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CONTRACT REPORT

Building America Industrialized Housing Partnership (BAIHP)

**Annual Report – Second Budget Period
March 1, 2007 – January 31, 2008**

FSEC-CR-1714-07
April 2008

Compiled by:
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A Research Institute of the University of Central Florida

Building America Industrialized Housing Partnership (BAIHP)

Annual Report – Budget Period 2 (BP2)
March 1, 2007 – January 31, 2008

FSEC-CR-1714-07

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ABSTRACT

This annual report summarizes the work conducted by the Building America Industrialized Housing Partnership (www.baihp.org) for the period 3/1/07 to 1/31/08. BAIHP is led by the Florida Solar Energy Center of the University of Central Florida. In partnership with over 50 factory and site builders, work was performed in two main areas – research and technical assistance.

In the research area we worked with two manufactured home builders to build two HUD code homes with unique interior ducts and to eliminate crossover ducts in unconditioned spaces. These duct systems have been successful in increasing energy efficiency and eliminating moisture problems. A two-year, 17-household study on the impacts of using instantaneous energy feedback devices was completed, showing on average a 7.4% decrease in energy use with the greatest % reductions occurring in the homes with the greatest energy use. We also completed the first year of tests on *NightCool*, an innovative use of night-sky radiation to cool a house during the night. After a full cooling season, the *NightCool* system averaged 15% energy savings with better humidity control than the conventional system.

Three prototype zero/ near zero energy homes are being constructed. Two in Gainesville, FL by Schackow Development and the third in Panama City, FL by Stalwart Built homes. The Panama City home will be the first Platinum LEED home in Florida. These homes are expected to be completed and instrumented by summer of 2008.

In the technical assistance area we provided systems engineering analysis, conducted training, testing and commissioning primarily in hot-humid and marine climates. In 2007, we assisted in the construction of 277 homes that exceed the 30% BA benchmark goals in hot-humid climates and another 35 Habitat for Humanity homes. Also we assisted in the construction of 151 homes that are near the 30% benchmark level in marine climates and over 3,700 Energy Star manufactured homes in the Pacific Northwest through the manufacturers participating in the Northwest Energy Efficient Manufactured Home program. In addition, factory builder partners Fleetwood Homes, Palm Harbor Homes and Southern Energy Homes produced over 13,500 homes with air tight ducts. The estimated energy savings from these homes constructed in 2007 is over 82,800 million Btu/year and the estimated savings in utility bills to consumers exceed \$1,500,000/yr. The cumulative number of homes and energy saved from the BAIHP project since its inception in 1999 is over 168,500 homes assisted and over \$14,400,000/yr in utility bill savings. We have provided technical assistance to several show homes constructed for the International Builders' Show in Orlando, FL. In the Gainesville, FL area we have several builders that are consistently producing ~10 homes per month in several subdivisions that meet the Builders Challenge goal of E-Scale score of 70 or below.

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Figure I-1 BAIHP researchers, DOE personnel and industry partners attended project review meeting at Florida Solar Energy Center, February 12, 2008.

INTRODUCTION AND SUMMARY

This annual report summarizes the activities of the Building America Industrialized housing Partnership (BAIHP, www.baihp.org) for the second budget period (BP2) spanning 3/1/07 – 1/31/08. However, summaries of significant work completed in budget period 1 (BP1) covering 4/1/06- 2/28/07 is also included. BAIHP is one of several U.S. Department of Energy (DOE) sponsored Building America teams (www.buildingamerica.gov) that perform cost-shared activities to develop and deploy systems engineering based solutions to enhance the energy efficiency, comfort and durability of new, retrofit, site- and factory-built housing in the U.S.A.

The BAIHP team is led by the University of Central Florida's (UCF) Florida Solar Energy Center (FSEC) in collaboration with subcontractors Washington State University (WSU), Oregon Department of Energy (ODOE), Florida Home Energy and Resources Organization (FLHero), Residential Energy Services Network (RESNET), Calcs-Plus and leaders from the housing industry that build over 100,000 homes/yr.

This BAIHP team was formed as a result of a competitive solicitation issued by DOE-NETL (www.netl.doe.gov) in 2005. It is a successor to the previous BAIHP team also selected competitively in 1999.

The overall objective of the BAIHP project is to conduct cost-shared research to accelerate the nationwide development of cost effective, production ready energy technologies that can be widely implemented by factory and site builders to achieve 30% to 50% savings in whole house energy use through a combination of energy efficiency and renewable energy measures. BAIHP will focus on factory builders (HUD code, Modular and Panelized), the housing segment not emphasized by the other BA teams. However, BAIHP will also work with site builders (primarily production and affordable housing) to explore synergies between the different housing segments, yielding a greater impact on the entire U.S. housing industry. BAIHP will employ BA systems engineering principles to enhance the energy efficiency, comfort, durability, indoor air quality, insurability, affordability, marketability and construction productivity of U.S. housing.

BAIHP's Goals

1. Perform cost-shared research to reduce the energy cost of housing by 30% to 70% while enhancing indoor air quality, durability, resource efficiency and marketability.
2. Assist in the construction of thousands of energy-efficient industrialized houses annually and commercialize innovations.
3. Make our partners pleased and proud to be working with us.

What is industrialized Housing?

Industrialized housing encompasses much of modern American construction including:

- Manufactured Housing – factory-built to the nation wide HUD Code
- Modular Housing - factory-built, site assembled modules meeting local code
- Panelized/kit Housing – factory produced sub-assemblies put together on site to meet local codes
- Production Housing - site-built systematically, factory built components

Manufactured Homes are one of the most affordable types of single-family detached housing available anywhere in the world, generally costing less than \$35/ft² plus land costs for centrally air conditioned and heated homes with built-in kitchens. Available in all parts of the country, manufactured homes are more popular in rural areas and in the southern and western US where land is still plentiful. Modular homes accounted for about 3.2% of 2007 housing starts. Many HUD Code home producers offer modular homes as well which are built to local codes and take advantage of many factory production benefits.

Industry Partnerships

BAIHP has partners in many stakeholder groups of the U.S. housing market including HUD-Code home manufacturers; modular, multifamily and production site builders; and product and material suppliers. Research organizations and other non-profits have worked with BAIHP to collaborate on field work, ventilation studies, ASHRAE committee work and training.

Table I-1 lists active BAIHP Project Industry Partners. Past and inactive partners can be found on the previous year's report, online at http://www.baihp.org/pubs/BAIHP_II_Yr_1_Report.pdf. The Industry Partners list is kept updated at <http://www.baihp.org/partners/index.htm>. The geographic distribution of our partners is depicted on the map in Figure I-2.

Table I-1 Currently Active BAIHP Industry Partners)

HUD Code Home Manufacturers	
Cavalier Homes	Kit Homebuilders West
Champion Homes	Liberty Homes
Clayton Homes	Marlette Homes
Deer Valley Homes	Nashua Homes
Fleetwood Homes	Palm Harbor Homes
Fuqua Homes	Redman Homes
Golden West Homes	Skyline Corporation
Homark Homes	Southern Energy Homes
Homebuilders North West	Valley Manufactured Housing
Karsten Company	Western Homes
Modular and Panelized Builders	
Louisiana Systems Built Homes	Stalwart Built Homes
Royal Concrete Concepts	
Production Builders	
GMD Construction	Pringle Development
G.W. Robinson Builders	Skobel Development
On Top of the World	Tommy Williams Homes
Affordable Housing Builders	
Atlantic Housing	Habitat for Humanity International
Brownsville Affordable Housing Corporation	Holiday Builders ICI Homes
Custom Builders	
Garst Homes	Schroeders Homes
Ferrier Custom Homes	Scott Homes
Homes by Point	Solar Homes of Florida
Marc Rutenberg Homes	Spain & Cooper Construction
Marquis Construction & Development, Inc	Stitt Energy Systems
Rainier Construction, Inc.	Westmont Homes
Developers	
Castle & Cooke	Schakow Development / Trunnel Homes
Organum Development (Lily Valley)	ZCS Development
Research, Education and Industry Association Partners	
Auburn University School of Architecture	Building Science Corporation
Building Science Consortium	Pacific Northwest National Laboratory
Florida Green Building Coalition	RADCO, Inc
Florida Solar Energy Research and Education Foundation	RESNET
IBACOS	Structural Insulated Panel Association
Northwest Energy Efficient Manufactured Housing Program (NEEM)	Stevens Associates (Home Ventilation Institute)
	Washington Manufactured Housing Assoc

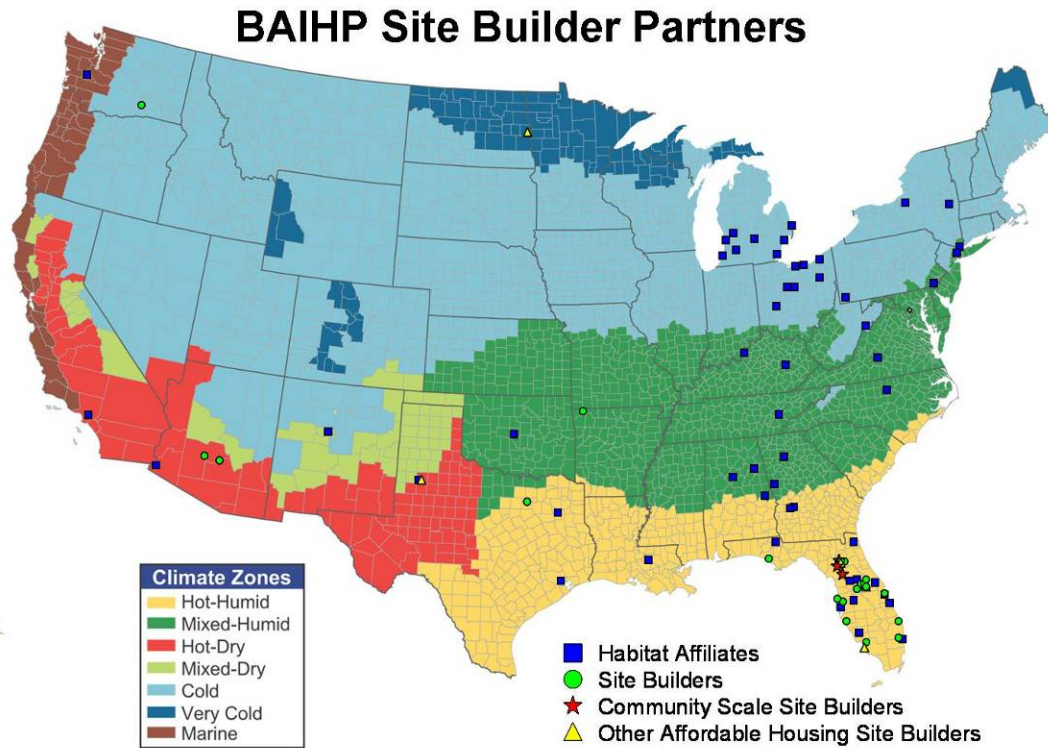


Figure I-2 *BAIHP Research and Technical Assistance Sites*

In the second budget period the BAIHP team conducted activities in four major task areas:

- Task 1: System Evaluations**
- Task 2: Prototype House Evaluations**
- Task 3: Community Scale Evaluations**
- Task 4: Other Activities**

The activities in each area are summarized in the following pages.

Task 1: System Evaluations

Subtask 1.1 Improved Duct Systems

In 2006 BAIHP began working with two manufactured housing partners -- Cavalier Homes and Southern Energy Homes on two different approaches to interior duct system designs to bring all duct work inside the thermal envelope. Cavalier Homes created a high side discharge supply register that is housed in the interior walls and connected to a floor trunk. Southern Energy Homes created ducts located in a single soffit located within the conditioned space at the marriage line. Both systems have been prototyped and field monitoring has begun at the Southern Energy prototype in November 2007. Full-scale monitoring was completed on the Cavalier Prototype. Simulation results show up to a 10% savings over conventional attic duct work and nearly 7% savings with a conventional floor system.

A full report can be found at <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1738-07.pdf>



Figure I-3 Floor duct system with high side discharge outlets under construction being tested with duct tester



Figure I-4 Interior view of prototype house with high side discharge outlet



Figure I-5 Southern Energy Homes Soffit Duct Mockup



Figure I-6 Southern Energy Homes Interior Crossover Duct Mockup

Subtask 1.2 Factory Integrated HVAC/DHW Systems

BAIHP team member DeLima Associates developed an integrated space heating, cooling, water heating and air distribution system for HUD-Code manufactured housing, to be installed at the manufactured housing factory, eliminating site work. A prototype Comboflair unit manufactured by Unico system was installed in a model center Palm Harbor Home in Austin, TX. This home was unoccupied and FSEC designed and installed an automated system to generate interior sensible and moisture loads. FSEC monitored the house from January 2006 to March 31, 2007. Data was posted online in a password protected website. This work was completed and the data logger removed in April 2007.

Subtask 1.3 Ventilation and Dehumidification

Two tasks were conducted on ventilation and dehumidification in the first budget period.

Advanced Cooling with Dehumidifier Mode (ACDM) equipment Evaluation

Partnering with Building Science Corp (BSC), BAIHP evaluated BSC's Advanced Cooling with Dehumidifier Mode (ACDM) equipment in the FSEC Manufactured Housing Lab (MHLab). This system was conceived in 2001 in an attempt to research ways to make a standard split-system cooling machine function as both a normal cooling machine and a dehumidifier. Data was collected at 1 min intervals and put on the FSEC web system for access by BSC.

Humidity Liability Evaluation of ASHRAE 62.2

FSEC conducted an evaluation of the humidity liability of ASHRAE 62.2 level of mechanical ventilation (*ASHRAE62.2, 2004*). During Nov 2006 – Feb 2007 the MHLab operated three types of whole house mechanical ventilation – None, 62.2 (which is 46cfm continuous for this house) and run time vent with 62.2 vent rate, i.e. 46 cfm supplied only when the heating or cooling system operated. Experiments showed that interior RH levels were high for all three vent types. The results for run time vent were unexpected as field data from a larger home in Ft. Myers, FL. with run time vent and occupied by a family of four showed good results. More research needs to be conducted to determine the humidity liability of ASHRAE 62.2 level of mechanical ventilation.

Subtask 1.4 Fortified® HUD Code Homes

In 2005 FSEC was asked to participate in the Institute for Business and Home Safety (IBHS) technical committee for HUD code homes. However, no significant activity occurred in this task area during BP1 or BP2.

Subtask 1.5 Plug Load Reduction

Homes around the world currently have no means to judge household energy use other than their monthly utility bill. Existing studies show that providing direct instantaneous feedback on household electrical demand can reduce energy consumption by 10-15%. Reducing and shifting electrical demand is particularly important in Zero Energy Homes (ZEH), where it would be desirable to match solar electric PV output with household loads. To obtain current data on the magnitude of savings that can be expected, 23 homes have been fitted with a real time energy feedback device called “*The Energy Detective*” (TED) which costs ~\$150. This is a small display unit, plugs into the wall and provides output on a digital display.



Figure I-7 TED The Energy Detective

The average savings from the energy feedback monitors of 3.7 kWh/day or 7.4%. However, this varied considerably from one home to another, ranging from an energy increase of 9.5% to a savings of 27.9%. Eleven homes showed savings while six homes showed energy use increases.

Generally, the homes with the largest consumption also experienced the largest savings. Notably, the two homes with the largest pre-monitor installation use also achieved the largest savings in the post period. Based on exit interviews with the occupants, these two household paid close attention to the monitors and used what they learned to make overt changes in household appliances as well as scheduling for some equipment. It also may indicate that the economics of feedback will be most persuasive for high energy consumers

In Miami one user reported savings of 13% on their January bill. This was broadcast by the local NBC affiliate in Miami, FL and aired February 21, 2007 as the beginning of a highly popular series of news segments focused on reducing household energy use.

Subtask 1.6 Setup and Finish Processes for Modular Homes

This task was conducted by the Housing Constructability Lab (HCL) of the UCF Industrial Engineering Department (UCFIE) in the first budget period.

Royal Concrete Concepts

Royal Concrete Concepts (RCC) produces innovative concrete modules for both residential and commercial markets throughout Florida. The HCL research team was tasked to identify and develop innovative concepts for the supply chain – stretching from construction material vendors, through the warehouse, to the production line. To maximize impact, the scope was limited to three critical materials: rebar, polyethylene foam and steel interior/exterior studs. A summary of this research with recommendations was issued to the RCC senior management team.

Habitat for Humanity

In March 2006, the UCF research team initiated efforts to assist Habitat for Humanity's Operation Home Delivery in the design of Habitat's first modular housing factory. The factory was envisioned as a high volume delivery method to replace homes destroyed by Hurricane Katrina. All designs were developed collaboratively with Habitat personnel in a series of workshops hosted at UCF. The team also recommended changes to the floor plans of the new modular home designs, making them more compatible with conventional home designs. Work was completed by summer 2006 but Habitat decided not to follow this path of modular housing factories.

Subtask 1.7 Green Products and Processes

During 2007, BAIHP assisted the following builders/homes by recommending green building materials and practices, and assisting in the certification process:

- *The New American Home 2008* – Florida Green Building Coalition (FGBC) and National Association of Home Builders (NAHB) Green home
- *Vision House 08 (Westmont Homes), Palm Harbor Homes, Castle & Cooke* – FGBC
- *Royal Concrete Concepts, Stalwart Built Homes, Lakeland Habitat* – Leadership in Energy and Environmental Design (LEED) for Homes
- *Homes In Partnership* – Enterprise Green Communities

Subtask 1.8 Cool Roofs

The Flexible Roof Facility (FRF) is a test facility in Cocoa, Florida designed to evaluate five roofing systems at a time against a control roof with black shingles and vented attic. Since 1989 the testing has evaluated how roofing systems impact summer residential cooling energy use and peak demand (Parker et al. 2005). In May of 2006 DOE recommended against conducting further research in this area as part of the FY07 AOP review process.

Subtask 1.9 Night Cool

Using a building's roof to take advantage of long-wave radiation to the night sky has been long identified as a potentially productive means to reduce space cooling in buildings. The night cooling resource is large and enticing for residential energy-efficiency applications. Problems, limitations, solutions and data collection are researched and explained using instrumented side-by-side 10' x 16' test buildings located at the Florida Solar Energy Center.

In 2007, *NightCool* performance was evaluated under standard operating conditions during a full Florida cooling season, from April to November. Air conditioning was used in both test buildings, but when favorable attic temperature conditions were met, *NightCool* activated with fan circulation in the experimental test building. Sensible internal heat gains were added similar in scale to what would be seen in an occupied home.

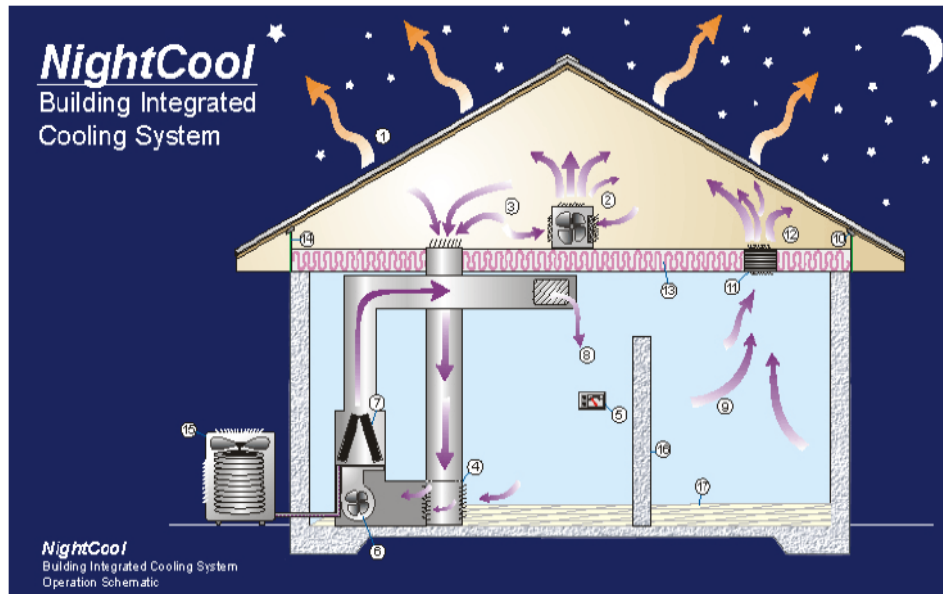


Figure I-8 Schematic of *NightCool* concept

Measured cooling energy savings averaged 15% over the 8 month test period. Monthly performance indices were produced. Daily *NightCool* system Energy Efficiency Ratios (EERs) averaged 24.9 Btu/Wh over the summer to fall test period – somewhat lower than simulations conducted earlier. However, a mid-summer adjustment to the system activation attic temperature was found to improve the performance by about 2 Btu/Wh after June. In any case, this level of performance compared favorably to an EER for the vapor compression air conditioner of about 9 Btu/Wh. This level of performance also exceeds the performance of any air source equipment currently available.

Subtask 1.10 Solar Integrated Roofing Panels

This subtask, conducted in budget period one, was performed by one of our subcontractors – University of Texas at Austin, School of Architecture (UTSOA). UTSOA focused on developing scenarios for two different modular houses and testing options for photovoltaic arrays for both. They analyzed type, size, cost, energy production, ease of installation and public acceptance for both differing scenarios. The two models developed were The Back Home and The Bloom Home. The Back Home is a house that could be rapidly deployed, but provide permanent affordable housing in areas of need, developed to meet FEMA’s Alternate Housing Pilot Program requirements. The Bloom House is an evolution of the University of Texas Solar Decathlon 2007 competition house, designed to be marketed as part of an urban infill development to a median income family in Austin, Texas.

Task 2: Prototype House Evaluations

In this section BAIHP documents our efforts in providing design and technical assistance to develop prototype high performance homes. Prototype design assistance usually functions in the following manner:

Subtask 2.1A

- Set Goals: First BAIHP staff work one-on-one with builders to set goals: 30% savings, HERS Index below 65, etc.
- Develop prototype: BAIHP works with builders to achieve those goals.
 - BAIHP staff suggest energy efficient features to achieve goals, including new techniques such as sealed attics, the use of PV or solar thermal and interior ducts.
 - BAIHP subcontractor Calcs-plus often assists in designing and sizing the HVAC system
- Commission Prototype: Once the prototype has been built, BAIHP conducts performance testing to determine infiltration and duct leakage and performs a Thermal Bypass Inspection to check for discrepancies in insulation, duct assembly and others.

Subtask 2.1B

- Monitor prototype: Many prototype homes are then monitored to check for comfort, energy use and effectivity of improved building components.

Task 3

- Community Scale Production: Once a successful prototype has been produced, Building America's goal is to build that prototype on a community scale, or at least ten times over.

Subtask 2.1A High Performance Prototype Homes Design Assistance

BAIHP provided design review, made energy efficiency recommendations and provided energy analysis including running EnergyGauge simulations, calculating benchmark savings, HERS Indices and tax credits to the following builders during the second budget period:

Builder	Location	Number of Homes Consulted
Armed Forces Federation	AZ and NC	1
Atlantic Housing Partners	Lakeland, FL	2
Bedsaul Development	Gainesville, FL	1
Brevard County Housing	Brevard Cty, FL	2
Brownsville Affordable Housing	Brownsville, TX	2
Capitol Home Builders	Thomasville, GA	1
Custom Homes	FL, GA, TX	5
David Axel Home	Oveido, FL	1
David Weekley Homes	Panama City, FL	9
East Bay Development Group	Panama City, FL	2
Federation of American Scientists	Houston, TX	3
Ferrier Builders	Dallas, TX	2
Florida Custom Homes	Sebring, FL	1
Garst Residence	Olympia, WA	1
GMD Construction	Palm Beach Gardens	2
HKW Enterprises	Gainesville, FL	7
Homes by Point	Tampa, FL	1
Homes in Partnership	Apopka, FL	1
Louisiana System Built Homes	Lafayette, KY	1
Marquis Construction	Masaryktown, FL	1
Newport Partners	Charleston, SC	1
Park Square Homes	Orlando, FL	2
Rainbow Springs	Dunellon, FL	5
Rainer Construction	Maitland, FL	1
R.P. Witt Construction	Jacksonville, FL	1
Schakow Development	Gainesville, FL	2
Shroeders Homes	North Port, FL	1
Southern Heritage Homes	Archer, FL	5
Skobel Developments	Boca Raton, FL	1
Spain & Cooper Construction	Gainesville, FL	6
Stalwart Homes	Calloway, FL	8
Stamets Residence	Shelton, WA	1
ZCS Development	Rockledge, FL	1
<i>Total number of homes consulted in Budget Period 2:</i>		<i>72</i>

Subtask 2.1B Instrumented Monitoring of Prototype Homes

In BP2 BAIHP monitored or planning to monitor the following homes:

Builder	Location	Number of Homes Monitored
Chasar Home	Cocoa, FL	1
Energy Structures & Systems, Inc.	Stuart, FL	1
Ft. Lewis Prototype	Ft. Lewis, WA	1
Garst Home	Olympia, WA	1
Hoak Home	Longwood, FL	1
2007 IBS Showhome – PHH	Siesta Key, FL	1
2008 Showhome – Vision House	Orlando, FL	1
LSU’s Louisiana House	Baton Rouge, LA	1
PATH HUD Concept Home	Charleston, SC	1
Schackow Development	Gainesville, FL	2
Schroeders Homes	North Port, FL	1
Scott Homes	Olympia, WA	3
Solar Homes of Florida	Stuart, FL	2
Stalwart Builders	Panama City, FL	1
Stamets Home	Shelton, WA	1
Terry Hill Residence	Arlington, VA	1
ZCS Development	Rockledge, FL	1
<i>Total number of homes monitored in Budget Period 2:</i>		<i>21</i>

Subtask 2.2 International Builders' Show High Performance Prototype Homes Design Assistance

BAIHP provided HVAC design assistance, green consultation and ENERGY STAR certification to many homes in the National Association of Home Builders International Builders' Show, including the outdoor show home exhibits and the National Association of Home Builder's show case homes built off site. These show homes are great opportunities to solicit builders to integrate more energy efficient and improved performance strategies in their homes as certifications and energy ratings can allow for a marketing edge.

BAIHP has provided assistance to the following homes in the second budget period:

- **2008 PHH Professional Builder Show Village homes** – provided information on green products and HVAC design as well as QA inspections and specifications review.
- **2008 Tradewinds Home** for Builder Magazine – suggested green features and HVAC design.
- **The Vision House Orlando** – provided HVAC system recommendations and testing, insulation inspection, Thermal Bypass Inspection and monitoring equipment installation.
- **Builder Magazine** “True Green” modular home – provided contact information and product information on green materials.
- **2008 The New American Home** - assisted IBACOS with construction documentation, home performance testing and monitoring equipment.
- **2007 Single Family PHH Show Home** – provided HVAC re-commissioning, FGBC and NAHB green home certifications and monitoring this solar thermal and PV home after its relocation to Siesta Key, FL.



Figure I-9 Glen Cairn “Comfortably Affordable” 2008 Palm Harbor Homes IBS Showhome HERS Index: 69



Figure I-10 Bimini II 2008 “Green” Showhome – Palm Harbor Homes HERS Index 58



Figure I-11 2008 The New American Home

Task 3: Community Scale Evaluations

In this section we document our efforts in providing technical assistance to builders that are building entire communities of high performance housing in hot-humid and marine climates.

The following builders are high performance homes on a community scale. The homes in italics are located in the Marine climate zone and are mostly coordinated by the Washington State University Energy Extension Program. The other homes are located in the Hot-Humid climate region and are mostly coordinated by BAIHP subcontractor Florida H.E.R.O.

Builder	Location	Number of Homes Built in BP2
Castle & Cooke	Orlando, FL	10
G.W. Robinson Builders	Gainesville, FL	135
HKW Enterprises	Apopka, FL	10
On Top of the World	Ocala, FL	92
Pringle Development	Eustis, FL	130
Tommy Williams Homes	Gainesville, FL	49
<i>Ft. Lewis Army Base</i>	<i>Ft. Lewis, WA</i>	<i>159</i>
<i>Scott Homes</i>	<i>Olympia, WA</i>	<i>14 assisted</i>
Total Number of high-performance homes built in Hot-Humid and Marine Climates		585

Subtask 3.1 Hot-Humid Climate

In subtask 3.1 two case studies highlight the energy and cost analysis, systems engineering process and lessons learned in the development of high performance communities for both Tommy Williams Homes and G.W. Robinson Builders. In addition, three other Florida builders—Pringle Development, On Top of the World and Castle & Cooke Development—have built performance housing on a community scale. As of July 2007, all homes built by On Top of the World meet the tax credit requirements and all Castle & Cooke designs achieve 30% benchmark savings.



Figure I-12 *G.W. Robinson Home*



Figure I-13 *Turnberry Lake Home*

Cost and market analysis performed for Tommy Williams Homes and G.W. Robinson Builders showed that the simple payback for the energy upgrades is in the range of 4 to 5 years. Market analysis of comparable homes indicate that the Building America builders are extremely cost conscious and are able to sell their homes at a price comparable to or less than the competition who sell typical homes close to code minimum levels of energy performance.

Subtask 3.2 Marine Climate

WSU is working with Building America partners Oregon Department of Energy (ODOE), Champion Homes and Equity Residential in an effort to build over 850 energy efficient modular homes at Fort Lewis Army base in Washington State. Almost 500 have been built so far, certified as ENERGY STAR and achieving 25%-30% source energy savings over the benchmark. BAIHP is currently working with Equity and Champion to move that savings to over 40%. Currently a demonstration duplex is being developed with over 40% benchmark savings.

In addition, BAIHP evaluated nine existing and five planned high performance homes by Scott Homes, a BAIHP partner since 2005. This Olympia, WA builder uses many high efficiency measures including SIPs and radiant heat with gas combo heat/hot water systems.



Figure I-14 *Two Story Modular Housing – Ft. Lewis Army Base, WA*



Figure I-15 *Brotherton 13th Ave Bungalows by Scott Homes, Olympia, WA*

Task 4: Related Activities

Subtask 4.1 Habitat for Humanity Partnership

BAIHP has had a very productive relationship with Habitat for Humanity (HFH) and various local affiliates spanning over 10 years. In 2007 we assisted the following affiliates. Each activity BAIHP participated in is explained in the subsection subtask 4.1 of this report. A brief summation of the activities are:

Lakeland, FL

This Habitat builds one of the highest performing homes among all affiliates: consistently building homes above the 30% BA benchmark level. BAIHP performed testing, Thermal Bypass Inspections and EnergyGauge calculations for Lakeland HFH in 2007.



Figure I-16 Lakeland, FL Habitat House under blower-door testing

Pinellas County, FL (PCHF)

In 2007, BAIHP provided utility bill analysis developed by FSEC's Danny Parker to reduce energy use in existing Habitat Homes. The affiliate because four ICF houses that have not yet been certified for ENERGY STAR.

Hillsborough County, FL

BAIHP assisted this affiliate in setting goals for ENERGY STAR and green certifications. We conducted testing, made recommendations to pass the Thermal Bypass Inspection and performed energy analysis in 2007

Highlands County, FL (Sebring)

Beginning in November 2007, BAIHP conducted performance testing, thermal bypass inspections and energy analysis for this affiliate. Highlands HFH wishes to build all ENERGY STAR homes, and BAIHP has already rated their first two ENERGY STAR homes.

Gulf Coast Recovery

BAIHP has assisted many major Habitat affiliates along the Gulf Coast. Mobile County in Alabama and Baton Rouge, LA affiliates have agreed to build a 30%-40% prototype under supplemental funding. New Orleans is working toward achieving ENERGY STAR. Slidell, LA HFH wishes to bring all homes into ENERGY STAR compliance and then build higher performing prototypes.



Figure I-17 Raising Walls in a Gulf Coast Habitat Build

Northwest Habitat affiliates

BAIHP is working with Washington HFH to build a 15 cottage project with 40% benchmark savings, as well as other affiliates to qualify over 100 existing homes to ENERGY STAR standards. BAIHP trained and equipped the Washington State Habitat Construction Managers Network Coordinator to further BAIHP outreach to Northwest Habitat Affiliates, which includes conducting training for over 50 HFH affiliates and qualifying all Washington State homes for ENERGY STAR starting in 2008-09.



Figure I-18 HFH volunteers in home performance testing training



Figure I-19 Habitat for Humanity 15 home Community Cottage project – Olympia, WA

Subtask 4.2 HUD Code ENERGY STAR

Palm Harbor Homes

BAIHP continues to provide technical assistance to Palm Harbor Homes under cost-shared funding received from them to certify their HUD code ENERGY STAR Homes and modular ENERGY STAR homes. In addition, we assisted in incorporating the Thermal Bypass Checklist, provided green recommendations and submitted several product improvement ideas for the Plant City PHH plant.

Homark Homes

Homark Homes has built 20 ENERGY STAR HUD-code homes since becoming a partner in 2006. BAIHP tested one home in May 2007 and will test one each year for ENERGY STAR certification and tax rebates.

Oregon Department of Energy (ODOE) and Northwester Energy Efficient Manufacturers (NEEM)

In 2007, BAIHP performed the following items for NEEM:

- Performed quarterly factory inspection visits,
- Inspected problem homes,
- Developed in-plant quality assurance,
- Detailed inspection manuals,
- Periodically upgraded the standards to higher levels of energy efficiency, and
- Conducted 11 two-day State of Oregon-certified installer classes in Oregon and Idaho.



Figure I-20 NEEM Logo

In addition, staff interviewed plant's general managers on the NEEM program with positive feedback from all.

Sixteen out of nineteen NEEM plants will receive an ENERGY STAR Leadership Housing Award for their 2007 production numbers. In 2007 NEEM plants produced approximately 65% of the nations ENERGY STAR homes, building 3786 ENERGY STAR homes.

