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Industry-Prioritized Research, Technology Transfer, and Education Needs and Opportunities in Residential Construction

Vladimir Kochkin
Ed Hudson
Robert J. Ross
Karen L. Martinson



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Abstract

This report identifies the priority areas in residential construction where technical research and technological advancements offer potential to benefit the industry as it strives to advance the quality of housing and meet today's market expectations for a home's cost, performance, durability, and environmental stewardship. The prioritization is performed by home builders based on their experience with constructing new homes.

Keywords: Needs assessment, residential construction, energy, indoor air quality, fire resistance, disaster resistance, durability

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Industry-Prioritized Research, Technology Transfer, and Education Needs and Opportunities in Residential Construction

Vladimir Kochkin, Director of Applied Engineering
Ed Hudson, Director of Market Research
Home Innovation Research Labs, Upper Marlboro, Maryland, USA

Robert J. Ross, Supervisory Research General Engineer
Karen L. Martinson, Program Specialist
USDA Forest Service, Forest Products Laboratory, Madison, Wisconsin USA

Preface

This report was prepared by Home Innovations Research Labs, Inc., at the request of the Forest Products Laboratory (FPL), a research unit within the USDA Forest Service. The FPL, established in 1910 in Madison, Wisconsin, was the first institution in the world to conduct general research on wood and its utilization. FPL works closely with research cooperators from industry, academia, and other government agencies to accomplish our mission. We rely upon accurate, comprehensive analyses to target our research and technology transfer activities; this enables us to focus on practical needs for the wood-using industry and consumers.

This report presents an in-depth analysis of current needs in the residential construction industry in the United States. Conclusions and recommendations presented are founded on a survey conducted of builders across the United States. A total of 120 specific challenges and issues across key categories were surveyed, including occupant comfort, fire-resistant construction, indoor air quality, energy efficiency issues, durability, disaster resistance, and costs and labor availability.

Background

Wood is the primary structural material in the United States. Residential construction in the United States continues to evolve at a rapid and often accelerating pace, creating new challenges and setting new frontiers of performance. Yet wood remains the primary construction material for above-grade structural members such as framing and sheathing. Wood is also used for many other functions in a modern house, including cladding, windows, exterior and interior finishes, and decks. It is important that continued utilization of wood in residential construction remains on sound technical footing as houses become more energy efficient, disaster resistant, and environmentally friendly. It is also important that wood-based solutions remain cost-competitive in the highly price-sensitive residential

construction market. The traditional appeal of streamlined, durable, practical, and cost-effective solutions is what earned wood construction its dominant position in housing.

Residential Market Diversity and Inertia

Low-rise residential construction is unlike any other major technology industry in the United States—it is dominated by small construction firms with nearly 80% of all single-family home builders constructing five or fewer homes per year. (This number changes depending on market conditions. The number of homes per year built by a small builder tend to be higher in a booming housing market, such as prior to the housing market downturn of 2007–2008.) In addition, building codes are adopted and often modified at the local or state level, further contributing to the fragmentation of the market. Construction practices vary substantially between geographical areas based on climatic factors, natural hazards, local architectural preferences, and many other considerations. The result is a market that is highly diverse. Shifts and changes in construction practices and preferences may happen slowly, but they can be unpredictable and even unintentional. The outcomes of broad initiatives intended to address the same policy (for example, increase energy efficiency, enhance disaster resistance) can be manifested very differently in various parts of the country or even by builders in the same market.

Innovation in Residential Construction

Innovation can take a variety of pathways, and it can take anywhere from a few months to many years for a new technology to become an acceptable option in the market. It can take even longer for a new technology to reach its full market potential. Past efforts to “industrialize” housing based on Henry Ford’s assembly line model—where one company is responsible for design, system integration, assembly, and site installation and can offer a streamlined path for technology innovation—either have failed or are confined to niche markets.

Even a relatively small change can be viewed by the industry as disruptive, in the negative sense. Because direct channels between the innovator and the homebuyer are lacking, any innovation requires multiple stakeholders to find a jointly acceptable solution. It is not sufficient for the new solution to be technologically feasible for each stakeholder; it needs to make enough business sense to each of them individually to justify the transition. Otherwise, the innovation must be rethought or abandoned.

Building Codes

Building codes have been one of the primary drivers of change in residential construction, often by one or more of several paths:

- Increasing the stringency through prescriptive requirements or performance targets
- Adding new materials and systems and new compliance options
- Aligning conventional construction practices with engineered solutions
- Expanding the scope of the code by including topics outside the traditional life safety realm

Product Innovation or System Innovation

Product innovation is relatively straightforward. System innovation is not. The following two examples highlight the difference. The purpose of this discussion is to provide context for the information in the survey part of the paper. Each situation is unique and multifaceted and cannot be easily generalized; these examples are intended to illustrate the concept and not to specifically highlight a particular material, system, or their features.

Lightweight Drywall

Lightweight drywall was first introduced a few years ago by a gypsum manufacturer and quickly became the industry norm, with most gypsum wall panel suppliers offering a lighter option in their product line. Even though each manufacturer may have taken a different approach to meeting the performance requirements for the new product, the path to market and value proposition were similar, for all practical purposes. The key attribute of the new product is that it provides a one-for-one substitution that does not require changes to either the construction process or the rest of the wall system. The lightweight drywall case study also shows that product manufacturers are fully capable of quick deployment of resources and achieving rapid results where the path to innovation is largely within their individual control. Although performance issues have been reported with lightweight drywall, the individual product manufacturers are capable of addressing concerns related directly to their product.

Continuous Exterior Insulation

A wide range of various foam sheathing products has been available to builders for over 20 years for use in exterior insulation applications. The value proposition of increased energy savings and improved moisture performance has been supported as compelling by many experts in the industry. Yet the market penetration has been lagging (less than 10% nationally and less than 20% in many cold climate areas), despite the recently increased energy code requirements. The key difference is that the use of exterior foam insulation triggers a host of system questions that require consideration with regard to other products used in the wall, construction processes, trades sequencing, and integration with other materials. Examples include cladding attachment, vapor retarders, drainage plane, drying, bracing, insulation thickness, and window integration. Although all these questions can be answered, it requires cooperation and alignment of multiple product manufacturers and trade partners to execute the transition to the new practice. Some of these questions continue to remain open and in some cases contentious. Continuous exterior insulation serves as an example of a cross-cutting technology that cannot be fully advanced by an individual product manufacturer without broader industry cooperation.

System Integration

With the two technologies following dramatically different innovation stories, it is the second path (system path) that is the more frequently encountered by those who had the courage to embark on innovating in housing and the stamina to see it through. The private sector of the industry can be relied upon for product innovation. In many cases, the new products are proprietary and the industry is not looking for or interested in assistance with getting the products to market. In fact, all product manufacturers, small and big alike, continually work on new products and improvements to their existing product lines. It is system integration of products that can create significant challenges for builders or cause unintended consequences when the new products are introduced for inclusion with tried-and-true construction methods and systems. Individual product manufacturers often are not well equipped to advance system integration issues. Builders, having to fulfill the role of the integrator, look for reliable and consistent information for basing design and construction decisions.

Survey of Home Builders

A survey of home builders was conducted to help establish priorities for the challenges facing the industry. The results of the survey are intended to provide input for defining strategic research and development initiatives.

Although factors ranging from interest rates to the Endangered Species Act to the cost of cement in China shape the housing industry, this survey focuses on

construction methods and technologies. The goal is to identify key challenges and opportunities facing builders and other stakeholders as a result of continuous technological changes in the market driven by many factors such as building codes, environmental regulations and programs, available labor pool, customer preferences, architectural styles, and occupancy types.

The survey was developed based on information gathered from focus groups of builders (App. C provides participant profiles) and from a web-based portal established for the specific purpose of soliciting input from other stakeholders. The survey included 120 specific challenges and issues across several key categories:

- Occupant comfort
- Fire-resistant construction
- Indoor air quality
- Energy efficiency issues
- Durability
- Disaster resistance
- Costs and labor availability

The complete questionnaire is provided in Appendix A.

Survey Metrics

A total of 308 homebuilders responded to the survey. Only those individuals who have decision-making responsibilities within their construction company were surveyed. The key survey metrics are summarized in Figure 1, including construction activities undertaken by the respondents and the types of buildings constructed. Over 90% of respondents were engaged in construction of buildings four stories or less, typically of light-frame wood construction. The majority of builders stated that they participated in an energy or green program. Reflecting the U.S. home builder population, local builders made up the majority of the sample. Respondents represented widespread geographic areas, including 47 U.S. states and the District of Columbia. Respondents were generally reflective of new single-family detached homes by custom, semi-custom, and production categories. Local building operations of respondents covered all U.S. climate zones, with the bulk in climate zones 2 through 6.

Survey Methodology

For each of the seven key categories, respondents were asked to rate and then rank specific issues to the degree they anticipate each being a challenge or issue in the foreseeable future:

- Rate each specific issue on a 1 to 5 scale (1 = Not a Challenge, 2 = Slight Challenge, 3 = Somewhat Big Challenge, 4 = Very Big Challenge, and 5 = Extremely Big Challenge.); and

- Rank the top five specific issues from each of the seven broad categories, #1 being the most challenging and #5 being the least.

At the end, respondents were shown a single list summarizing their top five from each of the seven categories and were asked to rank them overall. Respondents were then asked to allocate 100 points to the top overall topics where they would like to see industry efforts directed to solving specific issues and challenges.

Findings

Key findings of the survey are summarized by topic in this section. The items listed below are ranked highest by the respondents. The issues can be presented based on two primary categories: (1) labor, cost, and construction process and (2) technical and informational. A complete summary of results is available in a companion presentation (App. B).

Skilled Labor Shortage

Shortage of skilled labor was identified by builders across the board as one of the most pressing issues for the industry, with multifamily builders affected most. Builders were most vocal on this issue, both during focus groups and in comments on the survey. Among all labor categories, framing was identified as the highest priority item by both single-family and multifamily builders. Labor shortages lead to delays and increased cost, affect quality of construction, and limit industry's ability to adopt new code requirements and respond to market pressures. The issue of skilled labor is particularly important in light of the continuous transition of the residential industry to high-performance and optimized construction, which relies on more complex systems that often break away from conventional construction practices. The skilled labor must be able to keep pace with evolving technologies to ensure successful rollout of new requirements, products, and systems in the market. Research and development efforts in this area can include a wide range of initiatives, such as training, education, workforce development, apprenticeships, and community college programs. In terms of technology transfer, new and direct communication channels need to be developed to access trades people and share information in a manner that is timely, relevant to their projects, and delivered in a format that is actionable and applicable to real-life situations.

Rising Cost of Building Materials

Among all items related to cost, builders ranked rising cost of materials as the highest priority. This item is likely twofold—general rising cost of materials and higher cost of materials needed to achieve compliance with new code requirements and market demands for high performance homes. The primary research opportunity associated with this item is related to development of system and

