
seabec
seattle
building
enclosure
council

WELCOME TO SEABEC!

The Seattle Building Enclosure Council (SeaBEC) is a nonprofit organization whose purpose is to promote the pursuit of excellence in the design, construction, or other technical aspects of the building enclosure. We investigate why buildings fail, explore cures for building enclosure failure, and share information on materials and methods to promote better building science.

INTRODUCTIONS

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2020 SEABEC SCHOLARSHIPS

SeaBEC will award (2) $2,000 scholarships in 2020:

The 2020 application will be available shortly at:
https://www.seabec.org/students

ANNOUNCEMENTS

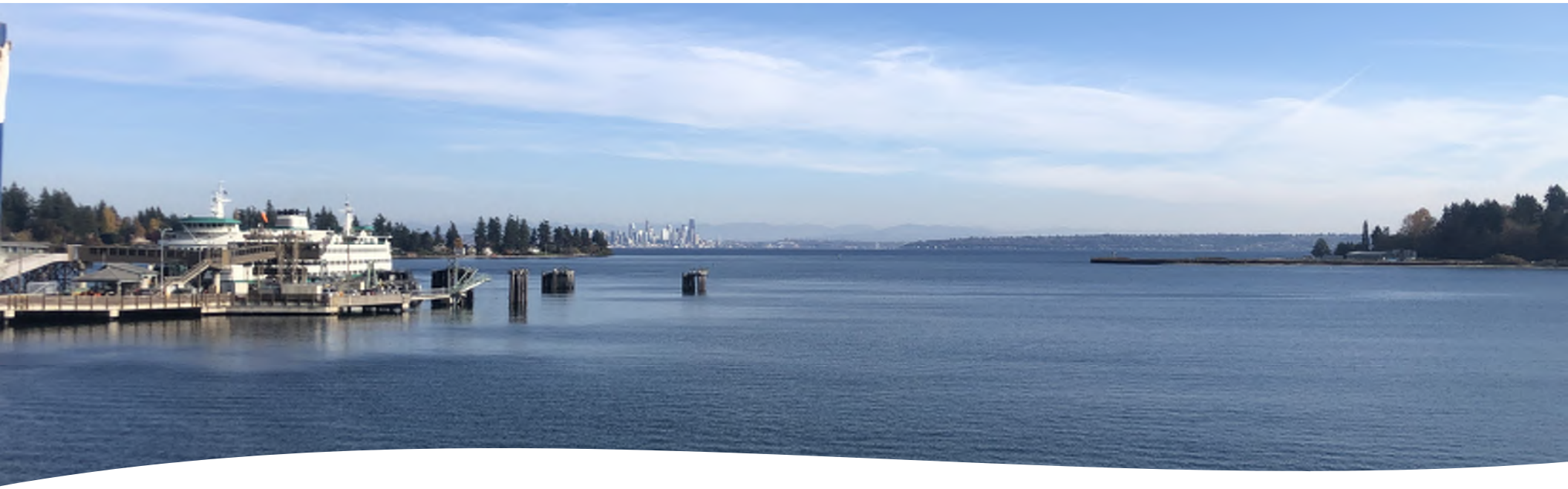
Next Meeting:

December 19, 2019 from 5pm to 7pm

Annual Holiday Party Fundraiser and White Elephant Gift Exchange

Dinner provided, cash bar available

Location: OAC Services Inc, 2200 1st Ave. S, Suite 200, Seattle, WA



BUILDING ENCLOSURE EVENTS:

IIBEC Puget Sound:

CSI Puget Sound:

SeaBEC Meeting:

Charity Mixer December 5th

Holiday Party and Auction

January 16th, David Nicastro,

UT Austin,

Durability of Weather Barriers

REFRESHMENT SPONSOR:

Patrick McMahon Innotech-Windows

TOPIC:

ENERGY CODE AND THE BUILDING ENVELOPE: RECENT AND UPCOMING CHANGES

Presented by:

Dr. Krishnan Gowri, Intertek

intertek
Total Quality. Assured.

PROVIDER: INTERTEK
PROVIDER NUMBER: 404108121
COURSE NUMBER: BCLUNA040-01P

ENERGY CODE AND THE BUILDING ENVELOPE

Recent and Upcoming Changes

Krishnan Gowri, *Ph.D., BEMP, LEED AP, Fellow ASHRAE*

Senior Consultant – Building Science Solutions

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

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COURSE DESCRIPTION

This course will provide a comprehensive summary of recent and upcoming energy code changes that architects and designers need to consider in building envelope design. Tools and techniques for determining energy code compliance using component trade-off and performance assessment methods will be discussed. Energy impact of air-barrier effectiveness will be presented with strategies to meet the mandatory air-barrier requirements. At the end of this session, attendees will be ready to identify and incorporate new energy code requirements early in the design process.

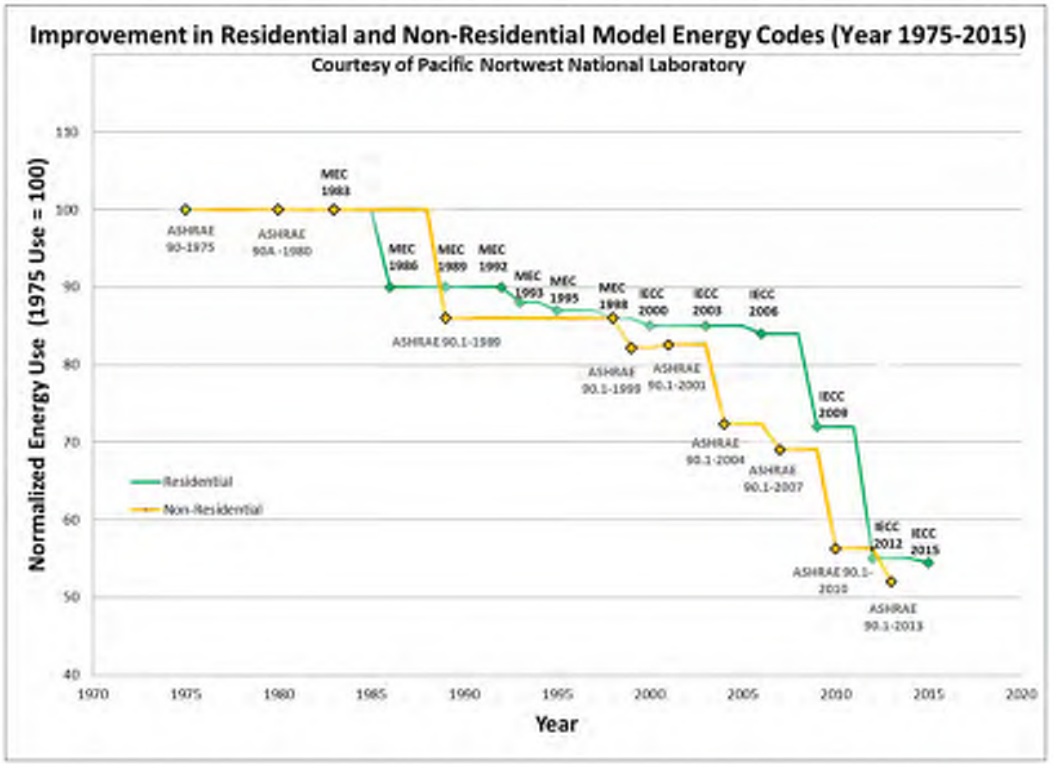
LEARNING OBJECTIVES

1. **Understand the history, scope, and objectives of energy codes**
2. **Learn the structure and contents of the Washington State energy code requirements**
3. **Acquire knowledge of new and upcoming mandatory, prescriptive and component trade-off compliance requirements for building envelope**
4. **Understand the details of air-barrier requirements and test methods to comply with the standard**

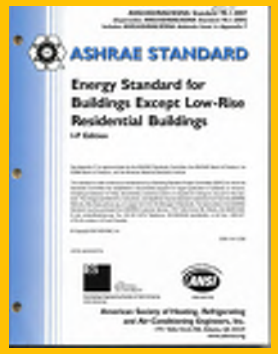
ENERGY CODES – OVERALL IMPACT AND DIRECTION

- ~20% savings in 2000 codes compared to 1980s
- ~50% savings achieved in 2013 codes
- Net Zero targeted in 2030

- *CA Title-24 Residential net-zero targeted by 2020 and Commercial net-zero targeted by 2030*



