DOCKETED

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Ventilation, Occupant Activities and Indoor Air Quality in New California Homes

Healthy Efficient New Gas Home (HENGH) Project

New California homes built to post-2008 Title 24 standards

Target 70 homes, 47 tested so far

- **Occupant Survey** – what do occupants think
  - Large scale – more than 2500 homes (online survey)
- **Diagnostic Testing**
  - Measure building envelope leakage and duct leakage
  - Measure mechanical air flows: whole building + exhaust fans
- **IAQ Monitoring**
  - Time-resolved PM2.5 indoors & outdoors, time-resolved CO_2 in several rooms, time resolved & integrated NO_2, time-resolved formaldehyde and integrated formaldehyde and acetaldehyde
  - Monitor mechanical ventilation usage and related activities (e.g., cooking) for one-week

https://hengh.lbl.gov/

Home Characteristics

- HENGH online survey

2771 responses, mostly by Southern California Gas Company Customers

- HENGH field study homes

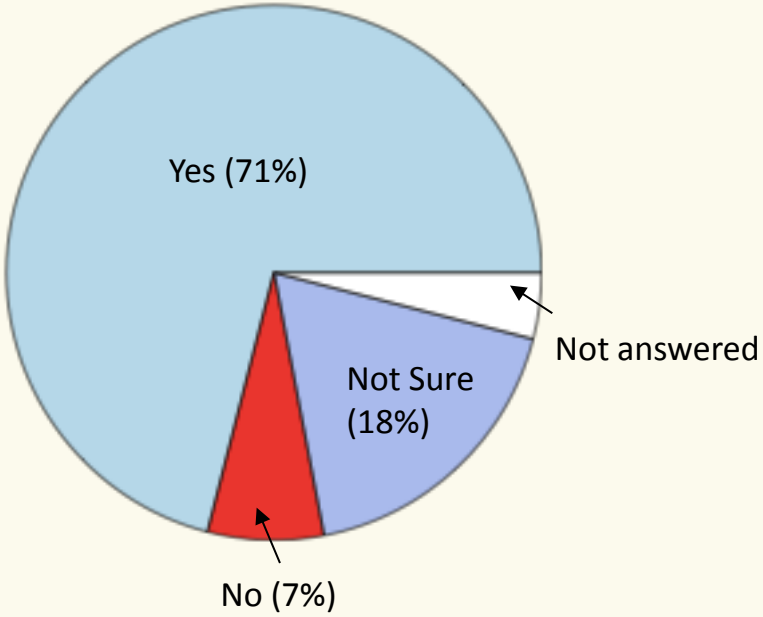
43 responses, mostly by PG&E Company Customers

	Mean	Range (Min-Max)
Size (m^2)	242	140 – 372
# of Bedrooms	3.7	2 – 6
# of Full Bathrooms	2.6	2 - 9
Year Built	2005	2002-2015
Number of Occupants	3.13	2 - 6

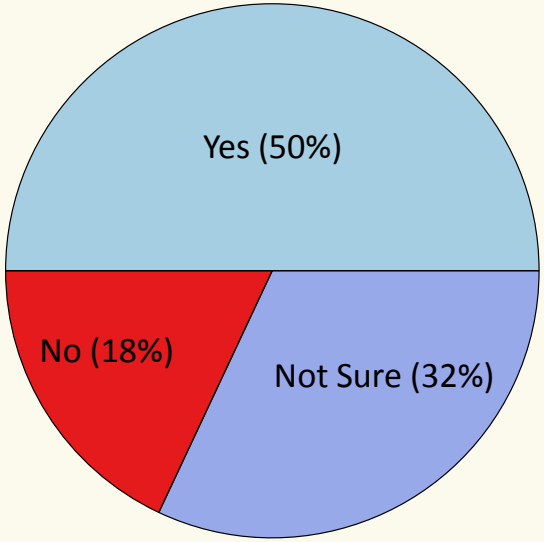
	Mean	Range (Min-Max)
Size (m^2)	254	153 – 390
# of Bedrooms	3.8	3 - 5
# of Full Bathrooms	3	2 - 5
Year Built	2013	2011- 2015
Number of Occupants	3.0	1 - 8

Do you feel you understand your mechanical ventilation system properly? ?

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

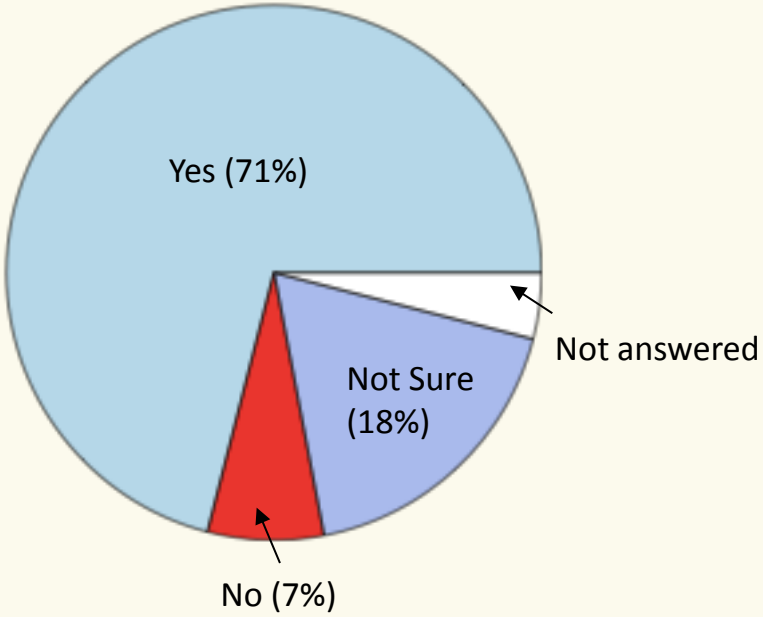


Results from HENGH homes (43 homes)

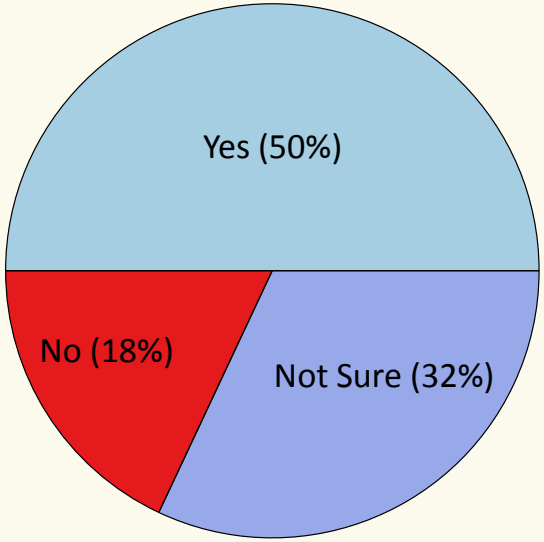


Do you feel you understand your mechanical ventilation system properly? ?