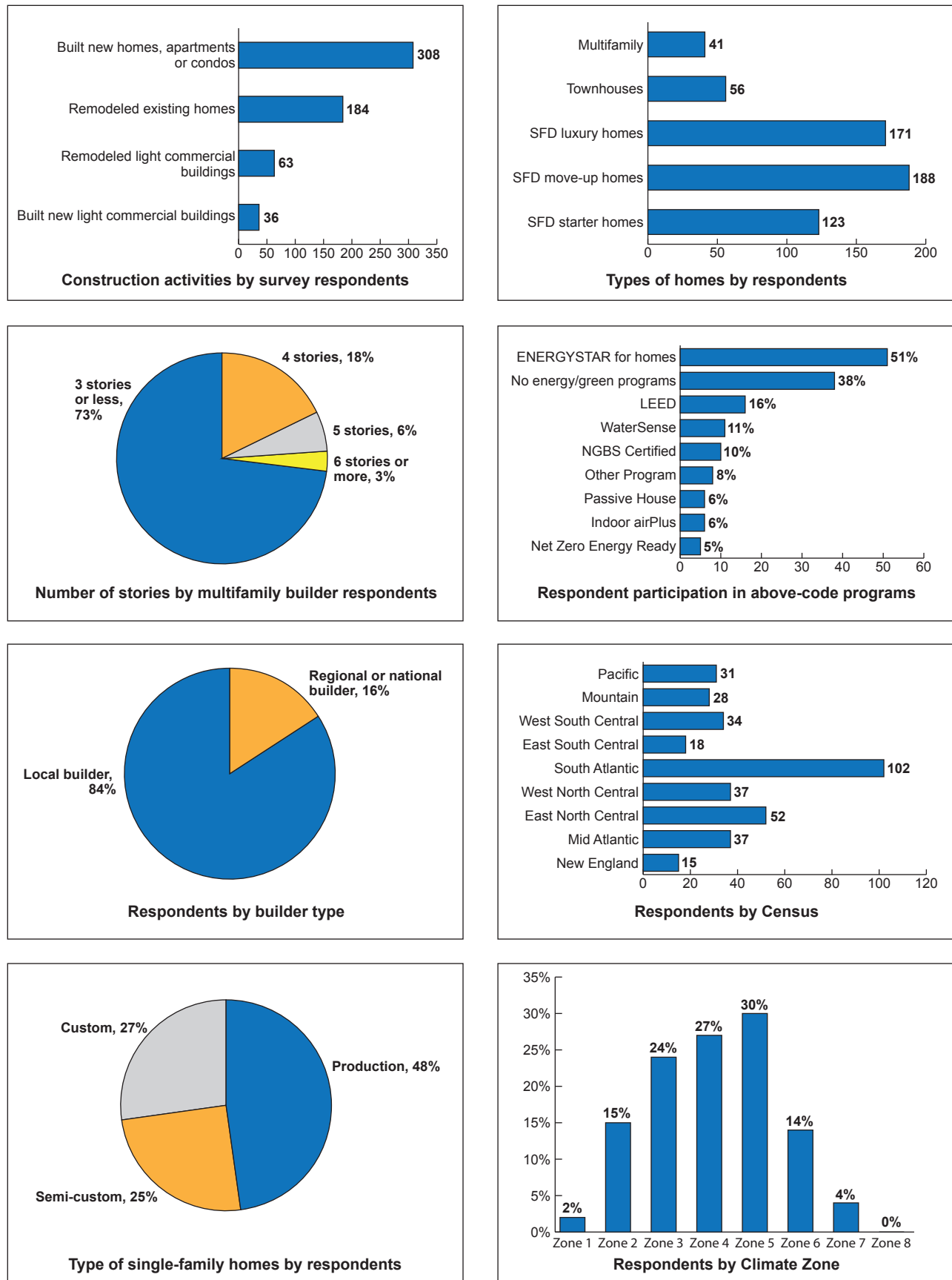


Figure 1—Survey metrics.

performance-based solutions optimized for the application to minimize the impact of transitioning to high-performance homes and achieving compliance with new code requirements.

Installation of Sprinklers and Increasing Costs of Compliance with Fire Requirements

Installation of sprinklers was ranked as the highest item in the cost and labor category. This reaction is in response to recent code changes that mandate fire sprinklers in single-family construction. This is a regulatory item that applies broadly to all builders in jurisdictions that adopted the model codes without amending this provision. Research and development efforts in this area can be focused on solutions that streamline and facilitate installation of such systems to reduce the overall installed cost.

Rising Cost Due to New Codes Requirements for Energy Efficiency and Structural Performance and Rising Cost of Design Fees

As building codes evolved over the past 15+ years since the introduction of 2000 International Residential Code (IRC), the stringency of structural requirements intended to improve resistance to natural disasters and energy requirements intended to reduce the energy cost of operating the dwelling has increased. These changes to the minimum code provisions continue to drive up construction costs and associated design fees. The increase in design fees is associated with need for more complex analyses to achieve code compliance and to find optimized solutions. Research and development efforts in this area can be directed to developing system solutions that are optimized for both increased efficiency and structural capacity at minimum added cost. (A traditional example of such systems is 2 by 6 construction using 24-in. on center framing.) In addition, the focus should be on design methods that enable designers and engineers to take full advantage of system solutions. (The perforated shear wall design method serves as a good example of such design solutions.) Following development and field validation, solutions should be standardized, and where possible, prescriptive compliance tools should be made available to help minimize the need for custom designs.

Consistency in Interpreting Building Codes

The rapid pace of change in building codes, complicated by local amendment processes and enforcement methods, leads to inconsistent interpretation of building codes across jurisdictions and among code officials. Because new code changes are introduced every three years, and sometimes more frequently, builders may be forced into multiple redesign efforts, longer plan review times, red-tagged projects, and other complications, all of which lead to added cost, construction delays, and reduced overall effectiveness of the design and construction process. Builders particularly

singled out the structural provisions of the code, where inconsistency in interpretation of the provisions has created challenges. Research and development efforts in this area should focus on developing informational tools and mechanisms that help code officials and builders with understanding and applying new code provisions, both performance-based and prescriptive, in a manner that is consistent with the intent of the code and is uniform across markets. Note that this topic was ranked first among all technical issues (that is, issues not related to cost or labor). (Also see “Solutions” section.)

Proven Durability of New Products and Moisture Performance of Energy-Efficient Systems

Mindful of the well-documented, widespread past failures, builders expect a high degree of confidence in the long-term performance of new products and systems they are willing to specify. Issues related to durability of products can be categorized into two groups:

- Product specific—whether the new or substitute product will perform the function of the standard product
- System specific—whether the new system will perform the intended function after a product substitution or a product addition has been made

Both types of issues can present a significant challenge in terms of evaluating long-term performance, with system evaluation being particularly difficult because of the much larger number of variables affecting its performance. Builders are particularly cautious of unintended consequences of switching to new products that may not be revealed until well into the service life of the building. Research and development efforts in this area should focus on development and advancement of evaluation protocols that are capable of capturing the wide range of exposure scenarios and material interaction combinations. The evaluation tools should rely on a combination of analysis, testing, and monitoring to provide a full assessment picture at minimum cost and in the shortest amount of time. Examples of recent challenges raised by builders include questions about long-term performance of High-R walls in energy-efficient homes and the issues reported with stucco-clad walls in Florida in the past few months.

Indoor Air Quality

Several topics related to indoor air quality (IAQ) were ranked high by builders, including lack of clear definition and simple metrics for acceptable air quality, air quality and ventilation in airtight homes, and lack of low-cost IAQ test methods. This is an emerging issue that has been brought to the front by various recent code changes and general market shift to high-performance homes, with a potentially significant cumulative effect on IAQ:

1. Increase of minimum thermal resistance of homes, leading to use of new insulation products with poorly understood impact on indoor environment
2. Increase in air tightness of homes, which reduces natural air exchange and can lead to air quality issues, increase relative humidity levels, and limit drying potential for some elements of the building
3. Increase in mechanical ventilation rates, which has an energy penalty and an unknown impact on IAQ as a result of introducing humid or polluted air.

Research and development efforts in this area should focus on several issues:

1. Benchmarking acceptable indoor air quality levels
2. Validating reasonable ventilation levels and developing climate-zone-specific and integrated ventilation (and where needed, dehumidification) solutions
3. Developing better understanding of the impact of various new and standard materials on air quality of homes, with particular emphasis on high-performance homes
4. Developing simple commercial tools accessible to construction industry for assessing air quality

Performance of Wood Buildings in Tornadoes

With frequent tornadoes reported recently, this issue is a concern for many builders. Research and development efforts in this area should focus on safety room solutions for extreme tornado conditions and on providing a continuous load path for high-wind events in general. Observations from wind events typically indicate that newer homes constructed in accordance with modern building codes fare much better than older homes. Tornado safety education and practical strategies for upgrading wind resistance of homes can be useful tools for engaging home owners.

Solutions

When builders were asked to prioritize potential solutions, their top-ranked items included (1) information on how to avoid unintended consequences when transitioning to new products and systems; (2) educational tools specifically for trades to help with transitioning to new products and codes and installation instructions that address a range of applications and account for field conditions; and (3) information about long-term performance of products and systems and ability to compare between products and systems.

Builders consistently indicated that they rely primarily on product manufacturers and suppliers for building science information and support, with less than a quarter of builders reporting hiring consultants or having expertise on staff. Therefore, these types of tools are particularly important to help builders with making informed decisions based

on balanced presentation of expected performance and function.

Interestingly, builders who do not participate in green or energy efficiency programs were almost twice as likely to be interested in information on how to integrate new products with the rest of the system. This is a group of builders who know that change is coming but do not have much experience with newer technologies. On the other hand, builders who do participate in above-code programs were more interested in having educational tools for transitioning to new code requirements be tailored for trades. Based on their experience, this group of builders identified the ability of trades to quickly and effectively make the transition as one of the key barriers to adoption of new practices.

When asked about an interactive building-science expert system, about three-quarters of all builders indicated that such a tool would be “extremely helpful” or “very helpful.”

Top Issues by Category

Table 1 lists the top-ranked issues within each of the seven broad categories.

Summary

Builders continue to be challenged on multiple fronts in providing homes that meet the increasing demands of building codes and the market. The challenges are often interrelated and cross-cutting in terms of their impact on multiple aspects of the design and construction process. The technical issues are closely related with labor market and cost implications. The issues identified in this survey suggest a broad range of barriers and gaps facing the industry in achieving its goals of providing high-performance homes that are welcomed by the market and advancing broader public goals of sustainability.

Cooperative private–public research partnerships have proven in the past to provide effective and credible mechanism for advancing broad integration challenges. The information and knowledge developed through such research can provide an objective basis for developing solutions that can be embraced by the building industry.

Table 1—Top-ranked issues

Category	Cost-related	Non-cost related
Occupant comfort	High cost of solutions that improve occupant comfort	Ability to maintain uniform temperatures during peak periods Lack of tools and metrics for measuring and defining comfort Ability to maintain humidity within comfort range
Fire-resistant construction	Installation of sprinklers	Compliance with fire code requirements in assemblies with wood-based products, new air-sealing products, and foam sheathing insulation
Indoor air quality	High cost of effective ventilation solutions (ERV, HRV)	Lack of clear definition and simple metrics for acceptable air quality Lack of low-cost IAQ test methods Indoor air quality and ventilation solutions for airtight homes
Energy efficiency issues	Rising cost of compliance with energy-efficient codes	Moisture performance of energy efficient walls and attics Whole-house integration when transitioning to energy efficient homes
Durability	N/A	Understanding impact of new code requirements on long-term performance Proven durability of new products and materials Durability of exposed exterior wood products
Disaster resistance	Rising cost of compliance with structural codes	Consistency with interpreting structural code requirements Ability of trades to understand and execute specified structural solutions and call-backs after structural inspections Need for engineering for wall bracing Structural solutions for buildings above three stories Performance of wood buildings in tornados
Costs, labor, and construction process	Rising cost of skilled labor Rising cost of building materials Labor availability for framing Cost increases due to labor shortages	Consistency with interpretation of building codes

Appendix A—Builder Survey Questionnaire

FPL NEEDS ASSESSMENT

- S1. Which of the following has your company's local operations done in the past 12 months? (SELECT ALL THAT APPLY.)

Remodeled existing homes	-1
Remodeled light commercial buildings	-2
Built new homes, apartments or condos	-3
Built new light commercial buildings	-4
None of the above	-5

PROGRAMMER: MUST SELECT PUNCH 3 IN S1 TO QUALIFY AND CONTINUE, OTHERWISE TERMINATE.

- S2. Which of the following phrases best describes how much influence you have when it comes to selecting the building materials and systems solutions your company uses?

I am the sole decision maker who selects the building materials and systems solutions we use	-1	
I have authority to specify the building materials and systems solutions we use	-2	
I strongly influence the selection of building materials and systems solutions we use	-3	
I have some influence over the selection of building materials and systems solutions we use	-4	[TERMINATE]
I have no influence over the selection of building materials and systems solutions we use	-5	

- D1. How many of each of the following did your company's local operations construct in the past 12 months? (ENTER NUMBER OF UNITS. IF NONE, ENTER 0.)

1	Single-family detached (SFD) Starter homes	_____
2	Single-family detached (SFD) Move-up homes	_____
3	Single-family detached (SFD) Luxury homes	_____
4	Townhouses or duplexes (living units)	_____
5	Apartments or condos (living units)	_____

PROGRAMMER: ASK S3 IF APARTMENTS/CONDOS > 0 IN D1.

- S3. What percent of the apartments/condos your local operations built in the past 12 months were ...? (TOTAL MUST = 100%.)

1	3 stories or less	_____
2	4 stories high	_____
3	5 stories high	_____
4	6 stories high	_____
5	7 or more stories high	_____

[IF 100% AND D1_1-4 = 0, TERMINATE]

PROGRAMMER: ASK D2 IF PUNCH 1 IN S1.

- D2. How many residential remodeling jobs did your company's local operations do in the past 12 months? (ENTER NUMBER OF JOBS.)

PROGRAMMER: ASK QE1 IF ANY TYPE OF SFD HOMES > 0 IN QC.

- D3. What percent of the homes your local operations built in the past 12 months were of each of the following types? (TOTAL MUST = 100%.)