BUILDING ENERGY CODES



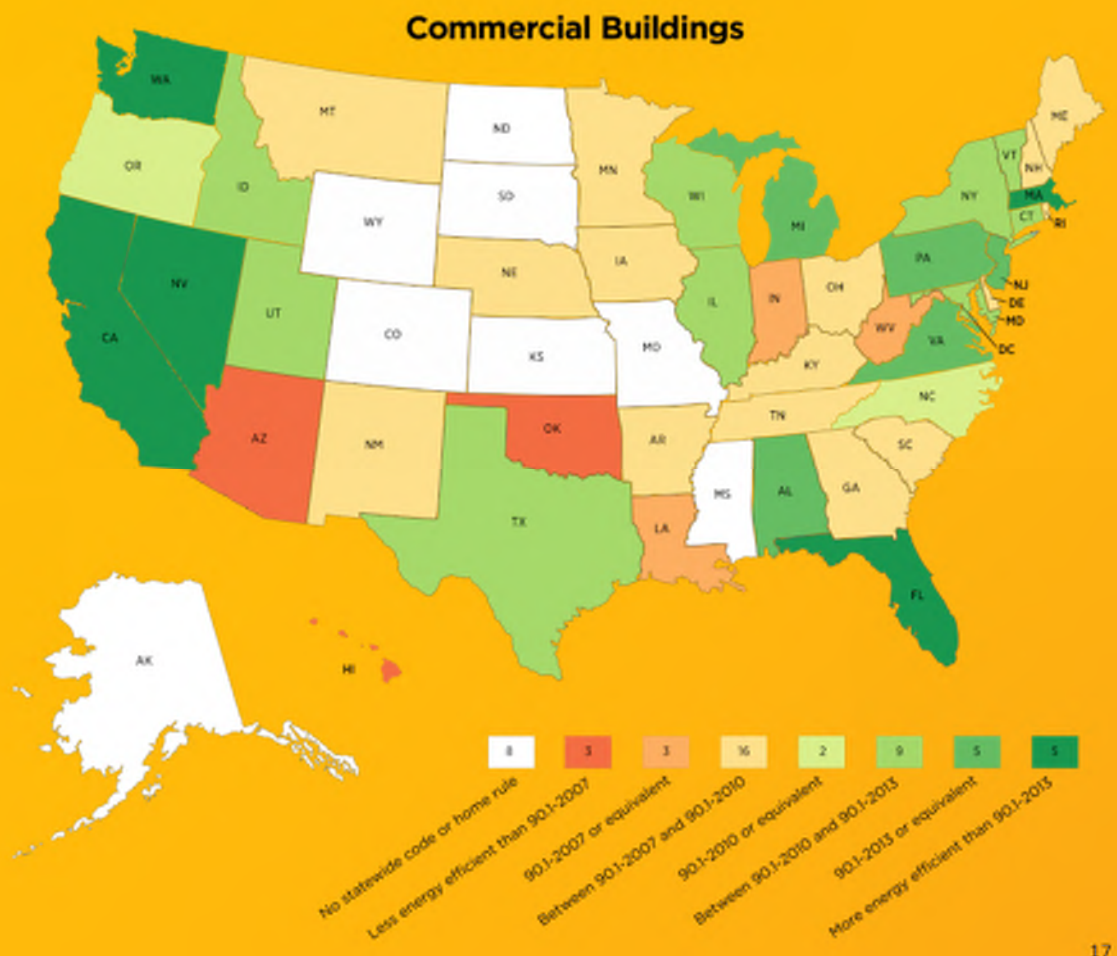
ASHRAE Standard 90.1

International Energy Conservation Code

State and Locally Adopted Codes

ENERGY CODE ADOPTION MAP

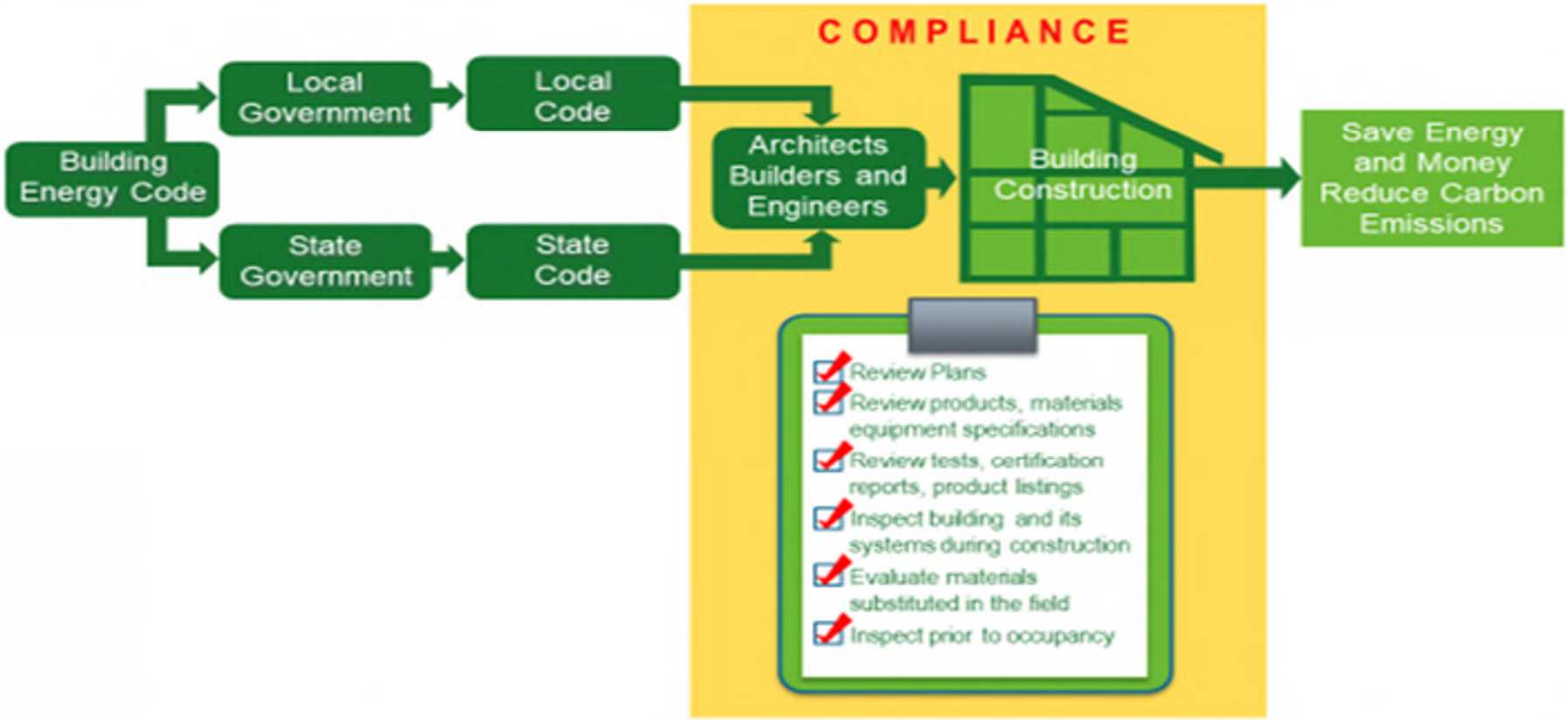
- 10 States – 90.1-2013 or better
- 27 States – 90.1-2007 to 2013
- 6 States – 90.1-2007 or lower
- 8 States – No Energy Codes



Updated as of December 2018
Source: https://www.energycodes.gov/adoptions/states

Codes and the Building Process

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



State Code Status: Washington

New Amendments to 2015 WSEC Effective July 1, 2019

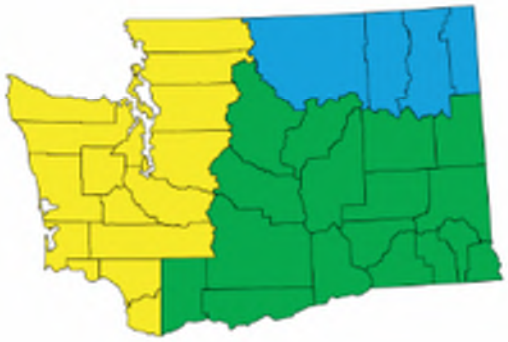
Current Commercial Code

2015 Washington State Energy Code (WSEC)
Based on the 2015 IECC with state-specific amendments
Passed 1/6/2016, effective 7/1/2016

Current Residential Code

2015 Washington State Energy Code (WSEC)
Based on 2015 IECC with state-specific amendments
Passed 1/6/2016, effective 7/1/2016

✓ Can use ***REScheck*** to show compliance.



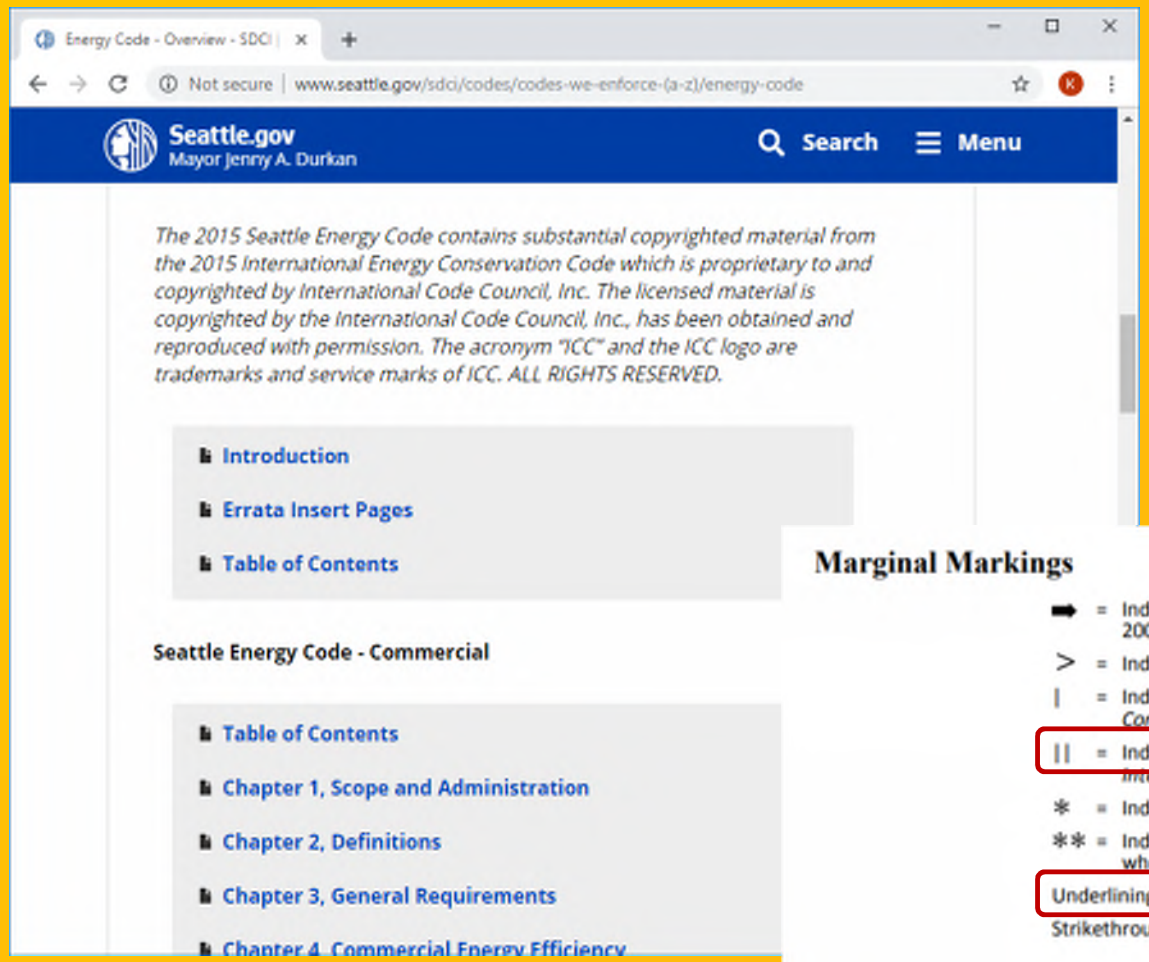
Climate Zones: 4C, 5B, 6B

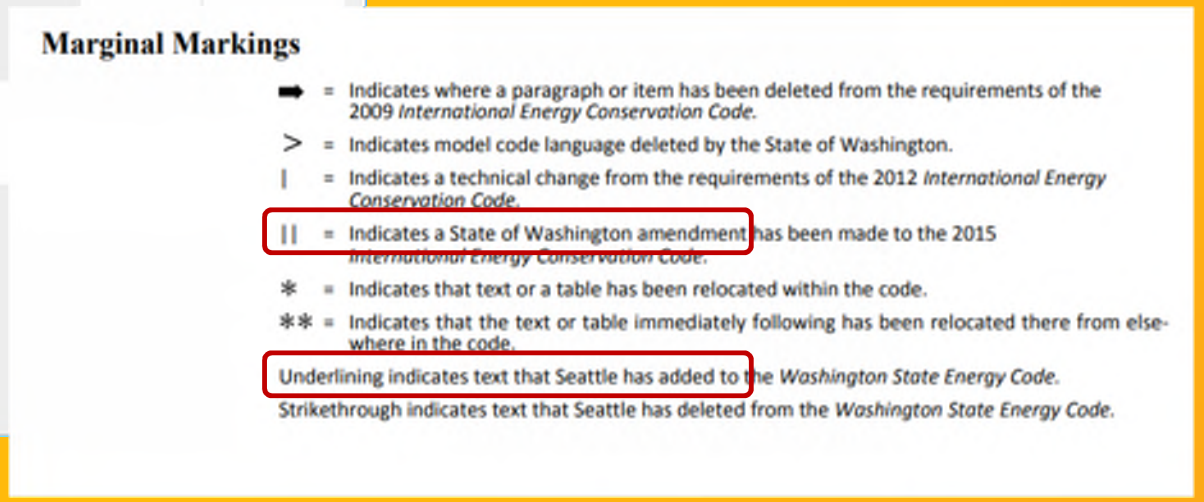
Code Enforcement

The State Building Code Act (Chapter 19.27 RCW) requires that each local jurisdiction enforce the State Building Code within its jurisdiction. Any jurisdiction can contract with another jurisdiction or an inspection agency to provide the mandated enforcement activities.

