USING SHOW HOMES (AND SPONSORSHIPS) TO PERSUADE COMMISSIONING RELEVANCY AND FACTORY CRAFTED HIGH PERFORMANCE MODULAR HOMES

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ABSTRACT

The International Builders' Show (IBS) sponsored by the National Association of Home Builders is a venue attracting over 100,000 builders and building related professionals every year. The increased attendances each year improves the educational sessions, vendor participation and "live" home construction demonstrations. The "live" home demonstrations are a great opportunity to integrate high performance construction and commissioning strategies into the marketplace to validate and distinguish products and the show home builders.

At this past year's IBS show in February, Palm Harbor Homes built the GenX home that included an installed and operational 4.08kWp photovoltaic system with inverter and back up battery management system, a solar hot water heater, completed and passed the thermal bypass inspection checklist required for EnergyStar certification and obtained Florida Green Building Certification.

The home also qualified for a local utility rebate for meeting EnergyStar, further demonstrating that incentive programs encourage high performance building practices and are vital to integrating commissioning procedures into the marketplace. Blower door and duct leakage tests were conducted to quantify as built conditions validating modular manufacturing quality assurance. This paper aims to provide a case study of commissioned, performance measures that justify costs for these demonstration projects and "live" show homes.

INTRODUCTION

The International Builders Show (IBS) (http://www.buildersshow.com/Home/) is the largest show for home builders and housing professionals in the U.S. With over 100,000 attendees, it is the premier show case for housing technologies. At a parking lot near the IBS convention center, several full-scale model homes are constructed every year to showcase the latest construction methods and technologies. These model homes are typically built as modular homes in a factory, transported to the parking lot and assembled and finished there in a period of two to three weeks.

As part of FSEC's Building America Industrialized Housing Partnership project (www.baihp.org), the authors have assisted Palm Harbor Homes (PHH) (www.palmharbor.com) in making their IBS show homes a good example of energy efficient and green housing since 2005. PHH has been a partner of FSEC since the early 1990's and has incorporated FSEC's suggestion of constructing ducts with mastic (rather than tape) and testing the duct system with a duct tester (Figure 1) in every home (5,000 to 10,000 homes/yr) PHH builds throughout its factories since 2000 (Chasar et al. 2004). Testing on over 100 home sections in the factory showed that this has resulted in over 50% reduction in measured duct leakage -- from a leakage of 5.7% (CFM25 to out measured as a % of floor area in sq. ft.) to 2.4% (Chasar et al. 2004). This not only saves energy but also results in improved indoor air quality and durability of PHH homes.

PHH is a producer of HUD code and modular homes. Due to the downturn in HUD code home sales (Table 1), PHH has been concentrating on increasing its production of modular homes built to local codes that can be financed as site built homes. The IBS affords PHH an ideal venue to demonstrate their high quality of home construction to developers and home builders and has resulted in significantly enhanced sales of modular homes in recent years.

Figure 1 Factory testing of Duct Systems with a Duct Tester

Table 1 HUD Code Home shipments and Site built housing starts (Source : Manufactured Housing Institute, http://www.mfghome.org/admin/template/subbrochures/396temp.pdf)

Year	HUD code shipments	Site built Starts	HUD code %
1995	339,601	1,076,300	24.0%
1996	363,411	1,160,900	23.8%
1997	353,377	1,133,500	23.8%
1998	372,843	1,271,400	22.7%
1999	348,671	1,334,900	20.7%
2000	250,550	1,230,900	16.9%
2001	193,229	1,274,600	13.2%
2002	168,491	1,358,500	11.0%
2003	130,937	1,499,100	8.0%
2004	130,802	1,610,500	7.5%
2005	146,744	1,715,800	7.9%
2006	117,510	1,463,700	7.4%

THE 2007 PHH IBS HOMES

Ever since the EnergyMiser® series of homes in the 1970s, PHH has been a producer of energy efficient HUD code homes and has been gradually increasing the energy efficiency of their homes. In 1997 the PHH Plant City, FL (the factory that builds the PHH IBS show homes) built the world's first two HUD code Energy Star homes. FSEC monitoring showed 30% savings in cooling energy use (Chandra et al. 1998). For the 2007 show homes, PHH decided to build two types of products – a two-story single family home for the move up buyer (the Gen-X, Figure 2) and a 3 unit townhouse for the affordable market (the "Echoboomer", Figure 3) . Both were modular products built to Florida codes. Both were built to meet Energy Star and the Florida Green Building Coalition Green Building standards. In addition, the Gen-X featured a PV system (Figure 4) with a battery backed up inverter system (Figure 5) to provide power for essential needs during power outages (e.g. after hurricanes, blackouts, etc.)

