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LAWRENCE BERKELEY NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

Low Rise Multi-Family Mechanical Ventilation

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SeaBEC
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Current WA code based on ASHRAE 62.2-2010

2010: *fan sizing*

- **assumed 2 cfm/100 sq.ft. of natural infiltration from envelope leaks**
  - Equivalent to a 4 ACH50, 2000 sq.ft. home in Seattle
- **Below this assumed infiltration a home is underventilated**
- **Tighter homes and Multifamily don't have 2 cfm/100 sq.ft. of infiltration**
  - MF has much lower leakage to exterior than a single family home
- **"Infiltration Credit" uses infiltration estimate from blower door air leakage test to reduce required fan size**
- **In 2010 62.2 Multifamily got no natural infiltration credit in 62.2**
  - **"Balanced" in new WA code** NOT required in 62.2.

Current 62.2

2013 onwards: *target ventilation rate*

- **Removed leaky home assumption**
- **Still no infiltration credit for multifamily**

2019 onwards:

Row and townhouses allowed infiltration credit proportional to exterior envelope area – from blower door testing

- Upgraded infiltration credit
  - Accounts for difference between balanced and unbalanced systems
    - Balanced simply adds to infiltration
    - Unbalanced is sub-additive – you need a bigger fan flow if unbalanced
    - Simple on-line calculators available, e.g., Residential Energy Dynamics

WA code 403.4.3 Ventilation Quality Adjustment

Table 403.4.3
SYSTEM COEFFICIENT (C_{system})

System Type	Distributed	Not Distributed
Balanced	1.0	1.25
Not Balanced	1.25	1.5

Rejected by ASHRAE 62.2

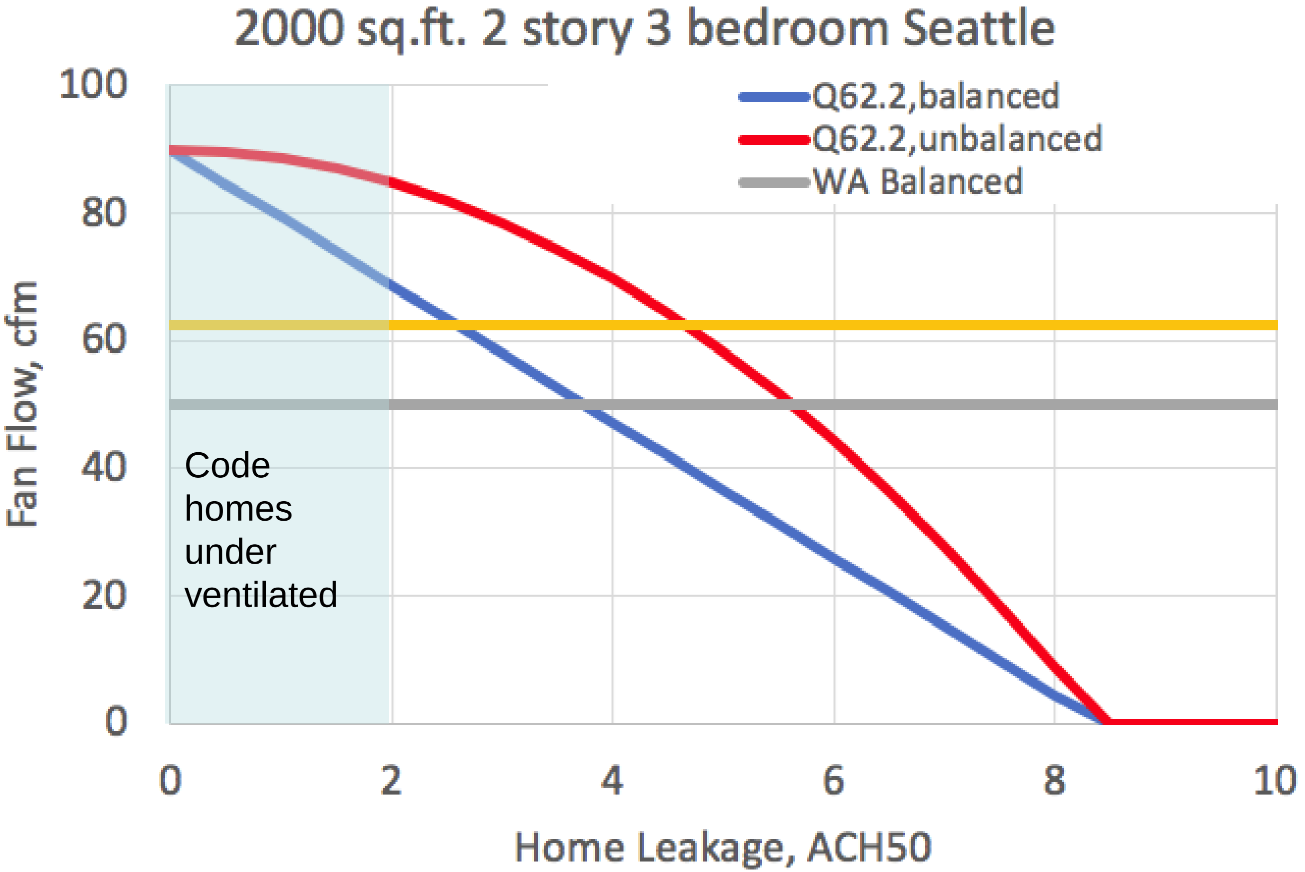
Balanced vs unbalanced:

