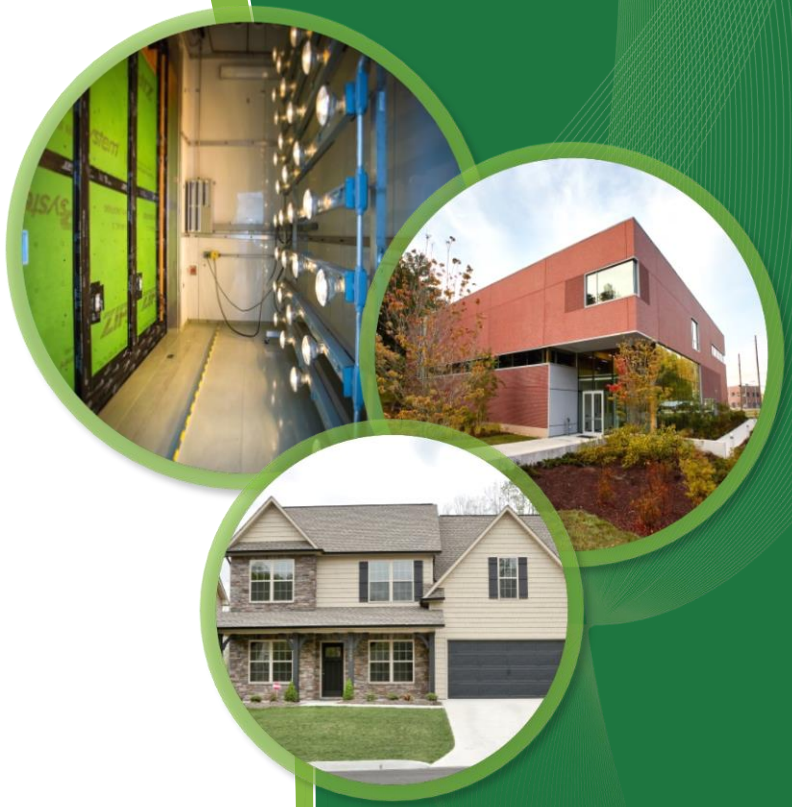
Building Enclosure Commissioning

Teaming to Improve Enclosure System Performance



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Agenda

- Energy savings potential
- The Building Envelope Technology Research Team
- Opportunities with Building Enclosure Commissioning
- Addressing Air Leakage
- Next Steps, get involved

Building Envelope: 5.81 Quads

The commercial **building envelope** is the **primary determinant** of the amount of **energy required** to heat, cool, and ventilate a building

Table 2. Primary Energy Consumption Attributable to Fenestration and Building Envelope Components in 2010 (Quads)[6]

Building Component	Residential		Commercial	
	Heating	Cooling	Heating	Cooling
Roofs	1.00	0.49	0.88	0.05
Walls	1.54	0.34	1.48	-0.03
Foundation	1.17	-0.22	0.79	-0.21
Infiltration	2.26	0.59	1.29	-0.15
Windows (Conduction)	2.06	0.03	1.60	-0.30
Windows (Solar Heat Gain)	-0.66	1.14	-0.97	1.38

Source: Office of Energy Efficiency and Renewable Energy 2011b; Office of Energy Efficiency and Renewable Energy 2011d; Office of Energy Efficiency and Renewable Energy 2011e; Office of Energy Efficiency and Renewable Energy 2011g

Barriers Identified for Envelope Technologies

- **Cost:** uncertainties, high first costs, ROI hurdles
- **Supply issues**: product fragility, availability, volume
- **Installation issues:** workforce training, complex systems, quality control
- **Decision culture:** resistance to new products, risk averse, code minimum culture
- **Information gap:** real world case studies, data on long-term performance, communicating effectively

Building Envelope Technology Research Team

Connecting Better Buildings partners with advanced building envelope technology solutions

- ✓ Technology verification studies
- ✓ Specification documents
- ✓ Case studies and fact sheets
- ✓ Calculators and analytic tools

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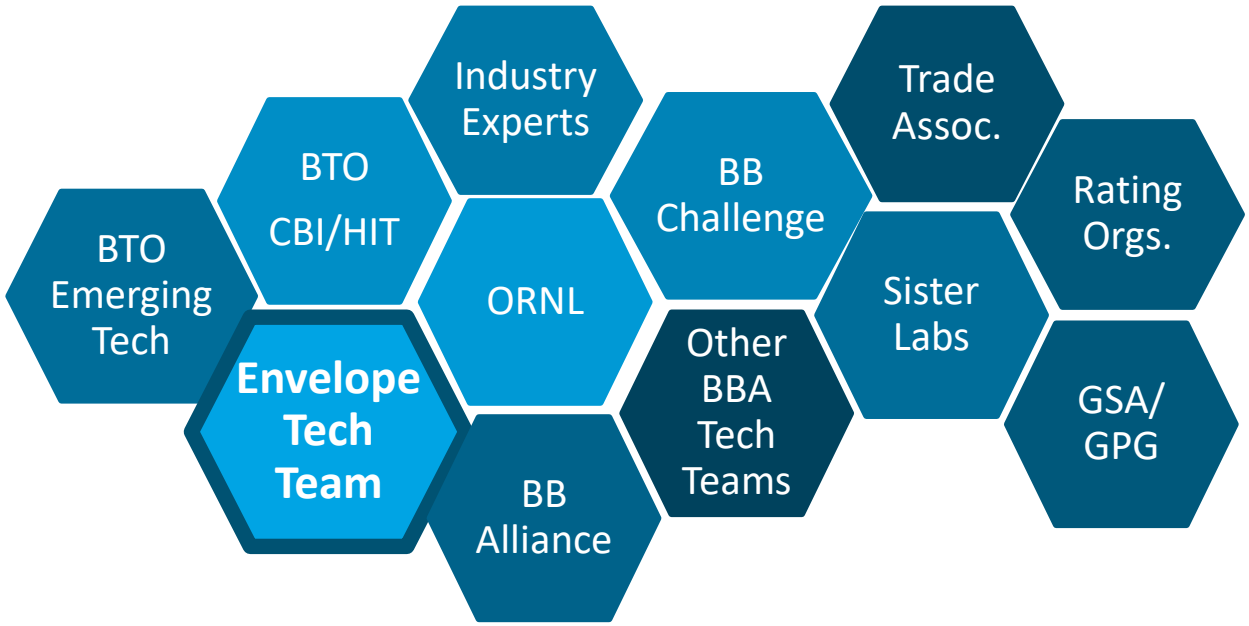
Building Envelope Tech Team Support

Caroline Hazard, M.S.

