WORKING
PAPER

Making a Tough Sell

Options for Promoting Energy Efficiency in New California Homes

MARK HANSON, MARK BERNSTEIN, AND JONATHAN KULICK

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SCIENCE AND TECHNOLOGY

Preface

California is one of the largest producers of homes in the nation—with over 100,000 new homes built each year across the state. Yet the housing market continues to favor sellers as desperate home buyers drive prices out of reach for most of those seeking home ownership in California. Increasingly, home buyers are turning to new housing developments in inland valleys, where land is available and housing more affordable, but also where energy use, especially for summertime cooling, is greater.

Even with the recent energy crisis fresh in their minds, most California home buyers continue to demand larger homes with "comfort" and "quality" amenities (e.g., countertop and flooring upgrades) that appear to equate to clearer investment value than do energy efficiency features sold explicitly as such (e.g., denser insulation). To remain profitable in a highly competitive industry, home builders seek to develop strong customer relationships by responding to specific consumer preferences—especially for comfort, quality, and affordability—while already following some of the nation's strictest building and energy codes.

Promoting residential energy efficiency remains an important pursuit in California given projected growth in less temperate regions of the state and the increasing consumer demand for larger, more comfortable homes. But, given the perceptions and motivations reflected in the process of constructing, selling, and buying homes, taking further steps to promote energy efficiency is a "tough sell" to builders and consumers alike. In this report, RAND researchers seek additional ways to promote energy efficiency by shedding some light on the following question:

What can be done to address the state's interest in increasing energy efficiency in residential construction, while respecting individual consumer demand for affordability and investment value, and increasing the profit of production home builders in California?

In 2001, the Building Industry Institute (BII) partnered with the RAND Corporation, the National Association of Home Builders (NAHB) Research Center, and ConSol to conduct research under the California Energy Commission's Public Interest Energy Research (PIER) program. The research program, Profitability, Quality, and Risk Reduction through Energy Efficiency, endeavored to understand the relationship between comfort, quality, and energy

efficiency; how homes are built; and the ability of builders to earn a profit. This report compiles a review of the literature, various consumer survey and customer-service data sets, and insights revealed in a series of interviews with executives of leading home building companies that have operations and experience in California.

Findings are presented within a broader framework describing the home building process, and identify some possible interventions that could achieve greater energy efficiency in new California homes. This report is intended especially to help energy policymakers better understand how market pressures affect home buyers' purchase decisions related to energy efficiency, and the important role that builders play in facilitating these decisions.

RAND Science and Technology

RAND is a nonprofit institution that helps improve policy and decisionmaking through research and analysis. RAND Science and Technology (S&T), one of RAND's research units, assists government and corporate decisionmakers in developing options to address challenges created by scientific innovation, rapid technological change, and world events. RAND S&T's research agenda is diverse. Its main areas of concentration are science and technology aspects of energy supply and use; environmental studies; transportation planning; space and aerospace issues; information infrastructure; biotechnology; and the federal R&D portfolio.

For more information about RAND S&T, see our website at http://www.rand.org/scitech/index.html.

Building Industry Institute

The Building Industry Institute (BII) was founded in 1993 by the California Building Industry Association (CBIA) to develop, implement and administer research and educational programs for home builders, developers, and the general public. The CBIA is a statewide trade association and represents over 6,000 construction related firms involved in both residential and light commercial construction. CBIA members produce nearly 80 percent of all new homes in California each year. The BII works cooperatively with a variety of state and federal agencies, local governments, utility companies, universities and private, not-for-profit organizations to provide information and research which facilitates the construction of quality homes for consumers. For more information about BII, see their website (http://www.thebii.org/).

Contents

Tables

Summary

Overview

The RAND Corporation, the Building Industry Institute (BII), the National Association of Home Builders (NAHB) Research Center, and ConSol were funded by the California Energy Commission (CEC) to conduct a research program that aimed to understand the relationship among comfort, quality, and energy efficiency as valued by consumers, how homes are built, and issues of home builder profit.

RAND's assignment in this research program was to explore the possibility that home features associated with home owner comfort and quality may also be associated with energy efficiency in the home. Further, RAND researchers explored the relationship of energy efficiency to builder profit through cost control. Both of these lines of inquiry were hoped to return insights for promoting energy efficiency in new California homes.

First, we reviewed the literature describing concepts and measures of comfort, quality, and energy efficiency in homes, and relationships among these notions (See Appendix 1 for further discussion of these). Second, we reviewed several available data sources describing both stated and revealed preferences by home buyers for comfort, quality, and energy efficiency in homes (See Appendix 2). Third, we reviewed data collected by home warranty companies, and elsewhere in available literature, looking especially for evidence that certain amenities or construction practices characterized as more energy efficient may also be associated with reduced costs of fixing problems in the home that are covered under warranty (See Appendix 3).

After this third step, we determined that we could not differentiate consumer values for comfort, quality, and energy efficiency using available data, nor could we conduct a rigorous quantitative analysis of warranty calls and associated costs to builders. However, it appeared that a qualitative analysis of expert knowledge of construction defects and associated costs, along with their understanding of consumer demand for comfort, quality, and energy efficiency could provide the information we needed.

In the summer and fall of 2003, we turned to executives of KB Home, Pardee Home, and Pulte Homes—each a home builder with operations in California—for some help with our assignment. Although not exhaustive in number (there are thousands of construction firms in California), participants were selected from companies that are industry leaders, differ in business strategy and market targets, and together represent a substantial share (approximately twenty percent) of the home building market in California. Together, participants represented more than one-hundred years of professional experience and knowledge developed in the home building industry in California.

We developed a discussion protocol (see Appendix 4) from our initial review of the literature and available data. Interviews were conducted with more than a dozen executives and high-level staff, as well as selected trade contractors that do business with our selected builders and others in California. Interview discussions formed the basis of several generalizations, and in some cases, certain specific relevant examples also emerged. In this report, interview statements are not attributed directly to individuals or their companies.

Along with estimates of construction problems and costs, and a review of consumer values, this report compiles builders' potentially useful insights into the production home industry, the housing market, builder practices, and profitability as they relate to energy efficiency of new homes in California. These insights suggest an important role played by builders at critical decision points during the home building process, and also some important constraints faced by builders related to promoting energy efficiency in new homes.

Findings

We have grouped our findings in three general areas. First, we describe the markets in which the home buyers and builders participate. Second, we describe effects on builder profit due to construction problems that increase builders' costs. Third, we take a broader look at builder profitability and describe some emerging options that may increase revenue (hence profit) to builders while also increasing energy efficiency in new homes.

Characteristics of new home markets in California, with respect to comfort, quality, and energy efficiency

- More affordable new-home opportunities are increasingly occurring in the inland valleys of California, where energy use, especially for summertime cooling, is greater.

- "Wow" features that are associated with greater comfort or quality (e.g., countertop and flooring upgrades) are perceived by most home buyers to secure greater resale value more than features promising greater energy efficiency (e.g., denser insulation).

- Two home features for which additional cost and risk to the home buyer and builder discourage promoting energy efficient options are heating, ventilating, and cooling (HVAC) systems and insulation. "Split HVAC" systems (either in the form of two smaller HVAC units, or as a single unit capable of cooling multiple zones), for example, promise greater comfort and energy efficiency, but are more expensive to purchase than conventional systems, and the newest of these are unproven.

- Builders seek long-term customer satisfaction. While builders are in a position to influence home buyers' decisions on certain home features, they have difficulty convincing home buyers (particularly first-time home buyers) of the additional benefit in upgrading features to a higher level of energy efficiency relative to the additional cost of doing so. The risk of customer disappointment in making energy-efficient choices threatens a lasting customer relationship and overall reputation of the builder.

The effect of warranty calls on builder profits, and their energy-efficiency implications

- Builders maintain active customer-service departments. Customer-service and warranty budgets typically amount to about ten percent of builders' after-tax profits.

- Builders review customer-service records and seek to improve practices that lead to the highest frequency and most costly problems in their homes. However, warranty calls with greatest frequency and costs are for "fit and finish" problems in the home (e.g., paint, walls, trim, flooring, and cabinetry), not for items with obvious energy-efficiency implications.

- The number of warranty calls for HVAC problems increases during summer months, but the effect of these calls on profit is small.

- HVAC systems that use wall registers appear to simultaneously satisfy consumer demand for comfort, reduce warranty callbacks to builders, and increase energy efficiency.

- Split-AC systems may also simultaneously satisfy consumer demand for comfort, reduce warranty calls to builders, and increase energy efficiency.

- Using green lumber (i.e., lumber that has not been dried in a kiln before use) may cause bowing of walls, which compromises the building envelope, especially in hotter, drier areas of the state. This problem appears to be infrequent, but may be emerging.

Opportunities for selling energy efficiency

- Energy efficiency in the home has broad marketing appeal that invites home buyers to consider builders that offer energy-efficient options, whether these options are ultimately selected in a new home purchase or not.
- Consumer values, home ownership experience, and equity drive decisions related to energy efficiency in home purchases, but the builder plays an important role in finalizing these decisions.
- Energy efficiency may be bundled with comfort and quality during sales, but options to do so need further review.
- The risks of buying and selling energy-efficient options need to be removed from the builder-home buyer transaction.

Emerging Policy Issues and Options

Out of our findings emerge three general observations that have implications for promoting energy efficiency in new homes in California:

- The greatest challenge for promoting energy efficiency in new homes is in the market for first-time home buyers looking inland, for the largest, most comfortable homes that they can afford. Information and resources to invest in energy-efficient options are least available to this group of home buyers.
- There is evidence that some design and construction measures may be taken to reduce cost to builders and improve energy performance of a home, but the greatest incentives to builders to control costs are for problems least associated with energy efficiency.
- Motivating builders through increased profit to promote energy efficiency in their home products may be more likely achieved by aiding their marketing and sales efforts in order to increase revenue, rather than by informing design and construction practices in an effort to decrease costs. Builders' marketing and sales teams can sell energy efficiency to

home buyers, with the credible information and risk-reduction options available to them. Making even a "tough sell" is what a trained salesperson is in the best position to do.

With these observations in mind, we present five interventions at various stages of the home building process that promote energy efficiency, and which are described in greater detail in Section 5. All of them highlight the role of the builder in achieving greater energy efficiency in new homes.

- Improve construction protocols and worker training, specifically to address HVAC design and framing problems such as bowed walls.
- Better educate home owners on basic HVAC use.
- Investigate performance and reliability of promising new technologies for homes, and support their use.
- Identify further options for cross-selling energy efficiency upgrades according to their promises of greater comfort and quality.
- Pursue strategies for promoting energy efficiency through builders, that also reduce risk to builders doing so.

Because these interventions are linked to potentially greater builder profit, builders may be more inclined to implement them. Government support is likely necessary to catalyze builders' initial response to these.

Organization of This Report

This report is organized as follows:

Section 1	describes the objectives for, and approach taken in, this study.
Section 2	examines consumer demand for comfort, quality, and energy-efficiency features in California homes.
Section 3	describes findings related to warranty calls, and their implications for builder profit and energy efficiency.
Section 4	explores possible roles for energy efficiency in home builders' business strategy, particularly as it relates to marketing and sales.
Section 5	summarizes emerging issues and suggests directions for policy development.

