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GREEN AND HIGH PERFORMANCE FACTORY CRAFTED HOUSING

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ABSTRACT

In the U.S., factory-built housing greater than 400 square feet is built either to the U.S. Department of Housing and Urban Development (HUD) code for mobile homes or site-built codes for modular housing. During the last few years, as the production of HUD code housing has dwindled, many leading-edge factory builders have started building modular homes to compete with site-built housing and stay in business.

As part of the Building America Industrialized Housing Partnership (BAIHP) we have assisted in the design and construction of several “green” and high-performance modular homes that Palm Harbor Homes, Florida Division (PHH) has built for the International Builders’ Show (IBS) in 2006, 2007, and 2008. This paper will summarize the design features and the “green” and energy-efficient certification processes conducted for the 2008 show homes, one of which received the very first E-Scale produced by BAIHP for the U.S. Department of Energy (DOE) Builders Challenge program¹.

INTRODUCTION

While the modular industry has seen a 30% decline in shipments from last year, high-performance, factory-crafted homes have gained increasing interest from builders and product manufacturers at the International Builders’ Show². Not just constructed for demonstration, the past two years’ show homes have been sold to developers and “re-located” to hot and humid climates. This has included re-commissioning and minor modifications to ensure climate-appropriate performance. During the past several years, the BAIHP has worked with PHH to ensure that the design and construction of the International Builders’ Show demonstration homes, and the strategies and “renewable” products integrated in the homes, are optimized with the end use and location in mind. The success of this work has resulted in over 100 “green” and energy-efficient home orders received by PHH. Each show home since 2006 was built for “temporary” demonstration then permanently relocated for occupancy. The main goal of BAIHP’s involvement is making sure

the homes perform in their permanent site as they were promoted at the show and also coordinating the “green” and energy-efficient certifications they qualify for.

BAIHP conducts systems research and provides technical assistance to factory and site builders in the hot-humid Southeast and the Pacific Northwest. While this paper will detail BAIHP’s involvement with “green” and high-performance factory-crafted homes, it is the other research and analysis that has allowed for cost-effective technical assistance for the show homes. BAIHP’s involvement includes, but is not limited to, coordination of system-enhancing strategies, integration of sustainable products, climate responsive designs, and occupant and builder friendly controls. The show homes are sponsored by product manufacturers that contribute both financial sponsorships and product donations to highlight their products and materials. BAIHP ensures that the sponsored products do not compromise the production of high performance and sustainable factory-crafted homes showcased at the IBS.

These high-performance factory-crafted homes have resulted in a market shift for the manufactured housing industry. From “trailers” - the term these homes were historically coined as - to desirable living environments, the modular home industry encountered a large growth rate in the 1990s, accounting for nearly 25% of housing starts³. However, as seen in the past couple of years, unfavorable real estate, financial and labor market trends have all contributed to the challenges that now exist for sellers of all types of housing – including modular homebuilders. The improved performance of these homes has awarded them “green” and energy-efficient certifications from several third-party programs. This makes factory-crafted housing competitive with site-built construction in a more sustainable demanding market shift.

BAIHP assists in the design and sponsorship meetings to coordinate these efforts. We also offer support during construction so that these “one or first time” integrations can be implemented with little hiccups or delays, ensuring potential cost competitiveness for future duplications of the show homes’ high performance specifications.

FACTORY CRAFTED HOME DEFINED

There is often confusion about what is considered a factory-crafted home. For the benefit of this paper, the National Modular Housing Council's interpretation will be defined⁴. Almost all homes built today are comprised of some type of "factory built" component. The differences in factory-built housing are as follows and may not even be visible when compared side by side:

Modular Homes: These homes are built in a factory as modules that meet the state or local building code where the home will be located. Modules are transported to the site, installed on foundations (either pier or slab) and completed. A modular home is comprised of two or more modules.

Panelized Homes: These are homes in which panels - a whole wall with windows, doors, wiring and outside siding - are transported to the site and assembled. The homes must meet state or local building codes where they are sited (i.e. Structurally Insulate Panels (SIPs)).

Pre-Cut Homes: This is the name for homes in which building materials are factory-cut to design specifications, transported to the site and assembled. Pre-cut homes include kit, log and dome homes. These homes must meet local, state or regional building codes.

Manufactured Homes: These are homes built entirely in the factory under a federal building code administered by the U.S. Department of Housing and Urban Development (HUD). Manufactured homes may be single- or multi-section and are transported to the site and installed.