1	Production homes	
2	Semi-custom homes	
3	Custom homes	

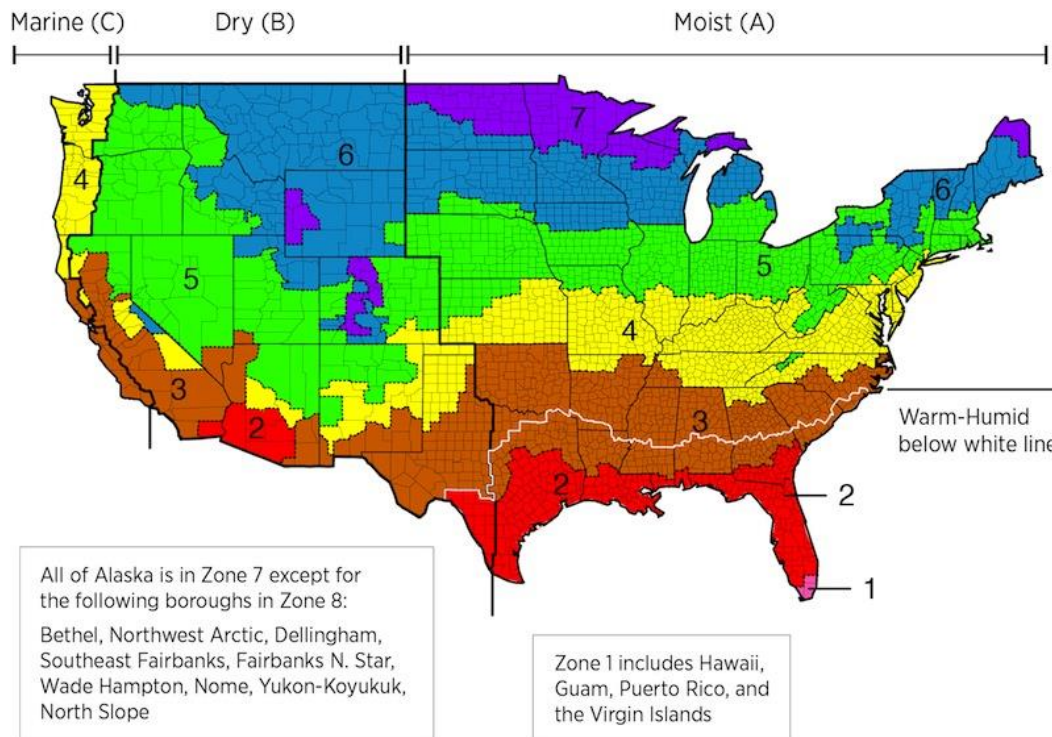
D4. In what state(s) does your particular office build homes, apartments and/or condos? (Select all that apply.)

- 1 Alabama
- 2 Alaska
- 3 Arizona
- 4 Arkansas
- 5 California
- 6 Colorado
- 7 Connecticut
- 8 Delaware
- 9 District of Columbia
- 10 Florida
- 11 Georgia
- 12 Hawaii
- 13 Idaho
- 14 Illinois
- 15 Indiana
- 16 Iowa
- 17 Kansas
- 18 Kentucky
- 19 Louisiana
- 20 Maine
- 21 Maryland
- 22 Massachusetts
- 23 Michigan
- 24 Minnesota
- 25 Mississippi
- 26 Missouri
- 27 Montana
- 28 Nebraska
- 29 Nevada
- 30 New Hampshire
- 31 New Jersey
- 32 New Mexico
- 33 New York
- 34 North Carolina
- 35 North Dakota
- 36 Ohio
- 37 Oklahoma
- 38 Oregon
- 39 Pennsylvania
- 40 Rhode Island
- 41 South Carolina
- 42 South Dakota
- 43 Tennessee
- 44 Texas
- 45 Utah
- 46 Vermont
- 47 Virginia
- 48 Washington
- 49 West Virginia
- 50 Wisconsin
- 51 Wyoming

D5. Which of the following best describes your company?

- | | |
|--|----|
| My company serves only our local market area | -1 |
| My company serves multiple markets in this region of the country | -2 |
| My company serves multiple markets across the nation | -3 |

D6. Please select the climate zones in which your particular office built homes, apartments and/or condos in the past 12 months. (SELECT ALL THAT APPLY.) **[PROGRAMMER: DISPLAY MAP SUPERIMPOSED WITH CLIMATE ZONES.]**



Zone 1	-1
Zone 2	-2
Zone 3	-3
Zone 4	-4
Zone 5	-5
Zone 6	-6
Zone 7	-7
Zone 8	-8

D7. Which, if any, of the following energy or green programs does your company participate? (SELECT ALL THAT APPLY.) **[RANDOMIZE]**

NGBS Certified	-1
LEED	-2
Net Zero Energy Ready	-3
ENERGYSTAR for Homes	-4
Passive house	-5
Indoor airPlus	-6
WaterSense	-7
Other (Please Specify) _____	-8
None—do not participate in any energy/green programs	-9

PROGRAMMER: FOR D8, DISPLAY EACH PROGRAM SELECTED IN D7. IF NONE (PUNCH 9), SKIP.

D8. What percent of the homes your local operations built in the past 12 months were in each of the following energy or green programs in which your company participates? **[RANDOMIZE]**

- | | | |
|---|-----------------------|-------|
| 1 | NGBS Certified | _____ |
| 2 | LEED | _____ |
| 3 | Net Zero Energy Ready | _____ |
| 4 | ENERGYSTAR for Homes | _____ |
| 5 | Passive house | _____ |
| 6 | Indoor airPlus | _____ |
| 7 | WaterSense | _____ |
| 8 | [D7_8_OTHER] | _____ |

D9. What is your exact job title?

- Q1. In this survey, we want to understand the different challenges and issues or concerns home builders like yourself expect to face for the foreseeable future when it comes to providing high-performance, superior quality, affordable homes. Your answers will help us to determine which areas to focus our research efforts in the coming years.

PROGRAMMER: RANDOMIZE Qs 2-8.

- Q2. In the following exercise you will see a series of potential challenges and issues or concerns related to **costs, labor or construction processes**. For each one, select the statement that best describes how much of a challenge you believe it will be for your home building company for the foreseeable future.

PROGRAMMER: RESPONDENT WILL EVALUATE ALL CHALLENGES. DISPLAY CHALLENGES ONE AT A TIME USING A CAROUSEL TECHNIQUE. RANDOMIZE CHALLENGES.

EXTREMELY BIG challenge for my company -1	VERY BIG challenge for my company -2	SOMEWHAT BIG challenge for my company -3	SLIGHT challenge for my company -4	NOT A challenge for my company -5
Availability of unskilled labor				-1
Availability of skilled labor for framing				-2
Availability of skilled labor for insulation				-3
Availability of skilled labor for exterior siding				-4
Availability of skilled labor for HVAC				-5
Availability of skilled labor for plumbing or electrical				-6
Availability of skilled labor for house wrap and flashing				-7
Availability of skilled labor for drywall and finishes				-8
Coordination between trades				-9
Coordination between trades when transitioning to new products or systems or code requirements				-10
Ability of trades to quickly adopt new code provisions and ensure code compliance (passing quality inspections and code inspections)				-11
Delays due to labor shortages				-12
Cost increase due to labor shortages				-13
Rising cost of building materials				-14
Rising cost of unskilled labor				-15
Rising cost of skilled labor				-16
Rising cost associated with energy efficiency requirements/specifications				-17
Rising cost associated with structural requirements/specifications				-18
Rising cost associated with fire requirements/specifications				-19
Rising cost associated with ventilation requirements/specifications				-20
Rising cost associated with dehumidification specifications				-21
Rising cost associated with plumbing and hot water specifications				-22
Rising cost associated with increased home buyer demand for customization				-23
Rising cost associated with design fees/costs				-24
Consistency in interpretation of new codes				-25

- Q3. In this exercise you will see a series of potential challenges and issues or concerns related to **disaster resistance and/or structural performance**. For each one, select the statement that best describes how much of a challenge you believe it will be for your home building company for the foreseeable future.

PROGRAMMER: RESPONDENT WILL EVALUATE **ALL** CHALLENGES. DISPLAY CHALLENGES ONE AT A TIME USING A CAROUSEL TECHNIQUE. RANDOMIZE CHALLENGES.

EXTREMELY BIG
challenge
for my company
-1

VERY BIG
challenge
for my company
-2

SOMEWHAT BIG
challenge
for my company
-3

SLIGHT
challenge
for my company
-4

NOT A
challenge
for my company
-5

Requirements for additional hardware (hold downs, anchor bolts, plate washers, straps, etc.) to comply with wall bracing provisions	-26
Need to adjust architectural floor plans (e.g., move walls/windows, etc.) to comply with wall bracing provisions	-27
Need for engineered design to comply with wall bracing provisions	-28
The need for specialty shear wall panels (e.g., Simpson Strong-wall) to comply with wall bracing provisions	-29
Requirements for additional roof blocking to comply with wall bracing provisions	-30
Need to reinforce or change foundations to comply with wall bracing provisions	-31
Attachment of cladding or siding products	-32
Consistency with interpreting structural code requirements	-33
Limitation of prescriptive structural solutions and need for relying on engineering (other than bracing)	-34
Engineers' lack of familiarity with wood framing and wood products	-35
Lack of integrated structural system solutions for the entire house	-36
Framing two-story foyers or family rooms	-37
Integration of energy efficient measures and their impact on framing and connections	-38
Field constructability of engineered structural systems	-39
Ability of trades to understand and execute the specified structural solutions	-40
Framing of decks	-41
Performance of wood buildings in tornados	-42
Cracking of foundation walls or slabs	-43
Structural solutions for wood buildings of more than 3 stories	-44
Solutions for tornado safe room in a house	-45
Call-backs for trades to go back to fix quality issues after structural code inspections	-46

- Q4. In this exercise you will see a series of potential challenges and issues or concerns related to **durability of materials and systems**. For each one, select the statement that best describes how much of a challenge you believe it will be for your home building company for the foreseeable future.

PROGRAMMER: RESPONDENT WILL EVALUATE **ALL** CHALLENGES. DISPLAY CHALLENGES ONE AT A TIME USING A CAROUSEL TECHNIQUE. RANDOMIZE CHALLENGES.

EXTREMELY BIG challenge for my company -1	VERY BIG challenge for my company -2	SOMEWHAT BIG challenge for my company -3	SLIGHT challenge for my company -4	NOT A challenge for my company -5
Understanding the impact of new code requirements (e.g., energy efficiency) on the long-term performance (durability) of the building -47				
Proven durability of new products and materials -48				
Durability of siding/cladding products -49				
Durability of sheathing products -50				
Durability of taped systems -51				
Durability of insulation materials -52				
Durability of water resistive barriers -53				
Durability of foundations -54				
Corrosion of fasteners and hardware -55				
Durability of wood materials used in contact with masonry or concrete -56				
Durability of exposed exterior wood trim and other finish wood products -57				
Durability of energy efficient windows (long-term insulative value) -58				
Durability of exterior plastic products -59				
Long-term performance of light-weight drywall -60				
Product integration that ensures long-term performance of the entire system -61				
Durability of exterior wall systems -62				
Determining correct vapor retarders for walls -63				
Selecting appropriate water resistive barriers (house wrap) for walls -64				
Durability of conditioned (unvented) crawlspace -65				
Durability of conditioned (unvented) attics -66				

- Q5. In this exercise you will see a series of potential challenges and issues or concerns related to **energy efficiency**, specifically as it relates to the building envelope and particular equipment. For each one, select the statement that best describes how much of a challenge you believe it will be for your home building company for the foreseeable future.

PROGRAMMER: RESPONDENT WILL EVALUATE **ALL** CHALLENGES. DISPLAY CHALLENGES ONE AT A TIME USING A CAROUSEL TECHNIQUE. RANDOMIZE CHALLENGES.

	EXTREMELY BIG challenge for my company -1	VERY BIG challenge for my company -2	SOMEWHAT BIG challenge for my company -3	SLIGHT challenge for my company -4	NOT A challenge for my company -5
Availability of practical insulation solutions for walls in energy efficient homes					-67
Availability of practical insulation solutions for attics in energy efficient homes					-68
Moisture performance of energy efficient walls					-69
Moisture performance of energy efficient attics					-70
Long-term effectiveness of insulation materials and systems					-71
Details for integration of exterior insulation with other materials (e.g., cladding, windows, skylights, etc.)					-72
Practical solutions for air sealing single-family detached homes					-73
Practical solutions for air sealing in townhomes or multifamily buildings					-74
Window installation solutions in walls with more insulation					-75
Use of radiant barriers in walls or attics					-76
System and whole-house integration issues when transitioning to more energy efficient homes					-77
Heating solutions in homes with loads reduced due to a better insulated building envelope					-78
Cooling solutions in homes with loads reduced due to a better insulated building envelope					-79
Duct solutions in energy efficient homes					-80

- Q6. In this exercise you will see a series of potential challenges and issues or concerns related to **indoor air quality**. For each one, select the statement that best describes how much of a challenge you believe it will be for your home building company for the foreseeable future.

PROGRAMMER: RESPONDENT WILL EVALUATE **ALL** CHALLENGES. DISPLAY CHALLENGES ONE AT A TIME USING A CAROUSEL TECHNIQUE. RANDOMIZE CHALLENGES.

