BERKELEY LAB
LAWRENCE BERKELEY NATIONAL LABORATORY
U.S. DEPARTMENT OF ENERGY

Cooking, Health and Kitchen Ventilation

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Building AMERICA
U.S. Department of Energy

Both food and & heat sources generate pollutants

Methane

Particles

NO_2 (and NO),
CO, Aldehydes

CO_2 & H_2O

Electric

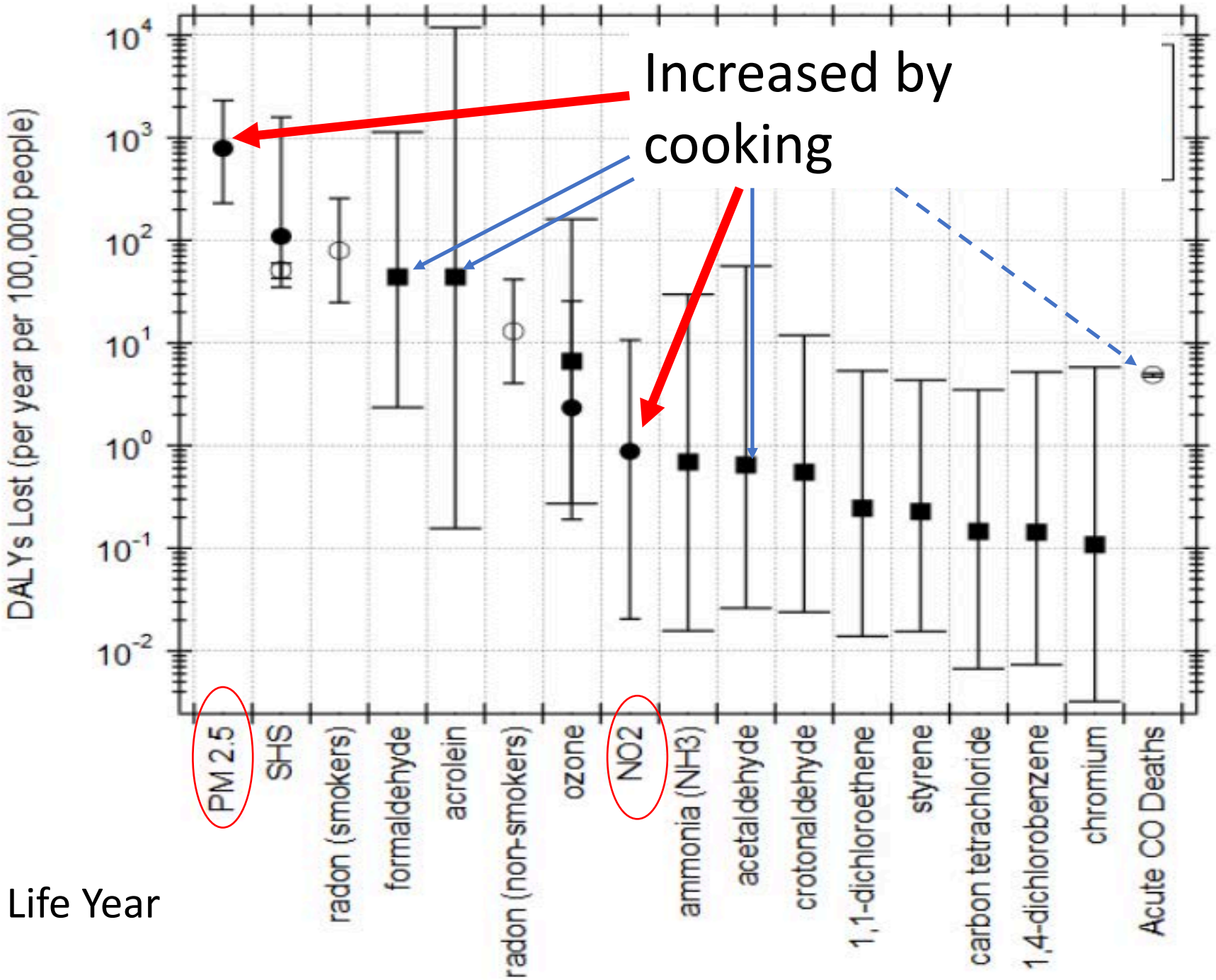
Particles

Food

Particles, Formaldehyde, Acetaldehyde, Acrolein,

H_2O, Odors

Critical contaminants related to health are emitted by cooking



DALY = Disability Adjusted Life Year

Background to kitchen ventilation studies

Well-established connection between children's health and gas cooking (see bibliography)

- Primarily NO_2

Well-established connections between PM2.5 and health

WHO, EPA etc. give limits for these contaminants

- 100 ppb for NO_2 over 1 hour
- 25 microgrammes/m3 for PM2.5 over 24 hours

How well do kitchens need to be vented to keep these contaminants below health thresholds?

