IECC 2015 Mandatory Provisions

- **C402.5 Building Envelope – Air Leakage**
- C403.2 Mechanical Systems - Heating and cooling loads, Equipment sizing, HVAC equipment performance requirements
- C404 Service water heating equipment performance requirements
- C405.2 Lighting controls
- C405.3 Exit signs
- C405.4 Interior lighting power requirements
- C405.5 Exterior lighting power requirements
- C405.6 Electrical energy consumption [relating to metering for individual dwelling units]
- C405.7 Electrical transformers
- C405.8 Electrical motors

IECC 2015

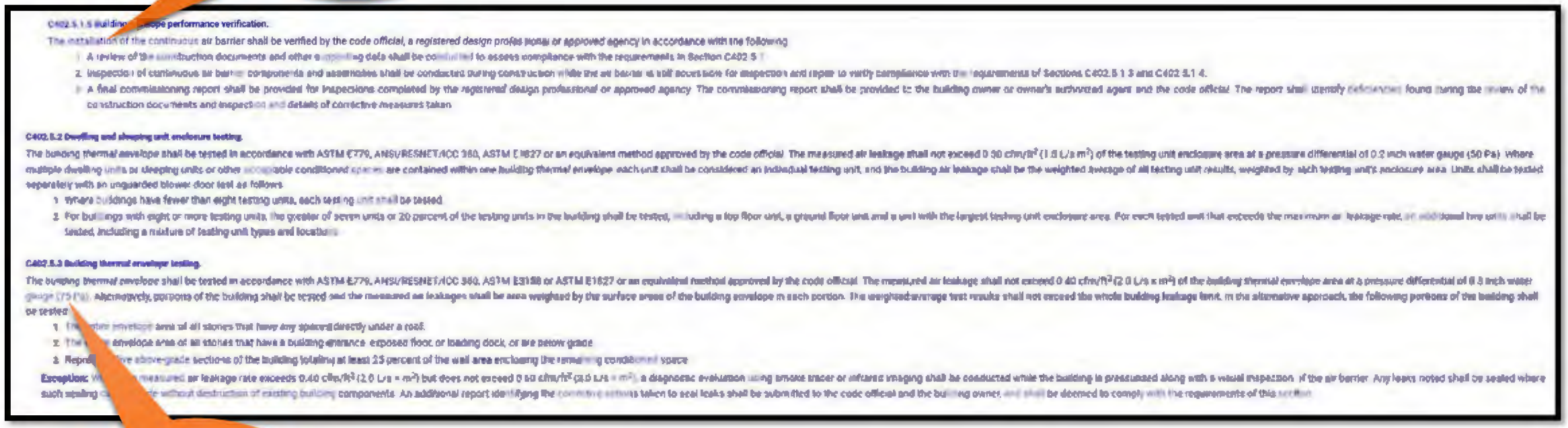
C402.5 Air leakage—thermal envelope (Mandatory). E

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/ft^2(0.2 L/s · m^2). Where compliance is based on such testing, the building shall also comply with Sections C402.5.5, C402.5.6 and C402.5.7.

Blower Door Testing Required

Review of Drawings, Inspection, Testing Required

IECC 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.

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 (1.8 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.

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 measured air leakage rate exceeds 0.40 cfm/ft² (2.0 L/s × m²) but does not exceed 0.50 cfm/ft² (2.5 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.

Blower Door Testing Required

LEED 4.1 Version (Enhanced Cx (2~6 points)

BECx in accordance w/ ASHRAE 0-2016 and ASTM E2947-16

Review of Submittals, Testing Required

10 month Warranty Inspection, Post occupancy

Option 2. Building Enclosure Commissioning (2 points)

Fulfill the requirements in EA Prerequisite Fundamental Commissioning and Verification as they apply to the building's enclosure in addition to mechanical and electrical systems and assemblies.

Complete the following commissioning process (Cx) activities for the building's thermal envelope in accordance with ASHRAE Guideline 0–2013 and ASTM E2947-16: Standard Guide for Building Enclosure Commissioning, as they relate to energy, air and water tightness, indoor environmental quality, and durability.

The qualified independent member of the design or construction team responsible for building enclosure commissioning must complete the following:

- Review contractor submittals.
- Verify inclusion of systems manual requirements in construction documents for enclosure systems.
- For specialty enclosure systems with controls and automation:
  - Verify inclusion of operator and occupant training requirements in construction documents.
  - Verify systems manual updates and delivery.
  - Verify operator and occupant training delivery and effectiveness.
  - Verify seasonal testing.
  - Review building operations 10 months after substantial completion.
- Develop an on-going enclosure commissioning plan for maintenance, renewal and revitalization cycles.