EXTREMELY BIG challenge for my company -1	VERY BIG challenge for my company -2	SOMEWHAT BIG challenge for my company -3	SLIGHT challenge for my company -4	NOT A challenge for my company -5
Availability of low-emitting products and materials -81				
Cost of low-emitting products and materials -82				
Reliable information on the emittance of new products -83				
Reliable information on the emittance of standard existing products -84				
Lack of clear and broadly accepted definition for low emitting products and materials -85				
Indoor air quality in airtight homes -86				
Availability of simple and effective ventilation solutions -87				
High cost of effective ventilation solutions (ERV, HRV) -88				
Installation issues with the more sophisticated ventilation equipment (ERV, HRV, balancing) -89				
Long-term performance of the more sophisticated ventilation solutions (ERV, HRV, balancing) -90				
Customer complaints about air quality in homes -91				
Impact of ventilation on comfort (humidity, temperature) -92				
Lack of clear definition and simple metrics for acceptable air quality in homes -93				
Lack of low-cost IAQ test methods to determine air quality in homes -94				
Ventilation solutions in airtight homes -95				

- Q7. In this exercise you will see a series of potential challenges and issues or concerns related to **fire resistance**. For each one, select the statement that best describes how much of a challenge you believe it will be for your home building company for the foreseeable future.

PROGRAMMER: RESPONDENT WILL EVALUATE **ALL** CHALLENGES. DISPLAY CHALLENGES ONE AT A TIME USING A CAROUSEL TECHNIQUE. RANDOMIZE CHALLENGES.

EXTREMELY BIG challenge for my company -1	VERY BIG challenge for my company -2	SOMEWHAT BIG challenge for my company -3	SLIGHT challenge for my company -4	NOT A challenge for my company -5
Compliance with fire requirements for walls on lots with short separation/zero lot lines -96				
Compliance with fire requirements in assemblies with foam insulation products -97				
Compliance with fire requirements in assemblies with new air sealing materials -98				
Compliance with fire requirements in basements or crawlspaces -99				
Compliance with fire requirements in assemblies with wood-based materials -100				
Installation of sprinklers -101				
Fire resistance of composite wood products -102				

- Q8. In this exercise you will see a series of potential challenges and issues or concerns related to **comfort**. For each one, select the statement that best describes how much of a challenge you believe it will be for your home building company for the foreseeable future.

PROGRAMMER: RESPONDENT WILL EVALUATE **ALL** CHALLENGES. DISPLAY CHALLENGES ONE AT A TIME USING A CAROUSEL TECHNIQUE. RANDOMIZE CHALLENGES.

EXTREMELY BIG challenge <u>for my company</u> -1	VERY BIG challenge <u>for my company</u> -2	SOMEWHAT BIG challenge <u>for my company</u> -3	SLIGHT challenge <u>for my company</u> -4	NOT A challenge <u>for my company</u> -5
Lack of clear metrics for defining comfort for occupants	-103			
Lack of low-cost diagnostic tools for measuring comfort in a house	-104			
Ability to maintain uniform temperatures throughout the residence	-105			
Ability to maintain uniform temperatures during peak periods	-106			
Ability to consistently maintain humidity within a comfort range	-107			
Ability to provide new minimum ventilation rates and maintain comfort	-108			
High cost of solutions that improve occupants' comfort	-109			
Customer dissatisfaction with the noise of operating equipment (HVAC, fans, range hood, etc)	-110			
Customer dissatisfaction with noise from outside the dwelling (road noise, neighbors)	-111			

PROGRAMMER: FOR Qs 9a-15b, REFER TO Qs 2-8. **RANDOMIZE Qs9a-15b.** ALWAYS KEEP Qs a & b together.

[PROGRAMMER: FOR Q9a DISPLAY CHALLENGES RATED PUNCH 1 or 2 IN Q2. IF NONE, SKIP TO Q9b.]

Q9a. In this exercise RANK the following **costs, labor and construction processes** in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. **[RANDOMIZE]**

Q9b. List and rank any other challenges and issues or concerns related to **costs, labor and construction processes** that you believe your company will face for the foreseeable future. If none, type none. Please be as specific and thorough as possible, and list them in rank order from biggest to smallest challenge.

1 _____
2 _____
3 _____

[PROGRAMMER: FOR Q10a DISPLAY CHALLENGES RATED PUNCH 1 or 2 IN Q3. IF NONE, SKIP TO Q10b.]

Q10a. In this exercise RANK the following **disaster resistance and/or structural performance** challenges in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. **[RANDOMIZE]**

Q10b. List and rank any other challenges and issues or concerns related to **disaster resistance and/or structural performance** that you believe your company will face for the foreseeable future. If none, type none. Please be as specific and thorough as possible, and list them in rank order from biggest to smallest challenge.

1 _____
2 _____
3 _____

[PROGRAMMER: FOR Q11a DISPLAY CHALLENGES RATED PUNCH 1 or 2 IN Q4. IF NONE, SKIP TO Q11b.]

Q11a. In this exercise RANK the following **durability** challenges in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. **[RANDOMIZE]**

Q11b. List and rank any other challenges and issues or concerns related to **durability** that you believe your company will face for the foreseeable future. If none, type none. Please be as specific and thorough as possible, and list them in rank order from biggest to smallest challenge.

1 _____
2 _____
3 _____

[PROGRAMMER: FOR Q12a DISPLAY CHALLENGES RATED PUNCH 1 or 2 IN Q5. IF NONE, SKIP TO Q12b.]

Q12a. In this exercise RANK the following **energy efficiency** challenges in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. **[RANDOMIZE]**

Q12b. List and rank any other challenges and issues or concerns related to **energy efficiency** that you believe your company will face for the foreseeable future. If none, type none. Please be as specific and thorough as possible, and list them in rank order from biggest to smallest challenge.

1	
2	
3	

[PROGRAMMER: FOR Q13a DISPLAY CHALLENGES RATED PUNCH 1 or 2 IN Q6. IF NONE, SKIP TO Q13b.]

Q13a. In this exercise RANK the following **indoor air quality** challenges in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. **[RANDOMIZE]**

Q13b. List and rank any other challenges and issues or concerns related to **indoor air quality** that you believe your company will face for the foreseeable future. If none, type none. Please be as specific and thorough as possible, and list them in rank order from biggest to smallest challenge.

1	
2	
3	

[PROGRAMMER: FOR Q14a DISPLAY CHALLENGES RATED PUNCH 1 or 2 IN Q7. IF NONE, SKIP TO Q14b.]

Q14a. In this exercise RANK the following **fire resistance** challenges in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. **[RANDOMIZE]**

Q14b. List and rank any other challenges and issues or concerns related to **fire resistance** that you believe your company will face for the foreseeable future. If none, type none. Please be as specific and thorough as possible, and list them in rank order from biggest to smallest challenge.

1	
2	
3	

[PROGRAMMER: FOR Q15a DISPLAY CHALLENGES RATED PUNCH 1 or 2 IN Q8. IF NONE, SKIP TO Q15b.]

Q15a. In this exercise RANK the following **comfort** challenges in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. **[RANDOMIZE]**

Q15b. List and rank any other challenges and issues or concerns related to **disaster resistance and/or structural performance** that you believe your company will face for the foreseeable future. If none, type none. Please be as specific and thorough as possible, and list them in rank order from biggest to smallest challenge.

1	_____
2	_____
3	_____

[PROGRAMMER: FOR Q16 DISPLAY CHALLENGES ranked 1-6 IN Q9a, ranked 1-5 IN Qs10a-11a, ranked 1-4 IN Qs12a-13a, or ranked 1-3 IN Qs14a-15a, THAT WERE ALSO PUNCH 1 IN Qs2-8. IF NONE, SKIP TO Q22.

- Q16. In this exercise RANK the following things from across all the earlier categories, overall, in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern.

[PROGRAMMER: FOR Q17 INSERT RESPONSES RANKED 1-4 IN Q16.]

- Q17. Listed below are the challenges, issues or concerns you said would be the biggest for your company for the foreseeable future. Indicate to what degree each one will be for your company in percentage terms. For example, if challenge 1 is twice as big as challenge 2, you might give challenge 1, 50%, and challenge 2, 25%. When finished, challenges 1-4 must equal 100%.

[INSERT CHALLENGE RANKED 1 HERE]	_____
[INSERT CHALLENGE RANKED 2 HERE]	_____
[INSERT CHALLENGE RANKED 3 HERE]	_____
[INSERT CHALLENGE RANKED 4 HERE]	_____
Total =100%	

[PROGRAMMER: FOR Qs18-21 INSERT RESPONSES RANKED 1-4 IN Q16.]

- Q18. You ranked [INSERT ITEM RANKED 1 IN Q16] as the BIGGEST challenge you expect your company to face for the foreseeable future. Please explain why you feel this way. Please be as specific and thorough as possible.

- Q19. You ranked [INSERT ITEM RANKED 2 IN Q16] as one of the biggest challenges you expect your company to face for the foreseeable future. Please explain why you feel this way. Please be as specific and thorough as possible.

- Q20. You ranked [INSERT ITEM RANKED 3 IN Q16] as one of the biggest challenges you expect your company to face for the foreseeable future. Please explain why you feel this way. Please be as specific and thorough as possible.

- Q21. You ranked [INSERT ITEM RANKED 4 IN Q16] as one of the biggest challenges you expect your company to face for the foreseeable future. Please explain why you feel this way. Please be as specific and thorough as possible.

- Q22. In this exercise you will see a series of potential **NEEDS** related to **the availability of information on the integration of new products into the building system and the performance of products at the system level** that may or not be a **NEED** for your company for the foreseeable future. For each one, select the statement that best describes how much of a **NEED** you believe it will be for your home building company for the foreseeable future.

PROGRAMMER: RESPONDENT WILL EVALUATE **ALL** NEEDS. DISPLAY NEEDS ONE AT A TIME USING A CAROUSEL TECHNIQUE. RANDOMIZE NEEDS.

EXTREMELY BIG NEED for my company	VERY BIG NEED for my company	SOMEWHAT BIG NEED for my company	SLIGHT NEED for my company	NOT A NEED for my company
-1	-2	-3	-4	-5

Information on individual new products, their performance characteristics, and code compliance	-1
Information on how to integrate a new product with the rest of the system	-2
Installation instructions for new products addressing the wide range of applications and account for real field conditions	-3
Information about long-term performance of new products and the entire system	-4
Availability of third-party information on the performance of individual products in a system	-5
Ability to compare the individual products to each other in terms of the performance of the entire system to assist with product selection	-6
Information on how to avoid unintended consequences (construction or performance related) when transitioning to a new product or a solution	-7
Educational tools targeted specifically for trades to help with transitioning to new products or code requirements	-8
Educational tools targeted for sales people and home buyers (occupants) on the high performance features of the building	-9

- Q23. List any other **NEEDS** related to **the availability of information on the integration of new products into the building system and the performance of products at the system level** that you believe your company will have for the foreseeable future. Please list them in rank order of their importance to your company.

1 _____
 2 _____
 3 _____

[PROGRAMMER: FOR Q24 DISPLAY ALL NEEDS RATED PUNCH 1, 2, OR 3 IN Q22. IF NONE, SKIP TO Q25.]

Q24. RANK the following needs in terms of how big of a need you expect them to be for your company for the foreseeable future. Rank from biggest to smallest need. **[RANDOMIZE]**

Q25. Please rate how helpful you believe each of the following would be to builders and trade contractors when new codes are adopted or new products are spec'd.