Building Envelope Tech Team Support

A Unique and Diverse Team



- Demonstration of high performance envelope technologies and solutions
- Comprised of Better Buildings Partners and representatives from the design community, including A&E firms

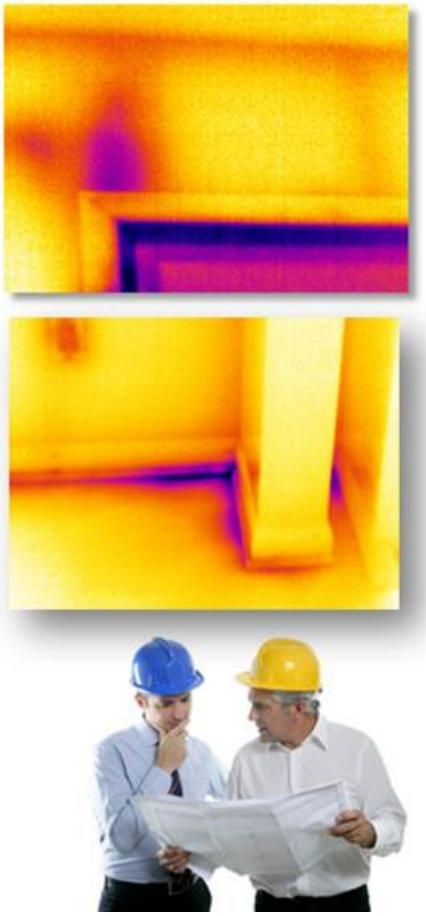
What does the Envelope Team do?

Stakeholder Engagement	• **Recruit** Team members among BBA partners and representatives from the design community • **Collaborate** to advancing investment in envelope technologies with team discussions, webinars, and participation in market studies
Build Awareness	• **Prime the market** by strengthening building owners/manager's understanding of envelope technologies • Conduct envelope technology **demonstrations** • Provide **guidance and tech assistance** for envelope projects
Document and Validate Results	• Prepare **site M&V plans** for technology demonstrations • **Document results and produce case** studies and/or guidance for use in training, codes and/or standards
Technical Resources	• Online resources: **Windows, Walls, Roofs** • Specifications, guidance, case studies, fact sheets, etc. **addressing market barriers** and assist advancement of envelope technologies

Current R&D Efforts

- Building Enclosure Commissioning
  - Benefits and Costs Study
  - Exploration of new enclosure performance metric
- Examination of Airtightness Requirements
  - Landscape Study
  - Sampling of air leakage rates

Why conduct Building Enclosure Commissioning?

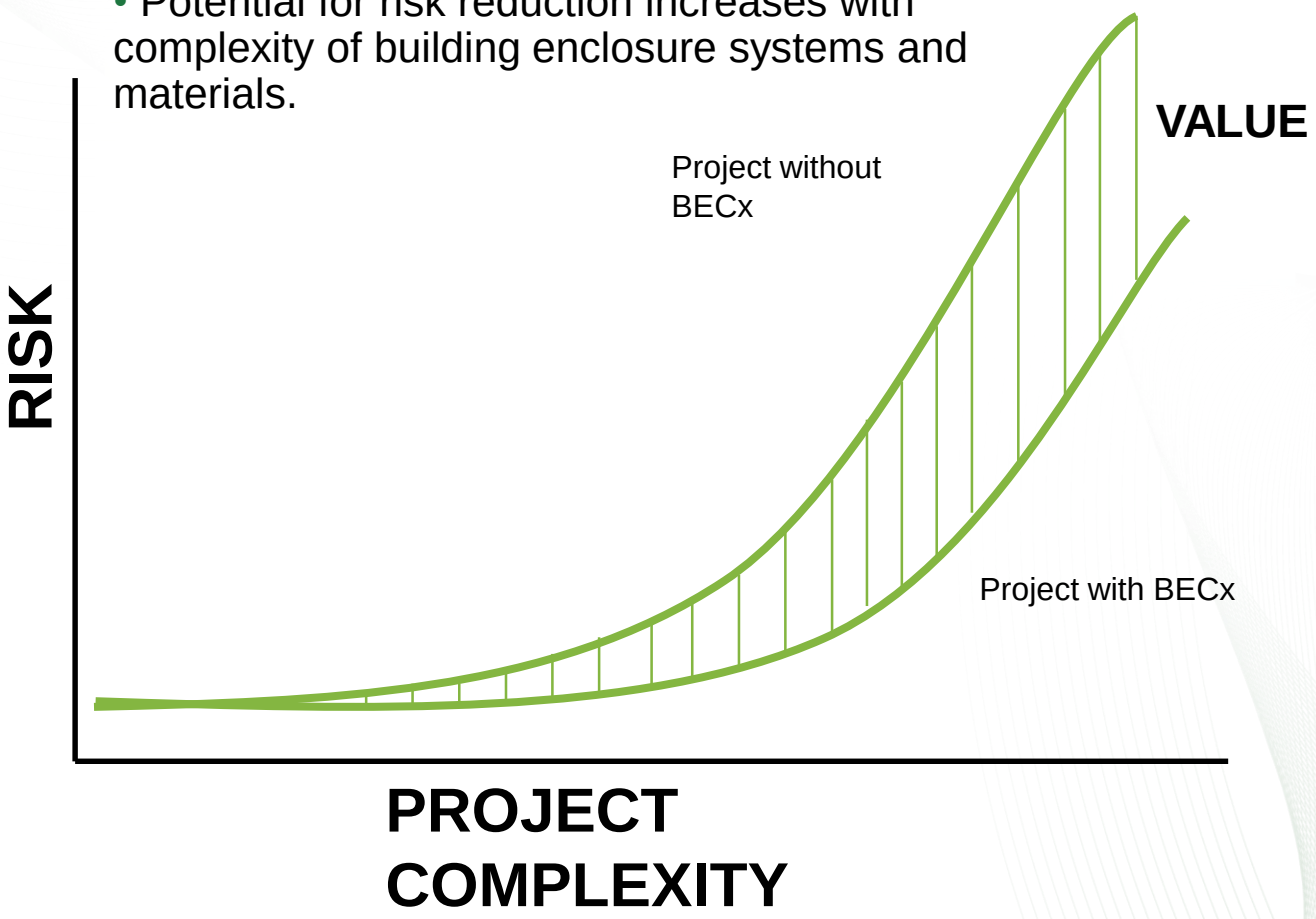


- To improve the design process
- To reduce building energy loads (typically for office, multi-family)
- To address human health and safety needs (typically for labs or hospitals with ventilation and pressurization requirements)
- To prevent moisture from compromising building
- To maintain thermal comfort
- To maintain air quality
- To improve overall quality of building
- To comply with building codes

