State of Connecticut
Department of Administrative Services
Division of Construction Services
Office of Education and Data Management

Daylighting Options and the 2012 IECC

Presented by
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for the

Office of Education and Data Management
Spring 2016 Career Development Series

- IECC History; Definitions
- Lighting Controls
- Lighting Basic LPD
- Daylighting Controls
- Daylighting Strategy
- LPDs; Add Options
- Commissioning
- ASHRAE Lighting Controls
- Lighting Power
- Daylighting Controls
- Daylighting
- Commissioning
- CT DEEP Regulations
- IECC/90.1 COM*check*

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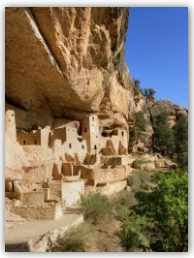
Lighting and Daylighting

Natural Light as a Historical Resource



- 40,000 years (or more)?
- Good example of how much we tend to forget or to ignore what we learned in history
- Solar is not 100% free, but maybe the least costly energy available

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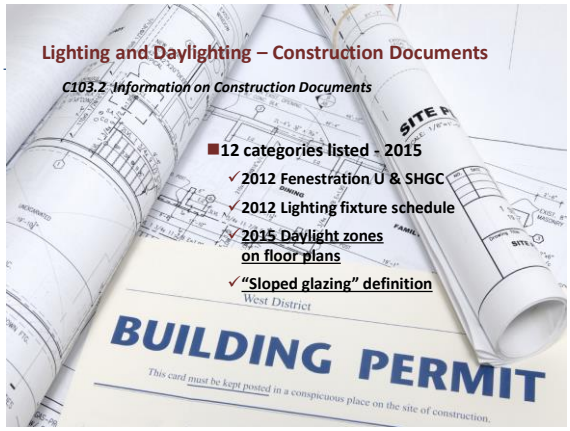
Daylighting History in IECC

IECC 2004-2009 Optional; Fenestration at 40% vertical, 3% skylighting

- **2000** Fenestration varies – 10-50%; 3% skylights; U-factors vary; no daylighting requirements
- **2004** No daylighting requirements
- **2006** No daylighting requirements
- **2009** No daylighting requirements; **505.2.2.3** requires 'independent' automatic lighting control if daylighting provided



Construction Documents

C103.2 Information on Documents (2 NEW in 2015)

2012 Details shall include, but not be limited to

- "insulation materials and their R-values; fenestration U-factors and SHGC's; area-weighted U-factor and SHGC calculations; mechanical systems and equipment types, sizes and efficiencies; economizer description; systems and controls; duct sealing, duct and pipe insulation and location; lighting fixture schedule with wattage and control narrative; and air sealing details"

2015 Creates Details List

1. Insulation materials; R-values
2. Fenestration
3. Area-weighted U- and SHGC factors
4. Mechanical system design, control
5. Mechanical, SWH system/equipment types, sizes, efficiencies
6. Economizer descriptions
7. Equipment & system controls
8. **Fan motor HP, controls**
9. Duct sealing; duct & pipe insulation
10. Lighting fixture schedule; narrative
11. **Location of daylight zones on floor plans**
12. Air sealing details

Important Definition Changes

Section C202

- **Above-Grade Wall – See C402.2.1- (15%)**
- **General Lighting**
- **Fenestration**
  - ✓ ***Vertical***
  - ✓ ***Sloped***
  - ✓ ***Dynamic glazing***
- ***Skylight (15^0->30^0)***
- ***Visible transmittance***

Applicable Definitions

C202; IBC 2404.2*

- Vertical Glazing
  - ✓ **Changes to 90.1 definition**
- Sloped Glazing *
  - ✓ **IBC 2404.2 Safety Glazing**
- Visible transmittance *[VT]*
  - ✓ ***drives SHGC***
- Dynamic glazing
- Undefined:
  - ✓ **Sidelighting**
  - ✓ **Toplighting**

Managing Lighting

Through Design and Control – C405

- Basic Design Goal: Safely and effectively illuminate all general and specific use(s) in building spaces / areas
  - ✓ **General lighting**
  - ✓ **Task lighting**
  - ✓ **M.O.E. illumination**
- Exterior and interior

Lighting Controls - Basics

Basic Concepts: Lighting Controls

- Manual lighting controls
  - ✓ **Light reduction**
- Additional control
  - ✓ **T.O.D. switch devices**
  - ✓ **Occupancy sensors**
  - ✓ **Override control**
- Daylight zone control
  - ✓ **Manual**
  - ✓ **Automatic**
  - ✓ **Multi-level**
- Dedicated applications

Lighting – Manual Control (Mandatory)

C405.2.1.1 Interior Lighting Controls

- Manual control of separate spaces with status indication
- Exceptions:
  - ✓ **Continuously lit security or emergency area**
  - ✓ **Stairways, corridors, M.O.E.**

Managing Natural Light

Through Design and Control – C402.3

- **Daylighting Scope:**
  All illumination uses where lighting energy can be effectively and safely reduced with natural lighting sources and controls
  - ✓ **Using practical building design solutions,**
  - ✓ **Adding daylight-responsive controls where achievable.**

Glazing Strategies

Taming Natural Lighting – Intensity & Glare

- **Coatings/films - SHGC**
- **Shading - PF**
- **Diffusion – Obscured**
- ***Redirection – Light shelf**
- ***Refraction films – (new)**

Glazing Strategies

Taming Natural Lighting – Redistribution

- ***Refraction films – (3M new product)**

Lighting Controls

Lighting Reduction Controls (Mandatory)

C405.2.1.2

- Manual light reduction control by at least 50% In a reasonably uniform manner
  - ✓ **All lamps or luminaires**
  - ✓ **Dual switching: alternate rows**
  - ✓ **Individual switching**
- Exceptions:
  - ✓ **One room, one luminaire**
  - ✓ **Occupancy sensor control**
  - ✓ **Spaces using < 0.6 w/sf**
  - ✓ **Spaces with daylight-responsive automatic controls**
  - ✓ **Eight specific use spaces**

Lighting Controls (Mandatory)

C405.2.2 Additional Lighting Controls

- Automatic time switch control
- Occupancy sensors
- Daylight-responsive control

- Exceptions
  - ✓ **Sleeping units**
  - ✓ **Patient care spaces**
  - ✓ **Safety & security spaces**
  - ✓ **Continuous utilized spaces**

Additional Lighting Controls

C405.2.2.2 Occupancy Sensors

- Spaces ≥ 300 sf
- Switch off after 30 minutes of non-occupancy

- Classrooms
- Meeting rooms
- Lunch/break rooms
- Private offices
- Restrooms
- Storage rooms
- Custodial closets

Additional Lighting Controls

C405.2.2.3 Daylight Zone Control

- Max. 2,500sf lighting zone
- Independent control; either manual or automatic
- Can be continuous dimming
- Can be multi-level stepped dimming controls
  - ✓ **Where daylight exceeds general lighting, a power rating reduction to ≤ 35% must be achieved**

Mars Hill **Maine**

Lighting Power - Basics

Basic Concepts: LPD by Type of Use

- Limits allowable power
- Basically LPD x A
  - ✓ **Of building**
  - ✓ **Of space**
- Special Exceptions
  - ✓ **Means of Egress**
  - ✓ **Safety/security**
- Rules for how to calculate
- Exempt Lighting
  - ✓ **14 categories**

