Air Barriers Had Nothing to Do With Energy
....at First
Higher Dewpoint Temperature
Higher Water Vapor Density
or Concentration
(Higher Vapor Pressure)
on Warm Side of Assembly

Low Dewpoint Temperature
Lower Water Vapor Density
or Concentration
(Lower Vapor Pressure)
on Cold Side of Assembly

Higher Air Pressure

Lower Air Pressure
4x8 sheet of gypsum board
Exterior at 74°F dewpoint
Interior at 75°F and 50% RH

1 1/2 pints of water

4x8 sheet of gypsum board
Exterior at 74°F dewpoint
Interior at 75°F and 50% RH

14 pints of water
Air Barriers Had Nothing to Do With Energy
....at First
Became a Big Deal with Attics
Air Barriers Had Nothing to Do With Energy 
....at First
Then Became a Big Deal with Walls
Air Barriers Had Nothing to Do With Energy
....at First
And A Really Big Deal with Compact Roofs…
Then Energy…..
Lo Cal House - USA - 1976
Lo Cal House - USA – 1976
Wayne Shick and Bud Konzo
R-30 double stud walls
R-30 vented roof
Triple glazed windows
Air to air heat exchanger
Saskatchewan Conservation House - 1977
Saskatchewan Conservation House – 1977
R-40 double stud walls
R-60 ceiling
Triple glazed windows
Air to air heat exchanger
0.8 ach@50 Pa
Leger House - USA - 1977
Leger House - USA – 1977
Double wall – R 40 walls R 60 ceiling
Airtight construction
Air to air heat exchanger
Parade of Homes - Saskatoon - 1980
Parade of Homes - Saskatoon – 1980
10 homes that were all less than
1.0 ach@50 Pa
R-2000 Program – 1982
1.5 ach@50 Pa
Chicago – 1990 to 1995
3.0 ach@50 Pa
Chicago – 1990 to 1995

3.0 ach@50 Pa

Became the EEBA metric

Became the Building America metric

Focus on big holes….EPA “Thermal Bypass Checklist”

Became the IECC code…
Leaky air handling unit and supply ducts

Air handling unit

Supply

Return

Supply

Depressurized conditioned space
inducing infiltration

Note: Colored shading depicts the building’s thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.
Air Barrier Metrics

Material  0.02 l/(s-m2) @ 75 Pa
Assembly  0.20 l/(s-m2) @ 75 Pa
Enclosure 2.00 l/(s-m2) @ 75 Pa
Air Barrier Metrics

Material     0.004 ft³/(min-ft²) @ 75 Pa
Assembly     0.04  ft³/(min-ft²) @ 75 Pa
Enclosure    0.4   ft³/(min-ft²) @ 75 Pa
Air Barrier Metrics

Enclosure  2.00 l/(s-m2) @ 75 Pa
          0.3 cfm/ft2 @ 50 Pa
          (3 ach@50 Pa)
Getting rid of big holes       3 ach@50
Getting rid of smaller holes   1.5 ach@50
Getting German                0.6 ach@50
Getting rid of big holes 3 ach@50  
(0.4 cfm/ft2@75)

Getting rid of smaller holes 1.5 ach@50  
(0.25 cfm/ft2@75)

Getting German 0.6 ach@50  
(0.08 cfm/ft2@75)
“this is a lie”
Flow Through Orifices

  Turbulent Flow - “inertial effects”

Flow Through Porous Media

  Laminar Flow - “viscosity effects”
Flow Through Orifices

Turbulent Flow - “inertial effects”

Flow Through Porous Media

Laminar Flow - “viscosity effects”

“true but not useful”
Bernoulli

Darcy
\[ Q = A \cdot C_D \left[ \frac{2}{\rho} (\Delta P) \right]^{\frac{1}{2}} \]  

Bernoulli

\[ Q = C_k \frac{\rho}{\mu} (\Delta P) \]  

Darcy

\[ Q = A \cdot C (\Delta P)^\frac{1}{2} \]

\[ Q = C (\Delta P) \]
\[ Q = A \cdot C_D \left[ \frac{2}{\rho} (\Delta P) \right]^2 \]

Bernoulli

\[ Q = C_K \frac{\rho}{\mu} (\Delta P) \]

Darcy

\[ Q = A \cdot C (\Delta P)^{\frac{1}{2}} \]

\[ Q = C (\Delta P) \]

\[ Q = A \cdot C (\Delta P)^n \]

Kronval “an engineer”
Figure 2.5

**Modes of Air Flow**
(from Bumbaru, Jutras and Patenaude, 1988)
Figure 2.5

**Modes of Air Flow**

(from Bumbaru, Jutras and Patenaude, 1988)
Figure 2.5

**Modes of Air Flow**
(from Bumbaru, Jutras and Patenaude, 1988)
\[ Q = f(Dp) \cdot k(Dp)^b \]

- **Q** = air flow, volume/unit of time
- **Dp** = pressure difference
- **k** = coefficient
- **b** = exponent in approximate leakage function

**Figure 2.6**
Characteristic Curve of Leakage Flow as a Function of Pressure Difference
(from Nylund, 1980)
The equation for leakage flow is given by:

\[ Q = f(Dp) \approx k (Dp)^b \]

- \( Q \) = air flow, volume/unit of time
- \( Dp \) = pressure difference
- \( k \) = coefficient
- \( b \) = exponent in approximate leakage function

**Figure 2.6**

**Characteristic Curve of Leakage Flow as a Function of Pressure Difference**

(from Nylund, 1980)
\[ Q = f(Dp) \times k(Dp)^b \]

- **Q** = air flow, volume/unit of time
- **Dp** = pressure difference
- **k** = coefficient
- **b** = exponent in approximate leakage function

**Figure 2.6**

**Characteristic Curve of Leakage Flow as a Function of Pressure Difference**
(from Nylund, 1980)
Possible air flows around sill of a wood-framed house modelled as a resistance network.