Subtask 4.3 BA Program / Analysis Support

During 2007, BAIHP supported the DOE Builders Challenge program (buildingamerica.gov/challenge), including participation in conference calls and discussions on the Challenge. This voluntary challenge to the homebuilding industry to build 220,000 high performance homes by 2012 was accepted by 18 BAIHP partners as of January 2008. These builders have committed to build homes that are between 70 and 0 on the EnergySmart Home Scale (E-Scale) also known as the HERS index.

In addition, we assisted NREL in the continued refinement of the Benchmark calculation methodology and BEOpt analysis tools through email exchanges and participation in conference calls.

Subtask 4.4 System Research Completion Report

Participated in conference calls and prepared two case studies for the 30% marine report – NEEM program and NOJI Gardens. Details are found in the report issued by NREL.

Subtask 4.5 Documentation, Resource Development and Related Activities

In 2007, The BAIHP team published 5 papers at various conferences. Twelve presentations were made at various national and regional venues and training on high performance housing was provided to approximately 500 people. During 2007, BAIHP projects received considerable media attention regarding feedback research (Subtask 1.5), zero energy homes and the Garst Home.

The web page www.baihp.org continues to be updated and revised periodically. All published papers and reports are put on-line.

Program Impact

BAIHP concentrates its work in hot-humid and marine climates but is active in most regions of the U.S. as shown in the map above (Figure I-2). In 2007, we assisted in the construction of 277 homes that exceed the 30% BA benchmark goals in hot-humid climates and another 35 Habitat for Humanity homes. Also we assisted in the construction of 151 homes that are near the 30% benchmark level in marine climates and over 3,700 Energy Star manufactured homes in the Pacific Northwest through the manufacturers participating in the Northwest Energy Efficient Manufactured Home program. In addition, factory builder partners Fleetwood Homes, Palm Harbor Homes and Southern Energy Homes produced over 13,500 homes with air tight ducts. The estimated energy savings from these homes constructed in 2007 is over 82,800 million Btu/year and the estimated savings in utility bills to consumers exceed \$1,500,000/yr. The cumulative number of homes and energy saved from the BAIHP project since its inception in 1999 is over 168,500 homes assisted and over \$14,400,000/yr in utility bill savings.



Figure I-21
BAIHP Logo

Subtask 4.6 RESNET activities:

RESNET activities and achievements include:

- The HERS Index, provided by RESNET Ratings, is now used for zero energy homes, ENERGY STAR, the DOE's National Builders Challenge and the 2030 Challenge.
- RESNET continued to provide support for the National Builders Challenge and served on the program's steering committee.
- RESNET offered a "Lessons Learned for Building America" technical track at the 2007 RESNET Building Performance Conference.
- Expanded and publicized the Habitat volunteer energy rater program that works with Habitat affiliates around the country to build energy efficient homes.

In 2007 RESNET® made solid progress in an international dialogue on harmonizing standards on how building energy performance is measured and labeled. Efforts include: attending and making presentations at the Energy Performance in Buildings Directive's Concerted Action in Warsaw, Poland on US rating systems; and entering an agreement for the Canadian rating program to adopt the HERS Index and RESNET standards.

Task 1. System Evaluations



Figure 1-1 *High Side Discharge Vent Systems – Cavalier Homes*

1.1. Improved Duct Systems

N. Moyer and D. Stroer

Leaky ducts in residential attics are a major cause of excessive energy use in hot humid climates (Cummings et al. 1991). Leaky ducts in manufactured housing can contribute to mold growth, soft drywall and comfort problems in addition to high cooling and heating energy use (Moyer et al. 2001).

Successful adoption of interior duct systems in manufactured housing will result in significant energy savings and improvement in durability, comfort and indoor air quality.

In 2006 we began working with our manufactured housing partners, Cavalier Homes and Southern Energy Homes, on a duct system design that brings all duct work within the thermal envelope. A different prototype design was produced by each of the partners. Cavalier Homes featured high side discharge supply register that uses the interior wall cavities as a conduit that connects to the floor trunks. Southern Energy Homes took a radical departure from the standard manufacturer duct system approach. A single soffit located within the conditioned space at the marriage line provides the space to aesthetically place the duct system. Both manufacturers are working on the elimination of the crossover duct as a field installed process. (Figure 1-2 through Figure 1-5)



Figure 1-2 *Floor duct system with high side discharge outlets under construction being tested with duct tester*



Figure 1-3 *Interior view of prototype house with high side discharge outlet*



Figure 1-4 *Southern Energy Homes Soffit Duct Mockup*



Figure 1-5 *Southern Energy Homes Interior Crossover Duct Mockup*

We also provided training and assistance to design the supply and return duct systems to manual D and size the heating and cooling systems to ACCA Manual J8. This is to help solve some comfort related complaints they get despite having tight ducts. This effort will also produce ductwork that has better airflow and lower noise.

The initial results of the simulation work show up to a 10% savings over conventional attic duct work construction techniques and nearly 7% savings with a conventional floor system.

Field monitoring is in the beginning stage of the Southern Energy prototype and is expected to be concluded in November 2008. Data is available online at <http://www.infomonitors.com/hsd/>. Cavalier Homes has prototyped the HSD unit and results are promising. A full scale monitoring effort is needed to assess the entire system design. That effort has not yet been scheduled.

A full report can be found at <http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1738-07.pdf>

1.2. Factory Integrated HVAC/DHW Systems

J. Sherwin

BAIHP team member DeLima Associates developed an integrated space heating, cooling, water heating and air distribution system for HUD-Code manufactured housing. This work is sponsored by the U.S. Department of Energy (SBIR grant), The Propane Education & Research Council (PERC) and Alabama Gas Company. The Comboflair system consists of a single-package heating/cooling unit (consisting of refrigerant coils, hydronic coil, compressor, blowers and hydronic pump), a water heater and an air duct system. The heating source is a natural gas or propane water heater that provides all space heating and domestic water heating needs. The air distribution system is a small-duct high-velocity system that minimizes duct losses. All equipment is installed at the manufactured housing factory, eliminating all site work. See Figure 1-6 and Figure 1-7.

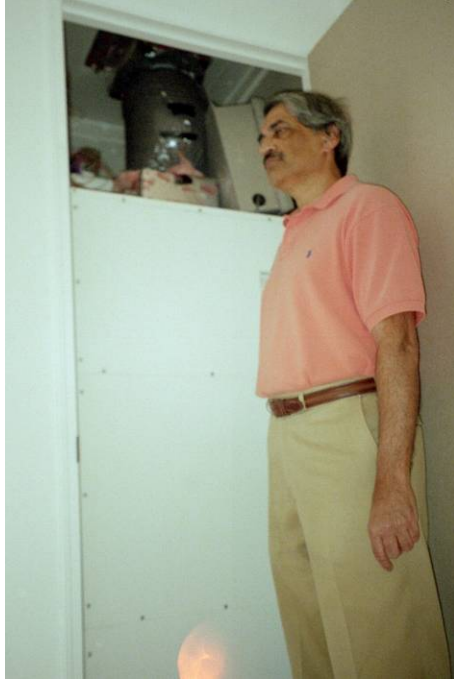


Figure 1-6 Interior view of the Comboflair System with Mr. Henry Delima, Comboflair project director



Figure 1-7 Exterior view of the Comboflair under test in Austin, TX at the Palm Harbor Home model center

A prototype Comboflair unit manufactured by Unico system was installed by them in a model center at Palm Harbor Homes in Austin, TX. This home was unoccupied and interior sensible and moisture loads were generated by an automated system designed and installed by FSEC. FSEC also installed a data acquisition system and collected house and equipment data from January 2006 to March 31, 2007. Data was posted online in a password protected website. According to Mr. Delima, “I must thank you for the outstanding job in monitoring the Austin test home. Unico now has considerable amount of data that can be used in further development and sizing of production models of Comboflair.” This task is completed as of April 2007.

1.3. Ventilation and Dehumidification

In 2007, Calcs-Plus lead an effort to develop a way to hook up dehumidifiers and ventilation systems for hot humid climates to avoid simultaneous running of a/c compressor and dehumidifier. A system developed to this purpose will be installed in the Gen-X prototype house in Siesta Key, FL.

Evaluation of Advanced Cooling with Dehumidifier Mode (ACDM) Equipment

The FSEC Manufactured Housing Lab (MHLab--Figure 1-8) was used to conduct research for ventilation and dehumidification strategies in 2006. The MHLab features three complete separate heating and cooling systems: an overhead duct system connected to a package unit air conditioner with electric resistance heating, a floor-mounted duct system connected to a split system air conditioner also with electric resistance heating, as well as an interior soffit duct system.



Figure 1-8 *The FSEC Manufactured Housing Lab*



Figure 1-9 *Completed ACDM Indoor unit in the MHLab crawlspace*

During BP1 two major activities were conducted in the MHLab. During April through November 2006 we partnered with Building Science Corporation (BSC) and evaluated their Advanced Cooling with Dehumidifier Mode (ACDM) equipment. This system is an attempt to research ways to make a standard split-system cooling machine function as both a normal cooling machine and a dehumidifier. It was conceived by Building Science Corporation (BSC) in 2001. This system employs an indoor condenser/reheat coil, placed in the process air stream of a standard split-system, to allow continued removal of moisture while supplying room-neutral-temperature air, essentially converting the cooling system to a dehumidifier. This system was bench tested by BSC in their facilities in 2005 and tested at the MHLab in 2006 using the overhead duct system and replacing the package equipment with the ACDM equipment which is based on SEER 14 Goodman HVAC components. The ACDM equipment was located in the conditioned crawl space of the MHLab (Figure 1-9).

The basic principle of design and operation follows. A thermostat and humidistat sense indoor space temperature and relative humidity. As the indoor temperature increases above the prescribed temperature set point, the compressor, the outdoor condenser fan and the indoor air circulation fan are energized in normal cooling mode. As cool supply air decreases the indoor temperature below the prescribed indoor temperature set point, if the relative humidity is below the prescribed humidity set point, then the system shuts off; if the relative humidity is above the prescribed humidity set point, then dehumidifier mode is energized whereby the compressor and indoor air circulation fan continue, but the outdoor condenser fan shuts off, and a 3-way valve diverts refrigerant to an indoor condenser/reheat coil which heats the normally cool supply air to near room temperature conditions. In this way, moisture removal continues but reduction in room air temperature does not. When the indoor relative humidity falls below the humidity set point, all the equipment shuts off. Dehumidifier mode can also be energized without a prior cooling call, and a cooling call can be energized taking priority over an active dehumidification call.

Instrumentation and data collection and equipment troubleshooting was performed by FSEC. Good data was collected at 1 min intervals and put on the FSEC web system for

access by BSC. The ACDM system performed well after troubleshooting was completed. BSC (Armin Rudd) should be contacted for further details.

Humidity Liability Evaluation of ASHRAE 62.2

The other major BP1 project conducted in the MHLab was to evaluate the humidity liability of ASHRAE62.2 level of mechanical ventilation (ASHRAE62.2, 2004). In 2004 ventilation experiments conducted with less than 62.2 levels of ventilation during the peak summertime showed good dehumidification performance for all ventilation and dehumidification systems tested (Moyer et al. 2004). During Nov 2006 – Feb 2007 the MHLab operated under three types of whole house mechanical ventilation -- None, 62.2 (which is 46cfm continuous for this house) and run time vent with 62.2 vent rate, i.e. 46 cfm supplied only when the heating or cooling system operated. The house was operated on an auto changeover thermostat designed to keep the house at 77°F for cooling and 70°F for heating. Internal loads simulated were typical for a family of 4 but the moisture generation went directly into the space (instead of being exhausted by spot ventilation fans).

The data collected in November when the MHLab was under 62.2 vent rate is shown in Figure 1-10 below.

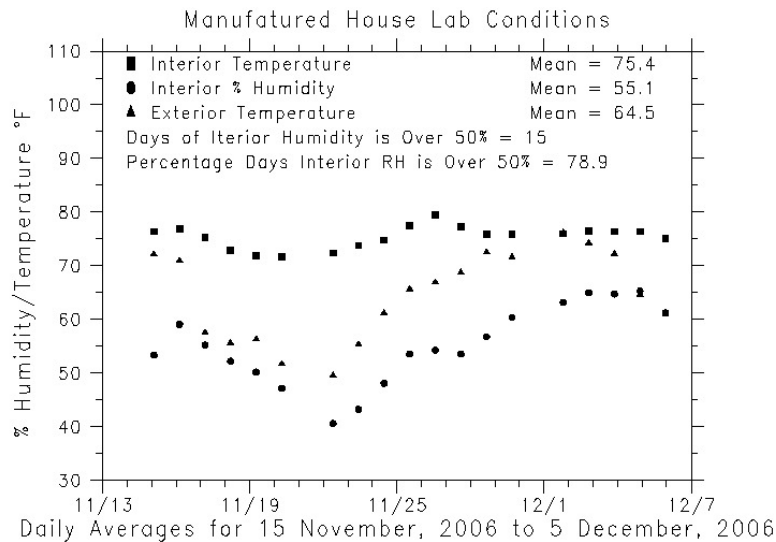


Figure 1-10 Interior and exterior conditions at the MHLab under ASHRAE 62.2 ventilation

Medical literature (Arlian et al. 2001) suggests indoor daily average RH be maintained below 50% RH for dust mite control, a major risk factor for asthma – especially in children. For this experiment, about 79% of the days the indoor RH exceeded that level suggested for dust mite control; it also exceeded 60% on average for a few days. Later experiments conducted in December and January showed that interior RH levels continued to stay high for no vent and run time vent cases as well. The results for run time vent were unexpected as field data from a prototype home in Ft. Myers, FL. with run time vent and occupied by a family of four showed good results. This house was bigger (~2,500 sq. ft. and with 4 bedrooms) and the run time vent rate was only 32 cfm. See Figure 1-11 below.

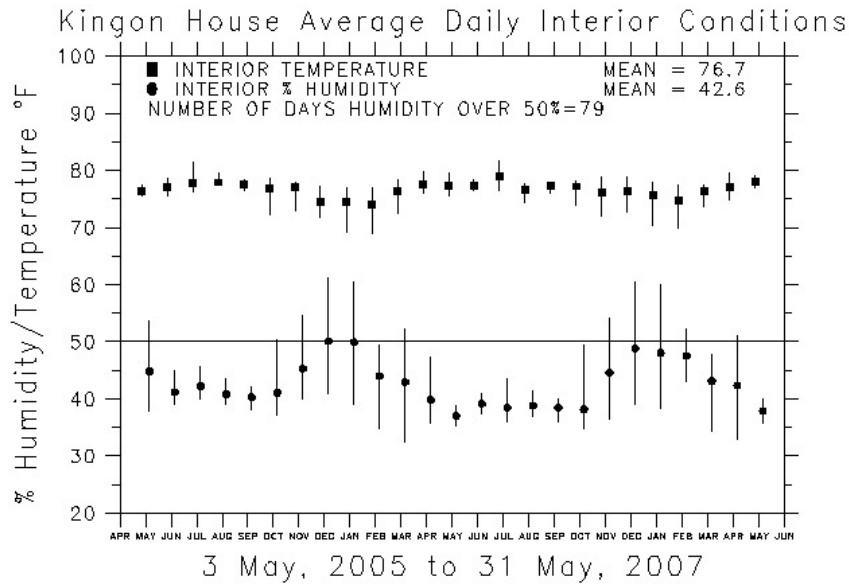


Figure 1-11 Interior T and RH for an occupied house in Ft. Myers, FL

For this house, the percentage of days that the interior RH was above 50% was only 11% of the time during this approximate 2 year long monitoring period.

1.4. Fortified® HUD Code Homes

In 2005 FSEC was asked to participate in the Institute for Business and Home Safety (IBHS) technical committee for HUD code homes. However, no significant activity occurred in this task area during BP1 or BP2.

1.5. Plug Load Reduction

Homes around the world currently have no means to judge household energy use other than their monthly utility bill. Unfortunately, this does not readily provide insight as to how or where the energy is being used. Existing studies show that providing direct instantaneous feedback on household electrical demand can reduce energy consumption by 10-15%. Recently, such feedback devices are commercially available and dropping in price. Not only are these reductions potentially large as they comprise *all* end-uses, they may provide unique opportunities to realize goals for high-efficiency buildings. Reducing and shifting electrical demand is particularly important in Zero Energy Homes (ZEH), where it would be desirable to match solar electric PV output with household loads.

To obtain current data on the magnitude of savings that can be expected, 17 homes were fitted with a real time energy feedback device called “*The Energy Detective*” (*TED*) which costs approximately \$150. This is a small 3.5 x 5” display unit which plugs into the wall and receives power line carrier signals from a sending unit installed in the central breaker panel. Output is available on a digital display as shown in Figure 1-12.



Figure 1-12 TED The Energy Detective

For a control group, we obtained average data on average energy use in the over 2 million, non seasonal, single family homes that are served by Florida Power and Light. These homes represent roughly 2% of the entire U.S. residential building stock and a third of all residential dwelling units of all types in the State of Florida.

Pre-installation consumption for these houses averaged 18,396 kWh/year—virtually identical to the 18,201 kWh seen in FPL’s two million home control group from May 2005 - April 2006. Our analysis showed that average electricity use in the overall group declined in the year after the installation of the energy monitor. However, as expected, the specific change varied substantially from one site to another.

Table 1-1 Energy Use Pre and Post Installation of Energy Monitors

Site	Install Date	Before Installation	After Installation	Reduction (%)	Weather Change* (%)	Raw Savings (kWh)	Normalized Savings (kWh)	Normalized Savings (%)
C1	6-May	49.9 kWh	52.1 kWh	-4.4%	1.36%	-2.2 kWh	-2.9 kWh	-5.9%
C2	6-Feb	41.3 kWh	41.3 kWh	-0.2%	1.20%	-0.1 kWh	-0.6 kWh	-1.4%
C3	6-May	39.9 kWh	38.1 kWh	4.4%	1.36%	1.8 kWh	1.2 kWh	3.1%
F1	6-May	51.4 kWh	50.0 kWh	2.6%	1.36%	1.3 kWh	0.6 kWh	1.2%
F2	6-May	113.3 kWh	92.2 kWh	18.6%	1.36%	21.1 kWh	19.5 kWh	17.5%
H1	6-Apr	39.7 kWh	37.9 kWh	-0.2%	0.88%	-0.1 kWh	-0.4 kWh	-1.1%
H2	6-May	30.2 kWh	27.1 kWh	10.3%	1.36%	3.1 kWh	2.7 kWh	9.1%
H3	6-Feb	40.8 kWh	36.7 kWh	10.0%	1.20%	4.1 kWh	3.6 kWh	8.9%
H4	6-Dec	76.0 kWh	66.4 kWh	12.6%	1.87%	9.6 kWh	8.2 kWh	10.9%
K1	6-Jul	43.8 kWh	44.3 kWh	-1.2%	3.95%	-0.5 kWh	-2.3 kWh	-5.4%
M1	6-May	18.3 kWh	19.1 kWh	-4.5%	1.36%	-0.8 kWh	-1.1 kWh	-5.9%
M2	6-Jun	32.8 kWh	31.2 kWh	5.0%	2.73%	1.7 kWh	0.8 kWh	2.4%
M3	6-May	45.6 kWh	38.3 kWh	16.1%	1.36%	7.4 kWh	6.7 kWh	15.0%
PI**	5-Jul	18.5 kWh	13.7 kWh	26.1%	-2.51%	4.8 kWh	5.3 kWh	27.9%
S1	6-Aug	26.0 kWh	27.4 kWh	-5.6%	3.56%	-1.4 kWh	-2.4 kWh	-9.5%
S2	6-May	31.8 kWh	28.9 kWh	8.9%	1.36%	2.8 kWh	2.4 kWh	7.7%
T1	6-Aug	138.4 kWh	114.1 kWh	17.5%	3.56%	24.3 kWh	19.3 kWh	14.5%
V1	6-May	38.8 kWh	32.7 kWh	15.7%	1.36%	6.1 kWh	5.6 kWh	14.5%
Overall		50.4 kWh	45.8 kWh	9.1%	1.80%	4.6 kWh	3.7 kWh	7.4%

* Average % energy use reduction for FPL customers in the same time period as each participant in the study, according to their TED

** Author's home; not included in overall averages

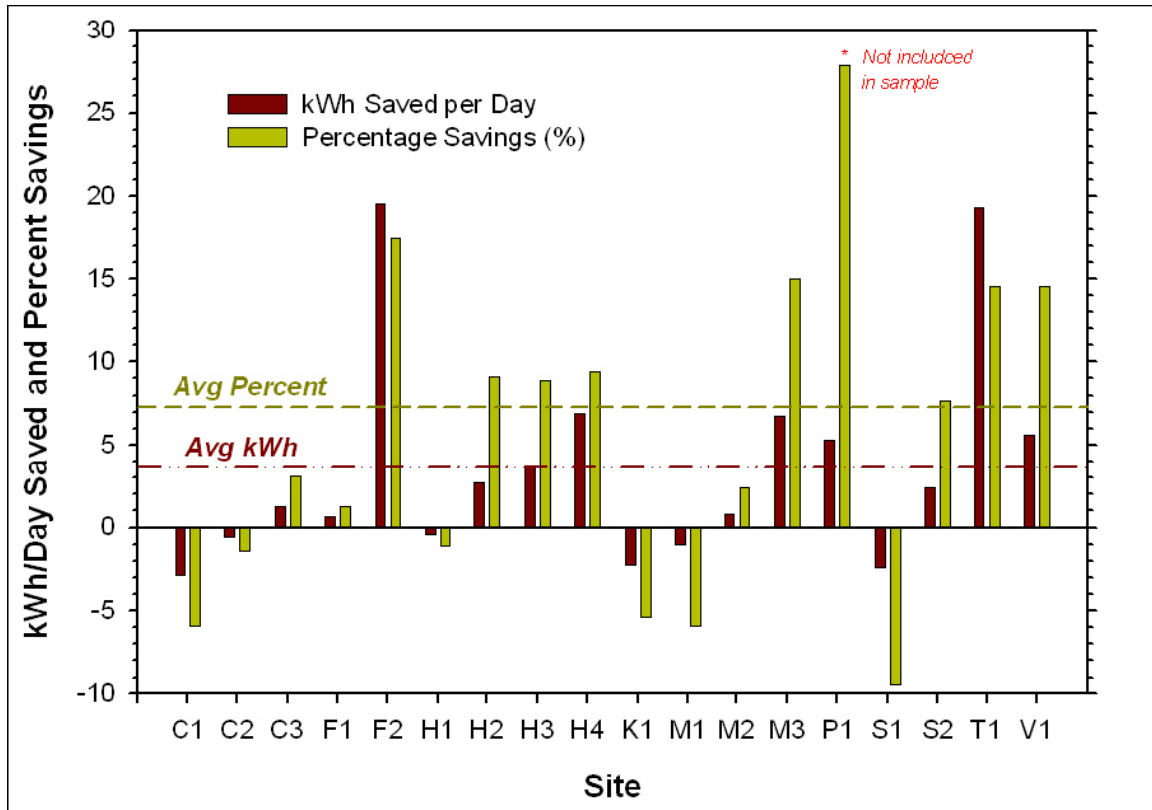


Figure 1-13 Average Daily Energy Savings

The average raw reduction was 9.1% or 4.6 kWh/day. We did complete a detailed analysis for each project participant which is given in the full report. When corrected to the control group (which often had weather related reductions in the post period) we saw the average savings from the energy feedback monitors of 3.7 kWh/day or 7.4%. However, this varied considerably from one home to another, ranging from an energy increase of 9.5% to a savings of 27.9%. Eleven homes showed savings while six homes showed energy use increases.

Homeowners became aware of large standby loads from home entertainment centers, home offices, computers and rechargeable power tools. They saw the large power draw of swimming pool pumps, clothes dryers, dishwasher and gas dryers.

Generally, the homes with the largest consumption also experienced the largest savings. Notably, the two homes with the largest pre-monitor installation use also achieved the largest savings in the post period. Based on exit interviews with the occupants, these two household paid close attention to the monitors and used what they learned to make overt changes in household appliances as well as scheduling for some equipment. This included large changes to household lighting, reduction of pool-pump hours and

replacement of an aging AC system in one. In Miami one user reported savings of 13% on their January bill. This was broadcast by the local NBC affiliate in Miami, FL and aired February 21, 2007 as the beginning of a highly popular series of news segments focused on reducing household energy use. This may mean that energy feedback monitors would have special value for utilities in homes with high bill complaints. It also may indicate that the economics of feedback will be most persuasive, for interested, but high energy consumers

1.6. Setup and Finish Processes for Modular Homes

This task was conducted by the Housing Constructability Lab (HCL) of the UCF Industrial Engineering Department in Budget Period 1. Two activities were undertaken by the HCL group for two builders – Royal Concrete Concepts and Habitat for Humanity.

Royal Concrete Concepts

Royal Concrete Concepts (RCC) produces innovative concrete modules for both residential and commercial markets throughout Florida. RCC currently operates a mid-size, unenclosed production operation in West Palm Beach. The existing plant consists of four production “lines” supported by various uncovered storage areas and small enclosed stockrooms. The plant can produce a maximum of four modules per day. To meet increasing demand, RCC is developing a new high-volume plant in nearby Okeechobee. The new plant will have 10 unenclosed production lines capable of producing 10 modules per day, increasing production capacity by 2.5 times. The new operation will be supported by a 20,000 square foot on-site, fully enclosed warehouse with two covered 2,500 square foot sheds; one on each end of the warehouse. The new warehouse will have conventional loading docks and a rail spur for receiving and shipping. The Housing Constructability Lab (HCL) research team was tasked to identify and develop innovative concepts for the supply chain – stretching from construction material vendors, through the warehouse, to the production line. To maximize impact, the scope was limited to three critical materials: rebar, polyethylene foam and steel interior/exterior studs.

In December 2006, the HCL research team presented a summary of this research to the RCC senior management team. Recommendations were well received and the RCC team agreed to review and implement the recommendations. The HCL research team continues to assist RCC with their new plant.

Habitat for Humanity

In March 2006, the UCF research team initiated efforts to assist Habitat for Humanity’s Operation Home Delivery in the design of Habitat’s first modular housing factory. The factory was envisioned as a high volume delivery method to replace homes destroyed by Hurricane Katrina. The team assisted Habitat in the selection of an existing facility, identifying retrofits necessary for modular home production (e.g., removing columns), designing layout alternatives that incorporated lean production concepts and detailing each production activity. All designs were developed collaboratively with Habitat personnel in a series of workshops hosted at UCF. The team also recommended changes

to the floor plans of the new modular home designs, making them more compatible with conventional home designs. Work was completed by summer 2006 but Habitat decided not to follow this path of modular housing factories.

1.7. Green Products and Processes

FSEC organized and moderated a conference session on green products and processes (identifying and documenting green aspects of HUD code and modular manufacturer products as they relate to achievement of Building America performance goals and green certifications) at the 3rd annual statewide GreenTrends conference in Gainesville, FL in May 2006.

In May 2006 after receiving DOE feedback on FY07AOP that this task area was of not high interest, efforts in this subtask were discontinued. Instead activities were pursued so that our builder partners could participate in existing green programs as they desired. Since May 2006 until the present, we have assisted partners to obtain such certifications including USGBC LEED-Homes, Florida Green Home Designation Standard and Enterprise Foundation Green Communities. These activities are described in sections 2 and 4 of this report.

During 2007, BAIHP assisted the following builders/homes by recommending green building materials and practices and assisting in the certification process:

- *The New American Home 2008* – Florida Green Building Coalition (FGBC) and National Association of Home Builders (NAHB) Green home
- *Vision House 08 (Westmont Homes), Palm Harbor Homes, Castle & Cooke* – FGBC
- *Royal Concrete Concepts, Stalwart Built Homes, Lakeland Habitat* – Leadership in Energy and Environmental Design (LEED) for Homes
- *Homes In Partnership* – Enterprise Green Communities

1.8. Cool Roofs

The Flexible Roof Facility (FRF) is a test facility in Cocoa, Florida designed to evaluate five roofing systems at a time against a control roof with black shingles and vented attic (Figure 1-14). Since 1989 the testing has evaluated how roofing systems impact summer residential cooling energy use and peak demand (Parker et al. 2005).



Figure 1-14 *The FSEC Flexible Roof Facility (FRF)*

In May of 2006 DOE recommended against conducting further research in this area as part of the FY07 AOP review process. Consequently, a very limited effort was expended in this subtask in BP1.

1.9. Night Cool

Using a building's roof to take advantage of long-wave radiation to the night sky has been long identified as a potentially productive means to reduce space cooling in buildings. The night cooling resource is large and enticing for residential energy-efficiency applications. On a clear desert night, a typical sky-facing surface at 80°F (27°C) will cool at a rate of about 70 W/m². In a humid climate with the greater atmospheric moisture, the rate drops to about 60 W/m² (Clark, 1981). Fifty percent cloud cover will reduce this rate in half. For a typical roof (225 square meters), this represents a cooling potential of about 1.5 - 4.0 tons each summer night if all roof surface night sky radiation could be effectively captured. However, the various physical properties (lower roof surface temperatures, fan power, convection and conductance) limit what can be actually achieved, so that considerably less than half of this cooling rate can be practically obtained. Even so, in many North American locations, the available nocturnal cooling exceeds the nighttime cooling loads.

A big problem with previous night sky radiation cooling concepts has been that they have typically required exotic building configurations. These have included very expensive "roof ponds" or, at the very least, movable roof insulation with massive roofs so that heat is not gained during daytime hours. To address such limitations, an innovative residential night cooling system was designed. The key element of the *NightCool* configuration is that rather than using movable insulation with a massive roof or roof ponds, the insulation is installed conventionally on the internal ceiling. The system utilizes a metal roof over a sealed attic with a main to attic zone air circulation system.

During the day, the building is de-coupled from the roof and heat gain to the attic space is minimized by the white reflective metal roof. During this time the space is conventionally cooled with a small air conditioner. However, at night as the interior surface of the metal roof in the attic space falls well below the desired interior thermostat set-point, the return air for the air conditioner is channeled through the attic space by means of electrically controlled louvers with a low power variable speed fan. The warm air from the interior

then goes to the attic and warms the interior side of the metal roof which then radiates the heat away to the night sky. As increased cooling is required, the air handler runtime is increased. If the interior air temperature does not cool sufficiently the compressor is energized to supplement the sky radiation cooling. The massive construction of interior tile floors (and potentially concrete walls) store sensible cooling to reduce daytime space conditioning needs. The concept may also be able to help with daytime heating needs in cold climates by using a darker roof as a solar collector. There is potential for mating the concept with Building Integrated Photovoltaics (BIPV) for combined heating, cooling and solar electric power production.

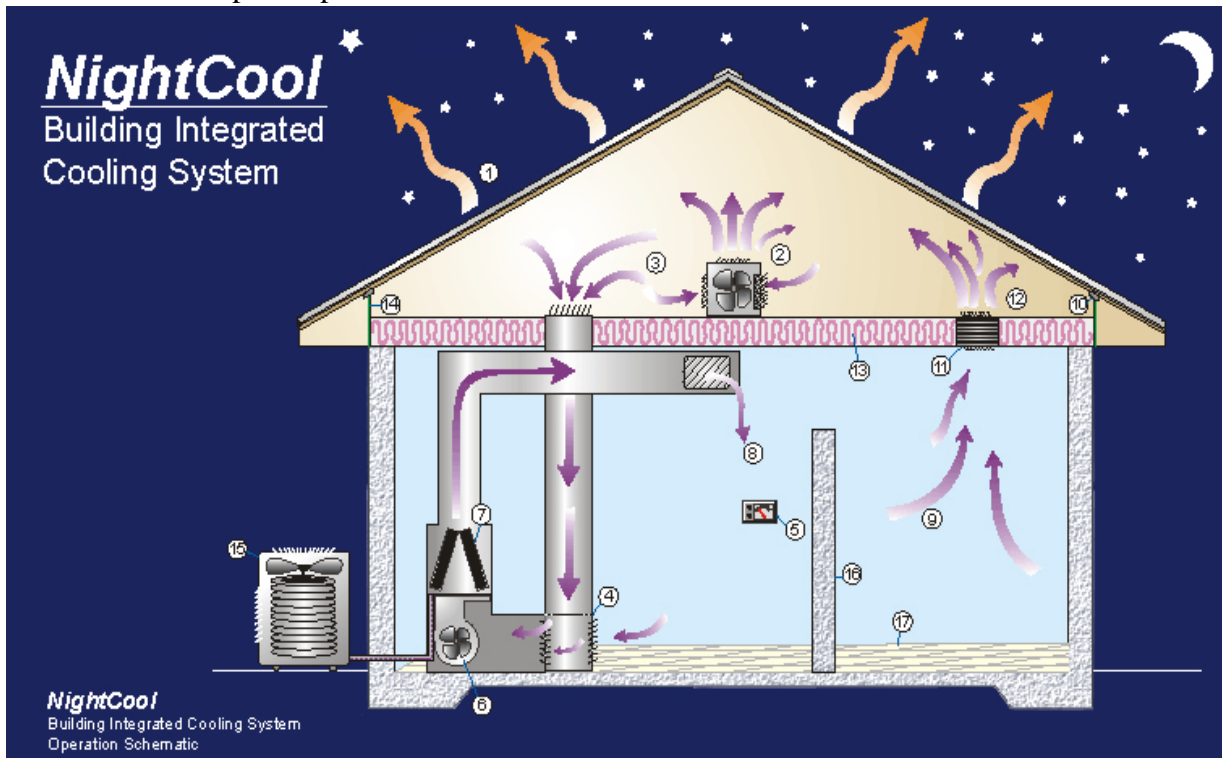


Figure 1-15 NightCool Operation Schematic

The empirical evaluation of the concept is being accomplished by using two highly instrumented side-by-side 10' x 16' test buildings located at the Florida Solar Energy Center. One of the test buildings is configured like a conventional home with a dark shingle roof and insulated ceiling under a ventilated attic (see Figure 1-16 and Figure 1-17). The experimental building features a white reflective roof on battens with a sealed attic where the air from the interior can be linked to the sealed attic and roof radiator when the roof temperature drops below the room target cooling temperature (see Figure 1-18 and Figure 1-19).



