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Oregon Energy Code Moves from 2014 OEESC to ASHRAE Standard 90.1-2016

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PNNL-SA-147959

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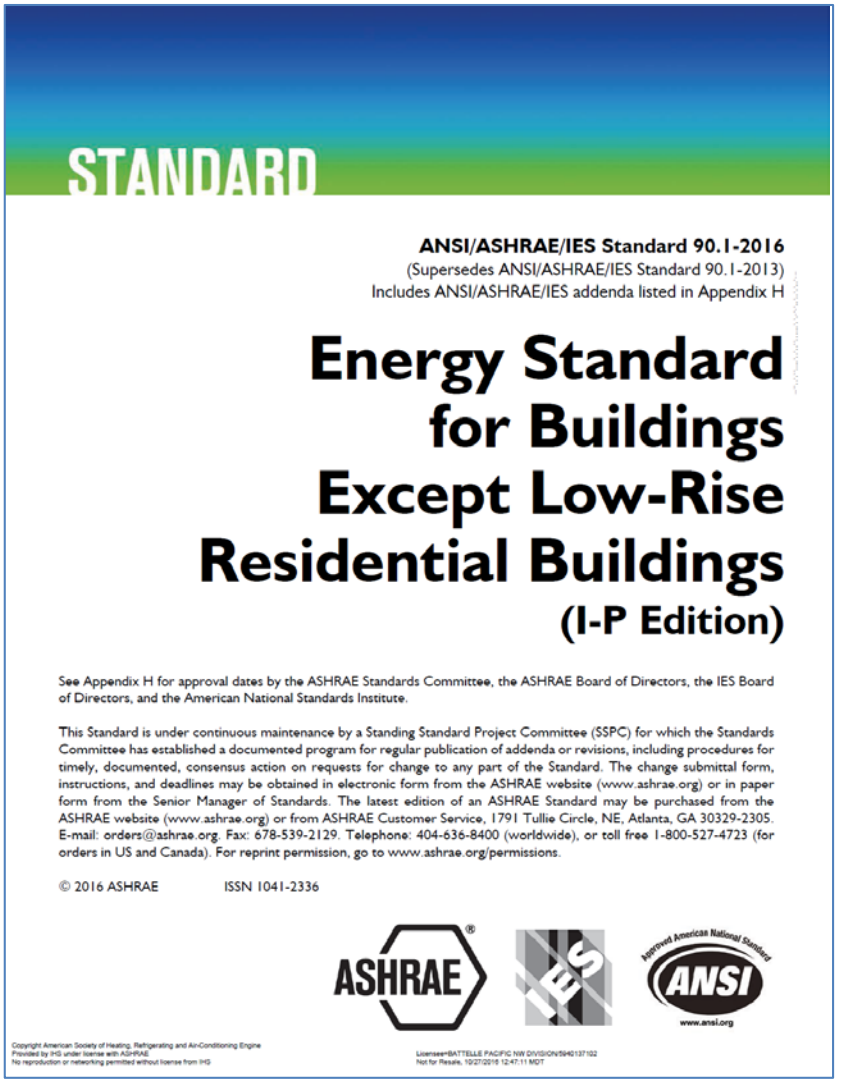
October 2019

Outline

- Oregon Energy Code Background
- Difference from 2014 OEESC to 90.1-2016
  - ASHRAE Climate Zones Change
  - High level overview
    - Commissioning
    - Envelope
    - Lighting
    - Power
  - Mechanical
  - A new performance path
- 90.1-2019 Sneak Peek

Energy Code Background

- Energy Savings Impact of Standard 90.1-2016
- Oregon Energy Code History
- ASHRAE 90.1 process



ASHRAE 90.1 Historic Savings

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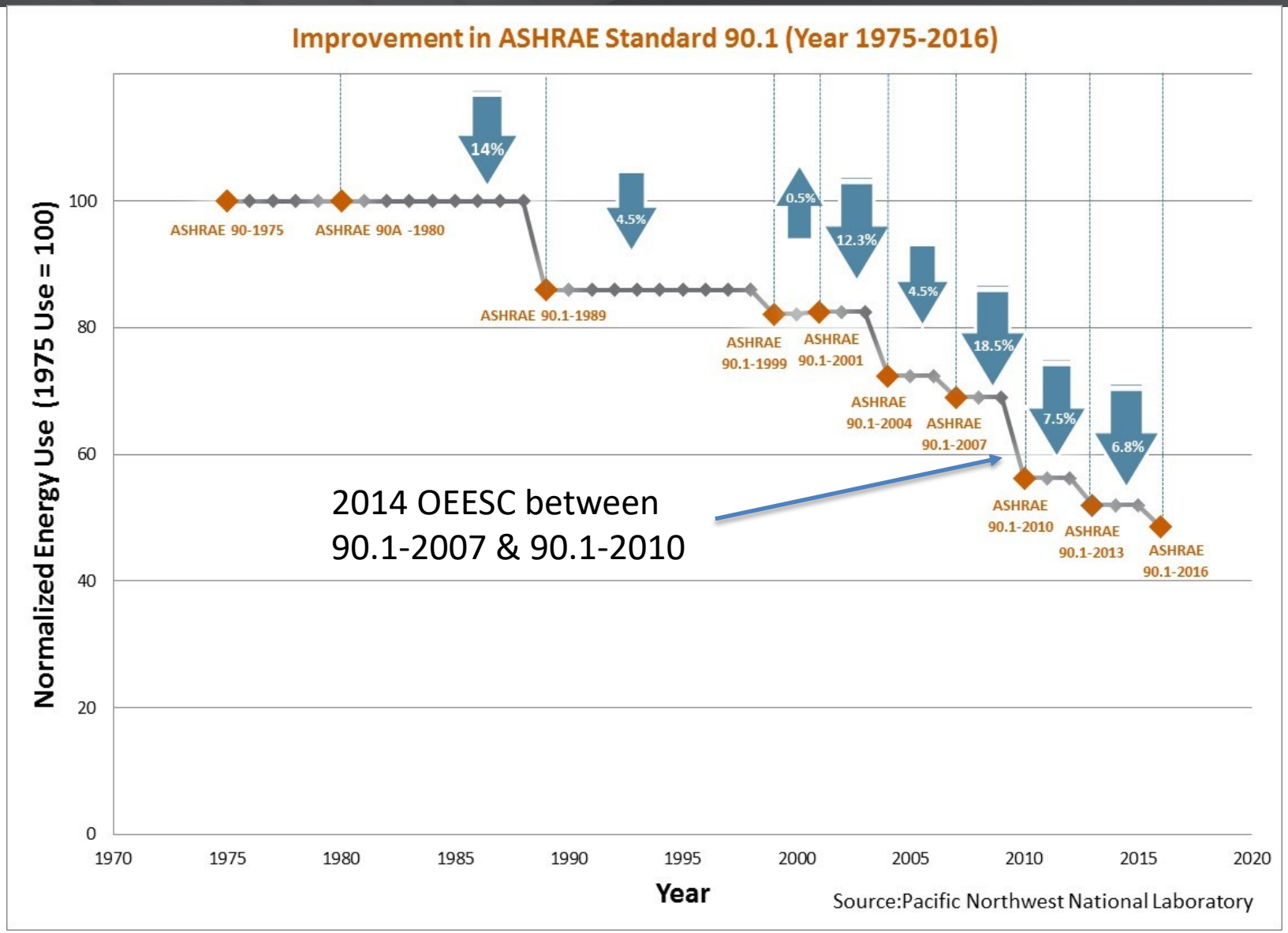

Oregon Energy Code History

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1974
- Oregon had first statewide energy code adopted in the nation

~1992
- Custom Energy Code generally updated from 90.1
- Highly progressive with multiple changes that later went to 90.1

~2008
- Oregon Energy Code converted to IECC Format
- Many amendments to maintain efficiency

2014
- 2014 Oregon Energy Efficiency Specialty Code (OEESC) based on 2009 IECC
- Several amendments from 90.1-2013 & 2012 IECC

2019
- Switch to 90.1-2016 October 1, 2019; Grace period thru Jan 1, 2020
- Minor administrative amendments

2020
- Plans to adopt 90.1-2019 in October 2020
- Minor administrative amendments

Where does Oregon Stack Up?

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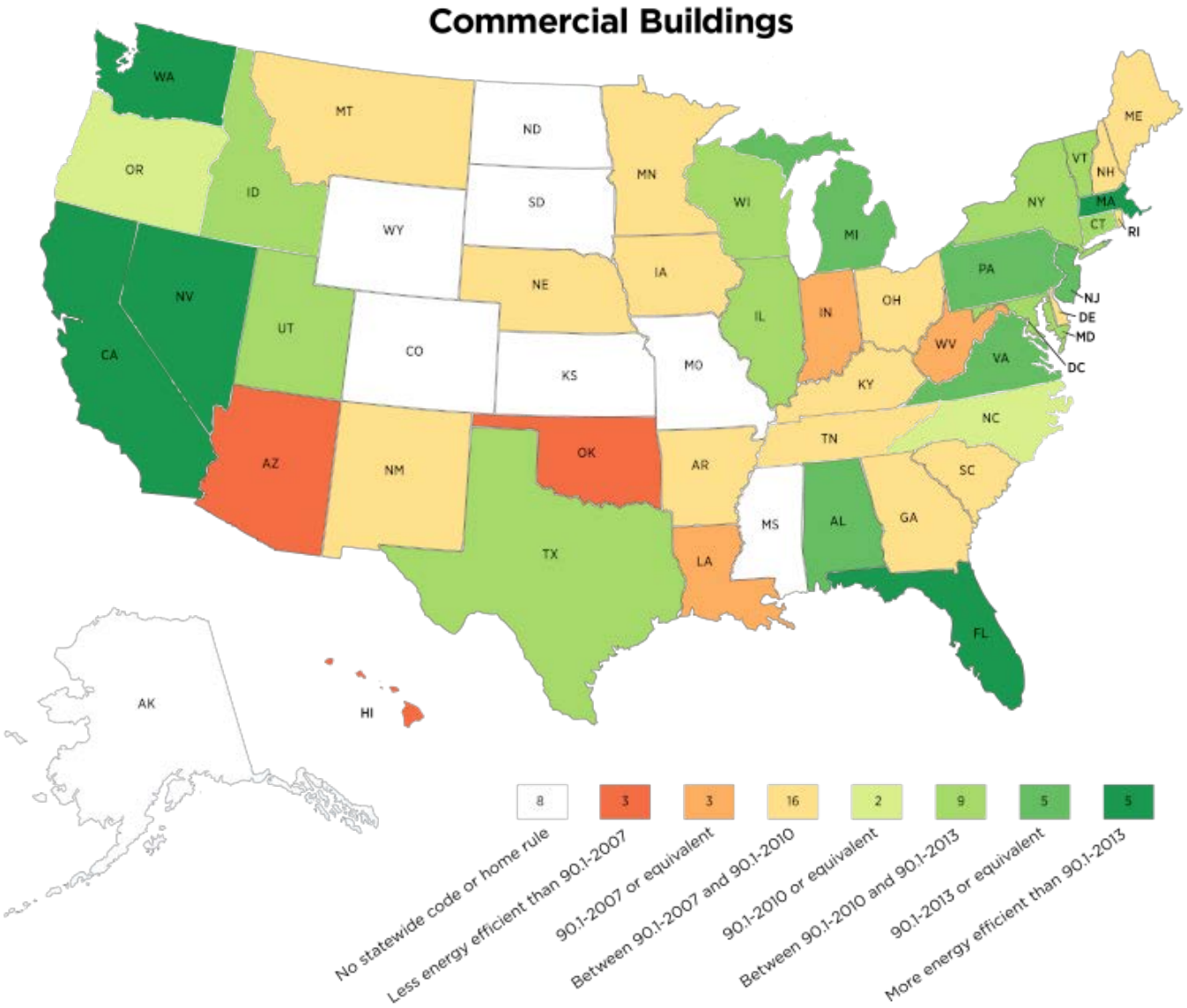

BCD Energy Codes Online

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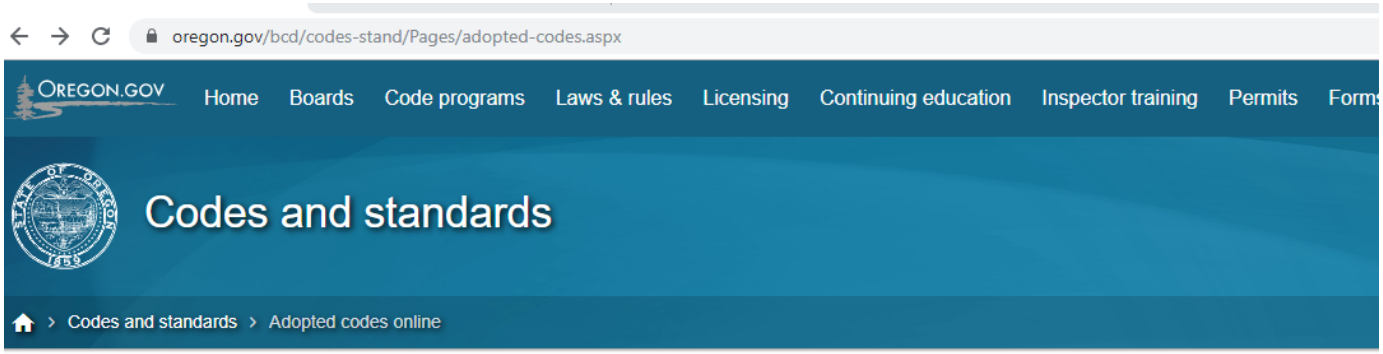
- https://www.oregon.gov/bcd/codes-stand/Pages/adopted-codes.aspx



Adopted codes online

2019 Oregon Zero Energy Ready Commercial Code

Effective Oct. 1, 2019

Construction provisions:

Commercial: ASHRAE Standard 90.1.

