Better Buildings
U.S. DEPARTMENT OF ENERGY

Better Buildings Residential Network
Peer Exchange Call Series

Smart Range Hoods vs. Indoor Air Quality: Coming Soon to Kitchens Near You

March 25, 2021

U.S. DEPARTMENT OF ENERGY

Agenda and Ground Rules

- Agenda Review and Ground Rules
- Opening Poll
- Residential Network Overview and Upcoming Call Schedule
- Featured Speakers
  - **Brady Seals**, RMI
  - **Iain Walker**, Lawrence Berkeley National Laboratory
  - **Sam Bowles**, Newport Ventures
- Open Discussion
- Closing Poll and Announcements

Ground Rules:

1. **Sales of services and commercial messages are not appropriate** during Peer Exchange Calls.
2. Calls are a safe place for discussion; **please do not attribute information to individuals** on the call.

The views expressed by speakers are their own, and do not reflect those of the Dept. of Energy.

Better Buildings Residential Network

Join the Network

Member Benefits:

- Recognition in media and publications
- Speaking opportunities
- Updates on latest trends
- Voluntary member initiatives
- One-on-One brainstorming conversations

Commitment:

- Members only need to provide *one number*: their organization's number of residential energy upgrades per year, or equivalent.

Upcoming Calls (2nd & 4th Thursdays):

- Apr 08: *Automation: Where is the Balance between Humans and Machines to Save Energy?*
- Apr 22: *Earth Day Special: Electrification, Batteries, Storage & Residential Efficiency*
- May 13: *Low Income, Market Rate Residential Efficiency: Reaching the Hard to Reach*

Peer Exchange Call summaries are posted on the Better Buildings website a few weeks after the call

For more information or to join, for no cost, email bbresidentialnetwork@ee.doe.gov, *or go to* energy.gov/eere/bbrn *& click Join*

Brady Seals
Rocky Mountain Institute

U.S. DEPARTMENT OF ENERGY

Health Impacts of Gas Stove Pollution

DOE Better Buildings Residential Network
RMI, Brady Seals
March 25, 2021

AGENDA

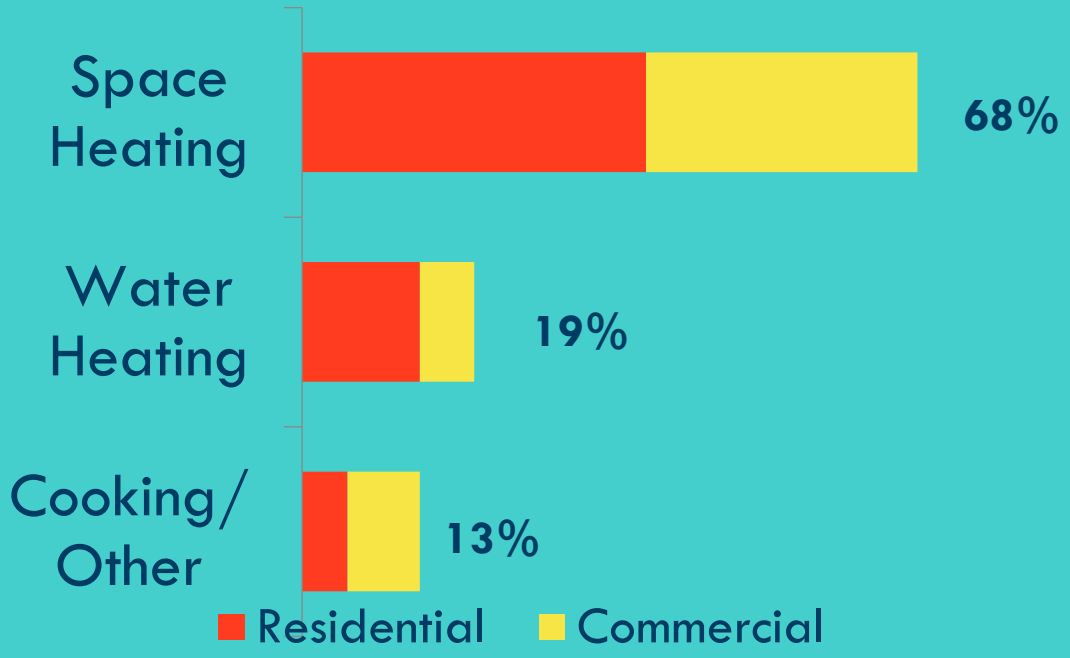
1. Why buildings?
2. Indoor air pollution
3. California building code updates: ventilation standards

Buildings: an overlooked source of climate pollution

Burning fossil fuels in buildings is responsible for

10% of US greenhouse gas emissions.

70 million homes and businesses burn fossil fuels



EIA Residential Energy Consumption Survey (RECS), 2015

Indoor Air Pollution

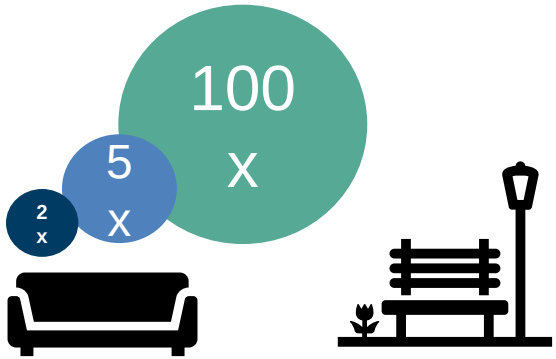
In the US, 1 out of 3 homes cook with gas.

American Housing Survey, US Census

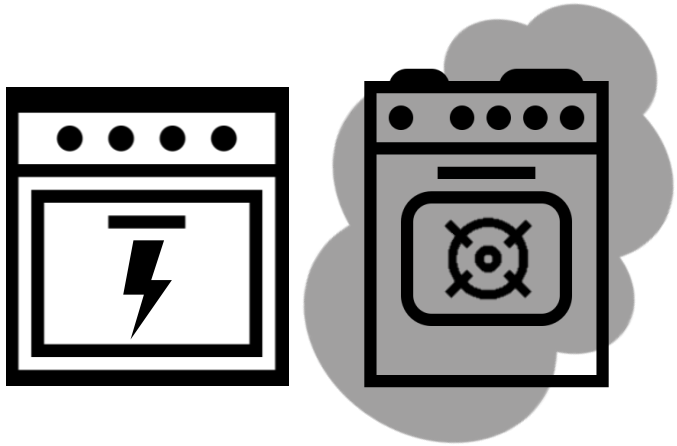
Indoor air quality is often worse than outdoor air

We spend up to **90%** of our time indoors

EPA states indoor pollutant levels may be **2 to 5** and as much as **100 times** higher indoors than outdoors



Homes with gas stoves have **50 - 400%** higher NO_2 emissions than homes with electric stoves

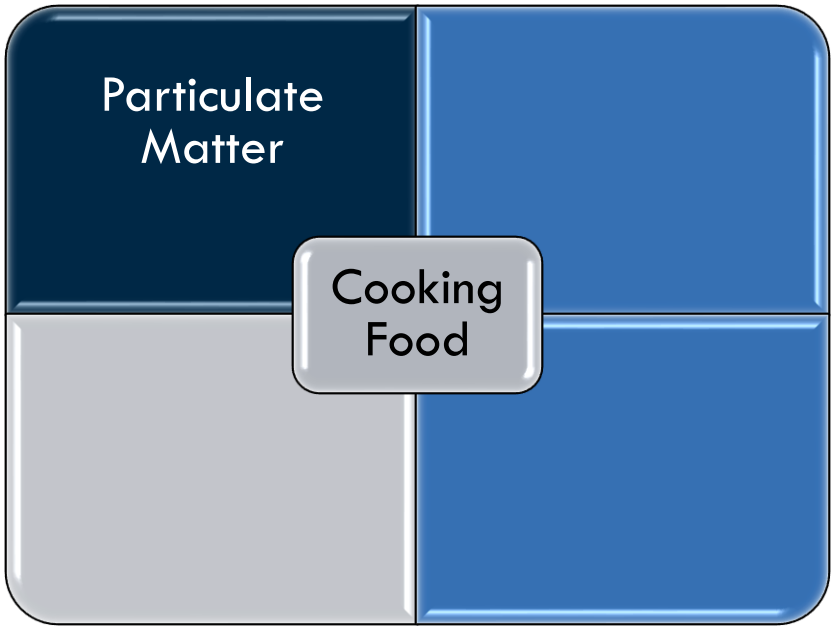


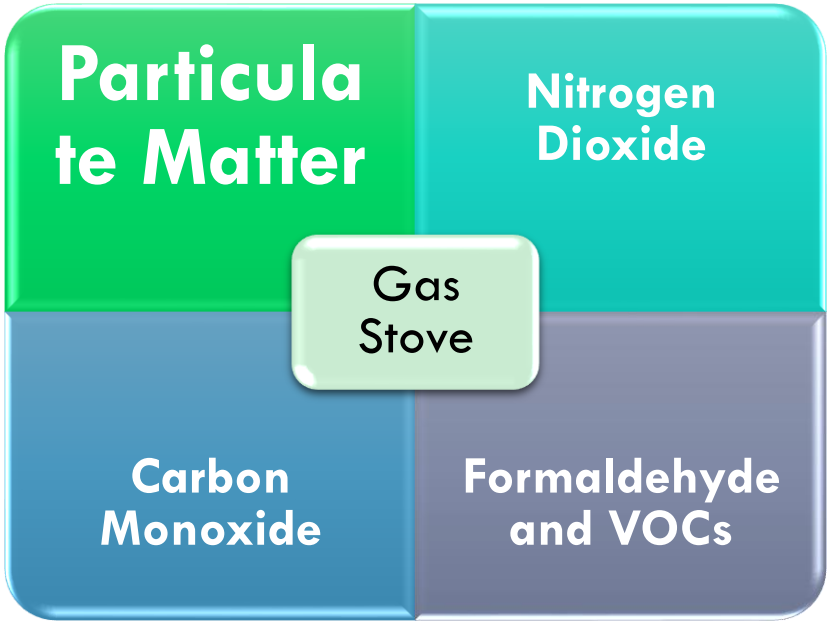
https://rmi.org/insight/gas-stoves-pollution-health/

HEALTH EFFECTS FROM GAS STOVE POLLUTION

PUBLISHED MAY 5, 2020

Differentiating Major Pollutants from Cooking Food vs. Gas Fuel





https://rmi.org/insight/gas-stoves-pollution-health/

Indoor NO_2 Emissions from Gas Stoves Often Exceed Outdoor Standards

Outdoor Standards for NO_2	1-hr average (ppb)
US National Standard (EPA)	100
Canadian National Standard	60
California State Standard	180
Indoor Guidelines for NO_2	**1-hr average (ppb)**
Canada	90
World Health Organization	106

Measured NO_2 Emissions from Gas Stoves	Peak (ppb)
Baking cake in oven	230
Roasting meat in oven	296
Frying bacon	104
Boiling water	184
Gas cooktop - no food	82–300
Gas oven - no food	130–546

https://rmi.org/insight/gas-stoves-pollution-health/

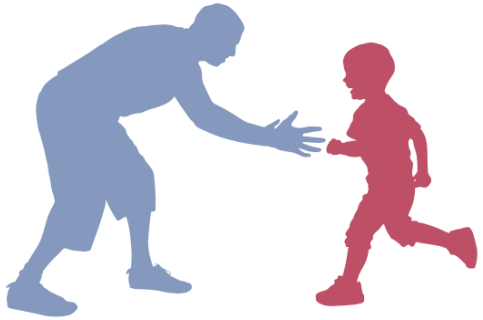
Living in a home with a gas stove increases the risk of asthma in children

42% increased risk of experiencing asthma symptoms

24% increased risk of being diagnosed with asthma by a doctor

32% increased risk of experiencing symptoms & being diagnosed by a doctor

Children are more susceptible to air pollution than adults.
3 main reasons:



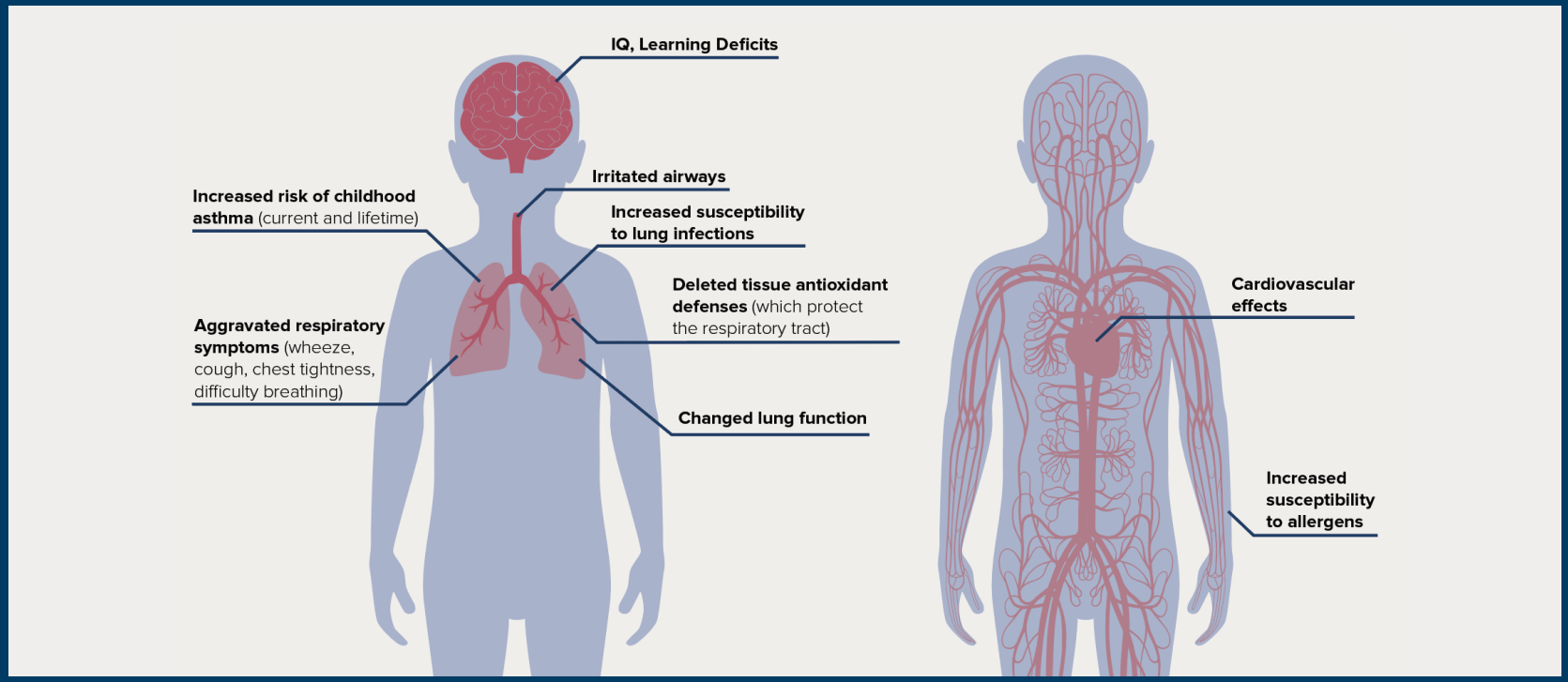
Higher **breathing rates** and more **physical activity**