Source: http://bcapcodes.org/code-status/state/washington/

SEATTLE ENERGY CODE





- Based on WSEC 2015
- WSEC 2015 – Adapted from IECC 2015

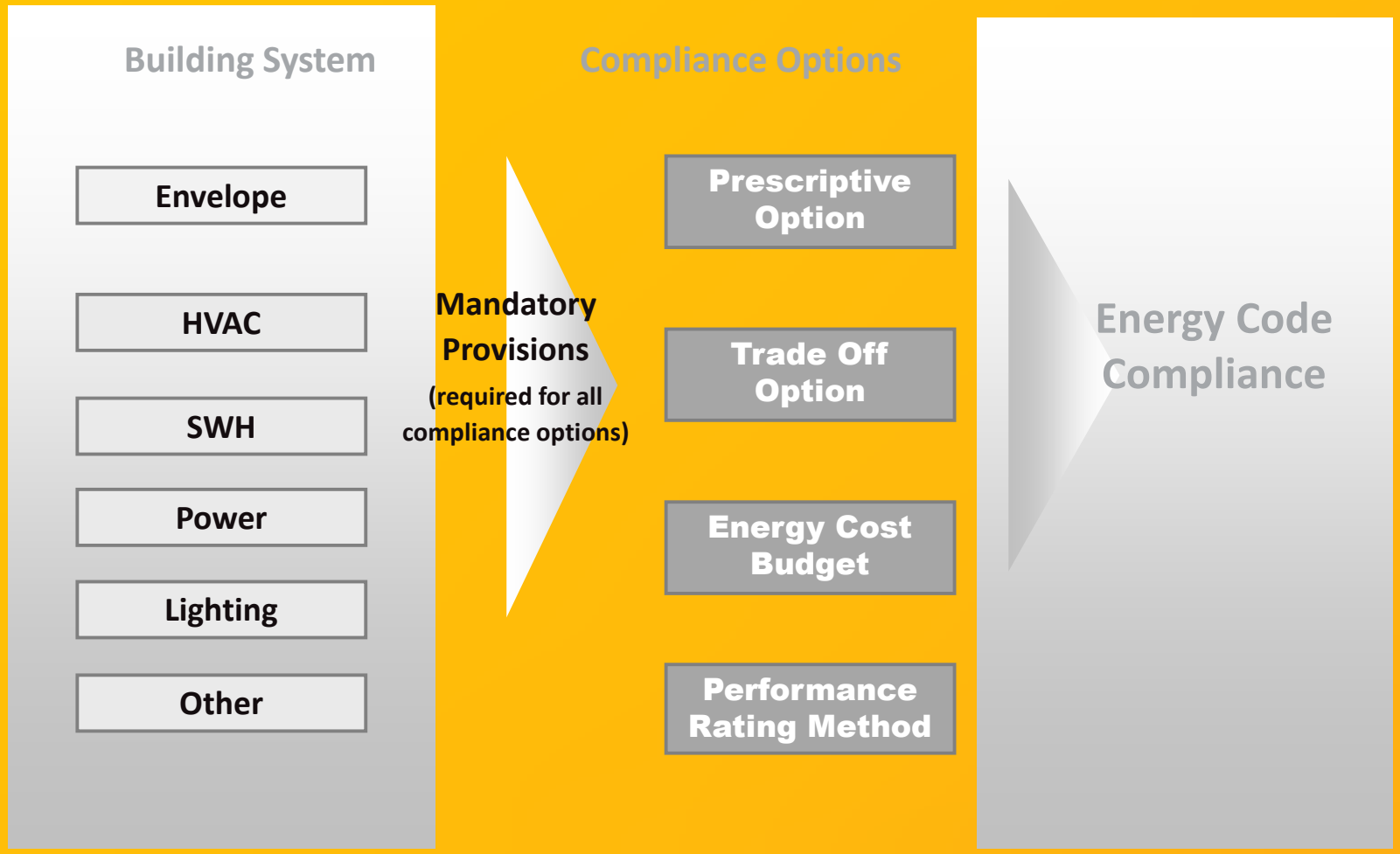
What Do Building Energy Codes and Standards Cover?

For both residential and commercial:

- Building Envelope
- Mechanical
- Service Water Heating
- Lighting
- Electrical Power

WSEC 2015 – COMMERCIAL ENERGY CODE PROVISIONS

Compliance Paths in Model Codes

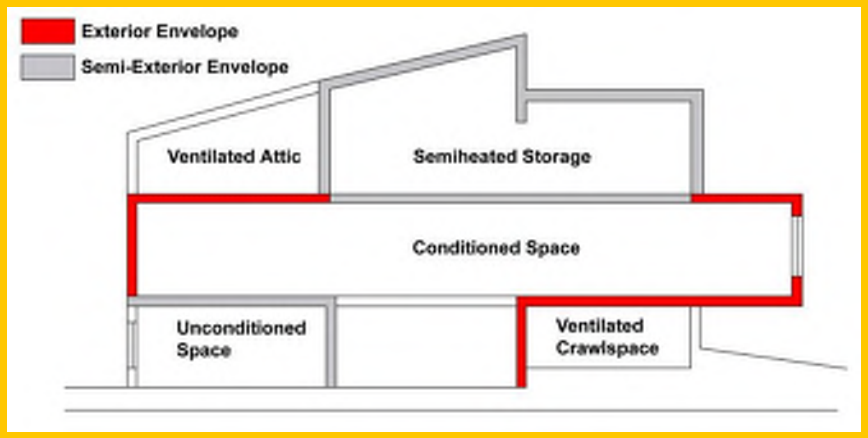


WSEC - COMMERCIAL CODE COMPLIANCE REQUIREMENT

C401.2 Application. Commercial buildings shall comply with one of the following:

1. The requirements of Sections C402, C403, C404, C405, C406, C408, C409 and C410.
2. The requirements of Section C407, C408, C409, C410, C402.5, C403.2, C404, C405.2, C405.3, C405.4, C405.6 and C405.7. The building energy consumption shall be equal to or less than 87, 90 or 93 percent of the *standard reference design* building, depending on the option selected per Section C407.3.

BUILDING ENVELOPE REQUIREMENTS – 2015 WSEC/C402



Building thermal envelope to comply with the following:

- Specific insulation requirements of Section C402.2
- Thermal requirements of either:
  - R-value-based method of Section C402.1.3
  - U-, C-, and F-factor-based method of Section C402.1.4 OR
  - Component performance alternative of Section C402.1.5
- Fenestration in building envelope assemblies C402.4
- Air Leakage of building envelope assemblies C402.5 (Mandatory)

SEATTLE ENERGY CODE COMPLIANCE PATHS

New commercial construction projects in Seattle can comply with the 2015 Seattle Energy Code (SEC) through one of three pathways:

1. **Prescriptive Path** (includes C402.1.5 Component Performance Alternative)
2. **Total Building Performance Path** (C407)
3. **Target Performance Path** (C401.3)

The Total Building Performance and the Target Performance paths each require whole building energy modeling.

The Total Building Performance Path uses only modeled performance to show code compliance.

The Target Performance Path also uses energy modeling to demonstrate that the proposed design is capable of hitting the operational performance target, but in addition, this path requires that the actual measured building energy consumption meets the target.

BUILDING ENVELOPE PRESCRIPTIVE COMPLIANCE OPTIONS

- Three Methods for compliance of building components:
  - C402.1.3 – Insulation component R-value based method
  - C402.1.4 – Assembly U-factor, C-factor or F-factor based method
  - C402.1.5 – Component Performance Alternative

THE PRESCRIPTIVE PATH – COMPONENT R-VALUE REQUIREMENTS (WSEC 2015)

Roof and Wall Assemblies

Table C402.1.3 - R-Value Method

CLIMATE ZONE	5 AND MARINE 4	
	All Other	Group R
Roofs		
Insulation entirely above deck	~~R-30ci~~ R-38ci	R-35ci
Metal buildings	R-25 + R-11 LS	R-25 + R-11 LS
Attic and other	R-49	R-49
Walls, Above Grade		
Mass	R-9.5ci	R-13.3ci
Metal buildings	~~R-13 + R-13ci~~ R-19ci	~~R-13 + R-13ci~~ R-19ci
Steel framed	R-13 + R-10ci	R-13 + R-8.5ci
Wood framed and other	R-21 int	R-21 int
Walls, Below grade		
Below grade walls	Same as above grade	Same as above grade

Table C402.1.4 - U-Factor Method

CLIMATE ZONE	5 AND MARINE 4	
	All Other	Group R
Roofs		
Insulation entirely above deck	~~U-0.032~~ U-0.027	~~U-0.032~~ U-0.027
Metal buildings	U-0.031	U-0.031
Attic and other	U-0.021	U-0.021
NEW - Joint or single rafter	U-0.027	U-0.027
Walls, Above Grade		
Mass	U-0.104	U-0.076
NEW – Mass transfer deck slab edge	U-0.20	U-0.20
Metal buildings	U-0.052	U-0.052
Steel framed	U-0.064	U-0.064
Wood framed and other	U-0.064	U-0.064
Walls, Below grade		
Below grade walls	Same as above grade	Same as above grade

- C402.1.4.1 Thermal resistance of cold-formed steel walls
  - U-factors of walls with cold-formed steel studs may be determined per Equation 4-1:

$$U = 1/[Rs + (ER)]$$

Rs = The cumulative *R*-value of the wall components along the path of heat transfer, excluding the cavity insulation and steel studs.

ER = The effective *R*-value of cavity insulation per Table C402.1.4.1.

Table C402.1.3 Alternate Prescriptive R-value Table

Assemblies with continuous insulation (see definition)	Alternate option for assemblies with metal penetrations, greater than 0.04% but less than 0.08%	Alternate option for assemblies with metal penetrations, greater than or equal to 0.08% but less than 0.12%
R-9.5ci	R-11.8ci	R-13ci
R-11.4ci	R-14.3ci	R-15.7ci
R-13.3ci	R-16.6ci	R-18.3ci
R-15.2ci	R-19.0ci	R-21ci
R-30ci	R-38ci	R-42ci
R-38ci	R-48ci	R-53ci
R-13 + R-7.5ci	R-13 + R-9.4ci	R-13 + R-10.3ci
R-13 + R-10ci	R-13 + R-12.5ci	R-13 + R-13.8ci
R-13 + R-12.5ci	R-13 + R-15.6ci	R-13 + R-17.2ci
R-13 + R-13ci	R-13 + R-16.3ci	R-13 + R-17.9ci
R-19 + R-8.5ci	R-19 + R-10.6ci	R-19 + R-11.7ci
R-19 + R-14ci	R-19 + R-17.5ci	R-19 + R-19.2ci
R-19 + R-16ci	R-19 + R-20ci	R-19 + R-22ci
R-20 + R-3.8ci	R-20 + R-4.8ci	R-20 + R-5.3ci
R-21 + R-5ci	R-21 + R-6.3ci	R-21 + R-6.9ci

Prescriptive Steel-Framed Wall

THE PRESCRIPTIVE PATH – COMPONENT R-VALUE REQUIREMENTS (WSEC 2018)

Roof and Wall Assemblies

Table C402.1.3 - R-Value Method

CLIMATE ZONE	5 AND MARINE 4	
	All Other	Group R
Roofs		
Insulation entirely above deck	~~R-38ci~~ R-38ci	R-38ci
Metal buildings	~~R-25 +~~ R-25 + R-11 LS	~~R-25 +~~ R-25 + R-11 LS
Attic and other	R-49	R-49
Walls, Above Grade		
Mass	R-9.5ci	R-13.3ci
Metal buildings	~~R-13 + R-13ci~~ R-19ci	~~R-13 + R-13ci~~ R-19ci
Steel framed	R-13 + R-10ci	R-19 + R-8.5ci
Wood framed and other	R-21 int	R-21 int
Walls, Below grade		
Below grade walls	Same as above grade	Same as above grade

Walls, Above Grade		
Mass	R-9.5* ci	R-13.3ci
Mass transfer deck slab edge	R-5	R-5
Metal building	R-19ci or R-13+13ci	R-19ci or R-13+13ci
Steel framed	R-13 + R-10ci	R-19 + R-8.5ci
Wood framed and other	R-21 int or R-15+5ci std	~~R-21 int~~ R-13+7.5ci std or R-20+3.8ci std or R-25 std

No change to U-factor method, except the U-factor change from U-0.054 to U-0.051 for "Wood frame and other" assemblies

COMPONENT PERFORMANCE APPROACH (WSEC 2015)

C402.1.5 Component performance alternative. Building envelope values and *fenestration areas* determined in accordance with Equation 4-2 shall be permitted in lieu of compliance with the *U*-, *F*- and *C-factors* in Tables C402.1.3 and C402.1.4 and the maximum allowable *fenestration areas* in Section ((~~C402.4~~)) C402.4.1.

