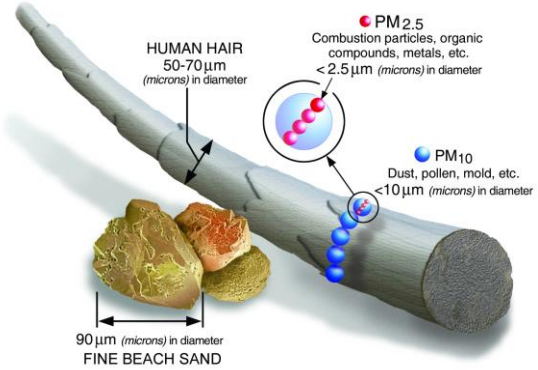
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Baseline Indoor Air Quality Field Study in Occupied New U.S. Homes: Cold and Marine Climate Zones



Pacific Northwest National Laboratory
Cheryn Metzger/Jian Zhang, Senior Research Engineers
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Images from epa.gov and medlineplus.gov

Project Summary

Timeline:

Start date: 10/1/2017

Planned end date: 3/30/2020

Key Milestones

1. Obtain IRB approval: 3/31/2018
2. Go/No-Go: Complete 8 homes, 12/31/2018
3. Complete 22 homes, 3/31/2019

Budget:

Total Project $ to Date:

- DOE: $528k
- Cost Share: $25k +58k (just contracted)

Total Project $:

- DOE: $795k
- Cost Share: $105k

Key Partners:

Cadmus	LBNL
WSU	FSEC
Panasonic	Ecotope
NEEA	University of Illinois
SWEEP	BPA

Project Outcome:

1) Improve understanding of potential health risks in new homes as industry works to achieve MYPP goal of 60% lower energy use.
2) Determination of how much the air flow, and specifically, correctly designed mechanical ventilation, affects the indoor air quality (IAQ) in new homes in the cold and marine climate zones.

Baseline IAQ Field Study in Occupied New U.S. Homes: Cold and Marine Climates

Team Lead: Pacific Northwest National Laboratory

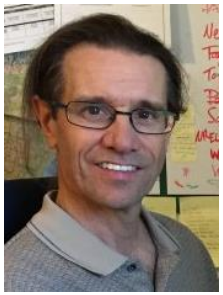
Cheryn Metzger
Senior Engineer
Project Manager/Co-PI

Dr. Jian Zhang
Senior Engineer
Co-PI

Chrissi Antonopoulos
Analyst

Michael Baechler
Senior Scientist

Cadmus, WSU, and Ecotope



Mitt Jones/Paul Norton
Lead Field Technicians

Mike Lubliner and **Dave Baylon**
QA/QC
Voting Members ASHRAE 62.2 Committee

Unique Team Traits:

Residential and indoor air quality and field data collection experts, all team members playing to their strengths for highest efficiency.

Challenge

- Air tightness reduces energy use for thermal conditioning but can increase risks of some IAQ problems.
- Adequate ventilation is necessary – though not always sufficient - for acceptable IAQ.
  - ASHRAE 62.2 sets requirements for ventilation equipment and minimum outdoor air rates in homes.
  - Several states and many home performance programs include mechanical ventilation requirements.
- Limited data indicate deficiencies:
  - many new homes lack general ventilation or kitchen exhaust
  - installed systems commonly don't meet standards
  - Installed systems often not used as intended

Approach

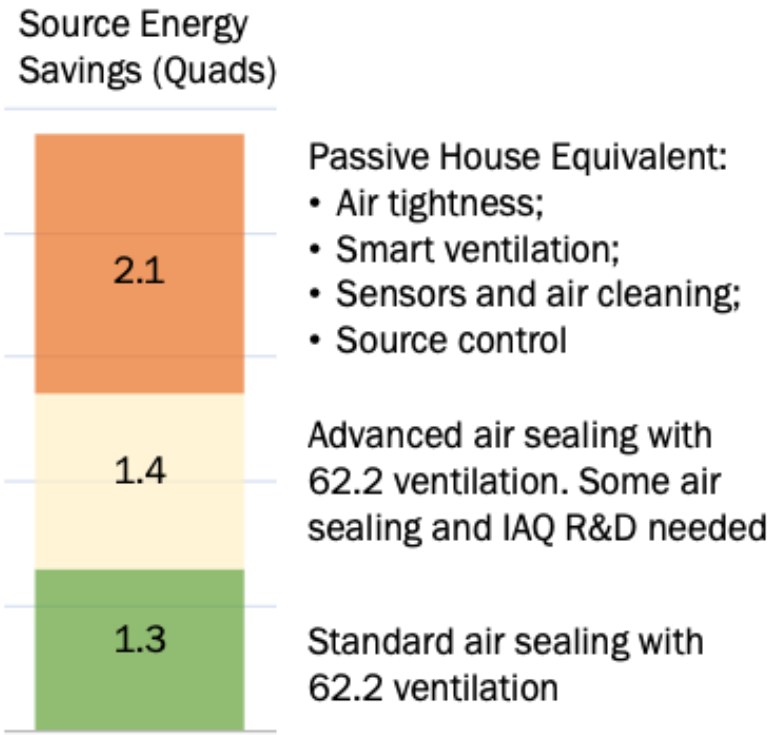
- Conduct field study in varied US climate zones.
- Recruit homes that represent diversity of construction styles and mechanical system designs in each climate zone.
- Visual characterization and performance measurements on site.
- Survey of occupants about activities and perceptions.
- Measurements of pollutants and equipment use over 1 week with windows closed (seasonally appropriate).
- Analyze data to quantify concentrations, emission rates, use and effectiveness of MV, etc.

