COULD PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA BECOME AN ALTERNATIVE CODE COMPLIANCE PATH?

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History of Code and Standard development

United States

1934-1973 – US Housing Act establishes FHA. ASHRAE established. HUD established. Civil Rights/Fair Housing Act. HUD Minimum Property Standards.

Initial National Building Standards

1975-1978 – First edition of ASHRAE Standard 90; BOCA, SBCCI and ICBO co-publish Code for Energy Conservation. Energy performance requirements to HUD MPS

Initial National building energy performance standards

1983 – HUD begins reference model or local code in lieu of MPS. CABO, a joint effort of BOCA, SBCCI, ICBO and the American Insurance Association publish first edition of the Model Energy Code (MEC)

Transition from national standards to privately written Model Energy Codes and Standards

1994-1998 – BOCA, SBCCI and ICBO merge into the International Code Council (ICC), ICC publishes first edition of IECC replacing the MEC

Multiple model code promulgators merge into ICC and publish 1st IECC

2001-2015 – ANSI/ASHRAE/IES 90.1 develops to include multiple paths to compliance. IECC commercial provisions add 'simplified' code text as alternatives to ANSI/ASHRAE/IES 90.1. 'Performance rating' method introduced with 'score' better than prescriptive/reference building level introduced to commercial in 2007 and residential in 2015

Multiple compliance paths develop –

ALL remain related to original prescriptive 'recipe' method

Canada

1941 – First edition of National Building Code published

Initial National Building Code

1974-1977 – Department of Energy, Mines and Resources request draft guidelines for energy conservation in buildings. First draft of guidelines, based largely upon prescriptive path option of the ANSI/ ASHRAE/IES Standard 90.1, completed.

Initial national building energy performance standards

1978-1983 – First edition Measures for Energy Conservation in Buildings (MECB) published. Second edition of MECB added new section specific to low rise residential (residences)

Model Codes replace national standards

1997 – National Research Council of Canada (NRCC) publishes first editions of Model National Energy Code for Buildings (MNECB) and Model National Energy Code for Houses (MNECH)

Model Energy Code for commercial buildings separated from energy provisions for houses and small buildings

2007-2011 – NRCC forms standing committee on Energy Efficient Buildings. MNECH becomes Part 9 of National Building Code applicable to Houses and small buildings. NRCC standing committee efforts result in 2011 edition of the MNECB and establishes policy to develop new editions every three years

Codes evolve – remain related to original prescriptive 'recipe' method

US States of California and Wisconsin

1978 – Title 23, Part 6 and Comm 22 established

Energy Performance Standards Established

PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

History of Government owned building performance policy

United States (GSA)

2006 – All Federal building projects to follow the USGBC's LEED rating system and achieve not less than a 'Gold' rating.

Appendix G

Compliance method for federal buildings established

2007 – Energy Independence and Security Act President George W. Bush executive order 13514 requires,

starting in 2020, all federally owned buildings to reduce their fossil fuel generated energy use **100% by 2030**.

Performance GOAL established

AND

States encouraged to progress by adopting most current code/standard edition

Canada (crown)

1991-2008 – Federal Building Initiative requires all crown owned buildings to improve their energy performance. Federal Sustainable Development Strategy requires reduction of emission levels of all crown owned buildings by **17% between 2005 and 2020 – Performance GOAL established**

2011 – All 40,000 crown owned buildings determined their 2005 annual CO^2e baseline emissions **(benchmark established)**

2012 – All new, build to lease and major renovation projects >1000 m^2 crown owned projects required to follow:

1) Canada GBC LEED (thus using ANSI/ASHRAE/IES Standard 90.1 Appendix G)

Appendix G

2) GBI Green Globes (one of 4 methods), **or**

3) BOMA BESt (Building Environmental Standards) assessment and certification

Compliance methods established

Nationally owned buildings establish energy/emissions benchmark goal

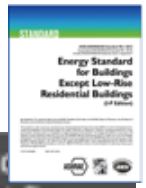
PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

Current most popular model codes and standards

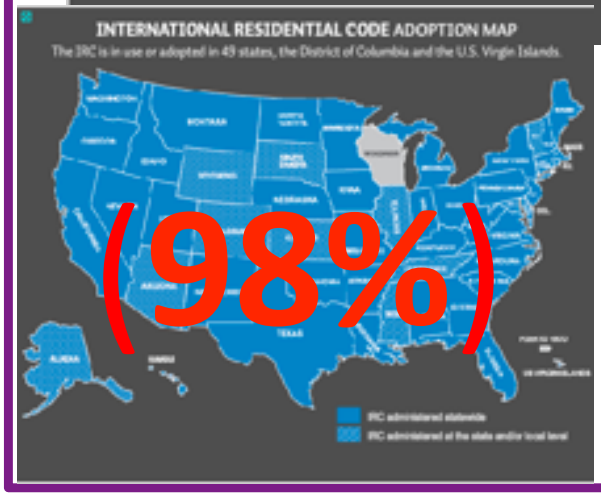
United States (as of 2014)

Residential and Commercial

Joint publication



Commercial only



Chapter 11 identical to IECC residential provisions

Canada (as of 2014)

2011 edition in use or adopted in 5 provinces/territories
British Columbia, Alberta, Manitoba, Ontario and Nova Scotia

1997 edition or other in use in 8 (62%) provinces/territories
Yukon, Northwest territories, Nanavut, Saskatchewan, Quebec, Newfoundland and Labrador, new Brunswick and Prince Edward island

Commercial only

(38+%)

(77+%)

Houses and small buildings

2010 edition in use or adopted in 10 provinces/territories
Yukon, Northwest Territories, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Nova Scotia. Prince Edward Island, Newfoundland and Labrador

Earlier edition or other in use in 3 provinces/territories
Nanavut, Quebec, New Brunswick

Part 9 of NBC

Model codes used in high % of US and Canada, residential > non-residential

PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

Though codes and standards vary in detail all similar in concept and methodology

- US National Model
- US State written
- Canadian National Model

- **All include**/address building energy used systems associated with human comfort and convenience
- **Some exclude** building energy use for:
  - **Process loads** (in support of a manufacturing, industrial or commercial process specific to a particular building or occupancy type)
- **All allow flexibility of multiple paths** to compliance

Code/standard compliance methodology development

Increase design flexibility
ALL comparisons to prescriptive

	ICC IECC residential and non-residential / IRC residential	ANSI/ASHRAE/IES Standard 90.1 non-residential	Sate of California Title 24, Part 6 residential and non-residential	State of Wisconsin Comm 22 residential	NRCC NECB non residential / NBC residential
Prescriptive 'RECIPE'	1998, 2000	1975	1978	1978	1978
Trade-off '=/better than' prescriptive for specific components/systems	2000	1980's	1980's	1980's	1997
Performance – Energy Cost Budget Comparison '=/better than' prescriptive for total building	2004, 2006	1990's	1990's	1990's	2011
Performance Rating % better than prescriptive for total building	2015	2007			

PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

US Model Code/Standard compliance path advantages/disadvantages

Prescriptive (and UA trade-off option) - IECC or 90.1

Advantages

1. Simple prewritten recipe, no software
2. **OR** free easy to use software (USDOE COMcheck or REScheck to document:
    1. prewritten recipe compliance, **or**
    2. UA trade-off for building envelope adding limited flexibility to building envelope components
3. Does not prevent any component or system from having superior performance
4. Likely least time/effort to document compliance

Disadvantages

1. Limited flexibility
2. No credit for better performing
    1. HVAC,
    2. Service Water Heating,
    3. MEL (plug-ins), or
    4. Lighting
3. Performance level (benchmark) not required to be transparent

Performance (energy cost) Comparison – IECC or 90.1

Advantages

1. Flexibility in all components and systems
2. Several free software tools tested in accordance with ASHRAE Standard 140 beyond USDOE's EnergyPlus – see software tools link

Disadvantages

1. Requires software tool competency and associated added effort/time/cost
2. Must simulate/model both reference and proposed buildings
3. 'Proposed' building need only be 'equal to' prewritten prescriptive recipe building
4. Performance level (benchmark) of either 'recipe' or 'proposed' buildings not required to be transparent

Performance (energy cost) Comparison Rating – IECC or 90.1

Advantages

1. Same as performance (energy cost) comparison path
2. Includes percentage improvement of 'proposed' over 'baseline' building performance score

Disadvantages

1. Same as items 1 and 2 in performance (energy cost) comparison path
2. Performance level (benchmark) of either 'recipe' or 'proposed' buildings not required to be transparent
3. Residential provisions 'recipe' building is based upon 2006 prescriptive IECC

Passive House 3-Pillar Benchmark Performance Criteria as an Alternative Code Compliance Path?