Multi-family: 2018 International Energy Conservation code

2014 Oregon Energy Efficiency Specialty Code

Effective July 1, 2014 - Dec. 31, 2019

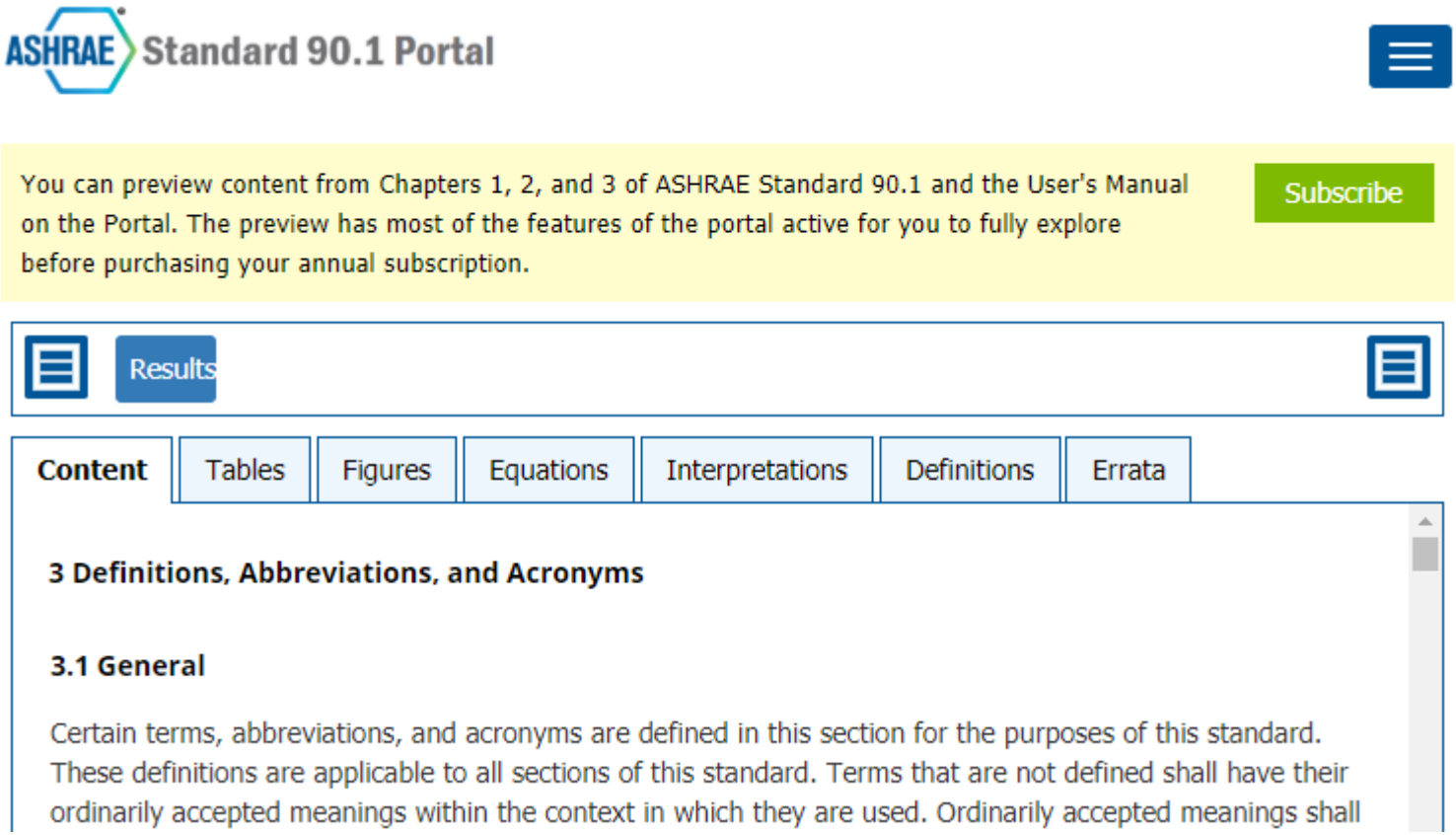
Based on the 2009 International Energy Conservation Code

90.1 Portal

New ASHRAE 90.1 online portal (annual subscription)

https://www.ashrae.org/technical-resources/90-1-portal

Includes user's manual, interpretations, redline & notes



ASHRAE 90.1 Adoption Process

- Oregon intends to continue with 90.1, with only minor amendments
- SSPC 90.1 manages 90.1 through an ANSI consensus process
  - Continuous maintenance – new edition every three years
  - All proposed addenda go out for public review
    - If suggest changes, include strikeout/underline different proposal

https://www.ashrae.org/technical-resources/standards-and-guidelines/public-review-drafts

  - Interpretations can be requested from the committee
    - Formal on the form with a clear yes/no question – becomes part of the standard; may take several months to a year
    - Informal for guidance - faster (also can use BECP web site)

      BECP: https://www.energycodes.gov/HelpDesk
  - Suggested changes can be made
    - Submit a 90.1 ASHRAE “Continuous Maintenance Proposal” (CMP)
    - Work with the subcommittee to integrate into the standard
    - Generally require cost effectiveness justification if cost increases

https://www.ashrae.org/technical-resources/standards-and-guidelines/pcs-toolkit/standards-forms-procedures

Summary of 90.1 Changes

ASHRAE 90.1-2010 to 90.1-2013

- Total of 110 addenda

ASHRAE 90.1-2013 to 90.1-2016

- Total of 121 addenda
- New climate maps aligning with ASHRAE Standard 169
- New performance-based compliance path

Significant whole building energy savings (~14%)

Generally showing where 90.1 requirements are stricter than 2014 OEESC

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MOVING TO 90.1-2016

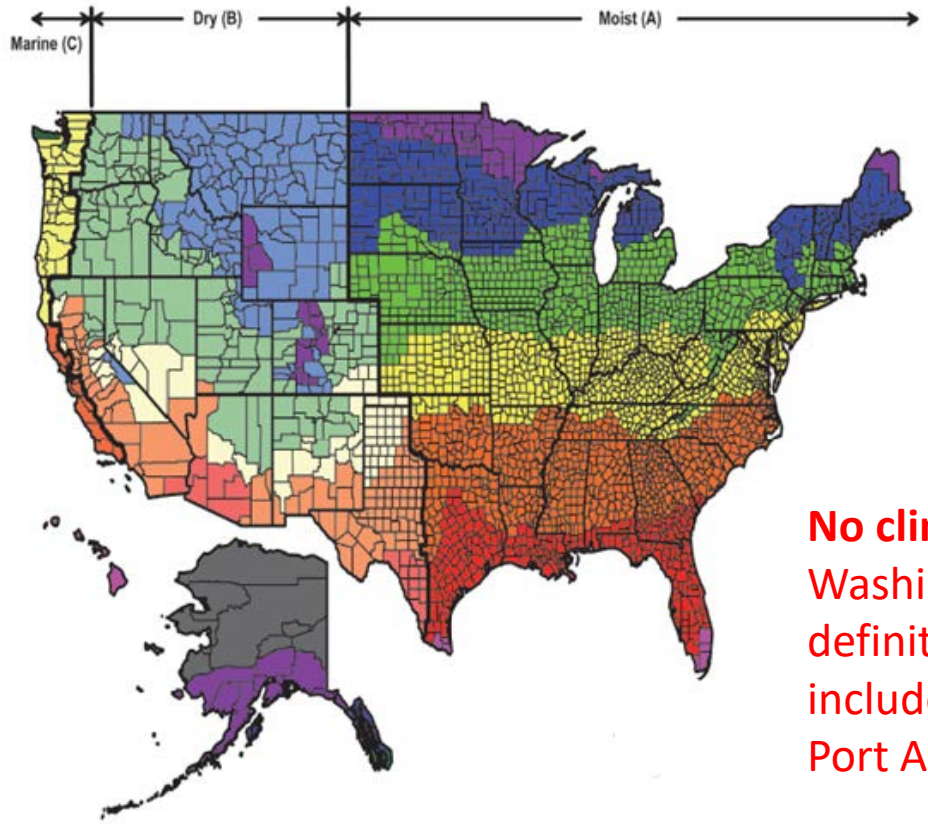
Generally, showing differences from
2014 Oregon Energy Efficiency Specialty Code

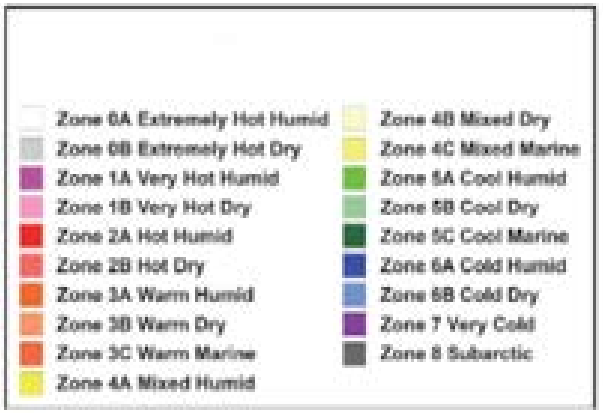
High level overview

- Climate Zones
- Verification, Testing and Commissioning
- Envelope
- Lighting
- Power

New Climate Zone Map

- Aligns with new ASHRAE Standard 169
- Reflects global warming trends over the most recent 30 years
- Adds new Climate Zone 0 (extremely hot)
- Approximately 10% of US counties reassigned to a warmer climate zone





No climate zone changes for Oregon
Washington uses their own climate zone definitions; similar to 4C/5B. They do not include ASHRAE move of 5C to include Port Angeles area.

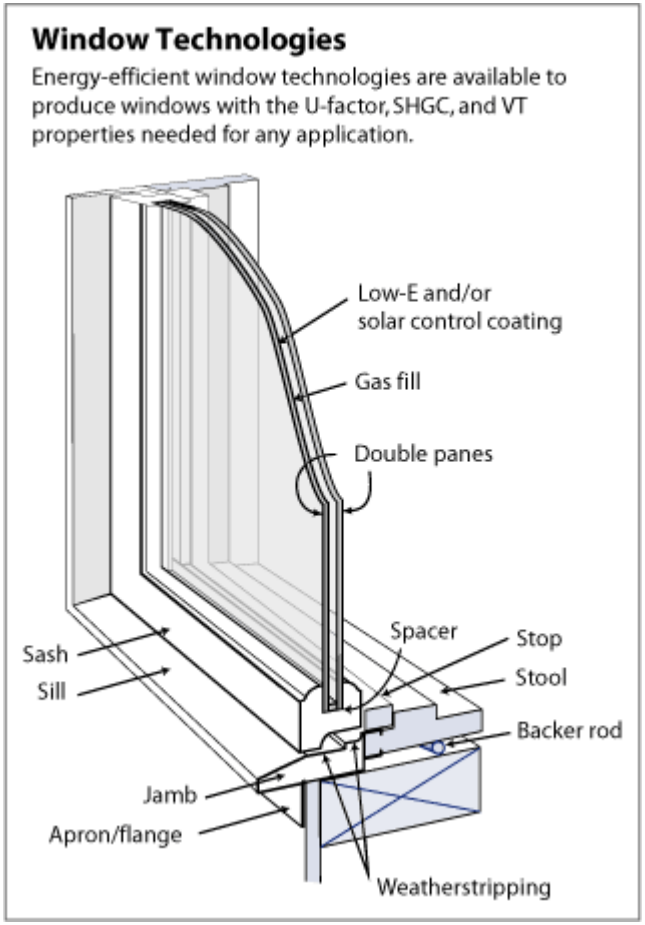
Verification, Testing, Commissioning

- Controls “Capable of” changed to add “configured to” throughout
  - Control functions and setpoints required at time of inspection
- Mechanical & lighting commissioning required in 90.1-2016
  - 90.1: General mechanical testing and verification
  - 90.1: Envelope verification
  - 90.1: Lighting control functional testing
  - **No** testing or commissioning requirements in 2014 OEESC
- 90.1-2019: Significant commissioning clarification

Envelope

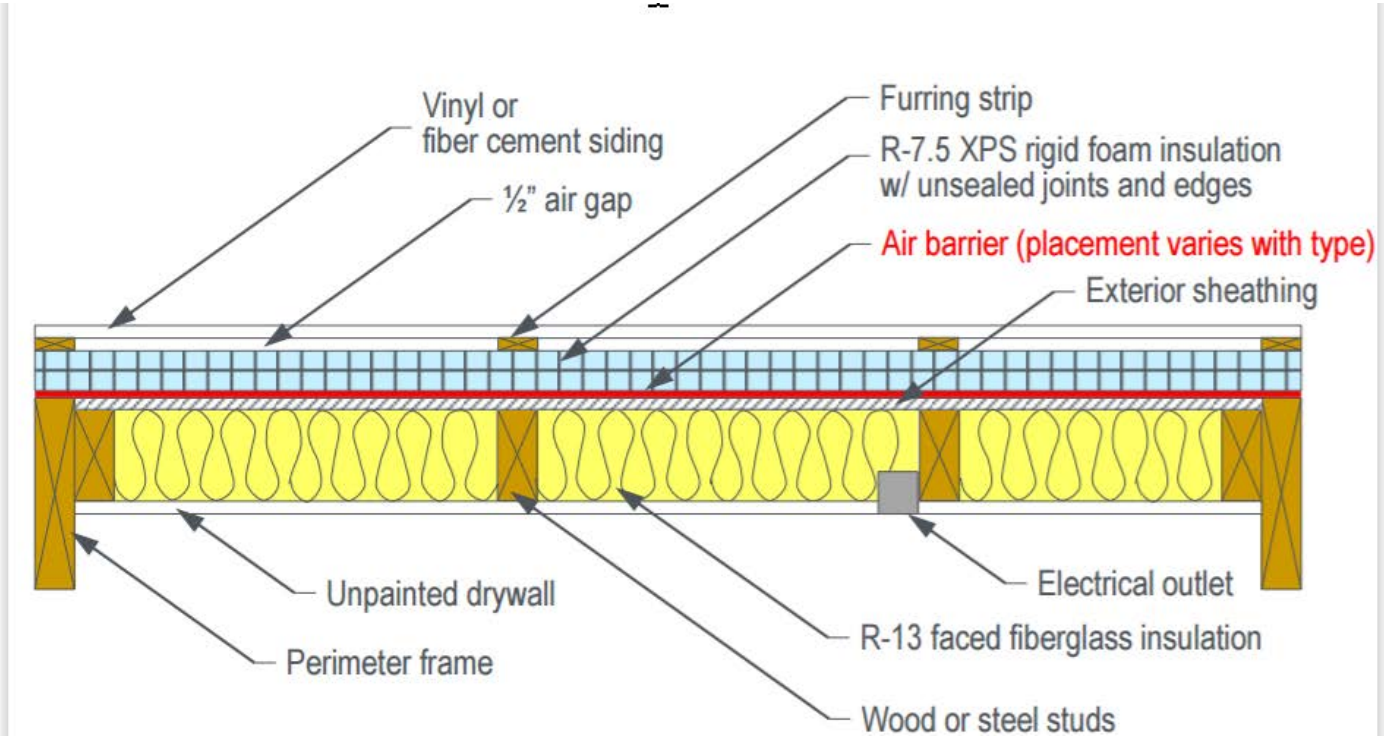
- Fenestration
  - 90.1-2016 includes a comprehensive update to the fenestration prescriptive requirements
    - U-factor reduced by as much as 22% in some climate zones
    - SHGC reduced by as much as 12%