Higher lung surface to body ratios and smaller bodies

Immature lungs and immune systems

Lin et al. (2013); https://rmi.org/insight/gas-stoves-pollution-health/

Health Effects of NO_2 in Children May Include:



https://rmi.org/insight/gas-stoves-pollution-health/

Lower-income Households May be at a Higher Risk of Exposure to Gas Stove Pollution

FACTORS CONTRIBUTING TO HIGHER LEVELS OF NO_2 IN HOMES:

Smaller unit size

More people per home

Older homes, inadequate ventilation

Using the stove/ oven for supplemental heat

Higher exposure to outdoor pollution

Greater asthma burden

https://rmi.org/insight/gas-stoves-pollution-health/

Recommendations for Individuals: Gas Stoves

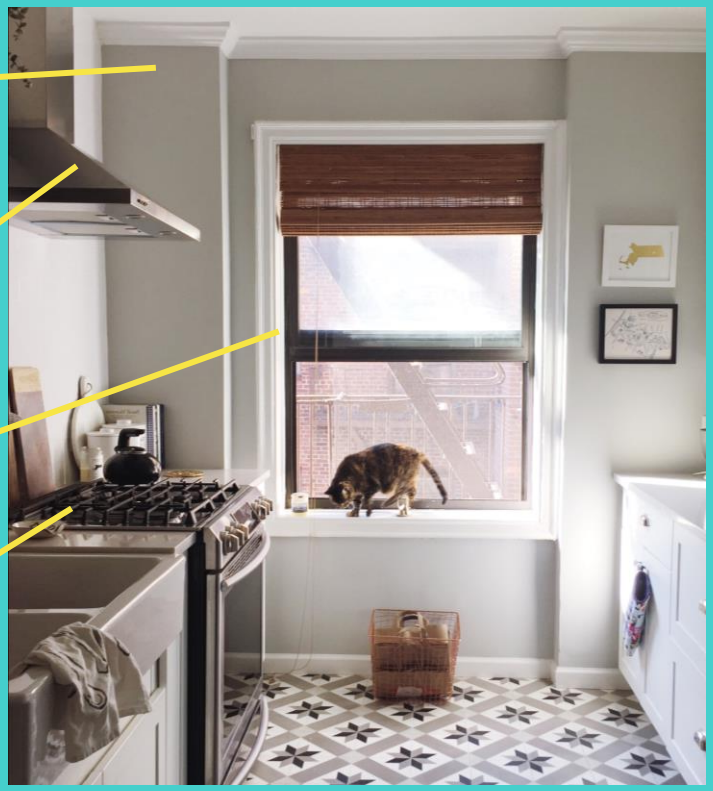
To reduce or eliminate exposure to gas stove pollution

Install & maintain a CO detector

If available, run your exhaust hood while cooking

Open a window while cooking

Cook on the back burners



Use other electric appliances like toaster oven or kettle.

Try a plug-in induction stove ($50)

Switch to an electric/ induction stove

https://rmi.org/insight/gas-stoves-pollution-health/

Recommendations for Policymakers

Indoor Air Quality Guidelines	Adopt health-based guidelines that protects the most sensitive populations
Building Codes	Require adequate ventilation & other protections: low-level CO detectors, auto ventilation
Warning Labels	Require manufacturers to warn consumers about gas stove pollution
Incentives	Financial incentives, such as tax credits or rebates, should be made available • (seems like no induction stove rebates available in CO)
Public Buildings & Funds	Funds should not be used to purchase/install appliances that could pose a health risk in homes, schools, and other public buildings.
Property Owners	Requirements to provide notice to tenants about the gas stove pollution risk. • (adaptive options: induction cooktops, stove replacement, ventilation to outdoors)

https://rmi.org/insight/gas-stoves-pollution-health/

California's Building Code Update (Title 24)

Advocates called on the CEC to include:

ALL-ELECTRIC 2022 BASELINE

DIFFERENTIATED REQUIREMENTS FOR GAS & ELECTRIC STOVES

MAXIMUM NOISE (SONE) STANDARDS

AUTOMATIC VENTILATION

CEC's proposed Differentiated Requirements

Table 120.1-F: Kitchen Range Hood Airflow Rates (cfm) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type

Dwelling Unit Floor Area (ft^2)	Hood Over Electric Range	Hood Over Natural Gas Range
>1500	50% CE or 110 cfm	70% CE or 180 cfm
>1000 - 1500	50% CE or 110 cfm	80% CE or 250 cfm
750 - 1000	55% CE or 130 cfm	85% CE or 280 cfm
<750	65% CE or 160 cfm	85% CE or 280 cfm

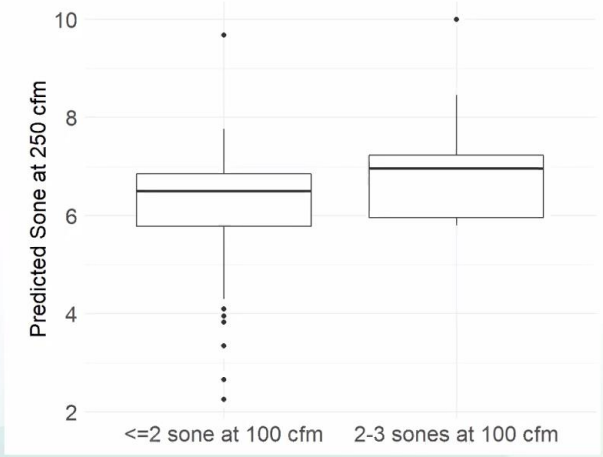
https://efiling.energy.ca.gov/GetDocument.aspx?tn=236876&DocumentContentId=70030

Maximum noise (sone) standard

Kitchen Range Hood Minimum Capture Efficiency

Why not tighten the sound requirement?

- Surveys indicate noise deters range hood use
- Title 24-2019, part 6 requires demand-controlled range hoods meet ≤ 3 sones at 100 cfm
- Originally considered adding a sound requirement at the proposed new required airflow (e.g., 250 cfm)
  - Would require product re-testing, and
  - Industry is moving away from current test points
- More recently considered tightening the sound to ≤ 2 sone at 100 cfm
  - Data did not clearly show that a low sone at low cfm correlated with a low sone at high cfm



Screenshot from 11/3/20 CEC workshop over Zoom

RMI
ENERGY. TRANSFORMED.

Thanks!

bseals@rmi.org

Iain Walker
Lawrence Berkeley National Laboratory

U.S. DEPARTMENT OF
ENERGY

BERKELEY LAB

LAWRENCE BERKELEY NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

Automatic Range Hood Laboratory Testing

Iain Walker

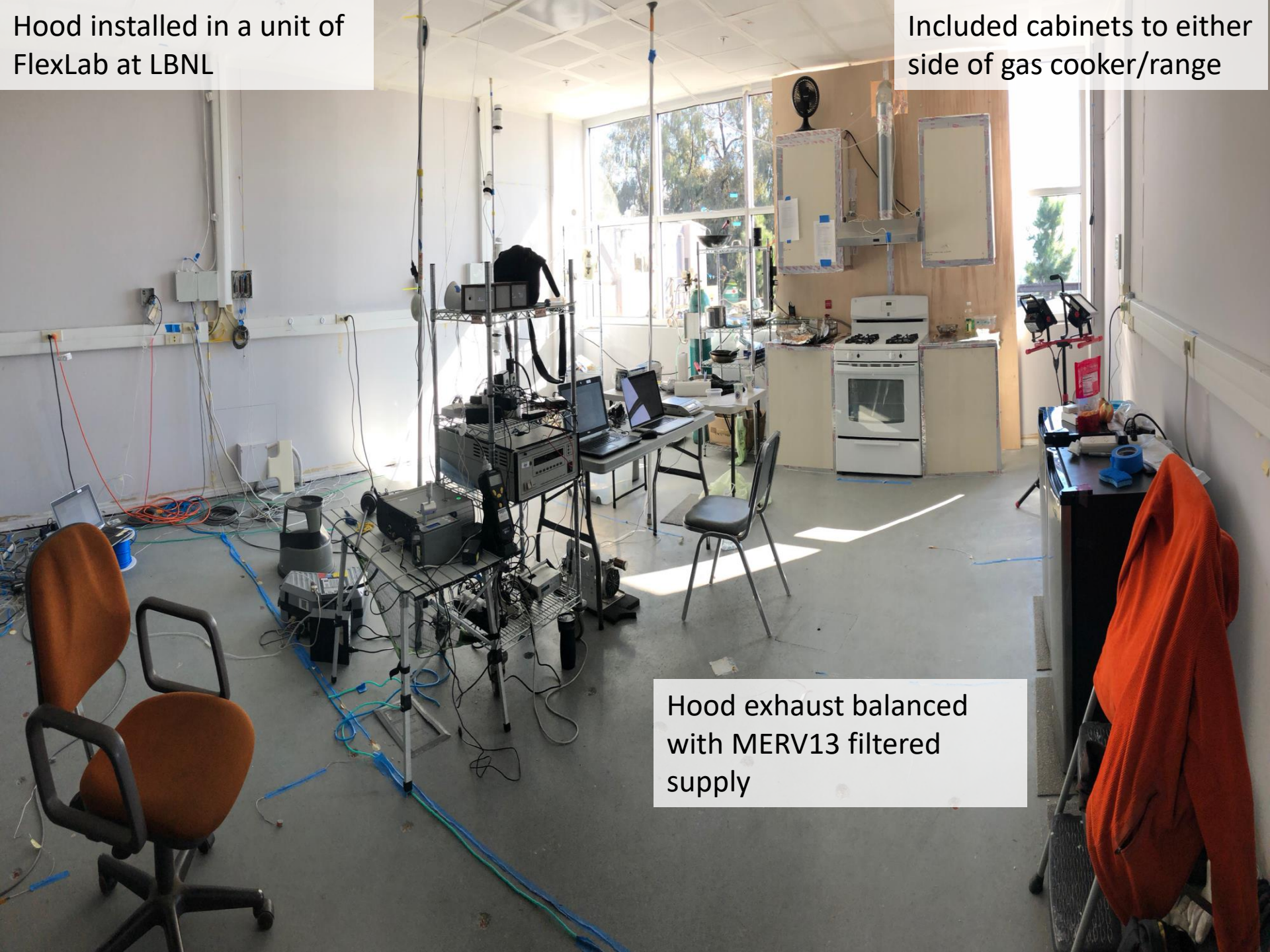
(with thanks to Woody Delp)

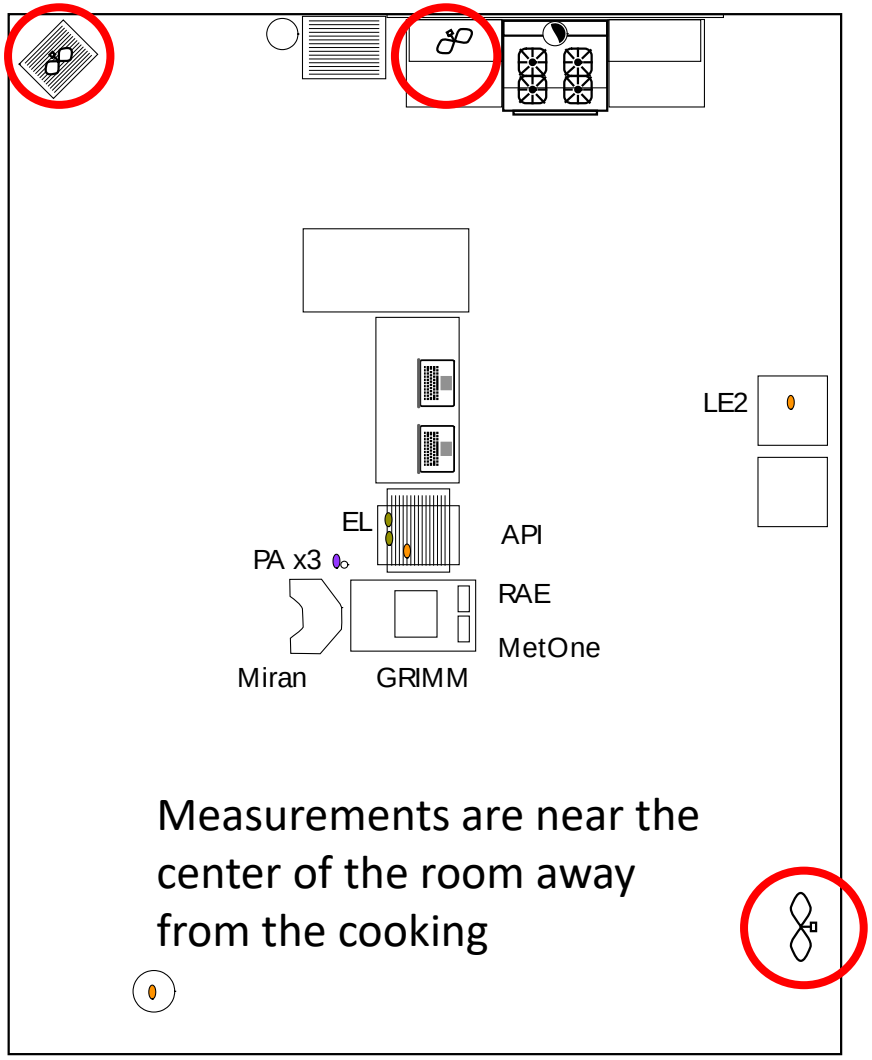
BERKELEY LAB

BUILDING TECHNOLOGY & URBAN SYSTEMS DIVISION

Energy Technologies Area

Building AMERICA U.S. Department of Energy


Hood installed in a unit of FlexLab at LBNL
Included cabinets to either side of gas cooker/range
Hood exhaust balanced with MERV13 filtered supply