US model code (IECC commercial) paths to compliance

2015 ICC International Energy Conservation Code Commercial provisions paths to code compliance

(Not allowed to be used for one and two-family dwellings, multiple single family dwellings (townhouses) or multi-family dwelling structures 3 stories or less in height)

Comment: prescriptive path in IECC Commercial provisions emphasizes building envelope more and HVAC and lighting efficiency less than ANSI/ASHRAE/IES Standard 90.1

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Mandatory provisions applicable under both paths listed below

C402.5 Air Leakage (Thermal envelope, **C402.5.2** Fenestration, **C402.5.3** Rooms containing fuel-burning appliances, **C402.5.4** Doors/openings to shafts/chutes/stairways/elevator lobbies, **C402.5.5** Air intakes/exhaust openings, **C402.5.6** loading dock weatherseals, **C402.5.7** vestibules, **C402.5.8** recessed lighting)

C403.2 Mechanical Systems (**C403.2.1** Load calculations, **C403.2.2** Equipment sizing, **C403.2.3** Equipment performance, **C403.2.4** Controls, **C403.2.5** Boiler outdoor temperature setback, **C403.2.6** Ventilation, **C403.2.7** Energy recovery ventilation, **C403.2.8** Kitchen exhaust systems, **C403.2.9** Duct/plenum insulation and sealing, **C403.2.10** Piping insulation, **C403.2.11** Systems commissioning, **C403.2.12** > 5hp fan air system control, **C403.2.13** Heating outside building, **C403.2.14** Refrigeration equipment performance, **C403.2.15 &16** Walk-in Coolers/Freezers/Warehouses, **C403.2.17** Refrigerated Display Cases)

C404 Service Water Heating (**C404.2** Equipment Efficiency, **C404.3** Heat Traps, **C404.4** Piping Insulation, **C404.5** Efficient heated water supply piping, **C404.6** Circulating and temperature maintenance systems, **C404.7** Demand recirculation controls, **C404.8** Drain water heat recovery units, **C404.9** Pools and permanent spa heaters/time switches/covers, **C404.10** Portable spas, **C404.11** Commissioning)

C405 Electrical Power and Lighting Systems (**C405.2** Lighting controls, **C405.3** Exit signs, **C405.5** Exterior lighting, **C405.6** Energy consumption meters, **C405.7** Electrical transformers, **C405.8** Electrical motors, **C405.9** Vertical and horizontal transportation systems)

C408 System Commissioning **C408.1** General, **C408.2** Mechanical and Service water heating systems (≥480,000 Btu/h cooling, ≥600,000 Btu/h combined space and service water heating), **C408.2.1** Commissioning plan (narrative, equipment/appliance/systems list and tests to be performed, functions to be tested including calibrations and economizer controls, conditions under which tests to be performed to confirm winter and summer design and full outside air conditions), **C408.2.2** Systems adjusting and balancing (air [> 1hp motors] and hydronic [> 5 hp pumps and > 5% nameplate draw] systems flow rates), **C408.2.3.1** Equipment performance testing (all modes in sequence of operation, redundant or automatic back-up mode, performance of alarms, loss of power to restoration of power mode, **C408.2.3.2** Controls (HVAC and Service water heating calibration and sequence of operation testing), C408.2.4 Preliminary commissioning report (accepted by building owner and copy to code official), **C408.2.5** Documentation requirements (drawings, manuals, system balancing report, final commissioning report), **C408.3** Lighting system functional testing (occupancy sensor controls, time switch controls, daylight responsive controls, documentation of meeting requirements)

PRESCRIPTIVE path

(With option for component tradeoff for Building Envelope provisions)

(Similar to ANSI/ASHRAE/IES Standard 90.1 prescriptive path with tradeoff building envelope provisions)

C402 Building Envelope
- C402.1 Opaque portions (R-value method), or
  - Opaque portions (U-, C-, F-factor assembly method), or
  - Opaque portions (U-, C-, F- factor component trade-off method using COMCheck or equivalent software tool)
  - Exceptions: (Low Energy, non-conditioned, greenhouse, electronic equipment buildings)
- C402.2 Specific Insulation requirements (multi-layer, roof assembly, above grade walls, floors, slab-on-grade perimeter, radiant heating systems)
- C402.3 Roof solar reflectance and thermal resistance
- C402.4 Fenestration (maximum vertical area with daylight responsive controls increase option, minimum skylight area, maximum U-factor and SHGC, Opaque doors)

C403 Mechanical Systems
- C403.3 Economizers
- C403.4 Hydronic and multi-zone HVAC sys. & equip. (fan control, hydronic system control, heat rejection equipment, complex systems, heat recovery for service water heating, hot gas bypass limitation)
- C403.5 Refrigeration systems

C405 Electrical Power and Lighting Systems
- C405.4 Interior Lighting power requirements
  - C405.4.1 Total connected power
  - C405.4.2 Interior lighting power (building area or space by space method)

C406 Additional Efficiency Package Options – at least one of
- C406.2 More efficient (≥ 10%) HVAC equipment performance
- C406.3 Reduced (≥ 10%) lighting power density
- C406.4 Enhanced lighting controls (continuous dimming luminaires, luminaires individually or group ≤ 4 addressable, ≤ 8 luminaires w/in a daylight zone, digital control system [addressability, load shedding, individual user control of overhead in open offices, occupancy sensor reconfiguration capability], sequence of operations included with construction documents, functional testing/commissioning)
- C406.5 On-site renewable energy (0.50 W / ft2 of CFA or ≥ 3% of HVAC, SWH and lighting energy demand)
- C406.6 Dedicated outdoor air ventilation system
- C406.7 Reduced (≥ 60%) energy use in Service Water Heating via SHW waste/chiller/building/equipment/process equipment/CHP heat recovery or a solar water-heating system

TOTAL BUILDING PERFORMANCE path

(Requires simulation software tool – i.e Energy Plus, Open Studio, BLAST or other software tested in accordance with ASHRAE Standard 140 to meet requirements of C407.6)

(Similar to ANSI/ASHRAE/IES Standard 90.1 Energy Cost Budget path)

Heating systems, cooling systems, service water heating, fan systems, lighting power, receptacles and process loads to result in an annual energy cost of the *proposed design building* ≤ 85% of the *standard reference design building*

C407.2 mandatory requirements
- C402.5 Air leakage
- C403.2 Mechanical Systems
- C404 Service Water Heating
- C405 Electrical Power and Lighting Systems

C407.3 Documentation
- C407.4.1 Compliance report (Building Address, checklist listing *proposed design building* component characteristics and annual energy cost of both *proposed* and *standard reference buildings*, name of report preparer, name/version of compliance/simulation tool)
- C407.4.2 Additional documentation – if requested (*standard reference design building* characteristics, thermal zone diagrams of both buildings, input/output reports, explanation of error messages, certification by builder of *proposed design building* component characteristics)

C407.5 Calculation procedure
- C407.5.1 Building specifications for both buildings (1. Space use classification, 2. Roofs, 3. Walls, above grade, 4. Walls, below grade, 5. Floors, above grade, 6. Floors, slab-on-grade, 7. Opaque doors, 8. Vertical fenestration other than opaque doors, 9. Skylights, 10. Lighting, interior, 11. Lighting, exterior, 12. Internal gains, 13. Schedules, 14. Mechanical ventilation, 15. Heating systems, 16, Cooling systems, 17. Service water heating)
- C407.5.2 Thermal blocks (1. HVAC zones designed, 2. HVAC systems not designed, or 3. Multifamily residential buildings)

C407.6 Calculation software tool capabilities for determining annual energy consumption
1. Building operation for calendar year (8760 hours)
2. Climate data for full calendar year inclusive of coincident hourly data for temperature, solar radiation, humidity, wind speed
3. Ten or more thermal zones
4. Thermal mass effects
5. Hourly variations in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage, process loads
6. Part-load performance curves for mechanical equipment
7. Capacity and efficiency correction curves for mechanical heating and cooling equipment
8. Printed code official inspection checklist listing each of *proposed design building* component characteristics along with their respective performance ratings (R-value, U-factor, SHGC, HSPF, AFUE, SEER, ER)

C407.6.1 Specific approval for analysis tools tested in accordance with ASHRAE Standard 140

C407.6.2 Input values not specified by C402, C403, C404 or C405 from approved source

C407.6.3 Exceptional calculation methods (1. Step-by-step documentation with reproducible results, 2. Spreadsheets, 3. Sensitivity analysis where input parameters varied from ½ to 2x value assumed, 4. Calculations performed on same step-by-step basis as analysis tool software, 5. Performance rating calculated with and without exceptional calculations)

PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

US ANSI/ASHRAE/IES 90.1 paths to compliance (alternative to IECC commercial)

ANSI/ASHRAE/IES Standard 90.1-2013 Energy Standard for Buildings Except Low-Rise Residential Buildings paths to code compliance
(Not allowed to be used for one and two-family dwellings, multiple single family dwellings (townhouses) or multi-family dwelling structures 3 stories or less in height)
Comment: prescriptive path in ANSI/ASHRAE/IES Standard 90.1 emphasizes HVAC and lighting efficiency more and building envelope less than 2015 IECC Commercial provisions by Joseph Zimmer, Architect ©2015

Mandatory provisions applicable under all 3 paths listed below

5.4 Building Envelope (**5.4.1** Insulation, **5.4.2** Fenestration and Doors, **5.4.3** Air Leakage [continuous air barrier, loading dock weatherseals, vestibules])
6.4 HVAC (**6.4.1** Equipment Efficiencies, **6.4.2** Calculations, **6.4.3** Controls, **6.4.4** Construction and Installation, **6.4.5** Walk-in Coolers and Freezers, **6.4.6** Refrigerated Display Case)
7.4 Service Water Heating (**7.4.1** Calculations, **7.4.2** Equipment Efficiency, **7.4.3** Piping Insulation, **7.4.4** Controls, **7.4.5** Pool Heaters/Covers/Time Switches, **7.4.6** Heat Traps)
8.4 Power (**8.4.1** Voltage Drop, **8.4.2** Automatic Receptacle Control, **8.4.3** Electrical Energy Monitoring, **8.4.4** Low Voltage Dry-Type Distribution Transformers)
9.4 Lighting (**9.4.1** Lighting Control, **9.4.2** Exterior Building Lighting Power, **9.4.3** Functional Testing)
10.4 Other Equipment (**10.4.1** Elec. Motors, **10.4.2** Service Water Pressure Booster Sys., **10.4.3** Elevators, **10.4.4** Escalators, **10.4.5** Whole-Building Energy Monitoring)