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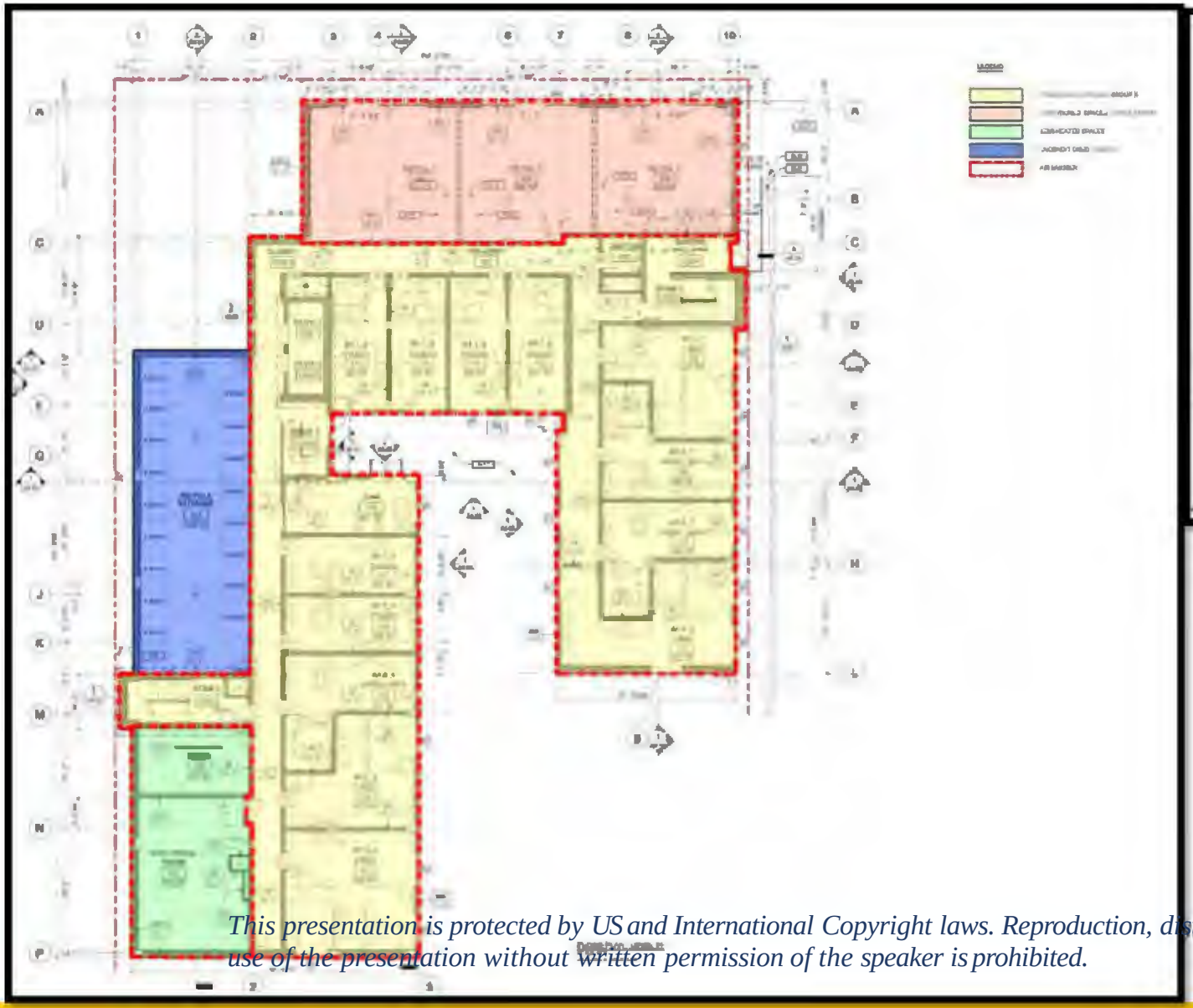

