RDH

Technical Bulletin

No. 006

ASHRAE Standard 90.1

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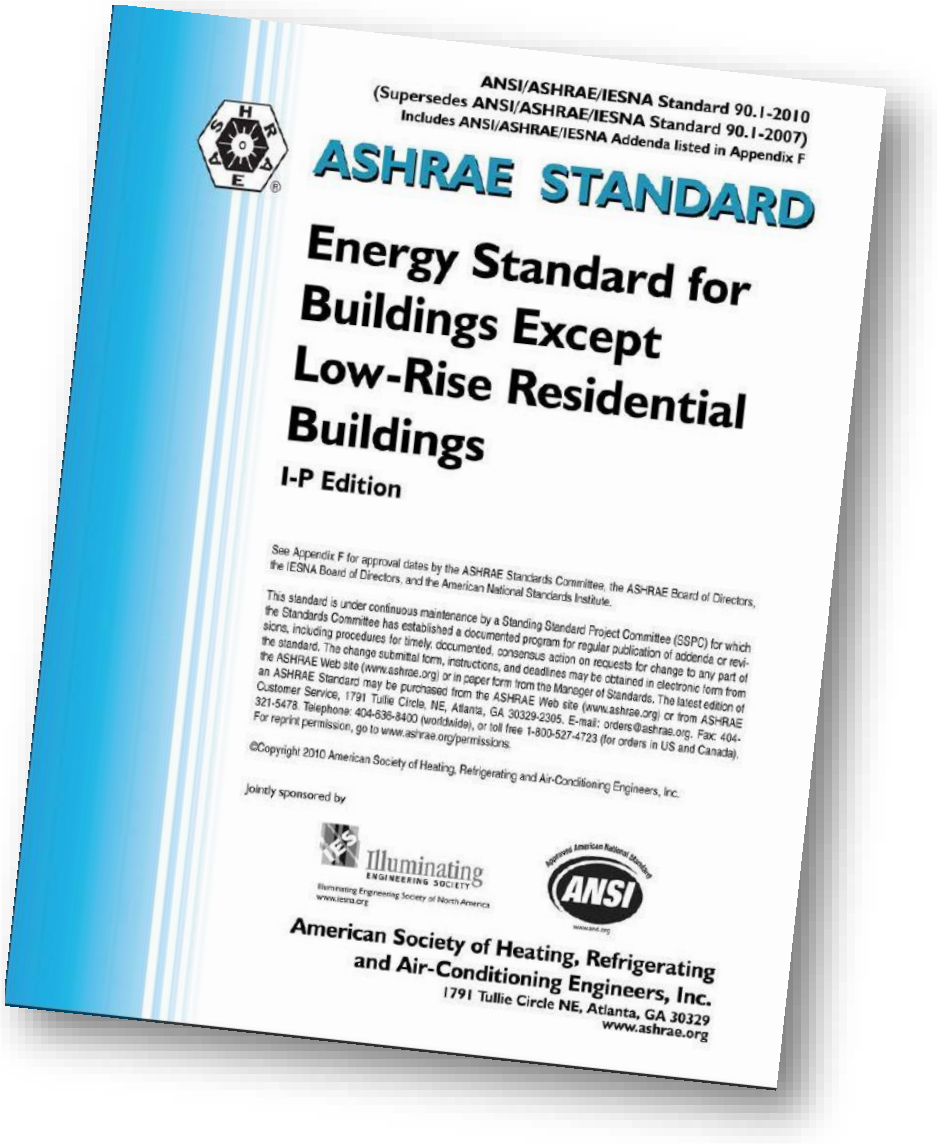


Introduction

Energy performance has become a mainstream design consideration, often being the primary driver for decisions regarding the building enclosure and most other systems of the building. Most jurisdictions establish minimum requirements for energy performance through reference to ASHRAE Standard 90.1, or similar standard. In this bulletin, we will examine the requirements of ASHRAE 90.1, how it impacts the building enclosure, as well as tips for effectively using this standard.

Background on ASHRAE Standard 90.1

ASHRAE 90.1 has been around since 1975, when the first oil shock got the industry thinking about reducing society's dependence on fossil fuels, particularly with respect to buildings. The standard is a voluntary guide, with the purpose, "to provide minimum requirements for the energy-efficient design of buildings except low-rise residential buildings." (A similar standard, 90.2, applies to low-rise residential buildings).

