



The decision-making
process in the design
of residential
structures

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EXECUTIVE SUMMARY

The construction and occupation of US buildings used 39 quadrillion BTU of energy in 2013, accounting for 40% of the total US end-use energy consumption [1] and one-third of US greenhouse gas (GHG) emissions [2]. 54% of the building energy use is attributed to the residential sector. Residential construction now comprises one-third of all construction dollars annually [3]. Building codes and standards have been key drivers in shifting industry towards more energy efficiency, but it is important to take a more holistic approach toward GHG mitigation and evaluate the impact of design decisions from construction, through operation, maintenance, repair and replacement, and end of life. Codes and standards are only just beginning to incorporate building materials into their frameworks.

To fill this gap, we are developing models and tools for the life-cycle assessment (LCA) and life-cycle cost assessment (LCCA) of residential buildings. Throughout the design process, practitioners make decisions regarding geometry, building systems, and materials. Ideally, they would have user-friendly tools available as they make decisions, rather than at the conclusion of a design process. Therefore, understanding the timing of decisions is a key step in identifying opportunities for influence.

We surveyed architectural firms, homebuilders and developers over the phone to understand what decisions are made at different points in the design process so that tools can be targeted accordingly. Most participants identified a need for better methods that aid the decision making process. The questions focused on the types of decisions that are made during the different design phases: conceptual design, schematic design, design development and construction documents. Figure ES1 presents an overview of the results from the survey of 16 small to mid-sized architectural firms. It demonstrates that decisions about building and system geometry tend to be made in the conceptual design phase, while decisions about system components and details are increasingly made toward the design development and construction document phases. Further, when the two homebuilders surveyed modify designs, it can impact many of their projects. The top 200 homebuilders accounted for 45% of residential construction value in 2013. Homeowners participate in the homebuilders' design process primarily in categories that impact visibility and function, with limited involvement on building and envelope systems. We also found that financing of projects drives the choice of building and envelope systems and zoning strongly influences the geometry among the four developers surveyed.

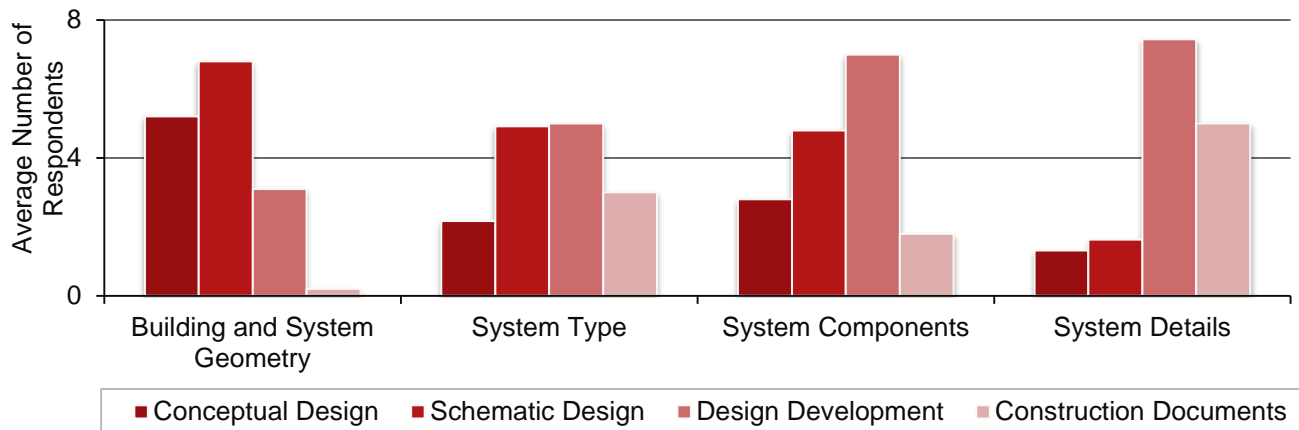


Figure ES1: Overview of architectural firm timing of building and system design decisions

1 INTRODUCTION

The construction and occupation of US buildings used 39 quadrillion BTU of energy in 2013 accounting for 40% of the total US end-use energy consumption; 54% of the building energy use is attributed to the residential sector (Figure 1a) [1]. The buildings sector contributed one-third of US greenhouse gas (GHG) emissions (Figure 1b) [2]. The number of homes built (represented by permits) has fluctuated considerably over the past several decades from a high of 2.2 million in 1973 to a low of 0.6 million in 2008, influenced heavily by the economy and credit (Figure 1c) [4]. Residential construction now comprises one-third of all construction dollars annually (Figure 1d) [3]. All of this points to the importance of understanding the environmental impact and costs associated with residential buildings.

