will affect supermarket open refrigerated casework systems
- Where cooling efficiency meets of exceeds efficiency requirements in Table C403.3.1(2)

Simple Systems Air Economizers C403.3.1.1.3

High-Limit Shutoff

- Air economizers to be capable of automatically reducing outdoor air intake to design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage
- High-limit shutoff control types to be chosen from Table C403.3.1.1.3(1) for specific climates

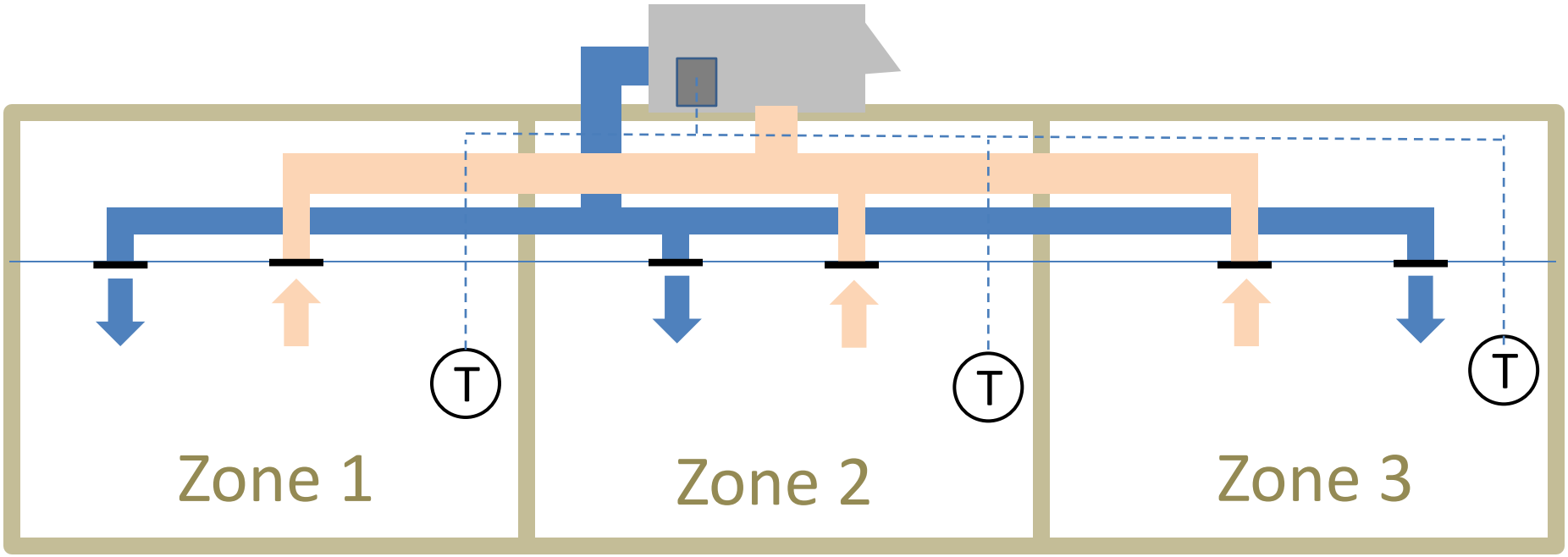
TABLE C403.3.1.1.3(1) HIGH-LIMIT SHUTOFF CONTROL OPTIONS FOR AIR ECONOMIZERS		
CLIMATE ZONES	ALLOWED CONTROL TYPES	PROHIBITED CONTROL TYPES
Climate Zone 6B	Fixed dry bulb	Fixed enthalpy
	Differential dry bulb	
	Electronic enthalpy[a]	
	Differential enthalpy	
	Dew-point and dry-bulb temperatures	

Simple System Air Economizers C403.3.1.1.4

Relief of Excess Outdoor Air

- **Systems to be capable of relieving excess outdoor air during air economizer operation to prevent over-pressurizing the building**
- **Relief air outlet to be located to avoid recirculation into the building**

Complex HVAC Systems *C403.4*



Source: NCAT

Examples: VAV systems, systems serving more than one zone, 4-Pipe Systems.

Complex System Economizers

Design Capacity C403.4.1.1

Water economizer systems

Capable of providing 100% of the cooling system load at 50°F dry bulb/45°F wet bulb and below

Exception:

Water economizer systems where dehumidification requirements can't be met at 50°F dry bulb/45°F wet bulb

Satisfy 100% of expected cooling load at 45°F dry bulb/40°F wet bulb

Complex System Economizers
Maximum Pressure Drop C403.4.1.2

Precooling coils and water-to-water heat exchangers in water economizer systems to have either a

- Waterside pressure drop of < 15 ft of water **OR**
- Secondary loop created so coil or heat exchanger drop isn't seen by circulating pumps when system is in normal cooling mode

Complex System Integrated Economizer Control

C403.4.1.3

Economizers

- Integrated with mechanical cooling system
- Capable of providing partial cooling even when additional mechanical cooling is required to meet remainder of cooling load

Exceptions:

- Direct expansion systems with controls that reduce quantity of outdoor air
  - required to prevent coil frosting at lowest step of compressor unloading
  - provided this lowest step is ≤ 25% of total system capacity
- Individual direct expansion units with rated cooling capacity < 54,000 Btu/h and using nonintegrated economizer controls that preclude simultaneous operation of the economizer and mechanical cooling

Complex System Heating System Impact

C403.4.1.3

Economizer operation to not increase building heating energy use during normal operation

Exception:

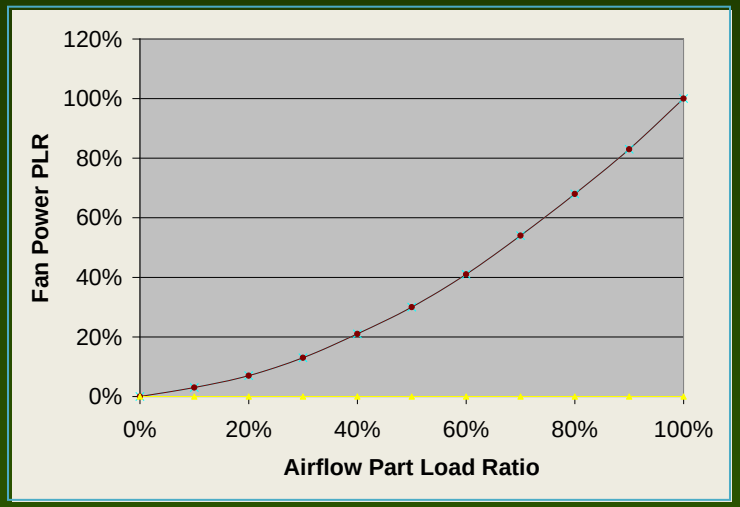
Economizers on VAV systems that cause zone level heating to increase due to a reduction in supply air temperature

Complex System Variable Air Volume Fan Control

C403.4.2

Individual VAV fans with motors ≥ 7.5hp must be:

- Driven by a mechanical or electrical variable speed drive **OR**
- Driven by a vane-axial fan with variable-pitch blades **OR**
- Have controls or devices to result in fan motor demand ≤ 30% of their design wattage at 50% of design airflow



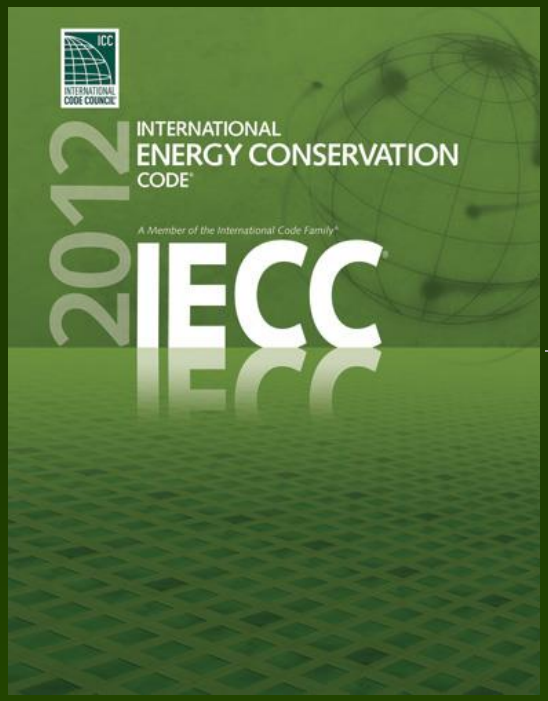
Static Pressure Sensor Location C403.4.2.1

Sensors used to control VAV fans

- **Placed so that the controller setpoint is ≤ 1/3 the total design fan static pressure**
  - Exception: systems with zone reset control complying with C403.4.2.2

Sensors installed downstream of major duct splits

- **At least one sensor to be located on each major branch so that static pressure can be maintained in each branch**



Section C405

Electrical Power and Lighting Systems

General Exception for Dwelling Units C405.1

75% High Efficacy either:

1. Lamps or

2. Permanently Installed Fixtures

High Efficacy Lamps

1. Compact Fluorescent Lamps (CFL)
2. T-8 or small Diameter Linear Fluorescent Lamps
3. Lamps that meet the minimum lumens/watt

Low-wattage do not count.

General Exception for Dwelling Units C405.1

High Efficacy Lamp Values

- 60 lumens per watt if over 40 W
- 50 lumens per watt if between 40 and 15 W
- 40 lumens per watt if 15 W less

Lamp Efficacy	
	Lum/Watt
Incandescent Tungsten Filament	7-18
Incandescent Tungsten Halogen	12-26
Linear Fluorescent	45-104
Compact Fluorescent	33-75
LED	70-140

Lighting Controls Overview C405

Interior Lighting Power Density

Building Area Method **OR** Space-By-Space Method *

Manual Lighting Controls

Interior Manual Controls **AND** Light Reduction Controls *

+

Additional Lighting Controls

Automatic Time Switch * **OR** Occupancy Sensors *

+

Daylight Zone Controls

Manual * **OR** Automatic *

+

Specific Application Controls *

* - Indicates Change from previous code.

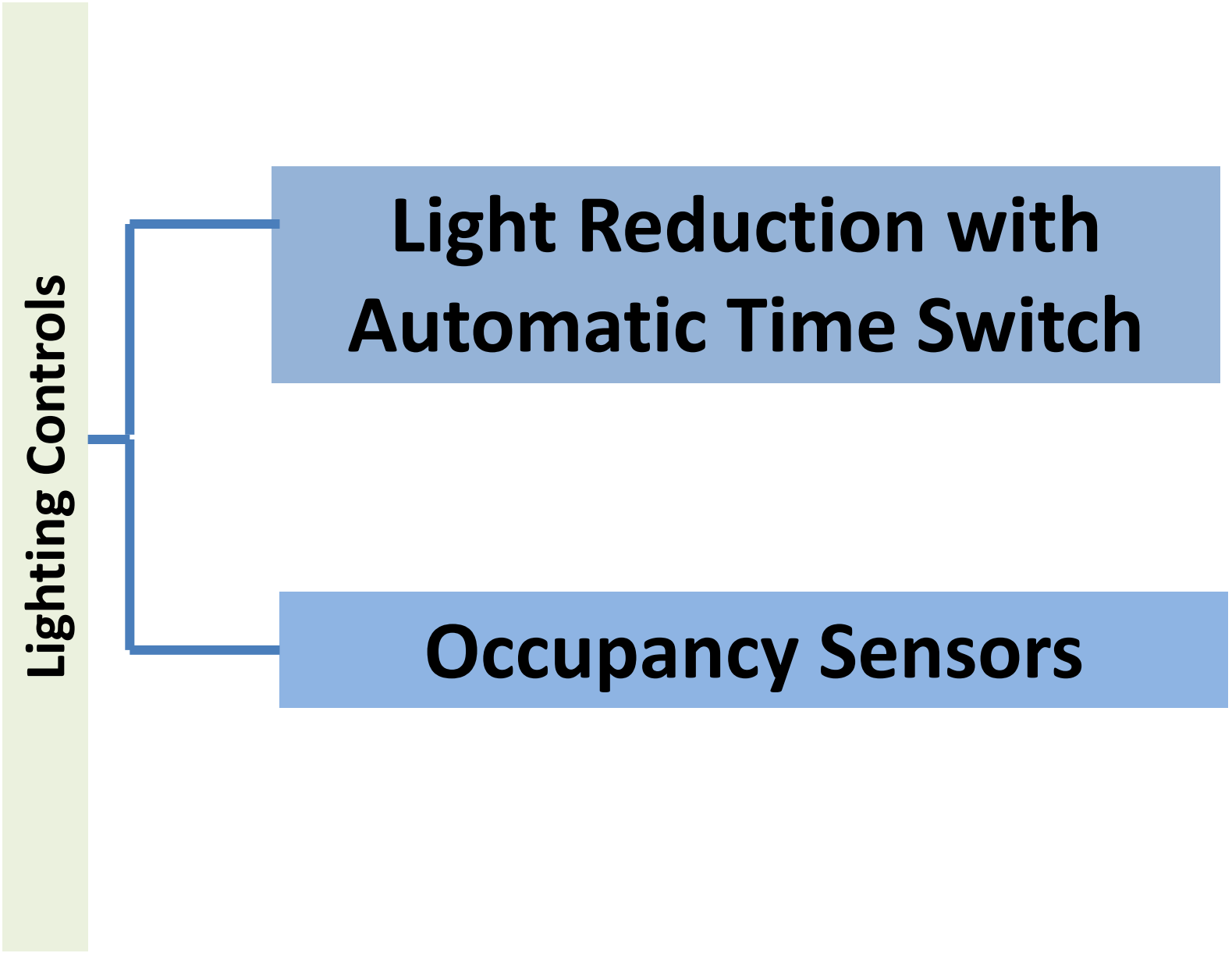
Lighting Controls

Exceptions:

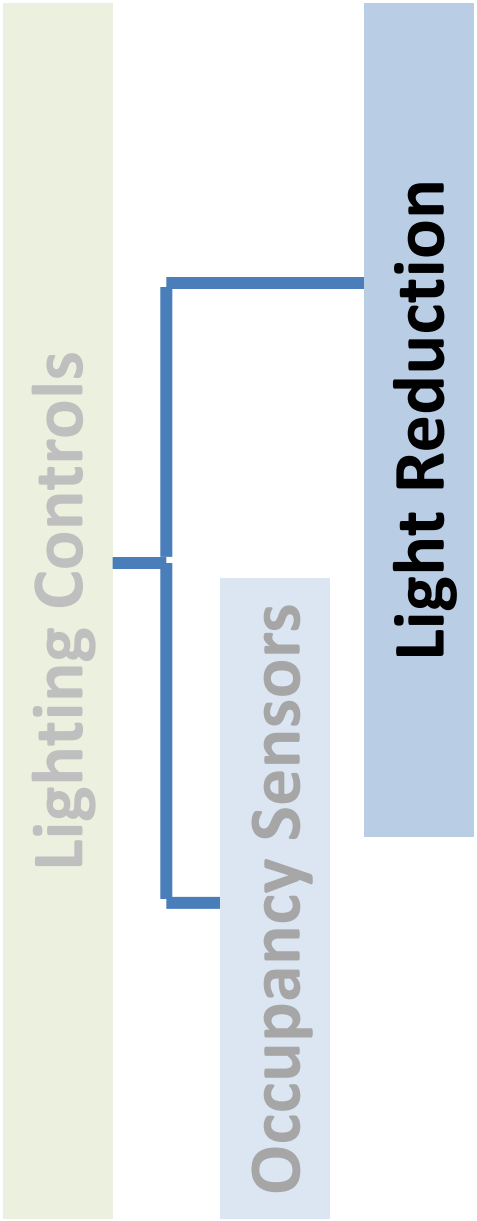
Emergency & Security Areas

Stair and Corridor Egress Lighting

Lighting Controls



Lighting Controls

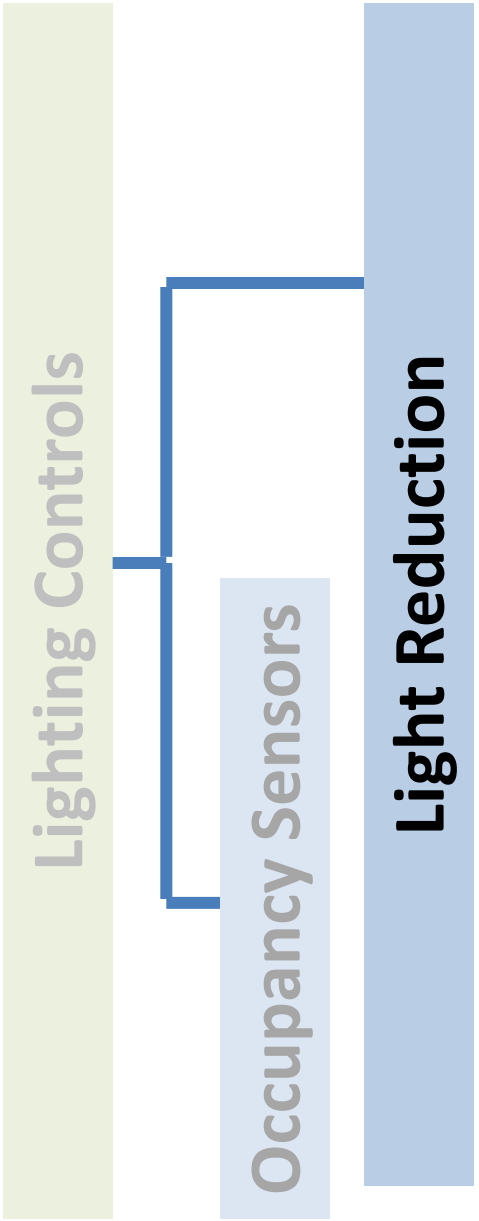


Minimum 50% Reduction

Approved Methods:

- Control lamps or fixtures
- Dual switching
- Middle lamp independent switched
- Switch each fixture