Figure 1-16 *Conventional Shed with Dark Shingle Roof*



Figure 1-17 *Conventional Shed with Vented Attic and R-30 Fiberglass*



Figure 1-18 *NightCool Shed with White Metal Roof*



Figure 1-19 *Exposed Metal Roof in NightCool Attic*

In 2007, *NightCool* performance was evaluated under standard operating conditions during a full Florida cooling season, from April to November. Air conditioning was used in both test buildings, but when favorable attic temperature conditions were met, *NightCool* activated with fan circulation in the experimental test building. Sensible internal heat gains were added similar in scale to what would be seen in an occupied home.

Measured cooling energy savings averaged 15% over the 8 month test period. Monthly performance indices were produced. Daily *NightCool* system Energy Efficiency Ratios (EERs) averaged 24.9 Btu/Wh over the summer to fall test period – somewhat lower than simulations conducted earlier. However, a mid-summer adjustment to the system activation attic temperature was found to improve the performance by about 2 Btu/Wh after June. In any case, this level of performance compared favorably to an EER for the

vapor compression air conditioner of about 9 Btu/Wh. This level of performance also exceeds the performance of any air source equipment currently available.

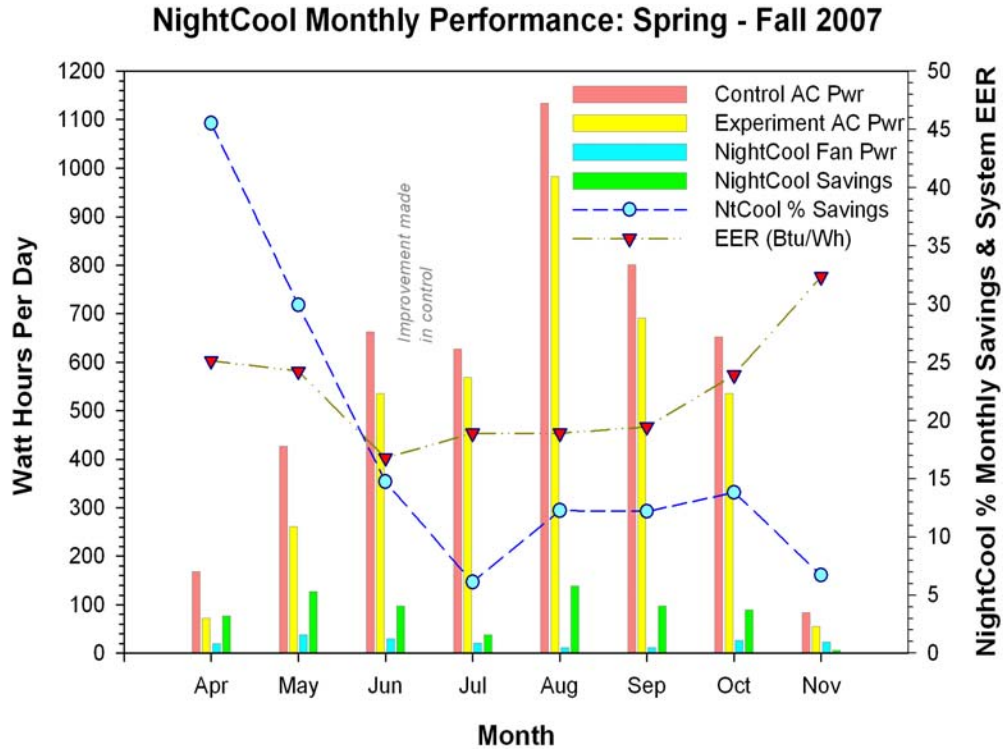


Figure 1-20

The delivered cooling rate averaged about 1.5 - 3.0 Btu/hr/ft² (5 - 10 W/m²) of roof surface on the average evening, implying that *NightCool* in a full scale 2,000 square foot home would cool at a rate of 4,000 - 8,000 Btu/hr depending on the season. Daily runtime fractions during which the *NightCool* fan operated varied from 12% (3 hours) in August - September to 36% to 8 hours in May. Over a typical 6 hour operating period, this would produce about 0.2 ton-hours of sensible cooling or 2 ton-hours in a full scale home.

The favorable experimental data collected indicates that *NightCool* can be a promising system technology for 50% or higher benchmark homes in hot-arid, hot-dry/mixed, mixed and humid climates. We plan to continue experimental and analytical work on the *NightCool* concept throughout 2008 concentrating on improving the dehumidification performance of the concept and refining the operational configuration.

1.10. Solar Integrated Roofing Panels

This subtask was performed by one of our subcontractors – U. Texas at Austin, School of Architecture (UTSOA) during the first budget period. UTSOA focused on developing scenarios for two different modular houses and then testing options for photovoltaic arrays for both. They analyzed type, size, cost, energy production, ease of installation and public acceptance for both differing scenarios. Two models were developed.

The Back Home

This is a house that could be rapidly deployed, but provide permanent affordable housing in areas of need. This model was developed in response to FEMA's Alternate Housing Pilot Program requirements, issued September 15, 2006. It is designed to meet health and safety requirements for hurricane prone areas. The house is 700 square feet and has one bedroom and one bath.

The Bloom House

This is an evolution of the University of Texas Solar Decathlon 2007 competition house, designed to be marketed as part of an urban infill development to a median income family in Austin, Texas. This model is 1300 square feet, with three bedrooms and two baths. UTSOA designed the development layout as part of a conservation development in central Austin to test a strategy for implementation of photovoltaics in the larger housing market.

Task 2. Prototype House Involvement and Evaluations

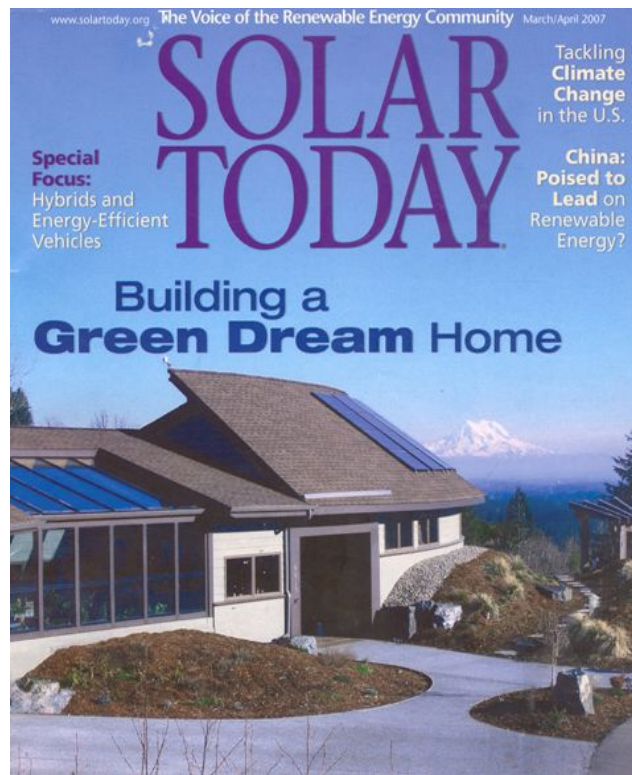


Figure 2-1 Garst Residence – Olympia, WA, as featured in *Solar Today*.

Section 2: Prototype House Involvement and Evaluations

In this section we document our efforts in providing design and technical assistance to over 40 organizations in 7 states in 2007. We have been instrumental in coordinating partnerships between organizations requesting help, renewable energy manufacturers and our prototype building partners. This section also documents instrumented monitoring in prototype home construction projects which included activities involving 15 organizations. BAIHP continues to support demonstration home projects and were active in the 2007 International Builders' Show and are providing support for several 2008 International Builders' Show homes. Handouts outlining the energy efficient, high performance and green features of both homes were disseminated at the show. They can be found in Appendix B - .

2.1. Prototype Homes

2.1A. High Performance Prototype Homes Design Assistance

This section describes in case study format the BAIHP work conducted on whole house systems engineering test houses (prototype) using the following general process:

- Begin with a review of preliminary drawings and perform energy analysis using detailed hourly simulation software.
 - Examine opportunities to bring the air handler and the ductwork within the thermal envelope and determine proper location of all ventilation inlets and exhaust outlets. Propose appropriate moisture tolerant wall and roof systems.
 - Propose envelope and HVAC equipment choices (including solar energy equipment) options to meet builder budget and efficiency targets.
 - Suggest Healthy and Green options.
- Finalize design and specifications after discussions with builder.
 - Perform detailed room by room load and duct size calculations to size the heating / cooling equipment and ductwork using ACCA procedures.
 - Provide mechanical drawings that include ductwork layout, mechanical equipment specifications and details to the builder and the HVAC sub.
- During construction, make periodic site visits to ensure quality—especially in the areas of window flashings, thermal and air barrier continuity, sealing of ductwork and envelope.
 - Determine envelope and duct tightness by blower door and duct test equipment.
 - Commission all systems ensure proper operation to design.
- Lastly, BAIHP often works with a partner to market their homes by educating customers about the uniqueness of the house and the BA project.

Armed Forces Foundation (AFF)

In December 2006, the Armed Forces Federation initiated discussions with FSEC along with other organizations to assist with a pilot project to provide accessible housing to injured veterans. They requested that DOE programs provide technical and financial support for the integration of solar energy and energy efficiency in two planned homes in Arizona and North Carolina. FSEC solicited Palm Harbor Homes, a Building America partner, to design and build the home, which incorporate the needs of the customers and solar energy and energy efficiency measures. This pilot project could produce a replicable product marketable to other Palm Harbor Homes customers. BAIHP offered technical support via teleconference calls to AFF until the effort was discontinued in early 2007 due to lack of response from the AFF.

Atlantic Housing Partners

Atlantic Housing Partners is a multi-family builder looking for rebates for energy efficiency and renewable energy use. The company (also a BAIHP partner in the past as Sandspur Housing) is working with BAIHP on a cost shared contract. BAIHP conducted a site visit and energy audit of Cambridge I, a Lakeland development that is already complete. Atlantic Housing received assistance with a sealed attic design, pool efficiency, outdoor lighting options and HVAC design review by Calcs-Plus for their clubhouse and standard apartment in their planned development, Cambridge II.

We also developed common area energy estimates and delivered common area PV bid specs for Cambridge II and another development, Fountains of Millenia. Atlantic Housing is looking into a net metering agreement with Orlando Utilities Commission (OUC).



Figure 2-2 Cambridge I Development with Site for Cambridge II Development below.

Brevard County Housing

New partner Brevard County Housing seeks higher efficiency, increased durability and tax credits for their entry level/affordable homes. FSEC talked with Brevard County builders Anchor Homes (a new BAIHP partner), Patrick Mulligan and Furnival Construction, and analyzed one home for Anchor. FSEC staff also performed preliminary analysis on an all-AAC construction house built by another Brevard County builder.

Brownsville Affordable Housing Corporation

New BAIHP partner, the City of Brownsville, TX's Brownsville Affordable Housing Corporation(BAHC) plans to build ten houses, five of which began construction on October 2007 and the rest began before then. Eight of the ten houses will be built from the same model home. BAIHP worked with Brownsville to make recommendations to bring the homes under a HERS Index of 70. In October 2007 BAIHP staff visited two homes under construction and made recommendations to increase energy efficiency and indoor air quality. As of February 2008, two homes have been tested and rated with HERS indices 73 and 77.

David Axel Home, Oviedo, FL

BAIHP provided feedback on house construction and combustion appliances for Dave Axel home. A site visit was made and construction documentation was monitored during construction. After the home was completed, FSEC representatives visited again to examine the variety of building products and techniques used.



Figure 2-3 Construction Detail



Figure 2-4 HVAC equipment installed

David Weekley Homes

David Weekley Homes is building homes as part of the East Bay Project (see below). Calcs-Plus performed HVAC load and energy code calculations, Energy Gauge USA Calculations & HVAC system design for nine houses.

East Bay Development Group (EBDC)

BAIHP provided assistance to several builders and manufacturers participating in the East Bay Project. This 2600-home development has adopted its own code, East Bay Code, that includes Green design and ENERGY STAR. East Bay Code encourages high performance and green design standards like ducts in conditioned space, ENERGY STAR lighting/appliances and estimates benchmark savings of 30% - 50%.

BAIHP visited partner East Bay Development Group in Calloway, FL in late July 2006 to inspect prototype modular homes that will be used to create high performance, affordable communities. Two buildings were inspected, and one was performance tested with favorable results. Recommendations were made regarding final specifications.

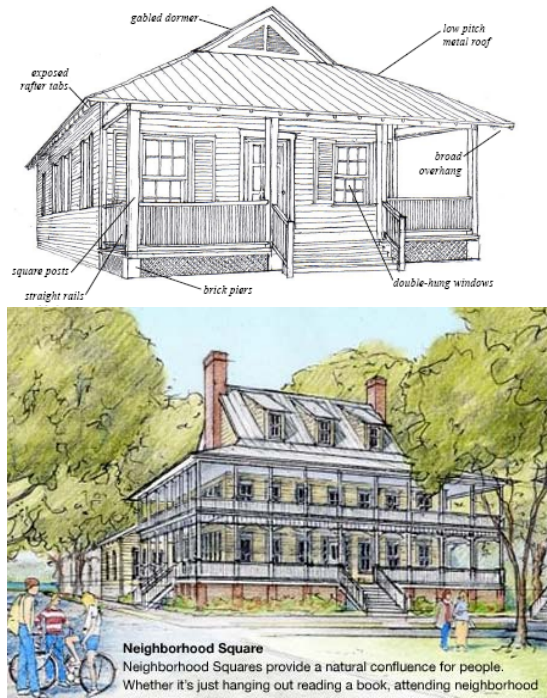


Figure 2-5 *Planned Development in East Bay, FL*

In 2007, BAIHP presented a green building/building science training to East Bay Development team and key staff from David Weekley Homes. Discussions were held regarding HVAC engineering on some specific plans, and schedules discussed for implementing prototypes at the community scale. In August 2007, BAIHP met with representatives of Stalwart Homes, East Bay, Earth Comfort, Honeywell and David Weekley Homes in Panama City, FL to discuss LEED certification, indoor air quality and geothermal heat pump among other issues for upcoming homes in Panama City to meet Building America energy standards.

Federation of American Scientists, Houston, TX

In 2007, BAIHP assisted the Federation of American Scientists with analysis and technical support for the 2200 of the total 5,000 affordable modular/HUD code homes being procured by the state of Mississippi with funding from FEMA have been built as of February 2008. BAIHP conducted analysis of three manufactured housing designs and revealed that all three, assuming duct and whole house leakage, achieved ENERGY STAR.



Figure 2-6 FAS Emergency HUD Code Home for Mississippi

The Federation of American Scientists also received assistance from BAIHP in the construction of a prototype home during BP1. The project location is in Houston, TX and is known as Rasbach House.

Ferrier Builders

Ferrier Builders was accepted into the BAIHP program in fall 2006. They are an award winning custom home builder in the Dallas, TX area who builds exclusively with SIP panels. The builder, achieving HERS Indices from 47-55, utilizes passive solar techniques, solar DHW and sealed attics. BAIHP performed multiple design reviews, made recommendations and consultations, including analysis and recommendations for a large (~5,000 sq. ft.) home with PV.

In 2007, BAIHP performed Energy Gauge simulations and prepared a report for the Hartsell Zero-energy concept home, recently redesigned by GGOA architects for Ferrier Custom homes of Ft. Worth, TX. The home includes a crawlspace foundation and SEER 17 Daikin ductless air conditioning.

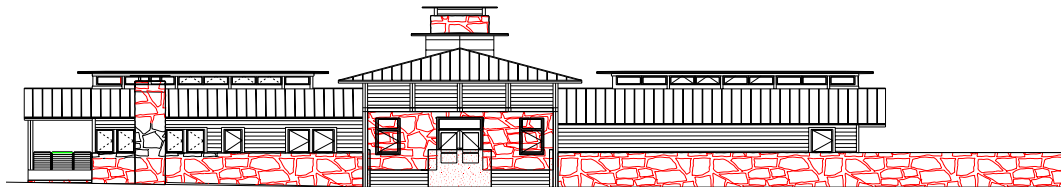


Figure 2-7 Elevation for Ferrier Builders prototype home in Dallas, TX

Florida Custom Homes - Peace River Villas

Florida Custom Homes is planning an 86-unit townhouse community (Peace River Villas) in Sebring, FL featuring PV and Solar DHW. In November 2007, BAIHP attended a strategic planning meeting for Peace River Villas. This builder is interested in the LEED for Homes Pilot Program and the Federal Tax Credit. Calcs-Plus performed HVAC load calculations & preliminary Building America analysis to achieve the tax credit. Not only is this builder planning on PV, but they are considering metal roofs and interior ducts as well.

Garst Residence

The Garst residence is a 2400 ft.² home built in Olympia, Washington to the Building America 50% benchmark. The Northwest ENERGY STAR qualified home features a ground source heat pump supplying domestic hot water and heat to an R15 radiant slab, ENERGY STAR lighting and appliances, solar sunspace, a 4.5 kW photovoltaic array, central energy recovery ventilator/forced air filtration system, tankless hot water for master bath and hybrid Icyne™/ loose fill R-49 ceiling insulation. Home construction began in summer of 2005 and was completed in May of 2006. BAIHP staff from WSU and FSEC coordinated during the design, field testing and monitoring stages. Field testing indicated envelope leakage of 4.9 ACH₅₀.

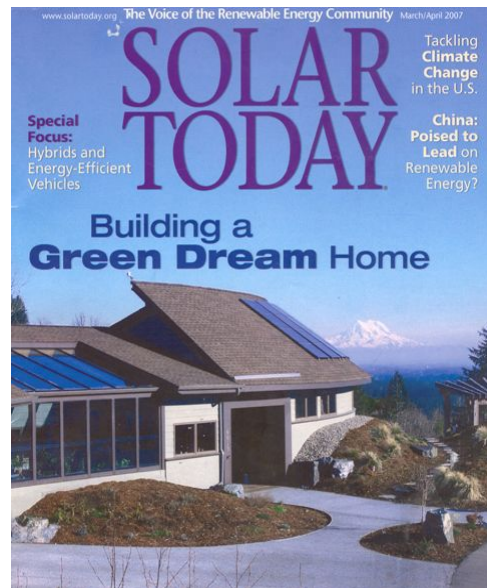


Figure 2-8 Garst Residence – Olympia, WA, as featured in Solar Today.

A full report is available in Appendix C - Washington State University Annual Report.

GMD Construction (DiVosta)

BAIHP provided technical assistance to Guy DiVosta with GMD construction in Palm Beach Gardens, FL. Mr. DiVosta was interested in improving the overall energy efficiency of his home designs and providing solar thermal or PV systems as options. GMD Construction (Divosta) received a lighting assessment and plan from California Lighting Technology Center (CLTC), which included extensive use of CFLs and occupancy sensors. BAIHP is awaiting the completion of a model home implementing this plan. In addition, GMD Construction consulted BAIHP on a home that had some indoor comfort problems in 2006.

In 2007, we performed design review and made recommendations for a 31 home development planned by GMD Construction in Jupiter, FL. Preliminary analysis of one

model shows that 30 to 40% benchmark savings (plus PV and SDHW) is attainable. GMD Construction adopted a new design suggested by BAIHP that reduces the cooling load from large, unshaded, single pane impact glass windows by reducing the number and size of windows.

Holiday Builders

This builder, based in Melbourne, FL, became a BAIHP partner in late 2007. The builder is interested in pursuing high performance and green strategies for upcoming homes and communities. FSEC staff provided energy analysis and recommendations in January 2008. The builder is considering building to BA standards

Homes by Point

This new Building America partner is a custom home builder in Tampa, FL that builds over 50 homes a year. It is willing to cost share. FSEC discussed Building America, ENERGY STAR and Green building design with staff from Homes by Point, tested an existing home and analyzed a set of plans for this builder.

Homes in Partnership

This developer and partner desired to build ENERGY STAR certified affordable housing. BAIHP worked with and made recommendations to meet ENERGY STAR and beyond in support of Enterprise grant application. In April 2007 the Enterprise grant application was accepted based on preliminary analysis for one home designed to ENERGY STAR and better.



Figure 2-9 *Homes in Partnership Pine Level Home undergoing performance testing*

Louisiana System Built Homes

Louisiana System Built Homes is based in Lafayette and wishes to achieve ENERGY STAR and Green Building standards. FSEC researchers toured the facility, performed energy analysis and provided feedback on cost-effective improvements. This modular home manufacturer is of special interest because it uses SIP panels in modular house construction.

Marquis Construction, Crimi Home, Masaryktown and Dade City, FL

Steven Crimi is the homeowner and sub-contractor for a home located in Masaryktown, Florida (west central FL). The shell was constructed by Marquis Construction, a Building America partner. He intends to integrate PV and DC circuit for LED lighting. This home uses SIP wall and roof panels, AAC floor, has a weather tight crawlspace that serves as a return for the whole house. During 2006 BAIHP has been involved with PV, lighting and whole house indoor air quality design recommendations.



Figure 2-10 *Weather tight and insulated crawlspace*



Figure 2-11 *Channels in roof construction to allow ventilation of potential heat generated from pv*

Marquis Construction also completed two all SIP homes that FSEC tested and submitted energy rating files to Calcs-Plus for tax credit and rating. The homes HERS Indexes were 62 and 68. BAIHP continued to work with this builder in 2007



Figure 2-12 *Back view of Marquis Construction home in Dade City, FL*



Figure 2-13 *Testing Marquis Construction home in Dade City, FL (HERS Index 62)*

Newport Partners

Newport Partners became a BAIHP partner in August 2007. BAIHP is providing support for the HUD concept home in Charleston, SC, contracted to Newport Partners by PATH.

The home will be a showcase for sustainability, energy efficiency, production efficiency, adaptability and affordability. See PATH Concept Home below.

Park Square Homes

In October and November 2007, FSEC staff met with Park Square Homes, a major production builder in Orlando. Park Square Homes indicated interest in the BA program and visited with G.W. Robinson builders in Gainesville. FSEC performed analysis of two home plans to achieve a HERS Index of less than 70.

PATH Concept Homes

In BP1, BAIHP performed benchmark analysis for the 2007 Path Concept Home in Omaha, NE to determine source energy savings over the BA benchmark. The two-story, 2021ft² Path home demonstrated benchmark savings of 28.7% and HERS Index 79 with specified SEER 13, HSPF 8.5 HVAC equipment and Low-E 0.35 SHGC / 0.35 U windows. To achieve a BA 30% energy savings level (HERS 77), the use of SEER 14 and 9.0 HSPF equipment was recommended to PATH.



Figure 2-14 2008 PATH HUD Concept Home to be built near Charleston, SC



Figure 2-15 2007 PATH concept home in Omaha, NE

The 2008 PATH Concept Home is a HUD-Code home to be built in Charleston, SC by Newport Partners, a new BAIHP partner. This project's objective is to design, build, evaluate and demonstrate America's 2nd Concept Home, creating a vision for the future of home building that resonates with both builders and the buyers. BAIHP is providing technical support in mechanical design systems, energy analysis and monitoring and assistance in green certification programs such as LEED-H, Earthcraft and NAHB Green. Conceptual design plans are currently being finalized and construction documents are expected to be complete by March 2008. Monitoring is planned for November 2008.

Rainier Construction

Rainier Construction was welcomed as a new BA partner in 2006. A home Rainier had completed construction on “pre-BA Partnership” was performance-tested to create a benchmark for this contractor. Rainier’s first BA home is currently under construction and is known as Oyler Residence. A pre-permit submittal meeting was conducted to ensure all disciplines were aware of high performance, energy efficient objectives for this project. City of Maitland plan reviewers were also prepared prior to permit submittal of atypical strategies that may raise flags. This initial preparation was designed to save delays during plan review and construction. This home is also designed to be ENERGY STAR, is expected to reach the 40% benchmark savings and apply for FGBC certification. Calcs-Plus performed HVAC equipment and duct layout design.

During 2007, BAIHP provided energy analysis—projecting the home at a HERS Index of 67; gave advice on window flashing details, siding installation and other building details; made periodic site inspections; and coordinated the final HVAC and dehumidification system including moisture control detailing and a redesign of the duct system by Calcs-Plus.



Figure 2-16 *Oyler Residence stem wall under construction*

Royal Concrete Concepts (RCC), Pt. St. Lucie, FL

In 2006, BAIHP worked with Royal Concrete Concepts to incorporate PV on concrete modular residential buildings while still in the factory. We also assisted in updating load and energy calculations and conducted performance testing on their panelized home. This home became the first certified USGBC LEED Home in Florida in 2007. They have 18 production lines that facilitate the structural strength of the panels to reach minimum 8,000 psi in 28 days and resist impact of a 2x4 at up to 84 mph. Other features of this prototype design are good R-values, tight envelopes and ducts in conditioned space.



Figure 2-17 *Royal concrete concepts modular section*



Figure 2-18 *Structure & chase details*

Schakow Development and Trunnell Homes

Schakow Development and Trunnell Homes are developing a Zero Energy Homes community in Gainesville, FL called Forest Creek Zero Energy Homes Community. These homes will be some of the most efficient residences ever constructed in Florida and include solar electric power and very low energy use appliances. This project represents the first community level ZEH program in Florida. BAIHP assisted with the development of detailed specifications, evaluation of systems and simulation of various program elements for two prototypes whose construction began in June 2007. FSEC and FLHero staff assisted developer in finding advice and products from various producers—Icynene, Classic Metals for roof, Florida Heat Pump for the water to air AC systems and Panasonic USA for house fans. They also assisted with discussions on net metering with GRU on behalf of the developer and assisted the developer in establishing a low cost plan for the PV system with Tom Lane, the solar water heating system installer. The two prototype homes will be monitored upon completion.



Figure 2-19 Zero Energy and Near Zero energy Community Prototype Home, Gainesville, FL

Schroeders Homes

In June 2007, BAIHP accepted and welcomed Schroeders Homes as a new BAIHP partner who is building a zero-energy concept home in North Point, FL. We performed Energy Gauge simulations and installed instrumentation wiring in the home. In addition, we made recommendations to optimize PV, prepared a plumbing and instrumentation plan for the water heating system that uses energy recovery units, as well as provided assistance for solar thermal and air conditioning systems.

Selkirk Homes, ND

BAIHP finalized ENERGY STAR ratings on (4), phase IV homes and mailed certificates. BAIHP also submitted analysis of (6) phase V homes including EPACK06 tax credit qualifications, however, Selkirk Homes decided in May 2007 not to apply for new home tax credits.

Southern Energy Homes, Cullman, AL & Cavalier Homes, Opelousas, LA

In 2006, manufactured home builders Southern Energy Homes and Cavalier Homes requested assistance in diagnosing and solving moisture related issues in their homes. During 2006 and 2007, BAIHP personnel helped both manufacturers develop duct designs that placed all the ductwork within the thermal envelope as well as eliminating

external cross-over ducts. Data collection began on November 23, 2006 and can be found at <http://www.infomonitors.com/hsd>. A full description of the project is given above in *Subtask 1.1 Improved Duct Systems*.

Stalwart Homes / Palm Harbor Homes Partnership

Two BAIHP partners, Stalwart Homes and Palm Harbor Homes have entered into an agreement to partner and build high performance, energy efficient, sustainable modular homes for the panhandle region. Stalwart plans for all homes, sourced from Nationwide in Cordel, GA and Palm Harbor Homes, to be LEED certified and attain very high levels of efficiency. The first five prototype homes are under construction in Callaway Corners, near Panama City, FL. BAIHP participated in a meeting that discussed the strategies Stalwart Homes would like implemented into the modular process, including but not limited to ground source geothermal system, solar water installations and other features being worked out.

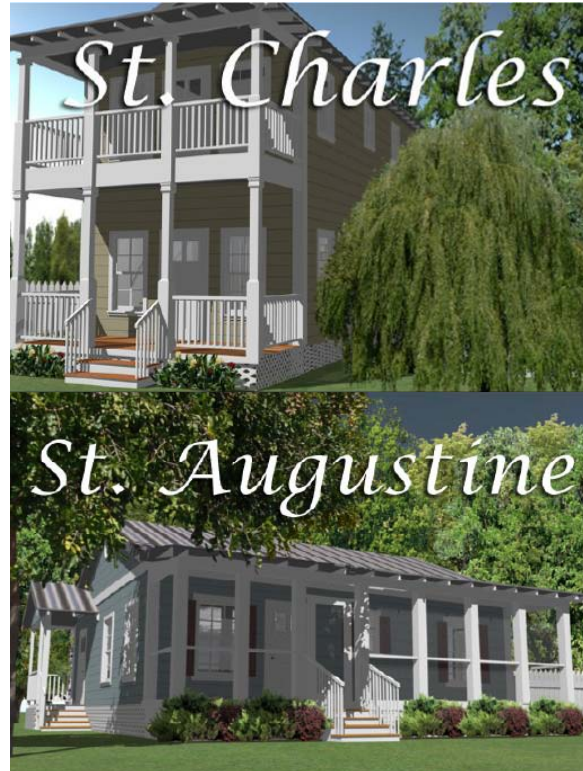


Figure 2-20 *Stalwart Homes in Callaway, FL*

Homes in Callaway Corners (see) consist of 8 floor plans in which BAIHP performed HVAC load calculations/worse case analysis and system design. BAIHP also investigated ground source heat pump equipment as per the owner's direction. The HVAC floor plans are ready for review by Nationwide Homes (manufactured home builder). This project includes two communities of 270 modular homes with ducts in conditioned space and outside air ventilation with supplemental dehumidification.

BAIHP assisted in photovoltaic system design (GE), performed inspection towards thermal bypass compliance for ENERGY STAR and green certification (LEED) and installed monitoring equipment for a two-story high performance PV home (Nashville model). The house will be manufactured by Nationwide in Cordel, GA, and will be delivered to the East Bay community in Panama City, FL.

BAIHP also assisted Stalwart homes in the selection of geothermal heat pumps. Researchers noted the trade-off in energy efficiency between units of same manufacturer and identical capacity (1.5 tons). Two utilized R-22 and achieved EERs of 18.3 and 19.4, however, the one that used the environmentally friendly R-410a is listed with a reduced efficiency of EER=13.4.

Stamets Residence

The Stamets residence is a 5000 ft.² home, constructed in 2005-06 in Shelton, Washington. The home, which is modeled to achieve a 50-60% Building America benchmark, features many ENERGY STAR features. BAIHP staff are coordinating the design and installation of a ground source heat pump to be installed in the summer 2008, and PV system to be installed in 2009. Installation of the ground source heat pump is scheduled for summer 2008; solar hot water and PV system installation is slated for 2009. The home was built with ENERGY STAR windows, lighting and appliances, HRV and HEPA filtration, a heat pump water heater and condensing dryer, Seisco tankless hot water heater, .74 AFUE propane fireplace and Seisco tankless electric boiler. The 2x6 standard frame wall is insulated with Icynene™ in the cavity and R-5 foam sheathing. Icynene was also used for the ceiling and vented crawlspace (R19 in each case).



Figure 2-21 *Stamets Resident – Shelton, WA*

In 2007, an additional ceiling and floor insulation was added. R-30 blown insulation was added to the ceiling, for a total of R-49. In addition, R19 unfaced batt was added to the floor insulation for a total of R-38. Monitoring of space heat and attic and crawlspace temperature and RH is currently underway to evaluate performance of these hybrid systems. BAIHP staff are also evaluating energy and lifestyle impacts associated with the use of electric hot tub, re-circulating DHW system and HEPA filtration systems.

WCI Communities, Naples, FL

BAIHP staff developed, scheduled and delivered a training seminar on Zero Energy Homes to the architecture division of partner WCI Communities in January 2007. The partner was planning construction of a ZEH in 2007. Four potential house plans were analyzed for performance potential, and BAIHP recommended efficiency and renewable energy packages were prepared for the builder to consider.

ZCS Development, Rockledge, FL

ZCS Development is developing a 100 unit subdivision named Sierra Lakes in Rockledge, FL that includes all steel and foam construction with a sealed attic. Steel members are produced on-site with a mobile manufacturing unit. Energy and HVAC

analysis was conducted and a BIPV design was provided to offset annual energy use to near-zero energy. The first model (Wesley) is complete. Data collection began in 2007 for the Wesley model and is available on infomonitors. BAIHP completed IR camera scan and envelope and duct tightness testing. Calcs-Plus found that the Wesley model achieved a HERS Index of 71 and qualifies for a tax credit (50.6%).

BAIHP assisted with the development of low energy lighting package, active solar hot water system and PV powered pool pump. Other features include R-22 roof deck sprayed insulation, R-24 foam walls, ducts in sealed attic space, SEER 17.0/HSPF 9.2 HVAC equipment, 60% fluorescent lighting, Low-E windows (0.32 SHGC/ U-Val 0.4) and instantaneous water heater (in addition to solar hot water heater). This development received media attention in *Florida Today* (*Florida Today*, "New homes boast energy efficiency: Developer uses recycled steel instead of concrete, wood", January 4, 2007.)



