FLORIDA SOLAR ENERGY CENTER®

CONTRACT REPORT

Building America Industrialized Housing Partnership (BAIHP II)

Annual Report – Budget Period 3 (BP3)
February 01, 2008 – December 31, 2008

FSEC-CR-1785-09
January 2009

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A Research Institute of the University of Central Florida

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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 2/1/08 to 12/31/08. 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 continued laboratory and field testing of interior duct systems to document their expected energy savings of about 20% in heating and cooling. Worked with Building Science Corp. to test an innovative air-conditioner with an extra dehumidification coil in the FSEC Manufactured Housing Lab. Assisted industry partners with homes experiencing comfort and moisture problems. Our research on measured savings of 7.4% with energy feedback devices in 23 test homes resulted in TV coverage and an article in *Home Energy* magazine. We completed the second year of tests on *NightCool*, an innovative use of night-sky radiation to cool a house during the night. After a full cooling season, and comparing the performance with a best in class conventional construction, the *NightCool* system averaged 15% cooling energy savings with superior dehumidification. We initiated a new effort to perform side-by-side testing of solar and conventional water heating systems at FSEC. A test facility is nearing completion at FSEC to test seven side-by-side systems and compare the energy performance of different types of solar and conventional water heaters, as well as their time-of-day electric loads.

Four prototype near zero energy homes were completed and instrumented. Two in Gainesville, FL by Schackow Development, one in Panama City, FL by Stalwart Built homes and the fourth in North Port, FL by Schroeder homes. The three occupied homes are performing well but in one home with an occupancy of 6 persons the actual solar savings is only about 25% compared to ~70% for the home with two persons in Gainesville with an energy conscious lifestyle. A total of 24 homes are being monitored or instrumented by FSEC (18 BAIHP, 4 IBACOS and 2 ORNL Habitat homes).

In the technical assistance area we provided systems engineering analysis, conducted training, testing and commissioning primarily in hot-humid and marine climates. In 2008, we assisted approximately 50 factory and site builders. Included was assistance for four International Builders Show (IBS) homes for 2008. We helped launch the Builders Challenge initiative - recruiting over 50% of the pioneering builders and assisted Secretary Bodman and Assistant Secretary Karsner on launch day, February 14, 2008.

Table below compares the total number of high performance homes built by BAIHP builders in 2007 and 2008. The HUD code numbers are for the NEEM (Northwest Energy Efficient Manufactured Homes) program led by the Oregon Department of Energy.

High Performance homes by BAIHP builders

	2007	2008 (through November)
Hot-humid Climates (site built and IBS show homes)	284	118
Marine Climates (modular)	151	0
Habitat for Humanity (all climates)	35	47
HUD code (NEEM homes)	3,718	2,926

The dramatic slowdown in the new housing market in 2008 is evident in the table above. The Habitat numbers are up because of the 30 Jimmy Carter Work Project Homes in the Los Angeles, Ca. area we finished certifications for in 2008. The NEEM program has slowed down some but not as much as site built homes.

In the research utilization area we published two magazine articles and nine conference papers. We are active in numerous professional societies and organizations and delivered over 50 presentations and training seminars.

DISCLAIMER

TABLE OF CONTENTS

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The authors appreciate the encouragement and support from George James, Ed Pollock, Terry Logee and Chris Early, program leads at DOE, and Bill Haslebacher, project officer at the National Energy Technology Laboratory. This work could not have been completed without the active cooperation of our industry partners and all collaborators. We greatly appreciate their support.

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 third budget period (BP3) spanning 1/1/08 – 12/31/08. Activities during the month of December, 2008 have not been completely included and will be included in the next annual report. Summaries of significant work completed in budget period 1(BP1) covering 4/1/06- 2/28/07 and budget period 2 (BP2) covering 3/1/07 – 1/31/08 are 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 other consultants. Industry partners include leaders from the housing industry that, together, build over 100,000 homes per year.

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/ft^2 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 on the following page lists active BAIHP Project Industry Partners. Past and inactive partners can be found on the previous years' reports, online at http://www.baihp.org/pubs/annualreports/index.htm 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	
Castle & Cooke	On Top of the World
Holiday Builders	Pringle Development
GMD Construction	Skobel Development
G.W. Robinson Builders	Tommy Williams Homes
Affordable Housing Builders	
Atlantic Housing	Habitat for Humanity International
Brownsville Affordable Housing Corporation	ICI Homes
Custom Builders	
Garst Homes	Schroeders Homes
Ferrier Custom Homes	Scott Homes
Florida's Green Showcase Envirohome	Solar Homes of Florida
Homes by Point	Spain & Cooper Construction
Marc Rutenberg Homes	Stitt Energy Systems
Marquis Construction & Development, Inc	Westmont Homes
Rainier Construction, Inc.	
Developers	
Castle & Cooke	Schakow Development / Trunnel Homes
Organum Development (Lily Valley)	ZCS Development
Research, Education and Industry Association Partners	
Advanced Energy	Progress Energy
Auburn University School of Architecture	Pacific Northwest National Laboratory
Building Science Consortium	RADCO, Inc
Florida Green Building Coalition	RESNET
Florida Solar Energy Research and Education Foundation	Structural Engineering and Inspections, Inc.
	Structural Insulated Panel Association
IBACOS	Stevens Associates (Home Ventilation Institute)
Northwest Energy Efficient Manufactured Housing Program (NEEM)	Washington Manufactured Housing Assoc.

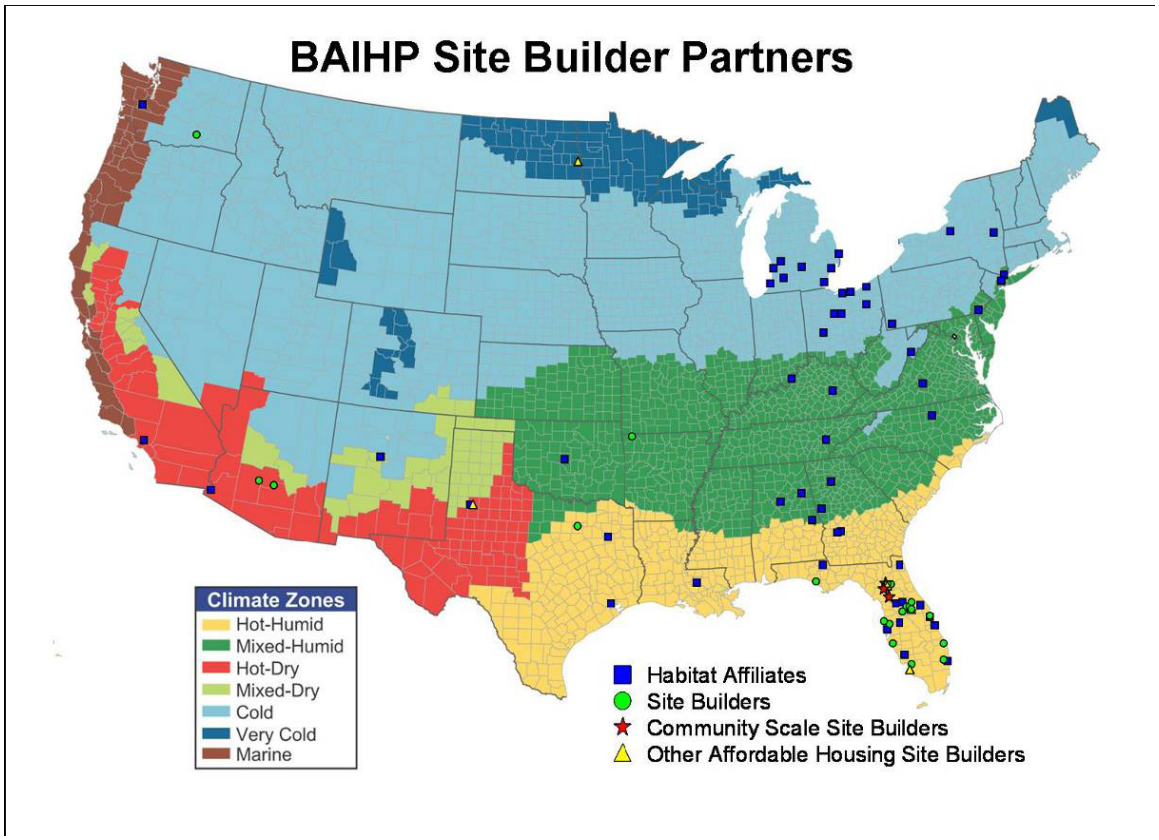

Figure I-2 *BAIHP Research and Technical Assistance Sites*

In the third 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: Post- Phase 3 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. Based on this continued analysis in 2008, the Cavalier home produced up to 19.8% electric energy savings, with 1.6% of that savings attributed to the new duct design. The Southern Energy home prototype reached 20.2% electric energy savings with 5.8% of that attributed to the duct design.

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 sidedischarge 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*

In 2008, baseline testing at the Manufactured Housing Lab (MHLab), located at FSEC in Cocoa, Fla., has been completed with all of the previously-installed equipment as well as with the efficient condenser fan (Parker et al.). Baseline testing in the MHLab continued during the third budget period on the interior air handler system that provides cooling for both the attic and new interior soffit ductwork. Based on this preliminary analysis, the MHLab appears to generate a savings of nearly 20% by simply having the ducts moved within the conditioned space. Data is still being collected at this time, and a full report of this work will be prepared in 2009.

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

Three tasks were conducted on ventilation and dehumidification.

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.

In the MHLab, an advanced prototype air conditioner with an integrated dehumidifier was tested in cooperation with Building Science Corporation and AAON Corporation. In summer of 2008, several days of MHLab time was provided to BSC (Armin Rudd) to test the new control board in AAON equipment. A TED (The Energy Detective) energy monitor was also installed in the MHLab with a "footprints" function to show real-time energy use inside the building.

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.

Industry collaborations on moisture and ventilation issues:
During 2008, the FSEC team evaluated two homes in north Florida, built by Palm Harbor Homes and Fleetwood Homes, which were experiencing moisture-related problems with flooring, energy and comfort. After the evaluation of these homes' moisture problems the team also made recommendations for mediation.

A number of meetings were held in 2008 with potential and new BAIHP partners to discuss participation in future and present projects. The BAIHP team coordinated with Palm Harbor Homes and NAHB-RC, as well as with Don Stevens of Panasonic, about ventilation and indoor air quality for FEMA homes. Discussions were held with AprilAire and input provided to them on optimal dehumidifier characteristics.

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, BP2 or BP3.

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 were fitted in 2006 with a real time energy feedback device called "*The Energy Detective*" *(TED)* which costs ~$200. It has a small display unit (Figure I-7), 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 was 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.

In 2008, a report was created that summarized the data collected in 23 central Florida homes with energy monitors used to evaluate the effectiveness of occupancy feedback in reducing home energy use. An overall savings of 7.4% was achieved by the homes, and the full report is available at http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1742.pdf

The results stemming from this energy feedback research were published in an article in the July/August 2008 issue of Home Energy. Authors of this articles included FSEC researchers Danny Parker, David Hoak and Jamie Cummings. These pilot studies were completed in July, 2008 with good results that are summarized on the BAIHP Web site.

BAIHP builder/developer partner Castle & Cooke is providing a TED monitor as a house warming gift to each of the buyers in the Oakland Park Development located in Winter Garden, FL. FSEC also installed TED power monitors in the zero-energy and near zero-energy homes built by Richard Shackow in Gainesville, Fla.

The BAIHP team also consulted with *GreenSwitch* regarding an automated system for home use utilizing wireless controls to dispatch various household electric loads. In September, 2008 the team began the process of selecting a pilot test location for *GreenSwitch* and also conducted an analysis of how dishwasher, clothes dyer and oven and range loads vary with household size.

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) during 2006 and early 2007 and summarized below.

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 and 2008, 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, Holiday Builders* – FGBC
- *Stalwart Built Homes, Lakeland Habitat* – Leadership in Energy and Environmental Design (LEED) for Homes
- *Homes In Partnership* – Enterprise Green Communities

BAIHP staff continues to support organizations such as Florida Green Building Coalition, US Green Building Council, and national, state, and local home builders associations by providing green training, expertise, and program compliance activities.

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. In May of 2006 DOE recommended against conducting further research in this area as part of the FY07 AOP review process. See http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1514-05.pdf for a typical report with data from the FRF facility.

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.

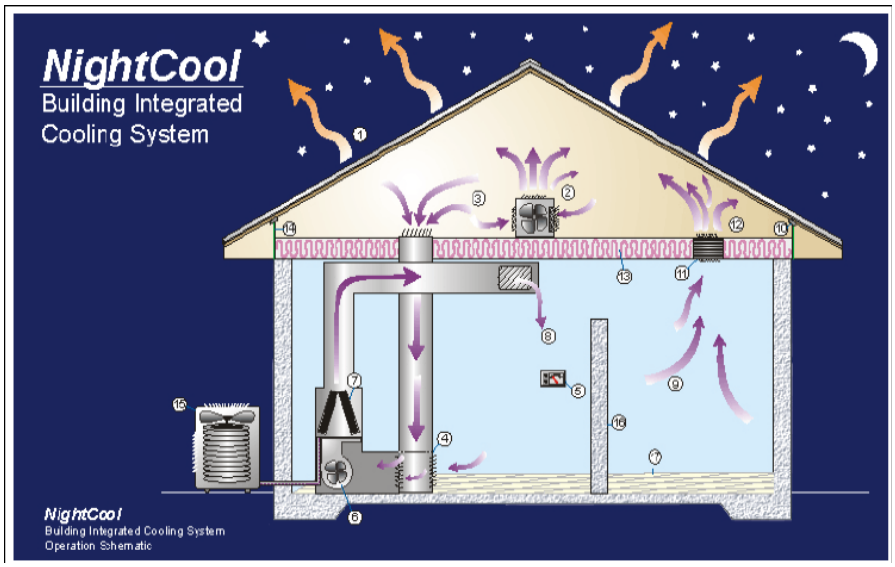

Figure I- 8 *Schematic of NightCool concept*

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.

Data collection on the two test buildings to evaluate the *NightCool* concept continued during 2008. In January, the BAIHP team implemented a control strategy using solar-dried attic desiccants and daytime enthalpy controlled attic ventilation to improve interior relative humidity. Consequently, the average interior relative humidity during the humid month of March resulted in about 6.5% lower in the *NightCool* building than in the control, which means the *NightCool* building was less than 60% relative humidity. Throughout the entire summer testing period, relative humidity has been consistently better in the *NightCool* building. Though these results are extremely positive for the *NightCool* system, a white metal roof was retrofitted onto the control building due to some uncertainty in estimating the true savings from the system.

Testing of the *NightCool* system was continued throughout 2008. During the third budget period, a number of operational configuration changes were made to the system. Changes made during the May and June testing periods include:

- Fan upflow arrangement changed to improve flow characteristics
- Evaluated specific moisture absorption of desiccant pack versus moisture-absorbing wood fiberboard. These both were compared to plywood and altered to a wood-based moisture absorption scheme.
- Altered *NightCool* control set points to optimize performance

- Changed the roof of the control building to a white roof so that the savings achieved for *NightCool* can be readily differentiated from the roofing system itself
- Created a flow pattern to distribute the heated air over the roof and verified its operation with overhead infrared thermography

Based on an engineering reevaluation, FSEC researchers John Sherwin and Danny Parker made more modifications to the system's operational configuration for July's testing results. Modifications were made to the datalogger programming responsible for the automated operation of the *NightCool* building system, and an attic ventilation hatch was installed in an effort to improve interior humidity levels. Interior RH levels were always found to be a few %RH lower in the *Night*cool test building. The air conditioner energy savings from *Night*cool is reported below for the summer months of 2008.

Table I- 2 ***Air conditioner Energy savings from NightCool in 2008.***

April	15%
May	19%
June	16%
July	11%
August	7%
September	10%

The *NightCool* concept, data and analysis is available in a recent paper (Parker, Sherwin and Hermelink, et. al, 2008) at:http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1749-08.pdf

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.

It is the hope of this team to eventually test this concept within the *Night*Cool project in a second or third year. This concept has the potential to provide combined heating, cooling and electric power production from a home's roof in a cost-effective and reliable fashion. However, due to need for long-term testing of the current configuration, no further results on this task are anticipated until 2010.

Subtask 1.11 Related Systems Research

This catch all category is reserved to perform research related to the first 10 subtasks and other new areas that might arise during 2006-2010.

Solar Water Heating

In Budget Period 3 the team initiated a new effort to perform side-by-side testing of seven solar and conventional water heating systems at FSEC. Because of federal, state and local utility incentives, solar water heaters are being installed in significant numbers across the nation. It is an excellent way to save energy on water heating and whole house energy to meet the BA program goals. A test facility is currently being constructed at FSEC in Cocoa, Fla., to test seven side-by-side systems and compare the energy performance of different types of solar and conventional water heaters, as well as their time-of-day electric loads. Another objective of this side-by-side testing is to enhance and validate simulation models for solar water heating systems, particularly the integrated collector and storage (ICS) systems.

The three solar collectors have been installed and the tank and tankless systems are also procured and plumbed inside the test shed. The types of systems being set up for testing include a standard 50-gallon electric unit, flat plate PV-pumped direct solar water heating system, flat plate differential-controlled direct solar water heating system, integrated collector storage (ICS) system with a standard 50-gallon electric tank for backup, tankless gas water heater, a conventional gas water heater, and a tankless electric water heater. All systems should be operational by early 2009. This work complements similar research done at NBS (now NIST) and FSEC in the 1980s.

Subtask 1.12 Full-Scale Testing of Innovative Condenser Fan

Over a two year period (2003-2005), FSEC tested potential enhancements to outdoor unit AC condenser fans by altering their shape and aerodynamic characteristics. Optimized fan blades were designed via a numerical flow simulation and fabricated using stereo lithography. After several months of testing, the research produced a fan exhibiting greatly superior air moving efficiency compared with conventional stamped metal blades. The evaluation was performed on a standard 3-ton *Trane* AC condenser. Measurements were made of condenser air flow, motor power, sound levels and condenser cabinet pressures. The developed prototype fan substituted on the original condenser reduced electric power by 25% (48 Watts) with slightly higher condenser air flow. Air moving efficiency (cfm/Watt) was increased by 35%.

The patented technology is being tested at FSEC's manufactured housing lab by substituting the innovative fan system for one which had very detailed AC unit baseline performance obtained in 2007. All instrumentation is currently installed and a full summer of baseline data is available. FSEC has renewed interest in the technology from a major U.S. AC manufacturer *(Trane Company* which is now a subsidiary of *Ingersoll Rand Group).* The change out was done on July 29, 2008, with a measured 70 - 100 Watt drop in the fan motor assembly power.

Original blade, Standard motor, Standard top:

-16.2 Pa cavity pressure (avg), 238 Volts, 0.8 Amps = 190 Watts

5-bladed efficient fan, ECM motor, elongated diffuser:

-16.0 Pa pressure (avg), 238 Volts, 0.4-0.5 Amps = 95- 120 Watts

We measured at least a 70 Watt or 37% reduction in measured outdoor unit fan/motor power. This was quite consistent with what we measured in the lab three years ago. In the MH Lab data since the change out, we have verified that maximum machine power is about 70 Watts lower than it was previously. Condenser air flow was measured to be the same if not slightly greater.

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:

- 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 suggested 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.
- Monitor prototype: Many prototype homes are then monitored to check for comfort, energy use and effectiveness of improved building components.
- 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 build ten homes in a community.

