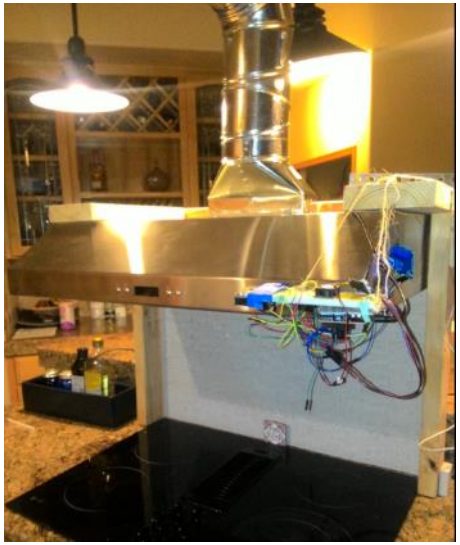
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Development of the Industry's First Smart Range Hood (SRH)



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Project Summary

Timeline:

Start date: October 1, 2016

Planned end date: September 30, 2019

Key Milestones

1. Develop Gen1 and Gen2 prototypes
2. Conduct laboratory tests

Budget:

Total Project $ to Date:

- DOE: $174,738
- Cost Share: $175,799

Total Project $:

- DOE: $462,803
- Cost Share: $213,819

Key Partners:

Newport Partners L.L.C.

BROAN NuTone

Project Outcome:

Support energy savings from building air sealing through early-stage research of an auto-responsive kitchen range hood ventilation system. Contribute to Building America MYPP goal of demonstrating reductions of EUI by 40% in existing homes and 60% in new homes while maintaining acceptable indoor air quality.

Project Goal:

Integrate smart features in future, commercially available range hoods.

Team

Newport Partners L.L.C.

Newport performs RD&D of ventilation products and specification tools and has proposed more successful changes to the ventilation provisions of the ICC and ASHRAE 62.2 than any other group in the last 7 years.

BROAN®

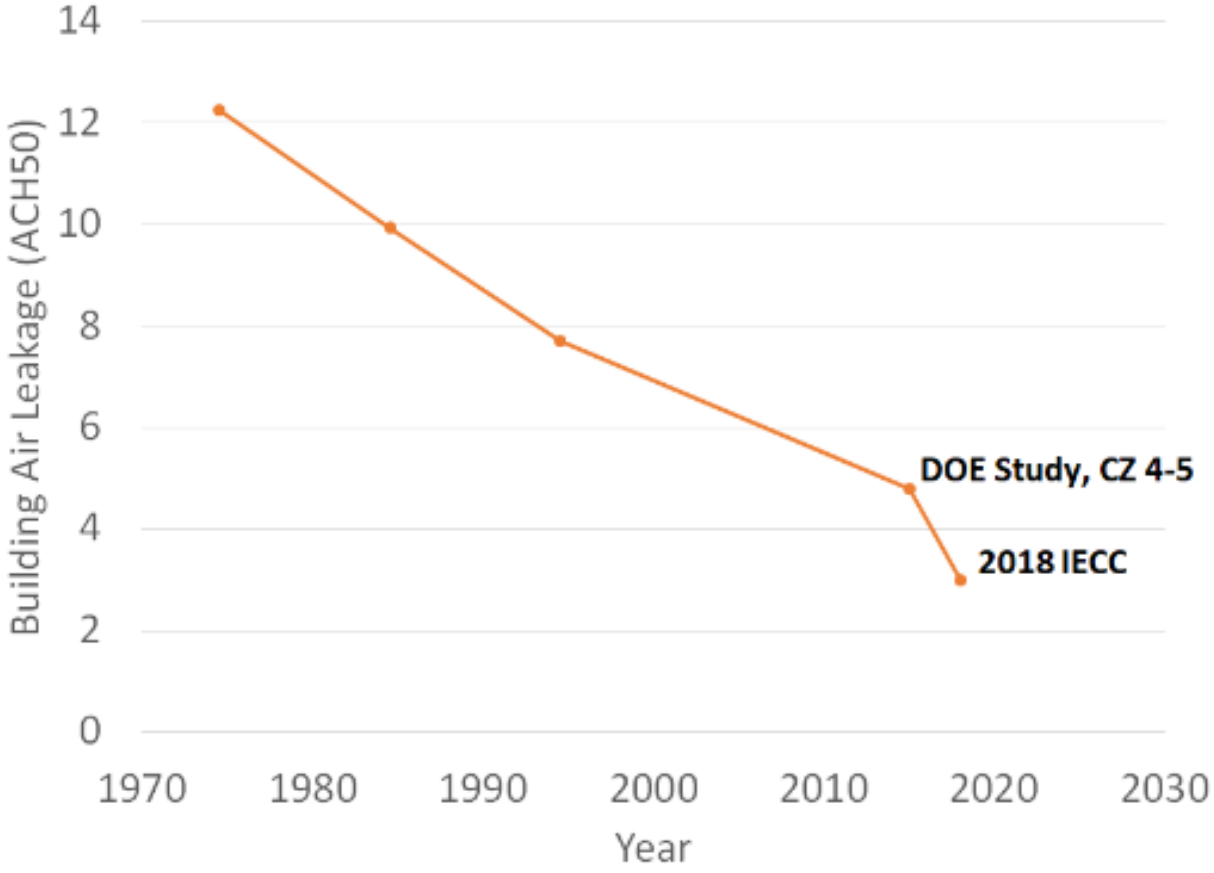
Broan is the largest U.S. manufacturer of residential range hoods