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



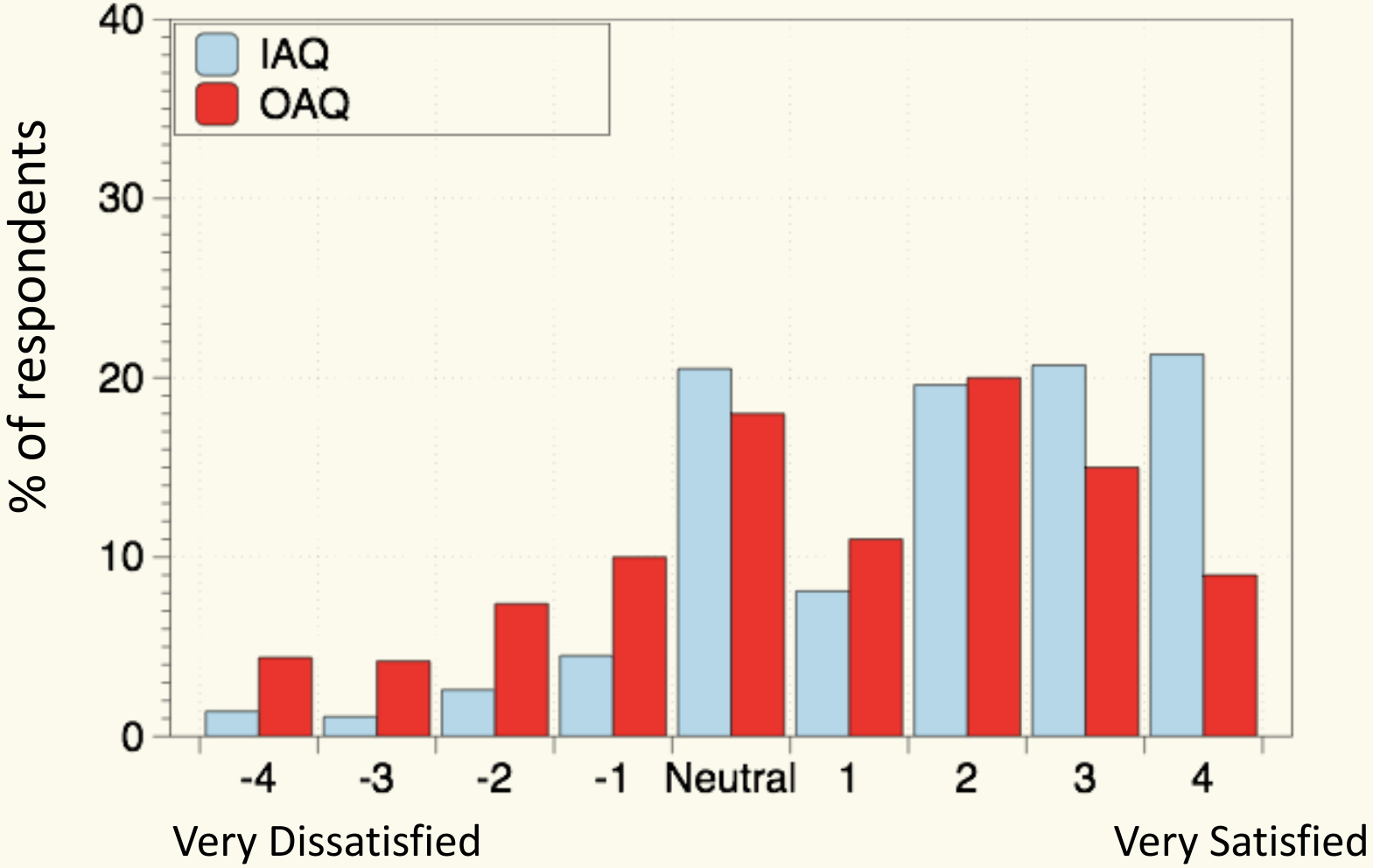
Results from 43 monitored homes



Only one home had operating mechanical ventilation system on our 1st visit

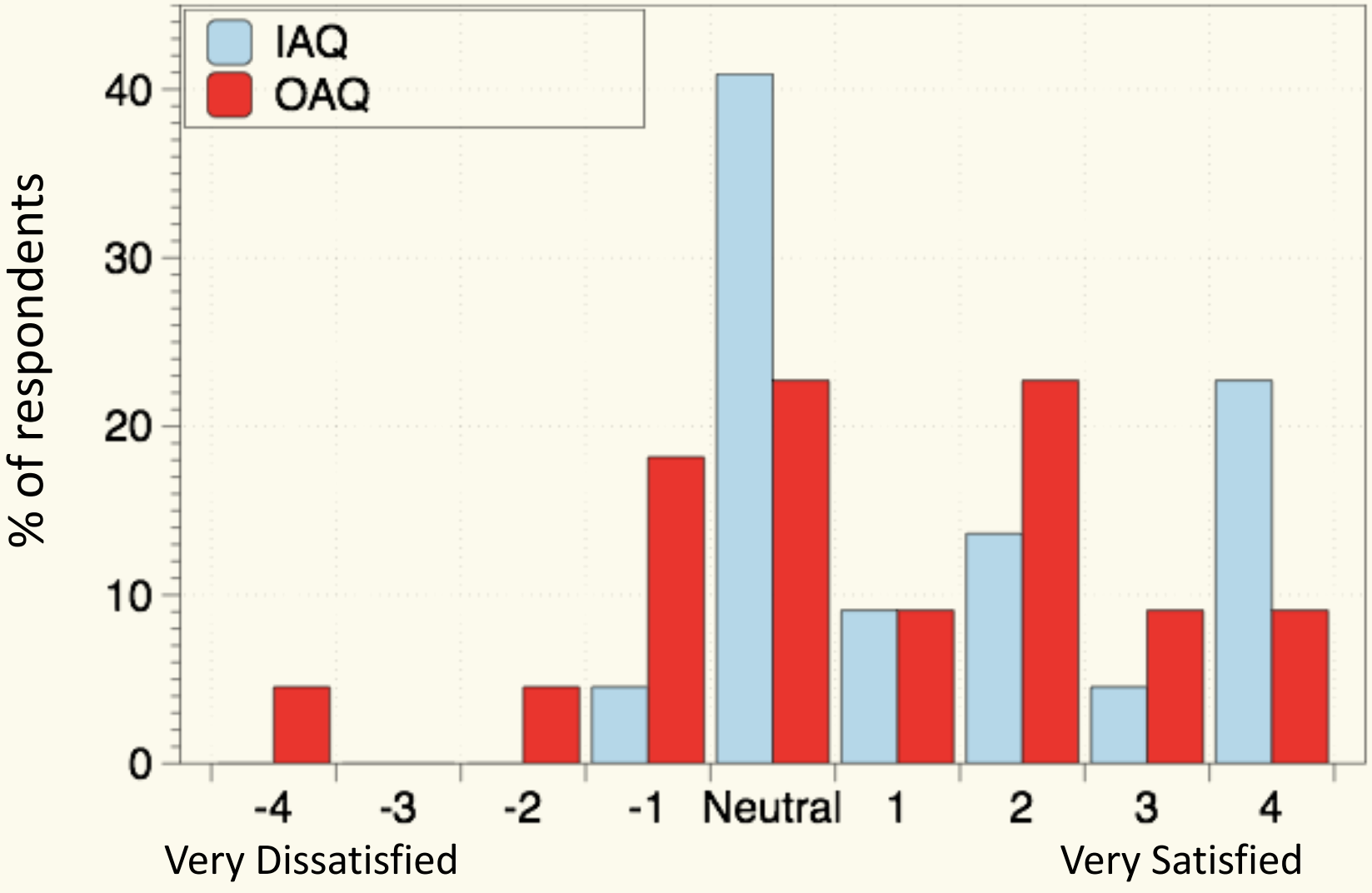
How would you rate the air quality at your home?

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



How would you rate the air quality at your home?

Results from 43 monitored homes

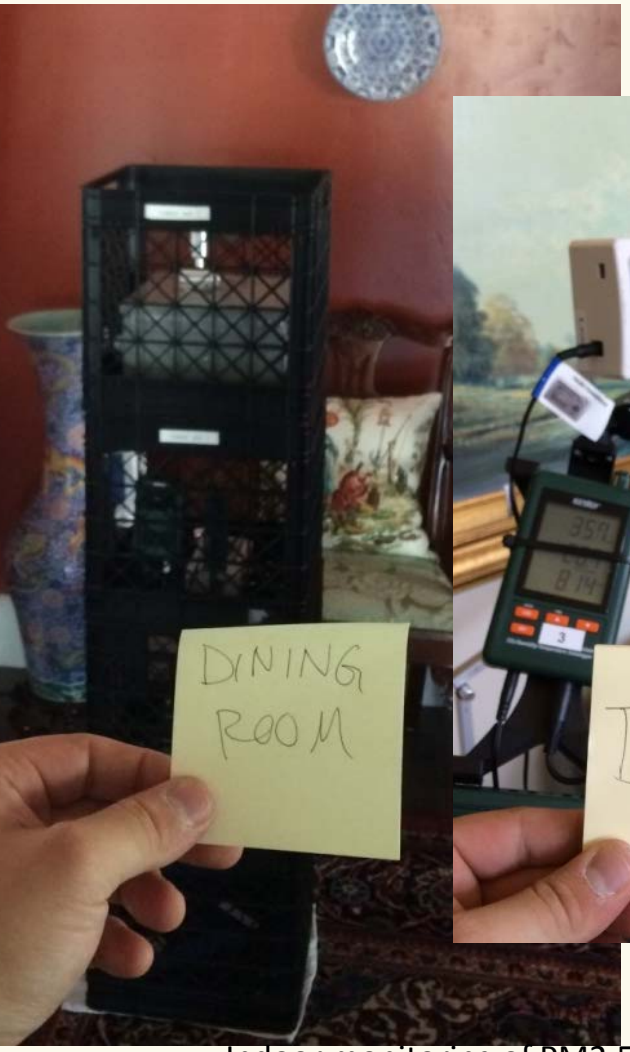


IAQ Monitoring

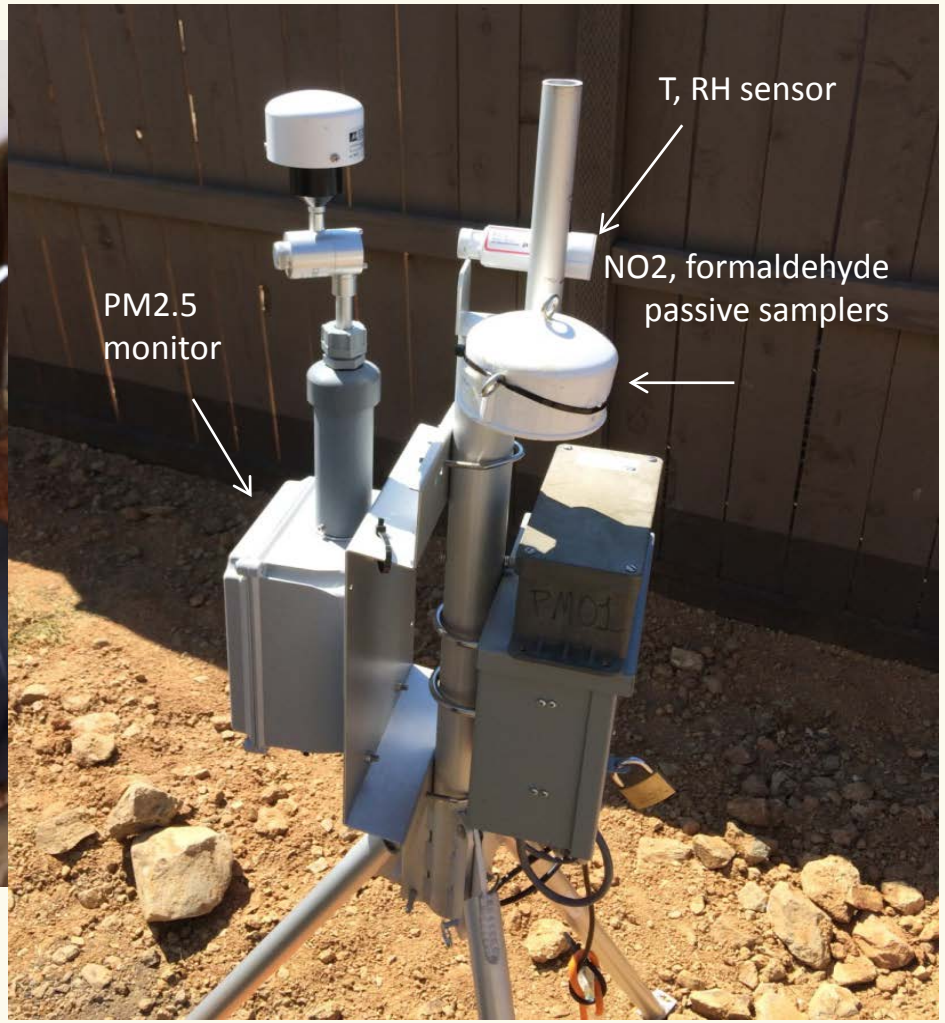
Contaminant	Instrument	Sampling Locations	Sampling Resolution
PM2.5	MetOne BT-642	Outdoor	1-minute
	MetOne BT-645	Indoor (main room*)	1-minute
CO_2 , T/RH	Extech SD-800	Indoor (main room, master & other bedrooms)	1-minute
NO_2	Aeroqual NO_2 Monitor	Indoor (main room)	1-minute
	Passive Ogawa Samplers	Outdoor Indoor (main room)	1-week
Formaldehyde	Shinyei Formaldehyde Monitor	Indoor (main room, master bedroom)	30-minute
	Passive SKC UMEx-100	Outdoor Indoor (main room, master bedroom)	1-week

* Main living space, typically in living / dinning room.