Subtask 2.1 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 and options analysis to reach a desired design goal. During the third budget period, the following builders this assistance:

Table I- 3 *Builders Receiving BAIHP Technical Assistance in 2008*

Builder	**Location**
Atlantic Housing Partners	Lakeland, FL
Bedsaul Development	Gainesville, FL
Brevard County Housing	Brevard County, FL
Brownsville Affordable Homeownership Corp.	Brownsville, TX
Capitol Home Builders	Thomasville, GA
Castle & Cooke	Winter Garden, FL
Custom Homes	FL, GA, TX
David Axel Home	Oveido, FL
Federation of American Scientists	Houston, TX
Ferrier Builders	Dallas, TX
Florida Custom Homes	Sebring, FL
Florida's Green Showcase Envirohome	Indialantic, FL
Garst Residence	Olympia, WA
GMD Construction	Palm Beach Gardens
GW Robinson Builders	Gainesville, FL
Habitat for Humanity	Throughout the U.S.
HKW Enterprises	Gainesville, FL
Holiday Builders	Central Florida
Holiday Builders	South Carolina
Homes by Point	Tampa, FL
Homes in Partnership	Apopka, FL
HUD concept home	Charleston, SC
Louisiana System Built Homes	Lafayette, LA.
Marquis Construction	Masaryktown, FL
Park Square Homes	Orlando, FL
Rainbow Springs	Dunellon, FL
Rainer Construction	Maitland, FL
Schakow Development	Gainesville, FL
Shroeders Homes	North Port, FL
Southern Heritage Homes	Archer, FL
Skobel Developments	Boca Raton, FL
Spain & Cooper Construction	Gainesville, FL
Stalwart Homes	Calloway, FL
Stamets Residence	Shelton, WA
Structural Engineering and Inspections, Inc.	Ruskin
Tommy Williams Homes	Gainesville, FL
Westmonte Homes	Montverde, FL
ZCS Development	Rockledge, FL

In the third budget period, BAIHP also provided, or initiated instrumentation for long-term monitoring to the following homes:

Table I- 4 *Instrumented homes in 2008*

Builder or Homeowner	Location	Number of Homes Monitored
Chasar Residence	Cocoa, FL	1
CPS Energy	San Antonio, TX	3
Garst Home	Olympia, WA	1
Hoak Residence	Longwood, FL	1
Fort Lewis Townhomes	Fort Lewis, WA	2
LSU's LaHouse	Baton Rouge, LA	1
Schroeders Homes	North Port, FL	1
Scott Homes	Olympia, WA	1
Schackow Development	Gainesville, FL	2
Sierra Lakes	Cocoa, FL	1
Southern Energy Homes	Double Springs, AL	1
Stalwart Builders	Panama City, FL	1
Stamets Home	Olympia, WA	1
Vision House	Orlando, FL	1
Total Number of Homes:		**18**

Performance of four Near Zero Energy Homes (NZEH)

Four prototype homes with PV have been completed and monitored since the summer of 2008. See Figure I-9 through I-11. Selected characteristics are shown in Table I-5 below.

Figure I- 9. *The Schroeders Homes NZEH in North Port, FL. The PV array is split on south and west roofs. Trees shade part of the array and the solar DHW collector in the afternoon*

Figure I- 10. *The NZEH#1 (l) and NZEH#2 (r) by Schackow Realty and Development.*

Figure I- 11. *The NZEH by Stalwart Built Homes (l) with its geothermal heat pump with heat recovery DHW (r).*

Table I- 5 *Selected Characteristics of Four Near Zero Energy Homes*

	Schroders	Schackow#1	Schackow#2	Stalwart Built
Location	North Port, FL	Gainesville, FL	Gainesville, FL	Panama City, FL
Conditioned Area, sq. ft.	1,446, one story	1,772 one story	1,520 one story	1,392 two story
Completed	May 2008	June 2008	July 2008	February 2008
Occupancy /Aug. 08	6	2	Unoccupied	1
Energy Feedback	No	Yes, TED	Yes, TED	No
Foundation	Slab-on-grade	Slab-on-grade	Slab-on-grade	Vented crawl w/R13 foam
Walls	CBS w/R7.8	2 x 4 w/R13	2 x 4 w/R13	2 x 6 w/R19 batt
Roof/Attic	Shingles on radiant barrier decking/Vented attic w/R38	Shingles on radiant barrier decking/Vented attic w/R30	Galvalume/Unvented attic w/R24 foam	Galvalume/Unvented attic w/R19 foam
Windows	U=.51, SHGC=.23	U=.34, SHGC=.28	U=.34, SHGC=.3 for most.	U=.35, SHGC=.25
Window/Floor Area %	10.8%	15.4%	14.2%	10.7%
Heating & Cooling	SEER 18.4/HSPFR 9.1 dual speed air source heat pump	SEER 19, 2-speed a/c 95% gas furnace	Geothermal, open loop well	Geothermal, closed vertical loop
A/C Size (@ hi spd), sq. ft./ton	723	818	760	1,044
Dehumidifier	No	No	No	Yes
Hot Water	Solar w/electric backup – open loop, pumped w/40 sf/80 gallon tank	Solar w/ electric backup, drainback systems, w/64 sf/120 gallon tank	Solar w/ electric backup, drainback systems, w/64 sf/120 gallon tank	40 gallon electric w/desuperheater
House ACH50	4.3	3.1	3.5	3.5
Duct Leackage to out (CFM25 % of floor) & location	4.5%, ducts in attic	2.2%, ducts in conditioned space, furred down	Ducts in unvented attic	1.1%, ducts in unvented attic
Whole House Ventilation	Runtime vent, 12 cfm	Runtime vent, 29 cfm	Runtime vent, 23 cfm	Runtime vent, 35 cfm
Lighting	90% cfl	92% cfl	92% cfl	100% cfl
Appliance	E-star dishwasher		E star refrigerator, washer & dishwasher	E-star refrigerator and dishwasher
Photovoltaic System Size	277 sq.ft., 3.4 kW_p	247 sq.ft., 3.15 kW_p	330 sq.ft., 4.2 kW_p	328 sq.ft., 3.6 kW_p
PV Array Orientation	½ South, ½ West	West	West	South
HERS Index	25	26	16	26
Green Certification	No	No	No	LEED-H Platinum, first in Florida
Instrumented	July 2008	June 2008	July 2008	August 2008

Of these four homes, three are occupied. The unoccupied home with the ground source heat pump is not performing well because of high well pump power and shading of the PV array. The three occupied homes also have some shading during late afternoons but in general they are performing to design specifications. Table I-6 shows a data summary through November 2008. Due to inverter malfunction data between 8/19-9/11/08 is not included for the Schackow home.

Table I- 6 *Performance summary of three occupied NZEH in 2008*

	Schroeders 7/28-11/30/08	Schackow 7/28-11/30/08	Stalwart 9/1-11/30/08
Total KWH/day	38.0	12.2	18.9
PV %	29.9%	67.6%	60.3%
DHW	131.5 gpd	n/a	n/a
% from solar dhw	46%	>85%	n/a

Because of the high occupancy (6 persons) the total energy/ day is much higher and the solar savings is much lower for the Schroeders home.

Subtask 2.1.2 Gulf Coast Affordable High Performance Prototype Homes

The primary objective of this Subtask is to provide a concrete example of affordable high performance housing to encourage all builders to adopt a high performance package as the areas affected by hurricanes Katrina and Rita are rebuilt. The demonstration homes will include a cost effective energy efficiency package as well as durability and indoor air quality features. The primary strategy to achieve this objective is to encourage builders and developers to embrace the system engineering principles and efficiency goals of the Building America program.

BAIHP is working with a limited number of the non-profit groups working in the affordable housing arena to raise the performance level of the new homes they produce in the Gulf Coast. These groups include Habitat for Humanity affiliates in the region and others as opportunities arise. Through hands on involvement in the design, construction, and testing of a small number of prototype affordable houses, BAIHP will be able to teach the systems engineering process while mitigating the risk associated with change by validating the performance. These prototypes will aid BA in directly demonstrating quality construction methods to builders in the region. To ensure project replicability, BAIHP will concentrate on strategies that builders can adapt to practically any new home (e.g. tight ducts, right sized a/c). Tours, case studies and workshops will be used to encourage and train other builders to adopt BA practices.

This effort was begun in Budget Period 2 and continued in Budget Period 3 (BP3). Although researchers offered the opportunity to participate to many non-profit builders, only five Habitat for Humanity affiliates in the region (New Orleans, Slidell, Mobile County and Baton Rouge) ultimately made the commitment to build two 30-40% prototypes each. By early 2009, four 30% Demonstration houses will be completed with a fifth underway. Researchers have conducted two workshops and made a presentation about the Mobile Demonstration house to the local ACCA chapter. Two other Habitat affiliates are interested in participation and will be drawn into the project if time and funds allow. More details on this subtask are included in this report under 4.1 Habitat for Humanity Partnership in the Gulf Coast Recovery Technical Assistance section under "Gulf Coast High Performance Affordable Demonstration Houses."

Subtask 2.2 International Builders' Show High Performance Prototype Homes

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.

Figure I- 12 *Glen Cairn "Comfortably Affordable" 2008 Palm Harbor Homes IBS Showhome HERS Index: 69.*

At the 2008 International Builder's Show, the U.S. Department of Energy announced its Builders Challenge program which challenges America's homebuilders to build 220,000 high performance homes into the marketplace by 2012. One of the tools used to differentiate these homes is the EnergySmart Home Scale, or E-Scale. Homes qualifying for the Builders Challenge must achieve a HERS Index score of 70 or better on the E-Scale. During the 2008 IBS, DOE Secretary Bodman placed the very first E-Scale inside the Bimini II "Green" home built by Palm Harbor Homes (Figure I-14).

Figure I- 13 *The '08 New American Home*

BAIHP provided assistance to the following homes in the third budget period:

- ***Two 2008 PHH Professional Builder Show Village Homes*** - provided information on green products and HVAC design as well as QA inspections and specifications review, developed "green tags" highlighting green features within the homes; coordinated NAHB Green Home Certification pre-qualifications and conducted Florida Green Home certifications; conducted thermal bypass inspections and Builders Challenge Quality Control Criteria. Figures I-12 and I-14.
- ***Two 2009 PHH Professional Builder Show Village Homes*** – provided Manual D and Manual J load calculations, reviewed HVAC testing and made recommendations, conducted thermographic survey, and verified current equipment certification; coordinated NAHB Green Home Certification pre-qualifications; conducted thermal bypass inspections and Builders Challenge Quality Control Criteria. Figure I-16 shows one of the homes.

- ***The Vision House Orlando*** – provided ACCA Manual J and D, completed Florida Green Home certification, installed monitoring equipment for ongoing data collection, and provided testing for four HVAC systems, total building power use and interior temperature and relative humidity.
- ***2008 The New American Home*** – assisted IBACOS with construction documentation and home performance testing and installed monitoring equipment; conducted first NAHB Green Home Standard Scoring Analysis (Figure I-13)

Figure I- 14. Bimini II 2008 "Green" Showhome
Palm Harbor Homes HERS Index58

Figure I- 15. *Secretary Bodman placing the first E-Scale; label on Bimini II 2008 "Green" Showhome.*

Figure I- 16. *T ularosa 2009 IBS home*

Subtask 2.3 Prototype House Evaluations for other BA Teams

In 2008, FSEC hosted Building America-monitored data Web sites at the request of other BA teams. The BA teams were responsible for installing the data acquisition systems, while FSEC acquired, archived and displayed the data from BAIHP and non-BAIHP monitored sites on the web. During this budget period, FSEC has assisted with a datalogging site for BSC and also assisted with implementing a new channel map, creating new graphs, and reprocessing old data for the IBACOS PRB project at the Broad residence in Henderson. In total 4 IBACOS sites are active. We are also collecting data for the two ORNL zero energy Habitat homes in Tennessee.

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 (Table I-7) are building high performance homes on a community scale. The homes in italics are located in the Marine climate zone.

Table I- 7. *BAIHP Community Scale Builders*

Builder	**Location**
Castle & Cooke	Winter Garden, FL
G.W. Robinson Builders	Gainesville, FL
HKW Enterprises	Apopka, FL
On Top of the World	Ocala, FL
Pringle Development	Eustis, FL
Stalwart Built Homes	Panama City, FL
Tommy Williams Homes	Gainesville, FL
Ft. Lewis Army Base	*Ft. Lewis, WA*
Scott Homes	*Olympia, WA 14*

Table I-8 compares the total number of high performance homes built by BAIHP builders in 2007 and 2008. The HUD code numbers are for the NEEM (Northwest Energy Efficient Manufactured Homes) program led by the Oregon Department of Energy.

Table I- 8. *High Performance homes by BAIHP builders*

	2007	2008 (through November)
Hot-humid Climates (site built and IBS show homes)	284	118
Marine Climates (modular)	151	0
Habitat for Humanity (all climates)	35	47
HUD code (NEEM homes)	3,718	2,926

The dramatic slowdown in the new housing market in 2008 is evident in the table above. The Habitat numbers are up because of the 30 Jimmy Carter Work Project Homes in the Los Angeles, Ca. area we finished certifications for in 2008. The NEEM program has slowed down some but not as much as site built homes.

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, four other Florida builders—Pringle Development, On Top of the World, Stalwart Built Homes 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.

Figure I- 17. *GW Robinson Home*

Figure I- 18. *Turnberry Lake Home*

Continuing the work done during Budget Periods 1 and 2, FSEC and Florida H.E.R.O. provided technical assistance to several builders in Gainesville, Fla., as well as in other hot, humid markets during the third budget period. The team worked to construct at least 100 homes in subdivisions where all homes reach the Builders Challenge goal of a HERS Index of 70 or less. BAIHP partners G.W. Robinson and Tommy Williams homes of Gainesville, Fla., are already building homes to this level in two subdivisions with approximately 200 to 350 homes each. 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.

FSEC and Progress Energy are working with Castle and Cooke as they develop the Oakland Park community in Winter Garden, FL. The developer's home building division completed the first ten homes during this BP, all of which meet the Builder's Challenge and achieve 40% benchmark savings.

FSEC and Calcs Plus are also working with Stalwart Builders, based in Panama City, FL, to create high performance factory built homes that achieve significant energy savings for affordable markets, primarily in hot, humid climates. At least thirteen homes have been completed, all of which will meet the Builder's Challenge. One NZEH Stalwart home has achieved platinum status under the US Green Building Council LEED for Homes program.

Subtask 3.2 Marine Climate Communities

Figure I- 19. *Two Story Modular Housing – Ft.Lewis Army Base, WA.*

Figure I- 20. *Brotherton 13th Ave Bungalows by Scott Homes, Olympia, WA.*

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 through 2007, certified as ENERGY STAR and achieving 25%-30% source energy savings over the benchmark. No new homes were completed in Fort Lewis in 2008 but 2009 should see new construction again. In 2008, Ft. Lewis Communities LLC, Equity Housing, Washington State University, and ODOE continue to monitor two test units at Ft. Lewis. Tankless hot water heaters, 94% efficient gas furnaces Panasonic Whisper Green fans. Fans were sized to ASHRAE 62.2 instead of WA VIAQ and were installed in bathrooms replacing the hallway whole house fan. The entire HVAC system in one home was sealed with Aeroseal. The ESTAR lighting fixtures were installed in both units as well as T-8 strip lighting above and below kitchen cabinets.

In addition,WSU 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.

In 2008, WSU supported housing developer, Unico Properties of Seattle, on one housing projects in the Seattle area. Results of design charettes conducted in 2008 were largely value engineered out by the developers. The only recommendation they adopted was the low-e windows.

Subtask 3.3 Post Occupancy Evaluation of Building America Homes vs. Non-Building America Homes

A BAIHP team consisting of FSEC and FL HERO, with assistance from Gainesville Regional Utilities and Clay Electric Cooperative is currently engaged in a study of BA and non-BA homes in the Gainesville, FL market, where the team has had considerable success, to determine whether project goals are met post-occupancy. This study is based on actual utility bill analysis, long term hourly measurements of indoor temperature (T) and relative humidity (RH), an audit of home features and operational characteristics, and home owner response to a questionnaire on energy use, comfort, indoor air quality, durability and related issues. During BP3 a study protocol was developed, reviewed by

NREL and other BA stakeholders, and submitted for IRB approval. The study was approved by the University of Central Florida Institutional Review Board in November 2008 and currently a group of 50 homes built with BA program elements is being identified, and a second group of 50 homes having similar size and age characteristics, which have not been built with BA program elements, is also being identified.

Task 4: Post-Phase 3 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 2008 we assisted the following affiliates. Each activity BAIHP participated in is explained in the subsection subtask 4.1 of this report. A brief summary of the activities are:

Lakeland, FL
This Habitat affiliate builds some of the highest performing homes among all affiliates, consistently building homes above the 30% BA benchmark level. BAIHP performed thermal bypass inspections and HERS ratings for Lakeland HFH in 2008, as well as duct performance and house tightness testing. BAIHP assisted the affiliate with USGBC LEED for Homes certification on one home.

Figure I- 21. *Lakeland, FL Habitat House conducting blower door testing.*

Indian River County, FL (Vero Beach Area)
After years of working with this affiliate and numerous incremental efficiency improvements to their homes, this HFH affiliate has taken a major step and installed solar hot water systems on their homes. Combined with previous improvements, HERS Indexes on these homes range in the mid to low 70s. Analysis shows that with the incorporation of more fluorescent lighting this affiliate's homes could qualify for the U.S. DOE's Builders Challenge.

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 multifamily project that will be started later this year. We tested two recently completed homes and found both duct and whole house air tightness levels to be in range. Based on analysis of single family detached homes tested in January 2008 and preliminary analysis of multi-family homes to be built later in 2008, the HERS Indexes of these homes meet or exceed ENERGY STAR requirements. This affiliate also hired a RESNET certified

home energy rater to provide rating services. In May 2008, 10 different improvements were analyzed and presented in several packages that were all designed to qualify the homes for ENERGY STAR.

Detailed technical assistance was also provided to HFH affiliates in Pinellas County (FL), Highlands County (FL), Hillsborough County (FL), South Sarasota County (FL), and Manatee County (FL).

Gulf Coast Recovery

BAIHP has assisted many major Habitat affiliates along the Gulf Coast. Mobile County HFH in Alabama, Mississippi Gulf Coast HFH in Gulf Port, Mississippi, and the HFH affiliates in New Orleans, Slidell, and Baton Rouge, Louisiana have all agreed to build a 30% prototype under supplemental funding. New Orleans is working toward achieving ENERGY STAR in all of their homes. For more information see Subtask 2.1.2.

Figure I- 22. *Raising Walls at a Habitat :"blitz build" in Slidell, Louisiana.*

Northwest Habitat affiliates

BAIHP is working with Tacoma, 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. Detailed technical assistance was also provided to HFH affiliates in Olympia (WA) and Kings County(WA).

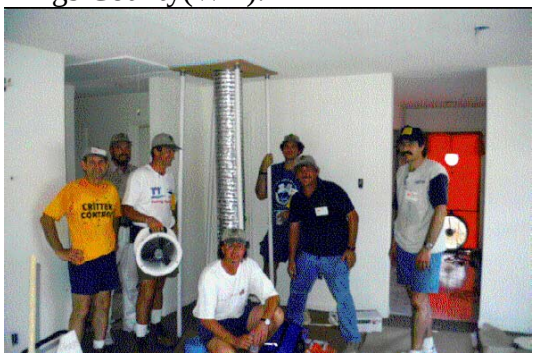

Figure I- 24 *HFH volunteers in home performancee testing training*

Figure I- 23. *Habitat for Humanity 15 home Community Cottage project – Olympia, WA.*

Subtask 4.2 HUD Code Energy Star

Oregon Dept of Energy Effort on the Northwest Energy Efficient Manufactured Housing Program

Staff performed quarterly factory inspection visits, inspected problem homes; developed in-plant quality assurance detailed inspection manuals. In March 2008 NEEM proposed upgrading the standards to higher levels of energy efficiency and presented the higher standards to the industry.

Other activities include updating and distributing a power point CD for factory technical staff and staffing a booth at the Salem, Oregon, regional home show from February 27 – March 2. and at the Idaho home show.