Credit: Anica Landreneau, HOK, ETRT presentation 1/31/18

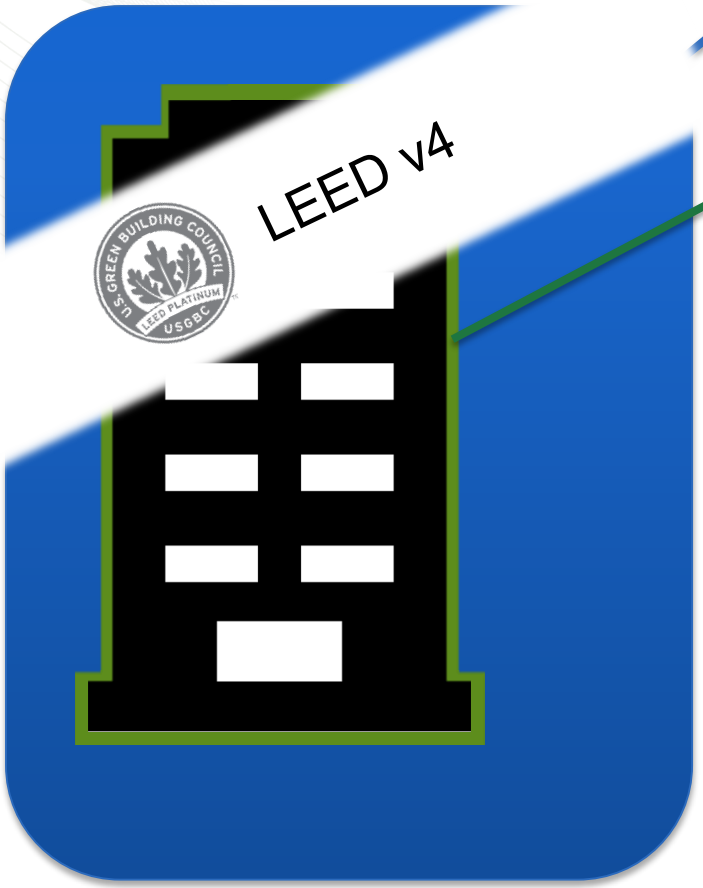
Where's the Value in BECx?

- Higher level of quality assurance = improved performance = reduced risk.
- Potential for risk reduction increases with complexity of building enclosure systems and materials.



Source Credit: Paul Totten, WSP, ETRT presentation, 6/13/17

BECx 101 - Standards, Guidelines, and Resources



ASHRAE Guideline 0-2013

- NIBS Guideline 3-2012
- ASTM 2947

Process

- ASTM 2813
- NIBS Guideline 3-2012

Laboratory

Field

Technical

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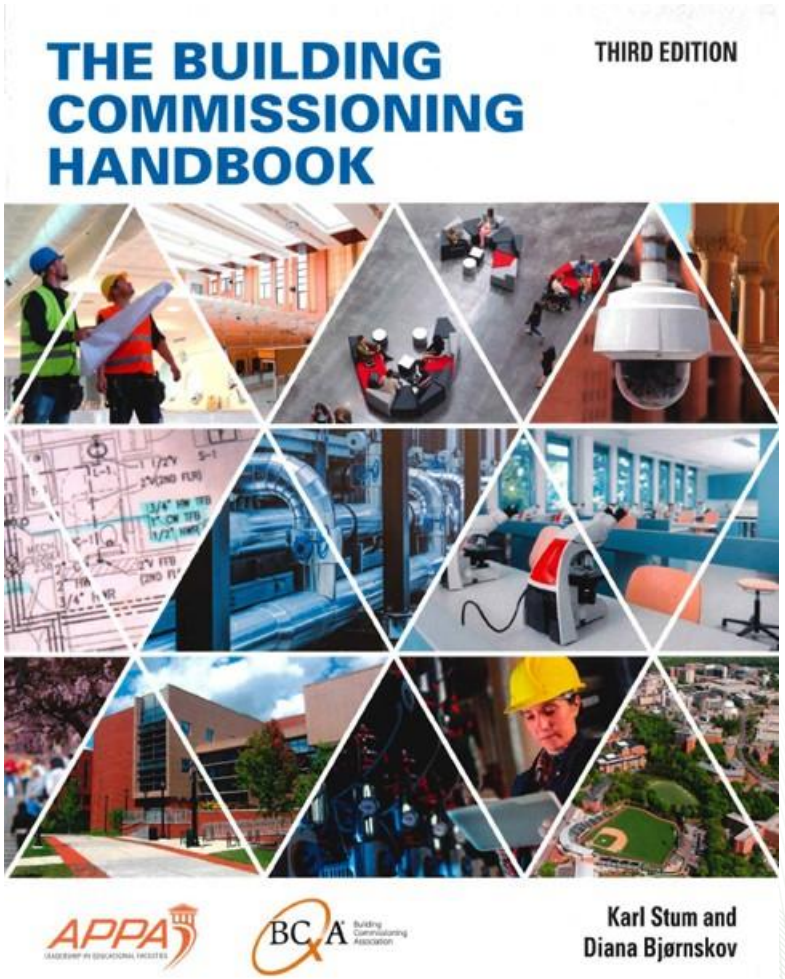
BECx 101 - Standards, Guidelines, and Resources