Lighting Density

C405.5.1 Connected Lighting Power Assumptions

Tables C405.5.2 LPD Values

- **Line voltage – lighting**
  - ✓**E26/other screw base: max. W**
  - ✓**Fixture rating, other luminaires**
  - ✓
  - ✓**Low Voltage – transformer or system rating**
- **Exceptions for 14 lighting categories**

Lighting Power Densities

C405.5 Indoor Lighting Power Allowances (ILPA)

LPD by Use and Occupancy

- 33 Building Area Types
- Unlisted – similar use

LPD Space by Space

- 93 Space Types
- 2 Atrium listings
- Unlisted – similar use

Building Area Type 33	LPD (w/SF)
Automotive facility	1.2
Convention center	1.2
Courthouse	1.2

Space by Space Type 93	LPD (w/SF)
Courthouse	
Courtroom	1.90
Confinement cells	1.10
Judge chambers	1.30

Lighting Power Density Calculations

C405.5.1 Connected Lighting Power

(1) Building Area Method

- **LPD x ∑ Actual Floor Area**
- **Mixed uses - sum separately**
- **There are 14 Exceptions**
  - ✓ **Exception for Casino Gaming Areas cannot be found in either interior ILPA Table**

Lighting Power Density Calculations

C405.5.1 Connected Lighting Power

(2) Space-by-Space Method

- **LPD x Area of Space and**
- **∑ Area 1 LP, area 2LP, etc.; divide by total floor area**

Lighting Power Density Changes

C405.5.2 Table C405.5.2

- Conforms with 90.1-2013 ILPD changes
- Two new Building Type Options:
  - ✓ **5 densities INCREASED**
  - ✓ **26 densities UNCHANGED**
  - ✓ **0 densities DECREASED**
- Space-by Space densities also change
- Toplighting and Sidelighting
- Combines lighting; new Tables
- Adds occupancy sensor controls
  - ✓ **Locker rooms, warehouse aisleways**
  - ✓ **Control 50% reductions**

https://www.ashrae.org/standards/90_1_2010_2013Addenda.pdf

Lighting Notes

Table C405.5.2(2) Notes - Additional Lighting for Specific Areas

- Four Merchandise Uses
- Vehicles, sporting goods,

I. Products unlisted below
II. Vehicles, sporting goods, electronics
III. Artwork, furniture, clothing, cosmetics
IV. Jewelry, crystal, china

- Switched separately

Lighting Notes to Table C405.5.2(2)

C405.2.3 Specific Application Dedicated Controls

Dedicated and Master Separate Lighting Control

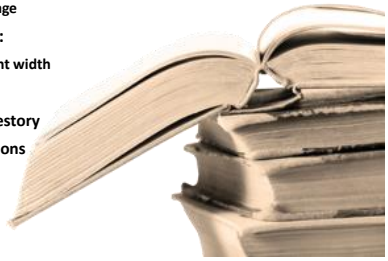
- Display / Accent Lighting
- Case Lighting
- Hotel Sleeping Units
- Individual task lights
- Food warming
- Lighting education

DAYLIGHTING

Daylighting Definitions

C202

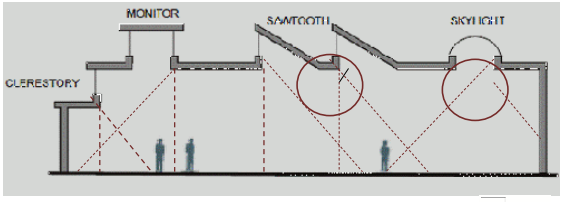
- **Adjacent to vertical fenestration**
  - ✓ 15 ft. primary daylight area width
  - ✓ 2 ft. side coverage
- **Under skylights:**
  - ✓ ≥ 15 ft. + skylight width
- **Not mentioned**
  - ✓ Transom; clerestory
  - ✓ Ends of partitions
  - ✓ Aperture



Glazing: What Counts? As What?

Basic Daylighting to Illuminate Interiors

Windows? **Skylights?**



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Daylighting Controls - Basics

Basic Concepts: Daylight-responsive control

- Natural light responsive
- Control lighting reductions
- May be multi-level or by individual fixture
- Immediate response to natural light changes with no delays
- Multiple orientations sensing

Measuring Daylight Opportunities / Problems

Solar Insolation "PATHFINDER" Tool

Sets for:
- Latitude
- Orientation

Determine:
- Bright sky
- Sun Angles
- Shading

Daylighting

C202; IBC 2404.2* Skylight and Sloped Glazing Definitions

IECC Definitions: Daylighting

C202; IBC 2404.2*

- Vertical Glazing [≥ 60^0 *]
  - ✓ **Changes to 90.1 definition**
- Skylight [< 60^0 *]
- *Sloped Glazing [> 15^0] per **IBC 2404.2 Safety Glazing**
- Undefined:
  - ✓ **Light tubes**
  - ✓ **Deck prisms**
  - ✓ **Rooftop monitor***

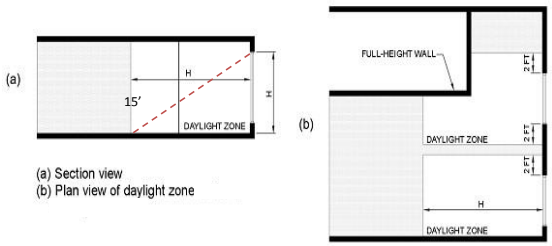
Averaging Fenestration U- Factors

C402.3.4 Area-weighted U-factor

Sidelighting

C202 Daylight Zone Adjacent to Vertical Fenestration

- Daylight zone is 15 feet, regardless of window head
- Zone width/depth extends over partitions less than ceiling height



(a) Section view
(b) Plan view of daylight zone

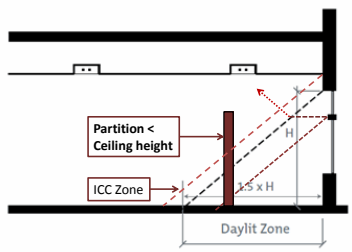
Sidelighting

C202 Prescriptive Definition

Daylight Zone =

- 15' – not head height
- Side margins of 2'
- Opaque wall cutoffs

- Light shelf does not change area measurement
- No allowances for technical strategies
- No penalties for non-uniformity of lighting



DAYLIT ZONE—SIDELIGHTING

Fenestration Limitations – *(prescriptive option)*

C402.3.1.2 Increased Skylight Area with Daylighting Controls

Vertical fenestration limits

- **30%** without auto controls
- **40%** with averaged F.A. ≥ 50%
  - ✓ **Limited to CZ 1-6**
  - ✓ **Applies to all stories**
  - ✓ **VT** compliance (visible transmittance)
- VT ≥ 1.1 x SHGC
  - ✓ **NFRC 200**

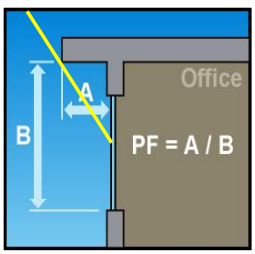
Sunlight Control in IECC

Daylighting Control: Projection Factor

Using Projection Factors

C402.3.3.1 SHGC Adjustment

- Fenestration U-factor constant; can be averaged
- SHGC factor modified by PF
- Modifications of SHGC are permitted by applying the percentages in Table C402.3.3.1



Daylighting

C402.3.2 Daylighting Required

- **Skylighting (Mandatory).** 15 areas with ≥ 50% of floor area (FA) using ***daylight-responsive*** controls
  - ✓ **Has ≥ 3% min. skylight area to daylight zone with VT ≥ 0.40; or with ≥ 1% effective aperture**
  - ✓ **Not required where lighting power densities are < 0.5W/s.f.**
  - ✓ **Not required in areas where daylight is obstructed**