Figure 2 – The 3,397 sq. ft. Gen X show home

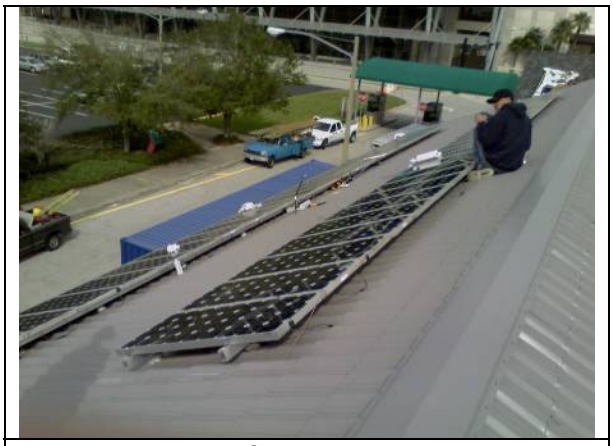

Figure 4 – 4.08 kW_p PV system on Gen – X

Figure 3– The Echoboomer show homes (3 townhouses- 1,840; 1,360 and 1,360 sq. ft.)

Figure 5 – Inverter system with battery backup

The energy, indoor air quality and green features of the show homes are listed below in Table 2

Table 2 Show Home Features

Feature	**Gen - X**	**Echoboomer**
Energy		
Windows	Low-E Vinyl (and impact resistant)	Low-E Vinyl
Attic Insulation	R-30 ceiling with Attic Radiant Barrier	R-20 closed cell foam on ceiling, vented attic
Wall Insulation	R-7 Batt	R-7/R-19 shared walls closed cell foam
Lighting	Mostly CFL	Mostly CFL
Appliances	Energy Star Refrigerator and Dishwasher	Energy Star Refrigerator and Dishwasher
Heating Cooling System	SEER 14 / HSPF 8.4 Heat Pump	SEER 15 / HSPF 8 Heat Pump

Water Heating	Solar Water Heater w/ Gas Instantaneous Water Heater	Gas Instantaneous Water Heater
Energy Star Certification	Yes	Yes
Tested HERS Index w/o PV system (solar dhw not included*)	71	76(left), 80(middle) and 75(right)
Photovoltaic System	4.08 kW_p with battery backup	None
Indoor Air Quality		
Fresh Air Ventilation	Yes, integrated with a whole house dehumidifier	Yes, runtime only via 4" flex duct
Source control	Zero VOC paint; formaldehyde free cabinets/millwork	Zero VOC paint; formaldehyde free cabinets/millwork
Central Vacuum System	Yes	Yes
Duct System	Mastic sealed and tested	Mastic sealed and tested
Bathroom Exhausts	Low sone fans	Low sone fans
Green Building and Noise Reduction Features		
Construction Waste Management	Yes	Yes
Handicap Accessibility	Universal Design	No
Durable, Low Maintenance Design	Yes	Yes
Water Efficiency	Water Efficient Appliances and Fixtures	Water Efficient Appliances and Fixtures
Soundproofing	Yes	Yes
Green Certification	Yes, By Florida Green Building Coalition (FGBC)	Yes, By Florida Green Building Coalition (FGBC)

* The ratings were computed as the show homes were sited in the convention center parking lot; water was not supplied therefore solar hot water system not included. When the home is sited in Siesta Key, FL the rating will be recalculated to include solar hot water system.

Please note that due to high levels of energy efficiency and other features, these homes qualified for the FGBC certification despite getting no credits in the site and landscaping categories as the homes were sited on the parking lot. The FGBC certification details area available online at http://floridagreenbuilding.org/

COMMISSIONING DETAILS

Several tests and inspections were performed on the show homes to assure their performance and quality and to obtain data needed to conduct Energy Star and Green certifications. These processes are discussed below:

Factory testing to measure total duct leakage:

The PHH Plant City factory produces homes with overhead duct systems, located in vented attics. The factory construction process is such that the ceiling sheetrock is done before the ducts are installed. The duct boots are foam sealed on top of the ceiling and then the flex ducts attached to the boots. The total duct leakage of each home section is quickly measured by a duct tester who has rigged the testing device in an easily transportable frame (see middle picture of Figure 1). A hole is cut on the top of the main supply trunk and the duct tester attached there. Connecting the hoses and measuring the total duct leakage takes less than two minutes and generally very little leakage is found nowadays after several years of practicing good duct construction techniques. After testing and recording the data, the hole is resealed by putting back the round piece of duct board and applying fab glass and mastic around the joint to seal it airtight.

