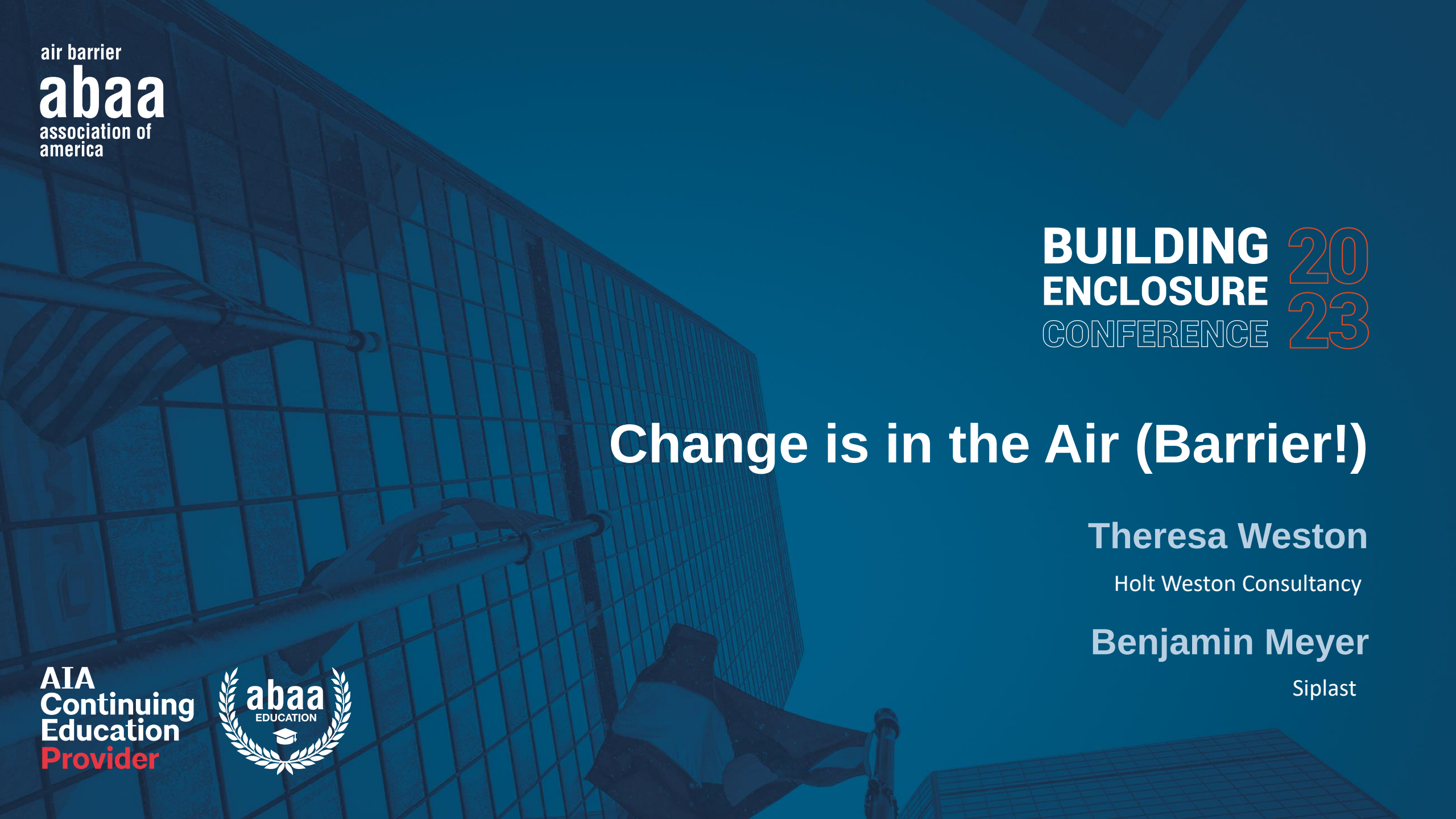

air barrier abaa association of america

BUILDING ENCLOSURE CONFERENCE 2023

Change is in the Air (Barrier!)

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BE BUILDING ENCLOSURE

Change is in the Air (Barrier!)

Air barrier requirements for commercial buildings are undergoing big changes in the 2022 ASHRAE 90.1 Standard and the 2024 IECC. Continuous Air Barriers have been required in most buildings for a number of years. Recently the model commercial energy codes, ASHRAE 90.1 Standard and the 2024 IECC, have been updated to provide more specific and more stringent requirements for buildings. This presentation will provide expert insight from two individuals who have been engaged in the code development process for years, and were specifically involved with the air leakage updates in both the ASHRAE 90.1 Standard and the IECC. The air barrier updates include clarifications to the Whole Building Performance testing methods and stringency, Design phase requirements, Material and Assembly requirements, and onsite Installation Verification requirements. We will discuss the appropriateness of applications and the interaction between the Building and Energy code requirements. This paper will discuss new code development updates, design-based applications, and construction best practices.

BUILDING ENCLOSURE CONFERENCE 2023

Learning Objectives

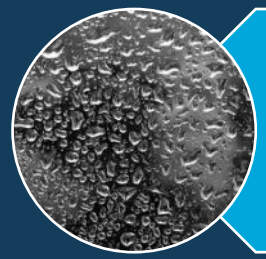
1. Discuss the impact of air barrier systems on energy efficiency and building codes
2. Recognize the changing building and energy codes, and their interaction with building envelope systems.
3. Understand the implementation an air barrier strategy to comply with the code.
4. Review specific examples of air barrier systems inclusion in codes

abaa EDUCATION

Importance of Air Leakage

Energy Efficiency

International Energy Conservation Code (IECC) ; ASHRAE 90.1; ASHRAE 90.2; ASHRAE 189.1/IgCC



Moisture Durability

ASHRAE 189.1/IgCC

Indoor Air Quality

ASHRAE 189.1/IgCC; ASHRAE 62.1; ASHRAE 62.2

International Energy Efficiency Code (IECC-2024)

"**The International Energy Conservation Code-Commercial provides market-driven, enforceable requirements for the design and construction of commercial buildings, providing minimum efficiency requirements for buildings that result in the maximum level of energy efficiency that is safe, technologically feasible, and life cycle cost-effective, considering economic feasibility, including potential costs and savings for consumers and building owners, and return on investment. Additionally, the code provides jurisdictions with supplemental requirements, including ASHRAE 90.1, and optional requirements that lead to the achievement of zero energy buildings, presently, and through glide paths that achieve zero energy buildings by 2030** and on additional timelines sought by governments, and achievement of additional policy goals as identified by the Energy and Carbon Advisory Council and approved by the Board of Directors. Requirements contained in the code will include, but not be limited to, prescriptive- and performance-based pathways. The code may include nonmandatory appendices incorporating additional energy efficiency and greenhouse gas reduction resources developed by the Code Council and others. The code will aim to simplify code requirements to facilitate the code's use and compliance rate. The code is updated on a three-year cycle with each subsequent edition providing increased energy savings over the prior edition. This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve this intent. This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances."

Energy Codes

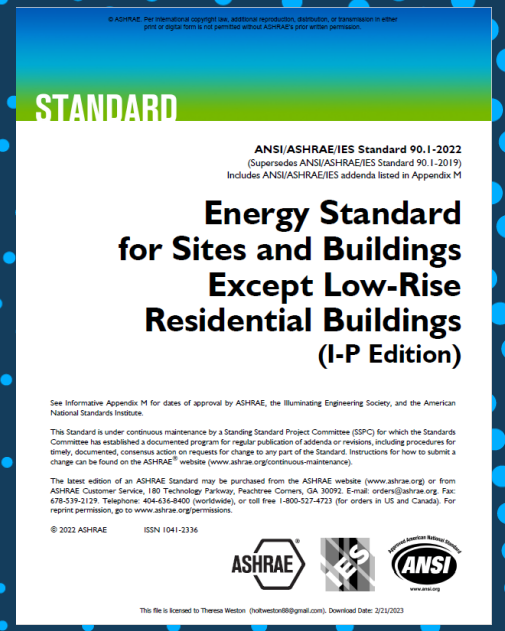
Commercial: *all buildings that are not included in the definition of "Residential building."*

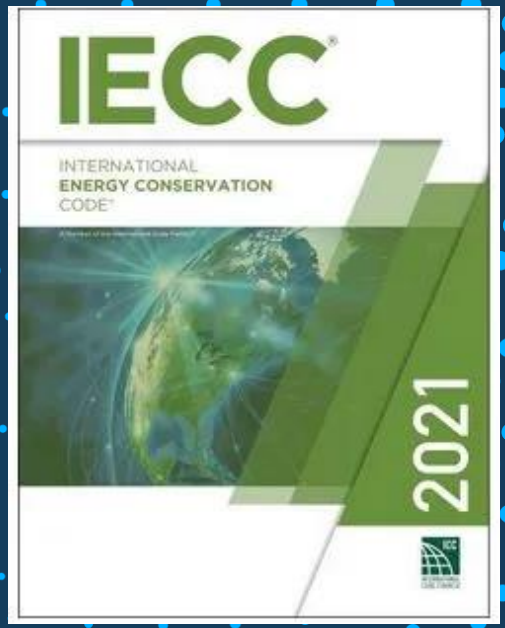
ASHRAE 90.1 – Federal minimum*

International Energy Conservation Code

Residential: *includes detached one- and two-family dwellings and multiple single family dwellings (townhouses) and Group R-2, R-3 and R-4 buildings three stories or less in height above grade plane.*

