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Air infiltration Reduction ECM Research

5 Case Studies

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AIA Learning Objectives

1. **Understand advanced building enclosure and air tightness best practices**, as well as air infiltration reduction implementation challenges

2. **Compare the air infiltration reduction Massachusetts Code criteria** and associated energy savings to other standards criteria beyond Code such as the US Army standards and the Passive House US standard

3. **Understand air infiltration building enclosure testing standards and methodology** for multi-family facilities

4. **Understand the air infiltration reduction energy savings value as an energy conservation measure beyond Code**

Agenda

- **Introduction**
- **Air Infiltration Reduction Research Overview**
- **Interactive discussion**
- **Wrap-up: Recommendations / Challenges**

Why Now?

- **Multi-Family market as a starting point**
- **State Regulations:**
  - IECC 2018 criteria (C406)
  - MEPA
- **Passive House's key criteria**
- **New Grounds for the MA PA (Utilities):**
  - Tacking the building enclosure

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Additional Efficiency Packages: Section C406

IECC 2015

- More efficient HVAC systems
- Reduced lighting power
- Enhanced lighting controls
- On-site renewable energy
- Dedicated Outdoor Air System
- High-efficiency service water heating

IECC 2018

- More efficient HVAC systems
- Reduced lighting power
- Enhanced lighting controls
- On-site renewable energy
- Dedicated Outdoor Air System
- High-efficiency service water heating
- **Enhanced envelope performance**
- **Reduced air infiltration**

Airtight Building Enclosures are essential

- **Predictable Infiltration supports better HVAC sizing**
  - Benefits HVAC system's first cost
  - Reduces energy use
  - Reduces dehumidification load
- **Fundamental for Passive house & Net Zero Energy (NZE)**
  - Supports lower energy loss
  - Requires controlled ventilation
  - Improves insulation efficiency by reducing uncontrolled air motion through insulation

Once in a "building's lifetime" opportunity…

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The Research Intent

Feasibility

Applicability

Scalability

The Research Intent

Feasibility

Contribution to Energy Savings

- **Target for 20% additional energy savings (by fuel)**
- **Evaluate the cost-effectiveness potential to utility and owners**
  - **Energy Conservation Measure (ECM) that fits the utility incentive model**
  - **Less than 15 yr. payback**
  - **Proven [measurable] savings**
  - **Demonstrate the utility's influential role for adoption within individual projects**

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The Research Intent

Applicability

Energy Analysis, Process and Needs

- **Inform best practices and methodology**
  - **Building energy simulation** (predicted savings)
  - **Commercial whole building air infiltration testing** (measured savings)
- **Supports PA's and other constituents buy in on Proven savings**
- **Identify Owners/Industry Process and needs**

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The Research Intent

Scalability

Market Adoption Potential

- Assess scalability within multi-family market
- Inform scalability to other commercial building types
- Identify Resources availability to sustain growth/demand
- Identify owners/industry needs to accelerate adoption

The Research Intent

Whole Building Infiltration Testing		
Standard	**CFM/SF (gross enclosure area) @ 75 PA**	**Comments**
IECC 2015 (MA Building Code)	0.4	References ASTM E-779
U.S. Army Corps of Engineers Standard	0.25	References ASTM E-779
PHIUS+ (v2.1) (Passive House US) Certification for Multifamily	0.08/0.11	References RESNET Standards Chapter 8. (0.11) criteria only applicable to noncombustible building enclosure assembly per the International Building Code (IBC).
Passivhaus Institute Standard (PHI) Darmstadt	N/A (uses ACH)	PHI requires 0.6 ACH50 maximum ACH metric vs. the CFM metric. Most US standards and Code require measurements using the CFM metric. ACH may be converted in CFM and vice versa.
EnergyStar Multifamily	N/A	The air infiltration testing is required for in-unit compartmentalization only, not whole building testing.

