

Mitigation of Fine PM from Cooking

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Outline

Performance metrics and standards

Measured effectiveness under controlled conditions

Real-world performance and practical challenges

Resources

Both cooking & burners are sources



CO_2 & H_2O

NO , NO_2 , HONO ,
Formaldehyde

Ultrafine particles



Ultrafine particles



$\text{PM}_{2.5}$, Ultrafine particles

Formaldehyde, Acrolein, PAH, etc.

Induction burners appear to emit many
fewer ultrafine particles (and no NO_x)

Less et al. 2015

Kitchen ventilation options



Ceiling exhaust fan



Wall exhaust fan



Standards and Codes for Kitchen Ventilation

California Building Code



ANSI/ASHRAE Standard 62.1-2016
Supersedes ANSI/ASHRAE Standard 62.1-2013
Includes ANSI/ASHRAE addenda listed in Appendix K

Ventilation
for Acceptable
Indoor Air Quality



- Range hood: ≥ 100 cubic feet per min (cfm), ≤ 3 sone
- Other fan: ≥ 300 cfm, ≤ 3 sone
- Verify installed airflow or use certified hood + prescribed ducting

Guidelines:

- Minimum 40 cfm / ft = 100 cfm for 30" range
- Recommend 100 cfm / ft = 250 cfm for 30"



ENERGY
STAR
Certified
Homes,
Version 3

- Similar to ASHRAE 62.2
- Allowance for unrated hoods if using low resistance ducting



International
Residential
Code

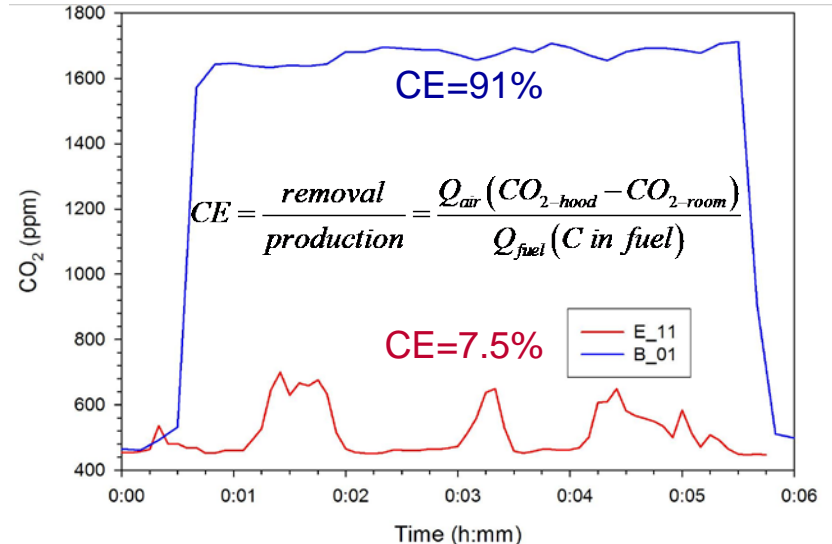
- *When installed*, ≥ 100 cfm on demand or **≥ 25 cfm continuous**, or recirculating hood!
- Make-up air required for > 400 cfm exhaust

How do we know if range hoods are effective?

Capture efficiency (CE): Fraction of pollutants released at cooktop or oven that are removed before mixing into home that are removed before mixing into home



Calculated by CO_2 from gas burners or tracer release
(Different approach needed for particles)



CE for combustion pollutants, lab testing

7 off-the-shelf hoods (2012 cost)

L1: Low-cost \$40

B1: Basic, quiet \$150

A1: 62.2-compliant, \$250

E1: Energy Star, \$300

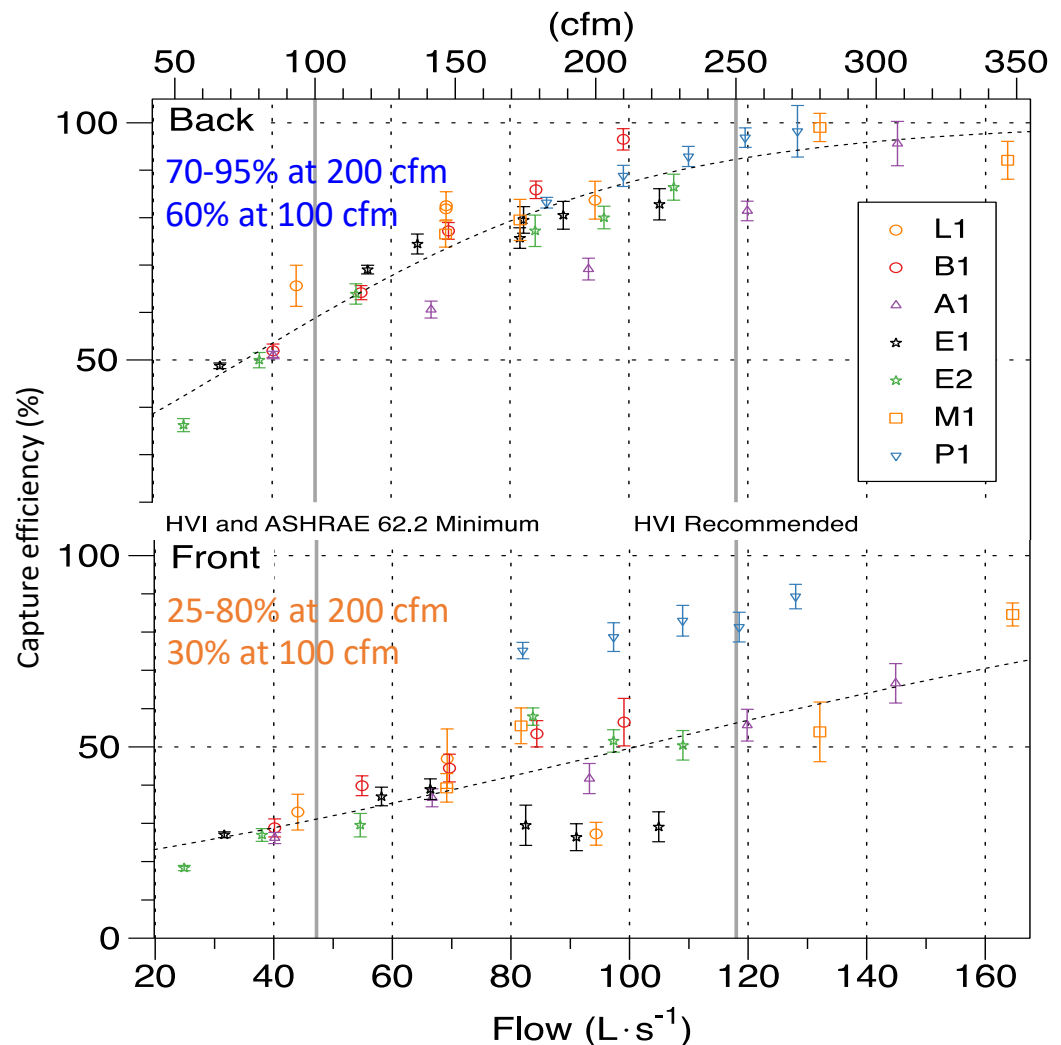
E2: Energy Star, \$350

M1: Microwave, \$350

P1: Performance, \$650

Capture increases with airflow.
Much better for back burners!