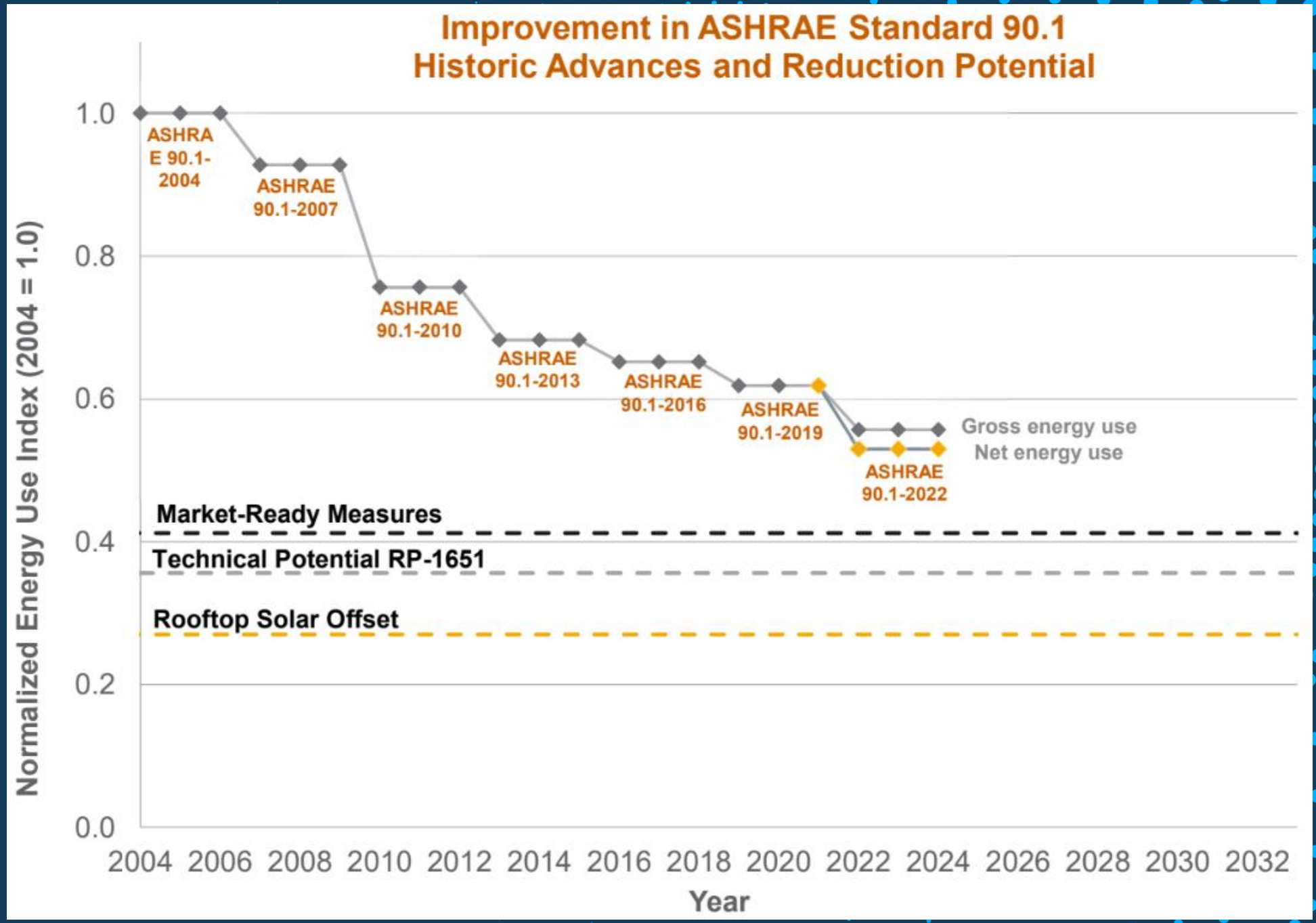
International Energy Conservation Code – Federal minimum*



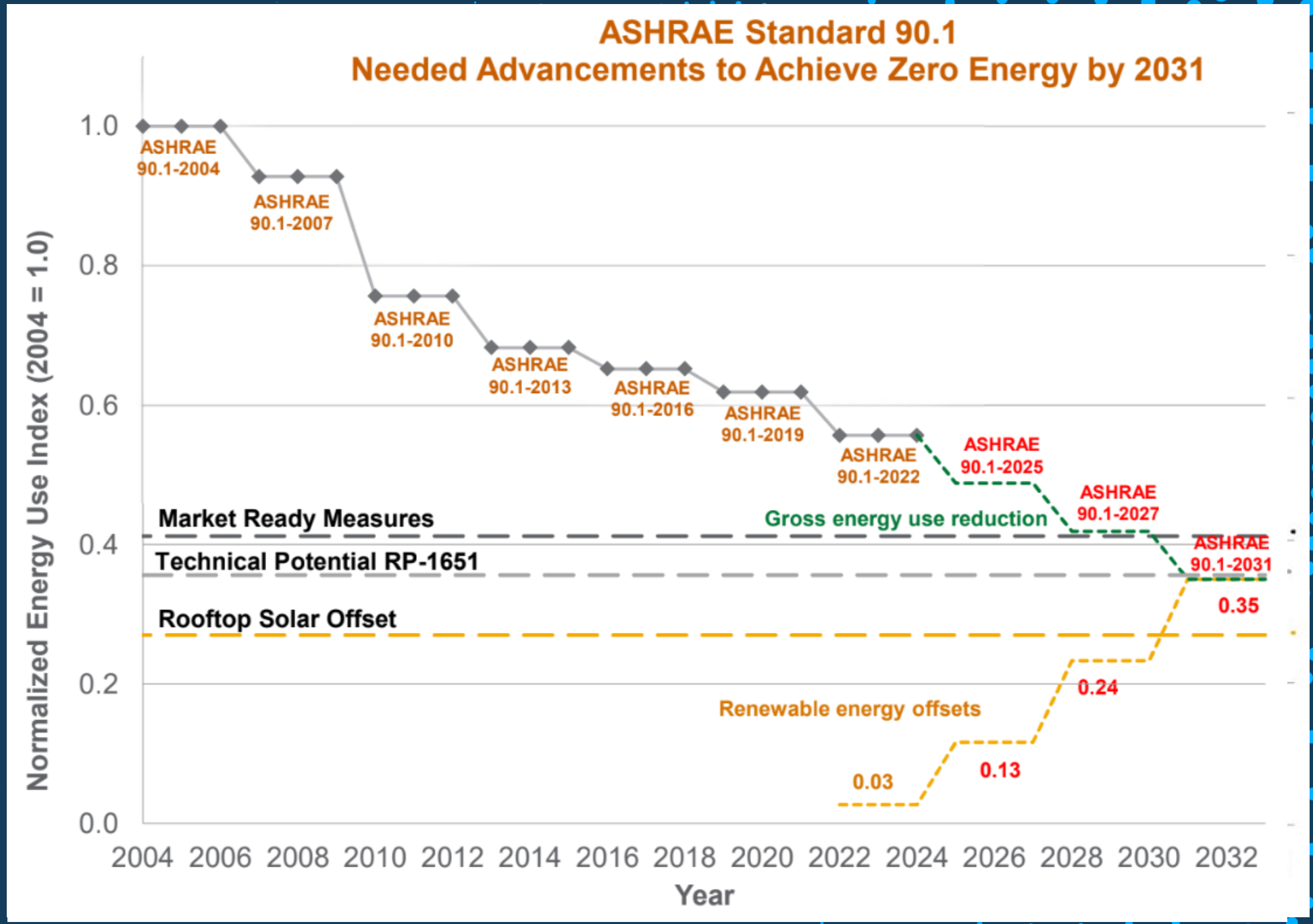


* First established by the Energy Policy Act of 1992

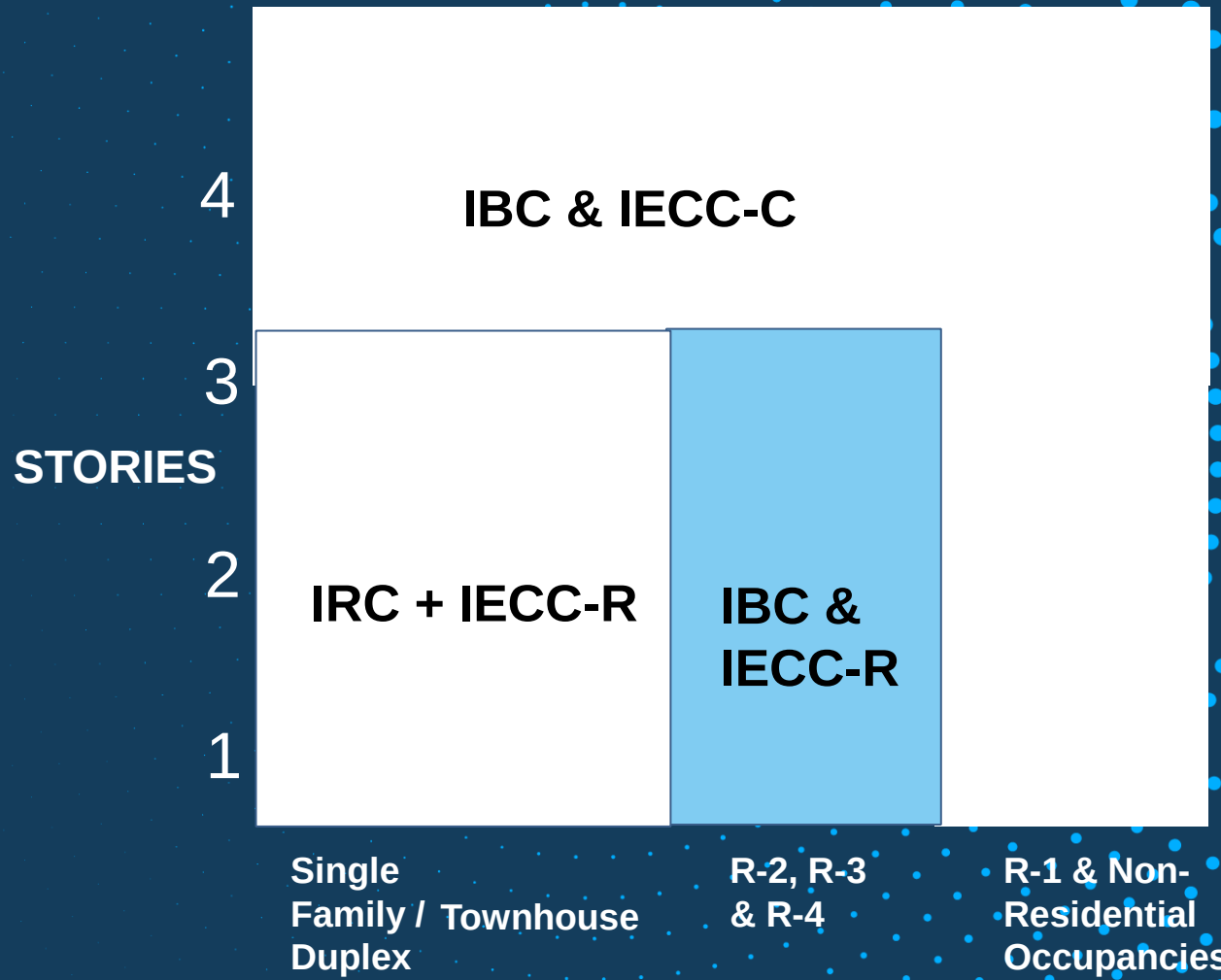
ASHRAE 90.1 is the Federal minimum code for commercial buildings