Additional reading…

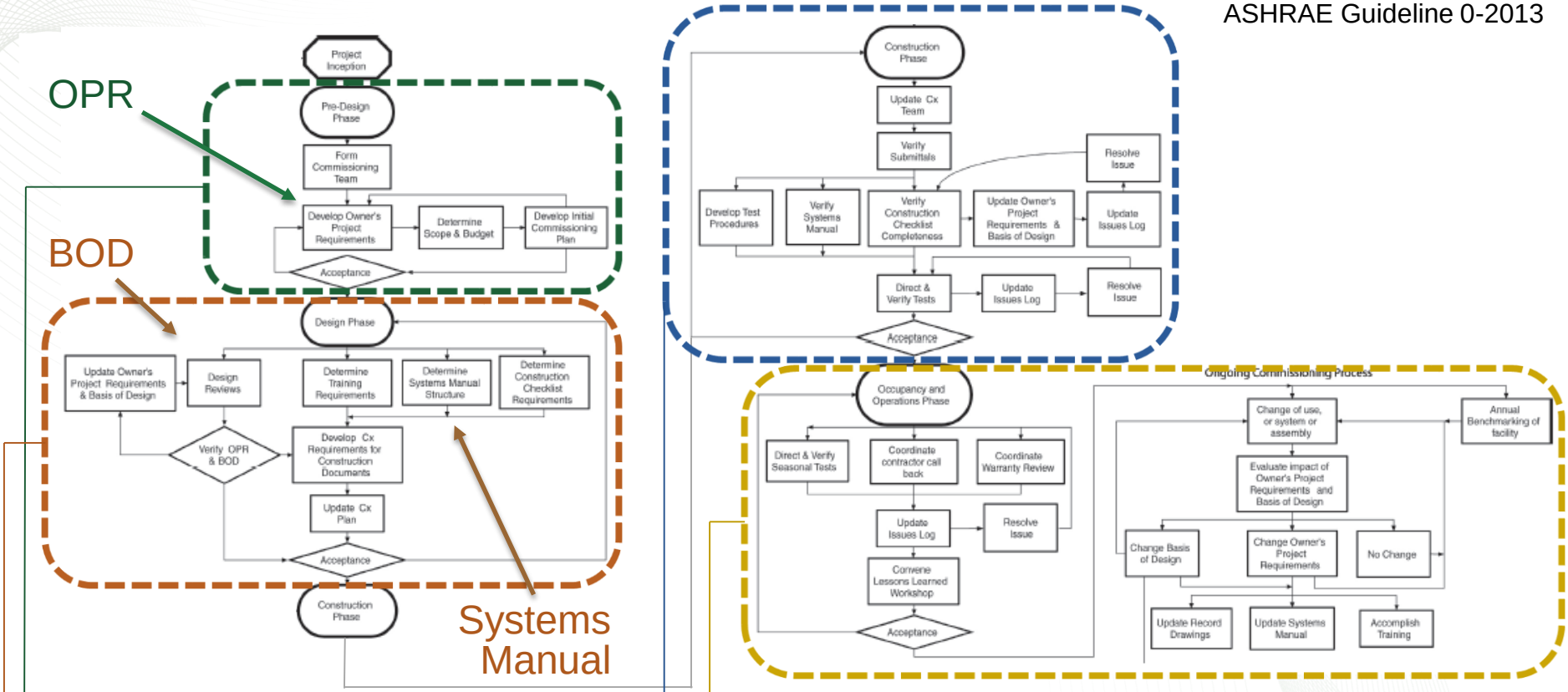


BECx 101 - Terminology and Definitions

- **Owner's Project Requirements (OPR):** A document that details the functional requirements of a project and the expectations of how it will be used and operated.
- **Basis of Design (BoD):** A document that records the concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements and to satisfy applicable regulatory requirements, standards, and guidelines.
- **Commissioning Plan (Cx Plan):** A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
- **Systems Manual:** A system-focused composite document that includes the operation manual, maintenance manual, and additional information of use to the Owner during the Occupancy/Operations Phase.

BECx 101 - Commissioning Flow Chart

ASHRAE Guideline 0-2013



- Predesign Phase
- Design Phase
- Construction Phase
- Occupancy/Occupation Phase

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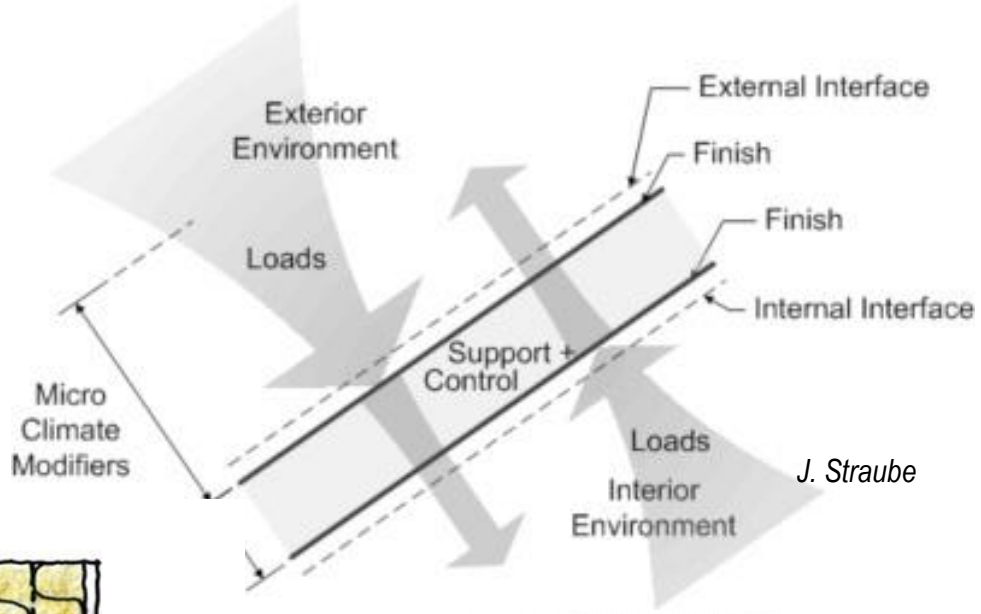
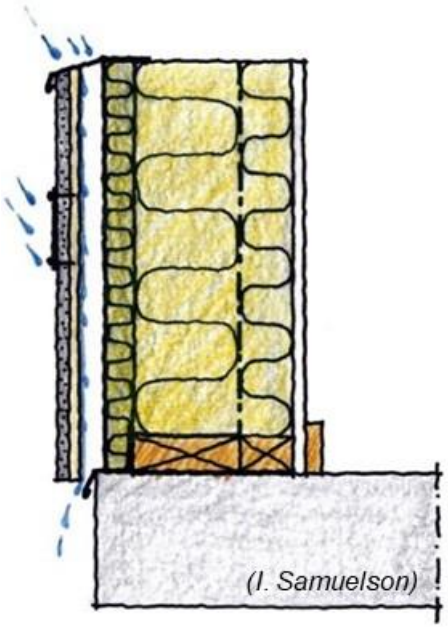
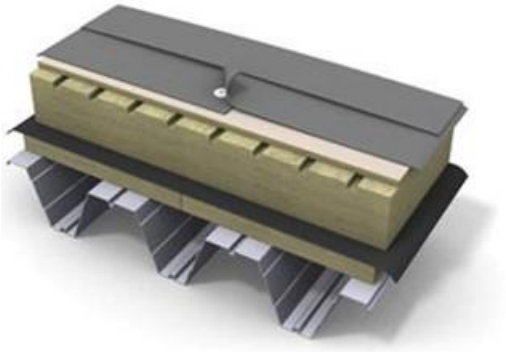
Holistic Assessment of Building Envelope