INTERNATIONAL BUILDER'S SHOW (IBS) PARTICIPATION AND HOME RELOCATIONS

Since 2006, BAIHP has assisted PHH each year in the design and construction of the demonstration homes "set" at the IBS, but built off-site in the factory. This venue attracts over 100,000 attendants and provides a platform for PHH to demonstrate the advantages of factory-built construction. Each year product manufacturers display their products in the homes that PHH builds, further showcasing the ability for any product to be integrated in factory construction. BAIHP distributes literature in the form of one-pagers that highlight "green" and energy-efficient strategies used in the high-performance homes. There are seven case studies that can be viewed on the web⁵ under the title "Profiles of high performance homes showcased at

the International Builders Show". Each year the homes that are showcased are eventually sold and relocated to permanent locations. Rarely is it known where the home will be permanently located during the design stages. This makes it difficult to climatically specify features reliant on solar exposure, prevailing winds, etc. The 2006 show home was relocated six months after the show to Auburndale, Fla., and an additional 1,250 square feet were constructed on-site.

Figure 1 highlights the specifications and tested data of the "Bellaire" as it was "set" at the IBS. Figure 2 shows the home relocated and retested. The home was featured in the Polk County Builders Association Parade of Homes and is Florida Green Building Certified.

The 2007 IBS had two factory-crafted structures set for demonstration. BAIHP was responsible for finding donations of the 3.25kWp photovoltaic (PV) system, solar hot water system, and inverter with battery back-up and energy management system, as well as integrating these features into the Gen-X home being showcased. This home, along with a tri-plex, was tested and exceeded the EnergyStar Homes standards under the new HERS Index (as opposed to the previous HERS score). Figure 3 shows the Gen-X as it was specified, set and tested during the show, and Figure 4 shows it relocated to its permanent site in Sarasota, Fla., where it was also tested and re-commissioned. It was fortunate that the future site plan (Sarasota) was provided for this home so that the PV and solar hot water system could be placed to optimize solar exposure without relocating the panels or compromising the structural integrity and weather protection of the roof. BAIHP is currently involved in commissioning the Gen-X, ensuring that the mechanical and renewable systems will perform as designed. Two systems - a whole-house, demand ventilation system and a dedicated dehumidification system - were integrated due to the air tightness of the home, allowing for controlled and dehumidified ventilation, which is desirable for acceptable indoor air quality (IAQ). This is in addition to local exhausts in bathrooms and kitchens recommended in energy-efficient homes among building scientists. This home is sold but not occupied to date. However, BAIHP plans to monitor its performance. The home will also qualify for FGBC Green Home certification.

BAIHP also assisted with the first time ever, demonstrated-in-the-show, multi-family structure built by PHH. This was a tri-plex and marketed as affordable, workforce housing. It highlighted that "green" and energy-efficient features could be

integrated into factory-built, affordable construction. All three units exceeded EnergyStar standards and FGBC Green Home certification. These homes could also qualify for local utility incentive programs.

The 2008 IBS was the show that unveiled the National Association of Home Builders' (NAHB) Green Home Standard. It elevated their Green Home Guidelines to a third party review and attempted to "nationalize" a "green" standard. The NAHB's National Green Building Standard has been

submitted to the American National Standards Institute (ANSI) for approval to become an American National Standard. The National Green Building Standard is awaiting approval by ANSI. At the 2008 show, the NAHB held its first ever "Green Day" promoting the practice of moving "green" building into the mainstream. PHH constructed two energy efficient, certified FGBC green homes that were scored in accordance with the NAHB Green



Energy Efficiency Features

- Low-E vinyl windows U=.34, SHGC=.35
- R-33 vented ceiling
- High efficiency heat pump, SEER 13, HSPF 8
- ENERGY STAR® Appliances
- Extensive use of compact fluorescent lighting
- Home Energy Rating Scale (HERS) Score = 89.6 out of 100

Indoor Air Quality Features

- VOC Source Control including zero VOC paint

- Central vacuum system
- Duct System Sealed with mastic and fiberglass mesh and performance tested