BERKELEY LAB

Leading national laboratory for residential kitchen ventilation research. Lab testing and review of test plans.

Challenge

- Homes are getting tighter and using less energy: YES!
- But…pollutant concentrations increase with reduced air changes

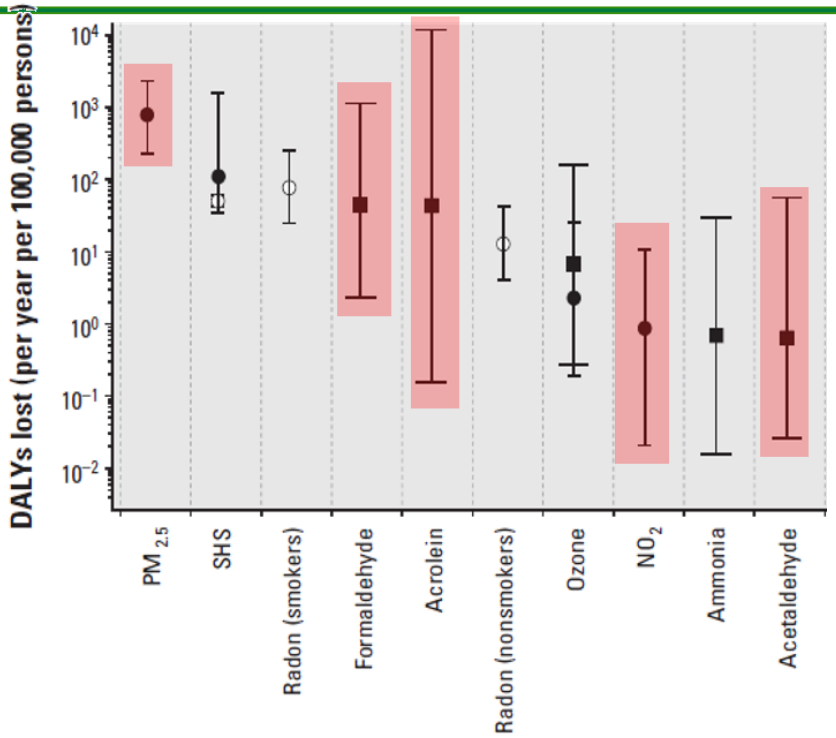


Source: LBNL Residential Diagnostics Database (CZ4, dry), DOE Residential Energy Code Field Study (climate zone 4-5), 2018 IECC (climate zone 3-8)

