

January 13, 2021 12:15 – 3:30

KEY COMMERCIAL ENERGY CODE COMPLIANCE AND REVIEW ISSUES

University of Minnesota, Annual Institute for Building Officials

Russ Landry, PE & Di Sui, PE

Moderated by Clint Zane, City of St. Paul



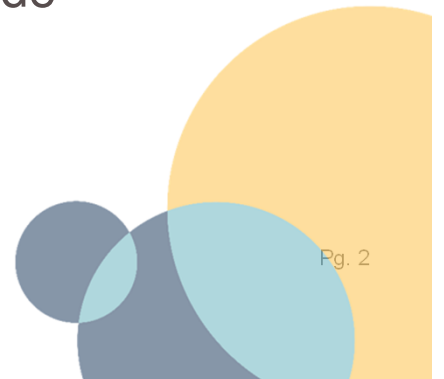
While you're waiting, you can download a quick-reference guide at: mncee.org/code

Near the bottom of the right panel, under Resources click on:

- Climate zone 6A

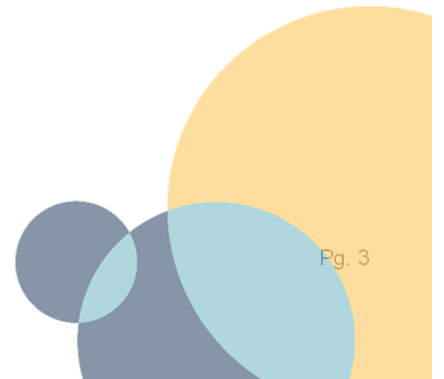
•• Presenters' Experience & 'Angle'

- 31 & 7 Years @ CEE on Energy Efficiency in Buildings
 - Existing buildings--field research, audit programs & recommissioning
 - Last 17 years on new construction review & building energy simulation
- Also Drawing on Others' Work & Knowledge
 - 2013 MN DOLI study on energy code compliance
 - Numerous studies & interviews from other states
 - Just completed Minnesota commercial energy code compliance study
 - Slipstream, LHB, Franklin Energy, IMT
 - Just completed DOE funded commercial energy code compliance study
 - Institute for Market Transformation & PNNL



•• Commercial New Construction History

- Design & Development Team Support (mostly 2004 – 2011)
 - Consulting & energy simulation for energy savings
 - Green building program certification
 - Consulting
 - Energy simulation
 - Field verification/commissioning
 - Pilot energy code support program
- Plan Review Energy Program & Code Reviews (2009→)
 - Reviewer for SB 2030 program
 - Performance path
 - Prescriptive path—created & review
 - Pilot energy code support program (2016-2017)



Commercial Energy Code Support Program

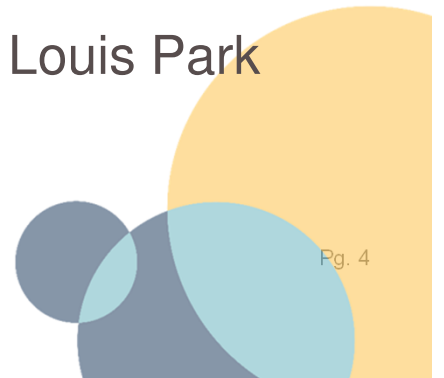


This project was supported by a grant from the Minnesota Department of Commerce, Division of Energy Resources through the Conservation Applied Research and Development (CARD) program.

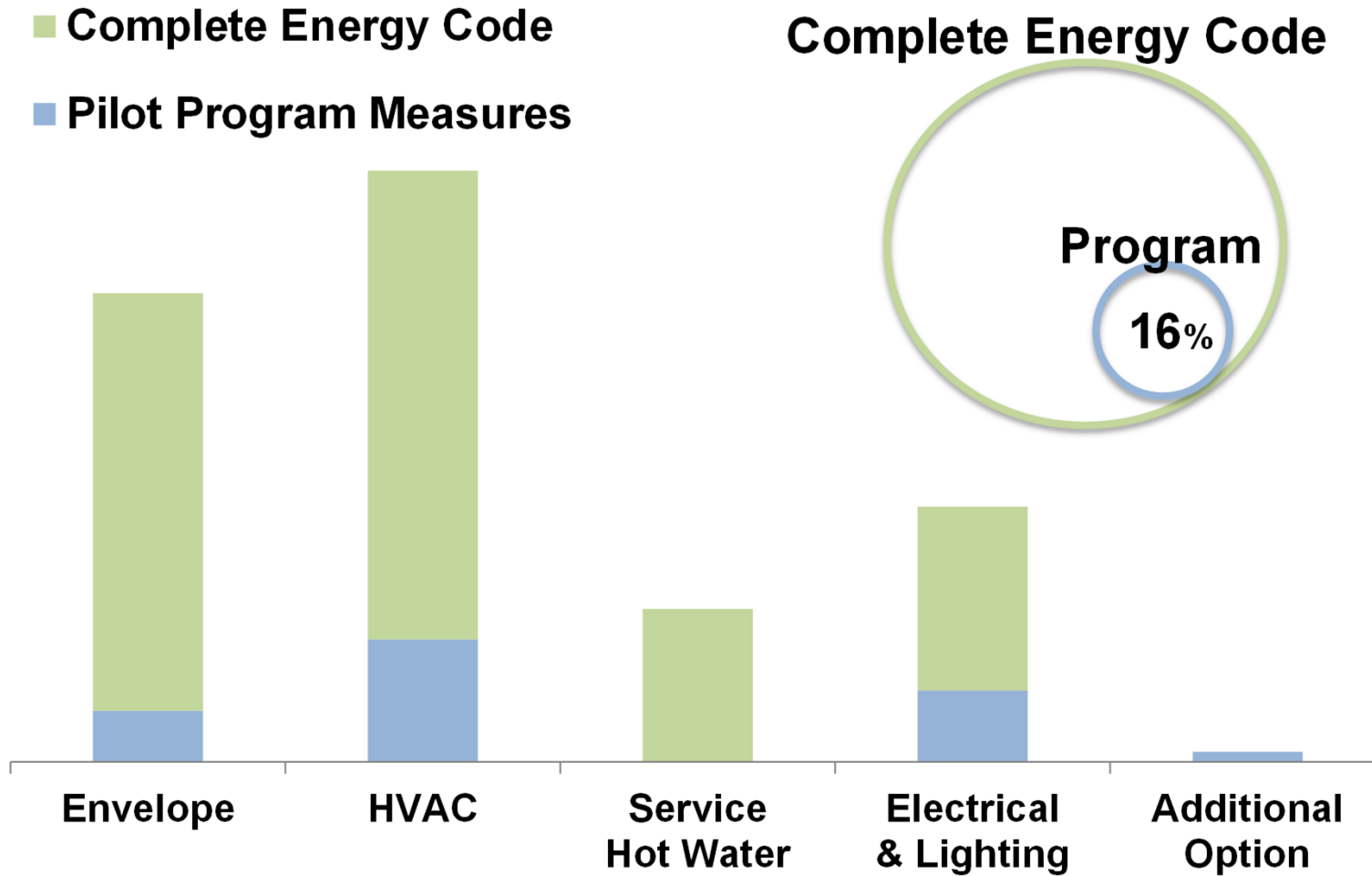
Anthony Fryer | CIP Coordinator

Thanks to our Partners:

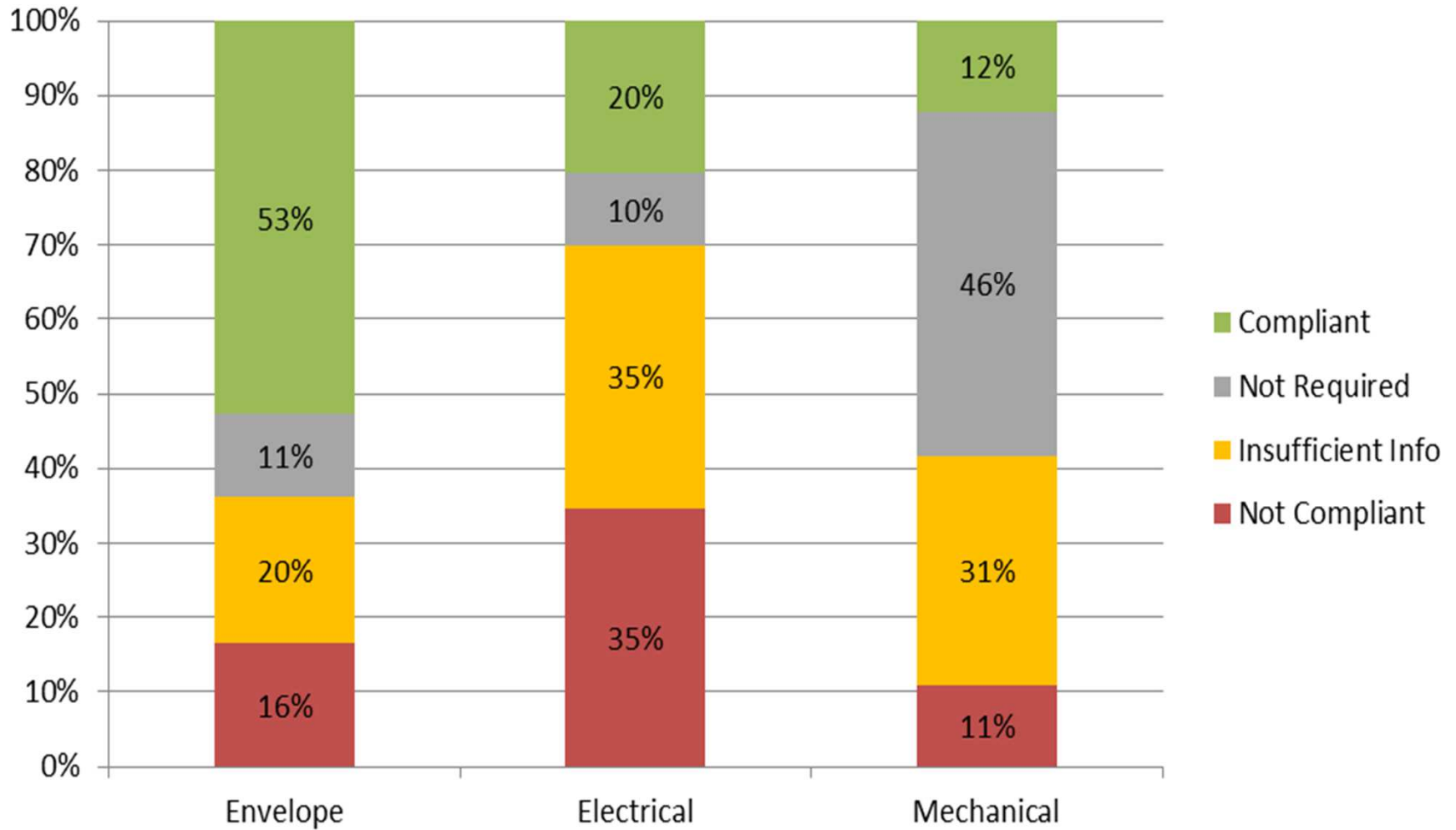
Tim Manz and the cities of Blaine, Minnetonka & St. Louis Park



❖ Focused Scope of Program Measures



• Breakdown of Compliance by Division



•• What We'll Be Discussing Today

- A. Energy Code Path Options & Code Organization
- B. Key Energy Code Items by Code Section
 - 1. Building Envelope
 - 2. Mechanical Systems
 - BREAK --
 - 3. Lighting & Other Electric Systems
 - 4. Special Paths
- C. Effective Compliance Review Process
- D. Final Q&A

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click on: • Climate zone 6A**

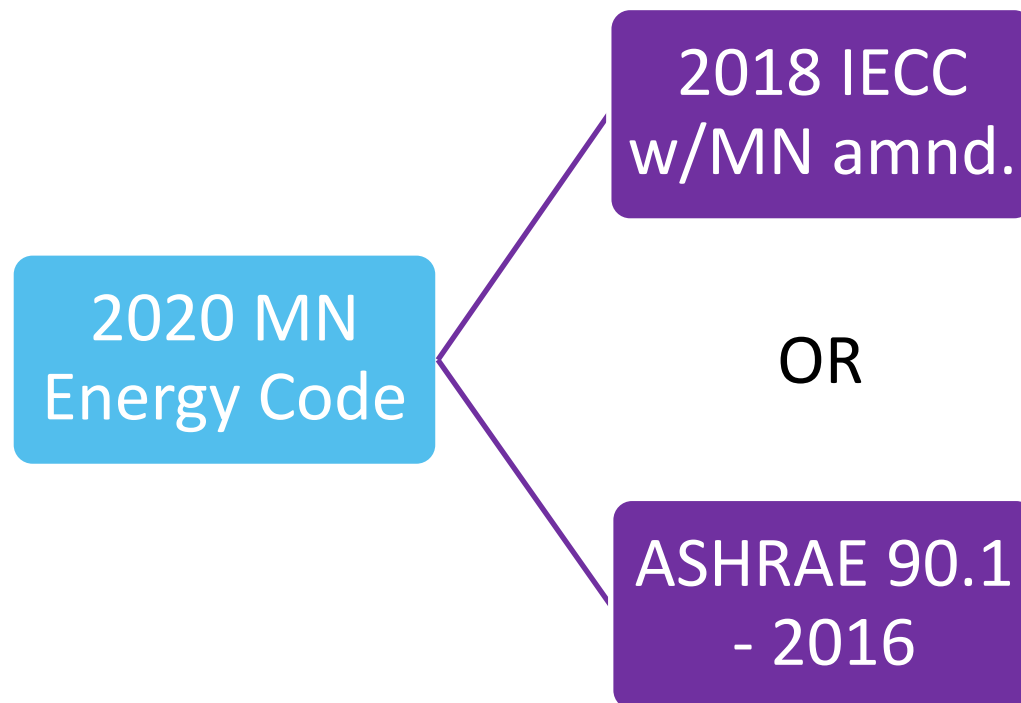
Overview of Energy Code Structure & Paths: IECC vs ASHRAE, Prescriptive vs Performance, Additional Efficiency Package Option

•• MN Commercial Energy Code Paths

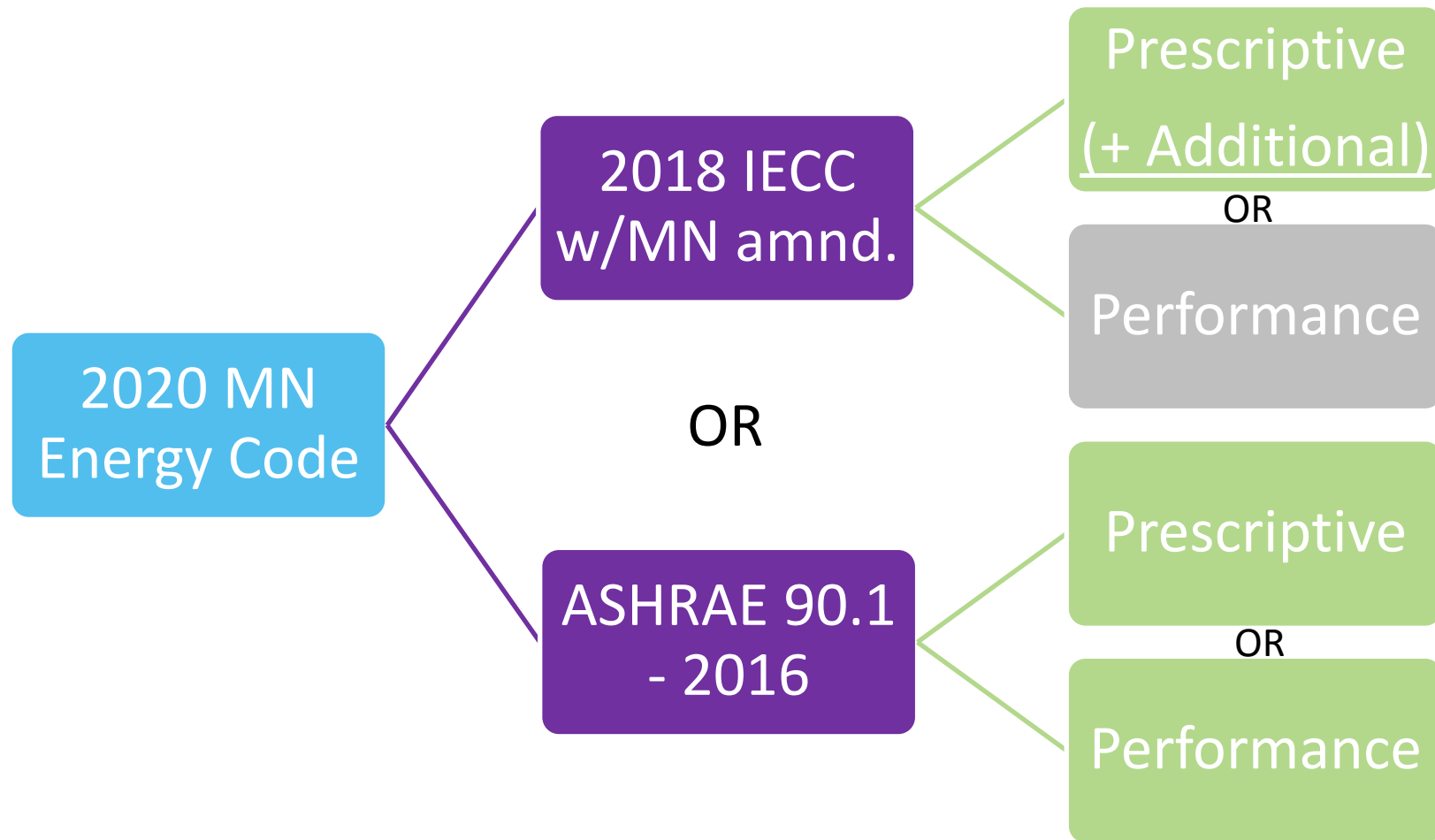
“There can be only one”

