U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES PROGRAM

Expert Meeting Report: Air Flow Control

William B. Rose, Paul W. Francisco, Larry Brand, Mark Milby

Partnership for Advanced Residential Retrofit

February 2016

Building AMERICA
U.S. Department of Energy

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Prepared by:
William B. Rose
Paul Francisco
Larry Brand
Mark Milby

University of Illinois Indoor Climate Research and Training

2111 S. Oak St., Suite 106

Champaign IL 61820

Partnership for Advanced Residential Retrofit

NREL Technical Monitor: Stacey Rothgeb

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1 Introduction

1.1 Introduction: Air Flow Control Project

The goal of the project is to reduce the ventilation energy used to assure acceptable indoor air quality (IAQ) in existing residential homes by using a systems approach to controlling the three contributing air streams: ventilation, infiltration, and duct system losses. The savings will be associated with system balancing, infiltration control, and duct leakage control to ensure acceptable IAQ without negatively impacting combustion safety. Key success factors include: (1) minimizing fan-driven ventilation air volume, (2) controlling infiltration from undesirable sources, and (3) reducing duct system losses in areas that produce no IAQ benefit.

PARR will study a minimum of 20 treatment homes and 20 control homes over 24 months to evaluate the proper systems approach. If funding allows, or if additional funding becomes available, additional sample homes will be included in the study.

Houses will be recruited from the pool of houses that will be upgraded as part of the Illinois Home Performance or Iowa HVAC SAVE programs. Respondents will be screened for having a crawl space or unoccupied basement, a ducted space conditioning system, and a ventilation system. A project investigator will visit each property to determine appropriateness of the house for the project. At that first visit the investigator will conduct blower door tests and zone pressure tests, will assess the condition of the basement and lowest level floor, will photograph the conditions, and will prepare a work order for the contractor.

The instrumentation package for each test home includes one on-site evaluation using a blower door, air handler flow meter, zone pressure readings, duct leakage assessment tools, infrared thermography, and a checklist to log housing characteristics. An instrumentation package will be left in place including sensors for temperature, relative humidity, radon, formaldehyde, CO_2 and state loggers for major exhaust fans as well as energy meters and temperatures in the plenum. Particle measurements may also be made. In order to get the most information from the project budget, an equal number of treatment houses and control houses will be evaluated for a period of 3-4 weeks before and after retrofit and then the instruments will be moved to the next set of homes.

1.2 Relevance to Building America's Goals

As residential buildings approach the Building America (BA) goals of 40% energy savings in existing homes (pre-post retrofit) by 2030 and 50% savings in new homes (over IECC 2009) by 2025, energy losses associated with heat conduction through the thermal envelope will be minimized and addressing other types of inefficiencies will become the challenge. In this project the Partnership for Advanced Residential Retrofit (PARR) team will investigate inefficiencies associated with air movement in buildings. The project will develop a "systems approach" for managing air sealing, ventilation, and air distribution systems for maximizing energy savings while maintaining acceptable indoor air quality (IAQ).

1.3 Expert Meeting

An Expert Meeting was held in Chicago on January 19 in compliance with EERE303: Statement of Project Objectives:

Subtask 1.2: Topical Report – Expert Meeting (D13) – A report covering the expert meeting with BA teams and other industry experts in the field of IAQ related to air flows in buildings.

The Milestone Summary Table included this summary:

An expert meeting with Building America Teams, appropriate national labs, and other industry experts will be held. Expert advice solicited and summarized for the program.

2 Meeting Planning

An announcement flyer was prepared. See Appendix A. A list of prospective attendees was drawn up. The invitation list included persons representing 1) DOE Building America program, 2) national labs, 3) building energy professionals, 4) building IAQ professionals, 5) DOE Weatherization, as well as members of the PARR team. The participants attending the meeting were:

Name	Organization
1. Eric Werling	DOE
2. Brett Singer	LBNL
3. Rick Chitwood	Chitwood Energy Mangement
4. Dan Cautley	Seventhwave
5. Jonathan Wilson	NCHH
6. Dick Kornbluth	DickKornbluth, LLC
7. Dave Jacobs	NCHH
8. Dave Bohac	MN Center for Energy and Environment
9. Larry Brand	GTI
10. Paul Francisco	ISTC
11. Bill Rose	ISTC
12. Will Baker	MEEA
13. Mark Milby	MEEA

A presentation was prepared to guide the participants through the meeting agenda. The presentation is shown in Appendix B.

3 Meeting Notes

3.1 Current and recent IAQ research roundtable

Dan Cautley reported results from the National Evaluation of the WAP program. The National Evaluation had these characteristics and findings:

- 500 homes
- Smaller study of 18 homes focused on impact ASHRAE Standard 62.2
- Added 62.2 ventilation with controller to give control/test intervals
- 62.2 ventilation in living spaces reduced radon levels by 12%
- Houses with basements saw larger radon reductions than other types of homes
- The larger the expected effect of a ventilation system, the larger the impact on radon levels

Paul Francisco reported on results of most recent radon research under the HUD-sponsored HEALTH-V research program: radon was 29% higher in basements but there was a 32% reduction in first floor with exhaust ventilation. He noted that these findings are consistent with the view that exhaust ventilation produces slight negative pressures (drawing soil gas through the foundation), but with significant dilution from outdoors leading to living space improvements.