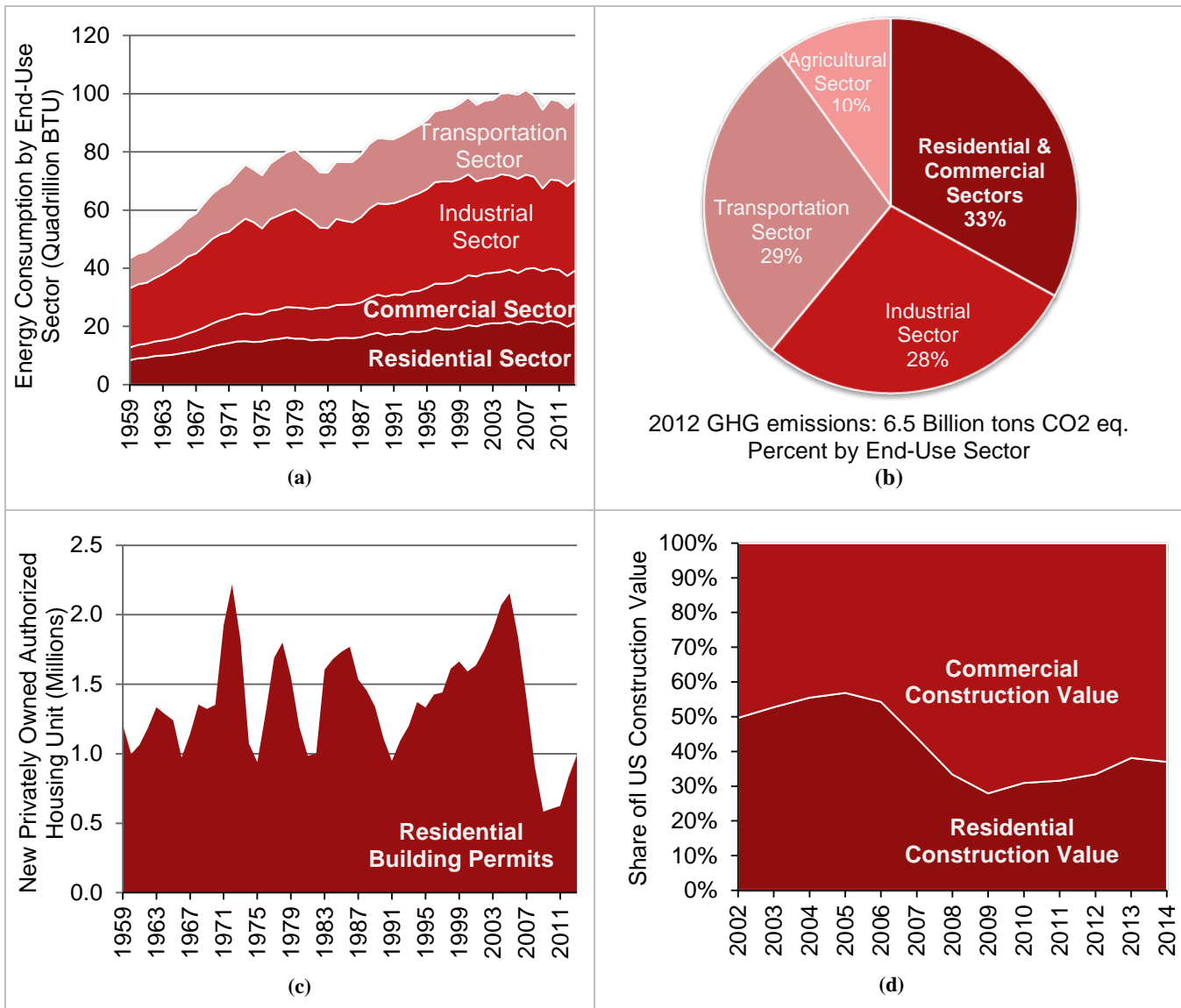


Figure 1: (a) Total Energy Consumption by End-Use Sector, 1959-2013 [1]; (b) Total 2012 U.S. Greenhouse Gas Emissions with Electricity Distributed to End-Use Sector [2]; (c) New Privately Owned Housing Units Authorized by Building Permits in Permit-Issuing Places, 1959-2013 [4]; (d) Share of value of US Construction Put in Place, Seasonally Adjusted Annual Rate, 2002-1994[3]

Building codes and standards, voluntary or otherwise, have been key drivers in shifting industry towards more energy efficient construction. Most codes and standards have primarily focused on energy efficiency and are only beginning to incorporate the environmental impact of materials into their frameworks as a more holistic means to meet GHG mitigation goals.

It is important to take a holistic approach and evaluate buildings from construction, through operation, maintenance, repair and replacement, and end of life. Life-cycle assessment (LCA) is often used as a method to estimate the life-cycle GHG impact of a building, and life-cycle cost assessment (LCCA) estimates the financial burden. Many different LCA tools exist that quantify different aspects of the LCA for the building sector. While guidance is available, fewer tools exist to quantify the LCCA.

Use phase-focused LCA tools analyze whole or partial building energy consumption. Other tools examine the environmental impact of the embodied and end-of-life phases of the materials used to create and maintain a building. These tools are not typically used by developers, builders, architects, and homeowners because they require specialized knowledge. In addition, there is a disconnect between the information needed as inputs for the tools and the information utilized by building designers. As a result, there is limited adoption of LCAs in design practice.

Building costs are typically evaluated by considering the payback period of design decisions. Often these analyses are simplistic, and consider different design features independently, such as opting for higher performing wall insulation and installing solar panels. Since buildings are susceptible to damage from hazards, hazard resistance and associated initial and repair costs should be factored in as well.

We are developing models and tools for LCA and LCCA of residential buildings. Throughout the design process, practitioners make decisions regarding its geometry, building systems, and materials. Ideally, homebuilders, developers and architects would have user-friendly tools available to them as they make decisions, rather than at the conclusion of a design process. We constructed a survey to understand what decisions are made at different points in the design process so that tools can be targeted accordingly. This report summarizes our findings and identifies opportunities to align those tools and methods with the design process.

2 APPROACH

We developed a survey that outlined the different types of building system and material decisions that need to be made during the design and construction process (see Appendix A). The survey was conducted primarily by phone with individual respondents and targeted two populations: architects and homebuilders/developers. The questions focused on the types of decision that are made during the different design phases: conceptual design, schematic design, design development and construction documents, as shown in Figure 2.

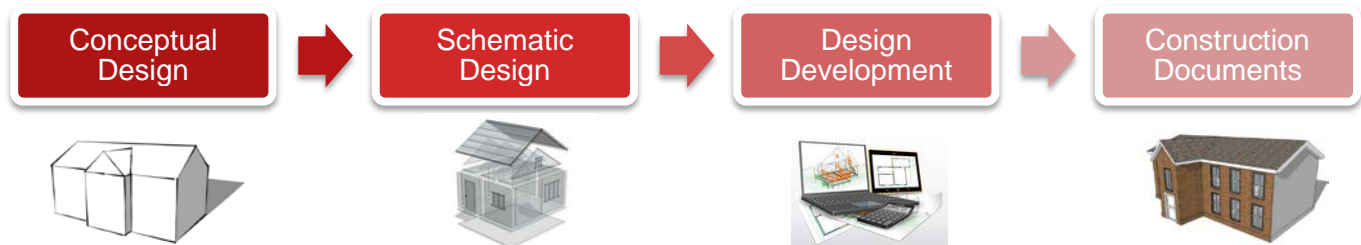


Figure 2: Building design phases, from the least detailed *conceptual design* through the most detailed *construction documents*.

The results reveal the timing of the decisions and other factors that may impact the design process. In the case of homebuilders and developers, opening questions illustrated whether and how architects were involved and whether standards and methods were established prior the process of developing a project. Questions regarding the process of selecting a site and developing a project ensued to understand opportunities for impacting the decision making process. Because the survey was conducted by phone, the nuances and differences between firms, clients, project types and local contexts became evident.

The profiles of the firms surveyed and the results of the survey are presented separately for the two survey populations: first architectural firms, and then homebuilders and developers.

3 ARCHITECTURAL FIRMS

The design and construction of residential buildings by architecture firms depends on a variety of factors. These include the nature of the client, the size of the architectural firm, the type of firm, the type of residential projects, the scale of residential buildings, the local context, among others. These factors impact who makes decisions and how these decisions are made during the design and construction process. This section will provide a profile overview of the survey respondents and outline some of the key factors impacting the decision making process.

3.1 Profiles of Firms

Sixteen architectural firms were interviewed for the survey. Of those, nine are from Massachusetts, two from Washington, two from New York, one from Alabama, and two from western Canada (Victoria and Vancouver). The firms are small to mid-sized firms, varying in size from 2 to 50 persons. They work on a range of project types varied from small-scale residential, including renovations and additions and high-end residential houses for individual clients, houses and developments for homebuilders and multifamily housing primarily for developers. Multifamily developments ranged from 6 units to hundreds of units in both apartment complexes and multiple smaller scale 1-2 family units and row houses agglomerated as part of a larger scale development.

Depending on the firm, the scale and type of projects varied significantly and impacted the process of making decision about material and building systems. The project types depended on the type of client the architect was working for, specifically individual homeowners or developers and homebuilders. Of the firms interviewed, seven of the firms worked on residential projects primarily, while the others worked on various combinations of residential and commercial/institutional projects.

