



FLORIDA SOLAR ENERGY CENTER*

Creating Energy Independence

Economic Impact of Residential Air Tightness Testing and Mechanical Ventilation

June 3, 2016

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A Research Institute of the University of Central Florida



Acknowledgements

- Thanks to
 - The Florida Building Commission for selecting this research project.
 - The Department of Business and Professional Regulation who administers the project.
 - Mo Madani, Program Manager, Building Codes and Standards at the Florida Department of Business and Professional Regulation.



Acknowledgements

- The 1000+ anonymous individuals that took time to respond to our survey requests
- David Crowe of the National Home Builders Association for valuable statistics and guidance
- Industry Advisory Committee Members (shared later)
- Industry Presentations at Brevard HBA, Refrigeration & Air Conditioning Contractors Association (RACCA), Manasota Air Conditioning Contractors Association (MACCA), ASHRAE Space Coast Chapter and ASME Cape Canaveral Chapter
- Wanda Dutton at FSEC for help with report preparation.



Delayed Code Requirements Study

- Mandatory Residential Air Tightness Testing (i.e., blower door testing) as found in section R402.4.1.2, Energy Conservation volume
- Residential Whole House Mechanical Ventilation Requirements as found in Section R303.4, Residential volume
- The requirement for two fire service access elevators in Section 403.6.1, Building volume



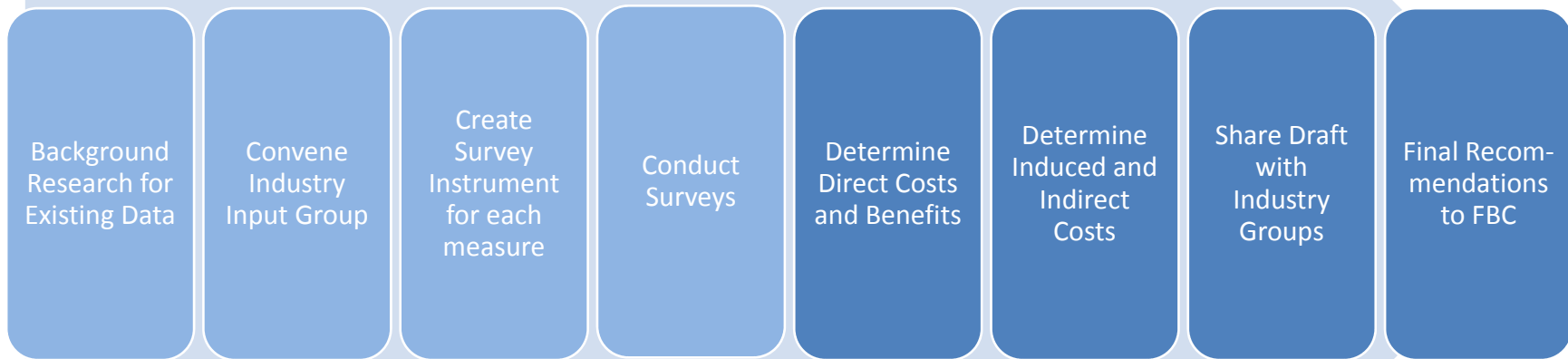
Air Tightening and Ventilation

- 2014 FEC requirement is ≤ 5 ACH50 (which will tend to make Florida homes more airtight)
- 2014 FMC requires mechanical ventilation for any home with an ACH50 < 5
- Combination of Energy and Mechanical Code requirements means that (if these sections of the 2014 Code went into effect unaltered) most new Florida homes would require mechanical ventilation



Work Scope

<----- September to December -----> <----- December to May ----->



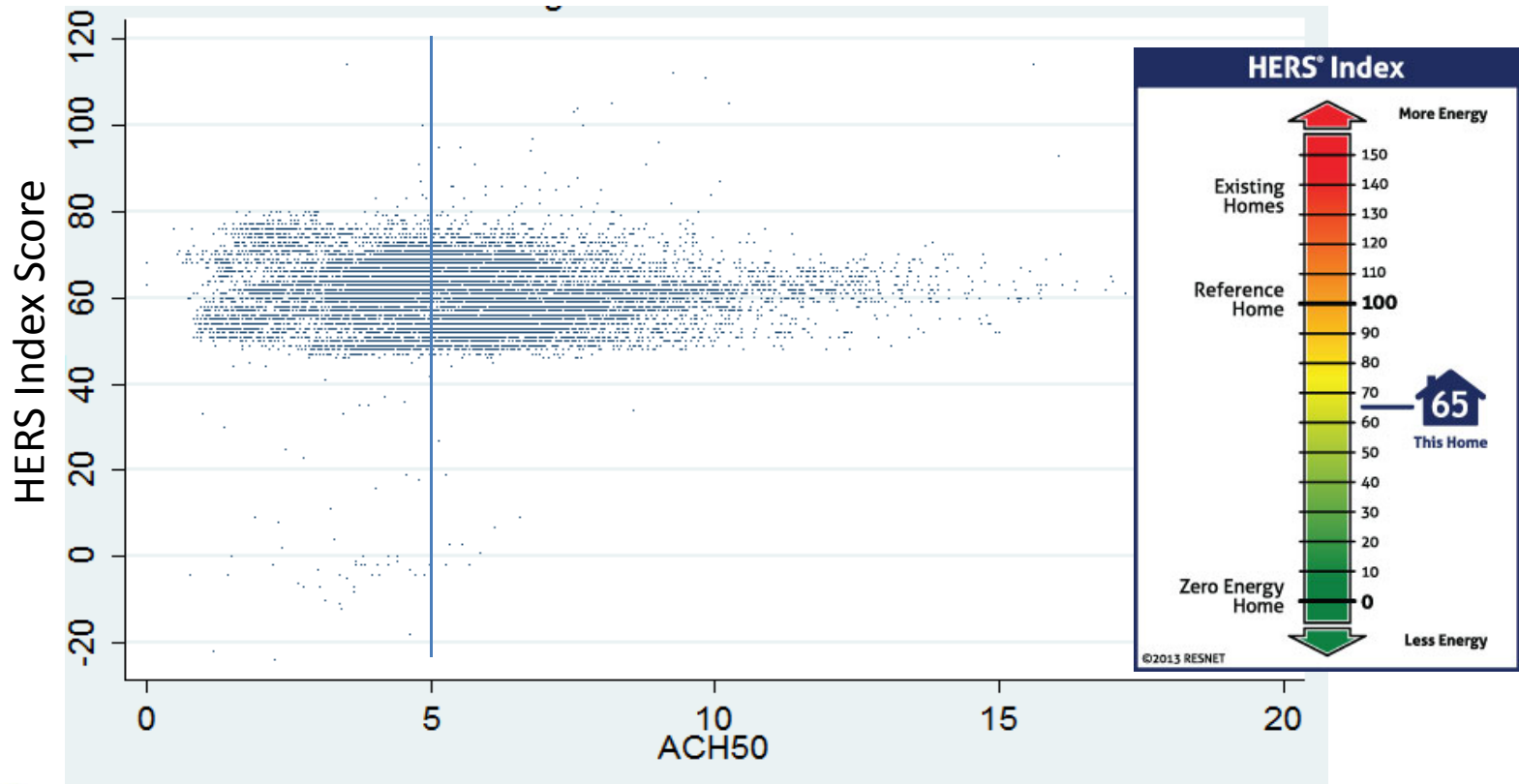
Background

- Air Tightness
 - We express air tightness in ACH50 which is the result of blower door testing to 50 Pascal pressure difference between inside and outside
- Blower Door Testing
- Whole-House Mechanical Ventilation



EnergyGauge Database ACH50 Values

ACH50 by HERS Index Score for Florida Houses Registered in EnergyGauge Database 10/31/2013 - 11/12/15



Background – Measured ACH50 Literature Search

FSEC Studies of Florida Homes	n	Average ACH50	Range ACH50	Year Built	Reference
Code Ventilation Study 2015, Sonne et al.	21	3.8	1.2 - 8.8	1987-2014	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-2002-15.pdf
Gainesville Ventilation Study 2014, Martin et al.	10	3.21	1 - 5.1	2009-10	http://fsec.ucf.edu/en/publications/pdf/FSEC-PF-461-14.pdf
Code Effectiveness Study 2014, Withers et al.	31	5.6	3 - 11	2009	http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1934-12.pdf
Multi-family Field Study 2014, Chasar	1,421	6.1	2.3 - 13.6	2010-13	http://fsec.ucf.edu/en/publications/pdf/FSEC-PF-457-14.pdf
Air Handler Leakage Study 2003, Cummings et al.	11	5.71	3.72 - 9.98	2001	http://www.fsec.ucf.edu/en/publications/html/FSEC-RR-138-03/index.htm



Air Tightening Benefits

- Allow for containment of the conditioned air produced by the heating and cooling systems
 - When envelope air tightness is consistent throughout a house, it improves the evenness of temperature
- Possibly fewer pollutants from garage spaces (depending on location of leaks) or other locations of unhealthy air such as dusty attics and damp crawlspaces.



Energy Savings

EnergyGauge Modeled Total Annual Energy Use Comparison for an Example Two-story, 2400 sq. ft., 3 Bedroom, 2014 FL Code House in Tampa (1 Watt/cfm ERV)(from Sonne et al. 2015)

ACH50	No ventilation		2014 FL Code Ventilation Requirement		ASHRAE 62.2-2013 Ventilation Requirement	
	cfm	kWh	cfm	kWh	cfm	kWh
3	0	12,146	60	12,855	72.8	13,003
5	0	12,315	60	13,008	53.3	12,933
7	0	12,464	60	13,140	34.0	12,851



Blower Door Testing Cost Research

- One high volume rating provider indicated they charge \$150 per test for large groups of homes in close proximity, with typical prices of \$200 - \$300 (similar to earlier HBA Green Building Committee estimate)
- Another rater provided cost data that averaged \$350 per test from a 70-home sample group.



Whole-House Mechanical Ventilation Cost Research

- NREL Residential Efficiency Measures Database indicates an average installed ERV cost of \$1,300
- 2013 DOE document notes simple whole-house [runtime] ventilation systems with installed cost of < \$350
- Minnesota Sustainable Housing Initiative article estimates recovery ventilators between \$600 and \$1,100, with installation adding \$1,200 to \$1,500 and high-efficiency adding \$250 to cost of otherwise comparable average-efficiency units.
- Lawrence Berkeley Lab cost examples for California range from less than \$300 - \$600 for single point exhaust systems to \$900 – above \$2,000 for ERVs



Whole-House Mechanical Ventilation Benefits

- EPA indicates benefits can include
 - improved indoor air quality
 - better control over the air flow rate
 - better control over the outdoor air source and
 - improved comfort through filtering and conditioning the outdoor air



Health Effects

- Limited medical research on health effects
- LBNL indicates chronic exposure to three pollutants dominate health effects:
 - PM_{2.5} (particulate matter up to 2.5 microns in size),
 - Acrolein (from materials, cooking and incomplete combustion), and
 - Formaldehyde
- LBNL estimates the disability-adjusted life-years (DALYs) lost *“from these three pollutants appear to be much larger than the DALY losses due to CO deaths from acute poisoning in homes. [Secondhand smoke] and radon are also significant contributors to population wide DALY losses, but these exposures occur in a smaller fraction of homes.”*



Home Ventilating Institute

- *The Case for Mechanical Ventilation and Air Tightness Requirements in Florida* (included in the Final Report as Appendix B) was provided by the HVI.
- *“If Florida’s legislature elects to roll back the mechanical ventilation requirement to only apply to homes tighter than 3 ACH50, studies indicate that the net effect will increase occupant formaldehyde exposure by 40% or more, with higher spikes expected in hot humid summer conditions when formaldehyde emissions are highest.”*



Humidity Concerns

- Bringing in outside air from infiltration or whole-house ventilation will increase indoor humidity during times of high humidity
 - Concerns during peak humidity and ventilation loads
 - Concerns during swing season with low sensible load but high latent load



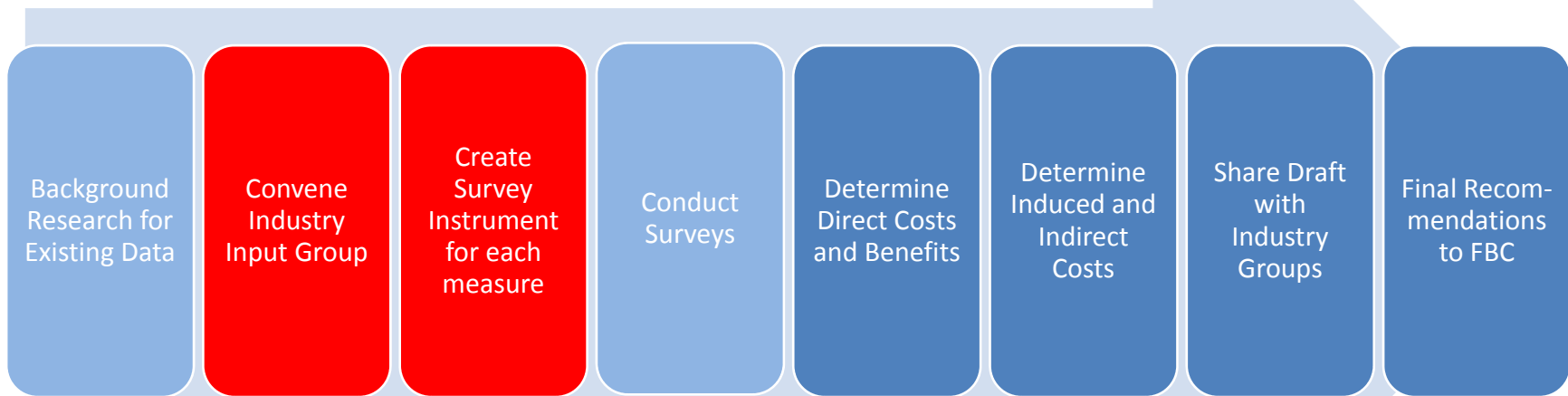
Humidity Control Measures

Supplemental Humidity Mitigation Options (adapted from Withers and Sonne 2014)
Overcooling (increased air conditioning to remove moisture)
Lowering air handler fan speed to increase contact time of air with cooling coil
Heat pipes
Enthalpy recovery ventilation
Dual capacity air conditioner
Variable capacity air conditioner ventilation
Dedicated outdoor air system
Mini-split Dedicated outdoor air system
Stand-alone Dehumidifier with Remote Humidistat
Integrated Ducted Dehumidifier
Sub-cooling Reheat
Full-condensing Reheat
Desiccant Dehumidifier



Work Scope

<----- September to December -----> <----- December to May ----->



Survey Development

 Restart Survey



Respondents may skip any question; however, skipping key questions may prevent you from seeing more detailed questions. That is, some survey questions will not be displayed depending on answers to preliminary questions. The survey is anonymous.

The survey automatically saves your answers. You can return later (from the same computer) to complete or change your answers for 1 week until the survey closes on November 20.

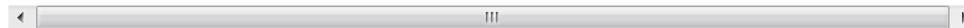
To report problems or malfunctions in the online survey, please contact Jeff Sonne at Florida Solar Energy Center at 321-638-1406. Thank you.

Part 1 - About Your Business

Have you been involved in the construction of new Florida homes over the PAST TWO YEARS?

Yes

No



>> Next



Testing and Ventilation Industry Advisory Committee

- Provide expert input and advice during the development of the survey tool
- Assist with recommending contacts for distribution of the survey
- Provide other relevant blower door testing and mechanical ventilation cost data
- Representatives from Central Florida ACCA, FHBA, Florida Weatherization Network, three energy rating companies, residential HVAC contractor, ENERGY STAR for New Homes and six builders (affordable, custom, and production).



Advisory Committee Members

Stakeholder Group	Organization(s)	First Name	Last Name
Homebuilders Production, independent	Viera Builders, Director of Purchasing	Trevor	Lewis
Homebuilders Production, national	VP of Purchasing in Orlando	Andrew	Moore
Homebuilders Above-code programs	ICF (Energy Star Program Management)	Charley	Haack
Homebuilders Affordable	South Sarasota Habitat for Humanity	Michael	Sollitto
Homebuilders Custom	Fallman, Inc.	Paul	Fallman
Homebuilders, Custom Florida Home Builders Association	Hickman Homes (Director of Governmental Affairs' designee)	Mike	Hickman
Mechanical Contractors, Testing - Home Energy Rater	CalcsPlus	Dennis	Stroer
Mechanical Contractors, Florida Refrigeration & Air Conditioning Contractors Association	AMBROSE AIR, INC. ACCA/Central Florida Board of Directors, Chair Code and Licensing Committee	Pat	Ambrose
Testing - Home Energy Raters	SkyeTec	Keinnie	Magruder
Testing - Home Energy Raters	TopBuild (Masco) Homes Services	Layla	Thomas
Testing - Home Energy Raters	Florida Solar Energy Center	Tei	Kucharski
Testing - Home Energy Raters	SkyeTec	Tommy	Spain
Testing – Weatherization Florida Weatherization Network	St Johns Housing Partnership	Bill	Lazar



Testing and Ventilation Survey Instrument

- Draft blower door testing and mechanical ventilation surveys developed and then reviewed by the industry advisory group during a combined live on site / webinar meeting Oct. 16
- Survey modifications were made and the separate testing and mechanical ventilation surveys were combined into one 53-question online survey with logic
- Second advisory group webinar held Oct. 30 to review the combined and refined survey.



Testing and Ventilation Survey Distribution

- Initial email announcing the online survey went out on Nov. 6 to list of 22,600 general contractors and energy raters and FSEC Buildings Research newsletter's mailing list
- Survey also sent to EnergyGauge office database and by DBPR to 5,000 people on their code mailing list
- Boilerplate announcement language provided to distribution partners – FHBA and FRACCA committed to distribute survey announcement
- Combined elevator / testing and ventilation reminder email sent out Nov. 16 to 47,000.