PRESCRIPTIVE path

(With option for UA tradeoff for Building Envelope provisions)
(Similar to ICC IECC prescriptive path with tradeoff building envelope provisions)

5. Building Envelope
   - 5.1 General (non-res./residential/semi-heated condition category, envelope alterations, climate)
   - 5.7 Submittals (space condition category, visible light transmittance, daylight areas)
   - 5.8 Product Information (insulation, fenestration and doors)
   - and, either
   - 5.5 Prescriptive (insulation, fenestration and doors), or
   - 5.6 UA tradeoff (using COMCheck or equivalent software program)
6. Heating Ventilating and Air Conditioning
   - 6.1 General (New, Addition, Alteration)
   - 6.7 Submittals (drawings, manuals, balancing, commissioning)
   - 6.8 Minimum Efficiency/performance Tables (HVAC & R equipment, duct insulation, pipe insulation)
   - and, one of the following
   - 6.3 Simplified Approach (allowed if ≤2 stories, ≤25,000 ft² and 1 zone)
   - 6.5 Prescriptive (economizers, simultaneous heating and cooling limitation, > 5 hp fan air system control, ≥1000 Mbtu/h boiler and > 10 hp pump controls, heat rejection [cooling] equipment, energy recovery, exhaust systems, radiant heating, hot gas bypass limitation, exterior door switch controls, refrigeration systems)
   - 6.6 Alternative Compliance (computer rooms)
7. Service Water Heating
   - 7.1 General (New, Addition, Alteration)
   - 7.5 Prescriptive (Space and water heating, ≥90% efficient if system ≥1000 Mbtu/h)
   - 7.7 Submittals (if requested by Authority having Jurisdiction [AHJ])
   - 7.8 Product Information (heaters, boilers, pool heaters, storage tanks)
8. Power
   - 8.1 General (New, Addition, Alteration)
   - 8.7 Submittals (drawings, manuals)
9. Lighting
   - 9.1 General (Scope, Alterations, Power, Wattage)
   - 9.7 Submittals (drawings, manuals, day lighting areas)
   - and, either
   - 9.5 Prescriptive building area method, or
   - 9.6 Prescriptive space by space method
10. Other Equipment
    - 10.1 General (New, Addition, Alteration)
    - 10.8 Product information (Motor efficiency)

ENERGY COST BUDGET METHOD path

(Requires simulation program tool – i.e Energy Plus, Open Studio, BLAST or other software tested in accordance with ASHRAE Standard 140 to meet requirements of 11.4)
(Similar to ICC IECC total building performance path)

11.1 General (Scope, trade-off limitation for < whole building, building envelope design prior to permit application)
11.2 Compliance
- a. Mandatory provisions (5.4, 6.4, 7.4, 8.4, 9.4, 10.4) met
- b. Simulation program calculation for 'proposed building' design results in an annual energy cost less than the annual energy cost of the 'budget building'
- c. Energy efficiency level of components specified meet or exceed the efficiency level of the components used in simulation program calculations.

11.4 Simulation General Requirements
- 11.4.1.1 Minimum capabilities (**a**. minimum 1400 hours, **b**. Hourly variations in occupancy, lighting power, misc. equipment loads, **c**. Thermal mass effects, **d**. Ten or more thermal zones, **e**. Part load performance curves for mechanical equipment, **f**. Capacity and efficiency correction curves for heating and cooling equipment, **g**. Air-side and water-side economizers, **h**. budget building characteristics)
- 11.4.1.2 Energy cost calculation options (directly calculated or hourly reports to be input into separate calculator)
- 11.4.1.3 HVAC system sizing capability (ASHRAE Standard 183)
- 11.4.1.4 Simulation program testing (ASHRAE Standard 140)
- 11.4.2 Climatic data (approved per city or best representative)
- 11.4.3 Renewable, Recovered, Purchased Energy
- 11.4.4 Compliance Calculations (a. same program, b. climate data and c. purchased energy cost rates for both buildings)
- 11.4.5 Exceptional Calculation Methods (a. no change to input parameters, b. input/output documentation agreed to by AHJ, c. supported with instructions for using method)

11.5 Calculation of Design and Energy Cost Budget
- 11.5.1 In accordance with Tabular requirements (1. Design Model, 2. Additions and Alterations, 3. Space Use Classification, 4. Schedules, 5. Building Envelope, 6. Lighting, 7. Thermal Blocks – HVAC Zones Designed, 8. Thermal Blocks – HVAC Zones Not Designed, 9. Thermal Blocks – Multi-family Residential Buildings, 10. HVAC Systems, 11. Service Hot water Systems, 12. Miscellaneous Loads, 13. Modeling Exceptions, 14. Modeling Limitations to the Simulation Program)
- 11.5.2 HVAC Systems (a through k)

11.7 Documentation Requirements
- a. Energy cost budget and design energy cost
- b. List of energy features for budget and design energy cost and how they differ
- c. input/output reports for not less than lights, internal equipment, SWH equipment, space heating equipment, space cooling and heat rejection equipment, fans and other HVAC equipment
- d. Explanation of program error messages
- e. Reduction in design energy cost associated with on-site renewable energy generation

PERFORMANCE RATING METHOD (Appendix G)

(Normative appendix, not yet contained within standard's chapter text)
(Requires simulation program tool – i.e Energy Plus, Open Studio, BLAST or other program tested in accordance w/ ASHRAE Standard 140 to meet requirements of G.2)
(Similar to ICC IECC residential provisions Energy Rating Index path)

G1.1 Scope (same as 11.1 plus rating of how much better proposed is than baseline building)
G.1.2 Performance rating
- a. Mandatory provisions (5.4, 6.4, 7.4, 8.4, 9.4, 10.4) met
- b. Performance rating calculation

$$100 \times \frac{\text{(baseline building annual energy cost – proposed building annual energy cost)}}{\text{baseline building annual energy cost}}$$

G1.3 Trade-Off Limit (if < whole building, only systems modified)
G1.4 Documentation Requirements (**a**. brief project description, efficiency improvements, simulation program name and version, results of baseline and proposed building performance and % of improvement, **b**. overview of project including # of stories, typical floor size, uses/occupancies, gross area per use/occupancy, if each use conditioned, **c**. list of energy related features and differences between proposed and baseline buildings, **d**. list documenting compliance with mandatory provisions, **e**. list identifying aspects less stringent than if met prescriptive provisions [5.5, 6.5, 7.5, 8.5, 9.5 and 9.6], **f**. table with summary by end use of energy cost savings, **g**. site plan showing what may shade proposed building, **h**. building elevations and floor plans, i. diagram of thermal blocks, **j**. explanation of simulation assumptions, **k**. back up calculations justifying input values, l. input/output reports for not less than lights, internal equipment, SWH equipment, space heating equipment, space cooling and heat rejection equipment, fans and other HVAC equipment, **m**. purchased energy rates, **n**. explanation of program error messages, **o**. exceptional calculation predicted energy savings by energy type, energy cost savings, narrative describing exceptional calculation method, theoretical or empirical information supporting method, **p**. reduction in design energy cost associated with on-site renewable energy generation)
G2.1 Performance Calculations (a. same program, b. climate data and c. purchased energy cost rates for both buildings)
G2.2 Simulation Program
- G2.2.1 Minimum capabilities (**a**. 8760 hours, **b**. Hourly variations in occupancy, lighting power, misc. equipment power, Thermostat set points, HVAC system operation, **c**. Thermal mass effects, **d**. Ten or more thermal zones, **e**. Part load performance curves for mechanical equipment, **f**. Capacity and efficiency correction curves for heating and cooling equipment, **g**. Air-side economizers with integrated control, **h**. baseline building characteristics)
- G2.2.2 Energy cost/performance options (directly calculated or hourly reports to be input into separate calculator)
- G2.2.3 HVAC system sizing capability including air and water flow rates (ASHRAE Handbook of Fundamentals)
- G2.2.4 Simulation Program Testing (ASHRAE Standard 140)
- G2.3 Climatic data (approved per city or best representative)
- G2.4 Renewable, Recovered, Purchased Energy
  - G2.4.1 On-Site Renewable and Recovered
  - G2.4.2 Annual Energy Cost (same rate for both buildings)
- G2.5 Exceptional Calculation Methods (**a**. step by step documentation with reproducible results, **b**. spreadsheets, **c**. sensitivity analysis where input parameters varied from ½ to 2x value assumed, **d**. calculations performed in same step by step basis as simulation program, **e**. performance rating calculated with and without exceptional calculations)

G3.1 Building Performance Calculations (1. Design Model, 2. Additions and Alterations, 3. Space Use Classification, 4. Schedules, 5. Building Envelope, 6. Lighting, 7. Thermal Blocks – HVAC Zones Designed, 8. Thermal Blocks – HVAC Zones Not Designed, 9. Thermal Blocks – Multi-family Residential Buildings, 10. HVAC Systems, 11. Service Hot water Systems, 12. Receptacle and Other Loads, 13. Modeling Limitations to Simulation Program, 14. Exterior Conditions, 15. Distribution Transformers)
G3.1.1 Baseline HVAC system type, Baseline HVAC system requirements if system using purchased heat or chilled water, Purchased heat, Purchased Chilled Water, Infiltration Calculation (75 Pa across total building envelope area), G3.1.2 Baseline HVAC System Requirements, G3.1.3 System-Specific Baseline HVAC System Requirements

PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

US model code (IECC Residential) paths to compliance

2015 ICC International Energy Conservation Code Residential provisions paths to code compliance

(Applicable to one and two-family dwellings, multiple single family dwellings (townhouses) or multi-family dwelling structures 3 stories or less in height)

Comment: Energy Rating Index path is structured parallel to the RESNET HERS Index methodology

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Mandatory provisions applicable under all 3 paths listed below

R401.3 Certificate (Insulation R-values on ceiling/roof, walls, foundation, ducts; U-factor and SHGC of fenestration, results from duct and building envelope air leakage tests; efficiency ratings of space heating and cooling, and service water heating equipment)

R402.4 Air leakage (**R402.4.1** Building thermal envelope, **R402.4.2** Fireplaces, **R402.4.3** Fenestration, **R402.4.4** Rooms containing fuel burning appliances, **R402.4.5** Recessed lighting)

R402.5 Maximum fenestration U-factor and SHGC (area weighted average Us0.48 in CZ 4&5, s0.40 in CZ 6-8; skylights Us0.75 in CZ 4-8)

R403.1 Heating and Cooling Systems Controls (**R403.1.1** programmable thermostats, **R403.1.2** heat pump supplementary [electrical resistance] heat prevention when heat pump compressor can meet heating load)

R403.3 Ducts (**R403.3.2** Sealing [including ≤2 % leakage at air handling unit], **R403.3.3** pressure test at 25 Pa [0.1 w.g.] with written report, **R403.3.5** no building cavities used as ducts/plenums)

R403.4 Mechanical System piping insulation (if > 105°F or <55°F fluid ≥R-3 and **R403.4.1** protected from damage by sunlight, moisture, equipment maintenance, wind, solar radiation with other than adhesive tape)

R403.5 Service hot water circulation and temperature maintenance systems (**R403.5.1.1** circulation system pump start on demand and off when temperature satisfied or no demand; **R403.5.1.2** heat trace systems to comply with IEEE 515.1 or UL 515)

R403.6 Mechanical Ventilation (quantity in accordance with International Residential Code section M1507 = 0.01 CFA + 7.5 (N_{br} + 1), or International Mechanical Code section 403 = > of 0.35 (CFA x 8') or 15 cfm/occupant as applicable)

R403.7 Heating and Cooling System sizing and efficiency rating (sized per ACCA manual S based upon ACCA manual J load calculations or other approved methodology; efficiency rating ≥ federal law for geographic location)

R403.8 Systems serving multiple dwelling units (Comply with **C403** Mechanical [Load calculations, Equipment sizing, Equipment performance, Controls, Boiler outdoor temperature setback, Ventilation, Duct/plenum insulation and sealing, Piping insulation, Systems commissioning, > 5hp fan air system design/control] and **C404** Service Water Heating [Equipment Efficiency, Heat Traps, Piping Insulation, Efficient heated water supply piping, Circulating and temperature maintenance systems, Demand recirculation controls, Drain water heat recovery units, Pools and permanent spa heaters/time switches/covers, Portable spas, Commissioning] in lieu of section R403)

R403.9 Snow melt and ice control systems (if power from building include control to automatically shut off when pavement temperature >50°F and no precipitation falling plus control that allows shut-off when outdoor temperature >40°F)

R403.10 Pools and permanent spas (**R403.10.1** where available only to individual household and guests comply with APSP-145, **R403.10.2** heaters to have on/off switch independent of thermostat and gas fired heaters not to have continuous burning pilot, **R403.10.3** time switches for heaters and pumps other than pumps that operate solar or waste-heat-recovery pool heating systems, **R403.10.4** vapor retardant covers except where >70% energy for heating from site-recovered energy)

R403.11 Portable spas (energy consumption of electrical powered controlled by APSP-14)

R404 Electrical Power and Lighting Systems (**R404.1** Lighting equipment - ≥ 75% to be ≥60 lumens/watt if > 40W, ≥50 lumens/watt if >15W, and ≥40 lumens/watt if ≤15W; **R404.1.1** fuel gas lights shall not have continuous burn pilot)

PRESCRIPTIVE path

(With option for component tradeoff for Building Envelope provisions)

R402 Building Thermal Envelope

- R402.1 Exceptions: Low energy and non-conditioned buildings
- R402.1.1 Vapor retarder (per IRC R702.7 for 1-2 family and townhouses or IBC 1405.3 for multifamily)
- R402.1.2 Insulation and fenestration criteria (Table R402.1.2 [R-values])
- R402.1.3 R-value computation (sum layers of settled, insulated siding label – R0.6)
- R402.1.4 U-factor alternative (Table R402.1.4 [U-factors] in lieu of R402.1.2 [R-values])
- R402.1.5 Total UA alternative (may trade-off components in building envelope if total U*A of envelope ≤ total U*A if all components in accordance with Table R402.1.2. Calculation to be consistent with ASHRAE *Handbook of Fundamentals* including thermal bridging effects of framing materials. SHGC shall meet table R402.1.2 – may use **RESCheck** or equivalent calculation tool)
- R402.2 Specific insulation requirements (**R402.2.1** ceilings with attics where insulation extends over wall top plate at eaves may reduce R-values from 38 to 30 and 49 to 38 respectively, **R402.2.2** smaller of ≤500 ft2 or 20% of total ceiling may reduce R-value to 30 where insufficient space for R38 or R49, **R402.2.3** provide ventilation baffles at eaves If air impermeable ceiling insulation, **R402.2.4** access doors from conditioned to unconditioned space to be weather stripped and insulated to level = adjacent assembly, **R402.2.5** mass walls considered above grade CMU, concrete, ICF, masonry cavity, brick, earth, solid timber logs, or any material ≥ 6 Btu/ft² x °F, **R402.2.6** steel framed walls to meet table R402.2.6 in lieu of R402.1.2 or may meet table R402.1.4 if calculation uses series parallel path calculation, **R402.2.7** continuous insulation R-value required by table R402.1.2 where structural sheathing ≤40% of wall may reduce ≤R-3 on areas of walls with structural sheathing, **R402.2.8** floor framing cavity insulation to maintain permanent contact with bottom of floor sheathing, **R402.2.9** conditioned basement walls to be insulated to lessor of 10' below grade or basement floor – unconditioned basements have same requirement if floor above basement not insulated to meet table R402.1.2 value or R402.1.4 factor, **R402.2.10** slab on grade <12" below grade to be insulated [vertical/horizontal or combination] to meet table R402.1.2, **R402.2.11** unvented crawl space walls to be insulated from floor above to grade plus 24" vertically or horizontally and exposed earth floors covered with class I vapor retarder, **R402.2.12** masonry veneer not required to have insulation on portion supported by foundation, **R402.2.13** thermally isolated sunrooms may reduce R-value at exterior walls and wall separating from conditioned space)
- R402.3 Fenestration (**R402.3.1** U-factor may be area-weighted average, **R402.3.2** SHGC may be area-weighted average, **R402.3.3** ≤15 ft² of glazing exempt, **R402.3.4** ≤24 ft² opaque door exempt, **R402.3.5** thermally isolated sunrooms may have ≤U0.45 windows/doors and ≤U0.70 skylights)

R403 Systems

- R403.3.1 Duct insulation (≥R-8 insulation on >3" dia., ≥R-6 insulation on ≤3" dia. in attics, ≥R-6, ≥R-4.2 respectively in other areas outside thermal envelope)
- R403.3.4 Duct leakage (rough-in test total leakage ≤4 cfm/100 ft² of CFA where air handler installed and ≤3 cfm if air handler not installed, post construction total leakage ≤4 cfm/100 ft² of CFA)
- R403.5.3 Hot water pipe insulation (≥R-3 insulation on ≥3/4" dia., serving >1 dwelling unit, outside conditioned space, from WH to distribution manifold, under an floor slab, buried, and supply/return piping in recirculation system)

SIMULATED PERFORMANCE ALTERNATIVE path

(Requires simulation software tool – i.e RESCheck, REMRATE or other software meeting minimum capabilities listed in R405.6)

R405.2 Mandatory provisions (in accordance with **all** above except all ducts outside thermal envelope insulated to ≥R-6)

R405.3 Compliance (annual energy cost [or source energy demand if mixed electricity source energy multiplier is 3.16 and source energy multiplier for all other fuels is 1.1] for proposed building is ≤ annual energy cost [source energy demand] of standard reference design. Energy cost/unit of energy to be approved by code official such as *US DoE, EIA State Energy Price Expenditure Report*)

R405.4 Documentation

- R405.4.1 Compliance software tool (verification that methods and accuracy of compliance software tools conform to code provisions of R405 provided to code official)
- R405.4.2 Compliance report (submitted with application for building permit showing proposed design complies with R403.5 and again prior to occupancy reflecting as-built conditions)
  - R405.4.2.1 with permit application (1. Address or other identification, 2. Statement indicating compliance with R405.3, 3. Inspection checklist documenting component characteristics of both *proposed* and *standard reference designs*, 4. Site-specific energy analysis report that is in compliance with R403.5 and, 5. Name of individual generating report, 6. Name and version of compliance software tool)
  - R405.4.2.2 for certificate of occupancy (1. Building location, 2. Statement indicating compliance with R405.3, 3 certificate indicating building passes performance matrix for code compliance and listing energy saving features of building(s), 4. Site-specific energy analysis report that is in compliance with R403.5, 5. Name of individual generating report, 6. Name and version of compliance software tool)
- R405.4.3 Additional documentation – if requested (1. Component characteristics of *standard reference design*, 2. Certification signed by builder providing component characteristics of *proposed design* as outlined in table R405.2(1), 3. Actual *proposed design* values used in software calculations)