Since 1975, the standard has proceeded through 4 "generations" of updates (where major changes took place), and is currently updated every 3 years. The most recently-released version dates from 2010, though it is still under public review.

This bulletin references ASHRAE 90.1-2007, unless otherwise noted, because it is currently the most frequently adopted across jurisdictions.

With so many iterations, it is important to always include a year when quoting the standard, ex: ASHRAE 90.1-2007

ASHRAE 90.1 is comprised of 12 sections and 7 appendices, which are summarized on the following page. Those most applicable to the building enclosure are highlighted, with a brief description of why they are important. These sections form the focus of this bulletin.

ASHRAE 90.1-2007 Outline
Similar from 2001-2010

SECTIONS

1 Purpose

2 Scope

3 Definitions, …

4 Administration

5 **Building Envelope**

6 HVAC

7 Service Water Heating

8 Power

9 Lighting

10 Other Equipment

11 **Energy Cost Budget Method**

12 Normative References

Section 5

Describes mandatory provisions and performance compliance paths for enclosure (minimum performance requirements), as well as:

5.1 General
5.2 Definition of Compliance Paths
5.4 Mandatory Provisions
5.5 Prescriptive Path
5.6 Building Envelope Trade-off Path
5.7 Submittals

Section 11

Describes ECB method of whole-building energy modelling used if the building meets the standard's energy requirements

Provides U-, C- and F-Factors for pre-determined assemblies

APPENDICES

A **Assembly U-, C- and F-Factor Calculations**

B **Building Envelope Climate Criteria**

C **Building Envelope Trade-Off Method**

D Climatic Data

E Informative References

F Addenda Description Information

G **Performance Rating Method**

Appendices A, B, C

A: Provides U-, C- and F-Factors for pre-determined assemblies

B: Designates Climate Zone for various locations

C: Outlines equations behind Building Envelope Trade-off Method

Appendices E, F, G

E/F/G: Informative appendices only
(not official part of the standard)

G: Describes PRM method of whole-building energy modelling if the building will exceed the minimum energy requirements of standard

Additional Components

Standard 90.1 is supplemented with:

→ **User's Manual**: For detailed interpretation of the standard

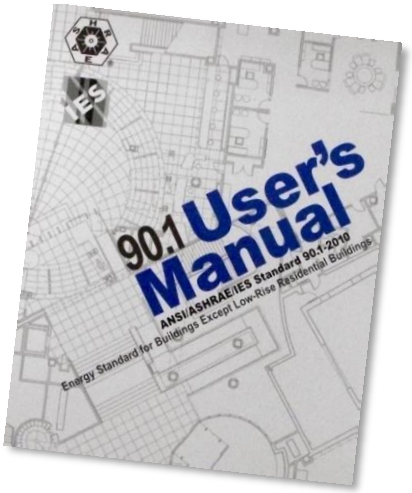


Figure 1: ASHRAE 90.1-2010 User's Manual

→ **ENVSTD Software**: For Building Envelope compliance path

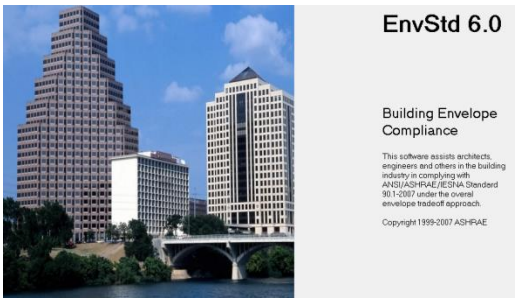


Figure 2: EnvStd 6.0 Software

→ **ASHRAE Compliance** Forms: For professional to complete & sign when complying with the following sections

Section 5- Building Envelope
Section 6- HVAC
Section 7- Service Water Heating
Section 9- Lighting
Section 11- Energy Cost Budget Model
Appendix G- Performance Rating Model

Where Does it Apply?

BC: ASHRAE 90.1-2004

In British Columbia, Part 10 of the BCBC (2006) mandates compliance with ASHRAE 90.1-2004, excluding only the following buildings:

"… parts of buildings of residential major occupancy in buildings of less than 5 storeys in building height …"

Note: There are still energy efficient requirements for these buildings, but the conditions are outlined explicitly in Part 10 rather than referenced to ASHRAE.