Source: Unpublished survey data from LBNL

Challenge

- Cooking is a primary source of indoor pollutants
  - PM2.5
  - VOCs
    - Aldehydes
    - PAH
  - NO_2
  - CO
  - CO_2



Logue JM, Price PN, Sherman MH, and Singer BC. 2012. A Method to Estimate the Chronic Health Impact of Air Pollutants in U.S. Residences. Environmental Health Perspectives 120(2): 216-222.

- Range hoods are used infrequently

Source: Unpublished survey data from LBNL

Result: Poor IAQ from cooking is a barrier to residential energy savings

What can we do?

1. Develop a Smart Range Hood that senses pollutants, with automatic operation
2. Save energy by specifying tight envelopes; Improve residential IAQ, extend lives, and save billions of dollars in health-related costs annually

Approach

Develop an SRH to address critical market barriers

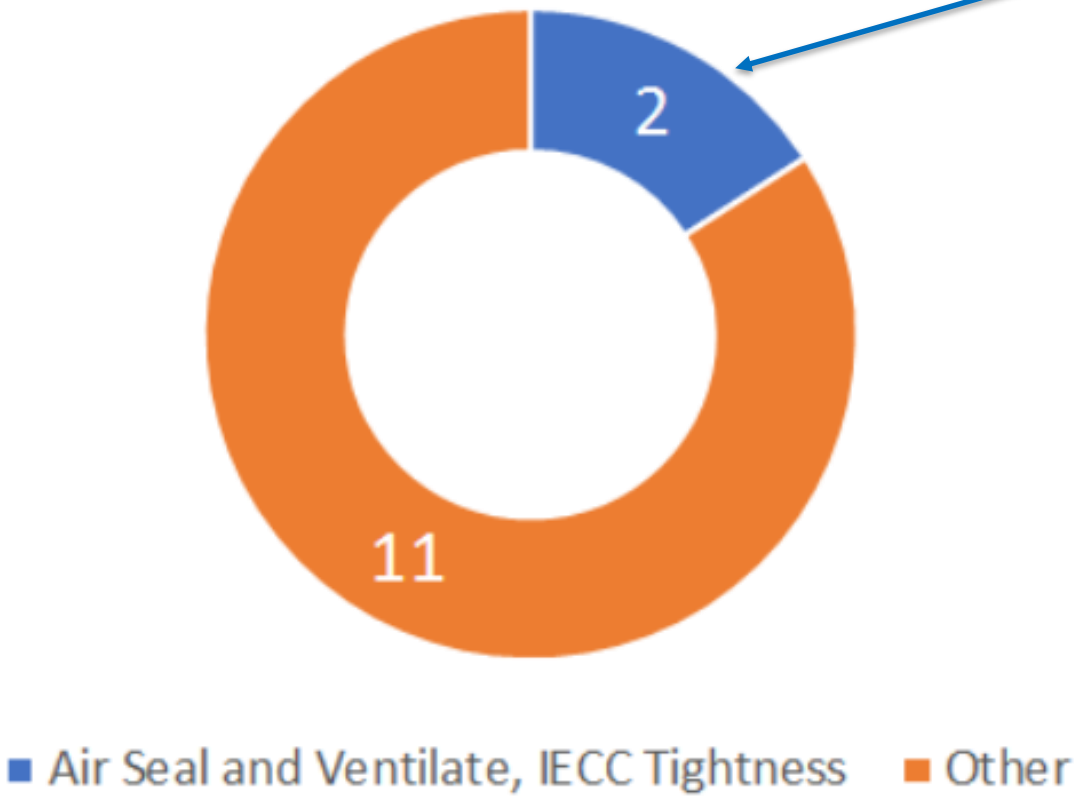
Problem	*Solution*
Too Noisy:	≤ 1 sone at 150 cfm
Poor Capture:	~100% CE
Not Operated:	auto response
Inefficient:	up to 5x more efficient than ENERGY STAR
High Cost:	pricing for intermediate market