Measurements in homes

Cooking and range hood monitoring

Monitor cooktop and oven use with iButton temperature sensors

Monitor range hood (RH) use with anemometer

IAQ Monitoring

Time-resolved IAQ

Formaldehyde

$PM_{2.5}$

$PM_{2.5}$, CO_2 T, RH*

NO_2

UFP

Time-integrated

$PM_{2.5}$

NO_x

Formaldehyde

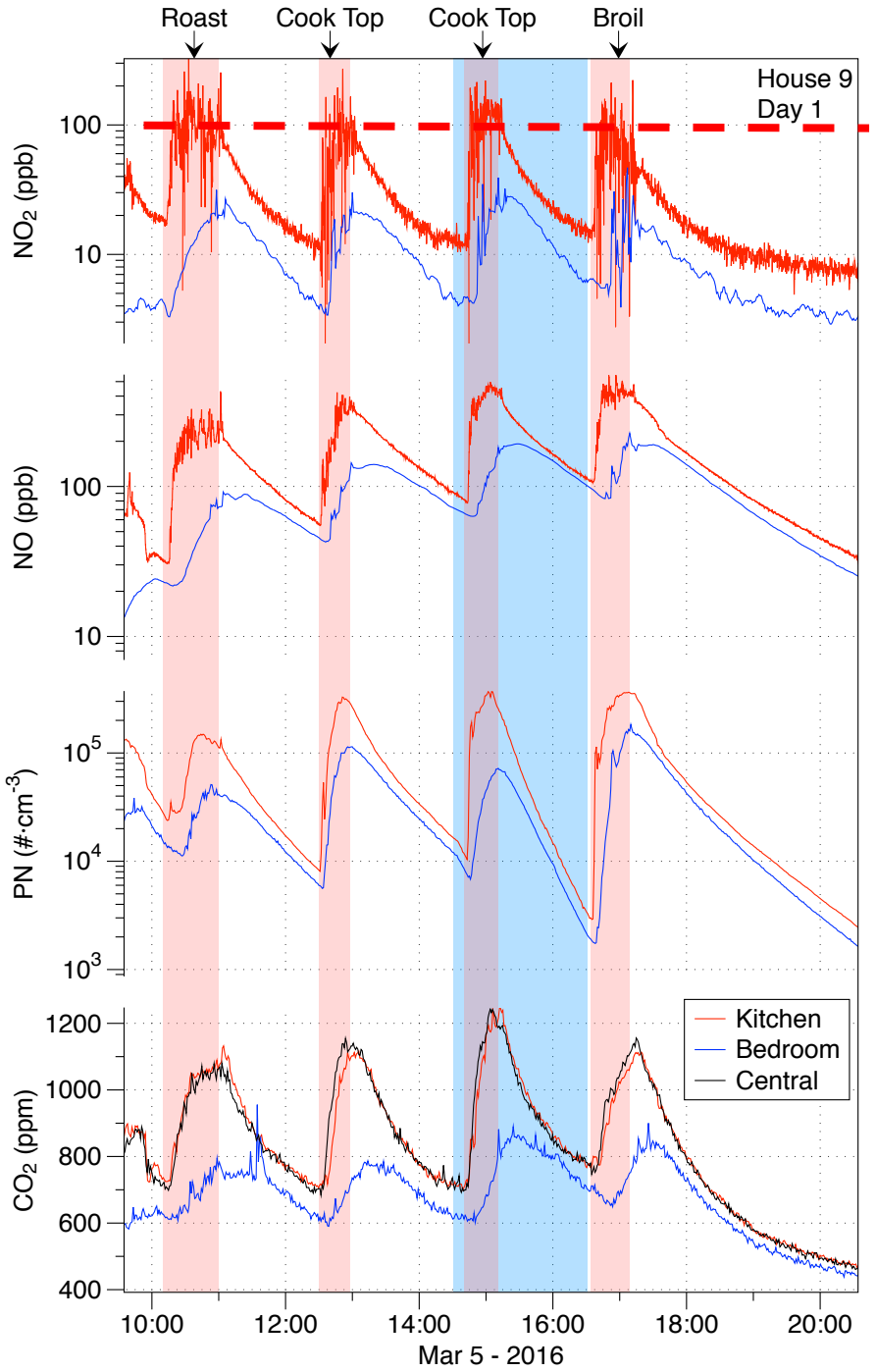
Concurrent Outdoor Monitoring

* Monitored at two locations: central area, bedroom

Scripted cooking with gas

NO_2 in kitchen exceeds ambient Air Quality threshold value

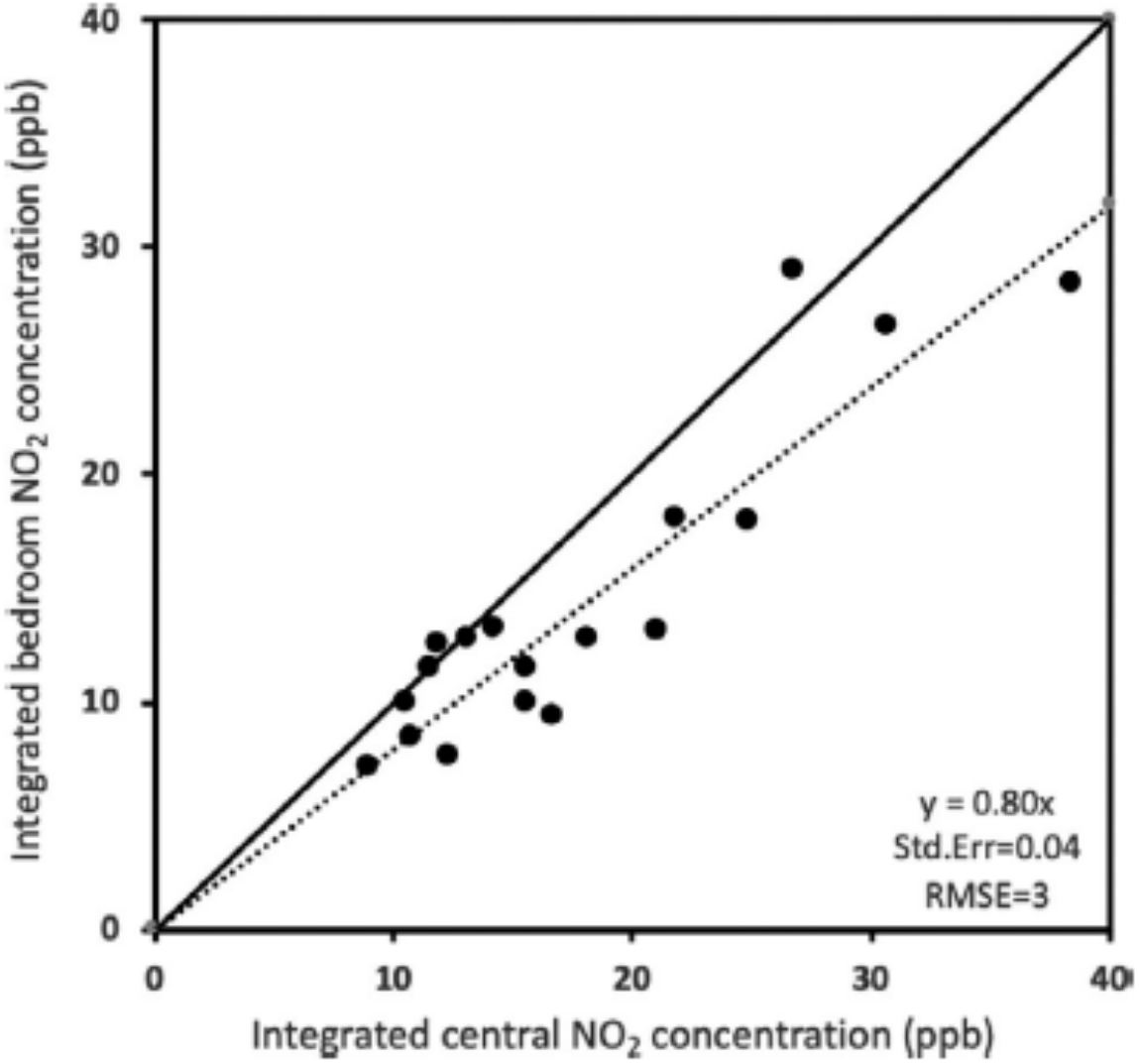
4 of 9 homes had kitchen NO_2 exceed 100 ppb over 1h