Daylighting

C402.3.2 Daylighting Prescriptive Requirement

Enclosed spaces **> 10,000 s.f.** directly under a roof with ceiling heights **≥ 15'**

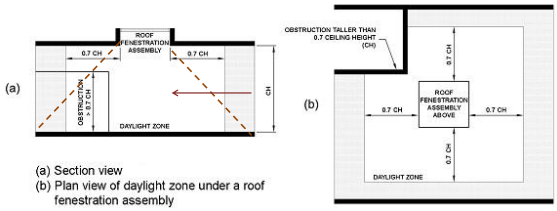
Assembly Uses:
Gym; convention & transportation centers
Business & Mercantile Uses**
Offices; Retail stores; Automotive services
Associated spaces
Lobby; Atrium; Concourse; Corridor
Factory Uses:
Manufacturing**; Workshop;
Storage Uses:**
Warehouses (non-refrigerated);
Distribution / Sorting, Storage

*** 90% haze factor; these uses*

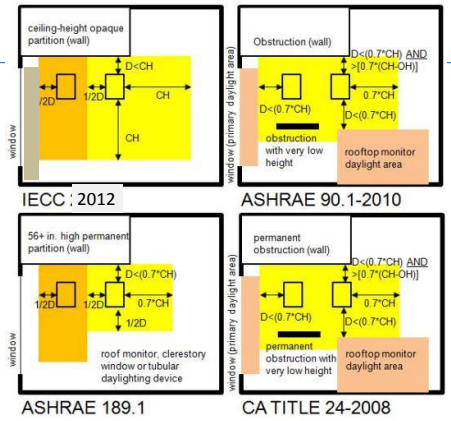
Skylights

C202 Daylight Zone Under Skylights

- Floor area dimension equals twice the height of the ceiling plus skylight width
- Only full-height partitions block the light to other portions of the illuminated area



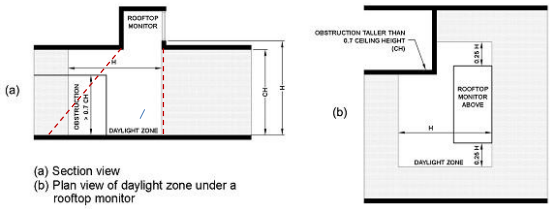
(a) Section view
(b) Plan view of daylight zone under a roof fenestration assembly



Toplighting

C402.3.2.1 Exception 4 (but does not define rooftop monitors)

- Monitor Floor Area Allowance
- Side illumination allowance

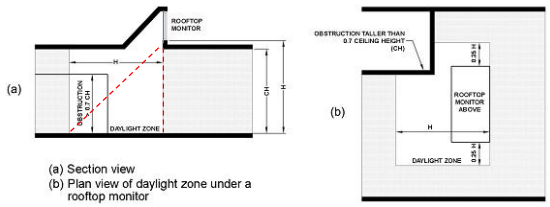


(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

Toplighting - Alternative Monitor

C202 (lacks definition and description)

- Treat like vertical fenestration
- Daylight zone = 15 ft from glass
- Sidelit area = 2 ft each side



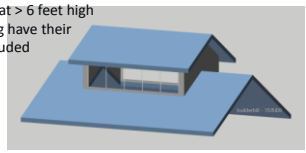
(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

Daylight Responsive Controls

C402.3.2 / Fig.C405.2.3.2 (2015)

Rooftop Monitor Zones Change

- Zone: sill height of roof monitor fenestration, not 15'
  - ✓ **Accounts for rooftop monitor glazing**
  - ✓ **Exception: where site shading occurs**
- VT in existing buildings determines if a zone
- Figure C405.2.3.2. Partitions at > 6 feet high using roof monitor daylighting have their floor area below monitor included



Skylight Haze Factor

C402.3.2.2 Obscured Toplight Glazing

- Glazing material OR diffuser
  - ✓ **> 90% obscuration**
  - ✓ **ASTM D 1003**
- **Exception**. Achieve equivalent:
  - ✓ **Geometry of skylight well**
  - ✓ **Fixed or automatic baffles**

Obscured Toplighting

C402.3.2.2 90% Haze Factor

SHGC Daylight Control Exception

C402.3.3.3 Increased Skylight SHGC

- Daylight zones with automatic daylight-responsive lighting controls
- SHGC increases from 0.40 to ≤ 0.60
- Limited to CZ 1-6

Fenestration Maximum U-factors and SHGC

C402.5 Area-weighted U-factor and SHGC (Mandatory)

- Average maximum using tradeoffs for vertical glazing in CZ 4-5 is U-0.48
- Average maximum using tradeoffs for skylights in CZ 4-8 is U-0.75
- SHGC tradeoffs in CZ4-8 are not allowed

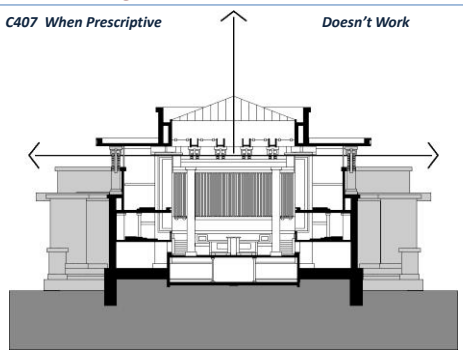
Additional Efficiency Options

C406.1 (2) Efficient Lighting System

- Use of an additional option beyond a single category
- Contributes to 21% DEEP goal
- HVAC and renewable energy are the other options
- 2015 adds two further options to this path

Total Building Performance

C407 When Prescriptive *Doesn't Work*



Total Building Performance

Table C407.5.1(1) Glazing Criteria

- **Fenestration limit**
  - ✓ **Proposed value if < 40%**
  - ✓ **40% if proposed is greater**
- **U-factor**
  - ✓ **0.38 Fixed**
  - ✓ **0.45 Operable**
  - ✓ **0.77 Entry door**
- **SHGC 0.40**
- **No daylighting requirements**

Total Building Performance

C407 Mandatory Compliance Inconsistencies

- **Fenestration at <u>40%</u>**
  - ✓ **Proposed value if ≤ 40%**
  - ✓ **<u>40%</u> if proposed is greater**
- **U-factor** **0.38 (all)** **0.45** **0.77**
- **SHGC** **0.40**

- **Skylight limit of <u>3%</u>**
  - ✓ **Proposed value if ≤ 3%**
  - ✓ **3% if proposed is greater**
- **U-factor** **0.50 (all)**
- **SHGC** **0.40**

Total Building Performance

Table C407.5.1(1) Glazing Criteria

- **Skylight limit of 3%**
  - ✓ **Proposed value if < 3%**
  - ✓ **3% if proposed is greater**
- **U-factor 0.50 (all)**
- **SHGC 0.40**
  - ✓ **Both from Table C402.3**
- **No daylighting requirements**

Total Building Performance

C407 Mandatory Compliance Inconsistencies

- **Skylight limit of 3%**
  - ✓ **Proposed value if ≤ 3%**
  - ✓ **3% if proposed is greater**
- **U-factor 0.50 (all)**
- **SHGC 0.40**

Total Building Performance

C407 Mandatory Compliance Inconsistencies

- Fenestration at 40%
  - ✓ **Proposed value if < 3%**
  - ✓ **3% if proposed is greater**
- U-factor 0.50 (all)
- SHGC 0.40