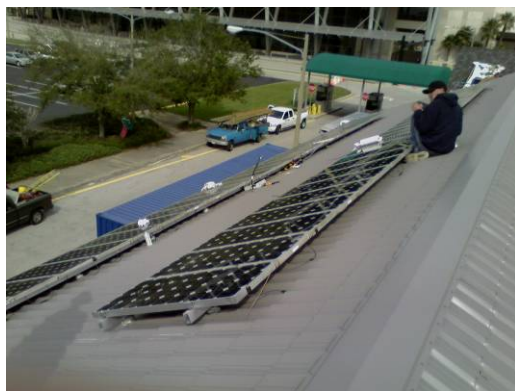
Other Green Building Features and Certifications

- Resource efficient construction and construction waste management
- Water efficient appliances and fixtures
- Fire protection system
- Durable, low maintenance design
- *Certified Florida Green Home* by the FGBC

Figure 1. 2,865 sq. ft. Palm Harbor Homes, the Bellaire – “Move up Buyer” Rendering



Figure 2. The Bellair with addition permanently located Auburndale, FL



Energy Efficiency & Renewable Energy Features

- Low-E vinyl windows
- R-33 ceiling, radiant barrier decking, metal roof
- SEER 14/8.4HSPF heat pump
- ENERGY STAR® Appliances
- Extensive use of compact fluorescent lighting
- 3.25 kWp BP Solar PV System with GridPoint Inverter & Instant, “Clean” Battery-Based Backup Power & Energy Management
- Solar Domestic Hot Water System
- Home Energy Index (HERS) = 71

Indoor Air Quality & Noise Reduction Features

- Low & zero VOC paint
- Outside Air Ventilation with Dehumidification
- Central vacuum system
- Duct System mastic and performance tested

Other Green Building Features and Certifications

- Resource efficient construction and construction waste management
- Water efficient appliances and fixtures
- Elevator for handicap accessibility
- Durable, low maintenance design
- *Certified Florida Green Home* by the FGBC
- Progress Energy Home Advantage Premium Energy Saver/Energy Star Qualified

Figure 3. 3,000 square foot Palm Harbor Homes, GenX photograph and features as set at show



Re-comissioned HVAC

- A/H and condenser match
- Blower Door and Whole House retested
- Monitoring to take place

Other Green Building Features and Certifications

- Raised 6’ above flood plain
- Will recertify for *Florida Green Home* by FGBC
- FPL’s BuildSmart Program & other (Federal and State incentive programs)
- EnergyStar Qualified

Figure 4. 3,000 square foot Palm Harbor Homes, GenX photograph and features, relocated to Sarasota (140 mph zone)

Building Standard. Had the ANSI approval and site minimum criteria been met, both show homes would have qualified for gold level. The Bimini II “Green” Home (Figure 6) received the very first EnergySmart Home Scale (E-Scale) produced by BAIHP for the U.S. Department of Energy Builders Challenge program. This initiative is called the Builders Challenge, and homes that qualify must achieve a score of 70 or better on the E-Scale. The E-Scale is a scale that allows homebuyers to understand - at a glance - how the performance of a particular home compares to that of others⁶. Both the Bimini II, and the other home showcased, the Glen Cairn “Comfortably Affordable” (Figure 7), were insulated with spray foam insulation. This was the first time PHH had utilized this technique in their factory. Due to the roofs on these modular homes using a “hinge” method to ensure that height restrictions are not exceeded during transportation, it does not allow for complete foaming at the factory. Some areas (roof hinges, marriage lines, etc.) had to be sprayed on-site. This continues to be a logistical hurdle (and cost factor) to accomplish this technique solely in the factory. Nevertheless, each of PHH’s show homes utilized both types of spray foam - open cell and closed cell.

This further enhances the indoor air quality, making it a more air-tight home and encouraging controlled, demand ventilation.

At the 2008 IBS, BAIHP also initiated a “green tag” that identified the “green” or energy-efficient products and/or strategies throughout the Bimini II and the Glen Cairn. This helped highlight the categories that each product or strategy was applicable to in accordance with NAHB’s green guidelines (Figure 5).



