# Kitchen Ventilation Should be High Performance (not Optional)

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# Acknowledgements

PROGRAM SUPPORT

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•U.S. Environmental Protection Agency – Indoor Environments Division

•U.S. Department of Housing and Urban Development – Office of Healthy Homes & Lead Hazard Control

•California Energy Commission – Public Interest Energy Research Program

TECHNICAL CONTRIBUTIONS

•Woody Delp, Tosh Hotchi, Melissa Lunden, Nasim Mullen, Chris Stratton, Doug Sullivan, Iain Walker

# Kitchen Ventilation Simplified

PROBLEM:

- Cooking burners & cooking produce odors, moisture and pollutants

SOLUTION:

- Install and use extra exhaust ventilation in kitchen

OPTIMAL SOLUTION:

- Effective, low-energy and quiet range hoods that operate automatically as needed

# What do we want from our range hoods?

- Remove smoke as needed
- Enhance kitchen aesthetics
- Remove odors & moisture
- Affordable

- Remove pollutants from burners and cooking
- Quiet, low-power operation
- Automatic operation

# What do we NOT want?


- Fire
- Noise
- Maintenance
- Bad aesthetics

- Higher energy bills
- Depressurization-induced backdrafting of natural draft appliances

# Pollutants from burners and cooking

- Gas burners
  - Moisture & $CO_2$
  - $NO_2$ and formaldehyde
  - Ultrafine particles & CO
- Electric elements
  - Ultrafine particles
- Cooking
  - Ultrafine and fine particles
  - VOCs including acrolein
  - Moisture and odors


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BERKELEY NATIONAL LABORATORY

Experimental Evaluation of Pollutant Emissions From Residential Appliances
Singer et al., LBNL-2897E

Dennekamp, Occup Environ Med 2001; 58:511–516


ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Compilation of PM2.5 Emission Rates for Cooking and Candles…
Hu et al., LBNL-5890E

# The pollutant thing is a serious issue!

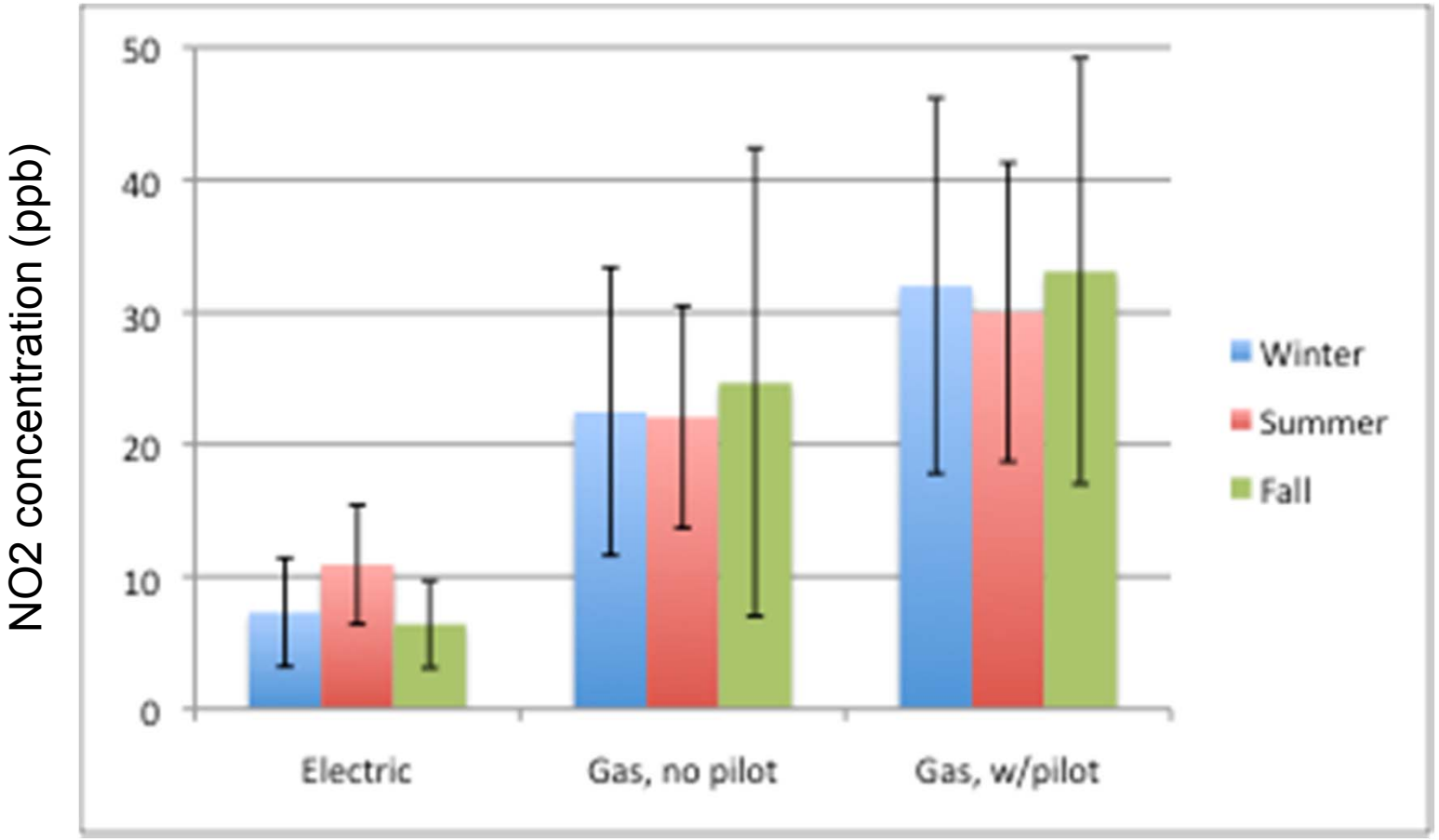
**Cooking burners backdraft and spill 100% of the time!**

Among homes that cook with gas & don't use range hood*:

- 55-70% exceed $NO_2$ 1-h standards
- 27% exceed formaldehyde 1-h guidelines
- 8% exceed CO 1-h and 8-h standards

*Results of a physics-based simulation model applied to a representative sample of Southern California households. Details in manuscript submitted to Environmental Health Perspectives by Logue et al.