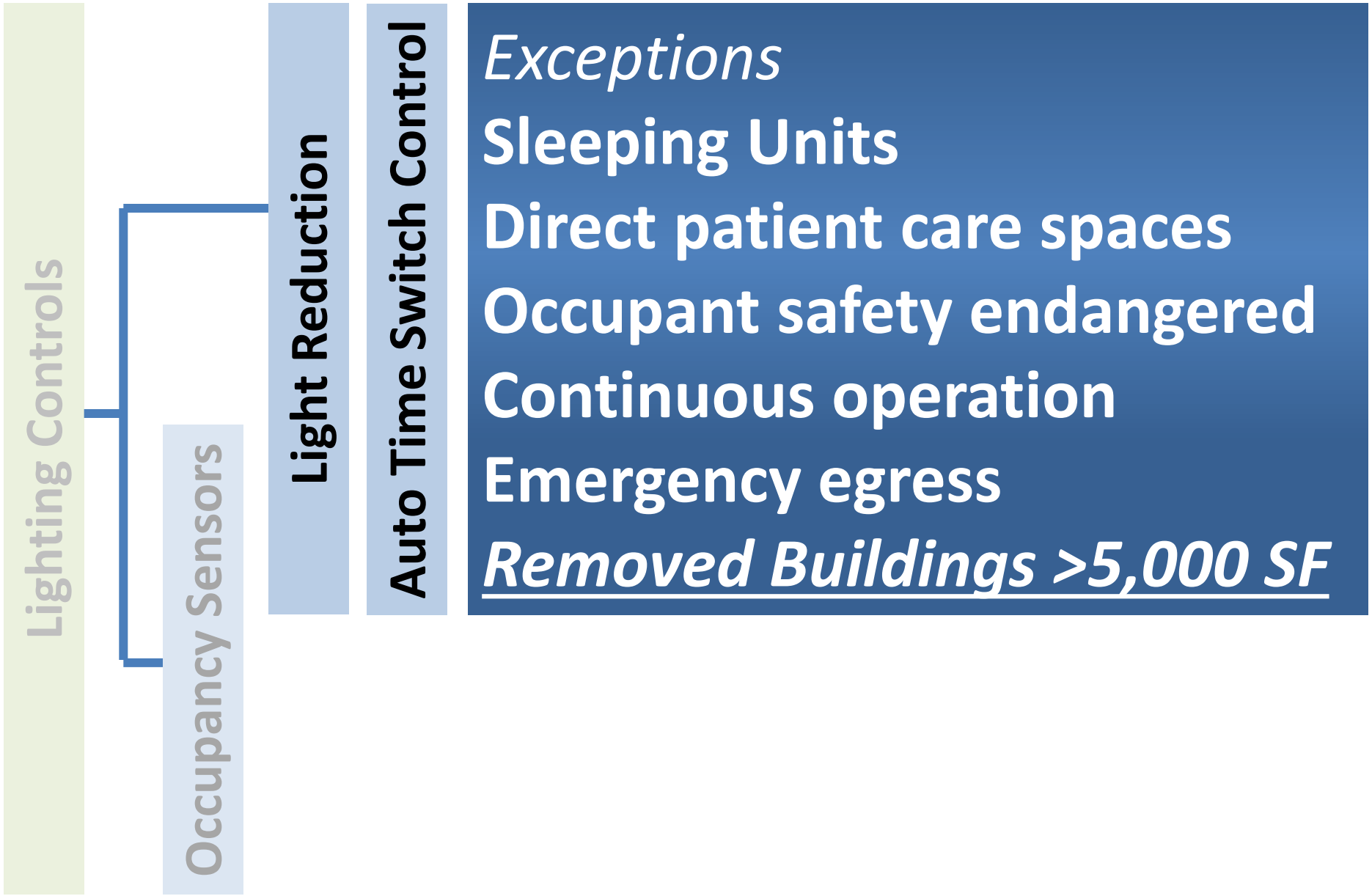
Lighting Controls



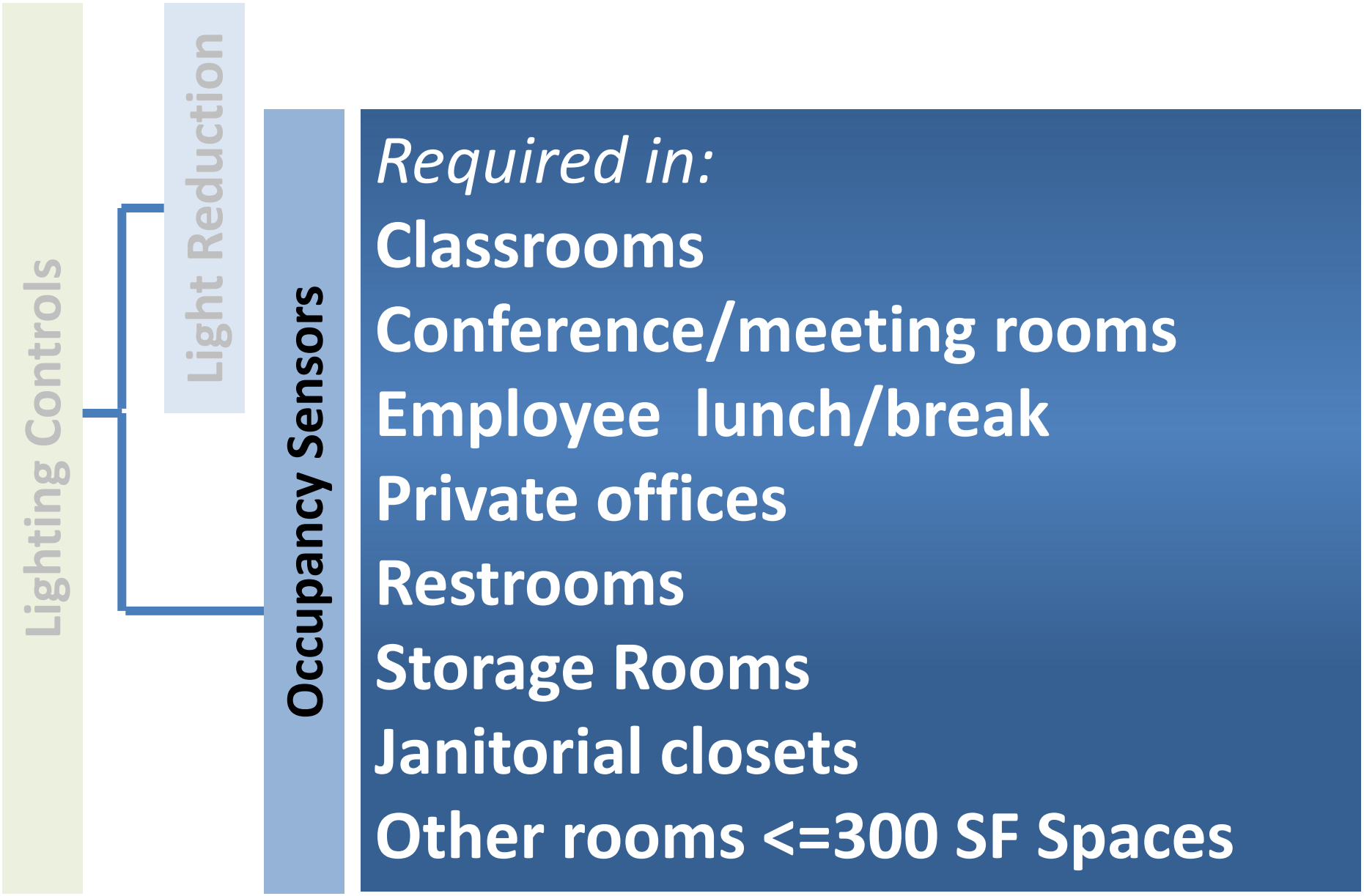
Need not be provided:

- **Areas 1 fixture <u>≤100w</u>**
- **Corridors, equipment rooms, storerooms, restrooms, public lobbies, <u>electrical/mech rooms</u>**
- **Sleeping unit**
- **Spaces with < 0.6 w/sf**
- **<u>Daylight areas with auto controls</u>**