Reference Instruments

GRIMM Particle Spectrometer - PM, PN, distributions

MetOne - PM

API Gas analyzer - NO, NO2, NOx

RAE VOC analyzer - tVOC

Miran IR gas analyzer - R124 tracer for ventilation rate

Consumer Instruments

eLichens - PM, CO2, tVOC, NO2, T, RH

LaserEgg2 - PM, T, RH

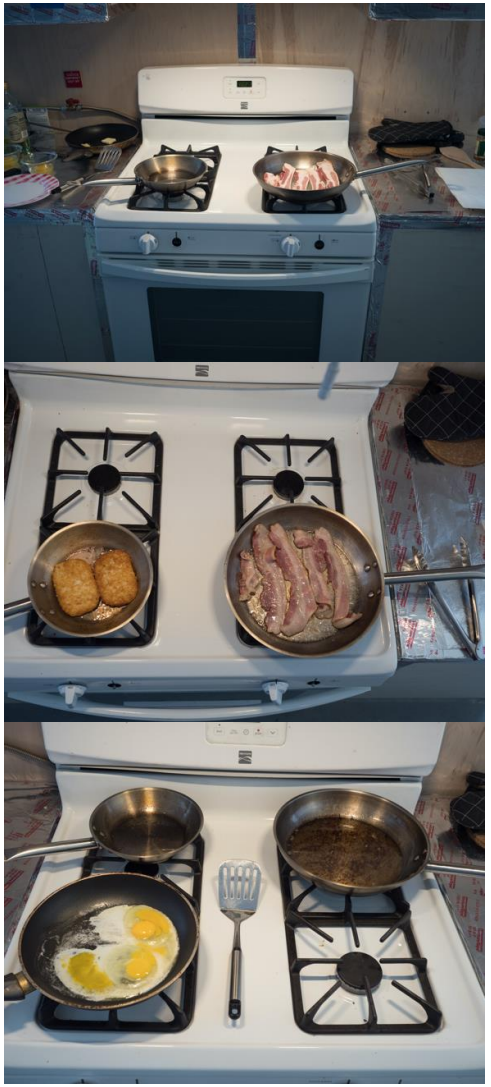
PurpleAir - PM, T, RH

Mixing fans

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	

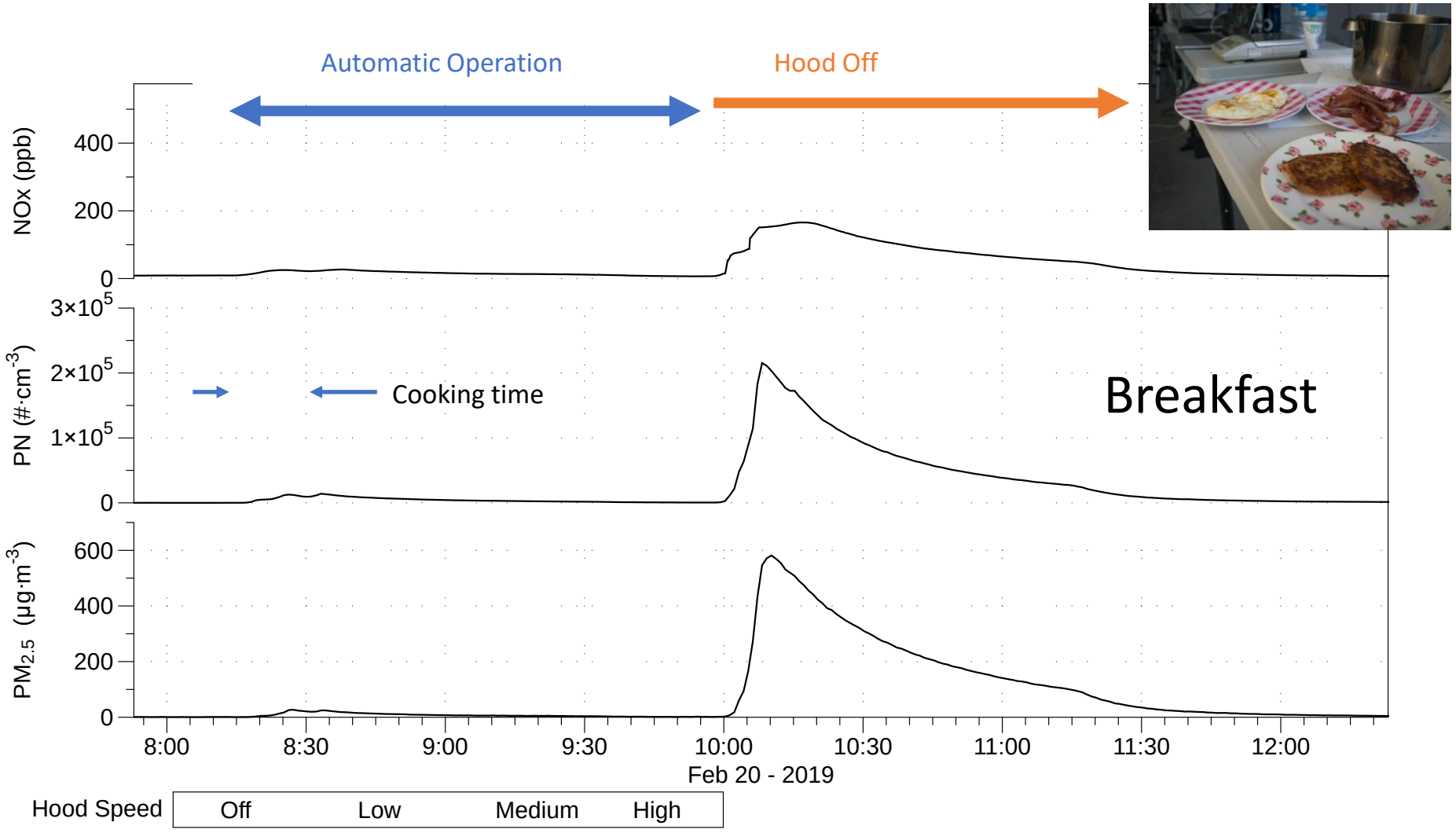


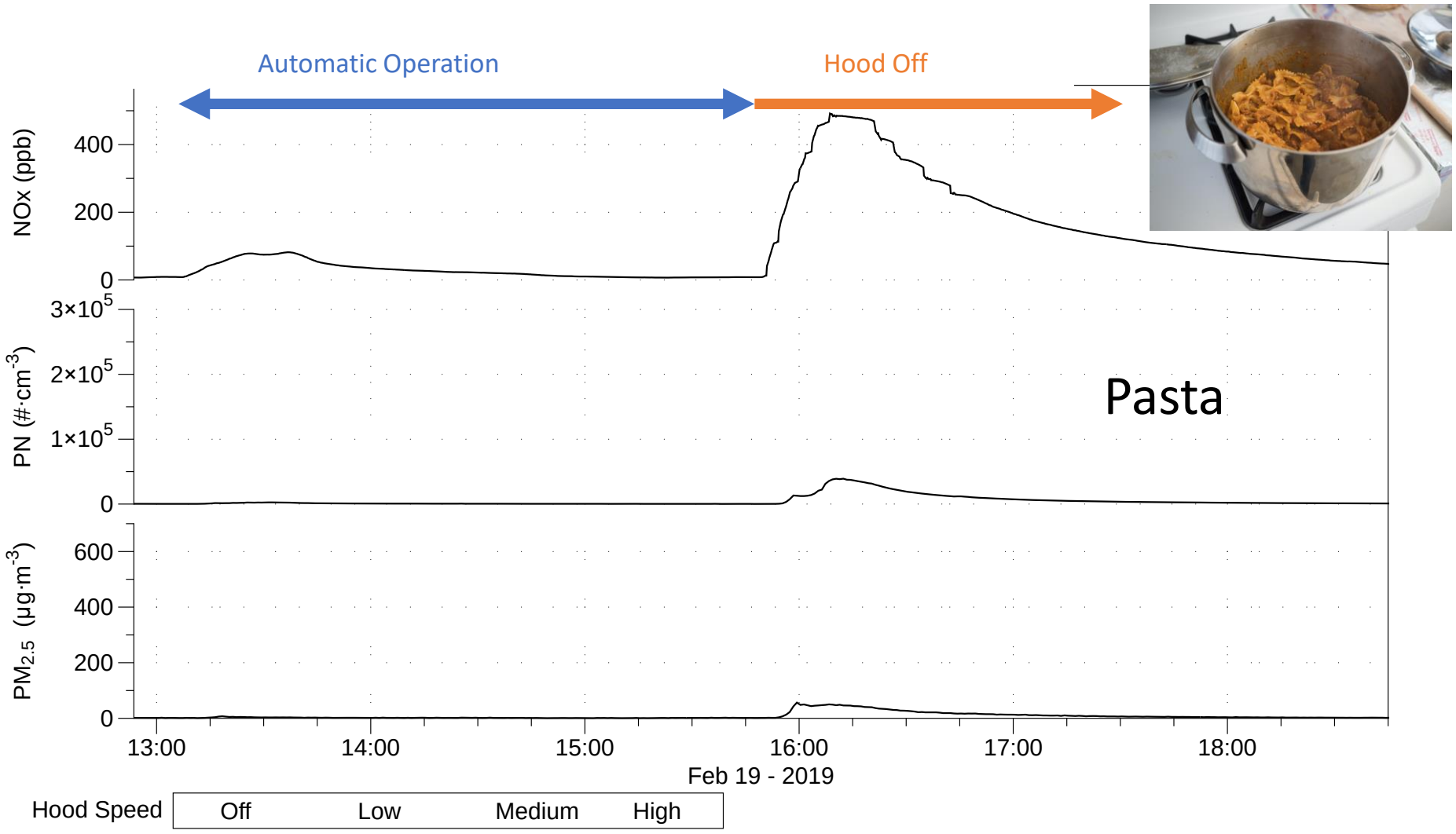
Scripted Pasta Meal

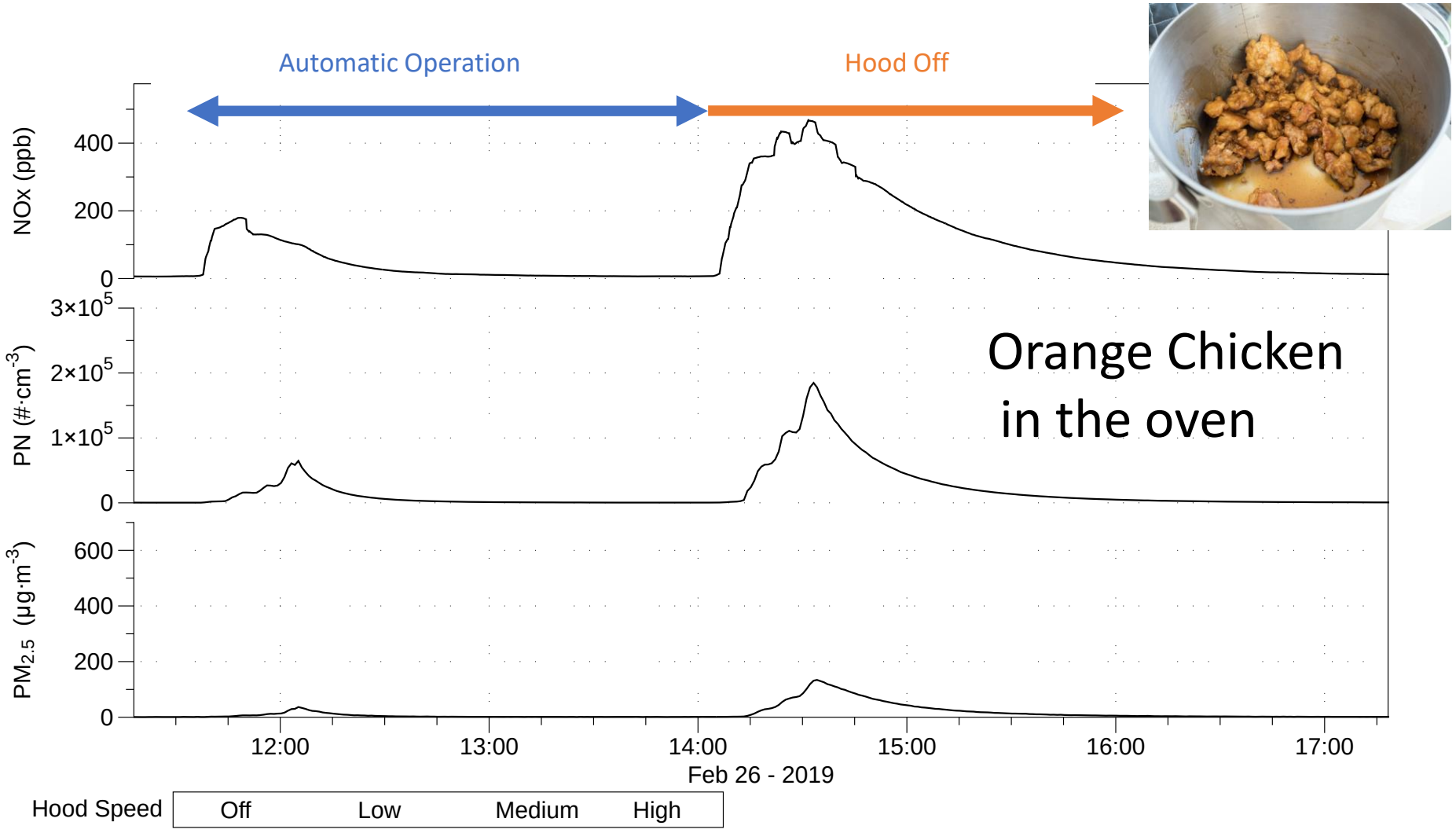
Time (min)	Activity	Gas (lpm)
0	Start **front right burner on high** (6 lpm) for pasta. Pasta lid is on; walk away	-> 6.03
1:30	Return; **start front left burner; adjust to medium** (+2 lpm, **8 lpm total**); remain	-> 8.06
3	Spread oil with wood spoon; add onions (cook 6 min); stir 15s; walk away	7.99
5	Return; stir onions 5s; Walk away	7.87
6	**Adjust flow of FRONT LEFT burner to 8 lpm total**; stay as far as possible from range hood	7.9
7	Return; stir onions 5s; remain	7.91
8	Stir onions 5s; remain	7.87
9	Add beef (cook 8 min); stir and break chunks for 30s	
9:30	Walk away	7.81
11	Return; stir beef for 30s;	
11:30	Walk away	7.75
14	Return; stir beef for 15s; lift pot lid to check water, replace lid; remain	7.70
15	Stir beef 15s; remain	7.68
16	Remove pot lid to confirm rolling boil; add pasta (cook 13 min); stir 5s; remain	7.66
17	Add jar of sauce to saute pan; stir 15s; place lid on saute; remain	->7.65
18	Stir pasta 5s; adjust **front right burner to medium (**+2.5 lpm, **4.5 lpm total);** remain	
18:30	Stir sauce 5s; remain	4.46
19	Stir sauce; **Adjust front left burner to medium-low (**+1.0 lpm, **3.5 lpm total)**; place lid on saute	->
19:30	Walk away	3.5
21	Return; stir pasta 5s; stir sauce 5s and replace lid; walk away	3.49
24	Return; stir pasta 5s; stir sauce 5s and replace lid; walk away	3.46
27	Return; remove one piece of pasta from pot, dip in water and taste; remain	->3.46
29	Taste another piece of pasta; **turn off front right burner;** drain pasta; put pasta back into pot and place on stove	->1.52
30	**Turn off front left burner** (sauce); pour meat sauce into pasta pot or another bowl on cooktop; cover saute pan; remove pasta and meat sauce; leave pots on back burners.	0
60	Remove pots from chamber	
90	Start venting chamber	