Figure 2-22 Sierra Lakes, Wesley Model



Figure 2-23 Steel trusses produced on site

Florida H.E.R.O. Activity:

- *Spain & Cooper Construction* – Willowcroft, Greystone and Custom Homes: Design review, TBIC, Tax Credit and Site visits for QA. Provided technical support and assistance for a high performance home with unvented attic. Introduced the BA Builders Challenge. Received commitment to accept the challenge.
- *Custom Homes* - Florida, Georgia and Texas - Multiple design reviews, recommendations, consultations & commissioning.
- *Southern Heritage Homes* - Archer, Fl - Developed Manual J's, Manual D's and Code Compliance forms. Multiple design Review & provided consultation to develop specifications for future homes achieving the tax credit level of performance. Final testing and commissioning for this builder's first home to achieve tax credit level of performance (HERS Index of 69).
- *Rainbow Springs* - Dunnellon, FL - Met with staff and representative from Progress Energy for preliminary discussion of ENERGY STAR and tax credit qualifications. Conducted multiple Design Reviews.
- *Bedsaul Development* - Gainesville, FL - Design Review & provided consultation to develop specifications for future homes achieving the tax credit level of performance.
- *Capital Home Builders* - Thomasville, GA - Design Review & provided consultation to develop specifications for a model home using a unvented attic. Performance tested and certified as the first ENERGY STAR Home in the area.

- *R.P. Witt Construction*, Jacksonville, FL - In November, FLHERO attended a LEED charrette with Paul Witt, his staff, a representative from JEA and others in Jacksonville. The LEED for homes pilot program's requirements were reviewed and preliminary LEED level was developed. Based on the results of this process, a verbal commitment to become the first builder in northeast Florida to build a LEED certified home was given. Work continues related to achieving LEED for Homes Certification.
- *Skobel Development* - Boca Raton, FL – FLHERO made a preliminary consultation with Alex Skobel, President, who will be constructing new homes in the Gainesville area. We introduced the BA approach and discussed general requirements inclusive of tax credits. We performed design review and Manual J and D calculations and made recommendations for final specifications.

Other Prototype Design Assistance

- Visited Florida's Showcase Green Envirohome in Indialantic, FL to view progress of construction and discuss documentation needs for green certification. HVAC design of the home is pending.
- ICI Homes, a builder in Kissimmee, FL, became a BAIHP partner in late 2007 and plans to work at the 50% level.
- Three FSEC representatives visited the home of Joe Havian in Ruskin, Florida in September 2007. The purpose of the visit was to examine the home's efficient building techniques. The SIP home is built on stilts and located on the coast. PV is planned.
- FSEC personnel met with Terry Hill, owner of a highly efficient house located in Washington DC. During the visit details of the house construction, along with house performance monitoring, were discussed.
- Calcs-Plus performed HVAC load calculations and Energy Gauge file conversions for two houses from Cambridge Homes in 2007.
- Performed analysis of a proposed remodel of a 1300 ft² 1960's CBS home by the City of Miami Gardens, FL and gave input for FGBC and ENERGY STAR compliance.
- Worked with Gainesville mayor, utility and commissioners to develop a more aggressive energy conservation program for Gainesville Regional Utility.
- In January 2008, FSEC provided energy analysis on a set of plans for new partner Marc Rutenberg Homes in Trinity FL.
- FSEC provided analysis for two Engle Homes to achieve HERS indices of 70 in January 2008
- BAIHP analyzed a set of floor plans for new partner, Deer Valley Homes. This HUD/modular builder is based in Tampa, FL with two plants in Alabama.

2.1B. Long Term Instrumentation and Monitoring Projects

BAIHP instruments and monitors some prototype homes. Data is continuously collected, monitored and posted on the BAIHP web site using the infomonitors site maintained by FSEC. Data collection also continues to be compared to the performance of other homes' results and unique information is disseminated to the builders, researchers and other interested stakeholders.

Energy Structures & Systems, Inc., Stuart, FL

Energy Structures & Systems, Inc. (ESSI) was welcomed in the BA program in BP1. FSEC conducted field inspections and commenced instrumentation on three homes being constructed in the Stuart, FL area. The homes feature unvented attics, AAC walls, solar water heater, roof integrated and stand-off PV, outside air ventilation, high efficiency a/c, fluorescent lighting, gossamer fans, xeriscaping and native plants etc. Houses are planned to have roof integrated PV systems installed, but as of yet, there is no PV on site.



Figure 2-24 Homes with solar hot water and BIPV on detached garage (not installed yet)

Chasar home, Cocoa, FL

BAIHP has monitored the Chasar home in Cocoa, FL during 2006 and 2007. Energy use, indoor conditions and attic conditions are being monitored. In 2007, the soffits were sealed to create a sealed attic space, and the envelope and ducts were retested for air tightness.

Hoak Home

BAIHP is monitoring this three-story, 4,250 square foot home in Longwood, Florida near Orlando. FSEC assisted by recommending a package of features to produce an exceptionally energy efficient design at a reasonable cost. The building envelope design and mechanical equipment selection were intended to work together as a system. As a result the home can be cooled with a much smaller air conditioner than is needed by most homes of this size in the hot and humid Florida climate.

LSU's LaHouse

BAIHP installed monitoring equipment in the LouisianaHouse demonstration home (<http://www.louisianahouse.org/>) being built on the LSU campus under the direction of Professor Claudette Reichel.



Figure 2-25 Louisiana State University's Louisiana House demonstration home—currently under construction

WSU, Olympia Washington

WSU is monitoring several prototype homes - the Garst home (<http://www.infomonitors.com/ws2>), the Stamets Home, three bungalow-style homes built by Scott Homes and a high performance modular prototype in Ft. Lewis, WA. More information can be found in Appendix C - Washington State University Annual Report, as well as in Subtask 2.1A – Prototype Design Assistance (Garst and Stamets) and Subtask 3.2 – Marine Community Scale Developments (Scott Homes and Ft. Lewis).

Other Monitoring Efforts

- *IBS Showhomes* – 2007 Showhome, Gen-X prototype with PV and Solar DHW in Siesta Key, FL, and the Vision House in Orlando, FL, which is a 2008 showhome.
- *Newport Partners* – the 2008 HUD concept home in Charleston, SC.
- *Solar Homes of Florida* - two solar homes built by Solar Homes of Florida in Stuart, FL.
- *Schackow Development* - two prototype homes (one with PV) in this ZEH/NZEH community, Forest Creek, in Gainesville, FL
- *Schroeders Homes* - one prototype home with PV in North Port, FL
- *Stalwart Builders* - one prototype home with PV in Panama City, FL
- *ZCS Development* - Rockledge, Fl - BAIHP is monitoring one prototype all steel and foam construction house (Wesley model) in Cocoa, FL, which incorporates mounting racks for a 5kW array.
- *Terry Hill residence* - Terry Hill residence in Arlington, VA



Figure 2-26 Terry Hill House, a high performance residence near Washington D.C.

2.2. 2008 International Builders' Show Homes (all in Orlando, FL)

BAIHP provided HVAC design assistance, green consultation and ENERGY STAR certification to many homes in the National Association of Home Builders International Builders' Show, including the outdoor show home exhibits and the National Association of Home Builder's show case homes built off site. These homes demonstrate the latest technology and products to the +92,000 attendees to the 2008 show, including builders and the general public. Product manufacturers use these projects as marketing avenues for displaying new products or even showcasing how-to guides for installation of products. These show homes are great opportunities to solicit builders to integrate more energy efficient and improved performance strategies in their homes as certifications and energy ratings can allow for a marketing edge.



Figure 2-27 2008 *The New American Home*

In addition, BAIHP helped several builders from previous shows relocate their homes. BAIHP assisted in recertifying those homes for green, ENERGY STAR and renewable credits and certifications.

In 2007 BAIHP provided assistance to the following homes:

- ***PHH Professional Builder Show Village homes*** – provided information on green products and HVAC design as well as QA inspections and specifications review.
- ***2008 Tradewinds Home*** for Builder Magazine – suggested green features and HVAC design.
- ***The Vision House Orlando*** – provided HVAC system recommendations and testing, insulation inspection, Thermal Bypass Inspection and monitoring equipment installation.
- ***Builder Magazine*** “True Green” modular home – provided contact information and product information on green materials.
- ***2008 The New American Home*** - assisted IBACOS with construction documentation and home performance testing and installed monitoring equipment.
- ***2007 Single Family PHH Show Home*** – provided HVAC re-commissioning, FGBC and NAHB green home certifications and monitoring the solar thermal and PV home after its relocation to Siesta Key, FL.

In 2006, BAIHP provided assistance to the 2007 Renewed American Home and The New American Home by providing FGBC green home certifications, as well as assisting IBACOS with construction documentation and home performance testing in 2006 and 2007 The New American Homes.

2008 PHH Professional Builder Show Village Homes

FSEC and Calcs-Plus researchers assisted Palm Harbor Homes(PHH) on the design of the “Green” and the “Comfortably Affordable” Homes. FSEC provided information on possible green products and Calcs-plus performed load calculations, equipment selection and duct design for the PHH “Green” Home.

During construction, BAIHP made inspections and conducted a preliminary specification review to ensure quality assurance and consistency with green guidelines. BAIHP also provided inspections and verifications that qualified the home for FGBC Green Home Certification and NAHB Green Home. The builder, PHH, also is a participant in the Builder’s Challenge whereby pledging to build homes that meet the EnergySmart E-Scale with HERS Indices of 70 or less (“Green” E-Scale – 58 and “Comfortably Affordable” E-Scale = 69)



Figure 2-28 *Glen Cairn – PHH “Comfortably Affordable” Showhome*

Detailed fact sheets can be found in Appendix B - 2008 International Builders’ Show Homes Fact Sheets



Figure 2-29 *Bimini II – PHH Green Showhome*

2008 Tradewinds Home

This is another custom IBS show home built in the Baldwin Park community for Builder Magazine. FSEC coordinated with the builder (Charlie Clayton Construction) on the green features and Calcs-plus proposed an enhanced HVAC design. Although the builder desired the home to be LEED-H certified, he pulled out of BAIHP assistance, citing time pressures and other constraints.



Figure 2-30 7,316 square foot 'Tradewinds' home for 2007 IBS Builder Magazine

2008 Vision House

The Vision House Orlando, a 2008 IBS show home, was built in Lake County. Sponsored by Green Builder Magazine, the home is targeting a high performance, systems engineered design, and has requested BAIHP assistance. FSEC assisted in selecting HVAC system components, inspecting insulation, conducting the Thermal Bypass Inspection for ENERGY STAR certification, and installing monitoring equipment in the Vision House. BAIHP subcontractor Calcs-plus assisted in designing and testing the duct system.

2008 The New American Home

Builder – Robertson Homes, Inc., Orlando, FL

6,725 square feet , 3 bedrooms, 3.5 bath + attached suite (1 bedroom, 1 bath)

Energy Efficiency, Renewable Energy and Green Features

- Exterior walls a.a.c. blocks (R-8) with R-4 rigid foam insulation on interior and R-5.7 insulation system on exterior
- Attic, unvented, sealed and indirectly conditioned
- Thermal and air barrier at underside of roof sheathing (R-20 spray foam insulation)
- Three high-efficiency heat pump units with 16.6 SEER and 7.4 HSPF
- Air distribution system is airtight and entirely within conditioned space
- Solar thermal hot water heating and instantaneous water heaters, EF = 0.82
- 42% whole house energy savings
- First Gold certified home under the NAHB's new *National Green Building Program "Pilot Scoring Tool"*



Figure 2-31 *The New American Home 2008*



Figure 2-32 *Solar Thermal on TNAH 2008*

BAIHP assisted IBACOS with construction documentation and photographed construction progress several times each month to monitor TNAH's process. In addition, FSEC assisted IBACOS in the installation of monitoring equipment, ventilation system design, Green certification and ENERGY STAR status with the help of IBACOS. BAIHP personnel performed a thermal bypass inspection and EnergyGauge calculations for ENERGY STAR certification. BAIHP was also the verifier for this home being the first home certified under NAHB's new Green Home Standards.

2007 International Builders' Show Outdoor Homes

FSEC supported Palm Harbor Homes with their outdoor show case homes at the 2007 International Builders' Show in the first budget period. There were two high performance homes: one single family and a tri-plex unit. We attended sponsor meetings ensuring that donated products met objectives of ENERGY STAR rated and FGBC green certified homes for the show. FSEC's PV Division also assisted in our involvement and helped procure donated renewable energy products like 3.25 kWp BP Solar PV System, GridPoint Inverter and Battery-Based Backup Power & Energy Management equipment and a solar domestic hot water system for the single family home, GenX.

During BP2, FSEC and Calcs-Plus coordinated the relocation of GenX to Siesta Key in Sarasota, FL (Sarasota County). They assisted in the re-install and re-certifications for ENERGY STAR, FGBC and renewable permits

The three unit town home, called the EchoBoomer, that PHH homes built for the 2007 International Builders' Show also included energy efficient features and green building design strategies. BAIHP coordinated specification compliance and conducted on site performance testing.



Figure 2-33 3,397 sq. ft. Palm Harbor Homes, the Bellaire – GenX



Figure 2-34 Palm Harbor Homes, the Bellaire GenX relocated to Siesta Key in Sarasota, FL



Figure 2-35 EchoBoomer Town Homes

Data sheets for these two homes can be found on the web at:

http://www.baihp.org/casestud/ph_homes2007/genx.pdf

http://www.baihp.org/casestud/ph_homes2007/echoboomer.pdf

2007 The New American Home

Each year the National Association of Home Builders also demonstrates site built housing. The 2007 The New America Home was located in a historical area adjacent to The Renewed America Home, both of which FSEC assisted IBACOS during Budget Period 1 by providing progress documentation, performance home testing, ENERGY STAR ratings and green building certifications for both homes. Energy rating file was completed and submitted to Calcs-Plus for \$2,000 tax credit and ENERGY STAR rating. (HERS-06 = 51)



Figure 2-36 2007 TNAH (with the Renewed American Home roof in background)



A PV system powers the refrigerator directly, and the excess energy is either used elsewhere in the home or stored.

Figure 2-37 2.25kWp Photovoltaic power system on roof top of 2007 TNAH

2007 The Renewed American Home

Built in 1909, the 2,462-square-foot “Renewed American Home” was completely renovated and expanded. The house was moved from its original site at the corner of Broadway Avenue and Ridgewood Street to the adjacent lot to make way for The New American Home. The final construction resulted in 5,860 sq. ft. conditioned, 4 bedrooms, 5 ½ bathrooms, with a library, additional basement and a detached garage with living space above. Additional features include latest in residential automation and home control for all low voltage systems, universal design, gas fired dehumidifier, ENERGY STAR certified HERS-06 Index = 65 and FGBC certified. BAIHP assisted in green certification of the home in budget period 1, and Eric Martin participated in an interview with HGTV regarding the Building America and green building process that was employed by the home.

2006 International Builders' Show Homes

Building America partner, Palm Harbor Homes, has been responsible for construction of homes within Reed Publications show space. FSEC provided oversight on the green and energy efficient features in the three homes PHH displayed in the 2006 IBS. The three homes were tested and certified for ENERGY STAR compliance and FGBC green home standard. The details of these show homes can be found at:

http://www.baihp.org/casestud/ph_homes/index.htm

The Bellaire Model was sold to a developer and permanently located on a lake view property in Auburndale, FL. FSEC assisted in the relocation in BP1. The developer commissioned Palm Harbor Homes to construct a 1,250 square foot addition to the home and it was showcased in the Polk County Builders Association Parade of Homes.



Figure 2-38 2,865 sq. ft. Palm Harbor Homes, the Bellaire –
Move up Buyer

Task 3. Community Scale Developments



Figure 3-1 Two Tommy Williams Homes



Castle & Cooke

OAKLAND
PARK

SMITH
AERIAL
PHOTOS 02-10-08

Figure 3-2 Oakland Park in Orlando, FL – Built by Castle & Cooke

Community Scale Developments

In this section we document our efforts in providing technical assistance to builders that are building entire communities of high performance housing in hot-humid and marine climates.

The following builders build high performance homes on a community scale. The builders in italics are located in the Marine climate zone and are mostly coordinated by the Washington State University Energy Extension Program, while the other builders are located in the Hot-Humid climate region. These are mostly coordinated by BAIHP subcontractor Florida H.E.R.O.

Builder	Location	Number of Homes Built in BP2
Castle & Cooke	Orlando, FL	10
G.W. Robinson Builders	Gainesville, FL	135
HKW Enterprises	Gainesville, FL	10
On Top of the World	Ocala, FL	92
Pringle Development	Eustis, FL	130
Tommy Williams Homes	Gainesville, FL	49
<i>Ft. Lewis Army Base</i>	<i>Ft. Lewis, WA</i>	<i>159</i>
<i>Scott Homes</i>	<i>Olympia, WA</i>	<i>14 assisted</i>
Total Number of high-performance homes built in Hot-Humid and Marine Climates		585



Figure 3-3 Brotherton 13th Ave Bungalows by Scott Homes, Olympia, WA



Figure 3-4 Two Story Modular Housing Assembly, Ft. Lewis Army Base, WA

3.1. Hot Humid Climate Communities

This section describes in case study format the BAIHP work done in partnership with builders that are building high performance homes on a community scale. It includes two extensive case studies created in early 2007 outlining the systems engineering process and lessons learned from coordinating high performance communities by G.W. Robinson Builders and Tommy Williams Homes.

Work continues with both Tommy Williams and G.W. Robinson through the efforts of BAIHP subcontractor, Florida Home Energy Rating Organization (FLHERO). FLHERO conducts design reviews, makes site visits for quality assurance and completion of the Thermal Bypass Inspection Checklist, commissions homes, gives diagnostic tests and recommendations and provides tax credit reports. In addition, BAIHP is working with Tommy Williams Homes to possibly improve the performance of homes even further.

BAIHP not only assists in developing and certifying high performance homes, but helps builders market their homes. During 2007, BAIHP developed and implemented new collateral marketing material that highlights the features, benefits and value of the BA Systems approach with full page ads in the Gainesville Sun in May 2007. The goal is to better educate potential buyers of the value of using the BA approach and promote the effective use of the HERS index.

In addition, in April 2007 BAIHP held a public event honoring GW Robinson Builders and Tommy Williams Homes. Both the City of Gainesville and Alachua County named this day as “Building America Day.” Steve Chalk from the DOE presented a Certificate of Recognition to both these builders. Details at <http://www.baihp.org/baday.htm>.



Figure 3-5 GW Robinson presented with a certificate by Steve Chalk from the DOE

Three other hot-humid climate builders have built over 200 high performance homes. FLHERO works with Pringle Development and On Top of the World, two production builders in Florida who integrated BA processes into their own. FSEC is coordinating the planned 675-home community by Castle & Cooke, and ten prototype homes have been built so far.

G.W. Robinson Builders Case Study

Communities: Cobblefield – Build out 265 homes, 260 built (as of March 2007)
Turnberry Lake - Build out 186 homes, 61 completed (as of March 2007)
Garison Way – Build out 110 homes, 23 completed (as of March 2007)

Developer/Builder: G.W. Robinson

Locations: Near Gainesville, FL (Alachua County)

Background and Summary

In 2000 GW Robison decided to build the healthiest, most energy efficient and “Green” subdivision possible for move up buyers and became a BA partner in 2001. Ken Fonorow of Florida H.E.R.O. worked with the builder to develop and implement a new set of specifications first in the Cobblefield community, then in the Turnberry Lake community and now in a third community Garison Way. This builder has chosen to incrementally improve his specs over the years and currently builds all homes with the recent most specs. All his homes have HERS Index values between 63 and 68 (average ~65) and Building America Benchmark savings range from 35% to 41%.

G.W. Robinson homes (Figure 3-6 through Figure 3-9) are typically 2,000 to 5,000 square feet with a selling price in 2006 of \$300,000 to over \$1,000,000 with a sales price average of \$165/sf. This builder’s homes are enjoying solid sales in the current down turned market environment of 2006-2007.



Figure 3-6 Cobblefield Home



Figure 3-7 Turnberry Lake Home



Figure 3-8 Cobblefield Site Plan



Figure 3-9 Turnberry Lake Site Plan

Energy Efficiency and Cost Neutrality Analysis

When Fonorow began working with G.W. Robinson, his homes were compliant with the Florida Energy Code. Over time the specifications improved and the current specifications are summarized in Table 3-1. All of the homes built to these specifications achieve a HERS '99 score of 88.6 or better (HERS Index scores of 68 or lower).

Table 3-1 also shows the specs for typical new homes built in the Gainesville, Florida market and the estimated added costs for the BA specs that G.W. Robinson has implemented. Then the costs to the homeowner are estimated and a monthly cash flow analysis is shown at the bottom of the table. The bottom line is a monthly mortgage cost of \$13.44 and an estimated monthly energy savings over typical construction of \$41 yielding a net positive cash flow of over \$27 per month. The simple payback for a cash buyer will be 4.1 years. Note that this cost neutrality analysis is done with respect to typical new construction specifications in the regional market, not with respect to the benchmark home.

All of the homes are individually performance tested as part of a commissioning (quality assurance) process. Simulation analysis shows these homes to be approximately 35% to 41% better than the benchmark with savings in all categories except appliances and plug loads (plotted in Figure 3-10 for a sample home saving 38.9% overall)

Table 3-1 Energy Features of a 2,786 sq. ft. 1 story 3BR, 2.5 Bath home with specifications typical for the region compared to GW Robinson Home with BA specifications meeting the 30% Benchmark savings target

<i>Note: Cost Difference shown in this table is relative to Typical practice NOT Benchmark</i>				
<u>Category</u>	<u>Typical Specs</u>	<u>BA Specs</u>	<u>Incremental Cost</u>	
Manuals J and Manual D Calculation, Commissioning and Rating				\$400
Wall Insulation	R-11	R-13 Cellulose		\$494
TBIC Compliance	No	Yes		\$300
Wall Framing	standard 2x4	advanced 2x4 w/Ca corners, Ladder T's		\$0
Windows	2-pane Aluminum	2-pane Vinyl Low-E		-\$128
Heating System	80% Gas	93% Gas		\$400
Capacity	100KBtu	60Kbtu		
Cooling System	SEER13	SEER14		\$350
Capacity	5tons	3.5tons		-\$1,500
Ventilation System	None	Run Time		\$300
Air Handler Location (Costs \$500, added appraised value \$1500)	Garage	Interior		-\$1,000
Duct Leakage	6% to out	4% to out		\$165
House ACH50	6	4.5		\$200
Attic Radiant Barrier	No	Yes		\$806
Lighting	10%cfl	50% CFL		\$50
Hot W pipe Ins	None	1/2" foam		\$100
Water Heater(Gas)	60%	83% tankless		\$900
Added cost to Builder =				\$1,837
Added cost to Consumer @1.1=				\$2,021
Added mo. pmt @7%, 30yrs=				\$13.44
Energy Savings Summary				
	Typical Specs	Cost (\$)	BA Specs	Cost (\$)
HERS Index	94		65	
Total kwh@12c/kwh	12792	\$1,535	10408	\$1,249
Total therms@\$1.48/therm	373	\$552	231	\$342
Total Annual Energy Cost		\$2,087		\$1,591
Average Monthly Energy Cost		\$174		\$133
Monthly Energy Savings			\$41	

Notes: Wall insulation @20c/sq. ft. extra. Actual price for vinyl low-e windows are cheaper. See Figure 3-10 below for air handler cost benefit.

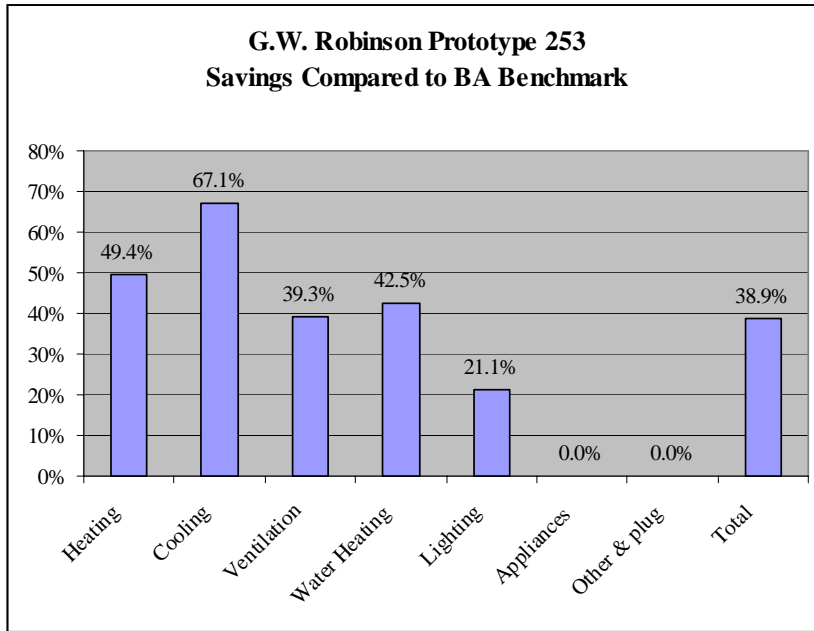


Figure 3-10 Source energy end use savings

Value Added Innovations

Fonorow has worked with this builder to develop a number of innovative techniques. One involves the position of the air handler. Previously, the builder located the air handler in the garage as is typical conventional practice in Florida. Fonorow recommended moving the air handler to a closet in the conditioned space. This was accomplished without changing the floor plan by moving the exterior wall to form a closet around the air handler separating it from the unconditioned garage (Figure 3-11). This adds approximately 15 square feet of conditioned space with an appraised value of about \$1,500. The first cost of the detail adds about \$500 to the total cost of the project for a net gain of \$1,000.

Another innovation in the air handler closet results in an improved air barrier between the closet and the attic overhead. Figure 3-12 shows the view looking up at the ceiling of the air handler closet before the air handler has been set. The supply trunk line on the right will be attached to the top of the air handler while the return trunk on the left will be connected to the return plenum below the up-flow air handler.



Figure 3-11 *Exterior walls around air handler isolate closet from garage, create valuable conditioned square footage.*



Figure 3-12 *Air barrier in top of air handler closet created with duct board by the mechanical contractor at the time that the ducts are installed.*

Typically, this closet would get a drywall ceiling just like all the other closets in the house. There are several problems associated with this. First of all, drywall isn't typically available on site during the mechanical rough in when these trunk lines are put in place. Even if it is available, it's difficult to cut precisely and mechanical contractors are not accustomed to working with it. And leaving this detail to the drywall crew (later in the construction process) jeopardizes the air tightness of the closet.

Fonorow's innovation here was to switch materials for the ceiling. Note in the picture (Figure 3-12) that the top of the closet is made of duct board, just like the trunk lines. The material is readily available during the mechanical rough in, is easier to cut than drywall, and the mechanical contractor is accustomed to working with it. While this innovation does result in a vapor barrier at the wrong side, it does result in less infiltration into the air handler closet where there is often very high negative pressure due to small leaks in air handler cabinet itself. Fonorow is currently working on an improvement using duct

board with a foil facing on both sides or simply doubling up on the duct board with foil facings out so that there is vapor barrier on both sides.

Outside Air Ventilation

In energy efficient homes in general, the natural infiltration rate tends to be low, occasionally resulting in odor or wintertime high humidity complaints from the homeowner. A general concern about energy efficient homes in the hot-humid climate is the magnitude of the remaining latent load (from infiltration and breathing) coupled with humidity in outside air ventilation.

In the hot-humid climate, outside air ventilation brings humidity to the conditioned space increasing the latent cooling load in the house. Air conditioners are better equipped to lower sensible heat than latent heat (warm moist air). And sensible heat is easier to reduce (with insulation and shading) than latent heat. Thus energy efficient homes in the hot-humid climate often have a very low sensible cooling load while still having a fairly typical latent cooling load.

Some measures such as exhaust fans ducted to outside help control the latent cooling load by removing warm moist air as it is produced (source control) and the use of a variable speed motor in the air handler which provides the opportunity to reduce the air flow rate across the evaporator coil resulting in enhanced dehumidification.

Fonorow also developed a passive ventilation system which is in use by G.W. Robinson and other builders in the Gainesville market such as Tommy Williams (see the next case study). When the air conditioning or heating system is running, the negative pressure in the return plenum draws outside air through a duct linking the return plenum to a filtered outside air inlet mounted in the soffit or a porch ceiling (Figure 3-13). The inlet is downstream of a filtered grill mounted to a standard one foot square boot. There is an in-line, pressure actuated damper with a manual override to prevent flow of outside air when it would be undesirable (for example when there is a fire in the area).

This outside air ventilation strategy has been implemented in over 500 homes in the Gainesville area including homes from G.W. Robinson and Tommy Williams Homes (see other case study). None of the homes have had problems with odor retention (from cooking, etc) or indoor humidity. In an evaluation of 54 homes built with the Fonorow design the mechanical vent rate averaged of 34 CFM when the air handler operated. Note that this is significantly lower than indicated by ASHRAE Standard 62.2.



Figure 3-13 *Outside air ventilation system details*

Durability, Indoor Air Quality and Landscaping

While recognizing that a home's most significant environmental resource impact will be the energy needed for its ongoing operation, this builder also addressed the issues of durability, health, maintenance, landscaping and irrigation.

To enhance durability, each home is treated with Bora-Care®, a termiticide whose active ingredient is Disodium Octaborate Tetrahydrate (DOT), which is a mixture of borax and boric acid. A 50+ year cementitious lap siding is installed over a continuous drainage plane. The entire exterior of the home receives three coats of paint which carries a ten year warranty. Thirty year architectural shingles have been selected. To help insure better indoor air quality low volatile organic compound (VOC) paint is used in the interior, all gas burning fireplaces receive outside combustion air and all rigid duct board material used in the distribution system is a coated style to help separate the air stream from any raw fiberglass. Where applicable, alkaline copper quaternary (ACQ) wood is used, which is arsenic and chromium free.

After protecting wooded areas whenever possible, homes are landscaped with drought tolerant indigenous species which are grouped according to their watering needs. Irrigation is provided through a municipal reclaimed water system where water that would normally be discharged via a deep well injection system is routed to the subdivision to meet the irrigation needs. It is important to note that this service is being provided to homeowners by the developer for \$10 a month while a homeowner who uses the potable water for irrigation often pays \$40-50 a month.

Quality Assurance: Systems Engineering and Site Inspections

The BA integrated systems engineering approach was used in both of these communities to optimize the performance of homes within a financial framework which enhanced the builder's profits.

After the initial analysis to determine the specifications for the communities, Florida H.E.R.O.'s systems engineering approach included an evaluation of each design (floor plan, elevations and specifications) to identify opportunities for improvements and ensure specifications were called out correctly. Next, Florida H.E.R.O. did a room-by-room ACCA Manual J load calculation to determine the heating and cooling equipment size and a duct system design based on ACCA Manual D calculations. Finally the duct system plan is drawn and a scope of work is developed for the mechanical contractor.

For quality assurance, site visits are conducted to complete the new ENERGY STAR Thermal Bypass Inspection Checklist which includes an inspection of the air barrier continuity, thermal barrier (insulation) integrity and duct system layout. Deficiencies are reported back to the developer/builder and meeting with the trades often occur to correct deficiencies and conduct training.

Lessons Learned

Following is a summation of lessons learned and ongoing challenges in achieving the systems engineering approach to new home construction:

- The first step in this process requires a clear and consistent commitment of the final decision maker, be it the builder or the developer. The support of this “champion” is necessary to maintain improvement and quality assurance efforts. Lip service will not result in high performance homes.
- A scope of work including specific *performance* criteria gives sub-contractors a clear idea of what is expected from them and provides a mechanism for linking payment to work quality. An example would be to include in the contract language, a provision requiring that the mechanical system will have no greater than 10% total leakage and 5% to out when using the standard cfm25 duct test.
- Effective communication of performance expectations to the person(s) responsible for implementation in the field must be performed, often in conjunction with education and demonstration activities.
- Ongoing quality assurance field inspections by either the project manager or an independent third party must be conducted to ensure consistency over time.
- Final commissioning of each home, including performance testing is an integral component of a systems approach, as it provides a timely feedback loop to the builder.
- In order for the builder to achieve sales goals, the sales representatives must be knowledgeable about the features and benefits that have been built into the home. Thorough and repeated sales training and advertisement is critical to success.
- Cost control is essential. This builder is able to offer BA homes for about the same price than typical efficiency homes.

Tommy Williams Homes Case Study

Communities: Longleaf Village: Build out: 225 Completed: 120
(Total Community Build out: 500. 275 lots allocated to a non-Building America builder.)

Belmont - Build out: 136 homes Completed: 66
(Total Community Build out: 275. 139 lots allocated to a non-Building America builder.)

Builder: Tommy Williams Homes

Location: Near Gainesville, FL in Alachua county.

Background

Tommy Williams (Figure 3-14 and Figure 3-15) has been building homes for 26 years and embraced the Building America high performance approach in 2004. Home sizes in the Longleaf and Belmont communities are 1,300 to 2416 square feet with a 2006 selling price of \$205,000 to \$315,000 and averaging ~ \$147/sq. ft.



Figure 3-14 Tommy Williams Homes



Figure 3-15 Site plan for Phase 2 in Belmont. Pink sites are Tommy Williams Homes. For a sales comparison with the other builder (purple sites) in this community, see next section “Energy Efficiency and Cost Neutrality” below.

Energy Efficiency and Cost Neutrality

Tommy Williams and his organization went from building Florida Energy Code minimum homes to being committed to build over 250 homes in two sub-divisions with HERS '99 scores of 88.6 or above (HERS Index 72 or below, average ~70).

Energy features are delineated in Table 3-2. Most of the homes built by this builder qualify for the \$2,000 Federal Energy Tax Credit and are individually performance tested as part of a commissioning process. Benchmark analysis shows these homes to be an average of 36-40% better than the benchmark with savings in heating, cooling and lighting (Figure 3-17).