Distinctive Characteristics: quiet, superior capture efficiency, energy efficient, responsive to pollutants

Key Issues: Sensor accuracy, control algorithms, user acceptance

Impact

BTO Goal: 40% reduction in residential EUI by 2030 (~13 quads)



Air seal & ventilate: could account for up to 2 quads (16%) of BTO's goal for the residential building sector

*Sherman et al. 2013. Residential Energy Savings from Air Tightness and Ventilation Excellence. CEC-500-2014-014

Impact

Occupant-vented

Expect up to 80% - 90% reduction in cooking pollutant exposure with auto-venting*

Auto-vented

Why do we auto-vent this but not this?

74 kBtu/hr

34 kBtu/hr

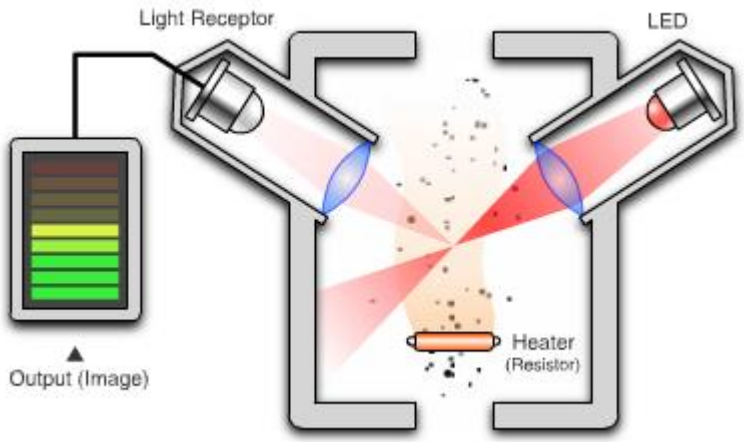
*Based on preliminary lab tests.