R405.5 Calculation procedure (**R405.5.1** standard reference and proposed design configured and analyzed using identical methods and techniques, **R405.5.2** components of both standard reference and proposed design configured in accordance with Table R405.5.2(1))

R405.6 Calculation software tools

- R405.6.1 Minimum capabilities (1. Generation of *standard reference design* using only input of *proposed design* w/o ability to modify components of the *standard reference design*, 2. Whole building (single zone) heating and cooling equipment in the standard reference design in accordance with R403.7, 3. Calculations that account for effects of indoor and outdoor temperatures and part-load ratios on the performance of HVAC equipment based upon climate and equipment sizing, 4. Printed inspection checklist for *code official* listing proposed design component characteristics in accordance with Table R405.5.2(1) indicating respective performance values [i.e. R-value, U-factor, SHGC, HSPF, AFUE, SEER, EF])
- R405.6.2 Specific approval (Tools meeting applicable provisions of R405 shall be permitted to be *approved* by *code official*, jurisdiction may approve tools based upon meeting a specified threshold, *code official* may approve tools for specified application of limited scope)
- R405.6.3 Input values (When calculations require input values not contained in sections R402, R403, R404 and R405, values shall be taken from source *approved* by *code official*)

ENERGY RATING INDEX COMPLIANCE ALTERNATIVE path

(Requires simulation software tool – i.e REMRATE or other software meeting minimum capabilities listed in R406.7.1)

R406.2 Mandatory requirements (**only** 1. in accordance with only R403.5.3 [≥R-3 hot water pipe insulation on ≥3/4" dia., serving >1 dwelling unit, outside conditioned space, from WH to distribution manifold, under an floor slab, buried, and supply/return piping in recirculation system], 2. all ducts outside thermal envelope insulated to ≥R-6, 3. **building thermal envelope** R-values/U-factor **and SHGC** to be ≥that required by Tables 402.1.1 or 402.1.3 of the ***2009 IECC***)

R406.3 Energy Rating Index (number value based linear scale such that the *ERI reference design* has an index value of 100 and a *residential building* that has net zero annual purchased energy has an index rating of 0. Each increase/decrease in index value shall represent a 1% change in **total** ~~annual energy use of the rated design~~ relative to the ~~*ERI reference design*~~)

100 x (reference building annual energy cost – design building annual energy cost) / reference building annual energy cost

- R406.3.1 ERI reference design (*ERI reference design* shall be configured to meet the **minimum requirements of** the ***2006 IECC***)

R406.4 Compliance (index value of *rated design* = 51 in Climate Zone (CZ) 3, 52 in CZ1 & 2, 53 in CZ7 & 8, 54 in CZ 4&6 and 55 in CZ5)

R406.5 Verification by approved agency (compliance shall be completed by a qualified third party *approved* by the *code official*)

R406.6 Documentation

- R406.6.1 Compliance software tool (verification that methods and accuracy of compliance software tools conform to code provisions of R406 provided to code official)
- R405.4.2 Compliance report (shall document that ERI of rated design complies with R406.3 and R406.4 and shall include 1. Address or other identification, 2. Inspection checklist documenting component characteristics of both *rated* and *ERI reference designs and document all inputs entered by the user to reproduce the results*, 3. Name of individual generating report and, 4. Name and version of compliance software tool)
- R406.6.3 Additional documentation – if requested (1. Component characteristics of *ERI reference design*, 2. Certification signed by builder providing component characteristics of *rated design*, 3. Actual *rated design* values used in software calculations)

R406.7 Calculation software tools

- R406.7.1 Minimum capabilities (1. Generation of *ERI reference design* using only input of *rated design* w/o ability to modify components of the *ERI reference design*, 2. Whole building (single zone) heating and cooling equipment in the ERI reference design residence in accordance with R403.7, 3. Calculations that account for effects of indoor and outdoor temperatures and part-load ratios on the performance of HVAC equipment based upon climate and equipment sizing, 4. Printed inspection checklist for *code official* listing *rated design* component characteristics determined by analysis to provide compliance, along with their respective performance values)
- R406.7.2 Specific approval (Tools meeting applicable provisions of R406 shall be permitted to be *approved* by *code official*, jurisdiction may approve tools based upon meeting a specified threshold, *code official* may approve tools for specified application of limited scope)
- R406.7.3 Input values (When calculations require input values not contained in sections R402, R403, R404 and R405, values shall be taken from source *approved* by *code official*)

PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

Compliance based upon results criteria as option to 'good' recipe or comparison thereto

3-Pillar benchmark performance criteria ALTERNATIVE

Max. results/min. performance

1. Space conditioning demand/load ≤ X
2. Envelope air leakage ≤ Y
3. Total **source** energy demand ≤ Z

≥

Proposed design

Advantages

1. No prewritten recipe to follow or compare to
2. Much flexibility in all systems and components
3. No need to determine or modify base/reference building with each new code edition
4. Inherently provides transparent building performance
   - (to project team, code enforcement personnel, building owner, occupants and renewable or distributed energy system engineers)
5. Performance results decision making, rather than checklist following
6. May optimize compliance process by omitting added documentation or computer simulation currently required

Disadvantage

1. Requires software tool competency and associated added effort/time/cost
2. May still require added Heating, Cooling and dehumidification system calculation/model if not built into computer simulation software capabilities

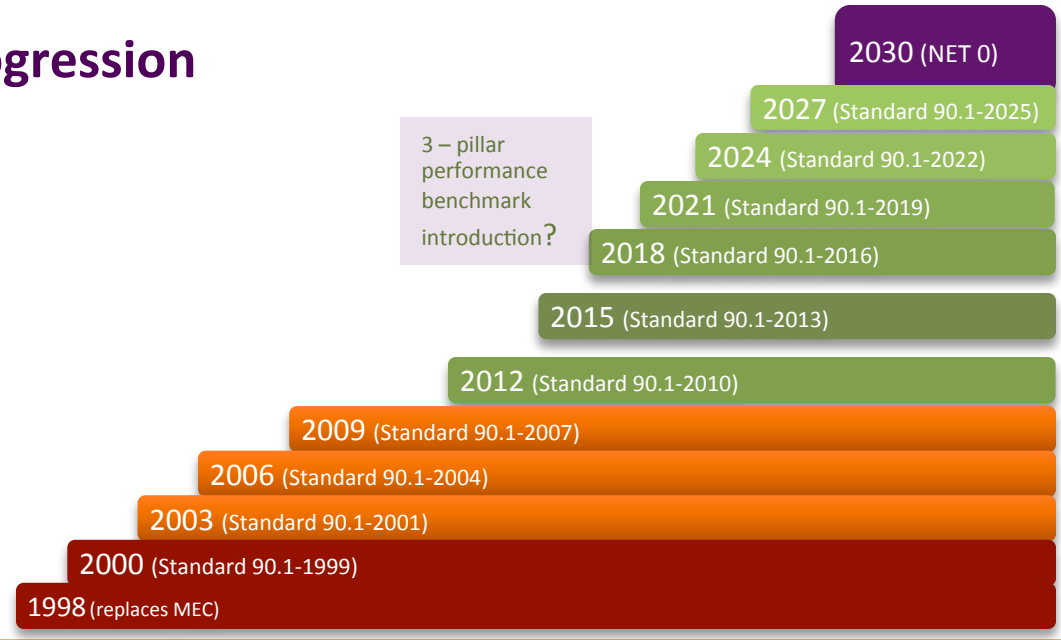
PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

Performance benchmark is the goal all are seeking to achieve

US EPA and DOE voluntary program progression

Reduction of space conditioning demand by 75 to 90% and total source building energy demand by 45 to 65% in all building types is recognized as prudent path to net zero energy/emission

IECC (Standard 90.1) editions progression



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PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

Recent past and current building performance data collection

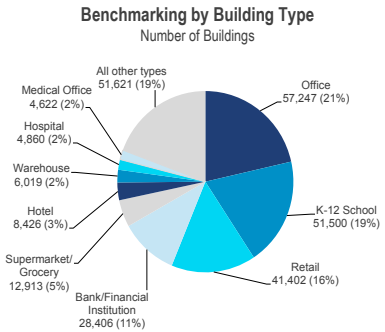
US Federal Government

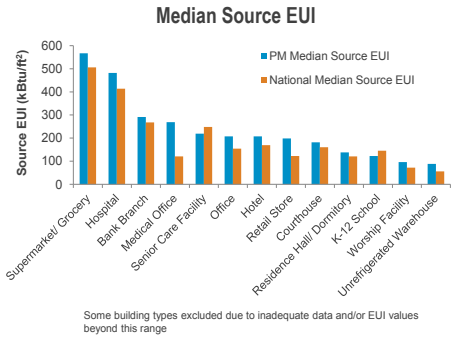
2011 Source Energy Use Intensity (EUI) documented for:

- **260,000** private and public **buildings**
- over 28 billion ft²
- across all 50 states
- approximately **40% of commercial market**
- **13 building types/occupancies**.