	Extremely <u>Helpful</u>	Very <u>Helpful</u>	Somewhat <u>Helpful</u>	Not at all <u>Helpful</u>
Simplified product or system <u>selection tools</u> based on user input of key specifications, climatic information, and design & construction preferences (<i>i.e., builder science expert system, code expert system</i>)	-1	-2	-3	-4

Q26. Which of the following best describe how your company responds to building performance issues or concerns? (Select all that apply.) **[RANDOMIZE]**

We ask our building science expert on staff	1
We hire a building science consultant (only when needed)	2
We rely on internal staff experience	3
We rely on manufacturer, supplier support	4
We rely on trade contractors	5
Other (Please specify)	6

Appendix B—Research Needs Assessment Survey Presentation



Research Needs Assessment Survey Report

Final Report

Prepared for:
U.S. Forest Products Lab



May 31, 2016

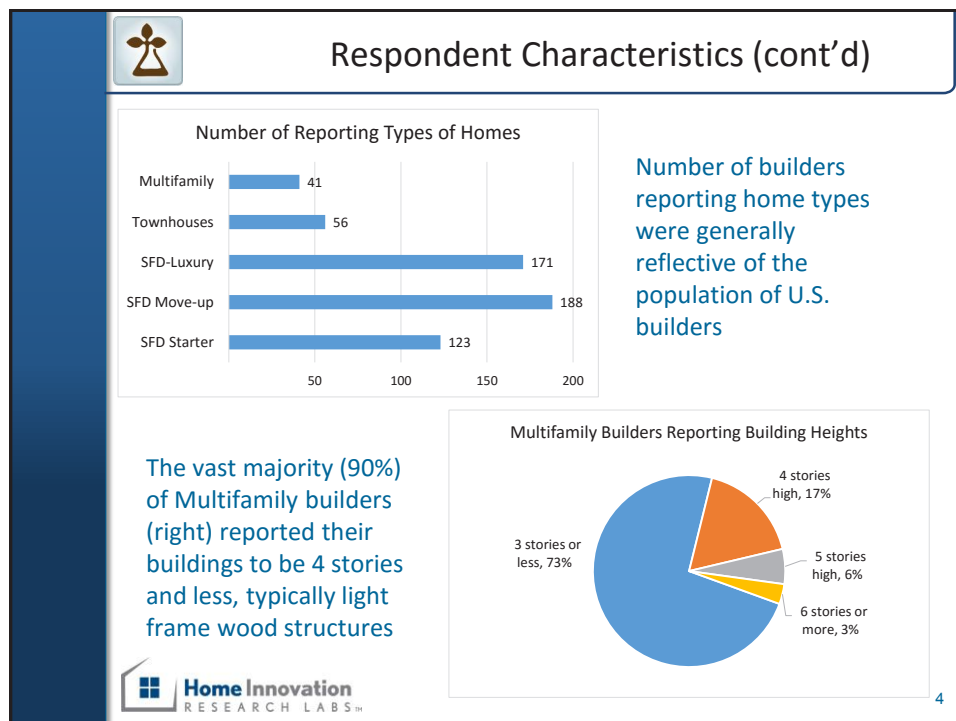
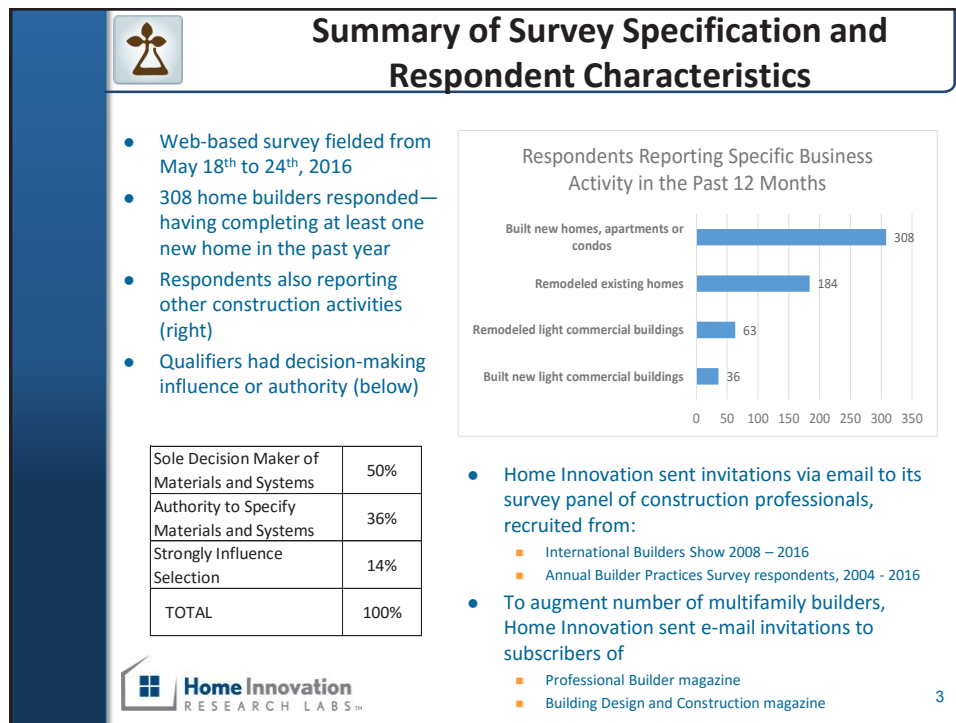



Survey of U.S. Home Builders

- The intent of this project was to prioritize needs of builders with respect to future research and development
- Earlier exploratory phases of this project uncovered a wide array of industry challenges and issues
 - The focus groups and building science industry input resulted in an enumeration of about 120 specific challenges and issues
- This survey intended to scientifically measure the degree to which each of these challenges and issues need to be addressed by future research

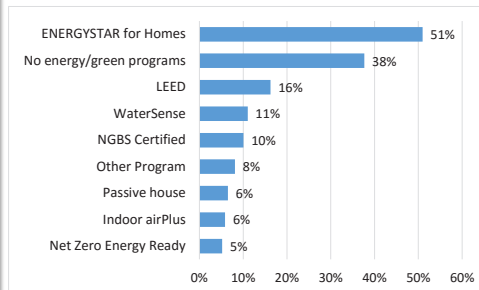


2



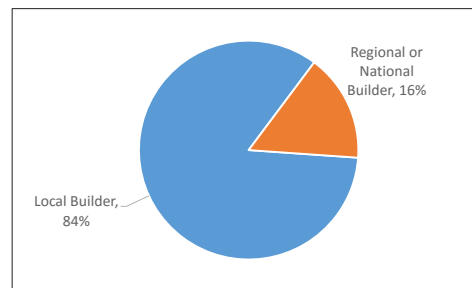


Respondent Characteristics (cont'd)



The majority of builders state they participate in some energy efficiency or green program (left)

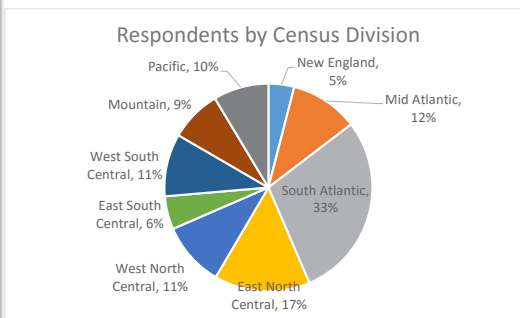
Reflecting the U.S. home builder population, local builders made up the majority of the sample (right)



5

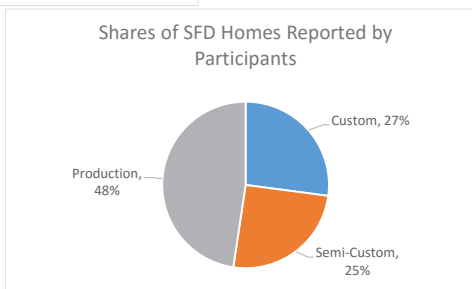


Respondent Characteristics (cont'd)

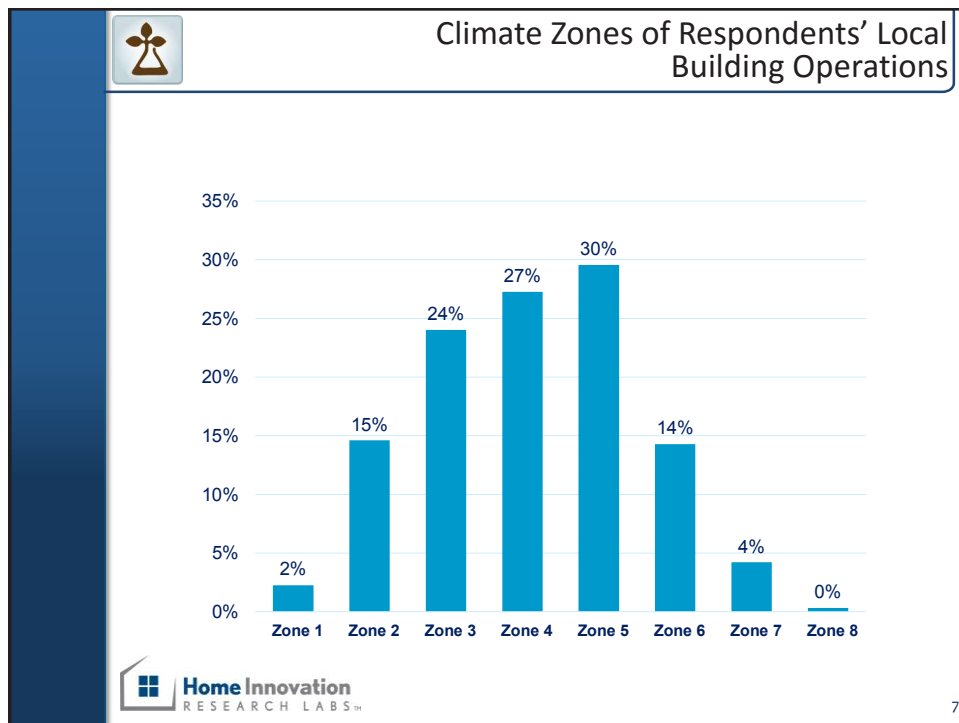


Respondents represented widespread geographic areas and included 47 states + District of Columbia

Respondents were generally reflective of annual new single family detached homes by custom, semi-custom and production (right)



6



Primary Questionnaire Categories and Approach

The Following Broad Categories of Home Construction Issues and Challenges Were Evaluated in this Survey:

1. Occupant Comfort
2. Fire Resistant Construction
3. Indoor Air Quality
4. Energy Efficiency Issues
5. Durability
6. Disaster Resistance
7. Costs and Labor Availability

Home Innovation RESEARCH LABS™

8



Questionnaire Approach

For each of the 7 broad issues and challenges categories (previous slide), respondents were asked to **Rate**, then **Rank** specific issues to the degree they anticipate each being a challenge or issue in the foreseeable future:

1. **Rate** each specific issue on a 1 to 5 scale (4 = Very Big Challenge and 5 = Extremely Big Challenge)
2. **Rank** the top five specific issues from each of the 7 broad categories, #1 being the most challenging and #5 being the least
3. At the end, respondents were shown a single list summarizing their top five from each of the 7 categories and were asked to **Rank them overall**
4. Respondents were then asked to allocate 100 points to the top overall topics where they would like to see industry efforts directed to solving specific issues and challenges

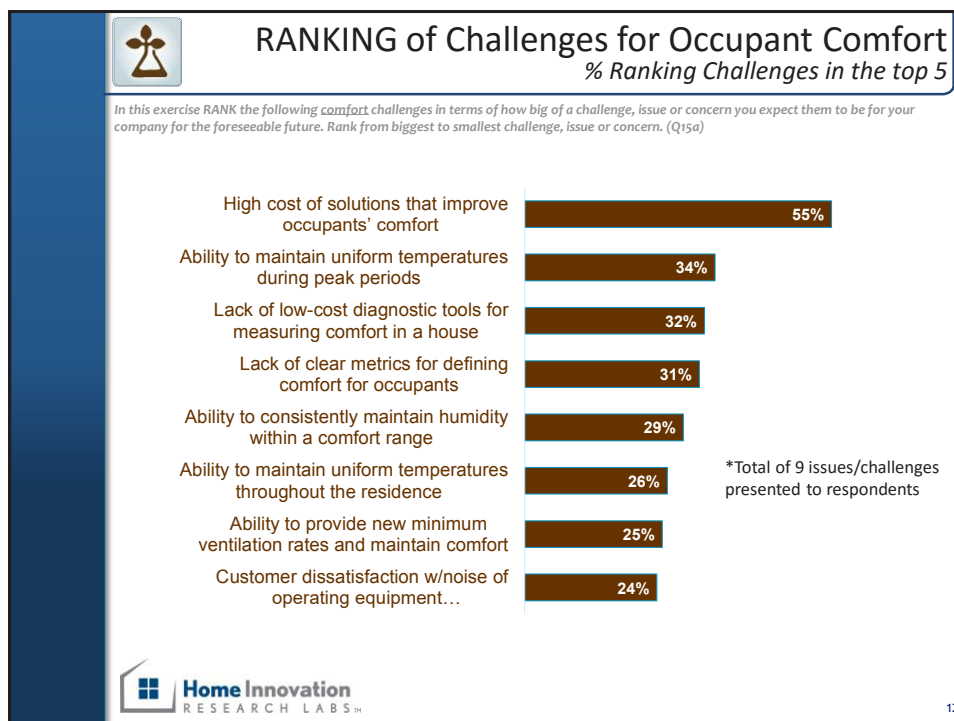
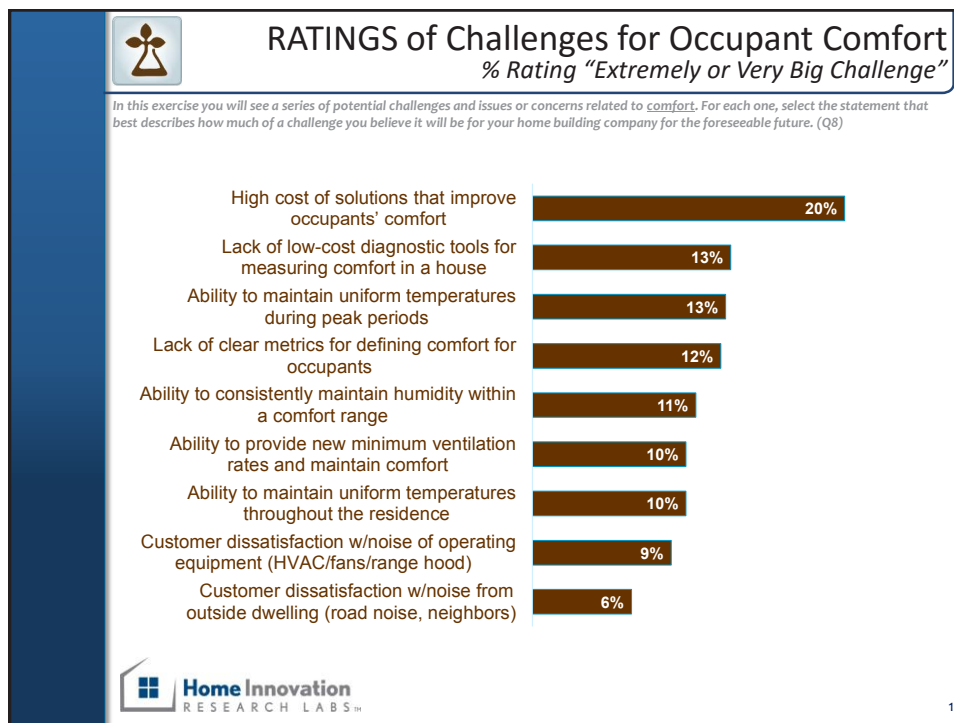