Appendix 1	presents concepts and measures of comfort, quality, and energy efficiency.
Appendix 2	reviews consumer valuations of comfort, quality, and energy-efficiency features of homes, and provides some guidelines for future market-survey instruments.
Appendix 3	describes an initial review of available warranty-call data, with emphasis on calls that have potential energy-efficiency implications.
Appendix 4	includes a discussion protocol for interviews with home builders.

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1. Introduction

The RAND Corporation, the Building Industry Institute (BII), the National Association of Home Builders (NAHB) Research Center, and ConSol were funded by the California Energy Commission (CEC) to conduct a research program that aimed to understand the relationship among consumer values, how homes are built, energy efficiency, and the ability of builders to earn a profit in markets for new homes in California.

In this program, RAND sought to:

- Understand the relationship between comfort, quality, and energy efficiency; how consumers value these characteristics of a new home; and how builders respond to consumer demand for these.
- Understand and identify categories of warranty call items—items that require home owners to call builders, and builders to fix problems in the home that are covered under warranty—and estimate the direct costs to address these problems.
- Determine whether some of these costs could be avoided through different construction techniques that could also result in increased quality, comfort, and energy efficiency in the home.
- Determine whether there are additional opportunities that simultaneously address the state's interest in maximizing energy efficiency in residential construction, while also serving individual consumer demand for investment value and increasing the profit of California home builders.

Approach

First, we reviewed the literature describing concepts and measures of comfort, quality, and energy efficiency, and relationships among these. Second, we reviewed several available data sources describing both stated and revealed preferences by home buyers for comfort, quality, and energy efficiency. Third, we reviewed data collected by home warranty companies, and elsewhere in available literature.

After this third step, we determined that a clear understanding of consumer values for comfort, quality and energy efficiency was not to be gained from available data. We also determined that a rigorous quantitative analysis of warranty calls and associated costs to builders was not possible. However, we suggested that a qualitative analysis of expert knowledge of construction problems and associated costs, and consumer values reflected in markets for new homes more generally, could be quite useful.

In the summer and fall of 2003, we turned to executives of KB Home, Pardee Home, and Pulte Homes—each a home builder with operations in California—for some help with our assignment. Our discussion protocol is included in Appendix 4. Although not exhaustive in number (there are thousands of construction firms in California), participating companies were selected from companies that are industry leaders, differ in business strategy and market targets, and together represent a substantial share (approximately twenty percent) of the home building market in California. The participants represent more than one hundred years of professional experience and knowledge developed in the home building industry. Participants included corporate executives and managers in architecture, construction, marketing, and customer-service divisions. In addition, we consulted with subcontractors that specialize in heating, ventilating, and cooling (HVAC) system design and installation; and framing. In combination with the literature we reviewed, this report compiles results of discussions with more than a dozen executives and high-level staff in these companies, as well as selected trade contractors that do business with these and other builders in California.

In this report, statements are not attributed to individuals or companies, and this intent was made clear to participants in an effort to elicit candid responses. Interview results were considered according to builder characteristics (e.g., size, target markets, etc.) so that generalizations could be drawn, and specific examples better understood. These interviews provided us with overall estimates of frequency and costs of construction problems, efforts to improve design and construction related to these, and several specific insights into additional opportunities to promote energy efficiency in homes.

The Home Building Process and the Role of the Builder

Findings of this study have implications for interventions at various stages of the home building process. According to Hassell et al (2003), this process is defined by the following stages, with each characterized by several steps:

- Land Development: Acquisition, use planning and subdivision, rough grading, and infrastructure construction.
- Design: Floorplan, lot layout, basic specifications and options, basic cost analysis.
- Pre-construction: Selection of home builder, selection of trade contractors, sequencing and scheduling, selecting and ordering materials.
- Construction: Excavation; foundation; structure; HVAC, plumbing, electrical, etc.; finishing (interior and exterior); certificate of use and occupancy.
- Post-construction: Purchase by owner, financing and insurance, purchasing durables and consumables, use by owner, warranty claims and customer service, operation and maintenance.

The above summary illustrates that the home building process is complex, and involves several specialized participants in various steps. The builder typically enters the process around the design and pre-construction stages and is often involved in the several stages that follow, including the final sale of the home to the owner. Although the owner typically enters the process at the post-construction stage, consumer preferences influence builder decisions and actions at earlier stages of the process, including design and pre-construction.

Importantly, we see that larger home building companies often coordinate information, decisions, and actions at almost all stages of the process. Builders are in a position to promote worker training that can influence performance at pre-construction and construction stages. Builders are also in a position to present information and options that can influence consumer decisions at the post-construction stage. Purchase decisions, facilitated by the builders themselves, can feed back to builders' design and construction decisions as well.

Specialized departments of home building companies are variously devoted to design, construction, marketing and sales, as well as warranty claims and customer service. These departments are staffed by experienced employees that are trained to facilitate and influence this complex process to achieve business goals. Overall, business strategy is motivated chiefly by profitability—either through increased revenue or decreased costs to home builders. Increasing revenue is tied largely to marketing and sales efforts, which generally follow opportunities defined by consumer demand. Decreasing costs are tied to achieving more efficient operations, customer service (e.g., handling warranty calls and claims), and production (i.e., home design and construction).

Business strategy reflects, and shapes, markets too. Decisions and actions of individual builders that reveal a profitable business strategy tend to ripple through the market to other builders. Interactions between builders' sales and customer-service staff are often described, by word of mouth, to other consumers.

In all, builders as individuals and in aggregate, amongst themselves and in relation to consumers, emerge as important stakeholders in the effort to promote energy efficiency in new California homes. And profitability is an essential motivator of their decisions and actions.

2. The Market for Comfort, Quality and Energy Efficiency in New California Homes

Creating equity through home ownership remains a desirable investment strategy, yet the possibility of home ownership remains out of reach for more than three-quarters of Californians.[1] While housing supply continues to increase in California,[2] demand growth is even greater and fuels a strong sellers market. Demand has created strong pressure to build affordable new homes on available land, increasingly in California's inland valleys.[3] Affordability is especially important to first-time home buyers.

Consumer demand for homes has created various housing market niches across four dimensions:

- Location
- Price
- Consumer perceptions of investment value
- Home ownership experience

Builders target home buyers in one or more niches as reflected in their respective business strategies. Competing well in their niches is essential to builders' profit goals and their survival in a highly competitive industry. Market pressures, especially in markets for first-time home buyers, have important implications for residential energy efficiency.

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[1] According to the California Association of Realtors, 23 percent of households in California were able to afford a median-priced home in December 2003. The minimum household income needed to purchase a median-priced home at $404,520 in California in December was $94,730, based on a typical 30-year, fixed-rate mortgage at 5.82 percent and assuming a 20 percent down payment. By comparison, 57 percent of households across the U.S. were able to afford a new home in December 2003; the minimum household income needed to purchase a median-priced home at $173,200 in the U.S. was $40,560.

[2] The California Association of Realtors reports 123,864 new single-family housing units built in 2002, up from 73,812 built in 1991.

[3] When comparing costs of comparable houses, the most affordable regions in 2003 were (in order): High Desert, Sacramento, Central Valley, and Riverside/San Bernardino.

Pressure to Build Inland, and to Build Big

Differences in home price are tied primarily to the price of land (which varies by location), and secondarily to floor area and amenities of the home. In coastal areas and in the largest metropolitan areas (i.e., Los Angeles and the Bay Area), location can account for the vast majority of a home's value.

Land is generally more available and homes are more affordable in the inland areas of the state, creating new opportunities to generate investment value in lower price ranges by upgrading the home itself. Consumers often seek to increase value of a home on a given plot of land by building two stories and/or upgrading amenities. Builder strategies to increase their own profit largely follow consumer demand for value.

Perceptions of Investment Value in New Homes

Appendix 3 provides further discussion of both stated and revealed preferences of consumers for comfort, quality, and energy efficiency in homes. When prioritizing home features according to their perceived investment value, consumers tend toward greater floor area, and "wow" amenities tied to appearance of greater comfort and quality (e.g., countertop and flooring upgrades), before energy-efficiency features sold explicitly as such (e.g., denser insulation).

According to a recent article[4] provided by one builder we interviewed, and echoed in most of our discussions, the top five "splurge" items from a consumer standpoint are windows, refrigerator, stove, flooring, and insulation. Interestingly, these are items with relatively greater energy-efficiency implications as well, yet their design, appearance, and durability—not energy performance—are most important to consumers. Besides heating, ventilating, and cooling (HVAC) systems, comfort-related features that appear to have the greatest energy-efficiency implications include water heaters, windows, insulation, and patio trellises. But consumers do not frequently demand upgrades for these that increase energy efficient performance beyond their desired level of comfort.

The implication is that if energy efficiency can be uncoupled from comfort and quality, home buyers generally will purchase comfort and quality, before energy efficiency, especially on items that that have identified as luxury items that they

[4] Farnsworth, C.B. 2003. "The Right Stuff." *Builder*. May.

would have to spend more on. That energy efficiency is inextricably tied to comfort and quality in many instances, however, is an important opportunity that will be explored further in Section 4.

The Influence of Experience on Home Buyer Preferences

Home buyers move between housing market niches as their purchasing power increases (largely through growth in equity of their previous home purchase) and as their lifestyles, perceptions, and experiences dictate. Thus a useful way to look at the housing market is through the eyes of first-time buyers and "move-up" buyers purchasing their second or third homes.

Some builders target home buyers in these groups separately; others target home buyers in both, and look to build an ongoing relationship with their customers, selling them both their first and subsequent homes. Differences between these consumer groups have important implications for residential energy efficiency.

First-time home buyers

Whether to and how to purchase a home is the defining decision of first-time home buyers. Qualifying for a home loan, paying closing costs on the purchase, and affording mortgage payments are the most important concerns of this group.

Also important to the first-time home buyers is creating investment value that allows them to "move-up" to their second home purchase, generally about five years after their first home purchase. Thus further considerations in their purchase are related to fetching a high price and quick turnaround on the resale market, which as described above are driven mostly by location, floor area, and "wow" amenities, if they can be afforded.[5] Energy efficiency itself may be important to this group, if only as a stated ideal, but generally not revealed over these other factors in their first-home purchase.

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[5] One interesting, recent shift in demand related to amenities in medium- to lower-priced homes is the separation of stove and over. Demand for more "gourmet" kitchen design specifies separate stovetop and oven appliances, yet because of increased cost of venting separate devices, they are less likely to be available as gas-powered appliances in lower-priced homes. Thus less efficient electrical stoves and ovens are generally selected to satisfy this demand.

"Move-up" buyers

With more equity to invest in their next home, often more experience with paying high energy bills, and an intention to stay in their next homes for longer periods of time, the importance of energy efficiency becomes more important to "move-up" buyers. Preferences for energy-efficient features are revealed to a greater extent in their investment decisions, even when such features represent greater initial cost.

