This has nothing to do with air leakage
This is Air Leakage!
You cannot see air leakage!
You cannot see energy savings!
Understanding Air Leakage

40% of total US prime energy expended

70% of all US electric energy used
Building Energy Use

In 2013, 40% of total U.S. energy consumption was consumed in residential and commercial buildings, or about 40 quadrillion British thermal units (40,000,000,000,000,000 BTUs).

Commercial uses 18% (7.2 quadrillion)
Of that 43% used to heat and cool (3.1 quads)
15 – 40% due to air leakage (@40%=1.2 quads)

Residential uses 22%
Of that 27% used to heat and cool
10 – 40% due to air leakage
**Energy Losses in the Building Envelope**

Primary energy consumption attributable to fenestration and building envelope components in 2010

<table>
<thead>
<tr>
<th>Building Component</th>
<th>Residential (quads)</th>
<th>Commercial (quads)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heating</td>
<td>Cooling</td>
</tr>
<tr>
<td>Roofs</td>
<td>1.00</td>
<td>0.49</td>
</tr>
<tr>
<td>Walls</td>
<td>1.54</td>
<td>0.34</td>
</tr>
<tr>
<td>Foundation</td>
<td>1.17</td>
<td>-0.22</td>
</tr>
<tr>
<td>Infiltration</td>
<td>2.26</td>
<td>0.59</td>
</tr>
<tr>
<td>Window (conduction)</td>
<td>2.06</td>
<td>0.03</td>
</tr>
<tr>
<td>Window (solar heat gain)</td>
<td>-0.66</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Adapted from the BTO Multi-Year Program Plan: https://energy.gov/eere/buildings/downloads/multi-year-program-plan
Understanding Air Leakage

Air Leakage in Existing Buildings

Average = 7.9 L/(s.m²)

IECC 2012 = 2.0 L/(s.m²)

NIST: National Institute of Standards and Technology
FSEC: Florida Solar Energy Center
PSU: Penn State University

NIST
Persily and Grot 1986
Persily et al. 1991
Musser and Persily 2002
n = 9

FSEC
Cummings et al. 1996
Cummings et al. 2000
n = 88

Camroden Associates
Brennan et al. 1992
n = 23

Army Corp of Engineers
n = 79

PSU
Bahnfleth et al. 1999
n = 2

Average = 7.9 L/(s.m²)
IECC 2012 = 2.0 L/(s.m²)
Air Barriers are the key to significant energy efficiency and impact all other energy saving measures.
Air Barriers Impact

- Thermal insulation
- Window performance
- HVAC efficiency
- Occupant behavior

which all impact the energy use in a building
Phase 2: Preliminary Results

### Monthly Heat Loss (W.h/m²)

<table>
<thead>
<tr>
<th>Air leakage @ 75 Pa [L/(s.m²)]</th>
<th>Level 1 (&lt; 0.02)</th>
<th>Level 2 ≈ 0.21</th>
<th>Level 3 ≈ 0.72</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 2011</td>
<td>564</td>
<td>629</td>
<td>990</td>
</tr>
<tr>
<td>December 2011</td>
<td>983</td>
<td>1057</td>
<td>1506</td>
</tr>
</tbody>
</table>
Air Barriers cannot be dealt with without understanding that they are part of a wall (building) assembly”

N.B. Hutcheon’s CBD-48 - Requirements for Exterior Walls
Understanding Air Leakage

A. Environmental Management

- 1. Heat Flow
- 2. Air Flow
- 3. Vapour Flow
- 4. Rain Penetration
- 5. Radiation (Light, Solar...)

Other Barriers

- 6. Noise
- 7. Fire Separation

B. General Characteristics

- 8. Strength, Rigidity
- 9. Durability
- 10. Aesthetic
- 11. Economical
- 12. Constructable
- 13. Maintainable

Envelope Requirements (Primary Functions)
Air Barriers

Six Sides of the Building

roof – walls - foundation
Air Barrier Performance Requirements

- **Air Barrier Material**
  - CFM/ft²@ 1.56 lbs/ft² pressure difference (ISO 14857 ASTM E2178) 0.004

- **Air Barrier Accessory** – tapes, strips, caulking, etc.
  - CFM/ft²@ 1.56 lbs/ft² pressure difference (ASTM E283) 0.004