Brett Singer pointed out that multiple contaminants have seasonal effects; warm weather leads to more formaldehyde than cooler weather, and increasing ventilation almost always decreases formaldehyde concentration. He noted that doubling the ventilation does not halve the formaldehyde. He pointed out that there is no national standard on formaldehyde. WHO recommended 100 ppb, California recommended 27, FEMA recommended 16, some groups recommended lower and California recommends 6 ppb. Ventilation is effective against formaldehyde since ventilation purges the air. He noted the importance of source strength.

Dave Jacobs described research showing solid evidence that IAQ has health impacts, usually allergies and respiratory distress, especially in children. He mentioned that health surveys are complicated and expensive because they may trigger an IRB process. Brett Singer described recent LBNL research[1] showing that the ranking of air contaminants in terms of health detriment was

1. Particulates ($PM_{2.5}$)
2. Second-hand smoke
3. Radon (smokers)
4. Formaldehyde
5. Acrolein

Jonathan Wilson noted that it is hard to pick an acceptable number for most contaminants, as there is no consensus or not enough research on health impacts.

[1] Logue, JM et al. 2012. A method to estimate the chronic health impact of air pollutants in U.S. residences. *Environmental Health Perspectives* 2:120, February 2012.

3.2 Ventilation and IAQ

The attendees turned their attention to the relation between ventilation and IAQ. A matrix was prepared showing how different ventilation strategies might impact dilution of contaminants. In the table below, a "+" indicates a positive effect on dilution of the contaminant.

Contaminant ⇨ ***Type of Vent.*** ⇩	**Radon**	**CH2O**	**CO2**	**PM2.5**	**H2O**	**Operational**	**Energy**
Exhaust	Basement -/0 Living +	+	+	Outside + Inside +	+		$$
Supply	++ depends on ducts	++	+	Outside -/0* Inside +	+	Filter Maint./Repair	$$$$
Balanced	+	++	+	Outside -/0* Inside +	+	Filter Maint./Repair	Clean $ Clogged $$$
Filtration	0	0	0	Outside ++ Inside ++	0	Runtime? Maint./Repair	
Kitchen	~0	~0	~0	Outside ~0 Inside ++	+		

Paul Francisco directed this discussion, saying we should focus less on what is the most appropriate ventilation rate (because we will not be able to find a single number that always works); rather we should focus qualitatively on what is the best way to do the ventilation. The first set of distinctions to be made are those among exhaust, supply and balanced whole house ventilation, as well as filtration and kitchen ventilation. Brett Singer stated the importance he would attach to installing multiple types of ventilation in the study, and switch back and forth. He noted that there might be only a small difference between a continuous ventilation system and an intermittent system, provided the intermittent system has a long run-time. He further noted that particulate reduction by ventilation is difficult, given that 50% of the particles are from indoors and 50% from outdoors.

Dave Bohac noted that increasing filtration but reducing ventilation may reduce particles by increase gaseous pollutants. Brett Singer noted that health impacts require large reductions in particulate matter.

3.3 Ventilation Strategy Selection

Paul Francisco asked which version of the ventilation standard should be used in the study—62.2-2010, 62.2-2013 or 62.2-2016? He noted the similarity between 2013 and 2016 for retrofit homes, except for the means of providing the occupant override control—with a labeled circuit breaker being permitted in the 2016 edition. Consensus was to use 62.2-2016 in the research test plan.

Brett Singer assigned importance to being able to compare exhaust-only ventilation to supply and balanced ventilation. Dick Kornbluth and others noted that exhaust-only represents almost all of the market, while supply ventilation represents perhaps a few percent and balanced ventilation represents less than 1% in existing buildings. Consensus was to install both exhaust-only and supply, and to flip-flop in the course of the monitoring period in a subset of the houses, if funds permit.

Dave Jacobs stressed the importance in having controls in the study, and not simply relying on pre- and post-treatment in the conclusions. The discussion led to a consensus regarding controls:

- Controls will consist of homes that receive programmatic upgrades with ASHRAE 62.2-2016 ventilation exhaust only.
- Enhanced Treatment will consist of
  - Programmatic upgrades
  - Air sealing at the foundation and garage interface with the living space
  - Duct leakage reductions for IAQ
  - System flow
  - ASHRAE 62.2-2016 exhaust ventilation. Opportunities to explore other ventilation treatments will be studied using a flipflop approach if funds are available, but are not part of the core study.

3.4 Research conditions

The testing period was discussed. To the extent possible, testing should occur during closed-house conditions in the winter and summer, avoiding swing seasons. The occupants may be asked to keep a log of window-open dates and times, and may be compensated. CO_2 may be used as an indicator of window-open condition. State loggers may be used, but cannot be used on all windows and will not work on casement windows. An appropriate monitoring period was selected as 3-4 weeks.