For firms that focused on individual homeowners, the type and scale of projects typically depended on the budgets of their clients, whether high-end or mid-range residential projects. High-end residential design firms tailored the process to the design of the project. Some had not developed a standard set of details or systems that they used. As a result, during the early design phases, both conceptual design and schematic design, options were being explored and, ideally, by design development, decisions were made. The decision-making process was flexible, though, and could extend throughout the design process. Small architectural firms that worked on budget constrained residential projects, with a significant number of them working on renovations and additions, identified pricing at the end of schematic design as a critical juncture in the decision making process. For most residential architects, the construction documents phase, and in some cases the during the construction process, was often

a key decision making time for items such as finishes, appliances and building system and envelope details, in particular for those architects who have an established working relationship with a select number of contractors.

Of those firms working with developers, one specifically worked with homebuilders, while the others were primarily involved in multifamily construction. The firm dedicated to working with homebuilders had developed a portfolio of home designs, roof and wall systems, foundation types, and details that were modified according to the project and context. It also engaged in designing custom homes to individual clients that were developed based on its portfolio. Firms working on multifamily developments designed a wide range of housing project types, from large apartment complexes to large developments composed of townhouses or 1-2 family structures in urban/suburban contexts. The availability of design standards, the process developed by the developer, the need for financing and the project schedule established, whether fast-track or not, impacted the timing of decisions.

3.2 Architect Survey Results

Key trends in residential design are evident from the surveys:

1. The design process is iterative and decisions can span across phases and be modified depending on available information at different times in the process.
2. The geometry of the buildings is defined in the conceptual and schematic design phases of the design process and, in this case, site location and/or the local zoning ordinance and building codes have significant implications on the geometry of a project.
3. Whereas the selection of envelope systems depends on previous experience and knowledge, there is continuous exploration of options across projects for refining the components of the envelope as new or different requirements, constraints and information is presented.
4. Project pricing after the schematic design phase is a critical point when many decisions are made on critical items such as mechanical, structural and envelope systems.
5. Interior finishes and skylights are less critical components to the project delivery process and could be identified during the construction process.
6. The majority of firms did not use LCA tools during the design process. If needed, a consultant is typically hired for energy modeling.

3.2.1 Tools

Most firms used a range of tools throughout the design process (Figure 3). Typically, more representational and three dimensional (3D) drawing tools such as hand drawing and sketching and Sketchup are combined with computer aided design (CAD) and building information modeling (BIM) tools in the early stages. As the process ensues, CAD/BIM tools dominate. Four out of 16 firms interviewed are using Autodesk Revit, with one of them transitioning to it. These firms, in particular, had a proportion of their work concentrated in the commercial/institutional sector and/or the multifamily sector. Most of the other firms are using a variety of other tools, including Adobe Creative Suite and Form Z for representation and Vectorworks, Archicad, Microstation, and AutoCad for drawing documentation, with AutoCad and Vectorworks being the most dominant. Multiple participants noted

that the use of 3D representation tools depends on team members, with the use of more advanced 3D modeling tools, such as Rhino, more common in teams with younger staff.

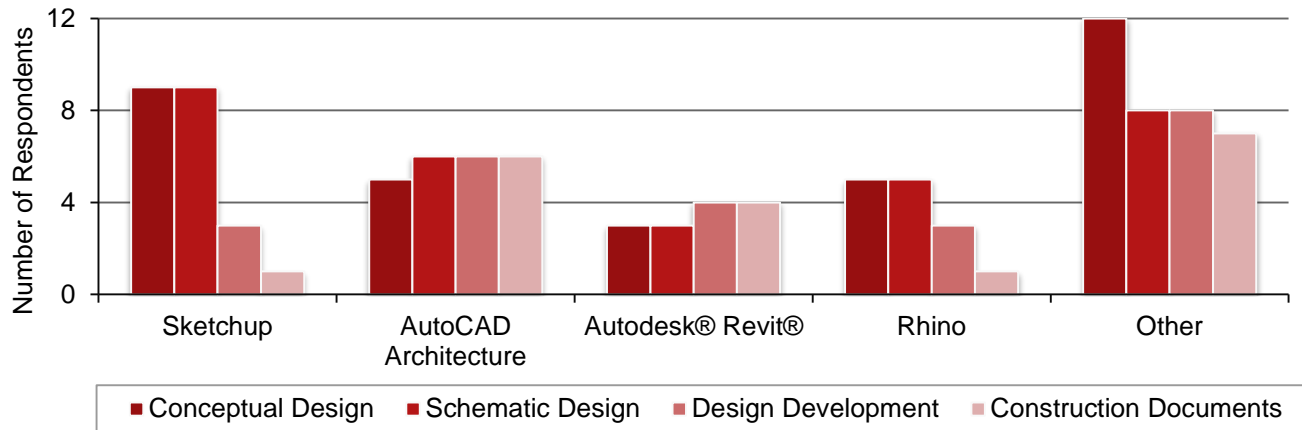


Figure 3: Drawing tools used throughout the design process

With regards to environmental LCA tools, the majority of the participants do not use any and if any were used, the focus is on energy efficiency. The survey did not ask about LCCA tools. The firms depend on using environmental and envelope consultants who are typically hired in the design development phase of a project when needed. This is particularly true in locations where municipalities require proof of compliance and requirements exceed traditional codes. For example, architects working on a project in Boston are required to provide proof that the building will meet the Stretch Code, which is 20% higher than the adopted state code. In Vancouver, where codes are currently changing to require more stringent energy efficiency requirements, third party methods to prove that buildings meet the changing codes will be required. Otherwise, rules of thumb, checklists, or prescriptive requirements by specific programs, codes and standards are common methods of addressing energy efficiency.

3.2.2 Geometry

Architects identified geometry as the first category to be addressed when beginning a project; 100% of the architects finalize decisions about geometry by the end of schematic design (Figure 4). This was consistent with our expectations, since geometry is necessary to visualize a building. However, depending on the context and design philosophy of the firm, different categories of geometry dominate.

A key differentiator is whether the site is in an urban, suburban, or more remote location. In the case of urban sites, the geometry is often predetermined based on existing constraints, such as adjacent buildings, street orientation, and zoning requirements. This is because the architect is often required by the client, whether a developer or individual, to maximize the square footage allowed by municipal zoning laws. In locations where these constraints are not an issue, such as for a home on a more ample site, orientation based on sun angle and views is a key driver.