- Water Resistive Barrier
- Air Barrier
- Thermal Resistance
- Vapor Barrier
- Light
- Noise
- Structural Performance





Envelopes are Systems

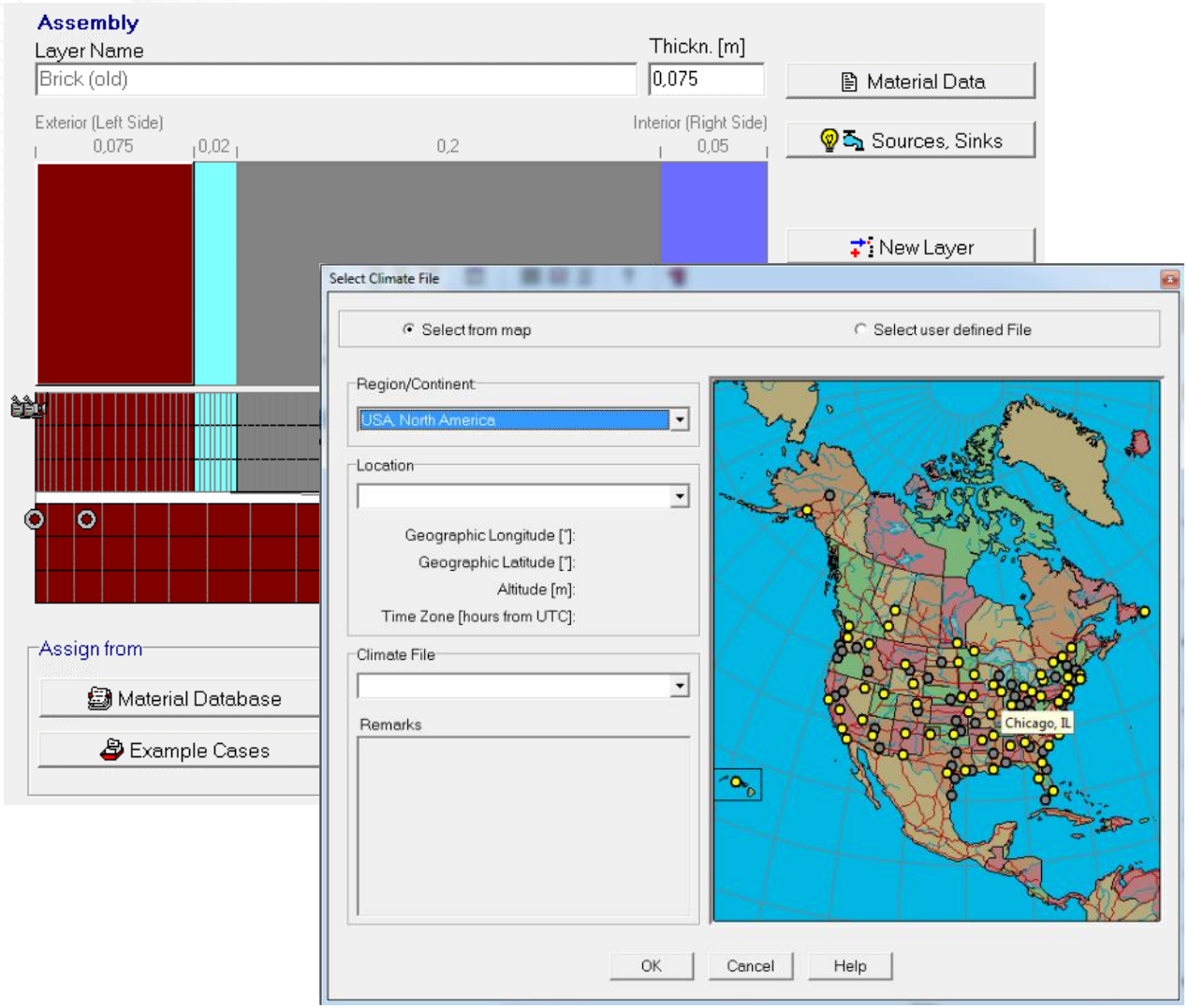


Example: Building Envelope Assessment

Example – Reduce energy losses through existing building envelope

Concerns - Impact on façade material

… entering information into WUFI



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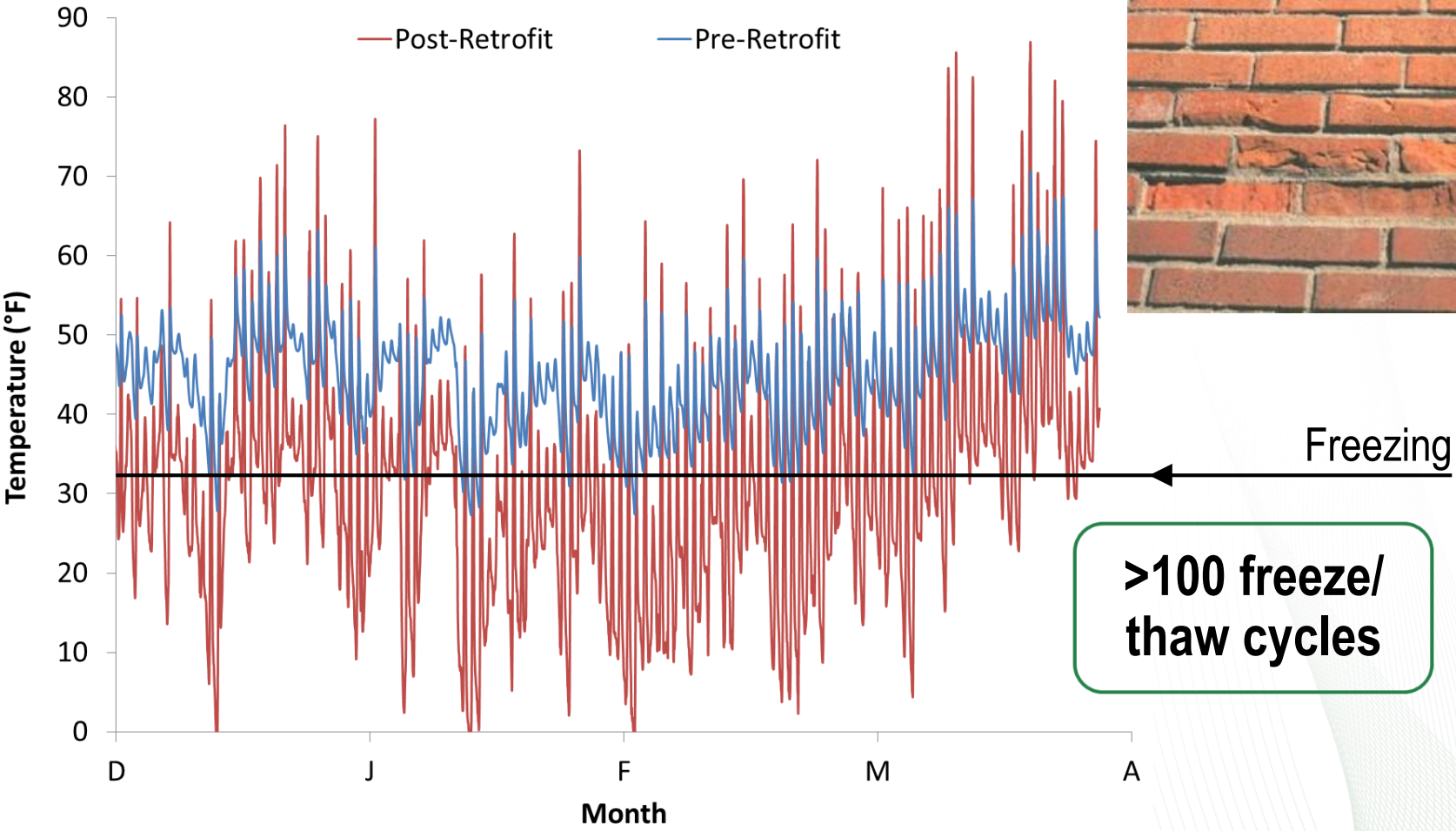
….seeing the WUFI output