ASHRAE 90.1 is the Federal minimum code for commercial buildings



Multi-Family Code Provisions



Commercial Energy Codes Status

Implementation

Local Adoption

Code Development

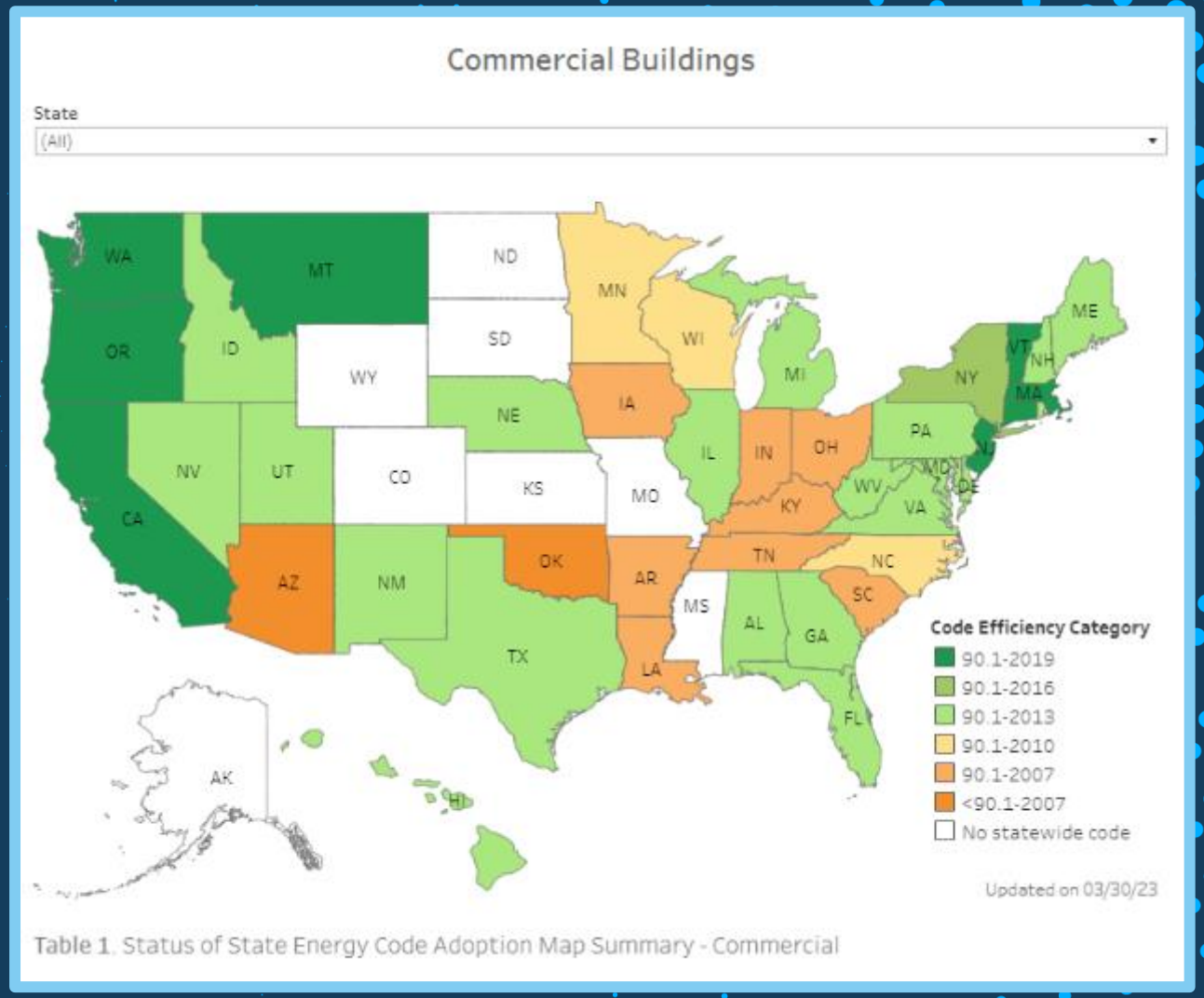
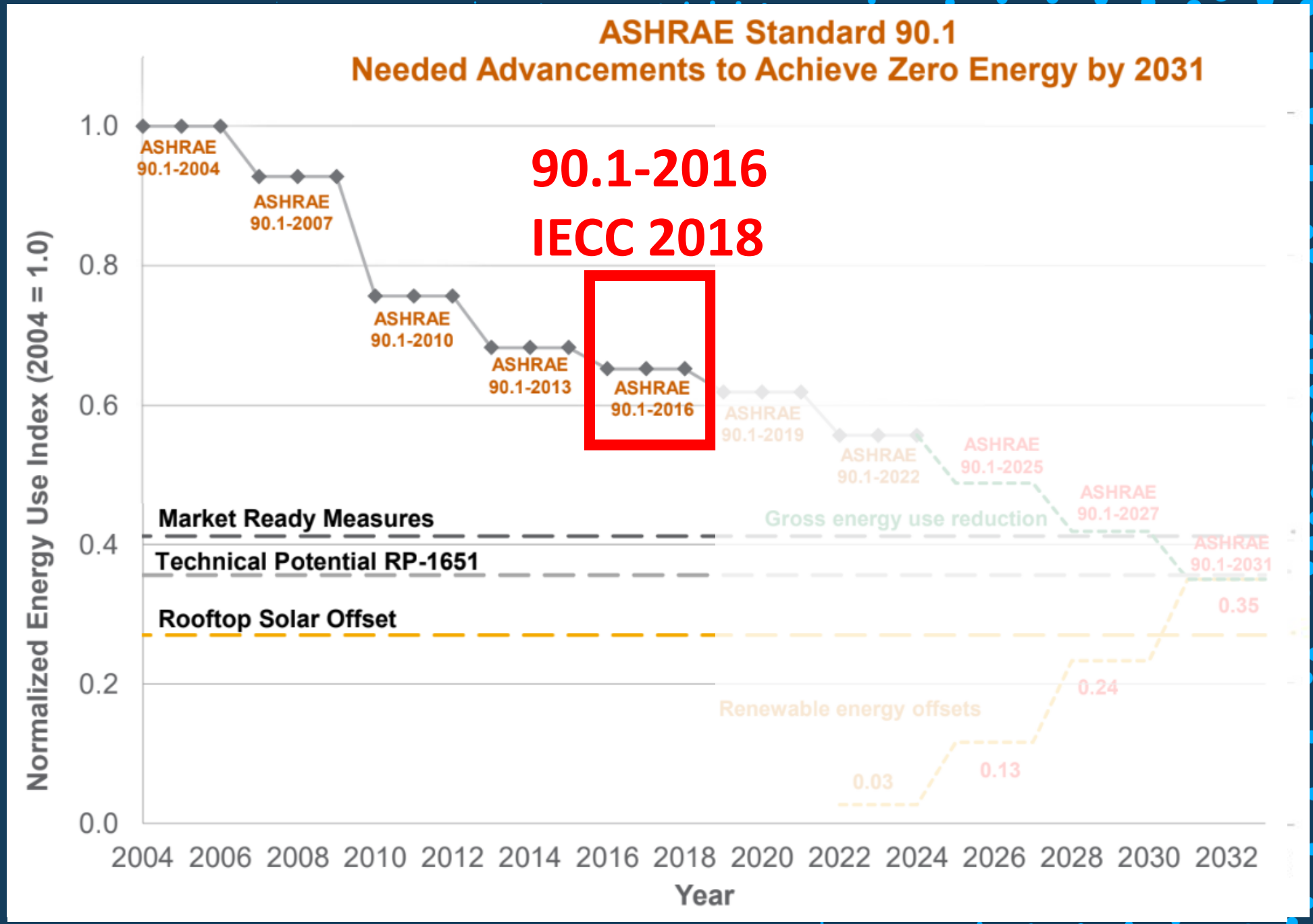


Table 1. Status of State Energy Code Adoption Map Summary - Commercial

The Baseline: ASHRAE 90.1-2016 & IECC-2018

ASHRAE 90.1 is the Federal minimum code for commercial buildings



Air Leakage Control Provisions

Introduction of Whole Building Testing Option

90.1 2016

5.4.3.1.3 Testing, Acceptable Materials, and Assemblies. The building shall comply with whole-building pressurization testing in accordance with Section 5.4.3.1.3(a) or with the continuous air barrier requirements in Section 5.4.3.1.3(b) or 5.4.3.1.3(c).

a. **Whole-building pressurization testing shall be conducted in accordance with ASTM E779 or ASTM E1827** by an independent third party. The measured **air leakage rate of the building envelope shall not exceed 0.40 cfm/ft2 under a pressure differential of 0.3 in. of water,** with this air leakage rate normalized by the sum of the above and below-grade building envelope areas of the conditioned and semiheated space.

90.1 2016

Exceptions to 5.4.3.1.3(a)

1. For buildings having over 50,000 ft^2 of gross conditioned floor area, air leakage testing shall be permitted to be conducted on less than the whole building, provided the following portions of the building are tested and their measured air leakage is area-weighted by the surface areas of the building envelope:

    a. The entire floor area of all stories that have any spaces directly under a roof.

    b. The entire floor area of all stories that have a building entrance or loading dock.

    c. Representative above-grade wall sections of the building totaling at least 25% of the wall area enclosing the remaining conditioned space; floor area tested per (a) and (b) shall not be included in the 25%.

