

Passive Low Energy Housing Paradox of behaviors

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ABSTRACT: Drawing from more than three decades of firsthand experience with designing and building passive low energy housing in the United States for the hot-arid Sonoran Desert of the Southwest, the cold high plains of the Rocky Mountain West, and the hot-humid Piedmont of the Southeast, this paper evaluates how changes in the construction industry have restricted access to this housing type by would-be occupants. It describes how this lack of access has colored the behavior of these potential occupants to the point that when passive low energy housing is provided there is little to no understanding of how it should be occupied. The paper then outlines the methods the author is using to change the behavior of future occupants of passive low energy housing so they can better realize the full benefit the housing offers. Lastly, it describes how the design-build approach and the integrative design process are well suited for passive low energy housing.

Keywords: passive low energy, housing, labor, materials, integrative design, design-build

INTRODUCTION

The title for this paper, Passive Low Energy Housing: Paradox of behaviors, comes from the recognition that there are two user groups of housing in the United States, the homeowners and the builders, and the relationship between the two groups has yielded contradictory behavior between and within the groups.

BACKGROUND

The primary source of information for this paper is the author's firsthand experience with designing and building passive low energy housing in the United States. Beginning in the 1970s, the author has worked as a carpenter, general contractor, architect and professor of architecture. The author built his first passive solar house outside of Laramie, Wyoming, which was designed by Michael Frerking of Chino Valley, Arizona. It was one of the houses to receive the First Passive Solar Home Awards from the United States Department of Housing and Urban Development and the Department of Energy. [1] Since that time, the author has designed and built other passive low energy houses for the cold high plains of the Rocky Mountains, as well as for the hot-arid Sonoran Desert of the Southwest, the cold temperate Great Plains of the upper Midwest, and the warm-humid Piedmont of the Southeast. Experiences with two recent passive low energy house projects, one in Chicago, Illinois and the other in Charlotte, North Carolina, are cited throughout this paper.

CHANGING PARADIGM

The paradigm for building housing in the United States is vastly different from what it was in the 1970s, when two energy crises heightened public awareness about passive low energy housing. Two of the more significant changes are:

1. Fragmentation of the labor force, which has led to the loss of skills; and,
2. Domination of the building products market by big-box home improvement centers, which has led to a two-tier pricing structure for materials.

Fragmentation of the Labor Force The U.S. Department of Housing and Urban Development (HUD) lists four barriers to innovation in housing. They are risk, education, cultural values and fragmentation. [2] For fragmentation, HUD cites a report from the RAND Science and Technology Policy Institute that claims, "... the housing industry is fragmented vertically, horizontally, and geographically." [3] While this is interesting, it does not reveal the full extent of the fragmentation because the research does not look at the structure of the labor force within the building companies. Doing so reveals more and more laborers are being hired on a piece work basis to do specific tasks, and less and less tradesmen are being hired on an hourly basis to do a wide range of tasks. Instead of having a dozen carpenters who each know how to frame a house from the foundation up, there are a dozen laborers who each know how to frame a portion of a dozen houses. The laborers are in fact sub-subcontractors. Both approaches produce a dozen houses, but the latter offers

the owners of the construction companies the benefits of using low-skilled workers, providing less instruction and training, and controlling cost. The consequence of this practice is greater fragmentation in the construction of each house and a reduction in labor force skills.

Big-Box Home Improvement Centers In 1979, Lowe's Home Improvement began trading on the New York Stock Exchange and The Home Depot opened its first two stores. [4,5] Since that time, they have become the two largest home improvement retailers worldwide. There are several reasons for their success, but one that has changed the paradigm for producing passive low energy housing in the United States is their focus on servicing the needs of homeowners and builders of mainstream housing.

In comparison to traditional lumberyards and hardware stores, big-box retailers tend to narrow their product selection to the more commonly used products. Their goal is to strike a balance between limiting selection and retaining customers. Doing so concentrates the volume of sales on key products and gives the big-box retailers the opportunity to negotiate with manufacturers for more favorable pricing for themselves and their customers. [6] However, this model does not work when the customer needs a product that is not already in the inventory of the big-box retailer. The pricing on special order products at big-box retailers tends to be as high, if not higher, than the prices at traditional lumberyards and hardware stores. In some cases big-box retailers are unable or unwilling to provide the product.