>100 freeze/ thaw cycles

Example 2:
Looking at Installation Quality and Built as Designed

Field Study - Airtightness of 12 Identical Buildings

Factors that influence airtightness

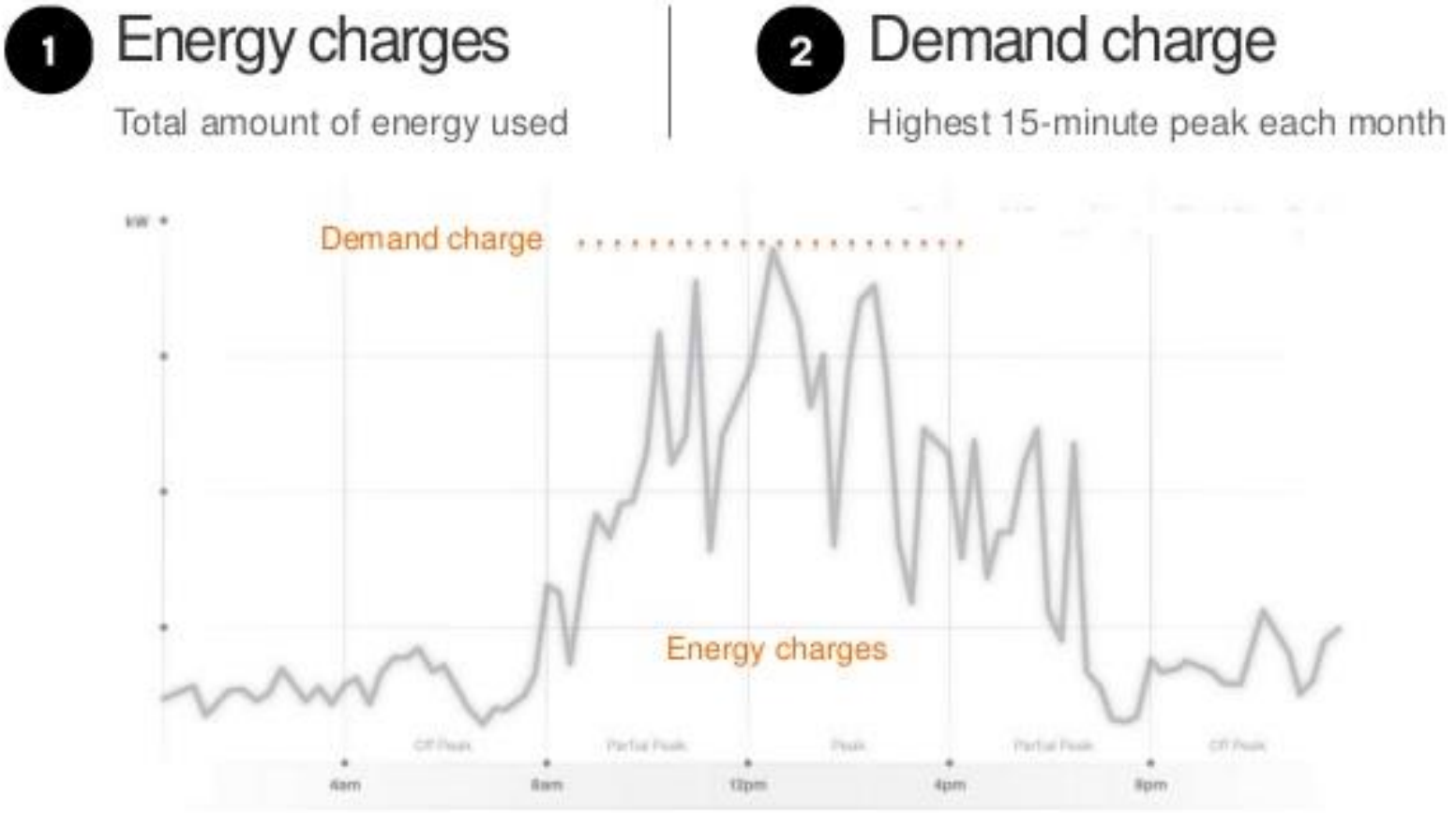
- Construction design
- Floor area / Volume
- Penetration / Installations
- Material properties
- Workmanship

...Field Study Results

Installation Quality – Built as Designed

Example 3: Operations and Energy Management

Return of Investment



Return on Investment

Customer A

50 kW load for 50 hours:

Usage

Energy = 50 kW x 50 hours = 2,500 kWh

Demand = 50 kW

Bill

Energy= 2,500 kWh x $0.15 = $ 375.00

Demand = 50 kW x $28.00 = $1,400.00

Total = $1,775.00

Customer B

5 kW load for 500 hours:

Usage

Energy = 5 kW x 500 hours = 2,500 kWh

Demand = 5 kW

Bill

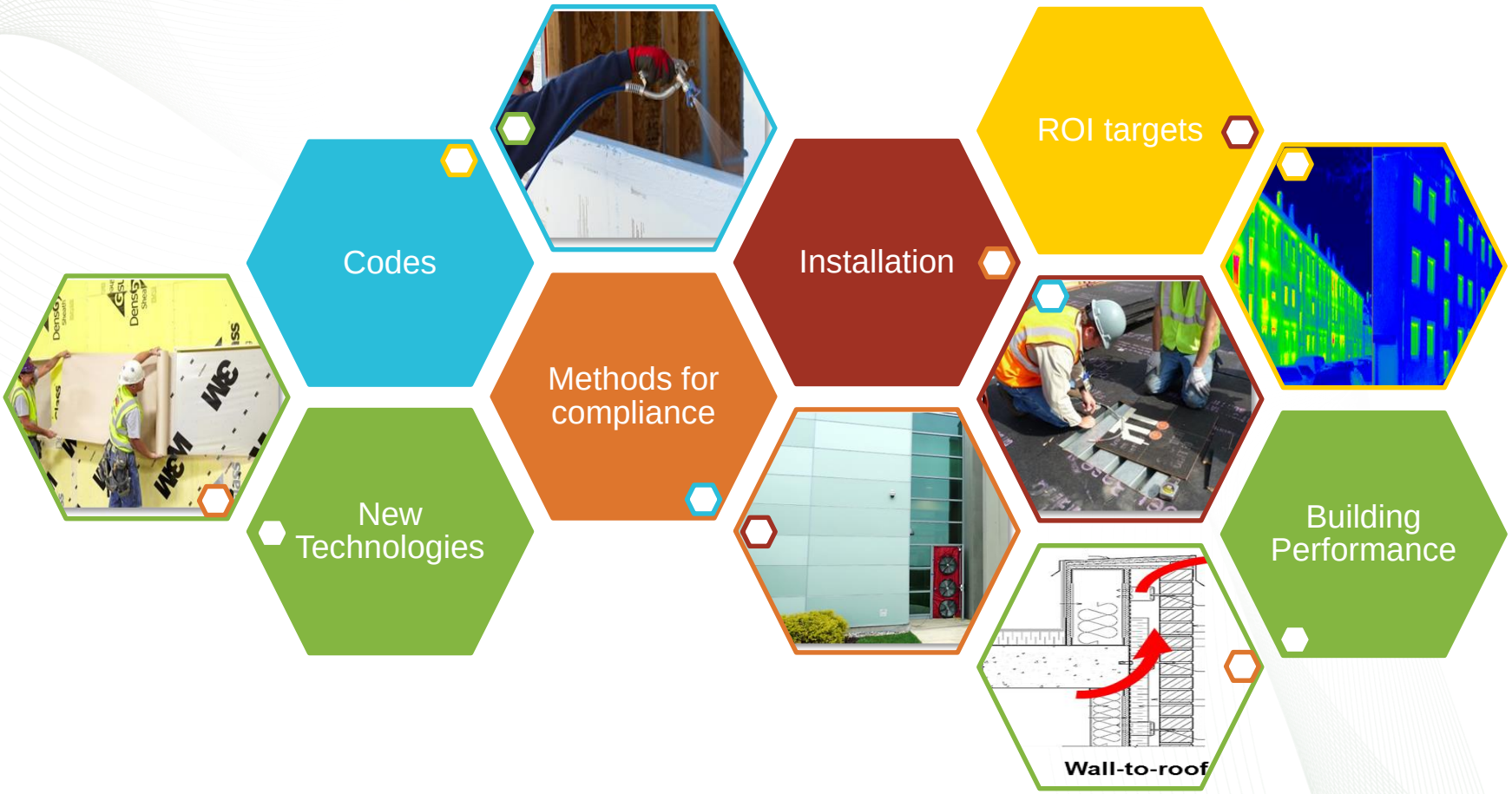
Energy= 2,500 kWh x $0.15 = $ 375.00

Demand = 5 kW x $28.00 = $ 140.00

Total = $515.00

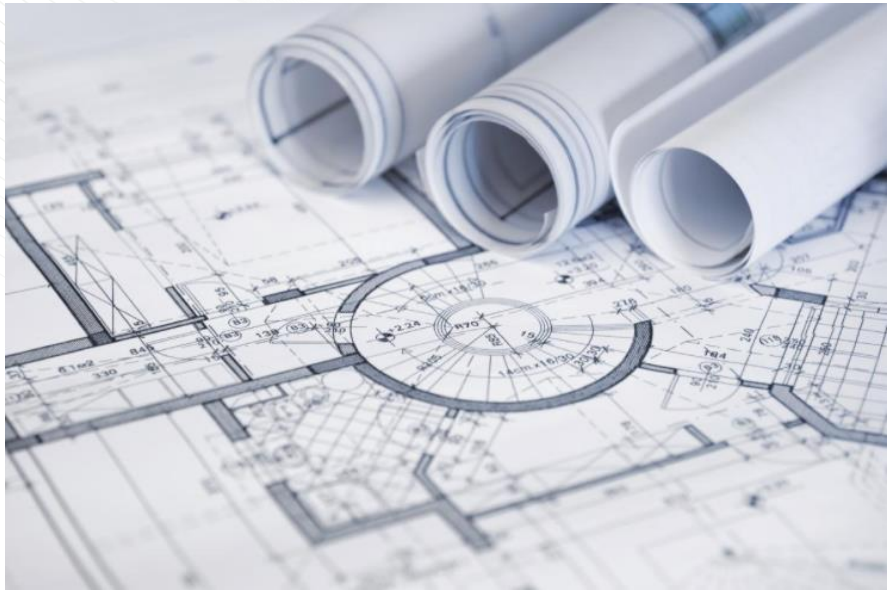
Identical energy usage, but very different totals due to PATTERN of energy usage

Addressing What's Hidden: Air Leakage



Air leakage accounts for up to 40% of buildings energy losses

Status of Current Airtightness Requirements



- Airtightness in new buildings is increasing
  - Requirements set by local governments
  - Requirements by the US Army Corps of Engineers
  - Advances in air barrier technologies and construction practices
- Building codes seem to slow to revise so that they establish a maximum air leakage rate requirement for new buildings