90.1 2016

Exceptions to 5.4.3.1.3(a)

1. For buildings having over 50,000 ft^2 of gross conditioned floor area, air leakage testing shall be permitted to be conducted on less than the whole building, provided the following portions of the building are tested and their measured air leakage is area-weighted by the surface areas of the building envelope:

    a. The entire floor area of all stories that have any spaces directly under a roof.

    b. The entire floor area of all stories that have a building entrance or loading dock.

    c. Representative above-grade wall sections of the building totaling at least 25% of the wall area enclosing the remaining conditioned space; floor area tested per (a) and (b) shall not be included in the 25%.

2. Where the measured air leakage rate exceeds 0.40 cfm/ft2 but does not exceed 0.60 cfm/ft2, a diagnostic evaluation, such as a smoke tracer or infrared imaging shall be conducted while the building is pressurized, and any leaks noted shall be sealed if such sealing can be made without destruction of existing building components. In addition, a visual inspection of the air barrier shall be conducted, and any leaks noted shall be sealed if such sealing can be made without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner and shall be deemed to satisfy the requirements of this section.

Mandatory Provisions on Air Leakage

IECC-C 2018

C402.5 Air leakage—thermal envelope (Mandatory). The thermal envelope of buildings shall comply with Sections C402.5.1 through C402.5.8, or the building thermal envelope shall be tested in accordance with ASTM E 779 at a pressure differential of 0.3 inch water gauge (75 Pa) or an equivalent method approved by the code official and deemed to comply with the provisions of this section when the tested air leakage rate of the building thermal envelope is not greater than 0.40 cfm/ft2 (2.0 L/s • m2). Where compliance is based on such testing, the building shall also comply with Sections C402.5.5, C402.5.6 and C402.5.7.

C402.5.1 Air barriers. A continuous air barrier shall be provided throughout the building thermal envelope. The air barriers shall be permitted to be located on the inside or outside of the building envelope, located within the assemblies composing the envelope, or any combination thereof. The air barrier shall comply with Sections C402.5.1.1 and C402.5.1.2.

Exception: Air barriers are not required in buildings located in Climate Zone 2B.

Mandatory Provisions on Air Leakage

IECC-C 2018

C402.5.1.1 Air barrier construction. The continuous air barrier shall be constructed to comply with the following:

1. The air barrier shall be continuous for all assemblies that are the thermal envelope of the building and across the joints and assemblies.

2. Air barrier joints and seams shall be sealed, including sealing transitions in places and changes in materials. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.

3. Penetrations of the air barrier shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Sealing shall allow for expansion, contraction and mechanical vibration. Joints and seams associated with penetrations shall be sealed in the same manner or taped. Sealing materials shall be securely installed around the penetration so as not to dislodge, loosen or otherwise impair the penetrations' ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation. Sealing of concealed fire sprinklers, where required, shall be in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.

4. Recessed lighting fixtures shall comply with Section C402.5.8. Where similar objects are installed that penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

Mandatory Provisions on Air Leakage

IECC-C 2018

C402.5.1.2 Air barrier compliance options. A continuous air barrier for the opaque building envelope shall comply with Section C402.5.1.2.1 or C402.5.1.2.2.

C402.5.1.2.1 Materials. Materials with an air permeability not greater than 0.004 cfm/ft2 (0.02 L/s • m2) under a pressure differential of 0.3 inch water gauge (75 Pa) when tested in accordance with ASTM E2178 shall comply with this section. Materials in Items 1 through 16 shall be deemed to comply with this section, provided that joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.

1. Plywood with a thickness of not less than 3/8 inch (10 mm).
2. Oriented strand board having a thickness of not less than 3/8 inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch (12.7 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch (12.7 mm).
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m3) and having a thickness of not less than 11/2 inches (38 mm).
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m3) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch (12.7 mm).
8. Cement board having a thickness of not less than 1/2 inch (12.7 mm).
9. Built-up roofing membrane.
10. Modified bituminous roof membrane.
11. Fully adhered single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch (15.9 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminum.
16. Solid or hollow masonry constructed of clay or shale masonry units.

Mandatory Provisions on Air Leakage

IECC-C 2018

C402.5.1.2.2 Assemblies. Assemblies of materials and components with an average air leakage not greater than 0.04 cfm/ft2 (0.2 L/s • m2) under a pressure differential of 0.3 inch of water gauge (w.g.)(75 Pa) when tested in accordance with ASTM E2357, ASTM E1677 or ASTM E283 shall comply with this section. Assemblies listed in Items 1 through 3 shall be deemed to comply, provided that joints are sealed and the requirements of Section C402.5.1.1 are met.

1. Concrete masonry walls coated with either one application of block filler or two applications of a paint or sealer coating.

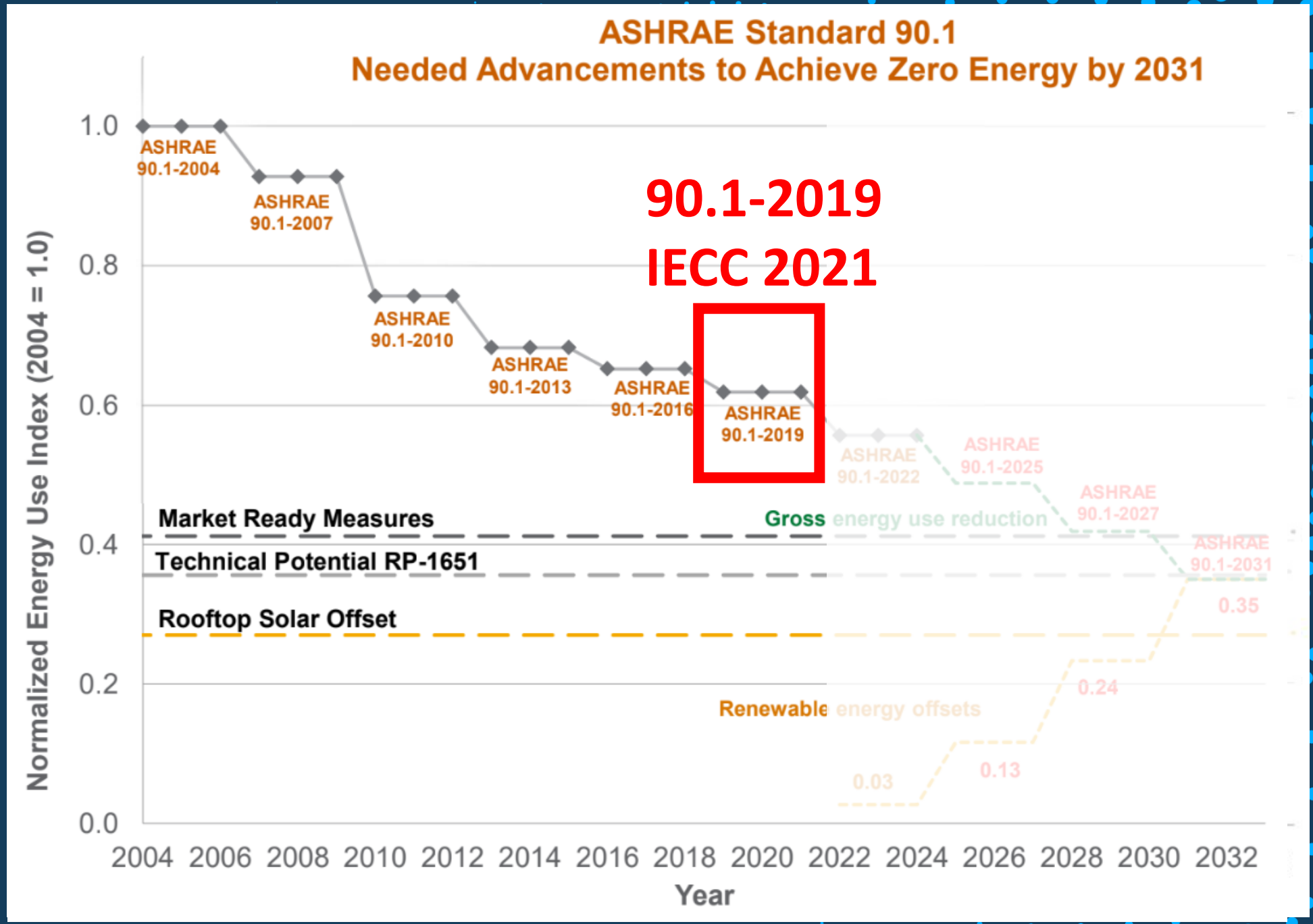
2. Masonry walls constructed of clay or shale masonry units with a nominal width of 4 inches (102 mm) or more.

3. A Portland cement/sand parge, stucco or plaster not less than 1/2 inch (12.7 mm) in thickness.

	ASHRAE 90.1-2016	IECC-2018
Compliance Testing Options	Materials, Assembly, or Whole Building	Materials, Assembly, or Whole Building
Maximum Air Leakage Level	Materials ≤ 0.004 cfm/ft2 @ 75 Pa	Materials ≤ 0.004 cfm/ft2 @ 75 Pa
	Assemblies ≤ 0.04 cfm/ft2 @ 75 Pa	Assemblies ≤ 0.04 cfm/ft2 @ 75 Pa
	Whole Buildings ≤ 0.40 cfm/ft2 @ 75 Pa	Whole Buildings ≤ 0.40 cfm/ft2 @ 75 Pa
Whole Building Testing	Option, Not required	Option, Not required
Exceptions	Semiheated spaces in Climate Zones 0 through 6	Air Barriers not required in Climate Zone 2B
	Single wythe concrete masonry buildings in Climate Zone 2B.	
Installation Verification	Design and Installation Verification, **or** Whole Building Air Leakage Testing	None specified
Performance Modeling Compliance	Design Phase: model specified air leakage (energy savings credit for performance 0.40 cfm/ft2 or less)	Follow mandatory requirements (.40 cfm/ft2 @75 Pa)
	Construction Phase: Adjust model for actual tested air leakage, energy savings credit for performance better than 0.40 cfm/ft2)	
Simplified Path Compliance	COMcheck Compliance - Default 0.40 cfm/ft2 air leakage input	Default 0.40 cfm/ft2 air leakage input. Allows Reduced Air Leakage package for .25 cfm/ft2 @ 75 Pa

The Next Step: ASHRAE 90.1-2019 & IECC-2021

ASHRAE 90.1 is the Federal minimum code for commercial buildings



Air Leakage Control Provisions

90.1 2019

5.4.3 Air Leakage. Air leakage control for the building envelope shall comply with this section. **Materials and assemblies that are part of the continuous air barrier and fenestration and doors shall comply with Section 5.8.3.**

5.4.3.1 Continuous Air Barrier. The exterior building envelope and the semiexterior building envelope **shall have a continuous air barrier complying with Sections 5.4.3.1.1 and 5.4.3.1.2.**

Exceptions to 5.4.3.1

1. Semiheated spaces in Climate Zones 0 through 6, except as required to complete the continuous air barrier of an adjacent conditioned space.