Targets

- 32 homes/zone
- 16 w/ mech vent
- 8 get 2-week test

Impact

Tighter US homes will use 3 Quads less source energy per year[1]



California study found acceptable IAQ in newish homes with MV

Mean indoor concentration	CA homes pre-MV	CA homes with MV
Formaldehyde	36.3 ppb	19.8 ppb
$PM_{2.5}$	13.3 µg/m^3	8.3 µg/m^3
NO_2	5.4 ppb	6.1 ppb

Since 2012, IECC requires dwelling unit mechanical ventilation (DUMV).

Kitchen exhaust still not required.

Some states requiring DUMV only for tightest homes, e.g. <3 ACH50.

Field data will inform future revisions to industry standards.

PNNL Progress

- **Designed recruitment strategy around trying to obtain calculated variation in homes**
- **Calculated percentages using Residential Energy Consumption Survey (RECS)**
  - House size
  - Basement or not
  - Occupancy
  - HVAC types
  - Natural gas use or not
  - Code or above-code
- **Mechanical Ventilation or not**

PNNL Progress

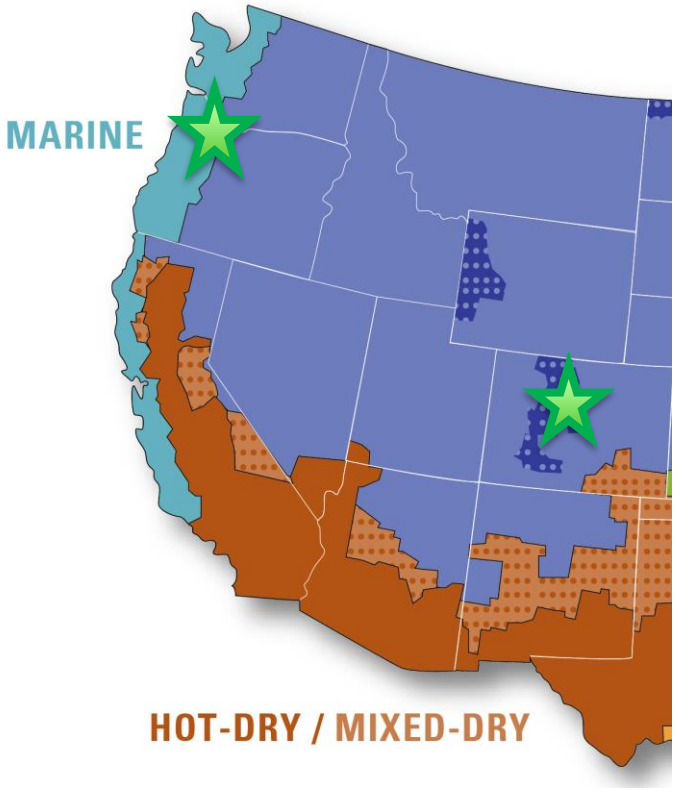
Focused on getting the homes with mechanical ventilation (harder to find) first. Once enough homes with mechanical ventilation have been recruited, code-built homes can be recruited by purchasing addresses through real estate sites.