Figure 3-16 Floor plan for Tommy Williams Homes' Mattair Model

Tommy Williams Prototype 248 Energy End Use Savings Compared to BA Benchmark

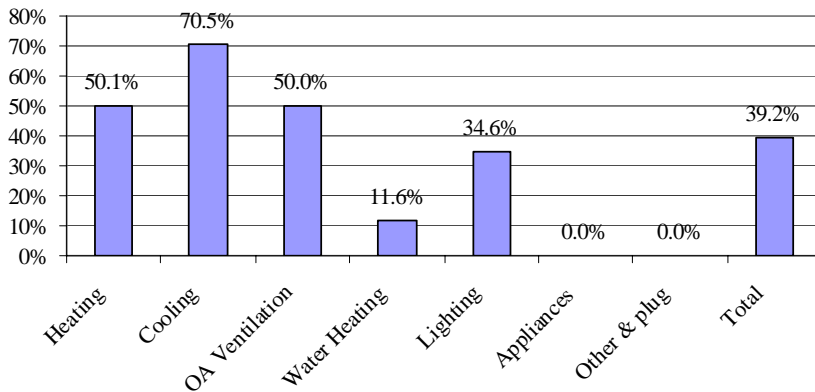


Figure 3-17 Estimated annual source energy savings by end use. Note significant reduction in heating and cooling energy use

Table 3-2 Cost analysis of energy features in a 1,809 sq. Ft. 1 story 3BR, 2 bath home with specifications typical for the region compared to a Tommy Williams Home with BA specifications meeting the 30% Benchmark savings target

<i>Note: Cost Difference shown in this table is relative to Typical practice NOT Benchmark</i>				
Category	Typical Specs	BA Specs	Incremental Cost	
Manuals J and Manual D Calculation, Commissioning and Rating	Specs	Specs	\$400	
Wall Insulation	R-11	R-15 Spider	\$370	
TBIC Compliance	No	Yes	\$250	
Wall Framing	standard 2x4	advanced 2x4 w/Ca corners, Ladder T's	\$0	
Windows	2-pane Aluminum	2-pane Vinyl Low-E	-\$71	
Heating System	HSPF 7.7 Heat Pump	HSPF 9 Heat Pump	\$0	
Capacity	42KBtu	36KBtu		
Cooling System	SEER13	SEER15.25	\$1,000	
Capacity	3.5tons	3tons	-\$500	
Ventilation System	None	Run Time	\$300	
Air Handler Location (Costs \$500, added appraised value \$1500)	Garage	Interior	-\$1,000	
Duct Leakage	6% to out	4% to out	\$165	
House ACH50	6	4.5	\$200	
Lighting	10%cfl	75%cfl	\$50	
Added cost to Builder =			\$1,164	
Added cost to Consumer @1.1=			\$1,280	
Added mo. pmt @7%, 30yrs=			\$8.51	
Energy Savings Summary				
	Typical Specs	Cost (\$)	BA Specs	Cost (\$)
HERS Index	92		70	
Total kwh@12c/kwh	9624	\$1,155	7650	\$918
Total therms@\$1.48/therm	166	\$246	166	\$246
Total annual bill		\$1,401		\$1,164
Av monthly bill		\$117		\$97
Monthly bill Savings			\$20	

In Table 3-2, the costs to the builder were estimated to the best of our knowledge and cost to the homeowner calculated at a 10% profit margin for the builder. The savings compared to a typical practice home is \$20/month at an added monthly payment of \$8.51 resulting in a net positive cash flow of over \$11 monthly. The simple payback for a cash buyer is ~5.3 years.

Value Added Innovations

With this builder, Fonorow has implemented the same innovative techniques described more fully in the G.W. Robinson case study. These include moving the air handler to a conditioned closet created in the garage and making the ceiling of the air handler closet out of duct board instead of drywall.

Both builders are also using advanced framing techniques that result in lower framing fractions (Figure 3-18 and Figure 3-19) enhancing comfort and performance. The spray in Spider® insulation is a fiberglass product that fills stud bays more evenly than batt insulation.

Tommy Williams’ sub-contractors work from a formal scope of work that details what is expected of them with quantitative performance requirements when possible. This in addition to a sub-contractor meeting during the early stages of the project helps establish expectations for high performance quality.



Figure 3-18 Details reduce framing fraction and improve comfort.



Figure 3-19 Close up of ladder detail at the intersection of an interior wall. “Rungs” provide drywall nailing surface without compromising insulation.

Outside Air Ventilation

Fonorow also developed a passive ventilation system that supplies filtered outside air to the return plenum when the air handler is running (heating or cooling) which is in use by Tommy Williams and other builders in the Gainesville market such as G.W. Robinson (see GW Robinson case study for full discussion of ventilation issues). The filter back intake grille for the outside air is located in soffit of the front porch where it is easily accessible by the homeowner (Figure 3-20.) A flex duct connects the intake register boot to the return plenum of the mechanical system to be mixed with return air from the house (Figure 3-21.) Outside air is only drawn when the mechanical system is running. It is outfitted with a pressure actuated damper with a manual override.



Figure 3-20 *Outside air intake boot in porch ceiling at front door*



Figure 3-21 *Outside air ventilation duct termination into return plenum*

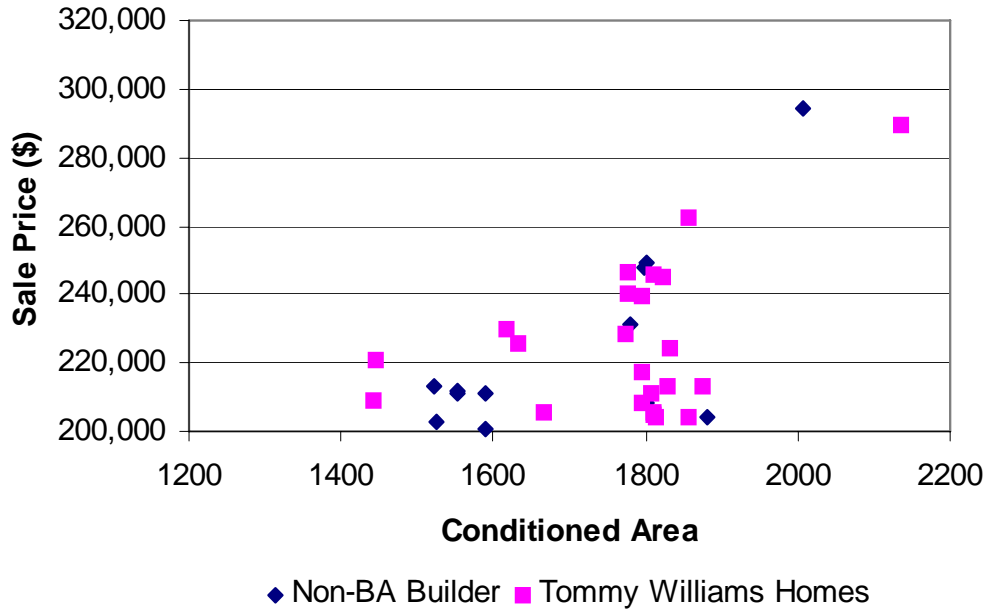
Market Reception

Tommy Williams is one of the two builders working in the Belmont subdivision. The other builder is not a Building America partner. One realty company handles all sales. 2005 and 2006 sales data for both builders are shown in Figure 3-22. These data were compiled from the public records of the county.

The sales data reveal that Tommy Williams had more sales than the non BA builder and there was no statistically significant difference between the price per square foot for both builders. In 2006, the average selling price for the BA builder was actually slightly less at \$147/SF compared to \$149/SF for the conventional builder but again, the difference was not statistically significant. The 2005 data also do not show a statistically significant difference between the BA and the non-BA builder. The 2006 prices, however, were on average about \$25/SF higher than 2005. It is clear that the BA builder, because of his building and management practices is delivering more efficient homes for the same \$ to

the homeowner and enjoying a larger market share. In 2006 the BA builder sold 26 compared to 12 homes for the non BA builder in this Belmont subdivision.

**Tommy Williams Homes vs Non-BA Builder
2005 Sales Comparison, Gainesville, FL Market**



**Tommy Williams Homes vs Non-BA Builder
2006 Sales Comparison, Gainesville, FL Market**

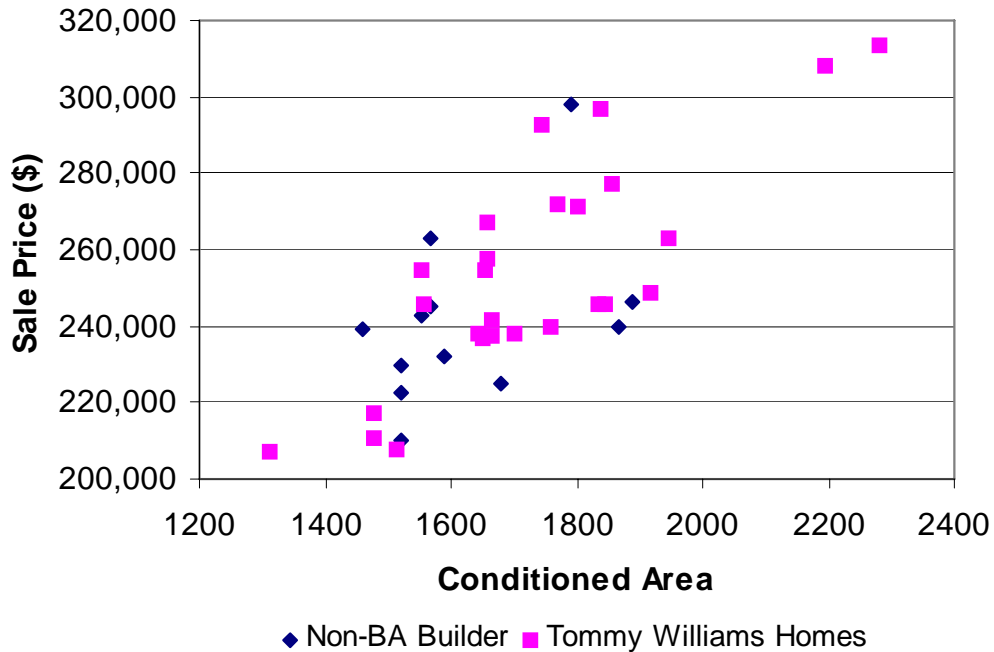


Figure 3-22 Sales data for Tommy Williams (squares) and non-BA builder in same subdivision (diamond) for 2005 (top) and 2006 (bottom).

Castle & Cooke - Oakland Park, Orlando, FL

BAIHP have continued to work with Castle & Cooke developers on design of a sales office/model home for the Oakland Park Development in Orlando, FL. There are 675 homes planned for this community with standard designs meeting 30% savings over BA benchmark. The scope also incorporates FGBC certification and high performance features like unvented attics, ducts in conditioned spaces, high efficiency HVAC equipment and whole house dehumidification systems.



Castle & Cooke

OAKLAND
PARK

SMITH
AERIAL
PHOTOS 02-10-08

Figure 3-23 Oakland Park, Orlando, FL built by Castle & Cooke

In March and April 2007, BAIHP performed Energy Gauge simulations for 10 Oakland Park homes, achieving HERS Indices between 70 and 75. Castle & Cooke provided feedback for the first time on the use of their high performance building techniques, including the use of spray foam insulation, interior ducts, whole house dehumidification equipment, fluorescent lighting and low-e windows.

HKW Enterprises

HKW has built ten homes to the Building America Goal. The partner builds multifamily units in Gainesville, FL with an average HERS Index of 73. BAIHP commissioned multiple homes, completed TBIC and created multiple tax credit reports for HKW.

On Top of the World

This builder is based in Ocala, FL. Florida Hero, a BAIHP subcontractor, worked with the builder to incorporate BA components and systems into the production schedule. All homes built by On Top of the World after July 2007 qualify for the federal tax credit. FLHero also provides commissioning, completion of the TBIC, on-site refresher training to review the requirements for TBIC and assists in-house staff with the development of collateral marketing material promoting the Building America Program. On Top of the World has committed to accept the Builders' Challenge and has implemented the measures necessary to meet the Builders' Challenge goal of 70 index or less.

Pringle Development

This over-55 community builder became a BAIHP partner in March 2007. Florida Hero is working with this partner to build homes in two subdivisions, Lakes of Mount Dora and Heritage Park in Eustis, FL, to Building America Goals. Florida Hero has provided multiple design reviews; made ongoing site visits for QA and completion of the TBIC, and commissioned the homes. Pringle Development is achieving an average HERS Index of 77 and has completed their first home that qualifies for the federal tax credit. In October 2007, FLHero introduced the BA Builders Challenge and received a commitment to accept the challenge.

3.2. Marine Climate Community

Washington State University (WSU), a BAIHP subcontractor, has provided BAIHP assistance to two community-scale builders in Washington State. A three-year build of 483 energy efficient modular homes at the Fort Lewis Army Base came to a close in 2007. The homes built in Ft. Lewis were built to Northwest ENERGY STAR requirements and achieve roughly 25% benchmark savings.

Scott Homes in Olympia, WA also received BAIHP help in 2007. WSU met with Scott Homes design and construction staff to assess existing and five future projects. BAIHP staff worked with Scott Homes on testing and monitoring three Bungalow homes in Olympia to improve the energy efficiency of the building envelope and HVAC systems. These homes are designed to meet the Building America 40%+ metric. BAIHP is also providing design assistance on a 15 home PV and DHW “solar ready” community project that is expected to benchmark in the 50% range.

Fort Lewis Army Base – Fort Lewis, Washington



Figure 3-24 *Two Story Modular Housing Assembly, Ft. Lewis Army Base, WA*



Figure 3-25 *Two Story Modular Housing – Ft. Lewis Army Base, WA*

WSU is working with Building America partners Oregon Department of Energy (ODOE), Champion Homes and Equity Residential in an effort to build 483 energy efficient modular homes at Discovery Village Fort Lewis Army base in Washington State. These factory-built homes are constructed to Northwest ENERGY STAR Homes standards, and feature .90 AFUE furnaces, efficient windows and ENERGY STAR appliances. The project consists of a mixture of ENERGY STAR manufactured and site-built programs. ODOE inspects the homes in-plant and provides quality assurance throughout the construction process. WSU provides evaluation of the HVAC performance and on-site quality assurance for the final inspection of the home.

Phase 1 of the project, which started in 2005, produced 174 units. Phase 2, completed in 2006 resulted in an additional 150 units. Phase 3 completed 159 homes in 2007 resulting in a total of 483 units.

Initial testing of Fort Lewis HVAC systems by BAIHP staff indicated leakage rates of worse than 400 CFM50. Hands-on efforts by BAIHP staff resulted in significant improvements over the life of the project, as noted in Table 3-3.

Table 3-3

	# of homes tested	Average duct leakage - CFM50	Average duct leakage – CFM25	Average duct leakage - % of floor area (CFM50)
2005	74	96.36	61.38	5.24%
2006	164	91.04	57.99	5.13%
2007	218	86.18	54.89	4.80%
Total	456	89.58	57.06	4.99%

Current Fort Lewis homes benchmark at around the 30% level. BAIHP worked with Equity and Champion to build a demonstration duplex that is expected to benchmark at or above the 40% level. Cost benefit analysis of these systems began in 2007 and are currently underway. Preliminary cost data suggests that duct and envelope tightness, lighting, furnace and DHW improvements made in the demonstration homes result in a net \$14 total monthly savings for the improved technologies and testing.

A more detailed analysis is underway in 2008, with the hope that some or all of these technologies will be adopted in future projects. Plans for a 290-unit multi-family project in Ft. Lewis are forming, groundbreaking is planned for 2009.

Scott Homes Olympia, WA



Figure 3-26 Brotherton 13th Ave Bungalows by Scott Homes, Olympia, WA



Figure 3-27 Infrared Image of Brotherton 13th Ave Bungalows

Scott Homes is a production and custom home builder in Olympia, Washington, emphasizing green and energy efficient construction techniques. A Building America partner since 2005, Scott Homes are built with high efficiency shell and equipment measures, including SIP panels, and radiant heating with high efficiency gas combo heat/domestic hot water systems.

In 2005 – 2006 BAIHP staff met extensively with Scott Homes, assessing 10 of Scott Homes' existing and future projects, providing design consultation, preliminary assessment of tax credit qualification and ENERGY STAR Homes Northwest technical assistance. In 2007 and early 2008, BAIHP staff met extensively with Scott Homes design and construction staff, assessing an additional 9 existing and 5 future projects.

Also in 2007, BAIHP staff worked with Scott Homes on testing and monitoring three Bungalow homes in Olympia to improve the energy efficiency of the building envelope and HVAC systems. These homes are designed to meet the Building America 40%+ metric, Northwest ENERGY STAR Homes and the Federal Tax credit.

Current design assistance on a 15 home PV and DHW “solar ready” community project is underway. The community's model home, to be built in 2008 and monitored in 2009, is expected to benchmark in the 50% range. BAIHP staff identified key elements in the homes' specifications that were a barrier to compliance with ENERGY STAR, tax credit and high Building America metrics.

A full report of these tasks can be found in Appendix C - Washington State University Annual Report.

Task 4. Related Activities



Figure 4-1 *Typical US Habitat for Humanity home; average costs \$60,000*



Figure 4-2 *Volunteers construct Habitat for Humanity homes*

Task 4: Related Activities

BAIHP has been involved in various activities over the course of 2007 relevant in the research towards zero energy homes. Subtask 4.1 highlights activities associated with Habitat for Humanity. Activities include testing homes, training volunteers, design review and recommendations, standard development, activity and analysis reports, instrumentation and monitoring. BA team members and subcontractors like Washington State University, Oak Ridge National Laboratory, RESNET and others, have actively partnered to develop a true synergy of community partnerships. BP1 proved to be an effective use of resources as over 13 HFH affiliates were personally assisted, in addition to 50 affiliates (almost all Northwestern HFH affiliates) that were reached through the training of a key HFH administrator in the Northwest.



Figure 4-3 Mobile County Habitat Home

Subtask 4.2 involved working with HUD code manufacturers and Northwest Energy Efficient Manufacturing (NEEM) Housing program to improve efficiency and marketability through various activities. These activities were primarily directed toward projects located in marine-cold and hot-humid climates, climates that other Building America contractors are not currently focused on. BAIHP made factory and field site visits to test homes and ensure low leakage ducts; we promoted better efficiencies in equipment and promoted solar ready concepts; we continued to train and educate factory personnel resulting in 3400 ENERGY STAR manufactured units in the second budget period.

In subtask 4.3 BAIHP continued to assist National Renewable Energy Laboratory in refining the Benchmark calculation methodology and BEOpt analysis tools. Carryover tasks are included in this section. The final report for the previous BAIHP project, which ended in June 2006, was submitted in October 2006 and is available online at: <http://www.baihp.org/pubs/finalrpt/index.htm>



In BP1 subtask 4.4 initiated preparation, research and completion of two case studies for the 30% marine report – NEEM program and NOJI Gardens.

Subtask 4.5 highlights a few of the conference papers, contract reports, trainings and presentations given at various national and regional venues. Full details are provided in

the References section of this report. This section also highlights other activities that may be relevant to projects with multiple tasks associated with them or are relevant in the research towards zero energy homes.

Subtask 4.6 describes the work that RESNET has done with BAIHP, including spreading and publicizing the use of the HERS Index, and participating in international home energy standards discussions.

4.1. Habitat for Humanity (HFH) Partnership

In 2007, BAIHP continued its decade-long partnership with HFH. We provided technical assistance to at least 13 HFH affiliates including those in the gulf coast recovery area and those affiliates identified by HFHI as those that are building up production capacity. BAIHP will continue providing training at national and regional conferences, focus builds and “blitz” builds. These affiliates play a role as pace setters in their communities and regions.



Figure 4-4 *HFH volunteers in home performance testing training*

The goals of BA technical assistance to HFH affiliates is to

- Move “standard practice” toward ENERGY STAR and beyond,
- Achieve high performance in affordable housing to spur change,
- Standardize the production processes and
- Make recommendations that are volunteer friendly, proven techniques, cost effective and readily available.

BAIHP staff trained and equipped the Washington State Habitat Construction Managers Network Coordinator, Jerry Fugich, whose training has allowed BAIHP to reach over 50 Northwestern HFH affiliates.

Another goal BAIHP has for HFH is to establish a network of volunteer HERS raters for each affiliate so that habitat homes can be performance tested as a standard practice to their program. RESNET has been instrumental in the formation of this network and details of volunteer HFH raters can be found below and in Subtask 4.6 RESNET Activities.



Figure 4-5 *Habitat Volunteer Energy Rater Logo*

In addition to technical support and training, BAIHP is monitoring HFH homes for long term data collection and analysis. A HFH home in West Virginia is being monitored to determine the performance of radiant floor heating systems and two HFH zero energy homes in Loudon County (Franklin, TN) are being monitored in collaboration with Oak Ridge National Laboratories (ORNL).

Building America activities with Habitat were included in the FSEC Building Research Newsletter, BR Post. Our “Habitat Update” newsletter was added to the ENERGY STAR website under a new “Affordable Housing” section and a link was emailed to 50 high-profile Habitat staff members. BAIHP contributed to a discussion of a Small House

Builder Option Package with the ENERGY STAR new homes program and their sub-contractor ICF.



Figure 4-6 *New Orleans Habitat Houses*

Building America has been supporting Habitat for Humanity for over a decade and shared principles like operating affordability, durability, reliability, occupant health, safety, comfort, quality of life and stewardship of resources have motivated this partnership. A detailed presentation given during the February project review meeting about the BAIHP and HFH partnership can be viewed online at:

<http://fsec.ucf.edu/download/br/baihp/feb08-presentations/Janet-Habitat-Feb08.ppt>

4.1A. High Performance Habitat for Humanity Design Assistance

Detailed activity of technical design, specification and standards development, performance testing and sustainable construction techniques training, with respect to affiliate and special programs, are highlighted in this section.

Florida Affiliates

Lakeland (FL) Habitat for Humanity

BAIHP works with local affiliates like Lakeland Habitat for Humanity. Lakeland HFH adopted an energy efficiency program in 2000 and has built total of 51 ENERGY STAR homes since that time. The first energy efficient home they built qualified as an ENERGY STAR and won a special \$20,000 grant for energy efficiency from the Walt Disney Corporation. BAIHP subcontractor Ken Fonorow (Florida H.E.R.O.) provided plan reviews for the house, specification recommendations and energy-efficiency testing once the house was completed. With technical support from Fonorow and FSEC, FSEC conducts periodic testing and rating of Lakeland Habitat homes (12 houses over the past five years) to verify specifications. Currently Lakeland Habitat plans to build at the rate of 7 to 10 homes per year at scattered sites throughout the area. Five homes were tested and rated by BAIHP in BP1. In 2007, Lakeland HFH passed the TBIC in it homes with ease because of its thorough pursuit of ENERGY STAR and 30% BA Benchmark savings homes. BAIHP continued to perform testing, TBIC inspections and EnergyGauge calculations for this affiliate throughout BP2.

The current specifications (Table 4-1) save over 30% in whole house energy in comparison to the Building America Benchmark. In addition to energy improvements, Lakeland HFH also incorporates outside air ventilation using an inexpensive, passive strategy that can be implemented by any builder in the hot-humid climate. To achieve 30% (Figure 4-10) whole house energy savings, the principal strategy is to reduce cooling energy use – the largest component of annual energy use. This was done through a combination of cooling efficiency improvements. While some of the features that reduce the cooling load also reduce the heating load, some actually increase it slightly. For example, sealed ducts reduce both the cooling and heating loads; whereas, low-E windows reduce the cooling load but increase the heating load by reducing winter time heat gain through the windows. At the 30% savings level in the hot-humid climate, these winter time disadvantages are not significant. However, they may become more significant as we strive toward zero energy homes.

A review of the peak cooling load (Figure 4-10, from Manual J system sizing calculation for the Benchmark



Figure 4-7 An interior air handler, return plenum and supply duct chase



Figure 4-8 Low-E windows are enhanced by 2ft overhangs, porches and site shading.



Figure 4-9 Radiant barrier reduces heat transfer from the roof, a major component of the cooling load.

house) helps analysts and builders prioritize improvements. Notice in the BA Benchmark house (blue) that conductive heat gain to the duct system, window heat gain and ceiling heat gain are the major envelope related components of the peak cooling load. To minimize these, Lakeland Habitat uses interior ducts and air handler closet, low-E windows with shading where possible and radiant barrier under the roof decking (Figure 4-7, Figure 4-8 and Figure 4-9). Lakeland Habitat HERS '99 scores range from 88.6 to 91.2 with an average of 89.3.

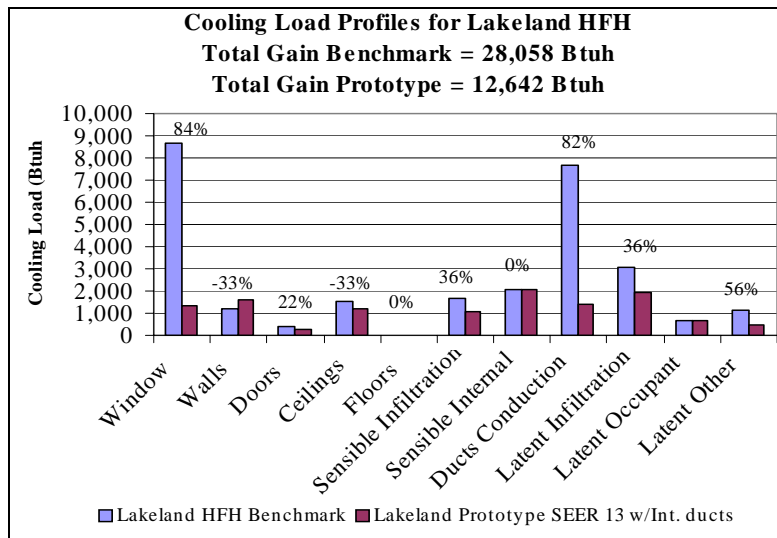


Figure 4-10 Lakeland Habitat peak cooling load reduction with savings noted in each category.

Table 4-1 Energy efficient features standard in Lakeland Habitat for Humanity homes

Roof/Ceiling	Radiant barrier, R-30 ceiling insulation, standard vented attic.
Windows	Double pane, vinyl frame, low-E windows, 24-inch overhangs, site shading and east-west orientation (when possible) to limit direct solar gain
Air Distribution System	Interior air handler closet and ducts in conditioned space (furred down duct chase) with joints and seams sealed with water-based mastic and fiberglass mesh, randomly tested to ensure duct leakage below 6%
Water Heating	Water-heater timers
Ventilation	Passive outside air ventilation ducted to the return side of the air handler with a filter-backed intake grill mounted in the soffit (at back door or porch). Ducted exhaust fans in the kitchen and bathroom(s) to improve indoor humidity control.
Cooling/Heating	14 SEER heat pump (up from 10 SEER in 1999)
Whole House Air Tightness	Extensive air sealing of building envelope after dry in. Random tests for whole house air tightness. In 2007 began implementing the ENERGY STAR Thermal Bypass Inspection Checklist.
Appliances	ENERGY STAR refrigerator

Lakeland HFH Green House

Lakeland HFH is working toward LEED certification. FSEC staff met with the director, construction supervisor and a site supervisor from Lakeland HFH to discuss bringing the affiliates' housing up to LEED for Residential Buildings standards. FSEC conducted preliminary ratings which showed that the affiliate would easily be able to be certified LEED Green and should be able to achieve the Silver level with some work.

BAIHP conducted final ENERGY STAR testing and LEED for Homes inspection for this affiliate. The house is expected to receive a Silver LEED designation from US Green Building Council once documentation is completed. The house was featured in The Ledger, Lakeland's local newspaper.

Indian River County, FL (Vero Beach Area)

We provided training and testing for Indian River County HFH, who received a grant from local developer WCI Homes. A volunteer energy rater was matched with this affiliate for performance testing. This affiliate built the first FGBC certified habitat home. In 2007, Calcs-plus continues to provide HVAC design and energy analysis assistance to this affiliate.



Figure 4-11 *Habitat for Humanity-WCI home, Vero Beach, FL*

Orlando, FL

In January 2008, BAIHP met with this affiliate and a LEED certifier on their green committee to discuss current specifications, the ENERGY STAR process and a multi-family project that will be started later this year. We tested two recently completed homes and found out duct and whole house air tightness to be in range. Preliminary evaluation of the multi-family project will begin in February 2008.

Pinellas County, FL

At the request of Pinellas County (PC) HFH, BAIHP visited this affiliate in 2006 to evaluate their current construction techniques related to energy efficiency and make recommendations for a future construction project consisting of 1200 ft² per unit triplexes. PCHFH desires to make these homes ENERGY STAR compliant. The HERS Indices as tested were ENERGY STAR compliant, 80, 83 and 84 (85 or less is ENERGY STAR certified); improvement recommendations were also made and included

comparison of ICFs to CMU block construction techniques. Two of Pinellas County HFH construction supervisors attended training in Gautier, MS.

In 2007, BAIHP inspected two ICF houses built by this affiliate. Using the results of the envelope and duct testing, FSEC established a baseline for the affiliate and generated recommendations to improve the affiliate's energy efficiency and building durability. In addition, we provided utility bill analysis developed by FSEC's Danny Parker to reduce energy use in existing houses.

Sarasota County, FL

Building America activities in 2006 with Habitat in South Sarasota County (FL) were featured in an October story on WWSB Channel 7, the ABC affiliate serving Sarasota and Port Charlotte. The story highlighted BA sub-contractor Calcs Plus' work with the Habitat affiliate to build ENERGY STAR certified SIP homes, and the story highlighted durability, IAQ and green aspects of the homes.

<http://www.mysuncoast.com/Global/story.asp?s=7304675>

Hillsborough County, FL

BAIHP began working with Hillsboro Co. HFH (Tampa, FL) in July, 2007. HCHF is planning a 25 home development that they want to make green and energy efficient. BAIHP hosted a conference call with FGBC, HFHI, HCHF and RESNET to go over the basics of what HCHF was going to do and what they needed to do for ENERGY STAR, FGBC and LEED for Homes. A preliminary analysis of their plans indicate that their planned houses could have a HERS index of 78. Their site plan did not look promising for FGBC Green Development Standard, but the individual homes should be certifiably green, either through LEED or FGBC. BAIHP conducted testing, made recommendations for thermal bypass inspection, discussed the USGBC LEED for Homes and LEED Communities Standards and performed energy analysis for this affiliate.

Highlands County, FL (Sebring):

In November 2007 this affiliate contacted BAIHP for technical assistance. BAIHP visited the affiliate and conducted a thermal bypass inspection and two blower door and duct blaster tests. Preliminary analysis shows this affiliate is building homes near ENERGY STAR (HERS Index ~87). Their goal is to build 100% ENERGY STAR homes. BAIHP completed analysis and ENERGY STAR ratings for this affiliate's first two ENERGY STAR homes and will provide 5 ratings annually to this affiliate.

Gulf Coast Reconstruction Efforts

BAIHP was involved in various activities to support reconstruction in the Gulf Coast. In 2006, BAIHP developed a partnership with the New Orleans, LA Global Green office to provide technical assistance to all local Habitat for Humanity affiliates. BAIHP sent out a joint FSEC-Global Green letter to affiliates in March 2007. In 2006, we provided extensive plan review, energy analysis and recommendations to Habitat for Humanity International's new Construction Standards for the Gulf Coast Habitat affiliates, which were released in November 2006. We continue to provide assistance to multiple Gulf Coast affiliates, described below.



Figure 4-12 *Raising Walls in a Gulf Coast Habitat Build*

Alabama Affiliates

Dothan, AL HFH

2006 - In partnership with Palm Harbor Homes and Oprah Winfrey BAIHP conducted testing and ENERGY STAR certification of 18 homes for the Dothan, AL Habitat for Humanity. BAIHP personnel followed along during the construction to determine the factory's ability to comply with the Thermal Bypass Checklist. We worked with PHH to rectify the issues not in compliance with the checklist, i.e. (many air barrier failures, incorrect use of can lights, etc.)



Figure 4-13 *Palm Harbor Homes built in Alabama for Oprah Winfrey-HFH partnership*

Mobile County, AL HFH

BAIHP conducted an initial site visit with this affiliate in November 2007. FSEC staff reviewed plans, conducted a thermal bypass evaluation and tested a completed home. Duct leakage was well within specification for ENERGY STAR and BAIHP made minor recommendations for passing the thermal bypass inspection. Preliminary analysis shows the homes achieving a HERS Index of 95 and benchmark savings of 13%. The affiliate is striving to bring specifications in line with ENERGY STAR for all their homes and has agreed to build a 30-40% benchmark savings prototype under BAIHP's supplemental funding for Gulf Coast High Performance Affordable Housing.



Figure 4-14 Mobile County Habitat Home

Louisiana Affiliates

New Orleans HFH (NOLA-HFH)

BAIHP performed multiple design reviews, provided energy efficiency and general building science knowledge and tested homes for TBIC compliance for this affiliate. The homes initially achieved a 98 HERS Index. The main problem with the houses was extremely leaky duct systems and high infiltration. The air handler is located in an interior closet that is open to the attic to provide combustion air for the atmospheric combustion gas water heater and gas furnace. FSEC discussed methods of securing safe combustion while resolving the infiltration and leaky ducts problem. New Orleans HFH has committed to building one ENERGY STAR all-electric prototype and one gas/electric prototype.



Figure 4-15 New Orleans Habitat Houses

In January 2007, BAIHP revisited this affiliate to conduct diagnostic duct testing and field testing of recommendations with Joe Ryan, a DOE contractor based in New Orleans. Results were excellent with duct leakage being brought into specification for ENERGY STAR certification with significant improvement in whole house air tightness. The affiliate has switched to all radiant barrier sheathing. Affiliate staff are still discussing plans to switch to an all electric strategy instead of using natural gas for heating, water heating and cooking.

HFH of Greater Baton Rouge, LA

In partnership with Habitat for Humanity International, Palm Harbor Homes and Oprah Winfrey, BAIHP conducted preliminary analysis, testing and ENERGY STAR certification of 15 modular homes for Baton Rouge Habitat for Humanity.