Progress

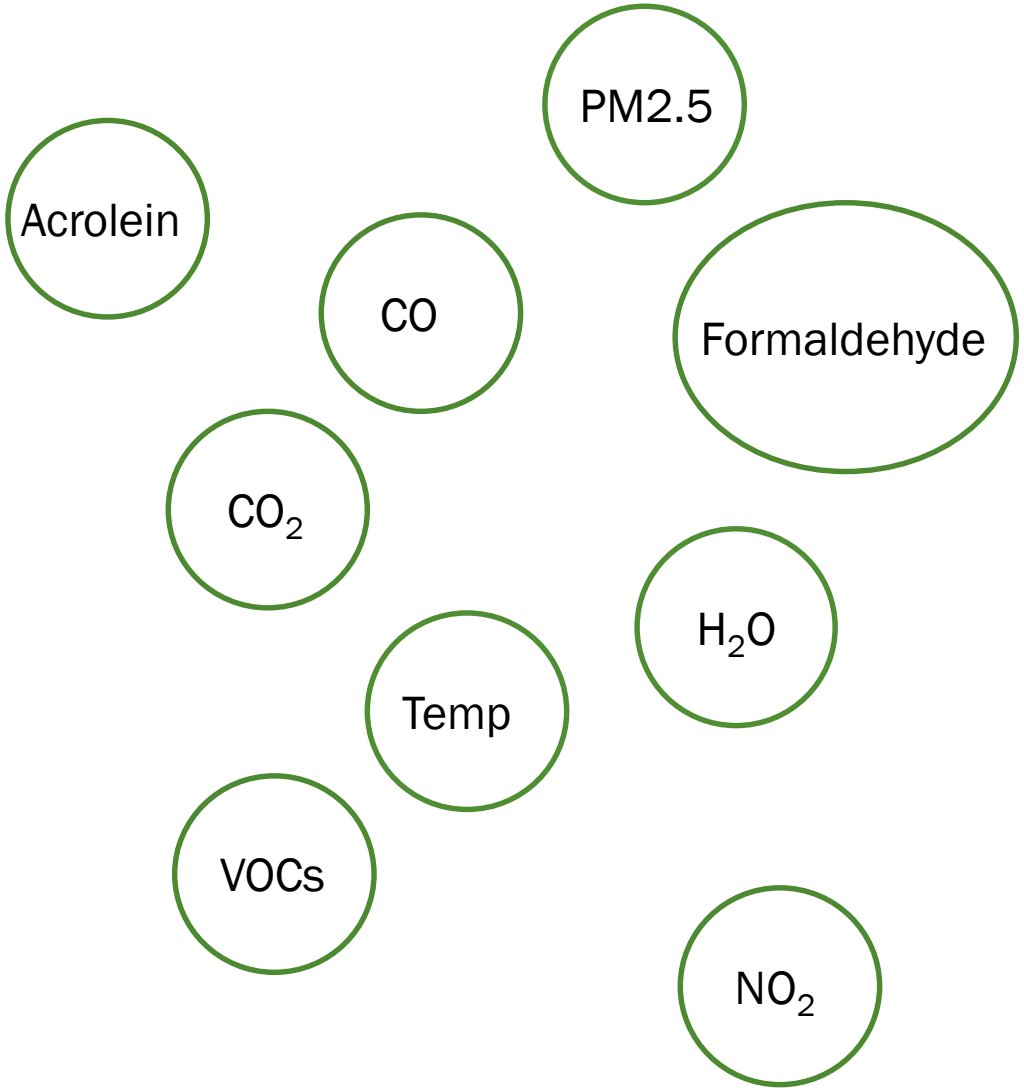
Milestones completed:
(late-stage project)

1. Pollutant and Sensor Matrix: concentration thresholds and ranges, sensor accuracy and costs

2. Sourced low-cost, accurate* sensors



PM2.5 Sensor Schematic; Image c/o Shinyei Technology



Progress

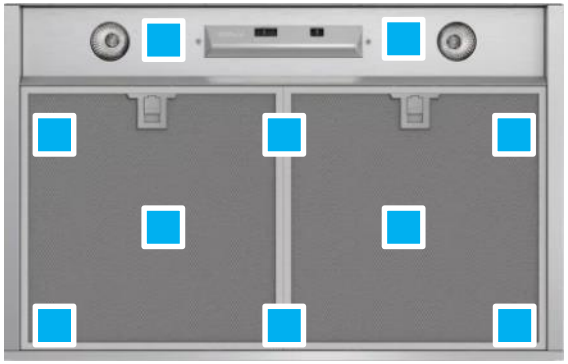
Milestones completed:

3. Control logic model

$$State = f(C_{P1}, C_{P2}, \ldots C_{Pn})$$

4. Proof of concept prototype

5. Optimized sensor location



Progress

Milestones completed

6. Gen1 integrated prototype

7. Gen2 integrated prototype

8. Lab tests

Metric	Target	Achieved
Efficacy	4.2 cfm/W	4.5 - 4.7 cfm/W*
Sound	<= 1 sone @ >= 150 cfm	0.3 – 0.6 sones @ 150 - 160 cfm*
Capture Efficiency	>= 90%	90% @ 250 cfm 98% @ 400 cfm