# Higher $NO_2$ in homes with gas cooking MEASUREMENTS




Lee et al., JA&WMA 1998, 517 homes total; 417 homes all 3 seasons

EPA annual standard is 53 ppb

# Range hoods can help!

Under cabinet

Microwave

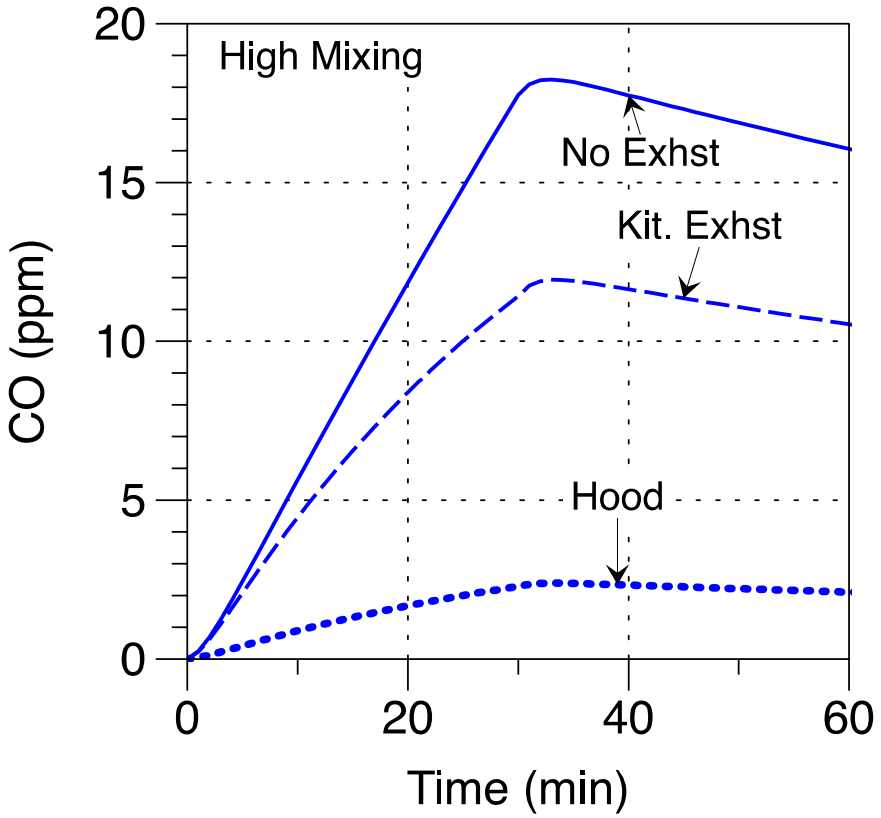
Chimney

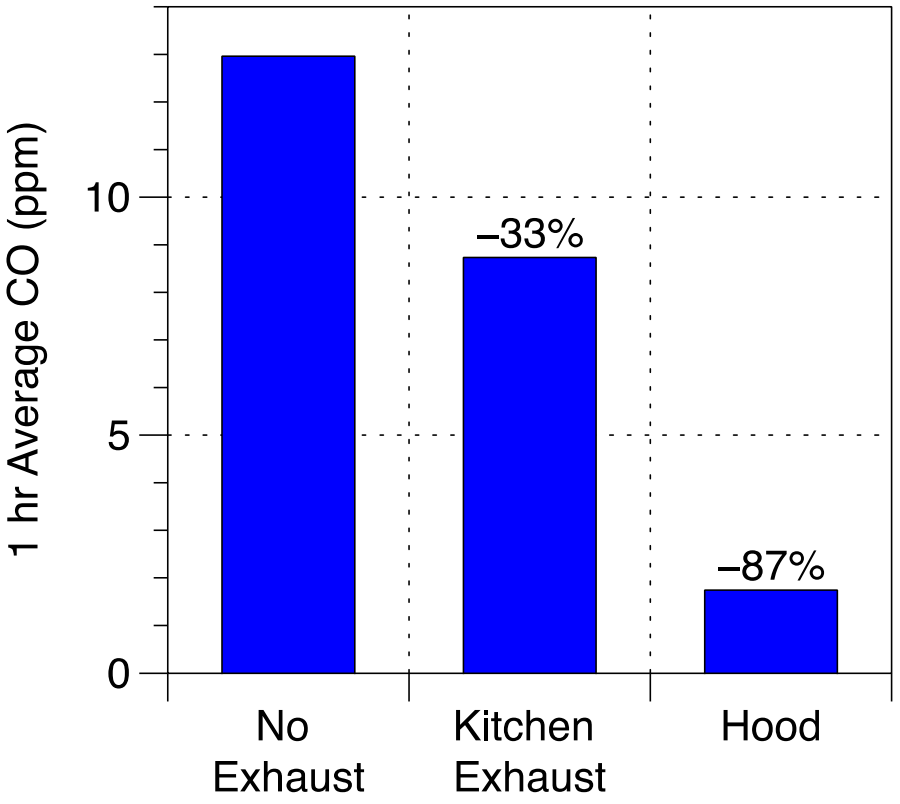
Downdraft*

# Range hoods better than general kitchen

## 200 cfm range hood or kitchen exhaust (simulations)

CO concentration throughout the **home**: **OPEN FLOOR PLAN**




15,000 btu/h
800 ng/J CO

# Current performance standards

ASHRAE
Advancing HVAC&R to serve humanity and promote a sustainable world

100 cfm range hood or 5 kitchen ach

≤ 3 sones

HVI
HOME VENTILATING INSTITUTE

Guidelines (30” range)

- Minimum 40 cfm / ft = 100 cfm
- Recommend 100 cfm / ft = 250 cfm

Ratings

- Airflow at 0.1” static P
- Sound (sone)