CO_2 sensing will involve use of Telaire sensors. Paul Francisco will study if daily calibration (resetting to 400 ppm at night) is needed.

Button loggers may be used to determine use of ranges and microwaves.

Homes with smokers are to be excluded from the study.

Homes with high ACH50 are to be excluded from the study. It was decided that selection of an appropriate cutoff for airtightness will be taken up at the Practitioners Meeting.

Crawl space homes are very common in the Midwest, the site of the study, so they are to be included. Discussions during the meeting and in a subsequent series of email exchanges led to the conclusion that both control and enhanced treatment houses with crawl spaces shall have, as part of the baseline program:

- Closed vents
- Ground cover
- Insulation and air-sealing of rim joist.

4 Outcomes

The key decisions taken in this Expert Meeting were:

- Baseline ventilation for both control and treatment houses: ASHRAE 62.2-2016
    - Balanced ventilation will be added if feasible. If added, it will be studied with flipflop instrumentation.
    - Panasonic balanced ventilation will be considered in homes requiring less than 40 cfm.
    - Kitchen ventilation will not be added as a baseline measure.
- Filtration will be whatever is the programmatic standard as a baseline. A new filter will be provided as part of baseline treatment.
- Health questionnaires will not be included in the study.
- Particles will be measured when opportunities permit. Particulate measurements will not be a central part of the control/treatment study. Opportunities depend on occupant agreement and instrument availability.
- Both gravimetric and particulate count instruments will be considered.
    - The work will be scheduled for closed- window seasons. Occupants will be asked to keep a log of any time that windows are opened.
- Crawl spaces will be included in the study. The baseline treatment for crawl spaces will be
    - Closed vents
    - Ground cover
    - Insulation and air-sealing of rim joist.

Appendix A: Announcement Flyer

Expert Meeting

Study: Energy Savings with Acceptable IAQ through Improved Air Flow Control in Residential Retrofit

The Building America team Partnership for Advanced Residential Retrofit (PARR) is in the process of designing a three-year research project focused on reducing energy consumption associated with ventilation while maintaining proper indoor air quality (IAQ) in residential buildings. The project goal is to determine, from a systems perspective, the most effective and affordable strategies for reducing ventilation energy and maximizing energy savings while maintaining acceptable IAQ through improved control of three air streams: ventilation, infiltration, and HVAC. The project will monitor 40 houses in the Midwest to determine the impact of selected measures on IAQ. Before embarking on this ambitious project, PARR wishes to engage industry experts and gain their input into study design, measure selection, the latest understanding of ventilation and IAQ research, and the best approaches to in-field evaluation.

Topics for discussion include:

- Effective air sealing techniques for targeting both infiltration and contaminants
- Best practices for combining ducted HVAC systems and ventilation systems for IAQ control, minimum energy consumption, and occupant comfort and safety
- Supply vs. exhaust ventilation in a systems context
- Best practices in temperature-based ventilation
- Humidity control

Please consider joining us in January to share your knowledge and help the PARR team develop measure packages and a research design that will positively impact common practices in the field and lend insight into important new approaches to residential retrofit.

Date and Location: 10:00am – 4:00pm on January 19, 2016 at the Midwest Energy Efficiency Alliance – 20 North Wacker Drive, Suite 1301, Chicago IL 60606. Lunch will be provided.

For more information: Larry Brand, larry.brand@gastechnology.org, or Paul Francisco, pwf@illinois.edu. Please RSVP to Mark Milby, mmilby@mwalliance.org.

Appendix B: Agenda Presentation

Test Plan Review

Project goal

- Reduce the ventilation energy used to assure acceptable IAQ in existing residential homes by 30% using a systems approach to controlling the three contributing air streams: ventilation, infiltration, and duct system losses.
  - Approx. 20% from temperature-based ventilation and 10% from infiltration and duct leakage control

Success factors

1. Minimizing fan-driven ventilation air volume through taking advantage of buoyancy and other driving forces
2. Controlling infiltration from undesirable sources
3. Reducing duct system losses from areas with no IAQ benefit

Test Plan Review

Sample

- 40 single family homes in Illinois and Iowa (climate: cold/very cold)
- 20 test/20 control, with matching on housing type if possible
- Recruitment through two local residential retrofit programs, Illinois Home Performance with ENERGY STAR® and HVAC SAVE ®

Test period

- June 2016 – March 2018
- Baseline testing will be conducted for six months and treatment and control houses will be tested for 12 months

Test Plan Review

Instrumentation

- Temperature and humidity data loggers
- Blower door (and zone pressure testing using "add-a-hole")
- ?
- ?

Potential Measures

- Air sealing
  - Especially between crawlspace/foundation and first floor
- Duct sealing
- ?

Test Plan Review

Intervention sequence

- Paul, I need your help here – we have discussed the pattern of recruitment, baseline, treatment, and post-measurement but I am not 100% of what we have decided.

Parking Lot

Remaining topics

Final thoughts

Recommendations for further discussion

Conclusion

Thank you for your participation!