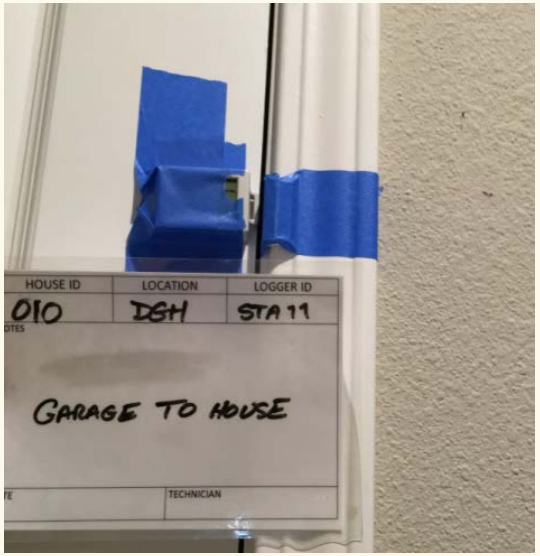
Indoor/Outdoor Air Quality Measurements

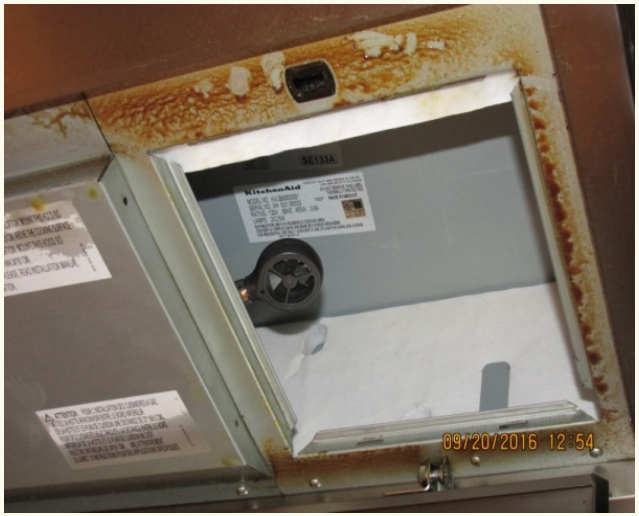


Indoor monitoring of PM2.5, CO_2, NO_2, and formaldehyde

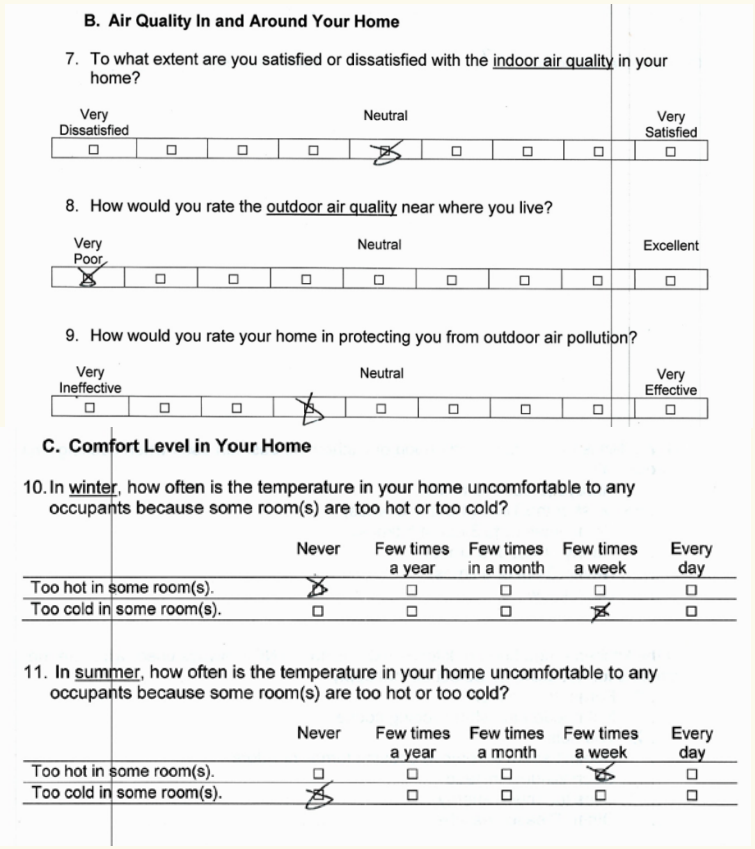


Activity Monitoring





Survey & Activity Log



B. Air Quality In and Around Your Home

7. To what extent are you satisfied or dissatisfied with the indoor air quality in your home?

Very Dissatisfied — Neutral — Very Satisfied

8. How would you rate the outdoor air quality near where you live?

Very Poor — Neutral — Excellent

9. How would you rate your home in protecting you from outdoor air pollution?

Very Ineffective — Neutral — Very Effective

C. Comfort Level in Your Home

10. In winter, how often is the temperature in your home uncomfortable to any occupants because some room(s) are too hot or too cold?

	Never	Few times a year	Few times in a month	Few times a week	Every day
Too hot in some room(s).	☒	☐	☐	☐	☐
Too cold in some room(s).	☐	☐	☐	☒	☐

11. In summer, how often is the temperature in your home uncomfortable to any occupants because some room(s) are too hot or too cold?

	Never	Few times a year	Few times a month	Few times a week	Every day
Too hot in some room(s).	☐	☐	☐	☒	☐
Too cold in some room(s).	☒	☐	☐	☐	☐

Healthy Efficient New California Homes Study
Occupancy and Indoor Activities Data Log

Instructions: Please fill out this data log each day, or on the following day.

Please enter your best estimates. If you are unsure, please provide your best guess. Do not list the names of any people.

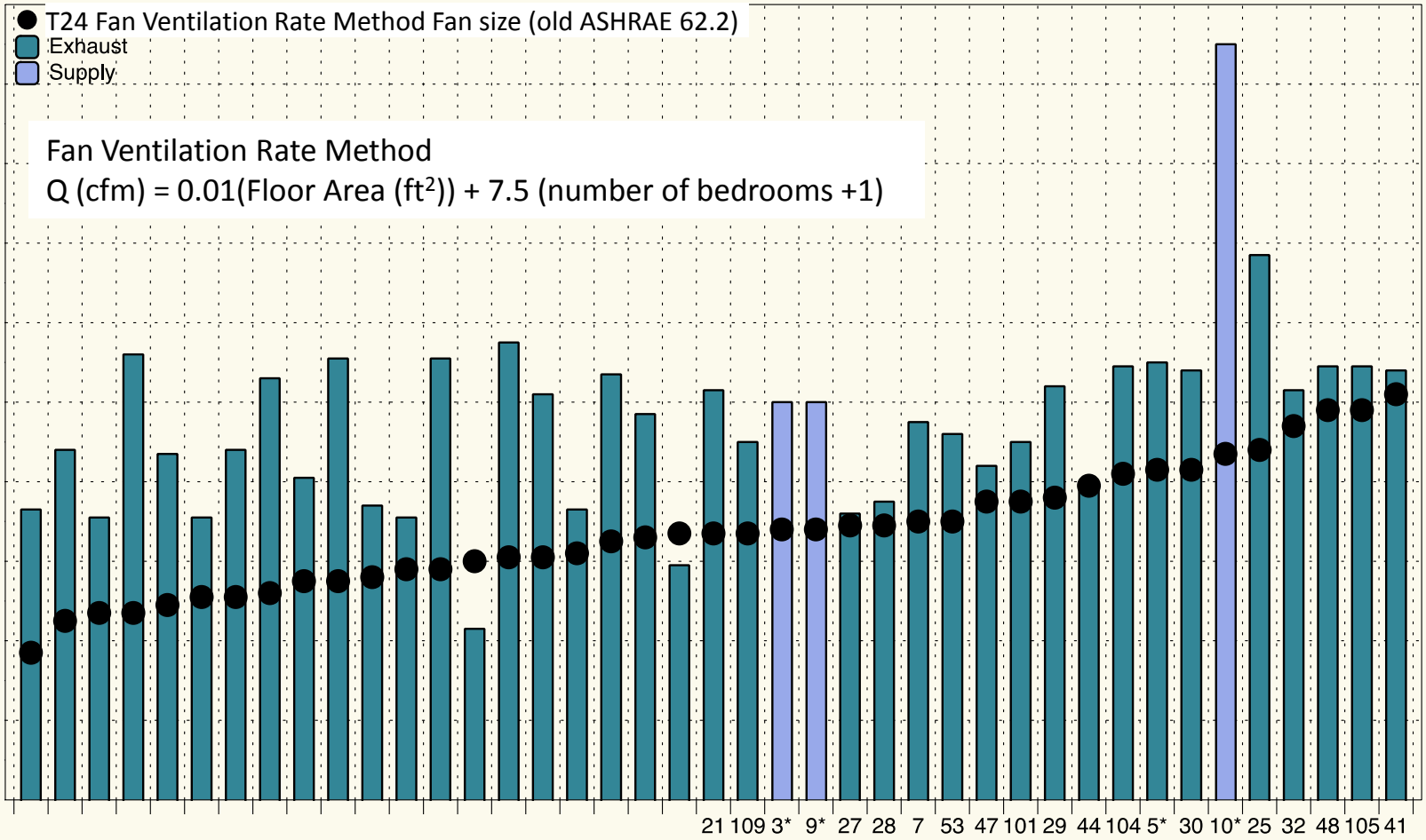
Code number for home _

Day 1: Date 1 ____ Date complete 1/6

	Midnight to 7am	7am to 11am	11am to 1pm	1pm to 5 pm	5pm to 9pm	9pm to Midnight
Number of people in home	2	4	4	2	2	2
Cooktop use Number of minutes	0	30	0	0	.45	0
Oven use Number of minutes	0	0	0	0	0	0
BBQ/outdoor grill Number of minutes	0	0	0	0	0	0
Vacuuming Number of minutes	0	0	0	.25	0	0
Window Use Number of minutes	0	0	0	0	45min 0	0
Other notable* indoor/outdoor events	3 aircleaners 24/7			carpet & floor clean		0

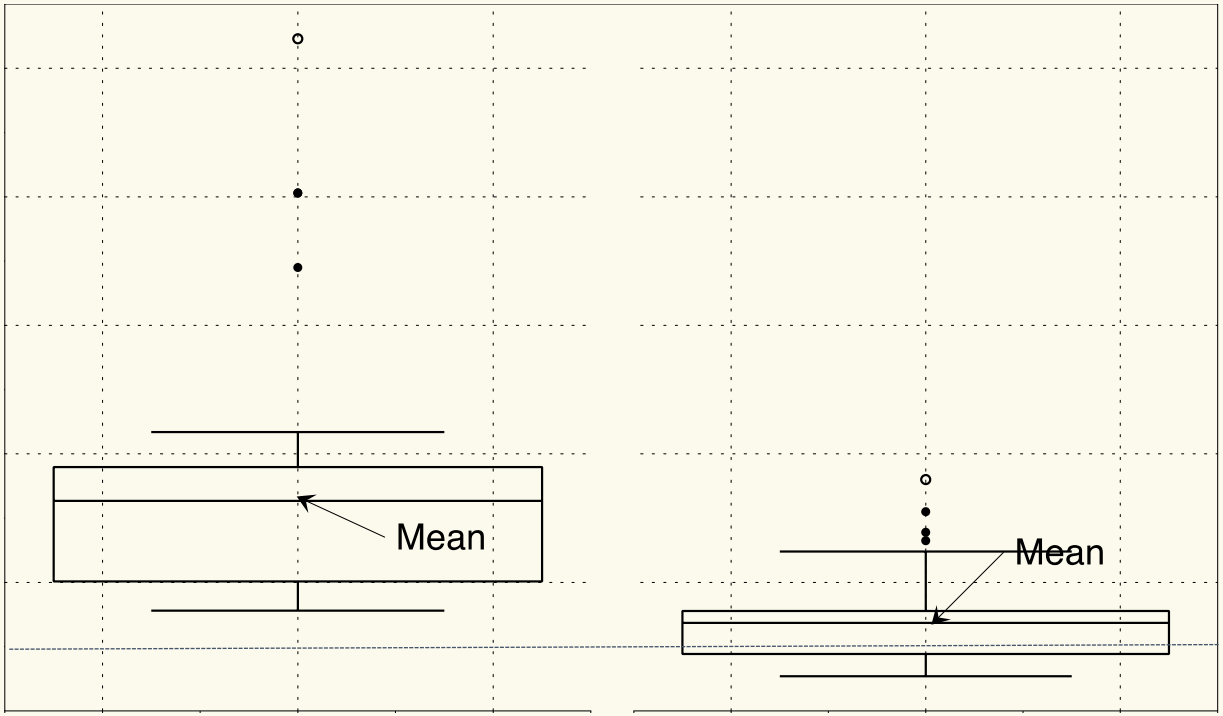
*For example, use of fireplace, candle, air freshener, air cleaner, humidifier, unusual outdoor air quality (wood smoke, wildfire), and so on.

