

# Operation and maintenance of residential mechanical ventilation systems in US homes

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## Key Questions

1. How reliable are these systems?
2. Are they installed correctly?
3. Is their performance monitored and what is an acceptable performance level?
4. What are the maintenance requirements?

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## Anecdotes from the field



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## 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.



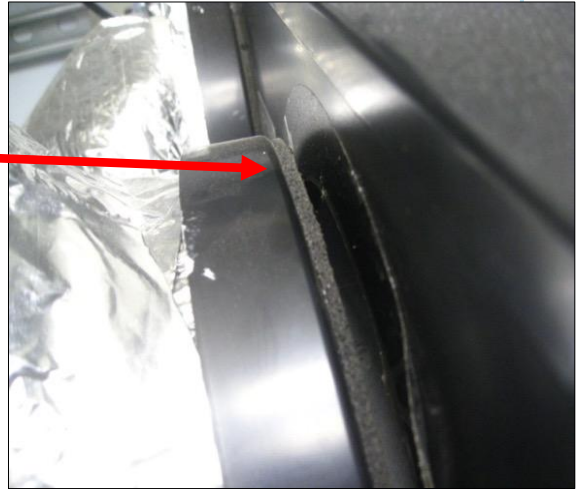
Hill, 1998

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# 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



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## FSEC Field Study

■ 21 homes with MV – mostly supply

- 19 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.

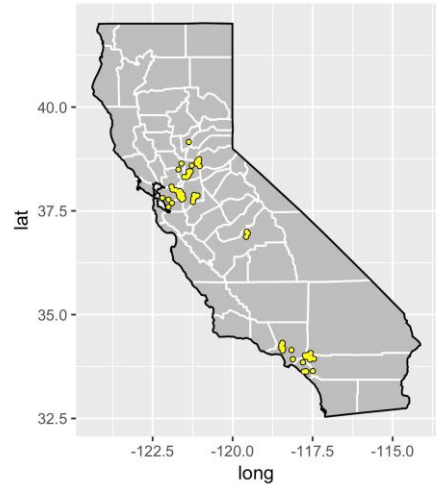
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## California 70 Home Study Whole-House Mechanical Ventilation

Only **1 in 4** homes with whole-house ventilation system running as found.

In all but 2 homes, the measured airflow of the exhaust fan exceeded the minimum requirements

- On average 50% higher than minimum requirement



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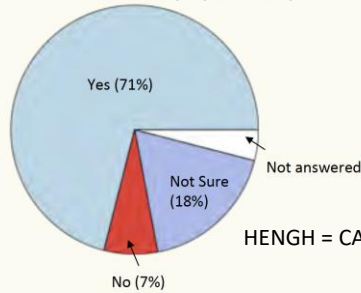
## DOE National New Home Study

Area (Total homes)	Oregon (29)	Colorado (26)	Illinois (30)	FL/GA/SC (52)
Any type of WHMV excluding uncontrolled CFIS	24	25	10	47
WHMV airflow not determined	6	1	0	1
Operating in some matter as found	15 (+4 unclear)	21	6	15 (+1 unclear)
Operating at $\geq 100\%$ 62.2-2010 as found	7 of 15	13 of 21	0	3 of 15
Capable of $\geq 100\%$ of 62.2 (of those with measured airflows)	15 of 18	16 of 24	2 of 10	23 of 47

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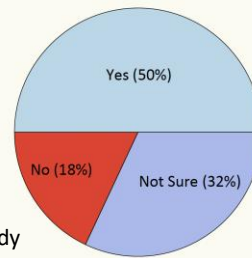
## Homeowner Awareness of WHMV System

Results from HENGH survey (2771 responses, mostly by Southern California Gas Company Customers)



HENGH = CA Study

Results from HENGH homes (23 homes)



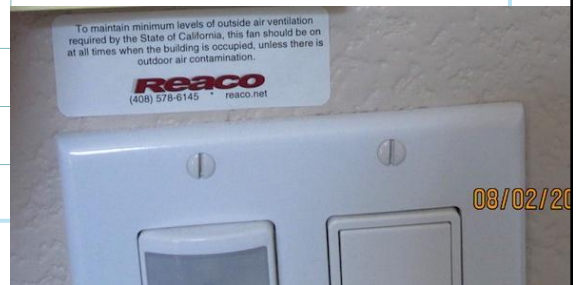
**Only one home** had operating mechanical ventilation system on our 1<sup>st</sup> visit

- In OR/CO, most reported that they had WHMV. In FL/GA/SC, only those with ERVs and Ventilating Dehumidifiers knew at a high rate.
- In FL/GA/SC, homeowners rarely aware of the existence or purpose of a CFIS system (4/11) or exhaust fan acting as WHMV (1/24).
- In CO/OR, 19 of 23 with exhaust knew they had WHMV, but only 3 knew how to operate the system.
- Very few homes had easy-to-understand labels on their WHMV systems.