In July 2007, FSEC began analysis on a HFH of Greater Baton Rouge site-built home. The homes being built by this affiliate were already ENERGY STAR, achieving HERS Indices of about 80 and benchmark savings of 25%. In November 2007, they agreed to build a 30%-40% benchmark savings prototype under BAIHP's supplemental funding for Gulf Coast High Performance Affordable Housing. In January, BAIHP visited this affiliate to work on specifications for the 30%-40% benchmark savings including identifying which floor plan would be used, when the house will break ground (March 1), and conducting the first few steps of the systems engineering process including identifying problems, coordinating with sub-contractors and developing solutions on paper. The affiliate will complete their first two ENERGY STAR homes in February and BAIHP will return then to conduct final testing of those houses and further systems engineering activities.

Slidell, LA East Tammany HFH

This affiliate wishes to bring all homes in line with ENERGY STAR and then build a higher performance prototype. BAIHP discussed ENERGY STAR requirements with the site supervisor and made suggestions for improving the thermal envelope and air barrier, including a strategy for enclosing the air handler closet at the attic interface. The affiliate implemented this strategy. In January 2008, BAIHP tested the houses and found favorable results. This affiliate is working with a local rater and their utility's builder incentive program to improve their specifications. No analysis has been done for this affiliate yet.

Mississippi Affiliates

HFH of Mississippi Gulf Coast

FSEC conducted analysis and Thermal Bypass Checklist evaluations for HFH of MS Gulf Coast homes in various stages of construction in June 2007. FSEC prepared a detailed report of the many deficiencies found with regard to the Thermal Bypass Checklist. The affiliate expressed interest in achieving ENERGY STAR.

Gautier, MS HFH

In partnership with Habitat for Humanity International and the local Habitat BAIHP conducted hands on energy efficiency training where 50 volunteers attended and participated in building 4 houses during a "Blitz Build" (accelerated construction pace) venue in 2006.

Washington Affiliates



Figure 4-16 Habitat for Humanity 15 home Community Cottage project – Olympia, WA

BAIHP staff are currently working with BAIHP partner Habitat for Humanity on a 15 unit cottage project in Olympia, WA. The goal is to achieve the 40% metric, using a tankless gas combo hydronic floor heating system with ICFs and advanced framed 2x6 walls with R5 foam sheathing.

In 2007 BAIHP staff have worked with other Habitat affiliates on qualifying over 100 existing homes to Northwest ENERGY STAR standards, and are continuing to provide technical assistance and outreach to other Northwest Habitat affiliates. BAIHP staff have also trained and equipped the Washington State Habitat Construction Managers Network Coordinator, Jerry Fugich, so that all HFH homes in 2008-09 will meet both ENERGY STAR and the Washington State Housing Trust Fund's "Evergreen Sustainability Standards," qualifying the homes for low-income funding. Through Mr. Fugich, BAIHP staff conducted class and field training to over 50 HFH affiliates throughout the Pacific Northwest and distributed Building America Builder Guides.

2007 Jimmy Carter Work Project, Los Angeles, CA

BAIHP also provided training at national and regional conferences, focus builds and “blitz” builds. These include site testing in Florida, West Virginia, Colorado, Tennessee and other states mentioned in this section. BAIHP provided assistance in the 2007 Jimmy Carter Work Project in Los Angeles where 100 homes were to be built in one week in October 2007. It consisted of duplexes, triplexes and attached townhomes at two sites, Vermont and San Pedro. The 2007 JCWP was not a typical blitz built project in that the dwellings were all completed through drywall.



Figure 4-17 Jimmy Carter Work Project 2007

Normally, Building America would provide on site training during a blitz build to train volunteers on air sealing, insulation installation, attic ventilation baffle installation, drainage plane detailing, etc. During the course of that training, volunteers are introduced to many energy efficiency concepts, but we did not have that opportunity in these homes since they were nearly finished when the volunteers arrived. BAIHP involvement included analysis, testing, HERS ratings and development of checklists and visual aids to guide proper installation of insulation, air sealing, flashing, drainage plane, air barrier, etc. to HFH volunteers.

Global Green, based in California, took on the task of certifying the JCWP homes under the LEED for homes standards. Troy Lindquist, a BAIHP subcontractor and RESNET certified rater based Los Angeles, worked with the Global Green, HFHI and the JCWP construction staff on behalf of BAIHP. Lindquist conducted training with the insulation contractor, HFH-LA construction staff and volunteers on air sealing and insulation detailing required for the Quality Insulation Installation (QII) inspection – the California ENERGY STAR program’s Thermal Bypass Inspection component. ENERGY STAR certification was finalized in November 2007.

Michigan Affiliates

A report was prepared in August 2006 and transmitted to Michigan affiliates summarizing recommendations to improve energy efficiency and indoor air quality in cold climate Habitat homes. This report resulted out of site visits to multiple homes in Michigan in 2005 as part of the Jimmy Carter Work Project 2005. The report included recommendations for a ducted return air plenum that pulls air only from the conditioned space - not from connected floors, walls, or ceilings. Note frame for filter back grill like the one pictured in **Figure 4-19**.



Figure 4-18 JCWP-CBA House built by Lansing (MI) Habitat for Humanity



Figure 4-19 Detail of a ducted return air plenum

Habitat for Humanity (HFH), Home in a Box, Nationwide

In BP1 BAIHP was involved with Habitat for Humanity International (HFHI) and Habitat for Humanity local affiliate nationwide. We continued to provide technical assistance and support to Habitat for Humanity International's department of construction and environmental resources and the new operation home delivery department. The operation home delivery department has developed Home in a Box program to provide a kit of parts deliverable to the Gulf States to help relieve housing and labor shortages due to Hurricane Katrina disaster. In addition to BAIHP assistance in specifying efficient specifications and proper construction techniques to high profile projects we were instrumental in the development of HFHI's Construction Standards which were released November 2006.

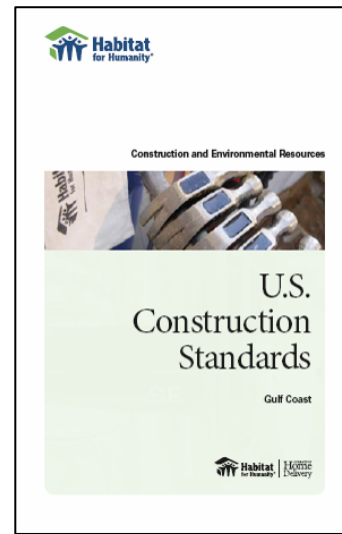


Figure 4-20 HFHI's Construction Standards which were released November 2006

Other Activities with Habitat

RESNET-BA-HFH Partnership

David Beal (BAIHP) and Claudia Brovick (RESNET) continue to respond to volunteer RESNET members who want to work with Habitat for Humanity affiliates. The RESNET volunteer corps is up to about 25. RESNET partnership materials online at:

<http://www.natresnet.org/rater/partnership/default.htm/>

Beginning in August 2007, RESNET's newsletter contained an article on their Habitat for Humanity Partnership. Several articles recognized volunteers and encouraged more

raters to volunteer. In addition, new material was posted on RESNET, BAIHP and HFHI's intranet web pages about the partnership. A case study template was developed using the one-page summary format common on other BAIHP projects. In July, BAIHP participated in a "rater roundtable" hosted by RESNET, which was a training conference call about the partnership. Two Habitat affiliates participated in the call.

Training and Outreach Activities with Habitat:

May: Janet McIlvaine participated in a nationwide conference call attended by 54 HFH construction staffers and hosted by HFHI as a National Training Event. McIlvaine covered ENERGY STAR qualifying procedures and fielded questions. This new HFHI training venue is followed up by making the audio from the call as well as supporting documents available online to all affiliates through the HFHI Intranet.

June: FSEC produced and submitted a resource guide to Building America online documents for "Building America - Habitat Partnership Update." This BAIHP deliverable was distributed electronically to hundreds of Habitat and building science contacts and featured in FSEC's quarterly Building Research e-newsletter the *BR Post*.

October: FSEC staff presented "Beyond ENERGY STAR" case studies to ~100 attendees at the National HFH conference, "Focus on the Future," in New Orleans. A building science field session conducted in NOLA-HFH's Musician's Village drew approximately 50 attendees. Co-presenter Claudette Reichel (LSU) provided an overview of hot-humid building science while BAIHP demonstrated blower door and duct blaster testing and air flow dynamics using a table top model. BAIHP also had a booth in the exhibit hall of this conference where approximately 25 HFH affiliates signed up for the RESNET-BA-Habitat partnership.

December: BAIHP staff worked with Habitat affiliates to draft one-page case studies of high performance homes that will be submitted for posting on the Building America website. (A no-cost extension for this deliverable was requested and granted through the end of March)

January 2008: BAIHP was asked to join a HFHI committee on training for a new building science program and participate in several conference calls to identify potential collaboration.

4.1B. Long Term Instrumentation and Monitoring Habitat for Humanity Projects

Detailed activity of instrumented and monitored for long term data collection Habitat for Humanity projects with respect to their locations is outlined below.

Loudon County, TN

BAIHP is continuing to monitor and collect data on two near zero energy Habitat houses with ORNL located in Loudon County. During BP1, the Zero Energy House 5 data logger was reprogrammed to accommodate an IBACOS hot water experiment designed to minimize water and energy waste.

Franklin, WV

In BP1, BAIHP installed ground and slab instrumentation for radiant floor heating in Habitat house being constructed in Franklin, West Virginia. Actual data on the performance of radiant slab heating systems is scant, but there are many claims of energy savings and greatly improved comfort. Instrumentation consists of temperature probes embedded in and around the slab. In total, 25 temperatures and humidities, solar load, loop flow and heating hot water tank power measurement are installed.



Figure 4-21 Rigid insulation being installed on rock bed within ICF stem wall



Figure 4-22 Radiant floor system installed prior to slab pour

4.2. HUD Code ENERGY STAR

BAIHP is currently working with several HUD-code home manufacturers that wish to achieve ENERGY STAR certification. FSEC has coordinated with three HUD-code manufacturers to assist in certifying homes for ENERGY STAR and providing diagnostic assistance.

BAIHP subcontractors, the Oregon Department of Energy (ODOE) and Northwestern Energy Efficient Manufacturers (NEEM), played a large role in spreading HUD-code ENERGY STAR homes. The nineteen factories that participate in NEEM produced over 3400 HUD-code ENERGY STAR homes during the second budget period.

Homark Homes

This BAIHP partner and builder has produced 20 ENERGY STAR HUD-code homes placed in MN, ND and WI. BAIHP Researchers tested one home in May 2007 and will test one home each year to comply with the MHRA ENERGY STAR program and tax rebates. In addition, they diagnosed a HUD home with moisture problems and will continue working with Homark Homes to ensure they continue receiving rebates.

Palm Harbor Homes: HUD-Code ENERGY STAR Testing/Research

BAIHP continues to provide technical assistance to Palm Harbor Homes under cost-shared funding to certify their HUD code ENERGY STAR Homes and modular ENERGY STAR homes. We provided assistance to HWC Engineering (PHH 3rd party inspector) with incorporation of Thermal Bypass Checklist and reviewing possible use of new RESNET approved sampling protocol. In addition, we compiled and submitted several product improvement ideas for the 2008 model year for Plant City plant and prepared Green recommendations for “Green Ready” PHH modular homes, which would have most of the FGBC requirements installed in the factory.



Figure 4-23 *Bottom plate air seal inspection –thermal bypass inspection checklist item*



Figure 4-24 *Insulation compression inspection – thermal bypass inspection checklist item*

Jacobson Homes

In January 2008, BAIHP provided technical assistance to this HUD/Modular builder in Safety Harbor, FL. Jacobson Homes is considering becoming a partner. BAIHP toured the Jacobson factory. BAIHP staff met with the engineering and company director and provided an overview of BAIHP program, covered basic building science and provided feedback on construction pitfalls of the modular industry.

Oregon Department of Energy (ODOE) and Northwestern Energy Efficient Manufacturers (NEEM)

This report appears in Appendix D - Oregon Department of Energy Annual Report.

Staff performed quarterly factory inspection visits, inspected problem homes; developed in-plant quality assurance detailed inspection manuals and periodically upgraded the standards to higher levels of energy efficiency. All ten out of ten Oregon plants, four out of four Idaho plants, three of three California plants and one of two Washington plants test all duct systems in each floor to ensure low leakage ducts using duct testing equipment.

In 2006, NEEM adopted the Oregon Residential Tax Credit standard for duct leakage as an airtight duct standard. The new NEEM standard is that total or net duct leakage shall not exceed 0.06 cfm50 X the floor area served by the system or 75 cfm50, whichever is greater. All nineteen plants test all duct systems in each floor to ensure low leakage ducts using testing equipment. As of June 1 2006, NEEM inspectors are requiring a written response to non-compliant energy details found during quarterly inspections.

Staff distributed to the industry multiple specification clarifications on subjects such as whole-house ventilation installation and product, ENERGY STAR appliances, insulation effectiveness and on monitoring of plant duct testing. ENERGY STAR built-in appliances are being installed in each ENERGY STAR home.

Other activities include

- completing and distributing a power point CD for factory technical staff 5 biggest problems in 2007;
- revising the NEEM specification for whole house ventilation;
- presenting CFL lighting and other program innovations to the industry;
- working with MHRA and Nevada



Figure 4-25 NEEM Logo

and California utility programs;

- certifying a new plant at Skyline in Woodland California;
- quarterly inspection for Champion Homes in Woodland California.

In addition staff was asked by four Oregon manufactures to certify energy efficient park models programs to develop a proposal to the industry. The proposal was very well received by the industry. Staff is pursuing ENERGY STAR certification for park models.

Staffs met with all plants general managers to interview them on the NEEM program.

Questions asked were:

- Is the NEEM/ENERGY STAR program helpful to your business?
- Is the NEEM program easy to use?
- Is the internet tracking and certification system easy to use?
- Do you consider NEEM part of your business team?
- With advancement in energy code in site built are you supportive in the future to expand technologies to increase overall home efficiency?
- What can NEEM do to improve its service to your company?
- Does the NEEM staff respond in a timely manner to your inquiries?

All manufacturers see NEEM as helpful to their business and see NEEM as part of their business team. Generally when asked the question of “how can NEEM improve our services to your business” all GM’s said staff was doing a great job. When staff explained that we may have to increase the efficiency of the ENERGY STAR homes, all plants GM were supportive of moving the bar higher.

Staff taught 6 two-day State of Oregon-certified installer classes in Bend, Salem Albany and Medford and 5 sessions through out the state of Idaho. The classes are cosponsored by the Oregon Manufactured Housing Association and the Idaho Manufactured Housing Association.



Figure 4-26 *In-plant duct testing training*

NEEM staff began a field study in January 2008. Staff will obtain duct tightness and pressure data, utility bill data, lighting wattages and other information from 24 homes. Five have been tested so far.

Sixteen out of nineteen plants will receive an ENERGY STAR Leadership Housing Award for their 2007 production numbers. In 2007 NEEM plants produced approximately 65% of the nations ENERGY STAR homes. The 2007 NEEM totals are 3786 ENERGY STAR homes built.

During the first budget period, NEEM activities included, but were not limited to:

- NEEM completed utility cost effectiveness for ENERGY STAR homes
- 59 regional utilities and two states now offer incentives and tax credits for NEEM homes
- NEEM met with the industry in September 2006 to discuss two specification proposals and other important issues
- NEEM wrote a two- page summary and distributed to the industry ENERGY STAR manufactured home about federal tax credits update
- NEEM promoted heat pumps, high efficiency gas furnaces, ENERGY STAR lighting
- NEEM promoted solar ready concepts
- NEEM distributed specification clarification on
 - Whole-house ventilation HUD rule
 - Foundation ventilation specification change
 - Spec change proposal from industry setup requirement of elbows on crossovers

4.3. BA Program / Analysis Support

In this subtask we assisted NREL in the continued refinement of the Benchmark calculation methodology and BEOpt analysis tools through email exchanges and participation in conference calls. In 2007, FSEC initiated exchange of benchmark and analysis files with NREL to verify the process of benchmarking and consistency of results. Air conditioning sizing was brought up as an issue. NREL showed that EGUSA appears to cut-off energy during hottest peak days leading to believe a reduced energy usage for the benchmark. This software code issue was addressed by FSEC staff.

FSEC and RESNET also continued to support DOE and NREL in the area of tax credit implementation procedures.

DOE National Builders Challenge Program

During 2007, BAIHP supported the DOE Builders Challenge program (buildingamerica.gov/challenge), including participation in conference calls and discussions on the Challenge as well as providing label information for the Challenge draft label.

This voluntary challenge to the homebuilding industry to build 220,000 high performance homes by 2012 was accepted by 18 BAIHP partners as of January 2008. These builders have committed to build homes that are between 70 and 0 on the EnergySmart Home Scale (E-Scale) also known as the HERS index.

Eighteen out of the 38 builders committed to the program as of February 2008 were recruited by BAIHP:

- Brownsville Affordable Homeownership Corporation, Planning and Community Development Department
- Castle & Cooke, Florida, LTD
- Ferrier Custom Homes
- Florida Custom Homes
- G.W. Robinson Builders
- Marc Rutenberg Homes
- Marquis Construction and Development
- On Top of the World Communities, Inc
- Organum Development (Lily Valley)
- Palm Harbor Homes, Inc
- Pringle Development, Inc
- Schackow Realty and Development
- Schroeders Homes
- Skobel Development, Inc.
- Spain & Cooper Construction
- Stalwart Built Homes
- Stitt Energy Systems, Inc.
- Tommy Williams Homes

4.4. System Research Completion Report

In 2006, BAIHP participated in conference calls and prepared two case studies for the 30% marine report – NEEM program and NOJI Gardens. Details are found in the report issued by NREL.

In 2007, FSEC submitted the 30% Savings in Hot Humid Climate Joule Report, including three case studies, the integrated design section and the mechanical and ventilation systems section. They solicited comment from the secondary authors for our sections and provided comment for those who sent us material for review. This work included performing benchmark analysis on 12 Building America (BA) builder homes, comparison of homes sales versus non-BA home sales prices and performing benchmark analysis on Lakeland Habitat for Humanity homes.

4.5. Documentation, Resource Development and Related Activities

Documentation and Resource Development

The BAIHP team published 5 papers at various conferences. Twelve presentations were made at various national and regional venues and training on high performance housing was provided to approximately 500 people. The details are provided in the References section.

The web page www.baihp.org continues to be updated and revised periodically. All published papers and reports are put on-line.

Media Attention

During 2007, BAIHP projects received considerable media attention:

- The recognition ceremony for BAIHP partners G.W. Robinson Builders and Tommy Williams Homes was covered by the Gainesville, FL newspaper, and both the city of Gainesville and Alachua County proclaimed the day “Building America Day.”
- The Garst Home in Olympia, WA was featured in the March/April 2007 issue of *Solar Today*.
- In addition, several articles have been produced about Zero Energy Homes featuring or written by BAIHP personnel.

Prompted by a homeowner’s results in the Feedback study (Subtask 1.5), we worked with NBC to produce four informational segments on reducing household energy use including: selecting energy efficiency televisions, improving appliance efficiency and reducing energy use in the home office. One final segment on improving automobile mileage which will aired in February. During spring 2008 we will also have a segment covering Zero Energy Homes as a way of describing Building America’s mission. These segments were among the most popular such pieces ever produced by the network. In fact, NBC 6’s “Going Green” segments have gotten the award for best “Public Affairs Program” for 2007 by the *Associated Press*:

<http://www.nbc6.net/goinggreen/12392982/detail.html>

Program Impact

BAIHP concentrates its work in hot-humid and marine climates but is active in most regions of the U.S. In 2006 we assisted in the construction of over 140 homes that exceed the 30% BA benchmark goals in hot-humid climates, over 160 homes that are near the 30% benchmark level in marine climates, over 4,400 ENERGY STAR manufactured homes in the Pacific Northwest and over 19,000 other energy efficient manufactured homes by partners Palm Harbor Homes, Fleetwood and Southern Energy Homes. The estimated energy savings from these homes constructed in 2006 is over 209,000 million Btu/year and the estimated savings in utility bills to consumers exceed \$3,600,000/yr. Figure 4-27 reveals savings since BAIHP has been part of the DOE.



4.6. RESNET® 2007 Annual Report on Building America Program Activities

With Building America support RESNET has been able to effectively advocate for high performance buildings. With adoption of the RESNET HERS® Index there is now a common metric that can map the progress to the net zero energy home. Programs such as ENERGY STAR, the Department of Energy’s National Builders Challenge and the 2030 Challenge are now using the index as a yard stick by which they can set their program’s performance goals. In addition, in 2007 an exciting opportunity emerged to work internationally to harmonize the way that building energy performance is rated and labeled.

This progress allows the market deployment of the technologies developed by the Building America Program because consumers, builders and program sponsors can easily understand and compare the energy performance of one home with another.

HERS® Index

RESNET Ratings provide a relative energy use index called the HERS Index – a HERS Index of 100 represents the energy use of the “American Standard Building” and an Index of 0 (zero) indicates that the Proposed Building uses no net purchased energy (a Zero Energy Building).

A number of high building performance programs use the Index to establish the thresholds for their program’s performance requirements. The U.S. Environmental Protection Agency has set an Index score of 85 for the ENERGY STAR for Homes Program.

In 2007 RESNET negotiated with the 2030 Challenge to base its performance goals on the HERS® Index. The 2030 Challenge has established the following thresholds for meeting its challenge of carbon neutral homes by 2030:

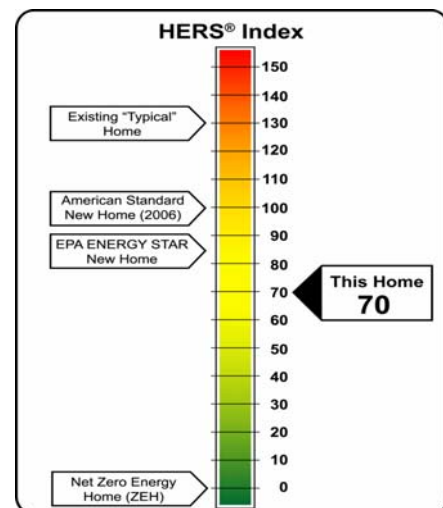


Figure 4-28 HERS Index Scale

Date	Target Index Score
2007 & Existing Homes	65
2010	52
2015	39
2020	26
2025	13
2030	0

This agreement is significant because the 2030 Challenge is a challenge from the architectural community that all new buildings will be net zero carbon by the year 2030. The challenge has gained a lot of publicity and support. The U.S. Council of Mayors, AIA and ASHREA have adopted the challenge.

U.S. Department of Energy (DOE) Builders Challenge

DOE has established the Builders Challenge as an effort to recognize those builders who are pioneering the path to the net zero energy home. RESNET has been involved in the process of developing the Challenge since its inception. RESNET's executive director Steve Baden served on the program's steering committee and on the subcommittee on the program's index.

DOE has elected that the performance target for the challenge be a 70 score on the HERS® Index.

In addition to serving on the steering committee, RESNET has supported the program through presentations at all of the quarterly meetings of the National Home Builder Association Energy Subcommittee. The presentations also included information on the federal tax credit for energy efficient homes and the RESNET HERS® Index was presented.

Building America Technical Session Track at the 2007 RESNET® Building Performance Conference

The RESNET® Building Performance Conference is the premier national forum on home energy ratings and building. In 2007 the conference attracted over 600 leaders of the home energy rating and building performance industry. Ed Pollock of DOE gave a plenary presentation announcing the National Builders Challenge.

A special feature of the 2007 conference was a technical track featuring the results of Building America research. The track's sessions had the theme of "Lessons Learned from Building America" and were developed by the Building America teams. Ren Anderson of the National Renewable Energy Laboratory moderated the sessions. Sessions featured in the track were:

- Lessons Learned from Building America: Duct Designs in Low Load Houses – Challenges and Solutions
- Lessons Learned from Building America: Effective Zoned Systems
- Lessons Learned from Building America: Mechanical Ventilation – How Much is Enough?
- Can There be Too Much?

International Dialogue on Harmonizing of Building Performance Rating and Labeling Standards

There is an emerging global market for the trading of carbon emission savings. There are estimates that this potential market could be as high as \$2 trillion. In industrial nations buildings emit 40% of all carbon emissions. This creates a dynamic opportunity for improved building performance as an international strategy for combating climate change. In order to achieve this potential there is a need to harmonize the standards on how building energy performance is measured and labeled.

In 2007 RESNET® made solid progress in an international dialogue on harmonizing standards. Accomplishments include:

- The chairman of the European Union’s (EU) committee tasked in developing a European rating standard, Eduardo Maldonado meeting with the RESNET Board of Directors and giving the keynote address at the 2007 RESNET Building Performance Conference.
- The International Energy Agency’s head of Energy Efficiency Policy Analysis presenting to the RESNET Board and at the 2007 RESNET Building Performance Conference.
- A Memorandum of Agreement entered into with the Canadian rating program, Canadian Residential Energy Services Network, where the HERS Index and RESNET standards were adopted in Canada. In addition, the Canadian rating program became a formal international affiliate of RESNET.
- A Memorandum of Agreement with the Shanghai Real Estate Science Research Institute where the HERS Index and RESNET Standards will be adopted to implement the city’s stringent building energy code. The Shanghai Institution also became an international affiliate of RESNET.

In December 2007, Steve Baden and Philip Fairey were invited by the European Commission to present at the Energy Performance in Buildings Directive’s Concerted Action in Warsaw, Poland. The cost of the travel was paid for by the European Commission. At the meeting RESNET gave the following presentations:

- Opening plenary session on an overview of RESNET and how ratings are conducted in the U.S.
- Break out session on the RESNET calculation method and on-site measurement procedures
- Breakout session on the RESNET procedures for the training and certification of raters and quality assurance of ratings
- Demonstration of how the U.S. rating software programs work

As a result of this dialogue, Eduardo Maldonado reported to the member nations that after a review of RESNET's standards and procedures, he believed that RESNET would qualify under the EU's Energy Performance in Buildings Directive.

An immediate result of RESNET's participation in the European Commission's Warsaw meeting was that the commission recommended that RESNET be a member of the International Standard Organization's (ISO) standard on calculating and labeling of building energy performance (ISO TC163). The American National Standards Institute (ANSI) nominated Philip Fairey as the American representative to the committee.

This progress is significant in laying the foundation for the rating and certification of building energy savings in a global carbon market.

Linking Raters with Affiliates of Habitat for Humanity

As the result of the 2006 agreement to expand the project from targeting specific markets to including all areas of the nation, RESNET® has devoted a page on the RESNET web site to promote this effort. The page can be viewed at www.resnet.us/rater/partnership

RESNET is now offering a specially designed "Habitat Volunteer Energy Rater" logo to raters who agree to provide free ratings to Habitat Affiliates posted next to their name on the RESNET website and available to them to use on promotional materials. This program has elicited over 30 raters nationwide to sign up for the program.



Figure 4-29 *Habitat Volunteer Energy Rater Logo*

Survey of Tax Compliant Homes

In BP1 RESNET conducted a survey of raters that have verified homes for the new federal tax credit for energy efficient homes. The purpose of the survey was to provide "real life examples for builders on what it takes to qualify for the tax credit." The goal is to have at least one example in each of the IECC climate zones. RESNET received homes that were certified by raters for the tax credit in the states of Colorado, Indiana, Massachusetts, Minnesota and Wisconsin on posted them on the RESNET web site at <http://www.resnet.us/taxcredits/examples/default.aspx>

RESNET presented examples of homes that made the federal tax credits at the 2006 Energy and Environmental Building Association Conference at the National Association of Home Builders October 2006 Energy Committee meeting.

RESNET documented examples of high performance homes that are eligible for the \$2,000 tax credit. Details at <http://www.resnet.us/taxcredits/examples/default.aspx>

RESNET continues to recruit raters to submit more examples of homes that have been certified for the tax credit.

Fannie Mae Including High Performance Manufactured Homes in Energy Efficient Mortgage Product

In an effort to make the energy efficient mortgage product more viable the RESNET Board of Directors adopted a policy statement on energy mortgages.

RESNET urges Congress to adopt as federal policy that by 2020 new homes be 50% more efficient than today's home. The policy would also be that as government chartered corporations Fannie Mae and Freddie Mac have a responsibility to assist in meeting the goal and must prepare a plan to Congress on how they will assist in meeting this policy objective and report annually on progress. – Since the federal lending institutions are chartered by Congress they have a responsibility to assist the nation in meeting its goal of dependence on imported oil. This is a logical conclusion of the new homes tax credit that was established in the Energy Policy Act of 2005.

Acknowledgement

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Appendix A - PUBLICATIONS

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- Fonorow, K., Chandra, S., Martin, E., McIlvaine, J., "Energy and Resources Efficient Communities through Systems Engineering: Building America Case Studies in Gainesville, FL.", Proceedings of the 2006 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Asilomar, CA., August 2006. http://www.baihp.org/pubs/aceee_fonorow/ACEEEpaper.pdf
- Thomas-Rees, S., Chandra, S., Barkaszi, S., Chasar, D. and Colon, C., 2006. "Improved Specifications for Federally Procured Ruggedized Manufactured Homes for Disaster Relief in Hot/Humid Climates," FSEC-CR-1645-06 Revised - September 2006. http://www.baihp.org/pubs/ImproveSpecificHomes/contract_report.pdf
- Mullens, M., Hoekstra, R., Nahmens, I., and Martinez, F., 2006. "Water Intrusion in Central Florida Homes During Hurricane Jeanne in September 2004," UCF Housing Constructability Lab, University of Central Florida, Orlando, FL. August, 2006.
<http://www.baihp.org/pubs/deliverables/WaterIntrusionReport8-21-06.pdf>

Trade /BA Publications:

Lubliner; et. al. Final Stagegate Presentation to BA teams in January 2008 “Zero Energy Manufactured Home Project”

Baechler, M.; Lubliner, M.; et. al. “Fort Lewis Army Base.” Building America Best Practices Series: Volume 5 – *Builders and Buyers Handbook for Improving New Home Efficiency, Comfort, and Durability in the Marine Climate.*

Baechler, M.; Lubliner, M.; et. al. “Sam and Christine Garst Build a House.” Building America Best Practices Series for High Performance Technologies: *Solar Thermal & Photovoltaic Systems in the Marine Climate.*

Mullens, M., I. Nahmens, and R. Hoekstra, “Lessons Learned from Lean Practice: Case Study of a Precast Concrete Panelizer,” Submitted to Engineering Management Journal. Submitted 3/06

Syal, M., M. Hastak, M. Mullens, and A. Sweaney, “U.S.-India Collaborative Research Directions in Urban Housing and Supporting Infrastructure”, ASCE Journal of Architectural Engineering, 12(4)163-167, December 2006.

Nasereddin, M. and M. Mullens, “Automated Simulator Development: A Strategy for Modeling Modular Housing Production”, Automation in Construction. Accepted for publication 4/14/06

Mullens, M. and M. Arif, “Structural Insulated Panels: Impact on the Residential Construction Process,” The Journal of Construction Engineering and Management, 132(7) 786-794, July 2006.

Brown, R., and Parker, D. “Roadblocks to Zero Energy Homes,” Home Energy Magazine, December 2006

Baechler, M.; Lubliner, M.; et. al. “Fort Lewis Army Base.” Building America Best Practices Series: Volume 5 – Builders and Buyers Handbook for Improving New Home Efficiency, Comfort, and Durability in the Marine Climate.

Baechler, M.; Lubliner, M.; et. al. “Sam and Christine Garst Build a House.” Building America Best Practices Series for High Performance Technologies: Solar Thermal & Photovoltaic Systems in the Marine Climate.

Papers with Presentations

ASHRAE Conference, June 2007 Symposium

Baylon, D.; Hales, D.; Lubliner, M.; Peeks, B. "NEEM Mastic Study." Accepted paper for 2007 ASHRAE Symposium (peer review comments addressed.)

Hadley, A.; Lubliner, M.; Parker, D. "HVAC Improvements in Manufactured Housing Crawlspace-Assisted Heat Pumps." Accepted paper for 2007 ASHRAE Symposium (peer review comments addressed.)

Fairey, P.; Lubliner, M.; Lucas, R. "National Energy Savings Potential in HUD code Housing from Thermal and HVAC Equipment Improvements"; Accepted paper for 2007 ASHRAE Symposium (awaiting peer review.)

ICEBO Conference, San Francisco, CA, Nov 2, 2007.

Fonorow, K., Chandra, S., McIlvaine, J., and Colon, C. "Commissioning High Performance Residences in Hot, Humid Climates"

Thomas-Rees, S., Chasar, D., Beal, D., and Chandra, S. "Using Show Homes (and Sponsorships) to Persuade Commissioning Relevancy And Factory Crafted High Performance Modular Homes"

2006 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Asilomar, CA., August 2006

Fonorow, K., Chandra, S., Martin, E., McIlvaine, J., "Energy and Resources Efficient Communities through Systems Engineering: Building America Case Studies in Gainesville, FL."

Danny Parker, David Hoak, Alan Meier, Richard Brown, "How Much Energy Are We Using? Potential of Residential Energy Demand Feedback Devices"

Fairey, P. and D. Goldstein, "Getting It Right Matters: Why Efficiency Incentives Should Be Based on Performance and Not Cost."

Baden, S., P. Fairey, P. Waide, P. de T'serclaes and J. Laustsen, "Hurdling Financial Barriers to Low Energy Buildings: Experiences from the USA and Europe on Financial Incentives and Monetizing Building Energy Savings in Private Investment Decisions."

Moyer, N., "Ducts in Conditioned Space"

Brown, Richard, Parker, Rittlemann, William, Homan, Greg, "Appliances, Lighting, Electronics, and Miscellaneous Equipment Electricity Use in New Homes."