- 62.2 already has a much better way of combining natural infiltration and mechanical ventilation
- Table does not account for actual building leakage

Distribution means what?

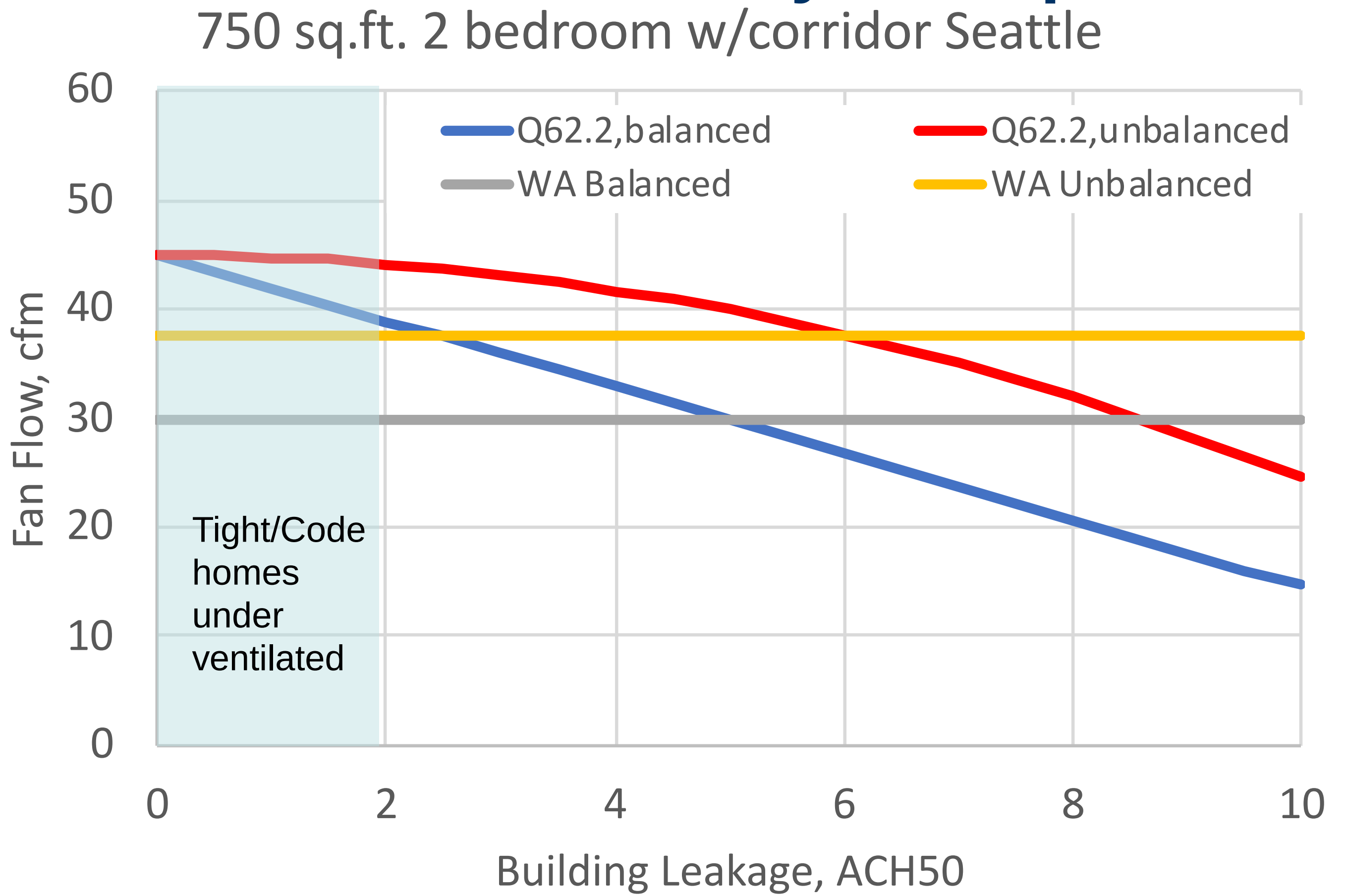
- Exhaust from kitchens and bathrooms and supply to other rooms (WA has adopted from IMC)
  - **NOTE 1:** Ducting required
  - **NOTE 2:** Distribution is undone by mixing – e.g., using central forced air system
  - **NOTE 3:** The values in this table were not developed for this definition of distribution. They were also extreme values that are incorrect for most contaminants – formaldehyde, other VOCs, kitchen and bathroom contaminants, etc.