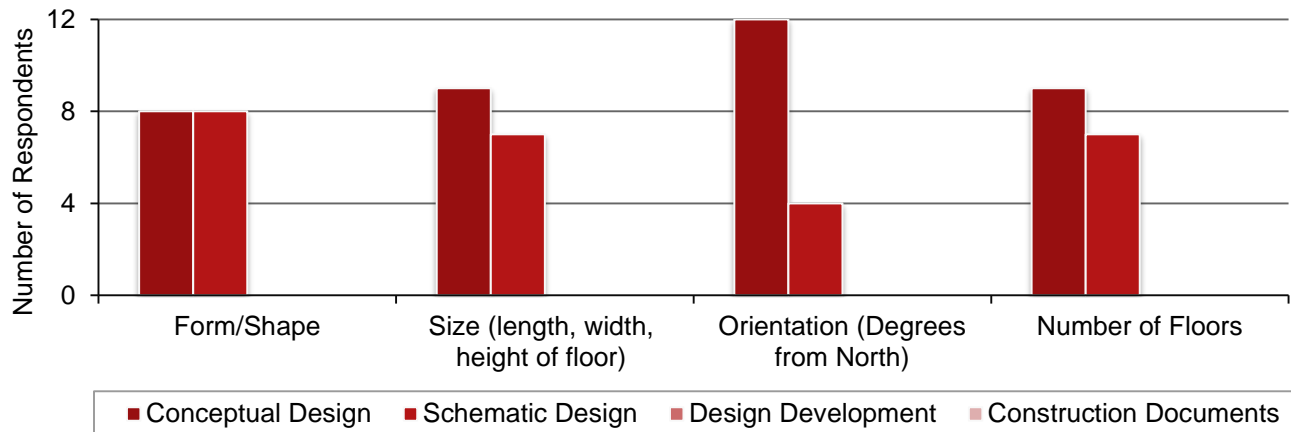


Figure 4: Timing of design decisions on building geometry

3.2.3 Envelope Systems

For single family residential homes or developments composed of multiple smaller scale structures, the structural systems used in roofs and exterior walls are primarily known based on prior project experience. In general, wood frame construction is assumed, except for high-end firms that defined themselves as focused on innovation and design. For both, roof (Figure 5a) and wall (Figure 5b), options can be considered until the end of schematic design when initial pricing occurs, even though firms expressed a strong preference for particular systems. A firm in Alabama noted that the ability to finance the home, as opposed to client budget, is a key determinant of envelope system selection because banks may not finance a more expensive energy efficient house. However, after a new home has been assigned an energy rating, Energy Efficient Mortgages (EEM) from conventional lenders, the Federal Housing Administration, or Veterans Administration can be utilized to include the cost-effective energy saving measures as part of the mortgage[5].

As shown in Figure 5, envelope system details are primarily defined in the latter stages, design development and construction documents. However, not all architects provide details as part of the drawing set. This is because the way a project is delivered to the contractor— whether by bid or based on a working relationship between the architect and a contractor— also impacts the amount of information the architect provides. For those firms using contractors that they have worked with multiple times, expectations between both parties are established. Jurisdictional requirements for the permitting documents also impact the information provided. Furthermore, some architects have developed sets of details as standards that are modified as needed for each project.

With regards to foundations (Figure 5c), the type of soil, local context and project requirements (such as underground parking) impact which foundation systems are chosen. Even though assumptions are fairly established by the end of schematic design stage, the type of foundation and its components can change based on value engineering after pricing at the end of schematic design.

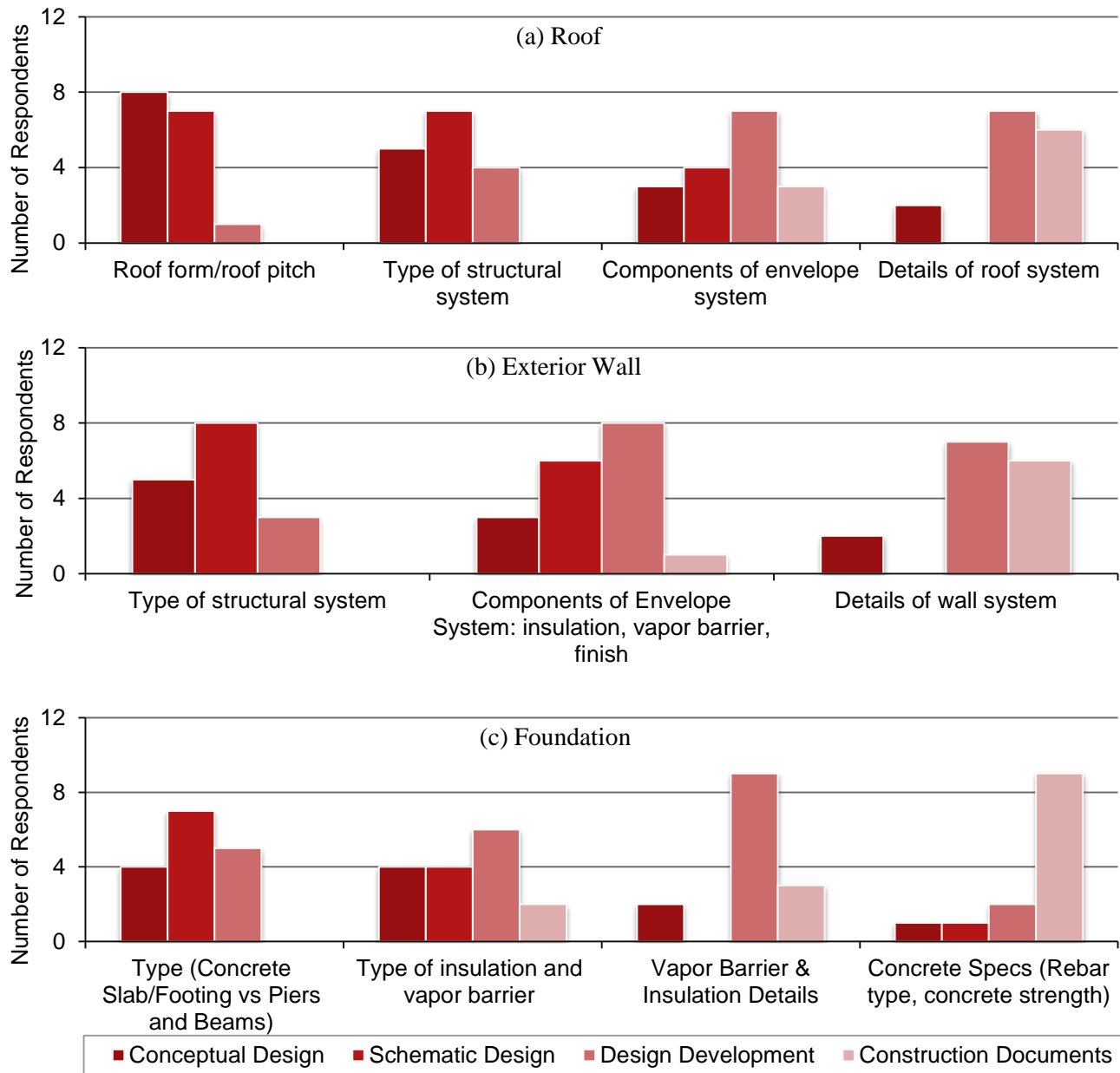


Figure 5: Timing of (a) roof, (b) exterior wall, and (c) foundation decisions.

3.2.4 Openings

For most firms, windows (Figure 6a) are considered a more important component of their projects than doors (Figure 6b) because of their quantity and visibility. As a result, they dedicate more time to selecting the type of windows they want to use. In general, firms established window and door areas, sizes and types in schematic design and design development. In the case of windows, this is due to the process of exploring the design after the geometry becomes more established. Pricing after schematic design impacts the manufacturer chosen except in the case of unique clients or projects. For larger scale projects, multiple manufacturers may be chosen with decisions left to the bidding process after the end of construction design.