NEEMgreen

In March of 2008 NEEM staff developed a NEEMgreen program, a green building program for manufactured homes. As a part of the NEEMgreen home, the higher energy standards for the Energy Star manufactured home program was incorporated. NEEM staff presented NEEMgreen to the industry regional marketing Board of Directors, NW Pride, in May 2008. At that same meeting with the industry, NEEM staff also presented higher energy standards for the regional Energy Star manufactured home program. The Board of Directors of NW pride voted to approve the NEEMgreen program as part of their efforts to improve the image of manufactured homes and deliver their Advanced Home to the market. NEEM staff presented NEEMgreen program to the Oregon manufactured housing industry, Oregon Manufactured Housing Assoc. Board of Directors on June 5, 2008. NEEMgreen was presented to the Marlette staff in Hermiston OR on July 23. NEEMgreen was presented to the Golden West staff in Albany OR on August 28. NEEMgreen was presented to Liberty on September 8, 2008. Golden West is building the first five NEEMgreen homes beginning in October, 2008.

Higher Energy Standards

On August 5, 2008, NEEM staff contacted suppliers and window manufacturers to set up conference calls to discuss the spec change. After NEEM staff held a conference call with window manufacturers to discuss the window spec change U=0.35 to U=.32, NEEM held a meeting with the manufactured home industry on September 10, 2008. Each of the 17 plants has 1 vote and the majority passes or fails the measures. Voting was held after the September 10th meeting. Votes will be tallied in late October 2008. A cost benefit analysis to the consumer with the energy upgrades was presented at the meeting. Seven regional plants were present at the meeting. The spec change includes the following new measures:

- Vaulted ceiling R-40 U=0.029 required
- Wall R-21 w no trade off U=0.52 required
- Windows, U=0.32 area weighted average required
- Lighting 50 % fixture CFL's required
- 90% AFUE gas furnace required

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

FSEC 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 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.

Subtask 4.3 Building America Program/Analysis Support

During 2008, 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.

Review of Miscellaneous Electric Loads (MELs) in Residences

FSEC researchers Danny Parker and Philip Fairey developed new algorithms for calculating the miscellaneous electric loads for ceiling fans, dishwashers and clothes washers. These algorithms will be vetted and eventually planned for inclusion in HERS and Building America benchmark calculations.

We have worked with NREL to incorporate the research done by TIAX for U.S. DOE to revise the estimating procedures used for miscellaneous electric end uses in homes. The following areas are being addressed:

- Absolute ranking of end uses and incorporation of TIAX findings into procedures
- Ceiling fans
- Dishwashers
- Clothes washers
- Televisions
- Energy Feedback and Controls

Progress on this task was reported on during the July DOE meeting. A final report will be prepared in early 2009

"Wind Washing" Retrofit Solutions in Two-Story Florida Homes

In Budget Period 3, FSEC is assisting DOE in evaluating the potential benefits of retrofits of existing, but recently constructed homes to improve air tightness and insulation in houses with complex architecture (e.g., houses with attic spaces over first-floor portions that abut the second story, creating potential breaches of the thermal and air boundaries). FSEC is working on the search, selection and scheduling of field assessments to be performed in 32 homes which can characterize wind washing failures of air and thermal boundary, and currently has a list of more than 15 homes which have been volunteered for this project. Testing includes a blower door test, air boundary location, pressure mapping, infiltration testing, infrared scans of house surfaces, and visual inspections. Repairs to restore the air and thermal boundaries will be implemented in 8 homes. A retrofit plan will be developed for each potential repair home. The retrofit plan could include installing air/thermal barriers at the perimeter of the between-floors cavity, replacing missing batts, applying expansive foam, or securing rigid panels (possibly board insulation) over second story insulation batts facing into attic spaces. The retrofit costs will be paid from project funds. AC energy use and space conditions will be monitored (15 minute data) before and after repairs (6-8 month monitoring period) to document cooling energy savings. This project will characterize the extent and magnitude of the energy and moisture consequences of these thermal and air barrier failures in a hot and humid climate, and evaluate the energy conservation potential of wind washing retrofit programs.

Staff have developed a draft field inspection and testing protocol, which will provide the framework for characterizing air and thermal boundary failures in two-story homes, calibrated instrumentation to be used in field assessments, and performed inspections and testing in five homes.

Subtask 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.

In 2008, BAIHP completed benchmarking analysis and sales analysis of GW Robinson and Tommy Williams Homes in Gainesville, Fla. GW Robinson met the 40% Joule goal and work was completed on an initial case study report that was transmitted to NREL and DOE.

Subtask 4.5 Documentation, Resource Development and Related Activities

In the research utilization area we published two magazine articles and nine conference papers. We wrote several contract reports and participated in several press interviews. We served in numerous professional societies and organizations and delivered over 50 presentations and training seminars. Details available in Appendix A and published articles and papers are listed below

Magazine Articles

Parker, D., Hoak, D. and Jamie Cummings - Article on Energy Feedback , Home Energy , July/August 2008 .

Lubliner, M.; Gordon, A. "Q and A – Zero Energy Manufactured Homes." Home Power Magazine. Fall 2008.

Publications with Presentations at the Conference

Chandra, S., Parker D., Sherwin, J., et al "An Overview of Building America Industrialized Housing Partnership (BAIHP) Activities in Hot-Humid Climates", Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

Chandra, S. "Energy Efficient High Performance New Housing in the United States: Building America Examples from Hot, Humid Florida", IAHS congress - Kolkata, India, November 3-7, 2008.

Hoak, D., Parker, D., Hermelink, A., "How Energy Efficient are Modern Dishwashers", Proceedings of ACEEE 2008 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Asilomar, CA, August 2008.

Lubliner, M. et.al. "Moving Ducts Inside: Big Builders, Scientists Find Common Ground." Proceedings: ACEEE 2008 Summer Study. American Council for an Energy Efficient Economy. Asilomar, CA, August, 2008.

Moyer, N. "Using Thermography in the Evaluation of the NightCool Nocturnal Radiation Cooling Concept." Proceedings- InfraMation conference , Reno, NV. November 2008

Moyer, N. et al. "Research Results From A Few Alternate Methods of Interior Duct Systems in Factory Built Housing Located In The Hot Humid Climate" , Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

Parker, D., Sherwin, J., Hermelink, A., "*NightCool*: A Nocturnal Radiation Cooling Concept", Proceedings of ACEEE 2008 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Asilomar, CA, August 2008.

Thomas-Rees, S. et al. "Green and High Performance Factory Crafted Housing", Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

Vieira, R., Parker, D., Gu, L. and M. Wichers " Energy Impacts of Various Residential Mechanical Ventilation Strategies", Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

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

A project review meeting was conducted on February 12, 2008. The purpose of the meeting was to present project plans and progress to DOE and partners and to seek input from them. Mr. Bill Haslebacher from N.E.T.L., BAIHP project officer, represented DOE at the meeting. Participants expressed satisfaction with the project.

Subtask 4.6 RESNET Tasks

RESNET Adopts Residential Energy Efficiency Policy Initiatives
One of key challenges to new President and Congress will be to crafting policies to address the nation's energy and climate change challenges.

To assist in this process the RESNET Board of Directors adopted a set of initiatives to tap the potential of residential energy efficiency.

RESNET used the set of principles adopted by the G8 as the foundation for the recommendations and vetted them with a wide variety of energy efficiency and environmental organizations.

At its Fall 2008 Board Meeting the RESNET Board of Directors adopted the following policy initiatives to recommend to the new President and Congress:

- Time of Sale Energy Assessments
- Financing of Energy Improvements of Existing Homes
- Utility Energy Efficiency Portfolio Standards With a Building Energy Efficiency "Carve Out"
- Performance-Based Federal Tax Incentives
- Energy Retrofit Emergency Fund
- Building Codes to be based on total cost over 30 year period
- Adopt Policy that Sets the Goal of Having Net Zero Energy Homes as the Standard of Construction by 2030
- Foster Development of Residential Energy Service Companies (ESCos)
- Revise Mortgage Financing Underwriting Guidelines to Factor the Energy Performance of a Home in the Mortgage Loan

ISO Standard 163 Technical Advisory Group
In August, 2008 RESNET recruited the RESNET International Initiatives Technical Advisory Group (TAG) to provide input on the development of ISO TC163 WG3. The members of the TAG are posted on the RESNET web site at www.resnet.us/hotnews/taskforce/international.

RESNET prepared a briefing paper on the issues involved with the development of the ISO TC163 WG3 and distributed to the TAG.

RESNET hosted the first meeting of the TAG on August 19, 2008 as a special session at the American Council for an Energy Efficient Economy's Summer Study on Energy Efficiency in Buildings in Pacific Grove, California. Good input was received as a result of the working session.

Task 1: System Evaluations

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

1.1 Improved Duct Systems

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 Mockkup*

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

Along with these two builders' efforts, the Manufactured Housing Lab (MHLab) at FSEC was retrofitted with an interior soffit duct. This duct system was added so that either the attic duct system or the new interior duct system would be able to supply air to the conditioned space using the same mechanical equipment (Moyer et al. 2008).

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 an approximate 10-20% savings when compared to conventional attic duct work construction techniques. Nearly 7% savings were achieved when compared to a conventional in-floor system (Moyer et al. 2008).

Field monitoring began in 2007 for the Southern Energy prototype and data was collected for the period where heating would most likely be used in the home. One of the desired outcomes from this prototype home, in addition to energy savings, was improved comfort. In Figure 1-6, the temperature difference between the master bedroom and the thermostat was less than 1°F. The ability to limit large temperature differences within the home means occupant comfort will be enhanced (Moyer et al. 2008).

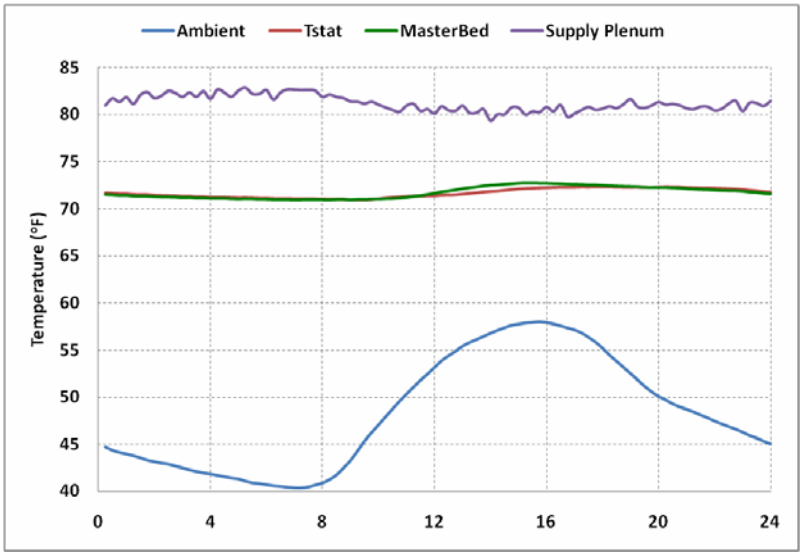

Figure 1- 6 *Southern Energy: an Hourly Temperature profile of the supply plenum, thermostat, master bedroom and ambient. Data from November 8, 2007 to April 14, 2008.*

The total daily energy use for heating versus temperature difference across the envelope is shown in Figure 1-7. The location of the home was Double Springs, Ala., which averages about 30°F to 39°F on a typical January day.

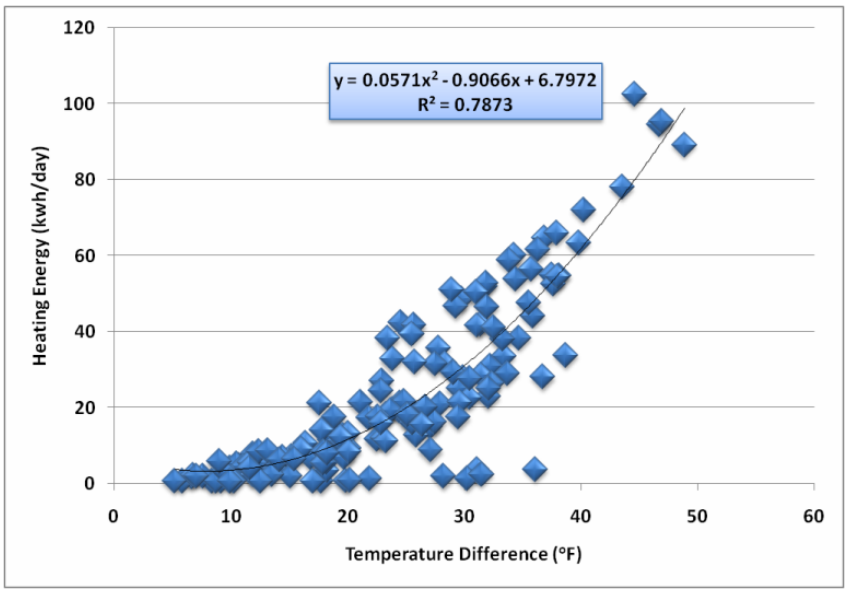

Figure 1- 7 *Heating energy vs. temperature difference.*

For the Cavalier Homes' HSD unit prototype analysis, data was collected in 15-minute intervals with a primary concern for whether or not the interior drywall would suffer from moisture damage. Even after continuous changes to the thermostat temperature throughout the home, the data in Figure 1-8 clearly shows that the interior dewpoint temperature is always below the supply plenum temperature, so condensation connot occur and none was detected during inspection (Moyer et al. 2008).

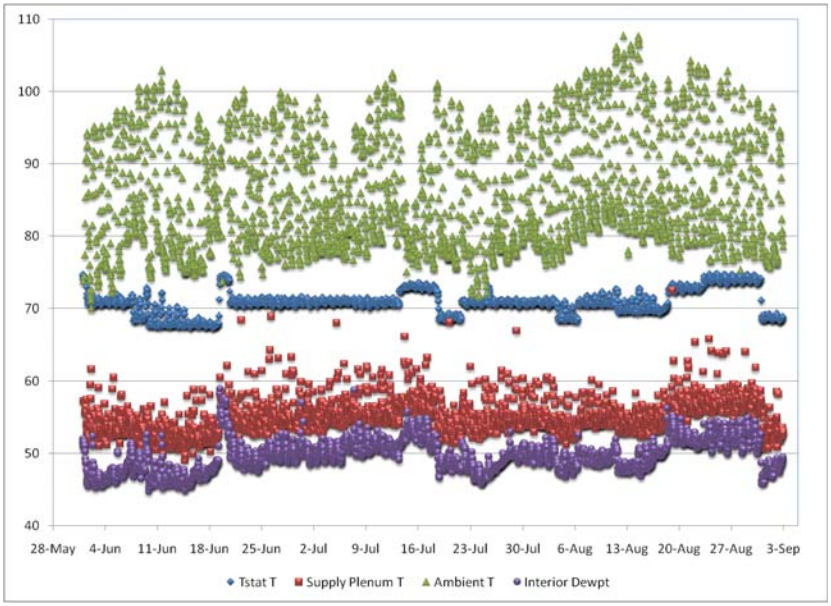

Figure 1- 8 *HSD prototype temperatures and dewpoint conditions on an hourly average 6/1/07 to 9/2/07*

Data reported for the Cavalier prototype was collected from June 1, 2008, through September 2, 2008. Figure 1-9 shows the energy usage plot or this prototype. This plot provides an evaluation of measured cooling performance based on a regression analysis of the total daily cooling energy per 1,000 square feet of floor area versus the average daily temperature across the envelope (Chasar et al. 2006). It should be noted, though, that while this energy usage plot shows less energy than that of the baseline comparison, this home is unoccupied without any attempt at occupancy simulation.

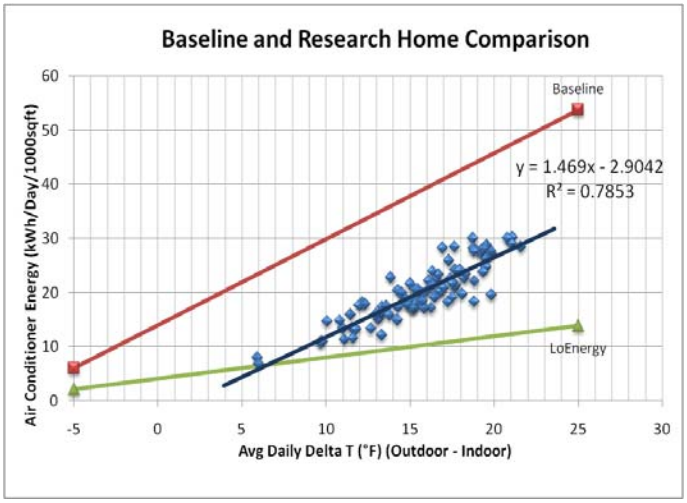

Figure 1- 9 *HSD daily energy usage verses average daily temperature difference across envelope*

The MHLab, on the other hand, simulates a typical family of four living in the home using computer-controlled, automated devices, such as appliances, showers, lighting, and sensible/latent heat generation given off by the "family".

The lab was operated with the attic duct system as the means to supply air to the conditioned space. The building operated in this mode for two weeks and was then switched over to the interior soffit duct system for a two week period. The cycle continues for the remainder of the summer and into the winter of 2008. The intent is to determine the energy savings from placing the duct system within the conditioned space. Figure 1-9 shows the daily hourly profiles for each of the test periods, ducts in attic and ducts in conditioned space. The interior temperatures were very close to each. The attic temperatures varied some due to Tropical Storm Fay that spent almost a week near the site. For that reason, there was an additional week of runtime on the interior duct system.

Interior power consuming appliances remained rather constant (Figure 1-11). The largest difference in overall power consumption was that of the air conditioning system.

Based on the preliminary analysis of the MHLab, it appears to generate a savings of nearly 20% by simply moving the ducts within the conditioned space.

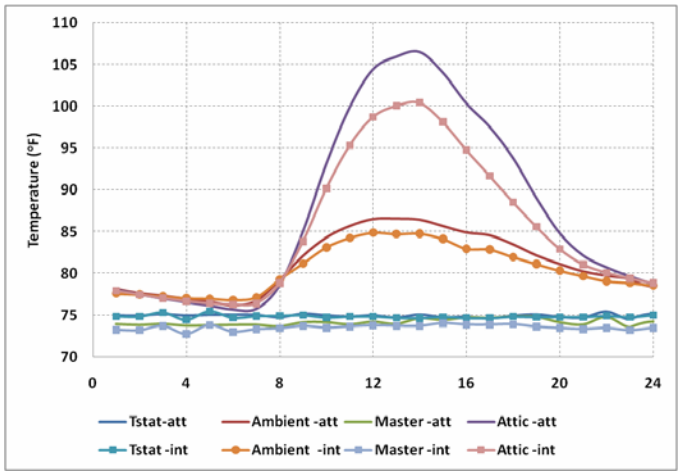

Figure 1- 10 *Average Hourly Temperature Profiles Comparing Attic to Interior Locations*

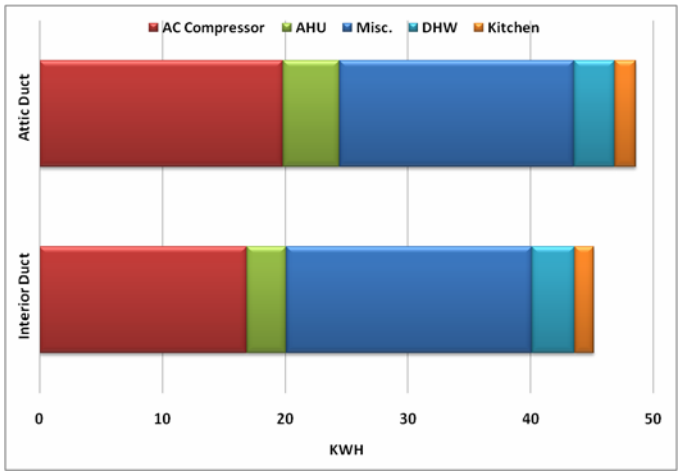

Figure 1- 11 *Average Daily Energy Usage*

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. 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 1-12 and Figure 1-13.