A + B + C + D + E ≤ Zero (Equation 4-2)

where:

A = Sum of the (UA Dif) values for each distinct assembly type of the *building thermal envelope*, other than slabs on grade ((~~and below-grade walls~~)).

- UA Dif = UA Proposed - UA Table.
- UA Proposed = Proposed *U*-value x Area.
- UA Table = (*U*-factor from Tables C402.1.4 or C402.4 ((~~or Section C402.1.3~~)) x Area.

B = Sum of the (FL Dif) values for each distinct slab-on-grade perimeter condition of the *building thermal envelope*.

- FL Dif = FL Proposed - FL Table.
- FL Proposed = Proposed *F*-value x Perimeter length.
- FL Table = (*F*-factor specified in Table C402.1.4) x Perimeter length.

$C = (CA \times UV) - (CA \times U_{Wall})$, but not less than zero

- CA = (Proposed *Vertical Fenestration Area*) – (*Vertical Fenestration Area* allowed)
- UA Wall = Sum of the (UA Proposed) values for each opaque assembly of the exterior wall
- UAW = Sum of the (UA Proposed) values for each above-grade wall assembly
- U_{Wall} = UAW/sum of wall area (excludes *vertical fenestration area*)
- UAV = Sum of the (UA Proposed) values for each *vertical fenestration* assembly
- UV = UAV/total *vertical fenestration area*

Where the proposed skylight area is less than or equal to the skylight area allowed by Section C402.4.1, the value of D (Excess Skylight Value) shall be zero. Otherwise:

$D = (DA \times US) - (DA \times U_{Roof})$, but not less than zero

- C402.1.5 Component performance UA calculation
  - U-factor * Area Trade-off Path
  - Allows one or more envelope elements that are better than Code to make up the difference for other envelope elements that do not meet Code.
  - When the percentage of fenestration exceeds the maximum allowed, the Code Target UA is adjusted to make up for the extra fenestration. (Target area adjustment)

COMPONENT PERFORMANCE APPROACH (WSEC 2018)

C402.1.5 Component performance alternative. Building envelope values and fenestration areas determined in accordance with Equation 4-2 shall be permitted in lieu of compliance with the *U*-factors and *F*-factors in Table C402.1.4 and C402.4 and the maximum allowable fenestration areas in Section C402.4.1.

For buildings with more than one *space conditioning category*, component performance compliance shall be demonstrated separately for each space conditioning category. Interior partition ceilings, walls, fenestration and floors that separate space conditioning areas shall be applied to the component performance calculations for the space conditioning category with the highest level of space conditioning.

~~A + B + C + D~~ **Proposed Total UA** ≤ ~~Zero~~ **Allowable Total UA** **(Equation 4-2)**

Proposed total UA	=	UA-glaz-prop + UA sky-prop + UA-opaque-prop + FL-slab-prop
Allowable total UA	=	UA-glaz-allow + UA-glaz-excess + UA sky-allow + UA-sky-excess + UA-opaque-allow + FL-slab-allow

C402.1.5.2 SHGC rate calculations. Solar heat gain coefficient shall comply with Table C402.4. The target $SHGCA_t$ and the proposed $SHGCA_p$ shall be calculated using Equations 4-3 and 4-4 and the corresponding areas and SHGCs from Table C402.4.

~~EQUATION 4-3~~
~~TARGET SHGCA$_t$~~

Proposed Total SHGCxA ≤ Allowable Total SHGCxA **(Equation 4-3)**

FENESTRATION PRESCRIPTIVE REQUIREMENTS (WSEC 2015)

- C402.4.1 - Prescriptive maximum area
  - ***Area Limit = 30%***
  - Calculated per gross above-grade wall area.
  - Fenestration area limit does not include opaque doors or opaque spandrel.
- Three alternates available that increase the area limit to ***40%***
  1. Substantial daylit zone area
  2. High performance fenestration
  3. NEW - High performance DOAS system
- Fenestration alternates allowed for Component Performance but not Total Building Performance.

Vertical Fenestration and Skylights

Table C402.4 - U-Factor & SHGC

CLIMATE ZONE	5 AND MARINE 4	
Vertical Fenestration		
U-Factor		
Non-metal framing (all)	U-0.30	
Metal framing (fixed)	U-0.38	
Metal framing (operable)	U-0.40	
Metal framing (entrance doors)	U-0.60	
SHGC		
Orientation	SEW	N
PF < 0.2	0.4	0.53
0.2 =< PF < 0.5	0.48	0.58
PF >= 0.5	0.64	0.64
Skylights		
U-factor	0.5	
SHGC	0.35	

- SHGC multipliers have been pre-applied.
- Area-weighting of fenestration U-Factors between ***like*** fenestration categories is allowed.

FENESTRATION PRESCRIPTIVE REQUIREMENTS (WSEC 2018)

C402.4.1 Maximum area. The total building vertical fenestration area (not including opaque doors and opaque spandrel panels) shall not exceed 30 percent of the total building gross above-grade wall area. The skylight area shall not exceed 5 percent of the total building gross roof area (skylight-to-roof ratio).

C402.4.1.1 Vertical fenestration maximum area with high performance alternates. For buildings that comply with Section C402.4.1.1.1 or C402.4.1.1.2, the total building vertical fenestration area is permitted to exceed 30 percent but shall not exceed 40 percent of the gross above grade wall area for the purpose of prescriptive compliance with Section C402.1.4.

- No less than 50 percent of the total conditioned floor area in the building is within the daylight zone that includes daylight responsive controls
- VT is greater than or equal to 1.1 times the SHGC or 0.50 which ever is greater

CLIMATE ZONE	5 AND MARINE 4
~~Vertical Fenestration~~ *U*-factor for Class AW windows rated in accordance with AAMA/CSA101/I.S.2/A440, vertical curtain walls and site-built fenestration products[a]	
Fixed[b] *U*-factor	U-0.38
Operable[c] *U*-factor	U-0.40
~~*U*-factor~~ *Entrance doors*[d]	
~~Nonmetal framing (all)~~ *U*-factor	~~0.30~~ U-0.60
~~Metal framing (fixed)~~	~~0.38~~
U-factor for all other vertical fenestration	
U-factor	U-0.30
~~Metal framing (operable)~~	~~0.40~~
~~Metal framing (entrance doors)~~	~~0.60~~

SHGC for all vertical fenestration		
Orientation	SEW	N
PF < 0.2	~~0.40~~0.38	~~0.53~~0.51
0.2 ≤ PF < 0.5	~~0.48~~0.46	~~0.58~~0.56
PF ≥ 0.5	~~0.64~~0.61	~~0.64~~0.61
Skylights		
***U*-factor**	U-0.50	
SHGC	0.35	

COMPLIANCE TOOLS

NEEA WSEC Tool

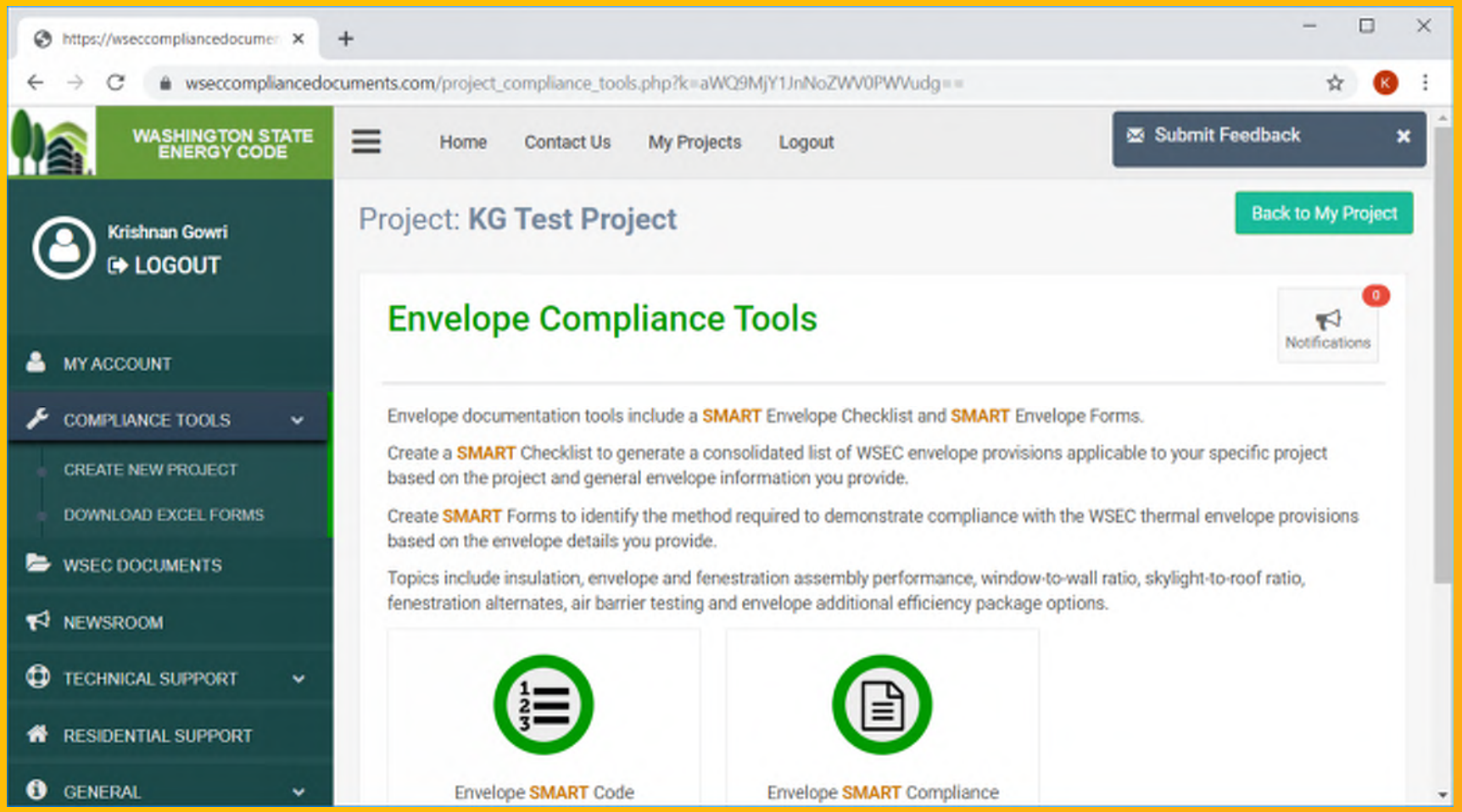
- Web-based
- Prescriptive/UA Compliance
- On-line Submission
- Spreadsheet, compliance checklist

COM*check*

- Web-based/Desktop
- No WA state version available

WSEC COMPLIANCE TOOL

https://wseccompliancedocuments.com/index.php



THE PRESCRIPTIVE PATH (WSEC 2015)

Projects pursuing the prescriptive option are required to comply with at least two additional efficiency package options, per **Section C406.**
This is in addition to meeting the prescriptive envelope requirements.