Combining natural infiltration and mechanical ventilation: Single-Family Example



WA code has a fixed factor to account for balanced vs. unbalanced difference – not recommended

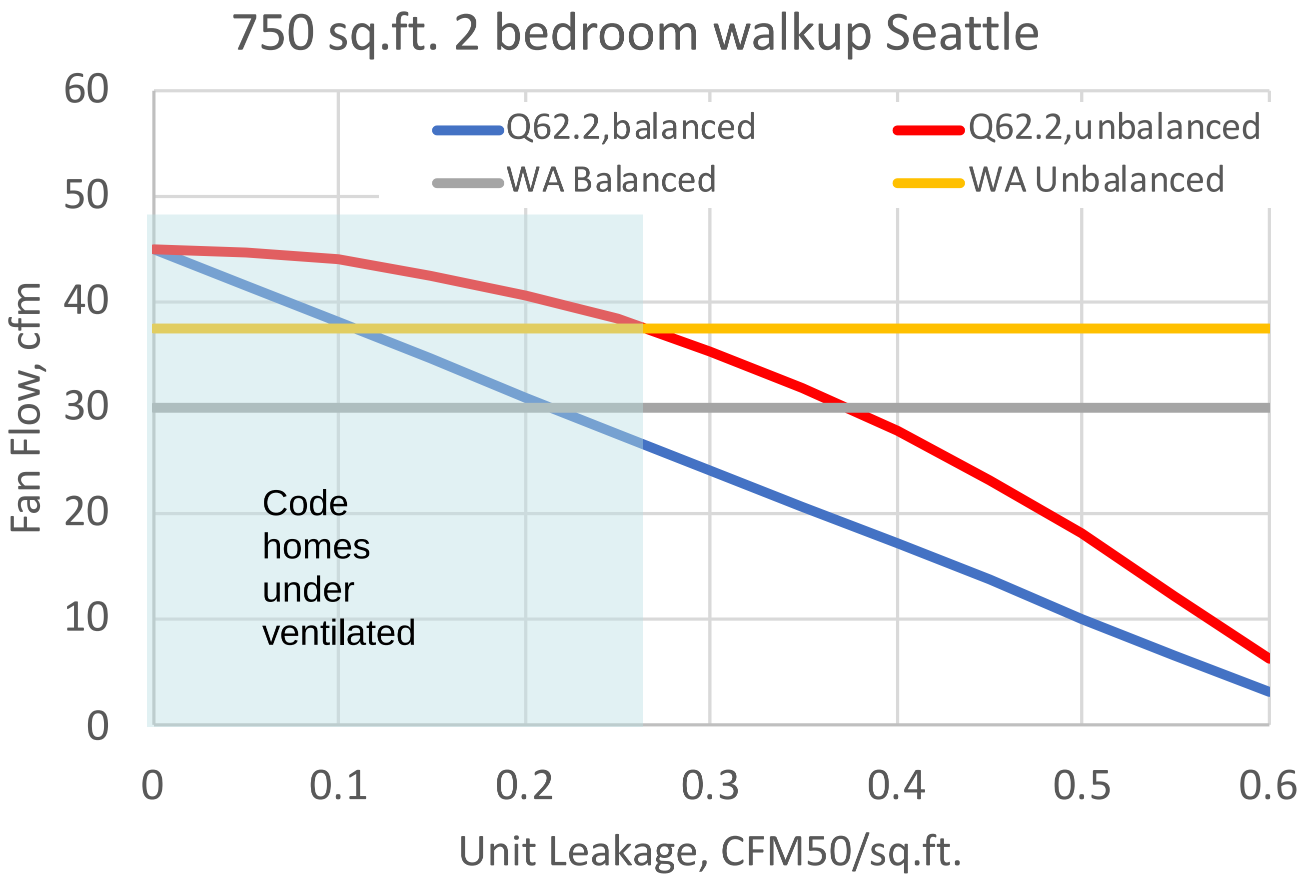
Combining natural infiltration and mechanical ventilation: : Multi-Family Example