For front burners, range hood
at 100 cfm captures ~30%

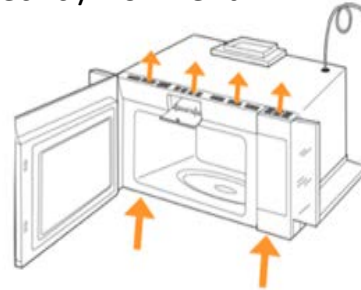


“Over-the-range” microwave range hoods

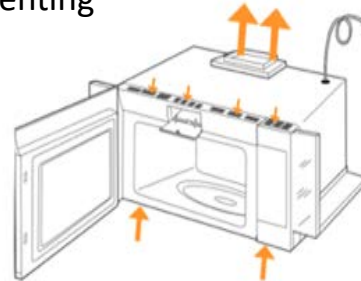
Can be installed as venting or recirculating. Shipped to recirc. Need to turn fan to vent.

Historically not rated for 62.2 and CA code compliance; now many certified models.

Recirc / non-vent



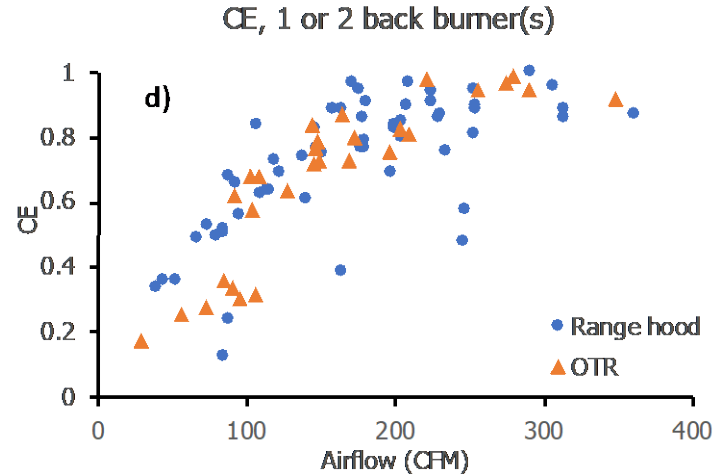
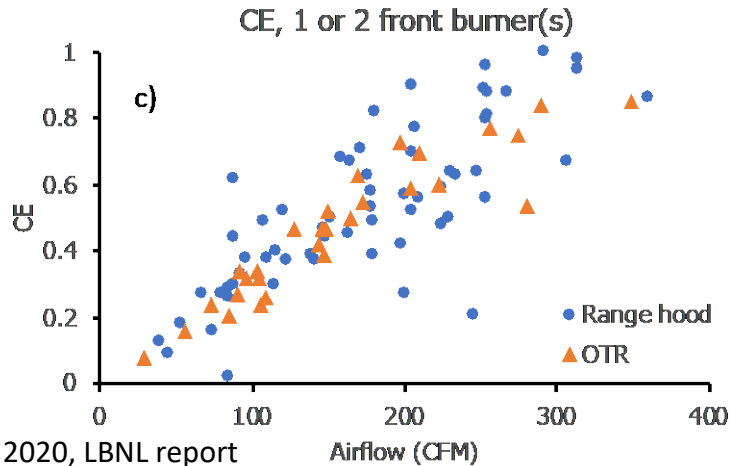
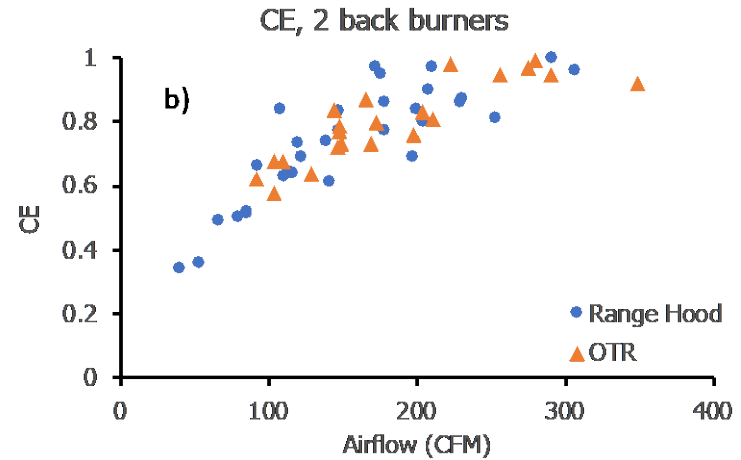
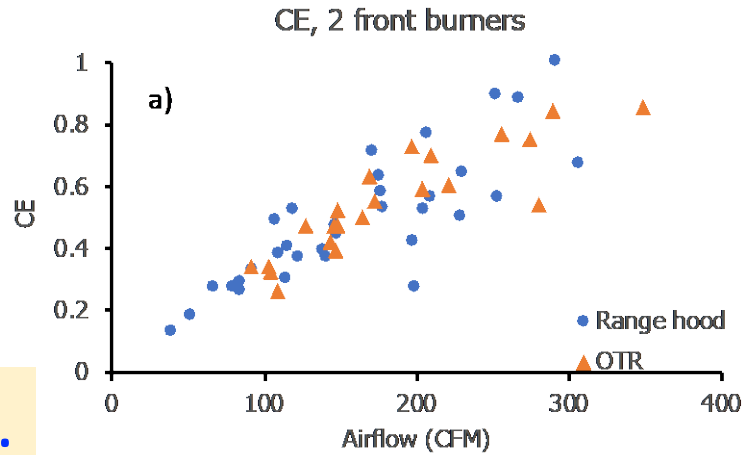
Venting



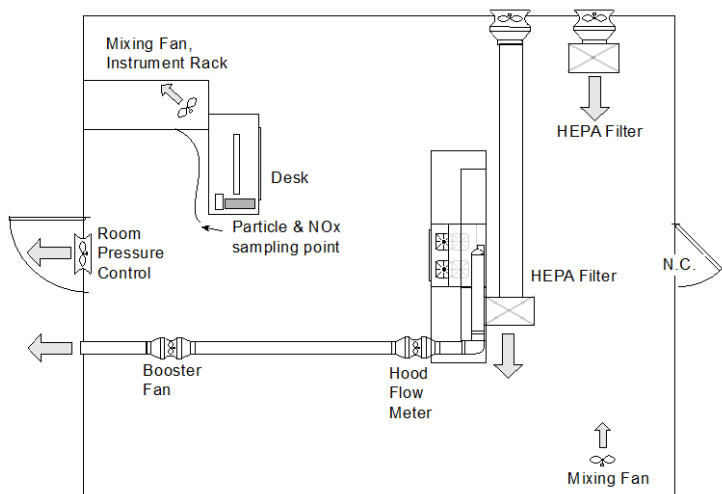
Do OTRs have similar CE as other range hoods?

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~Yes.