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The Research Team

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Project Owner's Coordination & Energy Analysis

Sustainable Energy Analytics

Constructive Code Consultants

Center for Eco-Technology

Air infiltration testing firms

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The Research Approach

5 Multi-Family projects

- New construction/ major renovation
- Construction phase
- Electric heating and/or natural gas heating
- MassSave Multi-Family Incentives program

1 Passive House project

Owner's and Construction Team "Buy In"

ICF lead the coordination with project owners/design teams

Timeline:

May 2018 – October 2018

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The Research Criteria

0.4

CFM/SF @ 75 Pa [Code Baseline]

0.2-0.3

CFM/SF @ 75 Pa [Targeted result]

ASTM E-779

Air Infiltration Testing Methodology

Residential units already undergoing Energy-Star Certification air infiltration testing. The residential unit air infiltration testing does not capture the full building enclosure air infiltration reduction.

Selected Projects Overview

Air Infiltration Reduction ECM Research					
	Project Description				
	Location	Area (SF)	Storey (#)	Units (#)	High Perf. Level
					Beyond Code
Project 1	Northampton, MA	58,019	4	70	High
Project 2	Saugus, MA	37,740	5	39	Low*
Project 3	Haverhill, MA	27,300	3	24	Low*
Project 4	Leominster, MA	47,776	4	43	Mid-range
Project 5	West Roxbury,MA	95,000	4	82	Mid-range
~~**Project 6**~~	~~Quincy,MA~~	~~150,000~~	~~4~~	~~140~~	
Project 7	Cambridge, MA	24,943	4	19	Low
Passive HS	*Boston*	*33,500*	*4*	*30*	High

**Code to Low High Performance Enclosure and HVAC efficiency measures reduce cost effectiveness and associated savings*

***No incentives were paid for air infiltration reduction savings on the Distillery Project*

Project 5 - National Grid Natural Gas &Eversource Electric
Project 7 - Eversource Natural Gas & Eversource Electric

Project Criteria

Air Infiltration Reduction ECM Research											
Project Description					Building Enclosure				HVAC		
roject Nam	Location	Area (SF)	Storeys	# units	Walls	Roof	Glazing	WWR	Heating	Cooling	ERV/HRV
							U-value /SHGC		HB: Hydronic basebrd heating HA: Hydronic air-based at units TW-AC: Through wall AC units		
Project 1	Northampton, MA	58,019	4	70	R19.5+R7.5ci	R-61	0.2/0.3	24%	VRF		yes
Project 2	Saugus, MA	37,740	5	39	R21+R7.6	Code	Code	24%	HB	Central	no
Project 3	Haverhill, MA	27,300	3	24	Code	Code	0.29 /0.26	23%	HB	TW-AC	no
Project 4	Leominster, MA	47,776	4	43	R23+R7ci	R-45	0.31/0.27	17%	Central blr/Fan Coil		yes
Project 5	West Roxbury, MA*	95,000	4	82	Code	R-38	0.27/0.3	26%	HA	Split Syst.	no
~~**Project 6**~~	~~Quincy, MA~~	~~150,000~~	~~4~~	~~140~~							
Project 7	Cambridge, MA**	24943	4	19	R-20+R6ci	Code	Code	20%	HA	Split Syst.	No
Passive HS	*Boston, MA*	*33,500*	*4*	*30*	*R26.1+R12.9ci FLR - R-30*	*R-46*	*0.13*	*31%*	*Ductless Mini-split*		*yes*