Underventing due to assumption of 2 cfm/100 sq.ft. in WA fan sizing

This is the 15cfm difference at zero leakage

Combining natural infiltration and mechanical ventilation: : Multi-Family Example



This individual unit leakage metric very different requirement c/w whole building

Multifamily Buildings – issues at 62.2

Need better compartmentalization to stop interior air flows

- Currently about 0.3 cfm50/ft^2 …. Area is all 6 sides NOT floor area
- Needs to be 0.1 cfm50/ft^2 or less?
  - Do we need kitchen and bath exhaust make up air systems if we are this tight?
  - Currently under study at LBNL

Challenges with limited wall area:

- Minimum 10 ft separation = Inlets too close to outlets (or use a certified ventilation product)
- Where to exhaust kitchens, bathrooms & dryers?
- Can we relax the 10 ft separation rule?
  - Maybe for ventilation exhaust
  - Maybe not for kitchen exhaust
  - New wind tunnel experiments under way

Multifamily Buildings – issues at 62.2

Trickle vents need to be properly sized and installed

- Working group developing new guidance: minimum air leakage, sizing requirements for inlets
- What to do about filtration? Tempering? Should we adopt practices from other countries?

Should we require balanced systems?

- Field studies inconclusive – mostly show that ***ALL systems are poorly installed and maintained and rarely compliant***
- Studies of exhaust only show very little air drawn from other units
  - Only 2-12% of air from other units averaged over a whole building (Bohac et al.(2011))
- Newer MF are better compartmentalized than older buildings (e.g., Wray et al. (2002) averaged 19% of flow from other units in highrise buildings)

What about corridor supply air?