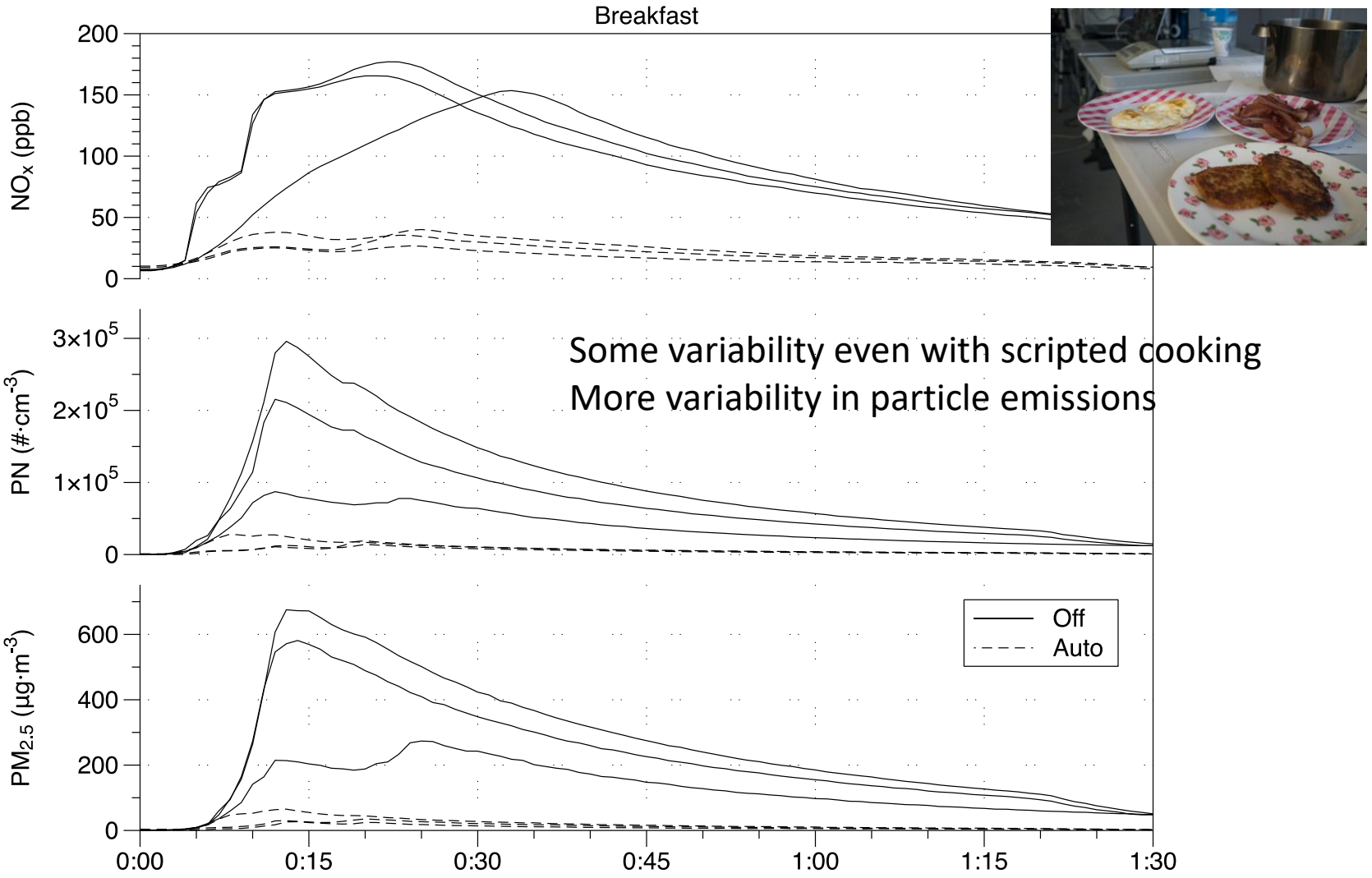
Scripted Oven Meal (Orange Chicken)

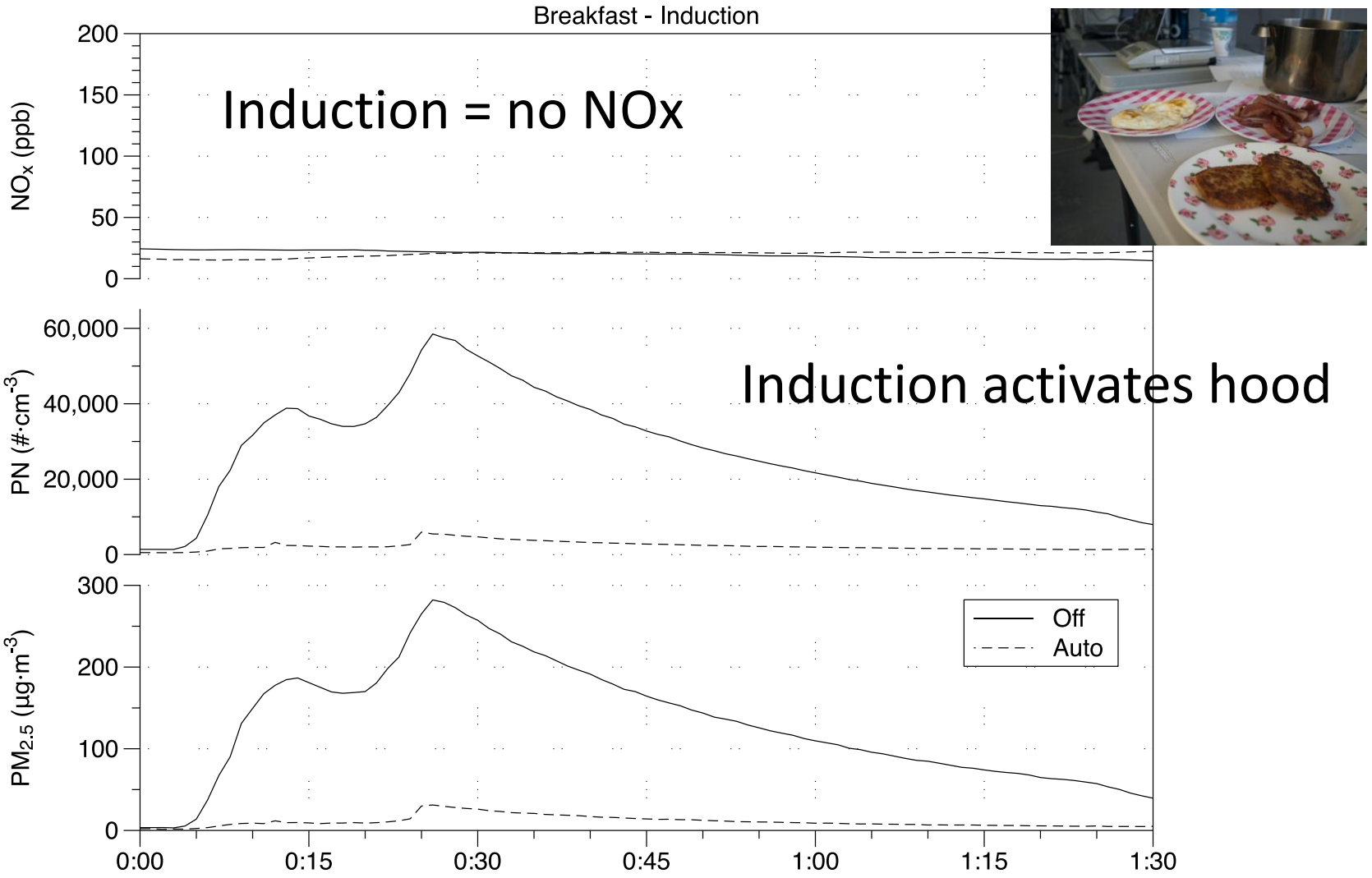
Time (min)	Activity	Gas (lpm)
0	Preheat oven to 400 dF for 10 minutes (start timer when gas valve opens)	-> 9.05
10:00	Place chicken nuggets on cookie sheet and insert in oven	-> 8.55
29:00	Turn oven off. Remove cookie sheet from oven, place cookie sheet on cooktop, transfer nuggets to a pot, cover, and move to separate table	
	Start purge	

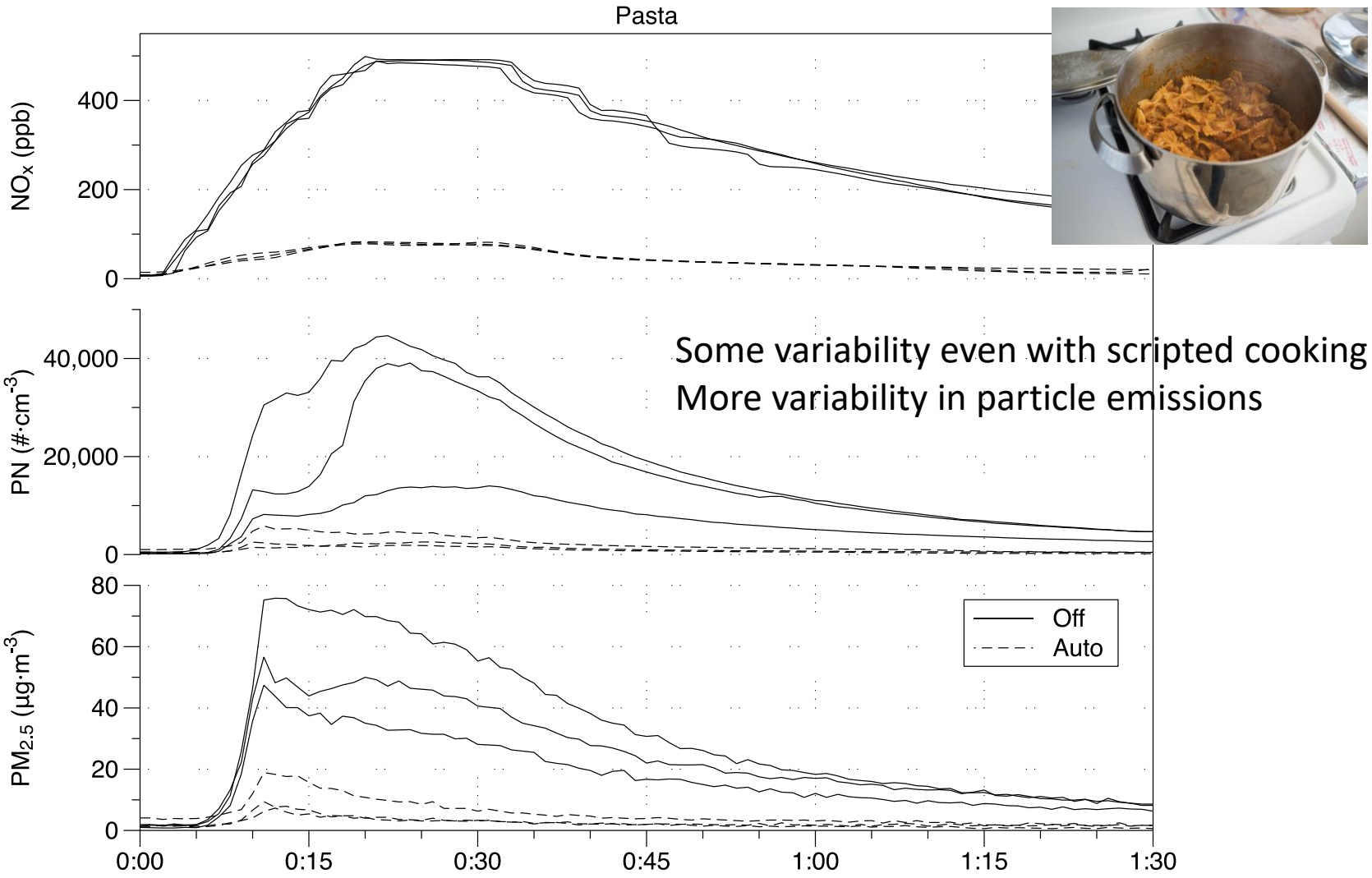

Automatic Operation
Hood Off
NOx (ppb)
400
200
0
PN (#·cm-3)
3×10^5
2×10^5
1×10^5
0
Cooking time
Breakfast
PM2.5 (µg·m-3)
600
400
200
0
8:00
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
Feb 20 - 2019
Hood Speed
Off
Low
Medium
High