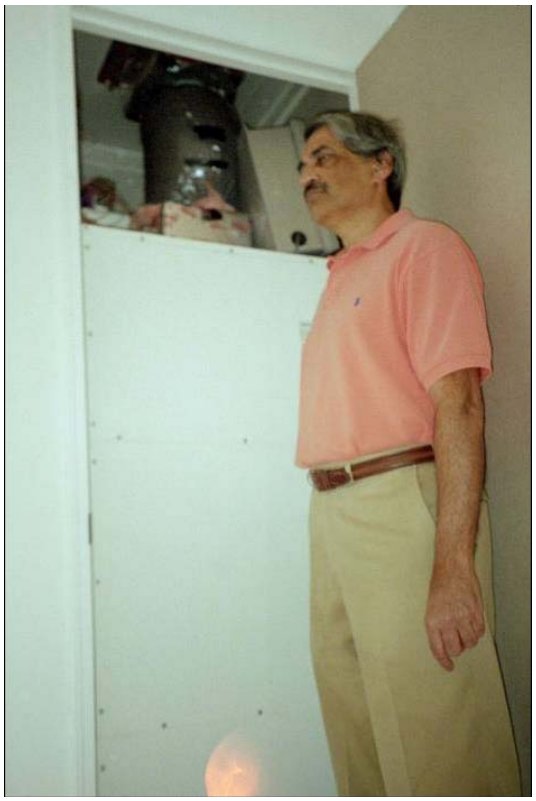

Figure 1- 12 *Interior view of the Comboflair System with Mr. Henry Delima, Comboflair project director*

Figure 1- 13 *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 sub task was completed in 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 is planned for installation in the Gen-X prototype house in Siesta Key, FL. In addition the following efforts were conducted under this sub task

Evaluation of Advanced Cooling with Dehumidifier Mode (ACDM) Equipment

The FSEC Manufactured Housing Lab (MHLab--Figure 1-14) was used to conduct research for ventilation and dehumidification strategies since 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- 15 *The FSEC Manufactured Housing Lab*

Figure 1- 14 *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 1-15).

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. In September 2008, 10 days of MHLab time was provided to BSC (Armin Rudd) to test the new control board in AAON equipment. A TED (The Energy Detective) energy monitor was also installed in the MHLab with a "footprints" function to show real-time energy use inside the building.

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 77ºF for cooling and 70ºF 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 1-16 below.

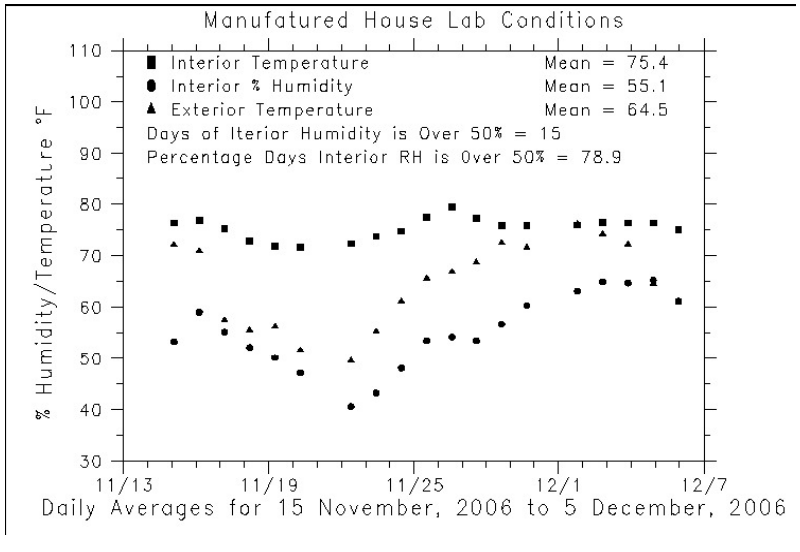

Figure 1- 16 *Interior and exterior conditions at the MHLab under ASHRAE 62.2 ventilation*

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 1-17 below.

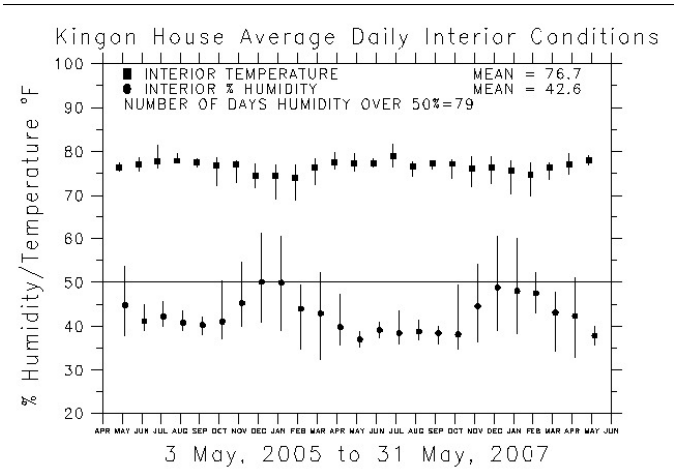

Figure 1- 17 *Interior T and RH for an occupied house in Ft. Myers, FL*

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.

Industry collaborations on moisture and ventilation issues:

During 2008, the FSEC team evaluated two homes in north Florida, built by Palm Harbor Homes and Fleetwood Homes, which were experiencing moisture-related problems with flooring, energy and comfort. After the evaluation of these homes' moisture problems the team also made recommendations for mediation.

A number of meetings were held in 2008 with potential and new BAIHP partners to discuss participation in future and present projects. The BAIHP team coordinated with Palm Harbor Homes and NAHB-RC, as well as with Don Stevens of Panasonic, about ventilation and indoor air quality for FEMA homes. Discussions were held with AprilAire and input provided to them on optimal dehumidifier characteristics.

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, BP2 or BP3.

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, 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 1-18.

Figure 1- 18 *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 Installations 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%
P1**	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 average*

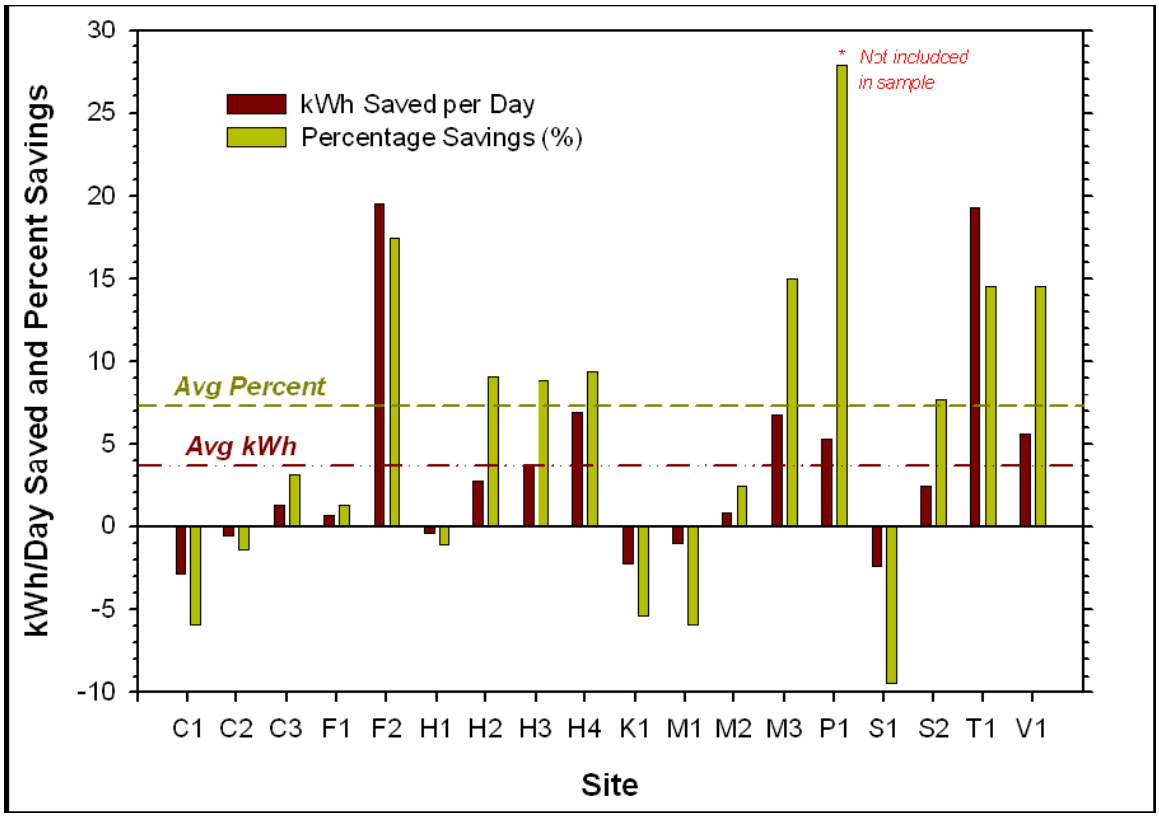

Figure 1- 19 *Average daily energy savings*

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.

As of BP3, residential energy monitors were installed in a total of 24 homes in the BAIHP effort , and the results have been very good. Use of energy monitors is being adopted by a number of Building America builders and an article about this feedback study also appeared in the *Washington Post*.

FSEC researchers David Hoak and Danny Parker worked to perform a variety of dishwasher performance tests and data analysis on the test results. An analysis was also conducted on how dishwasher, clothes dryer, range and oven loads varied with household size.

In May 2008, FSEC and the BAIHP team also began consultation with *GreenSwitch* regarding an automated system for homes using wireless controls to dispatch various household loads. The team is currently in the process of selecting a pilot test location for *GreenSwitch*.

The team also contacted other researchers who are engaged in a similar test for Pacific Gas and Electric. As an expert meeting with CONSOL at the ACEEE meeting on electric loads, held in August, 2008 it was shown that substantial research is ongoing in the feedback and controls area internationally.

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. These activities were completed in 2006 and early 2007.

<u>Royal Concrete Concepts</u>
Royal Concrete Concepts (RCC) produces innovative concrete modules for both residential and commercial markets throughout Florida. RCC currently operates a midsize, 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

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 2008, 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, Holiday Builders* –FGBC
- *Stalwart Built Homes, Lakeland Habitat* – Leadership in Energy and Environmental Design (LEED) for Homes
- *Homes In Partnership* – Enterprise Green Communities

More information on these activities is provided in sections of this report detailing assistance to IBS Show Homes, Prototype Homes, and Communities**.** BAIHP staff

continue to support organizations such as Florida Green Building Coalition, US Green Building Council, and national, state, and local home builders associations by providing green training, expertise, and program compliance activities.

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 1-20). Since 1989 the testing has evaluated how roofing systems impact summer residential cooling energy use and peak demand (Parker et al. 2005).

Figure 1- 20 *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 and no effort since then.

1.9 NightCool

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.

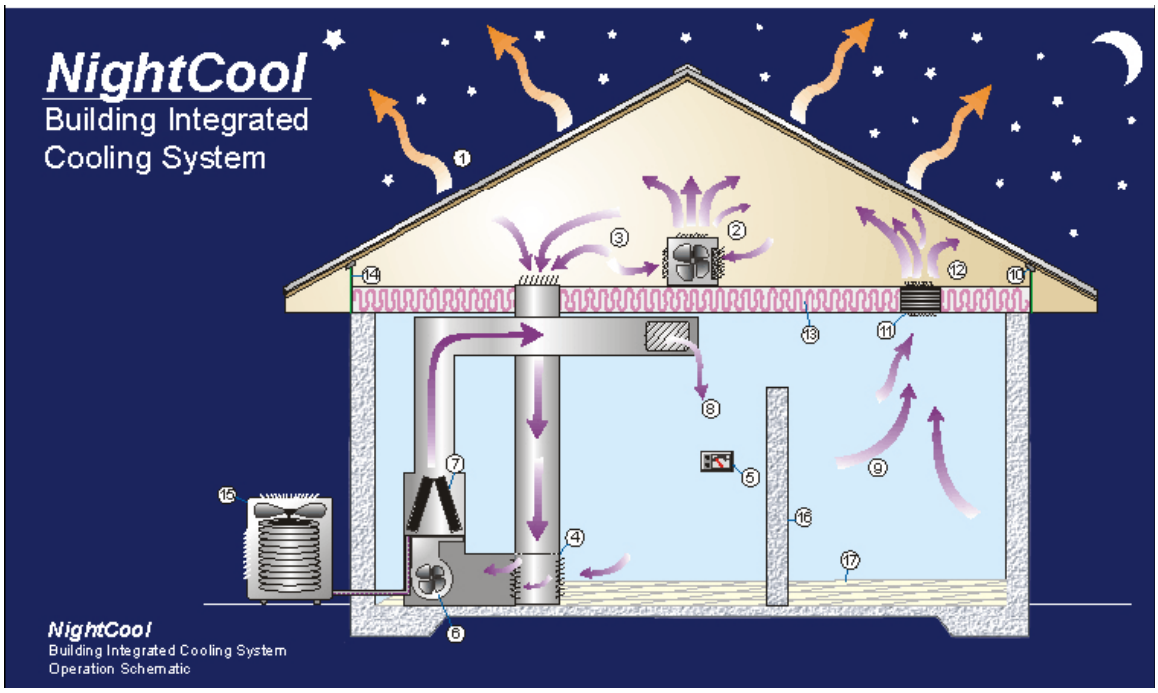

Figure 1- 21 *NightCool Operation Schematic*

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 1-22 and Figure 1-23). 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 1-25).

Figure 1- 22 *Conventional Shed with Dark Shingle Roof*

Figure 1- 24 *NightCool Shed with White Metal Roof*

Figure 1- 234 *Conventional Shed with Vented Attic and R-30 Fiberglass*

Figure 1- 25 *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.

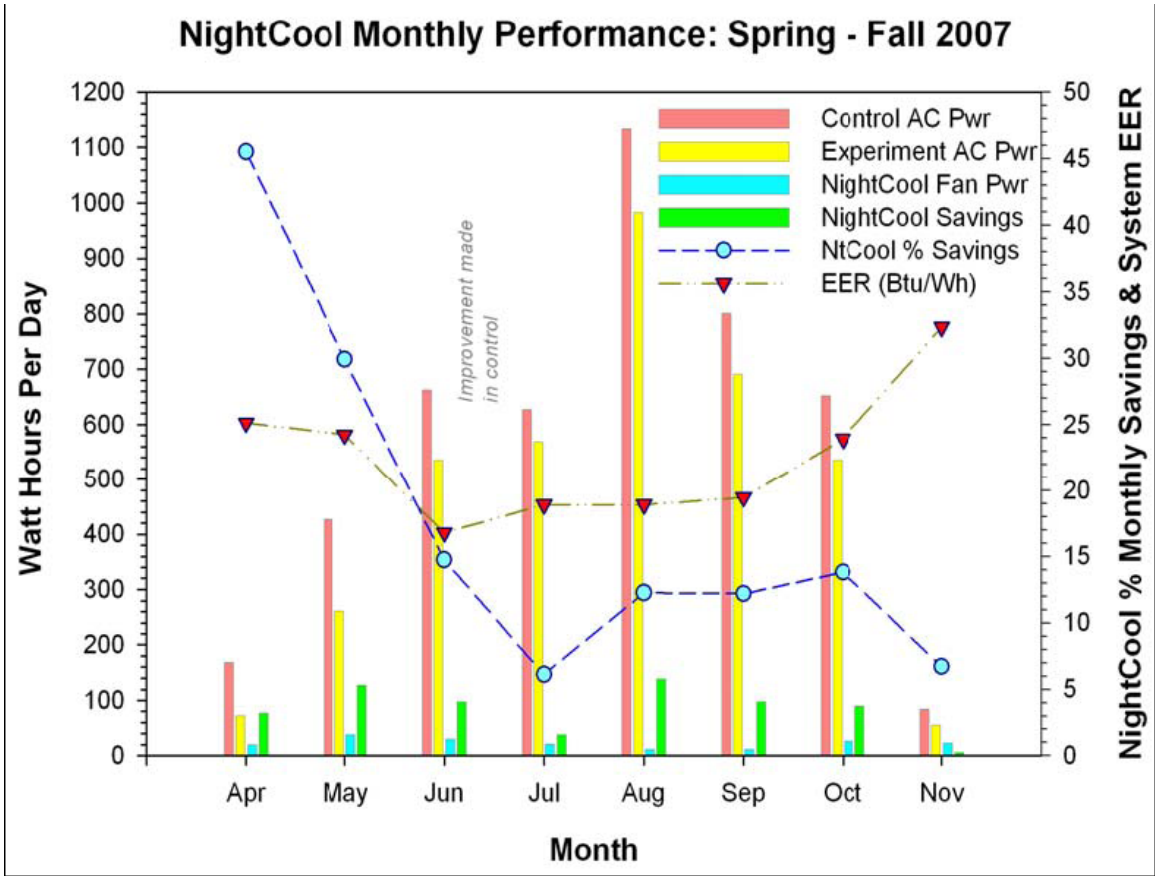

Figure 1- 26

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.

Throughout 2008, experimental and analytical work continued on the *NightCool* concept, which concentrated on improving the dehumidification performance of the concept, as well as refining the operational configuration. During testing at the beginning of the third budget period, tests were completed in central Florida's winter conditions, which are comparable to the early spring conditions in much of the U.S. Since cooling needs were non-existant at this time, more difficult dehumidification conditions prevailed. However, a major improvement to the *NightCool* building was accomplished when a solar dehumidification system was implemented.

In February 2008, the team ventilated the attic in the experimental building based on the difference in the ambient-to-attic humidity ratio. Moisture was also released into both prototype buildings according to ASHRAE Standard 160 to simulate occupancy. Although during the Florida winter conditions there were no reductions to the air conditioning in the control, the solar dehumidification system in the experimental building helped it to maintain a significantly lower relative humidity rate than the control building. The control building's average relative humidity in February reached 65.6%, while the *NightCool* building's averaged only 59.6%. In March, the experimental building maintained an average interior relative humidity that was 8% lower than the control building (61.6% vs. 53.7%).

During the third budget period, a number of operational configuration changes were made to the system. Changes made during the May and June 2008 testing periods include:

- Fan upflow arrangement changed to improve flow characteristics
- Evaluated specific moisture absorption of desiccant pack versus moisture-absorbing wood fiberboard. These both were compared to plywood and altered to a wood-based moisture absorption scheme.
- Altered *NightCool* control set points to optimize performance
- Changed the roof of the control building to a white roof so that the savings achieved for *NightCool* can be readily differentiated from the roofing system itself
- Created a flow pattern to distribute the heated air over the roof and verified its operation with overhead infrared thermography

Based on an engineering reevaluation, FSEC researchers John Sherwin and Danny Parker made more modifications to the system's operational configuration for July's testing results. Modifications were made to the datalogger programming responsible for the automated operation of the *NightCool* building system, and an attic ventilation hatch was installed in an effort to improve interior humidity levels.

Table 1- 2 *Energy Use Pre and Post Installations of Energy Monitors*

Average Annual Savings Generated Monthly by NightCool Concept in 2008	
April	15%
May	19%
June	16%
July	11%
August	7%
September	10%

Once testing began during the spring conditions of central Florida, the weather conditions reflected those of early summer for most of the U.S. August was deemed the least advantageous month for use of the *NightCool* concept and produced an average savings well below the rest of the months', even with the white roof on the control (2.8 kWh per day vs. 3.0 kWh/day). In September, savings in the *NightCool* building were not as low as August's results, but were still proof that September was another non-advantageous month for use of this concept. The average interior humidity of the experimental building still remained 1.3% lower than that of the control in August and 2.2% lower in September. Throughout the summer, the relative humidity was consistently better in the *NightCool* building than in the control.