Work Scope

<----- September to December ----->< ----- December to May ----->



Testing and Ventilation Survey Responses

- Survey closed November 23rd
- Total of 832 responses (combination of partially and fully completed surveys)
- Each Florida county is served by the respondents; 10 in Union County to 118 in Palm Beach County

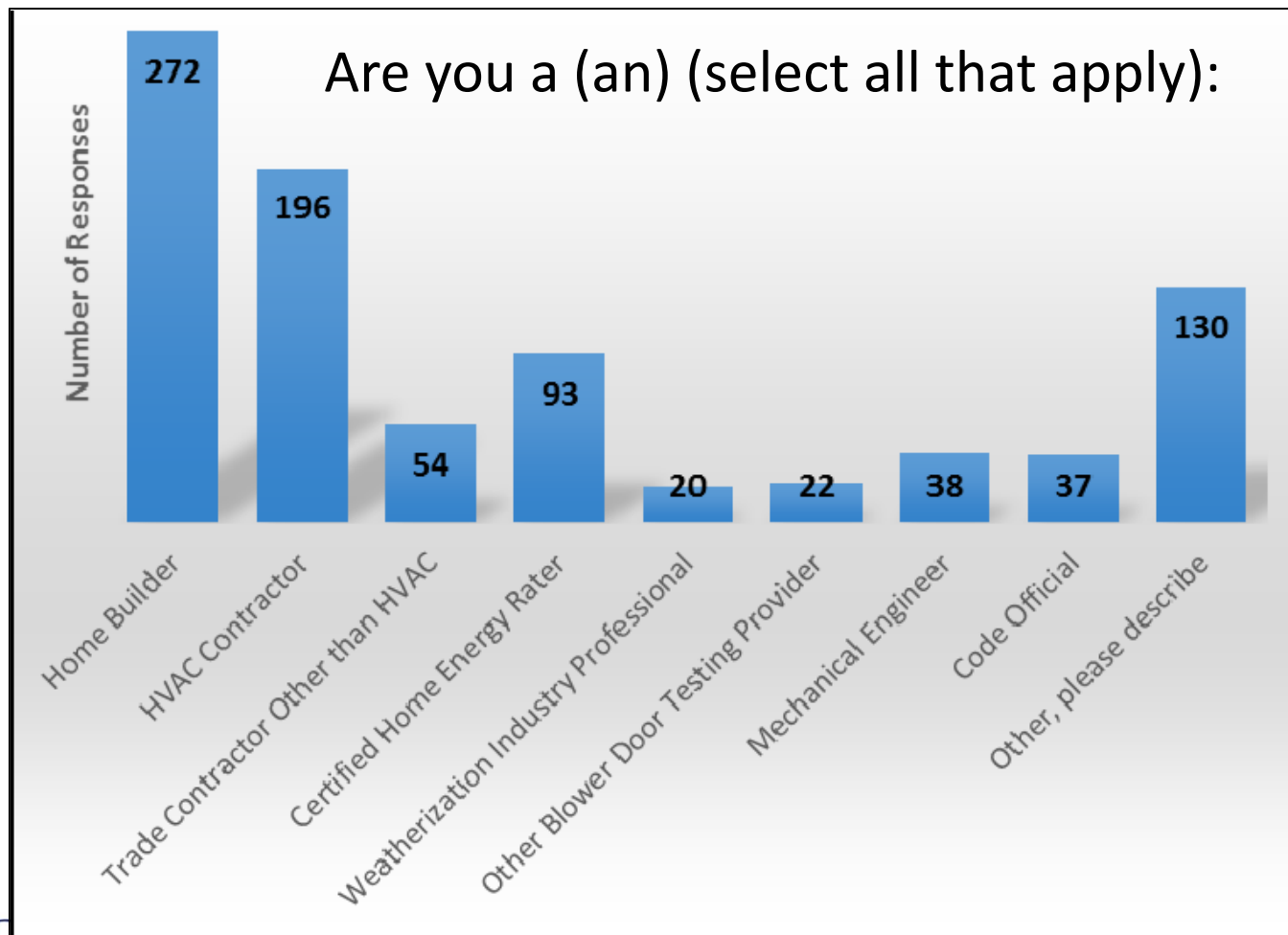


Survey Results

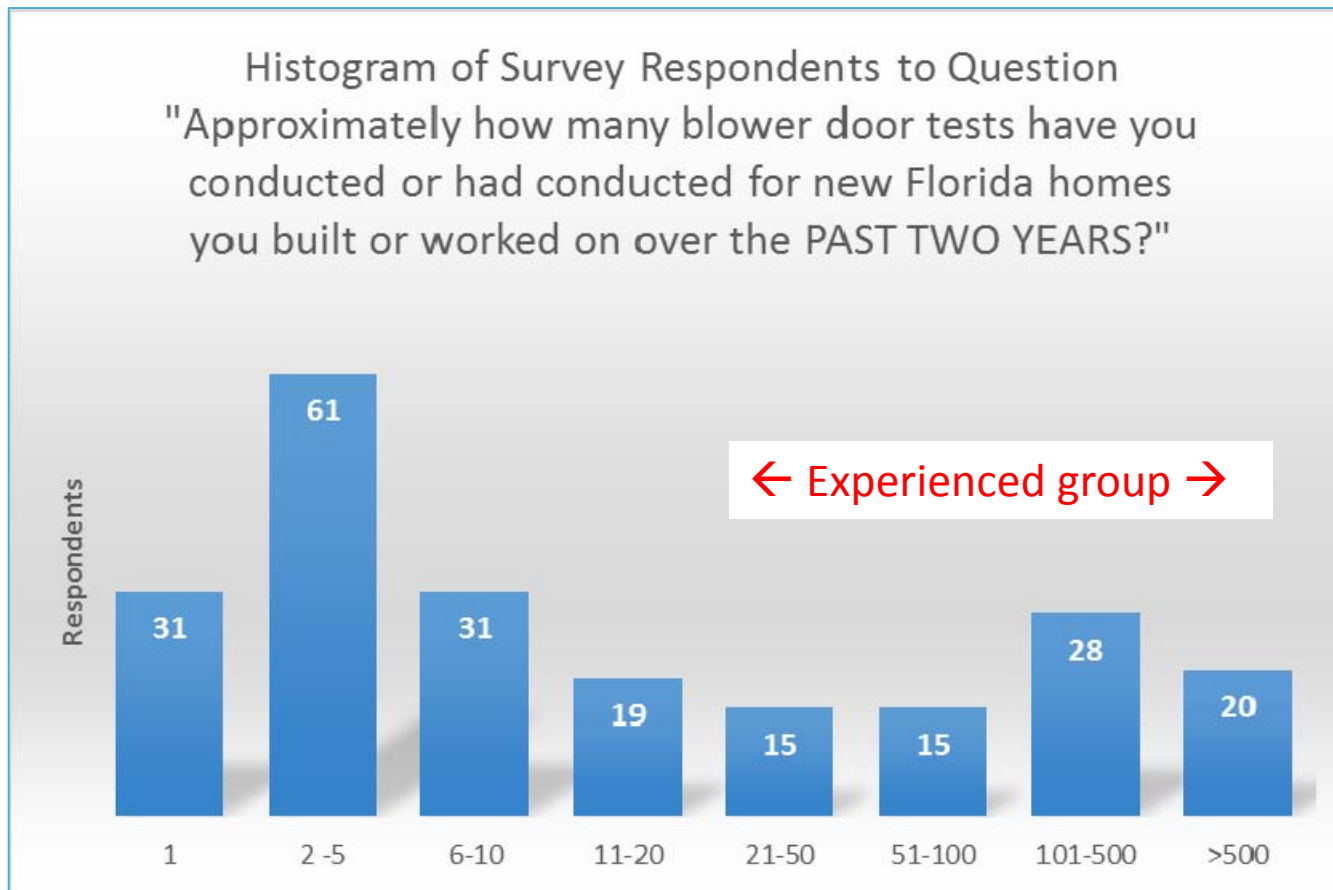
- Business



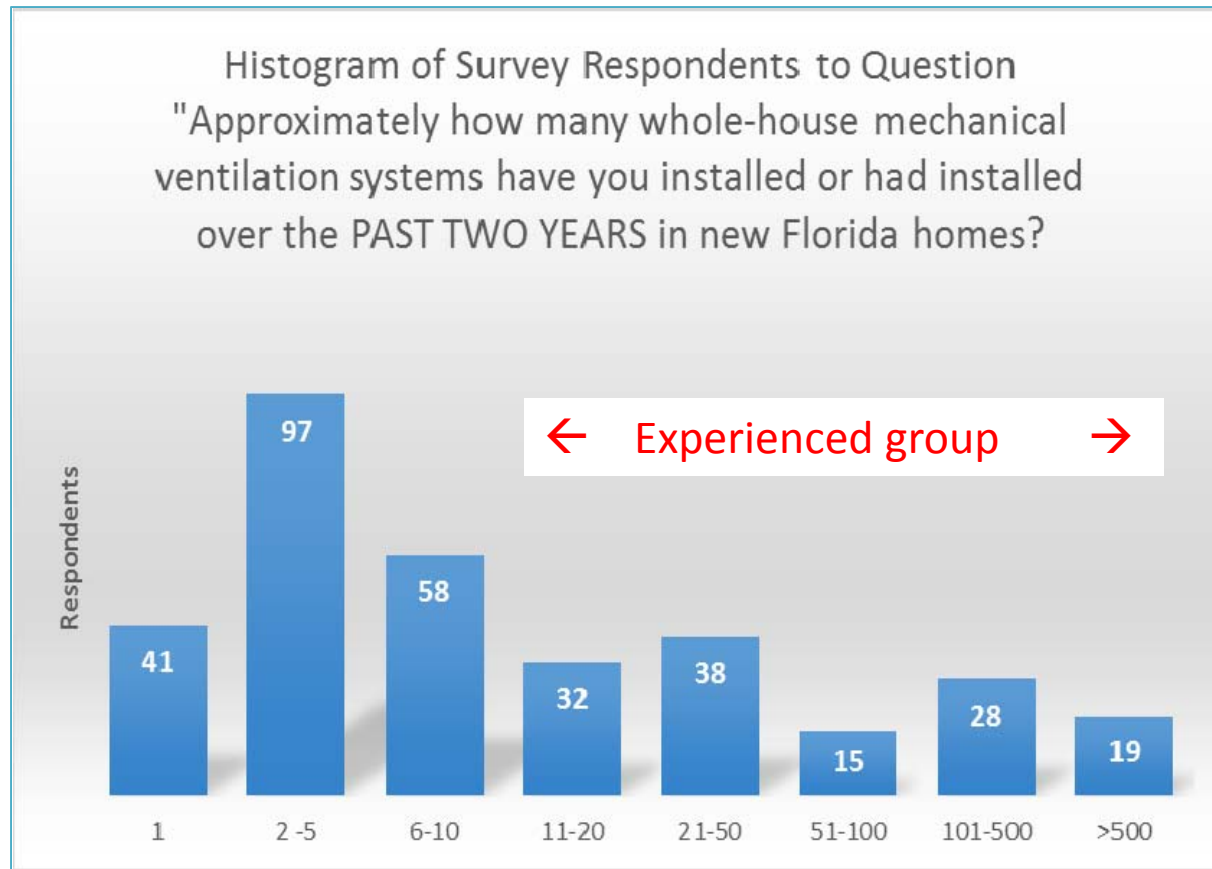
Respondents' Professions



Blower Door Tests Conducted



Whole-House MV Installations



Survey Results

- Business
- Example Home Questions



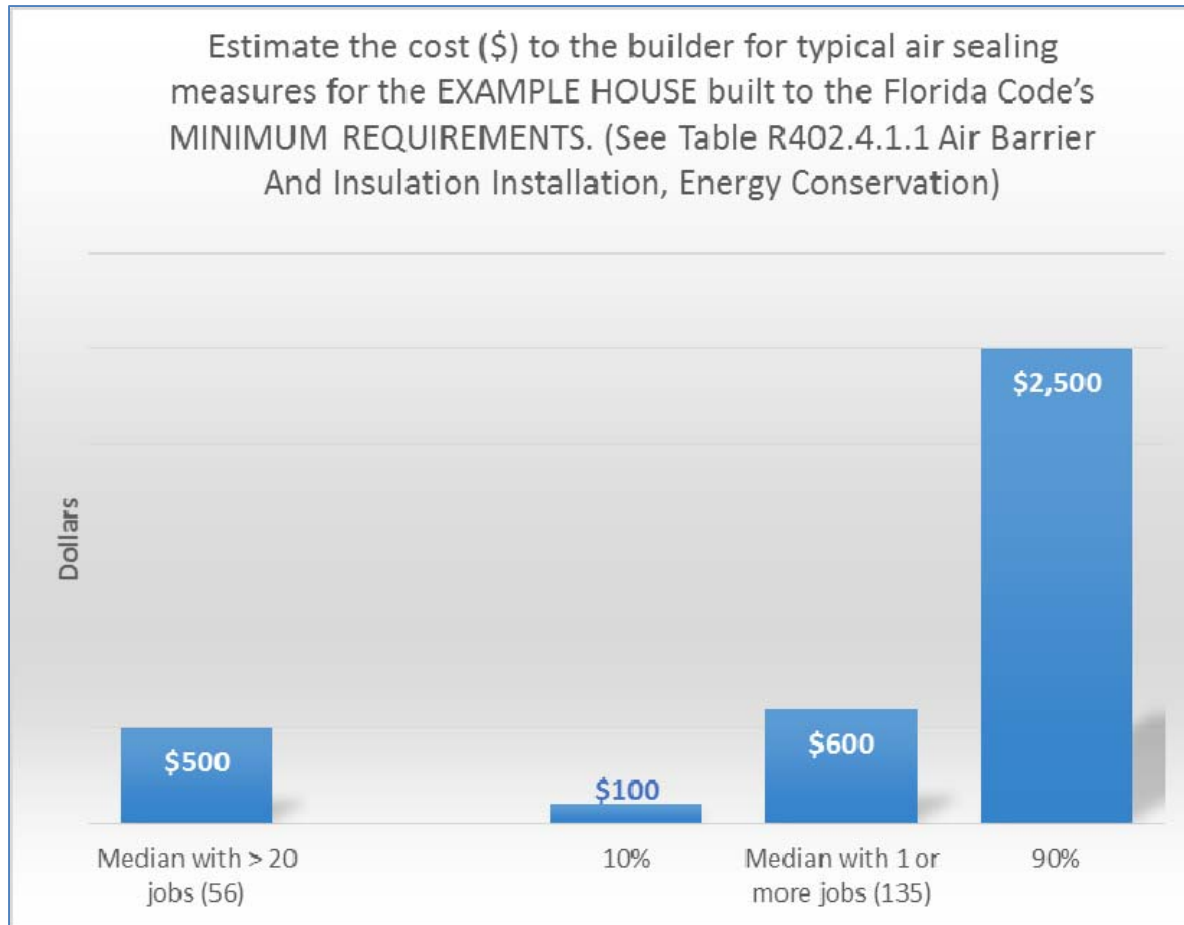
Example House

EXAMPLE HOUSE: A new, Florida Code compliant, single-story, single family detached, concrete block house, all electric (heat pump, water heater, and all appliances), with 2,000 ft² of conditioned area, 9' ceiling height, 3 bedrooms, and 2 baths.



Example House Current Code Air Sealing Cost

Estimate the cost (\$) to the builder for typical air sealing measures for the EXAMPLE HOUSE built to the Florida Code's MINIMUM REQUIREMENTS. (See Table R402.4.1.1 Air Barrier And Insulation Installation, Energy Conservation)



Cost Presentation - Data

- Large range of costs received
- Nonsensical responses removed (e.g., \$0 for something with costs, \$7654321 responses)
- Median average (midpoint of responses) is used to avoid skewed influence of very high answers that would effect a mean average



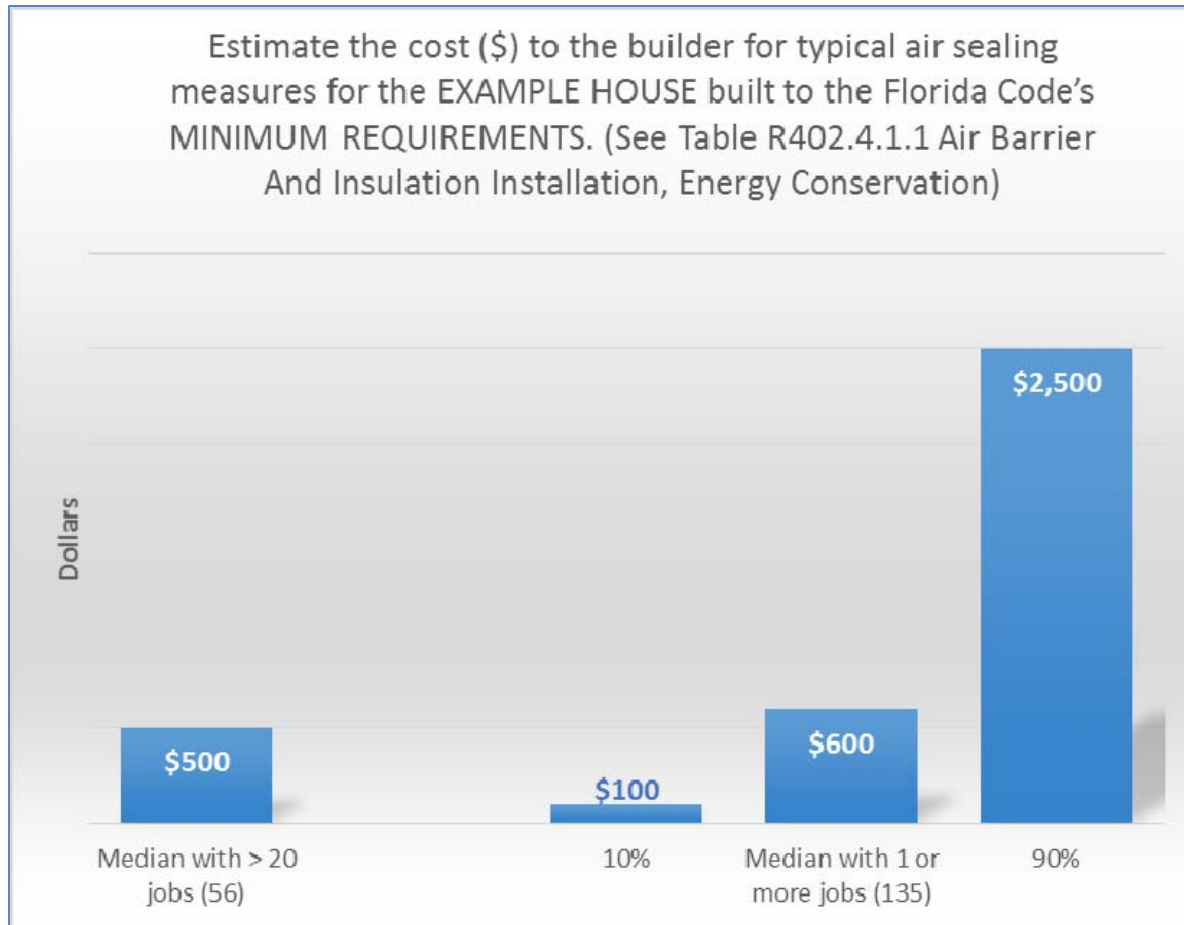
Cost Presentation – Medians and Ranges

- Bar charts display medians of experienced group and medians also for those with 1 or more jobs of experience.
 - Blower Door and Air Testing Experienced Group: those with more than 20 blower door jobs
 - Mechanical Ventilation Experienced Groups: Those with more than 10 mechanical ventilation installations for those costs.
Using 21 or more with the costs dropped sample sizes to lower levels than we would like.
- 10%: Values shown on bar charts marked 10% refer to a response whereby 10% of all responses with 1 or more jobs were at that value or lower.
- 90%: Values shown on bar charts marked 90% refer to a response whereby 90% of all responses with 1 or more jobs were at that value or lower.

