

## **Sustainable Engineering as a Tool for Improving the Manufactured Housing Industry within the United States**

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### **Abstract**

Over the last fifty years manufactured housing has been a major component of the affordable housing market in rural areas within the states of North Carolina and South Carolina, USA. The market experienced steady growth until the late 1990's when the market began to contract; in part because of the perception among homebuyers that manufactured housing is low quality. This perception is driven by the mobile home segment of the market where the houses are not constructed to conventional building codes and are often situated in poorly planned trailer parks. However, a significant portion of the market actually consists of factory built homes with construction and features comparable to conventional framed houses. This perception gap was noted by the U.S. Department of Housing and Urban Development's Commission on Affordable Housing and Health Facility Needs for Seniors in the 21<sup>st</sup> Century. This paper examines the implications of the Commission's findings on the Carolina manufactured housing industry and uses a sustainable engineered modular house designed and constructed by students at the University of North Carolina at Charlotte as a case study to explore how sustainable design principles can be used as a vehicle to overcome the perception gap and improve market competitiveness.

### **Keywords**

Manufactured Housing, Sustainable Engineering, Affordable Housing, Residential Housing

### **1. Introduction**

Since the 1960's, manufactured housing has represented a significant component of the affordable housing market within the United States as a whole and within the geographical region encompassing the states of North Carolina and South Carolina in particular. During the 1960's, manufactured housing accounted for approximately half of all housing starts in the Carolina region and shipments were growing at a rate of 20 percent per year in the early 1990's. However, like other traditional industries within the region – tobacco, textiles and furniture – the manufactured housing industry has been on a significant decline since 1998 (US Census, 2005). This decline has happened against the backdrop of a generally booming market for conventional homes during the same time period.

This paper reviews the findings from a study conducted by the U.S. Department of Housing and Urban Development's (HUD) Commission on Affordable Housing and Health Facility Needs for Seniors in the 21<sup>st</sup> Century and examines the implications of the Commission's findings on the Carolina manufactured housing industry. The paper then uses a sustainable engineered modular house designed and constructed by students at the University of North Carolina at Charlotte as a case study to identify lessons-learned that can be used by the manufactured housing industry to improve market competitiveness.

## **2. Distinctive Features of Manufactured Housing**

There are two primary supply components for the single-family residential housing market within the United States; site-built construction and manufactured housing. As the terminology used often varies within the market, for the purposes of this paper the principle sectors have been defined as follows.

### **2.1 Site-Built Construction**

Houses built on-site by traditional construction methods are called site-built houses and comprise the largest sector of the single-family housing market in the United States. Site-built houses must meet the building code standards adopted by the locality in which the homes are situated. In the last two decades, the number of newly constructed site-built housing units has consistently hovered around 1,000,000 homes per year (US HUD, 1998).

### **2.2 Manufactured Housing**

Houses built in a factory setting and delivered to the site are called manufactured houses. Because of their unique ability to be conveniently moved from one site to another, manufactured housing is commonly referred to as mobile or trailer homes. Mobile homes tend to be long and narrow and have lower pitched roofs to facilitate their movement over the roadway system. Manufactured housing is the second most important single-family housing type and accounted for over twenty percent of the housing starts (Weitz, 2004). The 2000 Census estimates that 8.6 million households reside in manufactured housing, an increase of nearly 41 percent between 1995 and 2000 (US Census, 2000). Manufactured housing is less expensive, on a square foot basis, than site-built housing as an average manufactured home costs \$30.90 per square foot compared to \$73.37 per square foot (including land) for a site-built home (Weitz, 2004).

Overall production of manufactured housing has decreased from 348,671 homes in 1999 to 193,120 homes in 2001 (Weitz, 2004). Manufacturers count production in one of two ways. The first is the number of floors or sections produced. The second is the number of homes produced (i.e. multiple sections combined to make one house). A single-section home consists of one floor. Multi-section homes can have two or more floors, typically all one level or story. In 2001, there were 275 plants producing manufactured housing in the United States (Weitz, 2004).

Modular housing is a sub-category of manufactured housing. In contrast to typical manufactured housing, modular housing is constructed to satisfy state and local building codes rather than the HUD code. The houses are usually situated on permanent foundations and are identical in construction to site-built homes. This feature limits the reach of modular housing as manufacturing plants must be geared to meet the code standards of the locality in which their homes will be sited. As a result, modular producers tend to be more localized, primarily working in only one or two states. Nationwide modular production was 37,800 homes in 2003 (NCMC, 2004).