9

DETAILED FINDINGS



10





Shares of Builders Rating Occupant Comfort Issues % as Very Big or Extremely Big Challenges (4 or 5 out of 5)

Challenges with occupant comfort seem to be strongest in the Northeast and weakest in the West. “High cost of solutions” is the top issue in each region.

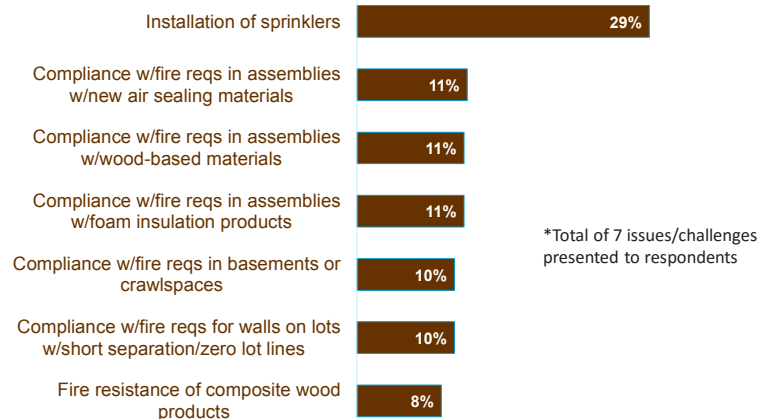
	Northeast	Midwest	South	West
Lack of clear metrics for defining comfort for occupants	19%	11%	14%	5%
Lack of low-cost diagnostic tools for measuring comfort in a house	24%	13%	12%	9%
Ability to maintain uniform temperatures throughout the residence	14%	11%	10%	5%
Ability to maintain uniform temperatures during peak periods	19%	13%	12%	9%
Ability to consistently maintain humidity within a comfort range	17%	11%	11%	7%
Ability to provide new minimum ventilation rates and maintain comfort	14%	16%	9%	4%
High cost of solutions that improve occupants' comfort	26%	18%	21%	15%
Customer dissatisfaction w/noise of operating equipment (HVAC/fans/range hood)	21%	9%	7%	7%
Customer dissatisfaction w/noise from outside dwelling (road noise, neighbors)	17%	9%	4%	2%

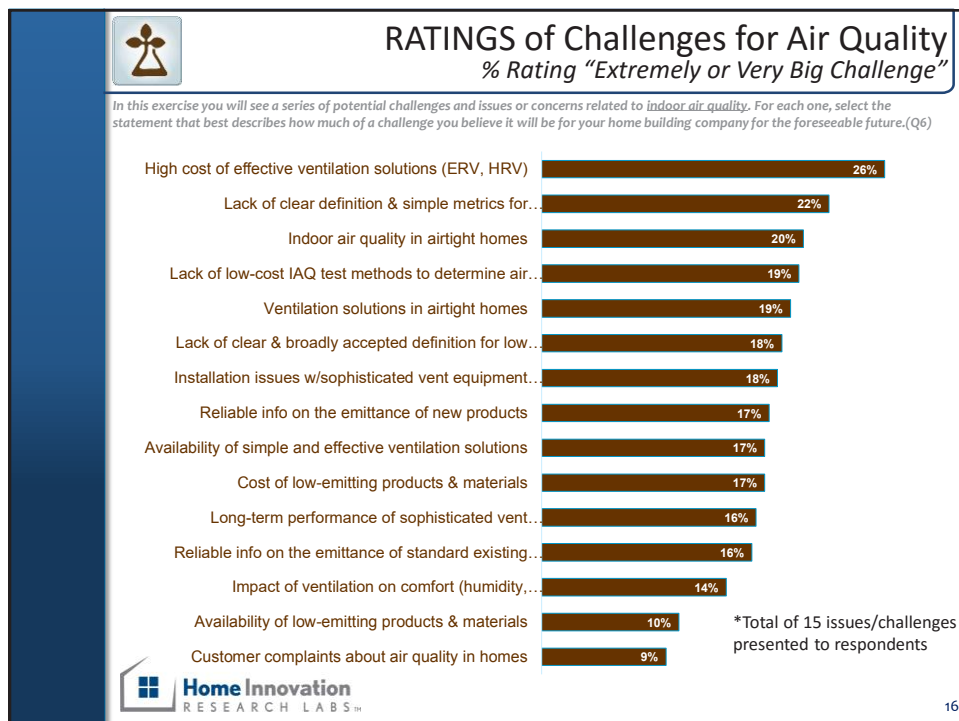
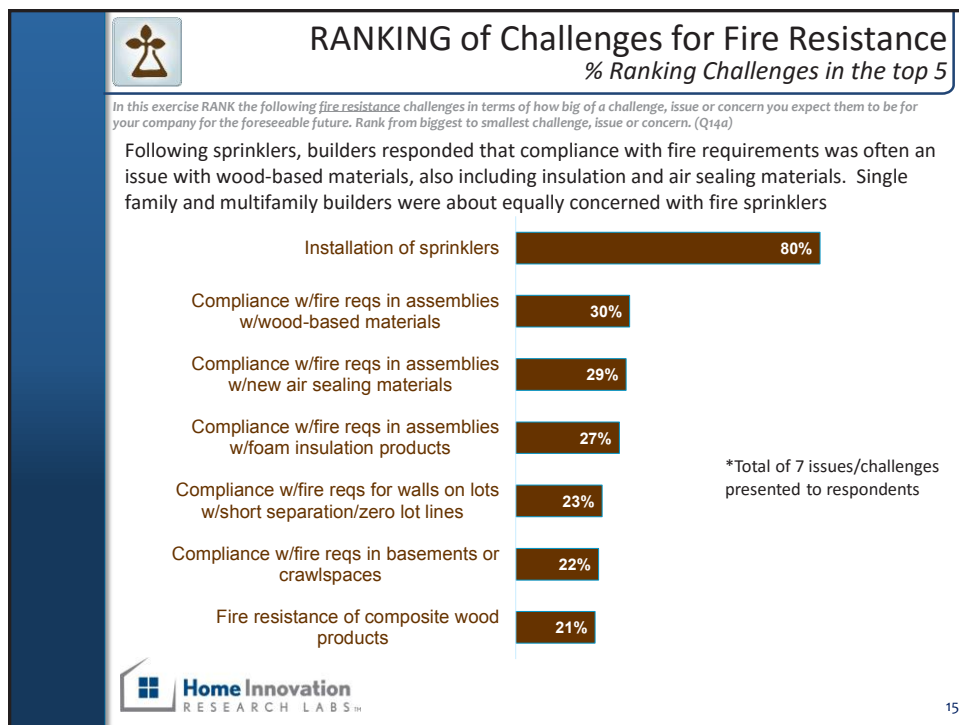


RATINGS of Challenges for Fire Resistance % Rating “Extremely or Very Big Challenge”

In this exercise you will see a series of potential challenges and issues or concerns related to fire resistance. For each one, select the statement that best describes how much of a challenge you believe it will be for your home building company for the foreseeable future. (Q7)

Not surprisingly, fire sprinklers rated at the top of challenges. Their mandate by building codes in recent years has become a contentious issue—many builders believe their cost and complexity make housing less affordable.





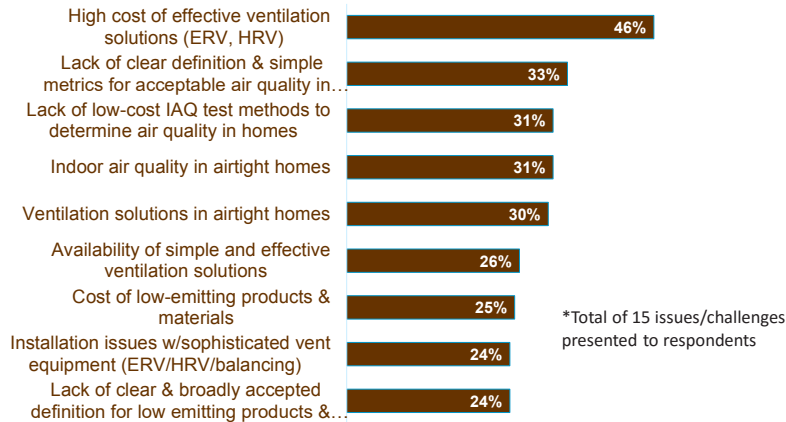


RANKING of Challenges for Air Quality

% Ranking Challenges in the top 5

In this exercise RANK the following indoor air quality challenges in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. (Q13a)

Solutions to current industry challenges should include less complex (and lower cost) solutions for energy efficient ventilation—but also clarify and simplify measuring acceptable IAQ.

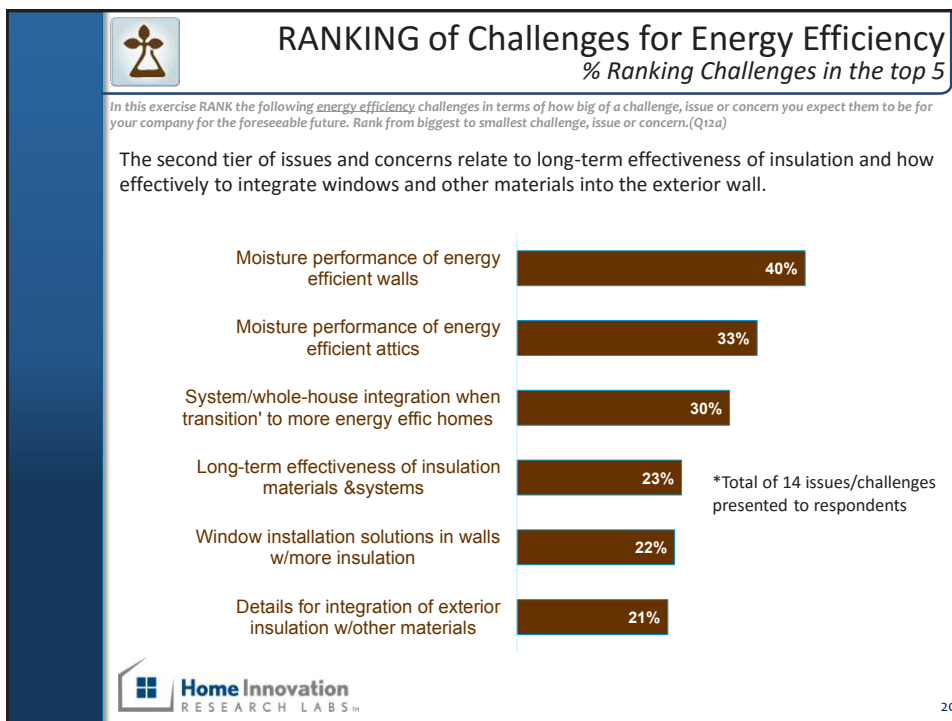
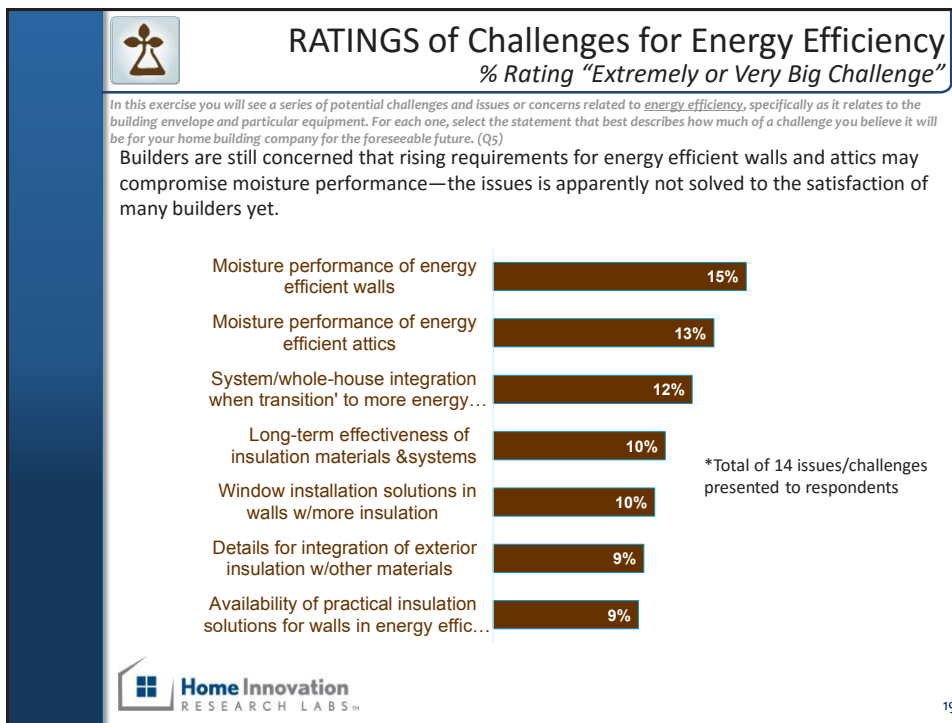