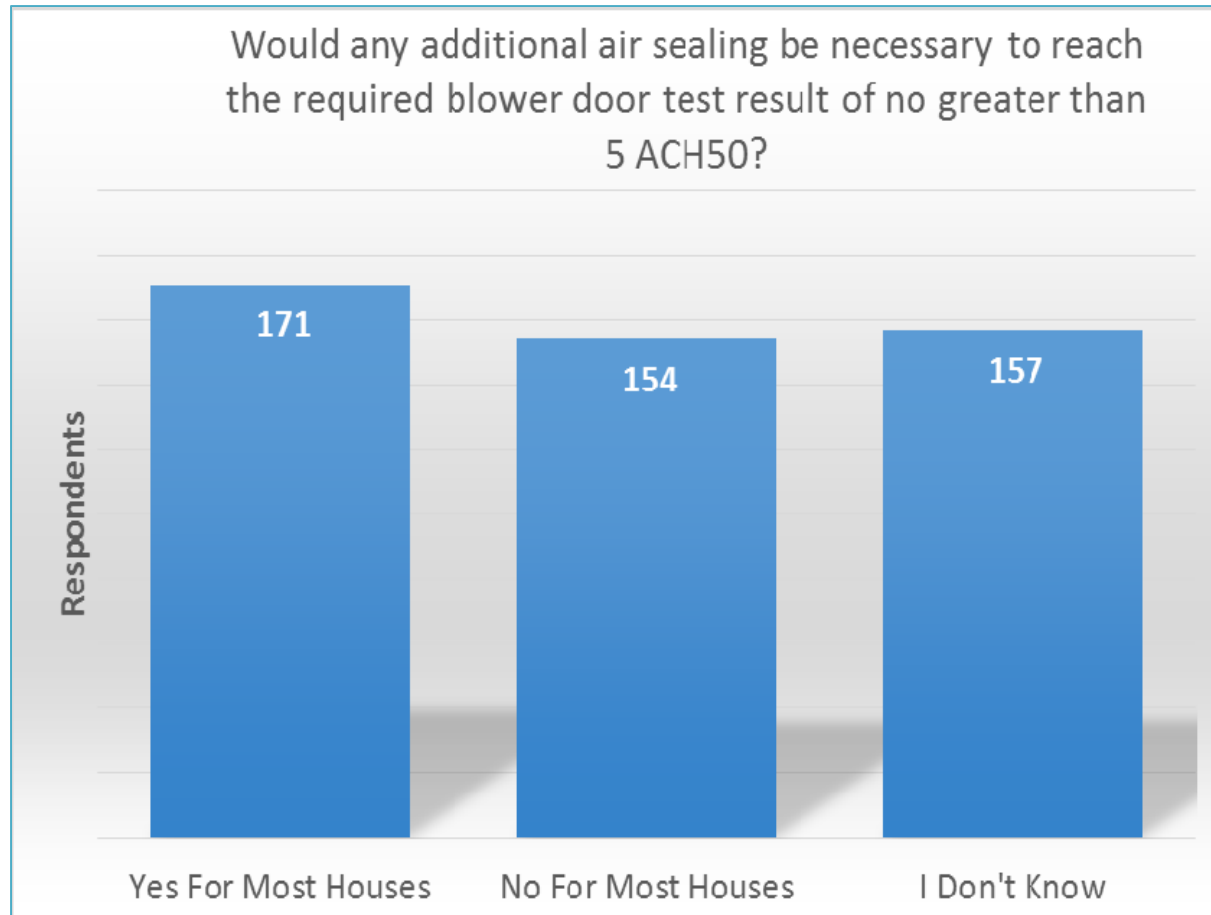


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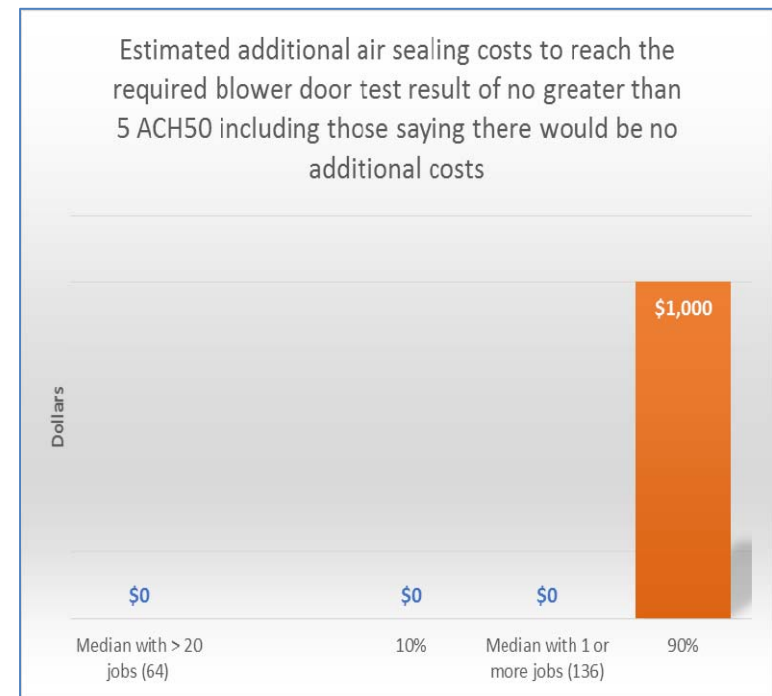
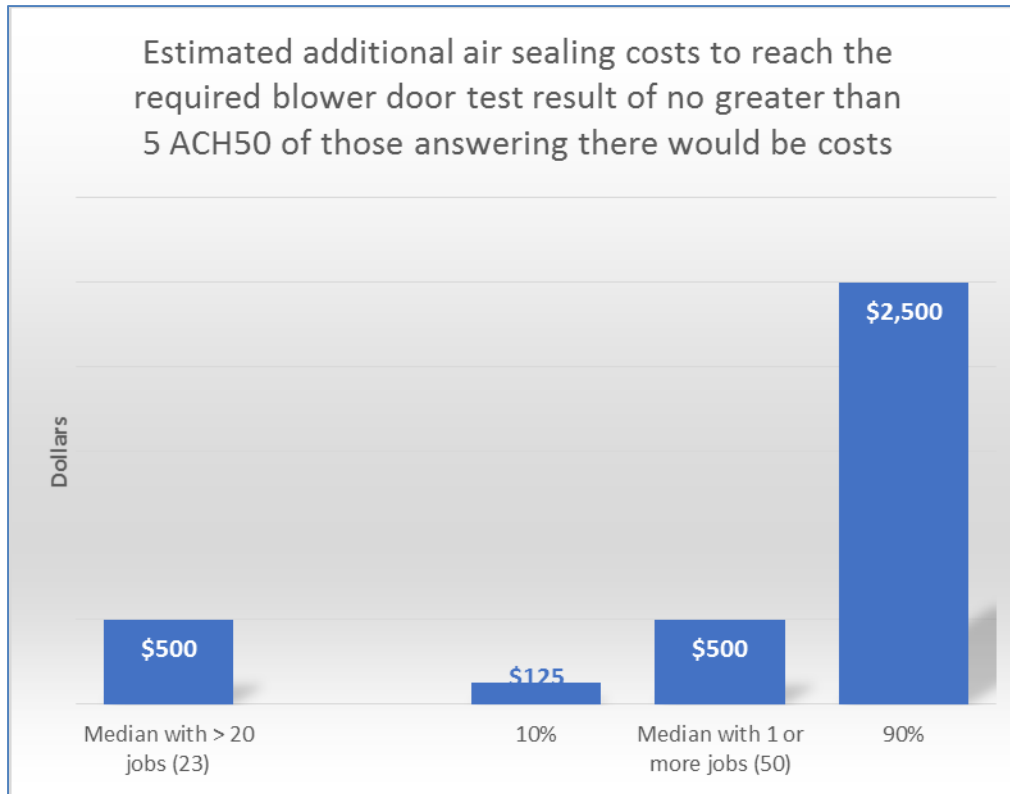


Additional Air Sealing Necessary?



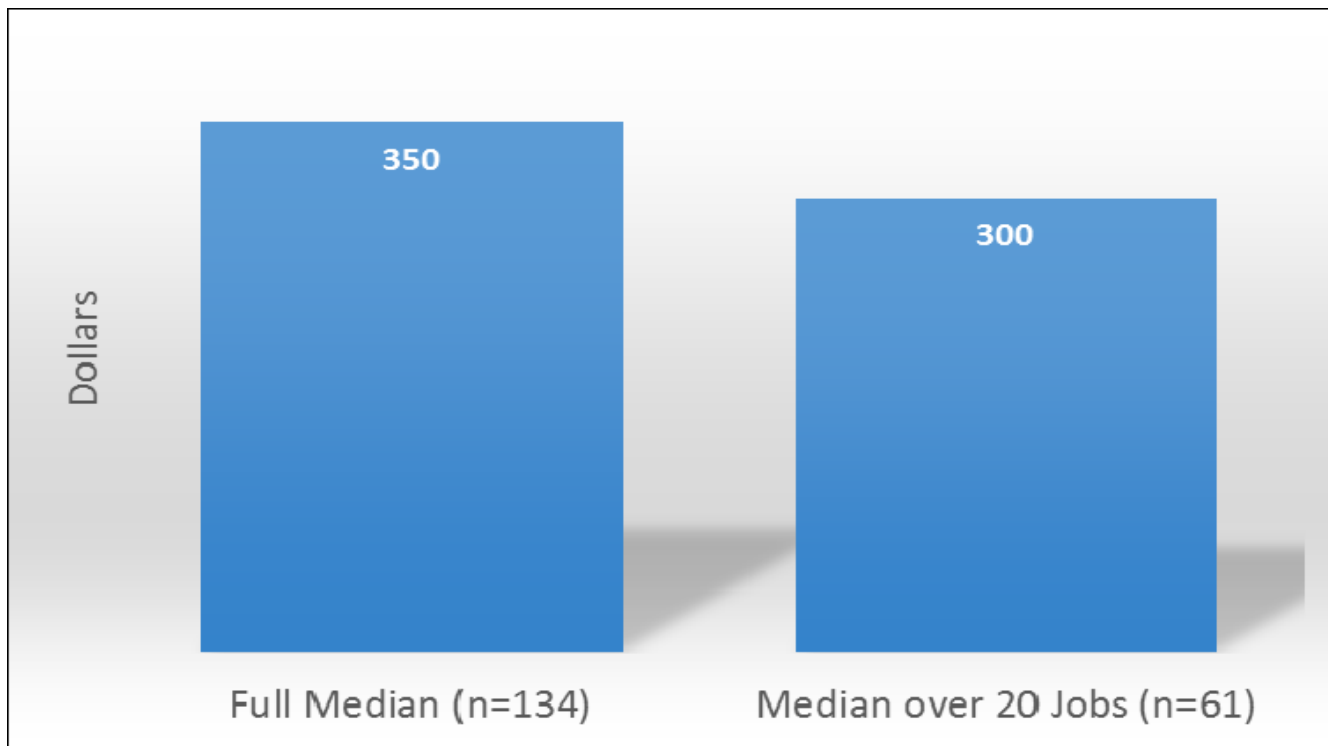
Additional Air Sealing Cost Summary

There were 154 respondents who indicated no additional air sealing needed.
There were 171 respondents who thought some air sealing was needed.



Blower Door Testing Cost Summary

Estimate the cost to builder for conducting a blower door test and all associated reporting and communications for the EXAMPLE HOUSE assuming it is within the tester's normal service area:



Blower Door Testing Cost Summary

Example House Blower Door Cost and Time	The Estimated cost to builder for testing, associated reporting, and all communications (\$)	On-site time needed to conduct test (hours)	How long, if at all, would normal site activity need to stop for testing (hours)	Fee for retesting, if necessary (\$)
Median of respondents with > 20 jobs	\$300 n=61	2.0 n=61	1.0 n=61	\$150 n=60
10% estimate of all respondents	\$150 n=134	1.0 n=134	0.0 n=133	\$75 n=130
Median of all respondents	\$350 n=134	2.0 n=134	1.0 n=133	\$200 n=130
90% estimate of all respondents	\$1,000 n=134	6.0 n=134	8.0 n=133	\$575 n=130



Are there any factors that might substantiate an **increase** in your estimate for the example house?

- “Resistant people who fail to coordinate this work in a timely fashion and work schedule.”
- “Trying to find leakage in concealed spaces could take up to 8 hours and require smoke testing at an additional cost. Accessing areas for repairs could force removal and replacement of finish materials adding days of delay and costs of up to \$1,000.”

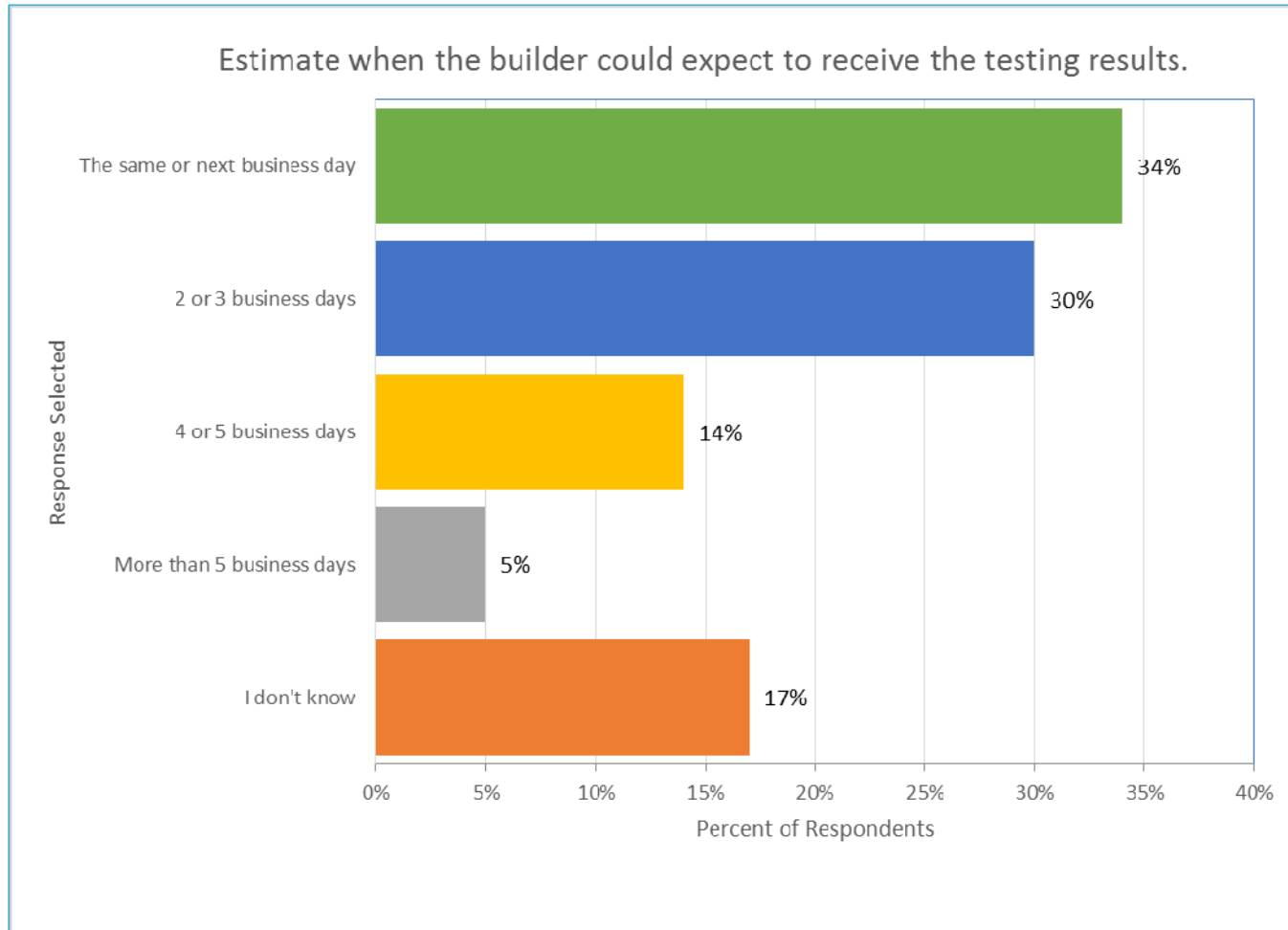


Are there any factors that might substantiate an **decrease** in your estimate for the example house?