** National Grid Natural Gas - Eversource Electric*

*** Eversource Natural Gas - Eversource Electric*

The Research Energy Savings Results

Air Infiltration Reduction ECM Research										
	Project Description	Testing Results	Energy Savings (Comprehensive ECMs)							
	Location	Measured Air Infiltration	Original TA Study Savings		Savings incl. Air Infiltration		Δ Savings		Incremental Savings (%)	
		CFM/SF @ 75 Pa	Electrical	Nat. Gas	Electrical	Nat. Gas	Electrical	Nat. Gas	Electrical	Nat. Gas
Project 1	Northampton, MA	**0.11**	134,303	0	178,324	0	44,021	0	33%	0%
Project 2	Saugus, MA	**0.34**	51,301	527	48,420	1,035	(2,881)	508	-6%	49%
Project 3	Haverhill, MA	**0.34**	49,799	560	49,831	576	32	16	0.1%	3%
Project 4	Leominster, MA	**0.22**	78,468	1,285	78,441	3,333	(27)	2,048	-0.03%	61%
Project 5	West Roxbury,MA	**0.33**	90,019	6,424	85,973	8,001	(4,046)	1,577	-4.5%	20%
~~**Project 6**~~	~~Quincy,MA~~	*Cancelled Testing*								
Project 7	Cambridge, MA	**0.23**	41,907	641	41,256	1,229	(651)	588	-1.6%	48%
Passive HS	*Boston*	***0.13***	*116335*	*600*	*139,585*	*600*	23,250	0	20%	0%
	**Code to Low High Performance Enclosure and HVAC efficiency measures reduce cost effectiveness and associated savings*									
	***No incentives were paid for air infiltration reduction savings on the Distillery Project*									
	Project 5 - National Grid Natural Gas &Eversource Electric *Project 7 - Eversource Natural Gas & Eversource Electric*									

The Research Energy Savings Results

Air Infiltration Reduction ECM Research											
	Project Description	Testing Results	Energy Savings (Comprehensive		Energy Costs Savings and Payback					Incentives	High Perf. Level
	Location	Measured Air Infiltration	Δ Savings		Air Infiltration Savings	Testing Costs ($)		Payback (yrs)		Air Infiltration	
		CFM/SF @ 75 Pa	Electrical	Nat. Gas	$0.17/kWh-$1.05/therm	Testing	ICF Mngmt		w/ Incent.	$0.35 kWh-$1.70 therm	Beyond Code
Project 1	Northampton, MA	**0.11**	44,021	0	$7,484	$6,200	*$2,000*	1	0.4	$15,407	High
Project 2	Saugus, MA	**0.34**	(2,881)	508	$533	$950	*$2,000*	6	2.1	$864	Low*
Project 3	Haverhill, MA	**0.34**	32	16	$22	$4,800	*$2,000*	216	112.1	$38	Low*
Project 4	Leominster, MA	**0.22**	(27)	2,048	$2,146	$1,650	*$2,000*	2	0.6	$3,482	Mid-range
Project 5	West Roxbury,MA	**0.33**	(4,046)	1,577	$968	$4,600	*$2,000*	7	1.8	$2,681	Mid-range
~~**Project 6**~~	~~Quincy,MA~~	*Cancelled Testing*				$14,000	*Cancelled testing*				
Project 7	Cambridge, MA	**0.23**	(651)	588	$507	$5,960	*$2,000*	16	5.3	$1,000	Low
Passive HS	*Boston*	***0.13***	23,250	0	*$3,953*	*$6,500*	*$2,000*	*2*	*1*	*$8,138*	High
	**Code to Low High Performance Enclosure and HVAC efficiency measures reduce cost effectiveness and associated savings*										
	***No incentives were paid for air infiltration reduction savings on the Distillery Project*										
	Project 5 - National Grid Natural Gas &Eversource Electric *Project 7 - Eversource Natural Gas & Eversource Electric*										

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The Research Energy Savings Results

$0.01-0.04/SF
saved for natural gas heated facilities

$0.13/SF
saved for electrically heated facilities

60%
avg. savings - therm
(natural gas heating)

30%
Avg. savings - kWh
(electrical heating)

1-3%
Total Savings (kBtu)

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The Research Energy Savings Results

2-10 yrs.

Payback without Incentives**

$0.05-0.18/SF

Air Infiltration Testing Fees*

0.4-2.5 yrs.