ENERGY STAR® PortfolioManager™

Energy Use Benchmarking





Some building types excluded due to inadequate data and/or EUI values beyond this range

NREL and US Private Utilities

- **2007** NREL calculated **source (primary) energy factors/multipliers for all US and Canadian electric grids**. Western grid 2.894 to Hawaii 4.022
- **2009** Average US multiplier **3.16 for mixed electricity** and **1.1 for all other fuels** now **appears in section R405 of IECC**

Canadian National Government

2011 +/- **40,000 crown-owned buildings** were required and have **documented 2005 annual CO^2e emissions baseline**. These benchmark levels are basis for measuring reductions.

BOMA of Canada

2010-2015 The Building Owners and Managers Association of Canada have collected building **performance data for:**

- **8 building types**/occupancies for Site EUI and water use intensity

Energy Benchmarking Matrix – Enclosed Shopping Centres

Energy Use Intensity
< 30 kWh/ft²/yr
< 28 kWh/ft²/yr
< 26 kWh/ft²/yr
< 24 kWh/ft²/yr
< 22 kWh/ft²/yr
< 20 kWh/ft²/yr
< 18 kWh/ft²/yr
< 16 kWh/ft²/yr
< 14 kWh/ft²/yr
< 12 kWh/ft²/yr

Energy Benchmarking Matrix – Open Air Ret

Energy Use Intensity Full tenant data	Points	Energy Use Intensity Exterior lighting only
< 30 kWh/ft²/yr	8	< 10 kWh/ft²/yr
< 28 kWh/ft²/yr	16	< 9 kWh/ft²/yr
< 26 kWh/ft²/yr	24	< 8 kWh/ft²/yr
< 24 kWh/ft²/yr	32	< 7 kWh/ft²/yr
< 22 kWh/ft²/yr	40	< 6 kWh/ft²/yr
< 20 kWh/ft²/yr	48	< 5 kWh/ft²/yr
< 18 kWh/ft²/yr	56	< 4 kWh/ft²/yr
< 16 kWh/ft²/yr	64	< 3 kWh/ft²/yr
< 14 kWh/ft²/yr	72	< 2 kWh/ft²/yr
< 12 kWh/ft²/yr	80	< 1 kWh/ft²/yr

Energy Benchmarking Matrix – Hospitals

	Zone 5	Zone 6	Zone 7	Zone 8	Points
<	80 ekWh/ft²/yr	80.2 ekWh/ft²/yr	80.4 ekWh/ft²/yr	80.6 ekWh/ft²/yr	7

Energy Benchmarking Matrix – Long Term Care

	Zone 5	Zone 6	Zone 7	Zone 8	Points
<	59 ekWh/ft²/yr	59.2 ekWh/ft²/yr	59.4 ekWh/ft²/yr	59.6 ekWh/ft²/yr	7

Energy Benchmarking Matrix – Medical Offices

	Zone 5	Zone 6	Zone 7	Zone 8	Points
<	34 ekWh/ft²/yr	34.2 ekWh/ft²/yr	34.4 ekWh/ft²/yr	34.6 ekWh/ft²/yr	7

Energy Benchmarking Matrix – Light Industrial

Energy Use Intensity Full tenant data		Points	Energy Use Intensity Exterior lighting only	Points
Workshops / Garages	Warehouses		Workshops / Garages /	
< 47 kWh/ft²/			< 1	
< 44 kWh/ft²/			< 9	
< 41 kWh/ft²/			< 8	
< 38 kWh/ft²/			< 7	
< 35 kWh/ft²/			< 6	
< 32 kWh/ft²/			< 5	
< 29 kWh/ft²/			< 4	
< 26 kWh/ft²/			< 3	
< 23 kWh/ft²/			< 2	
< 20 kWh/ft²/			< 1	

Energy Benchmarking Matrix – Office

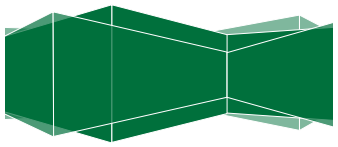
Energy Use Intensity	Points
< 36 kWh/ft²/yr	8
< 32 kWh/ft²/yr	16
< 28 kWh/ft²/yr	24
< 24 kWh/ft²/yr	32
< 20 kWh/ft²/yr	40
< 18 kWh/ft²/yr	48
< 16 kWh/ft²/yr	56
< 14 kWh/ft²/yr	64
< 12 kWh/ft²/yr	72
< 10 kWh/ft²/yr	80

Energy Benchmarking Matrix – Multi-Unit Residential Buildings

Energy Use Intensity	Points
< 23 kWh/ft²/yr	8
< 22 kWh/ft²/yr	16
< 21 kWh/ft²/yr	24
< 20 kWh/ft²/yr	32
< 19 kWh/ft²/yr	40
< 18 kWh/ft²/yr	48
< 17 kWh/ft²/yr	56
< 16 kWh/ft²/yr	64
< 15 kWh/ft²/yr	72
< 14 kWh/ft²/yr	80

BOMA BESt

5. Module Definitions and Performance Benchmarks



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Passive House 3-Pillar Benchmark Performance Criteria as an Alternative Code Compliance Path?

What to consider if developed into a code compliance path?

- **Must address at least all the same aspects** of performance as other compliance paths
- **Performance results must be better than** (or at least equal to) minimum performance levels of **other** compliance **paths**
- **Should allow performance benchmark values to progress** informed by real world experience
- Format and order of **codified text should read similar/parallel to other** performance based **compliance paths**
- **Definitions** not currently within code **that apply, should be added for clarity**
- As with other compliance path text, **must be simplified to level that allows codified presentation** without limiting performance levels superior to compliance path minimum
- Must be **submitted in format, procedure and schedule of the code promulgator**
- **Must avoid trademark and copyright infringement**, therefore 'Passive House' or 'Passivhaus' may not be within text (i.e. 'Total Building Performance' in IECC vs. 'Energy Cost Budget' in Standard 90.1; or 'Energy Rating Index' in IECC and 'HERS' for RESNET)
- **Ideally, all Passive House projects would** meet or **exceed** the 3-pillar performance benchmark **code compliance path requirements** – meeting the intent of optimized design/ construction process
- **Should align with** modeling/simulation **software and** climate **database capabilities** and output data from software should align with code required documentation
- **Should not create** documentation, simulation or other **requirements beyond** those addressed by **Passive House simulation software or QA/QC criteria**

What the new compliance path might look like (codified text)?

Preliminary draft codified text has been prepared in ICC code development process format (approximately 5 pages of text plus 3 pages for two tables)

Definitions

SECTION C202
GENERAL DEFINITIONS

BUILDING THERMAL ENVELOPE. The basement walls, exterior walls, floors, floor slabs, insulation, roof, and any other building elements that enclose *conditioned space* or provide a boundary between *conditioned space* and exempt or unconditioned space.

CONDITIONED FLOOR AREA is defined on page C-8

CONDITIONED SPACE. An area, room or space that is enclosed within the building thermal envelope and is directly or indirectly heated or cooled with systems capable of maintaining a minimum temperature of 68 °F (20 °C) heating (Source 2015 IBC 1204.1 and 2015 IMC 309.1) and, if cooled, a maximum 79 °F (26 °C) cooling. Spaces are indirectly heated or cooled where they communicate through openings within conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

LOW ENERGY BUILDING. A building, or portion thereof with *semi-heated spaces* and/or *conditioned spaces* separated from the remainder of the building by *building thermal envelope* assemblies complying with section C402 that has a peak design rate of energy usage less than or equal to 3.4 Btu/h * ft² (10.7 W/m²) or 1.0 W/ft² (10.7 W/m2) for space heating or cooling purposes.

LOW ENERGY CONDITIONED BUILDING. A building, or portion thereof with *conditioned spaces* that has a building envelope air leakage rate, an annual *source energy* demand, a space conditioning energy design rate and vertical fenestration and skylight performance less than or equal to values in Table C409.1

PROCESS LOAD. A load on a building resulting from the consumption or release of energy consumed in support of a manufacturing, industrial or commercial process other than conditioning spaces, service water heating, mechanical ventilation, fan, pump, lighting or receptacle loads associated with maintaining comfort and amenities for the occupants of a building.

PROPOSED DESIGN. A description of the proposed building used to estimate annual energy ~~use~~ demand for determining compliance based upon ~~total building performance~~ Section C407 (Total Building Performance) or Section C409 (Low Energy Conditioned Building Performance Framework).

SEMI-HEATED SPACE. An area, room or space that is enclosed within a building and is directly or indirectly heated with systems capable of maintaining a temperature of less than 68 °F (20 °C). *(source = 2015 IBC 1204.1 and 2015 IMC 309.1)*

SITE ENERGY. Total amount of energy used by the building and site energy consuming items in association with the operation of the building as measured by meters at the building site.

SOURCE ENERGY. Total amount of *Site Energy* plus the amount of energy it took to extract energy fuel source, transport it, refine it, convert it, transmit it and distribute it to the building site. The value of Source energy shall be determined by multiplying the *Site Energy* by the *Source Energy Factor*.