Whole-House Mechanical Ventilation Measured Airflow



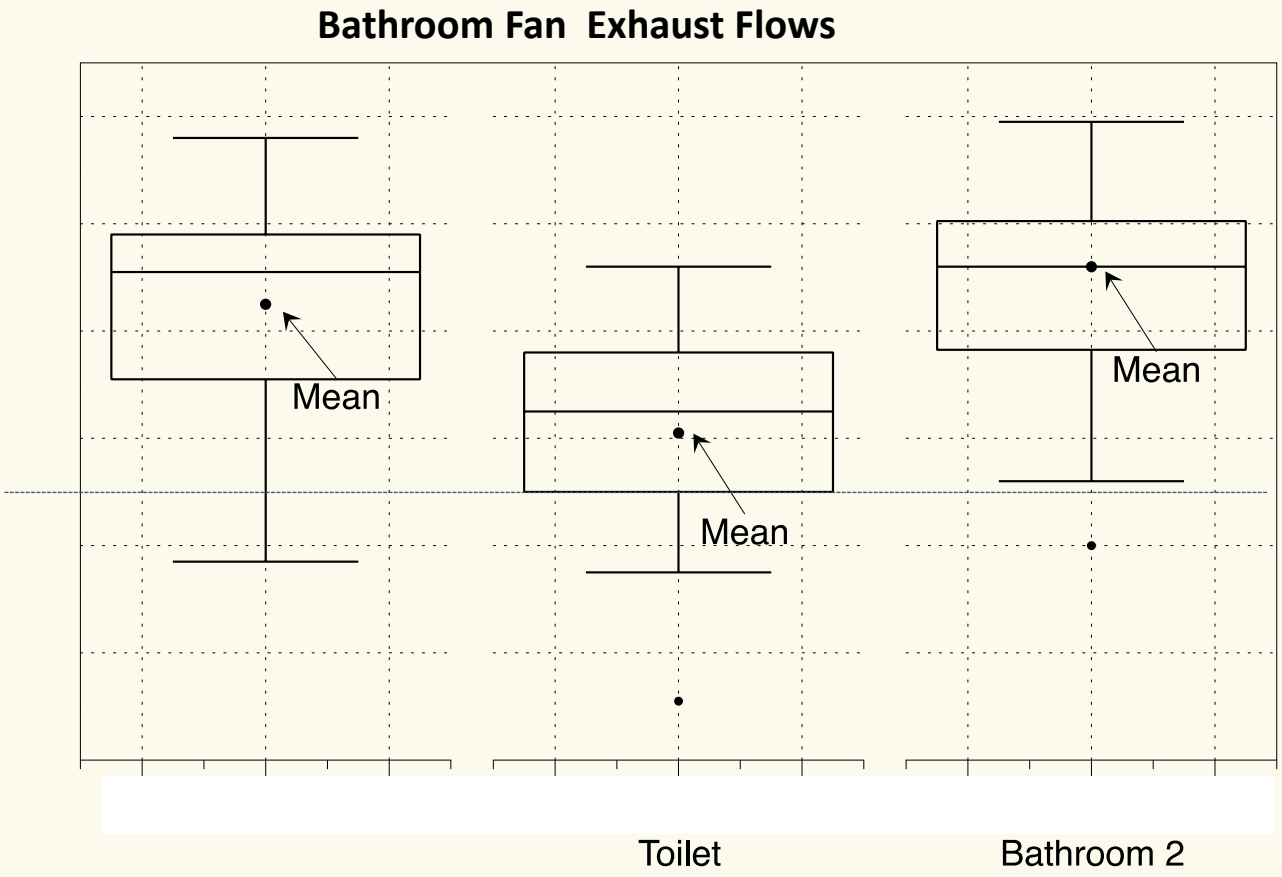
- Supplies are rated airflow rate: not measured
- Two homes did not meet T24 required air flow
- The mechanical systems are oversized by about 50% on average
- 2016 62.2 would require 20% bigger unbalanced fan or 25% smaller balanced fan if infiltration credit taken for a 5 ACH50 home

Range Hood Exhaust Flows



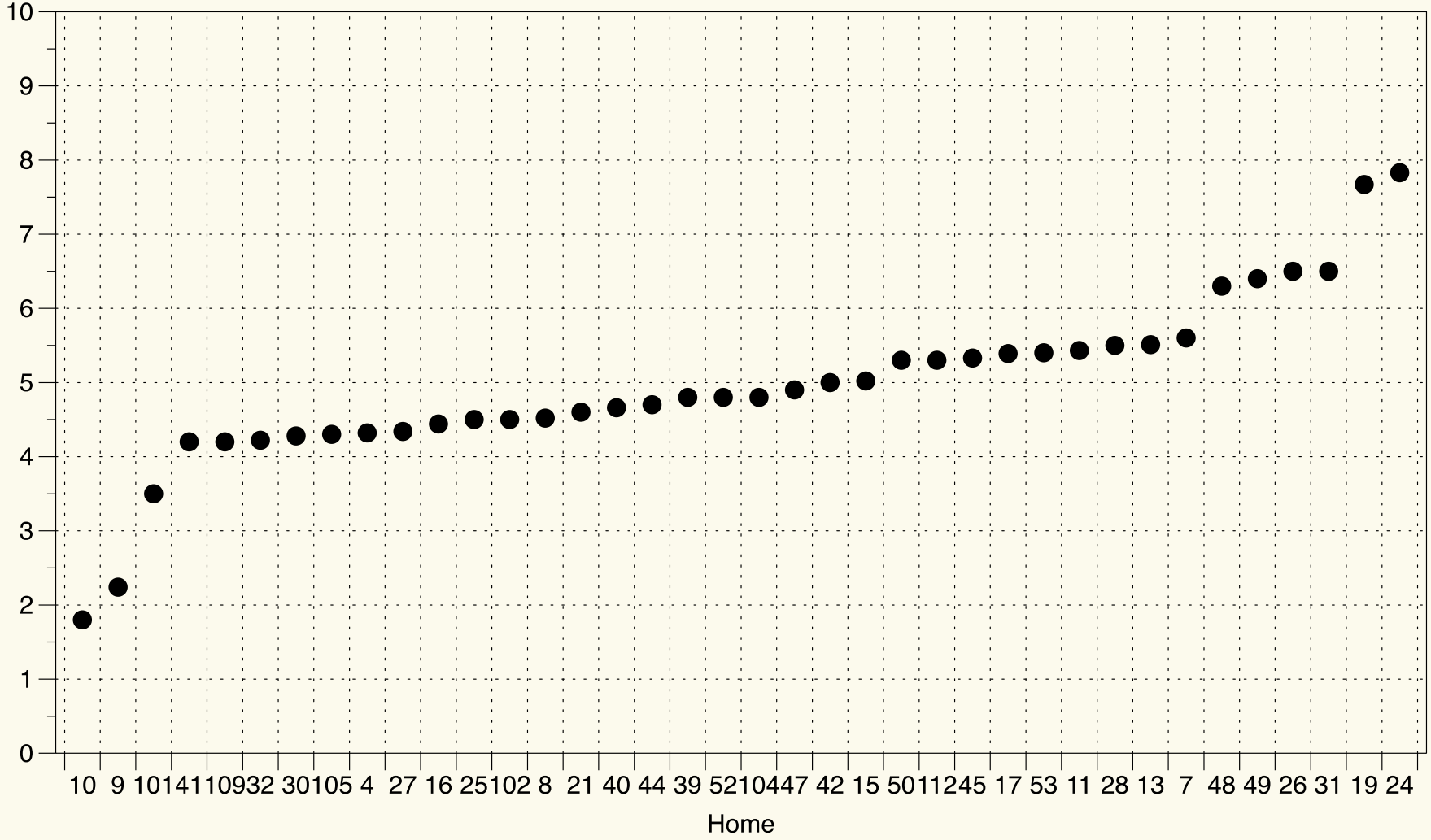
- 41/42 homes met 100 cfm on high. 20/42 homes met it on low setting.
- All of the houses used range hoods vented to outside
- Overall, Microwave range hoods have lower exhaust flows: average was 75 cfm on kigh and 45 cfm on low