NO_2 >100 ppb in kitchen

Singer et al., 2017, Building Environment

Does NO_2 just stay in the kitchen?



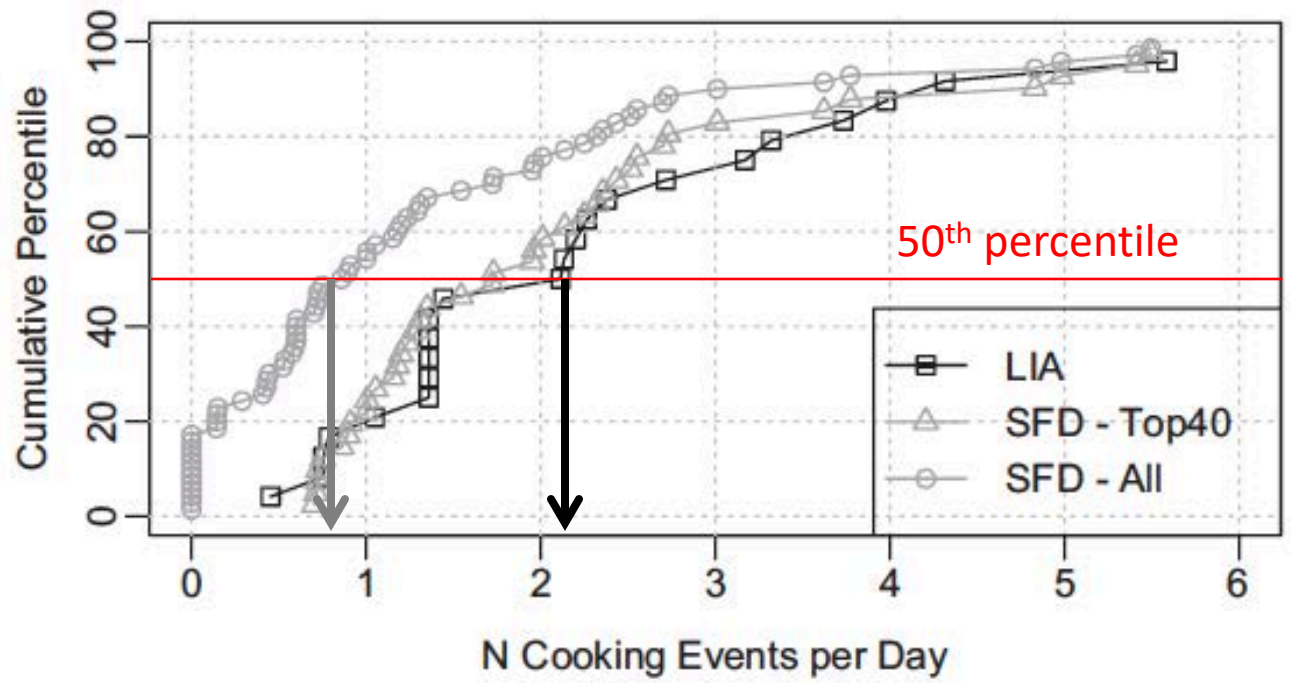
No it does not…..