Example	OR2014	90.1-2016	Reduction
Frame Wall	U-0.064	U-0.064	0.0%
Roof Deck	U-0.048	U-0.032	33.3%
Fixed Metal Windows	U-0.45	U-0.38	15.6%
SHGC	0.40	0.36	10.0%



Envelope

- Building Air Leakage
  - Air barrier design and installation verification required in 90.1
  - Whole building air leakage testing added as a compliance option in both codes



Lighting

Reduced Lighting Power Allowance

- Primarily based on improved efficacy of LED lighting
- Exterior lighting power reduced 40% (Zone 3)
- Retail display lighting reduced ~25%
- Interior LPD (Building):
- Space-by-space generally reduced more

Example LPD	OR2014	90.1-2016	Reduction
Office Building	0.91	0.79	13.2%
Retail Building	1.32	1.06	19.7%

Lighting Controls

Interior Lighting Controls

- New table format that includes LPDs
  - Occupancy sensor and bi-level control; Manual on vs. Auto on
  - Additional occupancy based control in some spaces plus max time reduced to 20 min from 30
  - New “partial off” control required in some spaces

TABLE 9.6.1 Lighting Power Density Allowances Using the Space-by-Space Method and Minimum Control Requirements Using Either Method

			Local Control (See Section 9.4.1.1[a])	Restricted to Manual ON (See Section 9.4.1.1[b])	Restricted to Partial Automatic ON (See Section 9.4.1.1[c])	Bilevel Lighting Control (See Section 9.4.1.1[d])	Automatic Daylight Responsive Controls for Sidelighting (See Section 9.4.1.1[e]6)	Automatic Daylight Responsive Controls for Toplighting (See Section 9.4.1.1[f]6)	Automatic Partial OFF (See Section 9.4.1.1[g] [Full Off complies])	Automatic Full OFF (See Section 9.4.1.1[h])	Scheduled Shutoff (See Section 9.4.1.1[i])
Common Space Types[1]	LPD W/ft^2	RCR Threshold	a	b	c	d	e	f	g	h	i
Conference / Meeting / Multipurpose Room	1.23	6	REQ	ADD1	ADD1	REQ	REQ	REQ	---	REQ	---
Confinement Cells	0.81	6	REQ	ADD1	ADD1	REQ	REQ	REQ	---	ADD2	ADD2
Copy/Print Room	0.72	6	REQ	ADD1	ADD1	REQ	REQ	REQ	---	REQ	---
…….	---	---	---	---	---	---	---	---	---	---	---

Lighting: Revised Daylight Controls

- Basis for daylighting controls changed from daylighted area to controlled lighting power
- Lower threshold for requiring daylighting controls – 150 W in primary sidelighted zone
- Controls required in secondary daylighted zone
- Primary and secondary daylighted areas controlled independently
- Controls required to turn lights all the way off
- Daylight sensing control even in occupancy sensor areas

Lighting: Exterior/Parking Controls

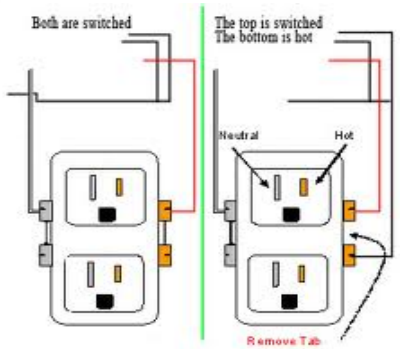
- Exterior lighting requirements to reduce power by 50% during unoccupied periods or after business hours
  - Increased reduction from 33% for exterior parking
  - Parking garage lighting control new vs. 2014 OR

Receptacle automatic shutoff control

- 50% of receptacles (wall plugs) in certain spaces
  - Private offices, conference rooms, print/copy, breakroom, classroom individual workstations
  - Requires automatic control (ex: occupancy sensor or time-of-day schedule)
  - Controlled receptacles must be marked and uniformly distributed
  - **Plug-in type devices do not comply**

Electricity Metering

- New construction only
  - Com. Buildings ≥ 25,000 ft^2
  - Tenant Spaces ≥ 10,000 ft^2
- Separate measurement for:
  - Total electrical energy
  - Interior & Exterior lighting
  - HVAC systems; Receptacle circuits
- Recording and data availability requirements



Not in current OR code

Mechanical Changes

Mechanical – Equipment Efficiency

- Increased HVAC Equipment Efficiency Requirements

Chillers

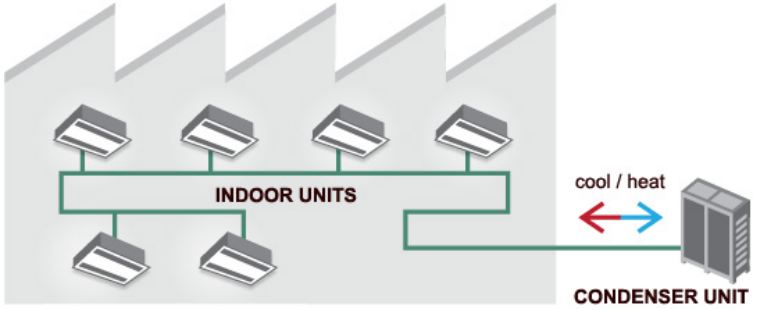
Heat Pumps

Computer Room AC

Dedicated Outdoor Air*

Rooftop AC Units

Cooling Towers



Variable Refrigerant Flow

* Newly regulated equipment

Generally follow Federal manufacturing requirements
Oregon mostly updated to 90.1-2013

Mechanical - Replacements

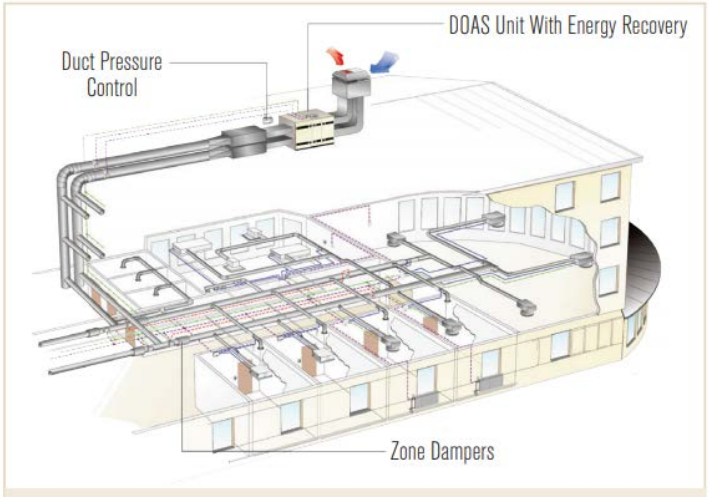
- Replacement equipment now needs to meet many of the requirements formerly for new equipment only. For example:
  - Various controls requirements
  - Economizer requirements
  - Fan efficiency
  - Boiler turndown

Mechanical – Controls

- Hotel/Motel Guest Room Controls
  - Heating, cooling, & ventilation automatically reduced when unoccupied;
  - Reduced further when unrented (or extended vacancy)
- Optimum start requires OAT as part of algorithm for DDC
- Economizer
  - Fault Detection and Diagnostics: ensures free cooling is configured and working correctly
  - Economizer high limit setpoints specified
- Humidity control not allowed between 30% and 60% RH for most cases

Mechanical –Other Controls

- Requirements for interlocking heating and cooling with external building doors.
  - Doors with auto closers / loading docks exempt
  - Includes residential/hotel patio doors
- Multi-zone DOAS shall not heat above 60°F when cooling is expected (No “neutral air”)
- Hot gas bypass for HVAC
  - Reduced to 15%/10% of capacity for <240 / >240 MBH
  - OEESC 2014 limits at 50%/25%

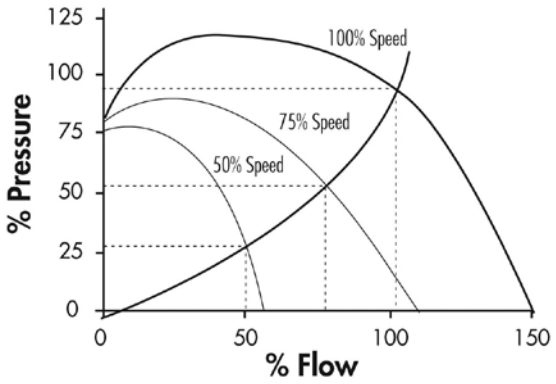


Mechanical – Refrigeration

- Refrigeration requirements for
  - Walk-in coolers and freezers (matching federal requirements)
  - General refrigeration equipment

Mechanical – Fans

- Fan power limits add deducts for systems without cooling devices, heating devices, and electric heat; ERV & sound traps clarified
- Requirements added for indoor fan control
  - Single zone DX units to have a minimum of a 2 speed fan with the lower speed no higher than 66% for capacity >65 MBH
  - Other units: minimum of 2 stages of fan control with the minimum speed not to exceed 50% for greater than ¼ HP fan motor.
  - Low speed fan used during low cooling, ventilation and low load economizer operation.
  - vs. VSD at 10 HP fan motor in OR
- New requirement for fractional HP fan motors
  - ECM or have a minimum efficiency of 70%
  - Except for units in rated package equipment



Mechanical – VAV Reheat & Other Controls

Variable Air Volume (VAV) Reheat systems

- New requirements for dual maximum reheat box control on VAV systems
- Ventilation optimization to reduce system OSA as zone supply air increases (Adjust for E_v changes)
- DDC now required for most VAV systems
- Enhanced static pressure reset with faulty zone detection

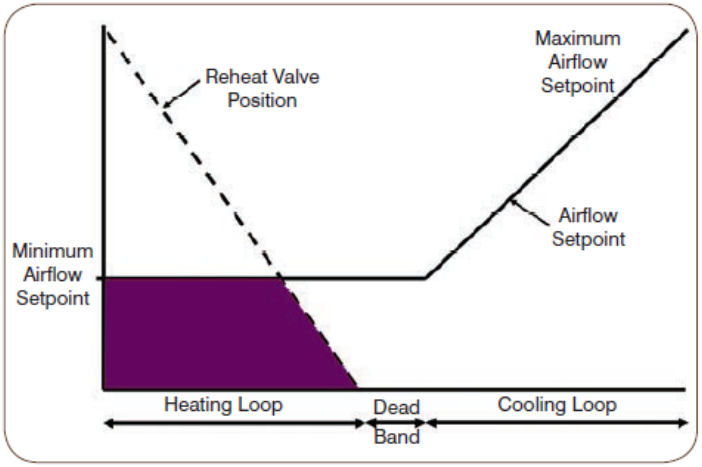


Figure 1: Conventional VAV reheat control diagram.

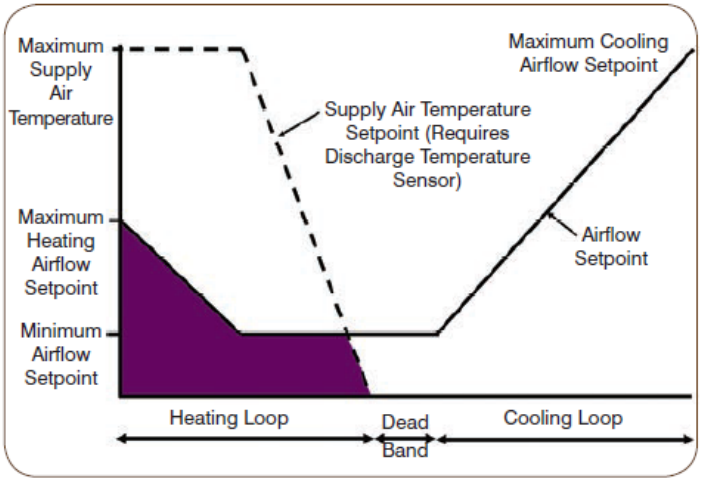
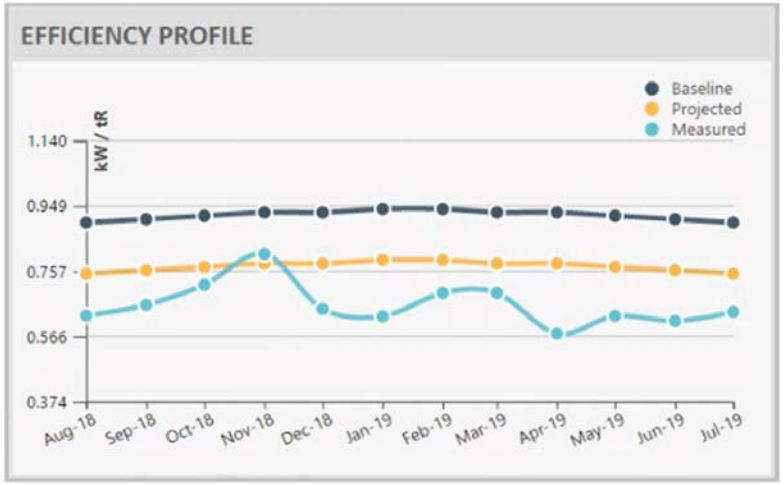


Figure 2: Dual maximum VAV reheat control diagram.