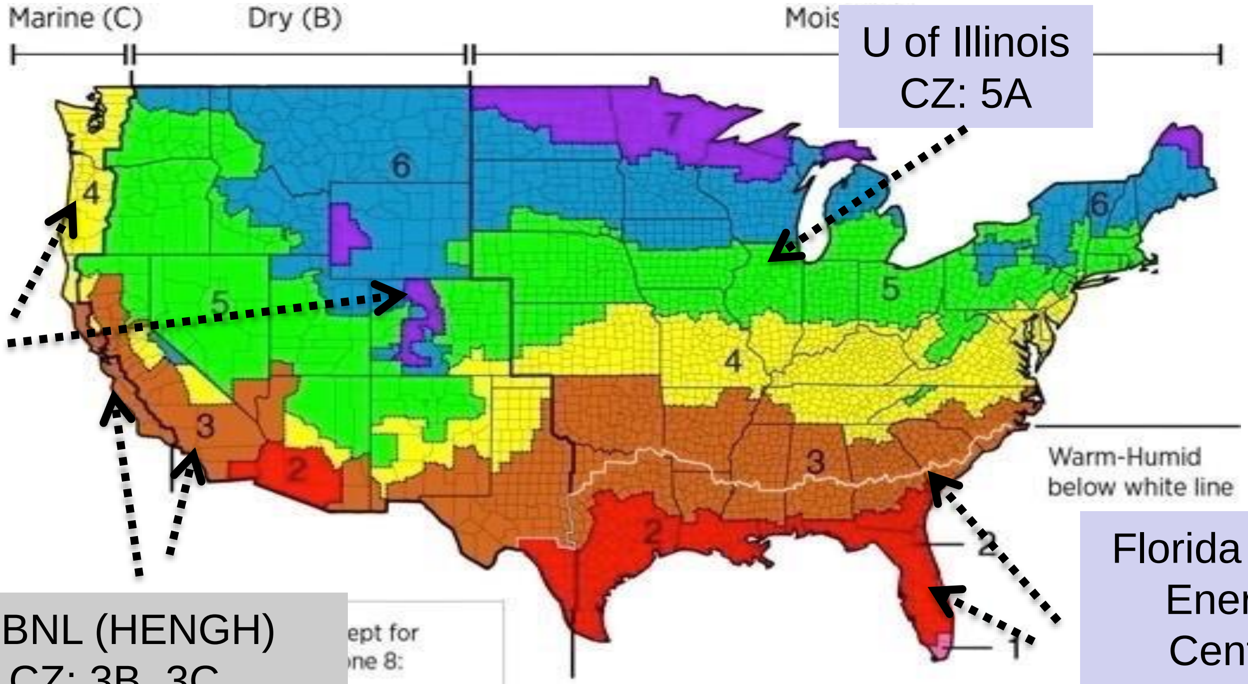
- Its common in many places and some jurisdictions have specific requirements

How reliable is residential ventilation?

DOE Building America program + California Energy Commission

National labs + Building America teams

150 new homes



U of Illinois
CZ: 5A

Pacific NW
National Lab
CZ: 4C, 5B

+LBNL (HENGH)
CZ: 3B, 3C
70 homes w/MV

Florida Solar
Energy
Center
CZ: 2A, 3A

How reliable is residential ventilation?

Operation

- Most systems are turned off
  - In California:
    - Primarily exhaust systems with unlabeled or poorly labeled switches.
    - Supply and HRV/ERV systems more likely to be switched on as the controls are not so readily available
  - In other states:
    - Most systems, independent of type are turned off or not functioning
    - About half of supply and supply dehumidifiers non-functional due to broken dampers and controls, miswiring, incorrect ducting.
  - Exhaust systems, when turned on, function correctly.

We need much better labeling of controls

We need much better commissioning

How reliable is residential ventilation?

Air Flow/Installation

- In California where its code required air flows were good – 150% of minimum for exhaust systems
- In other states where ventilation is voluntary flows much less likely to meet 62.2 minimum
- Inlets for supply/balanced systems usually inaccessible/not measurable
- Supply/balanced systems much less likely than exhaust to meet minimum flow requirements

We need to be very careful about *requiring* balanced systems that we know are not installed well and need lots of maintenance:
Filters replaced every 6 months
Inlets cleaned every 6 months

Who's responsibility is this?