-Highlander movie, 1986

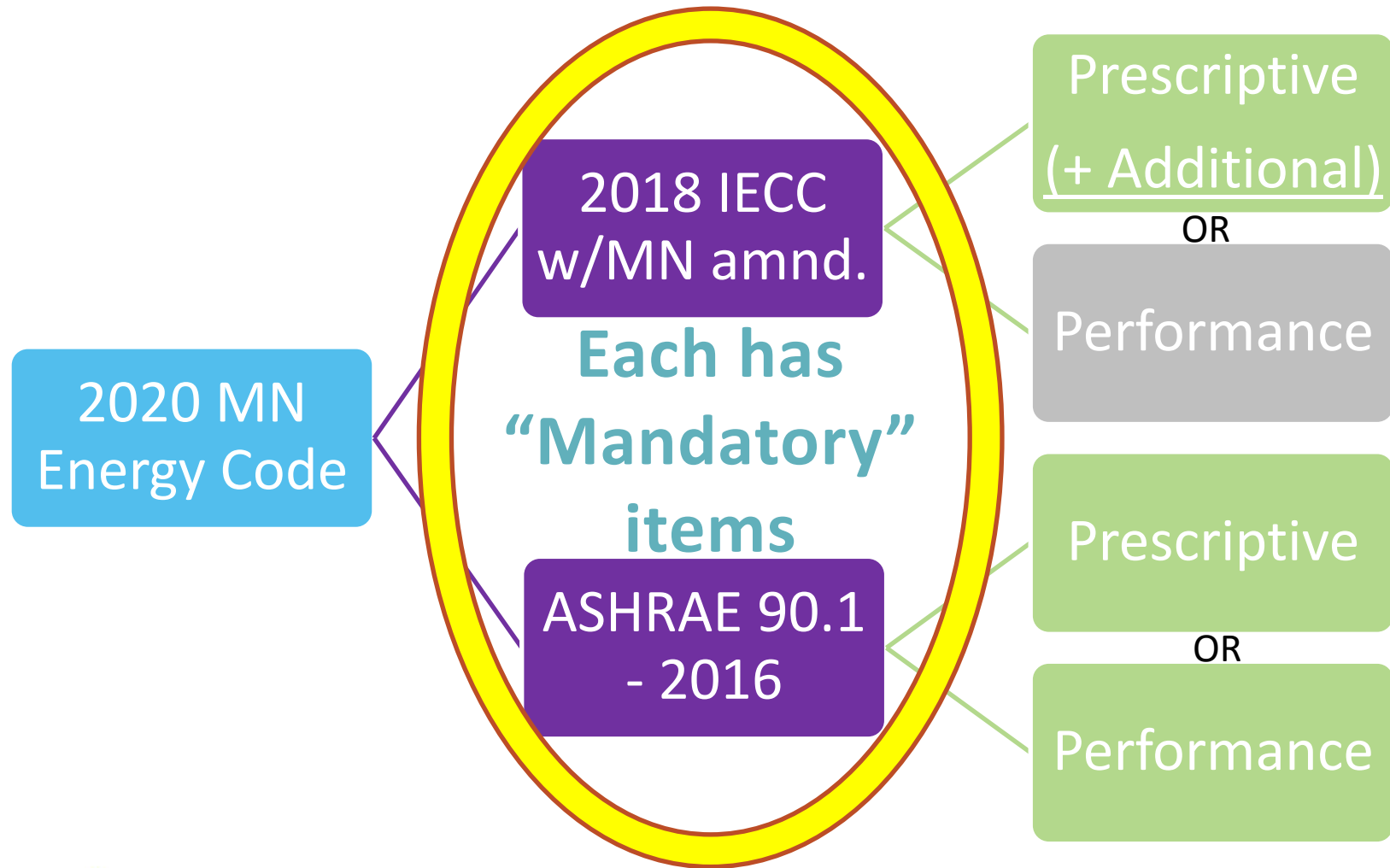
•• MN Commercial Energy Code Paths



•• MN Commercial Energy Code Paths



•• MN Commercial Energy Code Paths



Identifying Mandatory vs Prescriptive Requirements

- IECC
 - Labelled at Major Sections--look for “(Mandatory)”
 - Go up to xx.x level for anything at a xx.x.x.x level
 - IECC C40x.x.x.x look for “(Mandatory)”
- ASHRAE 90.1
 - sections x.4 are all mandatory
 - Sections x.5 are all prescriptive

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 - sections x.4 are all mandatory
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SECTION C402 BUILDING ENVELOPE REQUIREMENTS

C402.1 General (Prescriptive).

The building thermal envelope shall comply with Section C402.1.1. Section C402.1.2 shall be permitted as an alternative to the *R*-values specified in Section C402.1.1.

C402.1.1 Insulation and fenestration criteria.

The *building thermal envelope* shall meet the requirements of Tables C402.2 and C402.3 based on the climate zone specified in Chapter 3. Commercial buildings or portions of commercial buildings enclosing Group R occupancies

LIVE CH

5.4 Mandatory Provisions

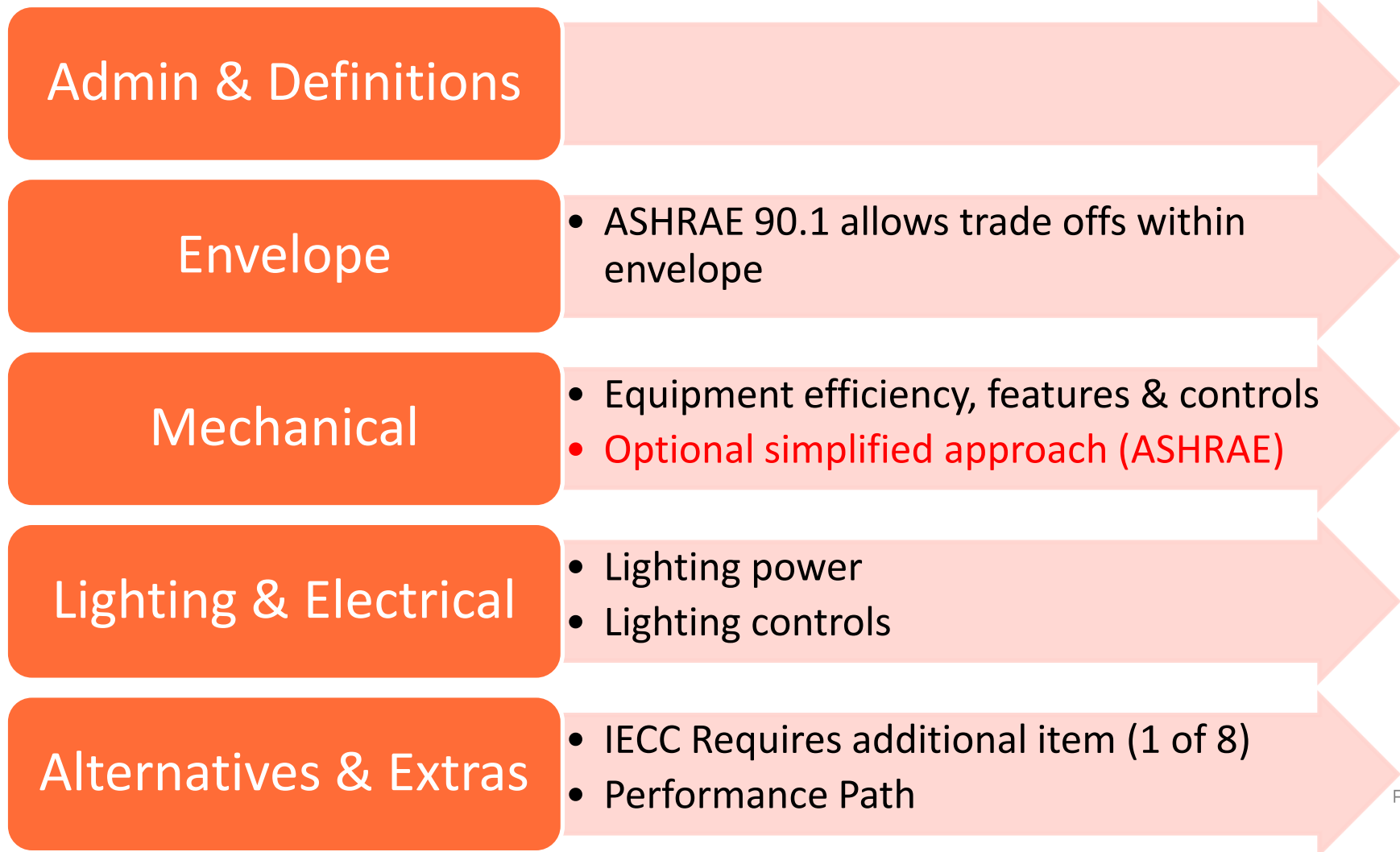
5.4.1 Insulation. Where insulation is required in Section 5.5 or 5.6, it shall comply with the requirements found in Sections 5.8.1.1 through 5.8.1.9.

5.4.2 Fenestration and Doors. Procedures for determining *fenestration* and *door* performance are described in Section 5.8.2. Product samples used for determining *fenestration* performance shall be production line units or representative of units purchased by the consumer or contractor.

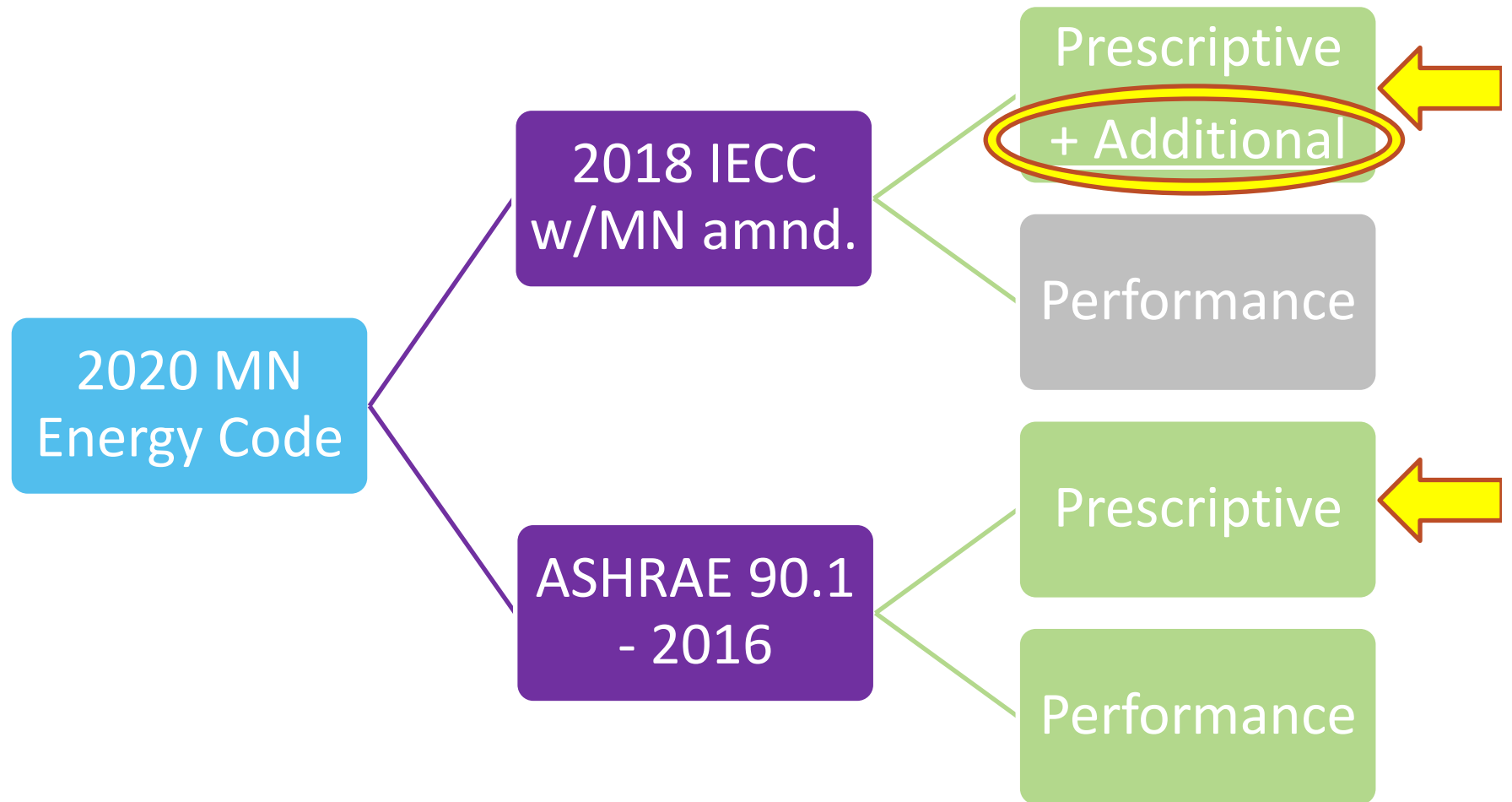
5.4.3 Air Leakage

5.4.3.1 Continuous Air Barrier. The entire *building envelope* shall be designed and constructed with a *continuous air barrier*.

•• Basic Outline of Both IECC & ASHRAE



❖ Prescriptive Paths



•• 1st Option in IECC & 90.1: Prescriptive

- Prescriptive Across All Areas:



- Envelope (Trade-Off Within)

- HVAC

- Service Water Heating

- Electrical Power & Lighting



- If IECC—Additional Efficiency Package (Pick 1 of 8)



- Consistent—Design Team Must Choose One Code

- All IECC w/MN Amendments or All ASRHAE 90.1

•• Envelope Trade-Offs & COMcheck

- Code Basis
 - ASHRAE 90.1-2016
 - Specifically allows envelope trade-offs within prescriptive (5.6) following a specific calculation procedure (in App.C)
 - COMCheck is most commonly used to do calculations
 - 2018 IECC
 - There is no specific reference to Envelope Trade-Off
 - COMCheck follows 90.1 calc guidance w/IECC thresholds
 - 1323.0100 Subpart 8 is often interpreted as allowing COMcheck to show compliance via envelope trade-offs
 - “The building official is authorized to approve specific computer software...that meet the intent of this code.”

•• 1st Option in IECC & 90.1: Prescriptive

- Prescriptive Across All Areas:

- Envelope (Trade-Off Within)
- HVAC
- Service Water Heating
- Electrical Power & Lighting



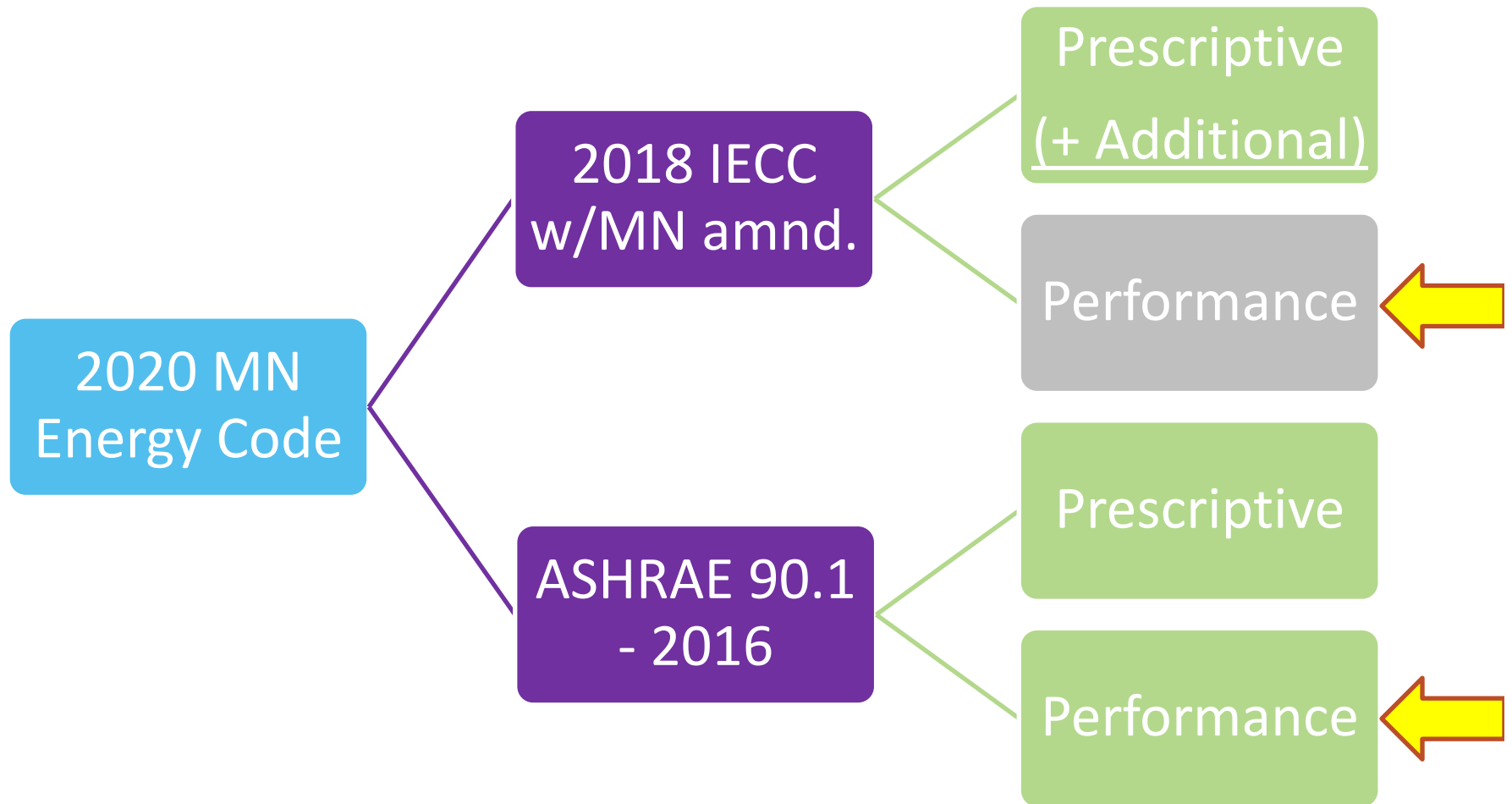
- If IECC—Additional Efficiency Package (Pick 1 of 8)