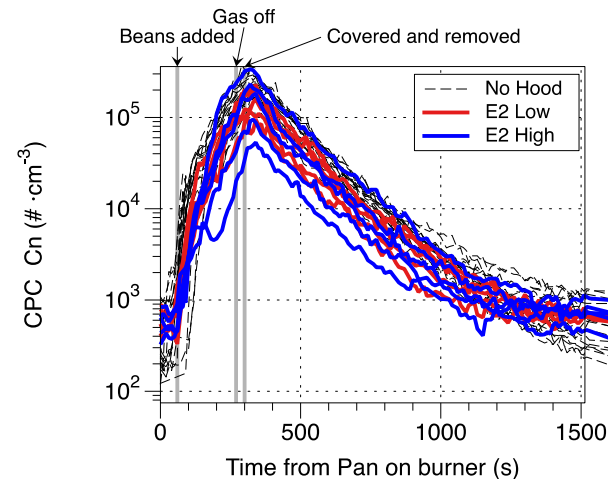
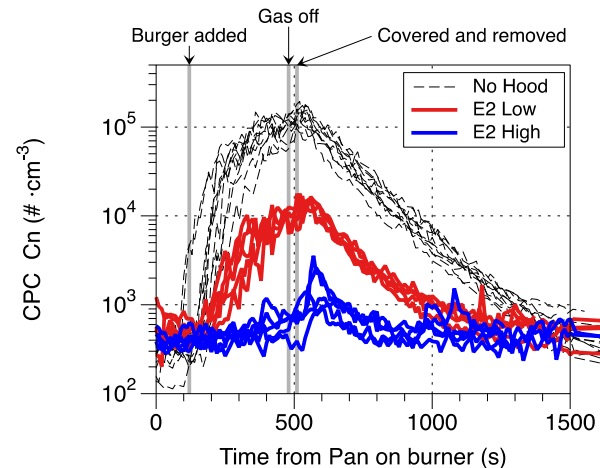


Does CE differ for cooking particles and combustion products?



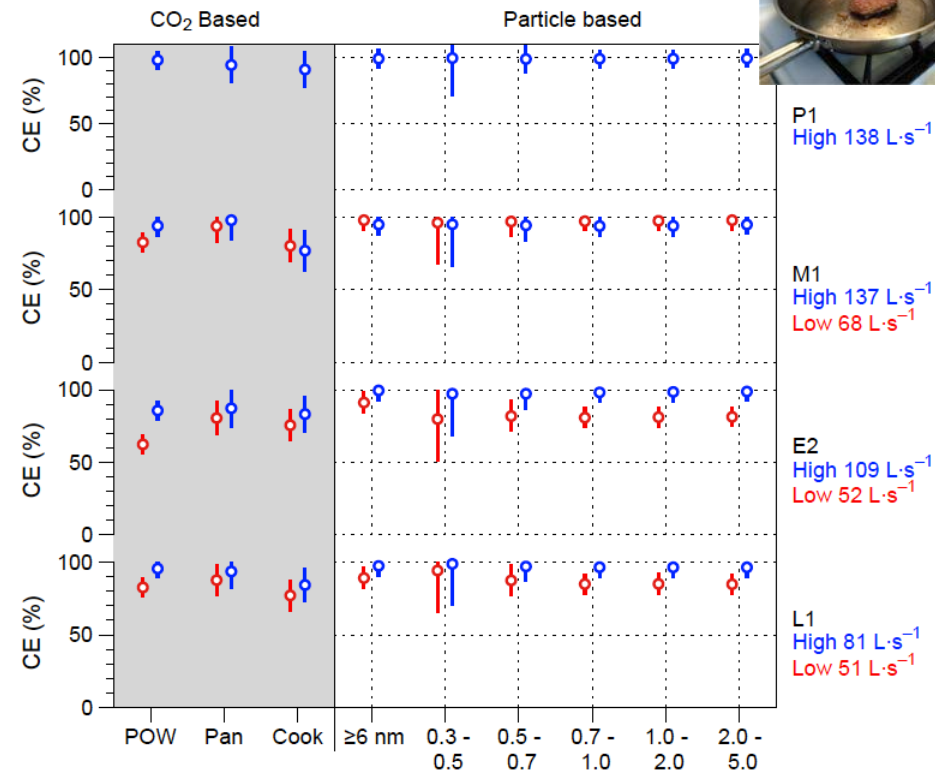
121 m³ (450 sf) room

Front: stir-fry, wok, high
Back: pan-fry burger, med
Also stir-fry on back
4 of the prior 7 hoods



Particles & gases similar at high CE...

Burger / Med / Back

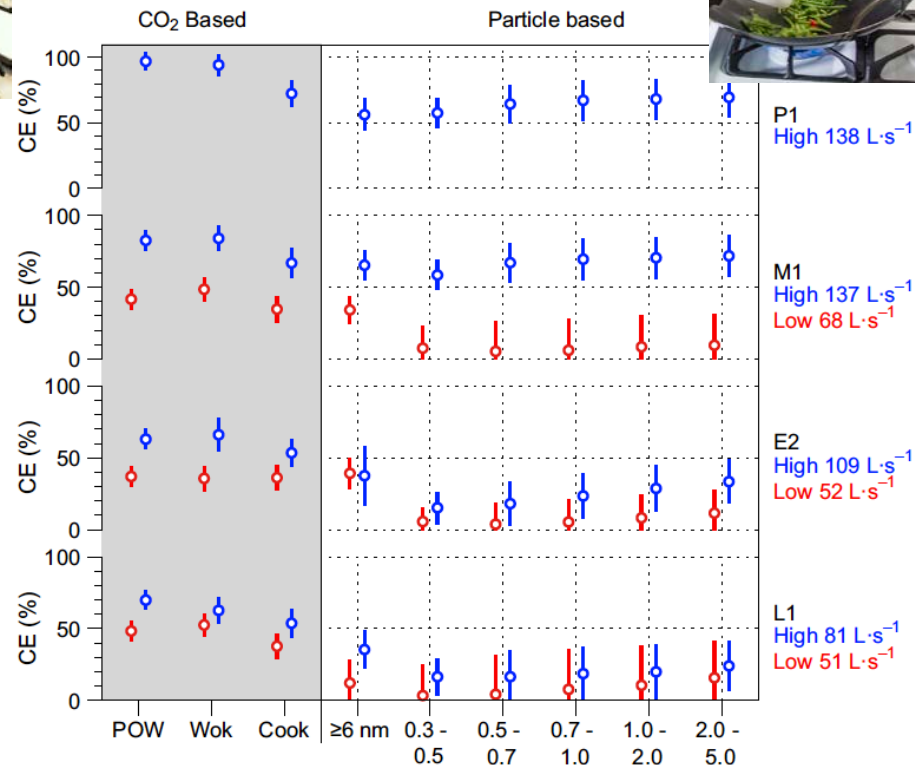
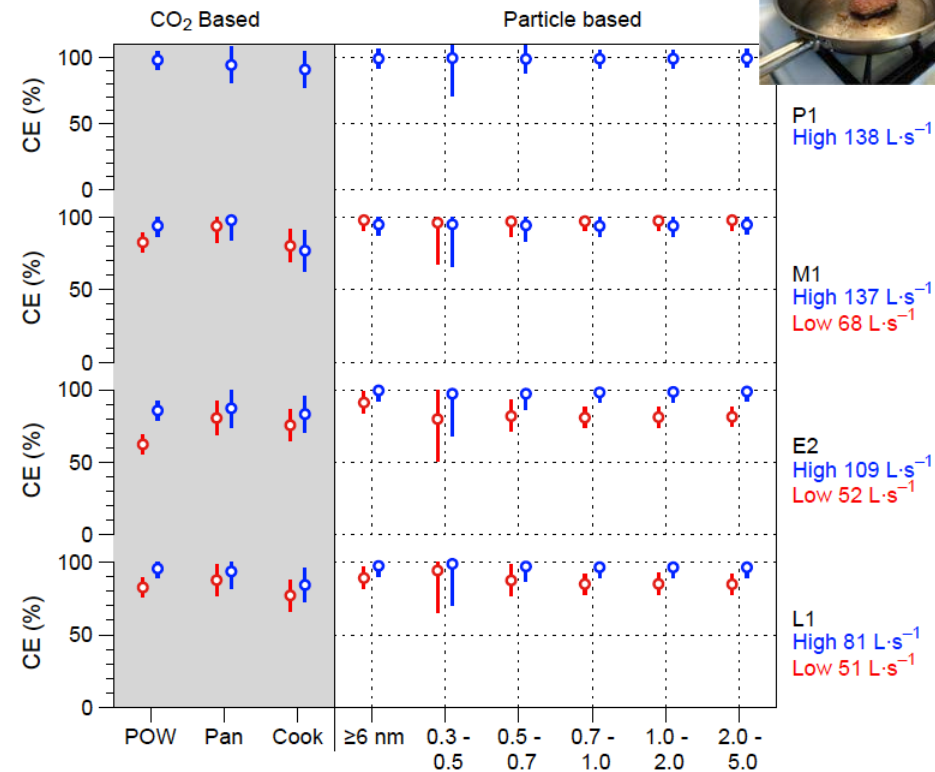