Field Survey of 60 Canadian HRVs

Cores & filters "clean" in ~50% of homes

7 inlets clogged with debris

4 HRVs not operational due to component failure

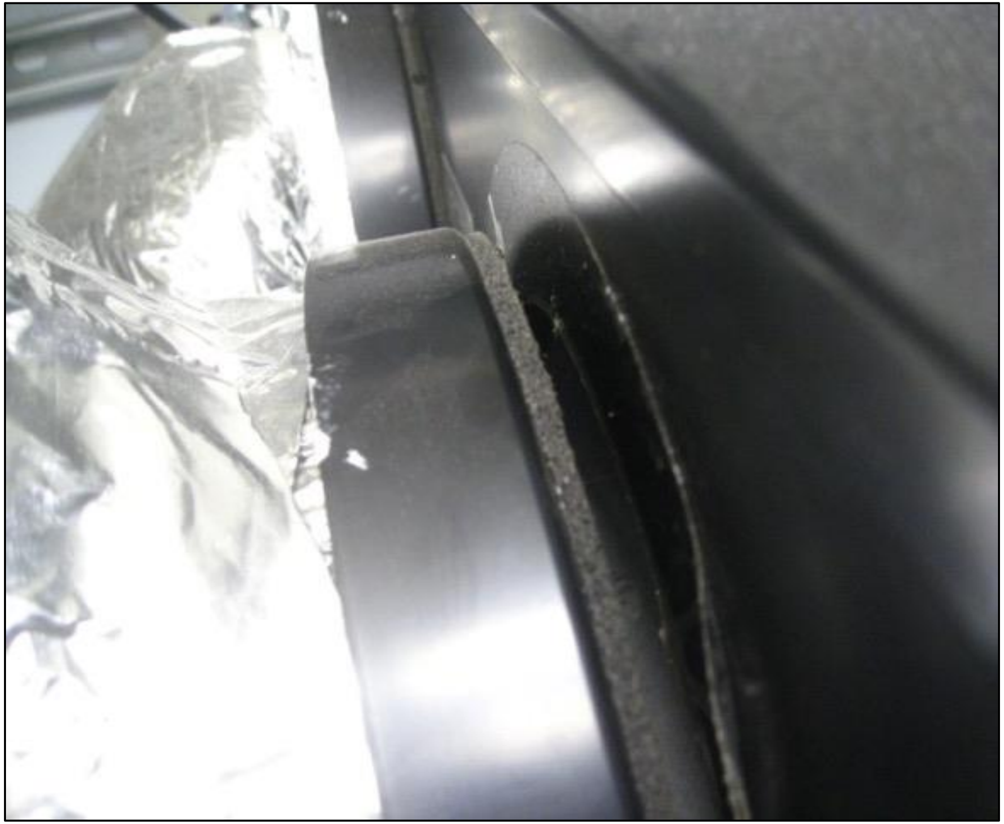
Occupant "knowledge" of system largely unrelated to performance, level of maintenance, etc.

Hill, 1998

Faults Observed in CA High Performance Home Ventilation Systems

5 of 9 ERV/HRVs had a problem

- Low airflows
- Failed duct connections
- Improperly installed duct connections
  (recirculating ERV)
- Erratic control of variable speed systems
- Clogged fresh air intake on ERV
- Some not operating, inactive for months



Less, 2012

FSEC 2014 Field Study

Sonne et al. 2015

21 homes with MV – mostly supply

- I9 of 21 systems not operating
- 12 of 21 ‘capable of operating’
- 3 of 21 had airflows close to design
  - 2 of these disabled by occupants

Faults

- Failed controllers and dampers
- Partially disconnected or crushed ducts
- Dirty filters & intakes
- OA intake directly above exhaust

Similar faults are found in other studies (Balvers et al., 2012; Offermann, 2009)

Dirty outdoor air intake.

Dirty ERV filters.