energy
ENERGY STAR

≥ 2.8 cfm / W

≤ 2 sone

< 500 cfm

# What's missing?

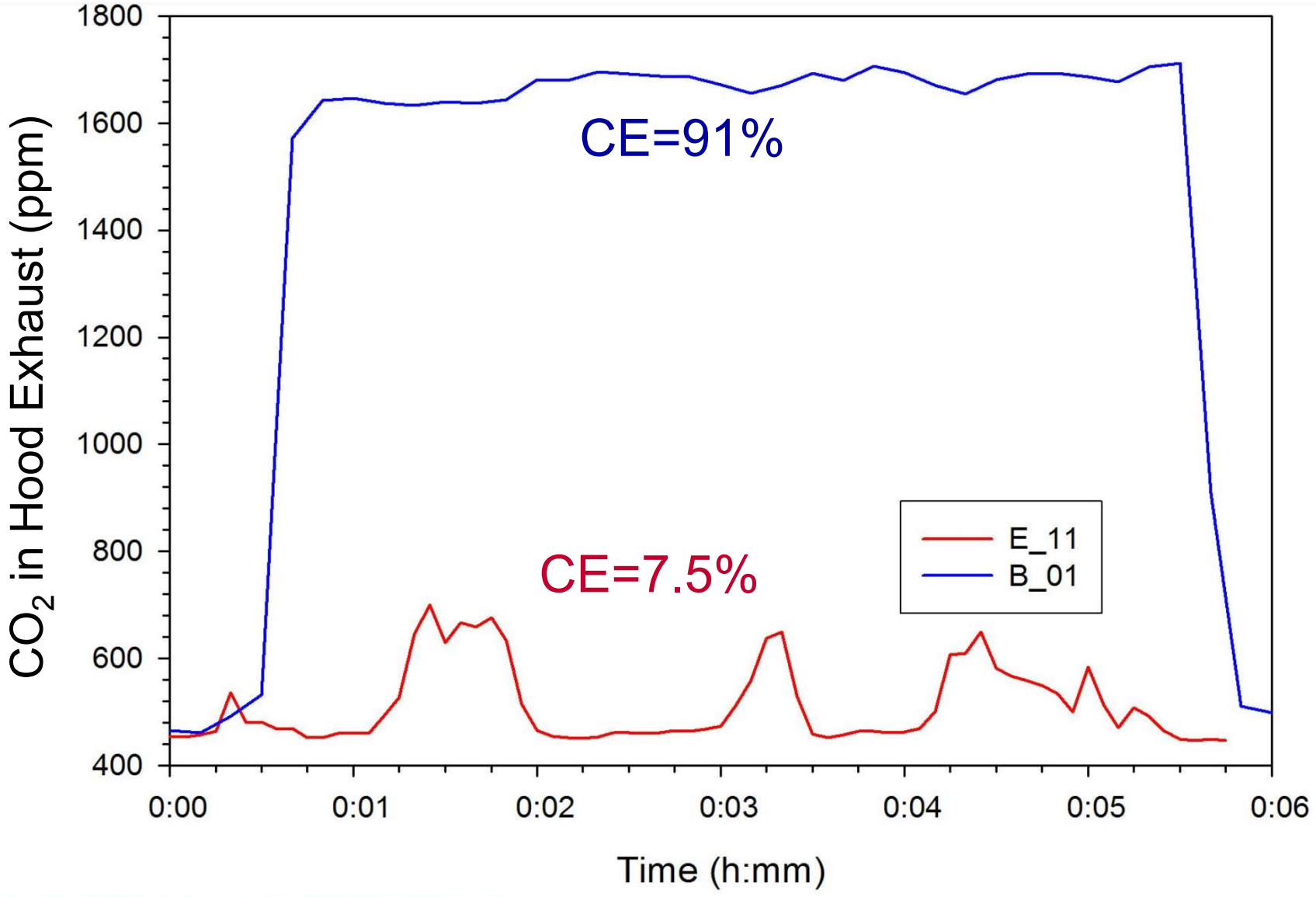
- CAPTURE EFFICIENCY
  - Fraction of emitted pollutants removed by hood
  - May differ for burner and cooking

# Measure capture efficiency using $CO_2$

- Emission rate based on fuel $CH_4$ ➔ $CO_2$
- Measure concentration in hood exhaust and room
- Separately measure flow in hood exhaust

$$CE = \frac{removal}{production} = \frac{Q_{air}\left(CO_{2-hood} - CO_{2-room}\right)}{Q_{fuel}\left(C\ in\ fuel\right)}$$

# Measure capture efficiency using $CO_2$



# Range Hood Performance Evaluation

## Laboratory

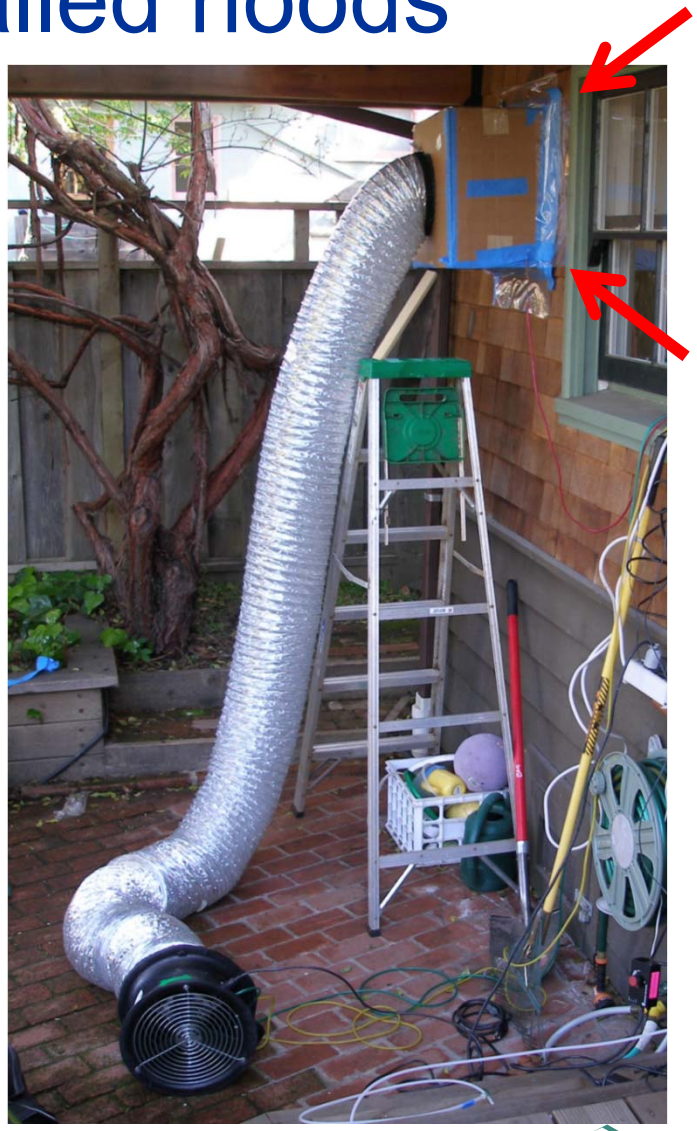
- Selected sample
- New, no wear
- Standard height(s)
- Control, vary pressure
- Measure airflow vs. system pressure
- Measure CE vs. flow
- Sound pressure (dB)
- Power (W)

## In home

- Opportunity sample
- Used, uncertain wear
- As installed height and system pressure
- Measure airflow and CE at each setting
- Sound pressure (dB)