Vancouver: ASHRAE 90.1-2007

The City of Vancouver (CoV) Building By-law requires that buildings comply with the 2007 version of ASHRAE 90.1 (soon to be 2010). The CoV has additional checklists that must be completed along with the Building Permit and Occupancy submissions. These mandatory checklists and a tutorial on how to fill them out can be found: http://vancouver.ca/home-property-development/application-forms-and-checklists.aspx under ASHRAE 90.1

State of Washington: No specific reference to ASHRAE 90.1 but is based on the standard.

The Washington State Non Residential Energy Code (NREC) also provides compliance forms that must be completed for non-residential buildings and MURBs. There is one form that focuses on the building enclosure, and requires additional information to be submitted above the ASHRAE 90.1 minimum.

Various jurisdictions within the State of Washington reference this portion of the NREC.

Seattle: Embedded within Code

Comparison to ASHRAE 90.1 is not explicitly outlined in the 2009 Seattle Energy code, because it was designed so that compliance with the code is intended to achieve approximately 20% energy savings over ASHRAE 90.1-2007.

Oregon: Embedded within Code

The 2010 Oregon Energy Efficiency Specialty Code has its own compliance pat that is similar to (and somewhat based on) ASHRAE 90.1-2007. For more information on this (and related energy code requirements for residential buildings in Oregon, you can check out the RDH Codes & Compliance bulletin "Oregon Energy Efficiency Specialty Code- Requirements for the Building Enclosure: Understanding the Compliance Paths for MURBs".

LEED Canada & US: ASHRAE 90.1-2007

Although there are several versions of LEED released in both Canada and the US, the most recent and widely-used for both countries is LEED 2009 for New Construction. ASHRAE 90.1-2007 is referenced in both countries.

Retrofits

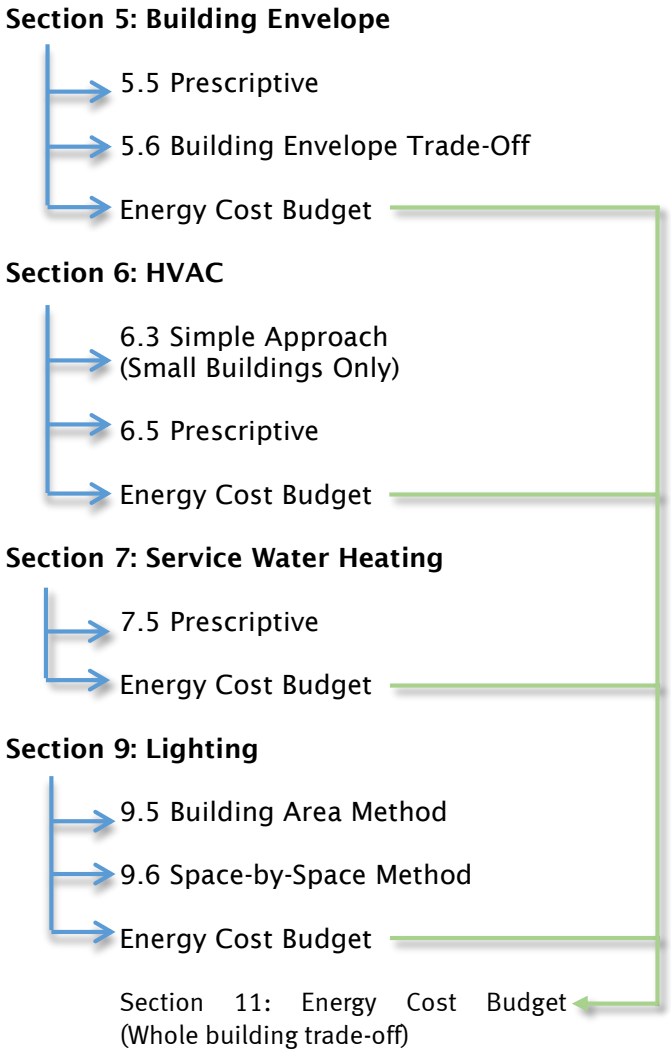
Any rehabilitation work will follow the compliance path of the code that would normally apply. That is, only when the code excludes retrofits would they also be excluded from complying with ASHRAE 90.1.

However, specific clauses within Section 4 of ASHRAE 90.1 clarify the scope of the standard, and can sometimes exclude or limit the applicability of the standard's requirements to retrofits.

