Air tightness requirements for high performance homes in mild climates

AIVC Workshop
March 2018

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What is air tightness link to “high performance”

Control building air flows to achieve:

• Less energy use & less peak load – climate-related
• Good IAQ:
  – Moisture
  – Health
  – Odour
  – Comfort (drafts)
  – Clean (leaky homes are dusty homes)

Air Flow = mechanical ventilation & natural infiltration (tightness and weather)
What is a “Mild” climate?

Mild = HDD + CDD < 1800

<table>
<thead>
<tr>
<th>City</th>
<th>HDD</th>
<th>CDD</th>
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<tbody>
<tr>
<td>Oakland</td>
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<td>Melbourne</td>
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<tr>
<td>Perth</td>
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<td>782</td>
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Climate Zone  | Maximum Leakage
---           | ----------------
3 - 8        | 3 ACH50
1 & 2        | 5 ACH50

All of Alaska in Zone 7 except for the following boroughs in Zone 8:
- Bethel
- Dillingham
- Fairbanks N. Star
- Nome
- North Slope

Zone 1 includes:
- Hawaii
- Guam
- Puerto Rico
- Virgin Islands
California always has to be special!

Does not use IECC – has its own energy code

No leakage limit

Typical new home: 5 ACH50

High performance (30% better than code) in Fresno: Target 4.4. ACH50 – actual 3.5 ACH50
Canada Air Tightness Requirements *(not mild climates!)*

<table>
<thead>
<tr>
<th>Köppen climate types of Canada</th>
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<table>
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<tr>
<th>Maximum Leakage</th>
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<tbody>
<tr>
<td>HOT2000</td>
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<tr>
<td>Vancouver</td>
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<tr>
<th>City</th>
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<th>CDD</th>
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<tbody>
<tr>
<td>Edmonton</td>
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<tr>
<td>Toronto</td>
<td>3892</td>
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Passive House Air Tightness

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Maximum Leakage</th>
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</thead>
<tbody>
<tr>
<td>All</td>
<td>0.6 ACH50</td>
</tr>
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</table>
How little is too little leakage?

• Measured pollutants in homes indicate 0.3 to 0.4 air changes per hour (ACH) as a reasonable minimum
  – Possibly higher needed for odour/moisture control

• How leaky does my home need to be to get this annual average air change rate?
  – Average US climate about 8-10 ACH50 (much of NZ)
  – Los Angeles about 11-13 ACH50
  – Edmonton about 6-7 ACH50
So... what’s the problem?

Even in a “mild climate”: **Variability**

- A leaky home uses more energy and has more peak consumption
  - Or… in unheated NZ homes warmer during cold weather?
- Not just how much ventilation, but when it happens
  - More ventilation when its cold, less when its mild
- Not enough ventilation in summer – potential IAQ issues

Tighter allows non-energy advantages:

- Control of outdoor pollutants (particles, ozone)
- Better control for moisture
- Better control enables smart ventilation approaches
- Less drafts – more comfort
Infiltration in a cold climate

5 ACH50 home

Higher in winter – bigger peak load

Average ~ 0.3
In winter ~ 0.4

About 30% more energy use than a tight house with mechanical ventilation with same annual total air flow.

Too low in summer
Infiltration in a mild climate

Small summer-winter change

 Doesn’t have the extra penalty of more infiltration in winter

Too low all year – needs mechanical ventilation
Mechanical Ventilation

For dwelling unit:

- Less extremes of ventilation
- Never gets too low (IAQ & moisture)
- Never gets too high (comfort, energy and peak demand)
- Based on home size and occupancy. E.g., ASHRAE 62.2:
  \[ 0.15 \text{ L/s/m}^2 + 3.5 \text{ L/s} \text{ (bedrooms +1)} \]

For “wet” rooms (very important for NZ homes):

  Mechanical exhaust from kitchens and bathrooms
Combining Natural Infiltration and Mechanical Ventilation

Two approaches:

#1. Some ventilation standards specify mechanical ventilation air flow requirements: either total for the dwelling or for each room/space in the dwelling
   - No infiltration/mechanical ventilation tradeoff
   - A tighter envelope always saves energy

#2. ASHRAE 62.2 allows infiltration to be included to reach the required total
   - Aims for same total ~ 0.3 ACH
   - Leakier envelope means adding a smaller fan
   - Reduces energy impact of tightening in mild climates
Fixed fan size - no Infiltration Credit

Leaky homes add a lot to air flow
Airtightness and 62.2

Ventilation Air Flow, cfm

- Mild Climate Weather factors
  - 0.4
  - 0.45
  - 0.5
  - 0.55
- 62.2 Minimum

Added fans to meet minimum

ACH50
Building Practice in California – mild climates

Envelope leakage mostly 4 to 5.5 ACH50

Tightening to 3 ACH 50 would save only 2-5% of space conditioning energy in mild CA climates

Builders not fan sizing with infiltration credit: typically 80 cfm (40 L/s)

CA energy code strongest in US – next iteration: Net Zero
Building Practice in California – mild climates

Envelope leakage mostly 4 to 5.5 ACH50

Tightening to 3 ACH 50 would save only 2-5% of space conditioning energy in these mild CA climates

Builders not fan sizing with infiltration credit: typically 80 cfm (40 L/s) – but almost all turned OFF!

CA energy code strongest in US – next iteration: Net Zero
Outdoor Contaminants?

A tighter envelope reduces all of the following:

- **Particles**
  - Most indoor particles from outdoors
  - A tighter envelope is a better filter
    - 5 ACH50 removes 70% of outdoor particles
    - Open windows – no reduction

- **Ozone**
  - Envelope a good ozone remover – 95% less than outside
  - Open windows only 50% less than outside
Retrofits – reducing air leakage

Median: -20%          -30%          -35%          -28%

<table>
<thead>
<tr>
<th>Category</th>
<th>Pre-Retrofit</th>
<th>Post-Retrofit</th>
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<tbody>
<tr>
<td>Single-Family</td>
<td>N = 9,999</td>
<td>N = 13,093</td>
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<tr>
<td>Manufactured Homes</td>
<td>N = 6,710</td>
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<tr>
<td>Multi-Family</td>
<td>N = 1,340</td>
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HPwES/utility programs   Weatherization assistance programs
Mechanical ventilation approaches for high performance homes in mild climates

Unbalanced exhaust:
- Inexpensive
- Easiest for retrofit
- Dual-duty: have a kitchen or bath fan operating continuously

Balanced:
- Heat recovery – more effect on peak for mild climates
- Exhaust from kitchen and bathroom
- Supply to bedroom/living space
- Be careful about fan power (~120W vs. 12W for exhaust)

Smart Ventilation:
- Typically 40% energy savings
- Time shifting for peak avoidance – good for GHG and infrastructure
- Sense operation of other systems
- Potential to directly control pollutants
- OR…. for same energy – ventilate more when occupied
High Performance Home Leakage Summary

- Mild climates don’t need to meet very low air tightness requirements for energy reasons
- Tightening helps more for peak load reduction & outdoor pollutants
- Setting a target in the 3-4 ACH50 range is reasonable and achievable for new homes
- Tightening existing homes: target 40-50% reduction
- HRV marginal for energy in mild climates – may be desirable for peak reduction
- Require mechanical ventilation operation!