Preferences for greater comfort and quality also follow move-up buyers in their next home purchases, and sometimes these preferences are tied to greater energy efficiency. According to one builder, home buyers purchase low-emissivity ("low-e") windows not only for increased energy efficiency performance, but because these windows provide greater protection of their furniture and drapes.

Implications for Energy Efficiency in California's New-Home Market

Demand for larger, more comfortable, yet more affordable homes in inland valleys creates an energy-efficiency challenge:

- Inland areas of California are hot in summer months. All else being equal, homes built in these areas require greater energy for cooling to achieve a given comfort level for home owners.
- Home owners differ in the way they use their homes, making it more difficult for builders to design HVAC systems to achieve a given comfort level throughout the home, while also maximizing energy efficiency. Two-story homes are particularly difficult to cool evenly.

There appear to be technology solutions that can achieve greater comfort and energy efficiency, even in larger, two-story homes. "Split-AC" systems—consisting either of two separate, smaller HVAC units for different parts of the house, or newer multi-zone systems—can be effective in simultaneously addressing summer cooling needs, increasing comfort, and perhaps also increasing energy efficiency. Using such systems allows potentially greater control over cooling only the areas needed, or differentially cooling areas according to different levels of comfort required by different occupants in different parts of the home.

Two challenges for cooling remain, and are greatest in the context of a home sale to a first-time home buyer:

- Split-AC options require a larger initial investment. The additional purchase cost, even for potentially increased comfort and energy savings, is less attractive to the first-time home buyer than are lower closing costs, or other value-creating options such as countertop or flooring upgrades.
- The performance and reliability of multi-zone HVAC systems are not yet proven, thus builders are more hesitant to promote them to their customers and potentially jeopardize the customer relationship.

Nonetheless, builders' sales staff are uniquely positioned to present and explain energy-efficient options, whether for cooling, or for other energy-demanding services (e.g., water and space heating, lighting.) Equipped with credible information and the necessary incentives to reduce profit risks to the builder and investment costs of the home buyer, the builder is more likely to make a sale on a more energy-efficient home.

3. Effects of Warranty Calls on Builder Profit and Implications for Energy Efficiency

Important environmental conditions in California include seismicity, heat and wind in the inland valleys, and moisture in the northern part of the state. These conditions, along with various demands of consumers, create challenges for the builder in the design and construction of new homes. Sometimes difficulties in meeting these and other challenges are reflected in the home's performance, and home owners register complaints with the company that handles the home's warranty. We reviewed several potential sources of data on construction and equipment defects that may be related to quality, comfort, and energy efficiency, but none of the sources proved to have adequate data to support rigorous analysis (see Appendix 3 for a summary of this review). Thus, we turned to several California builders for their expert opinion on these issues.

In our sample, the building companies handled their own warranties, and complaints from home owners were directed to builders' customer-service departments. How customer-service departments in our sample of builders were organized and the methods by which they served customers varied. Yet two general principles that relate warranty calls to profitability emerged:

- Customer-service records inform builders' design and construction practices, thus warranty calls potentially influence production and associated costs.
- Prompt, effective customer service is a priority of successful builders and an important part of overall marketing and sales efforts, which rely on word-of-mouth advertising and seeks to lock-in repeat customers.

Warranty-Call Data for New Homes: Type, Frequency, and Costs

Warranty-call data describe calls from home owners registering complaints about problems in their homes, and that potentially require fixing at builders' expense.

In this study, we include problems identified during the "walkthrough"[6] as well as problems identified during the warranty period. Warranty periods vary for different items according to state law, such as two to four years for patent defects (e.g., "fit-and-finish" items such as cabinetry, flooring, paint, and trim), and ten years for latent defects (e.g., structural problems).

According to the builders we interviewed, the highest frequency categories of warranty calls (expressed as a percent of total customer-service calls) accounted for nearly all warranty call items as follows:

- Paint and drywall (25−35%)
- Stucco (10−20%)
- Flooring (10−20%)
- Plumbing (10−20%)
- Electrical (5−15%)
- HVAC (up to 10% in summer, in certain areas)
- Soil / grading (less than 5%)

The vast majority of warranty calls are for fit-and-finish items: About half of these are for paint and drywall problems, about one-quarter for stucco problems (minor cracks of aesthetic nature only), and another quarter for flooring problems—mostly scratches, stains, and problems with carpet seams. About ten to twenty percent of calls are related to leaky plumbing—mostly at the fixtures. About five to fifteen percent are related to electrical systems—mostly broken switches. Almost five percent are related to soil grading issues—primarily in certain clayey areas, where surface water can accumulate after irrigation.

In general, budgets for handling customer calls amounted to approximately one-half to one percent of the sales price of a new home product, which amounts to five to ten percent of the after-tax profit from a new home. Costs related to warranty calls often get passed on, through subcontract agreements, to subcontractors. Costs for subcontractors likely correspond to about one percent of their billed work. Few problems were reported to go beyond customer-service departments to legal ends, but some small-claims and class-action lawsuits have been made.

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[6] The "walkthrough" describes the final inspection by the home owner at the time of sale.

These data, along with the experience of their executives, inform builders' design and construction practices. At the pre-construction and construction stages, in particular, the builders interviewed address known problems through training and supervision efforts. Throughout the industry, it was noted, important factors related to construction problems appear to be variability in available subcontractors and, more generally, worker turnover. Not surprisingly, builders' training and supervision efforts focus on the highest-frequency and highest-cost warranty-call items, which are generally not energy-efficiency related.

Energy-Efficiency-Related Warranty Calls

Very few warranty call items are obviously related to the energy performance of the home. The largest category of calls with obvious energy-efficiency implications regarded HVAC—accounting for up to ten percent of calls in certain inland areas, in summer months. Summertime HVAC calls from home owners in the state's warmest areas, and water intrusion calls at any time of year from home owners statewide, are the warranty holders' top callback response priorities.

Another problem identified in our interviews that has energy-efficiency implications was associated with bowed walls that result from using green lumber in home construction in some areas of the state.[7] This problem appeared to be infrequent, but may be emerging.

HVAC calls

A typical call for an HVAC problem is that the HVAC unit is not cooling the home sufficiently, or that cooling is uneven. This can mean that the HVAC unit itself needs to be adjusted, or that registers need to be adjusted. Sometimes additional dampers and returns must be added, which can be more costly, but significant and costly HVAC reconfigurations are rare.

The underlying problem is one of design—HVAC systems are not customized for the house and particular consumer behaviors, such as preferences for setting window blinds and opening and closing doors. It appears to be well known among builders and their HVAC subcontractors that larger, two-story structures, with more windows and larger kitchens, family rooms, and master suites create a greater heating and cooling challenge. While state code provides some guidance on standards and modeling, it is impossible to fine-tune HVAC systems for

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[7] Green lumber has not been dried in a kiln, and tends to warp as it dries out during home construction.

particular customers until after they have lived in their home for at least one complete heating and cooling season.

Although the builder's customer-service department takes the initial call from the home owner, responsibility for addressing HVAC problems typically lies with the HVAC subcontractor. To the builder, the average cost of handling customer calls reporting HVAC problems appears to be less than 0.25 percent of the after-tax profit on the sale of a new home.[8] Costs to the subcontractor may be slightly greater, but these problems appear to be resolved in the first two years, generally by simple adjustment of the HVAC unit or registers, and educating the home owner on how to use the HVAC system.

An interesting trend in consumer demand for HVAC is the preference for lower, wall registers instead of ceiling registers. This preferences appears to be for aesthetic reasons. Modeling of ceiling versus wall register placement elsewhere in this research program has also demonstrated more efficient cycling of air, as well as greater thermal comfort of occupants, when wall registers are assumed. In this case, consumer demand for comfort and quality appears to coincide naturally with greater energy efficiency and possibly reduced calls from customers.

None of the interviewees suggested that split-AC systems increase the frequency or cost of responding to warranty calls. From a customer-service standpoint, such systems may decrease warranty calls to the builder due to increased comfort and flexibility for the home owner.

Bowed walls

Another issue mentioned in our interviews with energy efficiency implications was that of bowed walls. The problem results when lumber used to frame the home warps, and the finished wall bows out (or in) from an otherwise flat, vertical plane. When this occurs near a window, part of the frame can pull away from the window and compromise the building envelope, resulting in a less energy-efficient home.

The problem is exacerbated when green lumber is used for construction in hot, dry areas such as the inland valleys of California. While green lumber is approximately five to ten percent less expensive than dried lumber, one framing

[8] This assumes that HVAC related calls take place in summer (one-quarter of the year), that these account for up to ten percent of calls at that time, and that total warranty calls account for ten percent of after-tax profit on home sales.

subcontractor we interviewed suggested that the savings on lumber is almost certainly lost to the builder when the additional construction labor involved in stud straightening[9] is considered.

This problem occurs infrequently, likely in less than a few percent of all new homes, and is apparently limited to homes with more energy-efficient design. Existing construction practices appear generally to address this problem,[10] but it persists as a practical challenge in building new homes in the hottest, driest areas in California, where new development is occurring, and as more energy-efficient homes are built. The possible roles of further builder training, supervision, and construction planning as they relate to this potentially emergent problem warrant further attention.

Energy-Efficiency Related Warranty Calls and Builder Profit

With the exceptions of HVAC system problems and possibly issues surrounding bowed walls, evidence that energy-related construction problems are responsible for substantial costs to builders is not compelling. In an effort to control costs, builders in our sample already address the highest frequency callback items in their construction practices, and the majority of these appear not to be energy-efficiency related. Energy-efficient construction doesn't appear to generate substantially greater builder profit through warranty-cost control.

However, in reviewing builders' customer-service efforts, we continue to see an important connection between home owners and builders through the builders' commitment to customer satisfaction and efforts to build lasting relationships with home owners. Word-of-mouth advertising between customers and builders seeking repeat customers through exceptional customer service emerge as common strategies and goals in the production-home industry. Promoting energy efficiency through builders' marketing and sales efforts to achieve builder profit shows potentially greater promise.

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[9] "Stud straightening" describes a process of either "felting" concave portions of the framing studs, or "planning" the convex portions of studs to achieve a flat surface that can receive interior drywall or exterior surfaces. According to one framing subcontractor we interviewed, stud-straightened homes constructed with green lumber require about twenty percent more labor than homes framed with dried lumber; the savings to the builder using dried lumber for framing can be several hundred dollars per home.

[10] The majority of homes in Northern California, where this problem is less likely to occur, use green lumber. Dried lumber is almost exclusively used in Southern California already.

4. Opportunities for Selling Energy Efficiency

Offering energy-efficient options appears to have broad marketing appeal, and acts to invite consumers to consider particular builders, even though home buyers may not choose more energy-efficient options in their purchase decision. One builder we interviewed sells only energy-efficient homes, and competes well in California's housing market, but admitted that the first-time home buyer remains the most challenging target market they face.

In keeping with their profit interests, builders consider new revenue-generating opportunities, but in keeping with customer-satisfaction interests—especially for building trust in first-time buyers—they recognize that energy-efficient upgrades must be presented in ways that demonstrate value in the home purchase. As described in Section 2, value appears to be secured by purchasing features satisfying demands for comfort and quality before energy efficiency.