Outdoor inlets/outlets very hard/unsafe to verify

Not safe to measure

If supply/balanced is mandatory, then access to inlets must be mandatory also

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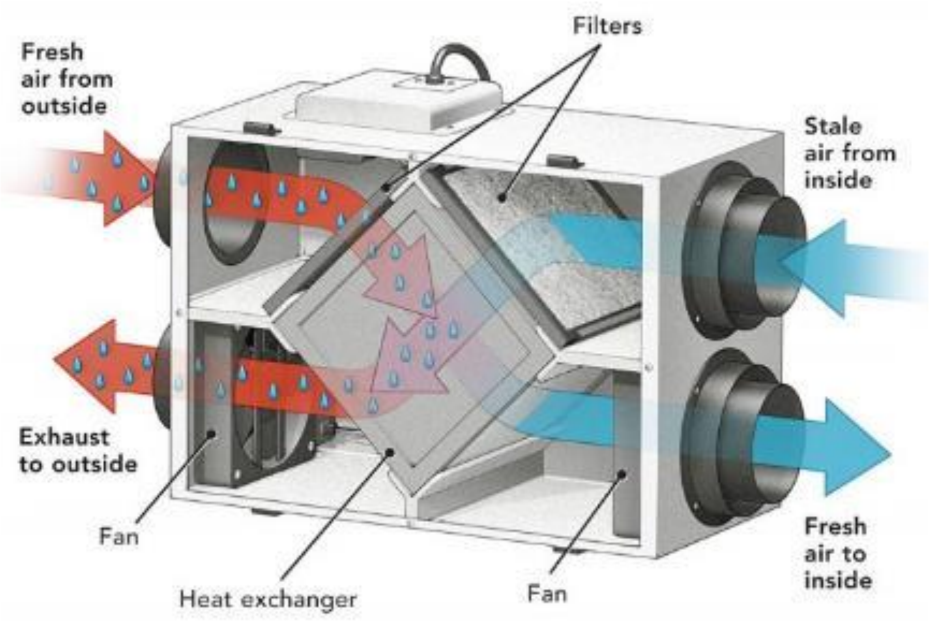
In-duct flows hard to measure

Not enough space for accurate velocity traverse

Four connections much harder to get right than one



Commissioning—Why It's So Important in Airtight Homes and Multifamily Buildings

If IAQ system fails, there is no natural infiltration backup

How well do these devices measure ventilation air flows?

Figure 1: The six commercially available flow hoods evaluated for this study

Air flow measurement issues – can we accurately measure 10,20, 30 cfm within 10% or 5 cfm?

	Minimum Air flow, cfm	**Accuracy, cfm**
Vane Anemometer*	5	2-3
Balometer*	25	8 above 50 cfm
Low Flow Balometer*	5	5
Fan assisted flow meter	5	2
Exhaust flow box	2-3	10%
Bag filling	10	10%
Pitot traverse	10	unknown

* - based on manufacturers data, real world accuracy much worse than this – sensitive to placement

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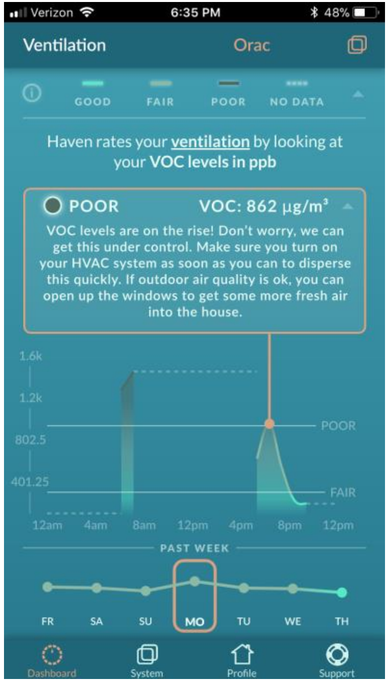
Air flow measurement issues… and solutions?

- WA code +/- 5% is too tight a specification for total flow and impossible for balanced systems with multiple inlets/outlets or at low flows for MF
- **Huge compliance problem**

Coming soon: built-in air flow diagnostics and user interfaces



Other stuff to think about…

- In MF all units need the same control – particularly if unbalanced
- Install extra capacity above code minimum:
  - allows more ventilation cooling in high performance units – reduces need for AC
  - party mode/boost function
- Install better filters. A balanced system needs MERV 13 to match envelope filtration using exhaust system

Summary

- **Consider allowing ASHRAE 62.2 air flows and calculation procedures**
  - New MF requirements coming to 62.2
- **Labels must be clear and in place**
  - NOTE: 62.2 requires remote switches in MF
- **Systems must be commissioned**
- **Air inlets and ducting need to be easily accessible**
- **Low flows from at HRV/ERV terminals almost impossible to measure**
- **More complex systems (CFIS, HRV, ERV) need much more care and attention to install and commission**
- **Need a verifiable system of maintenance for air inlets**

Panasonic says…..