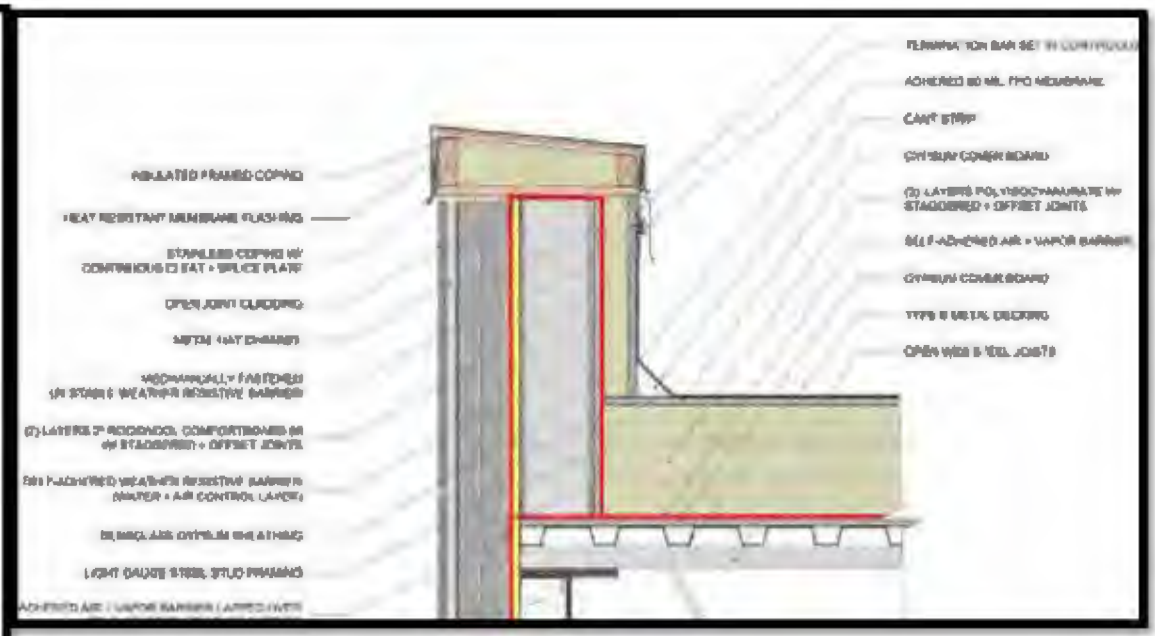

Commissioning Provider Costs

Total building commissioning costs for Commissioning Provider services can range from $0.13 to $0.48 per square foot for existing buildings and from $0.40 to $1.35 per square foot for new construction (U.S. Department of Energy. 2018 Commissioning Cost/Benefit Study Findings).

Benchmark Cost of Total Building Commissioning				
Building Type	Percentage of Construction Cost (ECC)		Cost per GSF of Building Area	
	Minimum	Maximum	Minimum	Maximum
Office	0.5%	1.75%	$3.25	$5.00
Courthouse	0.75%	2.25%	$5.00	$8.00
Laboratory	0.90%	2.50%	$7.00	$10.00
Land Port of Entry	0.5%	2.00%	$3.00	$5.00

(Source: GSA Cost and Schedule Management Team, 2015 Development of Professional Services Fee Look-Up Table)

Commissioning Cost

Table 6. Owners' reasons for implementing EBCx, 2009 vs. 2018

Reason for pursuing an EBCx project	Fraction of reporting projects with reason indicated (%)		
	2018	2009	Difference
Obtain energy savings	100	90	+10
Ensure system performance	91	47	+44
Ensure or improve thermal comfort	78	65	+14
Ensure adequate indoor air quality	47	57	-10
Train and increase awareness of operators or occupants	38	32	+5
Qualify for rebate, financing, or other services	38	18	+20
Participation in utility program	31	28	+3
Comply with LEED or other rating system	28	3	+25
Extended equipment life	25	3	+22
Comply with organizational mandate/policy	25	0	+25
Increase occupant productivity	22	23	-1
Reduce liability	3	0	+3
Research/demonstration/pilot	3	20	-17
Comply with existing buildings ordinance	3	0	+3
Other	9	0	+9

Building Commissioning Costs and Savings Across Three Decades and 1,500 North American Buildings

Eliot Crowe[1], Evan Mills[1], Tom Poeling[2], Claire Curtin[1], Diana Bjørnskov[2], Liz Fischer[2], and Jessica Granderson[1]

[1] Lawrence Berkeley National Laboratory, 1 Cyclotron Rd., Berkeley, CA 94720, USA
[2] New Buildings Institute, 1600 NE Compton Drive, Suite 200, Hillsboro, OR 97006, USA

Table 4. Comparison of median EBCx cost per square meter for data collected in 2009 and 2018

	2009 data	2018 data	All Data
Median cost per m^2 (Median cost per ft^2)	$3.93 ($0.36)	$2.65 ($0.25)	$2.84 ($0.26)
Sample size (projects)	325	660	985

Table 7. Comparison of NCCx cost data, comparing 2009 and 2018

	2009 Data	2018 Data	All Data
Median cost per m^2 ($2017) (Median cost per ft^2) ($2017)	$16.69 ($1.55)	$8.78 ($0.82)	$11.08 ($1.03)
Median cost as a percentage of overall construction cost	0.57%	0.25%	0.37%
Sample size (projects)	73	67	140

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C1 GENERAL ESTIMATE OF COSTS

C1.1 The level of effort of the Commissioning Process and size of the Commissioning Team for a given building can be strongly influenced by such factors as the owner's preferred level of building quality, the level of risk the owner will accept, as well as building size, type and complexity. Thus, it is difficult to develop general estimates of the level of effort required by the Commissioning Authority (CxA) and other members of the Commissioning Team.

C1.2 However, general rules of thumb can provide some guidance. Projects with construction budgets including tenant build out in excess of $20 Million typically require 0.002 of the construction budget for building exterior enclosure commissioning that is in addition to typical mechanical commissioning effort. This would be about $40,000 for a $20 million project.

C1.3 Projects including tenant build out less then $20 Million typically have increased costs due to reduction in scale with upper ranges for commissioning the building exterior enclosure from 0.003 to 0.01. This range of costs might result in $30,000 in cost to commission the exterior enclosure of a $10 million building (at 0.003) and $10,000 in cost to commission the exterior enclosure of a $10 million building (at 0.01)

Project >$20 Million,
BECx Estimate Cost $40,000

Project >$10 Million < 20 Million,
BECx Estimate Cost $30,000

Project < 10 Million,
BECx Estimate Cost $10,000

Source: NIBS Guideline 3-2012, ANNEX C

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