- Skylight limit of 3%
  - ✓ **Proposed value if < 3%**
  - ✓ **3% if proposed is greater**
- U-factor 0.50 (all)
- SHGC 0.40

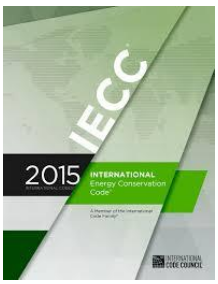
Commissioning

C408.3 Lighting System Functional Testing

- Installed lighting and power
- Luminaires; fixtures; systems
- Lighting controls
  - ✓**Time Switch controls**
  - ✓**Automatic controls**
  - ✓**Occupancy sensors**
  - ✓**Daylight-responsive controls**
- Override controls
- Safety; security;
- 24-hour operation

2015 International Energy Conservation Code

Previews of Coming Changes



- C402 Envelope
- C402 Daylighting
- C406 Lighting Power
- C406 Lighting Controls
- C407 Added Efficiency Options
- C408 Commissioning

Glazing: Orientation in 2015 *(prescriptive)*

Table C402.4: U-factor / SHGC Requirements by Orientation

Ciimate Zone	1		2		3		4 except Marine		5 and Marine		6		7	
Vertical Fenestration U-factors														
Fixed	0.50		0.50		0.46		0.38		0.38		0.36		0.29	
Operable	0.65		0.65		0.60		0.45		0.45		0.43		0.37	
Doors	1.10		0.83		0.77		0.77		0.77		0.77		0.77	
SHGC	ESW	N	ESW	N	ESW	N	ESW	N	ESW	N	ESW	N	ESW	N
PF < 0.2	0.25	0.33	0.25	0.33	0.25	0.33	0.40	0.53	0.40	0.53	0.40	0.53	0.45	N/R
0.2≤PF<0.5	0.30	0.37	0.30	0.37	0.30	0.37	0.48	0.58	0.48	0.58	0.48	0.58	N/R	N/R
PF ≥ 0.5	0.40	0.40	0.40	0.40	0.40	0.40	0.64	0.64	0.64	0.64	0.64	0.64	N/R	N/R
Skylights														
U-factor	0.75		0.65		0.50		0.50		0.50		0.50		0.50	
SHGC	0.35		0.35		0.35		0.40		0.40		0.40		N/R	

Increased Skylighting in 2015

C402.3.2 Mandatory Skylighting ***15 Types***

- **≤ 50% floor area coverage from Skylight Fenestration ≤ 2 stories**
- **≤ 25% floor area for > 2 stories**
- **Spaces ≥ 5ksf (*2.5ksf 2013)**
- **Ceiling > 15 ft. (* ≥ 75% 2013)**
- **Aperture ≥ 1-3% (two options)**
- **Exceptions: 8**

Daylighting Refinements in 2015

C402.4.1 Modifies Fenestration; [also C405.2.3 (2&3) Controls]

Requirements undergoing refinement

- C402.4.1.1 Increased to 40% glazing if total floor area:
  - ✓ **≥ 25% in buildings > 2 stories**
  - ✓ **≥ 50% in buildings < 2 stories**
- **ADDS** Exception for perimeter zones < 2.5kSF with controls
- *Daylight responsive controls* now defined

Daylighting Refinements in 2015

C402.4.1 Modifies Fenestration; [also C405.2.3 (2&3) Controls]

Mandatory skylighting refined

- C402.4.1.2 where skylight area for specific uses (15 types); room area decreases to < 2.5 kSF
  - ✓ **ADDS Exception for perimeter zones < 2.5kSF with controls**

Alternative Prescriptive Compliance Packages in 2015

Table C406.3 ILPA / ELPA Reductions

- Reduced LPD Limits
  - ✓ Whole building LPD values must use Table C406.3, or prescriptive Table C405.4.2(2) for individual space values; reduced by 10%

Increased Skylighting in 2015

C402.3.2 Mandatory Skylighting

15 Types

Assembly Uses:

- Gym; convention and transportation centers

Business & Mercantile Uses:

- Offices**; Retail stores** Automotive services**

Associated spaces

- Lobby; Atrium; Concourse; Corridor

Factory Uses:

- Manufacturing**; Workshop;

Storage Uses:**

- Warehouses (non-refrigerated); *Distribution / Sorting, Storage*

*** 90% haze factor; these uses*

Added Efficiency Compliance Options in 2015

Table C406.3 ILPA / ELPA Reductions

- Reduced LPD Limits
  - ✓Whole building LPD values must use Table C406.3, or prescriptive Table C405.4.2(2) for individual space values; reduced by 10%

Additional Efficiency Package Options in 2015

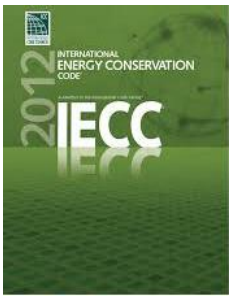
C406.3 / Table C406.3 Reduced LPD Values

- **Table C406.3 Notes**
  - ✓ **Use specific LPD values, not general**
  - ✓ **LPD values are 90% of TC405.5.2(1) where daylighting is ≥30% of FA**
  - ✓ **Use second LPD values when <30%**
  - ✓ **Warehouses must achieve ≥70% F/A**
  - ✓ **Daylighting must use auto controls/**

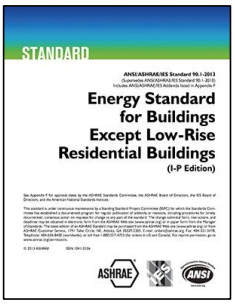
BREAK

The Commercial Option: ASHRAE 90.1

IECC C401.2.1 names 90.1 as option



Sections 5.5.4 & 9.4 elaborate



Lighting Control Outside the Envelope

9.4.1.3 Parking Garage Lighting Control

- Automatic lighting shutoff
- LPD reduction ≥ 30% in lighting zones unoccupied for > 30 min.
  - ✓ **Except where HID < 150w used**
- Daylight transition zone separately controlled using daylight sensors
- Daylight-responsive control of perimeter sidelighting areas
  - ✓ **Except transition zones and ramps without parking**

Construction Documents

4.2.2 Compliance Documentation 2010

Documentation shall show …in detail:

- All pertinent data of the building equipment and systems…
- To determine compliance by the building official and…
- Indicate compliance with this standard.
- Supplemental data, such as:
  - ✓ **Calculations,**
  - ✓ **Worksheets**
  - ✓ **Compliance forms**

Inspections required …before concealment:

a. **Wall insulation**
b. **Roof/ceiling insulation**
c. **Slab/foundation wall insulation**
d. **Fenestration after all glazing placed**
e. **Continuous air barrier**
f. **Mechanical systems and equipment**
g. **Electrical equipment and systems**

Interior Lighting: Basic LPD Controls

9.4.1 Manual and Automatic Controls

- Allows manual ON control at 50% power for daylighting circuits,
- Automatic OFF controls required
- Stepped control required for general lighting
- Space control exceptions:
  - ✓ **Lighting for MOE, restrooms, service and storage rooms**
- Occupant sensors also required in eight space categories

Lighting Controls

9.4.1 Building Lighting

- **Startup: ≤ 50% + step control**
  - ✓**All non-exempt spaces**
  - ✓**Step control to 30-70%**
  - ✓**Threshold 2500 sf max.**
  - ✓ **Four Exceptions**

- **Occupancy sensors – 8 uses**
  - ✓**Exceptions:**
  - ✓**Multi-scene control**
  - ✓**Shops, laboratories**
  - ✓**Safety/security**
  - ✓**24-hour operation**