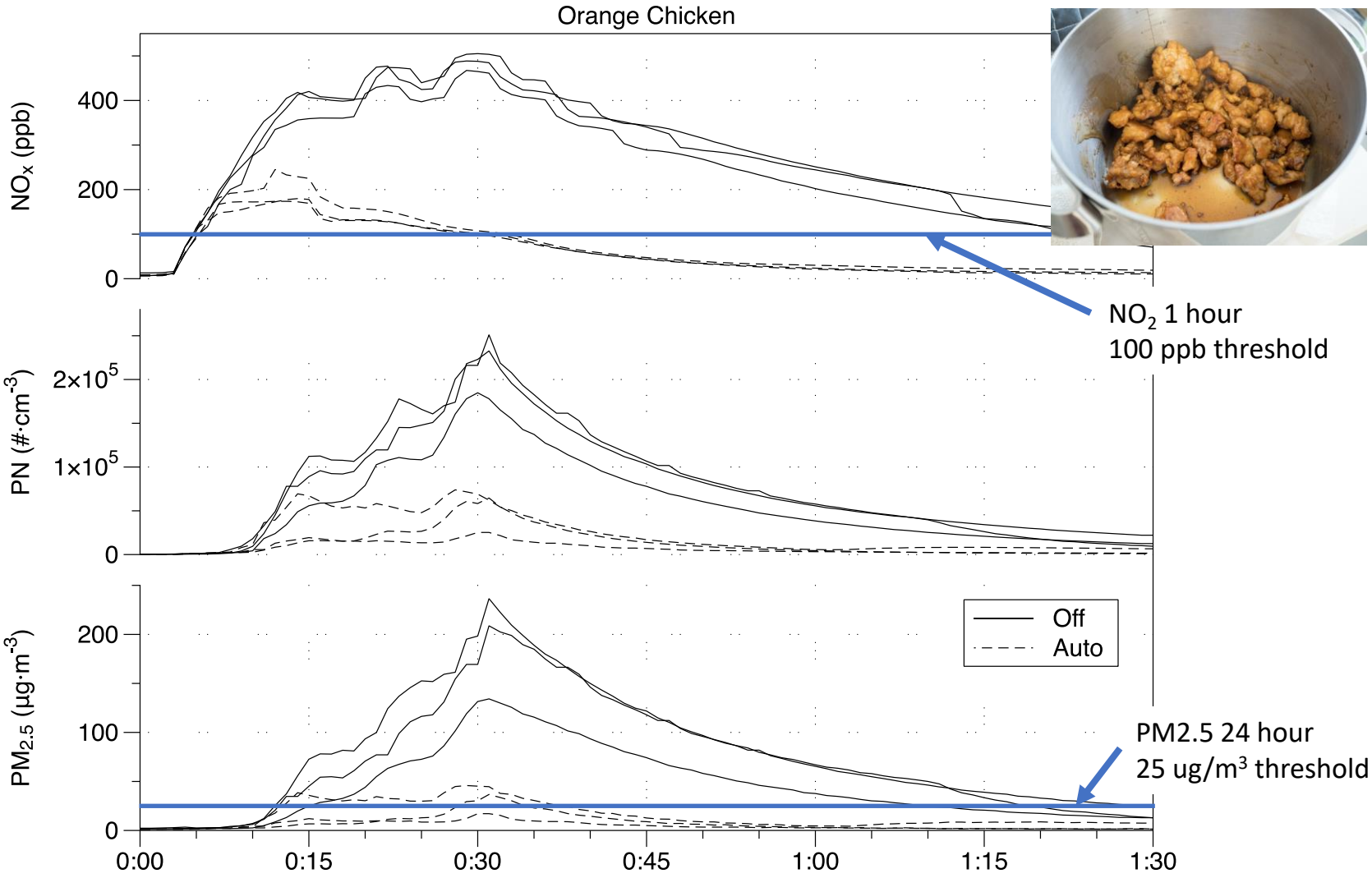

Automatic Operation
Hood Off
NOx (ppb)
400
200
0
PN (#·cm-3)
3×10^5
2×10^5
1×10^5
0
PM2.5 (µg·m-3)
600
400
200
0
Pasta
13:00
14:00
15:00
16:00
17:00
18:00
Feb 19 - 2019
Hood Speed
Off
Low
Medium
High


Automatic Operation
Hood Off
NOx (ppb)
400
200
0
PN (#·cm-3)
3×10^5
2×10^5
1×10^5
0
PM2.5 (µg·m-3)
600
400
200
0
12:00
13:00
14:00
15:00
16:00
17:00
Feb 26 - 2019
Orange Chicken in the oven
Hood Speed
Off
Low
Medium
High

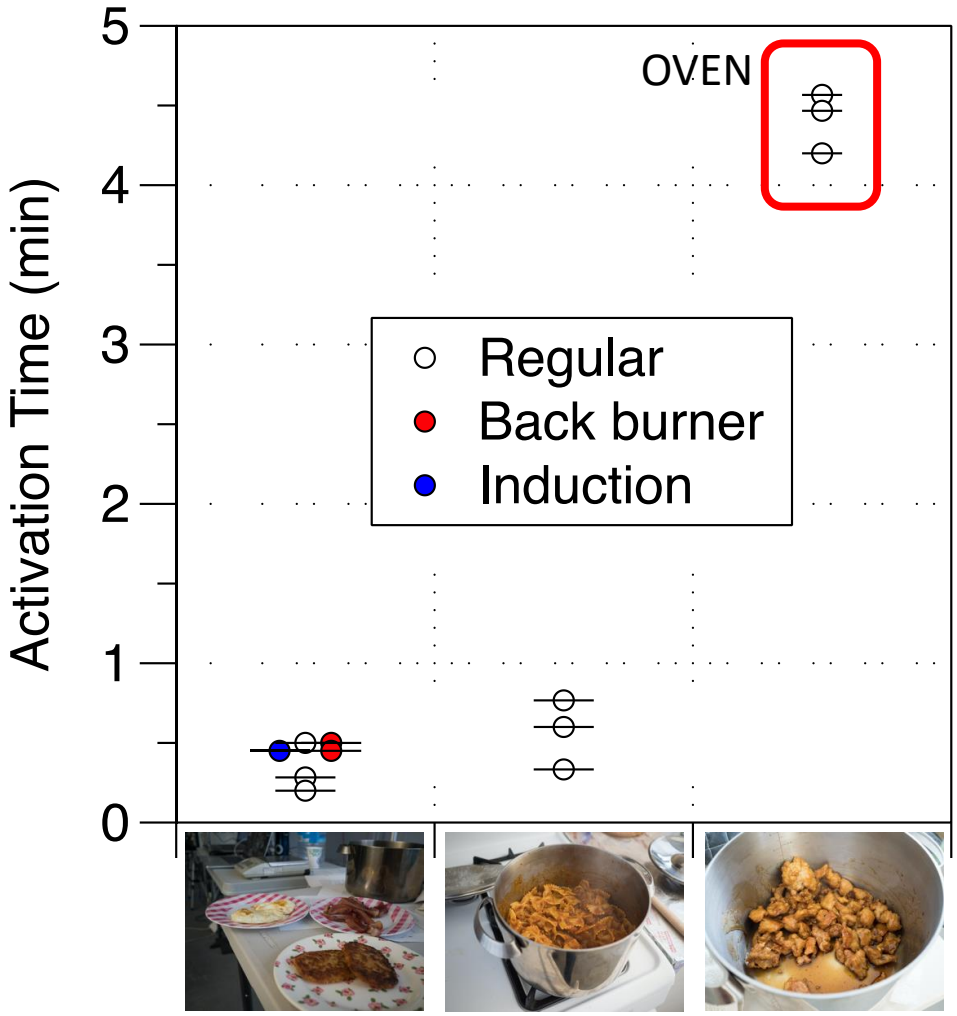

Breakfast
NO_x (ppb)
200
150
100
50
0
PN (#·cm^{-3})
3×10^5
2×10^5
1×10^5
0
$PM_{2.5}$ (µg·m^{-3})
600
400
200
0
0:00
0:15
0:30
0:45
1:00
1:15
1:30
Off
Auto
Some variability even with scripted cooking
More variability in particle emissions


Breakfast - Induction
Induction = no NOx
Induction activates hood
NOx (ppb)
200
150
100
50
0
PN (#·cm-3)
60,000
40,000
20,000
0
PM2.5 (µg·m-3)
300
200
100
0
0:00
0:15
0:30
0:45
1:00
1:15
1:30
Off
Auto


Pasta
NOx (ppb)
400
200
0
PN (#·cm-3)
40,000
20,000
0
PM2.5 (µg·m-3)
80
60
40
20
0
0:00
0:15
0:30
0:45
1:00
1:15
1:30
Off
Auto
Some variability even with scripted cooking
More variability in particle emissions


Orange Chicken
NO_x (ppb)
400
200
0
PN (#·cm^{-3})
2×10^5
1×10^5
0
$PM_{2.5}$ (µg·m^{-3})
200
100
0
Off
Auto
0:00
0:15
0:30
0:45
1:00
1:15
1:30
NO_2 1 hour
100 ppb threshold
PM2.5 24 hour
25 ug/m^3 threshold

The unit activated within a minute for the cooktop, but over 4 minutes for the oven



- The automatic function turns on quickly
  - Before particle emissions get underway
- The automatic function works with gas and induction cooktops
- The automatic function works for a range of cooking events
- The apparent exposure reductions are in the range of 60-97%
  - Pollutant dependent

Sam Bowles
Newport Ventures

U.S. DEPARTMENT OF
ENERGY

Newport Partners L.L.C.

Building AMERICA SM
U.S. Department of Energy

Developing and Demonstrating a Smart Range Hood

3/25/21

Sam Bowles

Newport Partners

Research Project Overview

Project Goal

Develop and demonstrate a Smart Range Hood (SRH) for use in domestic kitchens to *detect and automatically respond to pollutant concentrations during cooking events*

Project Team

NP
Newport Partners LLC

BROAN
NuTone

Smart Range Hoods: Why do we need them?

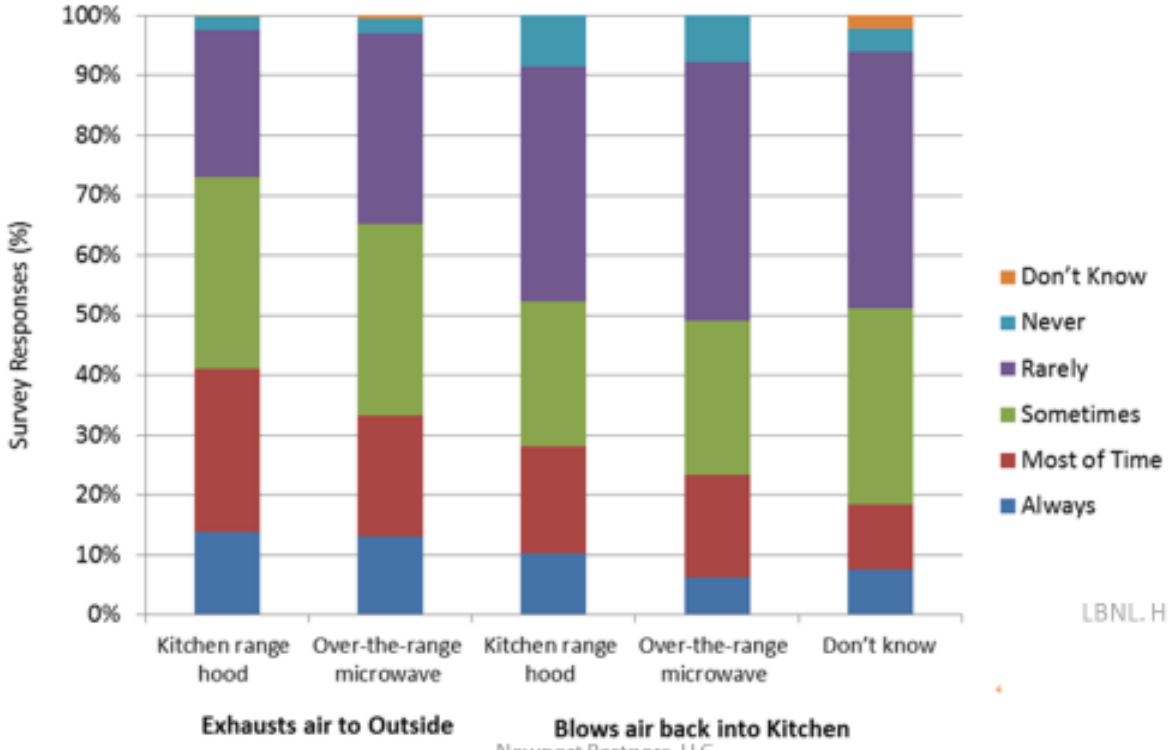
Kitchens are a primary source of residential indoor air pollutants

Range hoods are operated infrequently

An automated hood can respond to cooking events quickly, efficiently, and as-needed to