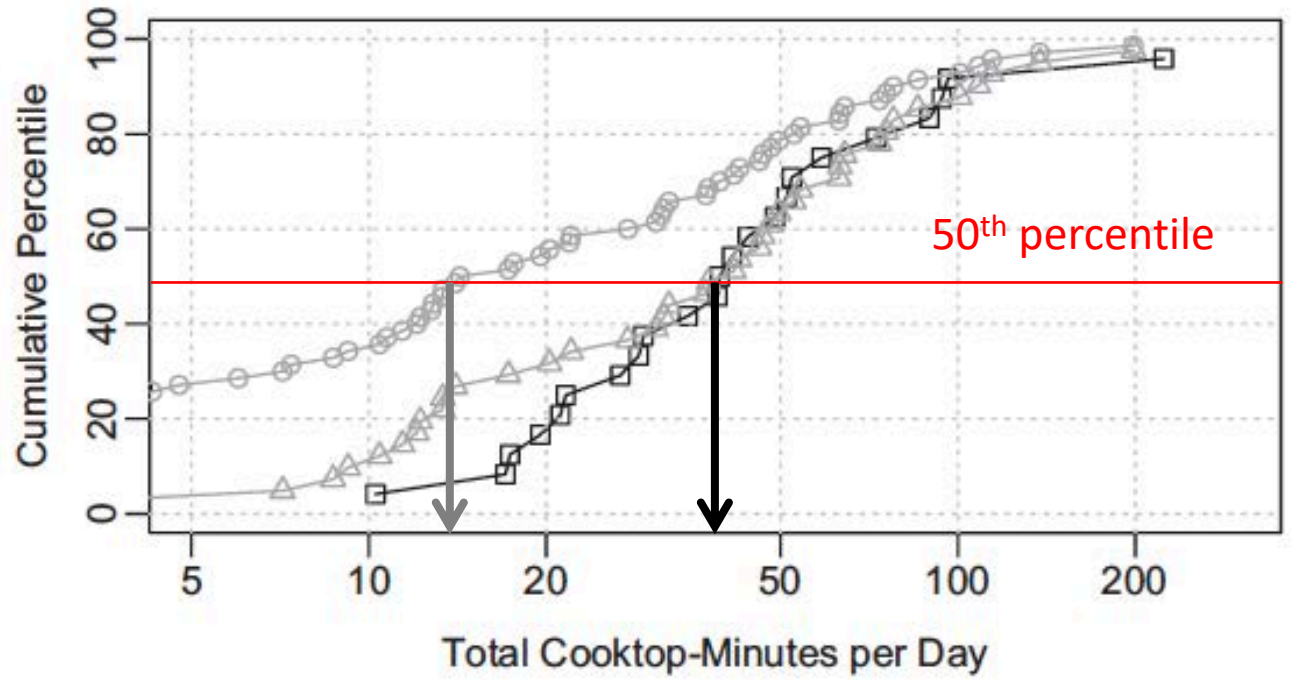
In this example: bedrooms about 20% lower than central location

Apartments & smaller homes more critical

LIA = Low Income Apartments
SFD = Single Family Detached

Low Income:
About twice as much cooking
More cooking for longer in smaller homes = Bigger Health Risk



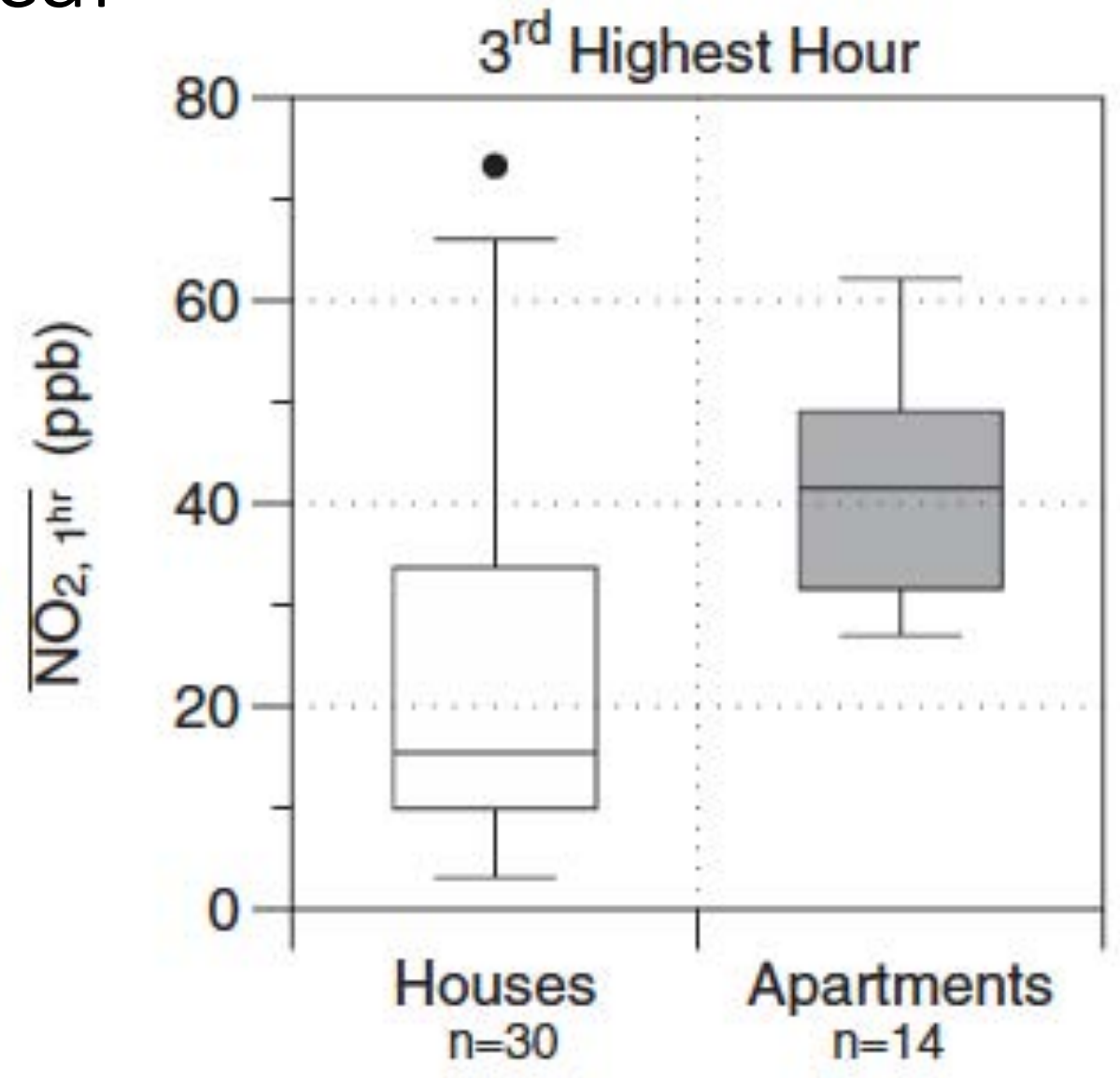


Apartments are more critical

Apartments more likely to be:

- Low Income
- Disadvantaged communities

Improvements in kitchen venting and switching to electric cooking are helping those that need it most