Mechanical - Central Plants

- Boiler turndown 3:1 if >1000 MBH (up to 5:1)

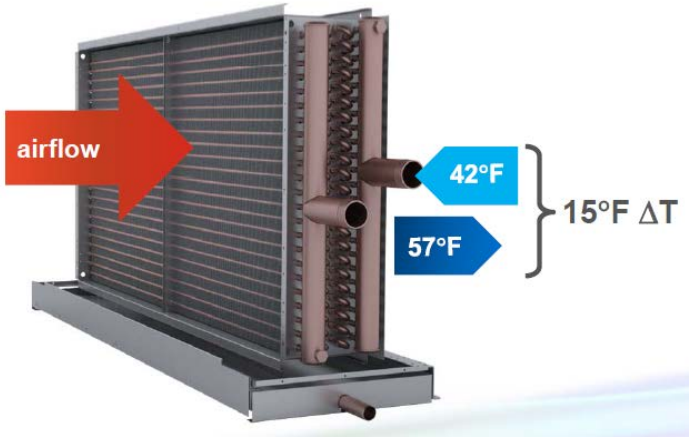
- Heat rejection equipment fan speed control
  at ≥5 HP fan vs. ≥7.5 HP in 2014 OEESC
- New requirements for cooling tower flow turndown in chilled water plants – select to run at 50%
- Chilled Water Plant Monitoring
  - >860 tons (WC>1500)
  - Large plants require interval metering for electricity and efficiency COP
  - ASHRAE Guideline 22



Mechanical – Hydronic Systems

- 6.5.4.7: Chilled Water Coil Selection
  - 15F dT minimum selection required
  - Min 57F LWT
    - Exception < 5000cfm

    (Trane ENL; May 2019)



- Hydronic reset for HW and CHW
  - 90.1: **Both** temperature reset and variable flow
  - 2014 OEESC: Either temperature reset or variable flow
- Minimum sizing requirements for CHW & HW piping (based on flow and hours)
- Piping defined so all fittings and accessories will be insulated

Service Water Heating

- Recirculation time controls
  - 90.1 for all recirculation systems
  - 2014 OEESC, only ≥ 100 MBH
- High capacity gas-fired SWH systems (≥ 1,000 MBH)
  - Weighted average of ≥90% thermal efficiency (Et)
  - Requires some, but not all units to be condensing
  - Can mix condensing and standard units

90.1 reduced stringency vs. 2014 OR code

- Exhaust air energy recovery
  - 90.1 does not require ERV/HRV in climate zones 4C & 5B if < 8000 hr/yr
  - 2014 OEESC does for greater than 5000 cfm & > 70% OSA
- Pump VSD limits increased from >5 HP in 2014 OEESC
  - Heating water ≥ 10 HP
  - Chilled water ≥ 7.5 HP (likely the same)
- SHW piping with recirculation
  - 90.1: Runouts after 8’ from recirculation do not require insulation
  - 2014 OEESC requires all recirculation piping to be insulated
- SHW systems ≥ 100 MBH
  - Recirculation: only a time switch in 90.1
  - 2014 OEESC requires demand sensing controls during “occupied” periods
- Indoor pool heat recovery
  - No 90.1 requirements; 2014 OEESC requires either:
    - Dehumidification recovery
    - HRV with variable bypass and humidity controls

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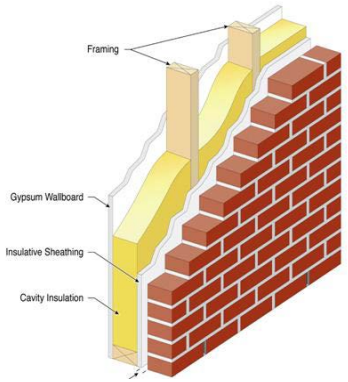
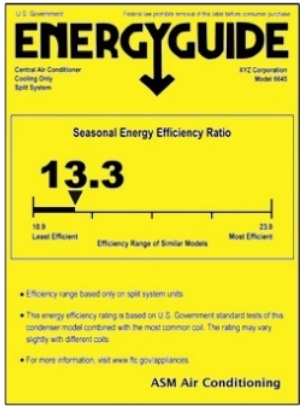
TWO PERFORMANCE PATHS CHAPTER 11 AND APPENDIX G

BACKGROUND - COMPLIANCE WITH STANDARD 90.1

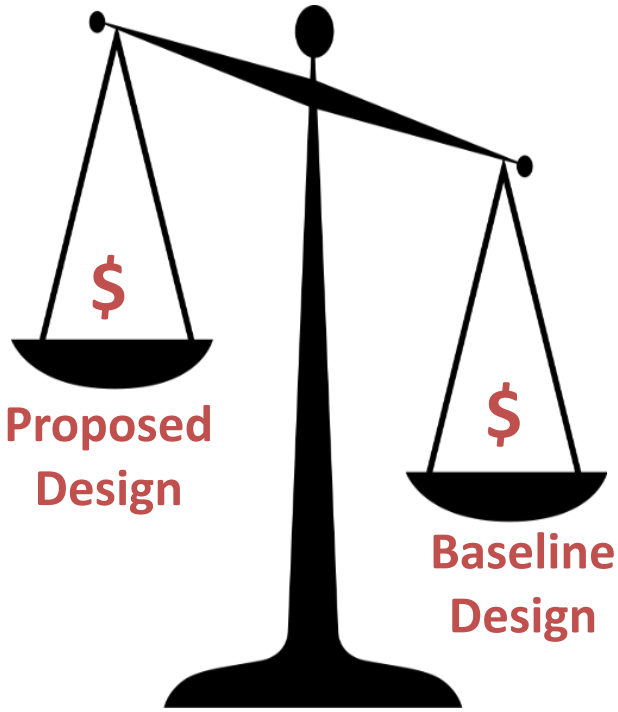
90.1-2013 Included Two Compliance Paths:

Prescriptive





Performance – Energy Cost Budget (ECB)



Three Paths Through 90.1

Prescriptive Requirements

Mandatory Requirements

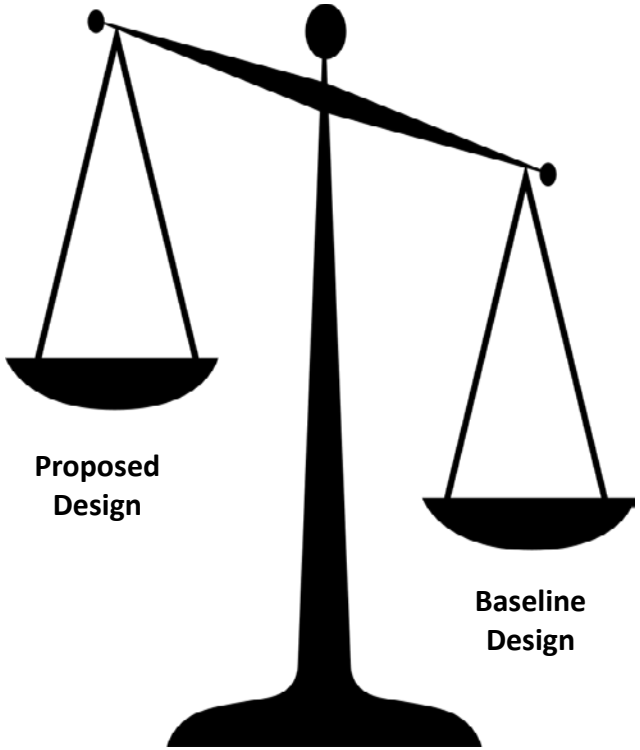
Plus One

Chapter 11 Performance

Appendix G Performance

Performance Paths in ASHRAE 90.1

- Standard 90.1-2016 includes two performance paths
  - Both based on energy simulation
  - Both compare a proposed building design to a baseline building meeting the prescriptive requirements of the code
  - Both compare the annual energy cost ($) of the proposed building to the baseline building
- Energy Cost Budget Method (ECB) - Chapter 11
  - Used for minimum code compliance for buildings that do not meet 90.1 prescriptive requirements
  - Requires no greater energy cost than a building that meets those prescriptive requirements
- Performance Rating Method - Appendix G
  - Used to rate building performance “beyond code”. LEED, EPACT tax credits, utility programs, ASHRAE Standard 189.1, IgCC
  - % improvement = 100 x (baseline – proposed) / baseline
  - Now (90.1-2016) used for code compliance



New Compliance Path

- 90.1-2016 Introduces a Third Path for Compliance
  - Appendix G, Performance Rating Method – similar to Energy Cost Budget but more flexible
  - Prior to 2016 not used for code compliance, but used for beyond code programs
    - LEED
    - ASHRAE Standard 189.1
    - International Green Construction Code (IgCC)
    - EPACT Tax Credits
  - Provides credit for good design choices typically not recognized in code
    - Good HVAC systems selection
    - Right sizing of HVAC systems
    - Optimized orientation and use of windows
    - Efficient use of thermal mass
  - Encourages the creation of tools that automate the simulation process as the market is increased

MULTIPLE PERFORMANCE RULE SETS

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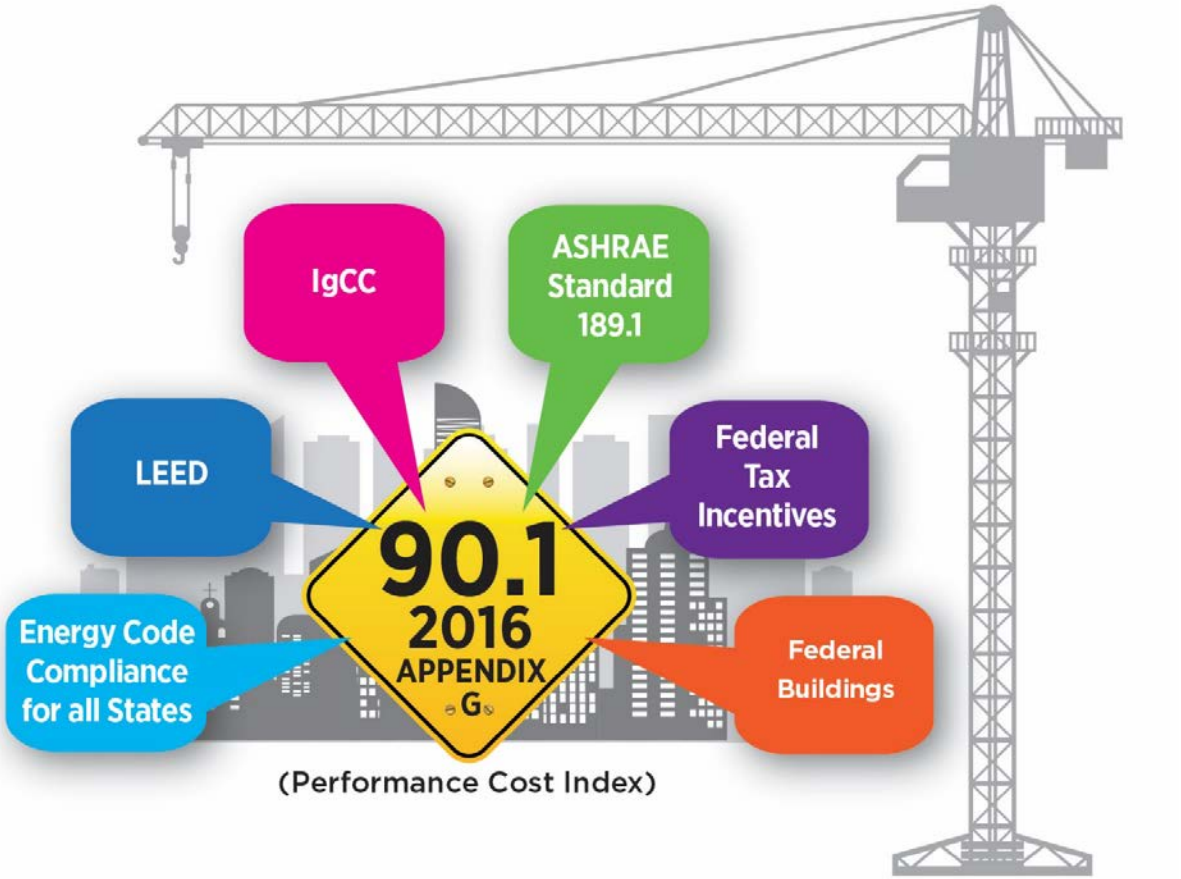
Appendix G – One Ruleset for Many Purposes



- Creates a larger market for automated software
- Encourages the creation of tools that automate the simulation process as the market is increased
- Is simpler, cheaper, more likely to be accurate

ECB–DEPENDENT BASELINE

ECB Baseline is more **Dependent** on the Proposed Design

- Baseline matches the proposed design in most ways, except backed down to prescriptive limits