Additional efficiency package options are **:**

- **Increased HVAC performance**
- **Reduced lighting power**
- **Enhanced lighting controls**
- **On-site renewable energy**
- **Dedicated Outdoor Air System**
- **High-Efficiency Service Water Heating**
- **Enhanced Envelope Performance**
- **Reduced Air Infiltration**

ADDITIONAL EFFICIENCY PACKAGE OPTIONS – ENVELOPE (WSEC 2015)

- Enhanced Envelope Performance
  - Total UA of building thermal envelope as designed to be not less than 15% below total UA of building thermal envelope per Section C402.1.5
- Reduced Air Infiltration
  - Air infiltration verified by whole-building pressurization test
    - Per ASTM E779 or ASTM E1827
    - By independent third party
  - Measured air-leakage rate not to exceed 0.25 cfm/ft² under pressure differential of 0.3 inches w.c. (75 Pa), with calculated surface area the sum of above – and below-grade building envelope
  - Submit report to code official and building owner
    - Including: tested surface area, floor area, air by volume, stories above grade, and leakage rates

THE PRESCRIPTIVE PATH (WSEC 2018)

SECTION C406
~~ADDITIONAL~~ EFFICIENCY PACKAGE ~~OPTION~~S

C406.1 ~~Requirements~~Additional energy efficiency credit requirements. ~~Buildings shall comply with no less than two of the following.~~New buildings and changes in space conditioning, change of occupancy and building additions in accordance with Chapter 5 shall comply with sufficient packages from Table C406.1 so as to achieve a minimum number of six credits. Mixed use buildings shall have a conditioned space area weighted average number of credits by building occupancy of at least six credits.

TABLE C406.1
EFFICIENCY PACKAGE CREDITS

Code Section	Commercial Building Occupancy					
	Group R-1	Group R-2	Group B	Group E	Group M	All Other
	Additional Efficiency Credits					
1. More efficient HVAC performance in accordance with Section C406.2	2.0	3.0	3.0	2.0	1.0	2.0
2. Reduced lighting power: Option 1 in accordance with Section C406.3.1	1.0	1.0	2.0	2.0	3.0	2.0
3. Reduced lighting power: Option 2 in accordance with Section C406.3.2[a]	2.0	3.0	4.0	4.0	6.0	4.0
4. Enhanced lighting controls in accordance with Section C406.4	NA	NA	1.0	1.0	1.0	1.0
5. On-site supply of renewable energy in accordance with C406.5	3.0	3.0	3.0	3.0	3.0	3.0
6. Dedicated outdoor air system in accordance with Section C406.6[b]	4.0	4.0	4.0	NA	NA	4.0
7. High performance dedicated outdoor air system in accordance with Section C406.7	4.0	4.0	4.0	4.0	4.0	4.0
8. High-efficiency service water heating in accordance with Sections C406.8.1 and C406.8.2	4.0	5.0	NA	NA	NA	8.0
9. High performance service water heating in multi-family buildings in accordance with Section C406.9	7.0	8.0	NA	NA	NA	NA
10. Enhanced envelope performance in accordance with Section C406.10	3.0	6.0	3.0	3.0	3.0	4.0
11. Reduced air infiltration in accordance with Section C406.11	1.0	2.0	1.0	1.0	1.0	1.0
12. Enhanced commercial kitchen equipment in accordance with Section C406.12	5.0	NA	NA	NA	5.0	5.0 (Group A-2 only)

a. Projects using this option may not use Item 2.
b. This option is not available to buildings subject to the prescriptive requirements of Section C403.3.5.

ADDITIONAL EFFICIENCY PACKAGE OPTIONS – ENVELOPE (WSEC 2018)

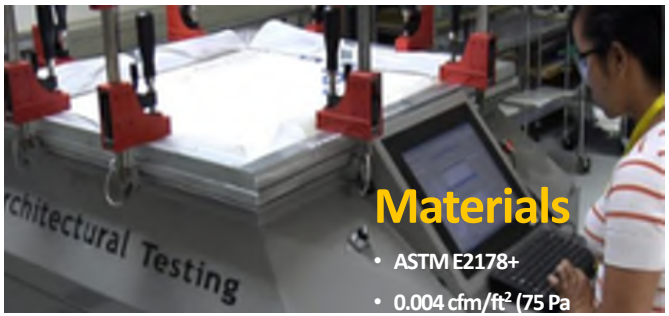
- Enhanced Envelope Performance
- *(no change)*
  - Total UA of building thermal envelope as designed to be not less than 15% below total UA of building thermal envelope per Section C402.1.5

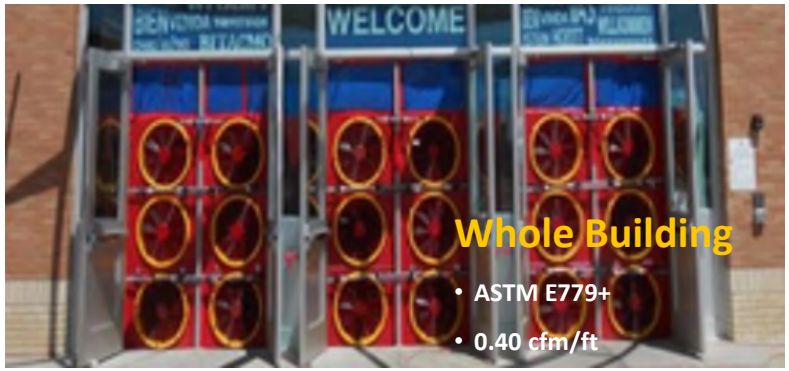
- Reduced Air Infiltration
  - Air infiltration verified by whole-building pressurization test
    - Per ASTM E779 or ASTM E1827
    - By independent third party
  - Measured air-leakage rate not to exceed **0.17 cfm/ft²** under pressure differential of 0.3 inches w.c. (75 Pa), with calculated surface area the sum of above – and below-grade building envelope
  - Submit report to code official and building owner
    - Including: tested surface area, floor area, air by volume, stories above grade, and leakage rates

MANDATORY REQUIREMENTS

- Air Leakage
- Air Barriers
- Fenestration Air Leakage
- Rooms Containing Fuel-Burning Appliances
- Air intakes, exhaust openings, stairways and shafts
- Loading dock weather seals
- Vestibules
- Recessed lighting

WSEC AIR BARRIER REQUIREMENTS





Air Barrier Requirement

The Air Barrier is the protection layer designed to separate the conditioned air from the ambient air. In most cases, the Weather Resistive Barrier (WRB) also acts as the air barrier. In rare cases you may design the air barrier to be the interior sheathing of the exterior wall. Other system materials may include membrane roofs, floor slabs, concrete floors, gypsum wall board (GWB) ceiling lids, closed cell spray foam, and roofing underlayment.

Materials installed as air barriers must have an air permeance of less than 0.004 cfm/ft² @ 75 Pa

Systems installed with air barrier materials must have an air permeance of less than 0.04 cfm/ft² @ 75 Pa

Buildings installed with air barrier systems must have a permeance of less than 0.40 cfm/ft² @ 75 Pa

(0.30 cfm/ft² - SEC; 0.25 cfm/ft² - Enhanced Efficiency Option)

AIR BARRIER REQUIRMENTS
WSEC ENERGY CODE UPDATE

Building Test Provision

2015 WSEC

- Target = 0.4 cfm per SF
- SF = Square foot area of the air barrier boundary
- Test pressure = 0.3" w.g. or 75 pascals
- Must perform test but meeting the target is optional.
- Follow-up leak-sealing efforts required if building doesn't pass.
- Re-testing not required.

2015 SEC Provisions

- Target = **0.3** cfm per SF

2018 WSEC

- Target = **0.25** cfm per SF
- Passing Target = **0.4** cfm per SF
- ***All commercial buildings will be required to pass!***

Additional Efficiency Credit

2015 WSEC

- Target = 0.25 cfm per SF
- ***Building must pass***

2018 WSEC

- Target = **0.17** cfm per SF
- Accounts for one credit (or two for Group R-2)
- ***Building must pass***

Image courtesy of Neudorfer Engineers

Example of a 34-story high rise that had a tested leakage rate of 0.20 cfm/sf!

What if the building fails the building enclosure test?

- Per the **2018 WSEC**, if the building fails the test…
  - Conduct inspection of all air barrier elements.
  - Document identified sources of air leakage and corrective action taken to remedy.
  - **Re-test until the building passes the 0.4 cfm/SF required maximum leakage rate.**
  - Provide test results to the code official.

Air Barrier 101

The **GOLDEN** rule:

The air barrier must be continuous. All air barrier materials must interface in such a way that the boundary is continuous along all 6-planes of the building.

Things to consider:

Penetrations Through the Air Barrier – Windows, Doors, HVAC, Electrical Outlets

Surface Mounted Materials – Thermal Bridge, Material Compatibility, Durability

Building Joints – Structural Movement, Sealant Dependent Details, Wear and Tear

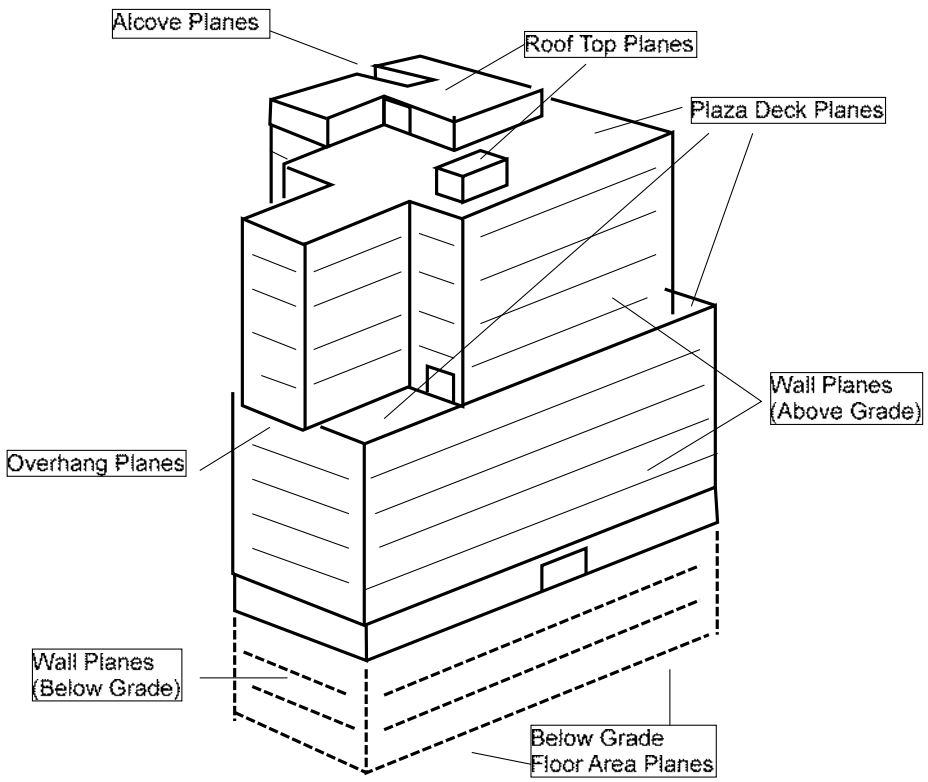
AIR BARRIER CONSTRUCTION - SECTION C402.5.1.1

- Continuous air barrier required
- Air barrier placement allowed:
  - Inside of building envelope
  - Outside of building envelope
  - Located within assemblies composing envelope OR
  - Any combination thereof
- Continuous for all assemblies part of the thermal envelope and across joints and assemblies
- Joints and seams sealed including sealing transitions in places and changes in materials, securely installed in or on the joint for its entire length to not dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation

AIR BARRIER CONSTRUCTION – SECTION C402.5.1.1

- Penetrations of air barrier and air leakage paths to be caulked, gasketed or otherwise sealed in a manner compatible with construction materials and location (sealing to allow for expansion, contraction and mechanical vibration)
- Joints and seals
  - Sealed in same manner or taped
- Sealing of concealed fire sprinklers where required in a manner recommended by manufacturer
  - Caulking or other adhesive sealants should not be used to fill voids between fire sprinkler cover plates and walls, or ceilings
- Recessed lighting to comply with C402.5.8
- Where similar objects are installed that penetrate the air barrier, make provisions to maintain the air barrier's integrity