- Consistent—Design Team Must Choose One Code

- All IECC w/MN Amendments or All ASRHAE 90.1

•• Performance Paths



•• 2nd Option in IECC & 90.1: Performance

- Compare: Proposed Design Energy VS Prescriptive Energy
 - ASHRAE 90.1
 - Energy Cost Budget (Ch.11): Proposed Cost \leq Prescriptive Cost
 - Performance Rating Method (App.G) [Cost vs EUI]
 - IECC: Proposed Cost \leq 85% of Prescriptive Cost

- Key Requirements



- Still meet all mandatory requirements
- Whole building energy simulation software



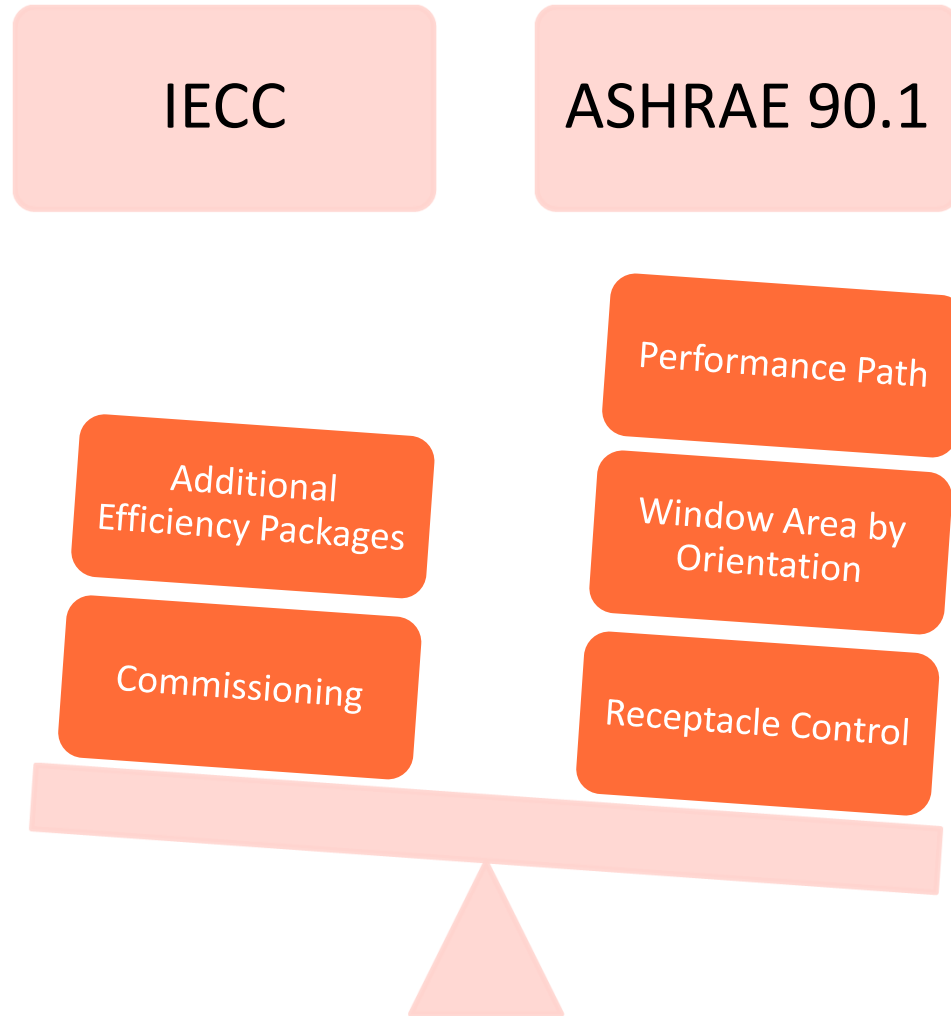
- Detailed list of energy design elements justifying simulation results



- Consistent—Choose One Code

- All IECC w/MN Amendments or All ASRHAE 90.1 for mandatory & performance

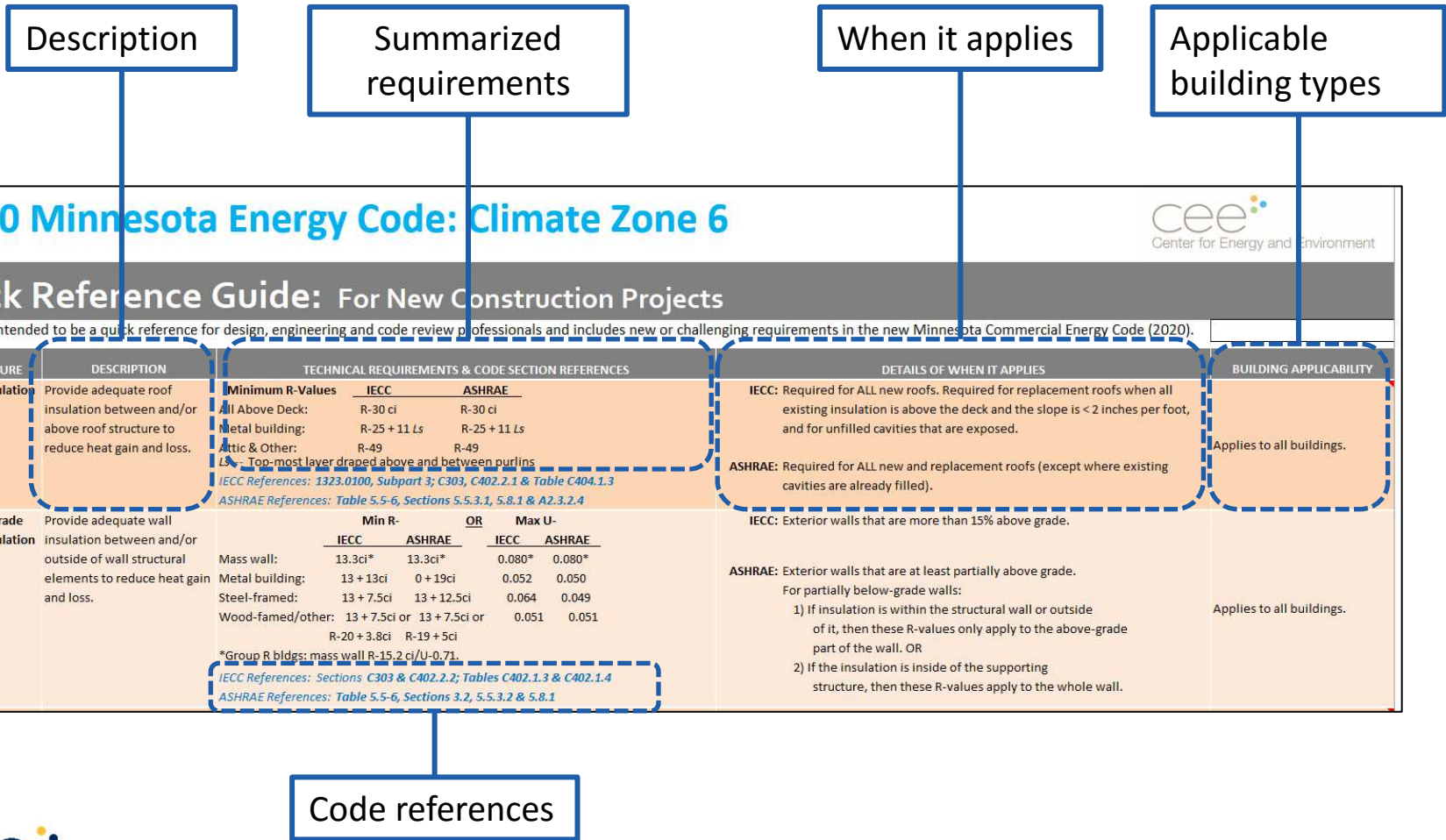
•• Key Differences IECC vs ASHRAE 90.1



Key Energy Code Items by Code Sections

Quick Reference Guide

Quick Reference Guide



2020 Minnesota Energy Code: Climate Zone 6		Center for Energy and Environment																																											
Quick Reference Guide: For New Construction Projects																																													
This tool is intended to be a quick reference for design, engineering and code review professionals and includes new or challenging requirements in the new Minnesota Commercial Energy Code (2020).																																													
MEASURE	DESCRIPTION	TECHNICAL REQUIREMENTS & CODE SECTION REFERENCES		DETAILS OF WHEN IT APPLIES	BUILDING APPLICABILITY																																								
Roof Insulation R-Value	Provide adequate roof insulation between and/or above roof structure to reduce heat gain and loss.	Minimum R-Values <table border="1"> <tr> <th></th> <th>IECC</th> <th>ASHRAE</th> </tr> <tr> <td>All Above Deck:</td> <td>R-30 ci</td> <td>R-30 ci</td> </tr> <tr> <td>Metal building:</td> <td>R-25 + 11 Ls</td> <td>R-25 + 11 Ls</td> </tr> <tr> <td>Attic & Other:</td> <td>R-49</td> <td>R-49</td> </tr> </table> Ls - Top-most layer draped above and between purlins IECC References: 1323.0100, Subpart 3; C303, C402.2.1 & Table C404.1.3 ASHRAE References: Table 5.5-6, Sections 5.5.3.1, 5.8.1 & A2.3.2.4		IECC	ASHRAE	All Above Deck:	R-30 ci	R-30 ci	Metal building:	R-25 + 11 Ls	R-25 + 11 Ls	Attic & Other:	R-49	R-49	IECC: Required for ALL new roofs. Required for replacement roofs when all existing insulation is above the deck and the slope is < 2 inches per foot, and for unfilled cavities that are exposed. ASHRAE: Required for ALL new and replacement roofs (except where existing cavities are already filled).	Applies to all buildings.																													
	IECC	ASHRAE																																											
All Above Deck:	R-30 ci	R-30 ci																																											
Metal building:	R-25 + 11 Ls	R-25 + 11 Ls																																											
Attic & Other:	R-49	R-49																																											
Above Grade Wall Insulation	Provide adequate wall insulation between and/or outside of wall structural elements to reduce heat gain and loss.	<table border="1"> <tr> <th rowspan="2"></th> <th colspan="2">Min R-</th> <th colspan="2">OR</th> <th colspan="2">Max U-</th> </tr> <tr> <th>IECC</th> <th>ASHRAE</th> <th>IECC</th> <th>ASHRAE</th> <th>IECC</th> <th>ASHRAE</th> </tr> <tr> <td>Mass wall:</td> <td>13.3ci*</td> <td>13.3ci*</td> <td>0.080*</td> <td>0.080*</td> <td></td> <td></td> </tr> <tr> <td>Metal building:</td> <td>13 + 13ci</td> <td>0 + 19ci</td> <td>0.052</td> <td>0.050</td> <td></td> <td></td> </tr> <tr> <td>Steel-framed:</td> <td>13 + 7.5ci</td> <td>13 + 12.5ci</td> <td>0.064</td> <td>0.049</td> <td></td> <td></td> </tr> <tr> <td>Wood-famed/other:</td> <td>13 + 7.5ci or R-20 + 3.8ci</td> <td>13 + 7.5ci or R-19 + 5ci</td> <td>0.051</td> <td>0.051</td> <td></td> <td></td> </tr> </table> *Group R bldgs: mass wall R-15.2 ci/U-0.71 IECC References: Sections C303 & C402.2.2; Tables C402.1.3 & C402.1.4 ASHRAE References: Table 5.5-6, Sections 3.2, 5.5.3.2 & 5.8.1		Min R-		OR		Max U-		IECC	ASHRAE	IECC	ASHRAE	IECC	ASHRAE	Mass wall:	13.3ci*	13.3ci*	0.080*	0.080*			Metal building:	13 + 13ci	0 + 19ci	0.052	0.050			Steel-framed:	13 + 7.5ci	13 + 12.5ci	0.064	0.049			Wood-famed/other:	13 + 7.5ci or R-20 + 3.8ci	13 + 7.5ci or R-19 + 5ci	0.051	0.051			IECC: Exterior walls that are more than 15% above grade. ASHRAE: Exterior walls that are at least partially above grade. For partially below-grade walls: 1) If insulation is within the structural wall or outside of it, then these R-values only apply to the above-grade part of the wall. OR 2) If the insulation is inside of the supporting structure, then these R-values apply to the whole wall.	Applies to all buildings.
	Min R-			OR		Max U-																																							
	IECC	ASHRAE	IECC	ASHRAE	IECC	ASHRAE																																							
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Key Energy Code Items by Code Sections

Building Envelope

Building Envelope

Mandatory Items

- Continuous Air Barrier

Prescriptive Items

- Thermal performance requirements
 - Roof
 - Above-grade walls
 - Window U-values
 - Window SHGC
- Window area & orientation

•• Building Envelope

Mandatory Items

- Continuous Air Barrier

Prescriptive Items

- Thermal performance requirements

- Roof
- Above-grade walls
- Window U-values
- Window SHGC

- Window area & orientation

- What it is
- How it is required
- When it applies
- Where to find in the design

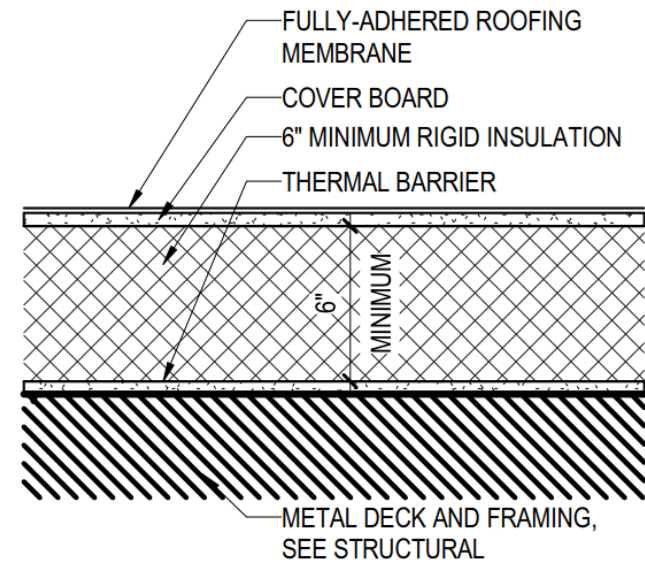
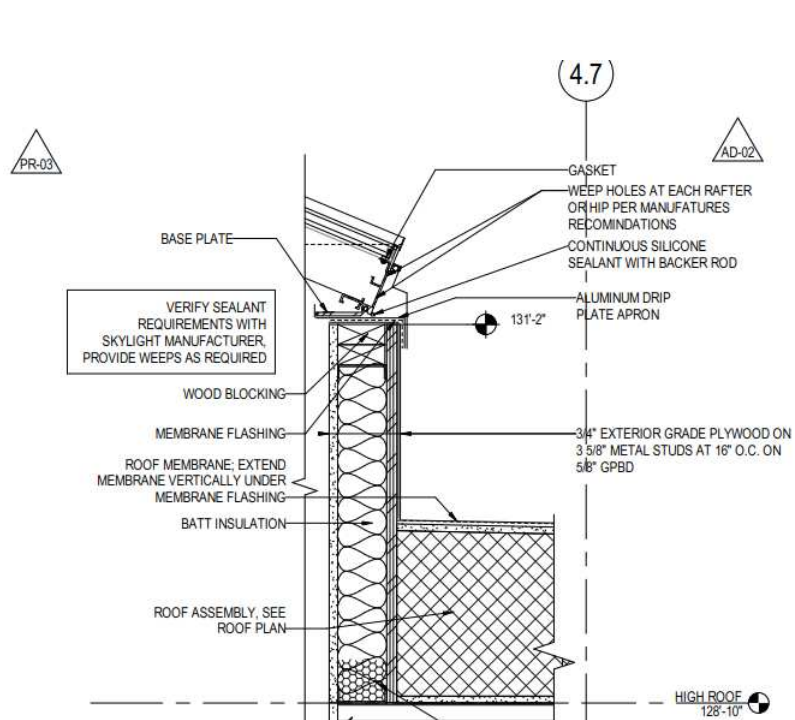
•• Continuous Air Barrier

A continuous air barrier shall be provided throughout the building thermal envelope.

	IECC <i>C402.5.1</i>	ASHRAE <i>5.4.3.1</i>
Option 1	Building test	<ul style="list-style-type: none"> - Building test - Construction requirements
Option 2	<ul style="list-style-type: none"> - Materials(16) or assemblies(3) listed <i>OR</i> Materials or assemblies meeting certain air permeability rate or air leakage rate tested under pressure differential of 0.3" w.g. - Construction requirements (e.g., joints sealed, penetrations caulked) 	<ul style="list-style-type: none"> - Materials(13) or assemblies(2) listed <i>OR</i> Materials or assemblies meeting certain air permeability rate or air leakage rate tested under pressure differential of 0.3" w.g. - Construction requirements

Roof Thermal Performance

Provide adequate roof insulation between and/or above roof structure to reduce heat gain and loss.