Baseline Modeling Assumptions

Design Parameter	Energy Cost Budget
Window Area	Matches proposed design (up to 40%)
HVAC System Type	Matches proposed design
HVAC System Sizing	Matches proposed design
Orientation	Average of 4 rotations
Fan power	Matches proposed design (up to limit)
Air Tightness	Matches proposed design
Use of Thermal Mass	Matches proposed design

APPENDIX G PRM – INDEPENDENT BASELINE

Appendix G Baseline is more **Independent** of the Proposed Design

- Design parameters set at standard practice - allows more credit for good design choices

Baseline Modeling Assumptions

Design Parameter	Energy Cost Budget	Appendix G
Window Area	Matches proposed design (up to 40%)	Set at standard practice based on building type
HVAC System Type	Matches proposed design	Set at standard practice based on building type and CZ
HVAC System Sizing	Matches proposed design	Set at standard practice
Orientation	Average of 4 rotations	Average of 4 rotations
Fan power	Matches proposed design (up to limit)	Set at standard practice
Air Tightness	Matches proposed design	Set at standard practice
Use of Thermal Mass	Matches proposed design	Set at standard practice

ECB – DEPENDENT BASELINE

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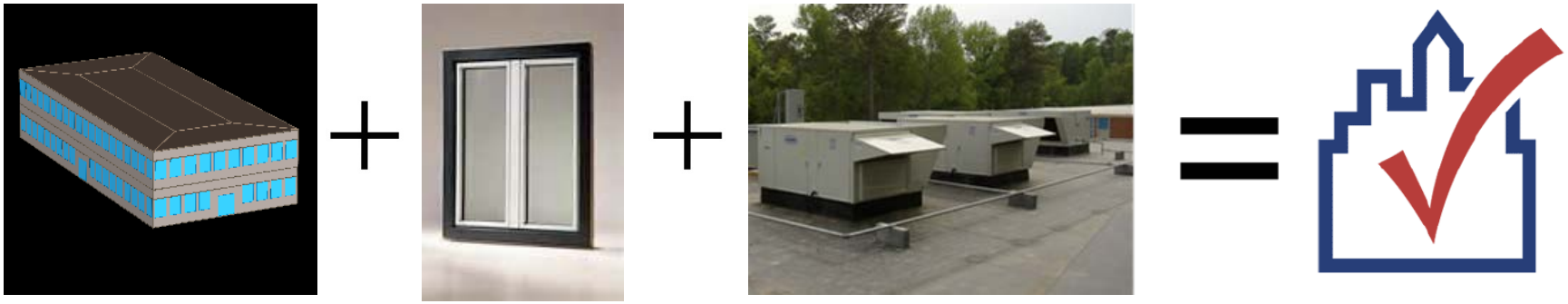
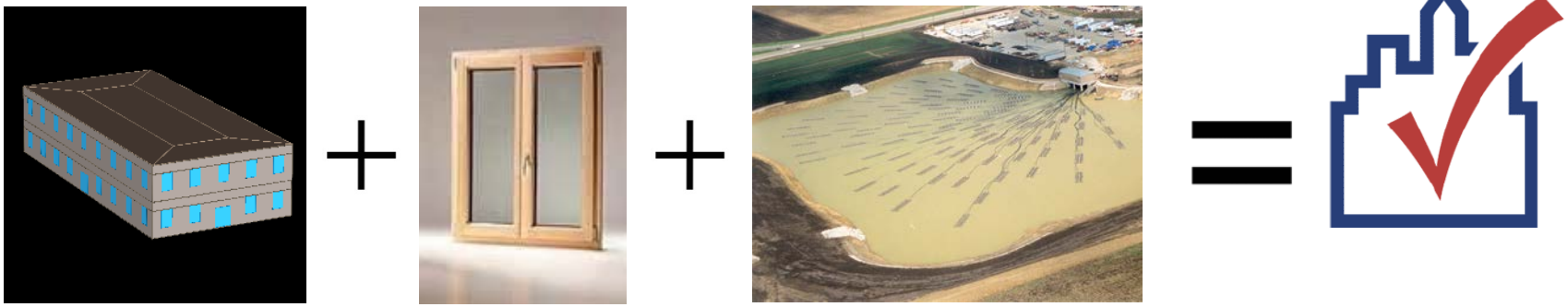
ECB compliance path does not prescribe energy use

- Multitude of prescriptive options – with it's baseline
- Each combination chosen results in very different energy use





APPENDIX G PRM – INDEPENDENT BASELINE

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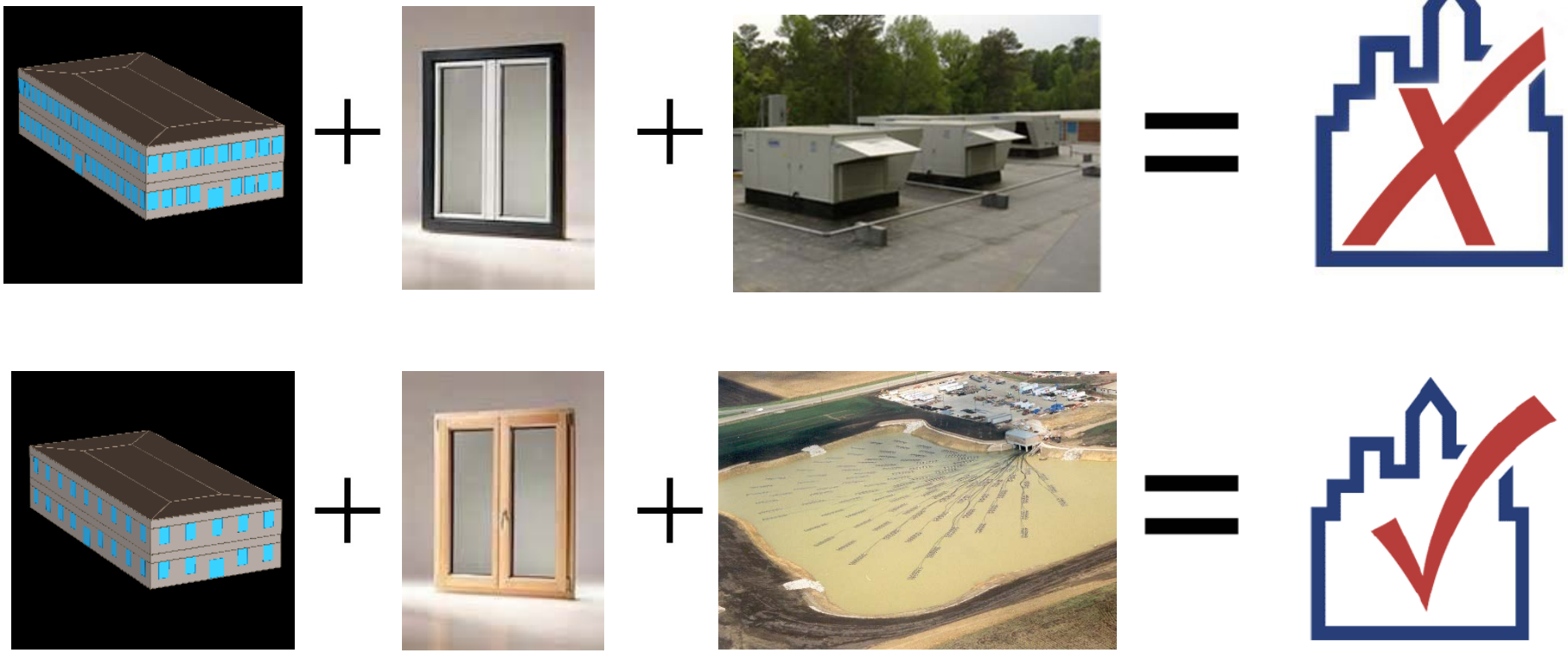
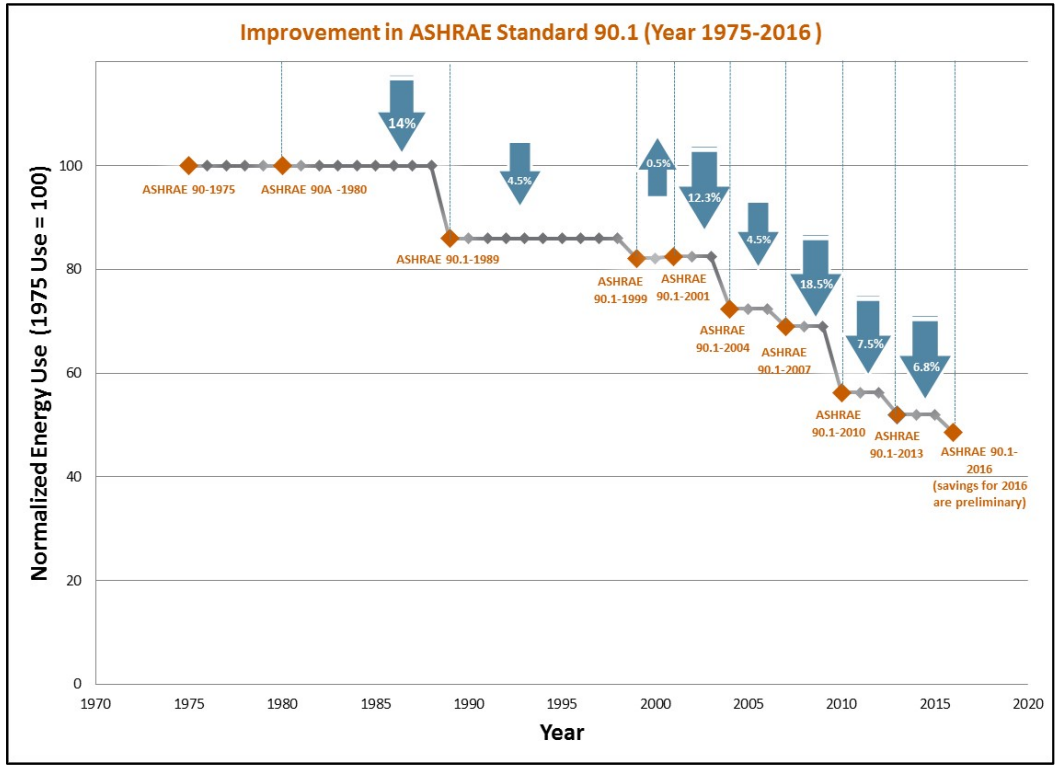
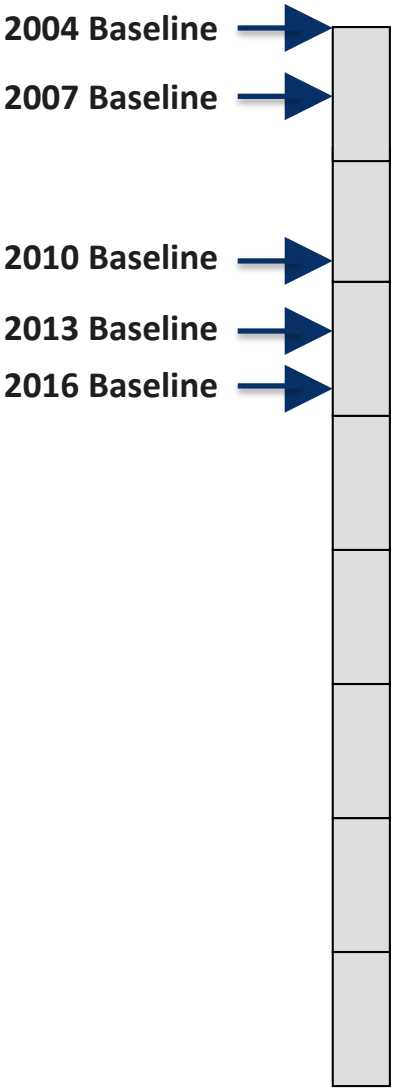


ECB BASELINE IS A MOVING TARGET

Baseline stringency changes with each new version

- New rules created to match prescriptive requirements
- Comparisons between buildings using different versions of the standard are very difficult
  - Which is better, 40% below 2007 or 20% below 2007?