2. Single wythe concrete masonry buildings in Climate Zone 2B.

90.1 2019

5.4.3.1.1 Whole-Building Air Leakage. **Whole-building pressurization testing shall be conducted in accordance with ASTM E779 or ASTM E1827 by an independent third party. The measured air leakage rate of the building envelope shall not exceed 0.40 cfm/ft2 under a pressure differential of 0.3 in. of water,** with this air leakage rate normalized by the sum of the above-grade and below-grade building envelope areas of the conditioned space and semiheated space. Where a building contains both conditioned space and semiheated space, compliance shall be shown

a. separately for the conditioned space and for the semiheated space, with the air leakage rate for the conditioned space normalized by the exterior building envelope area of the conditioned space and the air leakage rate for the semiheated space normalized by the semiexterior building envelope area of the semiheated space; or

b. for the conditioned space and for the semiheated space together, with the air leakage rate for the overall space normalized by the sum of the exterior building envelope area and the semiexterior building envelope area minus the semiexterior building envelope area that separates the conditioned space from the semiheated space. Reporting shall be in compliance with Section 4.2.5.1.2.

90.1 2019

Exceptions to 5.4.3.1.1

1. For buildings having over 50,000 ft2 of gross conditioned floor area, air leakage testing shall be permitted to be conducted on less than the whole building, provided the following portions of the building are tested and their measured air leakage is area-weighted by the surface areas of the building envelope:.

    a. The entire floor area of all stories that have any spaces directly under a roof.

    b. The entire floor area of all stories that have a building entrance or loading dock.

    c. Representative above-grade wall sections of the building totaling at least 25% of the wall area enclosing the remaining conditioned space. Floor area tested per (a) and (b) shall not be included in the 25%.

2. Where the measured air leakage rate exceeds 0.40 cfm/ft2 but does not exceed 0.60 cfm/ft2, a diagnostic evaluation, such as a smoke tracer or infrared imaging shall be conducted while the building is pressurized, and any leaks noted shall be sealed if such sealing can be made without destruction of existing building components. In addition, a visual inspection of the air barrier shall be conducted, and any leaks noted shall be sealed if such sealing can be made without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner and shall be deemed to satisfy the requirements of this section.

3. **Continuous air barrier design and installation verification program in accordance with Section 5.9.1.2.**

90.1 2019

5.9.1.2 Verification of the Design and Installation of the Continuous Air Barrier. Verification of the design and installation of the continuous air barrier shall be determined in accordance with the following by an independent third party when using Exception 3 of Section 5.4.3.1.1:

a. A design review shall be conducted to verify and document compliance with the requirements in Sections 5.4.3 and 5.8.3.2.

b. Periodic field inspection of the continuous air barrier materials and assemblies shall be conducted during construction while the continuous air barrier is still accessible for inspection and repair to verify and document compliance with the requirements of Sections 5.4.3.1.2 and 5.8.3.

c. Reporting shall comply with Section 4.2.5.1.2.

90.1 2019

5.4.3.1.2 Continuous Air Barrier Design and Installation. The continuous air barrier shall be designed and installed in the following manner:

a. Components designed to provide the continuous air barrier, and the component's position within each of the building envelope assemblies, shall be clearly identified on construction documents.

b. The joints, interconnections, and penetrations of the continuous air barrier components shall be detailed in the construction documents.

c. The continuous air barrier shall extend over all surfaces of the building envelope and be identified in the construction documents to be continuous.

d. The continuous air barrier shall be designed to resist positive and negative pressures from wind, stack effect, and mechanical ventilation and allow for anticipated movements.

e. The following areas of the continuous air barrier in the building envelope shall be wrapped, sealed, caulked, gasketed, or taped in an approved manner to minimize air leakage:

1. Joints around fenestration and door frames
2. Junctions between walls and floors, between walls at building corners, and between walls and roofs
3. Penetrations through the continuous air barrier in building envelope roofs, walls, and floors
4. Building assemblies used as ducts or plenums
5. Joints, seams, connections between planes, and other changes in continuous air barrier materials

90.1 2019

5.8.3 Air Leakage

5.8.3.1 Testing, Acceptable Materials, and Assemblies Air leakage for materials or assemblies used as components of the *continuous air barrier* shall be determined in accordance with the test method and minimum air pressure specified in Table 5.8.3.1 and shall not exceed the maximum air leakage specified in Table 5.8.3.1 when using Exception 3 of Section 5.4.3.1.1. Air leakage shall be determined by a laboratory accredited by a nationally recognized accreditation organization.

Table 5.8.3.1 Maximum Air Leakage for Materials and Assemblies

Continuous Air Barrier	Maximum Air Leakage, cfm/ft^2	Minimum Test Pressure, psf	Test Method
Materials [a]	0.004	1.57	ASTM E2178
Assemblies [b]	0.04	1.57	ASTM E2357, ASTM E1677, ASTM E1680, ASTM E283

a. The following materials comply with the requirements in Table 5.8.3.1:
1. Plywood—minimum 3/8 in.
2. Oriented strand board—minimum 3/8 in.
3. Extruded polystyrene insulation board—minimum 1/2 in.
4. Foil-faced polyisocyanurate insulation board—minimum 1/2 in.
5. Exterior gypsum sheathing or interior gypsum board—minimum 1/2 in.
6. Cement board—minimum 1/2 in.
7. Built-up roofing membrane
8. Modified bituminous *roof* membrane
9. Single-ply *roof* membrane
10. A Portland cement/sand parge, stucco, or gypsum plaster—minimum 1/2 in. thick
11. Cast-in-place and precast concrete
12. Sheet metal
13. Closed-cell 2 lb/ft^3 nominal density spray polyurethane foam—minimum 1 in.

b. The following assemblies comply with the requirements in Table 5.8.3.1:
1. Concrete masonry *walls* that are
   (a) fully grouted or
   (b) painted to fill the pores
2. Shale or clay masonry units that are assembled as a solid *wall*: without weeps, with nominal width of 4 in. or more, and with Type S mortar

Mandatory Provisions on Air Leakage

IECC-C 2021

C402.5 Air leakage—thermal envelope. The *building thermal envelope* shall comply with Sections C402.5.1 through Section C402.5.11.1, or **the building *thermal envelope* shall be tested in accordance with Section C402.5.2 or C402.5.3.** Where compliance is based on such testing, the building shall also comply with Sections C402.5.7, C402.5.8 and C402.5.9.

C402.5.1 Air barriers. A continuous air barrier shall be provided throughout the building thermal envelope. The continuous air barriers shall be located on the inside or outside of the building thermal envelope, located within the assemblies composing the building thermal envelope, or any combination thereof. The air barrier shall comply with Sections C402.5.1.1, and C402.5.1.2.

Exception: Air barriers are not required in buildings located in Climate Zone 2B.

C402.5.1.1 Air barrier construction. The continuous air barrier shall be constructed to comply with the following:

1. The air barrier shall be continuous for all assemblies that are the thermal envelope of the building and across the joints and assemblies.
2. Air barrier joints and seams shall be sealed, including sealing transitions in places and changes in materials. The joints and seals shall be securely installed in or on the joint for its entire length so as not to dislodge, loosen or otherwise impair its ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation.
3. Penetrations of the air barrier shall be caulked, gasketed or otherwise sealed in a manner compatible with the construction materials and location. Sealing shall allow for expansion, contraction and mechanical vibration. Joints and seams associated with penetrations shall be sealed in the same manner or taped. Sealing materials shall be securely installed around the penetration so as not to dislodge, loosen or otherwise impair the penetrations' ability to resist positive and negative pressure from wind, stack effect and mechanical ventilation. Sealing of concealed fire sprinklers, where required, shall be in a manner that is recommended by the manufacturer. Caulking or other adhesive sealants shall not be used to fill voids between fire sprinkler cover plates and walls or ceilings.
4. Recessed lighting fixtures shall comply with Section C402.5.10. Where similar objects are installed that penetrate the air barrier, provisions shall be made to maintain the integrity of the air barrier.

IECC-C 2021

C402.5.1.2 Air barrier compliance. A continuous air barrier for the opaque building envelope shall comply with the following:

1. Buildings or portions of buildings, including **Group R and I occupancies**, shall meet the provisions of Section C402.5.2.

    Exception: Buildings in Climate Zones 2B, 3C and 5C.

2. Buildings or portions of buildings **other than Group R and I occupancies** shall meet the provisions of Section C402.5.3.