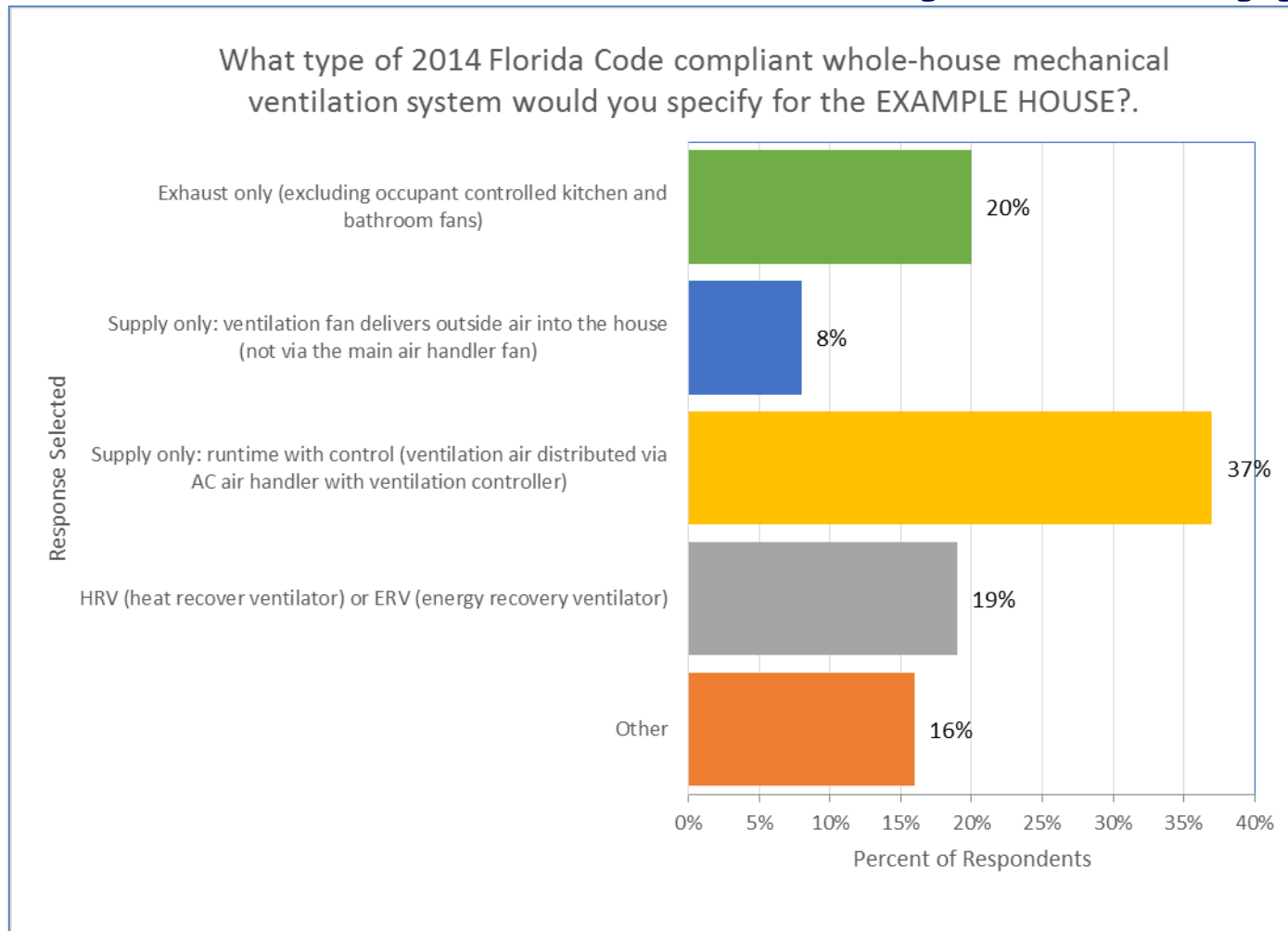
- “Helpful people who facilitate to coordinate this work in a timely fashion and work schedule.”
- “Multiple homes in same area available on same day.”



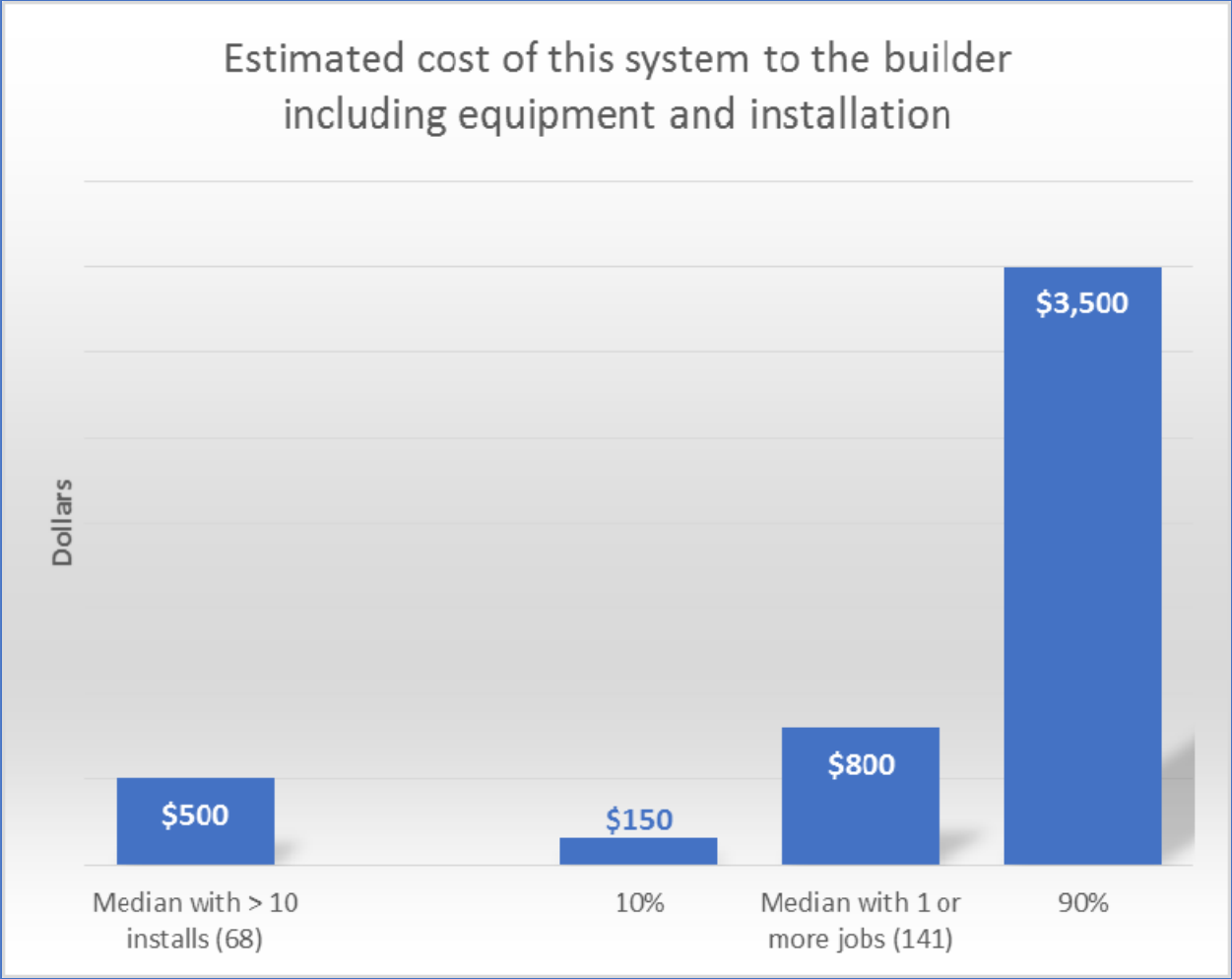
Time to Receive Blower Door Results



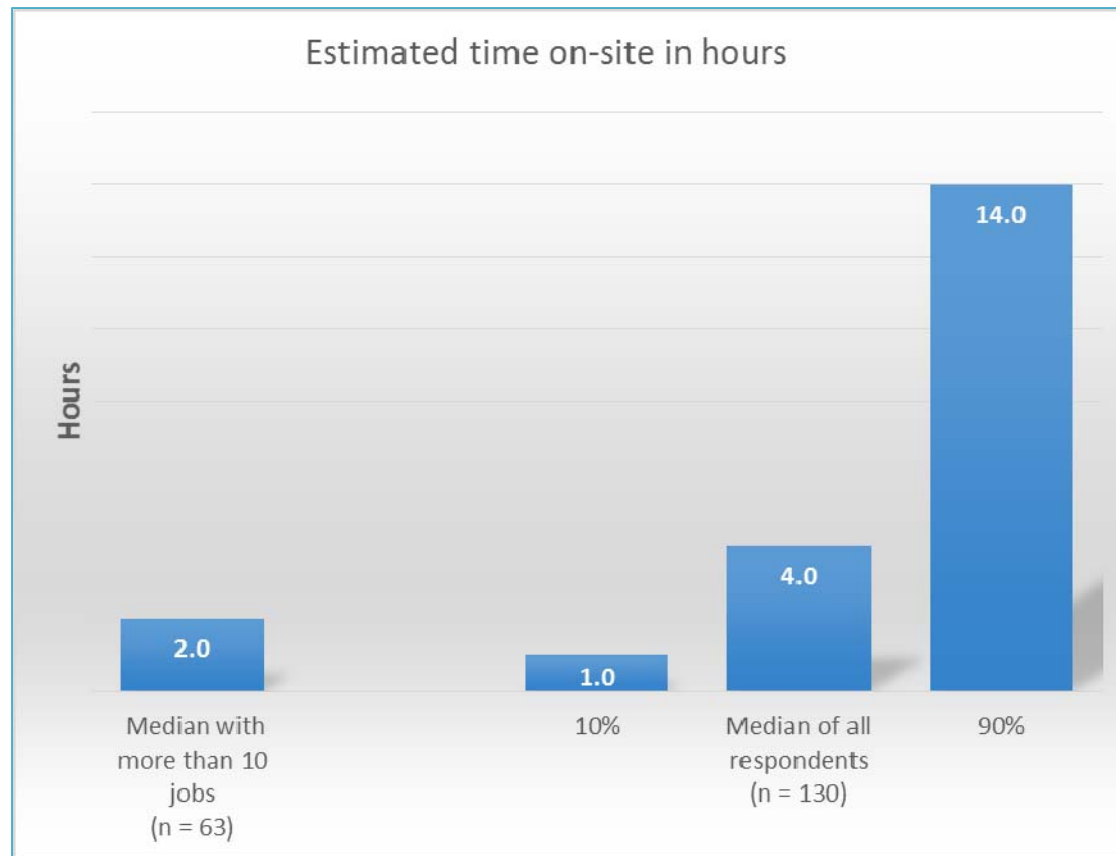
Mechanical Ventilation System Types



Mechanical Ventilation System Cost

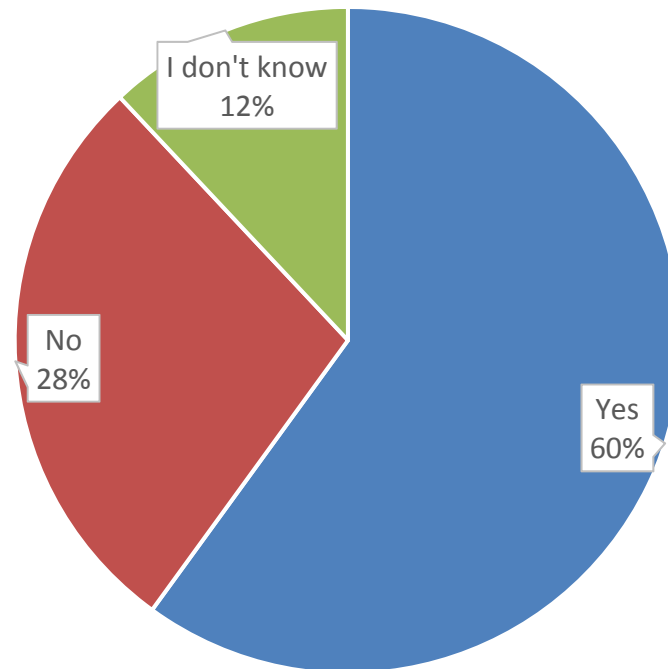


Time On-site to Install Whole-House Mechanical Ventilation System for Example House



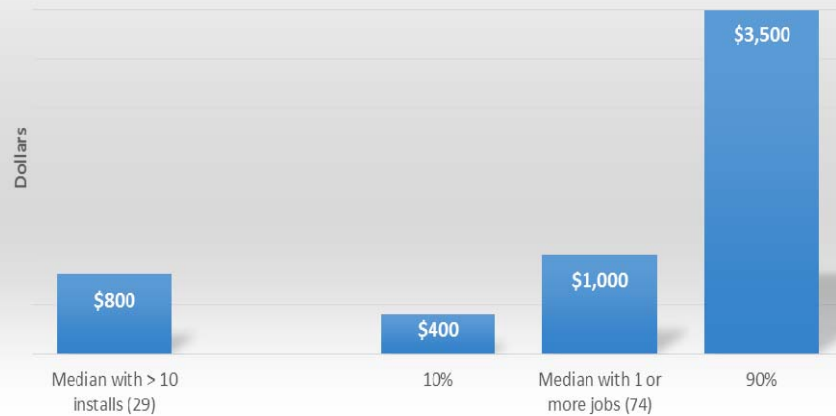
“Would you expect the selection or characteristics of the air conditioning and heating equipment to change with the addition of whole-house mechanical ventilation for the EXAMPLE HOUSE?”

Responses



Ventilation Additional HAC Costs

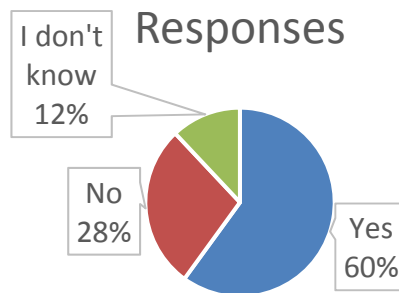
If you expect the selection or characteristics of the air conditioning and heating equipment to change with the addition of whole-house mechanical ventilation for the EXAMPLE HOUSE, please estimate the cost



If you expect the selection or characteristics of the air conditioning and heating equipment to change with the addition of whole-house mechanical ventilation for the EXAMPLE HOUSE, please estimate the cost (includes \$0 for no additional cost)



Responses



Why Increased HAC Costs?

- Increased equipment size was indicated by 43 respondents.
 - One response: “Larger system means larger duct work, means more expensive.”
- Another 19 respondents indicated a whole-house dehumidifier or a different system type to deal with the humidity.
 - One wrote, “To do this in our humid climate would necessitate a two-stage outdoor unit, or a dehumidifier added to the central system.”

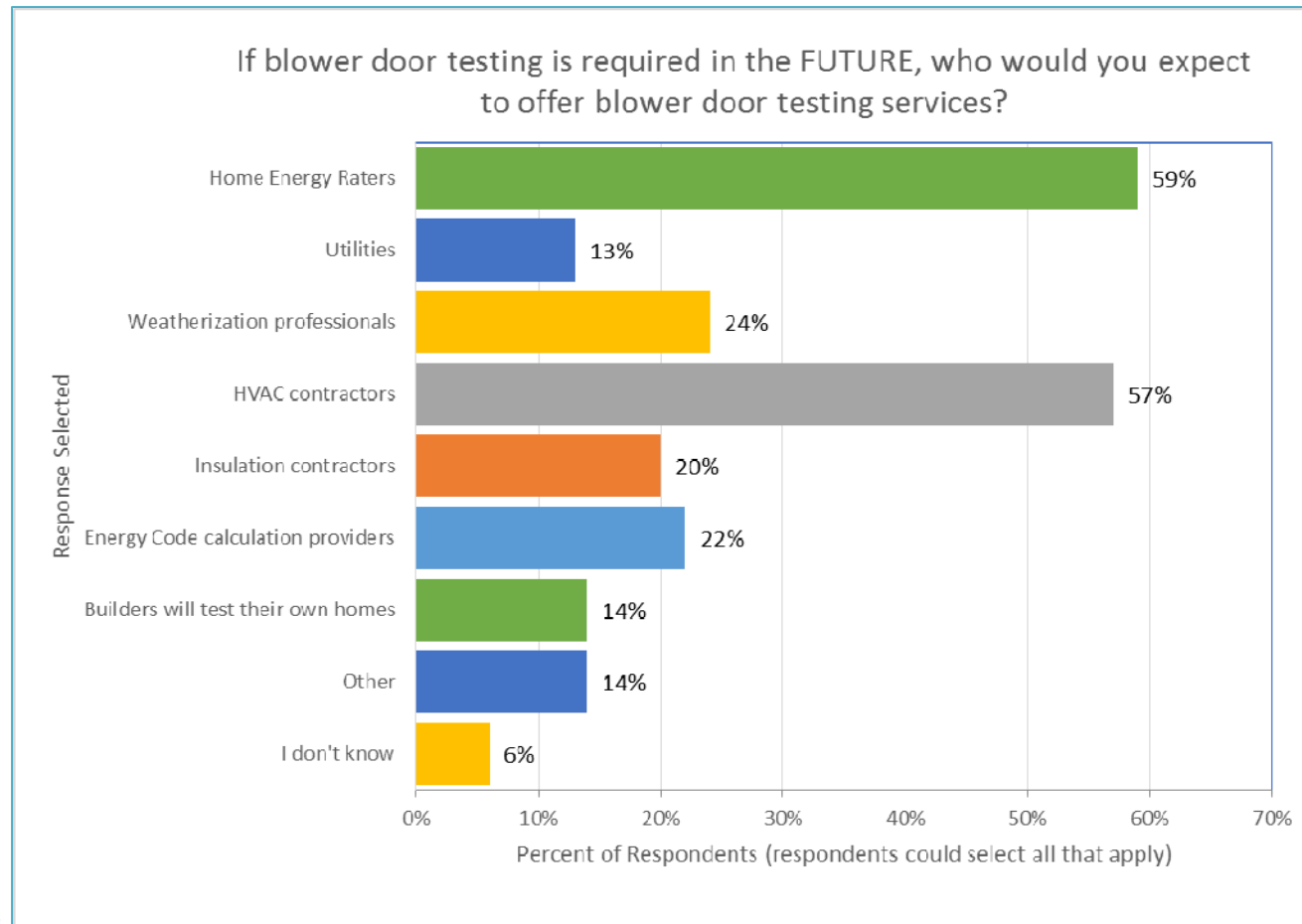


Survey Results

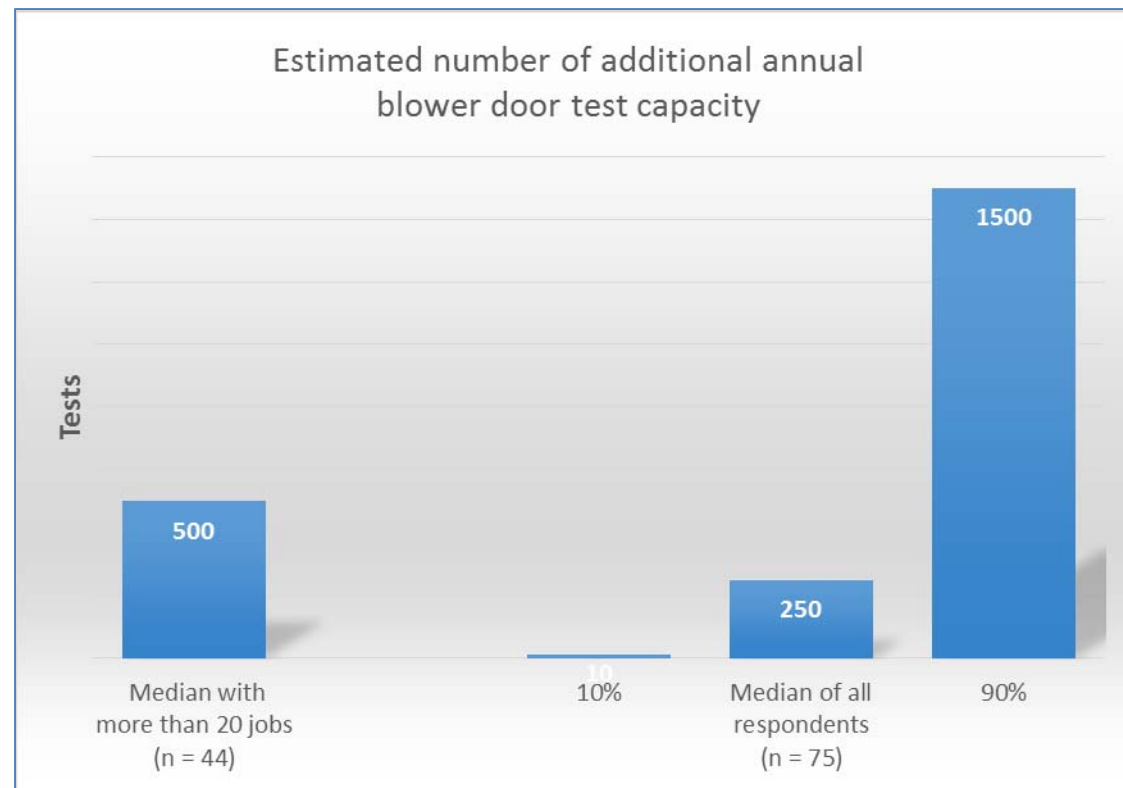
- Business
- Example Home Questions
- **Future Work**



Who Would Test?