On the Chicago project, fiber cement board siding was specified, yet neither of the big-box retailers providing the bulk of the materials for the project were able to provide the siding. It was ultimately obtained from a traditional lumberyard. On the Charlotte project, two-inch thick, closed cell, extruded polystyrene foam insulation board was specified. Both Lowes's and The Home Depot carry the product in a thinner thickness; however, when asked to provide the product in a two-inch thickness both quoted prices that were higher than what was quoted from a traditional lumberyard.

This is not to say big-box retailers are unwilling to add products to their inventory that are needed to produce energy efficient housing. In California, where tax incentives have heightened the demand for photovoltaic systems, The Home Depot sells photovoltaic panels, and provides installation. What is being said is big-box retailers service the market, not individual customers.

The problem for the traditional lumberyards and hardware stores is they can not match the pricing of the big-box retailers on the most popular products. This has lead to a two-tier pricing structure for building materials

that imposes a premium on materials not typically used by mainstream builders.

Both of these changes – loss of skills, and the creation of a two-tier pricing structure for materials – have yielded a paradigm that:

1. Makes it more difficult to utilize tried-and-true but non-mainstream building practices; and,
2. Severely limits the opportunity to introduce new technologies.

It is a paradigm that has left people seeking to live in passive low energy housing with few options for acquiring such housing. This is borne out by the fact that in the United States, passive low energy housing is absent from the market that provides the bulk of new housing, commonly called the production housing or speculative housing market.

ABSENCE OF PASSIVE LOW ENERGY HOUSING IN THE UNITED STATES

Looking at the web sites for the ten largest builders in the United States provides insight into how far the industry is from making a concerted effort to provide low energy housing. Five of the top ten builders make no mention of including energy efficient or environmentally responsible attributes in their houses. Among these five are the two largest builders – D. R. Horton and Lennar. One of the five that does mention energy efficient attributes – Fox Ridge Homes, a partner in NVR Inc. - only does so by displaying the Energy Star Partner logo at the bottom of their homepage. [7] The remaining four – Pulte, Centex, KB Home and Beazer Homes – tout programs they have in place to produce housing that is more energy efficient and environmentally responsible. Each of these programs focuses on enhancing the thermal performance of the building envelope with more insulation and tighter seals, and on using HVAC and lighting equipment that is more energy efficient. Not one of the ten makes any mention of using passive energy efficient strategies, such as passive solar heating or mass effect cooling. (See table 1.)

USER GROUPS

Most of the new housing built in the United States involves two groups of users/occupants, the homeowners and the builders; and it is the combined behavior of these two groups that defines the constraints and opportunities that exist for designers of passive low energy housing.

Builders As a user group, builders have a narrowly defined use for housing. It is a product for market with the goal to maximize profits. That being the case, designers have the opportunity to incrementally modify the behavior of builders by introducing changes that offer

Table 1 - Energy Efficient Attributes in Housing Produced by U.S. Home Builders

Energy Efficient Attributes in Housing Produced by the 10 Largest Home Builders in the United States		
Listed are the ten largest home builders in the United States, based on total closing in 2006, as reported by Builder Magazine. The listing of energy efficient attributes provided by each builder is based on information provided on their web site on January 23, 2009.		
Ranking	Company	Energy Efficient Attributes
1	D. R. Horton	No mention of energy or environmental attributes
2	Lennar	No mention of energy or environmental attributes
3	Pulte	"...more efficient central heating systems, and higher density insulation products. ...features like low VOC paint and air filtration systems. Recognized as an Energy Star partner, we ensure that our appliance packages guarantee low energy use with high comfort and durability."
4	Centex	"According to the NAHB Research Center, Centex Energy Advantage homes in a study demonstrated an improvement in energy efficiency of up to 22 percent over comparable homes built to the most widely used energy efficiency code (2006 International Energy Conservation Code). When compared to the energy efficiency of a typical 10-year-old home (as defined by the U.S. Department of Energy Building America Program), the Centex Energy Advantage homes in the study were shown to be up to 40 percent more energy efficient."
5	KB Home	My Home. My Earth. "We were the first major homebuilder to build exclusively with ENERGY STAR qualified appliances in every one of our new homes."
6	K. Hovnanian Homes	No mention of energy or environmental attributes
7	Beazer Homes	"We look for homebuilding materials strong enough to protect your family, while saving money and upkeep as years pass. Collectively, we call our approach eSMART™."
8	Ryland Homes	No mention of energy or environmental attributes
9	NVR Inc.	Fox Ridge Homes states it is an Energy Star Partner. They are one of the four home builders comprising NVR Inc.
10	Richmond American Homes	No mention of energy or environmental attributes

financial rewards for the builders. The rewards are needed because the building industry as a whole is extremely resistant to change, and builders equate change with risk, whether real or perceived. Expecting builders to make changes, even changes that cost nothing, solely on the basis of reducing energy costs for the homeowner or reducing the environmental impact of their product is naive. [8] In reality, the resistance to change is so extreme; it typically requires financial rewards that are disproportionately greater than the risks. This is the case for the adoption of tried-and-true non-mainstream building practices and the introduction of new technologies.