Particles & gases similar at high CE... but differ at low CE

Burger / Med / Back



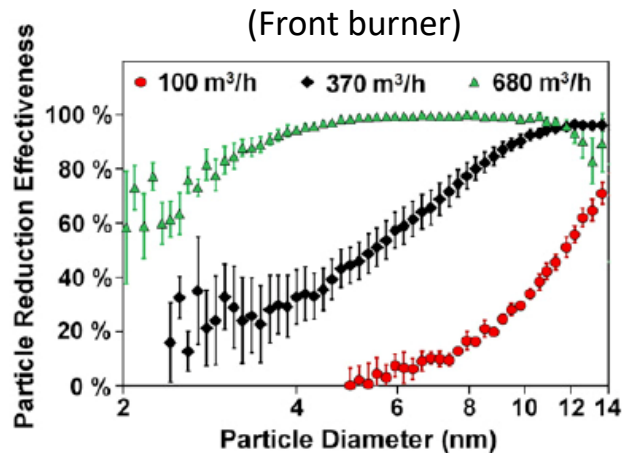
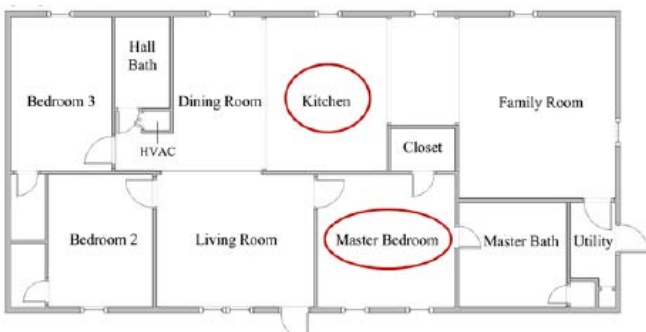
Stir-fry / High / Front



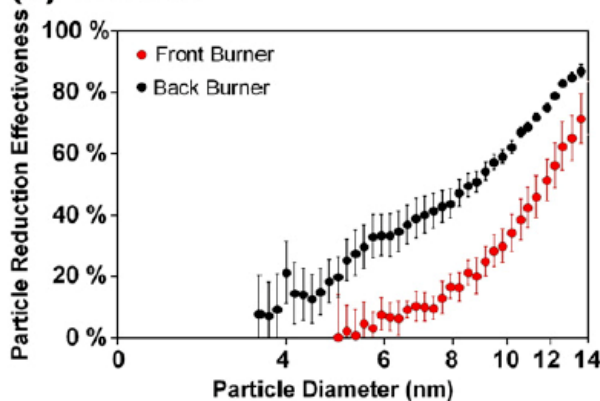
Are RHs effective for nucleation particles from gas burners?



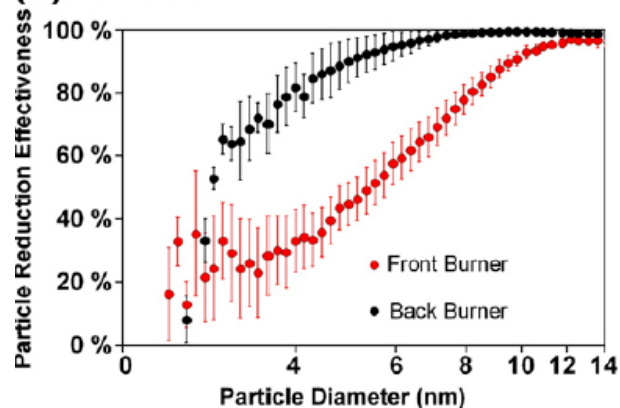
Testing in
Manufactured House
140 m², 340 m³



(a) 100 m³/h



(b) 370 m³/h



Moving to the field: performance in 6 homes with gas

Use burners to heat water: no cooking

- Cooktop, oven, broiler use

Measure CO_2 , NO_2 , NO_x , Particles >6 nm in kitchen, central and bedroom areas