    Exceptions:

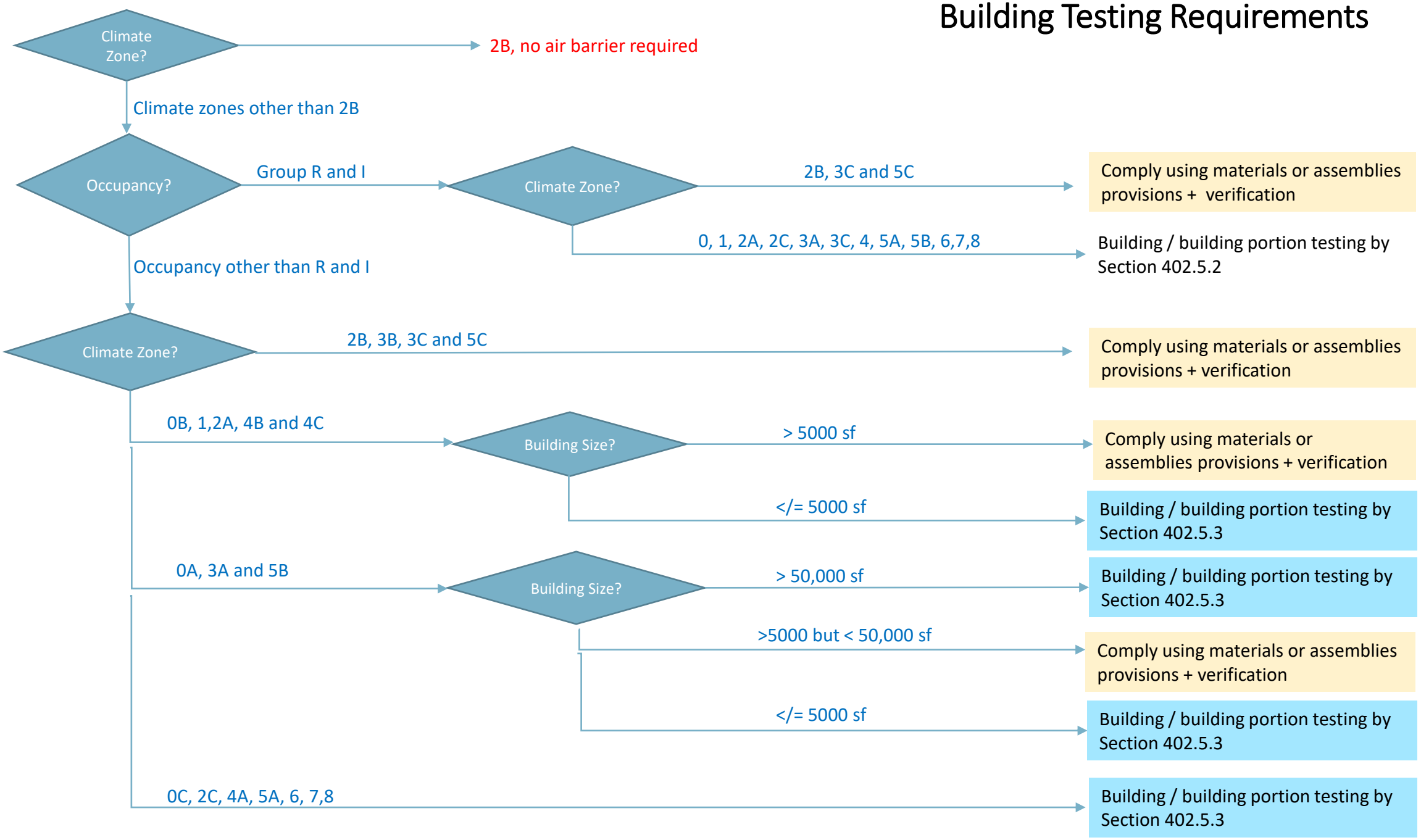
    1. Buildings in Climate Zones 2B, 3B, 3C and 5C.

    2. Buildings larger than 5,000 square feet (464.5 m2) floor area in Climate Zones 0B, 1, 2A, 4B and 4C.

    3. Buildings between 5,000 square feet (464.5 m2) and 50,000 square feet (4645 m2) floor area in Climate Zones 0A, 3A and 5B.

    3. Buildings or portions of buildings that do not complete air barrier testing shall meet the provisions of Section C402.5.1.3 or C402.5.1.4 in addition to Section C402.5.1.5.

Building Testing Requirements



IECC-C 2021

C402.5.1.3 Materials. Materials with an air permeability not greater than 0.004 cfm/ft2 (0.02 L/s × m2) under a pressure differential of 0.3 inch water gauge (75 Pa) when tested in accordance with ASTM E2178 shall comply with this section. Materials in Items 1 through 16 shall be deemed to comply with this section, provided that joints are sealed and materials are installed as air barriers in accordance with the manufacturer's instructions.

1. Plywood with a thickness of not less than 3/8 inch (10 mm).
2. Oriented strand board having a thickness of not less than 3/8 inch (10 mm).
3. Extruded polystyrene insulation board having a thickness of not less than 1/2 inch (12.7 mm).
4. Foil-back polyisocyanurate insulation board having a thickness of not less than 1/2 inch (12.7mm).
5. Closed-cell spray foam having a minimum density of 1.5 pcf (2.4 kg/m3) and having a thickness of not less than 11/2 inches (38 mm).
6. Open-cell spray foam with a density between 0.4 and 1.5 pcf (0.6 and 2.4 kg/m3) and having a thickness of not less than 4.5 inches (113 mm).
7. Exterior or interior gypsum board having a thickness of not less than 1/2 inch (12.7 mm).
8. Cement board having a thickness of not less than 1/2 inch (12.7 mm).
9. Built-up roofing membrane.
10. Modified bituminous roof membrane.
11. Single-ply roof membrane.
12. A Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch(15.9 mm).
13. Cast-in-place and precast concrete.
14. Fully grouted concrete block masonry.
15. Sheet steel or aluminum.
16. Solid or hollow masonry constructed of clay or shale masonry units.

IECC-C 2021

C402.5.1.4 Assemblies. Assemblies of materials and components with an average air leakage not greater than 0.04 cfm/ft2 (0.2 L/s × m2) under a pressure differential of 0.3 inch of water gauge (w.g.)(75 Pa) when tested in accordance with ASTM E2357, ASTM E1677, **ASTM D8052** or ASTM E283 shall comply with this section. Assemblies listed in Items 1 through 3 shall be deemed to comply, provided that joints are sealed and the requirements of Section C402.5.1.1 are met.

1. Concrete masonry walls coated with either one application of block filler or two applications of a paint or sealer coating.
2. Masonry walls constructed of clay or shale masonry units with a nominal width of 4 inches (102 mm) or more.
3. A Portland cement/sand parge, stucco or plaster not less than 1/2 inch (12.7 mm) in thickness.

IECC-C 2021

C402.5.1.5 Building envelope performance verification. The installation of the continuous air barrier shall be verified by the code official, a registered design professional or approved agency in accordance with the following:

1. A review of the construction documents and other supporting data shall be conducted to assess compliance with the requirements in Section C402.5.1.
2. **Inspection of continuous air barrier components and assemblies shall be conducted during construction while the air barrier is still accessible for inspection** and repair to verify compliance with the requirements of Sections C402.5.1.3 and C402.5.1.4.
3. A final commissioning report shall be provided for inspections completed by the registered design professional or approved agency. The commissioning report shall be provided to the building owner or owner's authorized agent and the code official. The report shall identify deficiencies found during the review of the construction documents and inspection and details of corrective measures taken.

IECC-C 2021

C402.5.2 Dwelling and sleeping unit enclosure testing. The building thermal envelope shall be tested in accordance with **ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827** or an equivalent method approved by the code official. The measured air leakage shall not exceed **0.30 cfm/ft2 (1.5 L/s m2) of the testing unit enclosure area at a pressure differential of 0.2 inch water gauge (50 Pa).** Where multiple dwelling units or sleeping units or other occupiable conditioned spaces are contained within one building thermal envelope, each unit shall be considered an individual testing unit, and the building air leakage shall be the weighted average of all testing unit results, weighted by each testing unit's enclosure area. Units shall be tested separately with an unguarded blower door test as follows:

1. Where buildings have fewer than eight testing units, each testing unit shall be tested.
2. **For buildings with eight or more testing units, the greater of seven units or 20 percent of the testing units in the building shall be tested, including a top floor unit, a ground floor unit and a unit with the largest testing unit enclosure area. For each tested unit that exceeds the maximum air leakage rate, an additional two units shall be tested, including a mixture of testing unit types and locations.**

IECC-C 2021

C402.5.3 Building thermal envelope testing. The building thermal envelope shall be tested in accordance with **ASTM E779, ANSI/RESNET/ICC 380, ASTM E3158 or ASTM E1827 or an equivalent method approved by the code official. The measured air leakage shall not exceed 0.40 cfm/ft2 (2.0 L/s × m2) of the building thermal envelope area at a pressure differential of 0.3 inch water gauge (75 Pa).** Alternatively, portions of the building shall be tested and the measured air leakages shall be area weighted by the surface areas of the building envelope in each portion. The weighted average test results shall not exceed the whole building leakage limit. In the alternative approach, the following portions of the building shall be tested:

1. The entire envelope area of all stories that have any spaces directly under a roof.

2. The entire envelope area of all stories that have a building entrance, exposed floor, or loading dock, or are below grade.

3. Representative above-grade sections of the building totaling at least 25 percent of the wall area enclosing the remaining conditioned space.

Exception: Where the measured air leakage rate exceeds 0.40 cfm/ft2 (2.0 L/s × m2) but does not exceed 0.60 cfm/ft2 (3.0 L/s × m2), a diagnostic evaluation using smoke tracer or infrared imaging shall be conducted while the building is pressurized along with a visual inspection of the air barrier. Any leaks noted shall be sealed where such sealing can be made without destruction of existing building components. An additional report identifying the corrective actions taken to seal leaks shall be submitted to the code official and the building owner, and shall be deemed to comply with the requirements of this section.