TBIC Inspection in the factory:

The Thermal Bypass Inspection Checklist (TBIC) is a new checklist required for Energy Star Compliance. The TBIC checklist and additional information on Energy Star homes are online at http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.homes_guidelns09. Basically, the TBIC requires visually inspecting the integrity and continuity of the air barrier of the envelope and uniformity of the insulation installation. This process

ensures very little gaps or voids in insulation and insignificant amount of insulation compression. The third-party inspectors who perform code inspection for the modular homes were trained by the second and third authors of this paper to perform TBIC inspections. For these show homes, the TBIC inspections were indeed performed by the third party code inspectors. Note that the use of expanding foam insulation for the Echoboomer show homes assures air tight construction and uniform application of insulation with no compression by the very nature of the product.

Electrical testing of all PV modules:

The PV system on the Gen-X home consists of 48 modules rated by the manufacturer at 85 peak Watts (W_p) each. The donated modules were used and consequently all were individually tested to measure open circuit voltage and short circuit current to verify sound electrical characteristics and they passed. In addition I-V curve traces were performed on 12 of the modules to determine the as received peak power rating. Figure 6 shows the results and the average peak power rating of the modules tested was 80.8 Watts or 95% of the rated Watts.

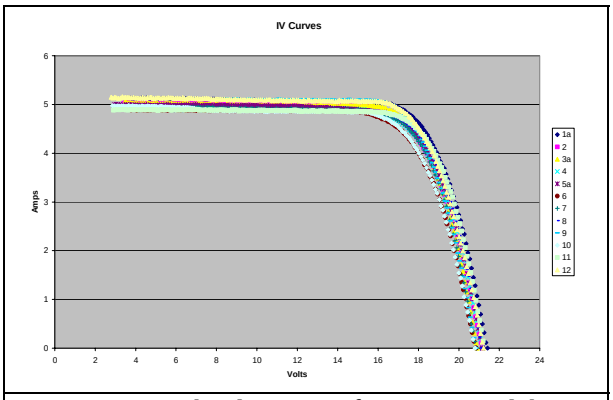

Figure 6 Normalized I-V trace for 12 PV modules tested

Site testing for Energy Star

To qualify for the US Environmental Protection Agency created Energy Star program for homes, a home needs to have a HERS Index of 85 or lower. The HERS Index is calculated after inputting the home geometry, envelope thermal and equipment efficiencies and measured values of envelope and duct air leakage. The software that generates the rating or index complies with RESNET (Residential Energy Services Network) standards. We used the EnergyGauge™ Software (www.energygauge.com) to calculate the HERS Index. Due to the hectic nature of the show home construction in the show parking lot, the envelope and duct airtightness values were measured in the evening and night hours by a 3-man crew.

Site inspections for FGBC

FGBC Green Home Designation qualification is achieved by attaining at least 100 Credit Points. The credits are gained through additional improvements that benefit the ecology, the environment and sustainability in Florida. There are pre-requisites dealing with pools and waterfront property that must be met, as well as, minimum credits within each of the 7 categories. Since this show home was built on a temporary site, the Site Category, Category 4, could not be quantified therefore penalties were imposed. When such occurs, credits must then be made up by exceeding the minimums in other categories. However, the categories have maximums that can be "borrowed" from. As mentioned, a minimum of 100 is required to qualify for Green Home designation and the GenX was imposed with a 7 credit deduction that was made up by exceeding other categories' minimums, such as renewable energy.

Monitoring Energy Production and Use

GridPoint, Inc. donated the inverter with battery back-up system for the home. This system will need reinstallation when it is permanently located. The display screen on the GridPoint is meant to show basic power flow to and from 1) the batteries, 2) the PV, 3) the secure load sub-panel and 4) the house's main load panel. The diagram below the screen is meant to depict the status of each (plus the status of the inverter, see Figure 7.)

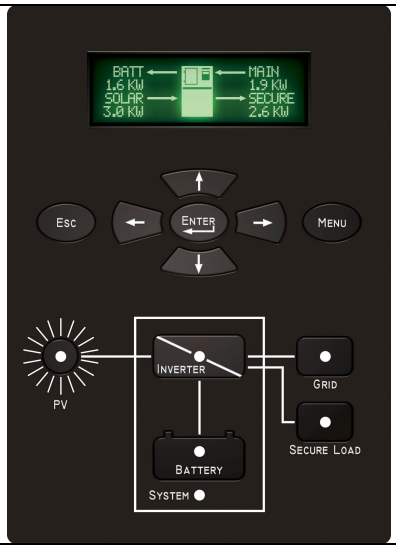

Figure 7 Screenshot of the Connect Display Panel

GripPoint Central is a powerful online energy management portal to provide home and business owners with detailed information and control over their energy consumption and costs. Customers learn the most cost-effective time to run appliances and create a personal energy profile to automatically manage energy according to fluctuating utility rates and consumption patterns. This feature will be implemented when the home is permanently sited in Siesta Key, FL (scheduled for install July 2007 – this paper was submitted prior to installation however, the author/s will report energy generation at the conference).