The Process of Complying

The compliance path options between the main sections of ASHRAE 90.1, Sections 5, 6, 7 and 9, are similar and are outlined in the diagram below.

Note: The Performance Rating Method (PRM) described in Appendix G is not included below because it is used only when a building exceeds the standard, whereas the diagram shows methods of meeting the standard's minimum requirements.



Section 5: Building Envelope, What to Know

This section provides a summary of each section within the Building Envelope chapter, and outlines some of the more important parameters.

Because of the intricacies of the standard, the diagram below summarizes the main components of this section:

Section 5: Building Envelope

5.1 General

5.2 Compliance Paths

5.3 Not Used

5.4 Mandatory Provisions
- Air Leakage
- Vestibules

5.5 Prescriptive Compliance
- 40% max. Vertical Glazing Area
- 5% max. Skylight Area
- Tables 5.5-1 to 5.5-8
- Opaque Elements
  - Assembly max. U-factor
  - Insulation min. R-value
- Fenestration Elements
  - Assembly max. U-factor
  - Assembly max. SHGC

5.6 Building Envelope Trade-Off

5.7 Submittals

5.8 Product Information & Installation Requirements

Remember, this information is from ASHRAE 90.1-2007, so may be different in other versions.

5.1 General

Most of this section is for administrative and background information; however, important information pertaining to rehabilitation projects is contained in sentence 5.1.3, which outlines building envelope alterations that can be excluded from the standard.

5.2 Compliance Paths

This section contains a simple outline of the 3 available compliance paths: Prescriptive, Building Envelope Trade-Off and Energy Cost Budget.

5.3 Not Used

5.4 Mandatory Provisions

The requirements outlined in this section are mandatory for all buildings, regardless of the compliance path chosen. Important items include:

> Air Leakage → The standard specifies junctions that require sealing, and outlines that fenestration and doors must be certified in accordance with NFRC 400, and labeled and certified by the manufacturer.

Vestibules → All buildings are required to have vestibules at main entrances; there are some exceptions listed in the standard.

5.5 Preservation Compliance

This compliance path outlines strict requirements that must be met in order for the path to be followed; if any are not then an alternative path must be chosen.

The first requirement is that the building may not exceed a 40% window-to-wall ratio. In addition, skylights may not exceed 5% of the total roof area. This somewhat limits the type of building that can comply under this path.

Next, each opaque and fenestration element must meet minimum performance requirements. These are provided in Tables 5.5-1 to 5.5-8, which are divided based on three key categories, as outlined in the graphic on page **Error! Bookmark not defined.**:

1. **Climate Location** (using ASHRAE's Climate Zones 1-8)

   Detailed climatic information, including zones, is provided in Appendix D; however, the cities containing RDH offices are listed below:

   Portland → Climate Zone 4
   Seattle → Climate Zone 5
   Vancouver → Climate Zone 5
   Victoria → Climate Zone 5

2. **Space Conditioning Categories** (Non-residential, Residential, and semi-heated)

   While the first two are self-explanatory, "semi-heated" spaces are defined based on the intensity of heating provided in the space (more than 3.4 Btu/h.ft^2 and less than "heated" space requirements).

3. **Construction Class** (opaque vs. fenestration)

   Opaque Elements

   Opaque elements can achieve compliance in one of two ways:

   a) Assembly maximum U-factor, F-factor or C-factor

Value	Description	Unit
U-	▪ Thermal transmittance ▪ Inverse of R-value ▪ Applies to walls & roofs	$\frac{Btu}{h.ft^2.F}$
R-	▪ Thermal transmittance ▪ Inverse of U-factor ▪ Applies to walls & roofs	$\frac{h.ft^2.F}{Btu}$
F-	▪ Perimeter heat loss ▪ Applies to slab-on-grade floors	$\frac{Btu}{h.ft.F}$
C-	▪ Thermal transmittance ▪ Like U-value but excludes soil & air films ▪ Applies to below-grade walls	$\frac{Btu}{h.ft^2.F}$

This method of compliance requires that the entire assembly U-value be calculated, including thermal bridging. Appendix A contains tables listing values for some pre-determined, typical assemblies. If an assembly is not listed in the tables, then it must be either modelled in accordance with Appendix A9.2, or tested in accordance with Appendix A9.3. Section A9.2 also outlines which option (modelling or testing) is permitted for the each building element type. Section A9.4 provides additional calculation background information, such as: R-values of individual components, and the standard air film assumptions to be used.

b) Insulation minimum R-value

This compliance method applies to the insulation only (both cavity and continuous). The intent, according to ASHRAE, was to provide a simpler method for projects that did not have the capacity to calculate or test each assembly

ASHRAE's definition of continuous insulation is "continuous across all structural members without thermal bridges other than fasteners and service openings."