Range hoods and house volumes



H1: 134 m²



H2: 124 m²

H6: 119 m²



H5: 108 m²

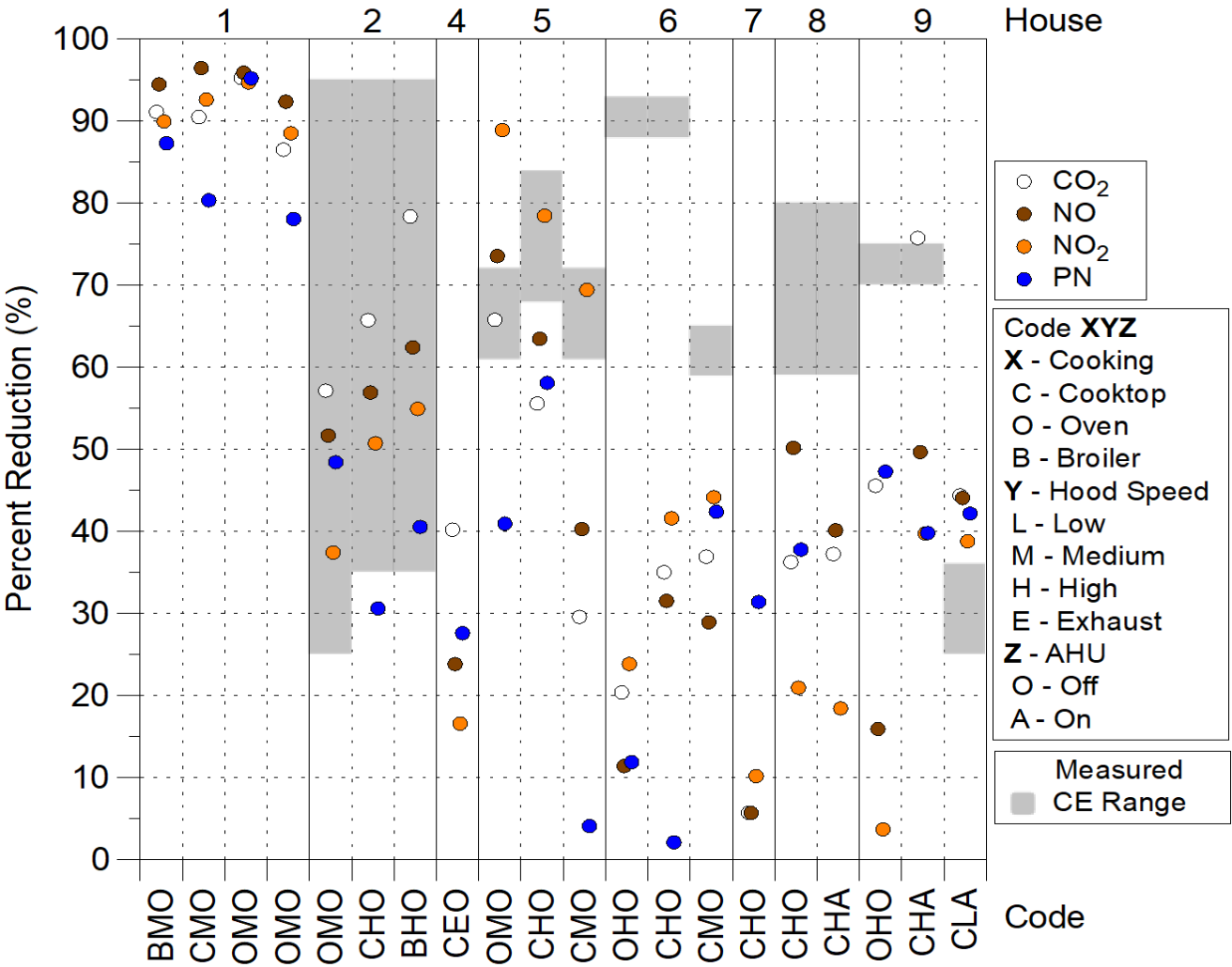


H9: 139 m²



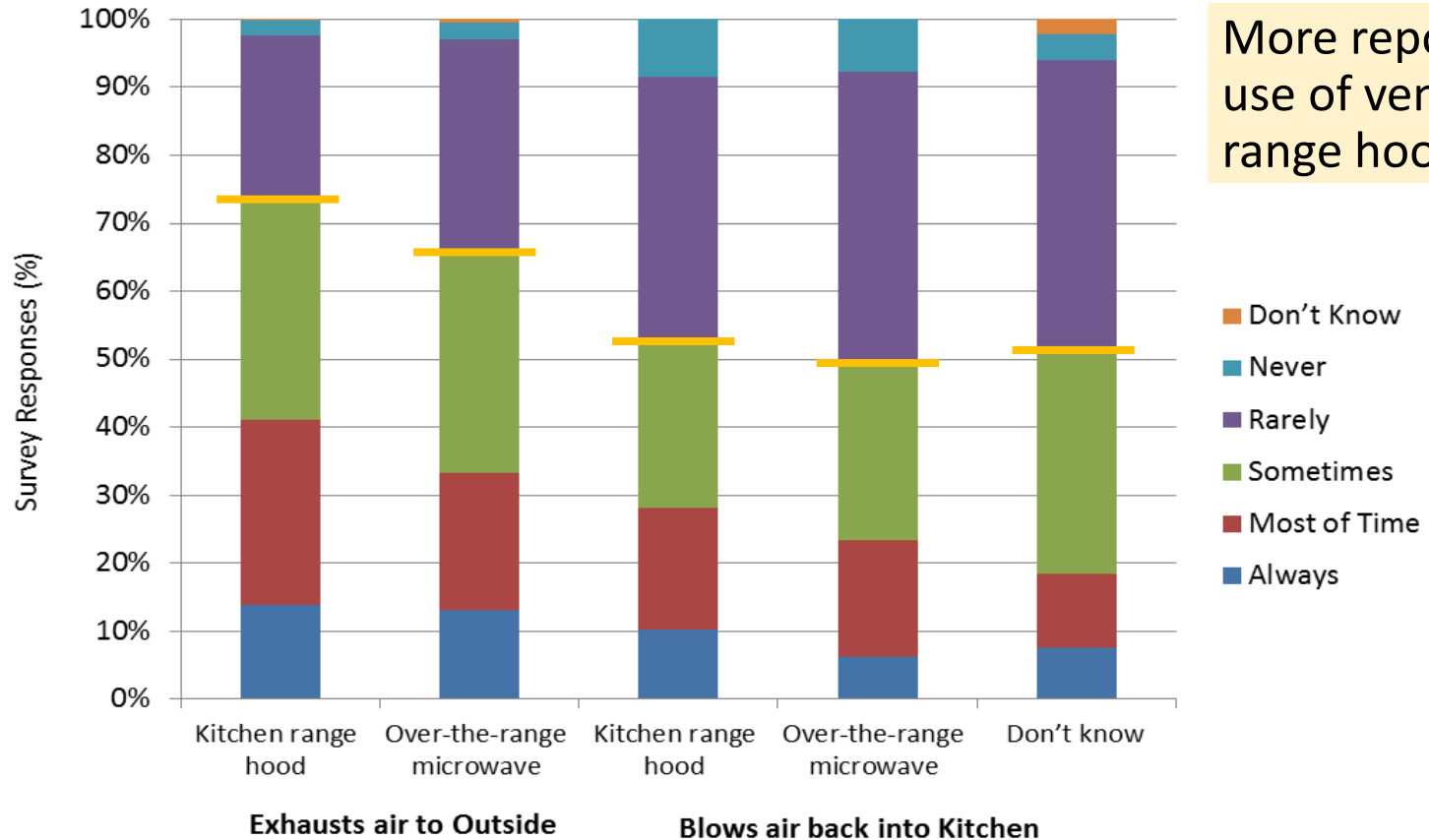
H8: 219 m²

Installed range hoods provided varied levels of exposure reduction
(Kitchen data shown)



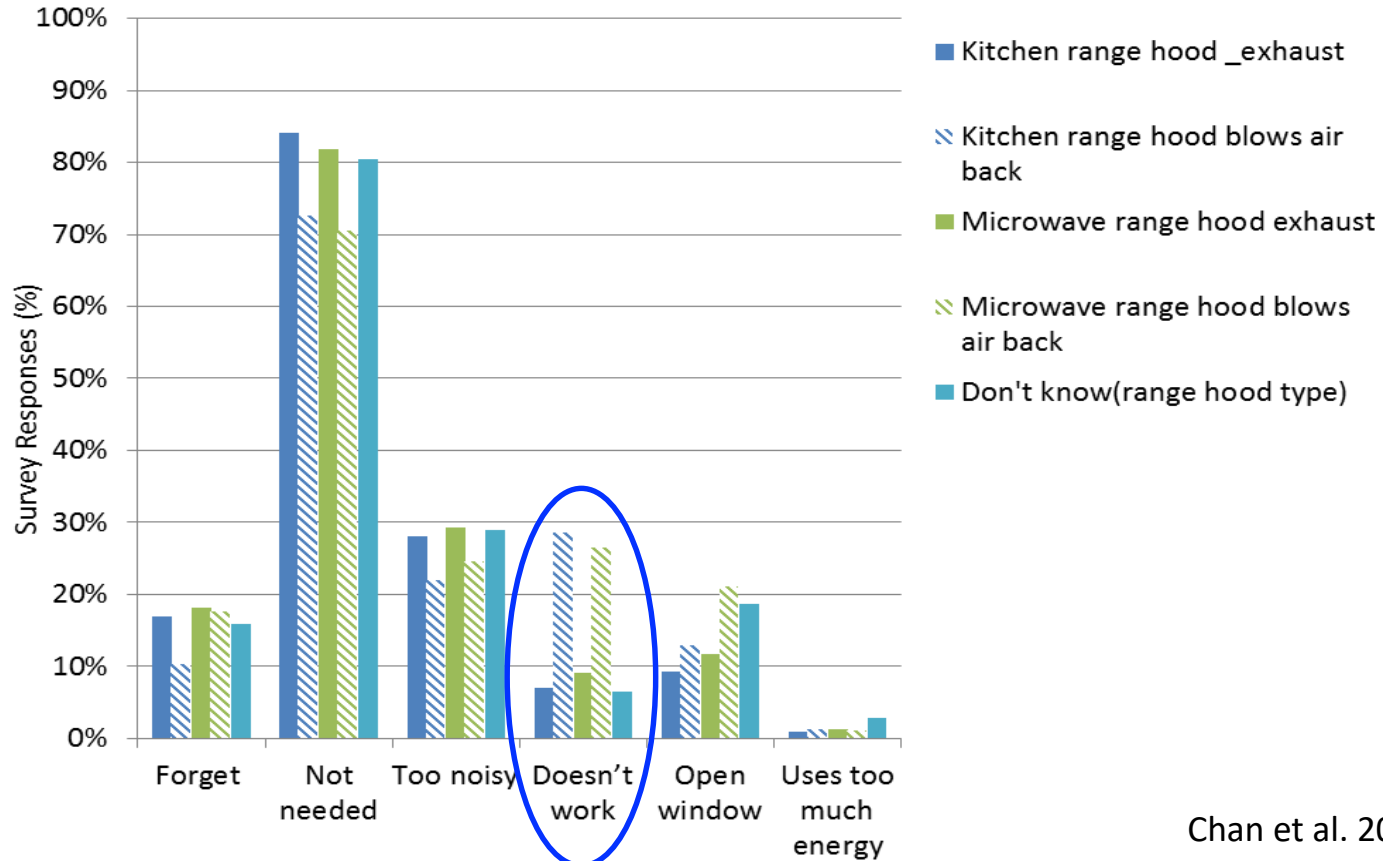
How frequently do you use range hood with cooktop?