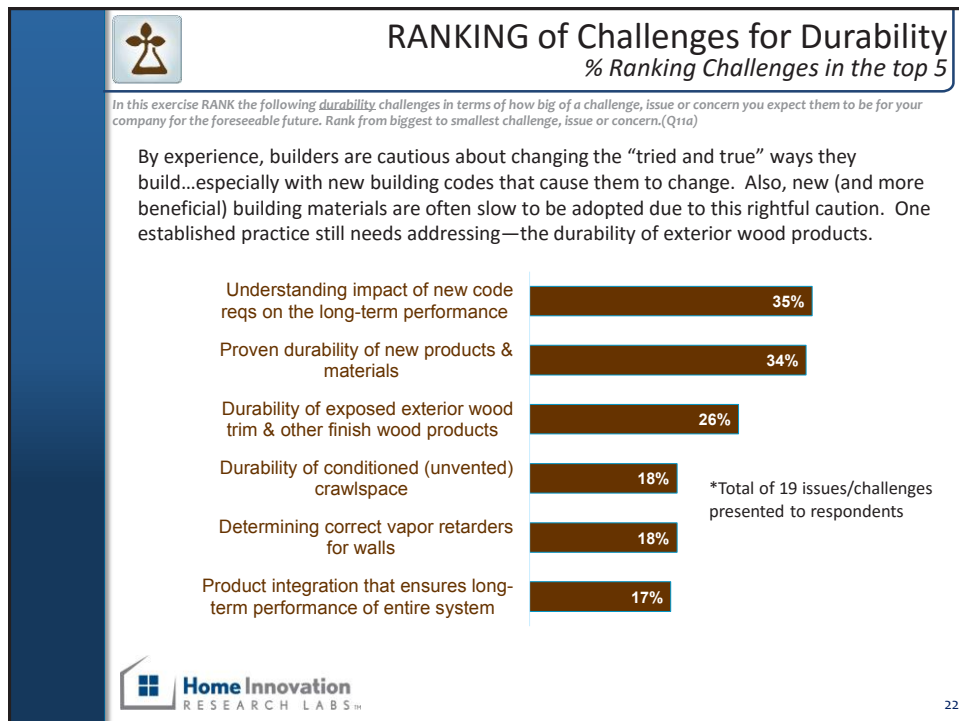
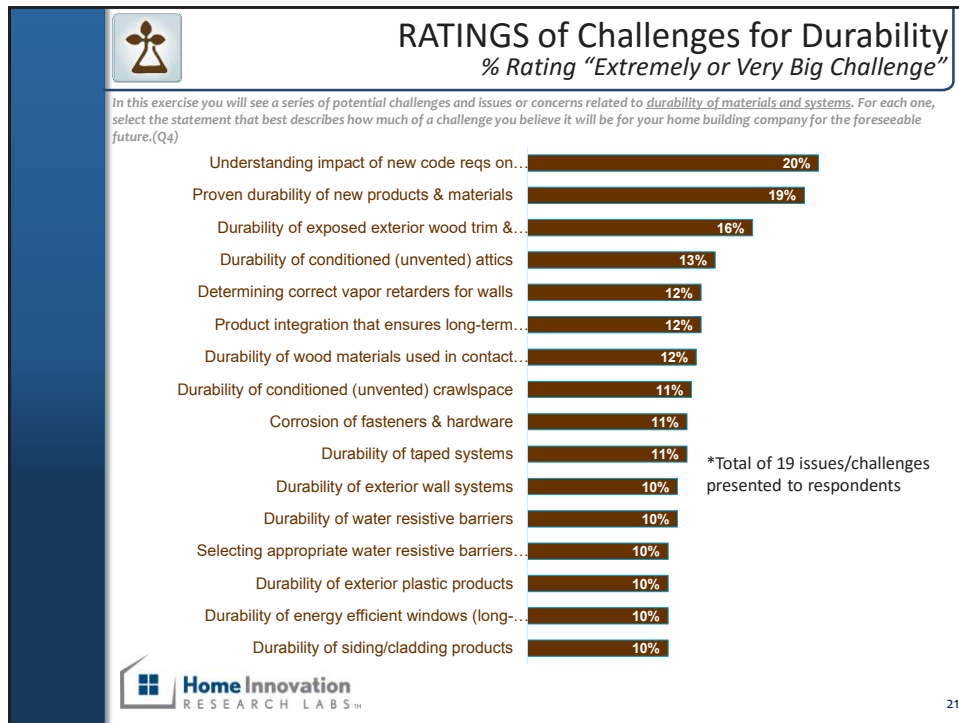
Shares of Builders Reporting Air Quality Issues

% Rating as Very Big or Extremely Big Issue (4 or 5 out of 5)

Like the issues surrounding Comfort, Northeast builders were far more likely than West builders to identify air quality challenges and issues EXCEPT the lack of low-cost IAQ testing methods.

	Northeast	Midwest	South	West
Availability of low-emitting products & materials	14%	15%	9%	4%
Cost of low-emitting products & materials	24%	16%	18%	11%
Reliable info on the emittance of new products	24%	18%	17%	11%
Reliable info on the emittance of standard existing products	29%	17%	14%	11%
Lack of clear & broadly accepted definition for low emitting products & materials	29%	23%	16%	11%
Indoor air quality in airtight homes	33%	22%	17%	15%
Availability of simple and effective ventilation solutions	19%	20%	17%	9%
High cost of effective ventilation solutions (ERV, HRV)	36%	30%	24%	24%
Installation issues w/sophisticated vent equipment (ERV/HRV/balancing)	26%	18%	20%	11%
Long-term performance of sophisticated vent solutions (ERV/HRV/balancing)	24%	16%	17%	7%
Customer complaints about air quality in homes	17%	7%	10%	5%
Impact of ventilation on comfort (humidity, temperature)	29%	11%	15%	7%
Lack of clear definition & simple metrics for acceptable air quality in homes	26%	27%	23%	16%
Lack of low-cost IAQ test methods to determine air quality in homes	24%	22%	18%	20%
Ventilation solutions in airtight homes	33%	20%	19%	13%







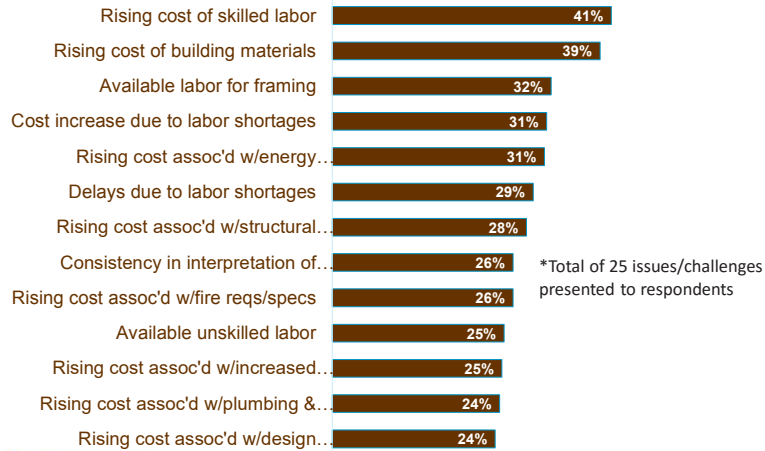


RATINGS for Cost, Labor, and Construction Process

% Rating “Extremely or Very Big Challenge”

In the following exercise you will see a series of potential challenges and issues or concerns related to costs, labor or construction processes. For each one, select the statement that best describes how much of a challenge you believe it will be for your home building company for the foreseeable future. (Q2)

Rising cost of labor and materials continue to put pressure on home builders and negatively impact the affordability of housing and the industry’s ability to meet growing demand.



25

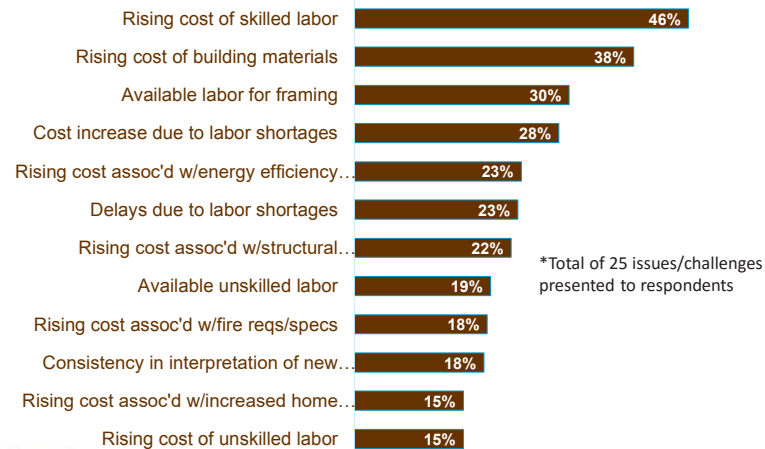


RANKING of Cost, Labor, and Construction Process

% Ranking Challenges in the top 5

In this exercise RANK the following costs, labor and construction processes in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. (Q9a)

If the skilled labor shortage—especially of framing labor—is not addressed, construction cycle time will continue to increase, lower quality homes will be built, and an insufficient new supply of housing will result.



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Builders Reporting Labor Availability as Serious Problem % rating as an *Extremely Big Problem* (5 out of 5)

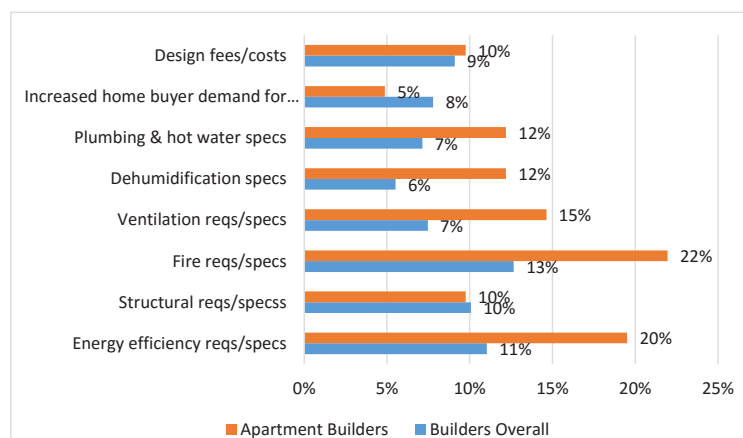
With the exception of framing and siding labor, the Multifamily industry seems more affected than single family detached by labor shortages. Overall, the West reported hardest hit by a shortage of framing labor.