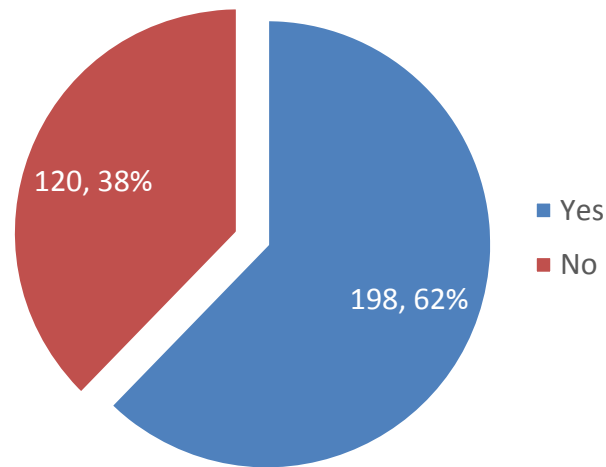
Available Additional Capacity For Those Respondents Indicating They Test Homes



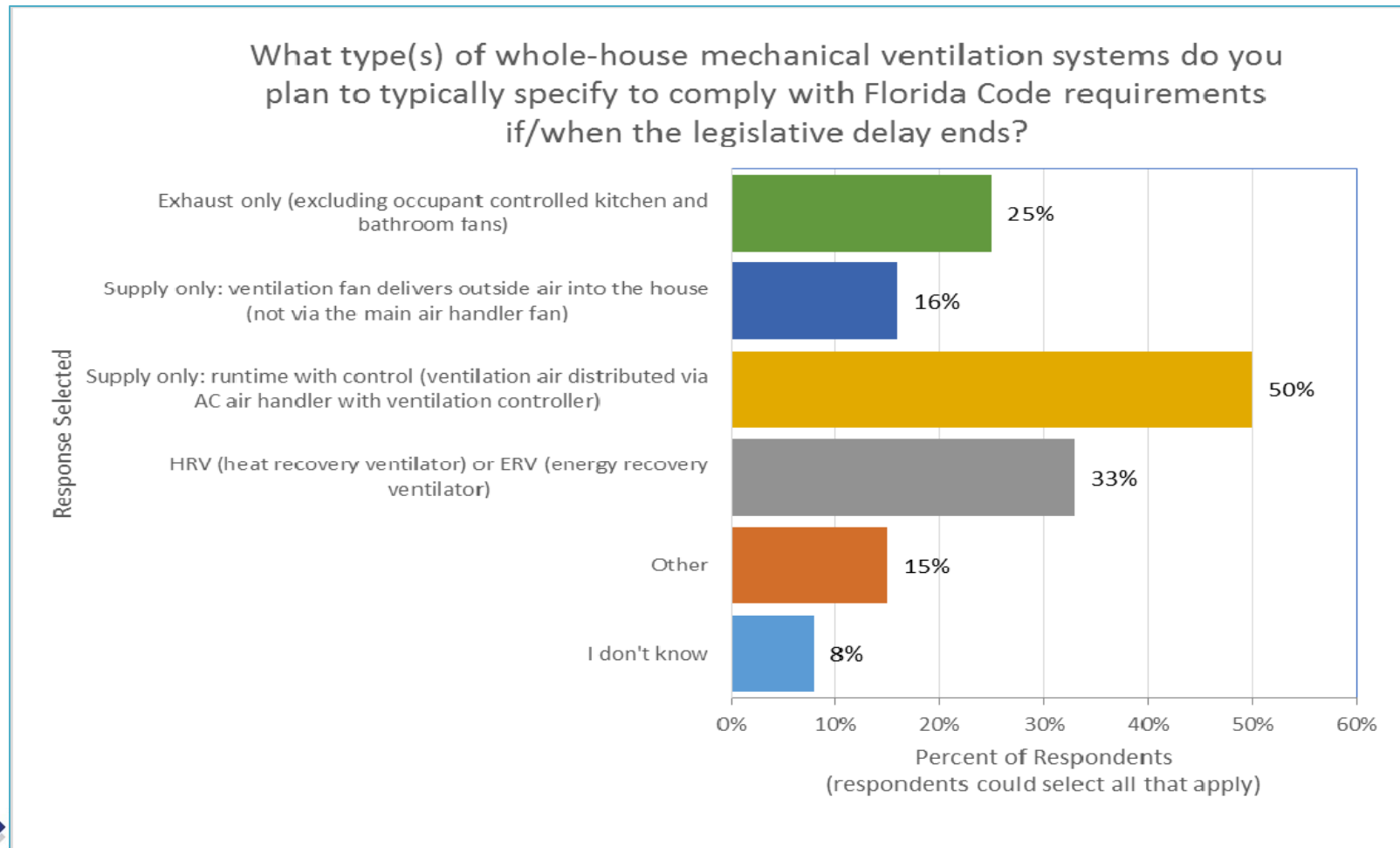
Future Mechanical Ventilation Work

- If whole-house mechanical ventilation is required in the FUTURE, will you or your company be involved in specifying such systems?

Responses



What System Type Will You Typically Specify?



Mechanical Ventilation System Types

Are there any types of whole-house mechanical ventilation system you would not specify to comply with the Florida Code requirement?

- 72 replied “Yes” and 38 replied “No”
- If it Doesn't Pre-treat Outdoor Air (18)
- Exhaust Only (16)
- ERVs or HRVs (11)
- Continuous (3)

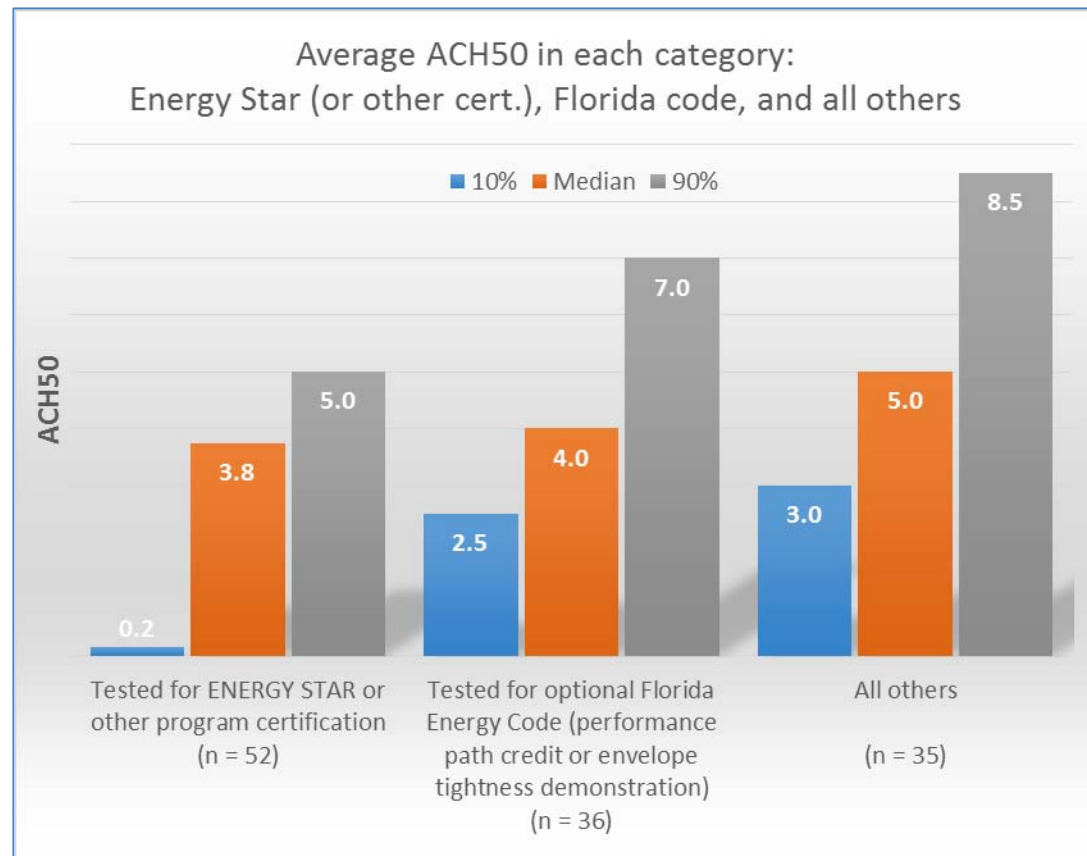


Survey Results

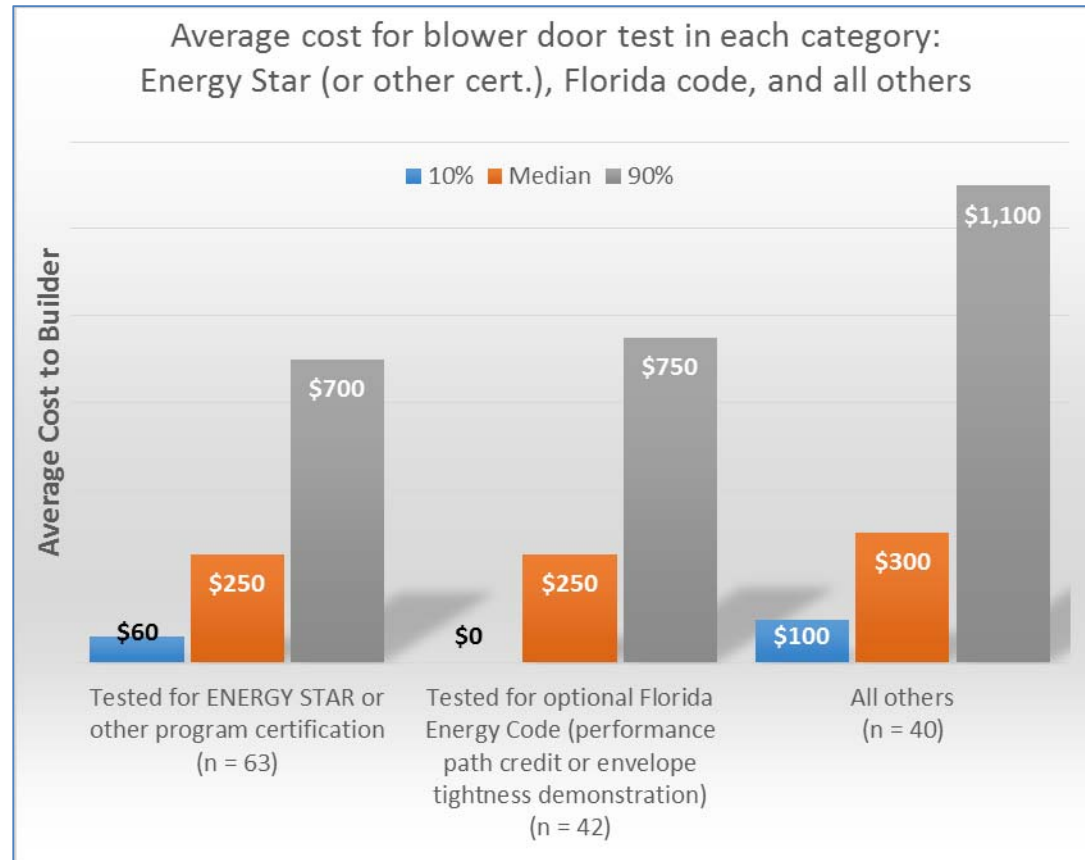
- Business
- Example Home Questions
- Future Work
- Experience Over the Last Two Years



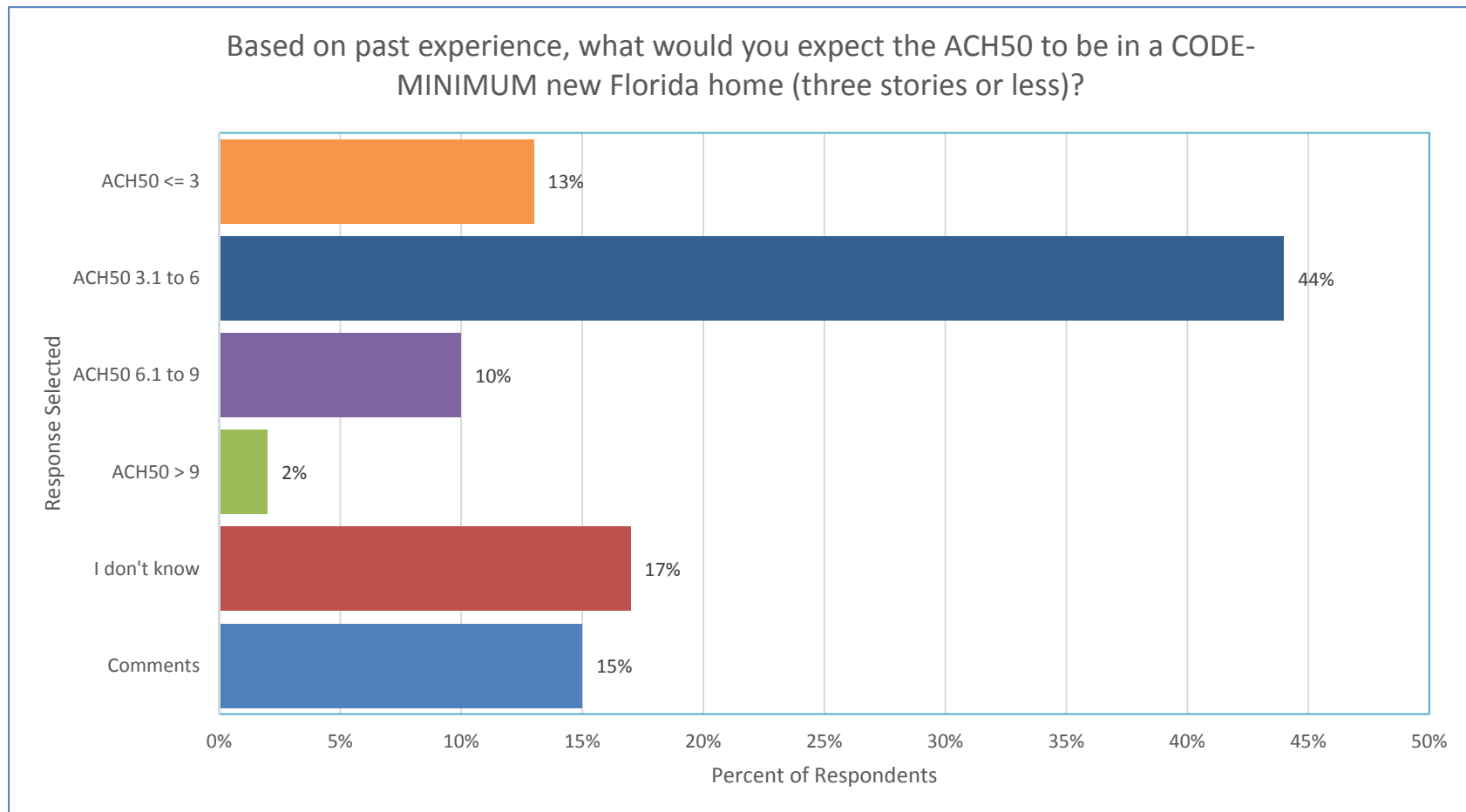
Air Tightness Last Two Years



Blower Door Testing Costs Last Two Years



What Tightness Would You Expect?



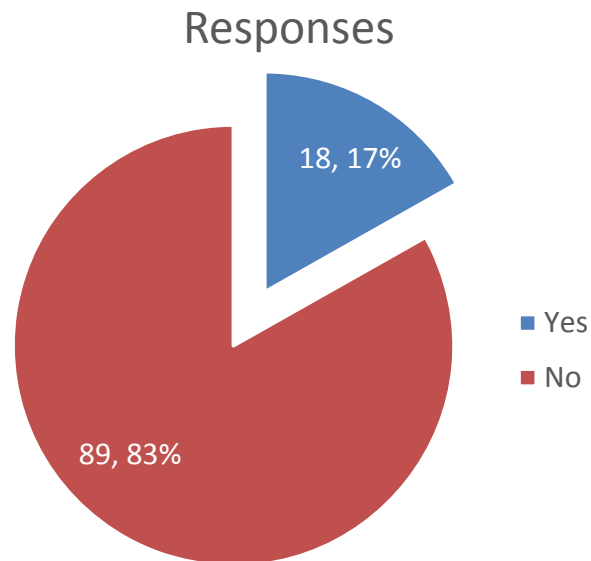
Detailed Comment

- All comments for all questions are in final report Appendix G
 - “I think below 5 is a good starting point for builders. Most of the new homes I tested were builder wanting to know how tight their house was and how then can get to under 5 ACH50. The majority of the houses that didn't meet 5 ACH50 were because contractors made penetrations through the building thermal envelope and did not seal the penetrations, air barrier was not continuous, and parts of the house were missing insulation or were not air sealed. On the other end some of the houses I have tested were under 2 ACH50. Houses like this really need outside [air] and the only [way] you can possibly know is to test the house.”