- **Air Barrier Component** – windows, doors, skylights, etc.
  - CFM/ft²@ 1.56 lbs/ft² pressure difference (ASTM E283) 0.04

- **Air Barrier Assembly** - wall assembly, roof assembly, foundation assembly
  - CFM/ft²@ 1.56 lbs/ft² pressure difference (ASTM E2357) 0.04

- **Air Barrier System** (Whole Building)
  - CFM/ft²@ 1.56 lbs/ft² pressure difference (ISO 9972, ASTM E 779 ABAA AB-500) 0.40

  (Requirement for Air Barrier Systems needs to be updated to 0.10)
Air Barrier

- Materials
- Accessories
- Components
- Assemblies
- Sub-systems
- Systems
Air Barrier Materials

Peanut butter

- Kraft smooth peanut butter
- Applied at 20 mils wet
- Tested to ASTM E2178
- Air leakage result - 0.0021 L/s·m²
- Is an air barrier material but cannot be installed as a continuous one and **will not stand up to service-life conditions** – not an air barrier material!
Air Barrier Accessories

Materials and components that connect the air barrier materials and the air barrier assemblies

- Tapes
- Strips
- Mastic
- Sealants
- Etc.
Air Barrier Components

- Not only do they have to be airtight but you need to connect to them
  - Doors
  - Windows
  - Skylights
  - Curtain walls
  - Etc.
Air Barrier Sub-Systems

- Assembly sub systems
  - Air leakage of penetrations, fasteners, etc
  - Adhesive attachment
  - Substitution of accessories
Air Barrier Assemblies

- **Wall Assemblies**
  - ASTM E 2178

- **Roof Assemblies**
  - ASTM E 1680
  - ASTM D 8052

- **Foundation Assemblies**
  - TBD
Air Barrier System (Whole Building)

- **System**
- ASTM E779, ISO 9972, ABAA 001
Air Barrier System Sub-Systems

- **System - Sub-systems**
  - Compartmentalization
    - Separate floors
    - Separate units
    - Separate common areas
Air Barrier Future

- Whole Building Testing is where you start – Everything else leads to there
- Then break it down to the needs to get there
  - Air Tightness within a Building
  - Key Requirements to make a good Air Barrier Assembly
  - Airtightness of Components
  - Sub Assembly Requirements
Air Barrier Future

Air leakage is where the energy saving are both new and existing buildings

Actual energy savings required to actually save energy

Air barrier industry in its infancy
8300 bldg excerpt
Seal 2 details & close mechanical dampers
(Reduce pipe freeze and costs)
Envelope gaps & Mechanical cost
14 story

-40pa low +5pa at top
=> high leaks dominate

8300 Building Pressure vs NOAA OAT

supply on

all fans off

y = 0.0024x - 0.2058
R² = 0.8321

filtered fan off, missing values excluded
>650,000 kwh/year extra cost

- Mechanical supply fans operated 24/7 in winter < 20F to stop pipe freezes (90 days)
  - 
- >20,000cfm of extra flow at night, conditioned.
  - 
- Mechanical system recommissioning requires sealing top leaks at parapet and low air leaks by pipe chase
Look at roof parapet with IR, 33F
Plans show opening

Parapet wall open to return plenum in design
Closer look at wall top
Roofer needed for access
Strong airflow out of top pulls in cold below (freezes 2nd floor pipes)
Spray polyurethane foam to a thickness sufficient to seal air leakage paths (1) and (2) of DWG AIR SEAL 1 a. Extend at least one inch above top edge of metal roof deck.

Install mineral woof safing to provide fire blocking between 3rd floor ceiling plenum and polyurethane foam.

SCOPE: Firesafing and foam
Foam seal over Mineral Wool
IR pre/post
2\textsuperscript{nd} floor pipe freeze in beam enclosure
Beam enclosure open all around building
5/8 Gypsum bulkhead, sealed
Wall top open at roof return relief plenum
Accessed & sealed
After all sealing

Is work complete?

Double check the hottest spot on the building (IR)
IR pre/post

Central section of return hot

Central section cool

Look here
Review after air sealing

- Top of the building still looks open
  - Louvers must close completely
  - Active components need maintenance
- Both Shell and Mechanical work are needed to manage the air.
Air Barriers Are The Future

Thank you

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