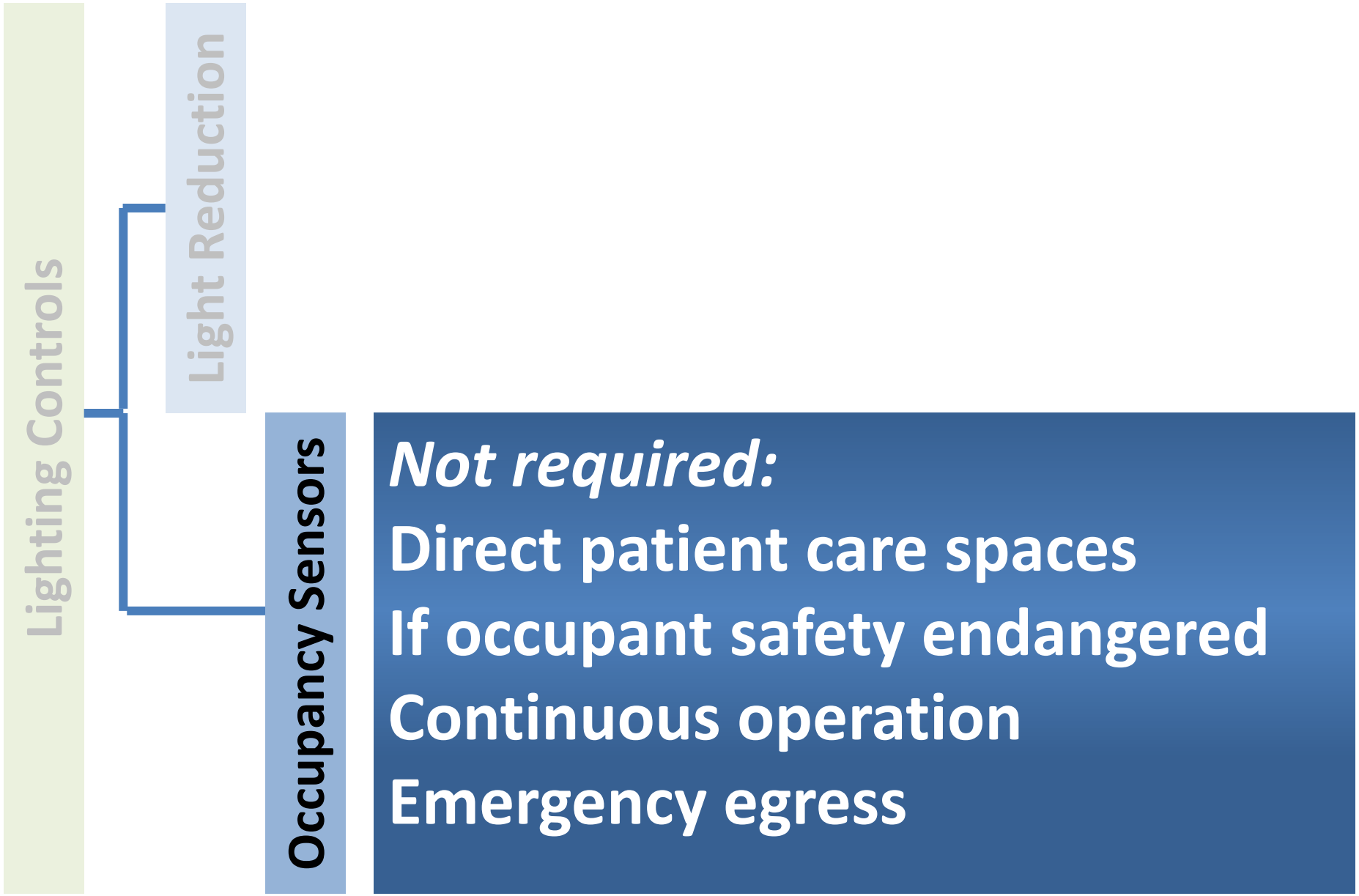
Lighting Controls



Lighting Controls



Lighting Controls



Lighting Controls

Lighting Controls

Light Reduction

Occupancy Sensors

Installation:

Turn off within 30 min

Manual on or auto to <50%

"Full on" ok in:

- **Public corridors**
- **Stairways**
- **Restrooms**
- **Primary entrance areas**
- **Safety or security endangered**

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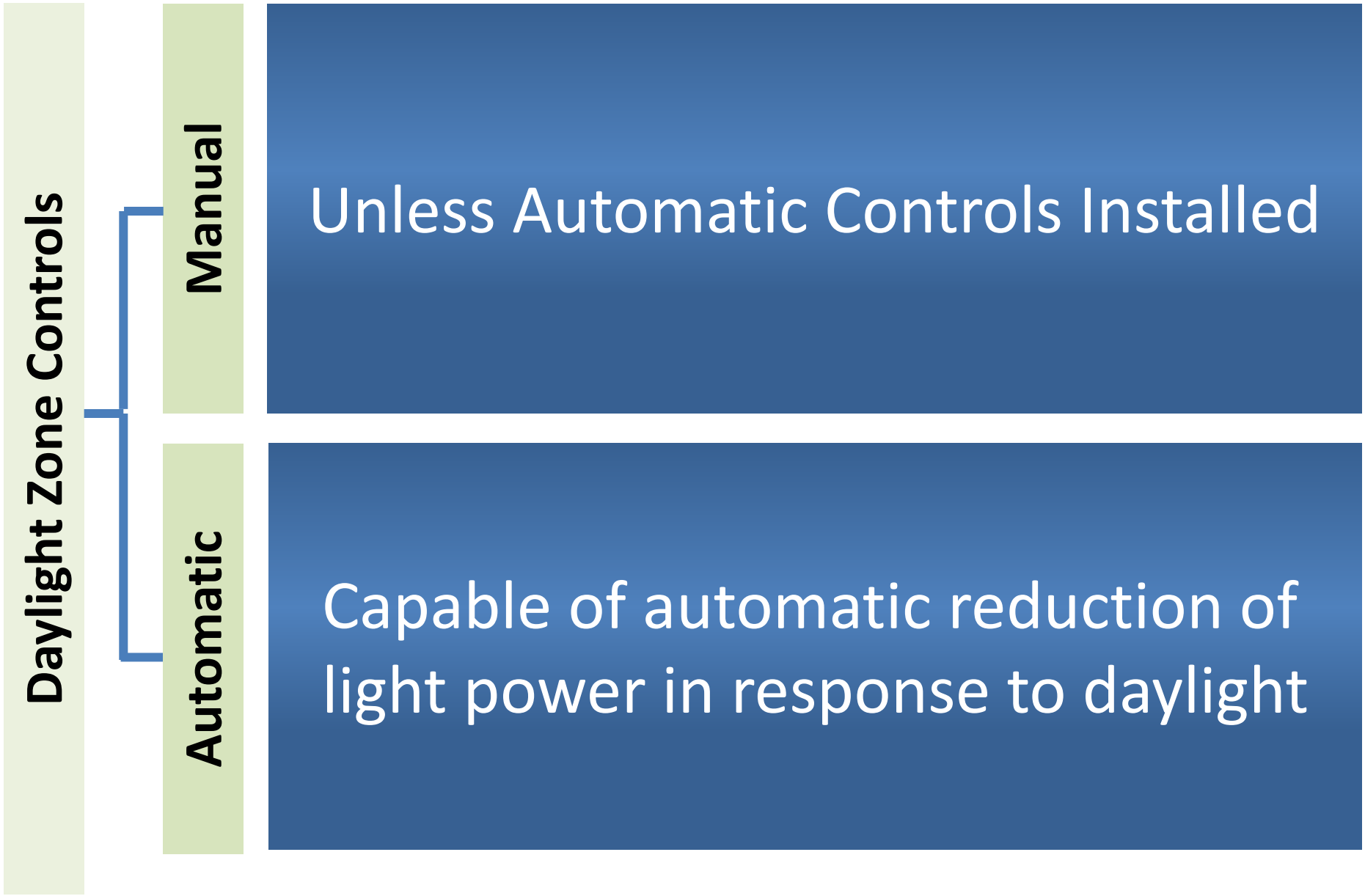
Daylight Zone Controls

Daylight Zone Controls

Independent of General Lighting

- Control Zone <= 2,500 SF
- Adjacent to vertical fenestration contiguous zones use one control devise (max. 2 cardinal directions)
- Under skylights more than 15’ from perimeter must be separate from vertical fenestration daylight zone
- Room <=2 fixtures, separate general lighting control not required

Daylight Zone Controls



Daylight Zone Controls

Daylight Zone Controls

- Manual
- **Automatic**

Methods:

- Continuous dimming to <35%
- Stepped dimming with 2 control steps:
  - 50% and 70%
  - <35%