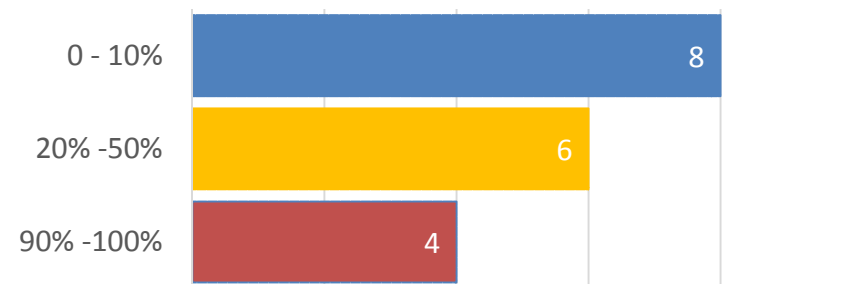


Delays Experienced

- In the PAST TWO YEARS, have you ever had a building delay of three or more days due to unavailability of house tightness testing personnel?



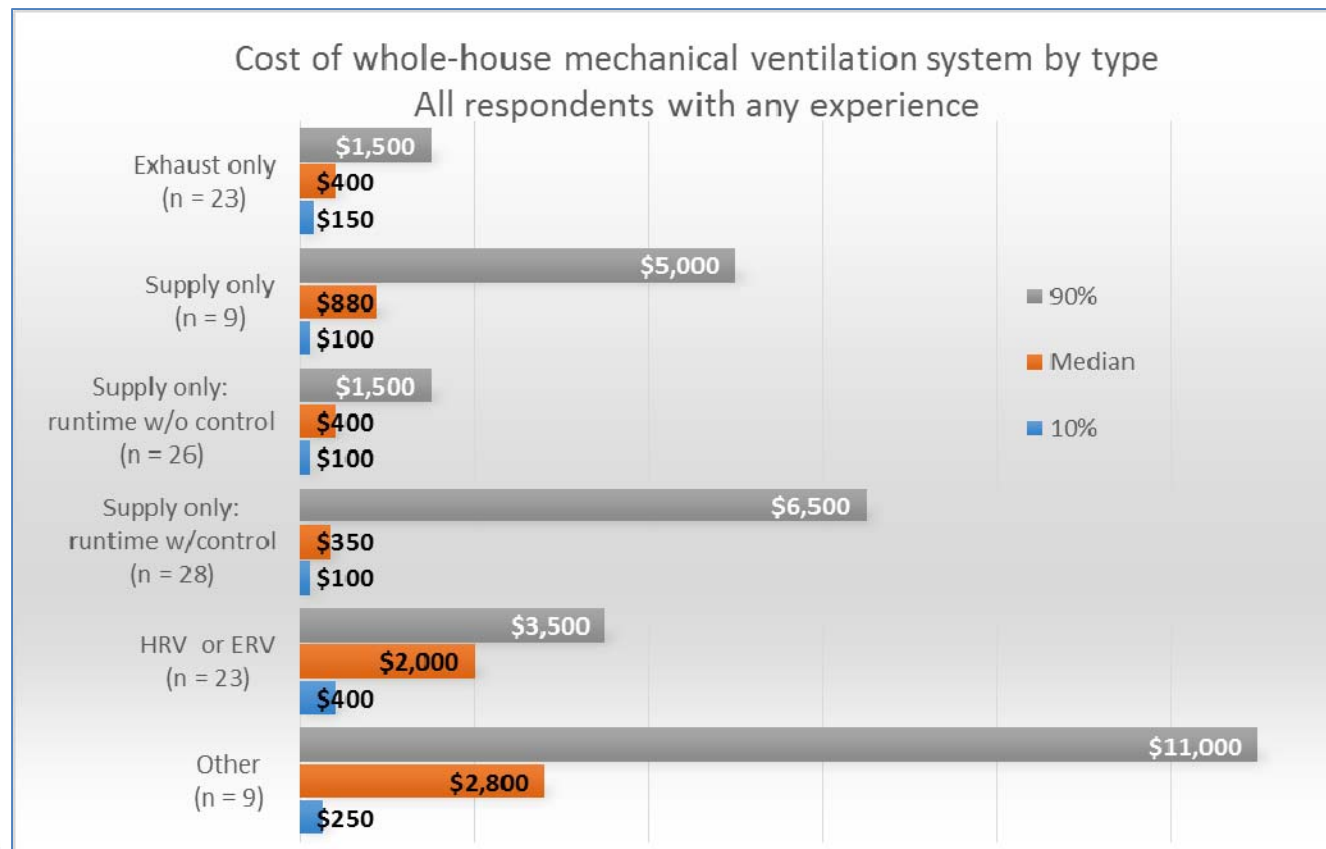
Responses to What Percent of Time Do You Experience the Delay?



Median cost of 3-day delay from 15 respondents: \$1200

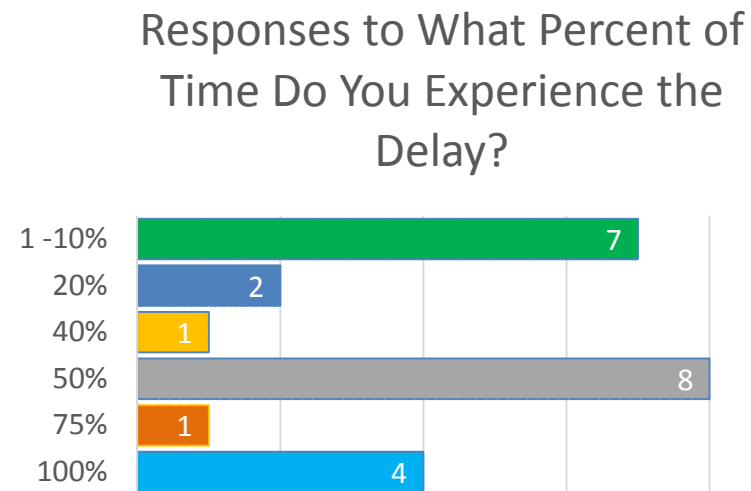
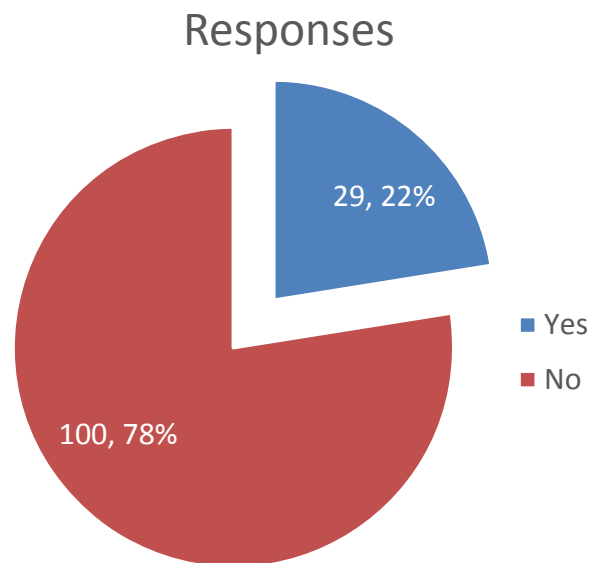


Whole-house Mechanical Ventilation Systems Installed in new Florida Homes over the PAST TWO YEARS



Delays Experienced

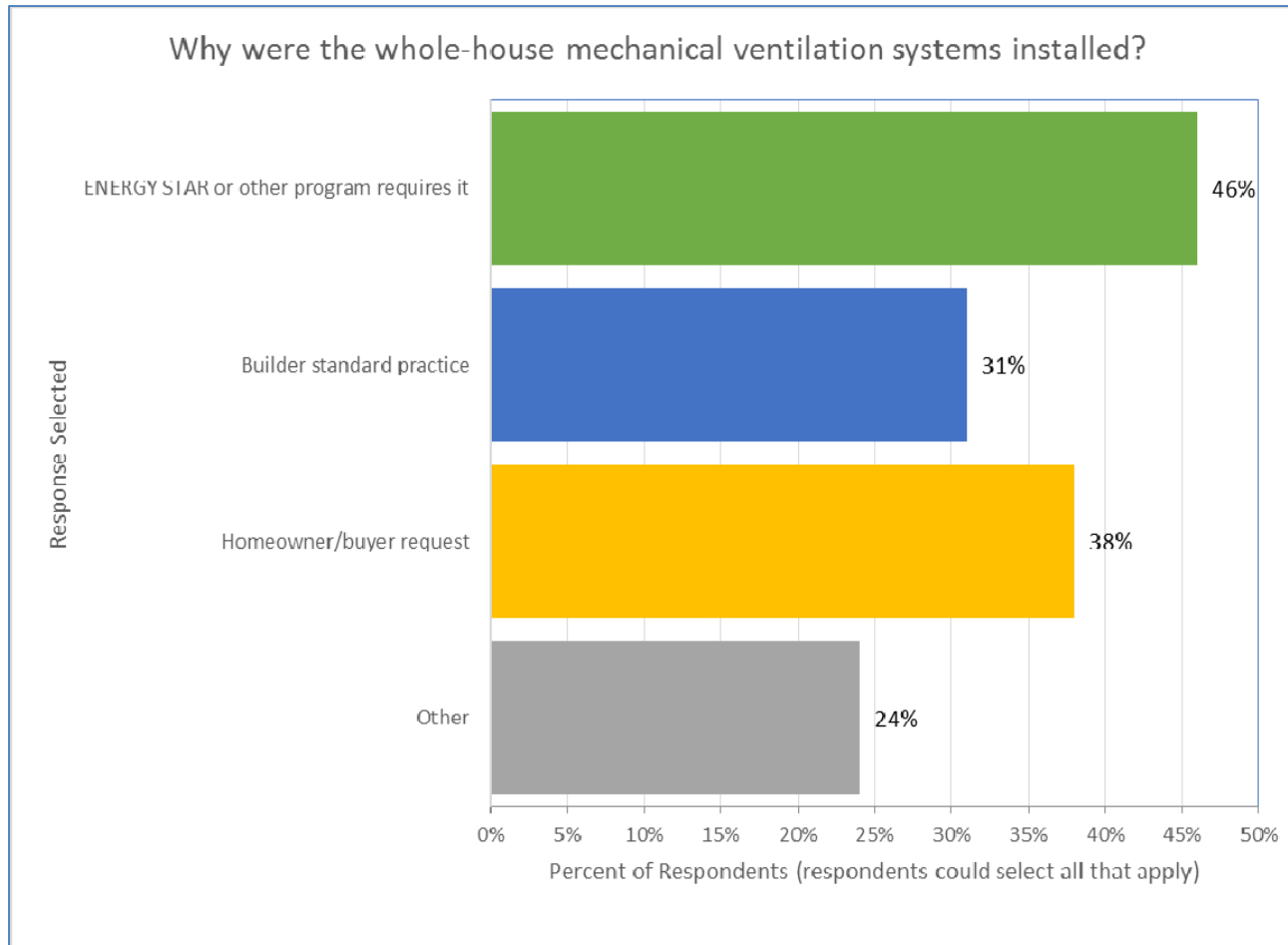
- In the PAST TWO YEARS, have you ever had a building delay of three or more days related to whole house mechanical ventilation installation?



Median cost of 3-day delay from 24 respondents: \$900



Why were these systems installed over the last TWO YEARS?



Survey Results

- Business
- Example Home Questions
- Future Work
- Experience Over the Last Two Years
- **Most Recent Experience**

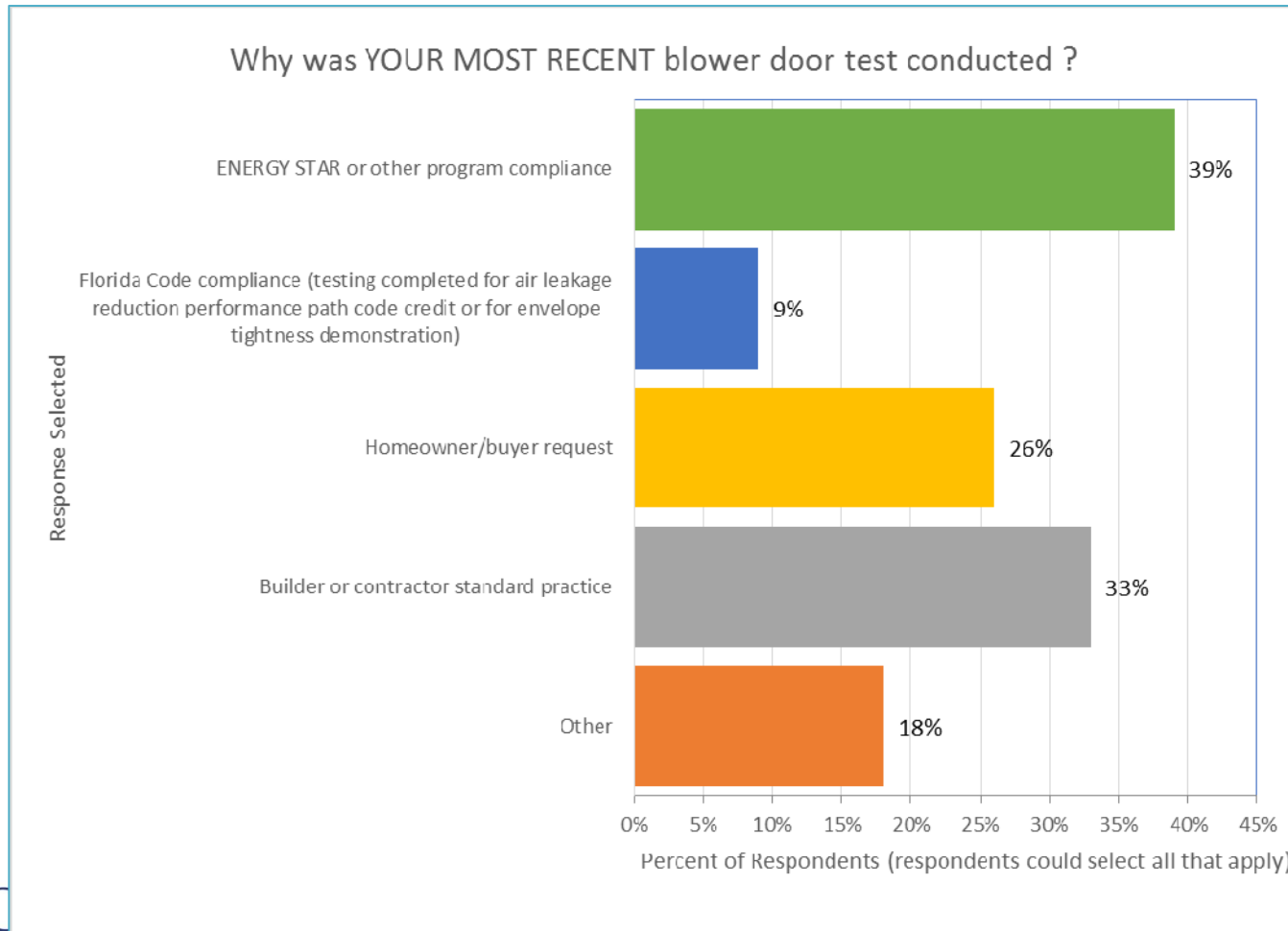


MOST RECENT Blower Door Test

Most Recent Blower Door Tests Conducted	Approximate Area (Ft ²)	Number of Bedrooms	Approximate ACH50	Approximate Cost to Builder
Median of respondents with > 20 jobs	2200	4.0	4.0	\$250
	n=43	n=43	n=39	n=41
10% estimate of all respondents	1250	3.0	2.0	\$113
	n=81	n=81	n=72	n=80
Median of all respondents	2200	4.0	4.0	\$300
	n=81	n=81	n=72	n=80
90% estimate of all respondents	4000	5.0	6.5	\$1,200
	n=81	n=81	n=72	n=80



Why was YOUR MOST RECENT test conducted?



Comments of those Selecting *Other*

- 19 respondents selecting *Other*
- One comment: “This builder was building his personal home and *wanted to make sure everything was done correctly* he had just recently changed insulation contractors because of the lack of quality the previous company was showing. He also wanted to make sure that his fireplace wasn't going to vent the gases back into his house like at his previous residence and request that the mechanical contractor added fresh air.”
- Another interesting response was “Mechanical Engineer recommended the test to determine source of moisture entering the space.”