	ASHRAE 90.1-2019	IECC-2021
Compliance Testing Options	Materials, Assembly, or Whole Building	Materials, Assembly, Dwelling Unit (Group R and I) or Whole Building (required under certain conditions)
Maximum Air Leakage Level	Materials ≤ 0.004 cfm/ft2 @ 75 Pa	Materials ≤ 0.004 cfm/ft2 @ 75 Pa
	Assemblies ≤ 0.04 cfm/ft2 @ 75 Pa	Assemblies ≤ 0.04 cfm/ft2 @75 Pa
	Whole Buildings ≤ 0.40 cfm/ft2 @ 75 Pa ("oops clause" allows up to 0.60 cfm/ft2)	Whole Buildings ≤ 0.40 cfm/ft2 @75 Pa ("oops clause" allows up to 0.60 cfm/ft2)
		Dwelling Units ≤ 0.30 cfm/ft2 @ 50 Pa, sampling allowed.
Whole Building Testing Requirements	Required with exceptions for (1) buildings over 50,000 ft2 can be tested in parts, and (2) when verification of the design and installation of the continuous air barrier is conducted.	Required for occupancies other than Group R and I with multiple exceptions for Climate Zone and building size Group R & I testing by dwelling unit, with sampling allowed
Exceptions	Semiheated spaces in Climate Zones 0 through 6	Air Barriers not required in Climate Zone 2B;
	Single wythe concrete masonry buildings in Climate Zone 2B.	
Design and Installation Verification	Verification by 3rd party required when not performing whole building testing.	Verification required when not testing by dwelling unit or whole building testing.
	Design to be detailed and identified in construction documents as continuous	Installation of continuous air barrier verified by the code official, a registered design professional or approved agency. Includes review of construction documents, inspection during construction and a final commissioning report.
Performance Modeling Compliance	Design Phase: model specified air leakage (energy savings credit for performance 0.40 cfm/ft2 or less)	Follow mandatory requirements (.40 cfm/ft2 @75 Pa)
	Construction Phase: Adjust model for actual tested air leakage, energy savings credit for performance better than 0.40 cfm/ft2)	
Simplified Path Compliance	COMcheck Compliance - Default 0.40 cfm/ft2 @75 Pa air leakage input	Default 0.40 cfm/ft2 air leakage input. Allows Reduced Air Leakage package for .25 cfm/ft2 @ 75 Pa

Multi-family Building Envelope Testing

IECC 2021

IECC-R 2021 Dwelling Unit Exception

When testing individual dwelling units, an air leakage rate **not exceeding 0.30 cubic feet per minute per square foot [0.008 m3/(s × m2)] of the dwelling unit enclosure area, tested in accordance with ANSI/RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pa),** shall be an accepted alternative permitted in all climate zones for:

- 1. Attached single and multiple family building dwelling units.
- 2. Buildings or dwelling units that are 1,500 square feet (139.4 m2) or smaller.

IECC-C 2021 C402.5.2 Dwelling and sleeping unit enclosure testing.

C402.5.2 Dwelling and sleeping unit enclosure testing. The building thermal envelope shall be tested in accordance with ASTM E779, ANSI/RESNET/ICC 380, ASTM E1827 or an equivalent method approved by the code official. The measured air leakage **shall not exceed 0.30 cfm/ft2 (1.5 L/s m2) of the testing unit enclosure area at a pressure differential of 0.2 inch water gauge (50 Pa).** Where multiple dwelling units or sleeping units or other occupiable conditioned spaces are contained within one building thermal envelope, each unit shall be considered an individual testing unit, and the building air leakage shall be the weighted average of all testing unit results, weighted by each testing unit's enclosure area. Units shall be tested separately with an unguarded blower door test as follows:

1. Where buildings have fewer than eight testing units, each testing unit shall be tested.

2. For buildings with eight or more testing units, the greater of seven units or 20 percent of the testing units in the building shall be tested, including a top floor unit, a ground floor unit and a unit with the largest testing unit enclosure area. For each tested unit that exceeds the maximum air leakage rate, an additional two units shall be tested, including a mixture of testing unit types and locations.

Air Leakage Provisions

189.1 2020

7.3.1.2 Continuous Air Barrier. The exceptions to the requirement for a continuous air barrier in ANSI/ASHRAE/IES Standard 90.1, Section 5.4.3.1, for specific climate zones and constructions shall not apply. The testing criteria of Section 10.6(a) shall supersede ANSI/ ASHRAE/IES Standard 90.1, Section 5.4.3.1.1.

10.6 Building Envelope Airtightness. Building envelope airtightness shall comply with ANSI/ASHRAE/IES Standard 90.1, with the following modifications and additions. Air leakage verification shall be determined in accordance with ANSI/ASHRAE/IES Standard 90.1, Section 5.9.1:

a. When implementing the testing option in ANSI/ASHRAE/IES Standard 90.1, Section 5.4.3.1.1, whole-building pressurization testing shall meet the following requirements:

1. It shall be conducted in accordance **with ASTM E779, ASTM E1827, CAN/CGSB- 149.10, CAN/CGSB-149.15, ISO 9972,** or equivalent standard by an independent third party.

2. The measured air leakage rate of the building envelope **shall not exceed 0.25 cfm/ft2 (1.25 L/s·m2) under a pressure differential of 0.3 in. of water (75 Pa),** with this air leakage rate normalized by the sum of the above- and below-grade building envelope areas of the conditioned and semiheated space.

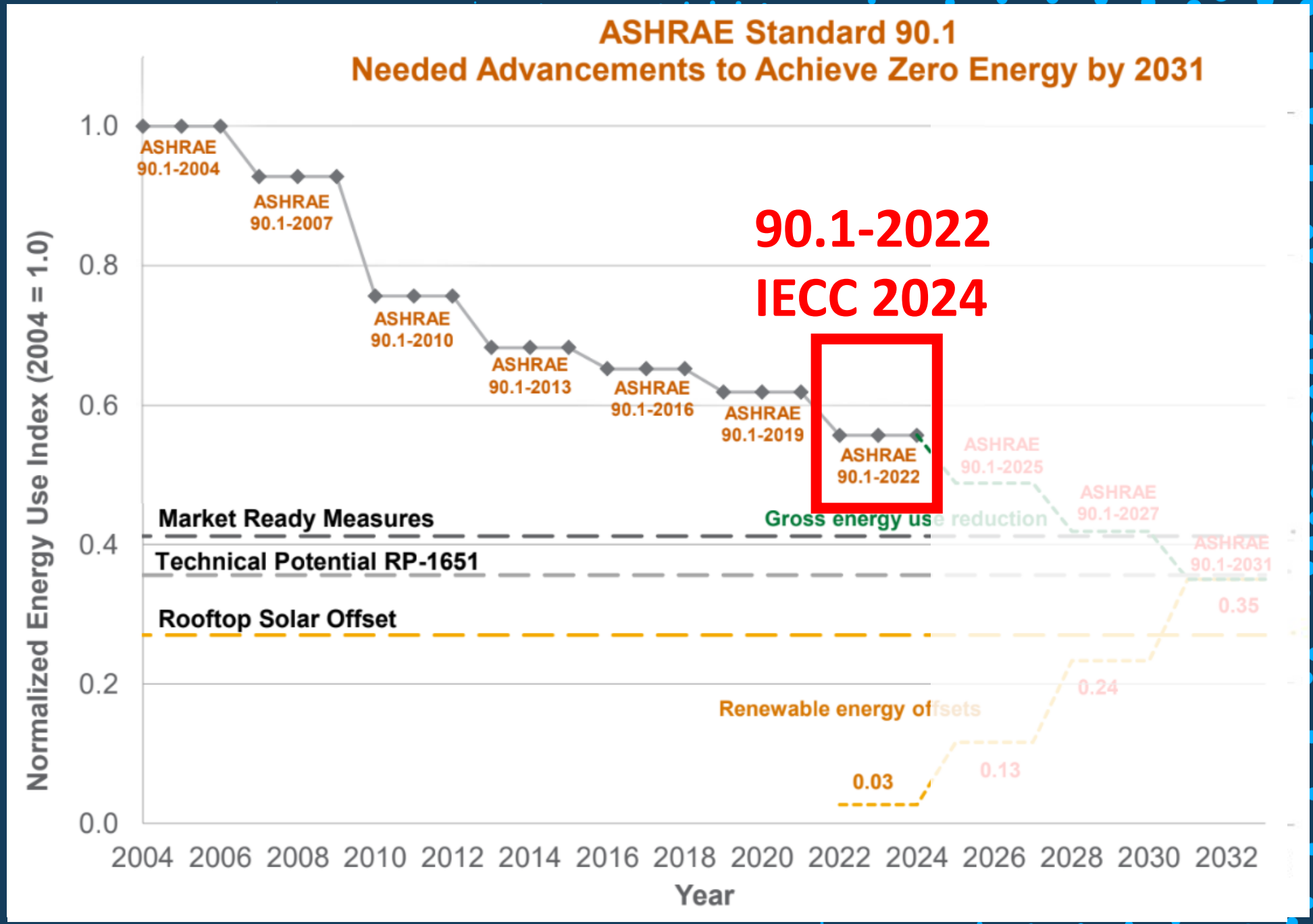
3. Section 5.4.3.1.1, Exception 1, is not allowed.

4. Section 5.4.3.1.1, Exception 2, is allowed **where the measured air leakage rate exceeds 0.25 cfm/ft2 (1.25 L/s·m2) but does not exceed 0.40 cfm/ft2 (2.0 L/s·m2).**

b. When implementing the verification program option in ANSI/ASHRAE/IES Standard 90.1, Section 5.9.1, the air barrier design review shall be performed by an independent third party.

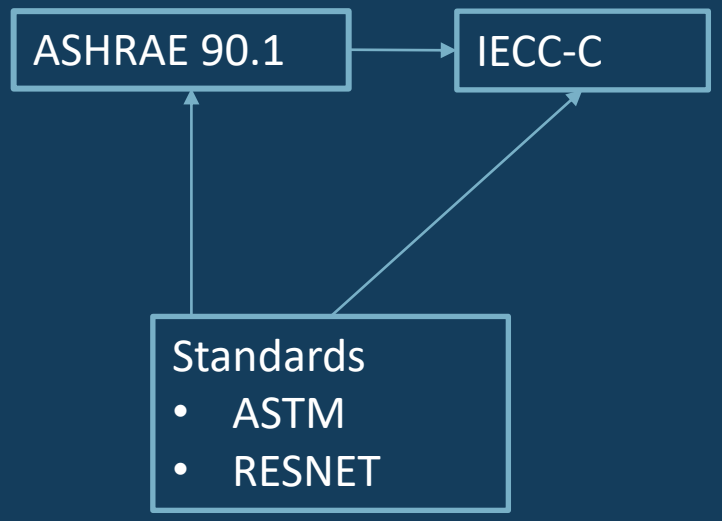
Just Arrived / Coming Soon: ASHRAE 90.1-2022 & IECC-2024