EPDM-1A: FULLY-ADHERED EPDM ON ROOF DECK (MINIMUM R-30)

ROOF TYPES

•• Roof Thermal Performance: R-value

IECC
C402.1.3

ASHRAE
5.5

Min R-value: Climate Zone 6 {CZ7 if it differs}

All Above Deck

R-30 ci {R-35 ci}

R-30 ci {R-35 ci}

Metal Building

R-25 + R-11 Ls
{R-30 + R-11 Ls}

R-25 + R-11 Ls
{R-30 + R-11 Ls}

Attic & Other

R-49

R-49 {R-60}

ci vs Ls

A2.3.2.3 Continuous Insulation

For assemblies with *continuous insulation* the *continuous insulation* is installed above or below the purlins, **uncompressed and uninterrupted** by framing members.

A2.3.2.4 Liner System (Ls)

A continuous membrane is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. For multilayer installations, the **last rated R-Value of insulation** is for unfaced insulation draped over purlins and then **compressed when the metal roof panels are attached**. A minimum R-3 thermal spacer block between the purlins and the metal *roof* panels is required unless compliance is shown by the overall assembly *U-factor*.

•• Roof Thermal Performance: U-value

IECC
C402.1.4

ASHRAE
5.5

Max U-value: Climate Zone 6 {CZ7 if it differs}

All Above Deck

U-0.032{U-0.028}

U-0.032{U-0.028}

Metal Building

U-0.031{U-0.029}

U-0.031{U-0.029}

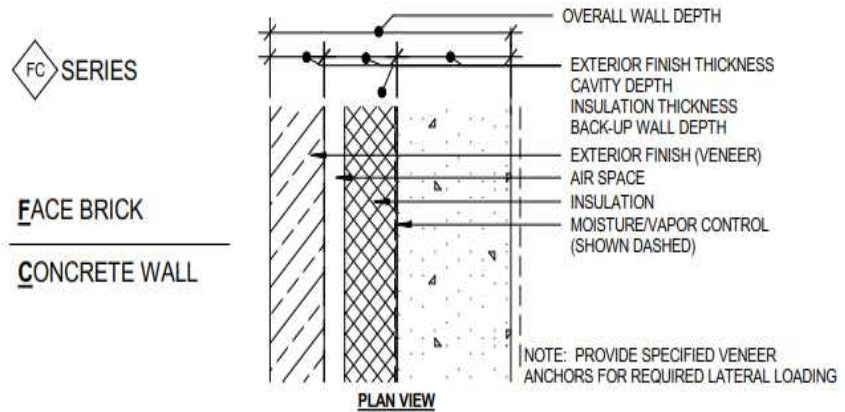
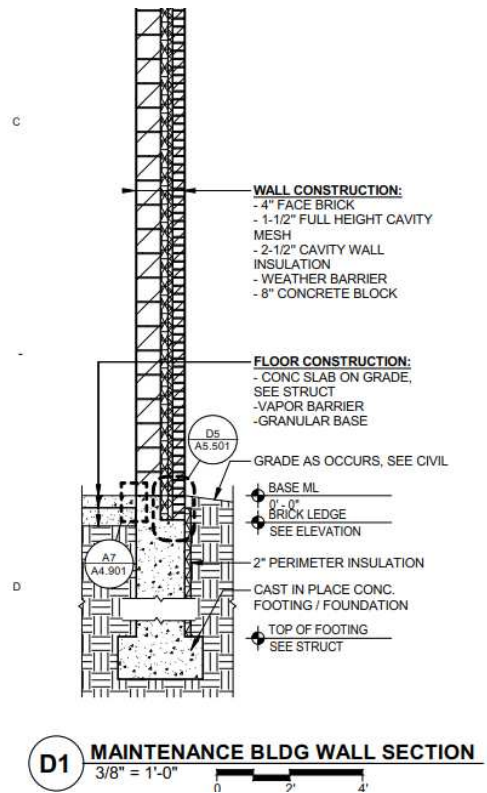
Attic & Other

U-0.021

U-0.021{U-0.017}

• Above-grade Wall Thermal Performance

Provide adequate exterior wall insulation to reduce heat gain and loss.



3 EXTERIOR WALL TYPE - FC SERIES
 1 1/2" = 1'-0"

• Above-grade Wall Thermal Performance

Provide adequate exterior wall insulation to reduce heat gain and loss.

D. Materials:

1. Batt Insulation: ASTM C 991 Type 1; preformed formaldehyde-free glass fiber batt conforming to the following:
 - a. Thermal Resistance: R of 3.2 per inch minimum.
 - b. Batt Size: Equal to purlin/girt spacing by manufacturer's standard lengths.
 - c. Unfaced.
2. Roof Insulation: Formaldehyde-free fiberglass batt or fiberglass blanket complying with ASTM C 991 Type 1 and ASTM E 84 with a thermal resistance and thickness as follows:
 - a. R-36; 11 1/2 inches (292 mm) total, 8 inches (203 mm) plus 3 1/2 inches (89 mm) (two layers).
3. Vapor Barrier Liner Fabric: Woven, reinforced, high-density polyethylene yarns coated on both sides with a continuous white or colored polyethylene coatings, as follows:

•• Wall Thermal Performance: R-value

IECC
C402.1.3

ASHRAE
5.5

Min R-value: Climate Zone 6 {CZ7 if it differs}

Mass Wall

R-13.3ci* {15.2ci}

R-13.3ci* {R-15.2ci}

Metal Building

R-13 + R-13ci {*}

R-0 + R-19ci
{R-0 + R22.1ci}

Steel-Framed

R-13 + R-7.5ci {*}

R-13 + R-12.5ci {*}

Wood-Framed

R-13 + R-7.5ci OR
R-20 + R-3.8ci

R-13 + R-7.5ci OR
R-19 + R-5ci

g. 36

*The requirement for Group R buildings differs.

Wall Thermal Performance : U-value

IECC
C402.1.4

ASHRAE
5.5

Max U-value: Climate Zone 6 {CZ7 if it differs}

Mass Wall

U-0.080* {U-0.071}

U-0.080* {U-0.071}

Metal Building

U-0.052 {*}

U-0.050 {U-0.044}

Steel-Framed

U-0.064 {*}

U-0.049 {*}

Wood-Framed

U-0.051

U-0.051

*The requirement for Group R buildings differs.

Wall Thermal Performance : U-value

⚠ U value read from ASHRAE appendix A

Table A3.4.3.1 Assembly U-Factors for Wood-Frame Walls

Framing Type and Spacing Width (Actual Depth)	Cavity Insulation R-Value: Rated (Effective Installed [see Table A9.4.3])	Overall U-Factor for Entire Base Wall Assembly	Overall U-Factor for Assembly of Base Wall Plus Continuous Insulation (Uninterrupted by Framing)																			
			Rated R-Value of Continuous Insulation																			
			R-1.00	R-2.00	R-3.00	R-4.00	R-5.00	R-6.00	R-7.00	R-8.00	R-9.00	R-10.00	R-11.00	R-12.00	R-13.00	R-14.00	R-15.00	R-20.00	R-25.00	R-30.00	R-35.00	R-40.00
Wood Studs at 16 in. on Center																						
3.5 in. depth	None (0.0)	0.292	0.223	0.181	0.152	0.132	0.116	0.104	0.094	0.086	0.079	0.073	0.068	0.064	0.060	0.056	0.053	0.042	0.035	0.030	0.026	0.023
	R-11 (11.0)	0.096	0.087	0.079	0.073	0.068	0.063	0.059	0.056	0.053	0.050	0.048	0.046	0.044	0.042	0.040	0.038	0.032	0.028	0.024	0.022	0.020
	R-13 (13.0)	0.089	0.080	0.074	0.068	0.063	0.059	0.056	0.053	0.050	0.047	0.045	0.043	0.041	0.040	0.038	0.037	0.031	0.027	0.024	0.021	0.019
	R-15 (15.0)	0.083	0.075	0.069	0.064	0.060	0.056	0.053	0.050	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.030	0.026	0.023	0.020	0.019
5.5 in. depth	R-19 (18.0)	0.067	0.062	0.058	0.054	0.051	0.048	0.046	0.044	0.042	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.027	0.024	0.021	0.019	0.018
	R-21 (21.0)	0.063	0.058	0.054	0.051	0.048	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.032	0.031	0.030	0.026	0.023	0.021	0.019	0.017
+ R-10 headers	R-19 (18.0)	0.063	0.059	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.031	0.027	0.024	0.021	0.019	0.017
	R-21 (21.0)	0.059	0.055	0.051	0.049	0.046	0.044	0.042	0.040	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.030	0.026	0.023	0.020	0.018	0.017
Wood Studs at 24 in. on Center																						
3.5 in. depth	None (0.0)	0.298	0.227	0.183	0.154	0.133	0.117	0.105	0.095	0.086	0.079	0.074	0.068	0.064	0.060	0.057	0.054	0.042	0.035	0.030	0.026	0.023
	R-11 (11.0)	0.094	0.085	0.078	0.072	0.067	0.062	0.059	0.055	0.052	0.050	0.047	0.045	0.043	0.041	0.040	0.038	0.032	0.027	0.024	0.022	0.019
	R-13 (13.0)	0.086	0.078	0.072	0.067	0.062	0.058	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.031	0.026	0.023	0.021	0.019
	R-15 (15.0)	0.080	0.073	0.067	0.062	0.058	0.055	0.052	0.049	0.046	0.044	0.042	0.040	0.039	0.037	0.036	0.035	0.029	0.026	0.023	0.020	0.018
5.5 in. depth	R-19 (18.0)	0.067	0.062	0.058	0.054	0.051	0.048	0.046	0.044	0.042	0.040	0.038	0.037	0.036	0.034	0.033	0.032	0.027	0.024	0.021	0.019	0.018
	R-21 (21.0)	0.063	0.058	0.054	0.051	0.048	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.032	0.031	0.030	0.026	0.023	0.021	0.019	0.017
+ R-10 headers	R-19 (18.0)	0.063	0.059	0.055	0.052	0.049	0.047	0.045	0.043	0.041	0.039	0.038	0.036	0.035	0.034	0.033	0.031	0.027	0.024	0.021	0.019	0.017
	R-21 (21.0)	0.059	0.055	0.051	0.049	0.046	0.044	0.042	0.040	0.038	0.037	0.035	0.034	0.033	0.032	0.031	0.030	0.026	0.023	0.020	0.018	0.017

•• Window Performance: U-value

Limits the U-value of windows, which saves energy by limiting the rate of heat gain or loss through windows.

⚠ U-value requirements are for the whole window assembly, not center-of-glass value

SECTION 08-4313 - ALUMINUM-FRAMED STOREFRONTS

PART 2 PRODUCTS

5. Overall U-Factor Including Glazing: 0.45 Btu/(hr sq ft deg F), maximum, tested in accordance with NFRC100.
6. Solar Heat Gain Performance Requirements:
 - a. Overall SHGC Including Glazing: 0.40, maximum, tested in accordance with NFRC 200.

•• Window Performance: U-value

IECC

C402.4.3

ASHRAE

5.5

Max Window U-Factor: Climate Zn 6 {CZ7 if it differs}

Fixed: U-0.36 {U-0.29}
Operable: U-0.43 {U-0.37}

Non-metal: U-0.30 {U-0.28}
Metal, fixed: U-0.36 {U-0.33}
Metal, operable: U-0.45 {U-0.40}

•• Window Performance: SHGC

Limits the SHGC of windows, which saves energy by limiting the solar heat gain entering the space through the fenestration assembly.

SECTION 08-4313 - ALUMINUM-FRAMED STOREFRONTS

PART 2 PRODUCTS

5. Overall U-Factor Including Glazing: 0.45 Btu/(hr sq ft deg F), maximum, tested in accordance with NFRC100.
6. Solar Heat Gain Performance Requirements:
 - a. Overall SHGC Including Glazing: 0.40, maximum, tested in accordance with NFRC 200.

•• Window Performance: SHGC

IECC

C402.4.3

ASHRAE

5.5.4.4

Max Window SHGC: Climate Zn 6 {CZ7 if it differs}

Vertical fenestration:

SEW: 0.4, N: 0.53 {SEW: 0.45, N: NR}

Skylight: 0.40 {NR}

SHGC \leq 0.40 {0.45}

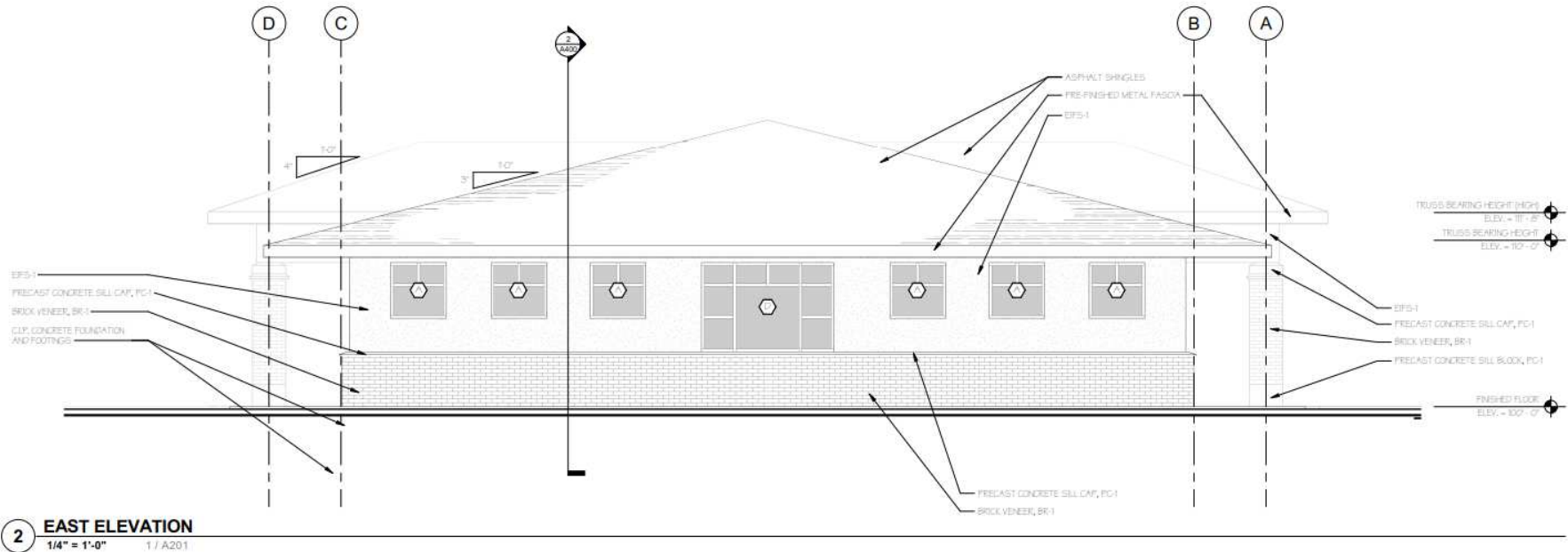
Exceptions

- Higher limits for Projection Factor > 0.2
- SHGC-0.60 for Skylight over controlled daylight zone

- Higher limits for Projection Factor > 0.1
- Exemption-Storefront w/overhang

Window Area & Orientation

Window area is limited to reduce heat gain and loss, which is much higher through windows than through opaque walls.



Window Area

IECC

C402.4.1

ASHRAE

5.5.4.2

Whole Building Window to Wall Ratio Max {Skylight:Roof}

$\leq 30\%$ { $\leq 3\%$ }

$\leq 40\%$ { $\leq 3\%$ skylights}

Exceptions

$\leq 40\%$ { $\leq 5\%$ } If

- $\geq 50\%$ floor daylit for 1&2 stories
- $\geq 25\%$ floor daylit for ≥ 3 stories &
- Daylight responsive control installed &
- VT $\geq 1.1x$ SHGC

$\leq 75\%$ for "Shop Storefront"
per 5.5.4.4.1(3)

•• Window Orientation

ASHRAE

5.5.4.5

Window Area by Orientation

West, East $\leq 1/4$ Total *OR*
West, East * SHGC_{W,E} $\leq 1/5$ Total * SHGC_{total}

Exceptions

- “Shop” Storefront per 5.5.4.4.1(3)
- Permanent shading on 75% of east and west fenestration
- East and West: WWR $\leq 20\%$ & SHGC $\leq 90\%$ required value

Wrap Up

Questions

Key Energy Code Items by Code Sections

Mechanical System

Mechanical Systems:

Key Mandatory Items

•• Key Mandatory Mechanical Items

- Commissioning
- Temperature Controls
 - *Deadband between heating and cooling
 - Heating setback
 - Cooling setback
 - Optimum start control
- *Economizer Fault Detection & Diagnostics (FDD)
- *Demand Control Ventilation
- Energy Recovery Ventilation (mandatory in IECC)
- Fan Power Limitation (mandatory in IECC)
- Air Leakage
 - Duct sealing
 - Damper leakage
- *SHW Recirculation Loop Automatic Shutdown
- Pool Covers

• Commissioning of Mechanical Systems

- Can be a big help for inspector—especially for control requirements

• Commissioning of Mechanical Systems

	IECC C408.2	ASHRAE 6.7.2
When Required	Cooling ≥ 40 tons Heating ≥ 600 MBH	>50,000 sf (Not SHW)
Plan Requirement	CD notes or specs shall clearly indicate provisions	Detailed instructions by the designer
Preliminary Report From	The design professional or approved agency	-

•• Temperature Controls

- Specific Items
 - Deadband between heating and cooling
 - Heating setback
 - Cooling setback
 - Automatic/optimum start

- “...capable of...” vs “...configured to...”