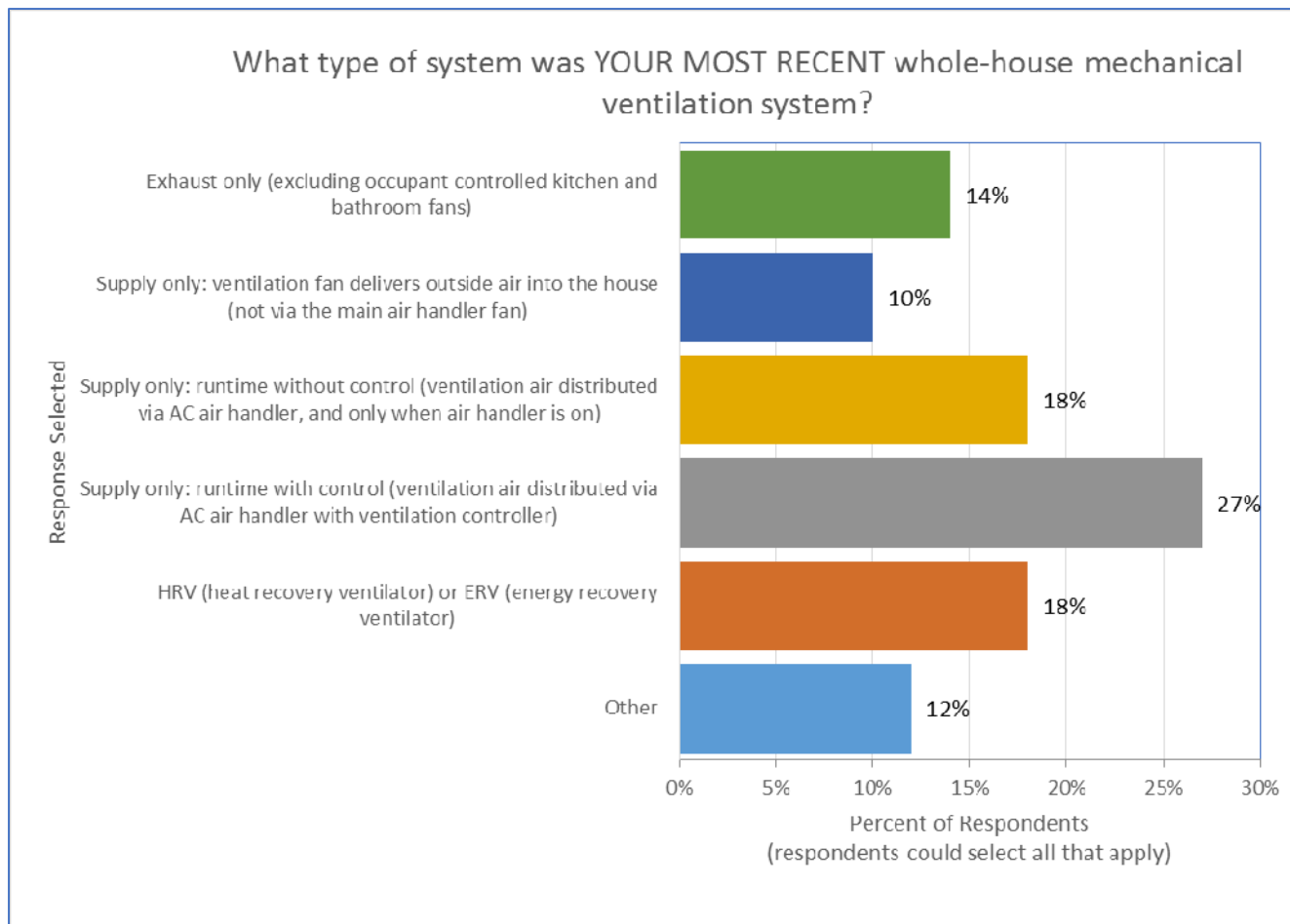


MOST RECENT Whole-House Mechanical Ventilation Installation Experience

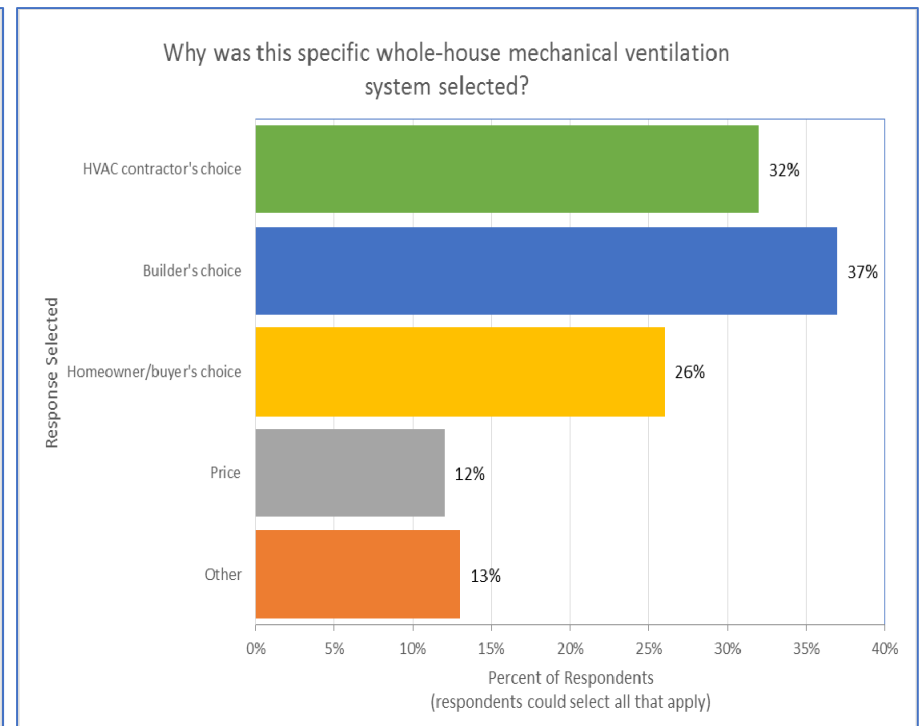
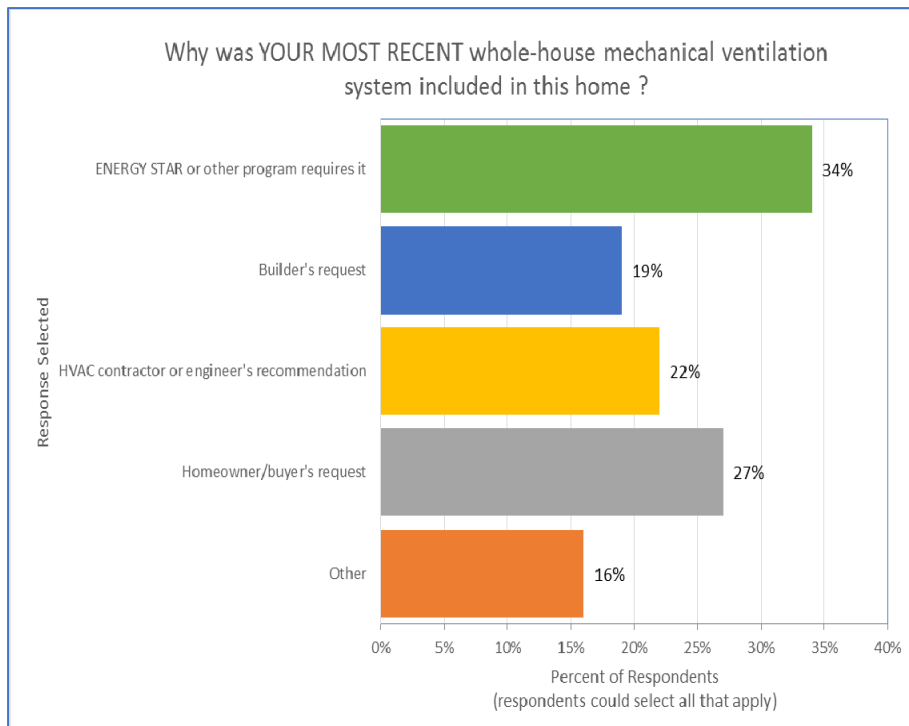
Most Recent Whole-House Mechanical Ventilation System Installed	Approximate Area (Ft ²)	Number of Bedrooms	Approximate Outside Airflow (CFM)	Approximate Cost to Builder
Median of respondents with > 10 jobs	2410	3.0	69	\$365
	n=38	n=38	n=30	n=36
10% estimate of all respondents	1400	3.0	5	\$150
	n=65	n=65	n=52	n=63
Median of all respondents	2500	4.0	80	\$1,200
	n=65	n=65	n=52	n=63
90% estimate of all respondents	5000	5.0	200	\$8,000
	n=65	n=65	n=52	n=63



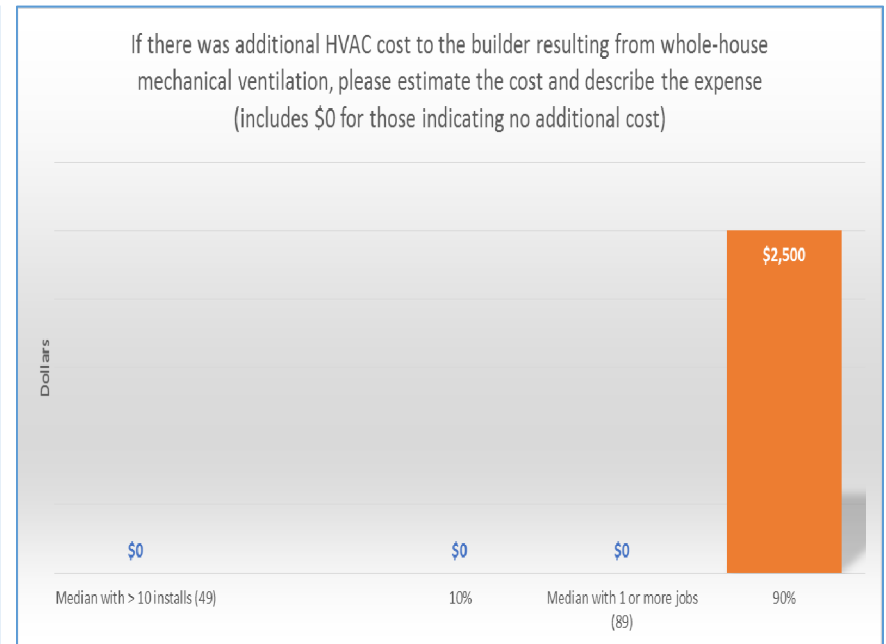
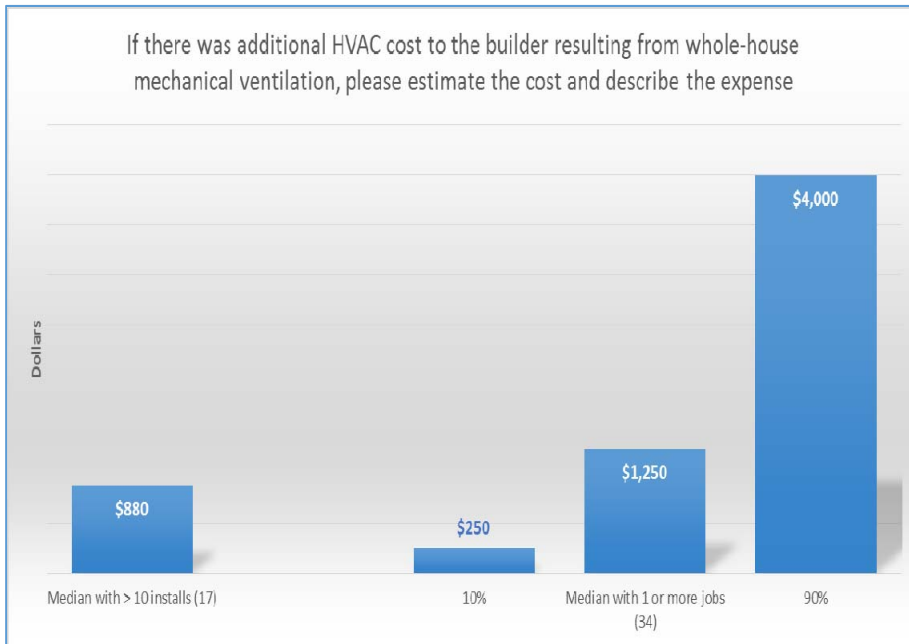
MOST RECENT System



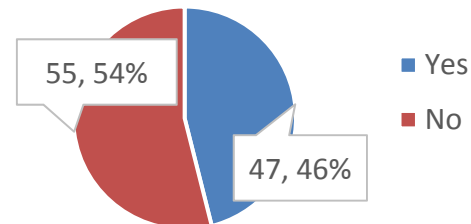
Why MOST RECENT system included and particular system selected



MOST RECENT Additional Heating, Cooling Costs



Would There Be Additional Costs?



Selected Comments on MOST RECENT Additional HVAC Costs

- “Time and materials”
- “Additional vent into the soffit and passive vent”
- “Variable speed air handlers, thermostat controls, intake duct and filtration along with control dampers”
- “HVAC controls to operate dehumidification system in different modes, i.e., fireplace on, kitchen hood on, elevated space humidity levels, turn off the system while unoccupied, etc.”
- Six responses indicated system sizing increases.



Any additional information or comments on YOUR MOST RECENT whole-house mechanical ventilation system?

- Answered by 25 respondents.
 - One explained their lack of support for residential whole-house ventilation in our climate, “Energy Star should be geographical. Nobody wants to automatically draw humid air into their Florida Home. We told customers to turn them to the off position.”
 - Another wrote, “This was and is a complete waste of client money.”
 - Another person was more adamant in their opposition: “I will never do this again. I would rather walk away from a job than deal with the nightmare brought on by whole house ventilation in Florida.”
 - A handful wrote of being pleased with their systems, such as this response, “The house preforms well. The customer is able to maintain 75 indoor temperature with 45% relative humidity. Also when the fire place runs the propane smell does not come back into the house.”



Cost Comparison

Blower Door Test Cost		
	Median 1 Plus Jobs	Median Experienced
Example House	\$350	\$300
Last Two Years...		
Energy Star	\$250	\$250
FL Code	\$250	\$250
Other	\$300	\$250
Most Recent Job	\$300	\$250

Ventilation Cost		
	Median 1 Plus Jobs	Median Experienced
Example House	\$800	\$500
Most Recent Job	\$1,200	\$365

Ventilation Additional HAC Cost		
	Median 1 Plus Jobs	Median Experienced
Example House	\$1,000	\$800
Most Recent Job	\$1,250	\$880



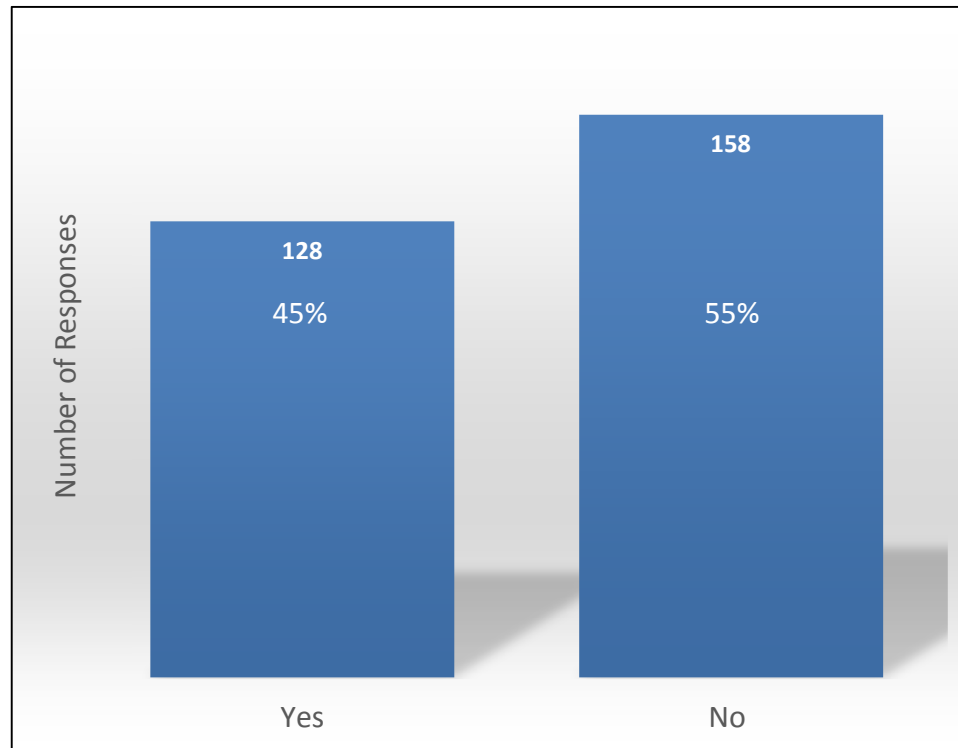
Survey Results

- Business
- Example Home Questions
- Future Work
- Experience Over the Last Two Years
- Most Recent Experience
- **Overall Benefits and General Comments**



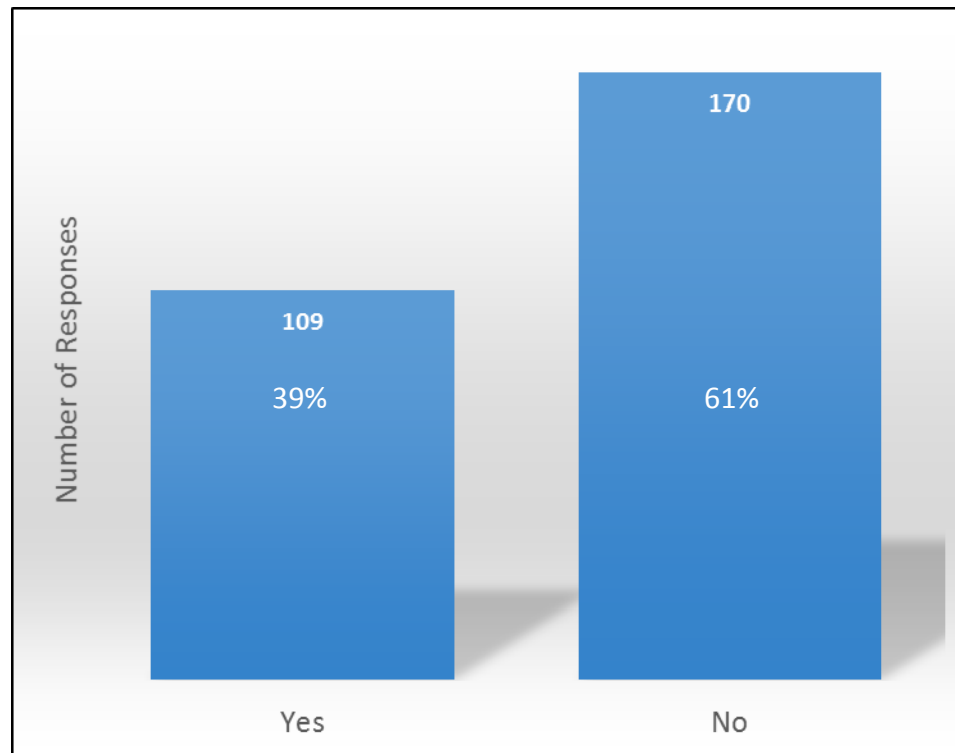
Blower Door Testing / Airtightness Requirements Beneficial Overall?

Do you anticipate that the Florida Code's blower door testing requirement and the associated whole-house air tightness requirement will be beneficial overall?



Mechanical Ventilation Requirement Beneficial Overall?

Do you anticipate that the Florida Code's whole-house mechanical ventilation requirement will be beneficial overall?



Blower Door Testing Comments

- 45 comments are of a negative nature.
 - Some of those are directed at the relationship with whole-house ventilation such as this one:
 - “If the house is built so tight you have to use ventilation then you are bringing in the hot humid air the house was built to stop, where is the savings?”
- 31 comments are of a positive nature
 - Some like this one
 - “It is good to test the houses and locate the leaks for repair.”