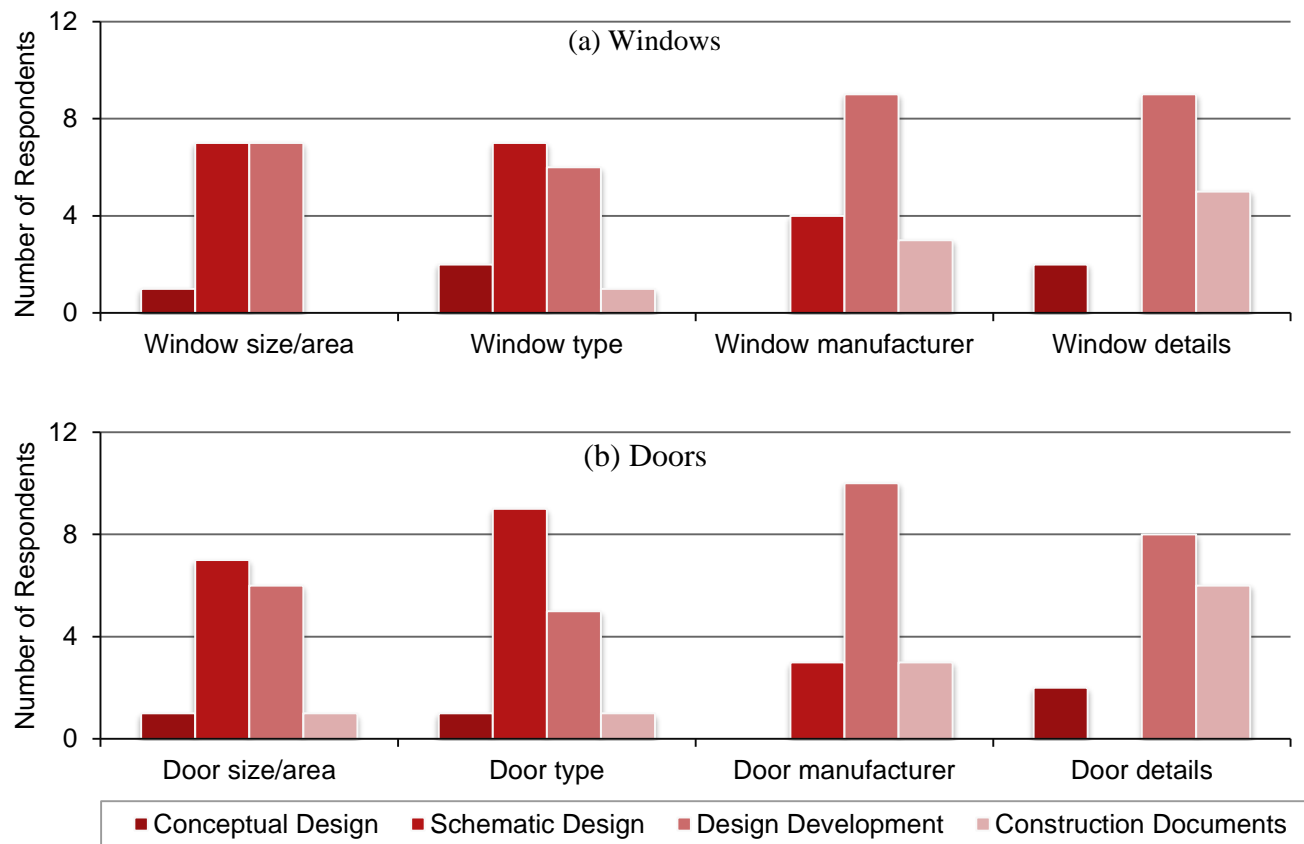


Figure 6: Timing of (a) windows and (b) doors decisions.

Decisions on other types of openings such as skylights can happen at any time during the design process unless they are visible or key to the design. Many architects noted that clients may even start considering them during the construction phase.

3.2.5 Interiors

For interior walls (Figure 7a) and floors (Figure 7b), decisions on structural systems were dependent on the availability of structural drawings in design development. As a result, assumptions are often made early based on standard framing practice and unique conditions are identified and accounted for but addressed in design development. With regards to finishes, the type of finishes for walls are identified and finalized in design development and construction documents. For floors, the timing for choosing the type of finish, whether tile, wood, etc., is more critical as it impacts the structural configuration of the floor. In both cases, the exact specifications of the material can be left to the construction phase.

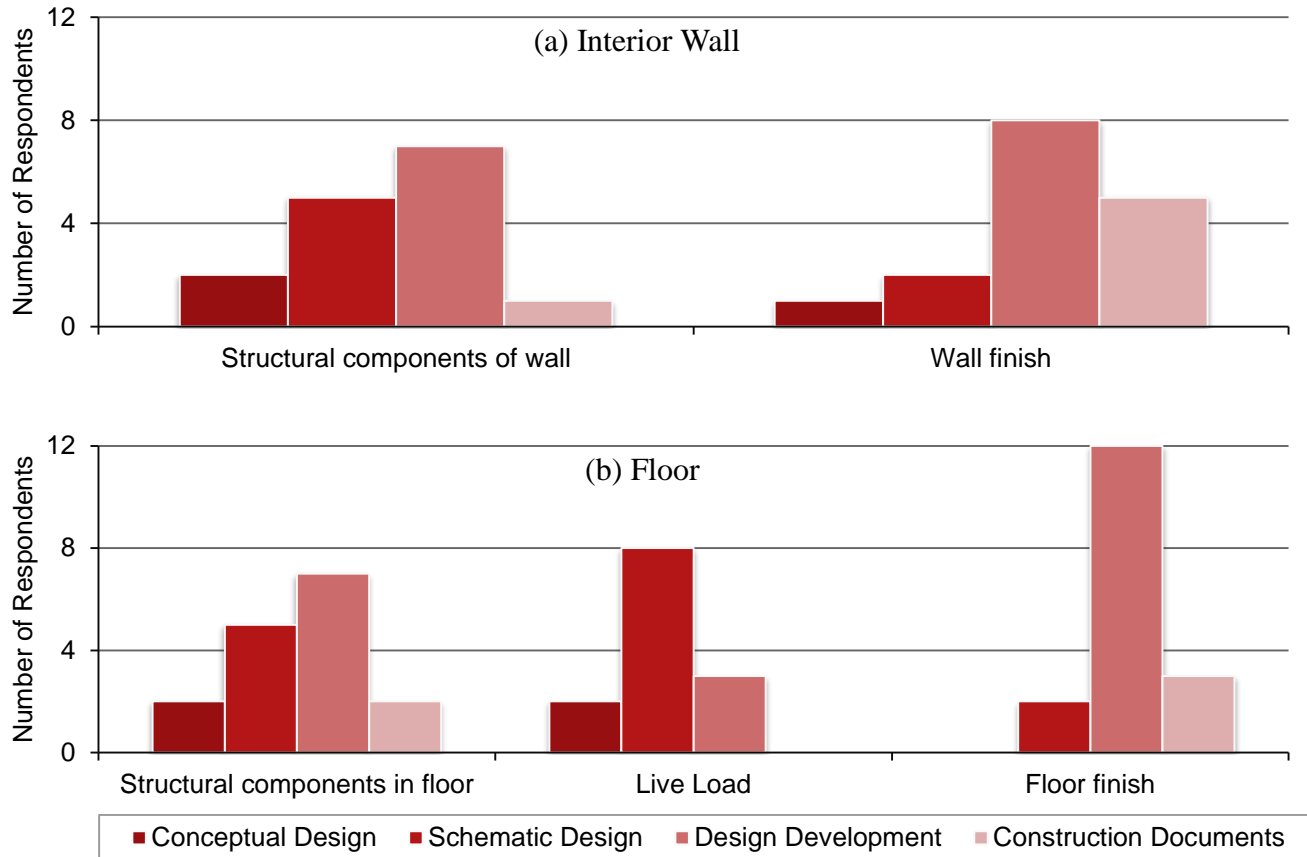


Figure 7: Timing of (a) interior wall and (b) floor decisions.