•• Temperature Controls

IECC

C403.4.1.2, C403.4.2

ASHRAE

6.4.3.1.1, 6.4.3.3

Htg/Clg Deadband

Configured to $\geq 5^{\circ}\text{F}$

Configured to $\geq 5^{\circ}\text{F}$

Heating Setback

Capable of 55°F

*Configured to 10F
Below Occ. Setting*

Cooling Setback

Capable of 85°F

*Configured to 5F
Above Occ. Setting*

Start Pre-Heat/Cool

*Automatically
Adjust Start Time*

Optimum if DDC

• Automatic/Optimum Start Definitions

- Automatic Start (IECC)—“..automatically adjust daily start time...to bring each space to the desired occupied temperature immediately prior to scheduled occupancy.”

= ?

- Optimum Start (ASHRAE)—“The control algorithm shall...be a function of the difference between space temperature and occupied setpoint, the outdoor temperature, and the amount of time prior to schedule occupancy...”

•• Temperature Controls

- Where to Look on Plans
 - Drawing Notes--especially on mechanical schedules
 - Sequence of operations—typically in specs
 - Specs for HVAC units and/or HVAC controls

SEQUENCE OF OPERATION

FIRE ALARM:


THE FIRE ALARM SHALL BE MONITORED. IF AN ALARM SIGNAL IS DETECTED THE UNIT SHALL BE OFF AND THE OUTDOOR AIR AND RELIEF AIR DAMPERS ASSOCIATED WITH THE UNIT SHALL CLOSE. AFTER THE FIRE ALARM IS CLEARED, THE UNIT SHALL NOT START UNTIL ALL OF THE ASSOCIATED FIRE/SMOKE DAMPERS END SWITCHES HAVE PROVEN OPEN.

OPTIMAL STARTUP MODE:

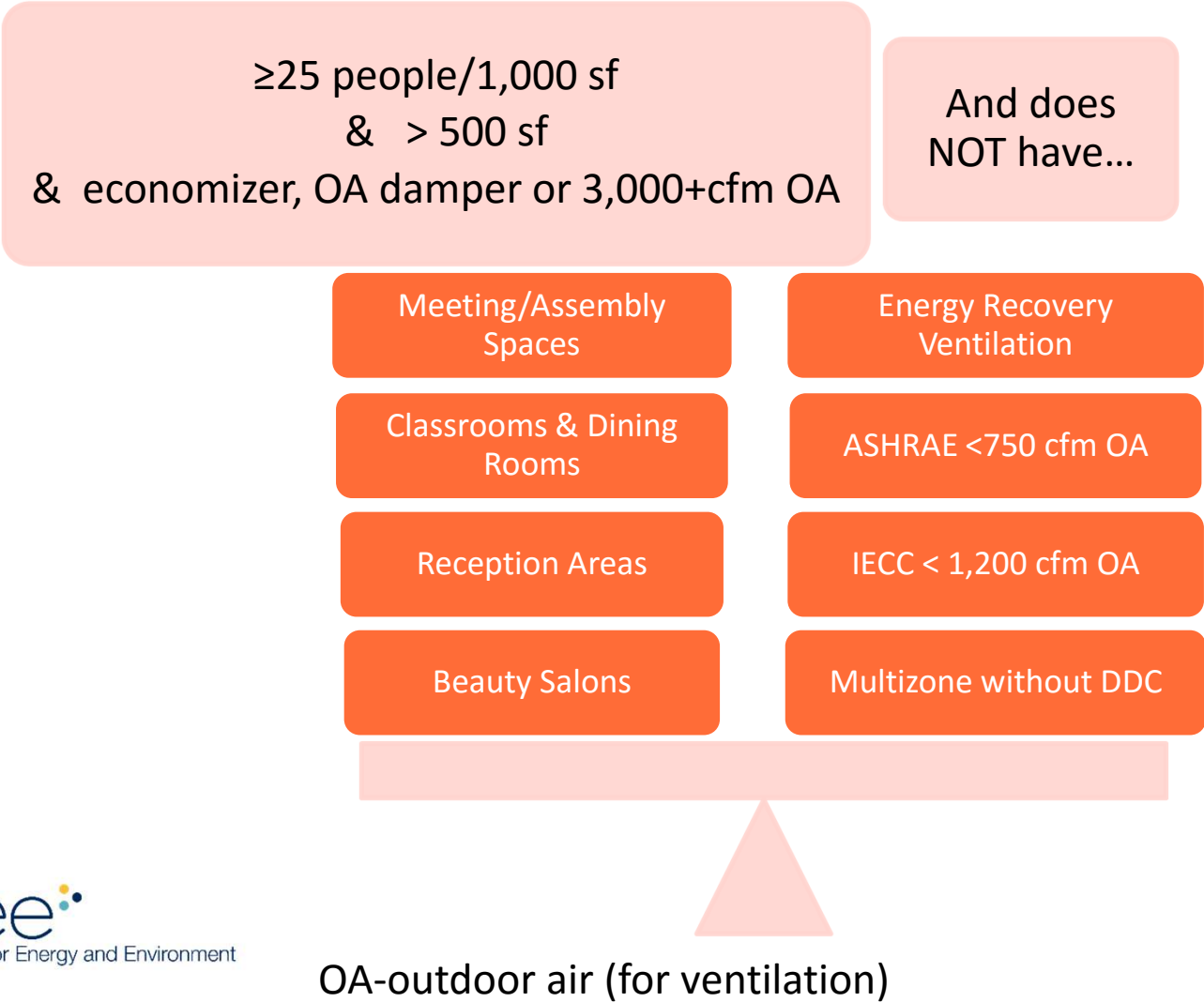
THE AHU SHALL START PRIOR TO THE SCHEDULED OCCUPANCY TIME TO CONDITION THE ZONES TO THEIR RESPECTIVE SET POINTS TEMPERATURE SO THAT EACH ZONE WILL BE AT THEIR HEATING OR COOLING SET POINT WHEN OCCUPANCY BEGINS. THE STARTUP FEATURE SHALL BE INTUITIVE AND MEMORY BASED USING DATA FROM PREVIOUS STARTUP TIMES SO THAT THE AHU WILL STARTUP WITH THE MINIMUM AMOUNT OF TIME REQUIRED TO GET ALL ZONES TO THEIR TEMPERATURE SET POINTS. ON INITIAL STARTUP, THE SUPPLY FAN VFD SHALL SLOWLY RAMP UP TO THE OPERATING SPEED SET POINT AND SHALL WAIT UNTIL OCCUPANCY BEGINS BEFORE OPENING THE OUTSIDE AIR DAMPER UNLESS THE OPTIMAL STARTUP MODE CAN UTILIZE THE ECONOMIZER COOLING CONTROL SEQUENCE TO CONDITION THE SPACE.

Economizer Fault Detection & Diagnostics

 New requirement to be covered in detail along with other economizer items.

 When an economizer is used, automated FDD is mandatory (even when economizer is not mandatory).

When High Occupancy Spaces Require Demand Control Ventilation (DCV)



•• Demand Control Ventilation

- Provides automatic reduction of outdoor air intake below design when occupancy is less than design
- In practice, done by sensing carbon dioxide
- Where to Look on Plans
 - CO2 sensor on drawings
 - Sequence of operations
 - Specs for HVAC units and/or HVAC controls

HVAC Air Leakage: Duct Sealing— Even for Low Pressure Ducts

What to Seal

- Longitudinal seams
- Transverse joints
- Connections
- Supply & return ducts

How to Seal It

- Mastics
- Welds
- Gaskets
- Mastic + embedded fabric systems
- Tapes (ASHRAE requires compliance with UL-181A or UL-181B)

HVAC Air Leakage: Duct Sealing— Even for Low Pressure Ducts

- Where to Look on CDs
 - Ideally in general notes on plans
 - Specifications is adequate

HVAC Air Leakage: Low Leakage Intake & Exhaust Dampers

	IECC <i>C402.5.5, C403.7.7</i>	ASHRAE <i>6.4.3.4.2, 6.4.3.4.3</i>
Motorized Intake, Exhaust or Relief	$\leq 4^*$	$\leq 4^*$
Gravity Intake & Gravity Exhaust/Relief in 3+ Story Building	Not Allowed	Not Allowed
Gravity Exhaust or Relief in 1-2 Story	$\leq 20^*$ (40 if <2' in one direction)	$\leq 20^*$ (40 if <2' in one direction)
Spring-Loaded Backdraft Damper	Allowed on up to 8" diameter exhaust	Not Allowed

*Tested cfm/sf leakage at 1.0" water per AMCA 500D.

HVAC Air Leakage: Low Leakage Intake & Exhaust Dampers

- Where to Look on Plans
 - Drawing notes--especially on mechanical schedules
 - Specs for HVAC units and/or HVAC controls
 - Probably also worthwhile to see if sample unit meets requirement based on manufacturer's literature (but don't count on this as substitute for spec)
- Inspection--Will typically see non-metal material on damper ends

SHW Recirculation Loop Control

Disabling of SHW recirc loop pump or heat tracing when no load.

	IECC <i>C404.6.1, C404.6.1</i>	ASHRAE <i>7.4.4.2</i>
Heat Trace	Turn off automatically when there is not a demand [timer or flowmeter?]	Automatic time switches or other control to switch off for extended period without demand
Recirculation Loop Pump	Start pump based on identification of demand and stop pump when setpoint reached and demand stops [flowmeter?]	Automatic time switches or other control to switch off for extended period without demand

•• Pool Cover

- Vapor cover is needed for all heated pools
- R-12 insulation is also required if heated above 90°F



•• Key Mandatory Mechanical Items

- ✓ Commissioning
- ✓ Temperature Controls
 - ✓ *Deadband between heating and cooling
 - ✓ Heating setback
 - ✓ Cooling setback
 - ✓ Optimum start control
- ✓ *Economizer Fault Detection & Diagnostics (FDD)
- ✓ *Demand Control Ventilation
- ✓ Energy Recovery Ventilation (mandatory in IECC)
- ✓ Fan Power Limitation (mandatory in IECC)
- ✓ Air Leakage
 - ✓ Duct sealing
 - ✓ Damper leakage
- ✓ *SHW Recirculation Loop Automatic Shutdown
- ✓ Pool Covers

•• Mechanical System

Prescriptive Items

- Economizers
 - General requirements
 - High limit control
 - Fault detection & diagnostics (M) —full description
- Energy Recovery Ventilation (prescriptive in ASHRAE) —full description
- Fan Power limitation (prescriptive in ASHRAE) —full description
- Supply air temperature reset on multizone systems
- Fan Speed Control (beyond multizone VAV)

•• Economizers – General Requirements

Equipment that uses cool outside air to meet air conditioning needs (when possible) instead of running the AC compressor(s). This reduces compressor energy use and wear.

Economizer required when fan systems reaching certain cooling capacity:

IECC
C403.5

Non Group R Occupancy: $\geq 54\text{kbtu}$ (4.5tons);
total capacity w/o economizer $\geq 20\%$ total or 300kbtu (greater)
Group R Occupancy: $\geq 270\text{kbtu}$ (22.5tons);
total capacity w/o economizer $\geq 20\%$ total or 1,500kbtu (greater)

ASHRAE
6.5.1

- General Spaces: $\geq 54\text{kbtu}$ (4.5tons)
- Residential: $\geq 270\text{kbtu}$ (22.5 tons)
- Computer rooms: 600kbtu (50tons) for single room or 3,000kbtu (250tons) for all computer rooms

•• Economizers – General Requirements

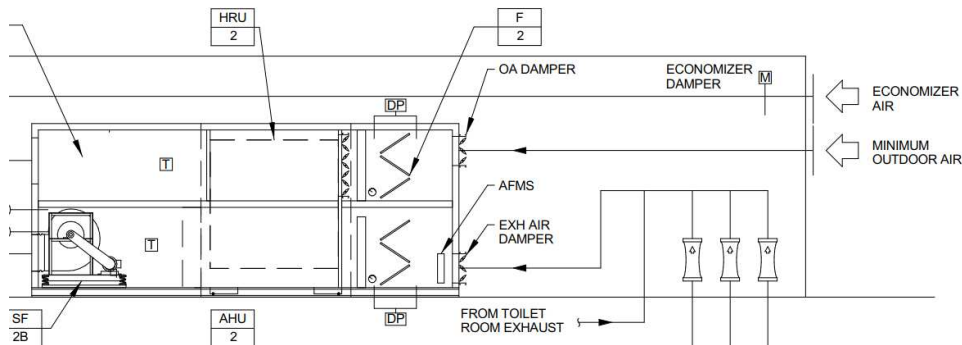
Requirement:

Specify and install air economizer system capable of providing up to 100% of design supply air as outdoor air (for cooling).

AIR HANDLING UNIT SCHEDULE														
UNIT NO.	LOCATION	AREA SERVED	MANUFACTURER	MODEL NUMBER	SUMMER DESIGN			WINTER DESIGN				CFM	OUTDOOR AIR (%)	FROST CONTROL
					O/A - ENTERING AIR TEMP. DB/WB (°F)	O/A - LEAVING AIR TEMP. DB/WB (°F)	E/A - ENTERING AIR TEMP. DB/WB (°F)	O/A - ENTERING AIR TEMP. DB (°F)	O/A - LEAVING AIR TEMP. DB (°F)	E/A - ENTERING AIR TEMP. DB (°F)				
AHU-1	MECH 156	DINING/KIT	VENMAR	ITF-HR-OU-HW-90x53(2)	92/73	80/66	75/63	-20	46	70	YES	14,630	50	
AHU-2	MECH 150	AUD/CLASS	VENMAR	ITF-HR-OU-HW-90x53(2)	92/73	79/66	75/63	-20	50	70	YES	10,960	40	
AHU-3	MECH 256	CLASSROOM	VENMAR	ITF-HR-OU-HW-78x42(2)	92/73	79/66	75/63	-20	46	70	YES	12,460	40	
AHU-4	MECH B118	BILLETS	VENMAR	ITF-HR-OU-HW-54x32(2)	92/73	80/66	75/62	-20	48	70	YES	2,620	100	
AHU-5	MECH B218	BILLETS	VENMAR	ITF-HR-OU-HW-54x32(2)	92/73	80/66	75/62	-20	48	70	YES	2,630	100	

NOTES:

1. PROVIDE UNIT WITH ECONOMIZERS
2. MOUNT AHU-4 & 5 HIGH AS POSSIBLE WITH STEEL STAND SUPPORT.



1 AIRFLOW RISER DIAGRAM

•• Economizers – High Limit Control

High-limit shutoff control ensure the different type economizers to reduce outdoor air intake when the outdoor air can not reduce cooling energy usage. It also ensure that the economizer will not be disabled when there is still chance for free cooling.

Economizer off when (Climate Zn 6) {CZ7 if it differs}

IECC

C403.5.3.3

ASHRAE

6.5.1.1.3

Device Type	High Limits
Fixed dry bulb	$T_{OA} > 70F$ { $T_{OA} > 75F$ }
Differential dry bulb	$T_{OA} > T_{RA}$
Fixed Enthalpy w/ fixed DB	$h_{OA} > 28Btu/lb$ OR $T_{OA} > 75F$
Differential enthalpy w/ fixed DB	$h_{OA} > h_{RA}$ OR $T_{OA} > 75F$

•• Economizers – High Limit Control

High-limit shutoff control ensure the different type economizers to reduce outdoor air intake when the outdoor air can not reduce cooling energy usage. It also ensure that the outdoor air will not be reduced when there is still chance for free cooling.

ECONOMIZER CONTROL:

WHEN THE OUTDOOR AIR TEMPERATURE IS BELOW 55°F, THE AIR-COOLED CONDENSING UNIT SHALL BE DISABLED AND THE OUTDOOR AIR DAMPER AND RETURN AIR DAMPER SHALL BE MODULATED TO SATISFY THE DISCHARGE AIR TEMPERATURE SET POINT.

- air temperature setpoint shall reset to 55 deg F.
11. Temperature Economizer Control: The outdoor air damper shall be at minimum setting. The outdoor air damper and exhaust air damper shall modulate open, and the return air damper shall modulate closed to maintain the supply air temperature setpoint of 55 deg F (adjustable) until the minimum outdoor air flow setting is reached or the low mixed air temperature of 40 deg F (adjustable) is reached. When the mixed air temperature drops below 40 deg F or the outdoor air temperature rises above the return air temperature, the economizer mode shall be disabled and the outdoor air damper shall reset to minimum position and the outside air and return dampers shall reset to the minimum outdoor air setting.

Economizers – Fault Detection & Diagnostics

Economizer malfunction is widely seen in buildings. This requirement ensure that the commonly seen faults will be detected and diagnosed.

IECC

C403.5.5

- Air-cooled DX units with Economizer
- VRF

- OA, SA, RA temp sensor installed
- System configured to provide 5 types of status(e.g. Eco. Enabled) and all sensor values
- Able to manually initiated each mode
- Configured to detect 5 common faults
- Configured to report faults
- Requirements on sensor accuracy

ASHRAE

6.4.3.12

Air-cooled DX units with Economizer

- OA, SA, RA temp sensor installed
- System configured to provide 5 types of status(e.g. Eco. Enabled) and all sensor values
- Able to manually initiated each mode
- Configured to detect 5 common faults
- Configured to report faults

•• Energy Recovery Ventilation

Equipment that uses the air being exhausted to preheat (and precool) fresh outdoor air that is brought into the building for ventilation. This reduces the amount of heating and cooling that must be done by the primary heating and cooling equipment.