*working speed, various configurations

Progress

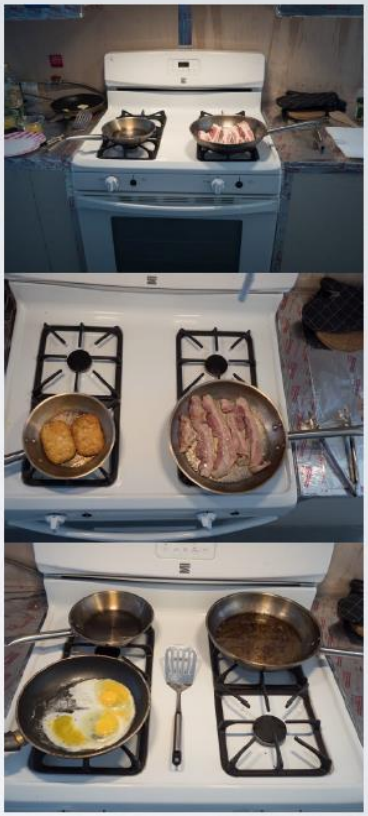
Milestones completed

8. Lab tests: scripted cooking events with and without auto-sensing hood

Breakfast - bacon, eggs, and hash browns

Breakfast Cooking Details - PARALLEL

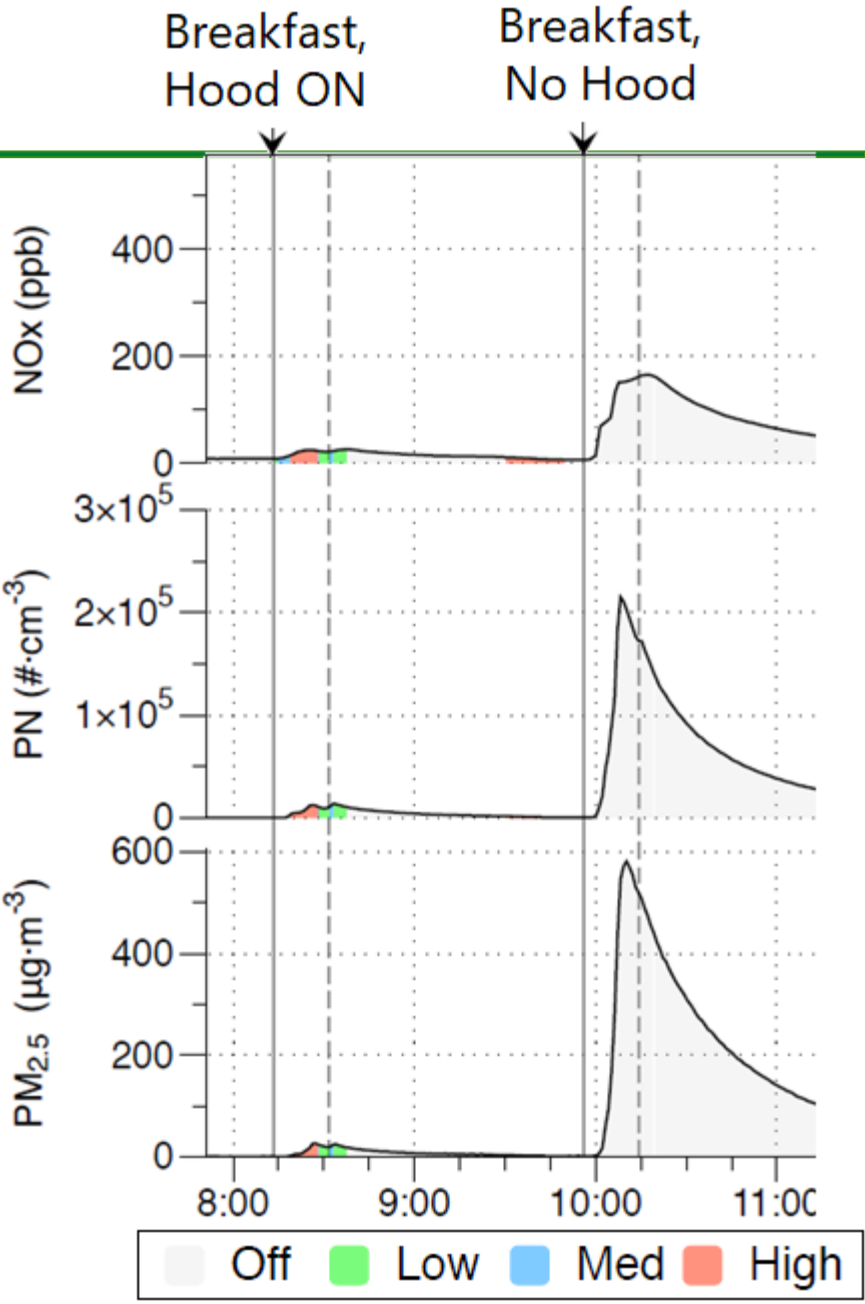
Time (min)	Activity	Gas (lpm)
0	**Start front left burner on medium (2 lpm)** for hash browns	->
0:15	**Start front right burner on medium** (+2 lpm; **Total 4 lpm**) - bacon in pan (cook 12 min); remain to watch oil	->4.04
1.5	Add 2 hash browns to small skillet (cook 9 min); remain	
2	flip bacon and 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	