3.2.6 Building Systems: Structural, Mechanical, Electrical, Plumbing Systems and Appliances

Depending on the impact of the building systems on the design of a project, different building systems are identified at different times during the design process. Structural systems and much of their requirements are identified and finalized during schematic design and design development, with scope in schematic design and more detailed information in design development (Figure 8).

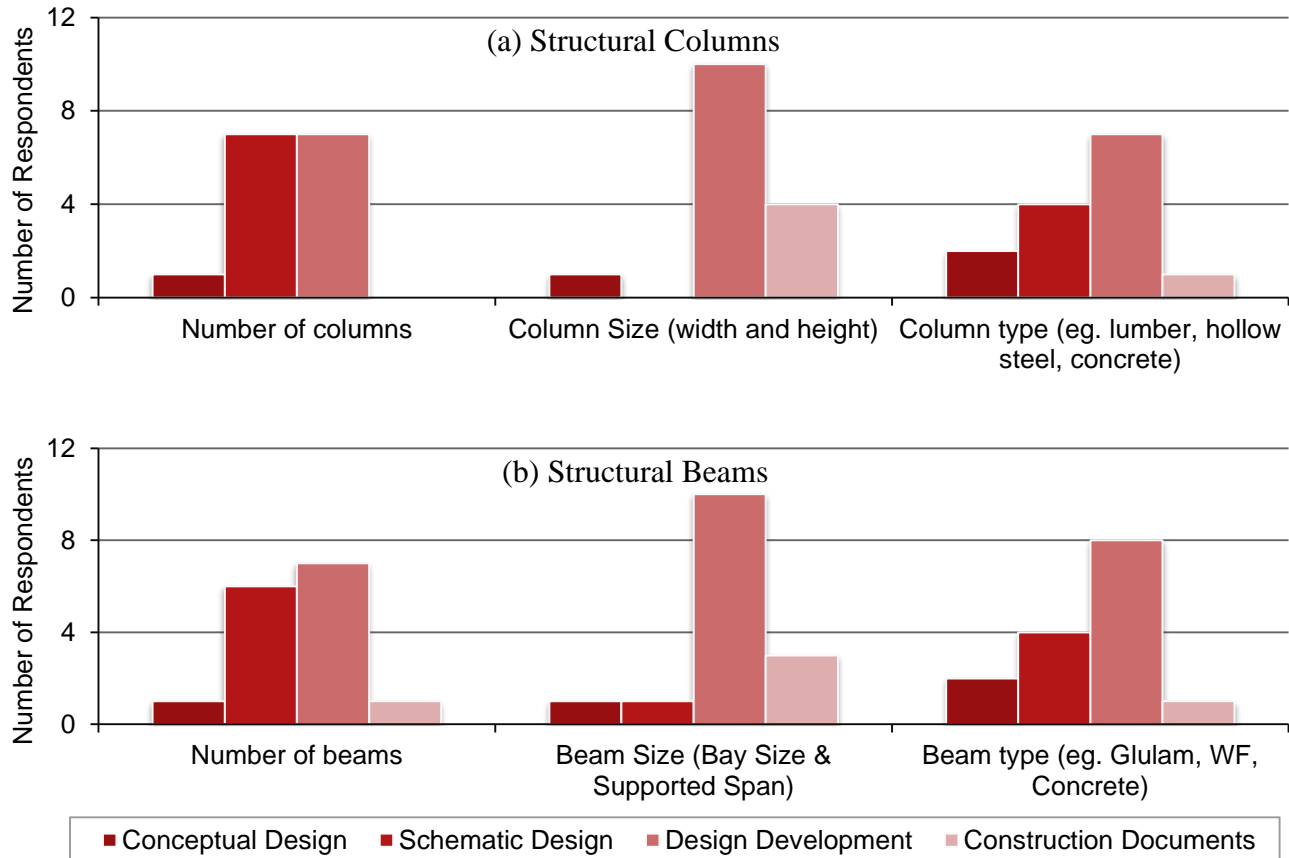


Figure 8: Timing of (a) structural columns and (b) structural beams decisions.

Mechanical systems (Figure 9a) and their requirements also are also identified in schematic design and design development. However, specific details of the systems can be left to later in the process. Electrical (Figure 9b) and plumbing systems (Figure 9c) are typically less critical to the design and can be identified in design development or later, except for type of lighting or plumbing fixtures and radiant heating systems. For small residential firms, many decisions on electrical and plumbing systems often occur during construction. With regards to appliances (Figure 9d), the number and type of appliances are identified in schematic design, while specifications can be finalized in construction documents or even during the construction phase.