IECC (M)

C403.7.4

ASHRAE (P)

6.5.6.1

Min SA cfm when ERV is required based on OA%

CZ	10%- 20%	20%- 30%	30%- 40%
6A	NR	NR	≥5,500
7	NR	NR	≥2,500

CZ	10%- 20%	20%- 30%	30%- 40%
6A	≥26,000	≥16,000	≥5,500
7	≥4,500	≥4,000	≥2,500

•• Energy Recovery Ventilation

Exceptions

- 1) More than 1/4 of the system's exhaust is somewhere other than the primary exhaust location
- 2) Required humidity control is via reclaimed heat
- 3) $\geq 60\%$ of heating is from renewables or recovered heat
- 4) System runs less than 20 hours a week

•• Energy Recovery Ventilation

ERV installed shall meet the following requirements:

- Enthalpy recovery ratio of at least 50%
- Include a bypass or controls to permit operation of the economizer if equipped

ENERGY RECOVERY UNIT SCHEDULE

TAG	LOCATION	SERVES	UNIT COOLING CAPACITY (BTU/H)		REHEAT CAPACITY (BTU/H)	UNIT HEATING CAPACITY (BTU/H)	ENERGY RECOVERY (BTU/H)		OA (CFM)	EA (CFM)	OUTSIDE AIR FAN				EXHAUST AIR FAN				FILTER		DX COOLING COIL						
			TOTAL	SENSIBLE			COOLING	HEATING			FAN QUANTITY	ESP (IN WG)	RPM	BHP	FAN QUANTITY	ESP (IN WG)	RPM	BHP	TYPE	EFFICIENCY (MERV)	EAT (°F)		LAT (°F)		REFRIGERANT TYPE	MAX AIR PD (IN WG)	COIL QUANTITY
ERU-2-1	ROOF	AREA D	119,523	84,118	49,274	160,000	66,839	197,552	2,936	2,936	1	2.30	1209	1.74	1	0.50	1580	1.59	COMBO	8	81	67	55	54	R410A	0.17	1
ERU-3-1	ROOF	AREA E	185,330	131,373	76,983	240,000	100,547	300,343	4,531	4,531	1	2.50	1759	3.23	1	0.50	1878	2.60	COMBO	8	81	68	54	54	R410A	0.23	1

ERV SCHEDULE

Tag #	Basis of Design	Model	Location	Fan Data				Wheel Data												Unit Information							
				Supply Airflow				Summer/Cooling						Return						Electrical				Electric Preheat	Minimum RER	Weight	
				Supply CFM	ESP	Motor HP	VFD	Outdoor		Supply		Return		Exhaust		Voltage/phase	FLA	MCA	MOCP	No	Cooling	lbs					
				Return CFM	ESP	Motor HP	VFD	Dry Bulb	Wet Bulb	Grains	Dry Bulb	Wet Bulb	Grains	Dry Bulb	RH	Wet Bulb	Grains	Dry Bulb	Grains	Type	Depth	Rating	Type	Depth	Rating	Heating	
ERV-1	SEMCO	FV+CM-3000	Outdoor Unit	2,200	1.00	2.00	No	100.0	75.6	96.1	79.3	64.6	70.2	72.0	50%	60.0	60.3	92.7	88.2	208V/1Ph	26.9606	29.9	40	No	Cooling	168.9	2250.0
				Return Airflow				Winter/Heating												Filters							
				Outdoor		Supply		Return		Exhaust		Outdoor		Return													
				2,200	1.00	1.50	No	21.6	18.0	8.4	58.8	49.7	39.7	72.0	50%	60.0	60.3	34.8	22.0	Pleated	2"	MERV 8	Pleated	2"	MERV 8	Heating	

•• Fan Power Limitation

Set high-limit to the fan power to prevent unnecessary energy usage of oversized fan

⚠ Especially for VAV systems (packaged systems typically meet is easily)

IECC (M)
C403.8.1

ASHRAE (P)
6.5.3.1

	Limit	Constant Volume	Variable Volume
Option 1: Fan system motor nameplate hp	Allowable motor nameplate hp	$hp \leq cfm_S \times 0.0011$	$hp \leq cfm_S \times 0.0015$
Option 2: Fan system bhp	Allowable fan system bhp	$bhp \leq cfm_S \times 0.00094 + A$	$bhp \leq cfm_S \times 0.0013 + A$

*A = sum of $(PD \times cfm_D / 4131)$, PD and cfm_D read from tables in codes

•• Fan Power Limitation

Set high-limit to the fan power to prevent unnecessary energy usage of oversized fan

⚠ Especially for VAV systems (packaged systems typically meet is easily)

IECC (M)
C403.8.1

ASHRAE (P)
6.5.3.1

Exceptions

- When the total fan motor nameplate horsepower for an HVAC system (including exhaust fans) <5 hp (Individual exhaust fan \leq 1hp are exempt from 5hp allowance calculation)
- Hospital, vivarium and lab that controls flow to maintain pressure – allow to use VAV allowance

Fan Power Limitation

Set high-limit to the fan power to prevent unnecessary energy usage of oversized fan

AIR HANDLING UNIT SCHEDULE																		
UNIT NO.	MANUFACTURER & MODEL NO.	TYPE	FAN SECTION	FAN SECTION DATA										COOLING COIL	HEATING COIL	MIN OA CFM	FILTERS MERV	NOTES
				WHEEL DIA	BLADE TYPE	GLASS	VFD	TOTAL CFM	ESP	HP	VOLTS	PH	DISC BY					
AHU-1	DAIKIN GAH0106DGC	H	SUPPLY	15.75	PL/AF	2	Y	4,600	2	7.5	480	3	MC	CG-1	HC-1	900	8 & 13	
MAU-1	DAIKIN GAH025GHGC	H	SUPPLY	27	PL/AF	2	Y	12,000	1.25	15	480	3	MC	FUTURE CG-2	HC-2	2,600	8 & 13	

H HORIZONTAL
 PL FLENUM
 AF AIRFOL
 DISC DISCONNECT
 MC MECHANICAL CONTRACTOR
 EC ELECTRICAL CONTRACTOR

NOTES:
1.

FAN SCHEDULE														
UNIT NO.	MANUFACTURER & MODEL NO.	TYPE	CFM	TSP (IN WG)	MOTOR				DISC BY	FAN RPM	DRIVE	SONES	CONT. BY	NOTES
					HP	VOLT	PH	VFD						
EF-1	GREENHECK GB-300-30	RM	8,000	0.75	3	460	3	Y	MC	658	B	15.3	MC	1
EF-2	GREENHECK GB-260-20	RM	6,400	0.75	2	460	3	Y	MC	666	B	14.1	MC	1
EF-3	GREENHECK G-098-VG	RM	500	0.8	1/4	115	1	N	MC	1587	D	9.3	MC	1
RLF-1	GREENHECK G-183-VG	RM	3,800	0.75	2	208	1	N	MC	1170	D	16.1	MC	1,2
EEF-1	CARMON CMB-30	C	4,200	4.5	5	460	3	N	EC	1971	B	--	MC	1,3
EEF-2	CARMON CMB-30	C	4,200	4.5	5	460	3	N	EC	1971	B	--	MC	1,3

C CENTRIFUGAL
 B BELT DRIVE
 D DIRECT DRIVE
 RM ROOF MOUNTED
 CEF CEILING EXHAUST FAN
 DISC DISCONNECT
 MC MECHANICAL CONTRACTOR
 EC ELECTRICAL CONTRACTOR

NOTES:
 1. PROVIDE SELF ACTING BACKDRAFT DAMPER, BIRDSCREEN, AND UNIT MOUNTED DISCONNECT SWITCH
 2. PROVIDE ECM MOTOR WITH CONTROLS TO ACCEPT A 0-10VDC SIGNAL FOR AIRFLOW MODULATION.
 3. PROVIDE SUSPENSION PLATFORM WITH VIBRATION ISOLATORS.

•• Supply Air Temperature Reset

Control that raises the cooling supply air temperature when the weather is not real hot. This saves energy by reducing overcooling and reheating that occurs when different zones have unbalanced cooling loads.

Multizone HVAC systems must include controls that automatically reset the SAT in response to building loads or OAT.

Exceptions

IECC

C403.6.5

- 75% of reheat energy is via site recovered heat or site solar
- Zones with peak supply air quantities of 300 cfm (142 L/s) or less

ASHRAE

6.5.3.5

- 75% of reheat energy is via site recovered heat or site solar
- Total system fan nameplate hp \leq 5 hp (including exhaust fans)

•• Supply Air Temperature Reset

Requirements:

SAT reset $\geq 25\% * (\text{design Room Air Temp} - \text{design SAT})$

1.4 HVAC SYSTEM CONTROL SEQUENCES

- b. Supply air temperature setpoint shall reset based on outdoor air temperature. When outdoor air temperature is 60 deg F or lower, supply air temperature setpoint shall reset to 60 deg F. When outdoor air temperature is 70 deg F or higher, supply air temperature setpoint shall reset to 55 deg F.

SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

23 09 93 - 2

•• Fan Speed Control

Requirement greatly reduce the fan power during low load periods

IECC

C403.8.5

ASHRAE

6.5.3.2.1

Requirements:

During low load and ventilation-only operation, DX cooling units and Chilled-water cooling units indoor fans shall go down to minimum speed stage, where the speed is 66% of full speed or lower with a power draw of 40% or less of the design value. *Minimum speed may be increased as needed to meet ventilation requirements (ASHRAE 62.1).*

When it Applies:

- DX cooling units $\geq 65,000$ Btu/hr (5.4 tons)
- Chilled water units with fan motors $\geq 1/4$ hp

Not Required If:

- Fan < 1 hp AND
- Unit doesn't provide ventilation air and the fan cycles with cooling demand

Wrap Up

Questions

Key Energy Code Items by Code Sections

Electrical System

Electrical System

Mandatory Items

- Lighting Controls
 - Automatic off
 - Light-reduction control/Bilevel control
 - Daylight responsive control
 - Exterior lighting control
- Lighting Functional Testing
- Automatic Receptacle Control

Prescriptive Items

- Lighting Power Density

Automatic Off

Install controls to automatically turn lights off when spaces are unoccupied (within 20min of all occupants leaving the space if using occupancy sensor).

IECC

C405.2.1 & C405.2.2.1

ASHRAE

9.4.1.1 (h) & (i)

When it applies

- Occupancy sensor control required for 10 space types and spaces ≤ 300 sf
- Space not provided with occupancy sensor shall be provided with time-switch control

- All lighting in space shall be automatically shut off with automatic control device (occupancy sensor) or time-switch

Automatic Off

Install controls to automatically turn lights off when spaces are unoccupied (within 20min of all occupants leaving the space if using occupancy sensor).

IECC

C405.2.1 & C405.2.2.1

ASHRAE

9.4.1.1 (h) & (i)

Exceptions

Occupancy sensor:

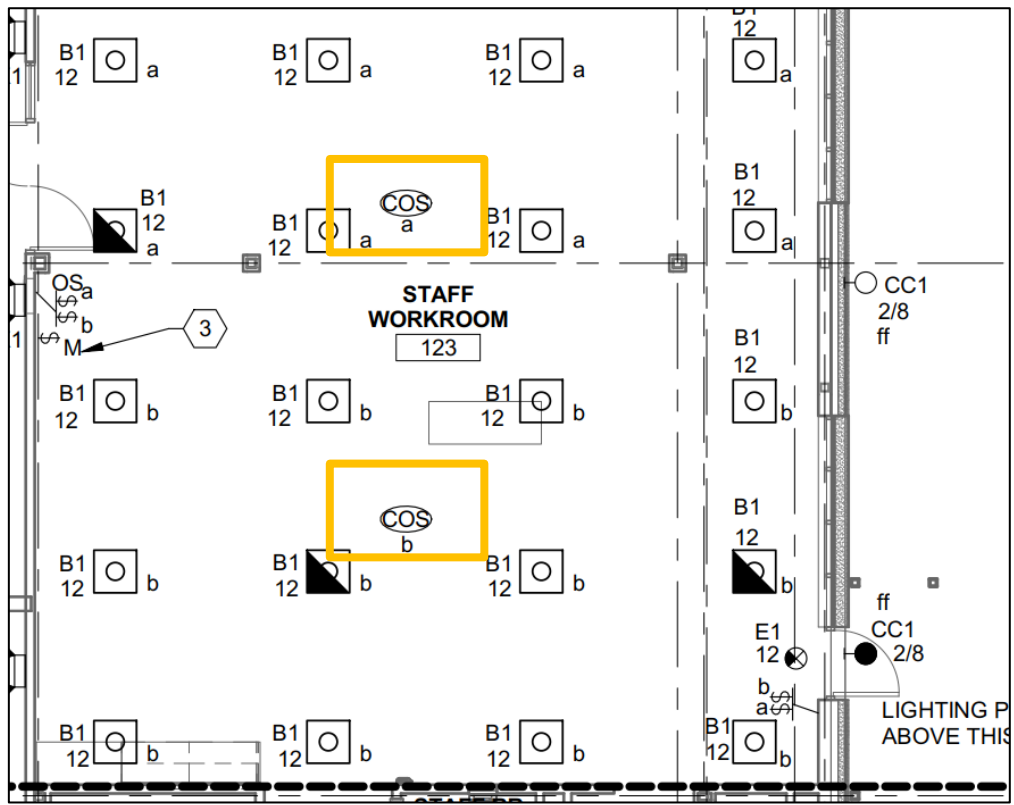
- Warehouse aisleways: $\geq 50\%$ reduction

Switch:










- Egress stairways/corridors
- Space provide patient care
- Auto off endanger safety
- Lighting intended for 24-7 operation
- Shop and lab
- Sleeping/dwelling units

- Emergency lights
- Space provide patient care
- Auto off endanger safety
- Lighting intended for 24-7 operation
- Shop and lab
- Lighting load $\leq 0.02\text{w/sf}$ * building gross lighted area
- Decorative gas lighting systems


Automatic Off



Legend

SWITCHES	
Other common symbols for Occupancy Sensor	
OS	S ^{OS}
	
	SWITCH & PILOT
	SWITCH & RECEPTACLE
	DIMMER SWITCH (SIZE AS REQUIRED)
	KEY SWITCH
	FLOW SWITCH
	TAMPER SWITCH
	CEILING OCCUPANCY SENSOR
	CEILING PHOTOCELL SENSOR

ELECTRICAL TITLE SHEET

1 FIRST FLOOR LIGHTING PLAN
 E1.1 1/8" = 1'-0" 

E0.0

•• Light-reduction/Bilevel control

Each space must have a lighting control that provides at least one step between on and off.

No change from previous code

IECC

C405.2.2.2

ASHRAE

9.4.1.1 (d)

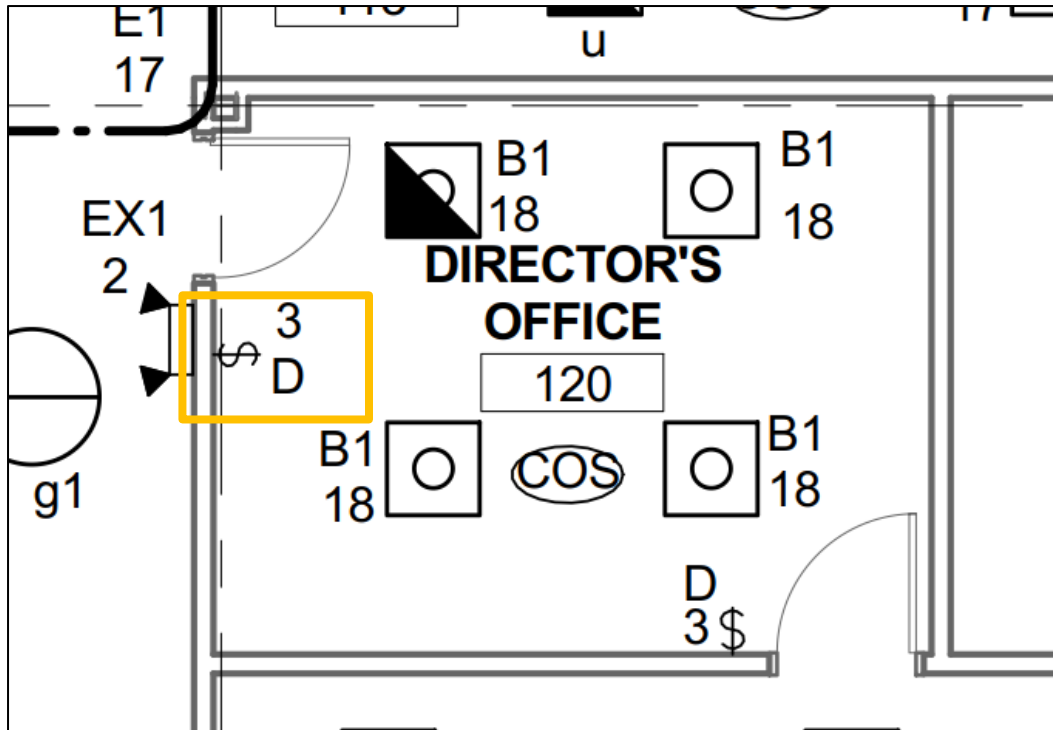
Light-reduction control shall be equipped with following characteristics:

- One intermediate step with no less than 50% reduction
- Not required in daylight zones with daylight control

- One intermediate step between 30% and 70% (inclusive) of full lighting power OR Continuous dimming

Light-reduction/Bilevel control

Legend



SWITCHES	
\$	SWITCH LOW VOLTAGE
OS\$	SWITCH LOW VOLTAGE, OCCUPANCY SENSOR
D\$	SWITCH LOW VOLTAGE, DIMMING
M\$	SWITCH LOW VOLTAGE, MASTER
2S\$	SWITCH LOW VOLTAGE, 2 SCENE
4S\$	SWITCH LOW VOLTAGE, 4 SCENE
8S\$	SWITCH LOW VOLTAGE, 8 SCENE
T\$	SWITCH LOW VOLTAGE, TIMER (0-30 MIN)
$\frac{3}{OR\ 4}$ \$	3 OR 4 WAY SWITCH.
2\$	2 - POLE SWITCH
\$	SWITCH & PILOT
\$	SWITCH & RECEPTACLE
\$	DIMMER SWITCH (SIZE AS REQUIRED)
\$ ^K	KEY SWITCH
o-o	FLOW SWITCH
o/x	TAMPER SWITCH
(COS)	CEILING OCCUPANCY SENSOR
(PC)	CEILING PHOTOCELL SENSOR