Background to kitchen venting proposal

- Assumes ASHRAE 62.2 ventilation
  - includes additional ventilation from range hood operation
  - Includes outdoor PM2.5 and NO2
- Same PM2.5 emissions for gas and electric cooking
- NO_2 emissions from gas only
- Both PM2.5 and NO2 emissions from LBNL lab testing of several meals
- Relationship between CE and air flow from lab studies

Kitchen Venting

Range hood effectiveness

Capture efficiency (CE):

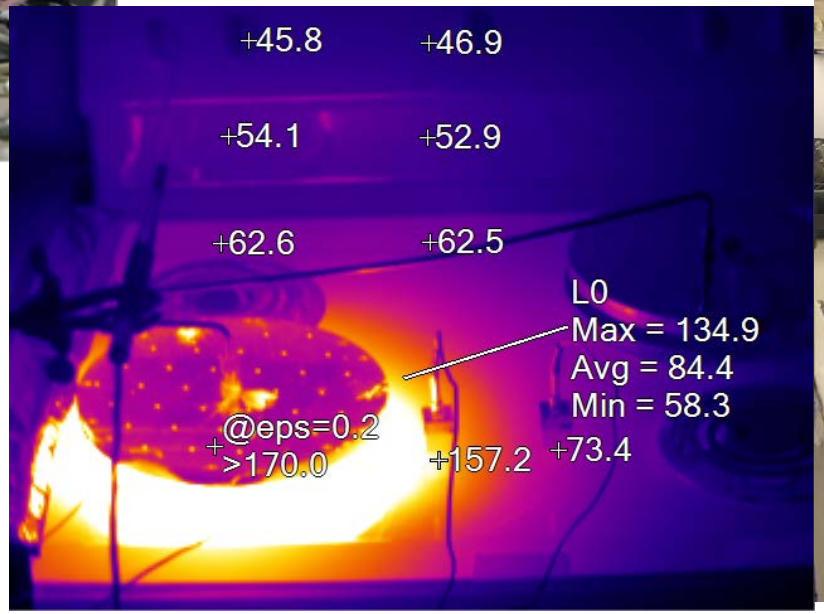
The fraction of pollutants emitted at the cooktop or in the oven that are removed before mixing into the air of the home

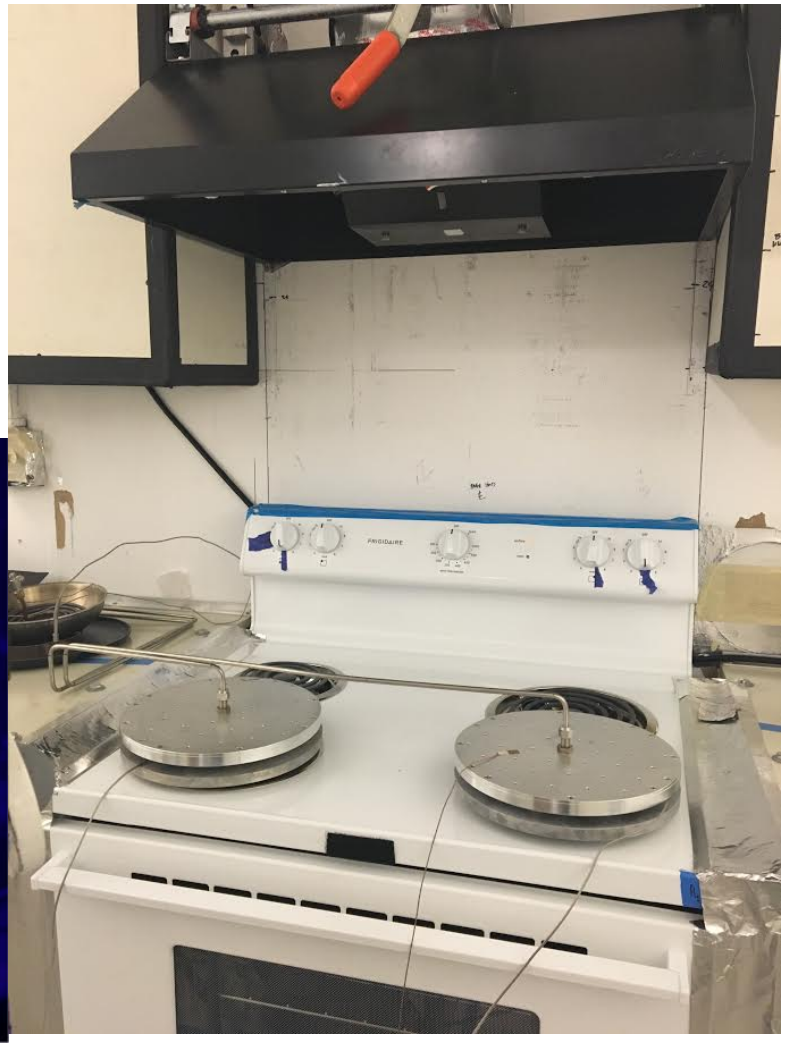
Standardized test method for rating about to become international = ratings coming soon

Designation: E3087 – 17

Standard Test Method for
Measuring Capture Efficiency of Domestic Range Hoods[1]