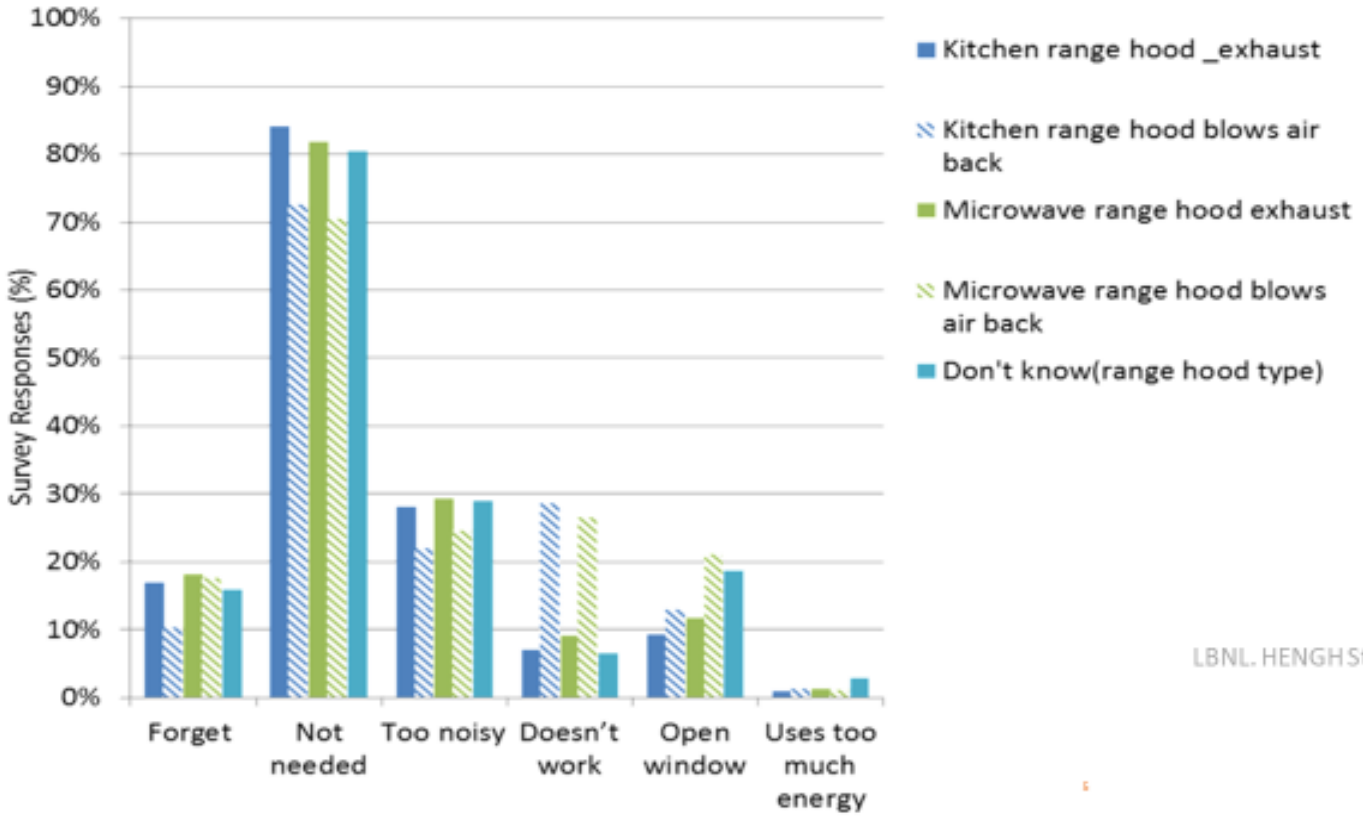
- Reduce occupant pollutant exposure
- Improve health outcomes

Frequency of Range Hood Use



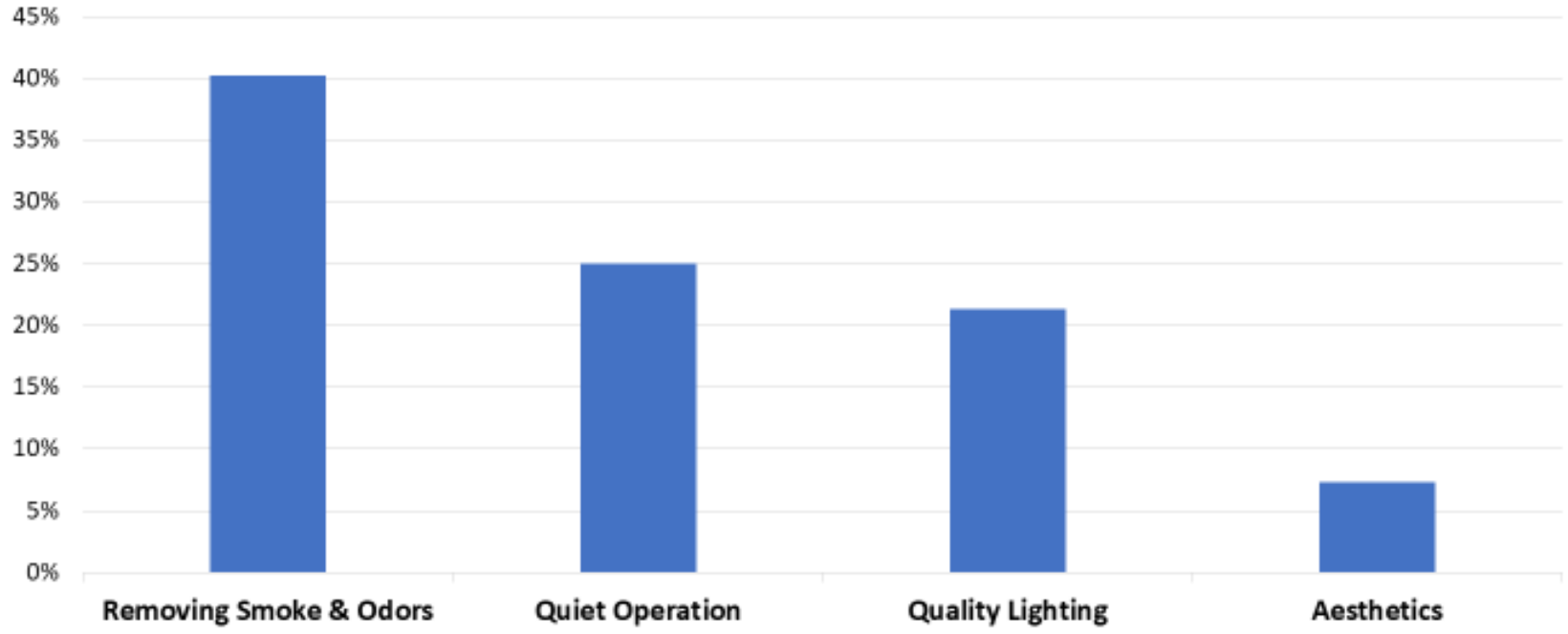
LBNL. HENGH study. Appendix A.

Why don’t we use our Hoods?



LBNL. HENGH Study. Appendix A

Most Important Attributes to Consumers



What Can We Do About It?

Kitchen pollutants are harmful

Range Hoods are…

- Bothersome
- Seldom used
- Often ineffective

US DOE Smart Range Hood Project

Develop a pollutant sensing Smart Range Hood with automated controls

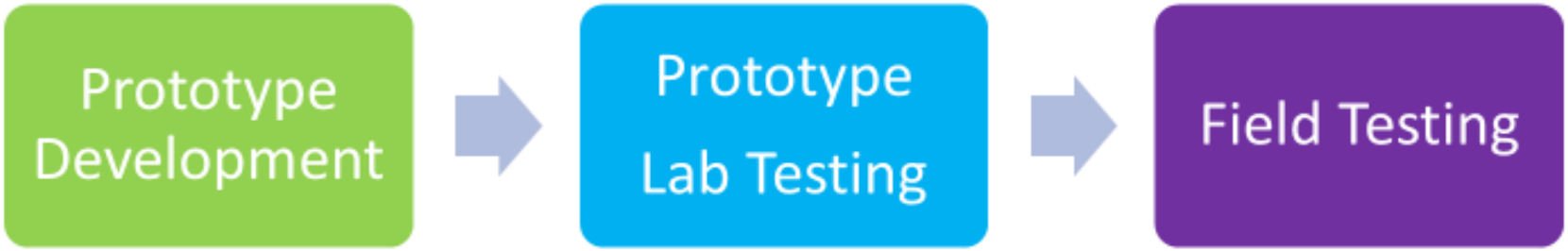
Improve residential IAQ and health outcomes

SRH Design Objectives & Phases

Smart Range Hood

Quiet	**Efficient Pollutant Capture**	**Energy Efficient**	**Sensor Driven Controls**
≤ 1 sone when at a flow no less than 150 cfm	≥ 90% capture efficiency	Fan efficacy exceeding 1.5 times ENERGY STAR® minimum	Auto sense and response to cooking pollutants

SRH Phases


Prototype Development
Prototype Lab Testing
Field Testing

Prototype Development

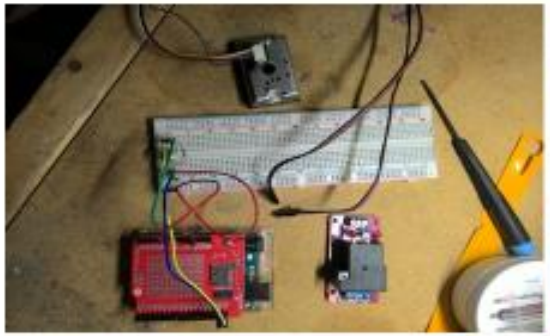
Research Question

Can a prototype SRH be developed that responds to cooking pollutants using IAQ sensors and controls?

Prototype Development

POC → Prototype

P1: Proof of Concept, Newport



P2: Refined model with integrated sensor array, Broan

Prototype Development

Broan Lab Testing and Optimization

Variants

- cooking fuel (electric and gas)
- cooking sequence
- cooking type (boiling water; panfrying meat)
- hood height (low, high)
- fan speed (off; 1, 2, & 3), and
- burner location

Improvements based on sensor:

- location, ability to detect events from all burners
- response time
- response magnitude
- repeatability and reliability
- climatological stability
- longevity, and
- acceptability of hood run times

Prototype Development

Research Question

Can prototype SRHs be developed that respond to cooking pollutants using IAQ sensors and controls?

Yes!

Prototype Lab Testing

Research Questions

1. *Can the prototype SRH operate at a **loudness** level ≤ 1 sone?*

2. *Can the prototype SRH provide a **capture efficiency** ≥ 90%?*

3. *Can the prototype SRH **automatically and effectively remove pollutants** generated by cooking events?*

Prototype Lab Testing

Loudness Testing

Goal: ≤ 1 sone at flow ≥ 150 cfm

Achieved: 0.3 – 0.6 sones at an airflow rate of 150-160 cfm; 5-6 sones at high speed

Only 3% percent of range hood sone listings in the HVI directory had a sone rating < 1 as of January 2020

Prototype Lab Testing

Range Hood Capture Efficiency

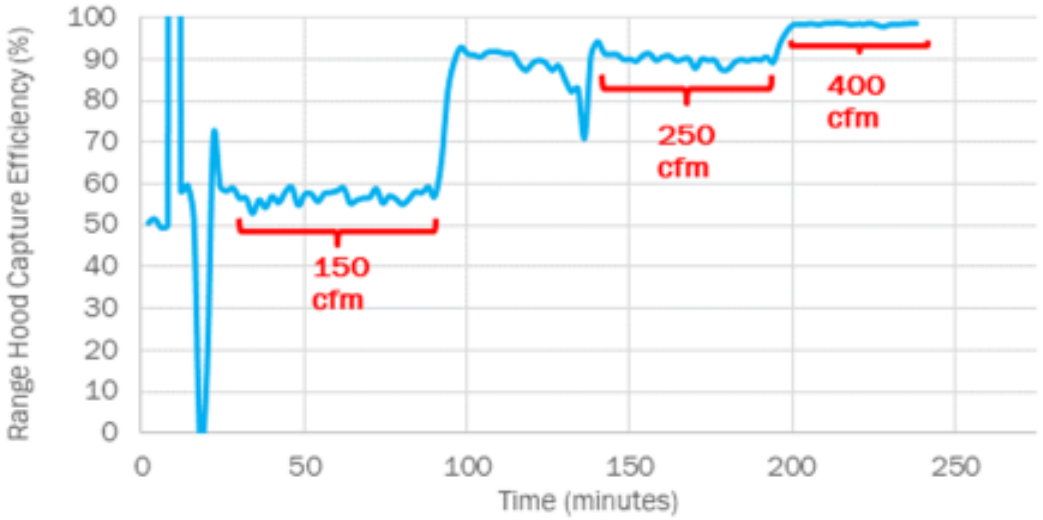
Goal: ≥ 90%

Achieved:

57% at 150 cfm,

90% at 250 cfm, and

98% at 400 cfm



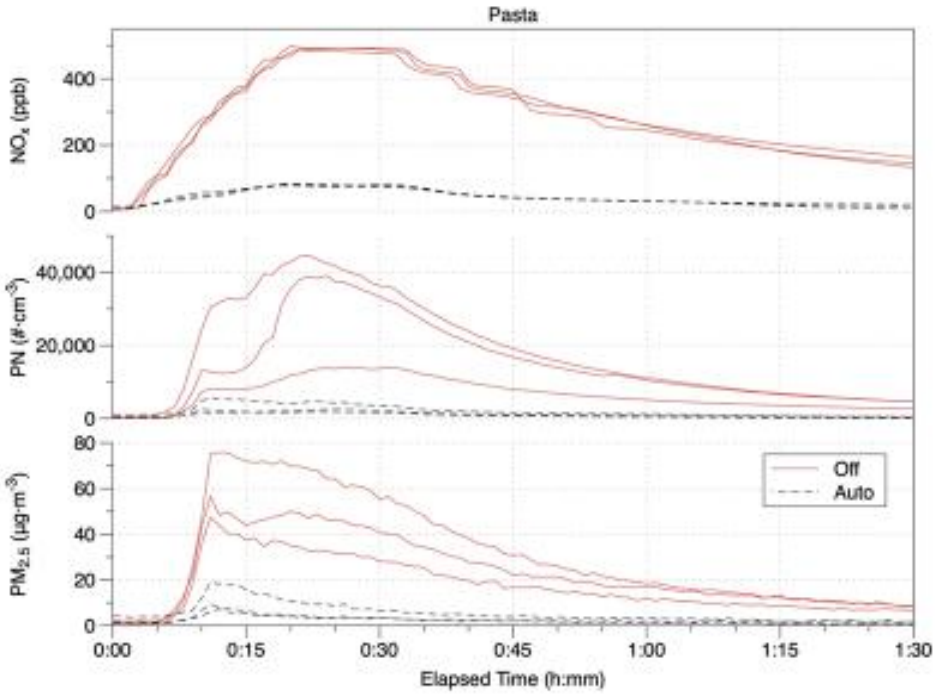
Prototype Lab Testing

LBNL: Response to Cooking Events

- Gas stove
- 3 meals:
  - Two cooktop, front burners: breakfast, pasta
  - One oven: mandarin orange chicken
- 3 replicates for "auto" and "off" conditions
- Monitored pollutants: NO_x, $PM_{2.5}$, PN