ELECTRICAL TITLE SHEET

1 FIRST FLOOR LIGHTING PLAN
E1.1 1/8" = 1'-0" 0 4' 8' 16'

E0.0

•• Daylight Responsive Control

Controls that reduce the power needed to light areas close to daylight sources

Code	Vertical Fenestration	Roof Fenestration
IECC	Sidelit Zone	Toplit Zone
ASHRAE	Primary Sidelighted Area; Secondary Sidelighted Area	Daylight Area under Skylights; Daylight Area under Rooftop Monitor

Daylight Responsive Control

Vertical Fenestration

IECC - Sidelit

ASHRAE — Primary Sidelighted Area

Top View



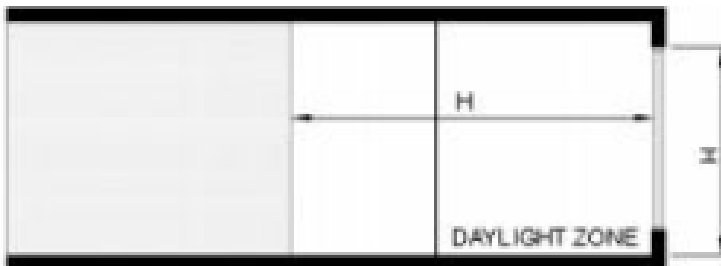
The smaller of :

- $0.5 * \text{fenestration head height}$
- Distance to 5ft or higher opaque vertical obstruction

The smaller of:

- Fenestration head height
- Distance to 5ft or higher opaque vertical obstruction

Section View



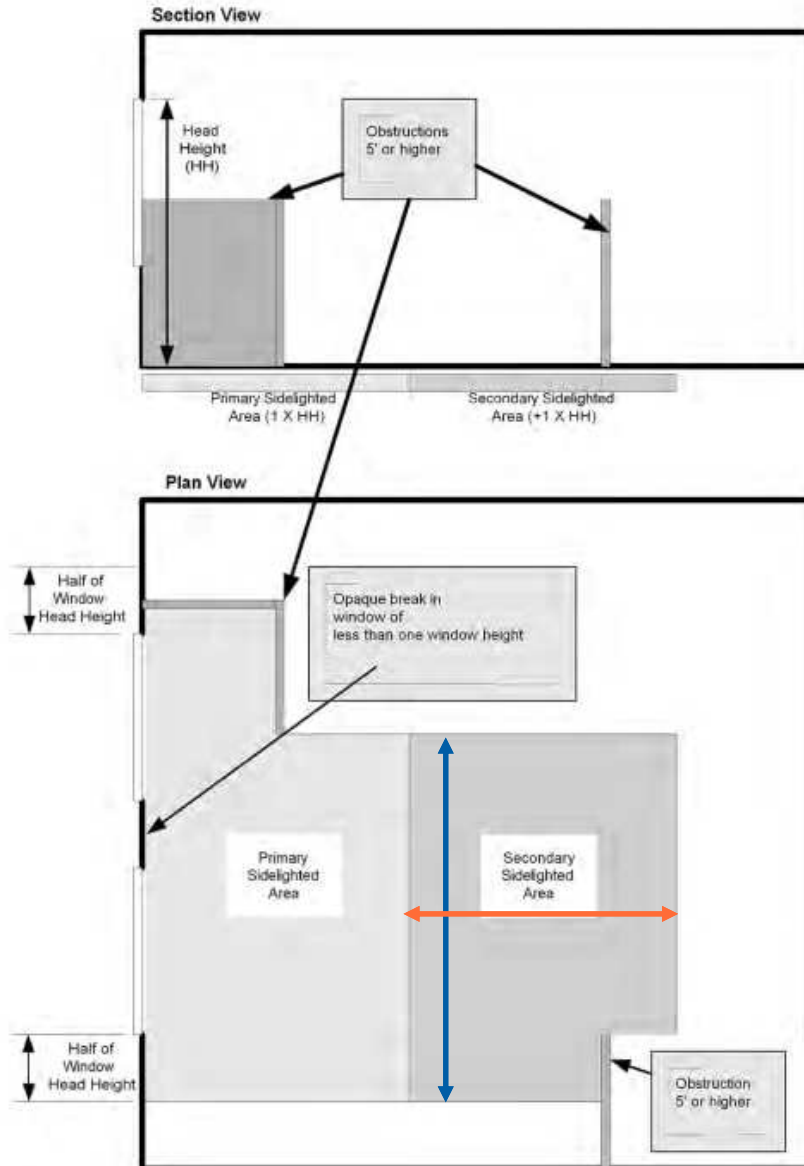
Daylight Responsive Control

ASHRAE

Secondary Sidelighted Area

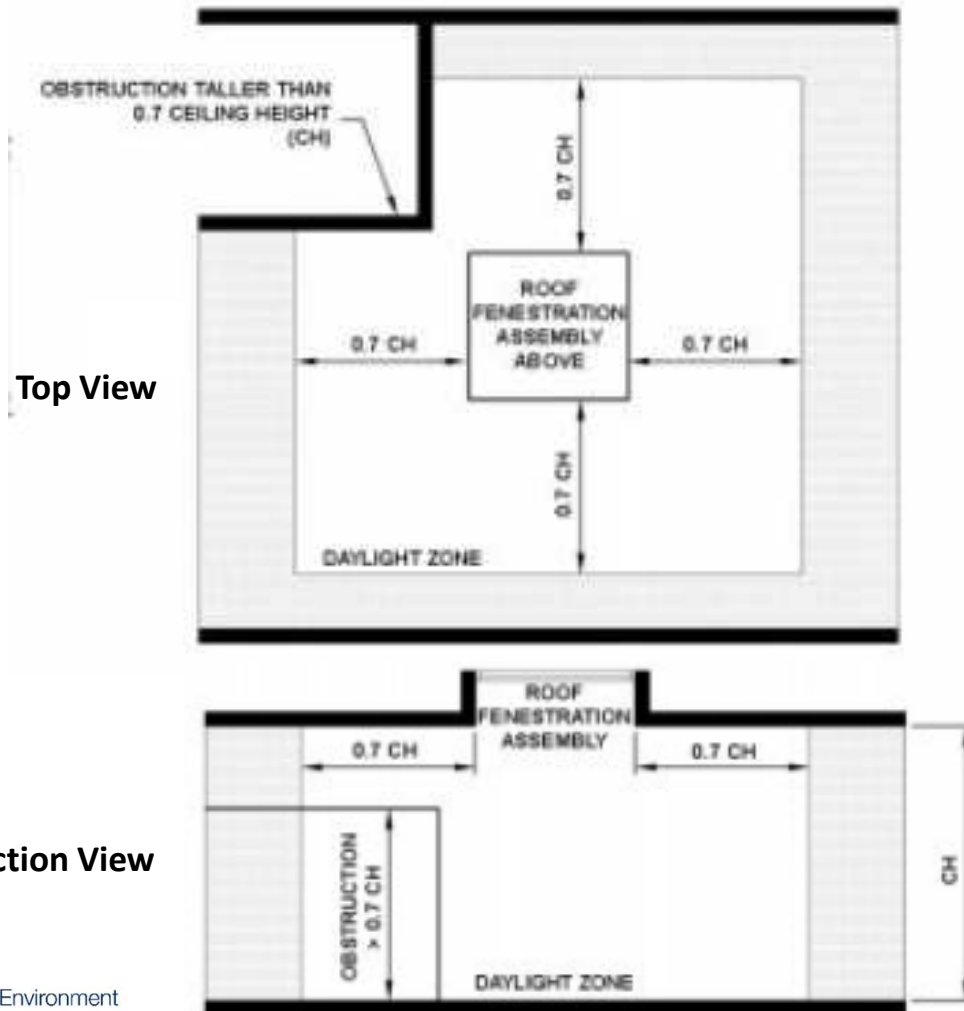
Width: Same as Primary

Depth: Same as Primary Area and adjacent to Primary Area



•• Daylight Responsive Control

Roof Fenestration - Skylight



•• Daylight Responsive Control

Controls that reduce the power needed to light areas close to daylight sources

IECC

C405.2.3

ASHRAE

9.4.1.1 (e) & (f)

When it applies

- Space with >150w general lighting within sidelit zone or toplit zone

- Space with >150w general lighting within primary sidelighted area or daylight area under skylights
- Space with >300w general lighting within primary and secondary sidelighted area

•• Daylight Responsive Control

Controls that reduce the power needed to light areas close to daylight sources.

IECC

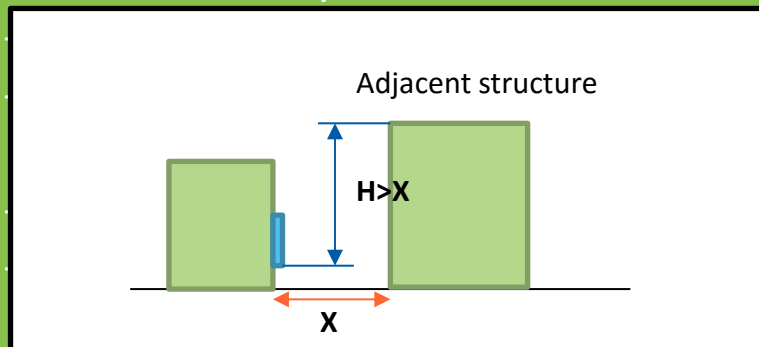
C405.2.3

ASHRAE

9.4.1.1 (e) & (f)

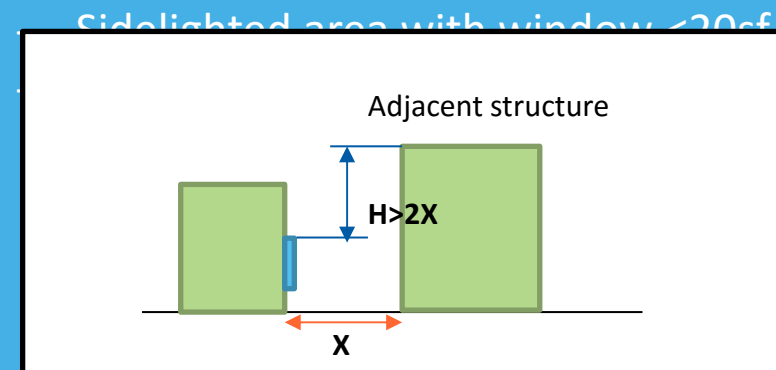
Exceptions

- Sidelit area has any adjacent structure that the height from the bottom of the window to the top of the structure is greater than its distance away from the window



- Visible Transmittance < 0.2

- Primary sidelighted area has adjacent structure twice as high above the window as it's distance away from the window



Sidelighted area with window $\leq 20\text{sf}$

•• Daylight Responsive Control

Controls that reduce the power needed to light areas close to daylight sources.

IECC

C405.2.3

ASHRAE

9.4.1.1 (e) & (f)

Exceptions

- Sidelit area has any adjacent structure that the height from the bottom of the window to the top of the structure is greater than its distance away from the window
- Sidelit area with window <24sf
- Space with food preparation occupancy or Retail
- Space provide patient care
- Lighting required to have specific application control
- Visible Transmittance < 0.2

- Primary sidelighted area has adjacent structure twice as high above the window as it's distance away from the window
- Sidelighted area with window <20sf
- Retail

☼ Daylight Responsive Control

Controls that reduce the power needed to light areas close to daylight sources.

IECC

C405.2.3

ASHRAE

9.4.1.1 (e) & (f)

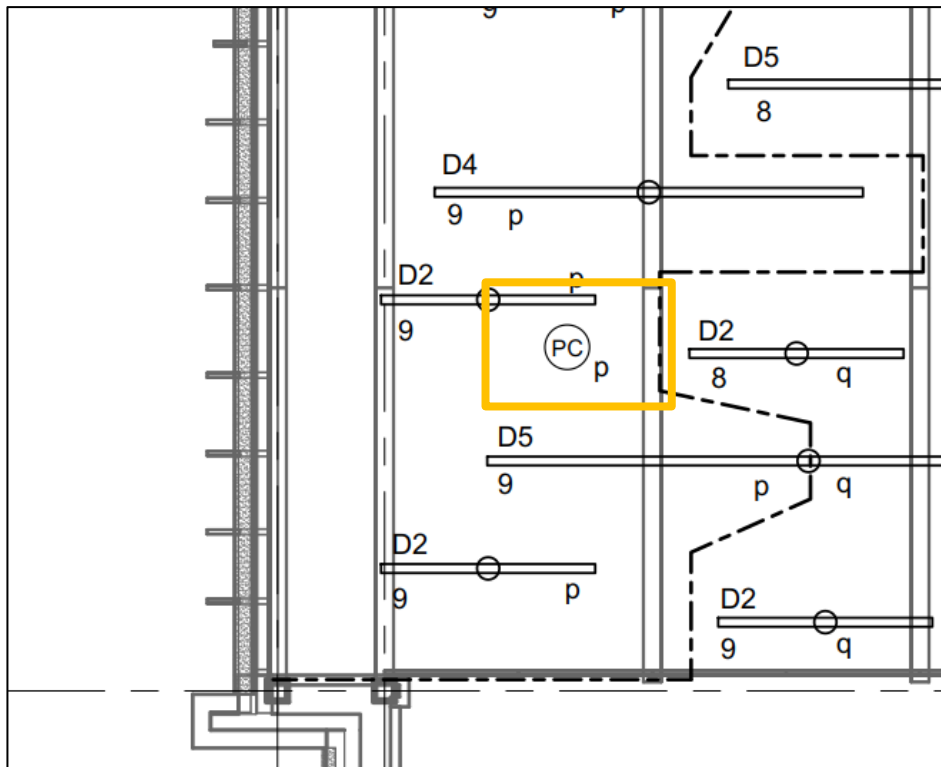
Control shall be equipped with following characteristics:

- Lights in toplit zones and sidelit zones shall be controlled separately
- Calibration within space and with ready access
- For office, classroom, lab and library reading rooms, control shall dim lights from full to 15% or lower
- Control shall be configured to shut off all controlled lights
- Lights in sidelit zones facing different orientation shall be controlled separately

- Lights in overlapping toplit and sidelit zones shall be controlled together
- Calibration within space and with ready access
- Reduce lighting with continuous dimming OR two steps (50%-70% and 20%-40%)

Daylight Responsive Control

Legend



SWITCHES	
\$	SWITCH LOW VOLTAGE
OS\$	SWITCH LOW VOLTAGE, OCCUPANCY SENSOR
D \$	SWITCH LOW VOLTAGE, DIMMING
M \$	SWITCH LOW VOLTAGE, MASTER
2S \$	SWITCH LOW VOLTAGE, 2 SCENE
4S \$	SWITCH LOW VOLTAGE, 4 SCENE
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2\$	2 - POLE SWITCH
\$	SWITCH & PILOT
\$	SWITCH & RECEPTACLE
Ⓢ	DIMMER SWITCH (SIZE AS REQUIRED)
\$ ^K	KEY SWITCH
∩	FLOW SWITCH
⊗	TAMPER SWITCH
Ⓞ	CEILING OCCUPANCY SENSOR
Ⓢ	CEILING PHOTOCELL SENSOR

1 FIRST FLOOR LIGHTING PLAN
 E1.1 1/8" = 1'-0" 0 4' 8' 16'

ELECTRICAL TITLE SHEET

E0.0

Interior Lighting Controls

INTERIOR LIGHTING CONTROL SCHEDULE

ROOM #	SWITCH ID	CONTROL TYPES
TEEN 101	a	M, 4S, PC
TEEN 101	b	M, 4S
FIREPLACE LOUNGE 103	c	M, 2S
LIBRARY 100	cc	M
FIREPLACE LOUNGE 103	cc	M
LIBRARY 100	bb	M, MANUAL SWITCH
CORRIDOR 113	u	M, OS
LIBRARY 100	d	M, PC
LIBRARY 100	e	M, PC
LIBRARY 100	h	M
LIBRARY 100	f	M, PC
CIRC DESK 104	g1, g2, g3	M
LIBRARY 100	i	M
CIRC DESK 104	k	M
LIBRARY 100	l	M, 8S, PC
LIBRARY 100	m	M, 8S
LIBRARY 100	n	M, 8S, PC
LIBRARY 100	hh	M, MANUAL SWITCH
CHILDREN'S AREA 105	o	M, 8S
CHILDREN'S AREA 105	p	M, 8S, PC
CHILDREN'S AREA 105	q	M, 8S
CHILDREN'S AREA 105	r	M, 8S, PC
CHILDREN'S AREA 105	s	M, 8S
CHILDREN'S AREA 105	t	M, 8S, PC
CHILDREN'S ACTIVITY ROOM 136	v1, v2, v3	M, 4S, OS, PC
VESTIBULE 129	x	M, PC
CIRC DESK 104	w	M
COMMUNITY ROOM 136	a	M, 4S, OS
COMMUNITY ROOM 136	b	M, 4S, OS
COMMUNITY ROOM 136	c	M, 4S, OS
COMMUNITY ROOM 136	d	M, 4S, OS
CHILDREN'S AREA	zz	M
LIBRARY 100	zz	M

PANELBOARD SCHEDULES

E6.4

• Exterior Lighting Control

Controls that reduce the power needed to light areas close to daylight sources.