Bathroom Ventilation

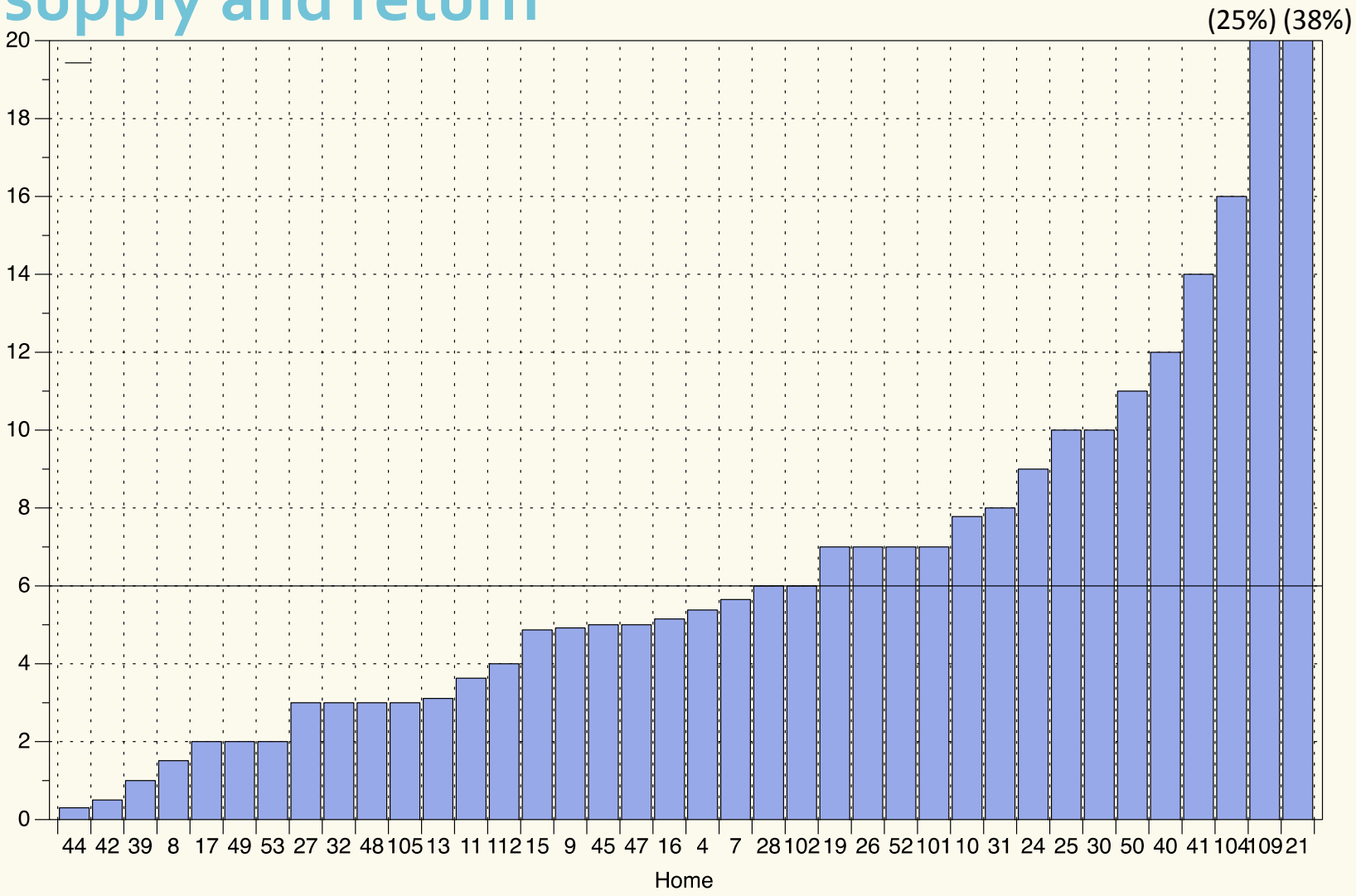


- 38/41 homes met the minimum requirement of 50 cfm

Building Envelope Airtightness

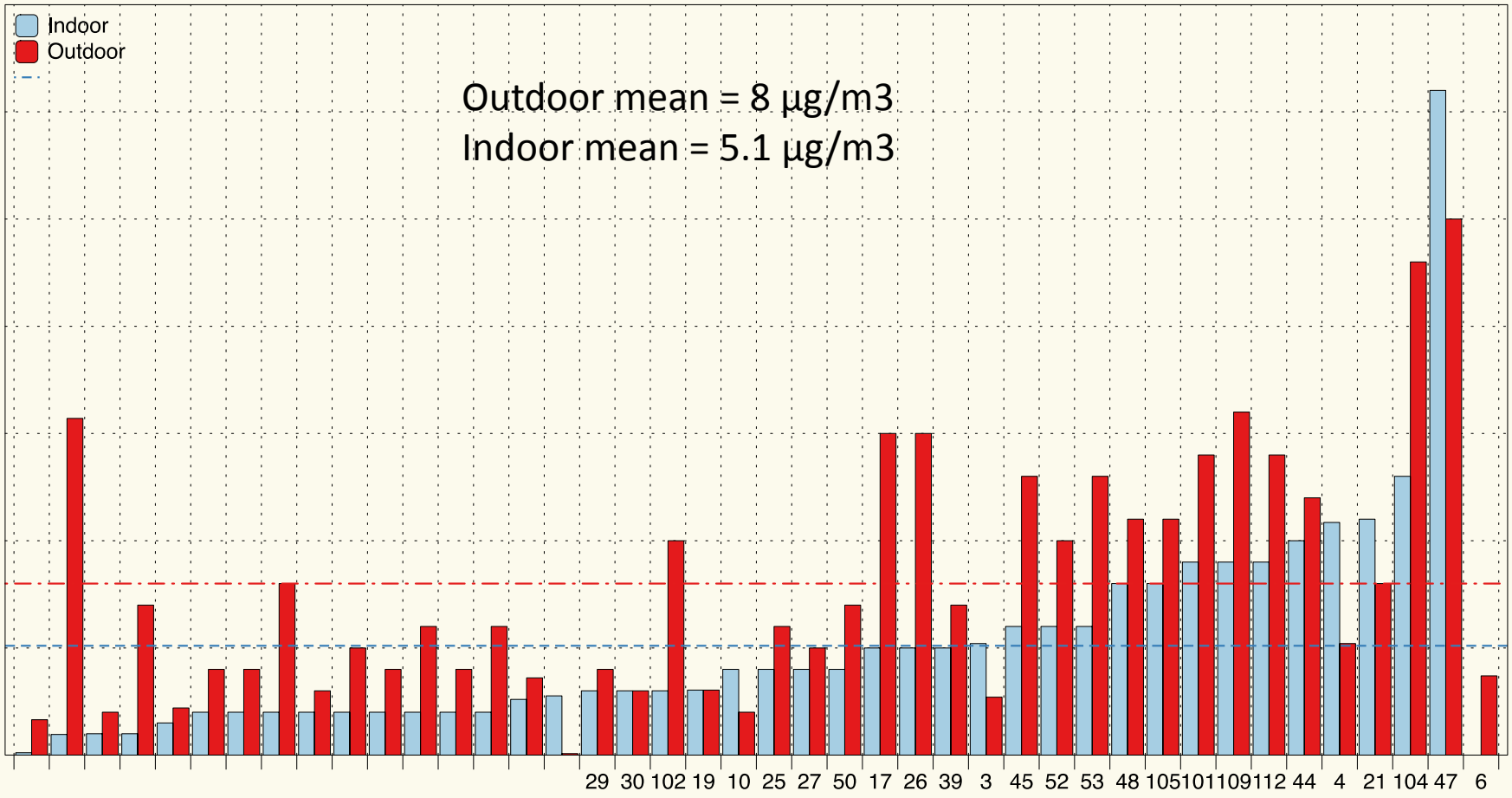


Duct system leakage – combined supply and return

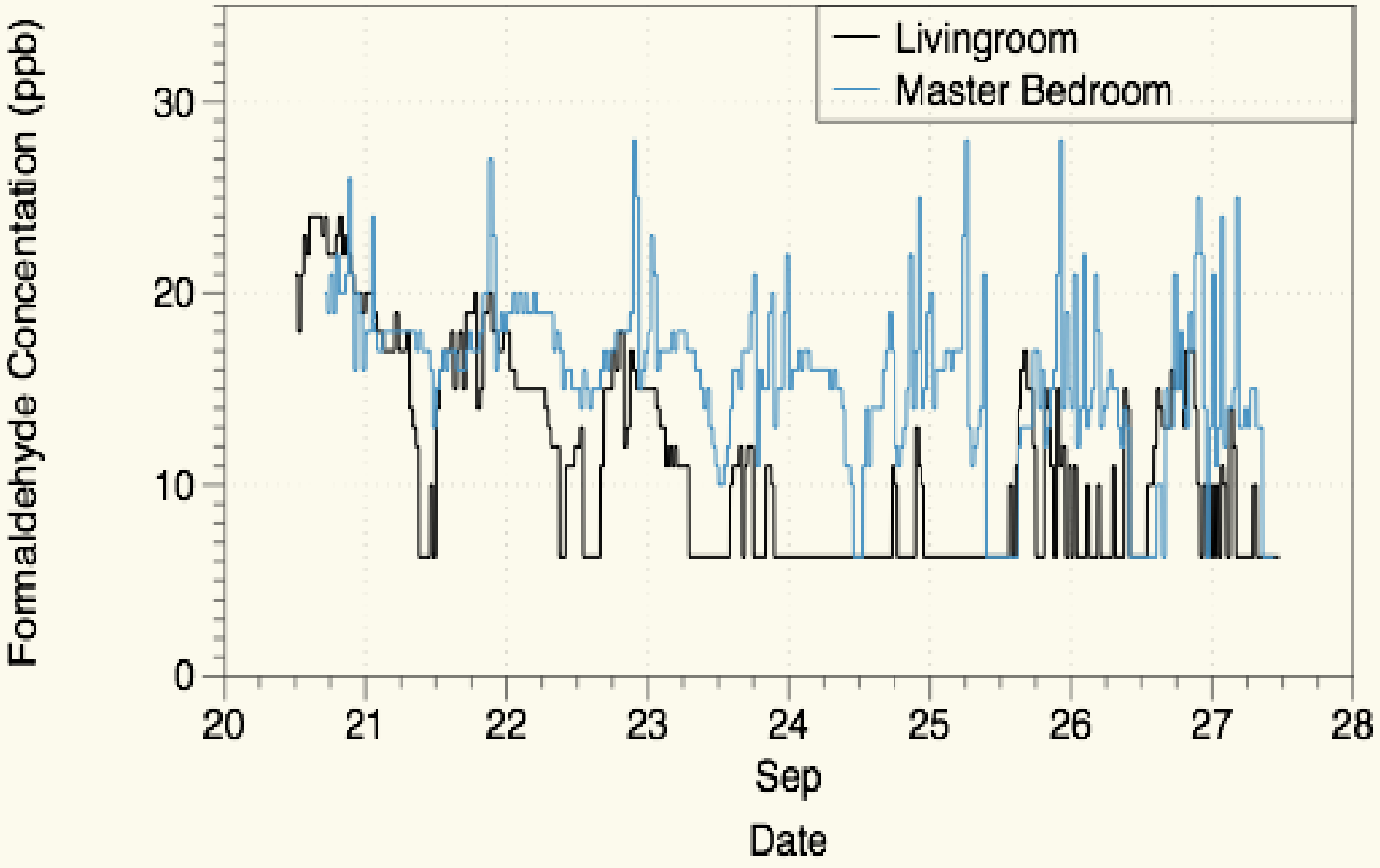


- Fraction Estimated using Title 24 system airflow(cfm), based on heating/cooling capacity.
- 27 of 39 homes met the duct air tightness requirement for Title 24