Managing Controls

Through Design and Control – 9.4.1.6

- Basic Control Goal: Effectively control all illumination within spaces without intervention
- Additional control:
  - ✓**Task lighting**
  - ✓**M.O.E. illumination**
- Manual control is still optional where automatic control is not mandated

Lighting Controls

9.4.1.2 Space-by-Space Control

- Same automatic startup to 50% power in all spaces w/o manual lighting control
- Exceptions:
  - ✓Public corridors
  - ✓MEP rooms
  - ✓Public lobbies, entrances
  - ✓Stairwells
  - ✓Storage rooms

Lighting Controls

9.4.1.2 Space-by-Space Control

- Step reduction between 30-70%
- Occupant sensor shutoff at ≤ 30 minutes w/ 2 hr. override
- No automatic control for 24hr operation; patient care spaces; safety/security spaces & uses

Lighting Control In Both Codes

Sections ICC C405 and 90.1-9.4

IECC [CE]	Controls	ASHRAE 90.1
C405.2	Space Control -50% on	9.4.1
C405.2.2	Auto shutoff	9.4.1.1
C405.2.2.3	Primary Sidelighting	9.4.1.4
C405.2.2.3.3	Secondary Sidelighting	N/R
C405.2.2.3	Toplighting	9.4.1.5
C405.2.3	Additional controls	9.4.1.6
C405.2.1.2	Lighting reduction controls in spaces that use < 6w/sf	9.4.2.1a

AKF

Lighting Power Densities

Table 9.5.1 Interior Lighting Power – Building Area Method

- 90.1-2010 LPD changes
- For most building types, LPDs are reduced.
  - ✓**Partial Table shown**
- Average LPDs:
  - ✓• **90.1-2007…… 1.09**
  - ✓• **90.1-2010……..0.906**
  - ✓• **Difference … -16.9%**

TABLE 9.5.1 Lighting Power Densities Using the Building Area Method

Building Area Type[a]	LPD (W/ft²)	
Automotive facility	~~0.9~~	0.82
Convention center	~~1.2~~	1.08
Courthouse	~~1.2~~	1.05
Dining: bar lounge/leisure	~~1.3~~	0.99
Dining: cafeteria/fast food	~~1.4~~	0.90
Dining: family	~~1.6~~	0.89
Dormitory	~~1.0~~	0.61
Exercise center	~~1.0~~	0.88
Gymnasium	~~1.1~~	1.00
Health-care clinic	~~1.0~~	0.87
Hospital	~~1.2~~	1.21
Hotel	~~1.0~~	1.00
Library	~~1.3~~	1.18
Manufacturing facility	~~1.3~~	1.11
Motel	~~1.0~~	0.88
Motion picture theater	~~1.2~~	0.83
Multifamily	~~0.7~~	0.60
Museum	~~1.1~~	1.06
Office	~~1.0~~	0.90
Parking garage	~~0.3~~	0.25

Lighting Power Densities

Table 9.6.1 Space-by-Space Method

TABLE 9.6.1 Lighting Power Densities Using the Space-by-Space Method

Common Space Types[a]	LPD, W/ft2	RCR Threshold
Atrium		
First 40 ft in height	0.03 per ft (height)	NA
Height above 40 ft	0.02 per ft (height)	NA
Audience/Seating Area—Permanent		
For auditorium	0.79	6
For Performing Arts Theater	2.43	8
For Motion Picture Theater	1.14	4
Classroom/Lecture/Training	1.24	4
Conference/Meeting/Multipurpose	1.23	6
Corridor/Transition	0.66	Width<8 ft
Dining Area	0.65	4
For Bar Lounge/Leisure Dining	1.31	4
For Family Dining	0.89	4

- The Room Cavity Ratio allows LPD values to be increased based on the geometry of the space meeting thresholds
- Modifies settings in lighting power control
- Adds power for complex room shapes and heights
- Not in IECC

Lighting Power Density Changes

9.6.2 / Table 9.5.1 ASHRAE 90.1 Addendum 'by'

- Conforms with 90.1-2013 ILPD changes
- Building Type Option:
  - ✓ **5 densities INCREASED**
  - ✓ **5 densities UNCHANGED**
  - ✓ **21 densities DECREASED**
- Space-by Space densities also change
- Toplighting and Sidelighting
- Combines lighting; new Tables
- Adds occupancy sensor controls
  - ✓ **Locker rooms, warehouse aisleways**
  - ✓ **Control 50% reductions**

https://www.ashrae.org/standards/90_1_2010_2013Addenda.pdf

LPD Room Geometry Adjustments

Table 9.6.1 Room Cavity Ratio [RCR] – Space Method Only

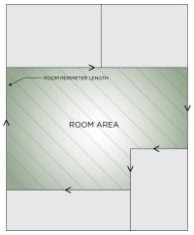
- Additional LPD for unusually shaped spaces
- RCR = $\frac{2.5 \times HC \times 2L \times 2W}{\text{Room Area}}$
- Min. threshold values – 4-10
- All Corridors < 8 ft wide

- Not applicable for:
  - ✓**Atriums**
- Allows 120% LPD

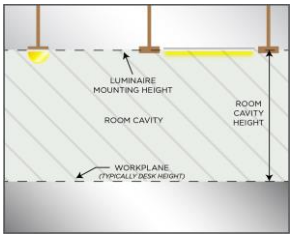
Room Cavity Ratio

9.6.3 Modifying LPD of Complex spaces

- Manual control



- Manual control



Lighting Power Density - Additions

Table 9.6.2 & 5.5.4.2.3 Credit for Additional Lighting Controls

- Control strategies beyond mandatory lighting control requirements (5.5.4.2.3) offer 12 different LPD adjustments
- Based on 5 space groups only
- Must meet all mandatory lighting control measures
- Notes describe operating features necessary to qualify

Additional Control Method (in Addition to Mandatory Requirements)	Space Type				
	Open Office	Private Office	Conference Room, Meeting Room, Classroom (Lecture/ Training)	Retail Sales Area	Lobby, Atrium, Dining Area, Corridors/ Stairways, Gym/ Pool, Mall Concourse, Parking Garage
Manual, continuous dimming control or Programmable multi-level dimming control	0.05	0.05	0.10[1]	0.10	0
Programmable multi-level dimming control using programmable time scheduling	0.05	0.05	0.10[1]	0.10	0.10
Multi-level occupancy sensors	0.05	0.05	0.05	0	0

Daylighting History in the ASHRAE Codes

90.1-2004 to 2010

- **2004** No requirements; fenestration at ≤40%; skylights at 2% & ≤5%
- **2007** No daylighting required; **5.5.4.4.1** introduces PF factors modified by building orientation for vertical glazing; **lower U- and SHGC factors** for skylight **areas ≤ 2.0%** of gross FA.