Web-based survey of >2000 mostly SoCal homes built 2003-2010



Why do you *not* use your range hood?

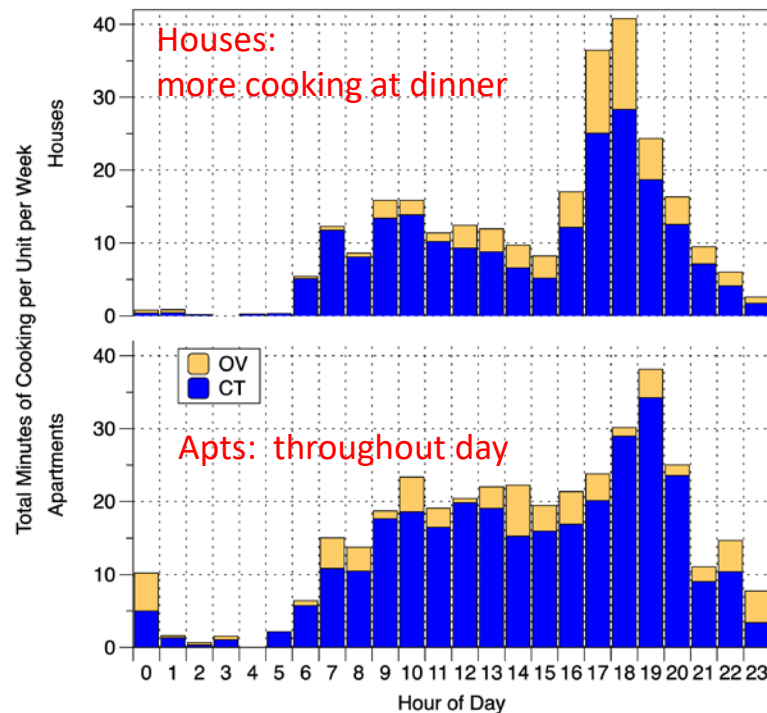
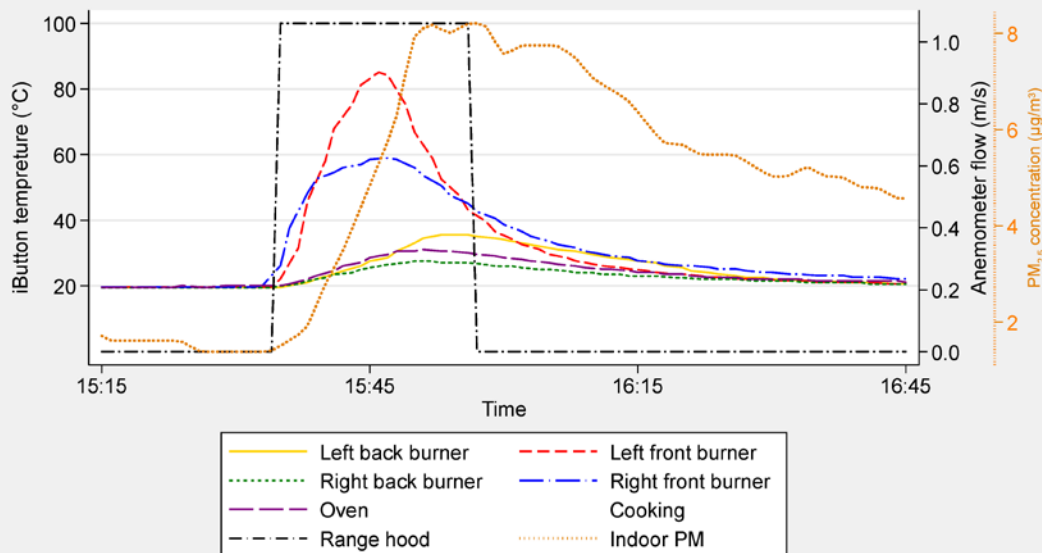
Web-based survey of mostly SoCal homes built 2003-2010



Do people actually use their range hoods as frequently as they claim?

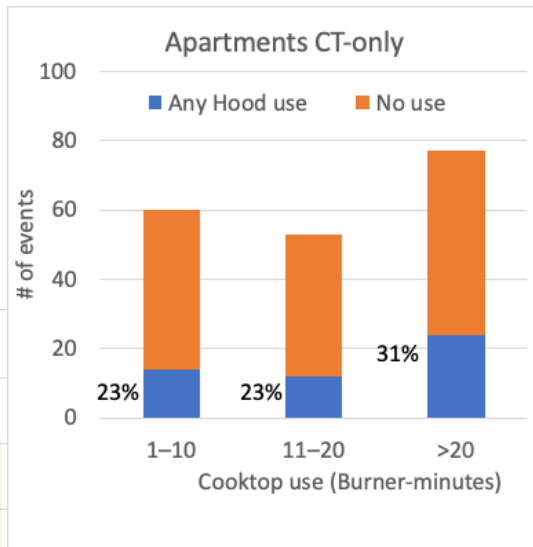
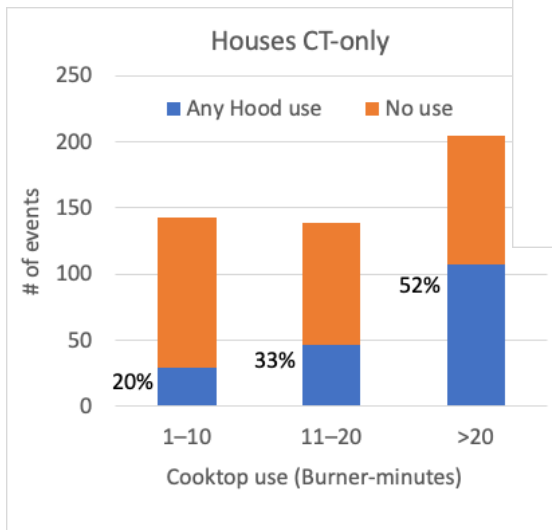
Zhao et al,
[IJERPH](#), 2020