Figure 5. The Home Builders Tag



Energy Efficiency & Renewable Energy Features

- Low-E, double glazed, impact resistant vinyl windows (U=0.35, SHGC= 0.30)
- 15 SEER/8.6 HSPF heat pump, Carrier with programmable thermostat
- Icynene foam insulation (walls = R13, roof = R21)
- Duct performance tested (duct leakage, Qn=0)
- ENERGY STAR® Appliances
- Extensive use of fluorescent lighting
- AllSolar domestic hot water system sponsored by SunBuilt Program with Rinnai tankless, gas back up
- Meets Builders Challenge Standards with a Home Energy Index (HERS) = 57

Indoor Air Quality & Noise Reduction Features

- zero and low VOC paint
- use of 75% reduced VOC caulks and sealants
- Formaldehyde free fiberboard
- Outside air ventilation
- Central Vacuum system
- Low sone exhaust fans
- Direct fireplaces (2)
- Water leakage detector

Other Green and Sustainable Building Features/Certifications

- Resource efficient and construction waste management
- Water efficient appliances and fixtures
- Meets the *Gold level in all categories except site per the new NAHB-National Green Home*
- *Certified Florida Green Home* by the FGBC
- *Progress Energy Home Advantage Premium Energy Saver (if sited in PE territory)*
- Builder is *Building America Partner* and *Builders' Challenge* participant
- Built for 140 mph wind zone

Figure 6. 3,242 square foot Palm Harbor Homes, Bimini II “Green” Home photograph and features at the show



Energy Efficiency Features

- Low-E, double glazed, vinyl windows (U=0.35, SHGC= 0.30) with impact resistant shutters
- 13 SEER/7.7 HSPF heat pump with programmable thermostat
- Honeywell (walls = R13, roof = R21)
- Duct system performance tested (total duct leakage, Qn=0)
- ENERGY STAR® Appliances
- 99% use compact fluorescent lighting
- Expected to Meet Builders Challenge Standards with a Home Energy Index (HERS) = 69
- Relocated to FGBC and LEED Development Community

Figure 7. 1,767 square foot Palm Harbor Homes, Glen Cairn “Comfortably affordable” Home photograph and features at the show

BAIHP assisted with seven homes over the years at the International Builders' Show. In addition to these "pre-built" demonstration homes, BAIHP created a high performance specification for FEMA to refer to for disaster relief housing. Two improved specifications are presented in this report to enhance energy efficiency, sustainability, indoor air quality and provide back up power, without compromising human health, safety or comfort, in typical ruggedized temporary housing. This analysis considered the tangible benefits, such as having back-up power capability for essential loads during extended power outages, as well as intangible benefits like more day-lit spaces and improved air quality. Nearly three years after Hurricanes Katrina and Rita, occupants of the temporary homes provided by FEMA have alleged that formaldehyde levels made them sick. There are about 17,000 plaintiffs that have joined in lawsuit claiming that chemicals emitted from the wood used in the temporary shelters have been linked to cancer and other respiratory problems. FEMA has since established a formaldehyde standard of 16 parts per billion, in line with the Centers for Disease Control and Prevention³. This report also generated areas for further investigation of innovative technologies and construction methods.

While this project never resulted in a built structure, it did model the efficiency, sustainability, self-sufficiency and cost savings that an improved ruggedized manufactured home could expect. The full report titled "Improved Specifications for Federally Procured Ruggedized Manufactured Homes for Disaster Relief in Hot/Humid Climates" can be found online⁷.

RESEARCH DRIVEN STRATEGIES

Through systems research that BAIHP has been involved in, atypical strategies that would not normally be implemented in modular factory built construction have been implemented cost-effectively. While the high-performance strategies were mentioned in the specifications and figures above, the detailed explanations are described further in another submission for the 2008 Symposium on Improving Building Systems in Hot & Humid Climates titled "An Overview of Current Building America Industrialized Housing Partnership (BAIHP) Activities in Hot-Humid Climates." These include, but are not limited to, interior duct systems, whole-house mechanical ventilation (WHMV), dedicated dehumidifier, plug load reductions, etc. It was mentioned in the showcased homes above, but there are instances where energy load reductions were addressed through automated controls, like

humidistats in the bathroom exhaust fans. All these strategies produced an improved factory-crafted home and the effects of these strategies are scheduled to be instrumented with monitoring equipment. This data will quantify the effectiveness of "green" and energy-efficient, factory-crafted homes⁸.

GREEN AND ENERGY EFFICIENT DISTINCTIONS AND AWARDS

The homes for which BAIHP has provided support have not only performed as proposed, but have also received "green" and energy-efficient distinctions and awards like FGBC Green Home designation. There are several "green" and energy-efficient rating/certification programs that the IBS show homes have "qualified" for, received certifications and have been "pre-certified" to achieve. The figures above highlight the certifications that the homes have qualified for and/or been awarded. These demonstration homes are rarely "pre-sold" during the design stage. This poses a challenge fulfilling some categories in "green" certification programs, such as FGBC, Leadership in Energy and Environmental Design for Homes (LEED-H) and NAHB Green, that are related to lot design, landscape, location and linkages, sustainable sites, swimming pool and water front considerations.