# Measuring airflow of installed hoods

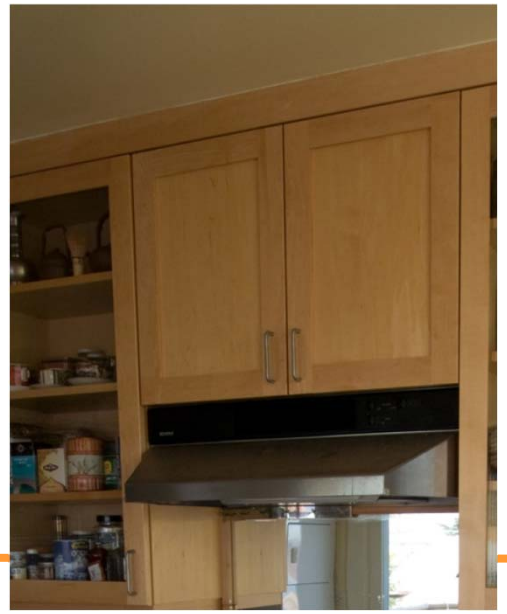
Routine set-up



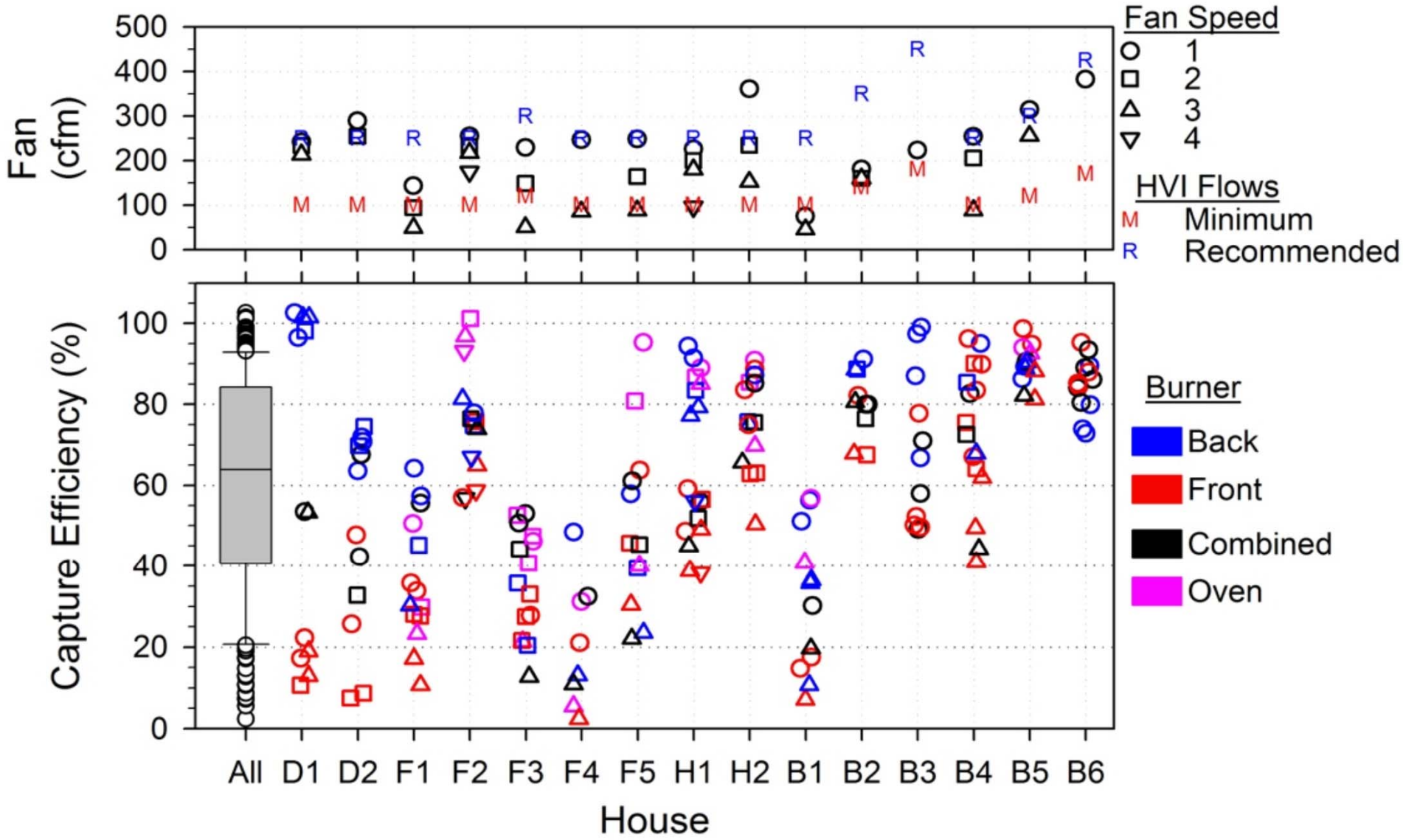
Special set-up

# In-Home Performance Study

- 15 devices
  - 2 downdraft
  - 2 microwaves
  - 3 no-hood hoods
  - 2 hybrid
  - 6 open
- Cooktops
  - Pots with water
  - Front, back, diagonal
- Ovens
  - 425 F, door closed
  - Cool between tests



# In-Home Performance Results



# Laboratory Performance Study

- 7 devices
  - L1: Low-cost hood, $40
  - B1: Basic, quiet hood, $150
  - A1: 62.2-compliant, $250
  - E1: Energy Star, $300
  - E2: Energy Star, $350
  - M1: Microwave, $350
  - P1: Performance, $650

Measurements:

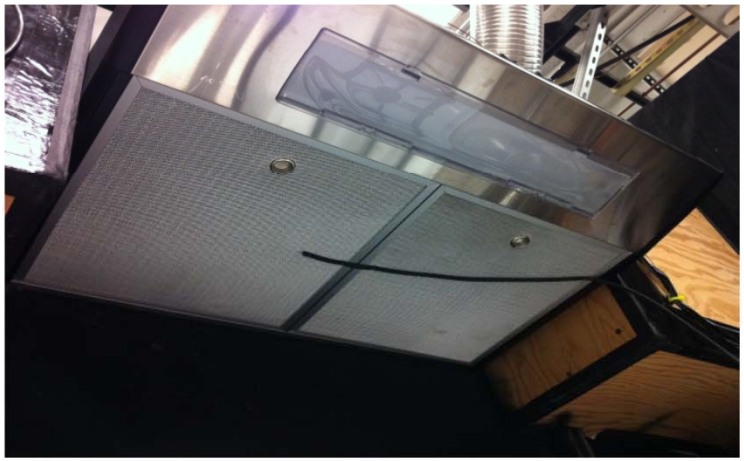
- Fan curves (flow vs. P)
- CE for varied flows
  - Vary duct P, fan setting
- Power and efficacy