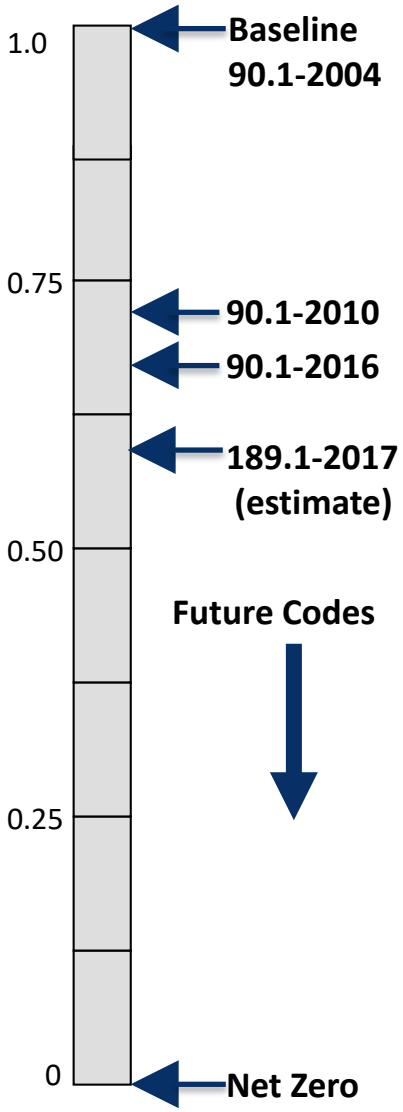


From ‘Moving’ Dependent Baseline To Stable Independent Baseline

- Appendix G requires a Performance Cost Index (PCI) specific to building type and climate zone

$$Performance\ Cost\ Index\ (PCI) = \frac{Proposed\ Building\ Performance}{Baseline\ Building\ Performance}$$

- Stable Baseline set ~ 90.1-2004
  - Intent is that the stringency of the baseline doesn’t change
  - Compliance requires meeting a performance target below the baseline
  - PCI target changes with each version of a code
  - Beyond code programs can choose a PCI to meet their needs



APPENDIX G – STABLE BASELINE

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Requires a Performance Cost Index (PCI) specific to building type and climate zone

$$Performance\ Cost\ Index\ (PCI) = \frac{Proposed\ Building\ Performance}{Baseline\ Building\ Performance}$$

- Performance Cost Index of 1.0 = baseline building
- Performance Cost Index of 0.0 = zero net energy
- For compliance, PCI < PCI_t
- PCI_t specific for building type, climate zone, and proportion of regulated loads : unregulated load

$$PCI_t = \frac{(BBUEC + (BPF \cdot BBREC))}{BBP}$$

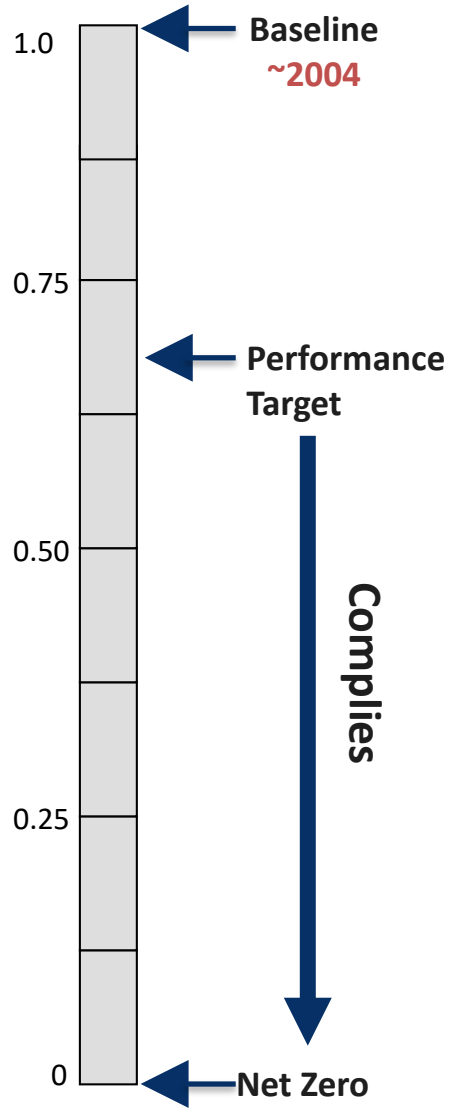
PCI = Performance Cost Index calculated in accordance with Section G1.2.

BBUEC = Baseline *Building* Unregulated *Energy* Cost, the portion of the annual *energy* cost of a *baseline building design* that is due to *unregulated energy use*.

BBREC = Baseline *Building* Regulated *Energy* Cost, the portion of the annual *energy* cost of a *baseline building design* that is due to *regulated energy use*.

BPF = *Building* Performance Factor from Table 4.2.1.1. For *building* area types not listed in Table 4.2.1.1 use "All others." Where a *building* has multiple *building* area types, the required BPF shall be equal to the area-weighted average of the *building* area types.

BBP = *Baseline Building Performance*.



APPENDIX G – STABLE BASELINE

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Building type and climate zone adjustment by Building Performance Factor

Table 4.2.1.1 *Building* Performance Factor (BPF)

Building Area Type[a]	Climate Zone																
	0A and 1A	0B and 1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.73	0.73	0.71	0.69	0.74	0.73	0.68	0.78	0.81	0.81	0.76	0.80	0.81	0.76	0.79	0.74	0.80
Healthcare/ hospital	0.64	0.56	0.60	0.56	0.60	0.56	0.54	0.57	0.53	0.55	0.59	0.52	0.55	0.57	0.52	0.56	0.56
Hotel/motel	0.64	0.65	0.62	0.60	0.63	0.65	0.64	0.62	0.64	0.62	0.60	0.61	0.60	0.59	0.61	0.57	0.58
Office	0.58	0.62	0.57	0.62	0.60	0.64	0.54	0.58	0.60	0.58	0.60	0.61	0.58	0.61	0.61	0.57	0.61
Restaurant	0.62	0.62	0.58	0.61	0.60	0.60	0.61	0.58	0.55	0.60	0.62	0.58	0.60	0.63	0.60	0.65	0.68
Retail	0.52	0.58	0.53	0.58	0.54	0.62	0.60	0.55	0.60	0.60	0.55	0.59	0.61	0.55	0.58	0.53	0.53
School	0.46	0.53	0.47	0.53	0.49	0.52	0.50	0.49	0.50	0.49	0.50	0.50	0.50	0.49	0.50	0.47	0.51
Warehouse	0.51	0.52	0.56	0.58	0.57	0.59	0.63	0.58	0.60	0.63	0.60	0.61	0.65	0.66	0.66	0.67	0.67
All others	0.62	0.61	0.55	0.57	0.56	0.61	0.59	0.58	0.57	0.61	0.57	0.57	0.61	0.56	0.56	0.53	0.52

STABLE BASELINE EXAMPLE: LEED V.4 PILOT CREDIT

LEED BD+C: New Construction | v4-LEEDv4
Alternative Performance Rating Method - Prerequisite

Whole-Building Energy Simulation

"Demonstrate a minimum reduction of 5% for new construction or 3% for major renovations in the proposed building Performance Cost Index (PCI) below the Performance Cost Index Target (PCI_t) calculated in accordance with Section 4.2.1.1 of ANSI/ASHRAE/IESNA Standard 90.1-2016, Appendix G, except with Table 1 below replacing Table 4.2.1.1"

Rating System Adaptation	Building Performance Factor (BPF)
New Construction (Except High-Rise Residential)	0.72
Retail (Incl. Restaurant)	0.72
School	0.65
Healthcare	0.69
Hospitality	0.76
Warehouse	0.70
Homes Mid-Rise & NC High-Rise Residential	0.89

Specific Updates to Appendix G

- Baseline Requirements:
  - Existing Building Envelope
  - WWR
  - Exterior shading
  - Specified HVAC systems by CZ & Building type
  - Cooling tower selection
  - Packages system fans
  - Specified HVAC / SWH fuels by CZ & Building type
- Credits that may be new:
  - Radiant heat credit
  - Tested air barrier credit
  - Renewable energy (PV, etc)
- Other options

Existing Building Envelope Baseline

- Existing building envelope construction baseline same new buildings
  - Previously: baseline = existing conditions
  - Now: baseline = prescriptive requirements equivalent to 90.1-2004
- Maintains consistency of ratings between new and existing buildings

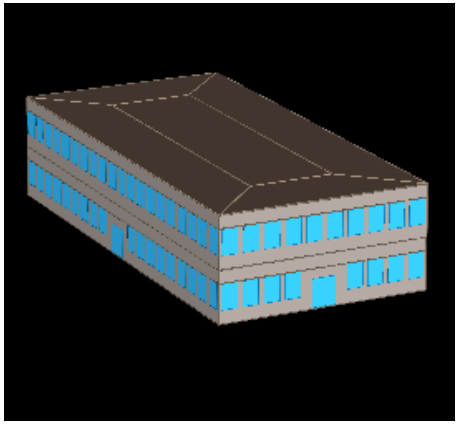
Table G3.1 Modeling Requirements for Calculating Proposed and *Baseline Building Performance (Continued)*

No.	*Proposed Building Performance*	*Baseline Building Performance*
5. *Building Envelope*		
a.	All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as built for *existing building envelopes*. **Exceptions:** The following *building* elements are permitted to differ from architectural drawings: 1. All uninsulated assemblies (e.g., projecting balconies, perimeter edges of intermediate *floor* stabs, concrete *floor* beams over parking garages, *roof* parapet) shall be separately modeled using either of the following techniques: a. Separate model of each of these assemblies within the *energy* simulation model. b. Separate calculation of the *U-factor* for each of these assemblies. The *U-factors* of these assem-	Equivalent dimensions shall be assumed for each *building envelope* component type as in the *proposed design*; i.e., the total gross area of *walls* shall be the same in the *proposed design* and *baseline building design*. The same shall be true for the areas of roofs, *floors*, and *doors*, and the exposed perimeters of concrete slabs on *grade* shall also be the same in the *proposed design* and *baseline building design*. The following additional requirements shall apply to the modeling of the *baseline building design*: a. ***Orientation.*** The *baseline building performance* shall be generated by simulating the *building* with its actual *orientation* and again after rotating the entire *building* 90, 180, and 270 degrees, then averaging the results. The *building* shall be modeled so that it does not shade itself.

Baseline Window-to Wall Ratio

- Establishes baseline WWR for building types – Basis: CBECS averages
  - Credit good design choices – appropriate glazing area
  - “Vertical fenestration area … shall equal that in Table G3.1-1”

Proposed 40% WWR



Baseline 19% WWR

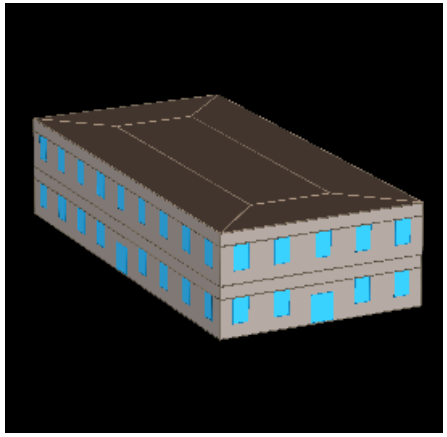


TABLE G3.3 Baseline Building Vertical Fenestration Percentage of Gross Above Grade Wall Area

Building Area Types[a]	Baseline Building Gross Above Grade Wall Area
Grocery Store	7%
Healthcare (outpatient)	21%
Hospital	27%
Hotel/Motel (< or =75 rooms)	24%
Hotel/Motel (> 75 rooms)	34%
Office (<or = 5,000 ft^2)	19%
Office (5,000 ft^2-50,000 ft^2)	31%
Office (>50,000 ft^2)	40%
Restaurant (quick service)	34%
Restaurant (full service)	24%
Retail (stand alone)	11%
Retail (strip mall)	20%
School (primary)	22%
School (secondary and university)	22%
Warehouse (non-refrigerated)	6%

Baseline Computer Room Systems

- Establishes rules for simulating baseline computer room HVAC systems
  - New system type 11- Single Zone VAV with chilled water (CRAH) for computer rooms in buildings with peak cooling load > 3,000,000 Btu/h (Section G3.1.1 exception 7)
    - HVAC fans "on" during unoccupied hours (Table G3.1 4c)
    - No reheat for dehumidification (Table G3.1 10)
    - Water side economizers required for CRAH System 11 (Section G3.1.2.7.1)
    - Supply air volume resets from 100% airflow at full load to minimum flow at 50% load (G3.1.3.17)
  - Establishes default monthly loading schedule to analyze efficiency at typical load growth patterns for large computer rooms

G3.1.3.16 Computer Room Equipment Schedules. Computer room equipment schedules shall be modeled as a constant fraction of the peak design load per the following monthly schedule:

Month 1, 5, 9—25%
Month 2, 6, 10—50%
Month 3, 7, 11—75%
Month 4, 8, 12—100%

New Baseline Mechanical Systems

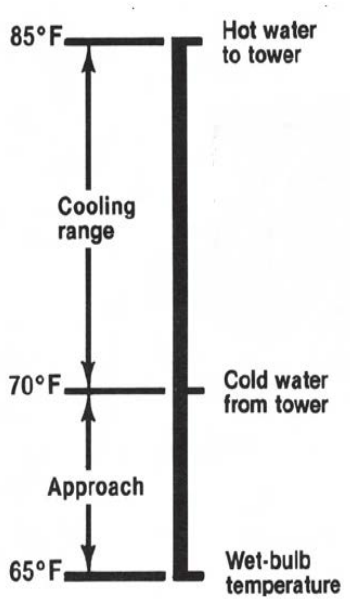
- Changes baseline system type for Big Box Retail to rooftop PSZ instead of VAV (Table G3.1.1A)
- Creates two new Single Zone, Constant Volume baseline system types for Public Assembly buildings (Tables G3.1.1.3 & G3.1.1.4)

TABLE G3.1.1-3 Baseline HVAC System Types

Building Type	Climate Zones 3b, 3c, and 4–8	Climate Zones 1–3a
Residential	System 1—PTAC	System 2—PTHP
Public assembly <120,000 ft^2	System 3—PSZ-AC	System 4—PSZ-HP
Public assembly ≥120,000 ft^2	System 12—SZ-CV-HW	System 13—SZ-CV-ER
Nonresidential and 3 floors or fewer and <25,000 ft^2	System 3—PSZ-AC	System 4—PSZ-HP
Nonresidential and 4 or 5 Floors and <25,000 ft^2 or 5 floors or fewer and 25,000 ft^2 to 150,000 ft^2	System 5—Packaged VAV with reheat	System 6—Packaged VAV with PFP boxes
Nonresidential and more than 5 floors or >150,000 ft^2	System 7—VAV with reheat	System 8—VAV with PFP boxes
Heated-only storage	System 9—Heating and ventilation	System 10—Heating and ventilation
Retail and 2 floors or fewer	System 3—PSZ-AC	System 4—PSZ-HP

Baseline Cooling Towers

- Requires variable speed fans for baseline cooling towers. Relaxes tower approach for climates with high design wet bulb temperature (G3.1.3.11& Table 11.3.2A)
  - Previous baseline requirement - design entering condenser water temperature of 85^0 F or 10^0 F. approach to 1% design wet bulb temperature, whichever is lower
  - New baseline requirement – design approach varies with design wet-bulb temperature. Prevents towers from being too large in humid climate zones



$$\text{Approach}_{10^\circ\text{F Range}} = 25.72 - (0.24 \times \text{WB})$$

where WB is the *0.4% evaporation design wet-bulb temperature* in °F

Baseline Packaged Equipment Fan Energy

- Provides rules for removing fan energy from baseline packaged equipment efficiency metrics (Section 11.3.2 & G3.1.2.1)
  - Efficiency metrics such as EER, SEER, COP, & HSPF include fan power, while simulation programs need efficiency without fan energy (COPnofan)
  - Simulation programs require fan power to be separated to simulate continually running fans with cycling heating or cooling

$$COP_{nfcooling} = 7.84E\text{-}8 * EER * Q + 0.338 * EER$$

$$COP_{nfcooling} = -0.0076 * SEER^2 + 0.3796 * SEER$$

$$COP_{nfheating} = 1.48E\text{-}7 * COP_{47} * Q + 1.062 * COP_{47}$$

(applies to heat pump heating efficiency only)

$$COP_{nfheating} = -0.0296 * HSPF^2 + 0.7134 * HSPF$$

Baseline Fuel Source - HVAC

- Establishes baseline fuel source for space heating dependent on climate zone (Table G3.1.1A)
- Warm climates zones 1,2 & 3a use electricity. Cold climate zones use natural gas (propane if NG is unavailable.)