Resistance to Tried-And-True Non-Mainstream Building Practices Building practices and materials vary throughout the regions of the United States. In

some regions of the country asphalt shingle roofs are rarely installed with open valleys and sheet metal flashings; yet, for other regions it is the norm. Cast-in-place concrete foundations are commonly used in many regions of the country, but there are places where CMU foundations are more commonly used, despite the fact that concrete is readily available and competitively priced. It is differences like these that lead to mainstream building practices in one region of the country being seen as unconventional, or even exotic, to builders in another region. Such a distinction more times than not results in a reluctance to adopt the practice, especially without a financial incentive.

Beyond the spatial differences, there are temporal differences in tried-and-true building practices. Before air conditioning, houses were built with transfer grills

and ducts to help promote passive cooling. After air conditioning, it became difficult to justify the benefits of transfer grills and ducts in the context of low energy costs and no environmental concerns, so they became a thing of the past. Today, as part of a passive low energy solution for housing, they facilitate passive cooling and enhance the performance of conventional air conditioning. However, since their use is no longer part of the mainstream practice, builders typically do not provide them, even as an upgrade.

Resistance to New Technologies Looking at Advance Wall Framing provides an example of how difficult it is to introduce new technologies. Advance Wall Framing reduces unwanted heat losses and gains for the homeowner, and requires no additional materials or labor. [9] In fact, the U.S. Department of Energy (DOE) contends Advance Wall Framing is less costly for builders than conventional framing. [10] However, it is a technique that is still not widely used because the cost of coordinating and training a fragmented low-skill work force to use new technologies is higher than with coherent skilled work force. This is an example of the paradoxical behavior within the builders. In an effort to reduce costs the builders make decisions that limit their ability to realize other cost reductions.

Homeowners In dealing with homeowners as a user group, designers need to think about how the housing engages the user as much as they think about how the user engages the housing. It is not enough to design housing that autonomously functions as passive low energy housing. Most homeowners have no sense of how much energy is being used at any one time to maintain their thermal comfort and lighting needs, and when the user has no sense of how energy is being used there is little opportunity to alter their behavior. One technique the author advocates is the addition of an annunciator panel along side the thermostat to notify occupants when conditions are suitable for additional cooling and heating via passive methods. It is worth noting that one of the ten largest builders in the United States does offer homeowners a similar option, but the annunciator only deals with energy usage by the conventional HVAC system and other equipment in the house. It does not address passive energy usage. Providing an annunciator that includes passive energy usage obligates the occupant to become actively involved in the functioning of the house, and rewards them with lower energy costs and greater insight into what more might be done.

The discussion about the builders and homeowners to this point has focused primarily on the current state of production housing in the United States, which is

devoid of passive low energy applications. It will now focus on how builders and homeowners react when introduced to passive low energy applications.

DESIGNING AND BUILDING PASSIVE LOW ENERGY HOUSING IN THE UNITED STATES

After designing and building a couple of passive low energy houses it became clear to the author that over time builders and homeowners were not gaining insight into what constitutes a passive low energy house. It was true thirty years ago when two energy crisis thrust passive solar housing into the American culture; and, it is no less true now, after changes in the political landscape relegated it to a subculture. Conversations with builders and homeowners that were introduced to the Chicago, Illinois house in 2006 were no different than those with builders and homeowners introduced to the Laramie, Wyoming house in 1979. It is an unflattering commentary on the state of housing in the United States.

Today most builders and homeowners think of thermal comfort only in terms of thermostat temperature and unwanted drafts. For most of them, the nomenclature in the dialogue has not evolved to be more precise and comprehensive, so this is where the conversation typically starts for the author when first discussing passive low energy houses. Builders and homeowners must understand how dry bulb temperature, mean radiant temperature (MRT), relative humidity and air movement effect thermal comfort, to fully understand how passive low energy approaches work. As with previous projects, this was the case for the Chicago house and the Charlotte house. The Chicago house has a solar heated radiant slab and trombe wall for heating. The roofing materials have a high albedo and emissivity to reduce cooling loads, and a two story atrium provides stack effect cooling. Similar approaches are designed into the Charlotte house.