1 week each in 54 houses, 17 apts
All had mechanical ventilation & vented range hoods
Monitored cooking & range hood + activity log

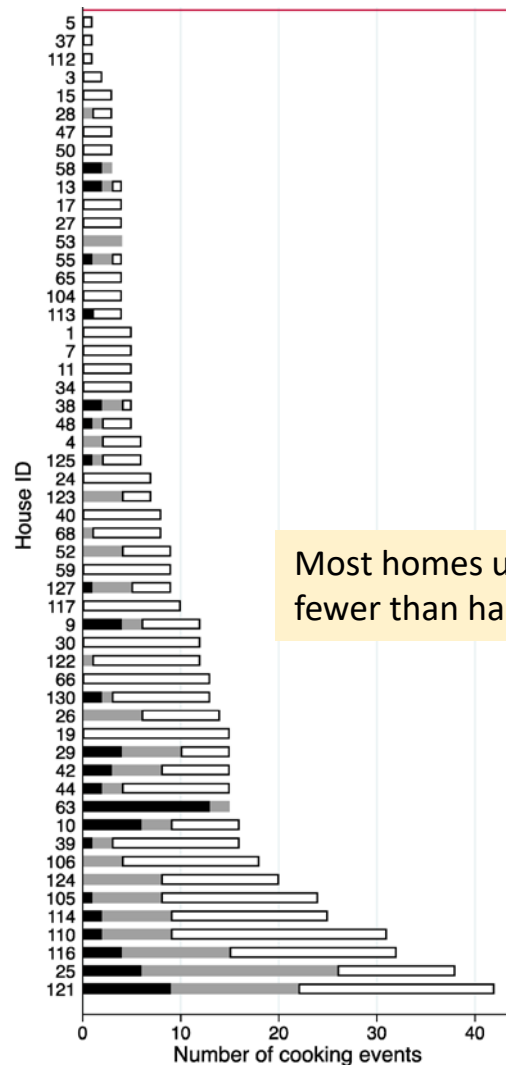


Actual Range Hood Use in California Houses and Low-Income Apartments

Longer cooking event -> range hood use more likely



Use increased with PM emissions in houses, but not apartments.



Most homes used a hood for fewer than half of events.

Residential cooking and use of kitchen ventilation: The impact on exposure

Sun and Wallace,
[J&AWMA](#), 2021

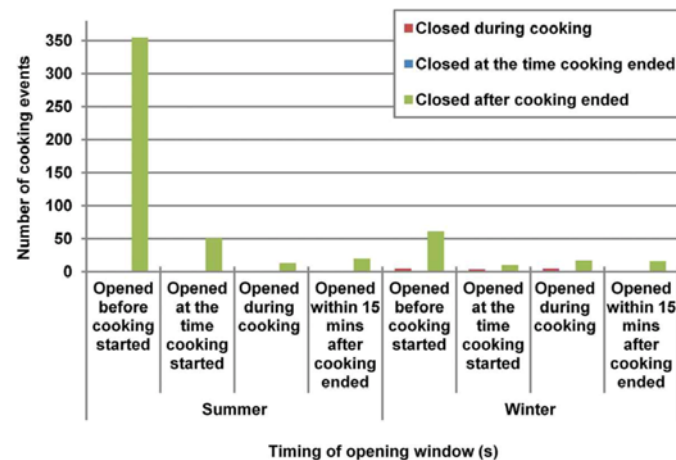
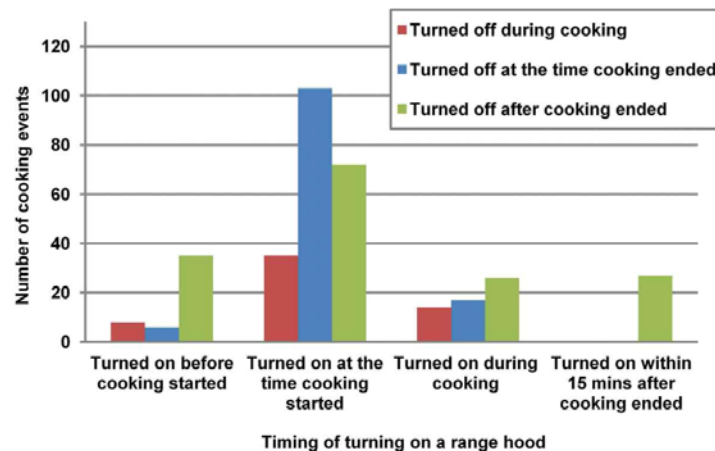
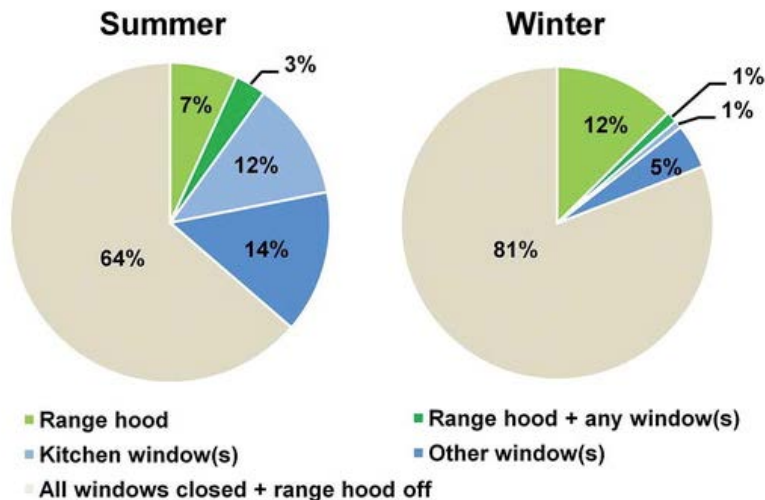
132 homes in Halifax and Edmonton (Canada)