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## Labels Matter

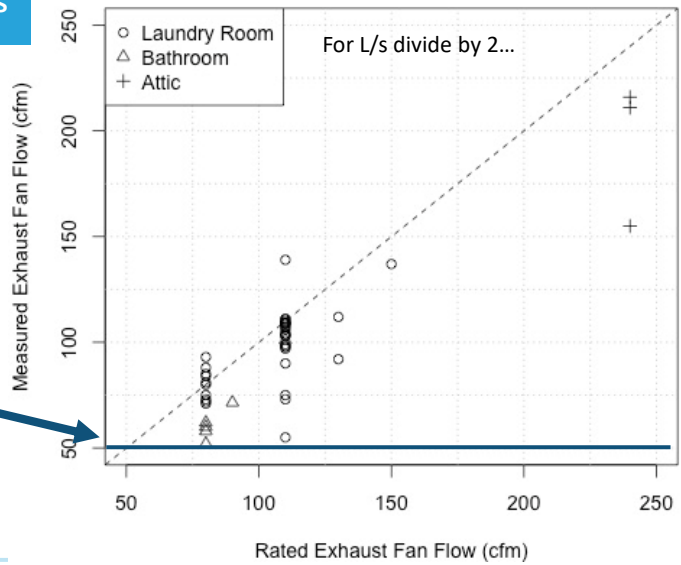
Whole-House Ventilation Control	Controller Labelled?	% On As-Found
On/Off Switch	No (N=42)	5%
	Yes (N=12)	58%
Programmable Controller	No (N=10)	50%
Thermostat	No (N=2)	0%
Breaker Panel	No (N=1)	100%
No Controller	No (N=3)	100%



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## Bathroom/Laundry Exhausts

*Rated* air flows rarely achieved.....  
But meet minimum standard



## 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



# In-duct flows hard to measure

Not enough space for accurate velocity traverse



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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



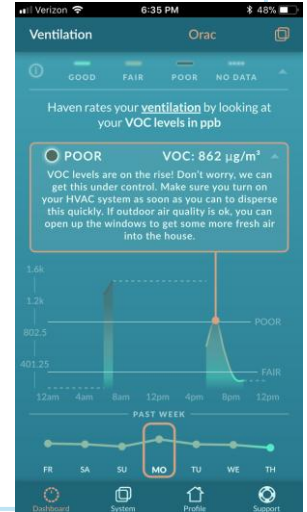
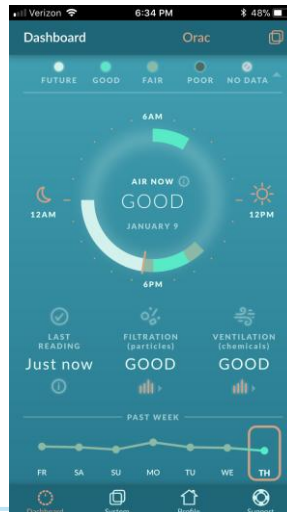
Systems Technology & Control Systems Division  
Energy Technologies Area

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

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## Air flow measurement solutions?

Built-in air flow diagnostics and user interfaces



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## Multifamily Issues

- Whole dwelling, kitchen and bath fans typically half the required air flow – same problems for exhaust, supply or balanced (Maxwell et al. 2014 & 2016)
  - Insufficient supply air to corridors
  - In-unit supply fans sensitive to indoor-outdoor pressure differences
  - Poor system design and installation issues for all systems
  - Poor commissioning
  - Poor trickle vent installation



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## Multifamily Issues: Maintenance

Who is responsible for maintaining all these inlets, outlets, fanbelts...???



Individual unit air inlets: a maintenance nightmare



## Summary

**Most systems are turned off**  
**No or bad labeling of controls**  
**Occupant lack of awareness**  
**Little/No maintenance**

Supply and HRV/ERV systems more likely to be switched on as the controls are *not* so readily available

About half of supply systems non-functional due to broken dampers and controls, miswiring, incorrect ducting

Exhaust systems, when turned on, function correctly

Supply/balanced systems much less likely than exhaust to meet minimum flow requirements

Air Flow/Installation

- In California where its **code required** air flows were good – 150% of 62.2 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 and highly prone to fouling

## Comments and Questions

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