Prototype Lab Testing

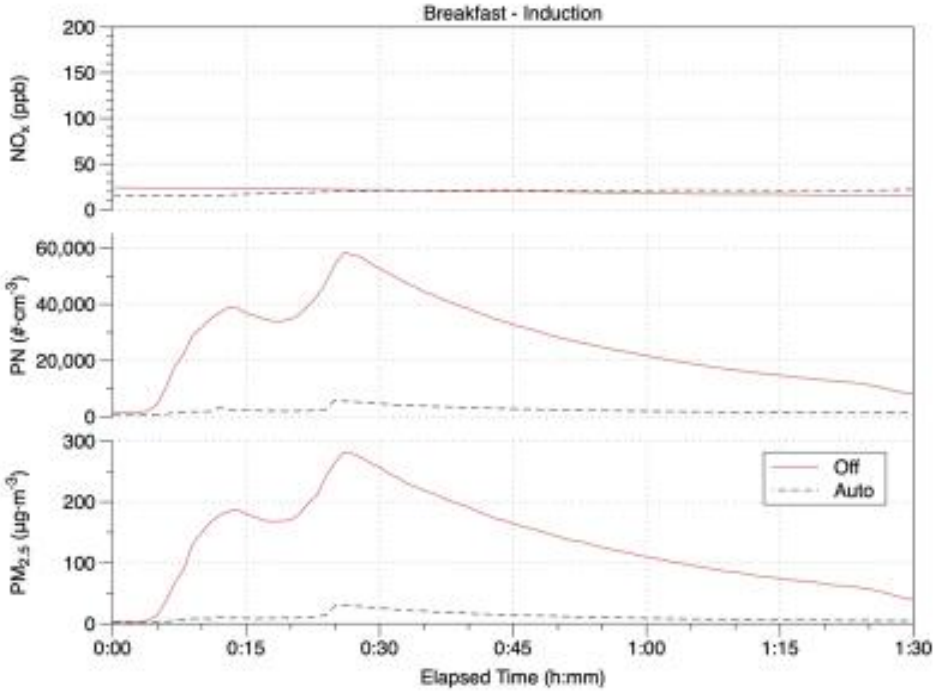
Cooktop: Pasta, Gas Range



Room air pollutant concentrations resulting from cooking pasta with meat sauce on a natural gas range, without (Off) and with (Auto) smart range hood operating.

Prototype Lab Testing

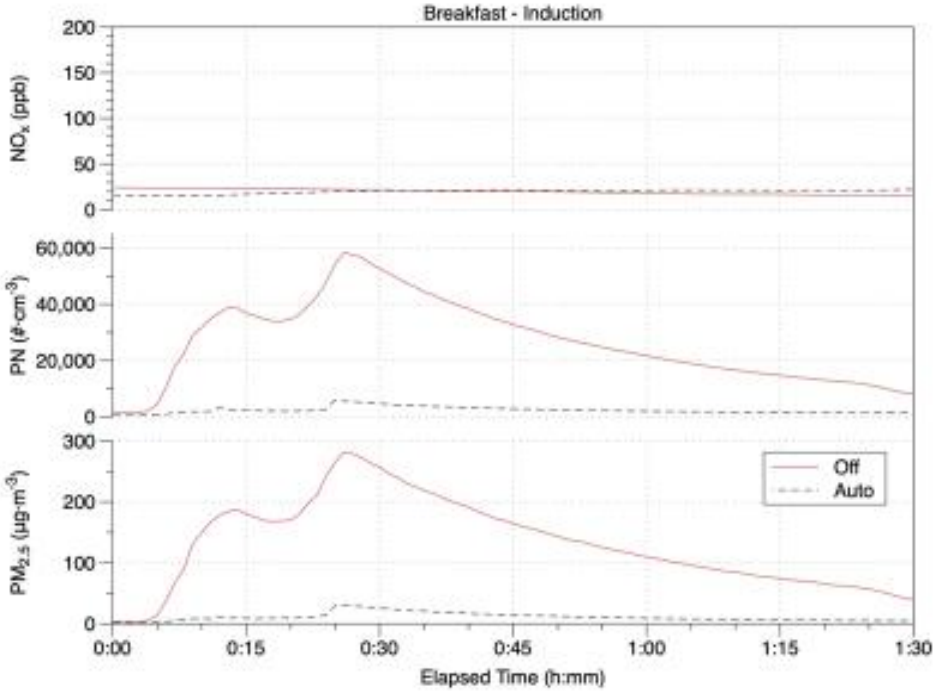
Cooktop: Breakfast, Induction



Room air pollutant concentrations resulting from cooking hash browns and bacon on a single induction burner, without (Off) and with (Auto) smart range hood operating.

Prototype Lab Testing

Cooktop: Breakfast, Induction

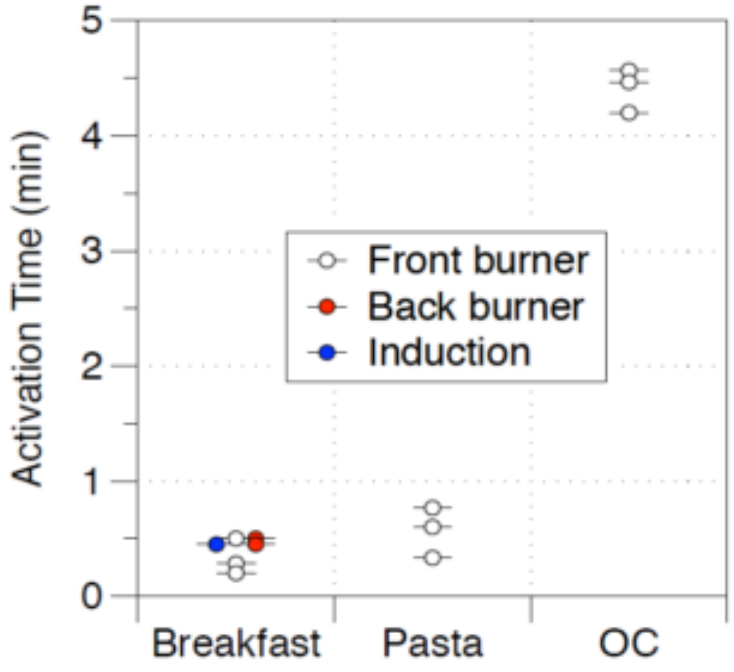


Room air pollutant concentrations resulting from cooking hash browns and bacon on a single induction burner, without (Off) and with (Auto) smart range hood operating.

Prototype Lab Testing

Response Time

- < 1 minute to all cooktop events
- Longer response time to oven; but not designed to respond to oven



Prototype Lab Testing

Research Questions

1. *Can the prototype SRH operate at **loudness** level ≤ 1 sone?*
2. *Can the prototype SRH provide a **capture efficiency** ≥ 90%?*
3. *Can the prototype SRH **automatically and effectively remove pollutants** generated by cooking events?*

Yes!

Field Testing

Research Questions

1. Can the SRH **substantially reduce air pollutant concentrations** in homes with frequent cooktop operation, compared to the reference case of occupants electively and manually operating their existing kitchen exhaust system “as needed” or “rarely/never”?

2. What are **occupant perceptions of the operation and effectiveness** of the SRH?

Field Testing

Configuration

- 3 owner-occupied homes (NY1, MD1, MD2)
- Pre-SRH retrofit: 2-weeks; elective use of existing hood; normal meals; incentivized to cook replicate meals frequently
- Post-SRH retrofit: 2-weeks
- Cooking log
- Exit interview

Field Testing

Participant Criteria

Home

- Owner occupied
- SF
- 1-4k ft^2
- < 7 ACH50
- Existing hood or OTR

Operation

- Frequent cooking
- No smoking
- No air cleaner use
- Central fan on "auto"
- Windows shut
- Report rare operation of range hood

Compensation

- $300 participation
- Free range hood at conclusion
- $20 per replicated cooking event

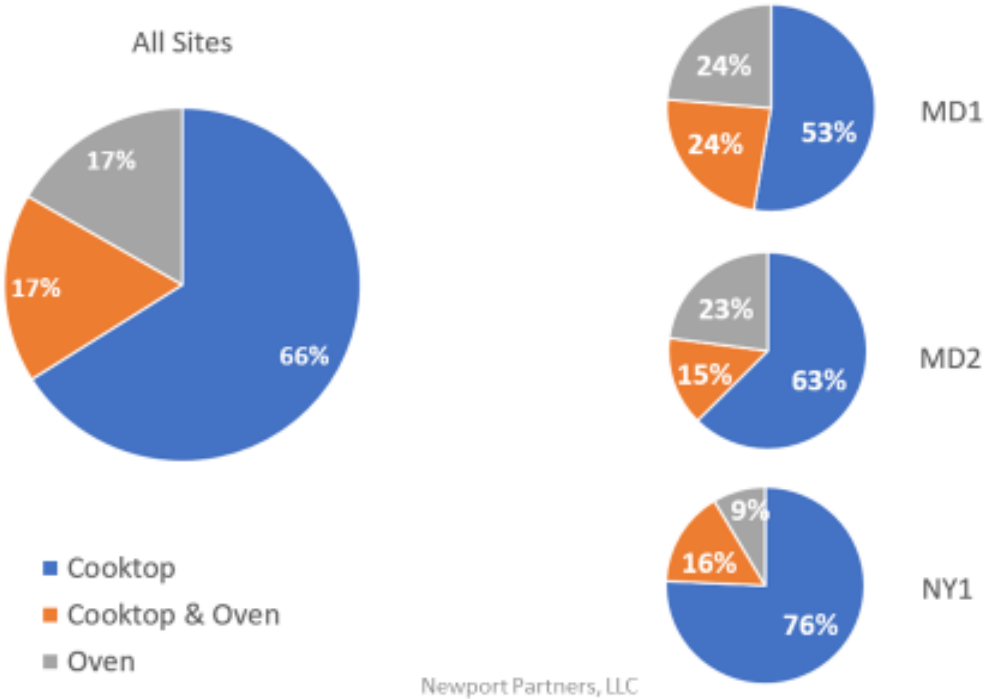
Field Testing

Cooking Events

Site	Cooktop events			Combined Cooktop & Oven Events			Oven Events			Total Events	
	Existing	SRH	Total	Existing	SRH	Total	Existing	SRH	Total	Existing	SRH
MD1	12	8	20	3	6	9	1	8	9	16	22
MD2	19	11	30	4	3	7	8	3	11	31	17
NY1	26	27	53	6	5	11	4	2	6	36	34
Total	57	46	103	13	14	27	13	13	26	83	73

Field Testing

Cooking Appliance



Field Testing

Cooktop Event Histogram

Sites: NY1 & MD1

Cooktop Burner Run Time (minutes)	Existing Hood		SRH	
	Events	Median Run Time (minutes)	Events	Median Run Time (minutes)
0-5	1	0	1	14
5-10	10	0	8	20
10-15	21	0	13	25
15-20	1	87	4	21
20-25	3	0	5	51
25-30	0	--	3	27
30-35	0	--	0	--
35-40	1	124	1	23
40-45	0	--	0	--
45-50	0	--	0	--
50-55	0	--	0	--
55-60	1	0	0	--
Total Events	38	--	35	--
Burner Run Time	--	12	--	17
Hood Run Time	--	0	--	25

Field Testing

Hood to Burner Run-Time Ratio

Sites: NY1 & MD1

Percent of Cooktop Events by Hood:Burner Run-Time Ratio													
Hood:Burner Run-Time Ratio	0	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	Median	Total Events
Existing	89%	0%	0%	0%	3%	3%	3%	0%	0%	0%	3%	0.0	38
SRH	6%	17%	23%	34%	9%	3%	3%	0%	0%	6%	0%	2.3	35