Comments on Whole House Mechanical Ventilation

- Forty-two of the 80 comments were generally negative, 21 were generally positive with a number of others either unclear or unresponsive.
 - Some were along the lines of it isn't broke, no need to fix it and this isn't going to help. An example of those responses is
 - “Generally a waste of money. Toilet/kitchen/dryer exhaust can provide that ventilation and has for years without any significant issues. Why fix something that isn't broken.”
 - Many were concerned about the potential health consequences of bringing in outside air, such as this response:
 - “BUT! Builder/buyer awareness of proper mechanical ventilation systems is not sufficient. Choosing the least expensive code compliance method will create more public health safety. The amounts of fresh air required through a tight home will create a science experiment inside most air handlers.”



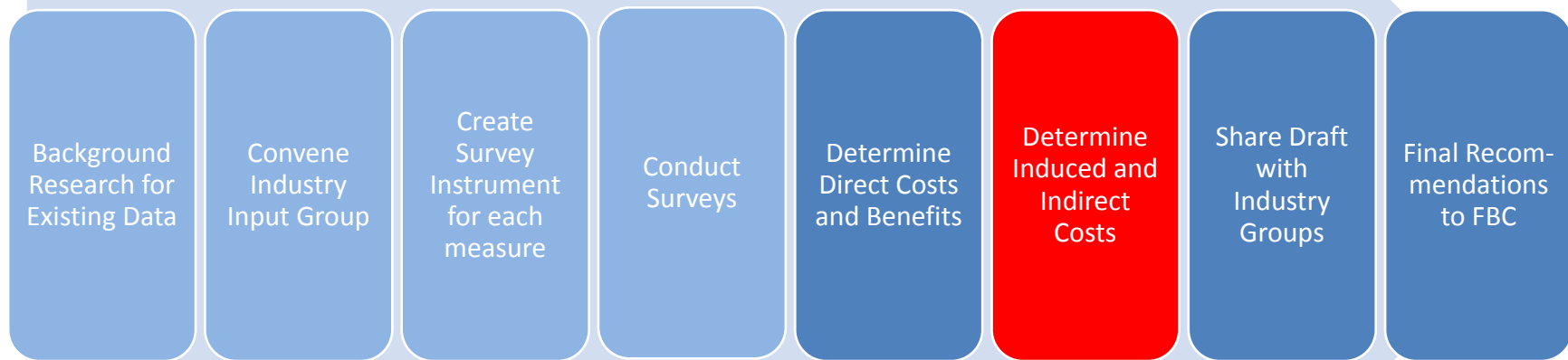
Comments on Whole-House Mechanical Ventilation

- One of the positive comments
 - “I have plenty of experience with mechanical ventilation from the houses I have worked on. When you use an HVAC contractor or engineer that knows how to design the houses properly for our climate zone. You will have no problems. Most of the home owners that I get to educate about ventilation request it. Florida is not the only state that is in Climate zone 2 we face the same problems as other South East Coastal areas do. If they can make mechanical ventilation work for them we can also make it work for us. Just as I have with my customers.”

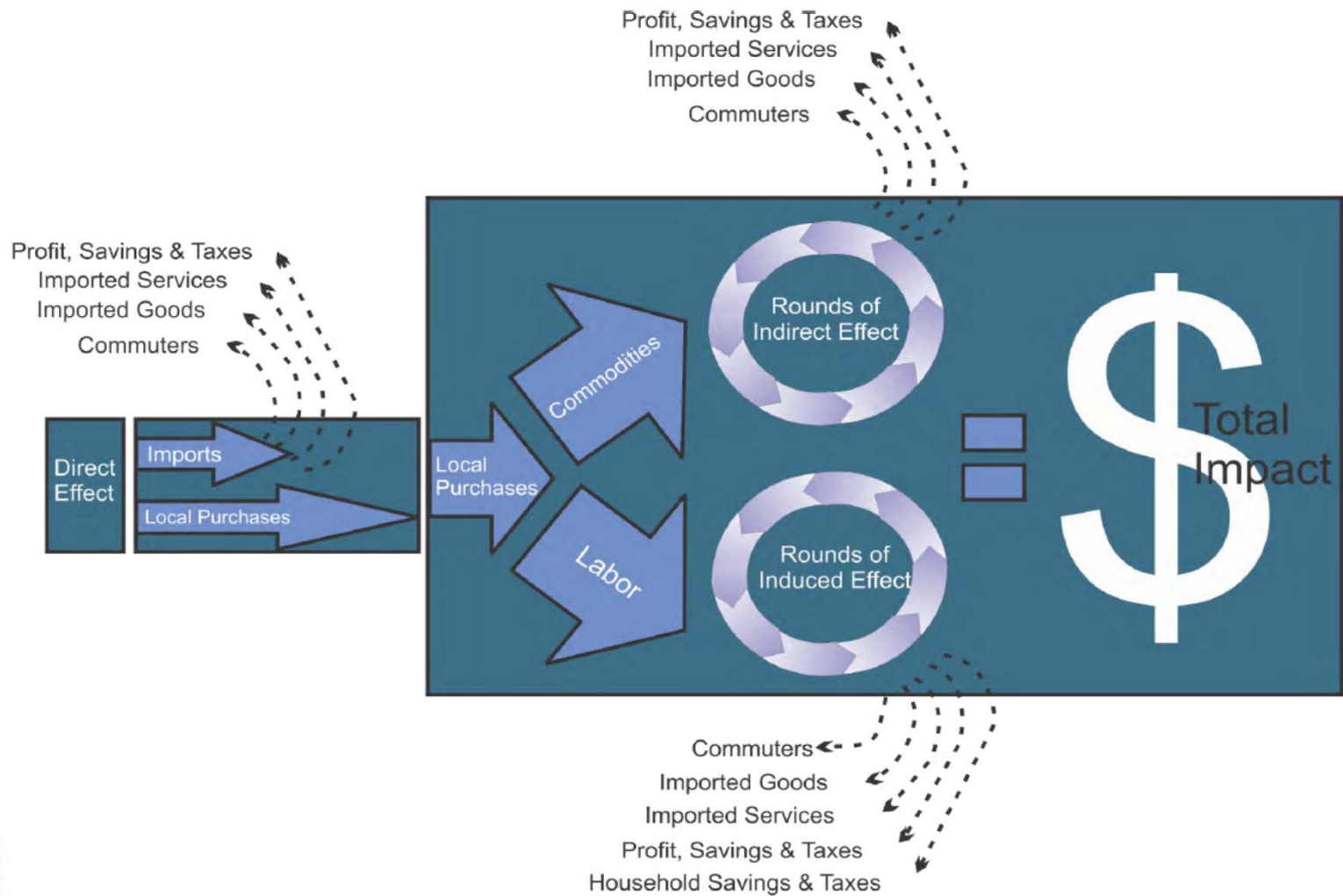


Work Scope

<----- September to December -----> <----- December to May ----->



Economic Impact



Economic Definitions

Direct Impact	The initial expenditures, or production, made by the industry experiencing the economic change.
Indirect Impact	The effects of local inter-industry spending through the backward linkages.
Induced Impact	The results of local spending of employee's wages and salaries for both employees of the Directly Impacted industry, and the employees of the Indirectly affected industries.



Economic Analysis

- Increases in Cost of House
 - Costs may result in fewer homes being built as some buyers are pushed out of market
- Increased Construction Spending
 - Job increases
 - Money spent in Florida's economy



Factors

- Costs Included:
 - The initial capital cost to implement the change on each building. This is the cost for extra air sealing, blower door testing, installation of a mechanical ventilation system based on the experienced group's response for the sample home. This includes the extra labor and material purchases required to meet the code and is considered *the direct economic impact*.
 - The builder/developer markup or gross profit (20% above the cost to builder numbers in the survey). This is another form of *direct economic impact*.
 - The lost revenue from lost sales due to an increased price to cover the code changes. This is another form of *direct economic impact*.
 - The effects of local inter-industry spending through the backward linkages. This is considered the *indirect impact*.
 - The results of local spending of employee's wages and salaries for both employees of the directly impacted industry, and the employees of the indirectly affected industries. This is referred to as the *induced impact*.



Factors

- Not included in the scope of this study:
 - The health, safety or energy benefit due to the code change. This would be a recurring value provided. Health benefits for these subjects are hard to quantify due to lack of studies.
 - The extra maintenance cost of a whole-house mechanical ventilation system. These would be costs after implementation, and would result in service jobs which in turn would benefit the economy.
 - Any increased cost due to construction delays related to the code changes (minority of people pointed to experience with delays).



Reduction in Housing Sales

- For \$1000 increase in price, 125 fewer Florida new homes are sold.
- Further, for the state of Florida it is estimated that the median sales price of a new home is \$319,174 of which for this study \$211,298 is attributed to construction costs and \$45,000 is attributed to gross margin with the remaining in fees and site expenses.
- Hence, for each house not sold the construction cost lost is modelled as a decrease in home construction while gross margin lost is modelled as a reduction in the industry spending pattern.



Summary Economic Results

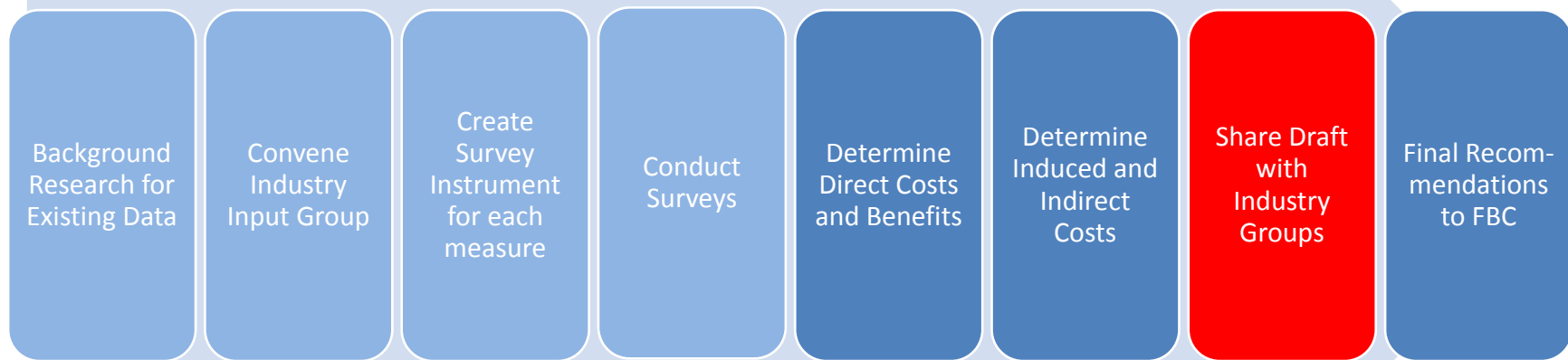
Details provided in the report Appendix N.
Residential values based on 70,000 housing starts per year

Code	Response	Gained	Lost
Elevator- Highrise (403.6.1)	Answer (08)	\$2,788,000	
Elevator- Highrise (403.6.1)	Answer (11)	\$771,800	
Extra Air Sealing (R402.4.1.2)	Construction Cost	\$35,000,000	-\$15,847,350
Extra Air Sealing (R402.4.1.2)	Gross Margin	\$7,000,000	-\$3,375,000
Blower Door (R402.4.1.2)	Construction Cost	\$21,000,000	-\$9,508,410
Blower Door (R402.4.1.2)	Gross Margin	\$4,200,000	-\$2,025,000
Mechanical Vent (R303.4)	Construction Cost	\$13,125,000	-\$15,847,350
Mechanical Vent (R303.4)	Gross Margin	\$7,000,000	-\$3,375,000
Other Changes Due to Mech Vent (R303.4)	Construction Cost	\$21,000,000	-\$25,355,760
Other Changes due to Mech Vent (R303.4)	Gross Margin	\$11,200,000	-\$5,400,000
	Total	\$123,084,800	-\$80,733,870



Work Scope

<----- September to December -----> <----- December to May ----->



Industry Presentations

Date	Group (and approximate attendance)	Location and Presenter	Topic	Key comments received
Dec. 10, 2015	Brevard HBA (10)	Melbourne Rob Vieira	Failure rates and cost of residential whole house mechanical ventilation systems (Residential Blower Door and Ventilation Survey Results and Ventilation Evaluation Study)	Keep the code changes simple; If a builder has to test their home to 5 ACH50 he will build it to 3 ACH50 to make sure he doesn't have to make any last minute changes.
Jan. 28, 2016	Expert Meeting on Smart Ventilation (25)	Cocoa Rob Vieira	Failure rates and cost of residential whole house mechanical ventilation systems	Manufacturers heard about Floridian's concerns and acknowledged issues, some are working on solutions for reliability
Mar. 10, 2016	Refrigeration & Air Conditioning Contractors Association (RACCA) (17)	Tampa Jeff Sonne	Mechanical Ventilation Costs and Failure Rates in Florida Homes	Don't want code to tell us when mechanical ventilation is required; Test and balance and it will take care of itself (slight negative pressure will bring in the outside air / but need to test and balance to make this happen); Due to occupant behavior differences, "one for all" type requirements won't work well; Homeowners will just turn the mechanical ventilation systems off; This is one of the most misunderstood and most costly aspect of our trade and interpretations of enforcement as well as status is widely conflicting. The 7 ACH change would help ease the apprehension of the blower door requirements.



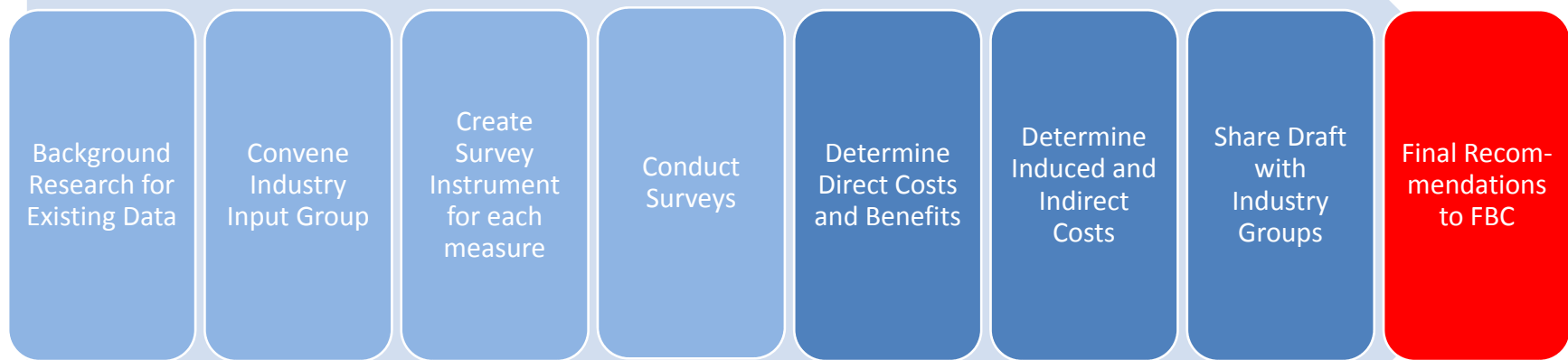
Industry Presentations (continued)

Date	Group (and approximate attendance)	Location and Presenter	Topic	Key comments received
Apr. 7, 2016	Manasota Air Conditioning Contractors Association (MACCA) (24)	Sarasota Jeff Sonne	Mechanical Ventilation Costs and Failure Rates in Florida Homes	This [presentation] was a gut punch-- now what should we do?; Inspectors don't know what to look for when inspecting mechanical ventilation systems; One individual stated he thought ventilation is needed.
Apr. 12, 2016	ASHRAE Space Coast Chapter and ASME Cape Canaveral Chapter (17)	Melbourne Rob Vieira	Mechanical Ventilation Costs and Failure Rates in Florida Homes	General reaction of not being surprised by results of the studies.



Work Scope

<----- September to December -----> <----- December to May ----->



1. House Air Tightness Testing

- House air tightness testing is recommended.
 - There is no way to know how tight a home is without measuring it. Visual inspection is limited to the amount of effort as well as the physical ability to access specific areas of construction.
 - Measurement can effectively determine if a specified target has been achieved.
 - Test can be one method of determining if there is a portion of the air barrier missing and would avoid houses with extensive air leakage from being built and occupied. The purpose of the code is to set a minimum acceptable level. Very leaky homes will use more energy and potentially have other health or comfort issues.



2. Air Tightness Level

- Allow whole-house air leakage level up to 7 AHC50
 - Recent research examining the current status of installed whole-house mechanical ventilation systems (Sonne et al. 2015)
 - Energy penalty of going from 5 to 7 ACH50 is small
 - Average house tightness will be under 7 ACH50 if they have to be tested to 7 ACH50 or under



3. Whole-House Mechanical Ventilation

- We recommend that whole-house mechanical ventilation systems be installed that are capable of ventilating the home to ASHRAE Standard 62.2-2013.
 - Guidance needed for the building industry to gain confidence that homes can be maintained at acceptable humidity and comfort.
 - Several variables must be considered such as how ventilation is provided, whether it is pre-treated, where the ventilation air is supplied into the home, type of central cooling system, moisture and thermal barriers, thermostat set points, and variability of internal moisture generation.



3. Whole House Mechanical Ventilation

- ASHRAE 62.2-2013 or 2016 would require some ventilation for homes up to close to 10 ACH50 typically
 - However, legislature indicated builders can select to install ventilation systems as an option, not mandatory until house is below 3 ACH50
 - References point to pros and cons of different types of systems
 - Manufacturers trying to address concerns



4. More Research Needed

- Real house measurements with and without ventilation systems
- Smart vent and hybrid technologies to reduce ventilation when moisture levels are high or to reduce possible negative consequences when ventilating
- Characterize health effects associated with indoor air conditions and pollutants.



Deliverables

- **Deliverable #1 Interim Report**
- *A draft report providing technical information on the problem background and resulting economic information gathered for each of the three delayed code requirements will be submitted by November 15, 2015. The report will be presented to the Commission or Commission's appropriate Technical Advisory Committee at a time agreed to by the Contractor and the Department's Project Manager.*
- Interim report was delivered November 13, 2015.
- Presentation to Mechanical, Fire and Energy TACs were conducted in December, 2015. The presentations included the interim report and highlights of the survey returns.



Deliverables

- *A final report providing background data/information, analysis, results, minutes from the stakeholder events and implication by May 15, 2016. The report will be presented to the Commission or Commission's appropriate Technical Advisory Committee at a time agreed to by the Contractor and the Department's Project Manager.*
 - The final report was sent in May 13, 2016.
 - TAC Presentations were made June 3, 2016.
 - Minutes were not always taken by the meeting organizers at stakeholder meeting but comments were gathered and included in the final report.



Acceptance

- Request the recommendation for acceptance of the final report and all deliverables.



Thank you

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