PERMIT SET



Air Barrier Enclosure Area (ABEA):
Floor plan + Roof plan (sim.) +
All Vertical Planes = **ABEA**

Example:
100,000 + 100,000 + 25,298 = 225,298 ft²

Allowable Leakage Rate = 0.40 cfm / ft²

225,298 x 0.40 = 90,119 allowable cfm
90,119 x .0007449 = 67 ft. sq. (8’ x 8’)

WHERE TO LOCATE THE WHOLE BUILDING AIR TEST IN THE PROJECT SPECIFICATIONS

Specification Section 01 41 00 – Air Barrier Test

Specification Section 07 27 26 – Fluid-Applied / Sheet-applied Air and Vapor Barriers

Extra Credit:

G-sheet mention of the 2015 Energy Code (State of Washington or City of Seattle)

EQUIPMENT – BLOWER DOORS

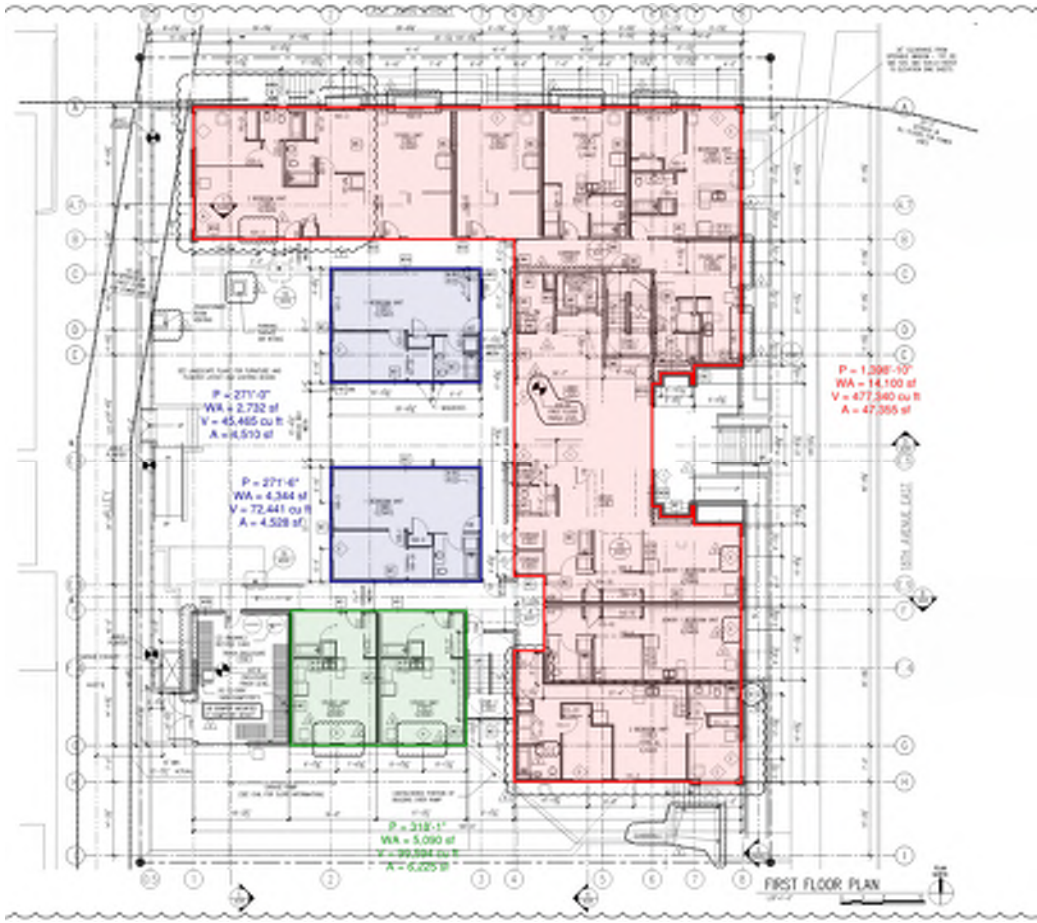
Equipment Layout

The importance of correct and accurate equipment placement:

…to within ± 10% of the measured inside/outside pressure difference.

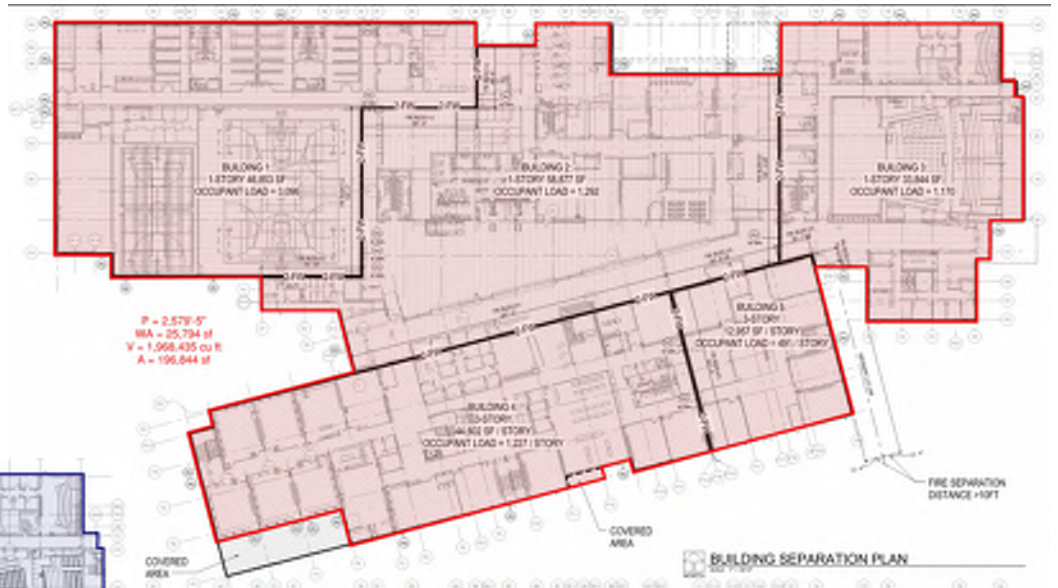
- **Fan placement –**
  - **In a well designed and constructed building, fans can be grouped close together in one section of the building and still achieve pressure equalization throughout the entire building.**
  - **In a building that has significant air leakage, fans will need to separated and staged in multiple area throughout the building to overcome the effects of air loss.**
    - **Example: In a 6-story multi-family building, six (6) fans were set-up in the main entry vestibule. Preliminary pressure verification found a significant pressure drop at the 4th floor. The single stairwell in the building was a choke point. We had to re-install 3 fans in the 6th Floor stairwell (roof access) door to achieve pressure equalization.**

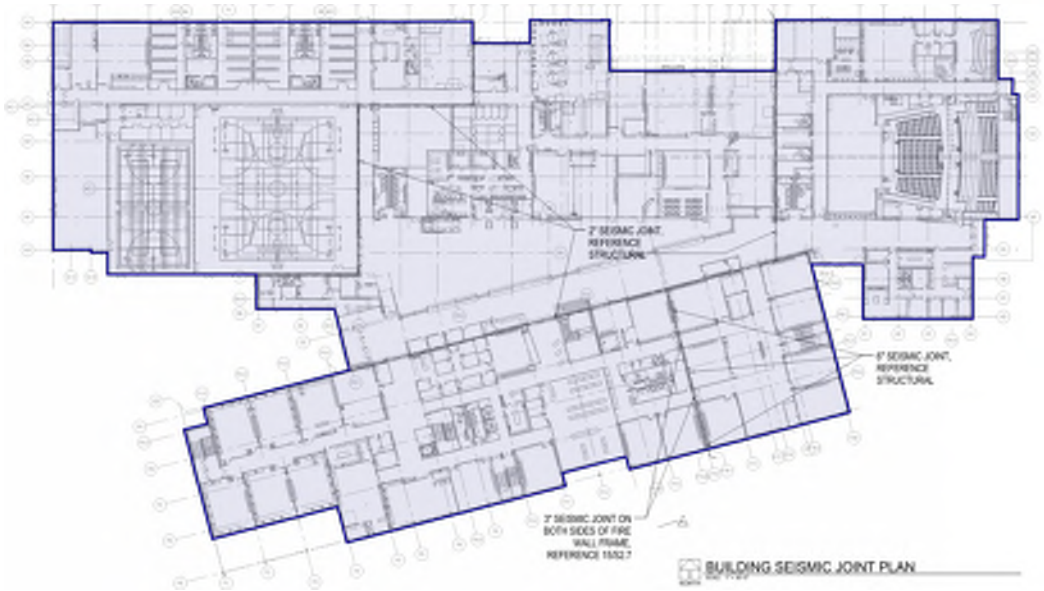
Equipment Layout



…to within ± 10% of the measured inside/outside pressure difference.

Equipment Layout

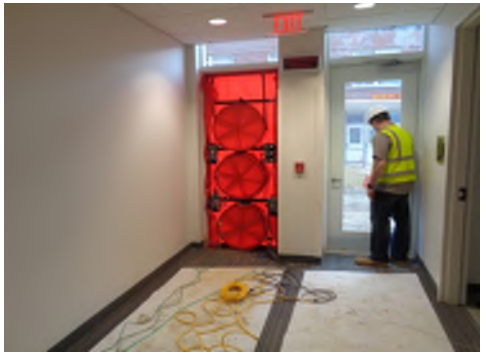




…to within ± 10% of the measured inside/outside pressure difference.

EQUIPMENT – LAYOUT

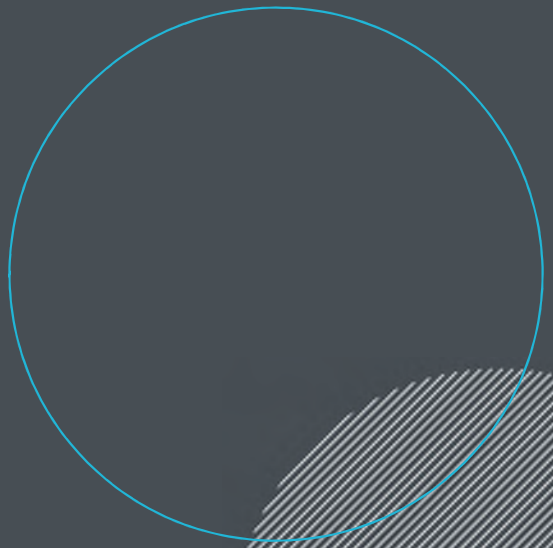
…to within ± 10% of the measured inside/outside pressure difference.



DIAGNOSTIC TOOLS

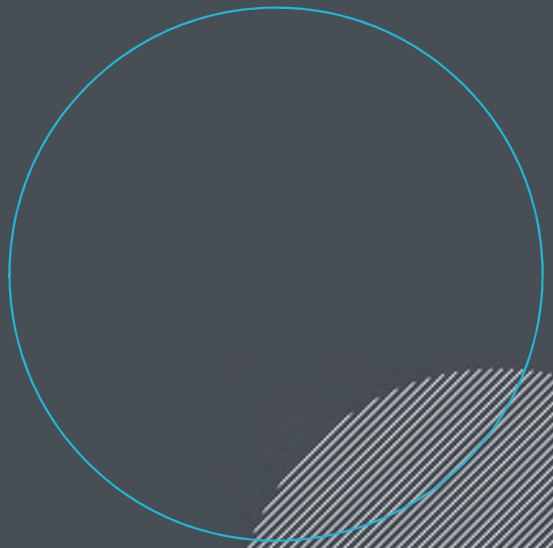
DO's:

- Provide Air Barrier Boundary Drawings in your Documents
  - Clearly define your design intent. You do not want test results that do not accurately account for the air barrier boundary.
- Know the air barrier area and insist the testing firm use it for the test
  - The air barrier area is crucial in determining the flow allowance and the test/fail result.
- Ask to review the testing layout prior to the test
  - Verify proper set-up. Does the layout make sense? Will the results be based on the code requirements?
- Plan to be present during the test
  - Verify the test is performed as planned, and if not, know why.