Payback with Incentives**

Cost effective when including the testing fee

**Fees were originally estimated at $0.20-$0.30/SF*

***assuming $0.35/kWh-$1.70/Therm. –Excludes facility #3*

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Additional Criteria Affecting Measurements

- **Stack effect**
- **Latent cooling**
  - Improves insulation efficiency by reducing uncontrolled air motion through insulation
  - Reduces dehumidification load
- **Applicability and Challenges for High Rise Facilities**
  - Audience Feedback Welcomed

Implementation & Market Response

- **An effort that is not routinely achieved in the current projects' "built to code".**
  - Proven fairly achievable, with support (role of ICF and Utility Programs)
  - 60% participation rate (projects already in construction!)
  - Address barriers that may restrain its rate of adoption.
  - MA PA's have the potential to address these barriers, however we have not yet examined how PAs would or if PAs should take on such role.
- **Best proven through the whole building air infiltration testing**
- **Research revealed availability of regional resources (testing firms)**

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Implementation & Market Response

Findings & Challenges

- Scheduling and completion needs to adapt to the construction schedule delays.
- Most projects experienced delays.
- Testing Firms will benefit from ongoing training/education
  - Evolve & improve the methodology by learning from each other
  - Additional field training
  - Consistency for testing/measuring methodology

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Implementation & Market Response

Testing Process Recommendations

- **Single zone for whole building testing (wherever possible)**
- **Process and Scheduling:**
  - Testing milestones to be included in the construction schedule
  - Coordination meeting prior to the testing - include contractor, owner, appropriate subs, testing company, etc.
  - Create an Air Infiltration Testing Plan

Testing Plan to identify:

1. **Fan/testing Equipment locations**
2. **Areas to be sealed**
3. **Field checklists & Data Collection**
4. **Staff Responsibilities for various tasks:**
   - Disabling HVAC Equipment
   - Wired or wireless equipment set up
   - Notes and Photographs as critical documentation

Market Practitioners Feedback – ABx 2018

Recommendations

- **Infra-red analysis**
  - Support results (during construction)
  - Imagery to support client proposal
- **Building Enclosure Commissioning (BE Cx)**
  - Standardized site monitoring
- **Incentives**
  - Tax credits (Ownership)
- How do we quantify/qualify the drafts?

Hone the client proposal ("pitch")

- **Promote non-energy benefits:**
  - Comfort
  - Mold remediation
  - Resiliency
  - Tenants retention
  - Acoustics
  - Air quality: air particle content Improvement (standard?)

How/who can work together to overcome challenges

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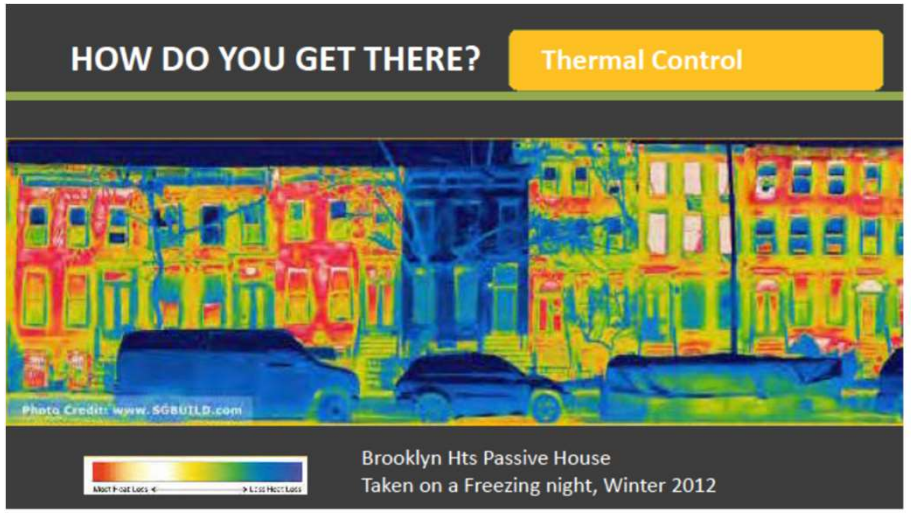
Interactive Discussion

- **Owners perspective**: What is needed to obtain buy in?
- **D&C Professionals perspective**: What do they need to know when?
- **Applicability** to other type of projects
- **Name Top 5 Challenges** for design and for construction industry
- Additional questions?



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