The Builder-Home Buyer Relationship and the Challenge of Promoting Energy Efficiency in New Homes

Because customer satisfaction is important to marketing and sales efforts, builders are less inclined to promote energy efficiency beyond specific consumer demand. An important obstacle in convincing buyers to purchase energy-efficient options is that energy savings are difficult to prove; they vary greatly with consumer use and energy prices. To save money with energy-efficient appliances, for example, the appliances need to be used; yet energy bills often encourage consumers to conserve energy (e.g., turn off the air conditioning). Builders are hesitant to recommend options when their value is questionable.

We were presented with examples of first- and second-time home buyers who purchased energy-efficiency upgrades and were disappointed with the extent to which these upgrades delivered performance relative to their additional first cost. In one housing tract, where the same builder offered energy-efficient homes along with standard homes, more customer

complaints arose from owners of the energy-efficient product. In this case, however, the builder believed that the increased incidence of complaint was due to some unique characteristics of these home owners and their home owner association, rather than the home product itself.[11]

In another example, when one builder offered a denser insulation option that supposedly provided additional soundproofing, more calls were received from disappointed home owners claiming that the insulation didn't work well enough with respect to soundproofing, relative to the additional cost they paid for it. Whether it improved energy-efficiency appeared to be irrelevant to these home owners. These examples indicate that energy efficiency is a "tough sell" to consumers, but perhaps an even tougher sell to builders seeking customer satisfaction and profitability.

But the fact remains that consumers often turn to builders for advice on certain features—including HVAC and insulation—that have clear energy efficiency implications. Note too that in a highly competitive market, builders appear willing to pursue novel revenue opportunities, which includes selling higher-priced energy-efficient options on the basis of consumer demand for comfort and quality.

Bundling Energy Efficiency with Quality and Comfort in New Home Sales

It appears difficult to sort out consumer preferences as they relate to comfort, quality and energy efficiency, especially as they are tied to costs. A builder trying to establish a trusting relationship with a home buyer is unlikely to speculate on savings or value of energy efficiency for a particular home owner, especially as the builder seeks a repeat customer on their next home purchase, or favorable word-of-mouth advertising to other consumers.

Above were illustrated two disappointing examples in builders' efforts to promote energy efficiency in new home sales. But at least three promising examples of "cross-selling" energy efficiency on the promise of greater comfort and quality also emerged from our discussions:

- Customers often choose low-e windows for the additional UV protection they provide, especially to reduce fading of drapes and furniture.

[11] In this tract, the type and frequency of warranty calls associated with the energy-efficient home did not differ substantially from those of the standard home.

- Patio trellises create additional attractive living areas. Plants can be added at a later time to provide additional shading, and as the home owner can afford to do so. Specially designed trellises can support solar panels, which can be installed at a later time as well.
- New technologies, such as multi-zone HVAC systems and tankless water heaters, promise greater energy efficiency and comfort than existing options.

Adding these items to the home sale increases builder profit through increased revenue, can add significant value to the home buyers' purchase, and has the potential to increase the energy efficiency of the home. According to one builder, offering solar panels on trellises, rather than on rooftops, reduced the potential for roof leaks (and potentially costs of warranty calls) as well as consumer hesitance to consider solar panels. Also, while a trellis that can receive solar panels may not achieve increased energy efficiency right away, it gives the builder another sale item, and the consumer an option that may have resale value with or without the solar panels installed at time of purchase.

Further research and demonstration of the reliability of some new technologies, notably multi-zone HVAC systems and tankless water heaters, is needed. These technologies promise greater energy efficiency and comfort, and potential for builder profit, but builders hesitate to offer them because they are new. Successfully promoting these items will require greater proof of their reliability and value to the home buyer before they can be incorporated effectively into the builders' sales pitch.

5. Options for Policy Development

Findings of this study suggest that there are some opportunities simultaneously to increase builder profit, customer satisfaction, and energy efficiency in new homes. In this section we present some options and interventions at various stages of the home building process that our findings support. These interventions emerge from three general observations that have implications for promoting energy efficiency in new homes in California:

- The greatest challenge for promoting energy efficiency in new homes is in the market for first-time home buyers looking inland, for the largest, most comfortable homes that they can afford. Information and resources to invest in energy-efficient options are least available to this group of home buyers.
- There is evidence that some design and construction measures may be taken to reduce cost to builders and improve energy performance of a home, but greatest incentive to builders to control costs are for problems least associated with energy efficiency.
- Motivating builders through increased profit to promote energy efficiency in their home products may be more likely achieved by equipping their marketing and sales efforts to increase revenue, rather than by informing design and contruction practices in an effort to control warranty costs. Builders' marketing and sales teams can sell energy efficiency to home buyers, with the credible information and risk-reduction options available to them. Making even a "tough sell" is what a trained salesperson is in the best position to do.

With these observations in mind, we present five interventions at various stages of the home building process that promote energy efficiency. All of them highlight the role of the builder in achieving greater energy efficiency in new homes. Because their implementation is linked to potentially greater builder profit, builders may embrace these interventions as well. Government support is likely necessary to catalyze builders' initial response to these.

Improve protocols and worker training, specifically to address HVAC design and framing problems such as bowed walls.

The nature of the construction industry—with relatively high turnover and variable availability of trade contract labor—makes worker training a continuing challenge. The builders we interviewed already analyze their customer-service records, with the intention of reducing the highest frequency customer complaints and otherwise controlling costs through better construction practices. These highest-frequency complaints and costs, however, are not energy-efficiency related. Of all problems occurring in new homes, addressing HVAC design and framing problems (i.e., bowed walls around windows) are most likely to have an effect on energy efficiency in homes.

Addressing HVAC and framing problems through better worker training and improved construction protocols may reduce some warranty calls and their associated costs to builders, but additional incentives and assistance are likely necessary to motivate builders. Incentives could include government sponsored rebates, tax incentives, and credit support for builders that extend their current efforts beyond "fit and finish" items to include HVAC and framing problems as well.

Better educate consumers on basic HVAC use.

Many new home owners simply do not know how to use their new HVAC system. In most cases, complaints related to cooling the home are simple to address, and require only adjustment of the registers or HVAC unit itself. Customer-service representatives often provide simple instructions on thermostat adjustment over the phone.

Better understanding of basic system operation, perhaps through improved documentation for home owners, may conserve energy, as well as reduce the number of calls and associated costs to builders. This information could also be provided through existing consumer-education programs.

Investigate performance and reliability of promising new technologies for homes, and support their use.

Business decisionmakers may entertain some risk when doing so may yield substantial profits or competitive advantage, but most builders are risk averse. Builders are hesitant to promote certain technological options to

consumers, such as multi-zone HVAC systems and tankless water heaters, because they are relatively new and their reliability is unproven. The fear is that these options may require not only greater up-front costs for home buyers, but incur greater warranty costs to builders, and customer dissatisfaction further jeopardizes ongoing client relationships or the builder's reputation. Yet these two particular technologies appear to promise greater energy efficiency and comfort in homes, and selling them introduces new revenue opportunities for builders.

More information is needed on these technologies and others, which could be provided to builders for use in their marketing and sales efforts. Useful information would describe performance results of further testing of these technologies under real operating conditions. Additional warranty support for newer technologies may also be necessary.

Identify further options for cross-selling energy efficient upgrades according to promise of greater comfort and quality in new homes.

Consumers seek value in making investments. While energy efficiency doesn't appear to weigh heavily in home buying decisions until home ownership experience and purchasing power increase—as in the second home purchase—the value of comfort and quality to consumers is apparently evident to all home buyers.

Certain energy-efficient home features such as low-e windows are often purchased for reasons other than energy efficiency (e.g., protection of furnishings from sun exposure.). There may be other energy-efficient amenities (e.g., multi-zone HVAC systems, tankless water heaters, and trellises that can support solar panels) that also have marketable consumer value in terms of comfort and quality.

Identifying these options, and making them even more attractive with additional incentives to builders and consumers, would present builders with additional revenue-generating options, increase customer satisfaction, and increase energy efficiency. The necessary dollar value of these incentives could be established through application of an appropriate survey methodology and analytic method (Appendix 2 presents more detailed guidelines on these).

Pursue risk-reduction strategies for selling energy efficiency through builders.

The builders' sales teams are nearest to the critical decision to purchase an energy-efficient upgrade in a new home, or not. Equipped with credible information and the necessary incentives (for both consumer and builder), experienced salespersons can make even a "tough sell." A variety of existing information and incentive approaches focus on the consumer to make more energy-efficient decisions, but few incentives for builders encourage these decisions. Builder incentives can be in the form of government-sponsored rebates, tax incentives, credit support, warranty support or otherwise focus on reducing risks to the builder when promoting energy efficiency in a home sale.

One approach may be through a government-backed price support system for the builder, allowing the builder to offer to the home buyer:

> *If this energy-efficient upgrade (e.g., for HVAC, insulation, or windows) doesn't save you X dollars on your energy bill, relative to the energy bills of others who purchase our standard product, we'll credit you the difference when you purchase your next home with us. Or you can pass the credit to a friend or family member who buys a home from us. You can't lose, even if we do.*

Then the government assumes this risk the builder takes through a builder-government agreement and pays the builder as necessary. The consumer is left out of this last transaction. The government may pay out in some cases, but is in a much better position to distribute risk across builders and markets than are individual builders and home buyers.

Such an approach takes advantage of the unique relationship the builder has, especially with the first-time buyer, and encourages builders to incorporate energy efficient options in their sales strategies. Such a guarantee gives the builder a revenue opportunity of an energy efficiency upgrade, and potentially strengthens returns from word-of-mouth referrals by home owners. In the case of a builder that targets both first-time and move-up buyers, such an approach potentially locks in a repeat customer.

Appendix 1: Quality, Comfort, and Energy Efficiency in New Homes—Concepts and Measures

The relationships among quality, comfort, and energy efficiency (QCEE) are conceptually central to this research program. In this appendix we seek to define these notions and consider relationships among them as they apply to homes.

The terms "quality," "comfort," and "energy efficiency" are not equally obscure. While its precise interpretation varies with the context, we have a clear notion of what energy efficiency entails and how to measure it. Quality and comfort are both more intimately familiar and more difficult to explain, and are more subjective than energy efficiency; as such they do not as easily lend themselves to quantification and rigorous valuation. Association pathways among quality, comfort and energy efficiency in new homes are gaining wider recognition, but the difficulty of measurement and valuation of these associations is at least as great as their component parts.

Energy Efficiency: Concepts and Measures

The construct of energy efficiency is well understood, and is readily quantified, for a device, a system, or a process, as the output of a good or service per unit input of energy.

Energy efficiency can be realized through *active measures* (such as compact-fluorescent lighting), which themselves consume energy but more efficiently than alternatives; through *passive measures* (such as high R-value insulation), which allow for less energy consumption in delivering energy services to the building occupant, without any intention on the occupant's part; and *behavioral measures* (such as adjustable window louvers), which require that the occupant engage in some particular behavior in order to reduce energy consumption.