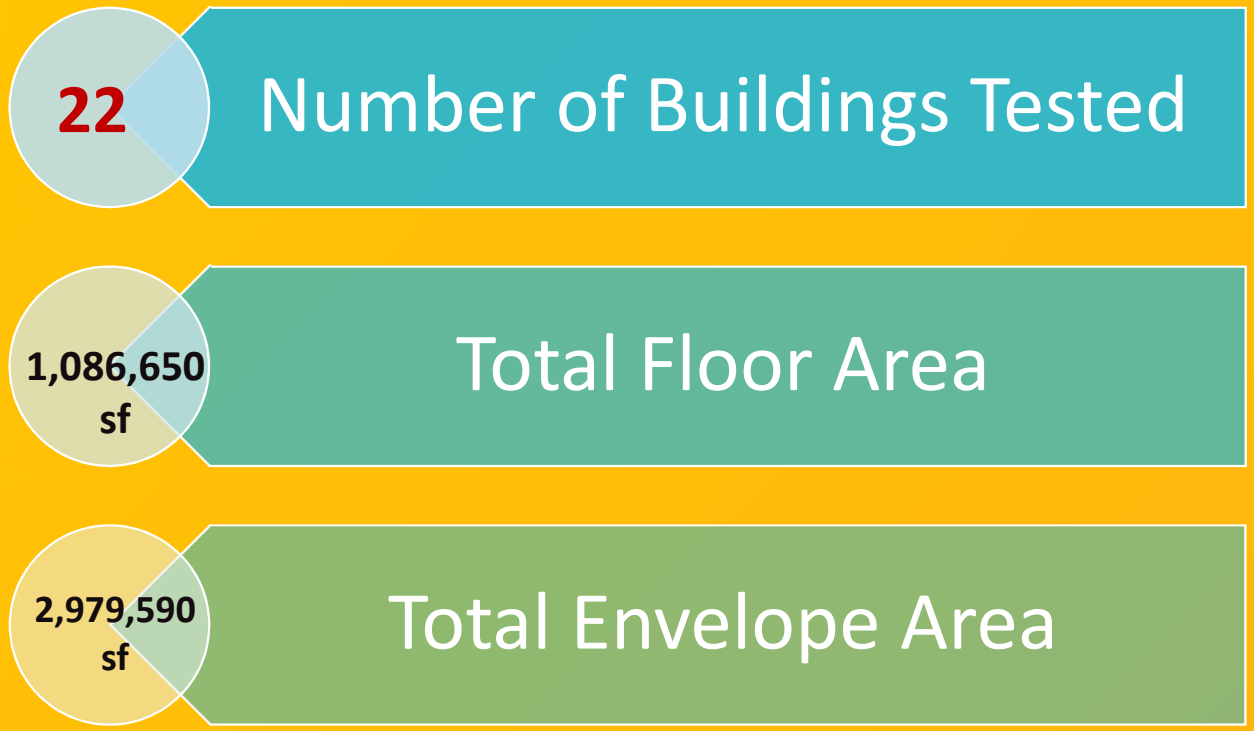


DO NOT:

- Accept passing test results EXTRAPOLATED below 60Pa without an explanation
    - Extrapolation is a guess based on collected data at lower pressures. It does not account for the possibility of failure under higher pressures.
- Base your test firm selections on price alone
    - There are plenty of firms that say they can test your building, but are they doing it correctly? The Owner can not afford to have a test report thrown out by an experienced Code Official.



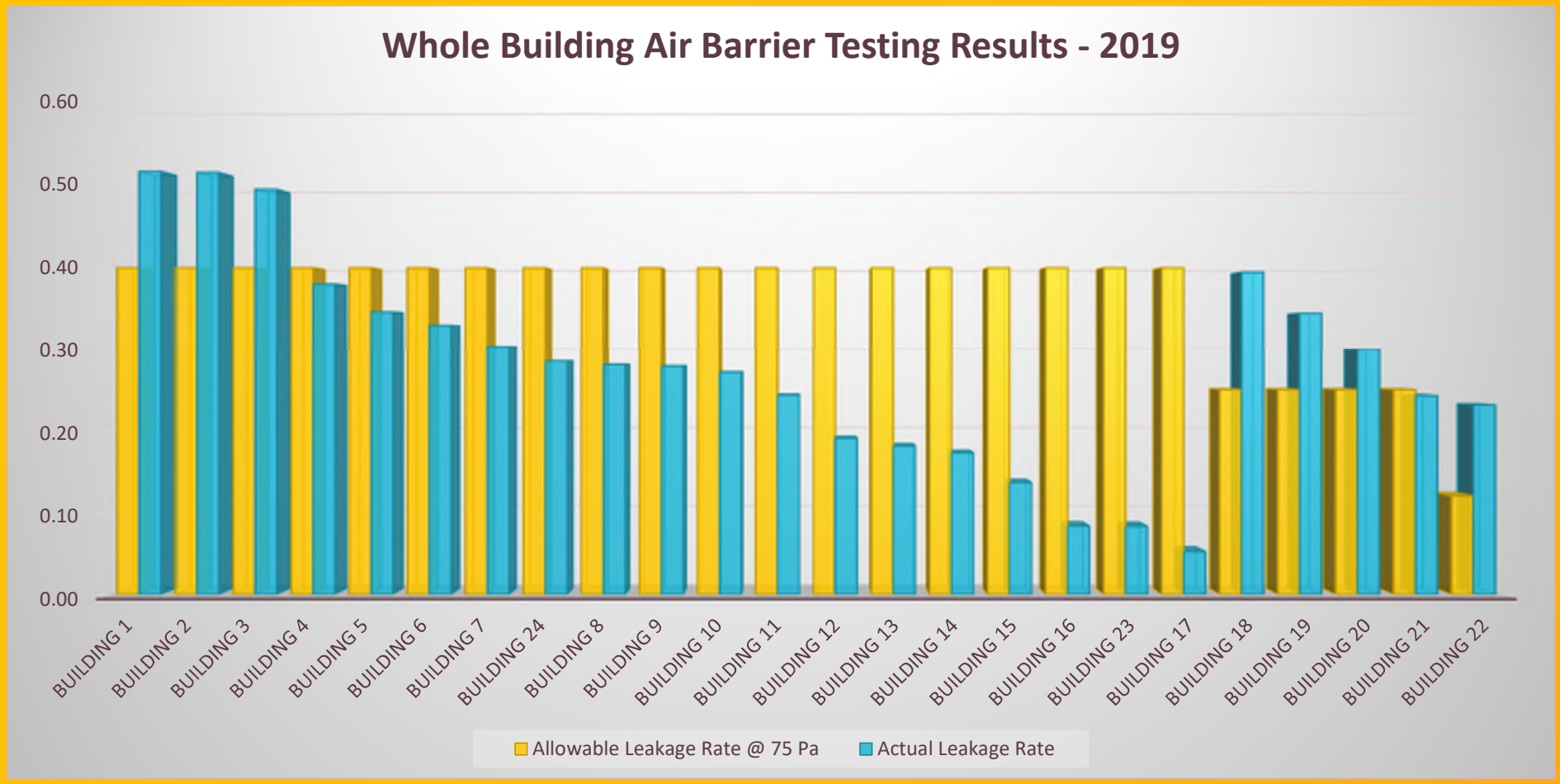
SEATTLE AIR-BARRIER PERFORMANCE – OUR OBSERVATIONS



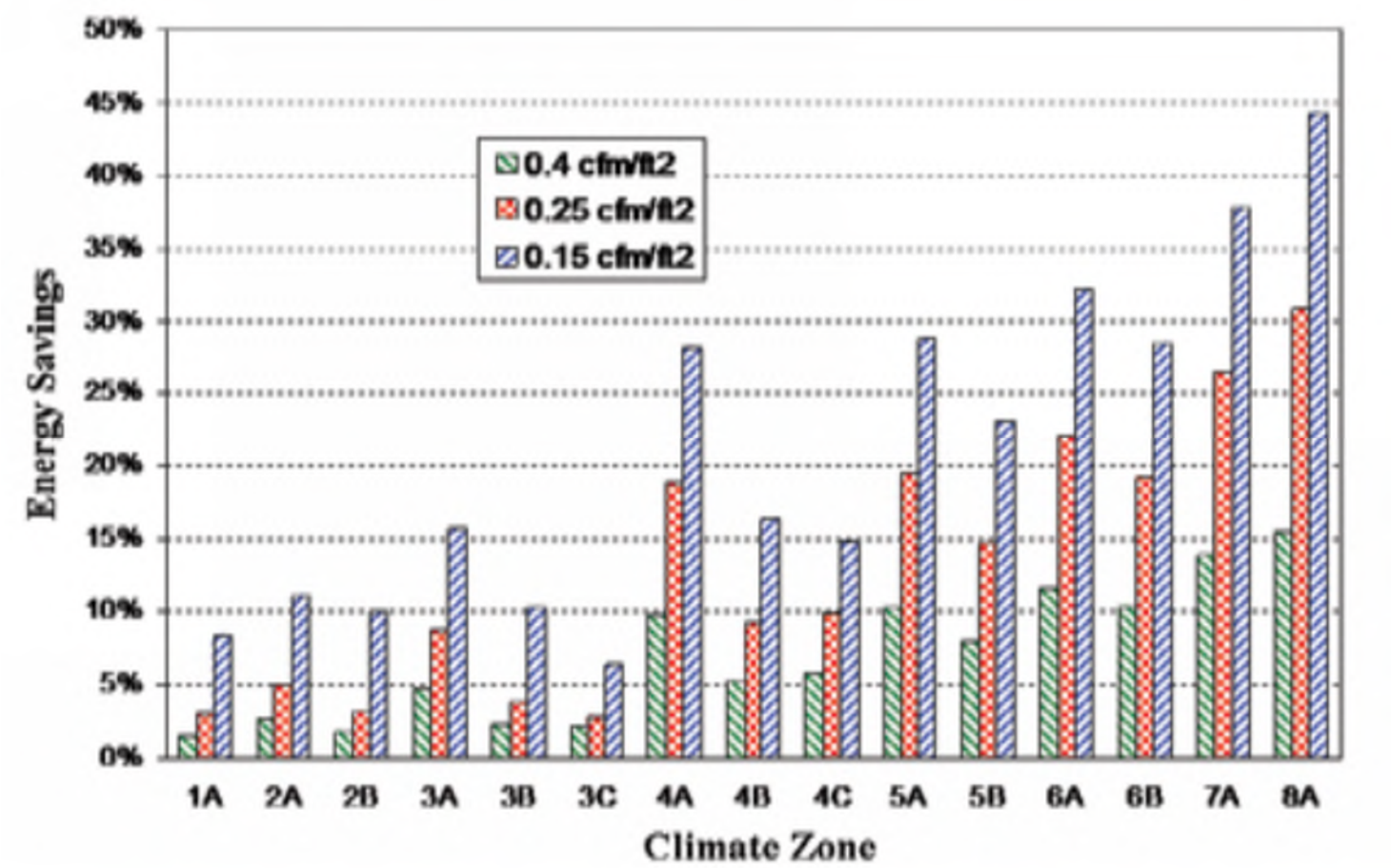
Average = 0.286 cfm/sf

Highest = 0.518 cfm/sf
Lowest = 0.052 cfm/sf

SEATTLE AIR-BARRIER PERFORMANCE – OUR OBSERVATIONS



MATERIALS, ASSEMBLIES, AND THE WHOLE BUILDING



Credit: Journal of Building Enclosure Design Summer 2011 "Improvement of Air Tightness in U.S. Army Buildings" pgs. 11-13

UPCOMING CHANGES TO ASHRAE 90.1-2019 AND BEYOND

- An Informative Appendix on Commissioning Requirements
  - Provides guidance on best practices for stand-alone functional performance testing (FPT) and commissioning processes (including FPT) that relate to Sections 4.2.5, 5.9, 6.9, 7.9, 8.9, 9.9, 10.9, 11.2(d), and G1.21(c) of Standard 90.1.