TABLE G3.1.1-3 Baseline HVAC System Types

Building Type	Climate Zones 3b, 3c, and 4–8	Climate Zones 1–3a
Residential	System 1—PTAC	System 2—PTHP
Public assembly <120,000 ft^2	System 3—PSZ-AC	System 4—PSZ-HP
Public assembly ≥120,000 ft^2	System 12—SZ-CV-HW	System 13—SZ-CV-ER
Nonresidential and 3 floors or fewer and <25,000 ft^2	System 3—PSZ-AC	System 4—PSZ-HP
Nonresidential and 4 or 5 Floors and <25,000 ft^2 or 5 floors or fewer and 25,000 ft^2 to 150,000 ft^2	System 5—Packaged VAV with reheat	System 6—Packaged VAV with PFP boxes
Nonresidential and more than 5 floors or >150,000 ft^2	System 7—VAV with reheat	System 8—VAV with PFP boxes
Heated-only storage	System 9—Heating and ventilation	System 10—Heating and ventilation
Retail and 2 floors or fewer	System 3—PSZ-AC	System 4—PSZ-HP

Baseline Fuel Source - SWH

- Established baseline fuel source for service water heating dependent on building function
- High SWH load building types use natural gas (propane if NG is unavailable.) Lower SWH load building use electric

Table G3.1.1C Baseline Service Hot Water System

Building Area Type	Baseline Heating Method	Building Area Type	Baseline Heating Method
Automotive facility	Gas Storage Water Heater	Multifamily	Gas Storage Water Heater
Convention center	Electric Resistance Storage Water Heater	Museum	Electric Resistance Storage Water Heater
Courthouse	Electric Resistance Storage Water Heater	Parking garage	Electric Resistance Storage Water Heater
Dining: bar lounge/leisure	Gas Storage Water Heater	Penitentiary	Gas Storage Water Heater
Dining: cafeteria/fast food	Gas Storage Water Heater	Performing arts theater	Gas Storage Water Heater
Dining: family	Gas Storage Water Heater	Police station	Electric Resistance Storage Water Heater
Dormitory	Gas Storage Water Heater	Post office	Electric Resistance Storage Water Heater
Exercise center	Gas Storage Water Heater	Religious building	Electric Resistance Storage Water Heater
Fire station	Gas Storage Water Heater	Retail	Electric Resistance Storage Water Heater
Gymnasium	Gas Storage Water Heater	School/university	Gas Storage Water Heater
Health-care clinic	Gas Storage Water Heater	Sports arena	Gas Storage Water Heater
Hospital	Gas Storage Water Heater	Town hall	Electric Resistance Storage Water Heater
Hotel	Gas Storage Water Heater	Transportation	Electric Resistance Storage Water Heater
Library	Electric Resistance Storage Water Heater	Warehouse	Electric Resistance Storage Water Heater
Manufacturing facility	Gas Storage Water Heater	Workshop	Gas Storage Water Heater
Motel	Gas Storage Water Heater	All Others	Gas Storage Water Heater
Motion picture theater	Electric Resistance Storage Water Heater		

Lighting Controls

- Adds lighting controls to baseline to match changes in Chapter 9 (Table G31.6 & 11.3.1.6)
  - Occupancy sensors required in more space
  - Daylighting required in some spaces
  - Allows for use of new Lighting Control Factors in Table 9.6.2
  - Eliminates Power Adjustment Table G32

TABLE G3.2 Power Adjustment Percentages for Automatic Lighting Controls

Automatic Control Device(s)	Non-24-h and ≤ 5000 ft^2	All Other
1. Programmable timing control	10%	0%
2. Occupancy sensor	15%	10%
3. Occupancy sensor and programmable timing control	15%	10%

TABLE 9.6.3 Control Factors Used in Calculating Additional Interior Lighting Power Allowance

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 multilevel dimming control	0.05	0.05	0.10	0.10	0
Programmable multilevel dimming control using programmable time scheduling	0.05	0.05	0.10	0.10	0.10
Occupancy sensors controlling the downlight component of workstation specific luminaires with continuous dimming to off capabilities	0.25[a]	0	0	0	0
Occupancy sensors controlling the downlight component of workstation specific luminaires with continuous dimming to off operation, in combination with personal continuous dimming control of downlight illumination by workstation occupant	0.30[a,b]	0	0	0	0
Automatic continuous daylight dimming in secondary sidelighted areas	0.10[c]	0.10[c]	0.10[c]	0.10[c]	0.10[c]

Exterior Shading

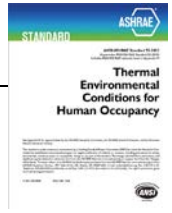
- Requires modeling of shading by adjacent structures provided that structure height is greater than the distance from the proposed building and width is greater then 1/3 of the proposed building (Table G3.1.14a)
  - H > D & W2 > 1/3 * W1

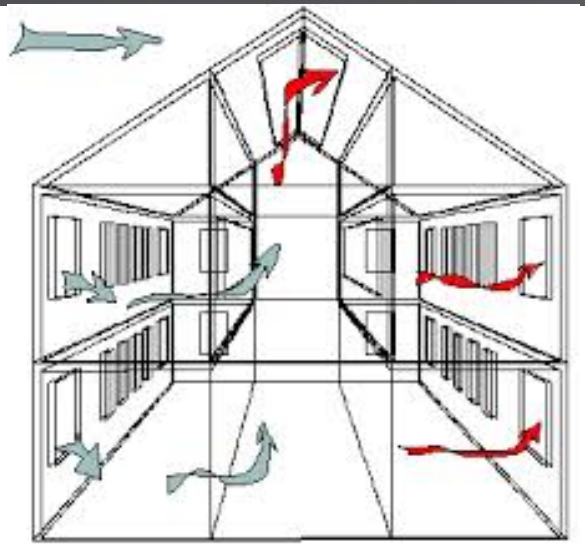
Credit for Equivalent Operative Temperature (Radiant Heating)

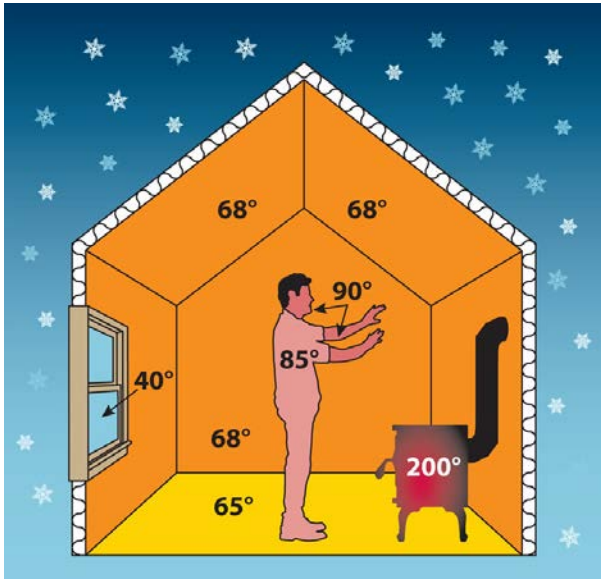
- Allows credit for providing equivalent thermal comfort by means other than dry bulb temperature control
- Must comply with ASHRAE Standard 55

TABLE G3.1 Modeling Requirements for Calculating Proposed and Baseline Building Performance *(continued)*

No. Proposed Building Performance	Baseline Building Performance
4. Schedules	
	Same as Proposed Design **Exceptions:** 1. Setpoints and schedules for HVAC systems that automatically provide occupant thermal comfort via means other than directly controlling the air dry bulb and wet bulb temperature may be allowed to differ provided that equivalent levels of occupant thermal comfort are demonstrated via the methodology in Section 5.2.3 Elevated Air Speed of Standard 55 or Appendix D-Computer Program for Calculation of PMV-PPD of Standard 55.







Credit for Tested Reduced Infiltration

- Specifies baseline infiltration rates
  - Allows credit for reduced infiltration **verified by whole building air leakage testing** (Table G3.1.5b)
  - Baseline air leakage set at 0.4 cfm/ft2 (entire envelope) @ 0.3”w.g. pressure differential
  - Provides direction on converting air leakage rates to infiltration inputs as required by common simulation tools (DOE2, E+, etc.) (Section G3.1.1.4)

G3.1.1.4 Modeling Building Envelope Infiltration.
The air leakage rate of the building envelope (I75PA) at a pressure differential of 0.3” w.g.(75Pa) shall be converted to appropriate units for the *simulation program* using one of the following formulas:

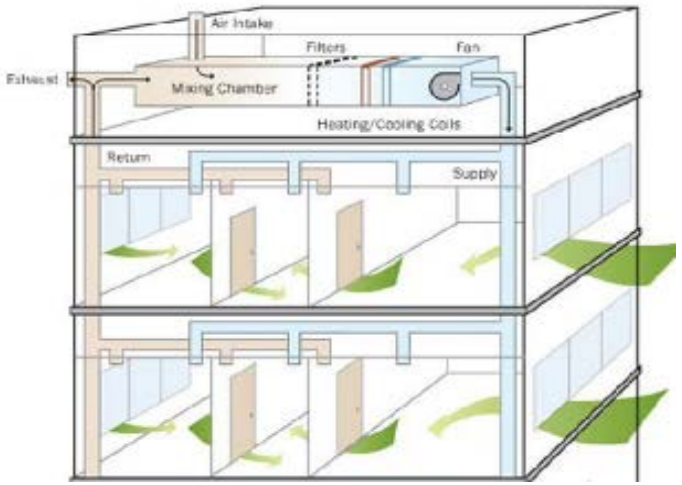
For methods describing *infiltration* as a function of floor area:

IFLR = 0.112 * I75PA * S / AFLR

For methods describing *infiltration* as a function of exterior wall area:

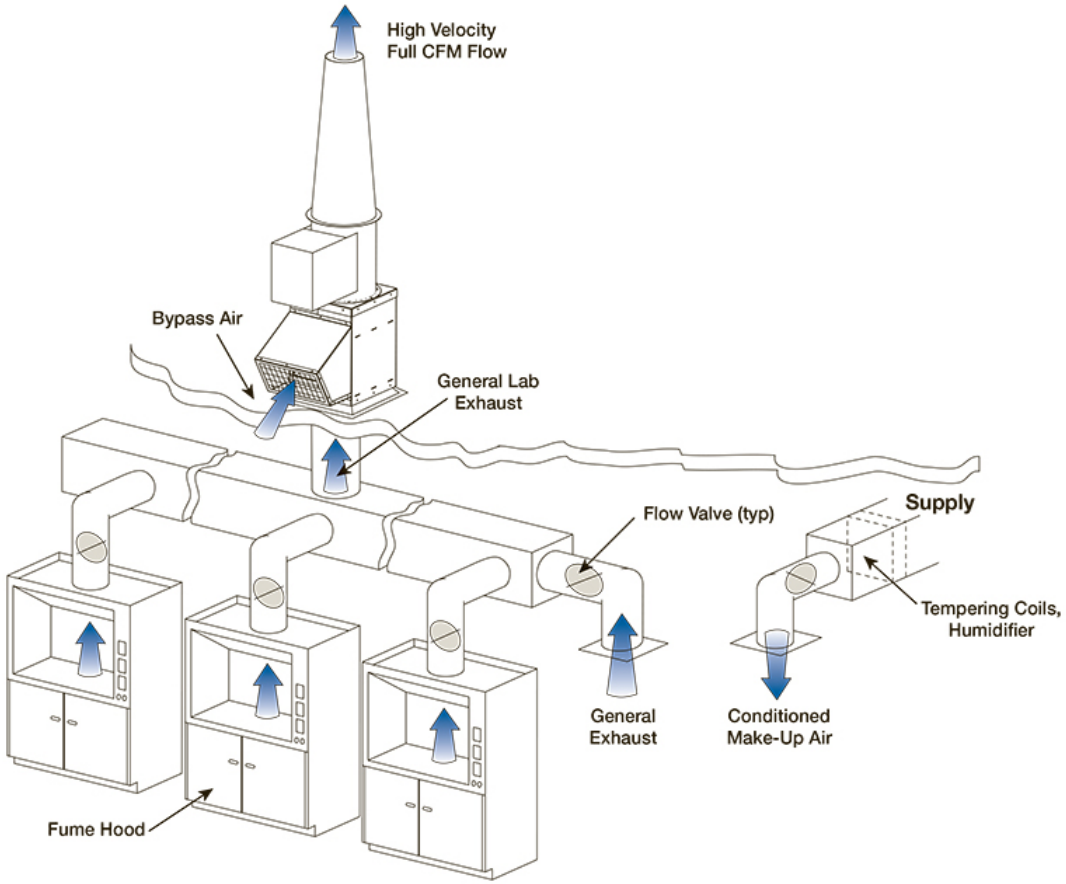
IEW = 0.112 * I75PA * S / AEW

S = area of entire envelope air pressure boundary



Laboratory Exhaust Fan Baseline

- Laboratory exhaust fan baseline modeled as constant flow with bypass at discharge (G3.1.1 exception 3)
- Allows credit for VAV exhaust systems



On-Site Renewable Energy

- Defines on-site renewable energy (Definition Section 3)
- Caps renewable credit available for compliance trade-off to 5% (Section 11.2.3.1)

3.2 Definitions

on-site renewable energy: energy generated from renewable sources produced at the building site.