Daylighting in the ASHRAE Codes

90.1-2004 to 2010

- **2010** Fenestration still at ≤ 40%; skylights ≤ 5%; **5.5.4.2.3** now requires mandatory skylighting of 15 types; **≥ 5,000sf** over at least 50% of the floor area (FA)

ASHRAE Definitions: Sidelighting

90.1 Section 3.2

- Primary sidelighted area
- Secondary sidelighted area
- Side extension [2’]
- Head height
- Daylight area
- Clerestory, dormer

ASHRAE Definitions: Toplighting

3.2 Toplighting

- Skylight [< 60^0 horizontal]
- Daylight area
- Skylight well
- Skylight aperture
- Rooftop monitor

Combining Sloped Glazing, Skylights

5.5.4.2 Using Both Percentages to Best Effect

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Fenestration Limitations

5.5.4.2.2 Vertical Fenestration Area – (prescriptive option)

Vertical fenestration limits

- **30%** without auto controls
- **40%** with averaged F.A. ≥ 50%
  - ✓ **Limited to CZ 1-6**
  - ✓ **< 3 stories ≥ 50% (2015)**
  - ✓ **≥3 stories ≥ 25% (2015)**

Visible transmittance [VT]

- VT ≥ 1.1 x SHGC

Fenestration Limitations

5.5.4.2.2 Maximum Skylight Fenestration Area – (prescriptive option)

Increased Fenestration Limit

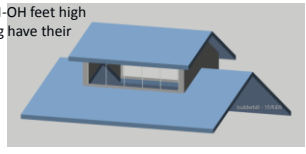
- Up to **75%**
- Street façade only
- 20ft max. height
- Separate SHGC computation for SHGC and glazing – no average

Daylight Responsive Controls

5.5.4.2.3 Exception (d)

Rooftop Monitor Zones Change

- Zone: sill height of roof monitor fenestration, not 15'
  - ✓ **Accounts for rooftop monitor glazing**
  - ✓ **Exception: where site shading occurs**
- VT in existing buildings determines if a zone
- Figure 3.2 Partitions at < MSH-OH feet high using roof monitor daylighting have their floor area totally included



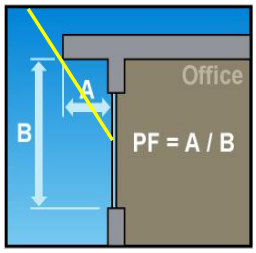
Direct Sunlight Control

Table 5.5.4.4 Daylighting Control: Projection Factor

Projection Factor: Direct Sunlight Control

Table 5.5.4.4.1 Maximum U-factor and SHGC

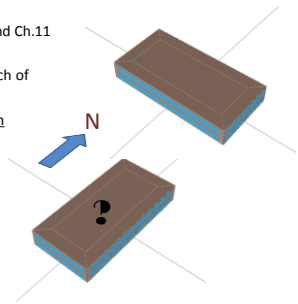
- Fenestration U-factor constant; can be averaged
- SHGC factor modified by PF – see Table 5.5.4.4.1
- Modifications of SHGC are permitted by applying the percentages



Fenestration Orientation - 2010

5.5.4.5 Fenestration – Addendum 'bn'

- Changes to section 5.5.4.5 and Ch.11 for locations of fenestration
- E & W orientations < 25% each of total vertical fenestration
- Physical dimensions of design solution may be affected



Building Thermal Glazing Changes

5.5.4 Prescriptive Envelope Fenestration Option

- Fenestration remains capped at 40%; SHGC by VT/SHGC; dependent on percentages of glazing
  - ✓ Vertical glazing orientation limitations covered by Section 5.5.4.5
  - ✓ Dynamic glazing SHGC 5.5.4.4.2
  - ✓ 5.5.4.2.1 Exception: Street Storefront (≤ 75% - a definite bonus) **2. PF

Building Thermal Glazing Changes

5.5.4 Prescriptive Envelope Fenestration Option

- 5.5.4.5 Fenestration Orientation
  - ✓ Façade glazed areas < 30^0 of true E/W
  - ✓ Fenestration improvements may be "traded off" against other components of the building envelope only per 5.6.1

Building Thermal Glazing Changes

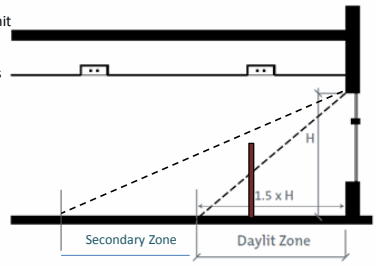
5.5.4 Skylight Area Limits

- Skylights remain at two niches: 0-2% and 2.1-5%
- Different U- and SHGC factors
- Table has3 classes for skylight glazing materials, curb heights
  - ✓ Exception: Skylights outside of scope NFRC 200, VT determined by ASTM E972

Sidelighting

3.2 Prescriptive Figures: Daylight Zones

- Equals head height
- 2x for secondary limit
- Side margins of 2'
- Opaque wall cutoffs
- Obstruction < 5 ft
- No allowances yet - technical strategies



DAYLIT ZONE—SIDELIGHTING

Increased Skylighting – *(prescriptive mandate)*

5.5.4.2.3(a) Minimum Skylight Areas; 15 Types

Assembly Uses:

- Gym/exercise center; convention and transportation centers

Business & Mercantile Uses:**

- Offices**; Retail stores** Automotive services**

Associated spaces

- Atrium; Concourse; Corridor; Lobby

Factory Uses:

- Manufacturing**; Workshop;

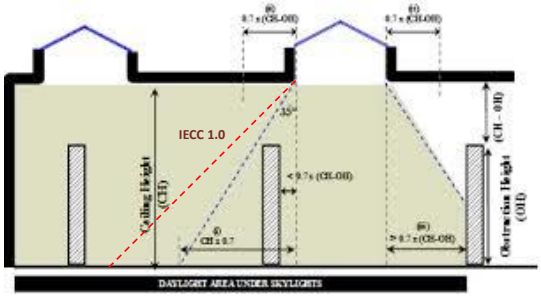
Storage Uses:**

- Warehouses (non-refrigerated); *Distribution/Sorting, Storage*

*** 90% haze factor; these uses***

Skylighting

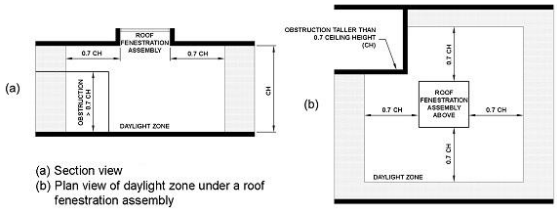
90.1 3.2 Illuminated Area more defined



Toplighting

5.5.4.2.2 Maximum Skylight Area

- 5% of gross roof area
- Building thermal envelope
- Maximum Floor Area calculated



(a) Section view
(b) Plan view of daylight zone under a roof fenestration assembly

ASHRAE Definitions: Effective Aperture

90.1 Section 3.2

Skylight illumination depends on:

- Skylight AREA
- Skylight VT
- Skylight WELL

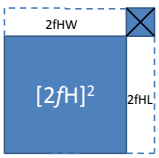
Understanding Effective Skylight Aperture

90.1 Section 5.5.4.2.3 Floor Area Ratio

Target: ≥ 50% F.A.