	Single Family Detached	Apartments
Available unskilled labor	6%	15%
Available labor for framing	15%	17%
Available labor for insulation	7%	12%
Available labor for exterior siding	7%	7%
Available labor for HVAC	7%	12%
Available labor for plumbing/electrical	9%	20%
Available labor for house wrap/flashings	5%	12%
Available labor for drywall/finishes	7%	12%



Builders Reporting Rising Costs as a Challenge or Issue % Ranking Challenges in the top 5

The multifamily industry also seems most affected by rising costs, many driven by increasing requirements and specs



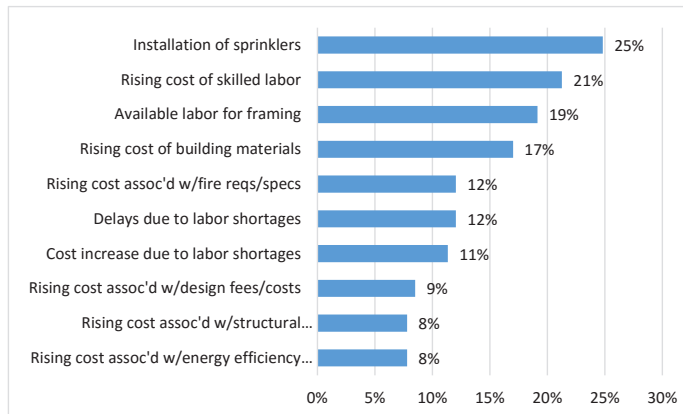


Top Cost and Labor-Related Challenges

% Ranking Challenges in the top 5

In this exercise RANK the following things from across all the earlier categories, overall, in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. (Q16)

Overall, the top themes in cost and labor are: 1) fire sprinkler requirements in single family have made construction more difficult, 2) lack of skilled labor slows construction and increases cost, and 3) materials cost is still a very top-of-mind issue

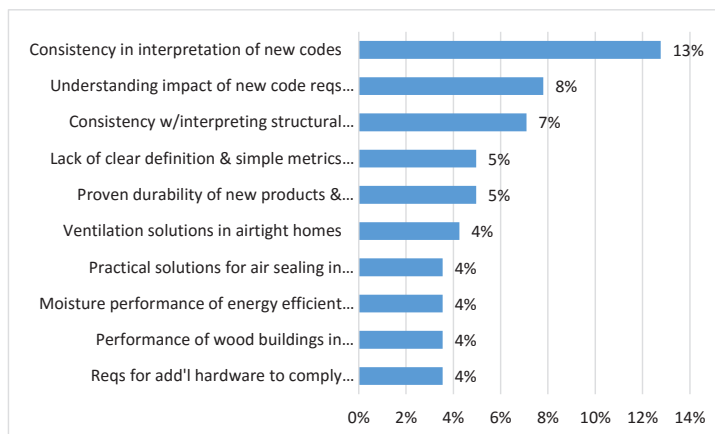


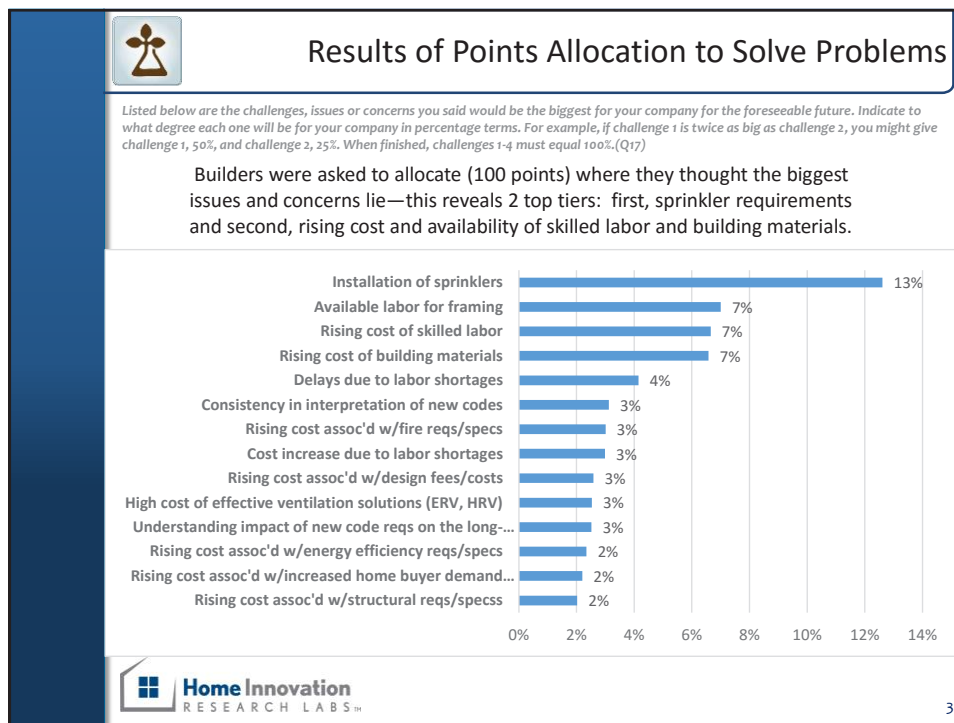
Top Technical Issues and Challenges

% Ranking Challenges in the top 5

In this exercise RANK the following things from across all the earlier categories, overall, in terms of how big of a challenge, issue or concern you expect them to be for your company for the foreseeable future. Rank from biggest to smallest challenge, issue or concern. (Q16)

The fast pace of code evolution and the inconsistency of interpreting the codes present problems to builders





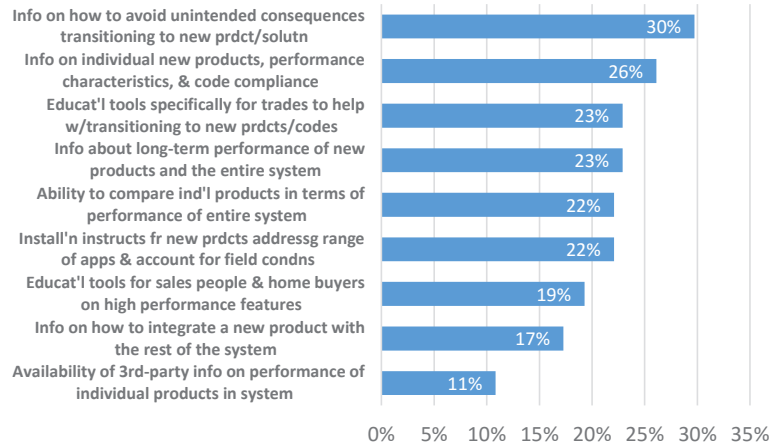


RANKING of Needs for Potential Solutions

% Ranking needs in the top 5

(Q24) RANK the following needs in terms of how big of a need you expect them to be for your company for the foreseeable future. Rank from biggest to smallest need.

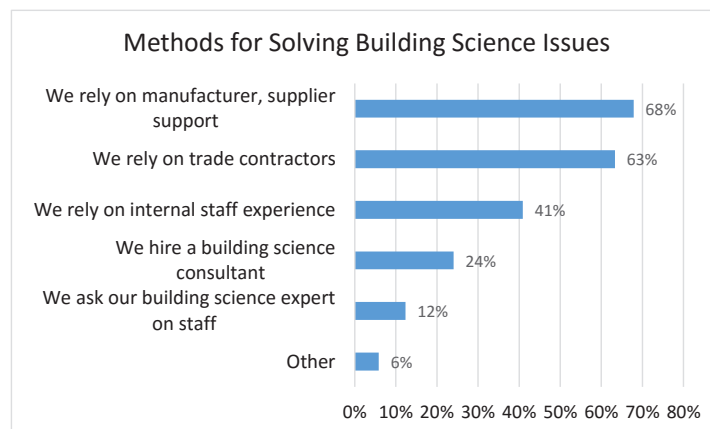
The top tier Needs in this analysis relate to information on selecting the right new products to meet code and avoid performance failures through uninformed choices

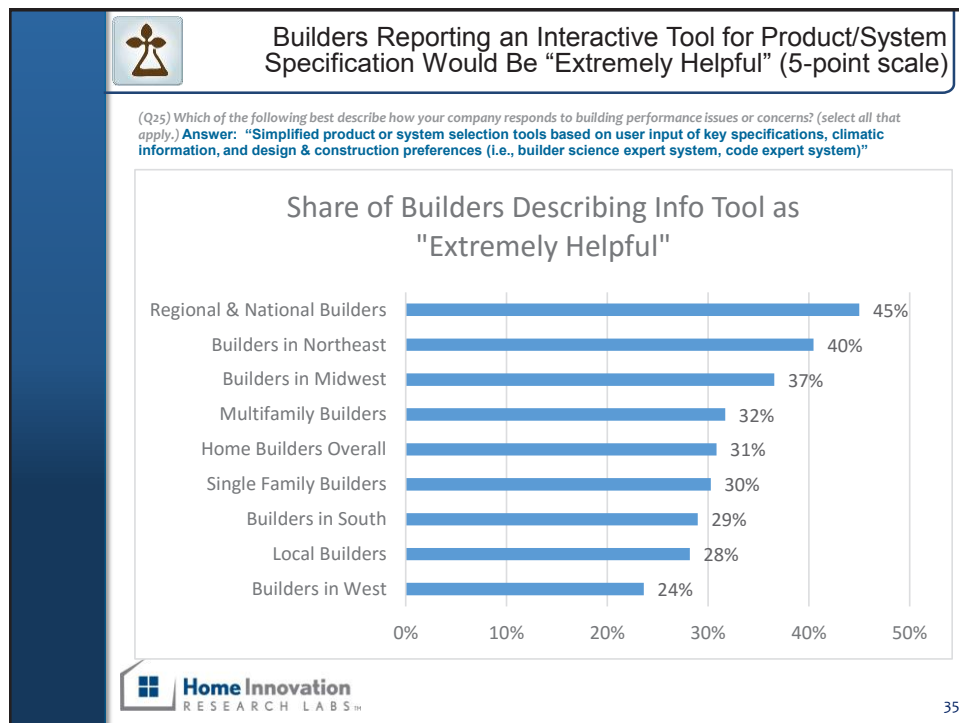


Methods Builders Use for Solving Building Performance Issues or Concerns

Which of the following best describe how your company responds to building performance issues or concerns? (Select all that apply.)(Q26)

Builders typically reported being reliant upon persons outside their firm for solving building science issues and concerns.





-  Summary of Finding
- Overall, categories of single family builders (large, small, custom, production, etc.) rated and ranked the challenges similarly—the exceptions were noted in this report
 - Frustration over fire sprinkler requirements were highly apparent in the findings—hence, any new tools, information, or solutions should consider reducing their impact on the industry.
 - Lack of skilled labor, particularly framing, will continue to challenge industry health, and solutions that alleviate this issue are needed
 - Builders generally rely on manufacturers and trade contractors for solutions to problems – a potential problem as these may be biased towards their own materials and methods – so a third-party resource is advised
 - A high degree of uncertainty exists over proper materials selection in the face of new codes and products—builders responded very favorably to a solution that provides them the necessary information to make these decisions
 - This solution should focus on problems that address proper product and design challenges but keep in perspective that they should not increase cost or make installation difficult or time consuming
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THANK YOU

Home Innovation Research Labs

400 Prince George's Blvd | Upper Marlboro, MD 20774

P: 301.430.6194 | F: 301.430.6180

HomeInnovation.com



Appendix C—Focus Group Builder Participant Profiles

Respondent Profiles

Production Builders

The six participants in the Production Builder group represented a mix in terms of geography, volume, and responsibilities. The group brought the construction perspective, as well as design/product development, and sales and marketing perspectives to the discussion.

Title	States Build In	Total # of Homes Built in Past 12 Months	# Move-up Homes Built in Past 12 Months	# of Luxury Homes Built in Past 12 Months	% of Homes that were Custom/Semi-Custom/Production
Director of Operations	CO	70	70	0	0%/0%/100%
VP of Product Development and Purchasing	VA	350	110	0	0%/0%/100%
Sales and Marketing	AZ	110	55	55	0%/0%/100%
Construction Manager	TX	36	19	5	10%/90%/0%
New Home Sales	WI	58	37	1	5%/65%/30%
Operations Manager	TX	26	26	3	0%/100%/0%



1

Respondent Profiles (cont'd)

Custom/Semi-Custom Builders

The second group consisted of eight participants, representing a mix of custom and semi-custom builders from various regions, as well as one production builder*. Similar to the Production group, participants in this group also offered design, sales & marketing and purchasing perspectives in addition to the construction perspective.

Title	States Build In	Total # of Homes Built in Past 12 Months	# Move-up Homes Built in Past 12 Months	# of Luxury Homes Built in Past 12 Months	% of Homes that were Custom/Semi-Custom/Production
Sales Operations Manager	OK	50	20	5	65%/20%/15%
President	FL	10	0	10	100%/0%/0%
President	NC	18	9	9	50%/50%/0%
Owner	CA	9	1	7	90%/0%/10%
Owner	TX	25	8	5	100%/0%/0%
Architect	KS	50	0	50	100%/0%/0%
Purchasing Manager*	TN	194	194	0	0%/0%/100%
Director of Construction	WI	203	100	24	0%/80%/20%



*The Production builder was included in the Custom group due to a scheduling conflict with the time of the Production builder group.

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