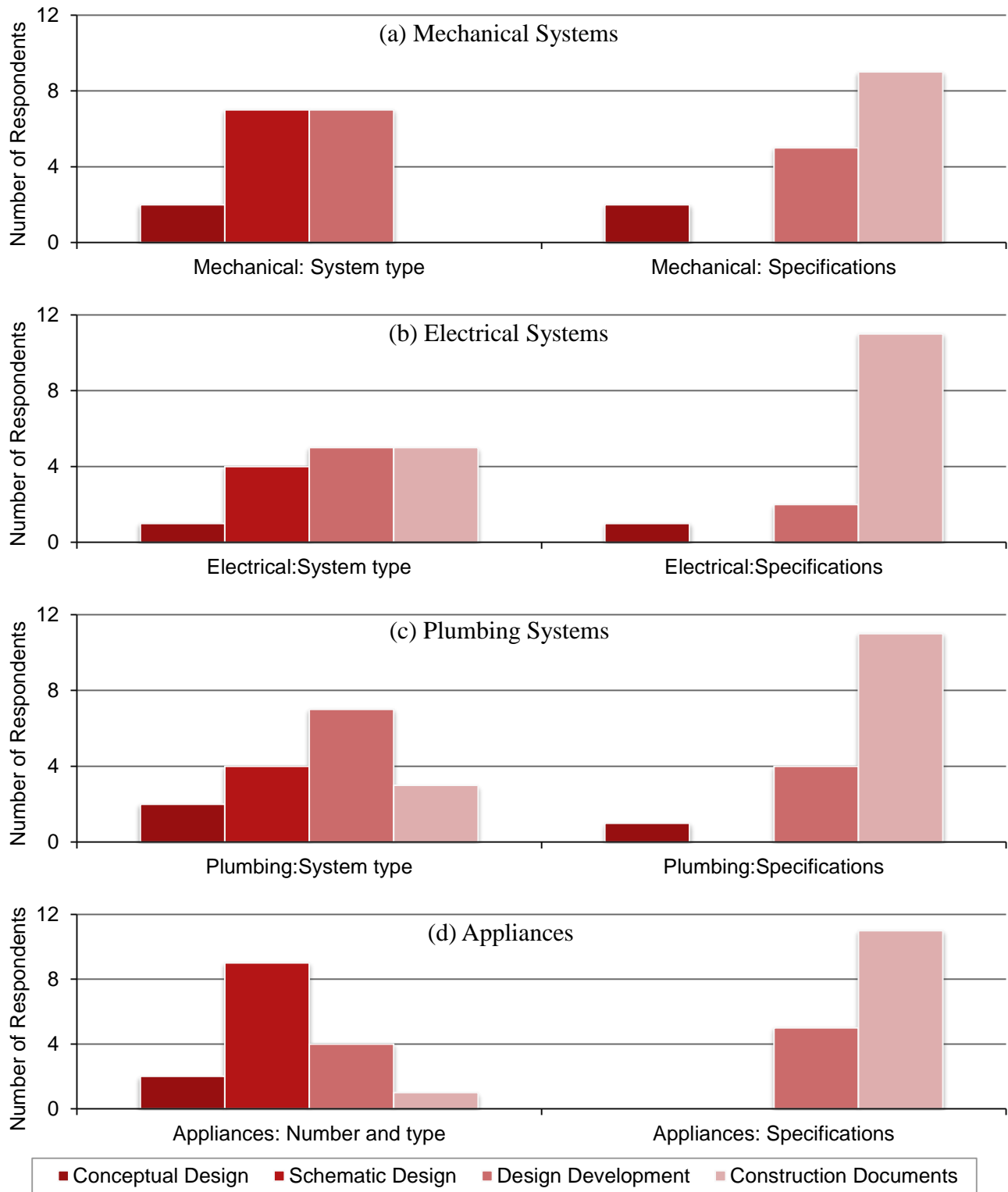


Figure 9: Timing of (a) mechanical systems, (b) electrical systems, (c) plumbing systems, and (d) appliances decisions.

4 HOMEBUILDERS AND DEVELOPERS

Homebuilders and developers play an important role in the design and construction of residential buildings, producing a large portion of single family homes. Figure 10 shows the total closings of the top 10 homebuilders in 2011-2013; each grew from 2011 [6]. At \$169 billion, private new single family homes accounted for half of all residential construction spending in 2013, which includes new multi-family homes, and improvements to existing homes [7]. The top 10 homebuilders earned \$34 billion in 2013, or 20% of new single family home construction value, and the next 90 homebuilders earned another \$34 billion. Together, the top 200 homebuilders in 2013 earned about \$76 billion, or 45% of the new single family home construction value.

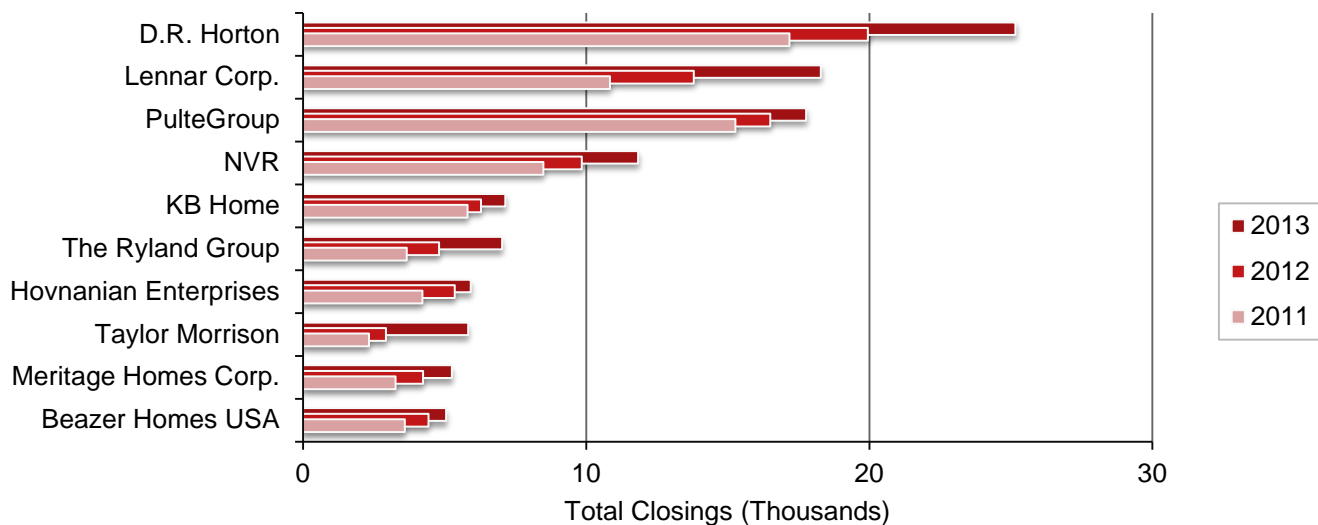


Figure 10: Total Closings from 2011-2013 of the Top 10 largest homebuilders in 2013 [6]

The design of homes by builders often occurs without the services of an architect or, if an architect is involved, it is based on pre-established designs and with no input from homeowners in the initial planning stages. In this case, homeowners pick and select from a series of house plans available, even though modifications can be made from the established kit of parts.

The developers interviewed are involved primarily in the multifamily residential market, typically in urban environments. As a result, the process typically involves larger scale developments that ranges from gut renovations and adaptive reuse of existing structures and new residential and mixed use developments that can take on multiple configurations. These include large developments of 1-2 family structures to large apartment complexes. Because of the complexity of the projects, architects are typically key players in the process. Unlike homebuilders, developers typically own and manage many of the properties that they build.

4.1 Profile of Firms

Two homebuilders and four developers were interviewed in order to understand the decision making process on housing. The homebuilders interviewed are composed of small teams, one with 2 persons

in Joplin, MO and the other with 5-9 persons in Tucson, AZ. The developers range from 11 – 400 persons. Two out of the four (the smallest and the largest) are non-profit organizations that develop primarily affordable with some mixed income housing. The smallest, at 11 employees, works in Cambridge, MA while the largest, with a staff of more than 400 persons, works in 12 states in the Eastern and Midwestern United States. The third developer, with a staff of 27 people, develops a mix of market rate and affordable housing and mixed-use developments in urban environments in Massachusetts. The last, with 35 employees, has a portfolio of two-thirds commercial and one third residential. Their residential work range from small-scale gut renovations to larger scale developments in Massachusetts and North Carolina.

4.2 Homebuilder Survey Results

The homebuilders interviewed do not typically retain the services of an architect. The first homebuilder builds custom homes for individual homeowners with a focus on energy efficiency and resilience. The second homebuilder builds innovative developments that integrate land use, stormwater management and native landscaping with building energy efficiency. They both use alternative building systems and are focused on a client base that understands the benefits of more energy efficient construction. Key conclusions from the homebuilders interviewed are noted below:

1. Homebuilders do not use architects in the design of their homes.
2. Previous experience or projects are starting points for most new projects and modifications can happen across projects.
3. Homebuilders rely on a kit of parts approach that can be applied across projects and varied as needed.
4. Homeowners participate in the process primarily in categories that impact visibility and function: plans, elevations, finishes, and appliances, with limited involvement on building and envelope systems.