### **2.3 Other Distinctions between Site-Built and Manufactured Housing**

Besides what has been stated above, manufactured housing differs from site-built housing in the following ways:

### **2.3.1 Differences in Codes**

One distinctive feature of manufactured housing is that it is not subject to local building codes and instead is constructed in conformance with the U.S. HUD code. The HUD code, created by the U.S. Congress in 1974, is the only national building code in the country. Under contract from HUD, the National Conference of States on Building Codes and Standards conducts plant inspections to assure that homes are built in conformance with the HUD code and each floor is required to receive a HUD label before it is shipped from the factory. The code, while having similar electrical and plumbing standards to state and local codes, differs from those codes in that the HUD code is a performance code rather than a prescriptive code. Furthermore, the HUD code covers only the production of the home in the plant and not the installation of the home on-site.

The HUD code is also unique in that it preempts all state and local housing codes. In doing so, it makes it possible for manufacturers to ship to different locales without the concern of complying with differing code requirements at each location. As a result, a few manufacturers with many plants ship homes to virtually every state.

### **2.3.2 Differences in Delivery System**

Manufactured housing relies on the basic retail commodity delivery model in that manufacturers sell their houses to independent retailers that in turn market the product to the consumer. The retailer frequently provides one-stop shopping including financing, insurance, and delivery and installation of the home on the purchaser's site. This delivery system has the advantage of simplifying the home purchase process but also creates some unique warranty issues for the consumer if problems arise with the house.

### **2.3.3 Manufactured housing parks**

Manufactured housing parks, also referred to as trailer parks, merit special attention, since approximately 36 percent of all residents of manufactured housing lived in parks in 1999 (Wilden, 2002). In such parks, the resident typically owns the manufactured home but leases the ground on which it sits. The closest parallel in the site-built housing sector is a condominium where residents own the air space but not the ground under or around it. However, whereas the condominium owner is represented by a condominium association, the manufactured home owner is in a landlord-tenant relationship with the park owner. Physical amenities at parks may include swimming pools, health clubs, common areas, and playgrounds.

One advantage of manufactured housing parks is that the residents can own their own home with a lower down-payment and debt accumulation than virtually any other housing alternative because the cost of land is not included in the transaction. However, most residents are on relatively short-term leases and, therefore, are vulnerable to substantial rent increases. Unfortunately, in strong markets, it is not uncommon for park owners to upgrade the park and substantially increase rents, thereby forcing lower income residents to sell or move their home to other locations.

## **3. HUD Commission Findings**

The HUD Commission on Affordable Housing and Health Facility Needs for Seniors in the 21<sup>st</sup> Century noted several trends that are directly applicable to the manufactured housing industry.

### **3.1 Blurring of Distinction between Manufactured and Site-Built Housing**

The distinctions between manufactured housing and other housing are becoming blurred as more production is being devoted to multi-section homes and less to single-section homes. The Final Report of the National

Commission on Manufactured Housing noted that from 1983 to 1993 the number of new multi-section homes sold compared to total manufactured housing units sold increased from 37% to 47%. This trend was confirmed in another HUD study which stated that in 1996 over half of all new manufactured homes were multi-section homes. The documented increase of multi-section homes, innovations such as hinged roofs, and the fact that more homes are being placed on permanent foundations has made manufactured housing almost indistinguishable from site-built housing.

Furthermore, a number of manufacturers have expanded into the retail business. In this way, their relationship with the consumer is more like that of a typical residential contractor. If problems occur with the home, the purchaser has only one entity to deal with in order to get the problem corrected instead of getting caught in the middle of arguments between the manufacturer and retailer over culpability.

### **3.2 Manufactured Housing Subdivisions**

Another significant change that is blurring the distinction between manufactured and site-built housing, is the entry of traditional site-built home developers into the market and are beginning to develop subdivisions using manufactured homes. For example, in 1993 the Pulte Home Corporation, a very large site-built developer, substituted manufactured homes for site-built homes in a subdivision development located in Apex, North Carolina (US HUD, 2000). The subdivision includes seventy-seven lots of double or triple-section homes with garages and porches. The initial homes ranged from 1,815 to 2,166 square feet and were located on lots averaging 10,000 square feet. The homes have roof pitches that are typical of site-built housing in the area and the appearance of the subdivision is such that it is impossible to differentiate it from traditional subdivisions. The cost savings achieved by using manufactured housing allowed the developer to offer the homes at a cost below comparable site-built units. Homes sold so fast initially that the developer raised prices in order to bring purchases more in line with production capacity. In order to facilitate more such developments, HUD published two new guides: "Manufactured Home Producer's Guide to the Site-Built Market" and "Home Builder's Guide to Manufactured Housing."