Once these approaches are explained there is typically a divergence in the attitudes of the homeowners and the builders. More often than not the homeowners become smitten with the idea of passive low energy housing; whereas, the builders become suspicious. It is at this point where the paradox in behavior between the homeowners and builders emerges. Homeowners want passive low energy housing but builders are reluctant to provide the housing. It is similar to what happened in the automobile industry in the 1970s. Buyers wanted fuel efficient vehicles but U.S. auto makers were reluctant to provide such vehicles. Where the similarity ends is the U.S. auto industry was ultimately forced to provide

fuel efficient vehicles, at least for awhile, when faced with competition from Japanese auto makers. For the homeowners there is no foreign competition forcing builders to make similar changes. What is emerging as a source of competition to the builders' business model is the integrative design process.

Integrative Design Thirty years ago, most municipal and county building departments did not require an architect's seal on drawings for single-family housing. This resulted in builders controlling the design process to the exclusion of architects. Today, it is more common for building departments to require an architect's seal, but builders are still controlling the design process by co-opting architects into a relationship that is unique to production single-family housing.

With most non-residential building types – educational, commercial, industrial, etcetera – owners who are knowledgeable about their specific needs, or their consultants, work directly with architects and engineers to produce buildings that are energy efficient, or at least strike a prescribed balance between initial and operating costs. It is a practice that gained momentum during the energy crises of the 1970s, and with an increase awareness about the environment, evolved into the integrative design process of today. Integrative design is, "... a discovery process that optimizes ... the interrelationships between all the elements and entities that are directly and indirectly associated with building projects in the service of efficient and effective use of resources." [11] It is also a process that is absent from the prevailing business model for production housing.

The reason why the interactive design process is absent from the prevailing business model for production housing is twofold.

1. Interaction between designers and homeowners is lacking, if not completely absent.

2. As discussed previously, homeowners have limited knowledge about passive low energy housing.

Builders position themselves between the designers and the homeowners to make their needs paramount. The only time the needs of the homeowners get relayed to the designers is when those needs serve the needs of the builder – that is, when it sells houses. Regarding the limited knowledge most homeowners have about passive low energy housing, it is unrealistic to think builders will choose to use their resources to educate homeowners when a more modest allocation of resources will sell houses. Telling homeowners compact fluorescents will reduce their energy usage is just as effective at selling houses as explaining the

nuances of passive solar heating, and it requires a less drastic departure from familiar building practices.

Bringing the interactive design process to housing requires a different business model. That model is design-build.

Design-Build Most architects are familiar with the cautionary phase, "Do not dictate means and methods." The problem they face when they do dictate means and methods is they are taking on additional liability which in turn jeopardizes their insurance. The down side of this practice is when architects ask builders to use non-mainstream practices and new technologies it leaves the builders feeling isolated and burdened. Faced with this condition, most builders opt to find other work or demand greater financial compensation. Either way, it is a chronic problem for architects working with passive low energy housing, unless they work around the cautionary phase by taking on the builder's role. In the design-build setting information flows more freely and costs are reduced. What the design-build setting also does is set the stage for the integrative design process.

The advantage the integrative design process brings to passive low energy housing, besides the environmental benefits, is the opportunity for design-build firms and homeowners to realize financial benefits not readily accessible through the prevailing business model used for production housing. For example, evaluating the costs of insulation systems, HVAC systems, windows and more in the context of financing options and energy costs typically results in housing that by comparison to production housing is more expensive to build but less expensive to heat, cool and illuminate. As a matter of fact, current standards used to build most production housing are so far from optimal it is not difficult to design and build passive low energy housing that is no more expensive to live in than production housing, despite the two-tier pricing structure for building materials created by the big-box retailers. Every dollar increase in the monthly mortgage payment is offset by a dollar decrease in the monthly utility bills. With this process, designers and builders realize the financial benefits of higher priced housing, and homeowners realize the financial benefits of shifting money from utility bills to equity and tax deductible interest. This is also the competition needed to effect changes within the production housing market.

CONCLUSION

The design-build approach and the integrative design process must be considered as the primary method for producing passive low-energy housing. Doing so

provides greater opportunity by removing one source of the paradoxical behavior, the production housing builders. It also provides competition, be it small, to builders producing production housing. Given enough time and growth it will in all likelihood bring passive low energy approaches to the mainstream. As the market shifts, the two-tier pricing for materials created by big-box home improvement centers will erode.

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