- Aperture ≥ 1% F.A.
- Aperture ≤ 10%
  - ✓ ***H* in the equation is the ceiling height distance - *f* is the fraction allowed by each code: 0.7, 0.9, 1.0**

Skylight Area – L & W

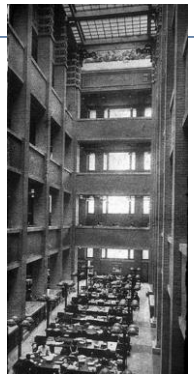


Total F.A. per skylight = 2fH2 + WL+2f(HL+HW)

Skylight SHGC

5.5.4.4.2 Exemption from Tables 5.5.x SHGC

- Diffuses/obscures ≥ 90% of light
- Has VT > 0.40
- General lighting in daylight zone below controlled with multilevel daylight-responsive controls
- Use of dynamic glazing



Skylight SHGC

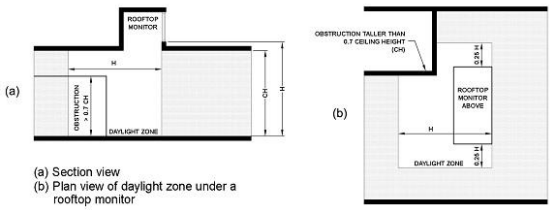
5.5.4.5 Exemptions Through Orientation

Any condition qualifies:

- Street-side façade per 5.5.4.4.1c
- Existing building within 20ft of south face ≥ height of proposed
- Permanently shaded on 75% of East & West fenestration areas between 9 to 3 at June solstice
- Alterations/additions with no added vertical fenestration area

Rooftop Monitor In 90.1

Basic Concepts: Luminaire Control

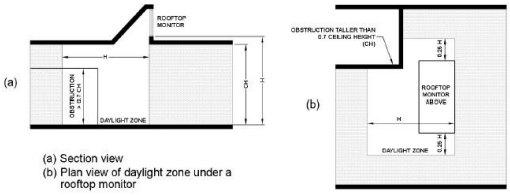


(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

Rooftop Monitors

IBC Issues – IECC & 90.1

- Wind, snow loadings
- Flashings

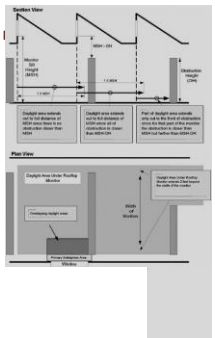


(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

Use of Rooftop Monitors

Table 9.5.1 Building Area Method

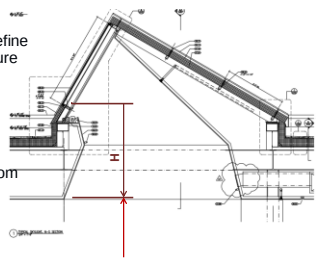
- **Daylighting starts vertically to the floor under the monitor lip**
- **Extends to a depth equal to the height of the glazing sill**
- **Partitions block lighting only when length from the vertical leading edge is greater than the height of the obstruction**
- **Overlapping side or top-lighted areas are not counted twice**



Tweaking Distribution – Performance Options

Height of Skylight Well Considered

- Using light paths to define a better lighting aperture and reduce glare
- Sill height thru well measured to the floor defines the FA length; skylights measured from ceiling to floor



Commissioning

9.4.4 Functional Testing

Devices and Control Systems

- Occupant sensors performance
- Programmable/T.O.D. controls can turn lights off
- Photosensors will reduce lighting levels based on usable daylight
- Safety/security exceptions
- **4.2.4** Inspections. Electrical equipment and systems; after installation; before concealment

Future Lighting Definitions

3.2 Definitions

- **Dynamic glazing properties**
- **Clerestory added to 'roof monitor**

Future Daylighting Definitions 2015

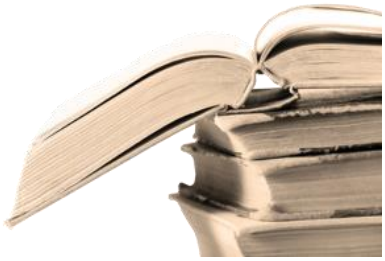
3.2 Definitions

- **Dynamic glazing properties**
- **Clerestory added to 'roof monitor**

Future Control Strategies 2015

Chapter 11 ('cf')

- Baseline Glazing Area ('cf')
- Changes based on Use Type



Targeting Daylighting - 2013

Integrating with General Lighting

90.1-2013, 9.4.1.3

- Revises skylight percentages
- Changes daylighting control by combining with general lighting where practical
- Adds more spaces to be top-lit
- Reduces E/W glazing allowed

Daylighting in future ASHRAE Codes

ASHRAE 90.1-2013

- **5.5.4.1** Vertical glazing and PF factors modified further through building orientation limits;
- **5.5.4.2.3** 6% skylight area allowed with all building and daylighting criteria met
- **5.5.4.5** Reduced glazing within 900 of true E/W ('bw')
- **9.6.2** Lighting and daylighting values/controls for more occupancy types
- Reduction in daylight-responsive control limits to 2.5k from 5.0k ('bv)
- Ch.11 Baseline glazing reductions based on use (cf')

DEEP Regulations 16a-38k

An OVERLAY - Not governed by the CT Codes Adoption

- Applies to State/State-funded construction
  - **> $5 million new**
  - **> $2 million addition**
- 21% less energy use
- Demonstrate whether building meets performance or tradeoff compliance
- If applicable, report is submitted with CDs.

AKF

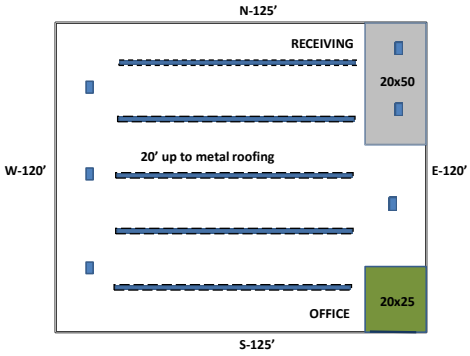
COM*Check* – *Compliance Option*

Version 4.0.2.8 UA Compliance Alternative

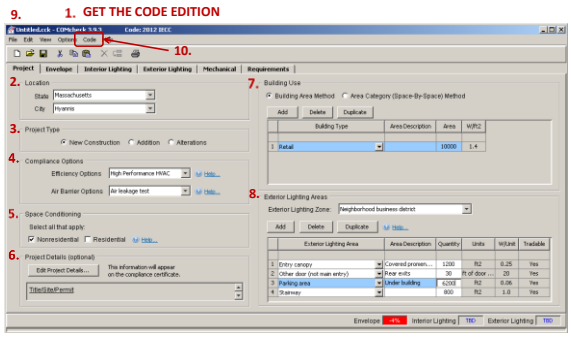
- Used to show compliance with either 2012 IECC or ASHRAE 90.1-2013
  - **Now updated to ICC 2015**
  - **Not updated to 90.1-2016**
- Completely electronic: user inputs all building data
- Will demonstrate whether building meets performance or tradeoff based compliance
- If used, report is submitted with construction documents.

www.energycodes.gov/comcheck

Case Study – 15ksf Warehouse



The Project Screen - Details



COMCheck

CODE: 2012 IECC ***(IECC 2015 available)***

- **PROJECT SCREEN TAB** (on left)
- Location
- Project Type:
  - ✓ **NEW? ADDITION? RENOVATION?**
- Compliance Options
  - ✓ **Air barrier Options**
  - ✓ **Efficiency Options**
- Interior Lighting Method TAB
- Project Details
  - ✓ **(get the information)**

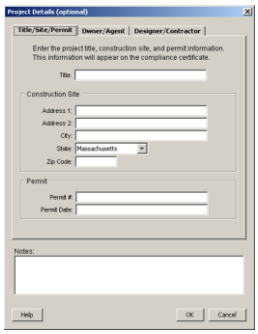
PROJECT FOLDERS (under on right)

- Building Envelope Area Type
  - ✓ **(dropdown for Categories)**
- HVAC Equipment
- Interior Lighting Method/Areas
  - ✓ **(dropdown for categories)**
- Exterior Lighting Areas
  - ✓ **(dropdown Zone categories)**
- Project Scoring (on bottom)