Current Air Leakage Requirements

		Code/ Standard/ Program	Requirements		
			Test Method	Air Leakage Rate (cfm/ft2) at 0.3 in. water gauge	Test Standard
Most Cities & States		2012 and newer IECC	Optional whole bldg. test	<0.40 (optional)	ASTM E779
		ASHRAE 90.1-2016	Optional whole bldg. test	<0.40 (optional)	ASTM E779 ASTM E1827
Reg. Leader	WA State	2015 WA State Energy Code	Whole bldg. pressurization & depressurization tests, or only pressurization	<0.40 (optional)	ASTM E779
	Seattle, WA	2015 Seattle Energy Code		<0.30 (optional)	ASTM E779
Fed. Sector	GSA	PBS-P100 (GSA 2014)	Whole bldg. test	Tier 1: <0.40 Tier 2: <0.15 Tier 3: <0.10	ASTM E779 or ASTM E1827
	US ACE	USACE (2012) Air Leakage Test Protocol	• Whole bldg. pressurization & dep. test in ≤ 4 stories • Floor by floor test in > 4 stories	<0.25	US ACE (2012) Air Leakage Test Protocol
Private Sector Building Owner		ASHRAE 189.1-2014	Whole bldg. test	<0.25	ASTM E779
		PHIUS+ 2015	Whole bldg. test	<0.08	ASTM E779
		USGBC LEED	Whole bldg. test	0.23 at 0.2 in water gauge	ASTM E779

Perspectives on Airtightness Rates

Blower Door Test Consultants

- Availability of consultants: varies by region – code is in enforcement
- Certification for testing credentials would provide credibility
- Challenges:
  - Added time
  - Added cost

Potential Solutions

- Collaborative design and construction teams
- Refinements to blower door test procedure
- Adjustments/innovation of testing equipment
- Addressing mechanical penetrations

Perspectives on Airtightness Rates

Owners Managers of Buildings

- Main driver of airtightness testing: to comply with building codes
  - Additional drivers, voluntary:
    - LEED, Passive House Institute, financial incentives or rebates
  - Energy savings does not seem to be driver
- Challenges:
  - Tenants typically pay the utility bills … but this cost is significantly lower than rent
  - Duration of ownership is typically less than 10 years
  - Owners seek higher rents which doesn't necessarilly drive improving energy performance
  - Potential loss of business and revenue due to time to conduct a blower door test and address identified problems.

Perspectives on Airtightness Rates

Construction Industry

Challenges:

- Cost of the blower door test
- Time and hassle to schedule
- Perceived difficulties in addressing test findings

For Further Consideration: Addressing Air Leakage

- Air leakage in commercial buildings accounts for about 1.14 quads
  - but very few building codes are mandating whole building leakage tests
- Better construction practices and code requirements are resulting into tighter buildings
  - Significant improvements noted in buildings with collaborative design and construction teams
    - Communications on timing and application of a blower door test
- A combination of solutions, perhaps tailored to the building type, size, and/or climate, should be explored

For more information:
ORNL will be presenting the AT Study at the 2018 ACEEE Buildings Summer Study

For Further Consideration: BECx

Costs

- Planning
- Testing
- Consultants
- Time
- Addressing findings
- Other

Benefits

- Reduction in direct energy use
- IAQ and comfort indices
- Moisture resilience
- Impact on durability and service life,
- Code compliance
- other

Potential new metric

Building Enclosure Performance Metric

- Thermal resistance
- Installation quality
- Air infiltration thermal resistance
- Indoor climate
- Weather

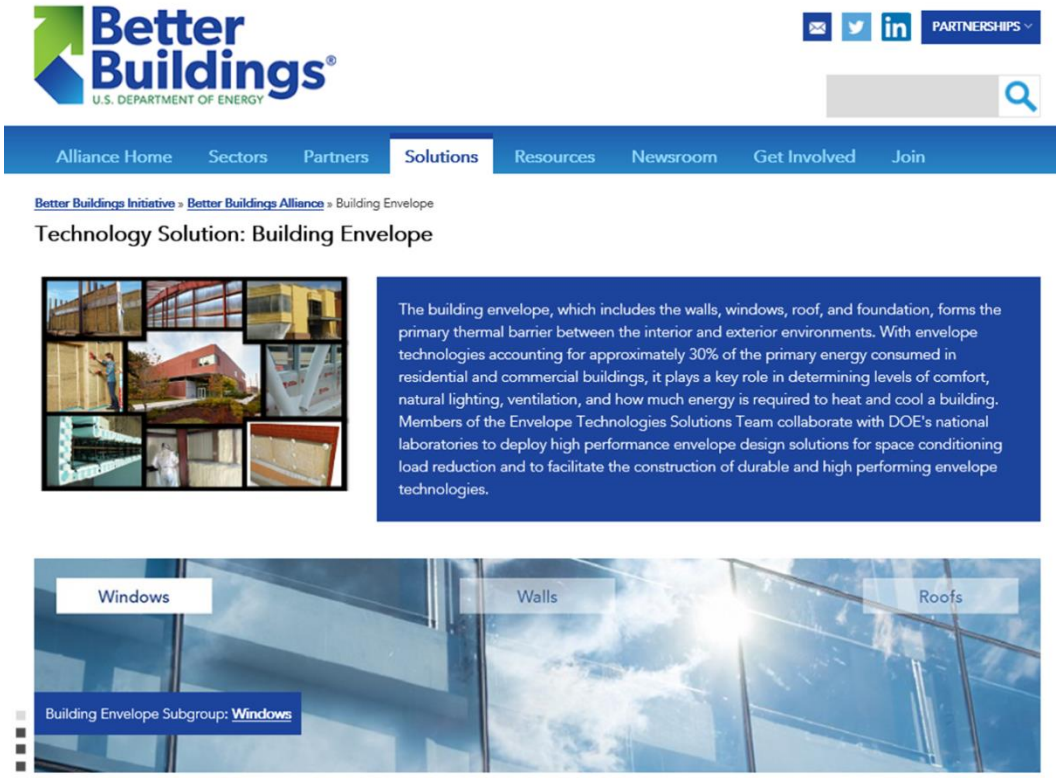
Collaboration: the Envelope Tech Team

Engage and support Members in efforts to accelerate adoption of building envelope technologies

- **Build awareness** with guidance and information on envelope technology solutions
- Conduct envelope technology **verification studies**
- Offer **technical assistance** for envelope projects

Check out the Envelope Tech Team Web Resources

- Topic Areas
  - Windows
  - Walls
  - Roofs
- Resources
  - Case Studies
  - Calculators
  - Design Guides
  - Fact Sheets
  - Toolkits
  - …and more…



https://betterbuildingsinitiative.energy.gov/alliance/technology-solution/building-envelope

Join the Envelope Tech Research Team!

Building Owners

Building Managers

Architects and Engineers

Trade Associations

Manufacturers

Installers/ Builders

Energy Service Providers

Researchers

Engage in R&D:

- Addressing airtightness requirements
- Investigating Building Enclosure Performance Metric

To join, email Melissa Lapsa: lapsamv@ornl.gov

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Envelope Tech Research Team:

https://betterbuildingsinitiative.energy.gov/alliance/technology-solution/building-envelope