# Lab Performance Study

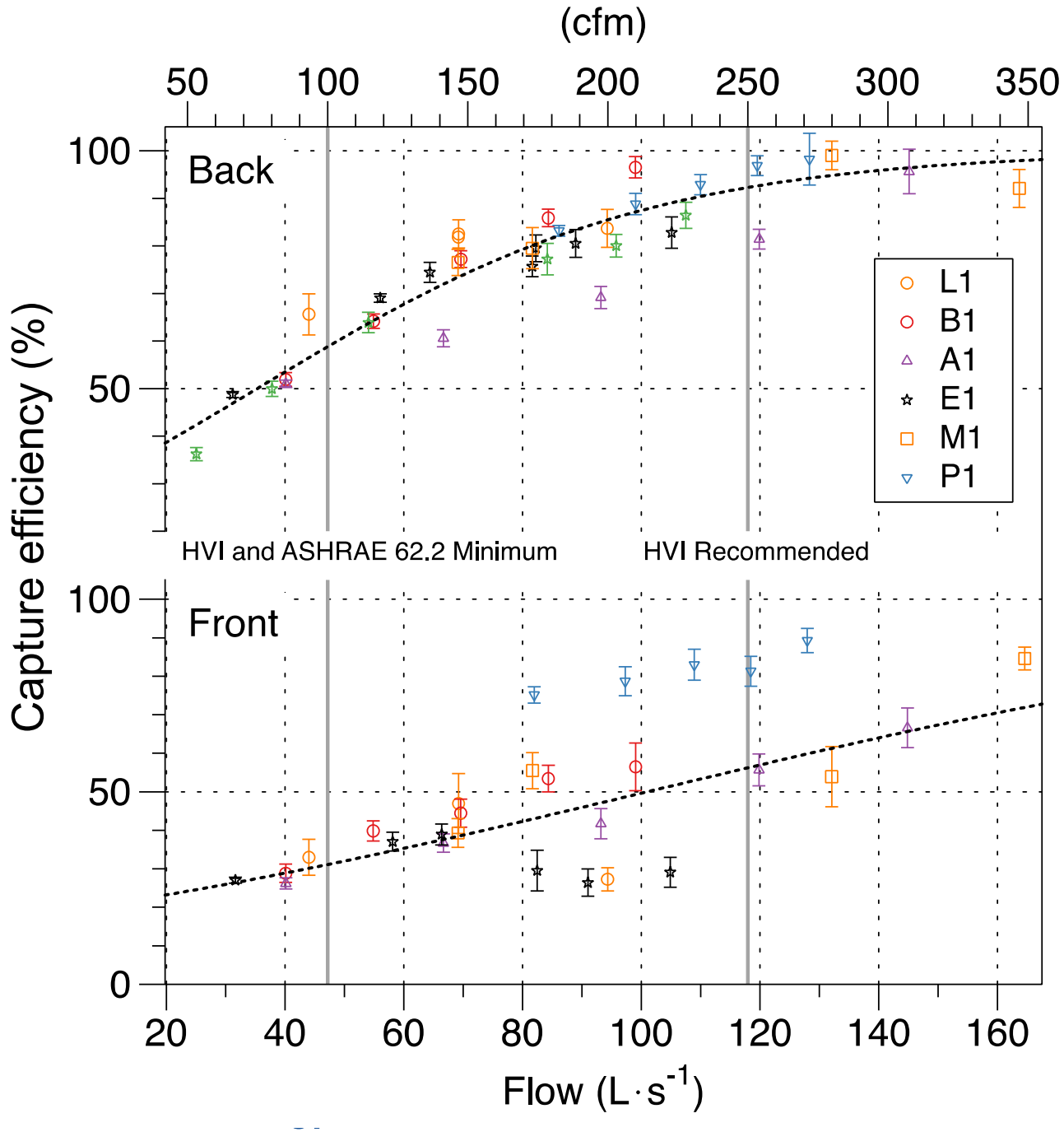
A: Microwave

B: Shallow capture hood

C: Deep hood; grease collection on plate, no screens.



D: Energy Star: no hood




# Capture Efficiency Results

- 100 cfm
  - 60% back
  - 30% oven, front
- 200 cfm
  - >80% back
  - 40-80% oven
  - 25-80% front

BERKELEY LAB

# What we have learned about performance

- Installed airflows often below advertised
- Capture efficiency varies from terrible to great
- Sensitivity to duct pressure also varies
- Capture much better for burners under hood
- Roughly 200 cfm needed for >80% capture
- Reducing airflow better than fan efficacy for energy
- Automatic devices available, some are promising
- USE BACK BURNERS

# What we still need to figure out…

- How does capture efficiency for cooking related pollutants relate to capture of burner exhaust?
  - How does this vary by hood design & downdraft?
- What are installed system pressures? Should tests for airflow and capture ratings use higher duct static P?
- How to provide effective ventilation in retrofits
  - Is there a role for better engineered recirculating hoods, perhaps linked with other ventilation?

# Some parting thoughts….

- Many US homes current don't have venting range hoods
  - Varies by building era, type and region of U.S.
- Many of the installed hoods are ineffective
- A minority of households use kitchen ventilation routinely
  - 25-40% of survey volunteers in CA (likely high)
- Do we need to require automatic operation?
  - Are we satisfied with leaving it to the user?
  - Will quieter products and education lead to more frequent use?

# Questions?

<u>Contact info and resources:</u>

bcsinger@lbl.gov

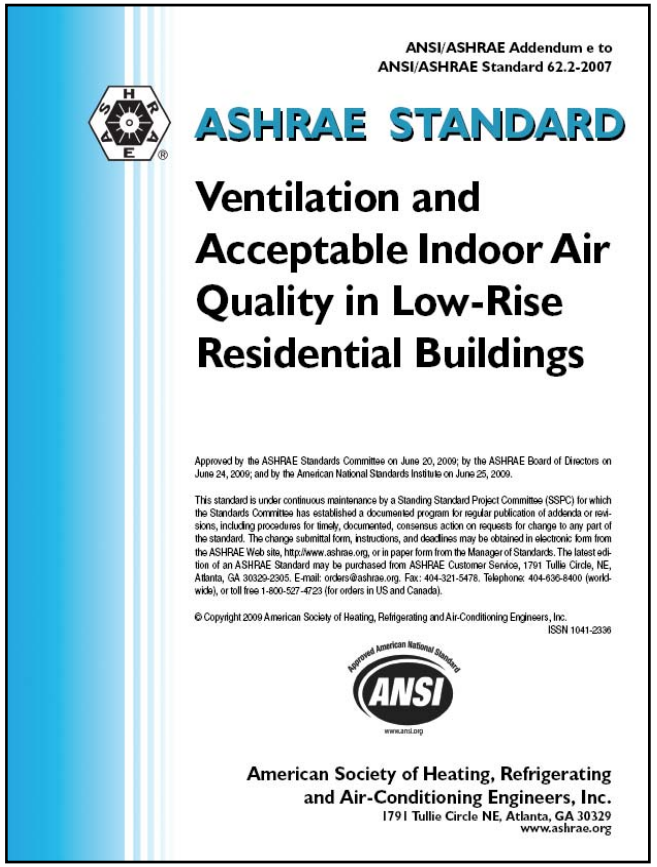
homes.lbl.gov/publications

# Extra Slides

- The following slides are included for potential use in Q&A

# ASHRAE 62.2 standard for residential IAQ

"... air toward which a substantial majority of occupants express no dissatisfaction with respect to odor and sensory irritation and in which there are not likely to be contaminants at concentrations that are known to pose a health risk."