.

G2.4.1 On-Site Renewable Energy and Site-Recovered Energy. On-site renewable energy generated by systems included on the building permit that is used by the building shall be subtracted from the proposed design energy consumption prior to calculating the proposed building performance.

11.2.3.1 On-Site Renewable Energy and Site-Recovered Energy. On-site renewable energy generated by systems included on the building permit that is used by the building shall be subtracted from the proposed design energy consumption prior to calculating the design energy cost. The
reduction in design energy cost associated with on-site renewable energy shall be no more than 5% of the calculated energy-cost budget.

Other Updates Since 90.1-2010

- Baseline requirements
  - Specifies that Heating and Ventilating systems 9 and 10 are single zone systems (G3.1.1)
  - Specifies baseline chillers shall use “Path A” chillers (11.3.2b & G.3.2.1).
- Credit options
  - Allows baseline supply air flow rate to be sized on latent loads instead of sensible loads for spaces with high latent load (G3.1.2.9, exception 2)
  - Allows baseline laboratories to be simulated with 100% outdoor air (G3.1.2.6)
  - Allows credit for improved transformer efficiency (Table G31.15)
- Updates the reference to ASHRAE Standard 140 – *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs* (G2.2.4 & 11.4.1.4)

Performance Path Conclusions

There are 3 basic paths to 90.1 compliance:

- Meet all relevant mandatory requirements, plus one of the following
  - Prescriptive option: Meet all relevant prescriptive requirements
  - Chapter 11 performance (baseline similar to prescriptive)
  - Appendix G performance (reduce cost to a fraction of ~2004 baseline)

2016 Version of Appendix G offers these benefits:

- Provides a new third option for compliance for increased flexibility
- Saves time and money dedicated to energy modeling by allowing a single modeling approach to be used for multiple functions
- Encourages the creation of tools that automate the simulation process as the market is increased
- Provides credit for good design practices that were previously not recognized for code compliance

PERFORMANCE REFERENCE MATERIAL

- Rosenberg, M.I., C. Eley, 2013. “A Stable Whole Building Performance Method for Standard 90.1” ASHRAE Journal 55(5): 33-45.
- Rosenberg, M.I., C. Eley, 2016. “A Stable Whole Building Performance Method for Standard 90.1, Part 2” ASHRAE Journal 58(6): 28-42.
- Rosenberg, M., R. Hart, 2016. Developing Performance Cost Index Targets for ASHRAE Standard 90.1 Appendix G – Performance Rating Method. PNNL 25202 Rev. 1, Pacific Northwest National Laboratory, Richland, WA.
- USGBC (United States Green Building Council). 2016. Pilot Credit – Alternative Performance Rating Method http://www.usgbc.org/node/10349433?return=/pilotcredits/New-Construction/v4

REFERENCE MATERIAL

- Building Energy Codes Program
  https://www.energycodes.gov/
- DOE Building Energy Codes Program
  www.energycodes.gov/training
- The Building Codes Assistance Project (BCAP)
  http://bcap-energy.org/
- ASHRAE Addendum
  www.ashrae.org
- Errata (corrections) (search for Errata for ASHRAE 90.1)
  www.ashrae.org
- Interpretations for ASHRAE 90.1 (search for interpretations)
  www.ashrae.org
- Public Review Drafts (search for public review drafts)
  www.ashrae.org

Discussion

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Sneak Peek: ASHRAE Standard 90.1-2016 to 90.1-2019

REID HART, PE

PNNL-SA-147959

Presented at ASHRAE Oregon Chapter, Portland OR

October 2019

Overall changes

- Big picture
  - 77 Addenda completed
  - 22 Addenda save energy
- Today – hitting briefly only those that save energy
- Determination still in process

PRELIMINARY

Oregon Energy Code History

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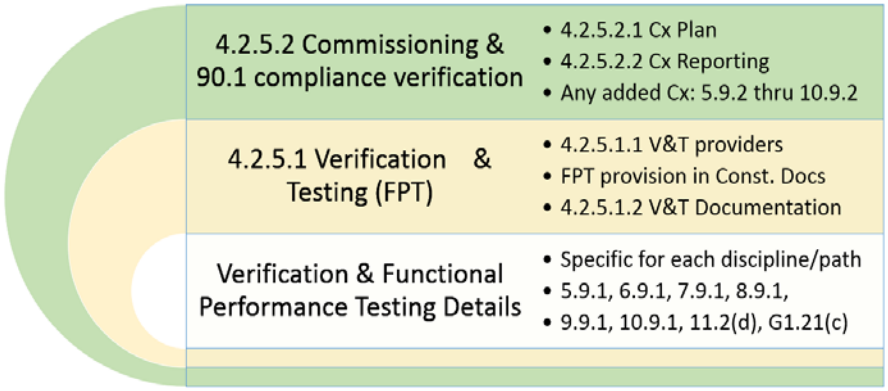
1974	• Oregon is first state to adopt an Energy Efficiency building code
~1992	• Custom Energy Code generally updated based on 90.1 • Highly progressive with multiple changes that later went to 90.1
~2008	• Oregon Energy Code converted to IECC Format • Many amendments to maintain efficiency
2014	• 2014 Oregon Energy Efficiency Specialty Code (OEESC) based on 2009 IECC • Several amendments from 90.1-2013 & 2012 IECC
2019	• Switch to 90.1-2016 October 1, 2019; Grace period thru Jan 1, 2020 • Minor administrative amendments
2020	• **Plans to adopt 90.1-2019 in October 2020** • **Minor administrative amendments**

Commissioning & Functional Testing

- Establishes uniform reporting requirements across disciplines
  - Functional Testing & Verification
  - Commissioning
- Verification and Functional testing required by discipline
- Commissioning reporting required at certain size
- 90.1 compliance verification in Cx

Level of Verification or Commissioning Required	Buildings <10,000 ft^2, warehouse use buildings, or buildings using the Simplified Approach Option for HVAC systems in Section 6.3	Other Buildings
Verification & Functional Performance Testing	X	X
Pre- & Design phase Commissioning		X
Construction Phase Commissioning		X

4.2.5 Verification, Testing & Commissioning

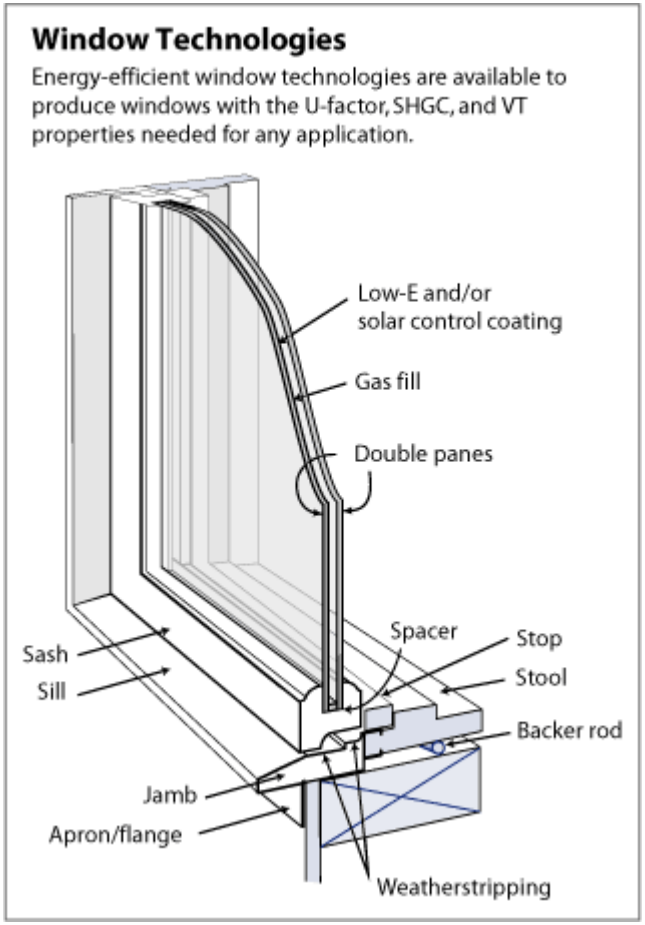


New Informative Appendix

- Indicates what commissioning reports and functions 90.1 needs
  - OPR/BOD not required
- Indexes sections of 90.1 that require FT or Cx

Envelope

- Fenestration
  - U-factor reduced and made material independent
  - SHGC reduced in some climate zones
- Thermal Bridging U-factor adjustments
  - *Considered, but did not make it*

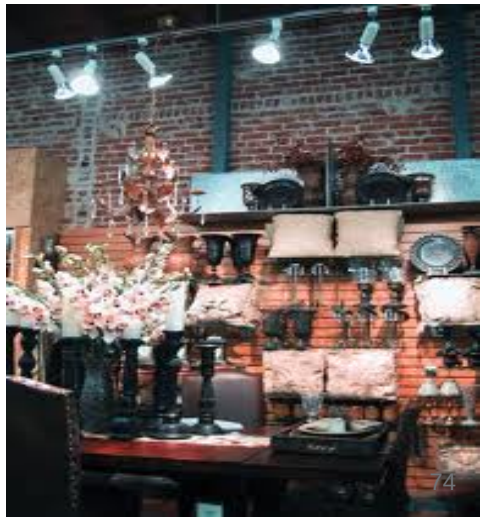


Lighting

Reduced Lighting Power Allowance

- Continue reduction based on improved efficacy of LED lighting
- Exterior lighting power table expanded to cover more types of areas
- LPD building area method revised & LPDs lowered
- Interior LPD (Building):
- Space-by-space generally reduced more

Example LPD	90.1-2016	90.1-2019	Reduction
Office Building	0.79 w/sf	0.64 w/sf	19%
Retail Building	1.06 w/sf	0.84 w/sf	21%



Mechanical – VAV

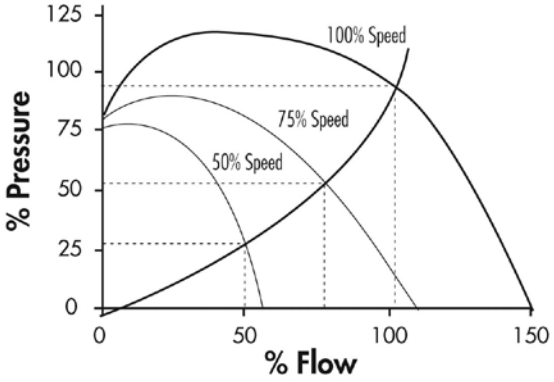
- VAV minimums lowered (au)
  - Divorced from multi-space equation
  - Uses new simplified 62.1 method (Min = 1.5 * zone required $\boldsymbol{V_{oz}}$)
  - Ventilation optimization of $\boldsymbol{E_v}$ still required

$$V_{bz} = R_p \times P_z + R_a \times A_z \qquad (6.2.2.1) \qquad V_{oz} = V_{bz}/E_z \qquad (6.2.2.3)$$

- Occupancy sensor air shutoff (g)
  - Where there are lighting occupancy sensors
  - Applies where 62.1 allows (not allowed in classrooms)
  - Box min to zero unless flow needed to maintain thermal temperature
  - Heat / cool setpoints expand deadband 1°F each way
- Expands supply air temperature (SAT) reset (ap)
  - VAV primary SAT reset now exempt in humid climate zones 0A thru 3A
  - Will be required in all zones SA ≥ 3000 cfm (2A: ≥ 10,000 cfm)
  - Requires separate OA cooling coil or RA bypass

Fans, Pumps, and Pools

- Fans move from FEG to FEI
  - FEG was size independent
  - FEI based on proper size selection
  - FEI is wire to fan HP, not shaft to fan HP
  - In addition to fan power limits
- Pumps
  - Federal efficiency requirements now in 90.1
- Pools over 500 square feet water surface require one of:
  - Exhaust air energy recovery with
    - sensible energy recovery ratio ≥ 50% or
    - total enthalpy energy recovery ratio ≥ 50%
  - Condenser (dehumidifer) recovery system rejecting 100% to pool heat
  - Exempt if 60% annual pool heating renewable or other recovery



ERV/HRV

- Hospital exhaust air recovery exception tightened as allowed by ASHRAE Standard 140

- Separate requirements for dwelling unit exhaust air energy recovery added – covers more apartments than commercial-only requirements
  - 50% cooling enthalpy recovery ratio (except climate zones 4 thru 8)
  - 60% heating enthalpy recovery ratio (except climate zones 0 thru 2)
  - Climate zone 3C exempt
  - Climate zones 0 thru 3, 4C and 5C exempt if smaller than 500 ft^2

- ERV economizer bypass requirements clarified

Equipment Efficiency improvements

- Adds new chiller table for heat pump and heat recovery chillers
- Updates efficiency requirements for Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and Condensing Units
- Removes water, evaporatively, and ground cooled heat pumps from Table 6.8.1.2 and establishes their efficiency requirements in new table 6.8.1.18. Updates efficiency requirements for all heat pumps
- Adds new definitions for CEER, CCOPc, and Off-mode power consumption. Updates efficiency for PTAC, PTHP, SPVAC, SPVHP, and room air conditioners. Update federally regulated equipment efficiency in Appendix F (residential equipment)
- Adds dry cooler efficiency requirements and slightly increases efficiency requirements for evaporative condensors
- Cleans up outdated language regarding walk-in cooler and walk-in freezer requirements, and make the requirements consistent with current and future federal regulations

Discussion

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