SOURCE ENERGY FACTOR. Value that *Site Energy* is multiplied by to determine the *Source Energy*. The value shall be:

1. Within the US, 3.16 for mixed grid connected electricity and 1.1 for fuels other than electricity, or *(source IECC 2015 R405.3)*
2. Within the US, as determined or approved by the US Energy Information Administration's (EIA) last published report prior date of publication of this code based upon the electrical or other fuel distribution system, or
3. Other source approved by the *code official*

1

General requirements

Format similar to C407. Text highlighted in yellow unique to C407

SECTION C409
LOW ENERGY CONDITIONED BUILDING BENCHMARK PERFORMANCE

C409.1 Scope. This section establishes criteria for compliance using *low energy conditioned building* performance benchmark criteria analysis. The following systems and loads shall be included in determining the *low energy conditioned building* performance: heating systems, cooling systems, service water heating, fan systems, lighting power, receptacle loads and process loads. This method may be used for buildings with use groups A-3 (Assembly for worship, recreation or amusement) and A-4 (Assembly for viewing of indoor sporting events), B (Business), E (Educational [K-12th grade]), F (Factory Industrial), I-1 and I-3 (select Institutional), M (Mercantile), R-1 (Hotels and Motels) and S (Storage) where occupant use patterns are predictable and *approved* by the *code official*. This method may only be used for buildings with A-1 (Assembly with fixed seating for performing arts or motion pictures), A-2 (Assembly for food and drink consumption) and A-5 (Assembly for participation or viewing outdoor activities), H (High Hazard) or I-2 (Medical care for persons not capable of self preservation) and U (Utility and Miscellaneous) occupancies, where specifically *approved* by the *code official*. More detailed descriptions of occupancy group classifications shall be in accordance with chapter 3 of the *International Building Code*.

C409.2 Mandatory requirements. Compliance with this section requires that the criteria of Sections C402.5, C403.2, C404 and C405 be met.

C409.3 Low energy conditioned building performance benchmark based compliance. Compliance based on *low energy conditioned building* performance benchmark requires that a proposed building (*proposed design*) be shown to be a *low energy conditioned building*. Annual *source energy* demand shall be total based upon *approved source energy factor*. *Code official* shall be permitted to require documentation supporting *source energy factor* used in simulation. Nondepletable energy collected off site shall use same *source energy factor* as depletable fuel source or shall provide *approved* documentation of *source energy factor* used. Energy from nondepletable energy sources collected on site shall be omitted from the annual energy demand of the *proposed design*.

Note: (1 kWh = 3412 Btu)

C409.4 Documentation. Documentation verifying that the methods of accuracy of compliance software tools conform to the provisions of section shall be provided to the *code official*.

C409.4.1 Compliance report. Permit submittals shall include a report documenting that the *proposed design* complies with Section C409.3. The compliance report shall include the following information:

1. Building street address, or other building site identification.
2. A statement indicating that the *proposed design* complies with section C409.3.
3. A statement indicating air leakage rate in accordance with C402.5 presumed in compliance software tool analysis.
4. A document summarizing building component characteristics of the *proposed design* as listed in Table C409.5.1 used as inputs in the compliance software tool analysis.
5. A site-specific energy analysis report that is in compliance with C409.3.
6. Name of individual completing the compliance report.
7. Name and version of compliance software tool.

C409.4.2 Additional documentation. The *code official* shall be permitted to require the following documents:

1. Copy of document summarizing building component characteristics of the *proposed design* as listed in Table C409.5.1 available during inspections by the *code official* or an *approved agency* to verify each characteristic installed with inputs entered into the software tool analysis. Inspections shall not be less than those required by Section C104.

4

Software tool capabilities

C409.6 Calculation software tools. Calculation software tools used to comply with this section shall be capable of calculating annual *source energy* demand of all building elements of the *proposed design* and shall include the following capabilities:

1. Building operation for a full calendar year (8,760 hours).
2. Climate data for a full calendar year (8,760 hours) and shall reflect *approved* coincident hourly data for temperature, solar radiation, humidity and wind speed representative for the site in which the proposed design is located. For cities and urban regions with several climatic data sets, and for locations where recorded weather data is not available, the individual performing the analysis shall select a data set that best represents the climate at the site. *Code official* may request or approve data set selected.
3. Calculate glazed wall, window, door and skylight U-factor specific to each wall or roof opening by summing (U_{frame} x $Area_{frame}$) + ($U_{glazing}$ x $Area_{glazing}$) + ($Psi_{glazing\ spacer}$ x $Length_{glazing\ spacer}$) + ($Psi_{installation\ gap}$ x $Length_{installation\ gap}$) and dividing by the Area of the wall or roof opening.
4. Calculate affects of solar radiation gains at glazed walls, windows, doors and skylights based upon orientation, shading from overhead and side projections at each wall or roof opening and SHGC of glazing.
5. Ten or more thermal zones or separate analysis calculations provided for each thermal block.
6. Thermal mass effects.
7. Hourly variances in occupancy, illumination, receptacle loads, thermostat settings, mechanical ventilation, HVAC equipment availability, service hot water usage and any process loads.
8. Part-load performance curves for mechanical equipment.
9. Capacity and efficiency correction curves for mechanical heating and cooling equipment.

C409.6.1 Specific approval. Performance analysis tools complying with the applicable subsections of Section C409 and tested according to approved method shall be permitted to be *approved*. Tools are permitted to be *approved* based on meeting a specified threshold for a jurisdiction or climate zone. The *code official* shall be permitted to approve tools for a specified application or limited scope.

C409.6.2 Input values. Where calculations require input values not specified by Sections C402, C403, C404 and C405, those input values shall be taken from an *approved* source.

C409.6.3 Exceptional calculation methods. Where the software tool does not model a design, material or device of the *proposed design*, an exceptional calculation method shall be used where *approved* by the *code official*. Where there are multiple designs, materials or devices that the simulation program does not model, each shall be calculated separately and exceptional demand determined for each. Applications for approval of an exceptional method shall include all of the following:

1. Step-by-step documentation of the exceptional calculation method performed, detailed enough to reproduce the results.
2. Copies of all spreadsheets used to perform the calculations.
3. A sensitivity analysis of energy consumption where each of the input parameters is varied from half to double the value assumed.
4. The calculations shall be performed on a time step basis consistent with the software tool used.
5. The performance rating calculated with and without the exceptional calculation method.

6

If to be considered for 2018 edition of IECC, proposed text and tables must be submitted to ICC via CDP Access (Code Development Process) not later than January 11, 2016

What the new compliance path might look like (commercial buildings)?

Performance Benchmark table

T C409.1
LOW ENERGY CONDITIONED BUILDING PERFORMANCE BENCHMARK CRITERIA[1]

Climate zone			1	2	3	4 except Marine	5 and Marine 4	6	7	8
Air leakage[2, 5]			0.1 cfm/ft² (0.05 L/s m²) of exterior surface area of the *building thermal* envelope at pressure differential of 0.3 inch water gauge (75 Pascals), or 1.25 air change per hour (ACH) (0.02083 changes per minute) of enclosed building volume at pressure differential of 0.2 inch water gauge (50 Pascals)							
Source (site)Energy Demand *per conditioned floor area* unit[3]	Occupancy group	A-3, A-4	100 kBtu/ft², 29.3 kWh/ft², 315.0 kWh/m² (15.98 kBtu/ft², 4.68 kWh/ft², 50.63 kWh/m²) if *source energy factor* is 3.16 if all *source energy* is mixed grid electricity							
		B	44.4 kBtu/ft², 13.0 kWh/ft², 140.0 kWh/m² (14.07 kBtu/ft², 4.12 kWh/ft², 44.30 kWh/m²) if *source energy factor* is 3.16 if all *source energy* is mixed grid electricity							
		E	41.3 kBtu/ft², 12.1 kWh/ft², 130.0 kWh/m² (13.07 kBtu/ft², 3.83 kWh/ft², 41.14 kWh/m²) if *source energy factor* is 3.16 if all *source energy* is mixed grid electricity							
		F	76.2 kBtu/ft², 22.3 kWh/ft², 240.0 kWh/m² (24.11 kBtu/ft², 7.07 kWh/ft², 75.95 kWh/m²) if *source energy factor* is 3.16 if all *source energy* is mixed grid electricity							
		I-1, I-3	63.5 kBtu/ft², 20.4 kWh/ft², 200.0 kWh/m² (20.09 kBtu/ft², 6.45 kWh/ft², 63.29 kWh/m²) if *source energy factor* is 3.16 if all *source energy* is mixed grid electricity							
		M	57.2 kBtu/ft², 16.7 kWh/ft², 180.0 kWh/m² (18.10 kBtu/ft², 5.28 kWh/ft², 56.96 kWh/m²) if *source energy factor* is 3.16 if all *source energy* is mixed grid electricity							
		R-1	54.0 kBtu/ft², 15.8 kWh/ft², 170.0 kWh/m² (17.09 kBtu/ft², 5.01 kWh/ft², 53.80 kWh/m²) if *source energy factor* is 3.16 if all *source energy* is mixed grid electricity							
		S	41.3 kBtu/ft², 12.1 kWh/ft², 130.0 kWh/m² (13.07 kBtu/ft², 3.83 kWh/ft², 41.14 kWh/m²) if *source energy factor* is 3.16 if all *source energy* is mixed grid electricity							
Space conditioning energy per *conditioned floor area* unit[6]	Annual Demand	Heating kBtu/ft² (kWh/ft²) [kWh/m²]	2.0 (0.586) [6.300]	3.5 (1.026) [11.023]	4.5 (1.319) [14.173]	6.5 (1.905) [20.472]	8.0 (2.345) [25.197]	9.0 (2.638) [28.346]	11.0 (3.224) [34.646]	17.0 (4.985) [53.543]
		Cooling kBtu/ft² (kWh/ft²) [kWh/m²]	24.0 (7.034) [75.590]	19.0 (5.568) [59.842]	12.0 (3.517) [37.795]	8.0 (2.345) [25.197]	5.0 (1.465) [15.748]	4.0 (1.172) [12.598]	2.0 (0.586) [6.300]	1.5 (0.440) [4.724]
	Peak Load[7]	Heating Btu/h*ft² (W/ft²) [W/m²]	5.0 (1.465) [15.748]	6.0 (1.758) [18.898]	7.0 (2.052) [22.047]	7.5 (2.198) [23.622]	8.0 (2.345) [25.197]	8.5 (2.491) [26.772]	9.0 (2.638) [28.346]	9.5 (2.784) [29.921]
		Cooling Btu/h*ft² (W/ft²) [W/m²]	8.5 (2.491) [26.772]	13.0 (3.810) [33.071]	10.5 (3.077) [33.071]	9.5 (2.784) [29.921]	9.0 (2.638) [28.346]	7.0 (2.052) [22.047]	6.5 (1.905) [20.472]	4.5 (1.319) [14.173]
Vertical fenestration and *skylight* performance[4, 5]	U_{unit}	Fixed window	≤ 0.25	≤ 0.25	≤ 0.23	≤ 0.19	≤ 0.19	≤ 0.18	≤ 0.15	≤ 0.13
		Operable window	≤ 0.33	≤ 0.33	≤ 0.30	≤ 0.23	≤ 0.23	≤ 0.22	≤ 0.19	≤ 0.17
		Entry/exit door	≤ 0.55	≤ 0.42	≤ 0.38	≤ 0.38	≤ 0.38	≤ 0.38	≤ 0.38	≤ 0.38
		Skylight	≤ 0.38	≤ 0.33	≤ 0.28	≤ 0.25	≤ 0.25	≤ 0.25	≤ 0.25	≤ 0.25
	SHGC		Dimensions of overhead (horizontal from face of glazing and vertical from bottom of glazing to underside of projection) and side (horizontal from edge of glazing and perpendicular to face of glazing) projections that shade glazing shall be entered into the *energy simulation tool*. SHGC of glazing of each individual glazed window, door and skylight shall also be entered into the *energy simulation tool*.							