Progress

Milestones completed

8. Lab tests: scripted cooking events at LBNL with and without auto-sensing hood



Stakeholder Engagement

- Outreach: manufacturers, industry standards bodies, builders and kitchen designers, media outlets
- Homeowners: Q3 field study
- Commercialization anticipated: 2020

Remaining Project Work and Goals

Near term, close of project

- Q2: Analyze lab test results
- Q2 – Q3: Field tests (3 homes) for pollutant concentrations and homeowner perceptions pre- and post-intervention
- Q3: Final report

Intermediate term: aim for product launch in 2020

Long term: 25% market penetration

Thank You

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REFERENCE SLIDES

Project Budget

Project Budget: $462,803
Variances: None
Cost to Date: $174,738
Additional Funding: None

Budget History					
FY 2017 (past)		FY 2018 (past)		FY 2019 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$67,697	$42,305	$92,064	$76,518	$303,041	$94,996

Project Plan and Schedule

Period of performance: October 1, 2016 - September 30, 2019

Milestone	Description	Federal Year Due Date
M1.1	Develop sensor specification table with primary pollutants and key criteria	2017 Q2
M1.2	Source affordable sensors that also achieve high performance	2017 Q2
M1.3	Develop project management plan (PMP)	2017 Q2
GNG1	Develop logic models that addresses auto-operation and 62.2 compliance.	2017 Q3
M2.1	Develop lab test plan	2017 Q4
M3.1	Develop first prototype of sensor and control module	2018 Q1
M3.2	Develop second prototype of sensor and control module	2018 Q2
M3.3	Develop a first-generation prototype with integrated sensors and controls	2018 Q3
M3.4	Develop a second-generation prototype with integrated sensors and controls	2018 Q4
GNG2	Test and verify the response of the second gen prototype to a typical cooking scenario.	2019 Q1
M4.1	Conduct lab tests for capture efficiency using the latest ASTM draft capture efficiency test	2019 Q2
M4.2	Conduct lab test for sound per HVI 915	2019 Q3
M4.3	Conduct lab test for auto operation with respect to pollution sensing and response	2019 Q3
M4.4	Develop field test plan, including human subjects review (HSR)*	2019 Q2
M5.1	Conduct first field test and report on performance	2019 Q3
M5.2	Conduct second field test and report on performance	2019 Q4
M5.3	Conduct third field test and report on performance	2019 Q4
M5.4	Final technical report and case study	2020 Q1
M6.1, M6.4, M6.7	Attend Building America stakeholder, expert or program planning meeting	2017, 2018, 2019
M6.2, M6.5, M6.8	Participate in Building America technical peer review process (up to 3 annually)	TBD
M6.3, M6.6, M6.9	Present results in webinars and conferences (up to 2 annually)	2017, 2018, 2019
M6.10	Participate in BTO Peer Review	TBD

*Delayed based on additional time required to complete DOE IRB submission