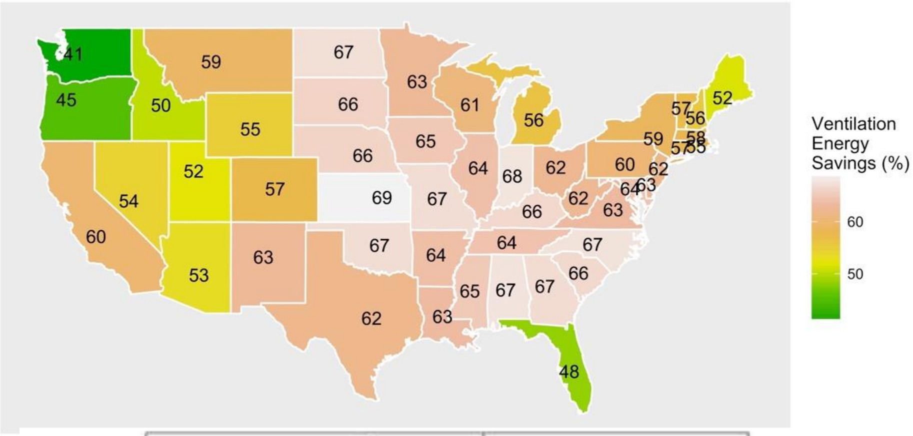
Both filters should be vacuumed with a soft brush attachment every 2-3 months or as needed, and the supply air filter should be inspected every 90 days and replaced every 6 months to maintain the ERV's peak

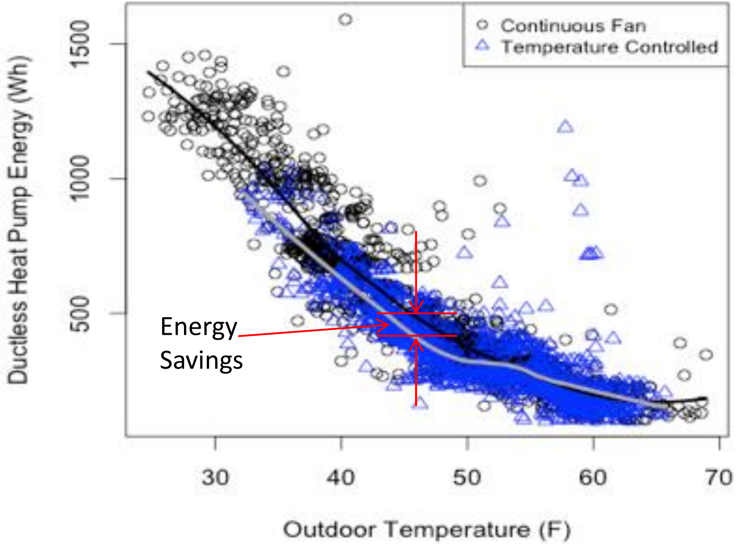
Smart Ventilation

Time shifting to reduce energy costs for same IAQ

- E.g., less ventilation 5 am to 9 am in winter, more ventilation at other times
- Appendix C of ASHRAE 62.2 has calculation procedures
- Can save about 50% of energy use – close to HRV performance at much lower cost
- Can move ventilation energy use off-peak
- Small scale field studies done – moving to larger scale and MF

Median Ventilation Site Energy Savings by State,
VarQ Smart Controller





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Stephens, B., & Siegel, J. A. (2012). Penetration of ambient submicron particles into single-family residences and associations with building characteristics. Indoor Air, 22(6), 501–513. doi:10.11

Where to find Iain’s band..

On youtube: https://www.youtube.com/channel/UCOe9gHjnKrzVTowLyE7B9kw

On bandcamp: https://lowbote.bandcamp.com/music

On Instgram: https://www.instagram.com/lowbote/