The FGBC Green Home Standard, while specific to Florida, allows the home to be certified even without a site. If any category minimums cannot be achieved, point deficiencies may be made up by adding the deficiencies to the minimum score requirement of 100. This has allowed the demonstration homes built and sited in Florida to be FGBC certified during the show at its temporary location and then recertified when relocated to permanent site. LEED-H is more stringent in their standards for their certification process, with regards to lot-related categories, and will not allow the home to be considered for certification unless the site is planned. They also do not have a standard for modular homes. BAIHP has attempted on several occasions to propose that homes be considered as "pre-certified," contingent on meeting the minimum site requirements when the lot has been identified. The NAHB's Green Home Standards (when the standards are approved by ANSI) will likely be similar to LEED-H, but the organization has allowed for language such as "Meets the Gold level in all categories except site per the NAHB-National Green Standards" to promote the home. Significant efforts toward creating a "green" building certification program for manufactured homes through the National Residential Green Building Standard developed by the ICC/NAHB is in the spotlight to

assist manufactured home builders' ability to market and sell homes certified at the same level of standards that site-built construction is (<http://www.modularcouncil.org/mc/>).

There are also energy-efficient certifications and programs that the homes detailed above qualified for, such as EnergyStar rating, Builders Challenge and Progress Energy BuildSmart. These federally-backed and local incentive programs validate the importance of improved performance. To earn the EnergyStar rating, a home must meet guidelines for energy efficiency set by the U.S. Environmental Protection Agency. These homes are at least 15% more energy efficient than homes built to the 2004 International Residential Code (IRC) and include additional energy-saving features that typically make them 20% to 30% more efficient than standard homes. Many of the homes demonstrated at the IBS also qualified for federal tax credits. This is a \$1,000 tax credit to the producer of a new manufactured home achieving 30% energy savings for heating and cooling over the 2004 IECC and supplements.

As mentioned earlier, two homes demonstrated at last year's IBS received the first two E-Scales administered by the Building America program. The Building America builder partners and other energy-efficient builders joined U.S. DOE Secretary Samuel Bodman on stage to "take the challenge" to build homes that are between 70 and 0 on the E-Scale. Secretary Bodman posted the first E-scale on the PHH Bimini II show home and was assisted by U.S. DOE Assistant Secretary Alexander Karsner and FSEC's Deputy Director Philip Fairey (Figure 8).



Figure 8. Secretary Bodman places E-scale in Bimini II at the show

The NextGen home, built in 2006, showcased storm-resistant construction and the latest in home electronics. Storm-resistant strategies included: built to Institute for Business and Home Safety's Fortified...for safer living program®, in-home storm shelter, impact-resistant glass and storm shutters, roof

sheathing with taped seams, galvanized metal screw-down shingle, and corrosion-resistant plumbing and fire protection system (Figure 9).



Figure 9. NextGen home at the 2006 IBS

CONCLUSIONS

BAIHP is working in several research areas to advance the energy efficiency and overall performance of new homes - factory, as well as site-built - in hot, humid climates. BAIHP is currently assisting with 2009 IBS demonstration homes, which will be built at the Tempe, Ariz., plant and "set" at the show in Las Vegas, Nev. Also, BAIHP is partnering with Federation of American Scientists and participating in the discussions with the International Codes Council (ICC) on high-performance manufactured housing. ICC⁹ and HUD are supportive of developing specifications that would increase the market share of such homes. The Builders Challenge quality metrics and energy performance levels would be the starting points. The unrealized potential for high-performance guidelines could advocate a potential turning point for the real estate industry. At a 2007 average cost of \$53 per sq. ft., it is clear that a manufactured home is much more affordable than a site-built home, which has an average cost of \$100 per sq. ft. (excluding land price for both)².

At the IBS show each year, attendees are always surprised to see how the modular industry has transformed, and it is a viable comparison to site-built construction. These demonstration homes, outfitted with the latest products in the construction industry are a confirmation that today's manufactured homes are not the "trailers" they were thought of in the past. With minimal initial costs, they can be desirable living environments with lower operating expenses, less maintenance and enhanced indoor air quality without compromising occupant comfort or safety¹⁰. BAIHP continue to encourage sustainability while supporting their partners with energy efficient and high performance technical assistance.

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