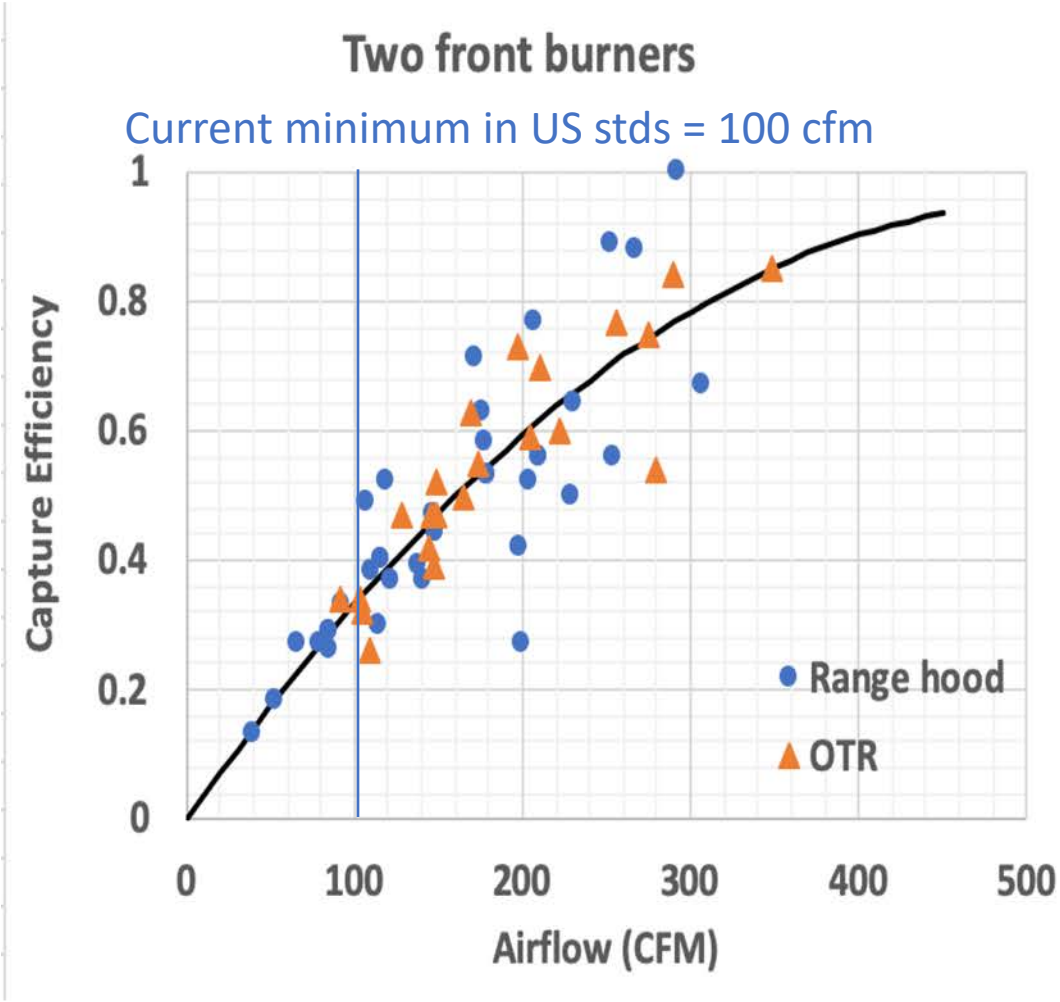
Lab Testing

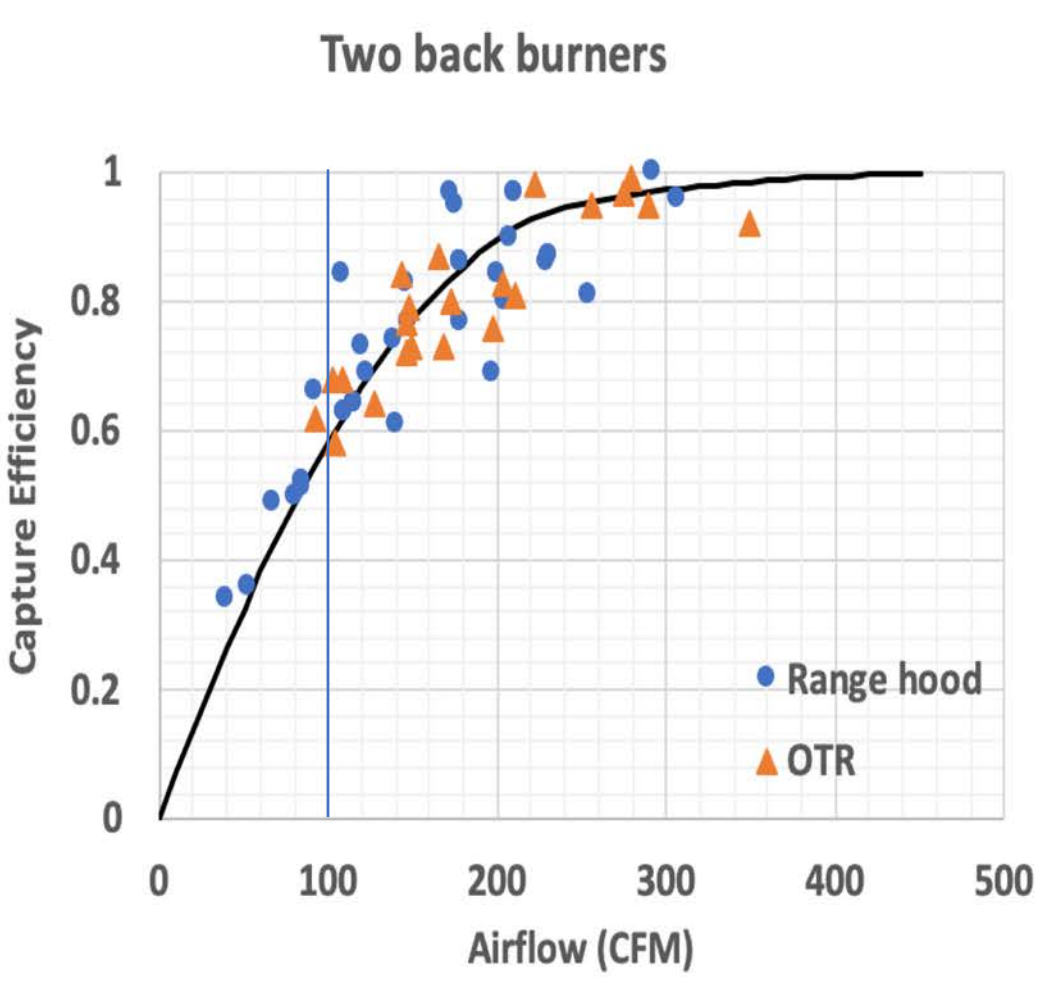

+45.8
+46.9
+54.1
+52.9
+62.6
+62.5
L0
Max = 134.9
Avg = 84.4
Min = 58.3
@eps=0.2
>170.0
+157.2
+73.4