55% vented, 22% unvented, 18% none, 5% unknown

Cooking by daily log; Monitored range hood, windows

2.4 cooking events per day, GM: 17 min

22% of PM from cooking

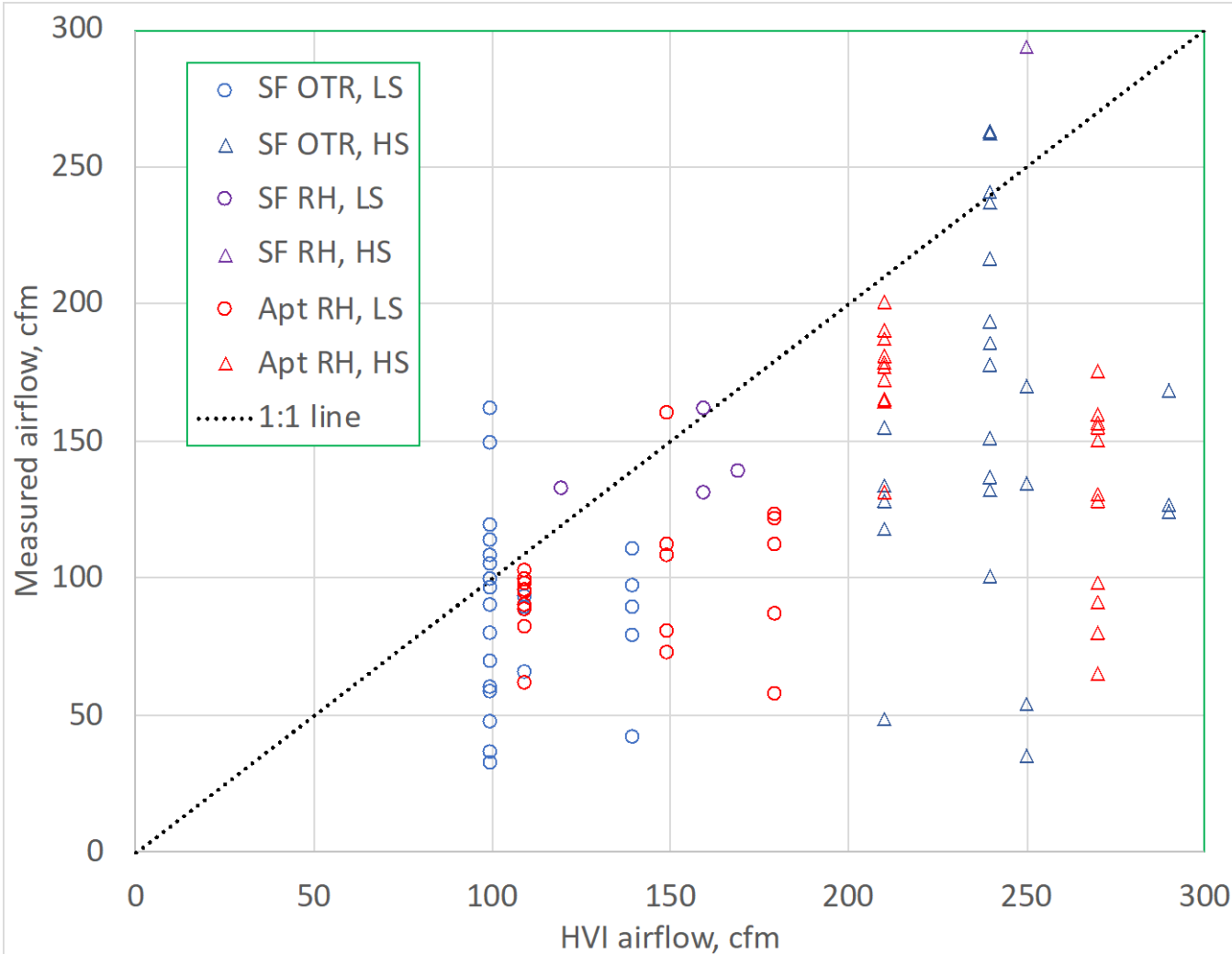


Airflows
measured in
California homes
much lower than
certification test
results.

Why?

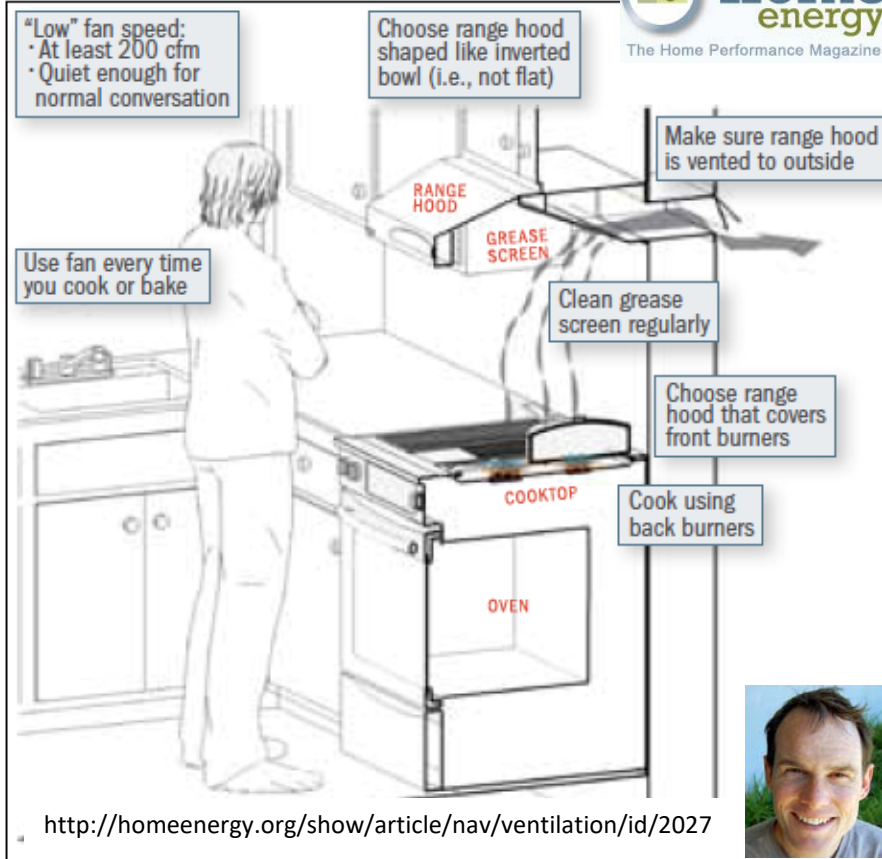
Consistent with static
pressure as installed in
homes being much
higher than test
conditions.

Data from Chan (2020)
and Zhao (2019)



Guidance and Resources

Tips for Increasing Range Hood Efficacy



<http://homeenergy.org/show/article/nav/ventilation/id/2027>

Certified Airflow & Sound Ratings

**CERTIFIED
HOME VENTILATING
PRODUCTS
DIRECTORY**



Certified Ratings in Air Delivery, Sound and Energy for Accurate Specifications and Comparisons
Not Listed = Not Certified

[HVI Product Directory](#)



[AHAM Product Directory](#)

Detailed Guidance & Webinar

<http://rocis.org/kitchen-range-hoods>



Simple Range Hood Guidance

Builder / Contractor

- Low-resistance ducting
- Quiet at 150–200 cfm
- 250 cfm available

User

- Use it, especially for frying & ovens
- Cook on back burner
- Higher settings as needed

Roofer

- Don't drop debris down the vent



Materials (287 g) extracted from RH vent.
Photo & arrangement: M. Lunden

Summary

- **Venting** range hoods **can** effectively capture cooking and burner particles.
- Capture efficiency varies by airflow, front vs. back burners, form factor.
- Capture for cooking particles can be lower than combustion gases.
- Over the range microwaves perform similarly to common range hoods.
- Many installed range hoods measured by LBNL performed worse than rated.
- Range hoods not used routinely and much less than people claim.
- Standard method for capture efficiency: Certified products coming soon
- Automatic range hood coming soon! LBNL testing indicated it works well.
- Need more studies of effectiveness for exposure reduction and health improvements when used as an intervention.

Thanks to the best colleagues ever!



Questions?

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- Zhao et al. 2020. Indoor air quality in new and renovated low-income apartments with mechanical ventilation and natural gas cooking in CA. *Indoor Air*. [\[Journal Link\]](#)

Datasets

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Extra Slides

Goal

Venting range hood in all homes,
required by code

Effective for front burners
Quiet at 200+ cfm
Automatic

Use with frying, bake, broil, meals;
Cook on back burners

Effectiveness confirmed with home
IAQ monitors

Reality

Above the stove venting not required in
most building codes, absent from many
homes; renters especially vulnerable

Large & quiet both exist; rarely together.
Quiet @150-200 cfm and >250 cfm \$250+
Auto hood coming to market

Variable use; as need is perceived
Most cook on front; use less with oven

\$200 monitor not accessible to
many