ANSI/ASHRAE Addendum e to
ANSI/ASHRAE Standard 62.2-2007

ASHRAE STANDARD

Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings

Approved by the ASHRAE Standards Committee on June 20, 2009; by the ASHRAE Board of Directors on June 24, 2009; and by the American National Standards Institute on June 25, 2009.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).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ANSI
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American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

# Ventilation characteristics

| | |
|---|---|
| General or Local | Passive or Mechanical |
| Manual or Automatic | Continuous or Intermittent |

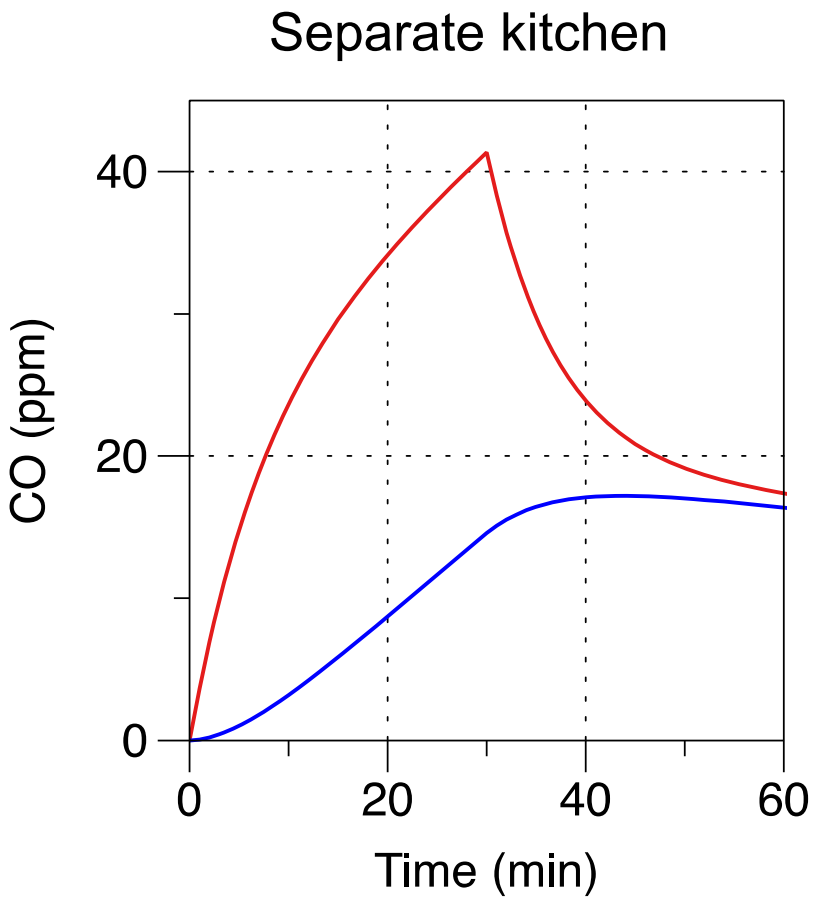
# Combustion appliance hazards depend on several factors

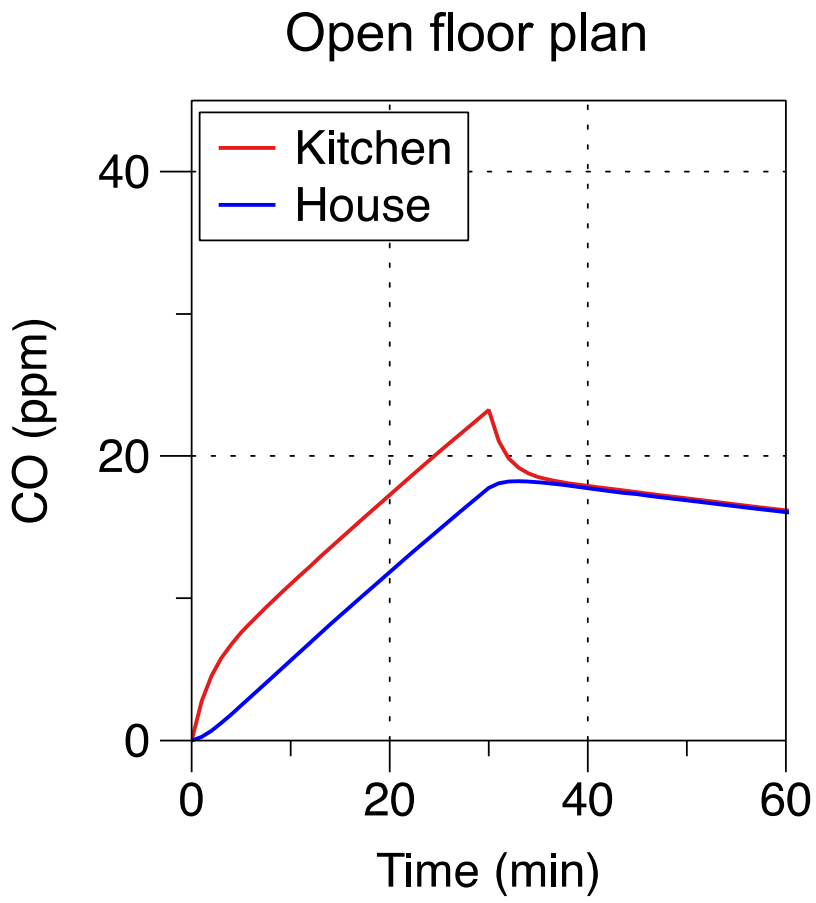
- Fraction of exhaust entering home
- Pollutant concentration in exhaust (emission rate)
- Burner size & frequency of use
- Proximity to people