- Envelope Backstop – Alternative methods of complying to envelope requirements
- Thermal Bridging Requirements (Could be delayed beyond 2019)

Prescriptive structural/insulation detailing solutions

- Roof-wall intersections
- Wall-floor intersections
- Fenestration-wall intersection
- Shading devices/fins/awnings
- Large elements penetrating envelope
- Simplified trade-off of thermal bridging details for more insulation

TYPES OF THERMAL BRIDGES ADDRESSED BY THE STANDARD

- Clear-field thermal bridge
- Linear thermal bridge
- Point thermal bridge

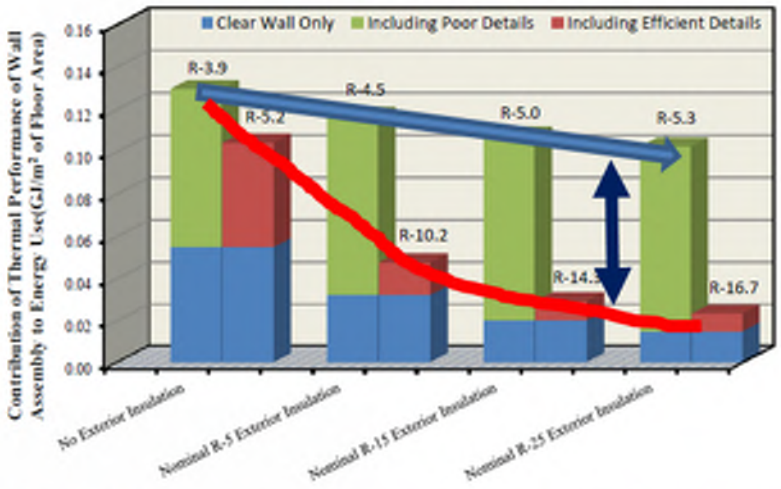
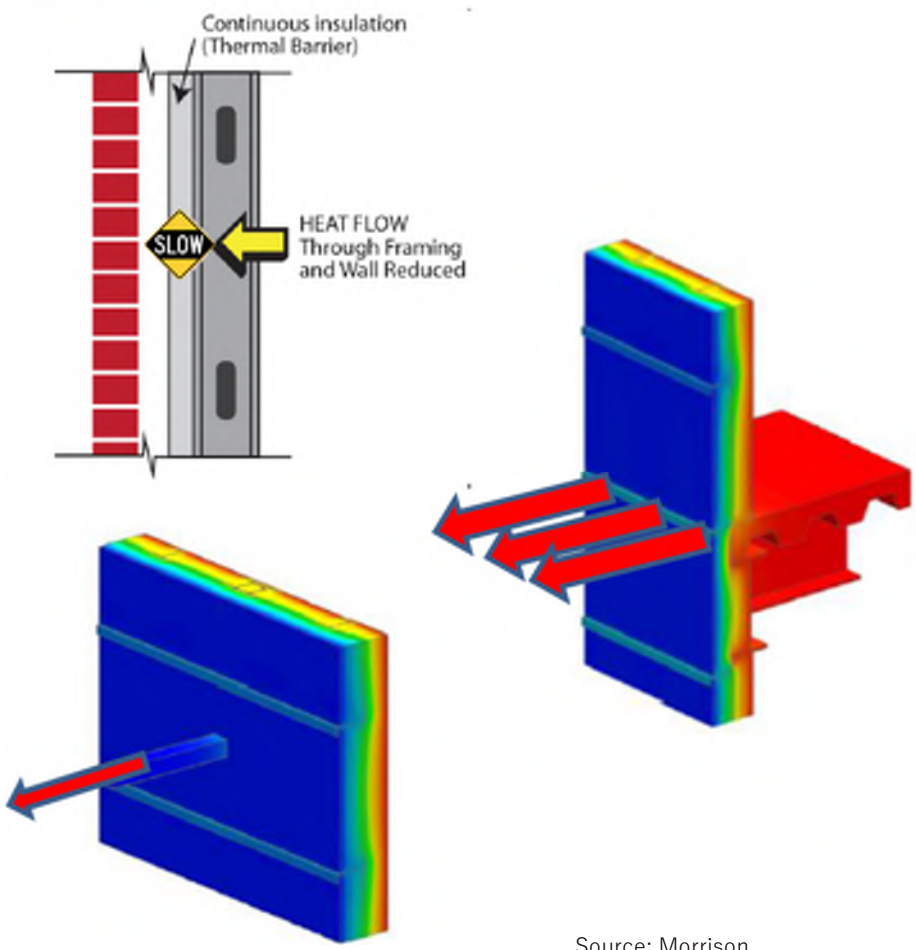
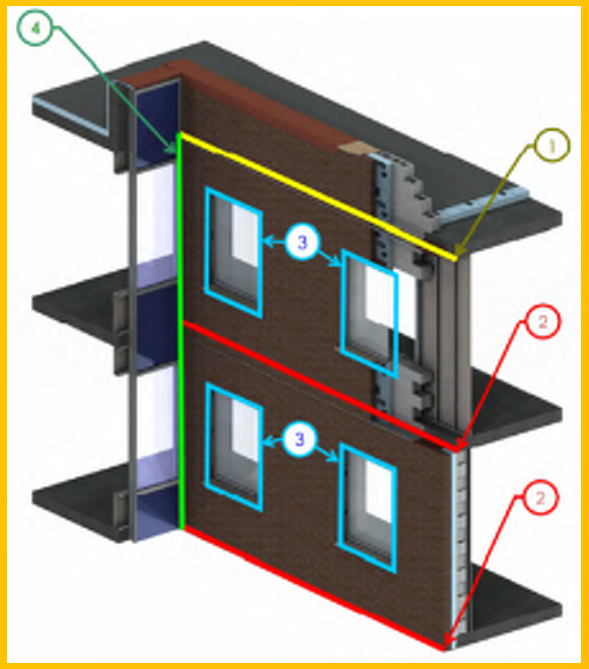


Figure 4.7: Additional building energy use based on thermal performance of the building wall assembly for varying amounts of nominal exterior insulation for a mid-rise MURB in Edmonton (overall assembly thermal resistance in ft²·°F·h/Btu also given)



Source: Morrison Hershfield LTD / ASHRAE RP 1365

CALCULATIONS TO ACCOUNT FOR POINT & LINEAR THERMAL BRIDGES



Source: BC Hydro BETB Guide / Morrison Hershfield LTD

$$Q = [\ \sum (U_i \cdot A_i\ ) + \sum (\psi_j \cdot L_j\ ) + \sum (\chi_k \cdot n_k)\ ]\ x\ \Delta T$$

where:

- **Q = heat transfer through envelope by conduction (static)**
- **U_i = U-factor for assembly type i**
- **A_i = Total surface area of assembly type i**
- **Ψ_j = Psi-factor for linear thermal bridge type j**
- **L_j = Total length of linear thermal bridge type j**
- **χ_k = Chi-factor for point thermal bridge type k**
- **n_k = number of point thermal bridges of type k**

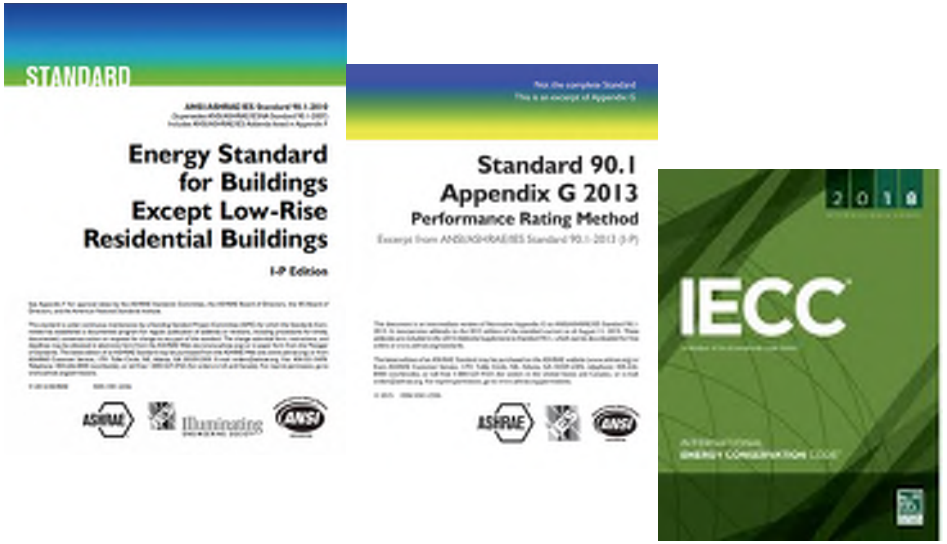
$$U_{adj} = \frac{\sum(\Psi \cdot L) + \sum(\chi \cdot n)}{A_{Total}} + U_o$$

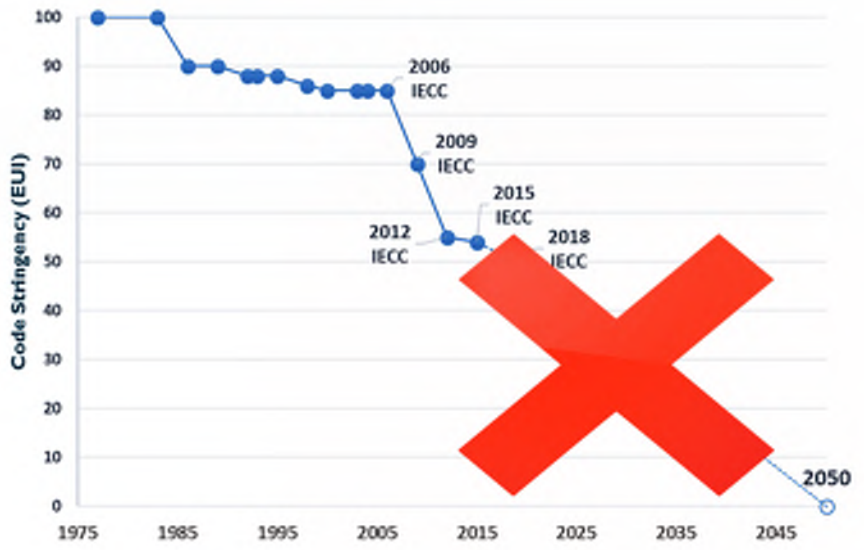
where:

- **U_{adj} = adjusted U-factor for use in "tricking" simulation model to account for thermal bridges that may be associated with but not "in" the assembly.**
- **U_o = clear-field U-factor for the assembly being adjusted**

SUMMARY

- Energy Codes are becoming stringent and more complex
- Commissioning and whole building air-barrier testing will become mainstream in all projects
- Performance-based Compliance and Energy Modeling will be needed in all high-performance projects
- Lots of new opportunities for modeling, analysis, testing, verification and design reviews.





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