Portland, OR, Recruitment

- Using database of homes certified by a local non-profit organization named Earth Advantage
  - All homes *should* meet ASHRAE 62.2 2010
- Focused on homes close to the Portland area

Boulder, CO, Recruitment

- Leverage Thrive as a builder partner (above code)
  - All homes should meet ASHRAE 62.2 2010
- Purchased database of new homes by zip code (code-built)
- Focused on homes within 30-minute drive



PNNL Progress - Portland

- Some infill, some new subdivisions

PNNL Progress – 8 Homes in Portland

Home ID	Yr. Built	Sq. Ft.	# of People	Whole House Vent?	FRM In (ppb)	FRM Out (ppb)	NO2 In (ppb)	NO2 Out (ppb)	PM In (ug/m3)	PM Out (ug/m3)	Radon (pCi/L)	ACH50	DuctLeak (cfm)
Threshold					7/80*	7/80*	53	53	12	12	4		
201	2016	2000	3	S	58	9	21	12	18	4	1.5	2.6	67
202	2015	1956	2	EX	15	4	6	6	10	29	1.5	3.9	36
203	2016	2546	2	None	43	3	6	8	51	45	0.9	4.8	155
204	2016	3010	2	S	27	3	2	3	4	5	0.6	NP	NP
205	2017	2164	2	S	20	3	3	6	6	7	0.5	3.9	190
206	2017	2856	3	S	32	3	18	5	10	5	0.8	2.5	101
207	2017	2480	3	S	28	2	3	<1	8	8	LP	5.2	TH
208	2017	1576	1	S	27	2	3	4	17	28	1.5	3.2	17

Red text indicates kitchen exhaust is non-compliant

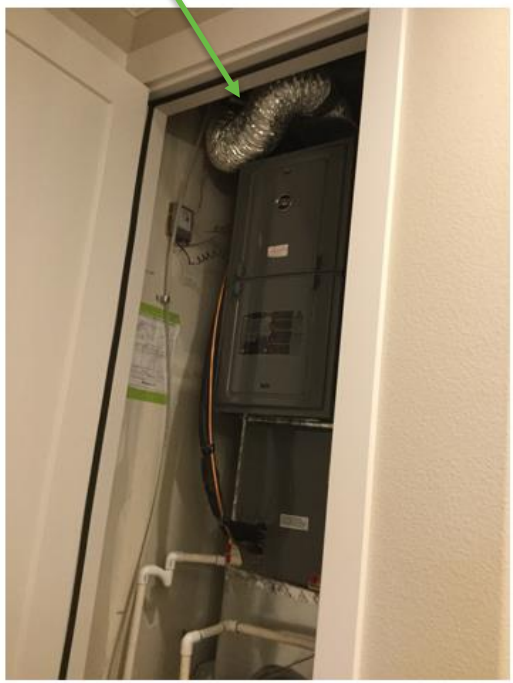
S= Supply EX= Exhaust

NP=Not performed due to wildfire TH=Too high to measure, likely due to open damper CP = Lab Processing

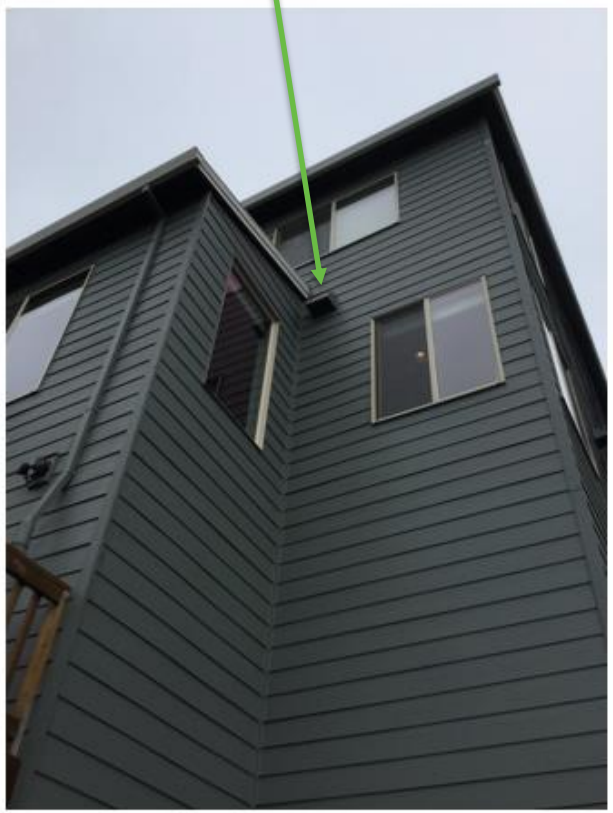
PNNL Progress - Portland

- 6 of the 8 Portland Homes had supply ventilation, all but one inaccessible to measure

Not enough space for accurate velocity traverse



Not safe to measure



Preliminary Results

- U.S. Annual Air Quality Standard for Ambient Outdoor Air = 12 $\mu g/m^3$
- 2 homes tested during the wildfire "season," with outdoor PM2.5 average above 25 $\mu g/m^3$. One home does not make a trend, but the home with continuous exhaust ventilation (and ACH50 of 3.9) had average indoor PM2.5 of 10 $\mu g/m^3$, while home with no mechanical ventilation (and ACH50 4.8) had average indoor PM2.5 of 50 $\mu g/m^3$.