Additional Lighting Controls C405.2.3
Specific Application Controls

Dedicated, independent control

- **Display and accent lighting**
- **Display case lighting**
- **Nonvisual applications (i.e., plant growth and food warming)**
- **Lighting equipment for sale or demonstration in lighting education**
- **Supplemental task lighting, permanently installed under-shelf or under-cabinet lighting**


The *Building Energy Codes Resource Guide: USDOE Building Technologies Program*

Hotel and motel sleeping units and guest suites

- Master control device at main room entry

Interior Lighting Power C405.5.2

Two methods to determine allowance:

- **Building Area Method**

  Allowance = the floor area for each building area type listed x the value from Table C405.5.2(1)

- **Space-by-Space Method**

  Interior lighting power allowance = the floor area of each space x the value for the space type in Table C405.5.2(2) that most closely represents the proposed use of the space and then summing the lighting power allowances for all spaces

The Building Energy Codes Resource Guide: USDOE Building Technologies Program

Interior Lighting Power C405.5.2
Building Area Method vs. Space-by-Space

TABLE C405.5.2(1) INTERIOR LIGHTING POWER ALLOWANCES: BUILDING AREA METHOD	
BUILDING AREA TYPE	LPD (w/ft^2)
Automotive facility	0.9
Convention center	1.2
Courthouse	1.2
Dining: bar lounge/leisure	1.3
Dining: cafeteria/fast food	1.4
Dining: family	1.6
Dormitory	1
Exercise center	1
Fire station	0.8
Gymnasium	1.1
Health care clinic	1
Hospital	1.2

TABLE C405.5.2(2)—continued INTERIOR LIGHTING POWER ALLOWANCES: SPACE-BY-SPACE METHOD	
COMMON SPACE-BY-SPACE TYPES	LPD (w/ft^2)
Atrium – First 40 feet in height	0.03 per ft. ht.
Atrium – Above 40 feet in height	0.02 per ft. ht.
Audience/seating area – permanent	
For auditorium	0.9
For performing arts theater	2.6
For motion picture theater	1.2
Classroom/lecture/training	1.3
Conference/meeting/multipurpose	1.2
Corridor/transition	0.7
Dining area	
Bar/lounge/leisure dining	1.4
Family dining area	1.4

Interior Lighting Power Density Comparison

	Building Area Method		Reduced INT LTG Power		Spaceby-Space Method	
2009 LPD w/ft^2	Building Area Type	2012 LPD w/ft^2	Building Area Type	LPD w/ft^2	Space Type	LPD w/ft^2
1.00	Hotel	1.00	Hotel/Motel	0.88	Dining area	1.3
					Guest rooms	1.1
					Hotel lobby	2.1
					Highway lodging dining	1.2
					Highway lodging guest rooms	1.1
1.00	Office	0.90	Office	0.90/0.85*	Office – enclosed	1.1
					Office – open plan	1

* - First LPD value applies if at least 30% of conditioned floor area is in daylight zones with automatic controls. In all other cases, second LPD value applies.

Space-By-Space Merchandise Additional Allowances
C405.5.2.1

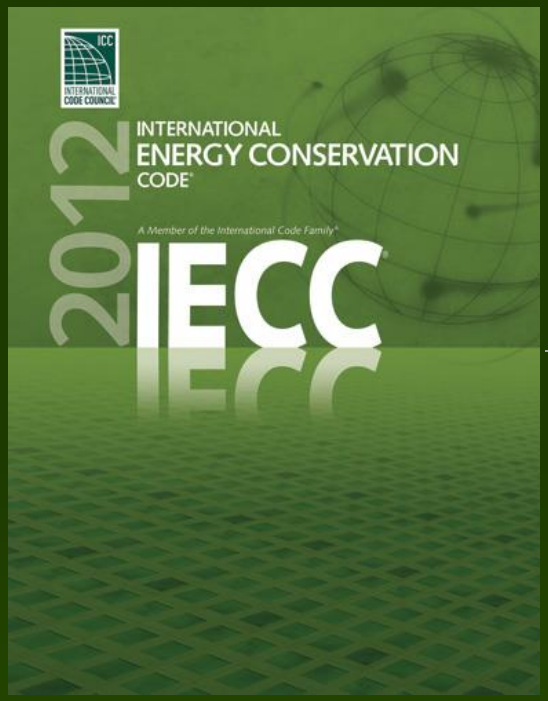
- **Deleted from Building Area Method**
- **Relocated to the Space-by-Space Method**

There is now no additional merchandise lighting power allowance using the Building Area Method.

Area 1: All Other (0.6 W/SF)
Area 2: Vehicles, sporting goods, small electronics (0.6 W/SF)
Area 3: Furniture, clothing, cosmetics, artwork (1.4 W/SF)
Area 4: Jewelry, crystal, china (2.5 W/SF)

Using the Space-by-Space method, the LPD for each space may not exceed the installed allowance for that space.

Using the Space-by-Space method, the LPD for each space may not exceed the installed allowance for that space.



Section C406

Additional Efficiency Package Options

Additional Efficiency Package Options C406

One additional efficiency feature must be selected to comply with the IECC

More efficient HVAC system

OR

More efficient lighting system
(consistent with 90.1-2010)

OR

Installation of onsite renewables; 3% of the regulated energy

Additional Efficiency Package Options C406

- **Efficient HVAC performance (C406.2)**
  - Per Tables C406.2(1) thru C406.2(7)
  - Only used when efficiencies in the above tables are greater than those in the efficiency tables in C403
- **Efficient lighting system (C406.3)**
  - Whole building LPD complies with C406.3.1
  - Determine total LPD of building using reduced whole building interior lighting power in Table 406.3 x floor area for the building types
- **On-site supply of renewable energy (C406.4)**
  - Total minimum ratings to comply with
    - Provide ≥ 1.75 Btu or ≥ 0.50 watts per ft^2 of conditioned floor area OR
    - Provide ≥ 3% of energy used for mechanical and SWH equipment and lighting

Individual tenant spaces to comply with either C406.2 or C406.3 unless documentation is provided that demonstrates compliance with C406.4 for the entire building

Additional Efficiency Package Options C406

- **Efficient HVAC performance (C406.2)**
  - Per Tables C406.2(1) thru C406.2(7)
  - Only used when efficiencies in the above tables are greater than those in the efficiency tables in C403
- **Efficient lighting system (C406.3)**
  - Whole building LPD complies with C406.3.1
  - Determine total LPD of building using reduced whole building interior lighting power in Table C406.3 x floor area for the building types
- **On-site supply of renewable energy (C406.4)**
  - Total minimum ratings to comply with
    - Provide ≥ 1.75 Btu or ≥ 0.50 watts per ft^2 of conditioned floor area OR
    - Provide ≥ 3% of energy used for mechanical and SWH equipment and lighting

Individual tenant spaces to comply with either C406.2 or C406.3 unless documentation is provided that demonstrates compliance with C406.4 for the entire building