Field Testing

Capture Efficiency





OTR = Microwave with Exhaust

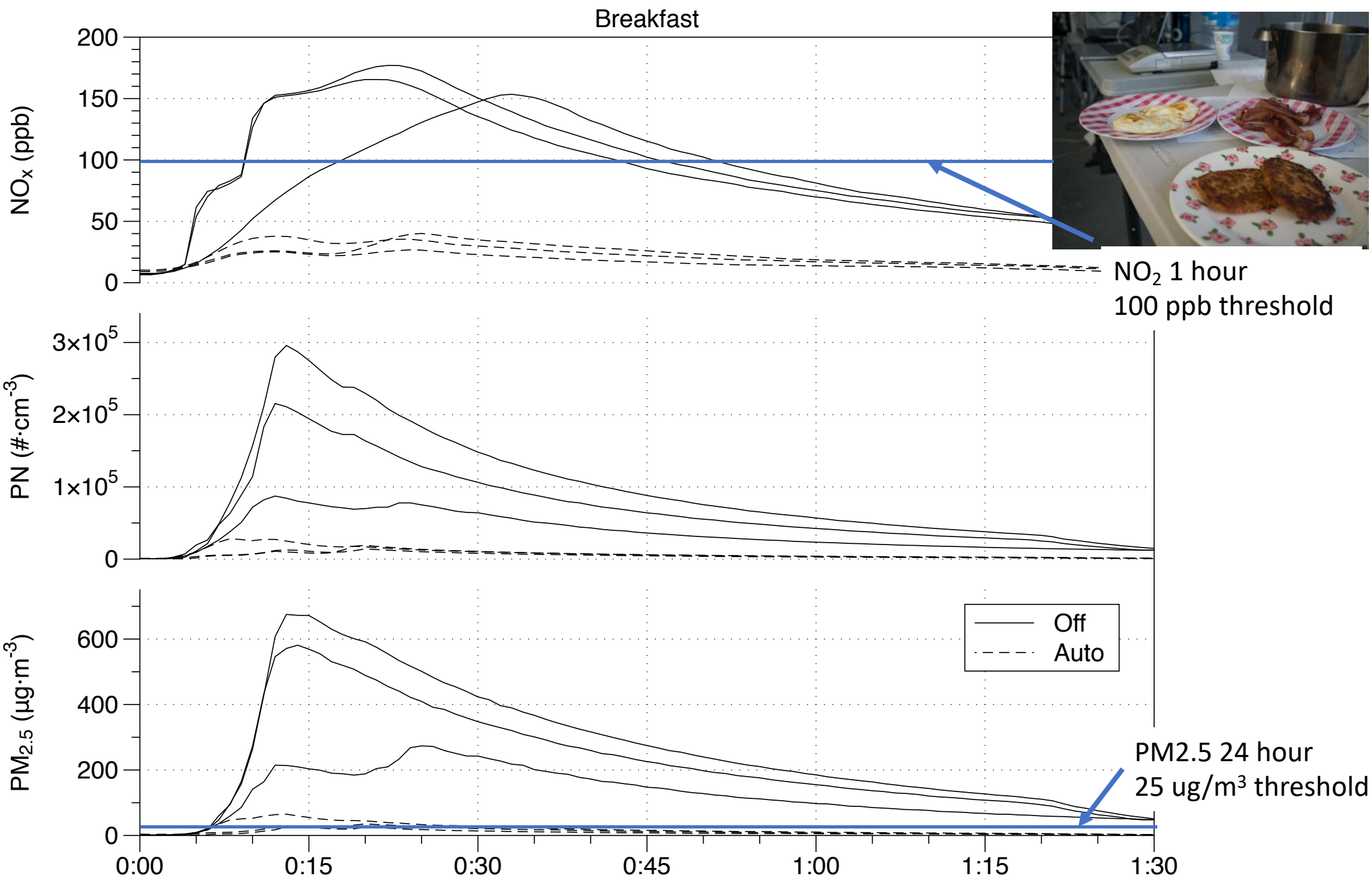
Laboratory Testing for Contaminants

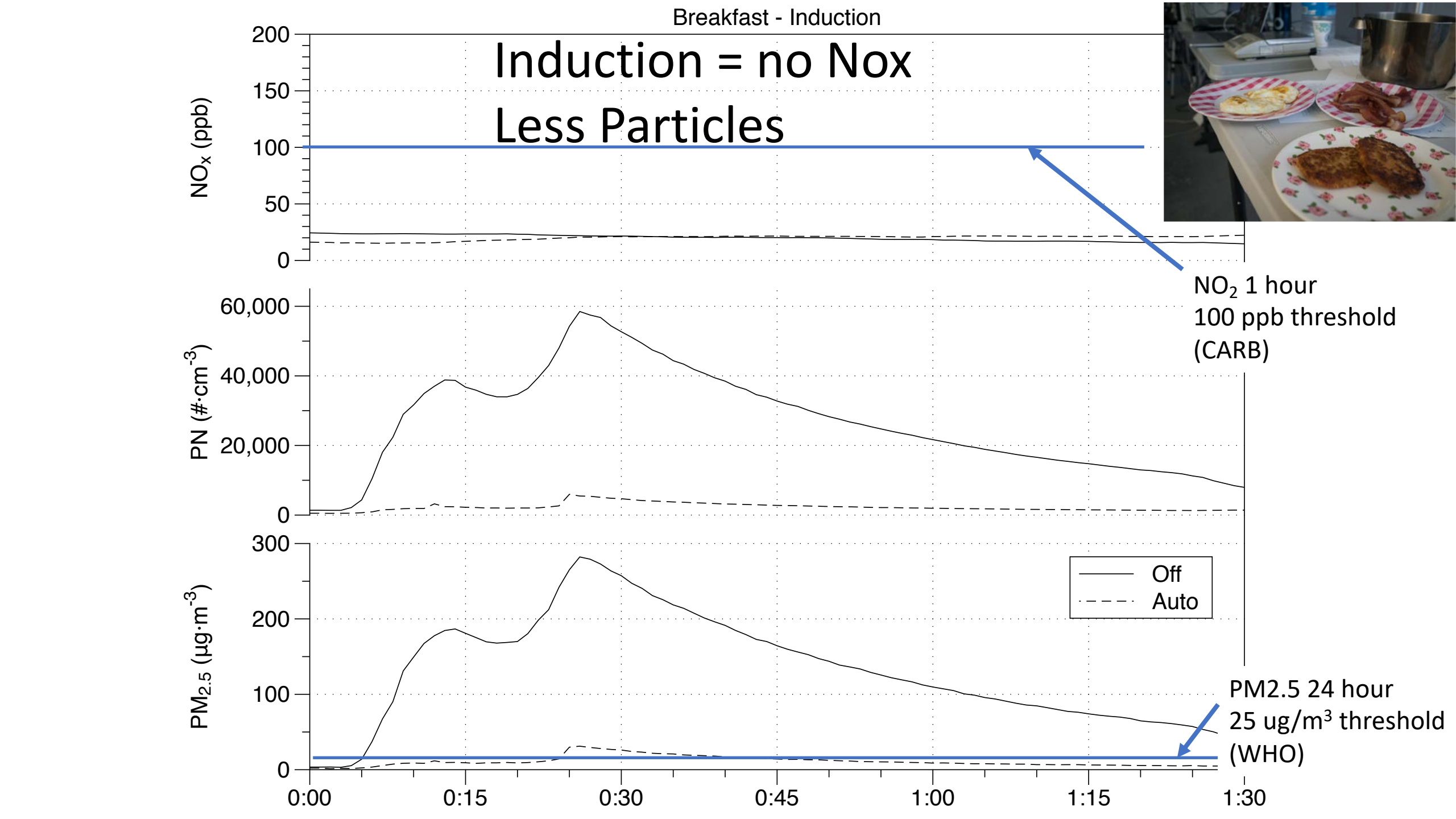

Gas Range in a unit of FlexLab at LBNL
Hood exhaust balanced with MERV13 filtered supply

Scripted Breakfast Meal

Breakfast Cooking Details - PARALLEL

Time (min)	Activity	Gas (lpm)
0	**Start front left burner on medium (2 lpm)** for hash browns	->
0:15	**Start front right burner on medium** (+2 lpm; **Total 4 lpm**) - bacon in pan (cook 12 min); remain to watch oil	->4.04
1.5	Add 2 hash browns to small skillet (cook 9 min); remain	
2	flip bacon and adjust in pan; remain	
3.5	Press hash browns 5s each; remain	
4	Flip bacon and adjust in pan; remain	
5.5	Flip hash browns; press 5s each; remain	3.99
6	Flip bacon and adjust in pan; remain	
7	Flip bacon and adjust in pan; remain	3.97
8	Press hash browns 5s each; remain	3.96
8-12	Flip bacon every 30s	
10	Return; flip hash browns; press	3.94
10:30	**Stop front left burner**; remove hash browns to plate with paper towel; place skillet on back left burner.	->2.02
12	**Stop front right burner**; remove bacon to plate; move pan to rear burner; leave uncovered	0
12.5	Place non-stick pan with butter on **front left burner, start and adjust to medium (2 lpm)**	->2.04
14	Add eggs to non-stick pan (cook 4 min); remain	2.05
17	Flip eggs	2.05
18	**Stop front left burner;** remove eggs to plate; place pan on front right burner	->0