The first homebuilder is based in Joplin, MO and has developed a palette of preferred envelope systems and HVAC systems. His preferred envelope system is insulated concrete forms but he will use wood frame construction depending on the budget and preference of his clients. His particular interest, in addition to energy efficiency, is developing homes that withstand tornadoes. Decisions are made on the home within the first three weeks of initiating a conversation with the client. During this time, three meetings occur. A critical driver of decisions on materials or systems is the budget of the homeowner. After an initial meeting, designs are provided based on the client budget and program requirements. The second meeting involves a review of the options with a focus on choosing a preferred design and systems, both envelope and HVAC systems. By the third meeting, a plan and basic systems are chosen and the project goes to bid with a subcontractor. Finishes and appliances are selected during the construction process.

The second homebuilder develops semi-custom homes in subdivisions in Tucson, AZ. Initially, a site is identified for a subdivision and site plans are drawn up. After site plan approval from the municipal authorities, a period of six months is dedicated to developing multiple home design options for the development and building a model home for viewing. In the case of one development, 6 plans and 18 elevations were developed as options for future homeowners. These increased to 12 home designs based on requests from potential homeowners. Decisions on envelope and building systems for the

homes were based on experience over multiple developments. The homebuilder has identified a system that maximizes thermal mass using insulated and solid filled 12" concrete masonry units and a 12" concrete slab. Opportunities for changes in the systems based on new technologies or the testing of new configurations typically occur during the initial 6 months when the building designs are being developed. With regards to finishes and appliances, multiple options, chosen by the homebuilder, are provided to the homeowner based on cost allowances. This ensures that the client has options within a range of costs. However, if the client prefers alternative choices outside of these allowances, the homeowner can incur additional costs.

4.3 Developer Survey Results

The developers interviewed all retain the services of an architectural firm. As a result, for the most part, they follow the timing of the design process developed by the architecture firm. However, certain key elements impact how decisions are made on envelope and building systems. As in the case of architects working in urban contexts, maximizing the buildable area based on zoning is critical in defining the cost of construction and the return on investment expected. One developer identified getting financing from a financial institution for a project as a critical driver in deciding on potentially more expensive energy efficient systems. Because many developers own their properties, staff in operations participate in the process and provide information and feedback on past experience with systems and materials. Key conclusions from the developers interviewed are noted below:

1. Developers retain the services of an architect.
2. Operations can impact decisions.
3. Some of the developers have developed design standards that impact the process while others have not, even though they may want to.
4. Financing of projects drives decisions on the choice of building and envelope systems.
5. Zoning requirements in urban environments often defines the geometry of the developments, because maximizing buildable area is critical to ensuring a return on investment.

Two of the developers have developed methods to ensure consistency and address sustainability. One of the developers hires architects as key players in their design and construction staff. These architects, based on previous practice knowledge and knowledge of financing and the housing market, put in place methods to ensure that decisions on energy efficient building systems are not eliminated as part of the typical value engineering process after the project goes out to bid. For example, for one project, they held a design charrette in schematic design with all the players, including the architect, engineers and energy consultants and identified all the systems required to meet the Enterprise Green Communities certification. They also secured financing to meet those goals. Decisions were based on a whole systems approach to building design. This meant that when cost estimates came in high, it was difficult to eliminate one system because of its implications on all other systems.

The second developer, an affordable housing developer based in Cambridge, MA, has developed their own set of performance guidelines and standards, initially based on LEED for Homes, but modified to be more relevant to the type of projects and locations it is working in. For a new project, an architect and energy consultant are selected simultaneously and initial energy modeling is performed on conceptual design options. A design charrette during schematic design defines the issues and systems

that need to be addressed and who is responsible for them. This is combined with an extensive and active monitoring of each system after each project is built to identify what works and what does not work. These inform decisions and any changes that need to be made for future projects.

5 CONCLUSIONS

Even though most of the interviewees were versed in the concepts of life-cycle environmental impacts, considerations were primarily focused on energy efficiency. Most participants identified a need for better methods that aid the decision making process. Robust, streamlined residential building LCA and LCCA tools and methods would help decision makers, builders, and architects make holistic decisions that integrate environmental impact and cost of all phases of the building's life cycle. In order to identify the most effective ways to integrate environmental performance and cost into the design and decision making processes of residential construction, understanding the timing of decisions is a key step in identifying opportunities for influence. Based on our research, the early stages, the planning stages prior to conceptual design and schematic design, are critical periods in the decision making process.

Simultaneously, decision making about the design of residential structures is dependent on many factors. These include the client, the project type, the context, the budget, the type of firm developing the project, building codes and zoning ordinances and the financial institutions. In order for LCA and LCCA to be scaled to fit the huge variety of housing types, methods are needed to calculate impact and cost under diverse conditions. Such methods could help stakeholders quantify the trade-offs between cost, performance, and environmental impact, whether embodied, end-of-life or use-phase.

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APPENDIX A: SURVEY

What tools do you use in the design process and in which stage(s)?

- Sketchup
- AutoCAD Architecture
- Autodesk® Revit®
- Rhino
- Other?

What Environmental Performance tools do you use in the design process and in which stage?

- Athena Impact Estimator
- Athena EcoCalculator
- OpenStudio
- SketchUP Plugin
- BEopt
- BEES
- B-Path
- HEED
- Other?

BASIC BUILDING GEOMETRY: At what stage in the design process is this level of specificity known?

- Shape
- Size (length, width, height of floor)
- Orientation (Degrees from North)
- Number of Floors

FOUNDATIONS: At what stage in the design process is this level of specificity known?

- Type (Concrete Slab/Footing vs Piers and Beams)
- Type of insulation and vapor barrier
- Vapor Barrier & Insulation Details
- Concrete Specs (Rebar type, concrete strength)

ROOFS: At what stage in the design process is this level of specificity known?

- Roof form/roof pitch
- Type of structural system
- Components of envelope system: insulation, vapor barrier, finish
- Details of roof system

EXTERIOR WALLS: At what stage in the design process is this level of specificity known?

- Type of structural system
- Components of Envelope System: insulation, vapor barrier, finish
- Details of wall system

FENESTRATION: At what stage in the design process is this level of specificity known?

- Door size/area
- Door type
- Door manufacturer
- Door details
- Window size/area
- Window type
- Window manufacturer
- Window details
- Overhang or Fin details
- Skylight size/area
- Skylight manufacturer
- Skylights details
- Daylighting controls: shading elements; etc

INTERIOR WALLS: At what stage in the design process is this level of specificity known?

- Structural components of wall
- Wall finish

FLOORS: At what stage in the design process is this level of specificity known?

- Structural components in floor
- Live load
- Floor finish

COLUMNS & BEAMS: At what stage in the design process is this level of specificity known?

- Number of columns
- Column Size (width and height)
- Column type (eg. lumber, hollow steel, concrete)
- Number of beams
- Beam Size (Bay Size & Supported Span)
- Beam type (eg. Glulam, WF, Concrete)

MEP SYSTEMS AND APPLIANCES: At what stage in the design process is this level of specificity known?

- Mechanical: System type
- Mechanical: Specifications
- Electrical: System type
- Electrical: Specifications
- Electrical: Photovoltaic System Specifications
- Plumbing: System type
- Plumbing: Specifications
- Appliances: Number and type
- Appliances: Specifications