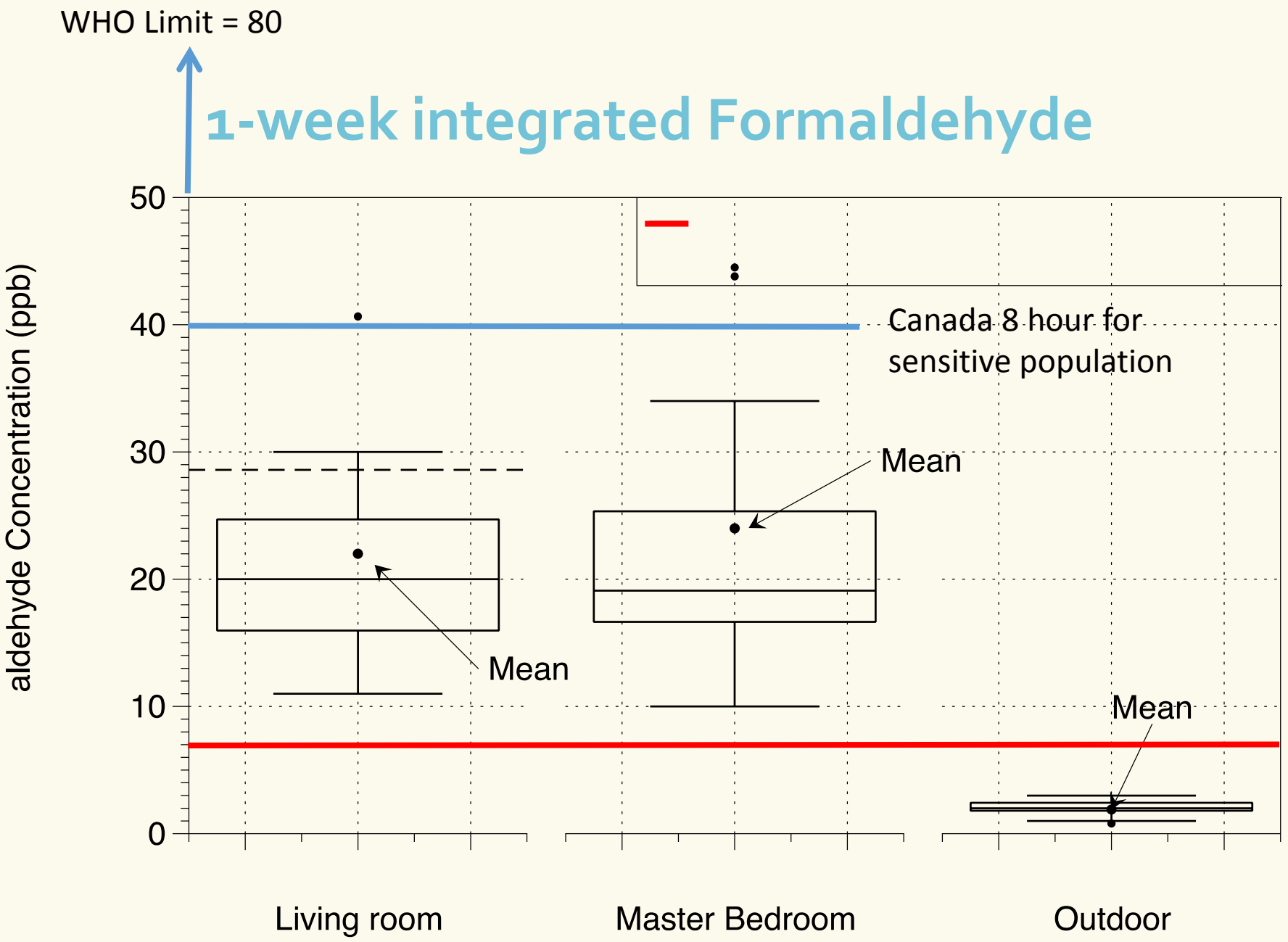
Particulate Matter Concentrations



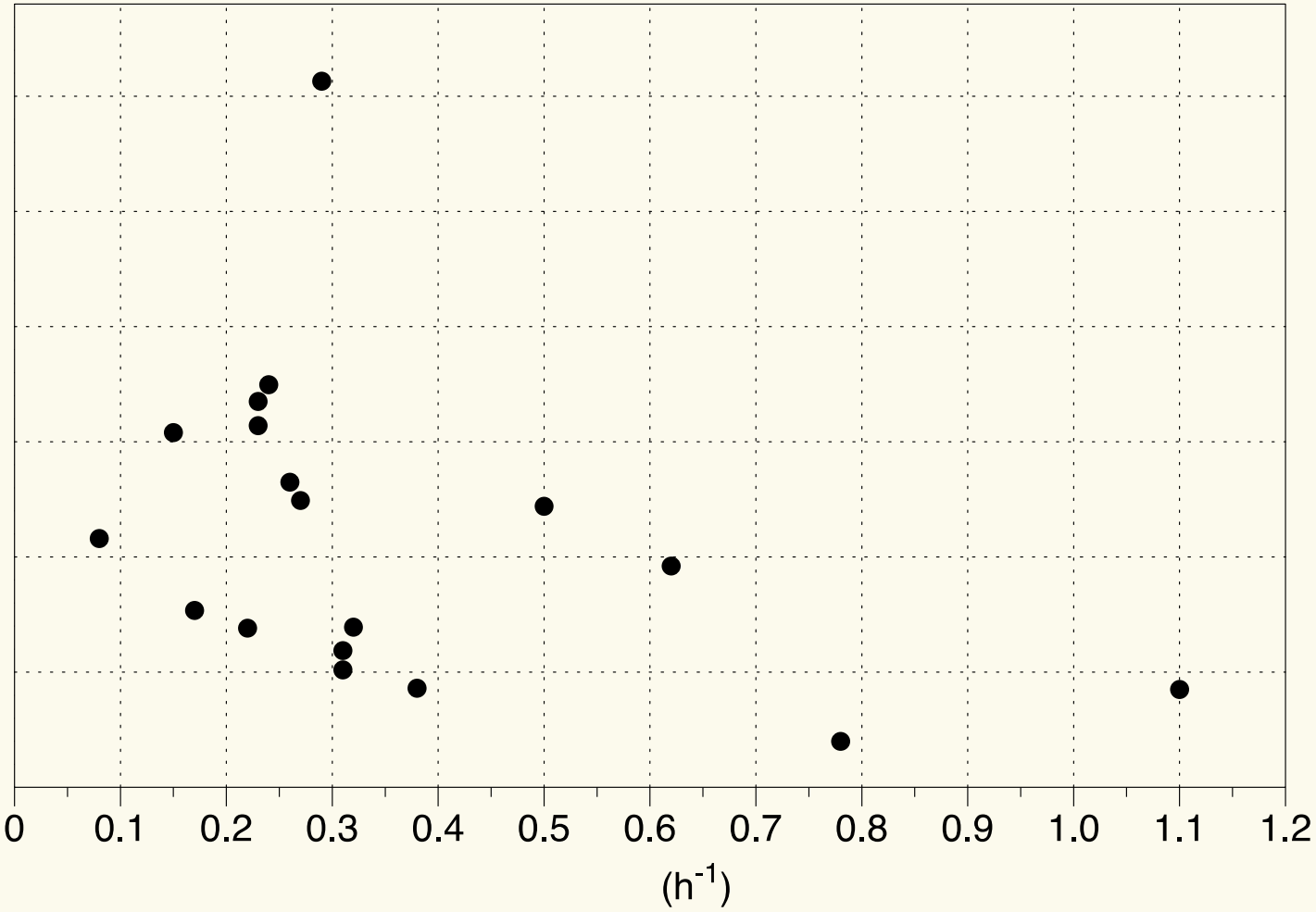
Real-Time Formaldehyde



Diurnal cycle – temperature changes emission rates

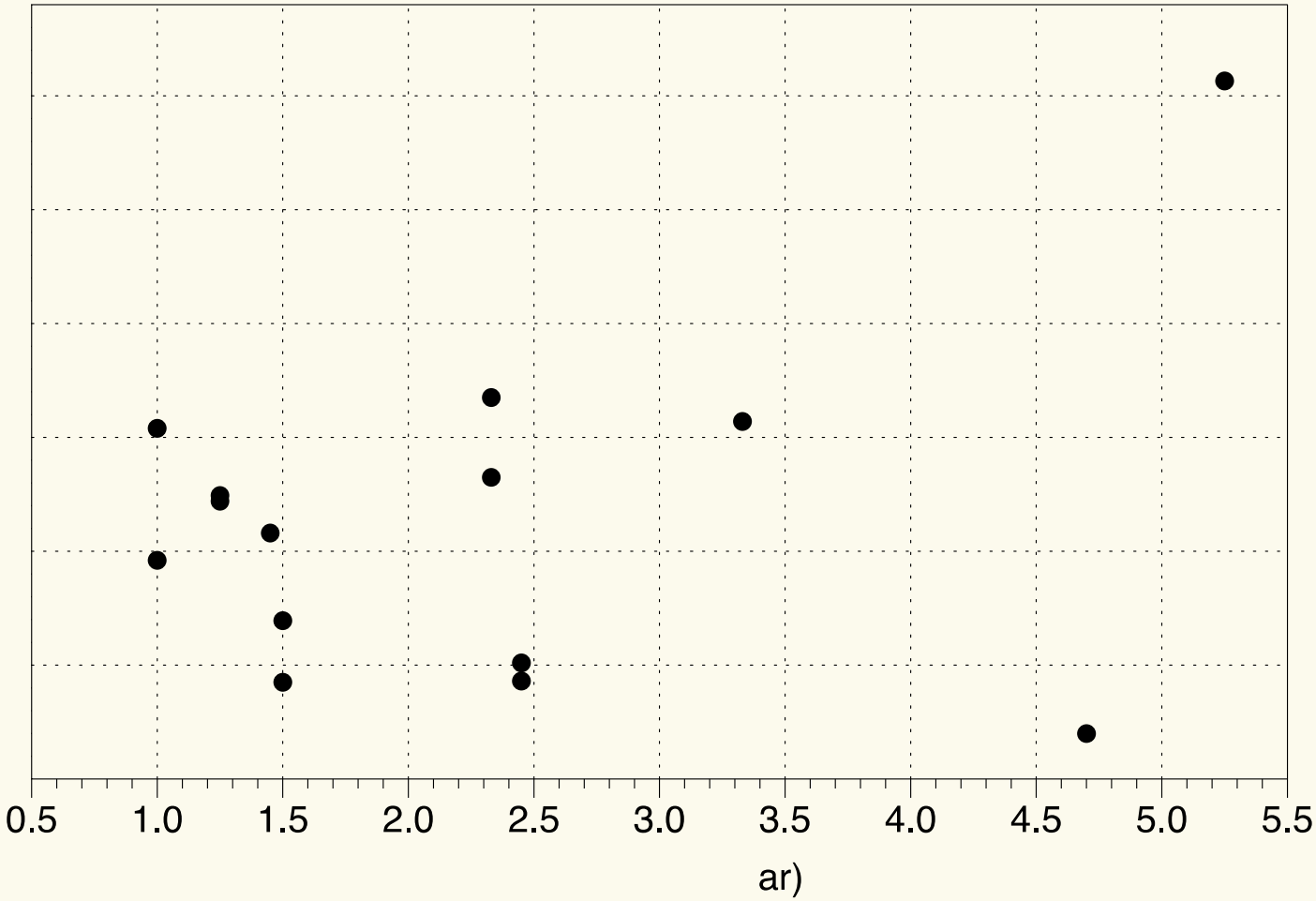

WHO Limit = 80
1-week integrated Formaldehyde
aldehyde Concentration (ppb)
50
40
30
20
10
0
Canada 8 hour for
sensitive population
Mean
Mean
Mean
Living room
Master Bedroom
Outdoor

Formaldehyde & Ventilation

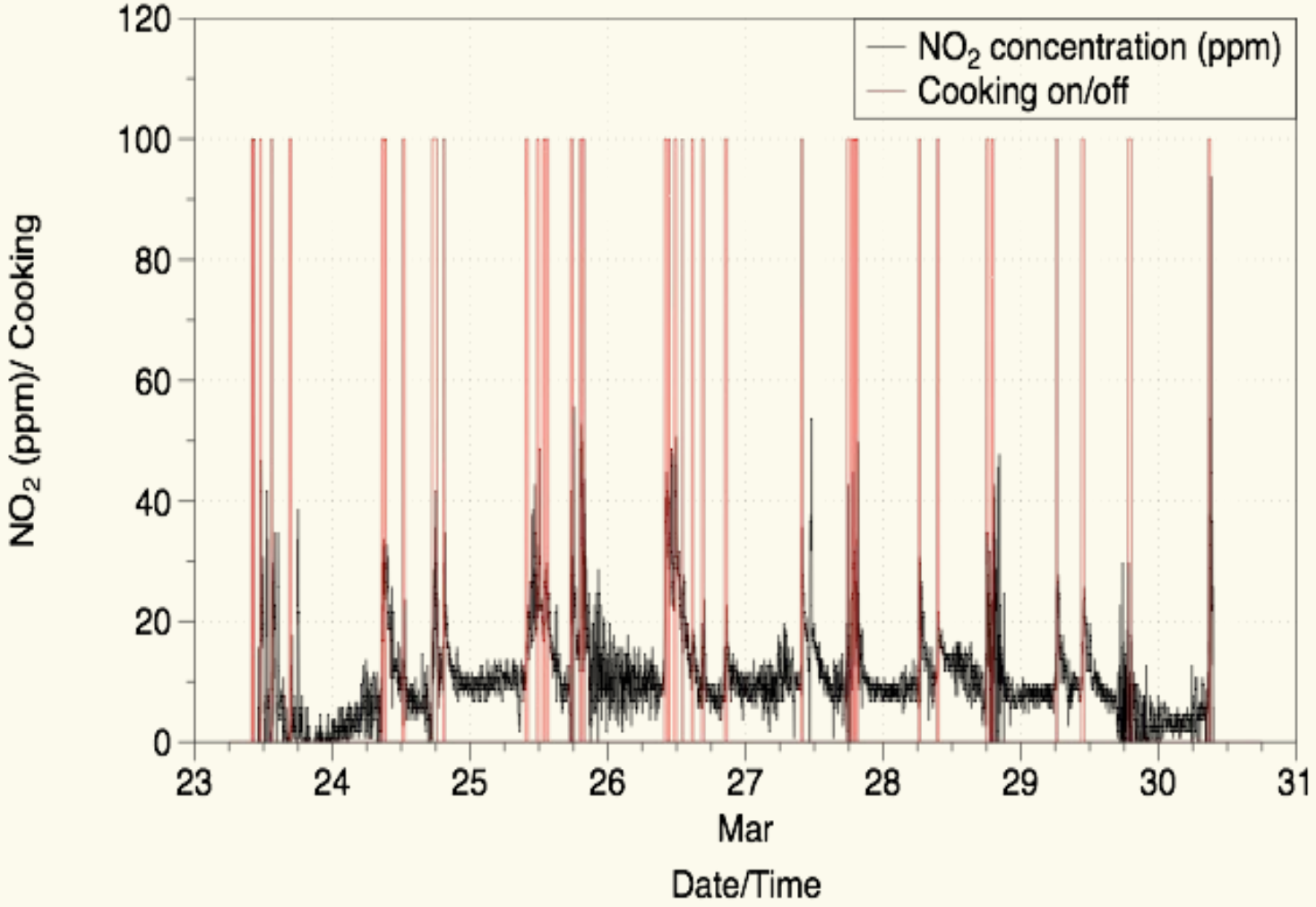


Air change rate based on measured mechanical system air flows and modeled natural infiltration