Additional Efficiency Package Options C406.3

- **Useful only in conjunction with the Building Area LPD method?**

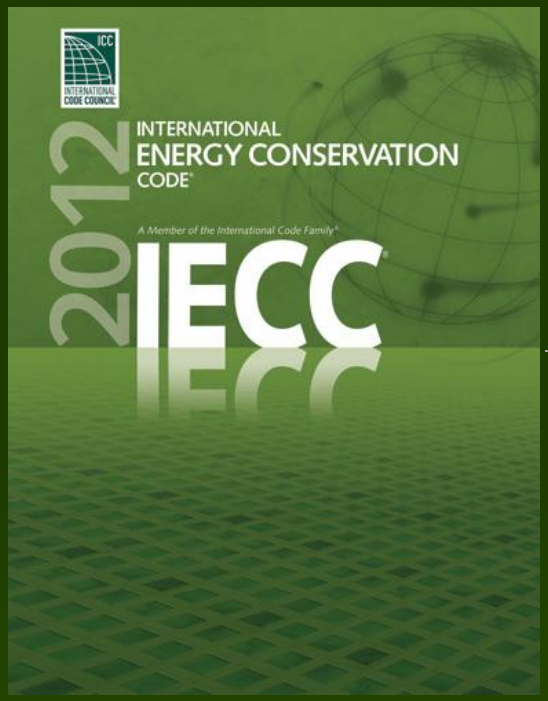
Watts/sq. ft.	LPD Building Area Method C405.5.2(1)	Additional Efficiency Package C406.3
Office	0.9	0.90/0.85
Retail	1.4	1.4/1.3
Hospital	1.2	1.10
School	1.2	0.99
Warehouse	0.6	0.60 *
Gymnasium	1.1	1.00
Town Hall	1.1	0.92

* - 70% of floor area in daylight zones with automatic daylight controls.

Additional Efficiency Package Options C406

- **Efficient HVAC performance (C406.2)**
  - Per Tables C406.2(1) thru C406.2(7)
  - Only used when efficiencies in the above tables are greater than those in the efficiency tables in C403
- **Efficient lighting system (C406.3)**
  - Whole building LPD complies with C406.3.1
  - Determine total LPD of building using reduced whole building interior lighting power in Table 406.3 x floor area for the building types
- **On-site supply of renewable energy (C406.4)**
  - Total minimum ratings to comply with
    - Provide ≥ 1.75 Btu or ≥ 0.50 watts per ft^2 of conditioned floor area OR
    - Provide ≥ 3% of energy used for mechanical and SWH equipment and lighting

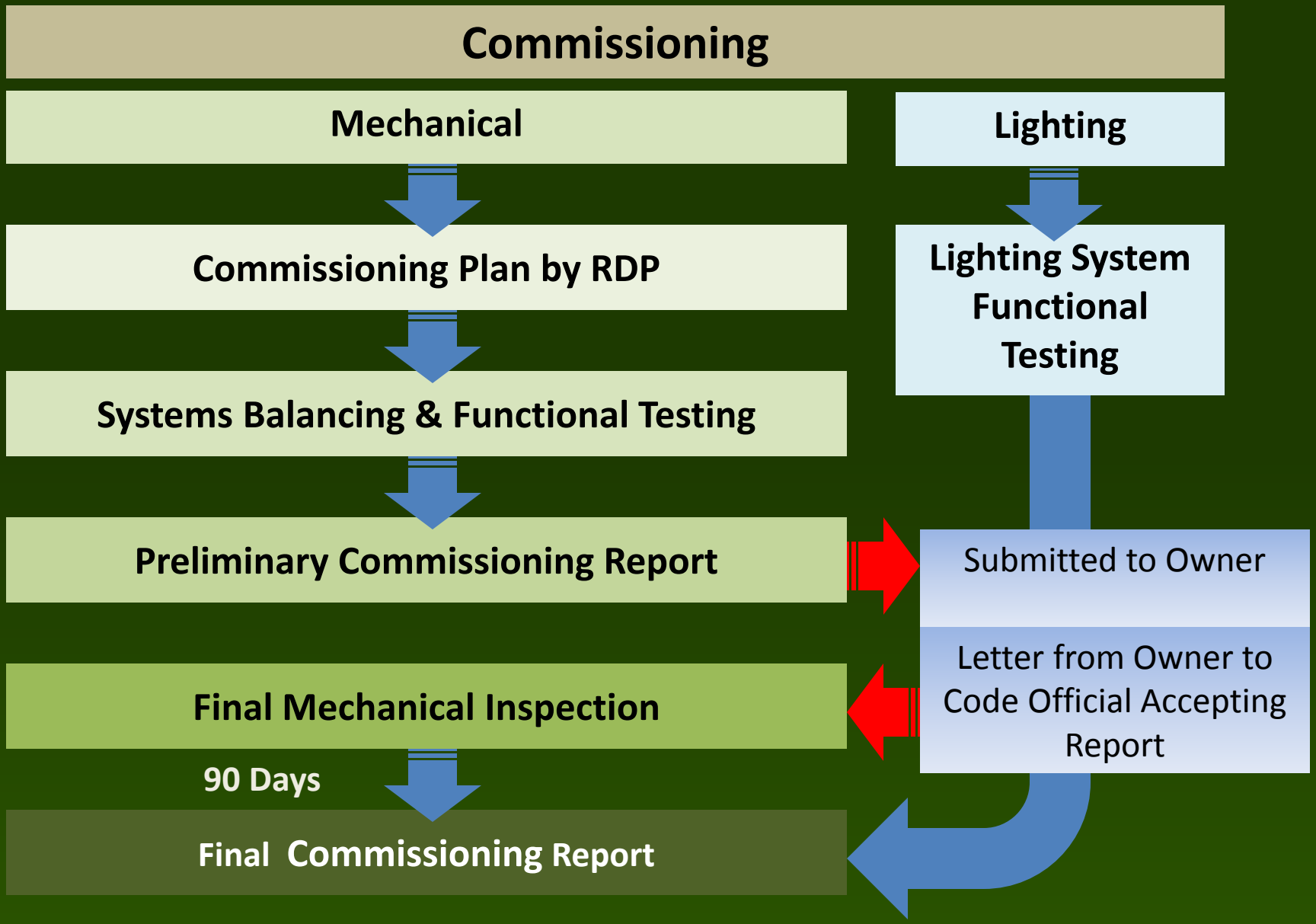
Individual tenant spaces to comply with either C406.2 or C406.3 unless documentation is provided that demonstrates compliance with C406.4 for the entire building



Section C408

System Commissioning

System Commissioning C408.1



Mechanical Systems Commissioning and Completion Requirements C408.2

- Places additional requirements on the registered design professional (or approved agency)
- RDP evidence of commissioning (and completion) before final mechanical inspection
- Construction documents indicate commissioning requirements
- Copies of all documents given to owner, made available to code official
- Written commissioning plan

Mechanical Systems Commissioning and Completion Requirements C408.2

- Prior to passing final mechanical inspection registered design professional to provide evidence of commissioning and completion
- Construction document notes to clearly indicate provisions for commissioning and completion requirements, may refer to specifications
- Copies of all documents to be provided to the owner and made available to code official upon request