Home energy efficiency may be achieved in space and water heating, in gas and electric appliances, in proper maintenance of the building's structure and systems, and in the materials and processes used in construction. With regard to residential construction, the principal energy efficiency concerns are for space

conditioning, water heating, and appliance and fixtures energy consumption. One home is regarded as more energy efficient than another if it can provide the same services with a lower level of energy consumption. However, unless the homes are identical in all palpable respects, they cannot be said to provide the same services to the occupants.

The outputs can be compared only to the extent that they provide similar quality of services, to achieve the same degree of occupant comfort. In this case, energy efficiency is often confused with energy conservation. Improving the energy efficiency of, say, a central air-conditioning unit will translate into energy conservation only insofar as the user maintains his comfort (room temperature) at the same level; if the user cares to increase his comfort for the same energy expenditures, he will take back some or all of the potential gains from energy conservation. The size of this effect for different energy uses is a matter of some dispute as is how to value increased comfort in determining the value of energy efficiency.

Measures of energy efficiency

Energy efficiency is measured at many different levels of aggregation. Standards institutes and professional associations establish units, measurement procedures, and performance standards for the energy efficiency of components and materials, such as heating elements and insulating fibers, and more integrated devices and processes, such as windows and air conditioning. Many of these standards are quality related as well.

Most useful for our purposes are methodologies for determining whole-house energy efficiency, such as Home Energy Ratings Systems (HERS). HERS entail comparing a rated home to a computer model of a reference home of the same size and shape and which meets the Council of American Building Officials Model Energy Code. A certified energy rater inspects the home and measures its energy characteristics, such as insulation levels, window efficiency, wall-to-windows ratio, heating and cooling system efficiency, solar orientation, and water heating system. The rater also conducts diagnostic testing, such as blower door for air leakage and duct leakage. The reference home is given a score of 80 out of 100; every five percent decrease in energy use earns the rated home a one-point rating increase. The widely used EPA Energy Star rating is given to homes scoring at least 86.

Quality: Concepts and Measures

Quality is a more elusive construct than energy efficiency, and discussions of quality tend to the metaphysical more than the physical. Yet a transcendent approach that poses quality as a metaphysical ideal is of little practical use to this effort. We consider the following more relevant approaches to assessing quality in new homes:

- *Product-based approach.* This approach holds that quality inheres in the quantity of one or more product attributes; e.g., the quality of a light bulb derives from its expected lifetime, color, temperature, etc.
- *User-based approach.* This approach holds that quality is contextual and subjective—that a quality product is suited to the uses to which it is put; this approach includes its value for money.
- *Manufacturing-based approach.* This approach finds quality in the degree to which a product conforms to specifications; it assumes optimal values of quality measures, rather than the open-ended positive scales of the product-based approach, and is most suited towards mass manufacturing, where consistency and interchangeability are paramount.
- *Value-based approach.* This approach shies away from superlative notions of quality, so that a satisficing product is adjudged to be of higher quality than a better performing but more costly alternative.

All of these approaches may be useful in considering QCEE for new homes. For the relationship between quality and energy efficiency, the product- and manufacturing-based approaches are likely best, as they are embodied in industry codes and standards. As comfort is more subjective and determined by the home occupant, a user-based approach should better capture the relation to quality.

Within any of the approaches to quality there are, to varying degrees, eight dimensions of quality, as described in Garvin (1984):

- Performance
- Features
- Reliability
- Conformance
- Durability

- Serviceability
- Aesthetics
- Perceived Quality

Features, conformance, and durability provide the most compelling links to energy efficiency. Indeed, the data-gathering effort summarized in Appendix 3 and also described in Section 3 largely entailed finding data on the instances of poor reliability and durability in new home construction. The Partnership for Advancing Technology in Housing (PATH) Program on Improving Durability in Housing (1999), for instance, takes a pragmatic and scientific approach, measuring the expected lifetime of housing components under standard use and care, as determined by accelerated testing to failure.[12] While comfort may derive from all of these dimensions of quality, the most direct manifestations that the occupant appreciates are in performance, features and aesthetics.

Any of the conventional structural elements of a home (i.e., frame, foundation, floors, roof, windows) can be of greater or lesser quality, independently in their design, workmanship, and materials or components. For instance, a roof can be well designed so as to shed snow, require little maintenance, and be attractive, but the skill and attention of the roofer and the choice of a roofing-materials supplier can either realize the quality of the design or render it moot. Similarly, a poorly designed roof could be laid precisely according to the specifications with very high quality slate, but not perform well by any of the occupant's criteria.

Measures of quality

As with energy efficiency, the housing industry and other interested parties have developed a wealth of operational measures of quality. International Standards Organization (ISO) 9000 is concerned with quality in the manufacturing process (interpreted as adherence to standards), which is expected to yield quality in outcomes. NAHB, PATH, and the Wood Truss Council have undertaken a pilot program to bring ISO 9000 certification to the framing industry, which is to yield tools including a framing quality manual; use-of-materials documents for basic materials, connectors, and hardware; training materials; job site inspection procedures and lists; methods to track and monitor quality; and contract templates that assign responsibilities and acceptance criteria. The NAHB

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[12] See also Uniacke, M. 1996. "Creating Quality in New Construction: A Practitioner's Perspective." *Home Energy Magazine.* January/February.

Research Center National Housing Quality Award is similarly concerned with construction processes rather than explicitly with outcomes.

The NAHB Residential Construction Performance Guideline is a collection of industry standards covering all aspects of home building, and is regarded as the only authoritative body of information on how new homes should behave under warranty. Industry standards and codes are inherently manufacturing-based approaches to quality.

Comfort: Concepts and Measures

Comfort may be perceived as an aesthetic judgment, through the physical senses, or as psychical well-being. Comfort is perhaps even more difficult than quality to measure and attribute—"comfort is not a condition, but a state of mind" (Goldman, 1999). As such, while surveys and experimental observation can yield normative measures of comfort, positive directives for comfort are less successful—if I insist that I am comfortable in a damp, 55 °F room, the fact that very few other people would find it comfortable does not have any bearing on my judgment.

Most of the comfort research literature relates to thermal comfort, which has external determinants that are more easily measured than other aspects of comfort and which is strongly associated with health outcomes, as well. This research has found that people tend to take notice of discomfort, rather than comfort; above some threshold, incremental improvements in comfort are not appreciated, while below the threshold discomfort is quite sensitive to improvements. Across a broad range of comfort attributes, it has been found that the subject's ability to control his personal environment (temperature, lighting, etc.) to his liking contributes heavily to the perceived level of comfort. Those housing comfort measures that have been developed do not strictly pertain to houses, but to their occupants; comfort rating schemes should be able to make use of these personal comfort measures.

The experience of comfort is a combination of aesthetic, physical, and psychical perceptions. While aesthetic judgments of quality can affect comfort perceptions (e.g., a well designed and installed window may be lend a higher comfort rating to a room's lighting than a lower-quality window that admits precisely the same natural light), physical perceptions of comfort are a more apt focus for this research program. All five of the senses (sight, hearing, touch, smell, and taste) can contribute, to varying degrees, to comfort perceptions. As noted earlier,

thermal comfort is the best studied, and is also the most important to home QCEE considerations, which focus on space conditioning concerns.[13]

As we have seen with quality, there is a matrix of responses of comfort senses to comfort attributes. Consider how a forced air register and its operation may affect the comfort of a room's occupant. Her comfort likely depends most strongly on the temperature of the air about her, but also on the distribution of temperature in the room (temperature gradients create discomfort). The air's smell and relative humidity (and associated electrostatic charge) likewise influence her comfort. Research has found that air velocities that would constitute a comfortable warming breeze outdoors (or through a room opening) are generally regarded as uncomfortable coming from an indoor source (Baker, 2000). The air motion induced by a fan is perceived as comfortable, while that from an air conditioning vent is not.

The air register also contributes to the occupant's acoustic comfort, from the sound of the air motion itself, the noise from the register grille, and HVAC system noise transmitted through the ductwork. The design quality of the register opening and grille, its location in the room, and the furniture layout dictated by its location all contribute to aesthetic comfort perceptions, as well. While we should not expect a comfort rating to account for all of these interactions, it must be kept in mind that a high comfort score along one dimension is not necessarily associated with high scores in other dimensions.

Measures of comfort

There do not appear to be any existing operational measures of comfort that can be applied to a whole house or even to a major system. Subjective comfort measures typically relate to an individual in an environment, and depend on the individual's behavior and condition, and so are multidimensional. For example, the optimally comfortable relative humidity varies by individual with the ambient temperature, clothing, and level of activity. The population distributions for this optimal humidity, furthermore, will vary by age and sex (Meier, 1994). With this variation, optimal comfort may not be the most appropriate measure; widely appreciated acceptable comfort may be the best that can be achieved.

Many measures for thermal comfort have been adduced (Nicol et al., 1995). The most widely used standard, developed by the American Society of Heating,

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[13] See Hackett, B. and B. McBride. 2001. *Human Comfort Field Studies Report*. California Energy Commission. Contract no. 500-98-024.

Refrigerating and Air-Conditioning Engineers (ASHRAE) is ASHRAE 55-1992R, Thermal Environmental Conditions for Human Occupancy, which focuses on workplace rather than residential environments. Visual comfort measures generally concern glare and daylighting (Sick, 1995.)

QCEE Associations

There are many association pathways among the quality, comfort, and energy efficiency attributes that we've considered and described above. These associations are gaining wider recognition; for instance, "ASHRAE's latest research programs attempt to link its thermal comfort concepts to incorporate effects of noise, odor, and other elements in indoor environmental quality (IEQ), and to link comfort with changes in such human behavior as productivity," (Goldman, 1999) and the similar efforts with regard to lighting (e.g., Veitch and Newsham, 1998).

The literature of consumer valuations (as opposed to perceptions) of quality, comfort, and energy efficiency is skewed heavily towards energy efficiency. While not conclusive, some rigorous analysis of revealed preference data from home sales suggests that energy efficiency investments in existing houses are fairly valued in the resale market (see Appendix 2). Yet it is not clear how these findings relate to new home sales. As noted elsewhere, very little is known about valuations of quality and comfort, and collective measures of QCEE associations do not appear to exist, likely because of the difficulty in measuring their component parts.

Appendix 2: Review of Consumer Value of Quality, Comfort, and Energy-Efficiency Data Sets

According to home builders, there is growing customer interest in energy efficiency and a perception that new homes are more energy efficient than resale homes. We are not aware of any rigorous analysis of how these perceptions of energy efficiency shape home buying behavior, let alone any that relates consumer preferences for quality, comfort, and energy efficiency (QCEE). In this section, we consider valuation data that reflect expressed preferences of home buyers, as from responses to surveys or interviews, and revealed preferences of home buyers, as from controlled experiments or econometric analysis of consumption data.