### **3.3 Perception versus Reality**

Perceptions of manufactured housing and its residents are every bit as important as the reality of manufactured housing because perceptions determine how the product is accepted and where it is able to be located. In order to examine the perception of manufactured housing by consumers, researchers conducted two surveys in eight rural counties in Virginia (Beamish, et al, 2001). In the surveys, they interviewed both residents and non-residents of manufactured housing residents and nonresidents in the same community concerning their attitudes about single-section and double-section manufactured homes. The reality was that residents of single-section and double-section homes had more education, income, ownership of the land as well as the home, and lived on open farm land in greater numbers than were perceived by either manufactured housing residents or community residents at-large. Thus, the manufactured home industry must address the common misperception that manufactured housing is associated with only socio-economic disadvantaged communities and residents. Although residents of manufactured housing do have average incomes below that of households in single-family housing, it is noteworthy that most households in manufactured housing are not poor, with well over half of them having incomes above 1.5 times the poverty level (Wilden, 2002).

## **4. Case Study of Sustainable Engineered Manufactured House**

As part of a Solar Decathlon Competition sponsored by the U.S. Department of Energy, University of North Carolina at Charlotte (UNCC) students designed and constructed a sustainable engineered manufactured

house. The 500 square foot, totally energy self-sufficient house was one of fourteen entries in the competition, which was held from September 30 to October 4, 2002 in Washington, D. C. As part of the requirements for the competition, the house was engineered with the following primary goals (Liou, 2004):

#### **4.1 Comfort and Livability**

The first goal was to build an energy-efficient house with adequate thermal insulation characteristics, lighting, and architectural features to provide a satisfying level of comfort and livability. To accomplish this, a preliminary design for the building envelope was developed based on the heating load requirement alone and then an energy simulation was used to verify the proposed building envelope's suitability for cooling loads as well. As a result, the house was constructed using insulated wall and roof panels produced by Insulspan and transparent window panels provided by Kal-wall. To enhance the livability, the studio-type house was designed to include one bath, a front porch, a rear sunroom and a fully functional kitchen including a range, oven, dishwasher, and a clothes washer and dryer. To increase the amount of natural lighting, the house was fitted with skylights throughout.

#### **4.2 Energy Systems**

The second goal was to build a house that relied solely on solar energy to provide the power required for normal living activities such as washing, cooking, office work, and transportation. This was accomplished by using a roof-mounted solar photovoltaic (PV) power system that could provide 4.5 kilowatts. The system was designed to provide enough power for lighting, appliances, and charging an electrical vehicle for the duration of the competition. As the PV panels produce direct current, a converter is required to run standard alternating current appliances. However, in order to minimize the size and cost of a converter, a marine-style direct current compact dishwasher, dryer, clothes washer, stove and convection oven were provided. Lighting and electrical wall outlets were all wired for standard 120-volt AC operation.

#### **4.3 Construction and Transportation**

The third goal was to build a house that could be easily disassembled, transported to another location, and reassembled for use at a new location. As the solar house had to accommodate multiple relocations from Charlotte, North Carolina to Washington D. C. and back again to Charlotte, several manufacturing-home builders were consulted concerning weight and transportation-related issues. As a result, the house was designed as an "irregular" mobile home in that the chassis was longer and had more axles than the typical mobile home, thus increasing the load carrying capacity. The chassis was also made of three connected sections instead of one single section. This allowed the rear two sections of the chassis to be uncoupled from the main section which added flexibility in re-configuring the house at a new location. The front section carried the main portion of the solar house and the two rear sections carried the front porch and back sunroom. It took 5 days to assemble, fit, and start up the house for the competition.