Mechanical Systems Commissioning and Completion Requirements C408.2 Exceptions

These systems are exempt from mechanical commissioning requirements

- In buildings where total mechanical equipment capacity is < 480,000 Btu/h cooling capacity and 600,000 Btu/h heating capacity
- Included in Section C403.3 (Simple Systems) that serve dwelling units and sleeping units in hotels, motels, boarding houses or similar units

Mechanical Systems Commissioning

C408.2.1 Commissioning Plan

Registered Design Professional to clearly detail:

- Who is to perform commissioning and provide documentation
- What equipment and systems are to be tested and by whom
- When commissioning is to take place and documentation turned over
- How tests are to be conducted with conditions of testing and measurable criteria

Mechanical Systems Commissioning

Balancing and Functional Testing C408.2.2, C408.2.3

- **Systems Balancing**
  - Air Systems
  - Hydronic Systems
- **Functional Testing**
  - Equipment
  - Controls
  - Economizers

Mechanical Systems Commissioning

Preliminary Commissioning Report C408.2.**4**

Registered design professional or approved agency to complete, certify, and submit to the building owner and will identify:

- Itemization of deficiencies found during testing that haven't been corrected at the time of report preparation
- Deferred tests that can't be performed at the time of report preparation due to climatic conditions
- Climatic conditions required for performance of deferred tests

Mechanical Systems Commissioning

Documentation Requirements C408.2.5

Construction documents to specify that documents be provided to building owner within 90 days of receipt of certificate of occupancy

- Drawings
- Manuals
- System balancing report
- Final commissioning report

Include location and performance data on each piece of equipment

Mechanical Systems Commissioning

Documentation - Manuals C408.2.5.2

O&M manual to be provided to include:

- Size and selected options for each piece of equipment requiring maintenance
- Manufacturer's manuals for each piece of equipment requiring maintenance. Required routine maintenance actions to be clearly identified.
- Name and address of at least one service agency
- HVAC controls system maintenance and calibration information
- Narrative of how each system is intended to operate

Mechanical Systems Commissioning

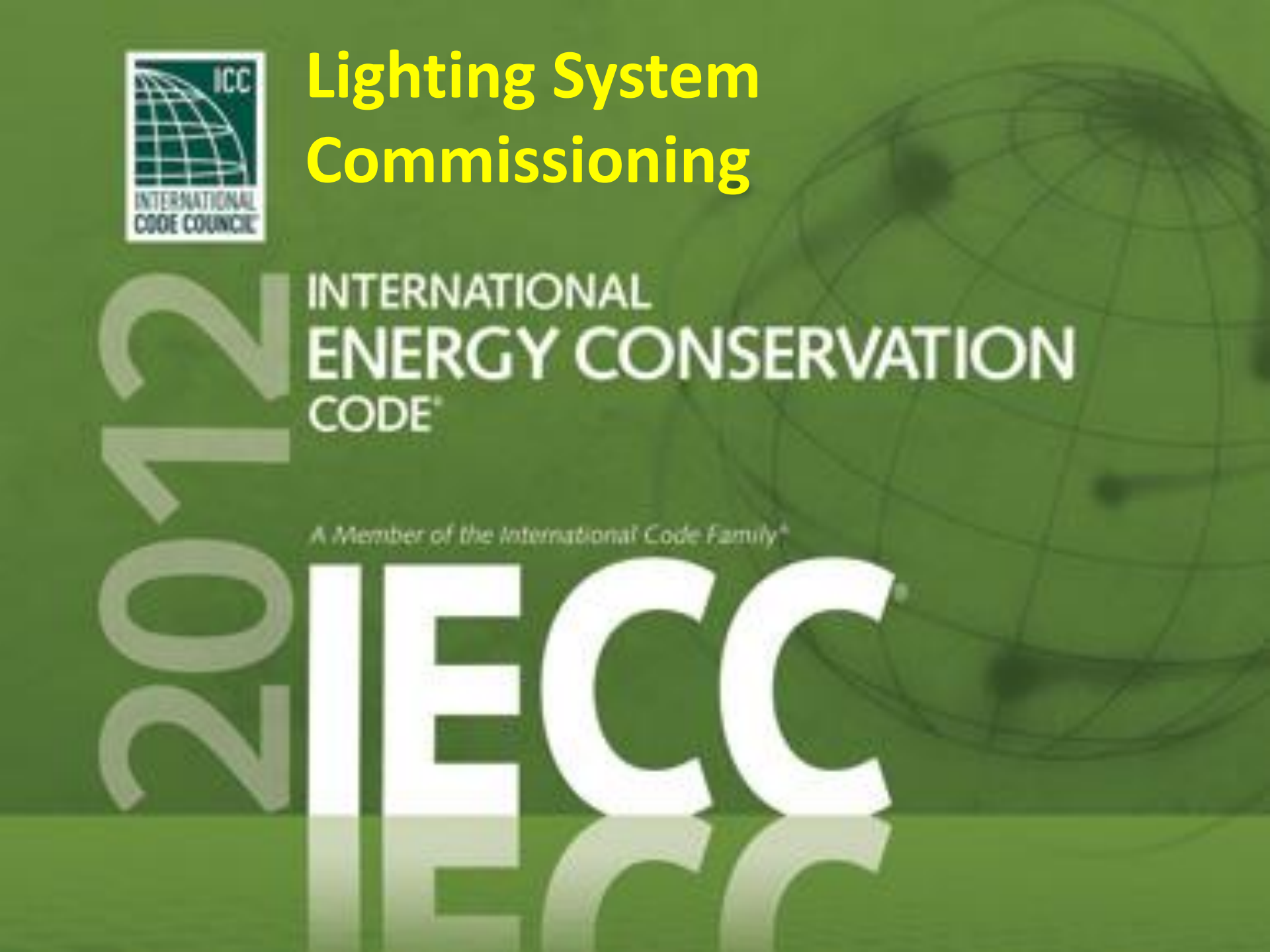
Documentation – System Balancing Report C408.2.5.3
Documentation – Final Commissioning Report C408.2.5.4

System Balancing Report: Written report of system balancing.

Final Commissioning Report: Registered design professional or approved agency to complete, certify, and submit to the building owner and will identify:

- Itemization of uncorrected deficiencies
- Deferred tests
- Climatic conditions required for deferred tests

Lighting System Commissioning



Lighting System Functional Testing C408.3.1

- **Testing to ensure that control hardware and software are calibrated, adjusted, programmed and in proper working order per construction documents and manufacturer's installation instructions**
- **Construction documents to state who will conduct the testing**
- **Where required by the code official….**

  …….an approved independent party shall be responsible for the testing and documentation certifying the installed controls meet the provisions

Lighting System Functional Testing C408.3.1

Where the following are installed:

- Occupant sensors
- Programmable schedule controls
- Daylighting controls
- Time switches
- Photosensors

It is required that the following be confirmed:

- Placement, sensitivity and time-out adjustments for occupant sensors yield acceptable performance
- Time switches and programmable schedule controls are programmed to turn the lights off
- Placement and sensitivity adjustments for photosensor controls reduce electric light based on the amount of usable daylight in the space as specified

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