Meyers Group Exit Survey Data

The Meyers Group conducts ongoing exit surveys of prospective buyers of builder homes in the Southwest; they also collect builder data on new-housing developments. The latest survey, published with Meyers' partners in The Vision Group (2000), reflects the responses of 1900 prospective buyers of the homes of twenty builders, in April and May 2000. The survey is quite broad, and many questions address housing and builder attributes that could relate to QCEE (depending on our construal of quality and comfort and on respondents' interpretations). Three of the questions are somewhat more pointed, and are discussed below.

Respondents assigned influence weights (four-point scale) to each of eight purchase-decision attributes, four of which might be regarded as embodying QCEE:

- Builder's reputation (Q)
- Warranty / customer service (Q)
- Large number of options (QCEE)

- Short commute (CEE).[14]

The survey questions are all very briefly stated, with no explication of the intended meanings of the response options. Many buyers might construe "builder's reputation" to be a reputation for quality (of workmanship and materials), but some might interpret it as a reputation for low cost or for housing-development amenities. "Warranty / customer service" seems less open to interpretation. "Large number of options" may reflect all three attributes of interest (especially considering the vagueness of "comfort").

The responses to all the purchase decision attributes are shown in Table 1; the figure in brackets is a weighted composite score of "strong impact" and "some impact" responses.[15]

Table 1. Purchase decision attributes, with composite scores

Anticipated price appreciation	[159]	Warranty / customer service	[138]
Builder's reputation	[144]	Large number of options	[127]
Interest rates	[140]	Master-planned community	[98]
Size of lot	[140]	Shorter commute	[96]

Source: The Meyers Group

The question methodology makes it difficult to test for statistical significance of differences in buyer valuations of these attributes; it seems clear, nonetheless, that buyers care most about the investment value of the house, and secondarily about other attributes.

Another question asks, "what determines the quality of workmanship?" Respondents chose their top two selections from a list of eleven options, six of which might relate to energy efficiency or comfort:

- Materials / structure / construction
- Flooring quality
- Windows
- Features / options

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[14] To the extent that a shorter commute reduces transportation energy use, the household becomes more energy efficient.

[15] Weighted composite score represents 2 x "strong impact" + 1 x "some impact."

- Appliances
- Other

The responses to all options are shown in Table 2; the figure in brackets is the percentage of respondents naming that attribute.

Table 2. Determinants of quality of workmanship, with percent citing in top two choices

Details / finish / edges	[51]	Windows	[14]
Materials / structure / construction	[45]	Features / options	[13]
Builder reputation	[43]	Fixtures	[12]
Cabinetry / cupboards	[25]	Appliances	[8]
Doors / molding / walls	[22]		
Flooring quality / squeaks	[16]		

Source: The Meyers Group

This question is ambiguously worded for our purposes, with at least two likely common interpretations: "in which of these areas is quality of workmanship most important to you?" and "which of these areas best reflects a builder's overall quality of workmanship?" A question worded explicitly to elicit the former interpretation would be more useful to our purposes, but the "builder reputation" option is inconsistent with that formulation, so perhaps Meyers intended the latter.

In any event, it seems evident that buyers *represent* that quality detailing and the overall structure are more important than any particular features. Empirically, however, buyers may take greater note than they are aware of features such as windows and fixtures, or they may be aware of their preferences but feel it less superficial to say that they value materials and construction quality. To the extent that comfort derives from a general satisfaction with one's house or from aesthetic appreciation, then all of the attributes (except, in the latter case, dealer reputation) relate to comfort; as noted above, many of the construction attributes may relate to energy efficiency, but it is not evident how to make analytical use of these data. (It is also curious and unfortunate that quality of workmanship was not one of the items in the prior question on purchase decision attributes.)

The only questions that speak directly to energy matters concern preferences for gas or electric appliances, by appliance type. Respondents do not indicate the

reasons for their preferences (QCEE or otherwise). The responses are shown in Table 3; the figure in brackets is the percentage of respondents preferring gas.

Table 3. Preferences for gas appliances, in percent of respondents

Water heating	[94]
Stove	[91]
Space heating	[89]
Clothes dryer	[86]
Oven	[74]

Source: The Meyers Group

Note that this survey was conducted before the 2000–01 electricity crisis; preferences for gas were actually lower than in the 1999 survey. Even so, this survey does not indicate why gas is preferred—energy efficiency as such, expected lower operating costs (due to efficiency and relative fuel prices), or performance characteristics. Additional questions find that 88 percent of respondents say that they notice whether appliances are gas or electric, and that 74 percent would "spend more for a home that provided efficient natural gas appliances." This latter question does not ask how much more the respondent would be willing to spend for which sorts of benefits, nor is it clear whether the appliances in question are (a) natural gas and *therefore* implicitly "efficient" or (b) natural gas *and* more efficient than some baseline standard (i.e., would the responses differ if the characteristics of fuel type and energy efficiency were made independent?).

The foregoing questions address buyers' stated preferences; as suggested above, these may differ from their revealed preferences through two effects. Respondents may be aware of their (revealed) behavior and its implications but choose to answer differently, or they may answer truthfully according to their misunderstanding of the questions or their own behavior. To the extent that we are concerned with the ultimate goal of improving the energy efficiency of new housing stock, it is not necessarily important that stated and revealed preferences align, so long as the corresponding attributes are correlated. A contrived example: if buyers were to say that they preferred energy efficiency in washing machines, but they actually preferred quiet operation (comfort) and durability (quality), it would not matter for our purposes so long as the more energy-efficient appliances were also quieter and longer lasting. This is not a merely theoretical point; The Meyers Group collects detailed data on new-home offering

characteristics, including features and pricing. It may be possible from these data to extract some measures of willingness to pay for QCEE attributes, but not with the specificity that this task requires.

Other Survey Data

National Association of Home Builders

NAHB (2001) conducted a survey of about 1,200 recent or intended home buyers nationwide (of new builder homes and otherwise), with detailed questions on preferences. While few relate explicitly to QCEE, some may be useful.

Questions on building materials ask which are preferred and for what reason, some of which could be construed as quality valuations. The responses vary strongly by region and price range, but the stated reasons for the preferences vary less: appearance, low maintenance, and strength / durability all rank much higher than cost. Even so, we again confront the difficulty with interpreting quality; many respondents might construe visually attractive materials necessarily to be of high quality, whereas for our purposes strength and durability may be more apt indicators.

Seventy percent say they are very concerned about structural materials, and twenty-eight percent are somewhat concerned. This question may be the most closely related to quality—why else be concerned about (hidden) structural materials? (As with many others, this question is briefly worded and broadly interpretable: We might expect that most respondents would construe structural materials to include frame, foundation, and roofing, and possibly drywall, insulation, flooring, etc.)

The survey asks how each of eighty-nine designs and features would affect the purchase decision (on a four-point scale). The only explicitly energy-efficiency features are multipane windows; double-pane windows ranked as the tenth most-essential feature (twenty-one percent), and as the sixth most essential (thirty-five percent) in the West region. The only other features that relate directly to energy are energy-*in*efficiency features, such as whirlpool tubs and fireplaces, which few buyers find essential. Many options could be construed as quality or comfort attributes: construction materials, kitchen counter materials, bathroom fixtures, etc.

There are no questions about appliances. (Some might argue that appliances are easily replaced and should not factor as heavily in a purchase decision as more

immutable features like fireplaces and basements, but the survey does include features such as exterior lighting and a fenced yard.) A separate question asked about the importance of an energy management system (it is not evident that any explication was provided); fifteen percent hold it to be very important and thirty percent somewhat important.

The survey asked how concerned were buyers about the "environmental impact" of their new-home decision. Ten percent were not concerned, twenty-six percent were concerned but it was not a factor in their purchase decision, fifty percent wanted to reduce the environmental impact but were not willing to pay for it, and fourteen were willing to pay (an unspecified amount). Results in the West region do not differ significantly from those nationwide. As elsewhere, this question is too vaguely worded to be especially useful; it is not clear how prominent energy efficiency is in buyers' conceptions of the environmental impact of houses, but we might speculate that it is among the top few factors.

Respondents were asked how much they would be willing to pay upfront to save $1,000 per year in utility costs; the median response is between $5,000 and $7,000 (for an implicit real discount rate of about twenty percent); willingness to pay skews somewhat higher in the West, and is not significantly different for new builder homes. This result is certainly an upper bound on the actual willingness to pay, and is somewhat higher than other surveys have found. Questions of this sort are problematic, as some respondents may overstate their willingness to pay in order to appear environmentally conscious, and many are unable to make an abstract calculation that reflects their true personal discount rate.

A 1999 NAHB survey reported that eighty-eight percent of consumers indicate that builders and developers should build more energy-efficient homes and equip them with energy-saving appliances. But a 2000 NAHB study asked prospective buyers if they would pay less than $1,000 in the purchase of their next house in order to save $1,000 every year in utility costs; about two-fifths said they would. An NAHB economist observed that people actually want "wow" features that will impress their friends, and will say with one breath that they want an energy-efficient house, and with the next that they want a host of energy consuming comfort features (Salant, 2002). Another 2001 NAHB report similarly finds that ninety-six percent want energy efficiency.

Cahners Business Information

The Cahners publishing group reported in *Professional Builder* the results of an online 2001 survey of potential home buyers, conducted in partnership with the

Partnership for Advancing Technology in Housing (PATH), the U.S. Green Building Council, builders, and appliance makers.[16] Ninety-four percent of buyers claimed that energy efficiency features were among the three most important home upgrades—the number-one response. Respondents said they would pay an average of $2300 up front for energy-efficiency upgrades that would reduce their monthly energy bills (the survey question did not specify the monthly savings, so we cannot infer a discount rate from these data); two percent said they were unwilling to pay any more up front. A separate question finds that respondents on average expect a four-year payback time on energy efficiency upgrades, compared with three years in the 2000 survey. The energy-efficiency features that respondents most want to have as standard are insulation above code (83%), high efficiency heating devices (83%), passive solar (76%), Energy Star certification (61%), ceiling fans (60%), and sealed combustion HVAC equipment (51%).

One question tangentially relates quality and comfort attributes to energy efficiency: among the perceived benefits of "green buildings" seventy percent cite quality, fifty-two percent durability; and sixteen percent quiet. Possibly illuminating the NAHB questions about environmental impact, eighty-seven percent of respondents cite saving energy as the foremost environmental issue with green buildings, up from seventy-eight percent in 2000.

Pulte Homes

The Tucson Division of Pulte Homes (a builder of 5-Star homes) conducted a survey of its buyers in 2001. Fifty-five percent said that energy efficiency was very important in their decision to buy a Pulte home, and two percent said it was not important. Eighteen percent would be willing to spend $1500–2000 to save $300 per year in energy costs, sixty-seven percent would be willing to spend $1200–1500, and twelve percent would not be willing to spend anything.

California Energy Commission/Washington State University

The California Energy Commission and Washington State University are conducting a study of residential electricity use in California, and have surveyed nearly 2000 households and interviewed several hundred of those in greater depth (preliminary results in CEC, 2002). The questions concern respondents'

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[16] The methodology likely suffers from a high degree of selection bias, as respondents were among those visitors to housing related web sites who followed a link for a green building survey.

electricity consumption and conservation behavior and related beliefs, but none address valuations of building energy efficiency.