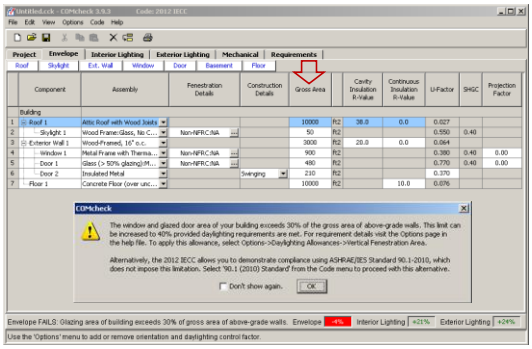
6. Get the Details

User to fill out:

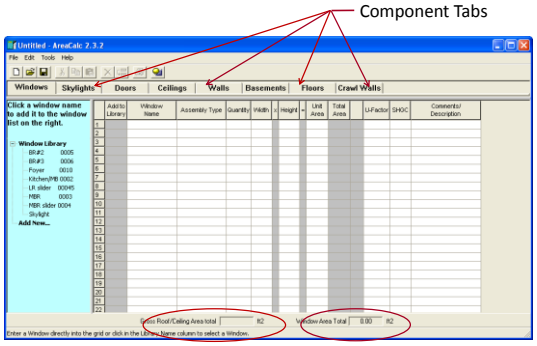
- Project title
- Address
- Owner/Agent
- Designer
- Contractor (if known)
- General description…



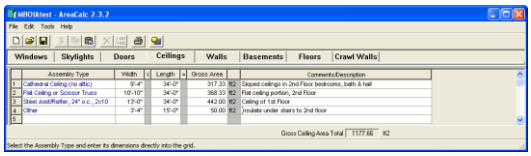
Envelope Compilation – OOPS!

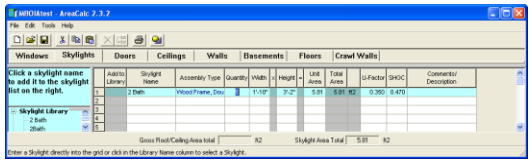


Tool Box: AREA CALC Take-Off

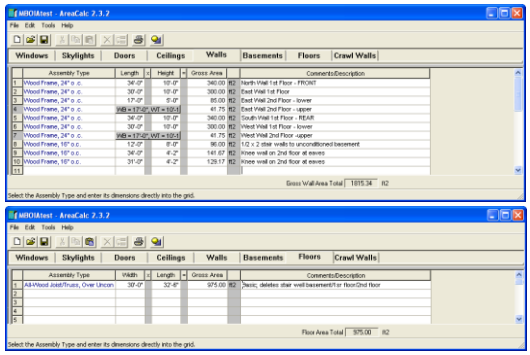


AREA CALC – CEILINGS & SKYLIGHTS

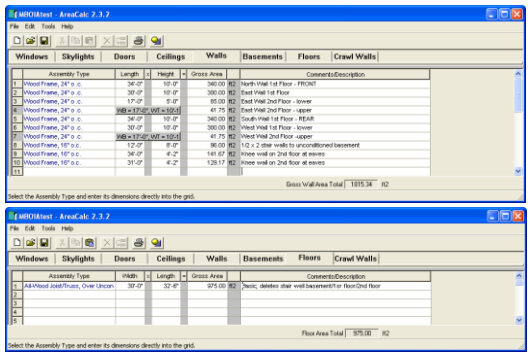




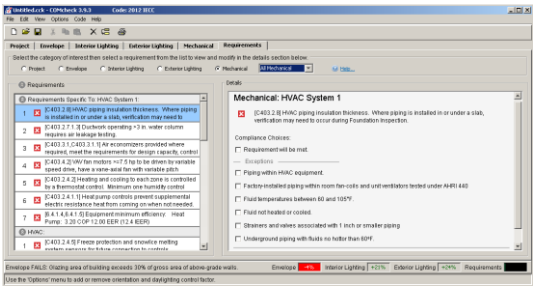
AREA CALC – WALLS AND FLOORS



AREA CALC – WALLS AND FLOORS



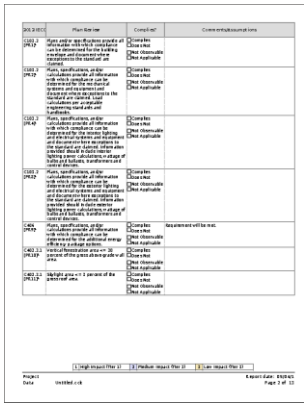
Requirements Reviews



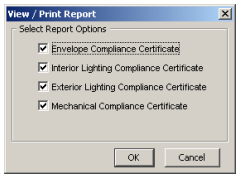
Final Report

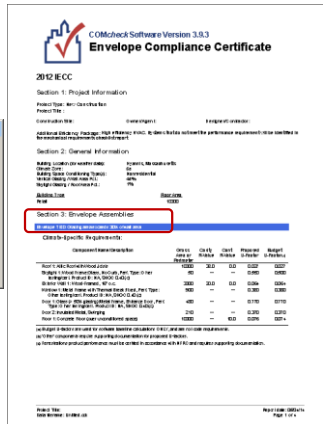
Checklists:

- Envelope
- Interior Lighting
- Exterior Lighting
- HVAC / SWH
- Add Options



(View) Certificates





COMCheck

CODE: 90.1-2010 (90.1-2013 available)

- **PROJECT SCREEN TAB** (on left)
- Location
- Project Type:
  - ✓ **NEW? ADDITION? RENOVATION?**
- Project Details
  - ✓ **(get the information)**

PROJECT FOLDERS (under on right)

- Building Envelope Area Type
  - ✓ **(dropdown for Categories)**
- HVAC Equipment
- Interior Lighting Method/Areas
  - ✓ **(dropdown for categories)**
- Exterior Lighting Areas
  - ✓ **(dropdown for Zone category)**
- Project Scoring: (on bottom)

COMCheck Data Entry

Code – Both ***(90.1-2013 / IECC 2015 available)***

■ **REQUIREMENTS** Project BUTTONS ✓ **Project** ✓ **Envelope** ✓ **Interior Lighting** ✓ **Exterior Lighting** ✓ **Mechanical** ■ **Requirements List Checkoffs** ✓ **Code requirement** ✓ **Plan review requirement** ■ Project Requirement Descriptions ■ Compliance Choices	**DETAILS** ■ Compliance Choices ■ Exceptions (if any) ■ **Plan Reference** ✓ **Page** ✓ **Section** ✓ **Table** ✓ **Figure**

Questions/Resources

Available Over Your Internet Connection

- http://www.ct.gov/dcs/cwp/view.asp?a=4447&q=521446&dcsNav=|
- www.iccsafe.org/erratacentral
- https://www.ashrae.org/standards/90_1_2010_2013Addenda.pdf
- http://www.energycodes.gov/sites/default/files/documents/901-2013www.energycodes.gov/resources
- www.bcap.org
- www.buildingscience.com
- www.akfgroup.com

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BCAP	Building Energy Codes	NREL
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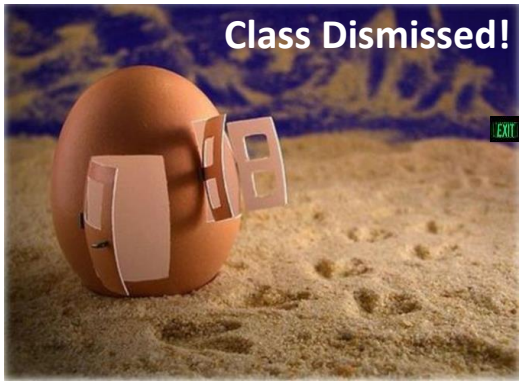
Class Dismissed!
EXIT