A full updated report on the 2007-2008 *NightCool* performance and latest innovations is available at: http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1771-08.pdf

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.

We hope to eventually test this within the *NightCool* project. This concept has the potential to provide combined heating, cooling and electric power production from a home's roof in a cost-effective and reliable fashion. However, due to the need for long-term testing of the current configuration, no further results on this task are anticipated until 2010.

1.11 Related Systems Research: Solar Water Heating

Because of federal, state and local utility incentives, solar water heaters are being installed in significant numbers across the nation. It is an excellent way to save energy on water heating and whole house energy to meet the BA program goals. A test facility is currently being constructed at FSEC in Cocoa, Fla., to test seven side-by-side systems (Figure 1-27) and compare the energy performance of different types of solar and conventional water heaters, as well as their time-of-day electric loads. Another objective of this side-by-side testing is to enhance and validate simulation models for solar water heating systems, particularly the integrated collector and storage (ICS) systems.

The three solar collectors have been installed (Figure 1-28), and the tank and tankless systems are also procured and plumbed inside the test shed (Figures 1-29 and 1-30). The types of systems being set up for testing include a standard 50-gallon electric unit, flat plate PV-pumped direct solar water heating system, flat plate differential-controlled direct solar water heating system, integrated collector storage (ICS) system with a standard 50-gallon electric tank for backup, tankless gas water heater, a conventional gas water heater, and a tankless electric water heater. All systems should be operational by early 2009. This work complements similar research done at NBS (now NIST) and FSEC in the 1980s.

Figure 1- 27. *The FSEC DHW Test Facility*

Figure 1- 28 *The solar collectors, with the ICS system in the rear top*

Figure 1- 29 *One half of the tanks inside the test shed.*

Figure 1- 30. *The other half of the tanks in test shed.*

1.12 Full Scale Testing of Innovative Condenser Fan

Over a two year period (2003-2005), FSEC tested potential enhancements to outdoor unit AC condenser fans by altering its shape and aerodynamic characteristics. Optimized fan blades were designed via a numerical flow simulation and fabricated using stereolithography. After several months of testing, the research produced a fan exhibiting greatly superior air-moving efficiency compared with conventional stamped metal blades.

The evaluation was performed on a standard three-ton *Trane* AC condenser. Measurements were made of condenser air flow, motor power, sound levels and condenser cabinet pressures. The developed prototype fan substituted on the original condenser reduced electric power by 25% (48 Watts) with slightly higher condenser air flow. Air moving efficiency (cfm/Watt) was increased by 35%.

The patented technology is being tested at FSEC's Manufactured Housing Lab by substituting the innovative fan system for one which had very detailed AC unit baseline performance obtained in 2007. All instrumentation is currently installed and a full summer of baseline data is available. FSEC renewed interest in the technology from a major U.S. AC manufacturer *(Trane Company* which is now a subsidiary of *Ingersoll Rand Group).* The change out was done on July 29,2008, with a measured 70 - 100 Watt drop in the fan motor assembly power.

Original blade, Standard motor, Standard top:

-16.2 Pa cavity pressure (avg), 238 Volts, 0.8 Amps = 190 Watts

5-bladed efficient fan, ECM motor, elongated diffuser:

-16.0 Pa pressure (avg), 238 Volts, 0.4-0.5 Amps = 95- 120 Watts

We measured at least a 70 Watt (37%) reduction in measured outdoor unit fan/motor power. This was quite consistent with what we measured in the lab three years ago.Data in the MHLab since the change out has verified that maximum machine power is about 70 Watts lower than it was previously. Condenser air flow was measured to be the same if not slightly greater.

Task 2: Prototype House Evaluations and Involvement

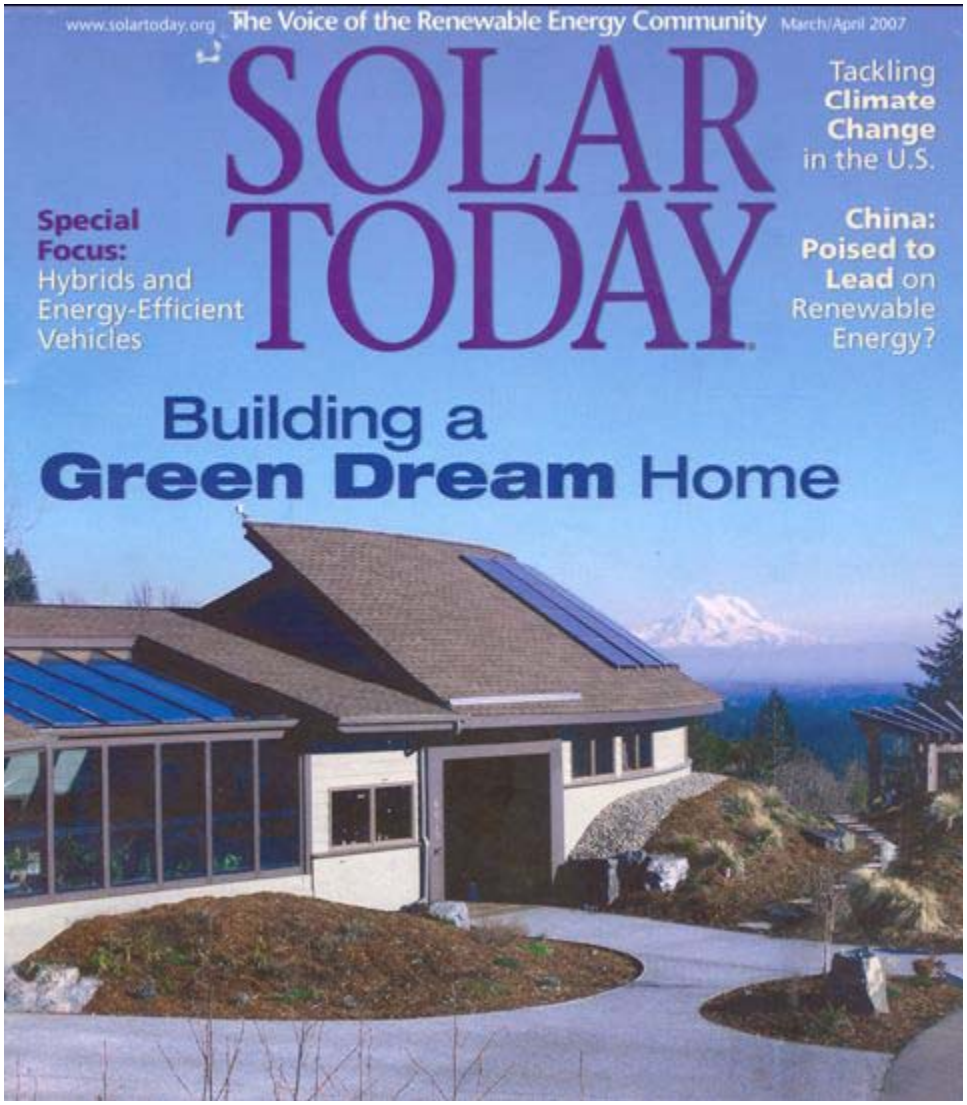

Figure 2- 1 *Garst Residence – Olympia, WA, as featured in Solar Today*

2.1 Prototype House Involvement and Evaluations

In this section we document our efforts in providing design and technical assistance. 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. BAIHP continues to support demonstration home projects and were active in the 2007-2009 International Builders' Show.

2.1.1 Prototype Homes

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

<u>Armed Forces Foundation (AFF)</u>
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.*

Throughout 2008, the BAIHP team continued contract support for the purchase and installation of PV arrays and provided assistance with utility interconnect agreements for Cambridge II and Fountains of Millenia. We also provided continued support through energy estimates for upcoming Atlantic multi-family projects and prepared datalogger instruments to compare tankless and standard gas water heater systems in a three-bedroom unit at Cambridge Cove II that includes hydronic space heat.

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. Furnival Construction has three SIP homes planned, but has not made any new developments as of BP3.

Brownsville Affordable Housing Corporation

New BAIHP partner, the City of Brownsville, TX's Brownsville Affordable Homeownership Corporation (BAHC) plans to build energy efficient houses and registered as one of the pioneering Builders Challenge builders. 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 November 2008, 14 homes have been built. Nine homes have met the HERS Index requirements of the U.S. Department of Energy's Builders Challenge.

CPS Energy – Woodside Homes, San Antonio

CPS Energy, the municipal electric and gas utility in San Antonio, TX, is working with Woodside Homes to build and test three side-by-side homes with identical floor plans of approximately 2,000 sq. ft. One will be the base case, the second will be energy efficient with a HERS Index below 60, and the third will utilize solar power with a 2.4 kW PV array and a HERS Index below 40. In response to an invitation by CPS Energy, BAIHP will provide monitoring and other technical assistance to this important project – the results of which may lead to utility incentives for energy efficient and solar homes in CPS territory. BAIHP team members participated in a site visit and meetings in San Antonio on October 2-3, 2008, which included a presentation to about 20 CPS Energy employees, builders and subcontractors on October 3.

BAIHP researchers visited San Antonio again later in 2008 and have completed all pre wiring for the three homes.

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. This activity was completed in 2007.

Figure 2- 3 *Construction Detail* *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 in 2006 and 2007.

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.

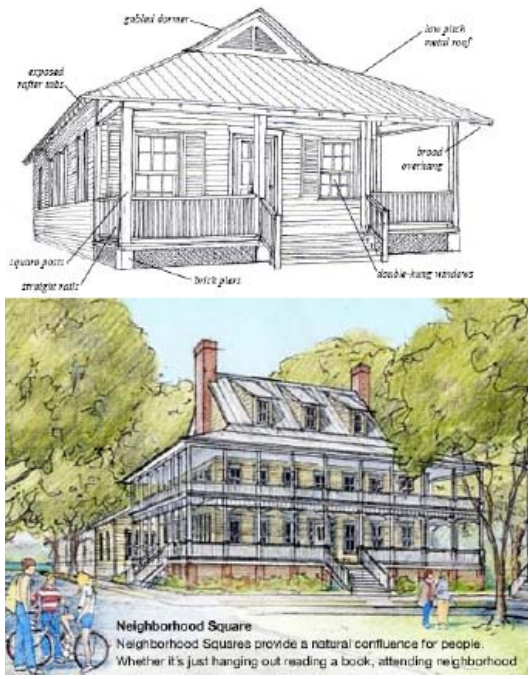

Figure 2- 4 *Planned Development in East Bay, FL*

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.

In 2008 the East Bay project was moth balled due to the severe decline in new home construction activity in Florida.

Dog Park, Ruskin, FL
This is the newest project (and partner) as of 2008. The Building America partner is Structural Engineering and Insprections, Inc.(SEI) located in Lutz, FL. SEI are the structural engineers for the project and requested design and systems assistance from BAIHP for a new zero energy home construction project. Calcs-Plus(BAIHP subcontractor) are working closely with this project as they are located within close proximity to the home site in Ruskin, FL._It will be a modest sized home with a detached garage/workshop that will hold the PV as the home will be located under shade trees. Very cooperative owner and architect. The owner is a vet who created this dog park for dog owners and this is to be the new caretaker's home as the existing home is being

removed as it has been destroyed by termites. The home is currently in the design stage. This home will also be featured in FSEC's Achieving Zero Energy Homes Webinar Series.

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- 5 ***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.

In 2008 BAIHP continued collaborations with FAS to develop an initiative on high performance manufactured homes. This effort is in the planning stages as of BP3.

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- 6 *Elevation for Ferrier Builders prototype home in Dallas, TX*

However, this home did not progress beyond the design stage.

In 2008, we continued discussions with Ferrier builders on a “dark green” development of several homes called “Rheudasil Farms” in Flower Mound, TX in the DFW metro area. A site visit and discussions were conducted on December 16, 2008.

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.

No activity on this project in 2008

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 Icynene™/ 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 ACH_{50}.

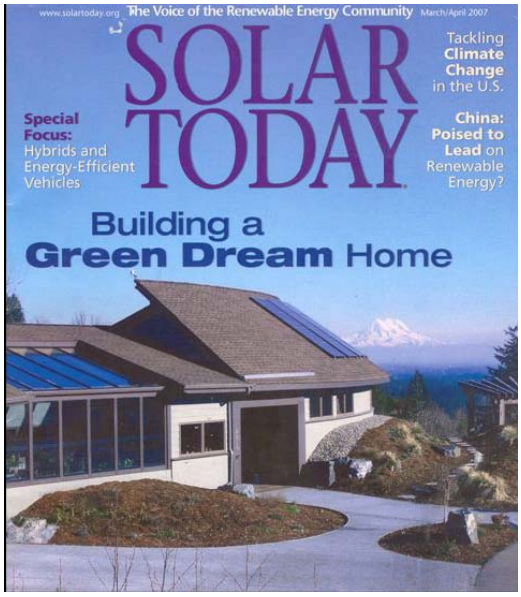

Figure 2- 7 *Garst Residence – Olympia, WA, as featured in Solar Today.*

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.

No activity in 2008.

Holiday Builders

This builder, based in Melbourne, FL, became a BAIHP partner in late 2007. The builder expressed interest in pursuing high performance and green strategies for upcoming homes and communities. FSEC staff provided energy analysis, recommendations, load calculations, duct design, and envelope/duct testing to support as they constructed their first ENERGY STAR homes in central Florida. Team members also met with Holiday corporate staff to discuss future partnership opportunities in Florida, as well as in other states. Energy analysis was provided for select home plans that may be built in South Carolina.

One highlight of this activity was assisting with the finalization and certification of Holiday Builder's first green / Energy Star home. The 1904 sqft, 4-bedroom home was certified by the Florida Green Building Coalition and received a HERS Index of 73. It was showcased during a local parade of homes and included educational material inside the home. The home sold before the parade, and the builder reports that it is the first home in more than one year that they did not have to discount the price to make the sale.

Figure 2- 8 *Holiday Builders Green Showcase Home*

Homes by Point

This Building America partner is a custom home builder in Tampa, FL that builds over 50 homes a year. 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.

In 2008 BAIHP team members also performed preliminary ratings on two more homes and provided load calculations for both homes prior to TBIC and FGBC inspections. Upon inspection, only one of the homes required modifications.

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.

No activity in 2008

Lifestyle Homes
Lifestyle Homes is planning to build a community of 40% or better homes in Melbourne, FL. They became a BAIHP partner in the summer of 2008. We provided them options to build homes with HERS <60 and provided sources for solar water heaters. They are planning to build their first Building America home in 2009

Louisiana System Built Homes
Louisiana System Built Homes is based in Lafayette and wishes to achieve ENERGY STAR and Green Building standards. In 2008 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.

Marc Rutenberg Homes, Trinity, FL
This BAIHP partner joined the team in 2008. This builder is interested in applying zero energy principles to larger, more upscale residences. BAIHP assisted with the energy analysis of the builder's first set of plans and helped enhance these designs to achieve energy savings of 50% and 70%. Home did not progress beyond design stage.

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 – 2008 BAIHP has been involved with PV, lighting and whole house indoor air quality design recommendations.

Figure 2- 9 *Weather tight and insulated crawlspace*

Figure 2- 10 *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 continues to work with this builder and assists in energy rating testing and inspections for the homes.

Figure 2- 11 *Back view of Marquis Construction home in Dade City, FL*

Figure 2- 12 *Testing Marquis Construction home in Dade City, FL (HERS Index 62)*

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.

Palm Harbor Homes

FSEC staff assisted Palm Harbor Homes in 2008 to help them develop a standard package of features that, when combined with some customer-selected options, will enable all homes to comply with green building standards. The BAIHP team also completed analysis of the homes built by the partners for the 2008 International Builders' Show to verify that these homes meet the U.S. DOE's Builders Challenge requirements –

a HERS Index score of 70 or below. These analyses also included runtime ventilation strategy with a compressor-activated motorized damper.

BAIHP also evaluated the plans for and pre-rated three new models to meet ENERGY STAR and FGBC standards and conducted IR scans of two model center homes – one with BASF foam and one with standard insulation. Periodic inspections of the buildings were conducted as well in an effort to incorporate TBC into the plant production of these modular homes.

In addition to these five buildings, BAIHP also reviewed FEMA home plans and specs to ensure ENERGY STAR ratings and qualification for Builders Challenge. The FEMA homes were also inspected for TBC compliance, and analysis reported some insulation problems.

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, 2,021 ft^2 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.

The 2008 PATH Concept Home is a HUD-Code home to be built in Charleston, SC. The project is being managed by Newport Partners, a HUD contractor. 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.

Due to the weakened real estate market, this project was placed on hold as of June 2008.

Figure 2- 13 *2008 PATH HUD Concept Home near Charleston, SC.*

Figure 2- 14 *2007 PATH concept home in Omaha, NE.*

Rainier Construction

Rainier Construction was welcomed as a 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 foundation and 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. Final testing of the home was conducted November 2008 resulting in HERS Index of 65. Home is occupied and BAIHP assisting with minor performance issues relating to the tankless water heating system/s.

Figure 2- 15 *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- 16 ***Royal concrete concepts modular section***

Figure 2- 17 *Structure & chase details*

In December 2008 a factory visit was conducted by FSEC researchers to plan for a new task on high performance concrete walls to be initiated in 2009.

Schackow Development and Trunnel Homes

Schackow 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.

These two prototype homes were completed in 2008, with extensive monitoring already conducted on the near zero energy home, since it was sold months before the ZEH was completed which remains unsold as of end of 2008. Each home was equipped with a TED energy feedback device to help the owners monitor the performance of their homes.

The results from the NZEH have been outstanding for the summer months. Total home energy use – without taking into account the solar energy production – averaged only 10.8 kWh per day during the hot, humid Florida summer months. Most homes in Florida use an average of 60 kWh each day during the summer. During July, and including solar energy production, average net daily energy use was 1.04 kWh per day, which is extremely close to zero energy, making this home's performance even more impressive

during the hot summer month. Impressive results also ensued during August and September. During these hot, humid summer months, the NZEH netted an average daily energy use of 4.9 kWh per day in August and 4.5 kWh per day in September. Even more impressive is the small amount of air conditioning energy consumption – 7.7 kWh per day in August and 5.9 kWh per day in September. These are remarkable results for Florida's hot, humid summer conditions.

The solar water heating system has provided more than 90% of the water heating needs with back up electrical production needed only occasionally (0.2 kWh/day). Air conditioning consumption has averaged only 3.8 kWh per day—remarkably low considering the 21 kWh/day average for typical housing in this month.

Figure 2- 18 ***Zero Energy and Near Zero energy Community Prototype Home, Gainesville, FL***

Schroeders Homes

In June 2007, BAIHP accepted and welcomed Schroeders Homes as a BAIHP partner who is building a zero-energy concept home in North Point, FL. We performed Energy Gauge simulations, installed data logger instrumentation, and began monitoring the energy use of this high performance home prior to the installations of the PV array to compare pre-PV energy use data against post-installation data. 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.

Data collected throughout the summer and fall of 2008 (June-October) showed that the 3.2 kW PV array on the home contributed between 25% and 28% of the electricity used to power the home, and achieved efficiency rates between 9.1% and 9.3% solar conversion. Daily hot water consumption for this household of six averaged between 112 and 150 gallons per day, with the solar thermal system limiting the auxiliary heating element to 3-7.5 kWh per day.

Selkirk Homes, ND

In BP1 and BP2 BAIHP finalized ENERGY STAR ratings on (4), phase IV homes and mailed certificates.

BAIHP also submitted analysis of (6) phase V homes including EPACT06 tax credit qualifications, however, Selkirk Homes decided in May 2007 not to apply for new home tax credits.