1. See limitations in C409.1.
2. Required *building thermal envelope* air leakage shall be tested in accordance with ASTM E779 at a pressure differential of 0.3 inch water gauge (75 Pascals) or, for enclosed volumes ≤100,000 ft³ (2831.68 m³), may be tested for air volume exchange rate in accordance with ASTM E779 or ASTM E1827 at pressure differential of 0.2 inch water gauge (50 Pascals).
3. Higher value allowed where specific process loads beyond HVAC, *service water heating*, lighting, MEL (plug) and auxiliary system pump/fan demands are *approved* by the *code official*.
4. See C409.6 for *energy simulation tool* capabilities.
5. Improved fenestration and skylight air leakage, U_{unit} and SHGC performance is required if necessary to meet other performance framework values in this table.
6. Based upon dry bulb temperature.
7. Based upon ANSI/ASHRAE/ACCA Standard 183 or by an *approved* equivalent computational procedure using the interior design conditions required by Section C302.1.

What the new compliance path might look like (residential buildings)?

Performance Benchmark table

T R407.1
LOW ENERGY CONDITIONED BUILDING PERFORMANCE BENCHMARK CRITERIA

Climate zone			1	2	3	4 except Marine	5 and Marine 4	6	7	8
Air leakage[1, 3]			0.1 cfm/ft^2 (0.05 L/s * m^2) of exterior surface area of the *building thermal envelope* at pressure differential of 0.3 inch water gauge (75 Pascals), or 1.25 air change per hour (ACH) (0.02083 changes per minute) of enclosed building volume at pressure differential of 0.2 inch water gauge (50 Pascals)							
Source (site)Energy Demand *per conditioned floor area* unit	Occupancy group	R-2	50.5 kBtu/ft^2				(15.98 kBtu/ft^2) If *source energy factor* is 3.16 if all *source energy* is mixed grid electricity			
		R-3	14.8 kWh/ft^2				(4.68 kWh/ft^2) If *source energy factor* is 3.16 if all *source energy* is mixed grid electricity			
		R-4	160.0 kWh/m^2				(50.63 kWh/m^2) If *source energy factor* is 3.16 if all *source energy* is mixed grid electricity			
Space conditioning energy per *conditioned floor area* unit[4]	Annual Demand	Heating kBtu/ft^2 (kWh/ft^2) [kWh/m^2]	2.0 (0.586) [6.300]	3.5 (1.026) [11.023]	4.5 (1.319) [14.173]	6.5 (1.905) [20.472]	8.0 (2.345) [25.197]	9.0 (2.638) [28.346]	11.0 (3.224) [34.646]	17.0 (4.985) [53.543]
		Cooling kBtu/ft^2 (kWh/ft^2) [kWh/m^2]	24.0 (7.034) [75.590]	19.0 (5.568) [59.842]	12.0 (3.517) [37.795]	8.0 (2.345) [25.197]	5.0 (1.465) [15.748]	4.0 (1.172) [12.598]	2.0 (0.586) [6.300]	1.5 (0.440) [4.724]
	Peak Load[5]	Heating Btu/h*ft^2 (W/ft^2) [W/m^2]	5.0 (1.465) [15.748]	6.0 (1.758) [18.898]	7.0 (2.052) [22.047]	7.5 (2.198) [23.622]	8.0 (2.345) [25.197]	8.5 (2.491) [26.772]	9.0 (2.638) [28.346]	9.5 (2.784) [29.921]
		Cooling Btu/h*ft^2 (W/ft^2) [W/m^2]	8.5 (2.491) [26.772]	13.0 (3.810) [33.071]	10.5 (3.077) [33.071]	9.5 (2.784) [29.921]	9.0 (2.638) [28.346]	7.0 (2.052) [22.047]	6.5 (1.905) [20.472]	4.5 (1.319) [14.173]
Vertical fenestration and *skylight* performance[2, 3]	U_{unit}	Fixed window	≤ 0.25	≤ 0.25	≤ 0.23	≤ 0.19	≤ 0.19	≤ 0.18	≤ 0.15	≤ 0.13
		Operable window	≤ 0.33	≤ 0.33	≤ 0.30	≤ 0.23	≤ 0.23	≤ 0.22	≤ 0.19	≤ 0.17
		Entry/exit door	≤ 0.55	≤ 0.42	≤ 0.38	≤ 0.38	≤ 0.38	≤ 0.38	≤ 0.38	≤ 0.38
		Skylight	≤ 0.38	≤ 0.33	≤ 0.28	≤ 0.25	≤ 0.25	≤ 0.25	≤ 0.25	≤ 0.25
	SHGC		Dimensions of overhead (horizontal from face of glazing and vertical from bottom of glazing to underside of projection) and side (horizontal from edge of glazing and perpendicular to face of glazing) projections that shade glazing shall be entered into the *energy simulation tool*. SHGC of glazing of each individual glazed window, door and skylight shall also be entered into the *energy simulation tool*.							

1. Required *building thermal envelope* air leakage rate shall be tested in accordance with ASTM E779 at a pressure differential of 0.3 inch water gauge (75 Pascals) or enclosed building volume air exchange rate in accordance with ASTM E779 or ASTM E1827 at pressure differential of 0.2 inch water gauge (50 Pascals).
2. See R407.5.1 for minimum *energy simulation tool* capabilities.
3. Improved fenestration and skylight air leakage, U_{unit} and SHGC performance is required if necessary to meet other performance framework values in this table.
4. Based upon dry bulb temperature.
5. Based upon ACCA Manual J or other *approved* heating and cooling calculation methodology using the interior design conditions required by Section R302.1.

Summary for discussion (in the US)

Past

1) 1934 – 1978 Federal standards respond to nationwide issues of concern
2) 1983 – Transition from Federal Standards to privately written model codes/standards
3) 1984 – 2006 – Alternative compliance paths add flexibility, but ALL remain comparison to prescriptive

Present

4) 2007-2015 – 'Performance rating' adds 'score/rating', but continues to remain a comparison to prescriptive 'recipe' – residential provisions compare to 2006 'recipe'
5) 2006-2007 – Federal policy establishes GOAL and compliance procedure for federally owned buildings
   Private and most non-federal government owned buildings allow flexibility of multiple code compliance paths
6) 2004-2007 – NREL determines source energy factor/multiplier values – contained in IECC code text
7) PHIUS+ is only pre-construction design simulation building performance standard in US for all building types that is based upon performance benchmarks rather than a comparison to a prescriptive 'recipe'
8) PHIUS+ projects likely require multiple energy models/simulations or documentation:
   1. PHIUS+ performance benchmark,
   2. ZERH/ESv3 comparison rating, and
   3. code/standard compliance documentation and HVAC load calculations
9) 2013 - USDOE recognizes PHIUS+ as prudent path toward Zero Energy Ready
10) 2014 -Building Science Corporation and PHIUS, under contract with USDOE determine climate specific optimized performance benchmark criteria
11) 2014 – Joint published ICC IECC and ANSI/ASHRAE/IES Standard 90.1 used in 94% to 98% of US States
12) 2011-2015 - Database of private and public building source energy performance levels documented

Future

13) 2015 - Midway between initial ICC 1998 IECC and Net Zero 2030 IECC
14) 2018 – Would adding a 3-pillar performance benchmark code compliance path help
    OPTIMIZE use of the Passive House 3- pillar performance methodology and, if contained within the ICC IECC would it have potential of **94** to **98%** nationwide impact ?
15) Is it time for additional flexibility, transparency and high performance ?

Goal: Encourage more to pursue Passive House 3-pillar performance

PASSIVE HOUSE 3-PILLAR BENCHMARK PERFORMANCE CRITERIA AS AN ALTERNATIVE CODE COMPLIANCE PATH?

Questions, comments

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