15th Symposium on Improving Building Systems in Hot and Humid Climates. Orlando, FL. July 24-26, 2006

Thomas-Rees, S., Chandra, S., Barkazsi, S., Chasar, D., Colon, C., "Improved Specifications for Federally Procured Ruggedized Manufactured Homes for Disaster Relief in Hot/Humid Climates"

Chasar, D., Chandra, S., Parker, D., Sherwin, J., Beal, D., Hoak, D., Moyer, N., McIlvaine, J., "Cooling Performance Assessment of Building America Homes"

Beal, D. and Chasar, D., "Measured Crawlspace Conditions in a HUD-code Home"

Moyer, N. "Diagnosing Moisture Problems"

Mcilvaine, J. "Minimum Standards for Rebuilding in the Gulf Coast Region – Building America Recommendations to Habitat for Humanity" (no paper)

Presentations

(Does not include presentations at BA quarterly meetings or presentations with papers/publications):

BAIHP Project Review Meeting, Cocoa, FL February 12, 2008

Presentations available for download at
<http://fsec.ucf.edu/download/br/baihp/feb08-presentations/>

Green Building Workshop, Austin, TX, Nov 29, 2007.

Martin, E. and Chandra, S. Green Building Presentations.

Insurance Company Executives Meeting, Orlando, FL, Nov 7, 2007.

Chandra, S. Green Buildings.

Environmental Commission of Titusville, FL, Oct 11, 2007.

Vieira, R. Energy Efficiency and Green Building for Local Governments.

Heating, Airconditioning & Refrigeration Distributors International Annual Conference, Orlando, FL, Oct 8, 2007.

Vieira, R. Green Building Programs.

Cameron Works Energy Expo, Brownsville, TX, Sep 7, 2007.

Chandra, S. Presentation

Northwest Habitat for Humanity, July 2007.

WSU- Presentation on Building America Program; handed out 35 copies of Building Science Corporations' s Cold Climate Guide.

Northeast Florida Regional Green Building Forum, July 24, 2007

Martin, E. "Green Building Programs Available to Builders and Developers"

Affordable Comfort, Inc. Summit, San Francisco, CA, July 12, 2007.

Parker, D. Keynote Address on the potential for extensive retrofits for existing U.S. homes. <http://www.affordablecomfort.org/event/aci_summit_moving_existing_homes_toward_carbon_neutrality/articles/232>.

National Association of Home Builders (NAHB) Energy Subcommittee Meeting, Washington, D.C., June 6-9, 2007.

Baden, S. Update on the federal tax credit for energy efficient homes and the HERS Index

Energy Conservation Strategies Commission, Alachua County, May 2007-Sept 2007

FLHero. Multiple presentations on the HERS Index, including the value of HERS Index to increase consumers' awareness of their homes' energy efficiency and for upgrading efficiency of low income homes.

Sierra Club, North Florida Chapter, May 2007

FLHERO. “The Value and Benefits of the BA Approach for the Environment.”

RESNET 2007 Conference , San Diego, CA, February 18-20, 2007

Presentations: Abstracts and presentation downloads available at

<http://www.resnet.us/conference/2007/agenda.htm> . BAIHP presentations

included:

Monetizing Building Energy Performance in Private Investment Decisions

Presenter: Steve Baden, RESNET

The RESNET HERS Index – The Path to Zero Energy Homes

Presenter:

- Philip Fairey, Florida Solar Energy Center

Carbon Trading – The Role of Building Energy Performance

Presenters:

- Steve Baden, RESNET

- Thomas Hamilton, Quality Built

- Kelly Parker, Guaranteed Watt Savers

Round Table Discussion of Construction Errors Identified during the Rating Process

Presenters:

- Ken Fonorow, Florida H.E.R.O.

- Dennis Stroer, Calcs-Plus

Time Has Come Today – A New Look at Energy Efficient Mortgages

Presenters:

- Steve Baden, RESNET

- David Goldstein, Natural Resources Defense Council

Lessons Learned from Building America: Effective Zoned Systems

Presenters:

- Ken Fonorow, Florida H.E.R.O.

- Dennis Stroer, Clacs – Plus

Lessons Learned from Building America: Mechanical Ventilation – How Much is Enough? Can There be Too Much?

Presenter:

- Subrato Chandra, Florida Solar Energy Center

- Armin Rudd, Building Science Corporation

ENERGY STAR Qualified Homes and Manufactured Housing: HUD Code and Modular Homes

Presenters:

- David Lee, Environmental Protection Agency

- Emanuel Levy, Manufactured Housing Research Alliance

- Neil Moyer, Florida Solar Energy Center

Codes, Ratings, ENERGY STAR and Tax Credits, Oh My!

Presenters:

- Philip Fairey, Florida Solar Energy Center

- Dave Roberts, Architectural Energy Corporation

ACCA Manual J Load Calculation - An Overview for the Energy Rater

Presenter:

- o Dennis Stroer, Calcs-Plus

BAIHP Steering Committee, Cocoa, FL February 6, 2007

Presentations available for download at

<http://fsec.ucf.edu/download/br/baihp/2007steering/>

Sustainable Housing, Brownsville, TX December 12, 2006

Chandra, S. "Sustainable Housing"

~25 attendees "Sustainable Housing"

Sustainable Housing, Corpus Christi, TX., November 30, 2006

Chandra, S. "Sustainable Housing"

~ 15 attendees

Sustainable Housing, Houston, TX., November 15, 2006

Chandra, S. "Sustainable Housing"

~60 attendees

Green Buildings Conference, FIU, Miami, FL November 3, 2006

Chandra, S., "Sustainable Housing in Florida: An Overview"

~50 attendees

GreenBuild International Conference and Expo., Denver, CO, November 2006

Martin, E. "Manufacturing Green Housing: Benefits of an Industrialized Approach."

1/2 hour presentation, ~80 attendees total

EEBA, Williamsburg, VA October 11-13, 2006

Parker, D., "Miscellaneous Energy Use and Energy Feedback Research in Energy Efficient Housing"

USGBC North Florida Meeting, Jacksonville, FL, October 2006.

Martin, E., LEED for Homes.

1 hour presentation, ~20 attendees total

Florida Housing Coalition Annual Conference, Orlando, FL, September 2006.

Martin, E., "Greening Affordable Housing."

3 hour workshop, ~60 attendees total

Ventilation expert meeting, Quebec City, Canada, June 27-29, 2006

Chandra, S., "Ventilation Data From Florida Homes and Lab Facility"

~20 attendees

National Association of Community Development, Hollywood, FL, June 23, 2006

McIlvaine, J., "Energy Efficiency Opportunities in Affordable Housing"

30 minutes, ~15 attendees

Affordable Comfort Conference, Austin, TX, May 24, 2006

Chandra, S. and Thomas-Rees, S., “High Performance Manufactured Housing”
40 minutes, ~20 attendees

*GreenTrends Statewide Green Building Conference and Trade Show, Gainesville, FL,
May 2006.*

Martin, E. “Greening Affordable Housing.”
3 hour workshop, ~30 attendees total

BuildSmart Expo, New Orleans, LA, April 22, 2006

McIlvaine, J., “Energy Urgency,”
1 hour, Keynote address, ~100 attendees

Structural Insulated Panel Association, Annual Conference, Austin, TX, April 11, 2006

McIlvaine, J., “Introduction to 2006-07 Energy Efficient New Home Tax Credits”
45 minutes, ~150 attendees

FRACCA Annual Conference, Tampa, FL, April 2006.

Martin, E. “Buildings that Work for Florida”
2 hour workshop, ~50 attendees total

Media/News Releases

- Crabbe, N. "Two Area Builders Recognized for Constructing Green Homes" *The Gainesville Sun*. May 2007.
<http://www.gainesville.com/apps/pbcs.dll/article?AID=/20070426/BUSINESS/704260330&SearchID=73279234256935>
- "Going Green: Summer Savings: The Results" South Florida NBC affiliate. Featuring Danny Parker and David Hoak. May 2007.
<<http://video.nbc6.net/player/?id=146814>>.
- "Going Green: Make the Most of Your Appliances." South Florida NBC affiliate. Featuring Danny Parker. Oct 2007. <<http://video.nbc6.net/player/?id=181720>>.
- "Going Green: Home Office Eco-Smarts." South Florida NBC affiliate. Featuring Danny Parker. Nov 2007. <<http://video.nbc6.net/player/?id=184428>>.
- "Going Green: Big Screen TVs, Big Savings." South Florida NBC affiliate. Featuring Danny Parker. Nov 2007. <<http://video.nbc6.net/player/?id=188510>>.
- "'Going Green' Wins Award." Patricia Andreu. Aug 2007.
<<http://www.nbc6.net/goinggreen/12392982/detail.html>>.
- Gainesville Today, "Longleaf Village: Partnership in Success", March 2007, Vol. 23, Issue 3, pp. 10-13.
- Garst, Lubliner "Advancing a Green Dream" *Solar Today*. March/April 2007.
<http://www.solartoday.org/2007/mar_apr07/green_dream.htm>.
- Hardy, B. "Creating a Zero Energy Home" BobVila.com. May 2007.
<http://www.bobvila.com/HowTo_Library/Creating_a_Zero_Energy_Home-Renewable_Energy_Solar_Biomass_and_Wind-A2665.html>.
- Jackson, J. "'Green' Houses Take Root with Building Industry, Orlando Conference Shows." 15 February 2008. <<http://www.orlandosentinel.com/business/orl-builders1508feb15,0,3473411.story>>.
- Lubliner, M., Hadley, A. "Zero-Energy Manufactured Home." *Home Energy Magazine*. May/June 2007. <http://www.homeenergy.org/article_preview.php?id=406&article_title=Zero-Energy_Manufactured_Home>.
- MySunCoast.com, "Building Zero Energy Homes", Aug 7, 2007.
<http://www.baihp.org/pubs/media/pdf/WWSB_article.pdf>.
- Salant, K. "Gadget Prods Homeowners to Cut Energy Use." *Washington Post*. 26 Jan 2008 issue, page F05. <<http://www.washingtonpost.com/wp-dyn/content/article/2008/01/25/AR2008012501621.html>>.

Smith, S. "Zero Energy Home Debuts." *Charlotte Sun*. Aug 8, 2007. <<http://www.sun-herald.com/Newsstory.cfm?pubdate=080807&story=tp1ch5.htm&folder=NewsArchive2>>.

TC Palm, "Indian River County project becomes first 'green' home built by agency", March 30, 2007.

Thomas-Rees, S. "FGBC Certification: Avoid Key Mistakes." FHBA.com. Oct 2007. <<http://www.fhba.com/index.cfm?referer=content.contentItem&ID=1595>>.

Walker, A. "Heat-Pump Water Heater Could Cut Bills" Central Florida News 13. May 28, 2007. <http://www.cfnews13.com/FamilyAndHome/YourHome/2007/5/27/heatpump_water_heater_could_cut_bills.html>.

Walker, A. "Energy Meters Track Power Usage" Central Florida News 13. Aug 21, 2007. <http://www.cfnews13.com/FamilyAndHome/YourHome/2007/8/21/energy_meters_track_power_usage.html>.

Builder Magazine, "The New American Home 2007", January 2007, pp. 118-144.

Florida Today, "[New homes boast energy efficiency: Developer uses recycled steel instead of concrete, wood](#)", January 4, 2007.

Brown, R and Parker, D. "Road Blocks to Zero-Energy Homes." *Home Energy Magazine*. January/February 2007, Volume 24.1, pg. 24.

NBC, "How Can 'TED' Help You", aired February 21, 2007, interviewee Danny Parker. <<http://www.nbc6.net/video/11081023/index.html>>.

Structural Insulated Panel Association, "Florida Solar Energy Center Specifies SIPs for FEMA Manufactured Homes", September 1, 2006, Number 06-22. <<http://www.sips.org/content/news/index.cfm?pageId=168>>.

Training:

Subrato Chandra conducted a Building America 101 workshop to ~20 builders, HVAC contractors and suppliers on January 23 in Gainesville, FL. This was hosted by Gainesville Regional Utilities.

Building America 101 Workshop, Gainesville, FL, January 2008

Trainer, Chandra, S.

~40 HVAC contractors and suppliers attended

Verification and Technical Principles of the LEED for Homes Pilot Standard, May 2007

Trainer; Martin, E

~40 individuals attended

Green Home Training,

Jacksonville, FL, July 2007.

Boca Raton, FL and FSEC, Aug 2007.

Town of Tioga, Newberry, FL, Oct 2007.

Trainer, Martin, E.

135 individuals total

High Performance Affordable Housing, Florida League of Cities Institute for Community Housing, Aug 2007

Trainer: Martin, E.

~35 staff attended

Systems Approaches to Green and Energy Efficiency, November 2007

Trainer: Martin, E.

Half-day workshop – 100 affordable housing developers.

Florida Green Home Designation Certification Course (5 offerings in FL) April 2007 and December 2007

Trainer: Martin, E.

Two-day workshops, 70 attendees each offering.

Santa Fe Community College, Santa Fe, NM, Apr and Sept 2007

FLHero - "Building a Green Home" 3 hr class

ACCA Manual ver8 HVAC Load Calculations using Elite Software, April 2007.

Trainer: Stroer, D.

~15 Cavalier Homes Builders engineers

Mechanical Portion of UCF Civil Engineering Class CCE 4813, Fall 2007

Teacher: Chandra, S.

RESNET Rater Core Test Training, Nov 2007

N. Moyer assisted

Half-day training

HFHI Conference Call Training April 18, 2006

McIlvaine, J., “Moisture Issues,”

1 hour, audio available on HFH intranet, ~25 callers from 15 affiliates

HFHI National Leadership Conference, Charlotte, NC, August 4, 2006

McIlvaine, J., “Green Building – Habitat Style”

1.5 hours, ~75 attendees

Florida Green Home Designation Certification Course (5 offerings in FL) April 2006-October 2006

Trainer: Martin, E.

6 hour workshop, ~120 attendees total

Mercedes Homes Green Building Workshop, Tampa, FL, April 2006

Martin, E., LEED for Homes

2 hour course, ~12 attendees total

Architectural Charrette for Oakland Park, Orlando, FL, August 2006.

Martin, E., “Green Building Design Strategies.”

2 hour course, ~12 attendees total

Patents:

Parker, D. and Sherwin, J. “High Efficiency Air Conditioner Condenser Fan,” U.S. 7,014,423 B2, 21 March 2006.

Parker, D., Sherwin, J., “High Efficiency Air Conditioner Condenser Twisted Fan Blades and Hub,” Application No. 29/231,433, Allowance received 17 October 2006.

References:

- Arlian, Larry G., PhD, and Thomas A. E. Platts-Mills, MD, PhD. March 2001. The biology of dust mites and the remediation of mite allergens in allergic disease. *Journal of Allergy and Clinical Immunology*. March 2001 (Vol. 107, Issue 3 (Supplement)), Pages 406-413.)
- ASHRAE 62.2 2004. Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings. ANSI/ASHRAE Standard 62.2-2004, ASHRAE
- Clark, Gene, 1981. "Passive/Hybrid Comfort Cooling by Thermal Radiation," *Passive Cooling: American Section of the International Solar Energy Society*, Miami Beach, 1981.
- Cummings, J.B., Tooley, J.Jr., Moyer N. (1991), "Investigation of Air Distribution System Leakage and Its Impacts in Central Florida Homes", Prepared for the Governor's Energy Office, FSEC-CR-397-91, January 31, 1991.
- Moyer, N., Beal, D., Chasar, D., McIlvaine, J., Withers, C, & Chandra, S. (2001). "Moisture Problems in Manufactured Housing: Probable Causes and Cures." ASHRAE - IAQ 2001 Conference Proceedings, San Francisco, CA.
- Moyer, N., Chasar, D., Hoak, D., Chandra, S. (2004). "Assessing Six Residential Ventilation Techniques in Hot and Humid Climates," *Proceedings of ACEEE 2004 Summer Study on Energy Efficiency in Buildings*, American Council for an Energy Efficient Economy, Washington, DC, August 2004.
- Danny Parker, Jeffrey Sonne, John Sherwin, (2005) "Flexible Roofing Facility: 2004 Summer Test Results", Prepared for U.S. Department of Energy Building Technologies Program, FSEC-CR- 1514-05, July 2005.

Appendix B - 2008 INTERNATIONAL BUILDERS' SHOW HOMES FACT SHEETS

The following fact sheets highlight some of the energy efficient homes at the 2008 International Builders' Show. These fact sheets were distributed at the show, providing the 92,000+ attendees valuable information on the BA approach and those energy efficient features used on the homes.

Research Toward Zero Energy Homes

**Palm Harbor Homes – Bimini II – “Green” Home
2008 International Home Builders’ Show
Orlando, FL**

Bimini II – “Green” Home Statistics

- 3,312 square feet, 3 bedroom, 3½ bath

Energy Efficiency and Renewable Energy Features

- Low-E double glazed, impact resistant vinyl windows (U=0.35, SHGC= 0.30)
- 17 SEER/9 HSPF heat pump (dual fuel) by Carrier with programmable thermostat
- Icynene spray foam insulation (walls = R13, roof = R21)
- Duct system performance tested
- ENERGY STAR® appliances
- 92% use of compact fluorescent lighting
- AllSolar domestic hot water system sponsored by SunBuilt Program with Rinnai tankless, gas back up
- Meets Builders Challenge Standards with an EnergySmart Home Scale (E-Scale) = 57

Indoor Air Quality and Noise Reduction Features

- VOC source control including zero VOC paint and use of 75% reduced VOC caulks and sealants by Henkel
- Outside air ventilation
- Central vacuum system by Beam
- Quiet exhaust fans
- Formaldehyde-free cabinets
- Duct system sealed with mastic and fiberglass mesh

Other Green Building Features and Certifications

- Resource efficient modular construction and construction waste management
- Water efficient appliances and fixtures
- Meets Gold level in all sections except lot design, preparation, and development per the new NAHB National Green Home Building program (nahbgreen.com)
- Certified Florida Green Home by the Florida Green Building Coalition
- Progress Energy Home Advantage Premium Energy Saver Program
- Built for 140 mph wind zone
- Builder is Building America Partner and Builders Challenge participant

More information at the house in the Professional Builder Show Village or at booth #W3659



Builders Challenge
Recognizing Energy Leadership in Homebuilding



Florida Solar Energy Center leads the Building America Industrialized Housing Partnership Consortium

Research Toward Zero Energy Homes

**Palm Harbor Homes – Glen Cairn – “Comfortably Affordable” Home
2008 International Home Builders’ Show
Orlando, FL**

Glen Cairn – “Comfortably Affordable” Home Statistics

- 1,767 square feet, 3 bedroom, 2½ bath

Energy Efficiency and Renewable Energy Features

- Low-E, double glazed, vinyl windows (U=0.35, SHGC= 0.30) with impact resistant shutters
- 13 SEER/7.7 HSPF heat pump (dual fuel) by Carrier with programmable thermostat
- Honeywell spray foam insulation (walls = R13, roof = R21)
- Duct system performance tested
- ENERGY STAR® appliances
- 95% use of compact fluorescent lighting
- Meets Builders Challenge Standards with an EnergySmart Home Scale (E-Scale) = 69

Indoor Air Quality and Noise Reduction Features

- VOC source control including zero and low VOC paint
- Formaldehyde-free fiberboard
- Outside air ventilation
- Central vacuum system by Beam
- Quiet exhaust fans

Other Green Building Features and Certifications

- Resource efficient modular construction and construction waste management
- Water efficient appliances and fixtures
- Certified Florida Green Home by the Florida Green Building Coalition
- Progress Energy Home Advantage Premium Energy Saver Program
- Builder is Building America Partner and Builders’ Challenge participant

More information at the house in the Professional Builder Show Village or at booth #W3659



Florida Solar Energy Center leads the Building America Industrialized Housing Partnership Consortium



Builders Challenge

Recognizing Energy Leadership in Homebuilding



Appendix C - WASHINGTON STATE UNIVERSITY ANNUAL REPORT



**Annual Report for Building America Industrialized Housing
Partnership for the Florida Solar Energy Center**

March 2007 – January 2008

Michael Lubliner
Andy Gordon
Todd Currier
David Hales
Bill Kingrey
Rick Kunkle
Chris Fuess
Luke Howard

Task Area 2 – Test House Evaluations - *Garst Residence*

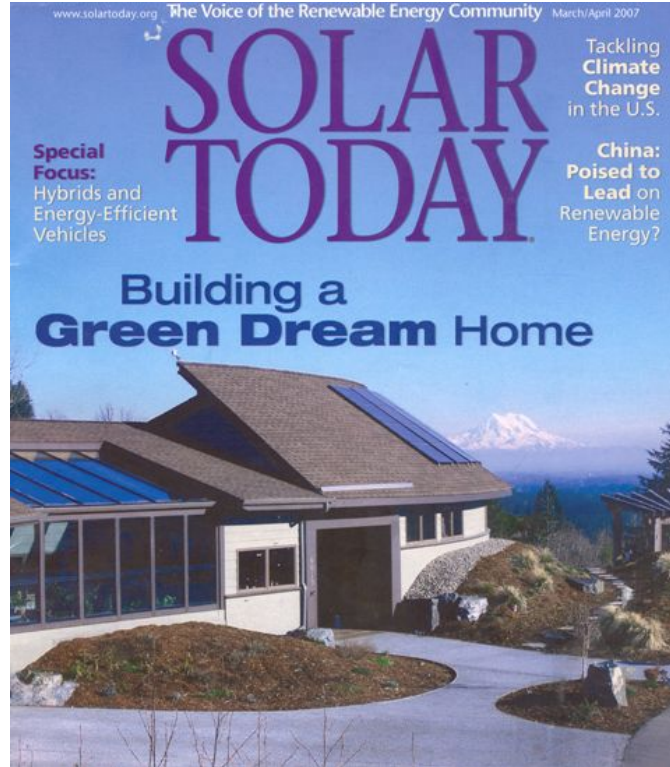


Figure C-1 *Garst residence – Olympia WA, as featured in Solar Today*

The Garst residence is a 2400 ft.² home built in Olympia, Washington to the Building America 50% benchmark. The Northwest ENERGY STAR qualified home features a ground source heat pump supplying domestic hot water and heat to an R15 radiant slab, ENERGY STAR lighting and appliances, solar sunspace, a 4.5 kW photovoltaic array, central energy recovery ventilator/forced air filtration system, tankless hot water for master bath, and hybrid Icynene™/loose fill R-49 ceiling insulation. Home construction began in summer of 2005, and was completed in May of 2006.

Data instrumentation of the home was completed in January 2007. Connection to the WEBGET system, data collection and analysis began in 2007, and continues into 2008. The 2007 energy use was 11077 kWh, including PV contribution to grid and house load. PV contribution to grid was 2588 kWh. Additional analysis is underway in 2008. **Error! Reference source not found.** provides a monthly breakdown of energy use and PV production.

WSU coordinated with PNNL on development of a Building America Best Practices case study on the Garst residence. (See publications section, below.) In addition, the Garst home was featured as the cover story for the March 2007 issue of Solar Today. Abstracts were submitted to ACEEE; discussion is also underway for publication in other forums.

BAIHP staff from WSU and FSEC coordinated during the design, field testing and monitoring stages. Field testing indicated envelope leakage of 4.9 ACH₅₀.

Based on energy use monitoring and IAQ perception, the Garsts have decided to make the following changes to the operation of their home:

- 1) Stopping use of the combined HRV and central filtration system, relying instead on a quiet 18W exhaust fan.
- 2) Discontinuing use of supplemental heat to the sunspace.
- 3) Discontinuing use of the master bathroom instant electric water heater, relying instead on the GSHP.
- 4) Turning off the radiant slab pump during non-heating months.

In 2007, WSU staff began the process of analyzing and optimizing well pump performance for the ground source heat pump. Mechanical drawings of the HVAC & PV systems are provided in **Error! Reference source not found.** and **Error! Reference source not found.**

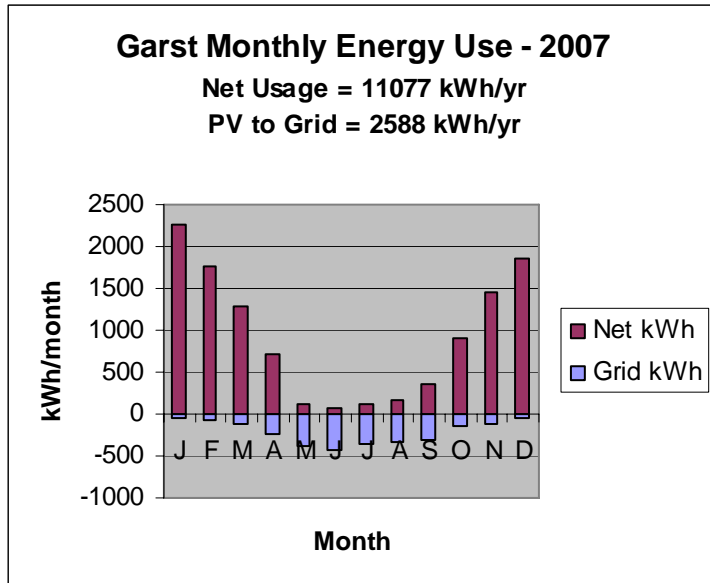


Figure C-2 Garst Residence, Monthly Energy Use, Including PV to Grid

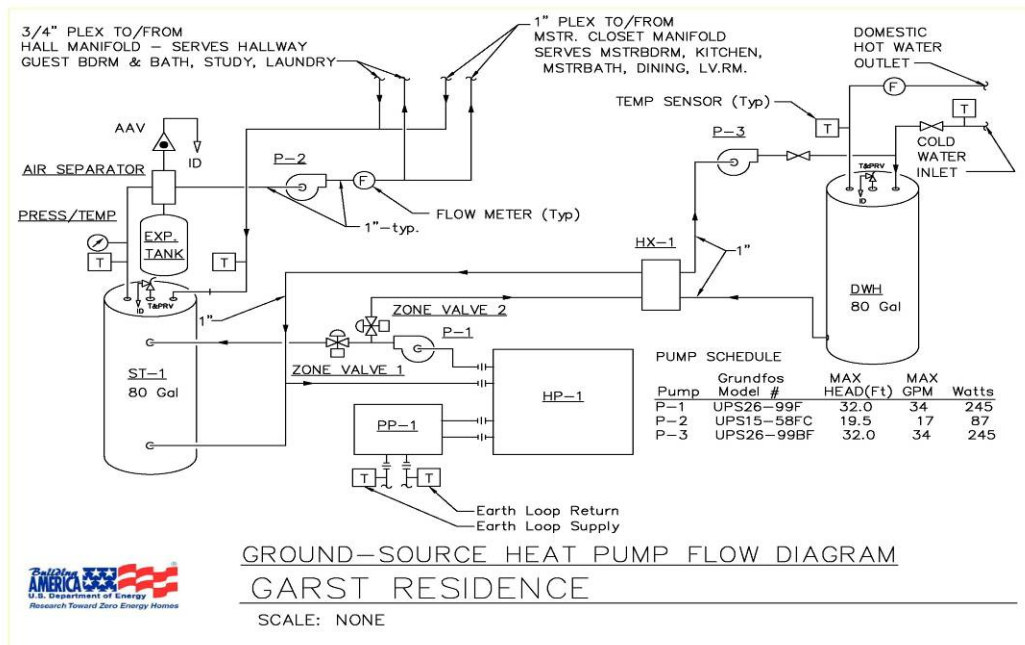


Figure C-3 Garst residence, ground source heat pump space heating and DHW system

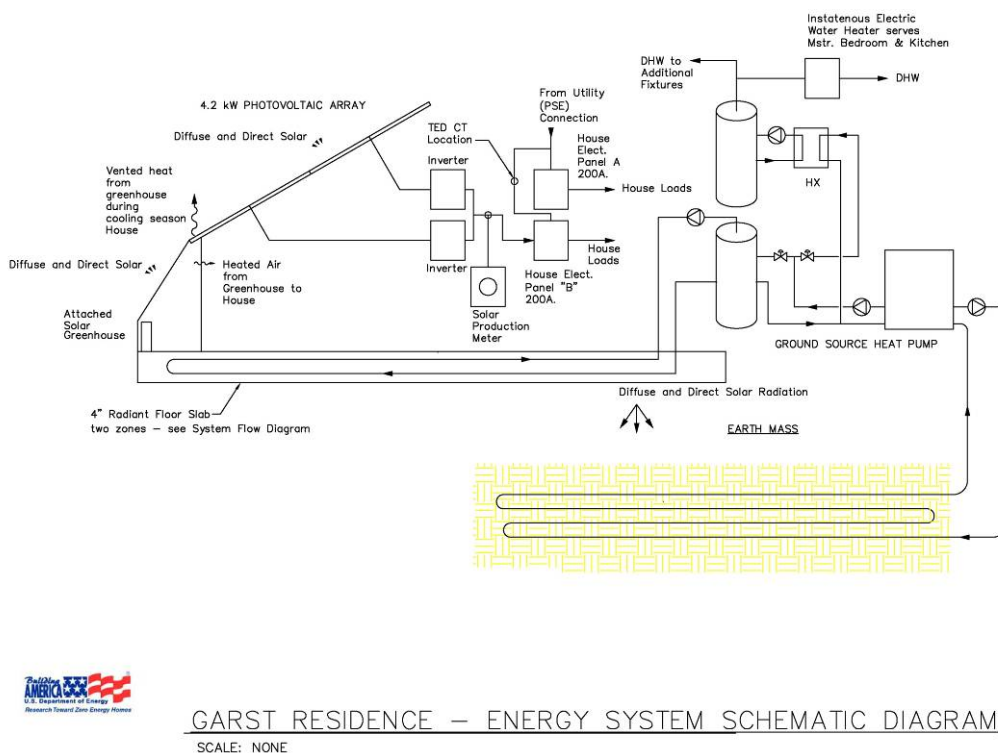


Figure C-4 Garst residence, home energy system diagram

Task Area 2 – Test House Evaluations - *Stamets Residence*

The Stamets residence is a 5000 ft.² home, constructed in 2005-06 in Shelton, Washington. The home, which is modeled to achieve a 50-60% Building America benchmark, features a ground source heat pump for hydronic radiant floor and DHW heat, zonal ceiling radiant heat panels, solar hot water and field mounted PV array. The home was built with ENERGY STAR windows, lighting and appliances, HRV and HEPA filtration, a heat pump water heater and condensing dryer, Seisco tankless hot water heater, .74 AFUE propane fireplace and Seisco tankless electric boiler. The 2x6 standard frame wall is insulated with Icynene™ in the cavity, and R-5 foam sheathing. Icynene was also used for the ceiling and vented crawlspace (R19 in each case).

In 2007, an additional R-30 blown insulation was added to the ceiling, for a total of R-49. In addition, R19 unfaced batt was added to the floor insulation for a total of R-38. Monitoring of space heat and attic and crawlspace temperature and RH is currently underway to evaluate performance of these hybrid systems. BAIHP staff are also evaluating energy and lifestyle impacts associated with the use of electric hot tub, re-circulating DHW system, and HEPA filtration systems.



Figure C-5 *Stamets residence – Shelton, WA*

The home was built to be PV, Solar DHW and GSHP “ready”. BAIHP staff are coordinating the design and installation of the ground source heat pump and PV system. Installation of the ground source heat pump is scheduled for summer 2008; solar hot water and PV system installation is slated for 2009. Monitoring is underway to evaluate the energy impact of these improvements. **Error! Reference source not found.** through **Error! Reference source not found.** illustrate total usage, as well as breakouts of space heating, water usage and other usage. **Error! Reference source not found.** provides the existing and future mechanical system design.