No activity in BP3

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 Built Homes NZEH Prototype

BAIHP provided assistance to Stalwart Built Homes as they designed 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. Homes in Callaway Corners 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.

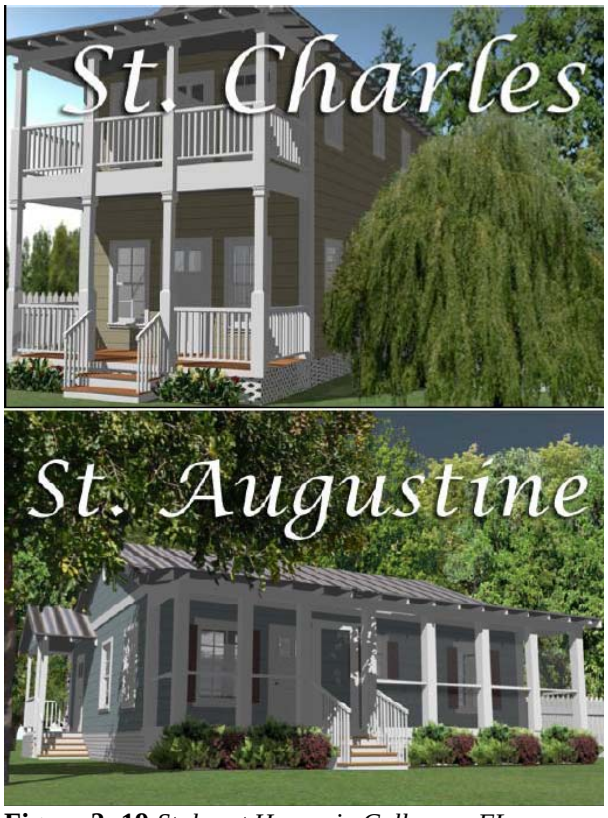

Figure 2- 19 *Stalwart Homes in Callaway, FL*

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.

As of 2008, Stalwart Homes has constructed their first NZEH Prototype. The 1371 sqft, 3-bedroom modular home features a 3.6 kW PV system, a geothermal heating/cooling system with desuperheater for water heating, and a high performance envelope. The house was manufactured by Nationwide in Cordel, GA and was delivered to the Callaway Corners Community in Callaway, FL. 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 the two-story high performance PV home (Nashville model) while the home was in the factory.

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.

Figure 2- 20 *Stalwart NZEH in Calloway, FL*

Once the home was completed on site, BAIHP assisted with the final rating, performance testing, and LEED for Homes Platinum certification. The home received a HERS Index of 26. Also, instrumentation was completed and data collection is ongoing. The home is currently occupied by a single person.

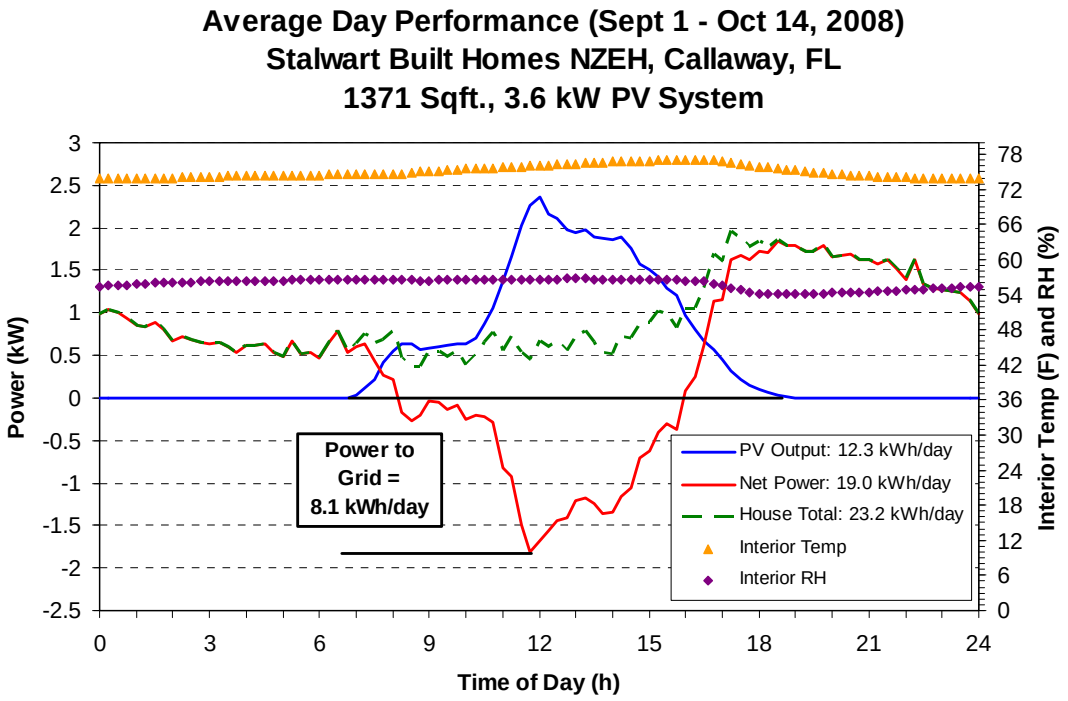

Figure 2- 21 *Performance of Stalwart Built Homes NZEH*

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- 22 *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.

No activity in 2008.

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 the $2,000 tax credit (50.6%).

Data collection was discontinued in the fall of 2008 as the model home remained unsold and unoccupied.

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- 23 *Sierra Lakes, Wesley Model*

Figure 2- 24 *Steel trusses produced on site*

Florida H.E.R.O. Activity

The very significant activities of FLHero in the Gainesville, FL area and elsewhere is summarized below.

- *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.
- *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. Also performed TBIC on first BA home.

- *GW Robinson Builder* – Gainesville, FL – Ongoing meetings with staff and various contractors to review specifications and improve information flow. Commissioning of multiple homes and completion of TBIC's. Performed design reviews and multiple tax credit reports.
- *Tommy Williams Homes* – Gainesville, FL – Ongoing site visits for QA and commissioning of multiple homes, completion of TBIC's and multiple tax credit reports
- *On Top of the World* – Ocala, FL – Multiple tax credit reports
- *Pringle Development* – Mt. Dora, FL – Review and discussed issues associated with the introduction of outside air and bringing air handlers into thermal envelope of the homes, as well as its impact on achieving a level of performance required to qualify for the federal tax credit. Ongoing site visits for QA, commissioning of multiple homes and completion of TBIC's
- *Trunnel Construction* – Gainesville, FL – Multiple site visits and met with representatives from Icynene on site to develop strategy to deal with higher than expected whole house infiltration rate. Began process to certify homes under Builders Challenge labeling program
- *Sutton Family Homes* – Newberry, FL – Introduced BA systems approach, provided design review and recommendations. Prepared Manual J, D and FL Energy Code form.
- *Tom Stephens Construction* – Melrose, FL – Commissioning of this custom home which has a 1.4 kW PV system designed to provide emergency power for select circuits
- *Norfleet Construction* – Newberry, FL – Design review, TBIC and commissioning. First BA home achieved HERS score of 67 and qualified for federal tax credit
- *Wright & Van Custom Homes* – Newberry, FL – Introduced to BA systems approach and provided multiple design reviews. Builder's first BA home met Builders Challenge with E-Scale score of 70, and received tax credit certification
- *Emerald Ventures* – Gainesville, FL – Introduced to BA systems approach and provided initial design review
- *Florida Certified Contractors* – Gainesville, FL – In process of building modular house plant in North Florida area. Provided ongoing consultations to review/develop component specifications. Conducted performance and diagnostic testing to identify opportunities to enhance the operational efficiency of the product.

Initial consultations to introduce builders to the BA systems approach and ongoing consultations were provided to the following builders:

- *Edinborough Development Corp.* – Gainesville, FL
- *AllWallSystem* – LaCrosse, FL
- *Weeks Construction* – Gainesville, FL
- *WD Moore Construction* – Keystone Heights, FL,
- *Real Building* – St. Petersburg, FL
- *Smoak Construction of Central Florida* – Williston, FL

- *Anderson Construction & Design* – Keystone, FL
- *Daybreak Equity Corporation* – Ocala, FL

Other Prototype Design Assistance:

- HVAC design was completed on Florida's Showcase Green Envirohome. This demonstration home aims to educate the public on how rebuilding after a hurricane can be done in a green and sustainable fashion. The project plans to utilize unique small capacity DC air conditioners that are powered by dedicated PV systems.

- 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 ft^2 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 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 partner, Deer Valley Homes. This HUD/modular builder is based in Tampa, FL with two plants in Alabama.

Long Term Instrumentation and Monitoring Projects

In addition to the monitoring efforts described above, the following additional activities were conducted.

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 standoff 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. The homes were not sold and BAIHP stopped monitoring activity in 2007. No activity in 2008.

Figure 2- 25 *Homes with solar hot water and BIPV on detached garage (not installed yet)*

Chasar home, Cocoa, FL

BAIHP has monitored the Chasar (a BAIHP researcher) home in Cocoa, FL since 2006. 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. The home also had a white metal roof retrofitted to it.

Hoak Home

BAIHP is monitoring this three-story, 4,250 square foot BAIHP researcher 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

In 2008 BAIHP installed monitoring equipment in the LousianaHouse demonstration home (http://www.louisianahouse.org/) being built on the LSU campus under the direction of Professor Claudette Reichel.

Figure 2- 26 *Louisiana State University's Louisiana House demonstration home*

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).

2.1.2 Gulf Coast Affordable High Performance Prototype Homes

The primary objective of this subtask is to make a direct contribution to ensuring that affordable housing constructed in areas affected by hurricanes Katrina and Rita is highly energy efficient, durable, and provides good indoor environmental quality. The primary strategy to achieve this objective is to encourage builders and developers to embrace the system engineering principles and efficiency goals of the Building America program.

Many groups are organizing efforts to construct new housing in the Gulf Coast area. These groups have been successful in soliciting funds and other donations, but tight budgets and risk aversion in the face of overwhelming need still limit the energy performance that is being delivered. Many of these projects will only construct houses to minimum building code requirements or focus only on particular aspects of energy efficiency. BAIHP will work with a limited number of the non-profit groups working in the affordable housing arena to raise the performance level of the new homes they produce in the Gulf Coast. These groups include Habitat for Humanity affiliates in the region and others as opportunities arise. Through hands on involvement in the design, construction, and testing of a small number of prototype affordable houses, BAIHP will be able to teach the systems engineering process while mitigating the risk associated with change by validating the performance. These prototypes will aid BA in directly demonstrating quality construction methods to builders in the region. To ensure project replicability, BAIHP will concentrate on strategies that builders can adapt to any new affordable home (e.g. tight ducts, right sized a/c). Tours, case studies and workshops will be conducted as discussed in the Project Replicability section below to encourage and train other builders to adopt BA practices.

While progress in Gulf Coast reconstruction has been slow, it is gaining momentum and the time available to influence construction practices is short. This short window of opportunity and the potentially significant benefits from using Building America practices in constructing even a portion of the large number of homes urgently needed in the Gulf Coast warrant a unique approach. This Subtask authorizes BAIHP to use strategies not normally pursued in the Building America program. Specifically, BAIHP may contribute or offset the cost of 1) more energy efficient equipment than would otherwise be specified, 2) components that reduce heating and cooling loads, and 3) energy efficient construction materials. These contributed items will be limited to those necessary to supplement standard construction in the pursuit of the 30-40% Building America benchmark savings for a small number of homes, subject to the restrictions and requirements specified below.

At this point, four Gulf Coast Habitat for Humanity affiliates are participating in this initiative: Mobile, Alabama; Baton Rouge, Louisiana; Slidell, Louisiana; and New Orleans, Louisiana. For more information on this subtask, please see *Subtask 4.1 Habitat for Humanity Partnership.*

Task 2.2 2008 International Builders' Show Homes (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.

Figure 2- 27 *2008 The New American Home*

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. 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 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 2008 BAIHP provided assistance to the following homes:

- ***Two 2008 PHH Professional Builder Show Village Homes*** - provided information on green products and HVAC design as well as QA inspections and specifications review, developed "green tags" highlighting green features within the homes; coordinated NAHB Green Home Certification pre-qualifications and conducted Florida Green Home certifications; conducted thermal bypass inspections and Builders Challenge Quality Control Criteria.
- ***Two 2009 PHH Professional Builder Show Village Homes*** – provided Manual D and Manual J load calculations, reviewed HVAC testing and made recommendations, conducted thermographic survey, and verified current equipment certification; coordinated NAHB Green Home Certification pre-qualifications; conducted thermal bypass inspections and Builders Challenge Quality Control Criteria.
- ***The Vision House Orlando*** – completed Florida Green Home certification, installed monitoring equipment for ongoing data collection, and provided testing for four HVAC systems, total building power use and interior temperature and relative humidity
- ***2008 The New American Home*** – assisted IBACOS with construction documentation and home performance testing and installed monitoring equipment; conducted first NAHB Green Home Standard Scoring Analysis

In 2007, BAIHP provided assistance to the 2007 Single Family PHH Show Home by providing HVAC recommissioning, 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). FSEC staff developed "green tags" which were applied to the show homes and highlighted the green features within each home.

Figure 2- 28 *Glen Cairn – PHH "Comfortably Affordable" Showhom*

The Glen Cairn "Comfortably Affordable" home was acquired by Stalwart Built Homes and was relocated to the panhandle. After a few efficieny improvements to the HVAC system, the home was outfitted with a PV system to bring the home to zero energy.

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

2009 PHH Professional Builder Show Village Homes

For the 2009 International Builders' Show, being held in Las Vegas, Palm Harbor Homes is building four modular homes in their Arizona factory. BAIHP has already provided technical support for two of the homes by developing preliminary Manual J Heat Load calculations, touring the Arizona plant to identify opportunities for product improvement, reviewing duct blaster testing and methodology, and verifying current equipment certification. Team members also toured the retail model center and conducted a thermographic survey to identify defects in the thermal envelope.

Figure 2- 30 *Tularosa – Media Enhanced*

Figure 2- 31 *The Deschutes – Quiet Living*

2008 Vision House

The Vision House Orlando, a 2008 IBS show home, was built in Lake County. Sponsored by Green Builder Magazine, the home showcased a high performance, systems engineered design, and included many green features. BAIHP subcontractor Calcs-Plus assisted in designing and testing the duct system and performing various ratings and inspections resulting in a HERS Index of 60. BAIHP staff performed inspections required for the home to achieve green certification from the Florida Green Building Coalition.

Figure 2- 32 *Vision House 2008*

The 6694 sqft home is constructed of SIPS and contains 4 heat pump mechanical systems, each with hot-gas reheat style advanced dehumidification control. Monitoring equipment was installed by BAIHP to monitor HVAC power, total building power, and interior conditions. Data collection is ongoing, and the house is currently occupied by two persons.

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"*

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.

Figure 2- 33 *2008 The New American Home*

Figure 2- 34 *Solar water heater on TNAH 2008*

2008 Tradewinds Home

This is another custom 2008 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- 35 *7,316 square foot 'Tradewinds' home for 2007 IBS Builder Magazine*

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.

Figure 2- 36 *3,397 sq. ft. Palm Harbor Homes, t he Bellaire – 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.

Figure 2- 37 *Palm Harbor Homes, the Bellaire GenX relocated to Siesta Key in Sarasota, FL*

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- 38 ***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)

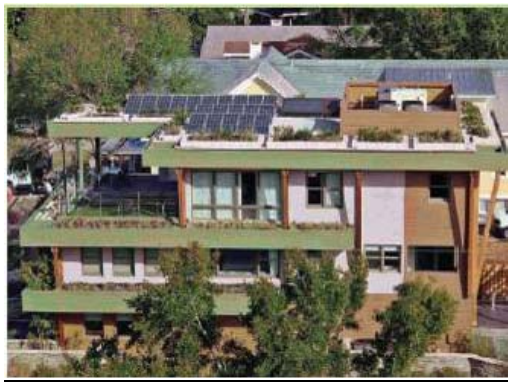


Figure 2- 39 *TNAH (with the Renewed American Home roof in background)*

Figure 2- 40 *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- 41 *2,865 sq. ft. Palm Harbor Homes, the Bellaire –Move up Buyer*

Subtask 2.3 Prototype House Evaluations for Other BA Teams

In 2008, FSEC hosted Building America-monitored data Web sites at the request of other BA teams. The BA teams were responsible for installing the data acquisition systems, while FSEC acquired, archived and displayed the data from BAIHP and non-BAIHP monitored sites on the web. During this budget period, FSEC has assisted with a datalogging site for BSC and also assisted with implementing a new channel map, creating new graphs, and reprocessing old data for the IBACOS PRB project at the Broad residence in Henderson. In total 4 IBACOS sites are active. We are also collecting data for the two ORNL zero energy Habitat homes in Tennessee.

Task 3. Community Scale Developments

Figure 3- 1 *Two Tommy Williams Homes*

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

Figure 3- 3 ***Brotherton 13th Ave Bungalows by ScottHomes, Olympia, WA***

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

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 (Table 3-1) are building high performance homes on a community scale. The homes in italics are located in the Marine climate zone.

Table 3-1 *BAIHP Community Scale Builders*

Builder	**Location**
Castle & Cooke	Winter Garden, FL
G.W. Robinson Builders	Gainesville, FL
HKW Enterprises	Apopka, FL
On Top of the World	Ocala, FL
Pringle Development	Eustis, FL
Stalwart Built Homes	Panama City, FL
Tommy Williams Homes	Gainesville, FL
Ft. Lewis Army Base	*Ft. Lewis, WA*
Scott Homes	*Olympia, WA 14*

Table 3-2 compares the total number of high performance homes built by BAIHP builders in 2007 and 2008. The HUD code numbers are for the NEEM (Northwest Energy Efficient Manufactured Homes) program led by the Oregon Department of Energy.

Table 3-2 *High Performance homes by BAIHP builders*

	2007	2008 (through November)
Hot-humid Climates (site built and IBS show homes)	284	118
Marine Climates (modular)	151	0
Habitat for Humanity (all climates)	35	47
HUD code (NEEM homes)	3,718	2,926

The dramatic slowdown in the new housing market in 2008 is evident in the table above. The Habitat numbers are up because of the 30 Jimmy Carter Work Project Homes in the Los Angeles, Ca. area we finished certifications for in 2008. The NEEM program has slowed down some but not as much as site built homes.

3.1 Hot Humid Climate Communities

This section describes in case study format the BAIHP work done in partnership with builders that are buildings high performance homes on a community scale. It includes two extensive case studies created in early 2007 (and updated in 2008) 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 improve the performance of homes even further. As of late 2008 they are including tankless gas water heaters and radiant barriers as standard items.

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 apublic 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, Deputy Assistant Secretary from the DOE***

Three other hot-humid climate builders have built over 200 high performance homes. FLHERO worked 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 (Data as of March 2008):

CobbleField –	Build out 265 homes,	263 completed
Turnberry Lake –	Build out 186 homes,	88 completed
Garison Way –	Build out 110 homes,	42 completed
Total –	Build out 561 homes,	393 completed

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.

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.

All of his homes are individually tested and rated. 123 recent vintage GW Robinson homes were analyzed for this report. They have a HERS Index between 59 and 69 (averaging 65) and Building America Benchmark (2008 version) savings range from 31% to 44%. As calculated by EnergyGauge USA (v.2.7.03), over 25% of G.W. Robinson homes achieved savings of 40% or higher.

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 3-3. 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 3-3 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- 3 *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*

Note: Cost Difference shown in this table is relative to Typical practice NOT Benchmark				
Category	Typical Specs	BA Specs		Incremental Cost
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.