Climate Location — TABLE 5.5-5 Building Envelope Requirements For Climate Zone 5 (A, B, C)*

Space Conditioning Category

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum (Max U-factor)	Insulation Min. R-Value (Min R-value)	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.119	R-7.6 c.i.
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097	R-10.0
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053	R-19.0
Walls, Above-Grade						
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[a]	R-5.7 c.i.[a]
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.123	R-11.0
Steel-Framed	U-0.064	R-13.0 + R-7.5 c..	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124	R-13.0
Wood-Framed and Other	U-0.064	R-13.0 + R-3.8 c..	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089	R-13.0
Walls, Below-Grade						
Below-Grade Wall	C-0.119	R-7.5 c.i.	C-0.119	R-7.5 c.i.	C-1.140	NR
Floors						
Mass	U-0.074	R-10.4 c.i.	U-0.064	R-12.5 c.i.	U-0.137	R-4.2 c.i.
Steel-Joist	U-0.038	R-30.0	U-0.038	R-30.0	U-0.052	R-19.0
Wood-Framed and Other	U-0.033	R-30.0	U-0.033	R-30.0	U-0.051	R-19.0
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.540	R-10 for 24 in.	F-0.730	NR
Heated	F-0.860	R-15 for 24 in.	F-0.860	R-15 for 24 in.	F-1.020	R-7.5 for 12 in.

Figure 3: Extract from Table 5.5-5, Climate Zone 5 Prescriptive Requirements for Opaque element

The Assembly maximum U-factor and Insulation min. R-value methods may both be used on the same project, for calculating compliance of different building elements.

An important consideration arises when using the min. R-value method to verify compliance of sloped insulation. The minimum value quoted by ASHRAE must be the lowest point of any sloped insulation, that is, the average insulation thickness may not be used to achieve the minimum requirement.

Fenestration Elements

Fenestration elements must meet two performance requirements:

a) Assembly max. U-factor

Similar to opaque elements, the U-factors of fenestration assemblies can be calculated using the tables provided in Appendix A, or modelling software.

The calculations must be in accordance with NFRC 100.

b) Assembly max. Solar Heat Gain Coefficient (SHGC)

An additional requirement for fenestration is that it does not exceed maximum SHGC factors, which are determined based on climate zone, in order to control cooling load. Since Climate Zones 4 & 5 (containing RDH offices) are both heating-dominant, the SHGC factors are less stringent.

Some glazing manufacturers quote Shading Coefficient (SC) values rather than Solar Heat Gain Coefficient (SHGC). ASHRAE uses the following conversion (if SC is determined in accordance with NFRC 300):

SHGC = SC x 0.87

5.6 Building Envelope Trade-Off

The second compliance path is fairly simple in concept; all mandatory requirements still apply, and the prescriptive minimum requirements (in Tables 5.5-1 to 5.5-8) are still the targets for each building element. The difference is that if one element fails to meet a prescriptive requirement, then another can over-perform to compensate for the loss. A common example is the prescriptive 40% maximum glazing; if this is exceeded, then higher-performance building enclosure elements must be considered.

ASHRAE uses the concept of a "proposed" building (representing the actual building being designed), compared to a "budget" building (using the same geometry as the proposed building, but all prescriptive performance criteria) to determine compliance. The designers must prove that the proposed building design will perform as well as or better than the budget building.

All other systems within the building (HVAC, service water heating, lighting, etc.) and building schedules (occupancy, equipment, lighting, etc.) remain constant between the proposed and budget buildings.

As previously noted, free software called ENVSTD is available to allow for simple comparisons between the proposed and budget buildings. Parameters for the pre-determined constructions from Appendix A are built into the software, however, project-specific constructions values that have been calculated or modelled can also be input.