IECC

C405.2.6

ASHRAE

9.4.1.4

When it applies

All exterior lights except:

- Lighting for covered vehicle entrances and exits that required for eye adaption
- Lighting controlled from within dwelling units

All exterior lights except:

- Lighting for covered vehicle entrances and exits that required for eye adaption or safety
- Lighting installed in the signage

• Exterior Lighting Control

Controls that reduce the power needed to light areas close to daylight sources.

IECC

C405.2.6

ASHRAE

9.4.1.4

Requirements

- Auto off when daylight is sufficient
- Façade and landscape: auto off between 1hr after business closing to 1 hr before business opening
- Other: $\geq 30\%$ off either based on business schedule (same as above) OR 12-6am OR anytime when no activity for 15min
- Requirement on time-switch control functions if used

- Auto off when daylight is sufficient
- Façade and landscape: lighting off between 12am/business close and 6am/business opening
- Other: $\geq 50\%$ off either based on the same schedule as above OR anytime when no activity for 15min
- Outdoor parking ($>78w, \leq 24ft$ height): 50% reduction when no activity for 15min

❖ Exterior Lighting Control

EXTERIOR LIGHTING CONTROL SCHEDULE		
DESCRIPTION	SWITCH ID	CONTROL TYPES
PARKING LOT LIGHT	mm	DUSK TO TIMER
PARKING LOT LIGHT	nn	DUSK TO DAWN
PARKING LOT LIGHT	mm	DUSK TO TIMER
BOLLARD LIGHT	ss	DUSK TO TIMER; M
MONUMENT SIGN	oo	DUSK TO TIMER; M
BOLLARD LIGHT	ss	DUSK TO TIMER; M
FLAG POLE LIGHTS	vv	DUSK TO TIMER; M
PATIO LIGHTS	dd	SWITCH & TIMER; M
BLDG LIGHTS	ff	DUSK TO TIMER; M
BLDG LIGHTS	gg	TIMER SWITCH; M
CANOPY LIGHTS	hh	DUSK TO TIMER; M

<p>LIGHTING CONTROL SCHEDULE LEGEND</p> <p>M = MASTER SCENE CONTROLLER 2S = 2 SCENE CONTROLLER 4S = 4 SCENE CONTROLLER 8S = 8 SCENE CONTROLLER PC = PHOTOCELL OS = OCCUPANCY SENSOR D = DIMMING TC = TIME CLOCK</p>	<p>LIGHTING CONTROL NOTES</p> <p>1. COORDINATION SET POINTS WITH OWNER</p>
--	--

PANELBOARD SCHEDULES

E6.4

•• Lighting Functional Testing

Testing ensures that lighting system controls are installed and calibrated properly and according to construction documents and manufacturer's standards.

IECC

C408.3

- Lighting control devices and control systems shall be tested
- Special requirements for occupancy sensors, time-switches, programmable schedule controls and daylight sensors
- Documentation requirements: drawing shows equipment locations; provide operating and maintenance manual; and provide test result report

ASHRAE

9.4.3

- Lighting control devices and control systems shall be tested
- Special requirements for occupancy sensors, time-switches, programmable schedule controls and daylight sensors (same as IECC)
- Require to be done by a 3rd party (not involved in design or construction)

•• Lighting Functional Testing

Testing ensures that lighting system controls are installed and calibrated properly and according to construction documents and manufacturer's standards.

SECTION 26 09 23

LIGHTING CONTROL DEVICES

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections. Testing agency shall be independent of design, construction, and manufacture of equipment. Provide functional testing and certification in accordance with the latest edition of ASHRAE 90.1.

26 09 23-5

Lighting Control Devices

•• Automatic Receptacle Control

Requirements:

Either use a schedule-based control device to turn receptacles off at specific time *OR* an occupancy sensor or a signal from other control systems to turn receptacle off within 20min of all occupants leaving a space

ASHRAE

8.4.2

When it applies:

- At least 50% of all 125V 15 or 20amp receptacles in private offices, conference rooms, printing/copying room, break rooms, classrooms and individual workstations
- At least 25% of branch circuit feeders for modular furniture not shown in the design.

Exceptions:

- Requires 24-7 operation
- Auto control could endanger the safety

• Interior Lighting Power Density

The total connected lighting power is limited based on the building (or space) size and type of use (e.g. office vs retail)

IECC

C405.3

ASHRAE

9.5 & 9.6

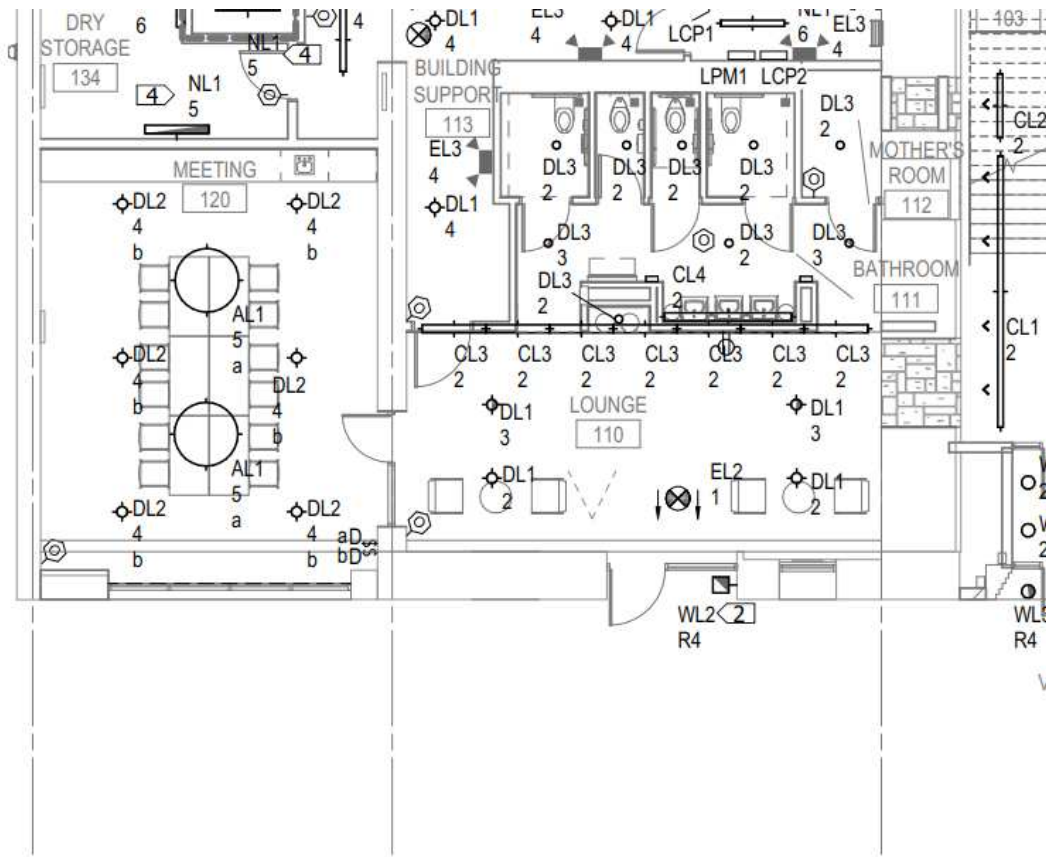
Building Area Method

Lighting power density allowance defined by building type

Space-by-Space Method

Power allowance determined by total of the allowance for each space (based on space type and size). This method allows additional power for Retail spaces.

Interior Lighting Power Density



1 LIGHTING PLAN - LEVEL 01
1/8" = 1'-0"

Interior Lighting Power Density

LIGHT FIXTURE SCHEDULE											
ELECTRICAL											
FITTURE LETTER	FITTURE STYLE	VOLTAGE	MOUNTING	LAMPS		BALLAST/ DRIVER	FITTURE MAX VA	CONTROL MEDIA (LENS, LOUVER, ETC.)	MANUFACTURER'S SERIES NUMBER	FITTURE DESCRIPTION	NOTES
				TYPE	COLOR						
A01	2X2 LED INDIRECT TROFFER	120	RECESSED GYP-BOARD AND/OR LAY-IN GRID INVERTED TEE	LED 3500 LUM MIN	3500K	DIMMING 0-10V	29 VA	ROUND CENTER PERFORATED SHIELD, UPPER REFLECTOR PAINTED WHITE	EATON-METALUX 22CZ-LD5 SERIES COLUMBIA LSTE SERIES LITHONIA 2BLT2 SERIES HE WILLIAMS DIG-S22 SERIES	POST PAINTED STEEL HOUSING, DIMMABLE DRIVER, DIMMABLE TO 10%	
A06	2X4 LED LENSED DIRECT/INDIRECT TROFFER	120	RECESSED GYP-BOARD AND/OR LAY-IN GRID INVERTED TEE	LED 4200 LUM MIN	3500K	DIMMING 0-10V	38 VA	HIGH PERFORMANCE ACRYLIC LENS	EATON-METALUX 24CZ-LD5 SERIES COLUMBIA LTRE SERIES LITHONIA 2BLT4 SERIES HE WILLIAMS DIG S24 SERIES	RECESSED 2X4 LENSED DIRECT INDIRECT STYLE LED WITH HIGH PERFORMANCE ACRYLIC LENS	
D01	2.9 DIAMETER DIMMABLE SQUARE LED DOWNLIGHT - VERY WIDE FLOOD	120	RECESSED GYP-BOARD AND/OR LAY-IN GRID INVERTED TEE	LED 1200 LUM MIN	3500K	DIMMING 0-10V	13 VA	SEMI-DIFFUSE REFLECTOR, CLEAR GLASS LENS, SILICONE FLANGE GASKET	AMERLUX EVOKE 2.9 SERIES PRESCOLITE D2 SERIES GOTHAM ICO SQ SERIES HE WILLIAMS 2DS SERIES	PRE-PAINTED BLACK STEEL HOUSING, SPUN ALUMINUM SELF-FLANGED REFLECTOR, PRE-WIRED J-BOX, INTEGRAL ADJUSTABLE LOCKING MOUNTING BARS	

Wrap Up:

Questions

Special Paths:

Performance & Additional Efficiency Packages

Documentation of Envelope Trade Off & Performance Path

- Envelope Trade-Off
 - COMCheck report showing better than baseline
 - Typically 1 or more input doesn't match design
- Performance Path Documentation: Key Report Items
 - Compliance path consistent with design (IECC vs ASHRAE)
 - Bottom line % better than code or pass/fail
 - Detailed list of design values for all key energy design items
 - IECC: 2-page table
 - 90.1: All items where design/simulation \neq baseline/prescriptive
 - Simulation input & output reports (enough detail to be able to confirm against design documents)
 - Simulation inputs inconsistent with design—wall & window U-values

Envelope Trade-Off: COMcheck example on envelope

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Proposed U-Factor	Budget U- Factor ^(a)
HM door: Insulated Metal, Swinging, [Bldg. Use 2 - Parking Garage]	24	---	---	0.700	0.700
Floor 1: Slab-On-Grade:Unheated, Vertical 3 ft., [Bldg. Use 2 - Parking Garage] (d)	1858	---	10.0	0.525	0.550

(a) Budget U-factors are used for software baseline calculations ONLY, and are not code requirements.

(b) 'Other' components require supporting documentation for proposed U-factors.

(c) Fenestration product performance must be certified in accordance with NFRC and requires supporting documentation.

(d) Slab-On-Grade proposed and budget U-factors shown in table are F-factors.

Envelope PASSES: Design 0.2% better than code

Envelope Compliance Statement

Compliance Statement: The proposed envelope design represented in this document is consistent with the building plans, specifications, and other calculations submitted with this permit application. The proposed envelope systems have been designed to meet the 90.1 (2010) Standard requirements in COMcheck Version 4.0.2.2 and to comply with the mandatory requirements listed in the Inspection Checklist.

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•• IECC Additional Efficiency Packages

- Must choose 1 of 8 options (for prescriptive path)
- C406 Options:
 - More efficient HVAC (per tables)
 - Lower lighting power density (per tables)
 - Enhanced lighting controls
 - On-site renewable energy
 - Dedicated outdoor air system
 - Reduced energy use in service hot water (limited building types)
 - Building envelope U 15% less
 - Reduced air infiltration (testing to 0.25 cfm/sf of envelope at 0.30 inches water)

Documentation of Envelope Trade Off & Performance Path

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Envelope PASSES: Design 0.2% better than code

Envelope Compliance Statement

Compliance Statement: The proposed envelope design represented in this document is consistent with the building plans, specifications, and other calculations submitted with this permit application. The proposed envelope systems have been designed to meet the 90.1 (2010) Standard requirements as implemented in COMcheck version 4.0.2.2 and comply with the mandatory requirements listed in the Inspection Checklist.

Envelope Trade-Off: COMcheck example on envelope

Assembly	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Proposed U-Factor	Budget U- Factor ^(a)
HM door: Insulated Metal, Swinging, [Bldg. Use 2 - Parking Garage]	24	---	---	0.700	0.700
Floor 1: Slab-On-Grade:Unheated, Vertical 3 ft., [Bldg. Use 2 - Parking Garage] (d)	1858	---	10.0	0.525	0.550

(a) Budget U-factors are used for software baseline calculations ONLY, and are not code requirements.

(b) 'Other' components require supporting documentation for proposed U-factors.

(c) Fenestration components must be certified in accordance with NFRC and requires supporting documentation.

(d) Slab-On-Grade proposed and budget U-factors shall be F-factors.

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Documentation of Envelope Trade Off & Performance Path

- Envelope Trade-Off
 - COMCheck report showing better than baseline
 - Typically 1 or more input doesn't match design
- Performance Path Documentation: Key Report Items
 - Compliance path consistent with design (IECC vs ASHRAE)
 - Bottom line % better than code or pass/fail
 - Detailed list of design values for all key energy design items
 - IECC: 2-page table
 - 90.1: All items where design/simulation \neq baseline/prescriptive
 - Simulation input & output reports (enough detail to be able to confirm against design documents)
 - Simulation inputs inconsistent with design—wall & window U-values

•• IECC Additional Efficiency Packages

- Must choose 1 of 8 options (for prescriptive path)
- C406 Options:
 - More efficient HVAC (per tables)
 - Lower lighting power density (per tables)
 - Enhanced lighting controls
 - On-site renewable energy
 - Dedicated outdoor air system
 - Reduced energy use in service hot water (limited building types)
 - Building envelope U 15% less
 - Reduced air infiltration (testing to 0.25 cfm/sf of envelope at 0.30 inches water)

Compliance Review Process Issues:

Documentation, Path, Forms



Compliance Review Issue #1: Energy Code Path(s)

- Basic Compliance Path
 - 2012 IECC w/amendments vs ASHRAE 90.1
 - Prescriptive vs performance
 - Coordination between reviewers for each discipline
- Lower Level Details
 - If prescriptive, using envelope trade-off or not
 - If IECC prescriptive
 - Which Additional Efficiency Package Option (C406)
 - Lighting
 - Building Area or Space by Space
 - Exterior Lighting Zone

•• Compliance Review Issue # 2: Documentation

- 1323.0100 ADMINISTRATION FOR COMMERCIAL ENERGY CODE
 - **Subp. 10. Information on construction documents.**
... Construction documents shall ... show in detail pertinent data and features of the building, systems, and equipment as governed in this code. The details shall include the following as applicable:
 - *Insulation materials and their R-value*
 - *Fenestration U-factors and SHGC*
 - *Area-weighted U-factor and SHGC calculations*
 - *Economizer description; equipment and system controls*
 - *Fan motor brake horsepower for fan motor 1 hp or larger*
 - *Fan motor hp & controls*
 - *Location of daylight zones on plans and provisions for functional testing of lighting controls*
 - *.....*



Compliance Review Issue # 2: Documentation

- Air Barrier
 - Additional details on drawings/submittals often needed for 1323.0100, Subpart 10.
 - Trace across details w/o lifting up
- Insulation
 - Drawings
 - Thickness—usually okay
 - R-value (say total or per inch) or clear reference to a specific insulation material exactly as it is named in specifications
 - Specifications
 - Name materials exactly as they are named on drawings
 - R or U-value per inch [note U or 1/R \neq Assembly U unless continuous insulation]
 - Prefab panels must have detailed information too
 - Assembly U-values from 90.,1 Appendix A



Compliance Review Issue # 2: Documentation

- Windows
 - *Assembly U-value*
 - Glass U-value is lower than assembly U-value (thermal bridging at frame)
 - NFRC 100 (or high default values)
 - Difficult to get ratings for site-built windows
 - If no NFRC sticker: submittals, invoices &/or on-line ratings
 - *Assembly SHGC—Space Heat Gain Coefficient*
 - NFRC 200 (or high default values)
 - Difficult to get ratings for site-built windows
 - If no NFRC sticker: submittals, invoices &/or on-line ratings
 - *VT—Visible Transmittance*
 - Only needed if:
 - Envelope trade-off
 - IECC & window area 30% to 40% or skylights 3% to 5%
 - Possible exception to sidelighting
 - NFRC 200 (or low default values)

•• Compliance Review Issue # 2: Documentation

- Forms & Checklist

- COMcheck
- ASHRAE



- Helpful, but confirm everything against CDs (that is what contractors look at when building)

- Notes from Plan Review to Guide Inspection

- Hi-level & detailed Code path options (e.g. building area vs space-by-space LPD)
- Exceptions invoked , etc. for specific spaces/equipment
- Note areas of concern
- C406 & Performance Path—List specific items that are “above code”

•• What We Discussed Today

- A. Energy Code Path Options & Code Organization
- B. Key Energy Code Items by Code Section
 - 1. Building Envelope
 - 2. Mechanical Systems
 - BREAK --
 - 3. Lighting & Other Electric Systems
 - 4. Special Paths
- C. Compliance Review Issues

**You can download a quick-reference guide at:
mncee.org/code**

**Near the bottom of the right panel, under Resources
click on: • Climate zone 6A**

THANK
you!

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