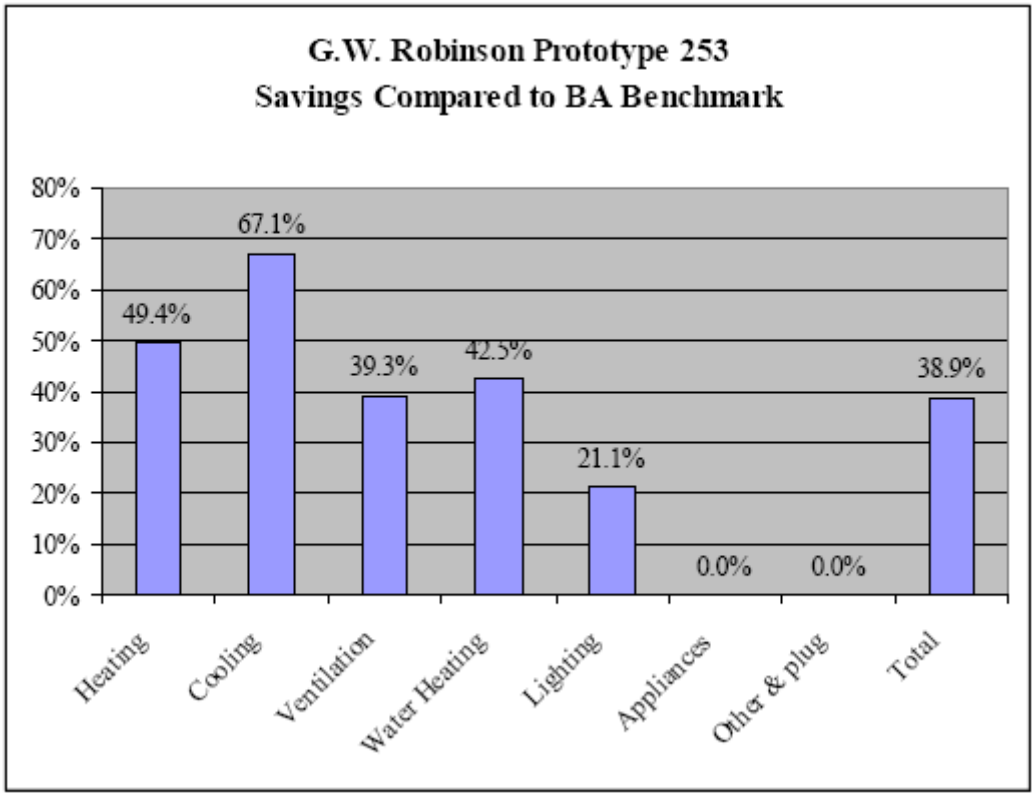


Figure 3- 10 ***Source energy end use savings***

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

Figure 3- 11 *Exterior walls around air handler isolate closet from garage, create valuableconditioned 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.*

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.

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 Octoborate 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 then 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: 275 Completed: 94 (thru march 2008) *(Total Community Build out: 500. 275 lots allocated to a non-Building America builder.)*
Belmont - Build out: 151 homes Completed: 45 (thru March 2008) *(Total Community Build out: 191. 40 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 salescomparison with the other builder (purple sites) in this community, see next section "Energy Efficiency andCost 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***

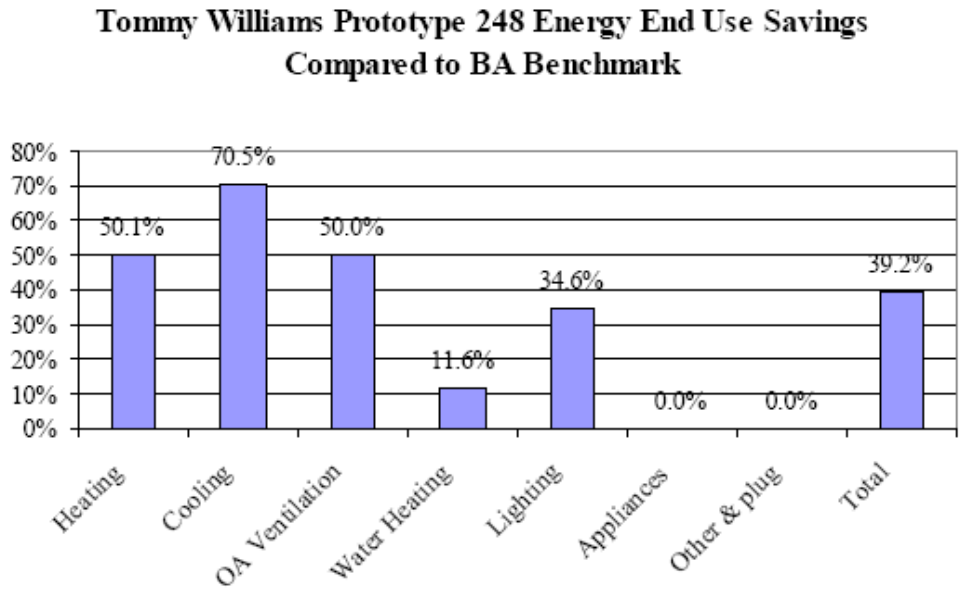


Figure 3- 17 ***Estimated annual source energy savings by end use. Note significant reduction in heating and cooling energy use***

Table 3- 4 *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*

Note: Cost Difference shown in this table is relative to Typical practice NOT Benchmark				
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 3-4, 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 subcontractor 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.

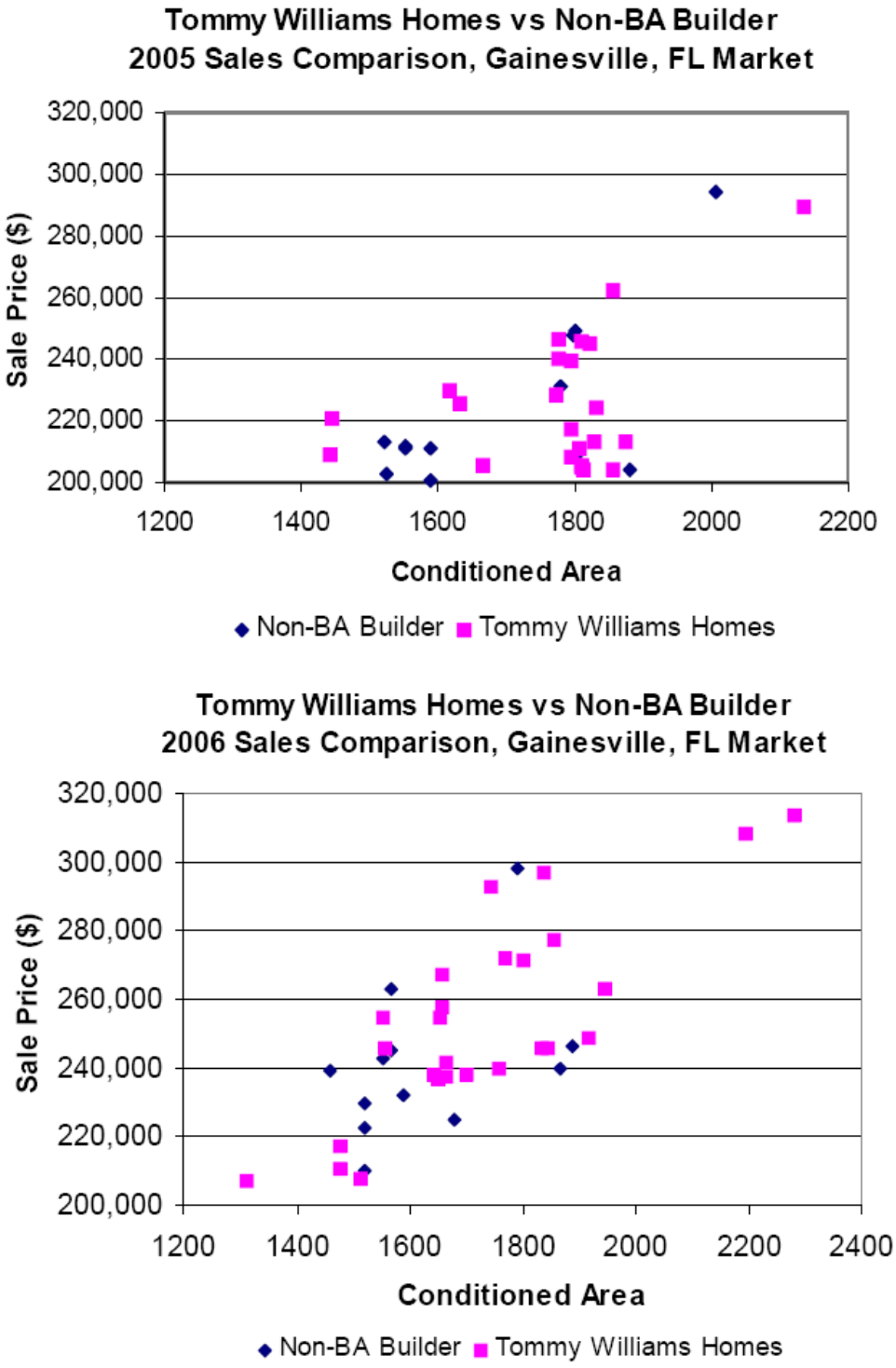


Figure 3- 22 *Sales data for Tommy Williams (squares) and non-BA builder in same subdivision (diamond)for 2005 (top) and 2006 (bottom).*

Tommy Williams Homes has expended significant effort and funds in sales and marketing, such as frequent newspaper and magazine advertisements; so that prospective home buyers are attracted to the model and can then talk to knowledgeable sales personnel about the homes' features. Particularly noteworthy is the Tommy Williams Homes sales center at the Longleaf Village, where prospective buyers can see and experience the benefits of low-E windows, radiant barrier roof decking and better insulation through well designed interactive displays. These displays were developed by Mr. Todd Louis of Bosshardt Realty who ran the sales center from late 2006 through mid-2008. Longleaf Village is a community of 550 homes where two builders sell homes -- Tommy Williams Homes (TW) and a competitor who sells homes with nearly code minimum energy efficiency features. Both builders have equal number of lots to build on. In 2007, according to the public records, the competitor homes were sold at a lower price per sq. ft ($148/sq. ft.) than TW homes ($161/sq. ft.) – yet more TW homes were sold than the competitor in 2007. In an 18-month period starting in December 2006, 42 homes were sold by TW versus the 22 sold by the competitor. Earlier in 2006, before the TW sales center was revamped, the situation was reversed -- more competitor homes were sold than TW (40 vs. 26). This proves that it is not sufficient to incorporate the technical features alone. A significant sales and marketing effort needs to be made to increase the market share of energy-efficient housing.

Castle & Cooke - Oakland Park, Orlando, FL

BAIHP have continued to work with Castle & Cooke developers on for the first ten homes in the Oakland Park Development in Winter Garden, FL. There are 675 homes planned for this community with standard designs meeting 40% savings over BA benchmark and the Builders Challenge. The scope also incorporates FGBC certification and high performance features including unvented attics, ducts in conditioned spaces, high efficiency HVAC equipment and mechanical ventilation.

Figure 3- 23 ***Oakland Park, Winter Garden, Fl built by Castle & Cooke***

In 2008 construction on all ten homes was completed. The homes range from 1819-2340 sqft and HERS Index ranged from 59-65. While the majority of the homes are single family, two of the homes are duplexes. BAIHP partner Progress energy performed energy ratings and Energy Star certification, and BAIHP staff performed inspections and submissions required for Builders Challenge certification. A complete case study for this community will be developed in 2009.

Interior conditions were monitored in a sample of homes for a period during the summer of 2008. Results showed that the homes were able to maintain target temperature and relative humidity, even during the period when historic rainfall occurred during tropical storm Fay.

Figure 3-24 *Completed Castle & Cooke Home*

Figure 3-25 *Custom designed outside air filter box installed in each house*

Stalwart Built Homes

BAIHP has worked with Stalwart Built Homes to design and engineer a set of high performance modular home specifications. Stalwart has partnered with a number of modular home producers including Palm Harbor Homes and Nationwide to produce a number of different home styles and floor plans with these specifications. Builders "license" the product, and after receiving training and becoming a part of the Stalwart Builders Guild, offer the product to consumers.

Figure 3-26 *Eric Martin leads a Stalwart Builders Guild training*

More than 13 homes have been placed in various developments and scattered sites throughout the Florida Panhandle and northeast Florida. A few of the homes receive PV and strive for NZEH status, but most of the homes include the following common specifications: high-performance envelopes, unvented attics with ducts in conditioned space, vented crawlspaces with spray foam insulation in the floor, geothermal HVAC with desuperheaters for water heating, supplemental dehumidification, and high efficiency lighting and appliances. All homes have been receiving HERS Index below 70.

Figure 3-27 *Stalwart modular home*

BAIHP partner Calcs-Plus completes a load calculation and duct design for each home based on final location and orientation. Inspections and performance testing take place in the factory and on site to qualify the homes for programs including Energy Star, Builders Challenge, LEED for Homes, and Florida Green Home Designation. BAIHP staff provide training for builders guild members in both classroom and field settings.

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.

As of mid 2008 Florida Hero is no longer serving as the energy rater for On Top of the World.

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. However, Pringle has not implemented the outside air vent strategy as of 2008. So despite building homes to a HERS <70 level they have not yet received a builders challenge certificate.

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. In 2009, construction should resume in Fort Lewis.

Scott Homes in Olympia, WA also received BAIHP help in 2007 and 2008. WSU met with Scott Homes design and construction staff to assessing nine 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- 28 *Two Story Modular Housing Assembly,Ft. Lewis Army Base, WA*

Figure 3- 29 *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 3-5.

Table 3- 5

	# 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- 30 *Brotherton 13th Ave Bungalows by ScottHomes, Olympia, WA*

Figure 3- 31 *Infrared Image of Brotherton 13th AveBungalows*

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 and analysis on a 15 home PV and DHW "solar ready" community project is underway. The community's model home, to be built in late 2008/ early 2009, and be monitored shortly after, 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 and other WSU tasks can be found in Appendix C - Washington State University Annual Report.

3.3 Post Occupancy Evaluation of Building America vs. Non-Building America Homes

Achievement of Building America (BA) program goals including whole house energy savings targets and durability / comfort targets are initially based on simulation and builder feedback. The final stage of the Residential Integration Systems Approach calls for a final evaluation of performance targets in occupied homes. The purpose of this task is to investigate whether program goals are met based on actual utility bill analysis and home owner feedback. During Budget Period 3, BAIHP assembled a team consisting of BAIHP researchers, Florida HERO, BA Partner builders, the local utilities, and a local area Realtor, finalized a study methodology to conduct an evaluation of Building America and non-Building America homes in the Gainesville, FL market, where BAIHP has had considerable success. The team received study approval from the University of Central Florida Institutional Review Board in the Fall of 2008.

The overall recruitment process for participating homes is expected to begin January 1, 2009 and conclude May 31, 2009. BA Researchers are looking to recruit participants who own qualifying *study* homes (homes built in partnership with BA) and *control* homes (homes of similar size and age not built in partnership with BA). Working with the builders who are already partners in the BA program and their sales representatives, researchers will identify a group of candidate study homes that meet minimum qualifications for participation. Researchers would like to secure participation from at least 25 study homes built by each of two Gainesville, FL area BA partner builders (50 total homes), and therefore expect to identify and target at least 50 candidate study homes built by each builder (100 total homes), yielding a participation rate of 50%. At least 100 candidate homeowners of control homes within the City of Gainesville / Alachua County that meet the minimum qualifications for participation will also be identified. This process will be conducted with cooperation from an area Realtor. Although there are numerous potential control homes within the region that would meet the general minimum qualifications of the study, the intent is to identify control homes that are built according to "regional standard practice" and act as direct competition to the BA builder's homes in terms of style, location, targeted buyer, and price point. In the case of one BA Builder, competing homes can be found within the same multi-builder subdivisions as the BA homes. In the case of another BA Builder, since the BA homes are constructed in single builder subdivisions, competing homes will come from other, similar subdivisions. The local real estate industry knowledge, combined with information from the Alachua County Property Appraiser's database, will enable researchers to identify at least 100 candidate control homes directly comparable to the BA builder's homes. Researchers expect a 50% participation rate, and expect to secure participation from at least 25 control homes comparable to each of the BA builder\'s homes (50 control homes total). In addition to selecting comparable homes for each BA builder on the basis of marketability, it is also important to identify comparable homes in terms of heating fuel for analysis purposes, which includes an even mix of heat pumps and gas furnaces.

Information that briefly describes the research study will be mailed to potential participants to inform them of the opportunity to participate.This information will include

a brief overview of the research methodology, along with the benefits of the research. In the case of the study homes, a cover letter from the builder will accompany the information that explains the benefits of the study and recommends their participation. After receiving the information, homeowners interested in participating will contact the IRB certified research study coordinator by phone for more information. The coordinator will answer any questions and ensure homes meet minimum qualifications. If the home and homeowners meet minimum qualifications and are preliminarily accepted into the study, a consent form will be provided to them for their review and an onsite interview will be scheduled. The actual consent form will be presented, explained, and signed during the onsite interview. Researchers expect that potential participants will be identified, the initial mailing will be sent, and interest and qualifications confirmed by phone during the January 1, 2009 - March 31, 2009 timeframe. Interviews will conclude May 31, 2009.

Participants must be from households that:

- purchased and occupied a new home in the Gainesville, FL area no earlier than 1/1/07 and no later than 12/31/07
- occupy the home year round (not seasonally)
- own a home between 1400 and 3600 square feet of conditioned area
- own a home that has less than three heating and cooling systems
- own a home that has a heat pump or gas furnace heating system.

Particpants cannot be from households that:

- have occupants that smoke
- have energy-intensive home-based businesses or hobbies
- have a swimming pool or a spa
- frequently open their windows to reduce heating and cooling costs
- have conducted or plan to conduct major rennovations on their home.

During the time period between January 1, 2009 and May 31, 2009 IRB certified study personnel will visit each qualifying home, and each visit is expected to last approximately two hours. This and all subsequent visits that are part of the study will be scheduled ahead of time with the homeowners. The initial objective of this first visit is to confirm and complete homeowner consent to participating in the study. Complete study details will be reviewed with the homeowner and a consent form will be singed. Upon receiving consent, an interview with the homeowner will be conducted, utilizing a questionnaire, with a purpose of learning about how the occupants operate the home. This data is important in order to qualify and better interpret the utility bill data also being collected as a part of the study. For example, past similar studies have found that a homeowner's degree of "conservation mindedness", or an inherent desire to reduce energy use, can have a large impact on the overall energy use of the home. Another purpose of the interview is to determine the homeowner's satisfaction with the home. Satisfaction is assessed in a number of areas including comfort, resource consumption, value, ease of operation, and realization of any benefits advertised as a part of builder marketing.

Researchers are interested in determining if owners of Building America homes are more satisfied with their homes than owners of non-Building America homes. At the conclusion of the interview, homeowners will be given the option to keep the questionnaire for submittal at a later date if they would like more time to consider their responses. The interview will also facilitate the completion of an audit of home features by the researchers by identifying presence of key features and equipment that should be audited. The audit is designed to collect information on the presence of and efficiency of features and equipment that affect energy use, and utilizes an audit form. Although this information, along with additional information, has already been collected for the study homes through the standard characterization and commissioning that is conducted on BA homes, very little of this information is available for the control homes. Information will be used to qualify utility bill analysis. The audit will also consist of taking digital photographs of the interior and exterior of the home.