The software will provide results indicating the magnitude of pass/failure of the proposed building with respect to the budget building, an example of which is shown below. Although some detail is given on the contribution of component types (roof, windows, walls, etc.) there is not enough information to determine the contribution of each particular

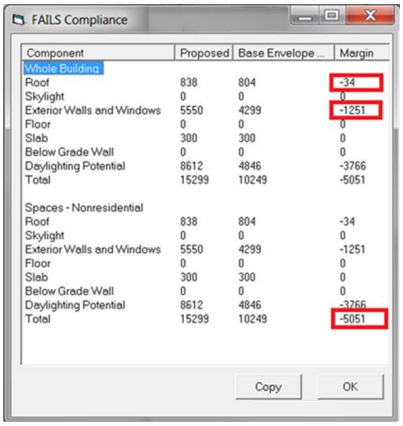


Figure 3: Sample ENVSTD output for a non-compliant building

(Total is negative)

detail. For example, in the figure below the walls and windows are the greatest cause of poor performance; however, which wall or window details have poor performance is not outlined. Therefore, it is recommended that an internal spreadsheet be used to supplement these calculations.

5.7 Submittals

This section outlines basic documentation that must be provided with ASHRAE 90.1 submittals if requested by the building official.

5.8 Product Information & Installation Requirements

Basic requirements outlined in this section include: product labelling, installation in accordance with manufacturer requirements, insulation protection and installation, fenestration and door rating, and more.

ASHRAE 90.1 and Energy Modelling

These days, energy modelling is frequently required for buildings, particularly on new construction projects, and ASHRAE 90.1 is commonly used as a standard of describing how the model should be set up. This ensures consistency between projects, and is important for external bodies, such as jurisdictions or building rating systems.

Similar to the Building Envelope Trade-off, ASHRAE uses the concept of a proposed building (representing the actual building being designed), compared to a budget building (using the same geometry as the proposed building, but all prescriptive performance criteria) to determine compliance.

However, the results are based on the difference in cost between the two models, rather than the difference in energy consumption. Factors unrelated to the energy efficiency of a building's design can therefore have a significant impact on how it will compare to the baseline building described by ASHRAE.

Energy Cost Budget (ECB) and Performance Rating Method (PRM)

Since the 2004 version, ASHRAE 90.1 has included descriptions for two methods of energy modelling:

Energy Cost Budget (ECB) method: For buildings that meet the standard

Performance Rating Method (PRM): For buildings that exceed the standard

The ECB proposed and budget models are described in Table 11.3.1. The PRM proposed and baseline models are described in Table G3.1.

ECB	Proposed	Model shall represent architectural drawings (or existing building components) with a few exceptions, including: → Assemblies < 5% of the total area of that assembly type (ex. external walls) may be lumped with adjacent areas, but their impact on the thermal performance of that assembly cannot be ignored. → Exterior surfaces with azimuth, orientation and tilt within 45 of one another may be represented as a single assembly → Roof reflectance must be modelled per ASHRAE description → Manually shading devices may not be included
	Budget	Geometry shall be the same as Proposed building, and building enclosure assemblies shall meet prescriptive minimum requirements, except: → Glazing percentage shall be limited per ASHRAE prescriptive standard (percentage calculated over whole building and distributed in same proportion as Proposed building) → Roof reflectance must be modelled per ASHRAE description
PRM	Proposed	Same as ECB Proposed except: → Uninsulated assemblies (ex. balconies) must be either separately modelled or have their U-value calculated and incorporated into the main energy model
	Baseline	Same as ECB Budget except: → Once the baseline building is created it must be rotated through the cardinal axes (0/90/180/270°). This rewards or penalizes the proposed design for considering the passive energy implications of the building's orientation. → Skylight percentages are limited to the ASHRAE prescriptive standard (same as glazing)

The Future

Building enclosure related changes to watch for in upcoming versions of the ASHRAE 90.1 standard include:

1. A requirement for minimum air-tightness
2. Requiring a higher percentage of glazing to be located on the south façade
3. More stringent insulation requirements for building enclosure assemblies
4. Eliminated "cool roof credit" for climate zones 1, 2 and 3 (in previous versions, buildings in these zones could decrease roof R-values if they had high reflectance and emissivity properties)

If you have any comments on the above items (or others currently under consideration), there are always addenda out for public review. Check them out at www.ashrae.org under "Public Review Drafts".

For additional information on this and other topics, please visit our website, rdh.com, or contact us at contact@rdh.com.

Additional Resources

- Access ASHRAE public review drafts here: https://www.ashrae.org/standards-research--technology/public-review-drafts