Data from other organizations

A 1997 National Family Opinion Research survey of recent new-home buyers found that eighty-nine percent reported wanting energy-efficiency upgrade options. A 2000 Realtors National Market Institute survey of realtors on buyers' wants had realtors saying that energy features were important in the buying decision for ninety-four percent of their clients. A 1998 survey by the Portland Cement Association (PCA) claimed that home builders underestimate how much buyers are willing to pay for energy efficiency. Earlier research had suggested that fifty-one percent of home buyers would be willing to pay five percent more for a home that offered twenty-five percent lower energy costs, whereas thirty percent of builders thought that home buyers would be willing to spend an additional five percent.[17]

Econometric Analyses—Revealed Preferences

Home buyers reveal their implicit valuations of various home attributes by their purchasing behavior. New homes are increasingly being offered with explicit options schedules; with data from cooperating home builders on options purchases we may be able to assess relative valuations of QCEE attributes.

A modest literature addresses revealed consumer valuations of home energy efficiency (with respect to both the thermal efficiency of the building shell and the efficiency of appliances and fixtures). Much of the analysis concerns whether consumers place a rational value on the financial returns (in lower utility bills) to investments in energy efficiency; that is, do they apply a consistent discount rate to all investments?

There appears to be an emerging consensus that improvements in building thermal-efficiency are fairly valued by resale home buyers (Nevin, Bender, and Gazan, 1999) while new, energy-efficient appliances and fixtures are not (Bataille and Nyboer, 2000). This discrepancy is attributed largely to differences in the perceived riskiness of the investments (Howarth and Sandstad, 1995). With funding from the U.S. Environmental Protection Agency (EPA) and the Housing

[17] In fact, the figures cited neither prove nor disprove the PCA contention; more detailed response distributions are required to assess whether builders properly estimate buyers' willingness to pay.

and Urban Development Department (HUD), ICF Consulting analyzed detailed data (from the U.S. Census Bureau's American Housing Survey) on 55,000 homes and found that, on average, an annual savings of $100 in utility bills from energy-efficiency upgrades translates into a $2000 increase in a home's value; these now widely cited results were published in Nevin and Watson (1998) and Nevin, Bender, and Gazan (1999). When accounting for the costs of the energy-efficiency upgrades, the increased home valuations reflect a twenty-three percent return on investment (Perkins, 2001a). These studies contend that the home appraisal industry has been slow to recognize the resale value of energy efficiency investments, an argument rejected by many appraisers (Perkins, 2001b).

The prior studies concern investments in energy-efficiency upgrades to existing houses. Horowitz and Haeri (1990) report on a study of new homes that were required to meet higher thermal-efficiency standards, and find that the real-estate market operates efficiently in capitalizing the value of energy savings into sales prices, with an implied discount rate of eight percent (at the time of the study, mortgage rates were about nine percent). Their review of the existing literature on consumer discount rates for energy efficiency finds values from seven to 378 [sic] percent; they attribute this discrepancy to measurement error in indirect measures of energy savings and costs. While comfort and quality attributes are not included in the econometric specification, the authors note that if a household discount rate for energy-efficiency investments is found to be lower than the prevailing mortgage rate, it might indicate that home owners view "the added expenditures as consumers as well as investors, finding additional, non-quantifiable benefits in the efficiency measures, such as decreased draughtiness or noisiness" (p. 128). While other analyses discuss such ancillary benefits of energy-efficiency investments, we have not discovered any empirical valuations of these benefits or any thoroughgoing discussion of their interrelationships.

Guidelines for Future Analyses of Consumer Valuation of Comfort, Quality, and Energy Efficiency

There are scant, largely anecdotal publicly available data on the value that consumers place on energy efficiency in new homes, and likewise for quality and comfort. It is apparent that consumers value quality, comfort, and energy efficiency to varying extents, but existing data are scarce and correspond poorly to the definitions of QCEE that we have elaborated in Appendix 1. We have, however, constructed an analytical framework that will allow for suitably targeted data gathering. This framework includes:

- Definitions of the terms of interest;

- Interrelationships among QCEE attributes; and
- Empirical studies of valuation of energy efficiency.

Based on this framework and on the results from existing surveys, we also provide some guidelines for future market-survey instruments. These guidelines correspond to operational definitions of quality, comfort, and energy efficiency, and provide for consistent comparisons of consumer values within and across the categories of interest.

Doing so rigorously, however, will require a more sophisticated survey methodology than that employed by The Meyers Group and other organizations whose findings we have reviewed. While these survey instruments are no doubt suited to these groups' needs for market research, it is difficult to infer relative preferences and willingness-to-pay for disparate goods from questions that ask for absolute valuations of individual goods. For example, if one randomly assigned set of survey respondents is asked to rate their fondness for apples on a five-point scale, and likewise for oranges and for bananas, and another set is asked to rate their relative preferences for the three fruits, we should not expect the outcomes of the two surveys to correspond. Survey participants are well known to value hypotheticals differently when presented individually or collectively, and commonly express nontransitive preferences. These problems are further magnified when the options are more disparate (e.g., relative preferences for apples, toothpaste, and television programs).

A host of survey methodologies and analytical methods have been developed to address these problems, including two paradigms of stated preference methods (conjoint analysis and discrete-choice modeling) and contingent valuation (widely used for valuation of nonmarket environmental goods). The hedonic pricing method, furthermore, allows for the implicit valuation of components of an aggregated purchase, when only the aggregate expenditure is observable; such an analysis of The Meyers Group builder survey data may reveal buyer valuations of quality, comfort, and energy efficiency attributes. A discussion of these and other candidate methodologies is beyond the scope of this report,[18] but any effort to pursue them should bear in mind several important classes of questions:

- How do home buyers interpret "quality" with respect to new home construction? These questions should be distinct from the relative

[18] See, e.g., Bateman et al. (2002) and Griliches (1971).

preference and valuation questions. Likewise, how do they interpret "comfort"?

- What associations do buyers make among quality, comfort, and energy-efficiency attributes and features?
- What relative preferences do buyers have for attributes from among these three classes? (i.e., pose discrete choices *between*, e.g., quality and energy-efficiency attributes.)
- What relative preferences do buyers have for attributes within these three classes?
- What relative preferences do buyers have for the three classes? These last three questions, together, may reveal inconsistent implicit valuations or misinterpretations of the classes and attributes.

These questions should be formulated and interpreted, to the extent possible, in a manner consistent with the definitions and metrics of QCEE as discussed in Appendix 1. We expect that meeting this condition should be challenging; while home buyers have an intuitive feel for quality and comfort and a rudimentary understanding of energy efficiency, the operational definitions and metrics for these attributes are, in the former case, arcane and, in the latter case, highly technical.

Furthermore, as noted above, The Meyers Group survey of builders is a potentially rich source of data on home buyers' implicit valuations of QCEE options in new homes; these data could be subjected to hedonic pricing analysis to yield estimates of willingness to pay for QCEE attributes. If these data (by homes) could be matched with survey data from those homes' respective buyers, then we could determine more rigorously the correspondence between stated and revealed preferences for quality, comfort, and energy efficiency.

Appendix 3: Review of Warranty-Cell Data Sources

We have identified several potential sources of data on construction and equipment defects that may relate to quality, comfort, and energy efficiency (QCEE) concerns (see also Appendices 1 and 2 on QCEE concepts, measures, and valuations). Ideally, we would like to associate particular causes for action with the QCEE attributes that we have defined, and to assess their frequencies, dispositions, and costs, as well as best construction practices that reduce their incidence. None of the potential data sources proved to have adequate data to support rigorous statistical analysis.

2-10 Home Buyers Warranty

2-10 Home Buyers Warranty (HBW) provides structural warranty protection for over one million houses nationwide. They collect few data on complaints. A small number of complaints go to claims, for which more information is recorded, but these are not necessarily representative of all complaints. Defect codes are sometimes entered with claims, but they identify defect types only generally, e.g., “workmanship,” “design,” and “heating.” These data are not readily called up from an electronic database.

We were provided some aggregate data on their activity in the last decade, which show that numbers of warranty enrollments have increased while the numbers of first- and second-year complaints and claims have declined. As their enrollments are not a random sample of new homes it is not evident whether building quality has improved in general or whether there has been some selection of higher quality home builders for coverage.

2-10 HBW tracks defect codes and year of complaint for only the ten-year structural component of the warranty; they do not track workmanship or systems defect codes, nor the costs of callbacks. Their customer service and claims departments are not sufficiently integrated to connect complaints data with cost data. They have published a pamphlet entitled “Top 10 Callback Items and How

Can You Avoid Them,"[19] but were unable to provide us with the data that support this list.

NAHB ToolBase Hotline

The NAHB Research Center ToolBase is a clearinghouse for home construction information. Its Hotline receives calls on a wide variety of building concerns, many of which concern construction defects that trigger warranty calls. Although the Hotline records do not include data on costs, we had thought that they might provide information on relative frequencies and consequences of various construction concerns, and aid in interpreting claims data. The Hotline database extends back to 1996.

The Hotline database is a four-level hierarchy, with each entry classified by:

- Industry Topic (27 codes)
- Subject 1 (8 codes)
- Subject 2 (55 codes)
- Construction Standards Institute (CSI) Level (16 codes)

Within each level, many of the codes *may* relate to QCEE concerns; we identified a small sample (twelve) of promising threads in this database, and requested copies of all of the corresponding database entries. These queries yielded approximately 200 entries from the 2000 and 2001 databases; of these, no more than seven explicitly mentioned a construction defect, two of those seven appeared to concern houses new enough to be under warranty, and neither of those was clearly energy-efficiency related. Numerous other shortcomings in the data collection render this database unsuited to our purposes.

Builders

Many large builders cover their own warranties, and likely collect detailed complaints and claims data, although they may be reluctant to disclose fully their numbers and costs. Our contact at The Meyers Group helped us identify potential data providers in these companies. Shea Homes was particularly responsive, and we visited the customer services department in the San Diego division.

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[19] http://www.2-10.com/whatsnew/pdf/top%2010%callback%20items%20all%20together.pdf

Shea's database is a Fox-based product called Service Tract, designed specially for home builders. They installed it in early 1999, and it is complete since February 2000. Earlier data are entered only if a new call arrives for the same house. We made one sample query of the database, which revealed that the problem descriptions are too cursory (e.g., "air conditioning not working") to allow for flagging as a build-quality or energy-efficiency concern with any certainty. Furthermore, the costs field is entered as zero if the call falls within the one-year limited warranty or a trade is at fault and absorbs the cost of mitigation. Even if the data were complete, unambiguous, and easy to query, they still reflect only a few thousand houses over two years, contra the CEC statement of work.

Absent any indication that other builders have a considerably more complete, refined, and accessible database, this approach does not appear fruitful.

Fannie Mae

Fannie Mae maintains detailed records of mortgage foreclosures, which include codes for energy costs and possibly for construction defects. Our contact at NAHB sought to determine whether these records are suited to inferring energy costs associated with construction defects, and concluded that they were not. We were unable to communicate with Fannie Mae directly on this matter.