During the show, there was no opportunity to display the GridPoint Connect features such as simply communicating the basic status of the system along with rudimentary statistics. GridPoint's online portal—personalized for each home —gives a panoply of graphics that are easily interpreted by consumers. The Central display is detailed online at http://www.gridpoint.com/consumer/objects/pdf/GridPoint_Central.pdf. Figure 8 shows an example of the summarized production, use back-up power available, etc.

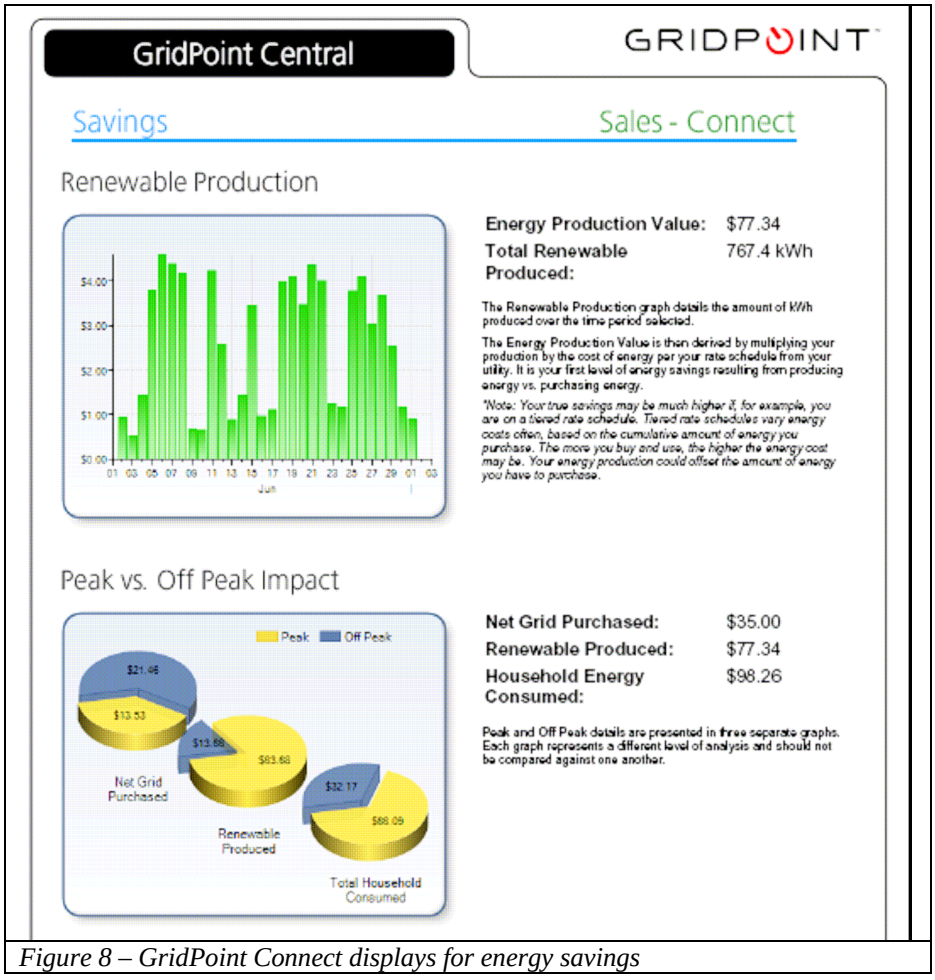

Figure 8 – GridPoint Connect displays for energy savings

The monitoring options provide visibility into the production and consumption of energy within the home (or business) and past studies show that providing feedback on electrical usage can reduce consumption by as much as 10-15% (Parker et al. 2006). Information is gathered directly from the unit by viewing data on the display panel or by logging into GridPoint Central. GridPoint Central has enhanced features for viewing this information and provides consumers with additional tools. Tracking the performance of appliances, as well as their energy use and production is a great way to validate building performance. Providing this amenity during the show (especially if compared to a standard show

construction product) would prove a great marketing strategy for high performance home builders and validate commissioning procedures.

CONCLUSIONS

Using show homes and "live" monitoring equipment can not only persuade commission relevancy of high performance modular homes, but as a side effect, educate the built community of judicious commissioning tools. Many contractors and sub contractors want to distinguish themselves in the marketplace. Quality assurance through commissioning tools can quantify their end product is as specified. This could potentially strengthen warranties and reduce liability for products, product manufacturers and installers resulting in less call backs and more satisfied. Since 2005, PHH has been constructing the IBS show homes in the parking lot for attendees to view their new and high performance modular products. PHH has welcomed improved efficiency specifications and commissioning procedures, such as blower door testing, site inspections for Energy Star and FGBC certifications. This past year they endorsed the integration of energy feedback equipment with the photovoltaic panels further validating their commitment to high performance modular construction.

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