Figure 2.10
Resistance Network
(from Kronvall, 1980)

1. Air permeating the wood-panel cladding
2. Air flow between floor slab and panel
3. Air flow between floor slab and wind protection
4. Air permeating the caulking
5. Air flow between wind protection and sill
6. Air flow between insulation material and sill
7. Air flow between inner lining and sill
8. Air flow between inner lining and floor slab
9. Air flow between fillet and inner lining
10. Air flow between fillet and floor slab
ELA = C \times \frac{\text{Rate of flow}}{\sqrt{\text{Pressure difference}}}

(Meters)^2 \approx \frac{1}{780} \times \frac{\text{Litres per second}}{\sqrt{\text{Pascals}}}

Building Science Corporation

Joseph Lstiburek 58
ELA = \frac{1}{780} \times \frac{\text{Flow rate}}{\sqrt{\text{Pressure difference}}}

ELA = 0.278 m^2
Return air → Supply air → Dehumidifier → Bedroom → Bath → Kitchen → Exhaust air

Outside air

Exhaust air

Interlocked kitchen hood make-up air
Diagram of a ventilation system:

- Bedroom
- Bedroom
- Bath
- Bath
- Heat exchange ventilator
- Kitchen
- PTHP
- Interlocked kitchen hood
- Make-up air
- Exhaust air
- Outside air

Dehumidifier
Polyethylene
Caulking / sealant

Polyethylene
Caulking / sealant

Vapor permeable housewrap wrapped around floor assembly
Caulking / sealant

Vapor permeable housewrap wrapped around floor assembly
Caulking / sealant

Sill plate installed over sill gasket and air flow retarder

Note: shaded components designate air barrier system
Ceiling gypsum board taped to wall gypsum board

Gypsum board caulked, glued or gasketed to top plate

Gypsum board caulked, glued or gasketed to bottom plate

Bottom plate caulked or gasketed to subfloor

Subfloor glued, caulked or gasketed to rim joist/rim closure

Rim joist/rim closure caulked or gasketed to top plate

Gypsum board caulked, glued or gasketed to top plate

Gypsum board caulked, glued or gasketed to bottom plate

Bottom plate caulked or gasketed to subfloor

Subfloor glued, caulked or gasketed to rim joist/rim closure

Rim joist/rim closure caulked or gasketed to sill plate

Sill plate installed over sill gasket (FoamSeal® Sill Plate Gasket)

Note: shaded components designate air control layer
Seal around rough openings of windows and doors

Seal along top plates on exterior walls

Seal drywall to first stud in the wall (see Figure 12.7)

Seal along inside of bottom of first stud in interior wall (see Figure 12.7) or hold back first stud to pass drywall behind stud (see Figure 12.8)

Partitions: seal at top plate where adjacent to an unconditioned space (see Figure 12.8)

Seal along bottom plate on exterior walls
Ceiling gypsum board caulked to top plate

Membrane strip

Building wrap with taped joints

Building wrap laps exterior of membrane strip “shingle fashion”; bottom edge taped to membrane strip

Membrane strip over primed concrete

Note: shaded components designate air control layer
Ceiling gypsum board caulked to top plate

Membrane strip

Membrane strip

Membrane strip over primed concrete seals exterior rigid insulation to foundation

Note: shaded components designate air control layer
Note: shaded components designate air control layer
<table>
<thead>
<tr>
<th></th>
<th>75 Pascals</th>
<th>50 Pascals</th>
<th>10 Pascals</th>
<th>4 Pascals</th>
<th>10 Pascal EqLA/100 ft²</th>
<th>4 Pascal EqLA/100 ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(l/s·m²)</td>
<td>ft³/min·ft²</td>
<td>(m³/h·m²)</td>
<td>(l/s·m²)</td>
<td>ft³/min·ft²</td>
<td>(m³/h·m²)</td>
</tr>
<tr>
<td>enclosure</td>
<td>2.000</td>
<td>0.394</td>
<td>7.200</td>
<td>1.537</td>
<td>0.303</td>
<td>5.532</td>
</tr>
<tr>
<td>assembly</td>
<td>0.200</td>
<td>0.039</td>
<td>0.720</td>
<td>0.154</td>
<td>0.030</td>
<td>0.553</td>
</tr>
<tr>
<td>material</td>
<td>0.020</td>
<td>0.004</td>
<td>0.072</td>
<td>0.015</td>
<td>0.003</td>
<td>0.055</td>
</tr>
</tbody>
</table>