# Cooking without ventilation

## Simulate 1200 ft$^2$ house, 200 ft$^2$ kitchen

15,000 btu/h
800 ng/J CO



# Impact of ventilation

## 200 cfm range hood or kitchen exhaust

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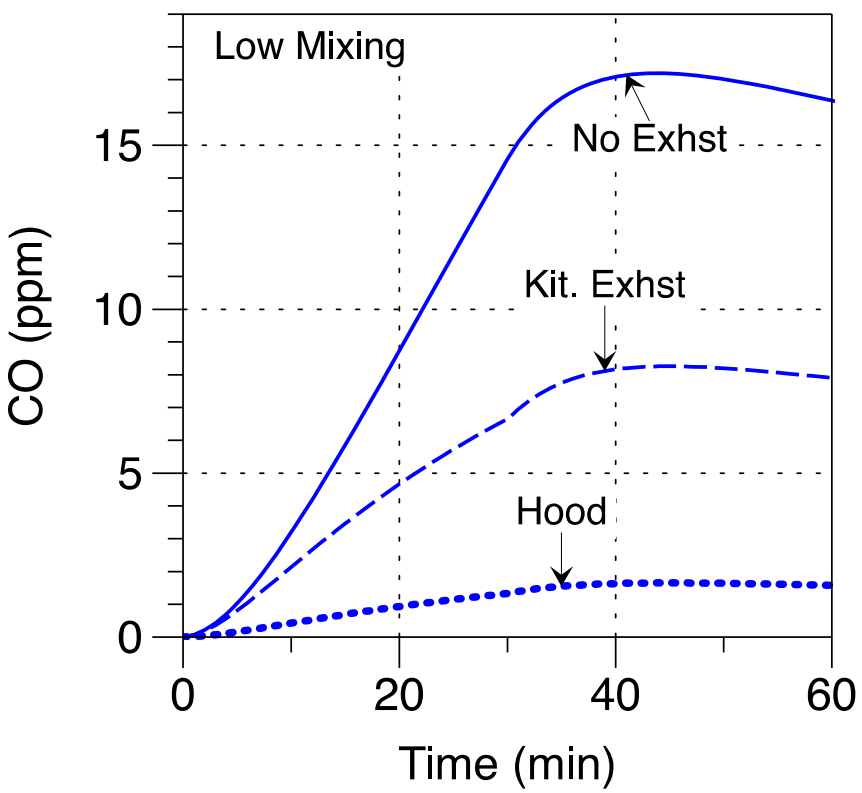
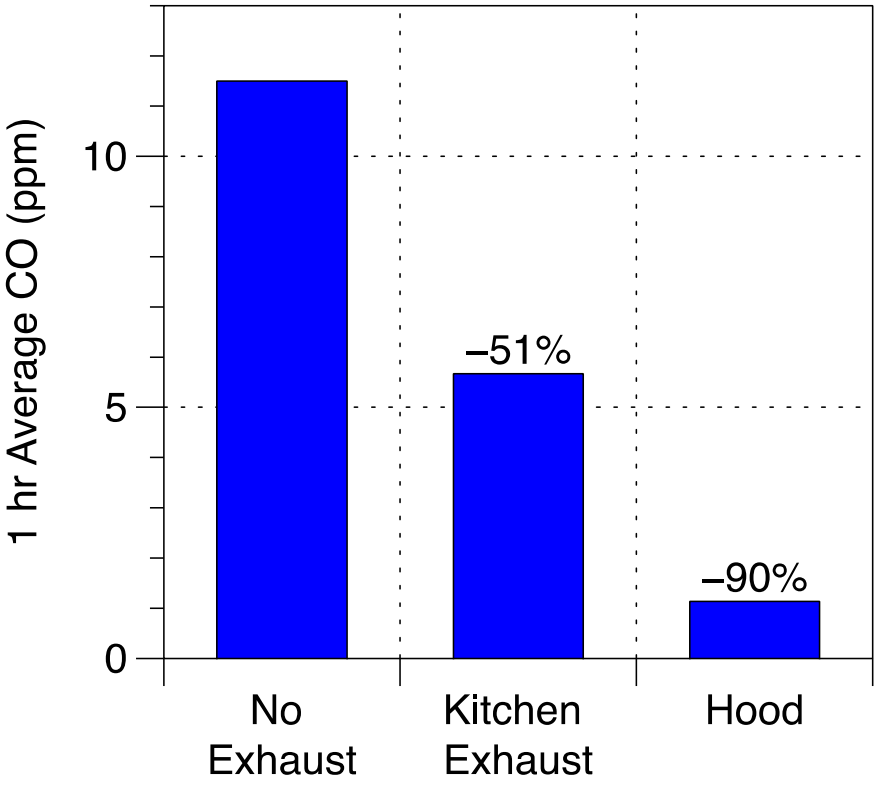
800 ng/J CO

CO concentration throughout the **home**: **SEPARATE KITCHEN**



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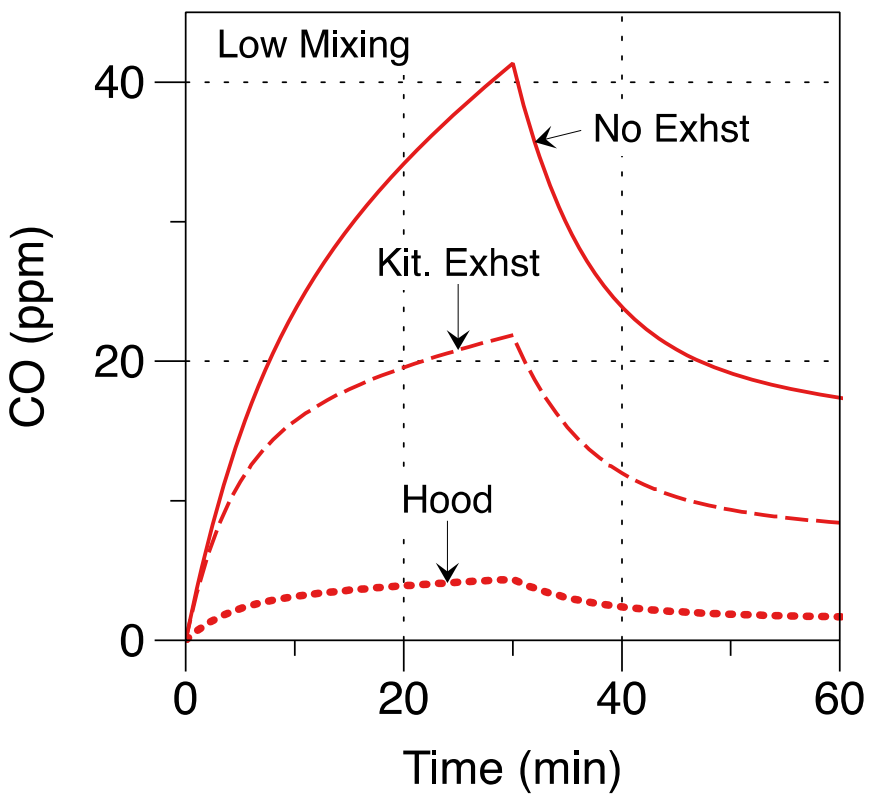
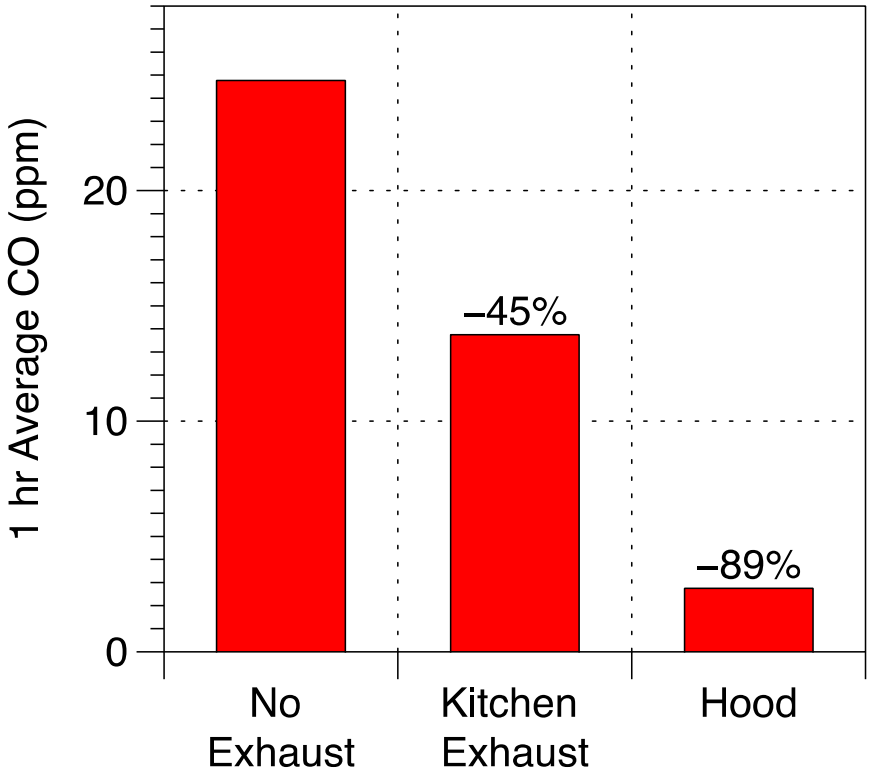
CO concentration in the **SEPARATE KITCHEN**