Other Potential Data Sources

A search of the literature produced no public documentation of housing defects, nor any further references to proprietary information. We sought other organizations that might be concerned with housing defects and in a position to collect such data. We identified as candidates and contacted: the American Society of Home Inspectors (ASHI), the American Association of Home Inspectors (AAHI), the Foundation of Real Estate Appraisers (FREA), the California Real Estate Inspection Association (CREIA), and the Council of American Building Officials (CABO/ICC). None of these groups collect such data.

Conclusion

We have not identified any sources of data adequate to the stipulated task in this research program seeking to associate warranty call types, frequencies, costs, and construction practices that could reduce warranty call occurrences. We are inclined to conclude that no such data exist. While it is impracticable to conduct

primary data collection to acquire the sort of data that we had hoped to receive in this research effort, a more qualitative analysis of expert knowledge of construction defects may be quite promising.

Appendix 4: Interview Questions for Home Builders

Background

1. Your company and construction related activities:
    a. How large is your company? (revenue, homes per year, employees, market share)
    b. What are the locations of past developments and future targets? (county, city, or climate zone)
    c. What are the construction-related weather issues in those areas? (temperature, humidity, precipitation)
2. Your product, marketing approach, and competition:
    a. How would you describe your market and product? (e.g., high end, affordable, type, size, price)
    b. Over what market opportunities do you consider that you have a competitive advantage? (e.g. location, type of product, price, other)
3. Please describe your participation in energy-efficiency programs:
    a. Do you participate in Energy Star, Comfortwise, or other programs? (names)
    b. Do you take advantage of available government incentives? (names)
    c. What energy-efficient features do you offer in your homes? (features)

Product and Construction Problems

4. What is your total cost/budget for rework and warranty callback items annually?
5. What are your top-five highest frequency rework or warranty callback items?

a. Can you estimate the percent of frequency and percent of total rework / callback costs for these items?

b. Are there factors that affect the frequency of the top five problems you listed? (e.g. location, price of house, quality of materials). Are there different frequencies for different products?

c. Are there factors that affect the cost of the top five problems? Are there different costs for different products?

d. When addressing these top five problems, do they have an order of priority? What are criteria for prioritizing (cost, frequency, short-term, long-term planning)?

6. Are any of the categories listed below, which are not on your top- five list, also major items? If so, what are their estimated frequency and cost?

   a. Foundation

   b. Frame

   c. Sheathing

   d. Interior finishes (drywall, paint, plaster, nail pops)

   e. Floors (hardwood floor movements, vinyl)

   f. Exterior cladding (siding, roofing)

   g. Insulation

   h. Fenestration (doors, windows, skylights, leaks)

   i. Plumbing (leaks)

   j. Electrical

   k. HVAC

   l. Other (e.g., basement leaks, surface drainage

7. Focusing specifically on HVAC, are there differences in frequency and cost of callbacks in homes with ceiling vs. wall registers? In homes with single-, split-, or dual-AC systems?

8. Are there additional costs that are hidden to the builder because they are in the subcontractor costs? If so, what are they?

9. How does your company respond to consumers regarding these construction problems?

    a. Do you generally defer to home-warranty companies?

    b. Are certain calls (e.g., leaks) responded to with higher priority? Are there significant cost savings associated with doing so?

    c. Have these problems resulted in changes in building practices by your company, or other strategic planning changes? If not, why not?

10. Do you think rework or warranty callbacks affect sales? If so, can you estimate how much?

11. Do insurance and legal fees associated with rework and callbacks affect construction costs? If so, can you estimate by how much?

12. Are there alternative building practices that can minimize the rework and callbacks on highest priority items? If so what are some reasons that you have not employed these practices?

13. Is there a role for construction protocols to help avoid the highest priority problems? If so, where should they concentrate and why?

14. Are there potential cost savings to the home owner, or builder, associated with alternative construction protocols? Would cost reductions occur over the short or long term?

Dimensions of Comfort and Quality Relevant to Construction Decisionmaking

15. What aspects of "comfort" and "quality," or consumer satisfaction more generally, dominate the decisions made as they relate to construction?

    a. When a customer buys a home, what do you believe are the key perceptions that distinguish a home that the buyer might feel has greater "comfort" than another? (aesthetic, physical, psychical)

    b. What features of a home are most important to achieve the comfort of its occupants? (heating, cooling, lighting color and intensity, wall and flooring aesthetics and layout, noise suppression and transmission, etc.)

    c. Is there a relationship between homes that you would consider higher quality and comfort and callback / rework events?

Business Decisionmaking Related to Participation in Energy-Efficiency Programs

16. If you have built energy-efficient homes, how do they differ from your standard product?

17. Are any specific energy-efficiency features more or less prone to further problems compared to standard construction / feature alternatives? In other words is there a relationship between some energy-efficiency measures and callback / rework items?

18. Are there energy-efficiency features that contribute to increasing the quality and comfort of a new home?

19. Regarding participation / non-participation in energy-efficiency programs:

    a. What is your estimate of participation cost to the builder? ($ / house, % of sales price)

    b. What is the value of the various incentives you receive? ($ / house, % of sales price)

    c. Do you capture the difference in the sales price? (yes, no)

    d. If you do not participate in energy-efficiency programs or take advantage of incentives, why not?

    e. To what extent does consumer interest in energy-efficient homes affect your company's design and construction practices?

    f. What do you believe is the consumer interest in energy-efficient homes relative to interest in comfortable and high-quality homes?

    g. How much are consumers willing to pay for energy efficiency? ($ / $ annual savings)

References

-----. 2004. “California Home Prices Continue Breaking Records.” Builder Online February 13. (http://www.builderonline.com/article-builder.asp?channelID=55&sectionID=26&articleID=43648).

Baker, N. 2000. “We are all outdoor animals,” in Steemers, K. and S. Yannas (eds.) Architecture City Environment, Proceedings of PLEA 2000. London: James & James. 553–55.

Bataille, C. and J. Nyboer. 2001. “How Do Consumers and Firms Purchase Equipment That Consumes Energy?” Canadian Industrial Energy End-Use Data and Analysis Centre.

Bateman, I. et al. 2002. Economic Valuation with Stated Preference Techniques: A Manual. Cheltenham, U.K. Edward Elgar Publishing.

Cahners Research. 2001. Housing Zone: Green Building Survey—Customers. Cahners Residential Group.

California Association of Realtors. 2004. “California’s Housing Affordability Index falls five points in December; Minimum household income needed to purchase median-priced home is $94,730.” February 5. (http://www.car.org/index.php?id=MzMzMjQ)

California Energy Commission. 2002. Summer 2001 Conservation Report. (http://www.energy.ca.gov/efficiency/2001_CONSERVATION_REPORT.PDF.)

Farnsworth, C.B. 2003. “The Right Stuff.” Builder. May.

Garvin, D. 1984. “What Does Quality Really Mean?” Sloan Management Review. 26(1):25–43.

Goldman, R. 1999. “Extrapolating ASHRAE’s Comfort Model.” Int. J. Heating, Ventilating, Air Conditioning and Refrigeration Research. 5(3):189–194.

Griliches, Z. 1971. “Hedonic Price Indexes of Automobiles: An Econometric Analysis of Quality Change,” in Griliches, Z. (ed.) Price Indexes and Quality Change, Cambridge: Cambridge University Press.

Hassell, S., A. Wong, A. Houser, D. Knopman, and M. Bernstein. 2003. Building Better Homes: Government Strategies for Promoting Innovation in Housing. Science and Technology Policy Institute. MR-1658. Santa Monica: RAND.

Hackett, B. and B. McBride. 2001. “Human Comfort Field Studies Report.” California Energy Commission. Contract no. 500-98-024.

Horowitz, M.J. and H. Haeri. 1990. “Economic Efficiency v Energy Efficiency.” Energy Economics. April. 122–131.

Howarth, R.B. and A.H. Sandstad. 1995. “Discount Rates and Energy Efficiency.” Contemporary Economic Policy. 13(3):101–109.

J.D. Power and Associates. 2000. 2000 New-Home Builder Customer Satisfaction Study, cited in Perkins, B. 2000. “New Home Buyers Get Satisfaction from Smaller Builders.” Realty Times. September 22. (http://newsletter.realtytimes.com/rtcpages/20000922_smallbuild.htm).

Meier, A. 1994. “Some Like It Hot.” Home Energy Magazine. March/April. (http://hem.dis.anl.gov/eehem/94/940312.html).

Mitchell, R.C. and R.T. Carson. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington: Resources for the Future..

National Association of Home Builders. 1999. Survey on Growth Issues.

——2000. What First Time Home Buyers Want.

——2001. What 21st Century Home Buyers Want: A Survey of Customer Preferences.

Nevin, R., C. Bender, and H. Gazan. 1999. “More Evidence of Rational Market Values for Home Energy Efficiency” The Appraisal Journal. October. 454–460.

Nevin, R. and G. Watson. 1998. “Evidence of Rational Market Values for Home Energy Efficiency.” The Appraisal Journal. October. 401–409.

NFO Research. 1997. Consumer New Home Survey, conducted for Professional Builder, cited in Allen, D.R. 1998. “Do Consumers Buy Energy Efficiency?” Home Energy Magazine Online. March/April. (hem.distributed.anl.government/eehem/98/980311.html).

Nicol, F. et al. (eds.) 1995. Standards for Thermal Comfort: Indoor Air Temperature Standards for the 21st Century. New York: Chapman and Hall.

Perkins, B. 2001a. “Energy Improvements Add $18,000 to Homes, Say Studies.” Realty Times. June 28. (http://realtytimes.com/rtcpages/20010628_energy.htm).

Perkins, B. 2001b. “Appraisers Don’t Put Much Value in Energy-Efficient Homes” Silicon Valley/San Jose Business Journal. July 23. (http://www.bizjournals.com/sanjose/stories/2001/07/23/focus4.html).

Portland Cement Association. 1998. “Concrete Homes Winners in NAHB Research Center’s Energy Value Housing Awards.” Press release. May 18.

Primen. 2001. Attitudes and Behaviors of Residential Customers About Energy Efficiency. Cited in press release.

RESNET. 2001. “Tucson Division of Pulte Homes Discovers Market Demand for Residential Energy Efficiency.” (www.natresnet.organization/herseems/pulte.htm).

Salant, K. 2001. “Pay Now to Save Later” HomeGain.com.

Sick, F. 1995. “A Simulation Approach to Determine a Visual Comfort Index Including Daylight for Adequate Building Performance Evaluation.” Proceedings of Building Simulation ‘95. 295–300.

Uniacke, M. 1996. "Creating Quality in New Construction: A Practitioner's Perspective." Home Energy Magazine. 13(1):33-37.

Veitch, J.A. and G.R. Newsham. 1998. “Lighting Quality and Energy-Efficiency Effects on Task Performance, Mood, Health, Satisfaction, and Comfort.” Journal of the Illuminating Engineering Society. 27(1):107–29

Vision Group. 2000. Vision 2000: Designing the Next Generation of Homes.