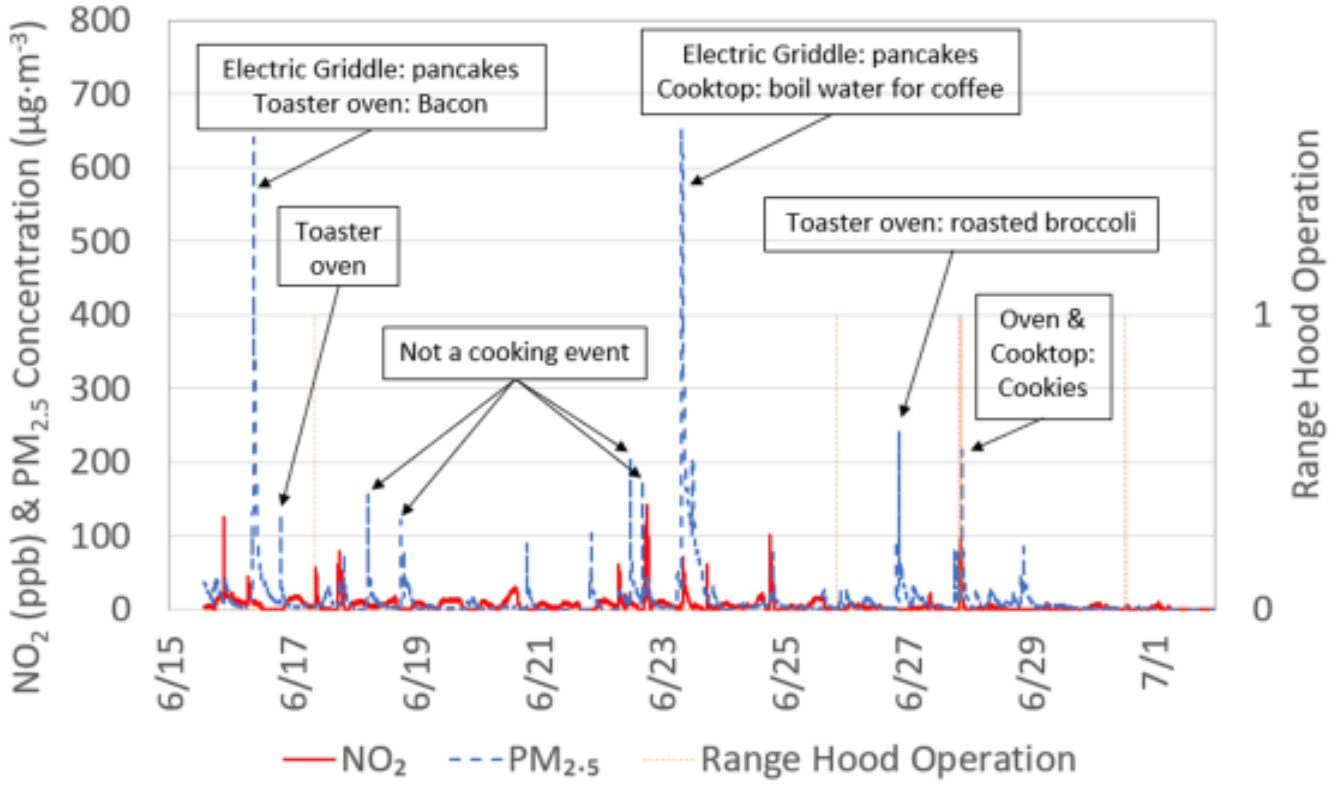
Field Testing

Hood Activation & Operation

Range Hood Operation Parameter	MD1		MD2		NY1	
	Existing	SRH	Existing	SRH	Existing	SRH
Percent of cooktop events where range hood was activated	0%	100%	--	--	15%	93%
Average delay in activation of range hood after start of cooktop event, when range hood was activated for an event (minutes)	--	< 1	--	--	8	< 1
Average daily range hood operation (low, medium, high minutes)	L: 0 M: 2 H: 1	L: 10 M: 14 H: 12	--	--	L: 7 M: N/A H: 87	L: 28 M: 63 H: 31
Average daily range hood air volume exhausted (MCF)	1	9	--	--	30	33

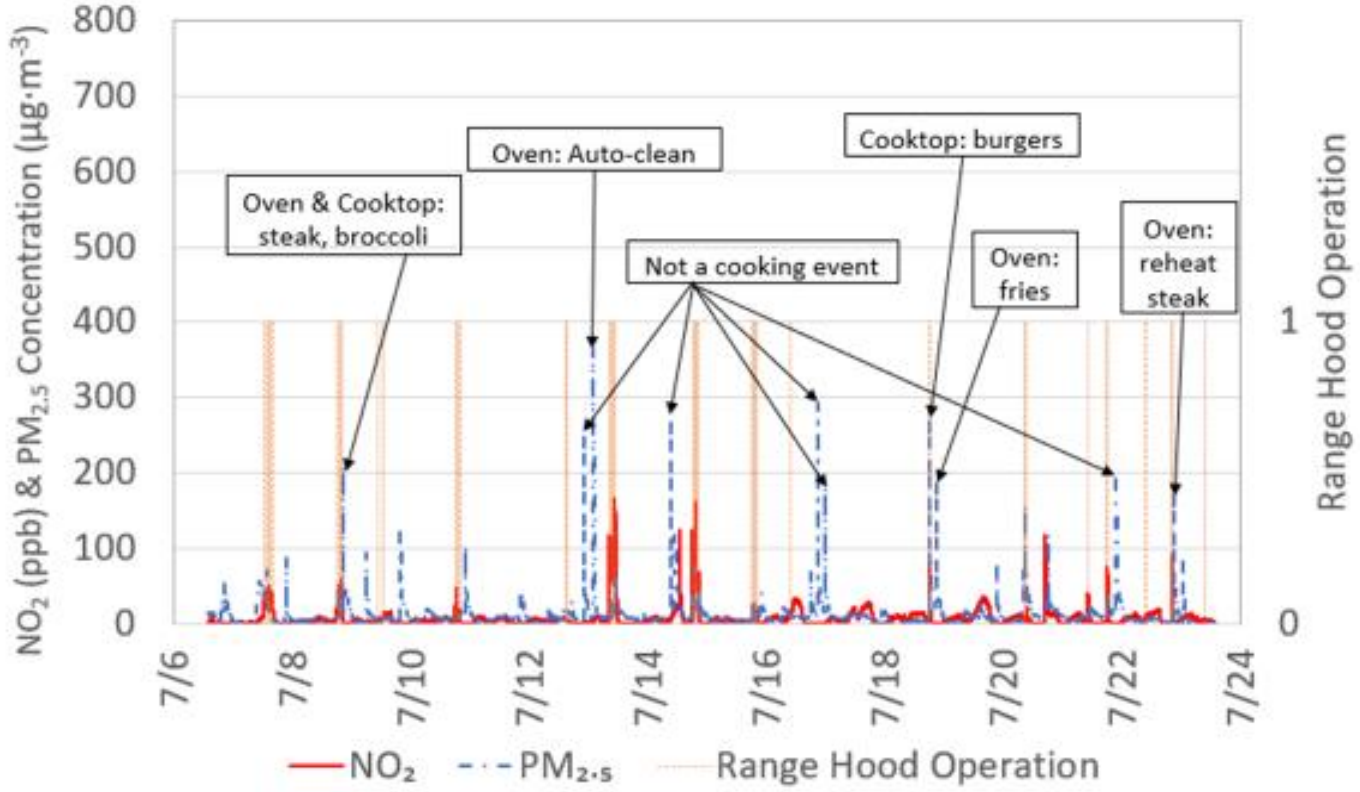
Field Testing

MD1: Existing Kitchen $PM_{2.5}$ & NO_2



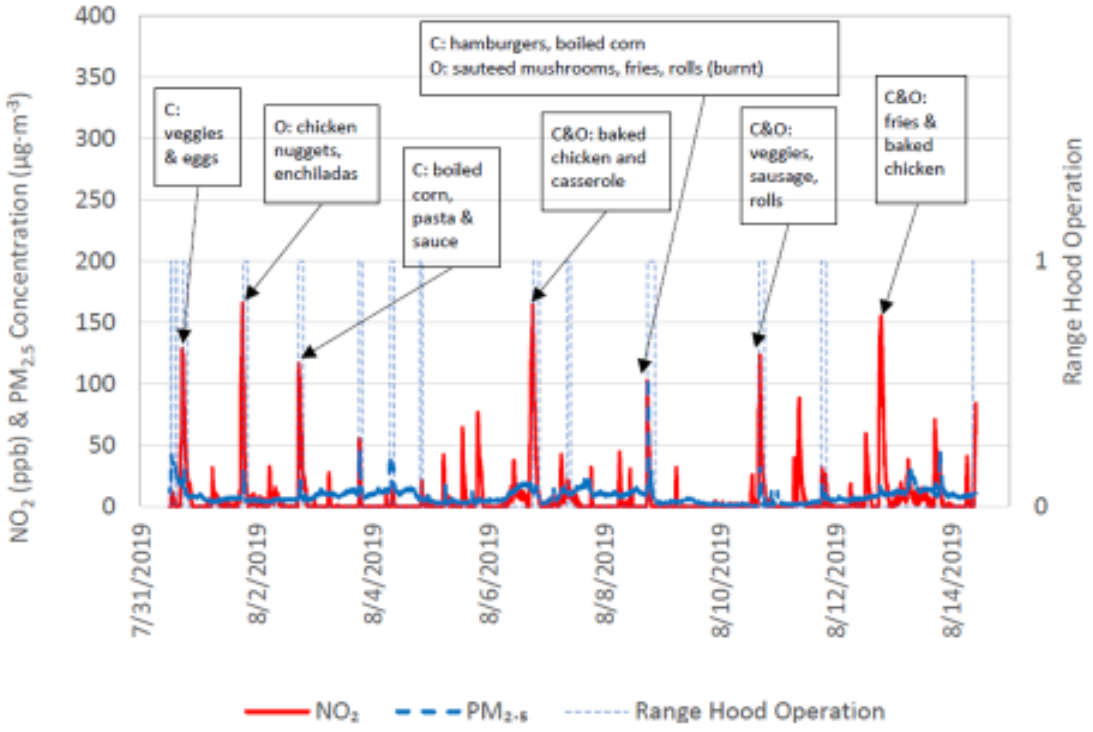
Field Testing

MD1: SRH Kitchen $PM_{2.5}$ & NO_2



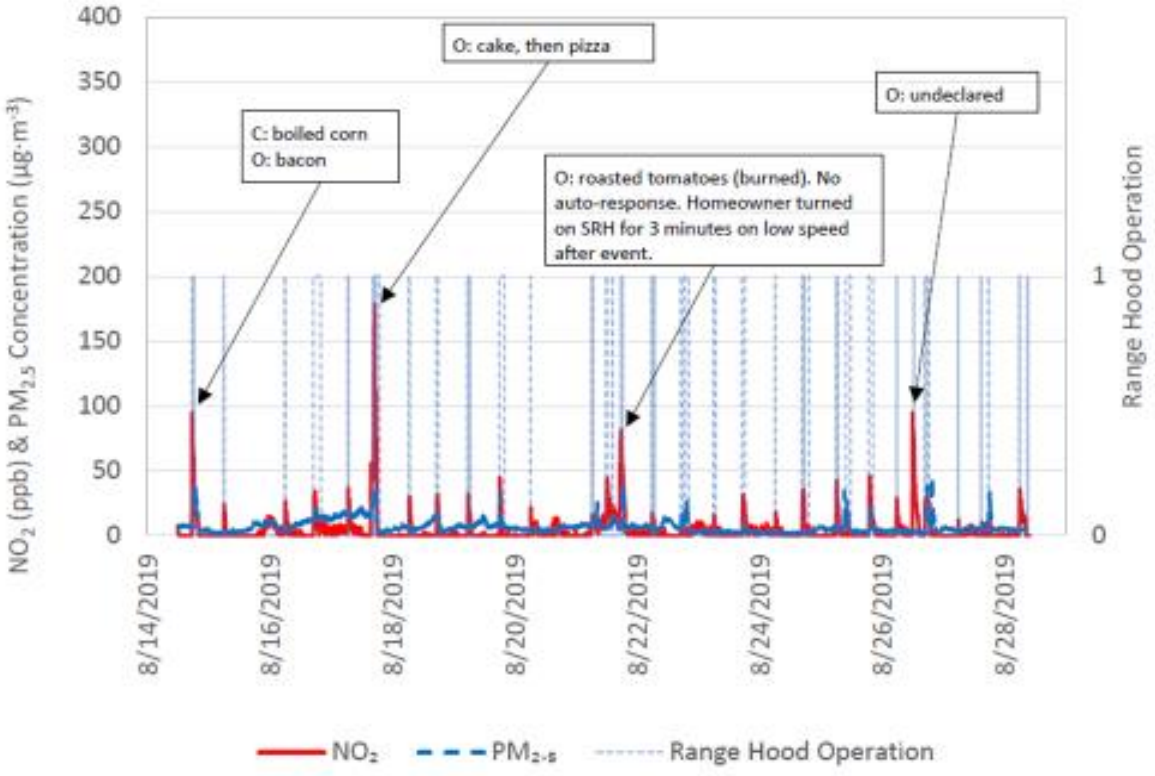
Field Testing

NY1: Existing Kitchen $PM_{2.5}$ & NO_2



Field Testing

NY1: SRH Kitchen $PM_{2.5}$ & NO_2



Field Testing

Performance: Major Findings

- The SRH detected and responded to **94% of cooktop events**
- The SRH had a **< 1 minute response time** to cooktop events on average
- The SRH provided a **40% reduction versus the existing hood case** in the median difference between the NO_2 peak and background for cooktop events
- The frequency of extreme NO_2 events was reduced under SRH operation, with **zero SRH cooktop events exceeding a 100 ppb increase** from the background NO_2 concentration and five cooktop events in the existing case exceeding a 100 ppb increase from the background NO_2 concentration.

Field Testing

Perceptions: Major Findings

Site	Ability to Remove Smoke and Odors	Noise
MD1	Significantly Better	Significantly Better
MD2	Significantly Better	The Same
NY1	Better	Worse

Field Testing

Perceptions: Homeowner Recommendations

- **Loudness**: "The lowest setting was pleasant. I would prefer it to run for 10 minutes at low-speed over 2 minutes at the highest volume."
- **Loudness**: Provide a "quiet" mode so that others in the house wouldn't be disturbed should cooking take place in the early morning or late at night. "When I would boil water at 5:30 AM with kids sleeping, it was sudden and loud; it actually woke people up."
- **Information**: Have the SRH connect to an app that would provide feedback to the homeowner. The app would let the homeowner know what the range hood is sensing and provide some insight as to why and for how long the hood operates.
- **Speed setting**: "a few times it cycled up and down (and beeped) 15+ times during cooking. It was too indecisive." Another homeowner noted, "It couldn't ever decide on a speed and would continuously adjust." The "clicking" associated with speed indexing was "annoying".

Thank You!

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301-889-0017

New Virtual Sessions from Solar Decathlon on Innovative Homes and Energy Careers

The Solar Decathlon announced a new webinar series starting in September that will include virtual tours of innovatively designed homes and address a variety of topics from the rise in zero energy homes to clean energy careers.

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

Register for Upcoming Session and Watch Prior Sessions at solardecathlon.gov/virtual_sessions.html

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bbresidentialnetwork@ee.doe.gov