48	Remove skillets and fry pan from cooktop	


Breakfast
200
150
100
50
0
NOx (ppb)
3×10^5
2×10^5
1×10^5
0
PN (#·cm^-3)
600
400
200
0
PM2.5 (µg·m^-3)
0:00
0:15
0:30
0:45
1:00
1:15
1:30
Off
Auto
NO2 1 hour
100 ppb threshold
PM2.5 24 hour
25 ug/m3 threshold


Breakfast - Induction
Induction = no Nox
Less Particles
NO_x (ppb)
200
150
100
50
0
PN (#·cm^{-3})
60,000
40,000
20,000
0
$PM_{2.5}$ (µg·m^{-3})
300
200
100
0
0:00
0:15
0:30
0:45
1:00
1:15
1:30
Off
Auto
NO_2 1 hour
100 ppb threshold
(CARB)
PM2.5 24 hour
25 ug/m^3 threshold
(WHO)

Proposed CA T24

- Key health contaminants are PM2.5 (gas and electric cooking) and NO_2 (only from gas)
- To meet health guidelines more/better kitchen ventilation is required for NO_2, i.e., gas cooking

Cooking Fuel	Floor Area (ft^2)	Capture Efficiency	Airflow as installed (cfm)
Electricity	>1500 ft^2	0.50	110
	1000 - 1500 ft^2	0.50	110
	750 - 1000 ft^2	0.55	130
	<750 ft^2	0.65	160
Gas	>1500 ft^2	0.70	180
	1000 - 1500 ft^2	0.80	250
	750 - 1000 ft^2	0.85	280
	<750 ft^2	0.85	280

Other ideas

- Do not allow gas cooking in apartments
  - Without automated hoods 70 to 90% of apartments will exceed 1 hr NO_2 limit
  - No automation = no safe use of gas cookers
- Require usage sensors
  - Readily available in other countries (e.g., Japan)
  - Provide improved kitchen safety
  - No technical reason to not require these controls in US homes

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