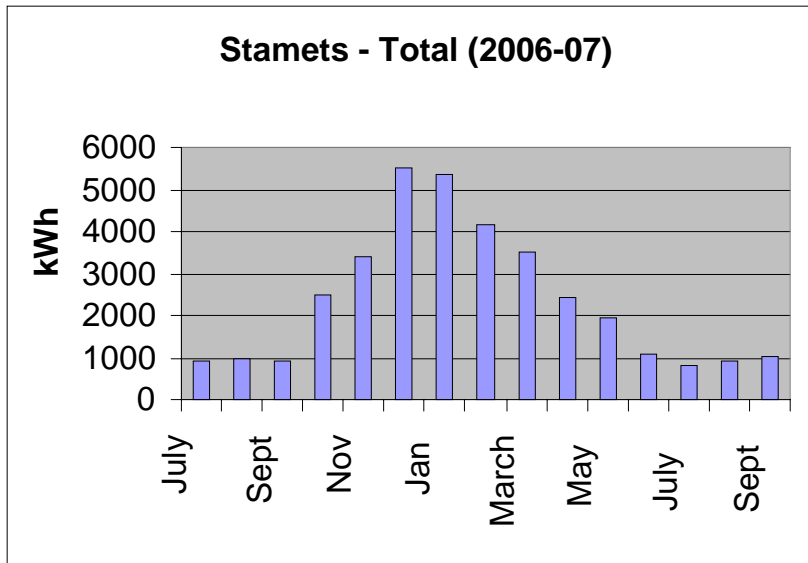


Figure C-6 Stamets Residence Total Energy Use - 2007

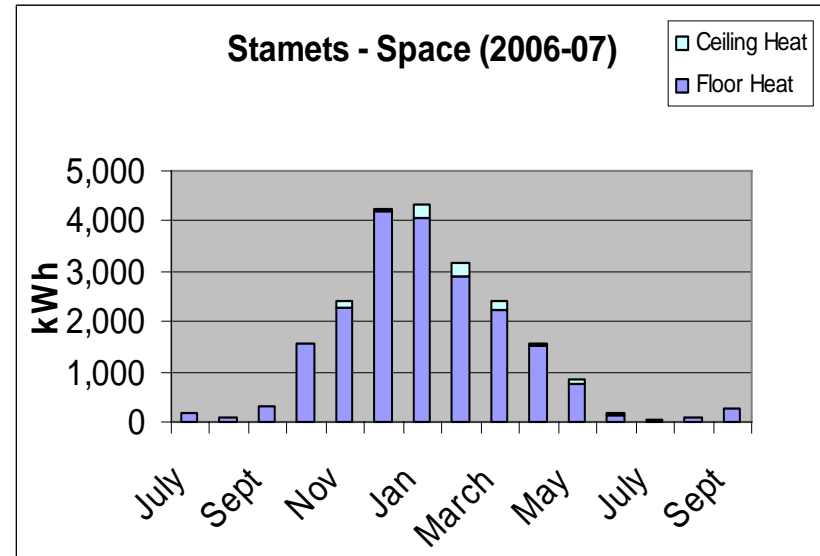


Figure C-7 Stamets Residence Space Energy Use - 2007

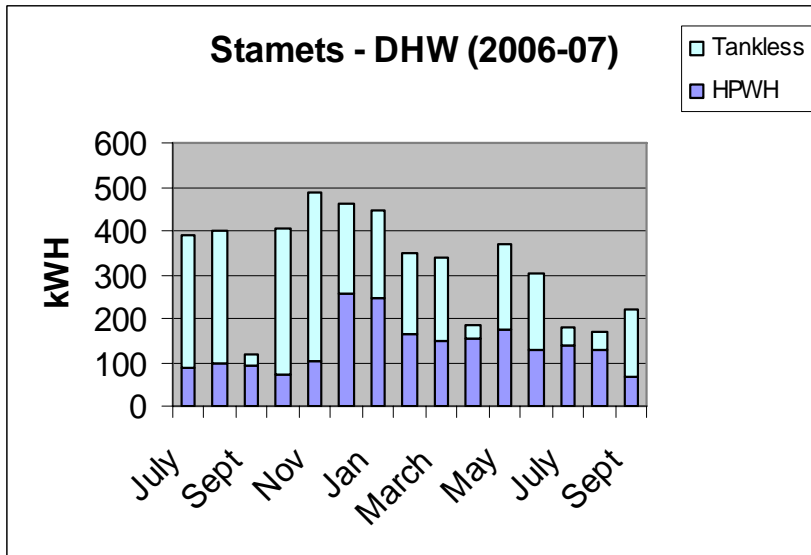


Figure C-8 Stamets Residence Hot Water Energy Use - 2007

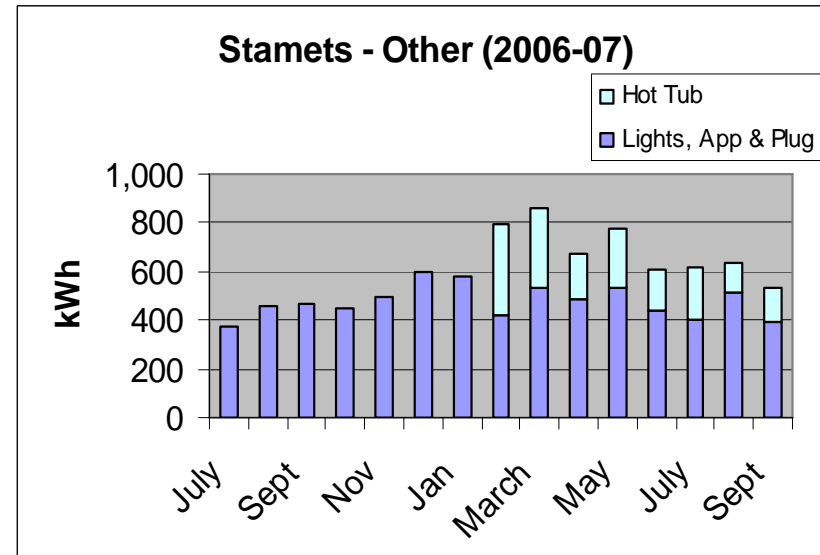
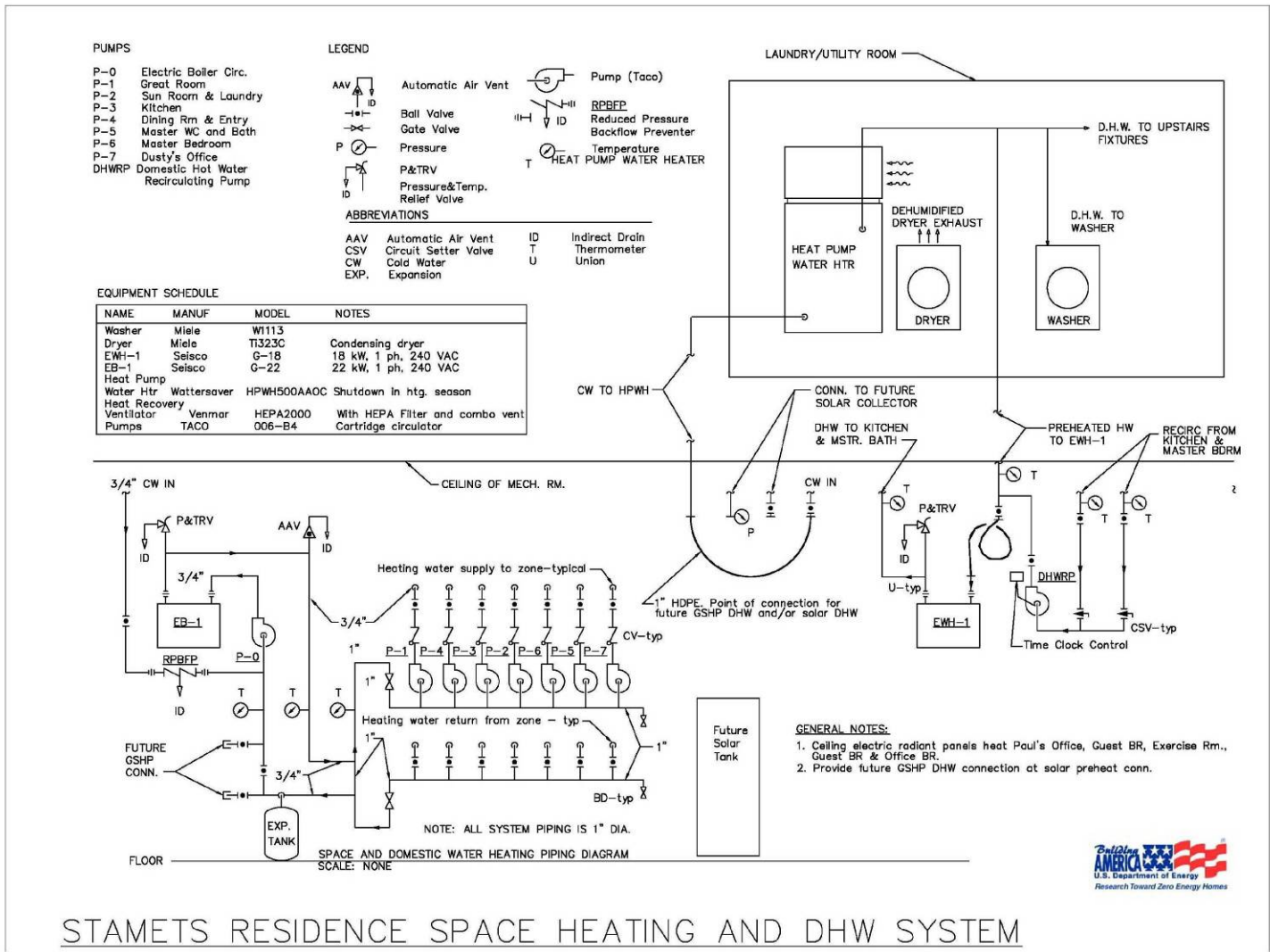


Figure C-9 Stamets Residence Other Energy use - 2007



STAMETS RESIDENCE SPACE HEATING AND DHW SYSTEM

Figure C-10 Stamets residence, mechanical drawings

Task Area 3 – Community Scale Evaluations

Fort Lewis Army Base – Fort Lewis, Washington



Figure C-11 *Two-story Modular Housing Assembly – Ft. Lewis Army Base*

WSU is working with Building America partners Oregon Department of Energy (ODOE), Champion Homes and Equity Residential in an effort to build 483 energy efficient modular homes at Discovery Village Fort Lewis Army base in Washington State. These factory-built homes are constructed to Northwest ENERGY STAR Homes standards, and feature .90 AFUE furnaces, efficient windows, and ENERGY STAR appliances.

The project is administered as a mixture of ENERGY STAR manufactured and site-built programs. ODOE inspects the homes in-plant and provides quality assurance throughout the construction process. WSU provides on-site quality assurance for the final inspection of the home, and evaluation of the HVAC performance.

Phase 1 of the project, which started in 2005, produced 174 units (homes are single story duplex, two story duplex, or two story triplex). Phase 2, completed in 2006 resulted in an additional 150 units. Phase 3 completed 159 homes in 2007 resulting in a total of 483 units.

Initial testing of Fort Lewis HVAC systems by BAIHP staff indicated leakage rates of worse than 400 CFM₅₀. Hands-on efforts by BAIHP staff resulted in significant improvements over the life of the project, as noted in Figure.

	# of homes tested	Average duct leakage - CFM ₅₀	Average duct leakage – CFM ₂₅	Average duct leakage - % of floor area (CFM ₅₀)
2005	74	96.36	61.38	5.24%
2006	164	91.04	57.99	5.13%
2007	218	86.18	54.89	4.80%
Total	456	89.58	57.06	4.99%

Figure C-12 *Ft. Lewis Duct Leakage Test Data 2005-2007*

Initial and final testing of building envelopes suggests improvement from 1600 CFM at 50PA to as low as 900 CFM at 50PA over the phases of the project.

Current Fort Lewis homes benchmark at around the 30% level. BAIHP worked with Equity and Champion to build a demonstration duplex with a .94 AFUE Carrier Infinity furnace with variable speed blower motor and AeroSeal™, Panasonic Whisper Green fans as well as ENERGY STAR lighting (GU24 fixtures), a Noritz tankless hot water system, and active crawlspace ventilation. These demonstration units are expected to benchmark at or above the 40% level. Cost benefit analysis of these systems began in 2007 and are currently underway. A breakdown of the costs and technologies are provided in Figure C-13.

Measure	Cost	Cost Source
Furnace	\$539	Carrier 58MVB vs. Pane PG9MAB
DHW	\$227	Noritz 069M=DV vs. State PR650XCVIT
Aeroseal	\$900	Carrier AeroSeal™
Mastic+Test	\$400	Auburn Sheet Metal
50% CFL	\$200	ENERGY STAR requirement
100% CFL+U24 (***)	\$1000	Based on bid from Seattle Lighting
R5 Foam Sheathing	\$500	Foam 0.30/ft2 x 20% labor – Champion
Ducts Inside	\$600	Estimates from previous BA projects
(*) 30 year, 7.5% interest (**) 1.20/therm, 7 cents/kWh – EGUSA (***) w/o ENERGY STAR fixture utility rebates		

Figure C-13 Ft. Lewis Army Base, Demonstration Home Measures and First Costs

Preliminary cost data suggests that duct and envelope tightness, lighting, furnace and DHW improvements made in the demonstration homes increase mortgage by roughly \$18 per month at 7.5% interest on a 30 year loan as shown in Figure C-14. Modeled energy savings using EGUSA estimated a \$32 per month savings at current fuel costs, resulting in a net \$14 total monthly savings for the improved technologies and testing.

Energy Conservation Measure	Mortgage \$/month	Saved \$/month	EGUSA analysis Annual Utility Bill
Base Case	n/a	n/a	\$1,453
Add 50% CFL	\$1.40	\$1.89	\$1,430

Add mastic on ducts+test	\$1.75	\$13.78	\$1,265
Tightest ducts Aeroseal test	\$5.25	\$1.05	\$1,252
Tightest envelope	\$2.10	\$3.95	\$1,205
Add 95% CFL bulbs & fixtures	\$2.10	\$3.01	\$1,168
Add Norwitz tankless DHW	\$1.59	\$7.80	\$1,075
Add Carrier Furnace	\$3.77	\$1.30	\$1,059
Total	\$17.96	\$32.77	

Figure C-14 Ft. Lewis Army Base, Featuring Mortgage and Energy Savings Impacts

Good duct leakage rates were achieved on the demonstration homes with Aeroseal™, at less than 93 cfm@50PA, however the cost was over \$900, and as observed above, the HVAC contractor was getting very good results with mastic.

A more detailed analysis is underway in 2008, with the hope that some or all of these technologies will be adopted in future projects. Planning is underway at Fort Lewis for a 290 multi-family units project, to break ground in 2009.

BAIHP staff are also working with Equity staff and Minol on an effort to conduct a community scale billing analysis of phases 1 and 2 (including the demonstration homes.) Annual electric use for 47 of the units with a full year of data is presented in Figure C-15. Unfortunately, incomplete billing data means that no meaningful annual natural gas estimates can be made at this time.

	Annual Electricity Use (kWh)
Count	47
Mean	8887
Median	7925
Maximum	29066
Minimum	1691
Standard Deviation	4178

Figure C- 15 Ft. Lewis Army Base, Annual Electricity Use

Figure C-16 compares natural gas usage for the high efficiency demonstration units with the overall sample for periods where data was available. Since these periods do not include the primary heating months, the data are inconclusive for the heating improvements. The summer usage is quite low for units 7224A and 7224B, suggesting there might be some benefit from the high efficiency domestic hot water heaters, but there are a variety of other household characteristics which could influence hot water usage.

Period	Dates	Overall Count	Overall Mean	Overall Median	7224A	7224B	7264A	7264B
7	2/14-3/16	106	60	57				
8	3/16-4/16	101	49	47	55	106		
9	4/16-5/15	211	32	29	31	35		
10	5/15-6/15	234	22	19	9	11	17	26
11	6/15-7/17	45	16	15	7	12	8	14
12	7/17-8/15	63	14	13	9	11	35	29

Figure C-16 Fort Lewis Army Base, Natural Gas Use for High Efficiency Units

Evaluation of utility bill data continues in 2008.

Task Area 3 – Community Scale Evaluations Scott Homes Olympia, WA



Figure C-17 Brotherton, 13th Avenue Bungalows by Scott Homes – Olympia, WA

Scott Homes is a production and custom home builder in Olympia, Washington, emphasizing green and energy efficient construction techniques. A Building America partner since 2005, Scott Homes are built with high efficiency shell and equipment measures, including SIP panels, and radiant heating with high efficiency gas combo heat/domestic hot water systems.

In 2005 – 2006 BAIHP staff met extensively with Scott Homes, assessing 10 of Scott Homes' existing and future projects, providing design consultation, preliminary assessment of tax credit qualification, and ENERGY STAR Homes Northwest technical assistance. In 2007 and early 2008, BAIHP staff met extensively with Scott Homes design and construction staff, assessing an additional 9 existing and 5 future projects.

Also in 2007, BAIHP staff worked with Scott Homes on testing and monitoring three Bungalow homes in Olympia. These homes, designed to meet the Building America 40%+ metric, as well as Northwest ENERGY STAR Homes and the Federal Tax credit, include gas tank-less combo systems, radiant floors, SIP walls, ENERGY STAR lighting and appliances, HRVs and the Energy Detective energy monitor. Figure 14a and 14b provide both visible and infrared photos of the Brotherton home, which was occupied in spring 2007. These homes are expected to benchmark in the 40-50% range. IR testing revealed significant slab edge heat loss, and investigations underway to further explore this issue.

All three homes were constructed with a hybrid ceiling – Icynene foam and fiberglass batts. Testing of these homes indicated envelope leakage of 2.42 at ACH₅₀. By contrast, Scott homes with 100% SIPS construction tested with leakage rates of under 1.5 ACH₅₀. The SIP wall/framed ceiling homes indicated leakage rates of greater than 4.0 ACH₅₀.

The feedback from these tests has helped Scott home greatly improve the energy efficiency of the building envelope and HVAC systems. BAIHP staff deployed HOBO dataloggers in the homes to collect zone temperature and HVAC performance data in 2007 and 2008. Monitoring of the homes supplementary electric resistance heat in the upstairs bedrooms is underway; one area of particular interest is how often the

supplementary heat operates. Figure C-18 provides a breakdown of the 19 Scott Home projects receiving BAIHP technical assistance, with information on envelope leakage and estimated HERS index.

Name	CITY	Cert Date	BOPID	ACH_50PA	HERS Index
Unknown	Olympia	7/11/2005	Gas with AC	1.67	
Unknown	Olympia	8/25/2005	Gas no AC	Not Available	
Unknown	Olympia	Not certified	Zonal Electric	5.3	
Unknown	Olympia	Not certified	Gas no AC	Not Available	
Knowles	Olympia	11/27/2006	Gas no AC	4.89	68
Kramer	Shelton	Pending	Heat Pump	1.57	63
Aguilar	Gig Harbor	12/11/2006	Gas no AC	2.5	61
Olympia	Olympia	11/27/2006	Gas no AC	2.3	61
Brotherton	Olympia	11/27/2006	Gas no AC	1.2	58
Heidal	Olympia	1/22/2007	Gas no AC	4.1	61
Harrell	Olympia	3/5/2007	Gas no AC	No BD performed	70
Washington	Olympia	10/2/2007	Gas no AC	0.5	56
Olson	Olympia	6/12/2007	Gas no AC	2.64	61
Linth	Shelton	6/27/2007	Gas no AC	3.91	72
Dennis	Longbranch	Not certified	Ground Source Heat Pump	2.8	77
Hauck	Olympia	10/3/2007	Gas no AC	3.55	63
Brink	Mossyrock	12/10/2007	Zonal Electric	2.3	Not modeled
Vollendorf	Olympia	12/10/2007	Gas no AC	4.5	64
Hahn	Olympia	1/14/2008	Gas no AC	1.56	Not yet modeled

Figure C-18 Scott Homes receiving BAIHP assistance

From the beginning of the partnership with Scott Homes, WSU has assisted in the development of tax credit qualification analysis and ENERGY STAR Homes Northwest certification. Current design assistance on a 15 home PV and DHW “solar ready” community project are underway. The community’s model home, to be built in 2008 and monitored in 2009, is expected to benchmark in the 50% range. BAIHP staff identified key elements in the homes’ specifications that were a barrier to compliance with ENERGY STAR, tax credit, and high Building America metrics. One significant element was the use of electric resistance boilers in the standard design; this created a significantly higher compliance threshold for ENERGY STAR, and made compliance for tax credit impossible.

Habitat for Humanity Olympia, WA

BAIHP staff are working with BAIHP partner Habitat for Humanity on a 15 unit cottage project in Olympia, WA. The goal is to achieve the 40% metric, using a tankless gas combo hydronic floor heating system with ICFs and advanced framed 2x6 walls with R5 foam sheathing.

BAIHP staff have worked with other Habitat affiliates on qualifying over 100 existing homes to Northwest ENERGY STAR standards, and are continuing to provide technical assistance and outreach to other Northwest Habitat affiliates. BAIHP staff have also trained and equipped the Washington State Habitat Construction Managers Network

Coordinator, Jerry Fugich, so that all HFH homes in 2008-09 will meet both ENERGY STAR and the Washington

State Housing Trust Fund’s “Evergreen Sustainability Standards,” qualifying the homes for low-income funding. Through Mr. Fugich, in 2007 BAIHP staff conducted class and field training to over 50 HFH affiliates throughout the Pacific Northwest and distributed Building America Builder Guides.

Figure C-20 provides a breakdown of past and future homes built with BAIHP assistance.



Figure C-19 *Habitat for Humanity 15 home Community Cottage project – Olympia, WA*

WA Habitat for Humanity Homes Meeting NW ENERGY STAR - Benchmark 35-45%				
Affiliate County	2006	2007	2008	2009
E. Jefferson (*)	2	3	2	3
Ellensburg (*)	0	0	1	1
E. King	12	3	20	17
Lewis	1	1	1	1
Island	3	2	5	3
Kitsap	3	6	11	15
Seattle/S. King	14	12	10	20
Skagit	2	1	3	3
Snohomish	5	1	1	3
S. Puget Sound	0	3	4	4
Tacoma/Pierce	17	14	18	20
Whatcom County	1	1		5
Total	60	47	76	95

(*) cold climate, other marine climate

Figure C-20 *Habitat for Humanity homes built with BAIHP assistance to NW ENERGY STAR*

Subtask 4.5 – Documentation, Resource Development and Related Activities

ASHRAE: BAIHP WSU staff Lubliner and Hales, continue active participation in 2007 as follows:

- Voting member of TC 6.3 participating in programs, research, handbook and standards
- Chair of TC 6.3 research subcommittee and RP-144P “Energy Efficiency and Cost Assessment of Humidity Control Options for Residential Buildings” funded by ASHARE and ARTI.
- Voting member of TC 9.5 “Residential and Small Building Applications” participating in programs and public sessions.
- Voting member of SSPC 62.2 subcommittee developing Guideline 24
- Chair SPC-193 Standard “MOT to determine the air leakage of HVAC equipment”
- June 2007 ASHRAE symposium 3 BAIHP related papers (see references) for ASHRAE Transactions Session 3 “Improvements in Manufactured Housing”
- June 2007 Chair of Seminar 66 “Heating for Forced-Air Heat Pump Systems; Past, Present and Future” with four BAIHP/STAC funded presentations.

Other BAIHP Partner coordination

- *ACEEE:* BAIHP staff submitted 4 abstracts to 2008 Summer Study TBD.
- *Fleetwood Homes:* BAIHP staff and partners at Fleetwood conducted structural testing of Solar Ready mounting brackets developed by FSEC.
- *NFPA and MHCC:* Used BAIHP research to support 10 new proposals to improve energy efficiency, durability and IAQ in HUD new code homes.
- *NIST:* BAIHP staff working with BAIHP partner Energy Conservatory and NIST on retrofit efforts to reduce duct and envelope leakage. Tests indicate 80% reduction in duct leakage and 15% reduction in envelope leakage possible but at higher costs and lower performance as a “lost opportunity” if not done during construction. WSU staff provided peer review of the first of two NIST research reports on this project, for publication in 2008-09.
- *NAHB Energy Value Housing Awards:* WSU staff David Hales participated as judge.

Press, References and Publications

Building America Case Studies

Baechler, M.; Lubliner, M.; et. al. "Fort Lewis Army Base." Building America Best Practices Series: Volume 5 – *Builders and Buyers Handbook for Improving New Home Efficiency, Comfort, and Durability in the Marine Climate.*

Baechler, M.; Lubliner, M.; et. al. "Sam and Christine Garst Build a House." Building America Best Practices Series for High Performance Technologies: *Solar Thermal & Photovoltaic Systems in the Marine Climate.*

Lubliner; et. al. "Final Stagegate Presentation to BA teams in January 2008 "Zero Energy Manufactured Home Project"

ASHRAE

Baylon, D.; Hales, D.; Lubliner, M.; Peeks, B. "NEEM Mastic Study." Accepted paper for 2007 ASHRAE Symposium (peer review comments addressed.)

Hadley, A.; Lubliner, M.; Parker, D. "HVAC Improvements in Manufactured Housing Crawlspace-Assisted Heat Pumps." Accepted paper for 2007 ASHRAE Symposium (peer review comments addressed.)

Fairey, P.; Lubliner, M.; Lucas, R. "National Energy Savings Potential in HUD code Housing from Thermal and HVAC Equipment Improvements"; Accepted paper for 2007 ASHRAE Symposium (awaiting peer review.)

ASHRAE Proposed Standards 193P Subcommittee (chair) – "Method of Test for determining the air-leakage rate of HVAC equipment – 3rd draft under development. ASHRAE Standard 62.2 technical Subcommittee (co-author) "24 Guidelines." – Approved for public comment in Jan 2008.

Magazines

Hadley, A.; Lubliner, M. "Zero Energy Manufactured Home." Published June 2007 Home Energy.

Garst, Lubliner "Advancing a Green Dream" Article published in March/April 2007 Solar Today

Appendix D - OREGON DEPARTMENT OF ENERGY ANNUAL REPORT

Oregon Department of Energy

Annual Report for Building America Industrialized Housing Partnership

March 2007 – January 2008

Task 2 – Test House Evaluations

Random home field-testing

As part of the quality control process, we conducted field studies of a random sample of in 1992-93, 1997-98 and 2001-02, 2005-06. The Northwest Energy Efficiency Manufactured Home (NEEM) program randomly selected and is recruiting homes for an 86 home field study. Staff presented the field study funding proposal to the Regional Technical Forum, RTF, on October 9. The RTF committed 10k, and Bonneville Power Administration committed 15K, The Energy Trust of Oregon 5K, Idaho Power 5K.

In December the NEEM staff from the 4 NW states met in Portland to go over test protocols and calibrate test equipment. Dent Instruments manufacture of the ELITEPRO data logger also attended and trained staff in installing and initializing their data logger.

New to this study is a lighting survey. So far, in homes tested, some ENERGY STAR CFL lighting is installed in 100% of survey homes. Survey results show from a 2-3 bulbs to as many as 20 bulbs have been installed. Since 2006 manufactures and retailers offer an upgrade CFL lighting package. Palm Harbor includes three CFL fixtures standard in their Earth Advantage home.

The selection of homes in this study was random, and included 19 of the region's 19 manufacturers and all of the major manufacturers in the NEEM program. This study will further the comparison between the homes that received in-plant duct testing and the field duct test results as a measure of overall performance. All 19 manufactures have adopted in plant duct testing as an important in-plant quality control step. The NEEM standard is total or net duct leakage shall not exceed 0.06 cfm50 x floor area served by the system or 75 cfm50, whichever is greater.

Study design/ recruit select home

The field study on manufactured homes built to current ENERGY STAR specifications will be the first look at ENERGY STAR only homes. Work will be carried out on at least 86 units, the sample size being dictated by the expected coefficient of variation in the key measurements (e.g. duct tightness and envelop air tightness). Sampling should be done to provide adequate state-by-state samples in the states of this region. It is expected this

will lead to numbers on the order of 25 sites for Oregon and 26 sites for Washington, and approximately 18 sites in Idaho and western Montana.

The basic study design and protocol would parallel the previous studies. Field work will be carried out by NEEM staffs, who are experienced field technicians (many of whom worked on previous field assessments). The project's term would run from November 2007 to December 2008. Work on the protocol commenced in December. Fieldwork began in January and be substantially complete by May 2008.

Specific field activities:

- Measure tightness of building shell and duct system
- Compare factory duct tests to field duct tests
- Measure airflow and static pressure in the HVAC system in order to calculate supply leakage fraction (which has direct bearing on overall heating system delivery efficiency)
- Measure flow rate through whole-house exhaust fan and spot fans
- Evaluate compliance of home set-up with statewide set-up rules
- Record other key data which have a bearing on home performance and occupant health/safety (such as whole house fan run-time, etc)
- Collect utility bill releases

Decommissioning of older mobile homes

ODOE staff involved in the NEEM Program continues to distribute and coordinate with utilities, low income programs, and community development corporations regarding the decommissioning of older mobile home. NEEM staff continues to cooperate with our industry partners and attended Indian weatherization conferences.

Task 3: Community Scale Evaluations:

For phase 3 homes construction began in the plant in March 2007 through November 2008. In late October, Ft Lewis inspector, Al Rust, made final inspections on Ft Lewis homes in the Champion plant in Silverton Oregon. Up through February 2008, Ft. Lewis homes were then delivered and finished, ENERGY STAR built-in appliances installed, duct tested, compact fluorescent bulbs installed in all the homes. Auburn Sheet Metal technicians continue to test all the ducts. WSU followed up with a Quality Assurance tests.

ODOE staff spends two days per week with Champion homes inspecting homes, reviewing changes in home designs, factory processes, discussing durability of components, and advising champion staff. As a result the Ft Lewis staff feels less water damage has occurred in phase 3. On March 22-23 ODOE staff traveled to Ft. Lewis and with WSU, performed blower door and duct tests and other tests on two prototype buildings . We meet with Mechanical contractor, Auburn Sheet Metal and Noritz tankless hot water heater representatives and witnessed the installation of the Noritz tankless heaters.

Champion and Ft. Lewis Communities LLC, Equity Housing, built several experimental duplexes starting in December 2006 as part of Building America Industrialized Housing Partnership (BAIHP) project. It was sited and constructed at Ft. Lewis in January 2007. Ft. Lewis Communities LLC, Equity Housing, Washington State University, Champion Homes, and ODOE agreed to test and monitor two test units at Ft. Lewis. Panasonic Whisper Green fans will replace Panasonic 110 cfm. Fans are sized to ASHRAE 62.2 instead of WA VIAQ and were installed in bathrooms replacing the hallway whole house fan. The entire HVAC system was sealed with Aeroseal. The ESTAR lighting fixtures are being installed in both units as well as T-8 strip lighting will be added above and below kitchen cabinet lighting.

On September 10, 2007 a conference call was held between BAIHP staff, Champion staff and Ft. Lewis Communities. Tom Hewes, Steve Leedom, Al Rust Andy Gordon, Steve Matus, Mike Lubliner, Ron Stein, Richard Meuret, Vic Guerrero to discuss the status of the BAIHP research and to discuss results of testing. BAIHP staff also discussed possible projects for the next phase, Panasonic Whisper Green™, more CFL lights bulbs especially for can light and bath fan vanity fixtures and/or ENERGY STAR fixtures, ductless mini splits, tank less water heater more units plus feedback good or bad, HRV.

Steve Leedom explained that during the last building phase at Ft Lewis’s Discovery Village, homes were completed at the Silverton Champion factory at the end of November 2007. No more homes will be built for Ft Lewis for at least 4 months. It will take some time for the completion of the last of the units at Ft Lewis. Steve Leedom, General Manager at Champion Homes of Oregon, shared update on Ft Lewis and other upcoming projects. Mid December 2007 keys for phase 3 will be handed to Equity Residential. Champion built 483 homes all completed - 184 buildings total. Possible next projects for Champion are Town Center and Elliot Marsh – start date in 2008. Town Center project is a 450 unit commercial/residential mixed use at McCord Air Force base which is under bid process using Champion designs. Champion is also bidding on air force base in Spokane. At Spokane and McCord and FT Lewis, ENERGY STAR is in bid specification. Staff developed a power point for ENERGY STAR modular homes and traveled to NW plants to present the ENERGY STAR Modular program.

ODOE Progress March 1, 2007 - January 30, 2008	
Ft. Lewis ENERGY STAR homes site built by Champion of Oregon	138
Total	138

Subtask 4.2 NEEM Program Support

Staff performed quarterly factory inspection visits, inspected problem homes; developed in-plant quality assurance detailed inspection manuals and periodically upgraded the standards to higher levels of energy efficiency. All ten out of ten Oregon plants, four out of four Idaho plants, three of three California plants and one of two Washington plants test all duct systems in each floor to ensure low leakage ducts using duct testing equipment.

Staff distributed to the industry multiple specification clarifications on subjects such as whole-house ventilation installation and product, ENERGY STAR appliances, insulation effectiveness, and on monitoring of plant duct testing. ENERGY STAR built-in appliances are being installed in each ENERGY STAR home.

Other activities include completing and distributing a power point CD for factory technical staff 5 biggest problems in 2007; revising the NEEM specification for whole house ventilation; presenting CFL lighting and other program innovations to the industry; working with MHRA and Nevada and California utility programs; certifying a new plant at Skyline in Woodland California; quarterly inspection for Champion Homes in Woodland California. In addition staff was asked by four Oregon manufactures to certify energy efficient park models programs to develop a proposal to the industry. The proposal was very well received by the industry. Staff is pursuing ENERGY STAR certification for park models.

Staffs met with all plants general managers to interview them on the NEEM program. Questions asked were: Is the NEEM/ENERGY STAR program helpful to your business? Is the NEEM program easy to use? Is the internet tracking and certification system easy to use? Do you consider NEEM part of your business team? With advancement in energy code in site built are you supportive in the future to expand technologies to increase overall home efficiency. What can NEEM do to improve its service to your company? Does the NEEM staff respond in a timely manner to your inquiries? All manufacturers see NEEM as helpful to their business and see NEEM as part of their business team. Generally when asked the question of “how can NEEM improve our services to your business all GM’s said staff was doing a great job. Mike Wolf, GM at Kit Homebuilders, commented that he would like to see NEEM staff more often and would appreciate NEEM staff opinion on Kit’s overall construction/energy process. All plants said that staff responds quickly and the internet system works well. When staff explained that we may have to increase the efficiency of the ENERGY STAR homes, all plants GM were supportive of moving the bar higher.

Staff taught 6 two day State of Oregon certified installer classes in Bend, Salem Albany, and Medford and 5 sessions through out the state of Idaho. The classes are cosponsored by the Oregon Manufactured Housing Association and the Idaho Manufactured Housing Association.

Sixteen out of nineteen plants will receive an ENERGY STAR Leadership Housing Award for their 2007 production numbers. In 2007 NEEM plants produced

approximately 65% of the nations ENERGY STAR homes. The 2007 NEEM totals are 3786 ENERGY STAR homes built.

ENERGY STAR homes produced March 1, 2007 to January 31, 2008	
Northwest Energy Efficient Manufactured Homes	
ENERGY STAR Gas	737
ENERGY STAR Electric	2701
Total	3438

Subtask 4.5 – Documentation, Resource Development and Related Activities

BAIHP project coordination:

- Presented decommissioning study to Indian Tribe Energy Programs
- Attend BAIHP review committee meeting

Other BAIHP Partner coordination:

- Coordinated with BAIHP partners at Fleetwood on heat pump testing research
- Met with Oregon Building Codes on HUD-code manufactured housing technical issues
- Attended monthly Oregon In Plant Inspection Agency (IPIA) and Oregon State Administrative Agency (SAA) staff meetings
- Copied all in-plant and consumer complaints to State of Oregon IPIA/SAA
- Developed curriculum and taught six two-day classes for State of Oregon certified installers and local jurisdiction installation inspectors