### **5. Potential Applications for the Manufactured Housing Industry**

As noted previously, the manufactured home industry suffers from general misperceptions that impact the marketability of their homes, particularly the perception that because manufactured housing is low cost it must also be low quality and, therefore, suitable for only socio-economic disadvantaged individuals. Lessons-learned from UNCC's solar house provide three ways that the manufactured housing industry could use to overcome this perception and improve the marketability of their homes. The first is to incorporate sustainable or green engineering principles into their houses. The general public is becoming

more environmentally conscious and products that can be labeled environmentally sensitive have strong resonance in the consumer market. Steps to improve the energy efficiency of the homes, including inclusions of alternative energy sources where possible, would allow the manufactured housing industry to position themselves in that niche of the consumer market.

Another way to improve their marketability would be to continue to expand the architectural variety and amenities associated with their houses. This could be accomplished by developing innovative methods for building and delivering “irregular” manufactured housing to the site that moves further away from the typical box or trailer home perception of the industry. As discussed previously, the industry has already taken steps that have begun to blur the distinction between manufactured and site-built housing and additional steps to increase this blurring can only help the industry. As seen from the UNCC solar house, porches and sunrooms can be built and delivered to improve the livability and aesthetics of a home. In addition, innovative ways in configuring and connecting sections at the site could be developed that would allow more interesting floor plans and exterior features.

Finally, as manufactured homes become more indistinguishable from site-built housing, the use of manufactured housing in subdivisions will become more acceptable. This would provide developers with another option besides the traditional trailer park for providing homeownership opportunities to moderate and low-income households. The key would be to design such developments in a manner that would provide all of the advantages of a site-built subdivision (i.e. long-term tenancy, low-cost financing; real estate appreciation, etc.) and at the same time offer the substantial cost savings of manufactured housing. To accomplish this would likely require the homes to be situated on permanent foundations, thus moving away from the traditional mobility of manufactured housing.

## 6. Conclusions

Although the manufactured housing industry continues to provide home ownership opportunities to those who either choose manufactured housing over site-built homes or are unable to afford site-built housing, the industry has been experiencing a significant decline since 1998. However, lessons-learned from a sustainable engineered manufactured house designed and constructed by students from the University of North Carolina at Charlotte highlights ways the industry can use to improve the marketability of their homes. Available options include: 1) incorporating sustainable engineering concepts into the homes so that they can be marketed as environmentally sensitive, 2) expanding the architectural variety and amenities associated with the homes, and 3) promote the increased use of manufactured housing in regular subdivisions. These steps, if incorporated, will help overcome the misperceptions among consumers that have restricted the growth of the manufactured housing market and industry.

## 7. References

- Beamish, J. O., Goss, R. C., Atilas, J. H., and Kim, Y. (2001), “Not a Trailer Anymore: Perceptions of Manufactured Housing”, *Housing Policy Debate*, Vol. 12, No. 2, pp. 373-392
- Liou, Donald (2004), “Engineering A Sustainable House for Solar Decathlon 2002”, *Proceedings of International Conference on Sustainable Engineering and Science*, Proceedings Abstracts Book, pp. 88-89, and PDF Proceeding Book, Paper #25, pp 1-10, Auckland, New Zealand.
- National Modular Housing Council (2004), *Modular Housing News Spring 2004*, [http://www.manufacturedhousing.org/pub\\_mod/default.asp?id=1&article=48](http://www.manufacturedhousing.org/pub_mod/default.asp?id=1&article=48) (4/14/05)
- U.S. Census Bureau (2000), “Census Bureau Housing Topics”, <http://www.census.gov/hhes/www/housing.html> (4/14/05)
- U.S. Census Bureau (2005), “Manufacturing, Mining and Construction Statistics”, <http://www.census.gov/const/www/mhsindex.html> (4/14/05)

- U.S. Department of Housing and Urban Development, (1998), “Factory and Site-Built Housing – A Comparative Analysis.”
- U.S. Department of Housing and Urban Development, (2000), “Manufactured Home Producer’s Guide to the Site-Built Market” and “Home Builder’s Guide to Manufactured Housing.”
- Weitz, Jerry (2004), “Manufactured Housing: Trends and Issues in the ‘Wheel Estate’ Industry”. *Practicing Planner*, Vol. 2, No. 4, American Planning Association, <http://www.planning.org/affordablereader/pracplanner/essentialsvol2no4.htm> (4/14/05)
- Wilden, Robert W. (2002), “Manufactured Housing And Its Impact on Seniors,” Wilden and Associates, LLC, a report prepared for the Commission on Affordable Housing and Health Facility Needs for Seniors in the 21st Century.