Formaldehyde & House Age

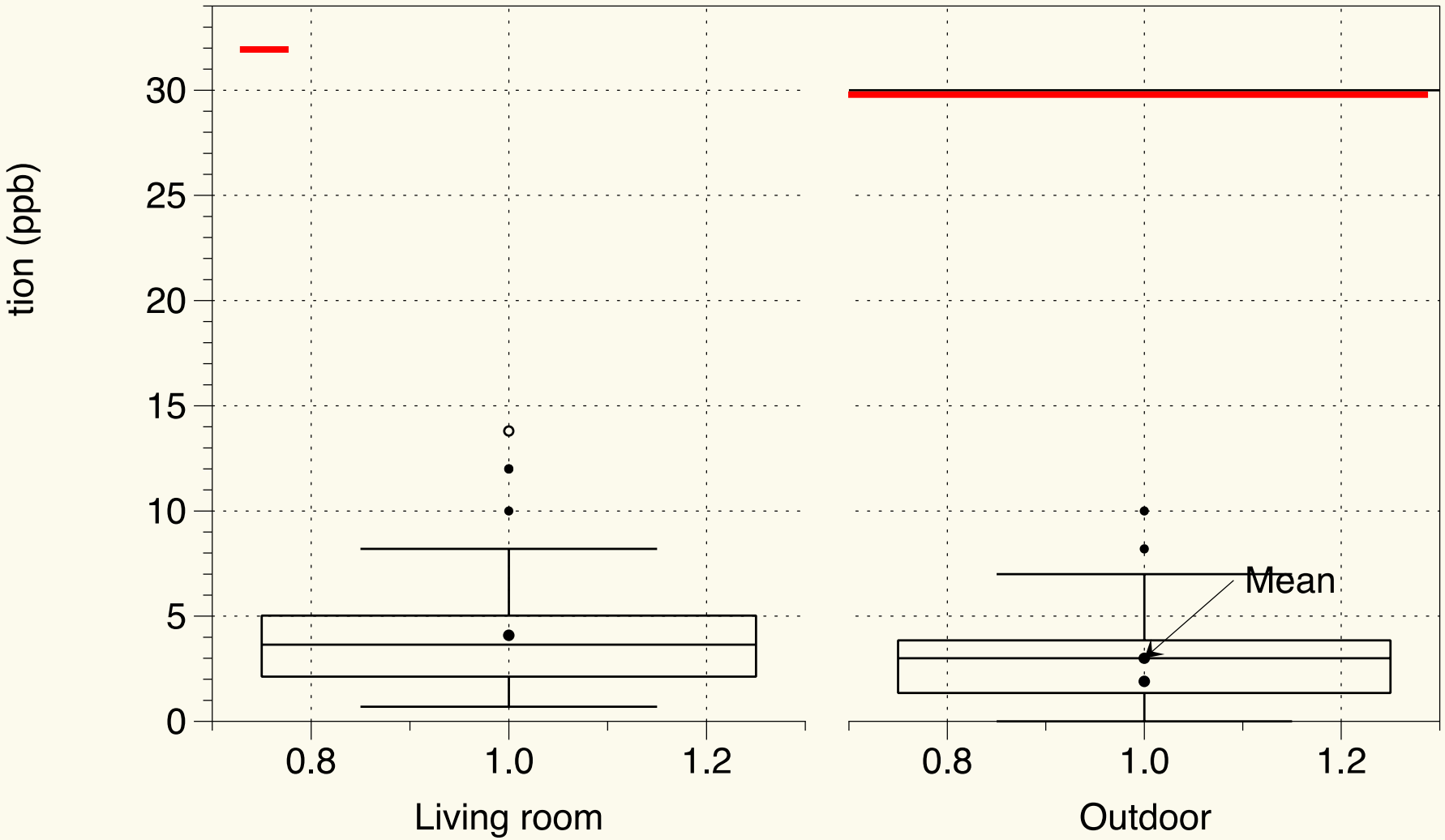


Real Time NO2



Sharp peaks – cooking events

1-week Integrated NO_2



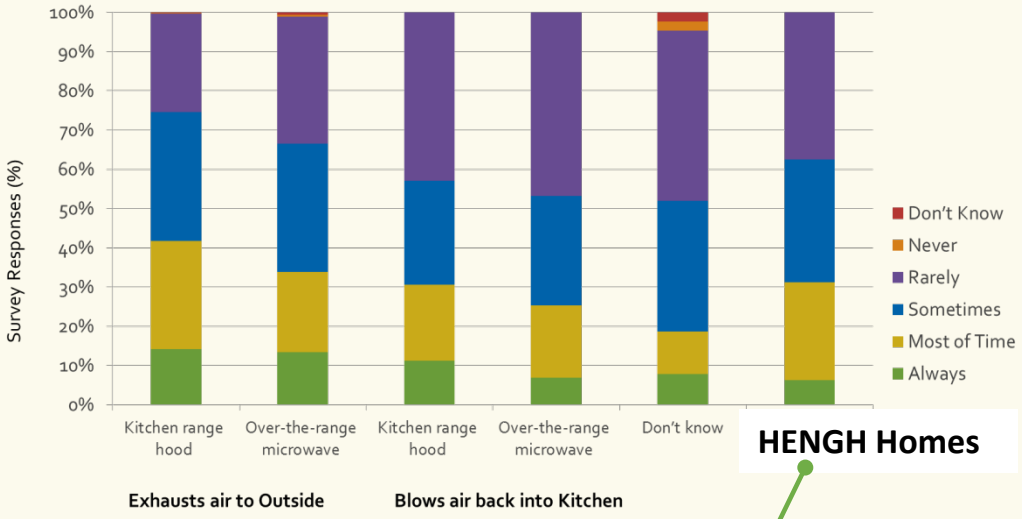
Summary

- Mechanical Ventilation installed to meet T24 requirements
- Whole house systems not operating (despite occupants perceptions)
- Homes typically 5 ACH50
- Ducts - still work to be done
- Particles, Formaldehyde and NO2 – better than previous study – generally OK
- Formaldehyde – strong temperature dependence
- NO2 & particles – even driven – mainly cooking

When mechanical ventilation operates IAQ is f
in new CA homes

Kitchen Ventilation

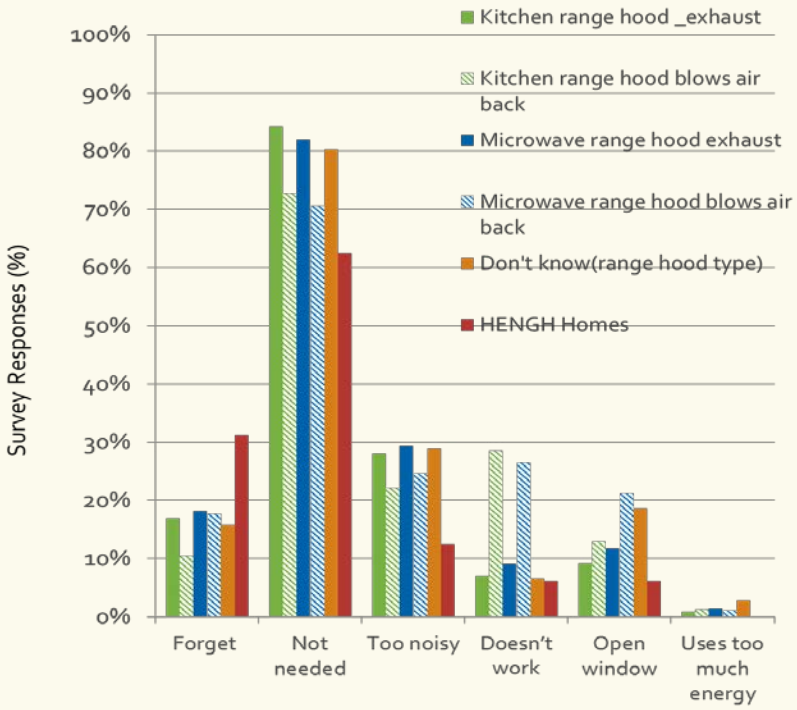
How often do they use the range hood?



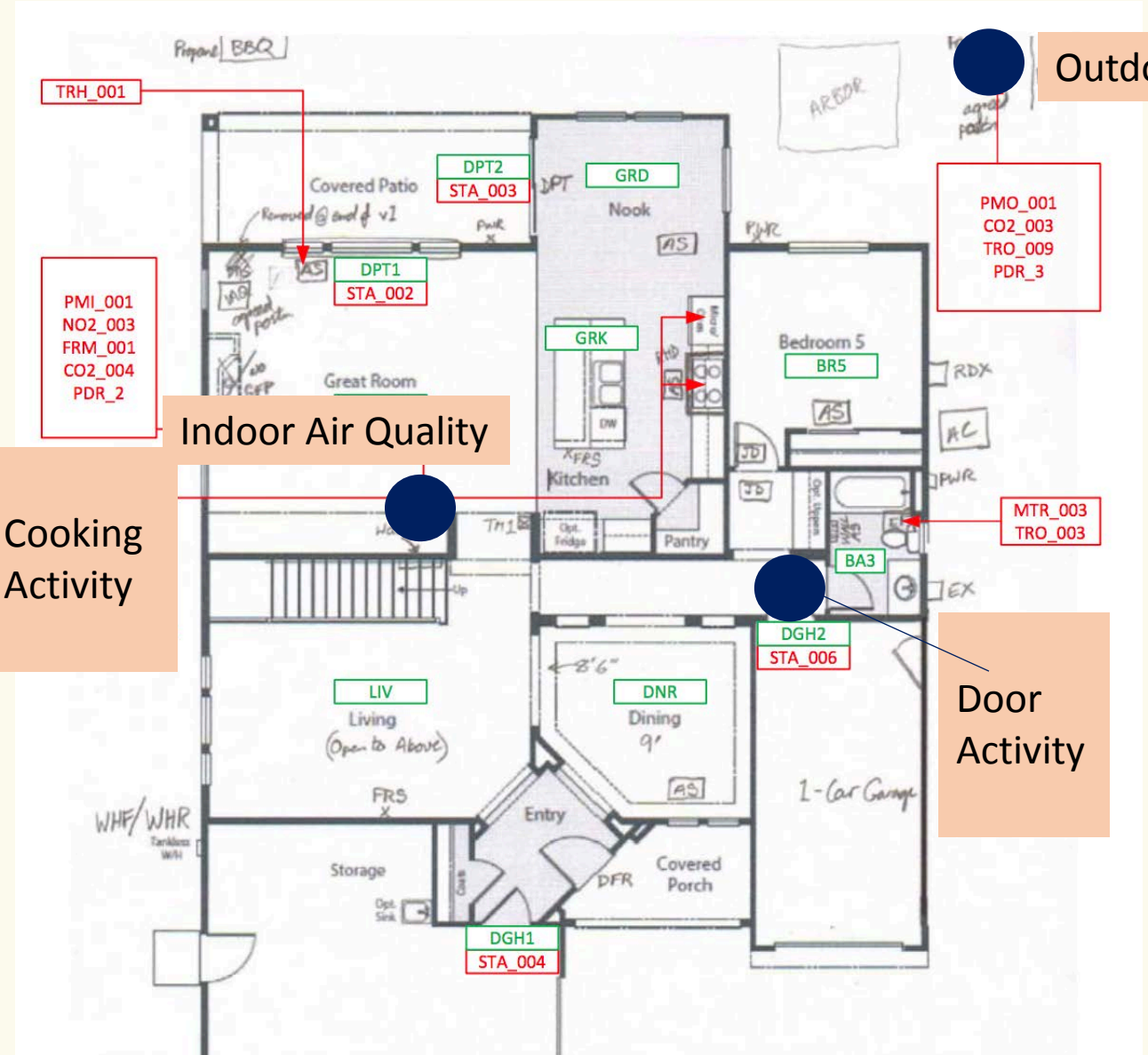
HENGH Homes

Out of 43 cooking events, only 30 % of them use the range hood during cooking

What are the reasons for not using the range hood?