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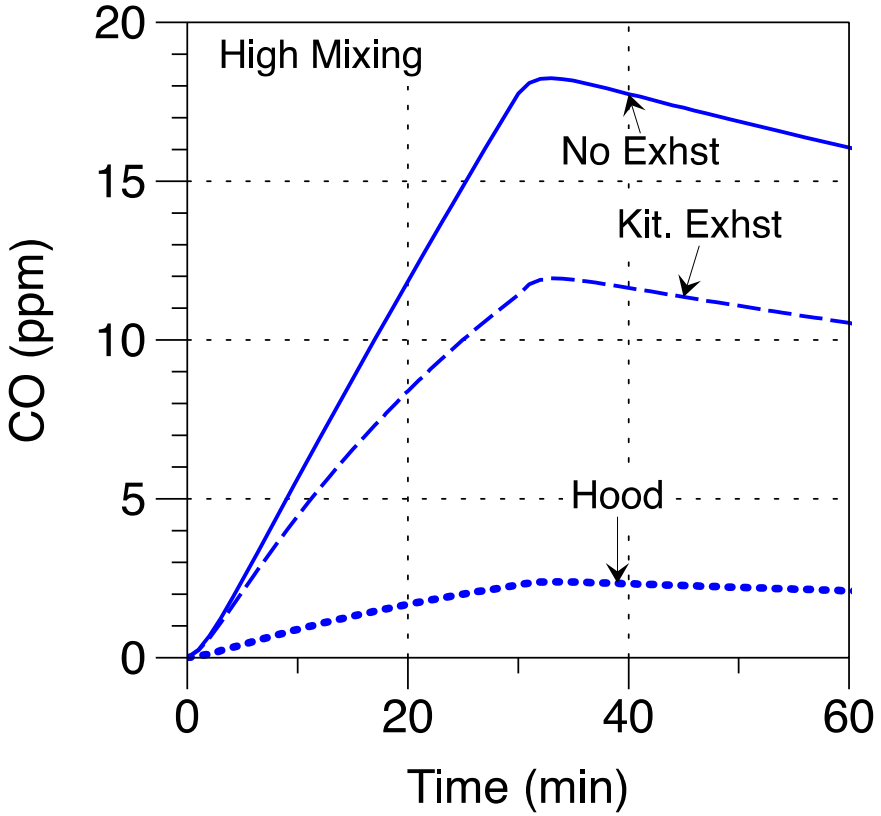


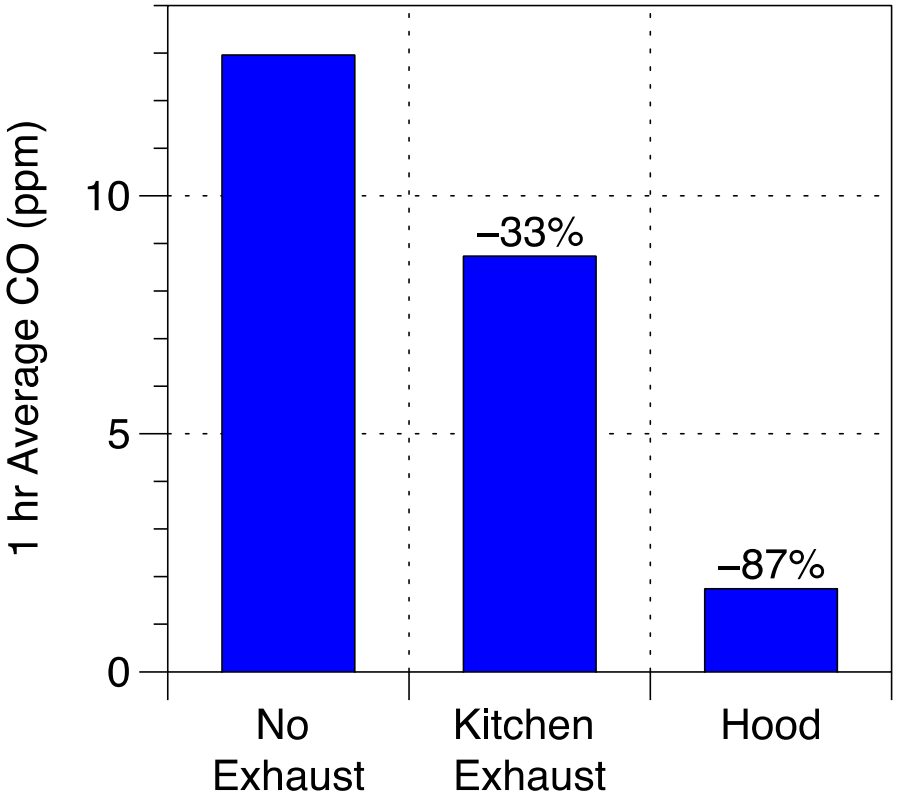

# IAQ hazards from gas appliances

| |  |  | |  |  |
|---|---|---|---|---|---|
| Exhaust into home | Always | Always, less w/range hood | | Cracked H.E. or Backdraft | Backdraft |
| Carbon monoxide | Relatively common | Relatively common | | Uncommon | Uncommon |
| Nitrogen dioxide | Common | Common | | Not enough data | Rare |
| Particulate matter | Rare | Rare | | Rare | Extremely rare |
| Burner kbtu/h | 10-40 | 5-30 | | 10-50 | 30-100 |
| Use | Hours each day | 5-40 min, 1-3x daily | | Hours each day | 5-30 min, hours daily |
| Proximity | Usually close | Usually close | | Usually close | Varies |