ASHRAE 90.1 is the Federal minimum code for commercial buildings



	ASHRAE 90.1-2022 *published*	**IECC-2024** *forecasted, based on current IECC revisions*
Compliance Testing Options	Materials, Assembly, or Whole Building	Materials, Assembly, Dwelling Unit (Group R and I) or Whole Building (required under certain conditions)
Maximum Air Leakage Level	Materials ≤ 0.004 cfm/ft2 @ 75 Pa	Materials ≤ 0.004 cfm/ft2 @ 75 Pa
	Assemblies ≤ 0.04 cfm/ft2 @ 75 Pa	Assemblies ≤ 0.04 cfm/ft2 @75 Pa
	Whole Buildings ≤ 0.35 cfm/ft2 ("oops clause" allows up to 0.45 cfm/ft2)	Whole Buildings ≤ 0.35 cfm/ft2 ("oops clause" allows up to 0.45 cfm/ft2)
		Dwelling Units ≤ 0.27 cfm/ft2 @ 50 Pa, sampling allowed.
Whole Building Testing Requirements	Required for buildings less than 10,000 ft2 and single-zone buildings	Required for occupancies other than Group R and I except for buildings less than 25,000 sq ft in Climate Zones 0 through 4
	Required exceptions for when verification of the design and installation of the continuous air barrier is conducted	Group R-2 and I-1 occupancies are allowed to be tested by dwelling unit, with sampling.
Exceptions	Semiheated spaces in Climate Zones 0 through 6	Air Barriers not required in Climate Zone 2B;
	Single wythe concrete masonry buildings in Climate Zone 2B.	
Design and Installation Verification	Verification by 3rd party required when not performing whole building testing.	Verification required when not testing by dwelling unit or whole building testing. Installation of continuous air barrier verified by the code official, a registered design professional or approved agency. Includes review of construction documents, inspection during construction and a final commissioning report.
	Design to be detailed and identified in construction documents as continuous	Design to be detailed and identified in construction documents as continuous
	Construction documents to include inspection details, including: 1. schedule/frequency, 2. scope of work, 3. critical observations, 4. document requirements, 5. corrective actions provisions	Construction documents to include inspection details, including: 1. schedule/frequency, 2. scope of work, 3. critical observations, 4. document requirements, 5. corrective actions provisions
Performance Modeling Compliance	Design Phase: model specified air leakage (energy savings credit for performance 0.35 cfm/ft2 or less)	Follow mandatory requirements (.35 cfm/ft2 @75 Pa)
	Construction Phase: Adjust model for actual tested air leakage, energy savings credit for performance better than 0.35 cfm/ft2)	
Simplified Path Compliance	COMcheck Compliance - Whole Building Testing: Default 0.35 cfm/ft2 @75 Pa air leakage input	COMcheck Compliance - Default 0.35 cfm/ft2 @75 Pa air leakage input
	COMcheck Compliance - Verification Only: Default 0.45 cfm/ft2 @75 Pa air leakage input	Allows Reduced Air Leakage package on a sliding scale based on % reduction of base mandatory level
		Reduced air leakage package extended to testing by dwelling unit

Energy Codes & Standards



Air Barrier Testing Standards Referenced in IECC

- **Materials**
  - ASTM E2178 Standard Test Method for Air Permanence of Building Materials
- **Assemblies**
  - ASTM E283 Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen
  - ASTM D8052/D8052M Standard Test Method for Quantification of Air Leakage in Low-Sloped Membrane Roof Assemblies
  - ASTM E283 Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors Under Specified Pressure Differences Across the Specimen
  - ASTM E1677 Specification for Air Barrier (AB) Material or Systems for Low-rise Framed Building Walls
  - E2357 Standard Test Method for Determining Air Leakage of Air Barriers Assemblies
- **Buildings / Dwelling Units**
  - ASTM E779 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
  - ASTM E1827 Standard Test Methods for Determining Airtightness of Building Using an Orifice Blower Door
  - ASTM E3158 Standard Test Method for Measuring the Air Leakage Rate of a Large of Multizone Building
  - ASTM E1186 Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems
  - ANSI/RESNET/ICC 380 Standard for Testing Airtightness of Building, Dwelling Unit and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems, and Airflow of Mechanical Ventilation Systems

Designation: E779 – 10

Standard Test Method for Determining Air Leakage Rate by Fan Pressurization[1]

This standard is issued under the fixed designation E779; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method measures air-leakage rates through a building envelope under controlled pressurization and de-pressurization.

1.2 This test method is applicable to small temperature differentials and low-wind pressure differential, therefore strong winds and large indoor-outdoor temperature differentials shall be avoided.

1.3 This test method is intended to quantify the air tightness of a building envelope. This test method does not measure air change rate or air leakage rate under normal weather conditions and building operation.

NOTE 1—See Test Method E741 to directly measure air-change rates using the tracer gas dilution method

1.4 This test method is intended to be used for measuring the air tightness of building envelopes of single-zone buildings. For the purpose of this test method, many multi-zone buildings can be treated as single-zone buildings by opening interior doors or by inducing equal pressures in adjacent zones.

1.5 Only metric SI units of measurement are used in this standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements see Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E631 Terminology of Building Constructions

E741 Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution

E1258 Test Method for Airflow Calibration of Fan Pressurization Devices

3. Terminology

3.1 For definitions of terms used in this test method, refer to Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air-change rate, n*—air-leakage rate in volume units/h divided by the building space volume with identical volume units, normally expressed as air changes/h, ACH.

3.2.2 *air-leakage, n*—the movement/flow of air through the building envelope, which is driven by either or both positive (infiltration) and negative (exfiltration) pressure differences across the envelope.

3.2.3 *air-leakage graph, n*—the graph that shows the relationship of measured airflow rates to the corresponding measured pressure differences, plotted on a log-log scale.

3.2.4 *air-leakage rate, n*—the volume of air movement/unit time across the building envelope including airflow through joints, cracks, and porous surfaces, or a combination thereof driven by mechanical pressurization and de-pressurization, natural wind pressures, or air temperature differentials between the building interior and the outdoors, or a combination thereof.

3.2.5 *building envelope, n*—the boundary or barrier separating different environmental conditions within a building and from the outside environment.

3.2.6 *effective leakage area, n*—the area of a hole, with a discharge coefficient of 1.0, which, with a 4 Pa pressure difference, leaks the same as the building, also known as the sum of the unintentional openings in the structure

3.2.7 *height, building, n*—the vertical distance from grade plane to the average height of the highest ceiling surface.

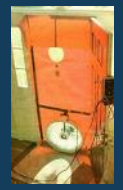
3.2.8 *interior volume, n*—deliberately conditioned space within a building, generally not including attics and attached structures, for example, garages, unless such spaces are connected to the heating and air conditioning system, such as a crawl space plenum.

3.2.9 *single zone, n*—a space in which the pressure differences between any two places, differ by no more than 5 % of the inside to outside pressure difference including multi-room

[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.41 on Air Leakage and Ventilation Performance.

Current edition approved Jan. 15, 2010. Published April 2010. Originally approved in 1981. Last previous edition approved in 2003 as E779 – 03. DOI: 10.1520/E0779-10.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



US Army Corps of Engineers Air Leakage Test Protocol

Measuring Air Leakage in Buildings for the US Army Corps of Engineers

Written by:
Colin Genge, Retrotec Inc
cgenge@retrotec.com, 604 732-0142

Designation: E3158 – 18

Standard Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building[1]

This standard is issued under the fixed designation E3158; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard test method provides a quantitative field-test procedure and calculation method for assessing an air leakage rate using a fan-induced pressure differential(s) across the building envelope, generated by blower doors or equivalent equipment.

1.2 Building setup conditions in accordance with defining the test boundaries appropriate for testing the envelope's air leakage are defined in this test method.

1.3 Procedure to determine the air pressure boundaries of the test envelope to be tested are provided in this test method.

1.4 This test method applies to all multizone and large building types and portions or subsections thereof.

1.5 This test method defines three test procedures: multi-point regression, repeated single point, and repeated two-point air leakage rate testing.

1.6 This test method allows for testing the test envelope in a pressurized condition, a depressurized condition, or in both conditions and averaging the results.

1.7 This test method applies to an air leakage rate specifi- (0.04 in.

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priate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.11 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E456 Terminology Relating to Quality and Statistics

E631 Terminology of Building Constructions

E779 Test Method for Determining Air Leakage Rate by Fan Pressurization

E1186 Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

E1258 Test Method for Airflow Calibration of Fan Pressurization Devices

E1827 Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door

E2178 Test Method for Air Permeance of Building Materials

E2357 Test Method for Determining Air Leakage Rate of Air Barrier Assemblies

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of general terms related to building construction used in this test method, refer to Terminology E631 and for general terms related to accuracy, bias, precision, and uncertainty, refer to Terminology E456.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *baseline pressure, n*—internal test envelope pressure with the air movement equipment off and sealed, recorded while the building is configured for the test.

3.2.2 *building envelope, n*—defined boundary of the test sample to determine its air leakage rate excluding the HVAC-related devices (HVAC devices sealed).

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

RESNET
RESIDENTIAL ENERGY SERVICES NETWORK

ICC INTERNATIONAL CODE COUNCIL

ANSI/RESNET/ICC 380-2019

Standard for Testing Airtightness of Building, Dwelling Unit, and Sleeping Unit Enclosures; Airtightness of Heating and Cooling Air Distribution Systems; and Airflow of Mechanical Ventilation Systems

Approved American National Standard
ANSI

November 21, 2018

Residential Energy Services Network, Inc.
P.O. Box 4561
Oceanside, CA 92052-4561
http://resnet.us/

International Code Council
500 New Jersey Avenue, NW, 6th Floor
Washington, D.C. 20001
www.iccsafe.org

Future Developments

- Improvements in air leakage modeling methodology.
- Accurate costs for whole building testing and onsite verification. Cost analysis is required for the inclusion of provisions in building energy codes. Few cost surveys or data summaries on the cost of air barrier verification or whole building air leakage testing are available. Specific data that are needed include:
  - the reduction in test cost as the test process becomes more common,
  - the reduction in test cost as air leakage thresholds are reduced, and
  - the frequency of verification required for performance improvement and associated costs.
- Improvements to the quality of whole building testing. There can be variability in the accuracy and experience of whole building testing providers. To provide guidance and establish a testing quality control process, industry training and certification programs are beginning to be initiated.
- Understanding the relationship between energy efficiency benefits and other building benefits. Currently, air leakage is contained primarily within energy efficiency codes and standards and the benefits air leakage control provides for indoor environmental quality (IEQ), moisture durability, and building resilience are in other documents or ignored. A more holistic understanding of how these different performance facets work together and are evaluated is necessary for a complete understanding of the value of reducing air leakage.

Questions?

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Benjamin.Meyer@siplast.com