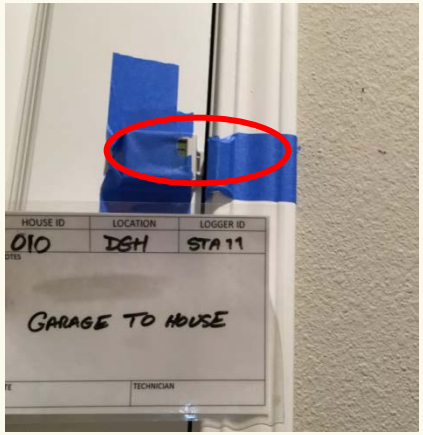
Monitoring Locations

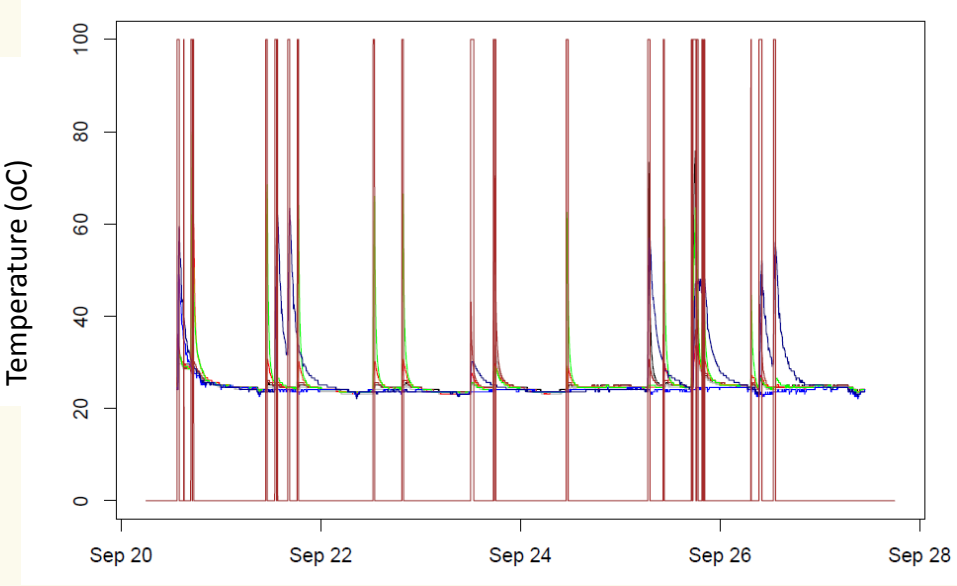


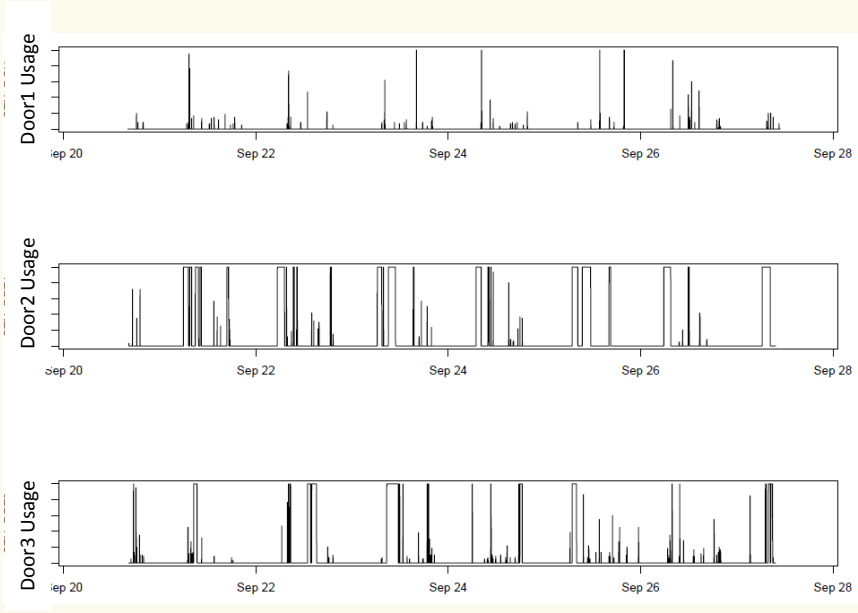
Activity Monitoring

Cooktop Usage

Door Usage

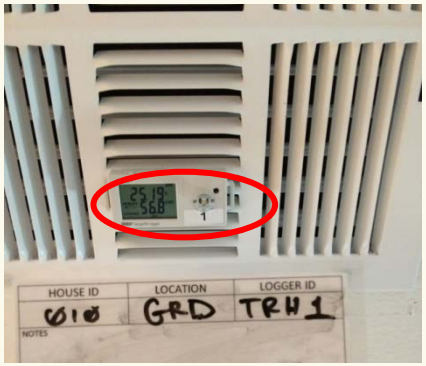




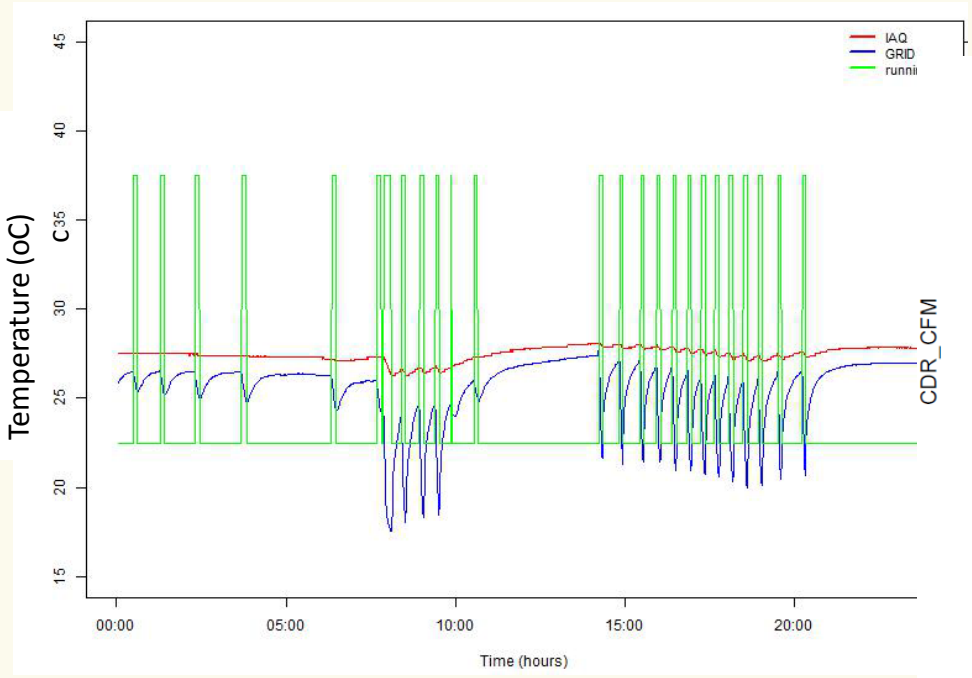


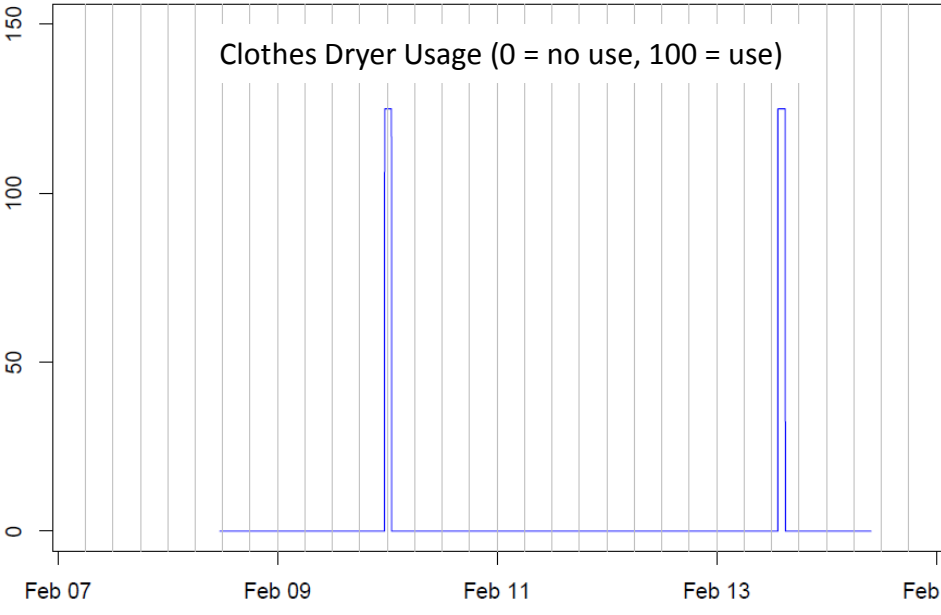
Activity Monitoring

Heating & Cooling Supply Air T/RH



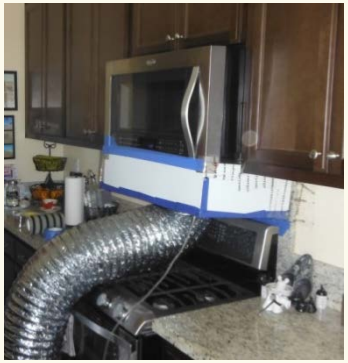
Clothes Dryer Usage





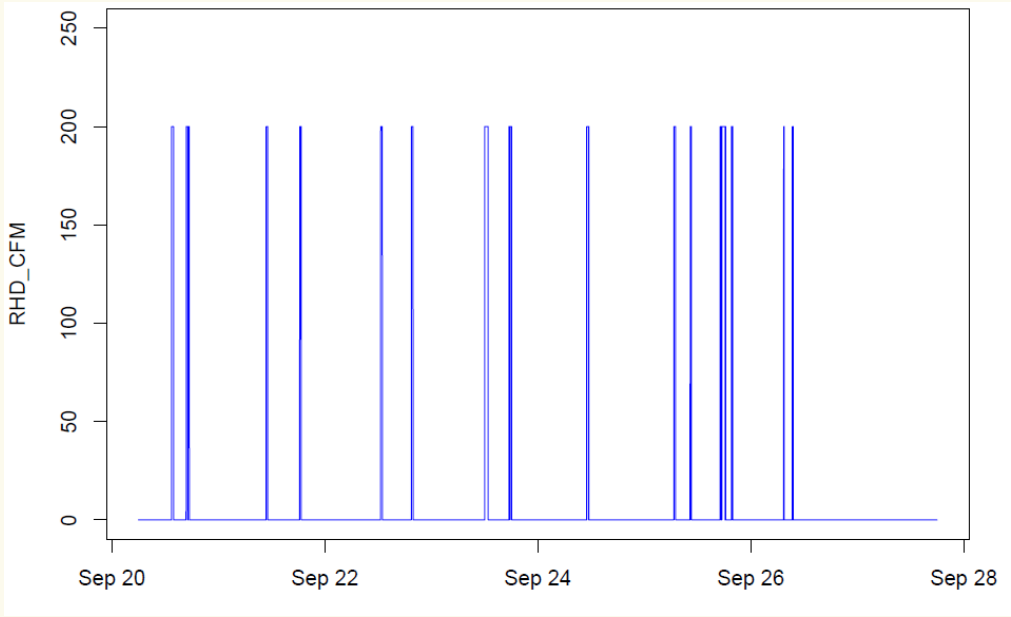
Activity Monitoring

Range Hood



Range hood airflow measured using a capture hood and calibrated fan

Anemometer to monitor the range hood use



Activity Monitoring

Exhaust Fan