Photo: weather.gov

PNNL Progress – Boulder Area

- 14 homes complete
- Some infill, some new developments
- 5 2-week homes

PNNL Progress – Boulder Area

- Mostly exhaust systems, some ERV
- No challenges measuring airflow

ERV intake within reach!

Stakeholder Engagement

- **Advisory Committee**
  - Meets approximately bi-annually
  - Specific questions to specific entities more frequently

Remaining Project Work

- Finish data collection in Boulder, CO
- Send equipment out for calibration
- Send equipment back to Portland, OR
- Finish data collection in Portland, OR
- Institutional Review Board (IRB) approval caused ~ 2 month delay to field work early in project
- Remaining data collection likely to continue into middle of FY20
- Analyze data for each climate region
- Report results to ASHRAE 62.2 committee

Thank You

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REFERENCE SLIDES

Project Budget

Project Budget: See below
Variances: No variances
Cost to Date: 66% spent to date
Additional Funding: None

Budget History					
FY 2017- 2018 (past)		FY 2019 (current)		FY 2020 (Future)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$795,000	$105,000	$0 additional	$0 additional	$0 additional	$0 additional

PNNL Project Plan and Schedule

Milestone Summary Table							
Recipient Name:							
Project Title:	Baseline Indoor Air Quality (IAQ) Field Study in Occupied New U.S. Homes: Cold and Marine Climates						
Task Number	Task or Subtask	Milestone Type	Milestone Number	Milestone Description (Go/No-Go Decision Criteria)	Milestone Verification Process (What, How, Who, Where)	Anticipated Date (Months from Project Start)	Completed?
1.0	Development and Approval of Study Protocol						
		Milestone	1.2	Submit Sampling and Recruitment Strategy	Approval by DOE	4	Yes
		Milestone	1.3	Obtain Institutional Review Board (IRB) Approval	Letter from IRB Authority.	6	Yes, 2 months late
2.0	Field Test Preparation						
		Milestone	2.1	Complete instrumentation acquisition.	Instrument specs approved by DOE	7	Yes
		Milestone	2.2	Complete training for field measurements and sensor package installation	Submit list of training events and number of people trained	10	Yes
3.0	Field Data Collection and Monitoring						
		Milestone	3.1	Complete assessments in 8 homes, QA review and upload data.	Data uploaded to central repository.	15	Yes
		Go/No-Go Decision Point	Go/No-Go #1	Complete assessments, QA review, and upload data for 8 homes in compliance with the BA New Home IAQ Study test protocol.	Data uploaded to central repository and approved by DOE.	16	Yes, 1 month early

Project Plan and Schedule

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Recipient Name:							
Project Title:	Baseline Indoor Air Quality (IAQ) Field Study in Occupied New US Homes: Cold and Marine Climates						
Task Number	Task or Subtask (if applicable) Title	Milestone Type (Milestone or Go/No-Go Decision Point)	Milestone Number* (Go/No-Go Decision Point Number)	Milestone Description (Go/No-Go Decision Criteria)	Milestone Verification Process (What, How, Who, Where)	Anticipated Date (Months from Start of the Project)	Anticipated Quarter (Quarters from Start of the Project)
3.0	Field Data Collection and Monitoring (continued)						
		Milestone	3.2	Complete assessments in 20 additional homes (total of 28), QA review and upload data.	Data uploaded to central repository.	19	7
		Milestone	3.3	Complete assessments in 30 additional homes (total of 58), QA review and upload data.	Data uploaded to central repository.	23	8
		Milestone	3.4	Complete assessments in remaining homes (total of 64), QA review and upload data.	Data uploaded to central repository.	25	9
5.0	Report Results						
		Milestone	5.1	Submit Draft Technical Report	Draft report detailing approach, analysis, and results.	28	9
		Milestone	5.2	Present results	Presentation or article	29	9
		Milestone	5.3	Submit Final Technical Report	Final report detailing approach, analysis, and results.	30	10