During the interview/audit visit, researchers will place small, battery operated dataloggers in the home to record interior temperature and relative humidity. Data will be collected at 15 minute intervals near each thermostat. For homes with only one thermostat, a suitable location for a second datalogger will be determined such that each home has a minimum of two dataloggers. Temperature and relative humidity measurements will assist researchers in determining level of comfort, evenness of comfort throughout the home, and assist with qualification of utility bill data by providing an indication of thermostat set point temperature. As the dataloggers have a limited data storage capacity, data will need to be retrieved from them every few months throughout the course of the study by IRB certified study personnel. Each data retrieval visit is expected to last 15-30 minutes. Data will be collected during the period of March 31, 2009 until September 30, 2009. During the time period of June 1, 2009 and Aug 31, 2009 IRB certified study personnel will visit each home to acquire an indoor ambient air sample. A kit supplied by an analytical laboratory will be used. This visit is expected to last 1 hour. Each sample will be mailed to an analytical laboratory for analysis. Formaldehyde and Volatile Organic Compounds are off gassed from many materials used to construct and furnish new homes, and are markers of indoor air quality. Researchers are interested in whether Building America homes have lower concentrations of these chemicals present in the indoor air.

BAIHP will collect each home's utility bill data dating back to the start of occupancy, and continuing throughout the course of the study. This data will be obtained through partnerships already secured with area utilities. Gainesville Regional Utilities serves gas to all homes within the study boundaries and electricity to a portion, and Clay Electric Cooperative serves electricity to the remainder of the homes. Each utility has already agreed to provide data upon request upon given the assurance that it will only be used for and presented as aggregate (not individual home) analysis. Even though this study is exclusively based on aggregate analysis, researchers are still seeking homeowner consent specifically for acquisition and analysis of utility bill data. Utility bill data will be collected for the period of 1/01/07 to 9/30/09. Researchers are interested in whether Building America homes use less energy than non-Building America Homes. Utility bill data will be analyzed for total energy use amongst the groups, and will be disaggregated

into the following end uses: cooling energy, heating energy, non-heating gas use, and miscellaneous electric loads (MEL). In cases where electricity is used for cooking and clothes drying, non-heating gas use will largely equate to water heating energy. Cooling energy use will be determined by identifying the month with the lowest electricity consumption as a baseline, and subtracting the baseline from months determined to be cooling months. Cooling months will be determined by analyzing the utility bills in conjunction with area weather data. Heating energy use will be determined in a similar fashion, but gas data will be analyzed instead of electricity data for gas heated homes. MEL energy use will be total monthly electricity use minus cooling energy (and heating energy for electrically heated homes), and non-heating gas use will be monthly total gas use (minus heating energy for gas heated homes). Monthly and annual comparisons between the BA and non-BA homes will be made for total energy consumption, and energy consumption for each of the target end uses.

Data gained through the interview and audit process will help qualify conclusions from the utility bill analysis. For example, higher than typical occupancy or the presence of more than a typical amount of miscellaneous equipment may help explain higher than expected utility bills. Data gained through long term monitoring will also help qualify the utility bill analysis by providing relative thermostat set point temperatures in both the study and control homes. Unknown variations in thermostat set point temperature among homes would result in variations in heating and cooling energy use outside the scope of BA Program elements. This indoor temperature measurement, along with area weather data, will also enable researchers to analyze energy use as a function of differences between indoor and outdoor temperature. This will enable this set of BA homes to be compared with other BA homes in different areas of Florida for which data has already been collected.

Task 4. Post - Phase 3 Activities

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

Figure 4- 2 *Former President Jimmy Carter with solar panels on the site of Habitat's 2007 Jimmy Carter Work Project in Los Angeles.*

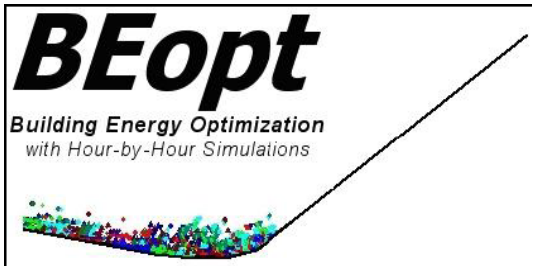
Section 4: Post- Phase 3 Activities

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. BP3 proved to be an effective use of resources as over 22 HFH affiliates were directly assisted. In addition, 50 affiliates (almost all Northwestern HFH affiliates) were reached through BAIHP providing technical training to key personnel in the HFHI Washingtoin State Support Office, the 30 pilot affiliates of the HFHI Partners in Sustainable Building program, and the many affiliates that attended other training activities.

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 2008, BAIHP continued its decade-long partnership with HFH. We provided technical assistance to at least 22 HFH affiliates including those in the gulf coast recovery area and those affiliates chosen by HFHI to participate in the pilot phase of the new Partners in Sustainable Building (HFHI-PSB) program. BAIHP provided training at for this pilot program and at regional conferences.

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

The goals of BA technical assistance to HFH affiliates is to

- Provide technical assistance to move “standard practice” toward ENERGY STAR and beyond and to achieve high performance in affordable housing to spur change
- Provide training
- Conduct research in support of DOE goals

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.

In an effort to increase the availability of technical assistance to HFH's 1600+ local affiliates, BAIHP worked with RESNET to establish a network of volunteer HERS raters. RESNET has been instrumental in the formation of this network and details of volunteer HERS raters can be found below and in Subtask 4.6 RESNET Activities.

BAIHP provided technical support and training to the new HFHI Partners in Sustainable Building initiative funded by the Home Depot foundation.

In addition to technical support and training, BAIHP is monitoring two HFH zero energy homes in Loudon County (Franklin, TN) are being monitored in collaboration with Oak Ridge National Laboratories (ORNL).

Figure 4- 5 *Habitat Volunteer Energy Rater Logo*

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 staff at 50 high-profile Habitat affiliates. BAIHP contributed to a discussion of a Small House Builder Option Package with the ENERGY STAR new homes program and their subcontractor 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

TechnicalAssistance to Habitat for Humanity

In April of 2008, HFHI launched the pilot phase of a new program, Partners in Sustainable Building, funded under a $30 million donation from the Home Depot foundation. BAIHP researchers contributed to the technical content of the program, training the pilot affiliates (see training with Habitat below), as a member of the advisory

board, and by directly assisting several of the pilot affiliates in Mobile (AL), Valdosta (GA), Tampa (FL), and Gulf Port (MS) with the selection of energy efficiency measures. The program, in it's pilot phase, provides a $2,000 grant to affiliates for building an Energy Star home and a $4,000 grant to affiliates for building a Green certified home.

In addition to this support to HFHI, in BP3, BAIPH provided detailed technical assistance including design, specifications and standards development, performance testing and sustainable construction techniques to affiliates in Florida, Washington, California, and to affiliates participating in the Gulf Coast High Performance Affordable Demonstration Home project in Alabama, Louisiana, and Mississippi.

Prior to BP3, BAIHP has provided technical assistance to dozens of Habitat affiliates. A sample of these has been included in this report.

Nationwide 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.

In February 2008, the RESNET-Building America-Habitat partnership went through a number of changes. Due to management changes at Habitat International and increased interest in the program, partnership responsibilities have changed. RESNET is coordinating communications with RESNET volunteers who will contact the Habitat affiliate(s) operating in their service areas directly (instead of going through Building America). Building America will produce one-page case studies of selected partnerships between RESNET volunteers and Habitat affiliates for the joint use of RESNET, the RESNET member, Habitat, and Building America. Two of these were completed in 2008. They are included in Appendix B and available online at: http://www.baihp.org/habitat/pdf/Central-Oklahoma-Case-Study.pdf and http://www.baihp.org/habitat/pdf/Houston-Case-Study.pdf.

Alabama Habitat Technical Assistance (also see Mobile under Gulf Coast Demonstration Homes)

Auburn University designHABITAT Studio
BAIHP researchers provided guidance on how to achieve high performance in affordable housing to Auburn University's College of Architecture professor David Hinson and his students as the developed a new designHABITAT project.

Florida Habitat Technical Assistance

Broward County (FL) Habitat for Humanity
A long time partner of BAIHP, this affiliate has been building Energy Star homes with rating support from Florida Power and Light since the late '90's. They consulted researchers several times in 2008, most notably in September to request assistance with LEED certification. We set up a conference call to help them understand the process and resources available. They held their LEED for Homes internal design charrette (required for certification) in December.

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. In BP3, BAIHP conducted thermal bypass inspections at 11 of the affiliate's homes, as well as duct performance and house tightness testing in these residences, followed by analysis using EnergyGauge USA.

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

In 2008, Lakeland HFH completed a LEED certified home with technical assistance from FSEC staff. The house was featured in The Ledger, Lakeland's local newspaper. Work continued on Beyond ENERGY STAR homes, and two BAIHP team members met with the affiliate's Board of Directors to discuss the possibility of using solar water heating and building another LEED certified or NZEH home. In June 2008, three of the 30% homes built by Lakeland HFH were tested. The current specifications (Table 4-1) save approximately 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% 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 and load reduction strategies. 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.

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.*

A review of the peak cooling load (*Figure 4-10*, from Manual J system sizing calculation for the Benchmark 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 an interior 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 abandoned their interior duct chase strategy in 2008 because the added labor was creating conflict within the affilaite. Lakeland Habitat HERS '99 scores range from 88.6 to 91.2 with an average of 89.3.

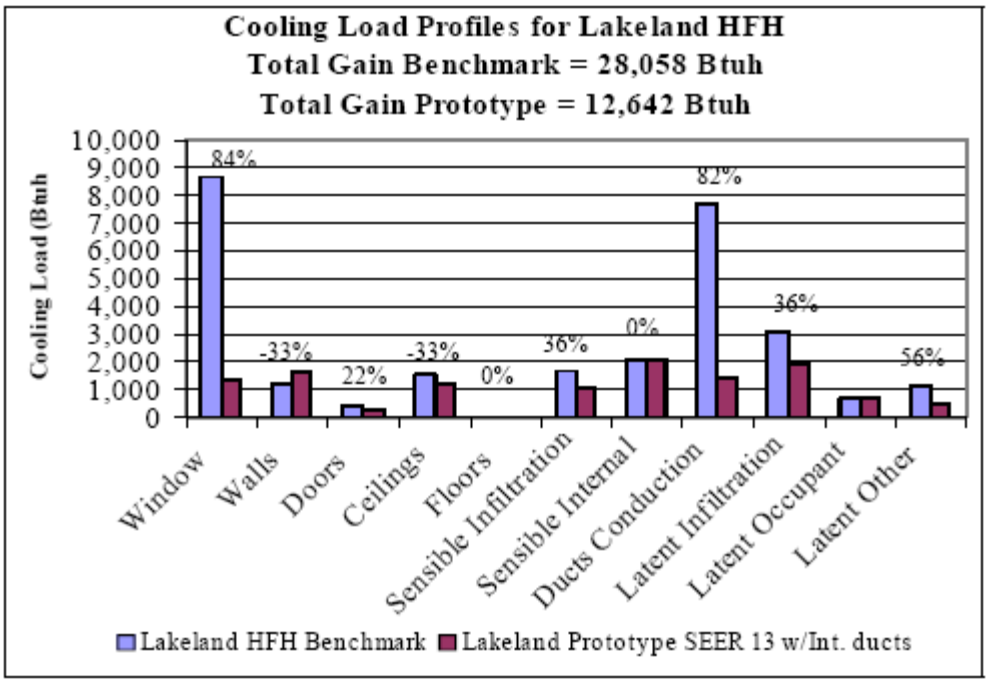


Figure 4- 10 *Lakeland Habitat peak cooling load reduction with savings noted in each category.*

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, in some homes, ducts in conditioned space with joints and seams sealed with water-based mastic and fiberglass mesh. Prior to 2008, BAIHP randomly tested homes to ensure duct leakage below 6%. In 2008 all homes were tested.
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. In 2007 began implementing the ENERGY STAR Thermal Bypass Inspection Checklist (TBIC). Prior to 2008, BAIHP randomly tested whole house air tightness. In 2008, all homes were inspected and tested.
Appliances	ENERGY STAR refrigerator

Case studies of Lakeland Habitat:
http://www.baihp.org/habitat/pdf/Lakeland-Case-Study.pdf
http://www.baihp.org/habitat/pdf/Lakeland-Habitat-Case-Study.pdf

BAIHP also assisted Michael Baechler and his associates at Pacific Northwest Laboratory with a case study of Lakeland Habitat for the forthcoming Building America Best Practices document for the Hot Humid Climate. In the spring of 2009, Home Energy magazine will be running a story on Lakeland Habitat.

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. 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*

After years of working with this affiliate and numerous incremental efficiency improvements to their homes, this HFH affiliate has taken a major step and installed solar hot water systems on their homes. Combined with previous improvements, HERS Indexes on these homes range in the mid- to low 70s. Analyses show that with the incorporation of more fluorescent lighting this affiliate's homes could easily qualify for the U.S. DOE's Builders Challenge. A volunteer energy rater, matched with this affiliate through the RESNET partnership, has taken over technical assistance with this affiliate.

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 multifamily 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. Based on analysis of single family detached homes tested in January 2008 and preliminary analysis of multi-family homes to be built later in 2008, the HERS Indexes of these homes meet or exceed ENERGY STAR requirements. In May 2008, 10 different improvements were analyzed and presented in several packages that were all designed to qualify the homes for ENERGY STAR.

- 80% fluorescent lighting
- ENERGY STAR refrigerator
- Better windows (U=0.4, SHGC = 0.4)
- SEER 14 heat pump
- Whithe shingles and RBS decking
- Programable T-stat
- RBS Decking

- R-30 attic
- Tight Ducts (Qn = 0.03)
- White Shingles

This affiliate has now hired a RESNET certified HERS rater.

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 ft^2 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.

This affiliate has chosen ICF construction to replace frame construction in the hurricane prone Tampa Bay area. During the visit two different ICF houses were inspected and tested, one in the pre-drywall state to do a Thermal Bypass Inspection Checklist (TBIC), and a completed house envelope and duct testing. Plans for Pinellas's 5 bedroom 2 bath house were received and entered into rating software, Energy Gauge USA, using the results of the envelope and duct testing to establish a baseline for the affiliate and to generate recommendations (see table) to improve the affiliate's energy efficiency and building durability.

Improvement	**HERS Index**	**kWh/ year**	**$Cost/ year**	**$Savings/ Year**	**$Over 20 Years**
As Built	85	10320	$1114	$0	$0
SEER 14 HSPF 8.5	81	9974	$1082	$32	$640
RBS decking	83	10102	$1095	$19	$380
Windows U=0.35 SHGC=0.35	81	9935	$1079	$35	$700
90% Fluorescent lighting	79	9395	$1030	$84	$1680
90% Fluorescent +RBS	77	9183	$1012	$102	$2040
90% Fluor + SEER 14	76	9068	$1001	$113	$2260
90% Fluor + Windows	75	9000	$994	$120	$2400
90% + RBS + Windows	73	8798	$976	$138	$2760
All of the above	70	8538	$953	$161	$3220

This affiliate was chosen by HFHI to participate in the pilot phase of the Partners in Sustainable Building program.

Sarasota County and Manatee 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

Achievements at this affiliate inspired the HFH affiliate in Manatee County to build Energy Star homes also. In BP3, Calcs Plus registered 18 Energy Star homes for these two affiliates.

Hillsborough County, FL
BAIHP began working with Hillsboro Co. HFH (Tampa, FL) in July, 2007. HCHFH is planning a 25 home development that they want to make green and energy efficient. BAIHP hosted a conference call with FGBC, HFHI, HCHFH and RESNET to go over the basics of what HCHFH 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). BAIHP completed analysis and ENERGY STAR ratings for this affiliate's first two ENERGY STAR homes.

Washington Habitat Technical Assistance
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.

Figure 4- 12 *Habitat for Humanity 15 home Community Cottage project – Olympia, WA*

In 2007, BAIHP staff worked with other Habitat affiliates on qualifying over 100 existing homes to Northwest ENERGY STAR standards, and continue 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.

In 2008, Washington State University (WSU) met with FSEC staff on HF efforts in the Pacific Northwest, and provided ongoing design and field assistance on HFH demonstration homes in community projects in Olympia and Tacoma. WSU staff met with Tacoma Public Utilities and BAIHP partners Panasonic and HFH to discuss planning for the October HFH conference and ongoing coordination between HFH and BAIHP. The WSU team also worked with BA partners Panasonic and Broan on a ventilation study of 2 of 15 homes being built by Tacoma HFH.

There is also potential for another collaboration with King County HFH to provide technical design assistance for a 60-unit, multi-family project to be constructed in 2008 or 2009. WSU has provided technical assistance to King County HFH by recommending a less expensive HRV unit that is better suited for western Washington State. The WSU team also provided technical assistance to Seattle South King County and East King County habitat affiliates on elevating and interpreting the benefits and tradeoffs of ductless heat pump technology in a 41-unit complex plan.

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 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- 13 *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. A case study of the project was developed and is available at http://www.baihp.org/habitat/pdf/JCWP07-Case-Study.pdf

Michigan Habitat Technical Assistance

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 form the conditioned space - not form connected floors, walls, or ceilings. Note frame for filter back grill like the one pictured in Figure 4-15.

Figure 4- 14 *JCWP-CBA House built by Lansing (MI) Habitat for Humanity*

Figure 4- 15 *Detail of a ducted return air plenum*

Gulf Coast Recovery Technical Assistance

BAIHP was involved in various activities to support Habitat's reconstruction efforts in the Gulf Coast region. 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. In 2007, we participated in leadership training and provided technical assistance to several affiliates and launched Subtask 2.1.2 Gulf Coast High Performance Affordable Demonstration Houses to build at least eight 30% benchmark saving prototypes with affordable housing providers. These initiatives are describe below.

Palm Harbor Homes and the Oprah Winfrey Angel Network – HFH in Dothan, AL and Baton Rouge, LA

Figure 4- 16 *Raising Walls at a Gulf Coast Habitat Build*

2006 - In partnership with Palm Harbor Homes and Oprah Winfrey BAIHP conducted testing and ENERGY STAR certification of 33 modular homes donated to Habitat for Humanity in Dothan, AL (18) and Baton Rouge, LA (15). 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.) Then researchers conducted final tested and rating after the homes were set up. The homes in Baton Rouge are the site of a DOE funded crawl space research project led by Advanced Energy in partnership with Habitat for Humanity of Greater Baton Rouge. BAIHP researchers provided home energy ratings, EnergyGaugeUSA simulation files, initial testing in 2006, and re-testing of many houses after duct repairs. This work was conducted in conjunction with on-going technical assistance to the Baton Rouge Habitat affiliate as described below under the Gulf Coast Demonstration Project.

Figure 4- 17 *Palm Harbor Homes built in Alabama for Oprah Winfrey-HFH partnership*

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

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.

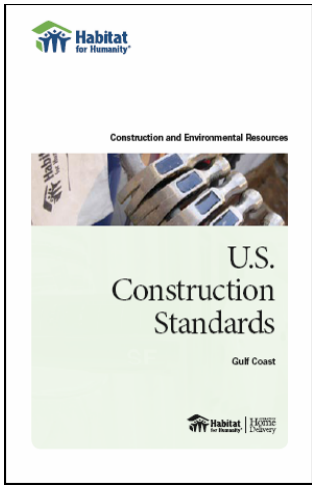


Figure 4- 18 *HFHI's Construction Standards which were released November 2006*

2008 Jimmy Carter Work Project, New Orleans, LA

The 2008 JCWP was conducted across the Gulf Coast region. From May 12-16, seven houses were "blitz built" at the New Orleans site. Working with the New Orleans habitat affiliate, a BAIHP researcher provided on-site training. BAIHP staff spent part of the week inspecting the homes for the Thermal Bypass Inspection. Ultimately, due to a change in staff, the homes were not qualified as Energy Star.

Gulf Coast High Performance Affordable Demonstration Houses

This subtask (2.1.2) also falls under the Habtiat for Humanity Partnership due to the technical assistance provided to the Habitat affiliates in the Gulf Coast recovery region. This subtask is to make a direct contribution to ensuring that affordable housing constructed in areas affected by hurricanes Katrina and Rita is highly energy efficient, durable, and provides good indoor environmental quality. The primary strategy to achieve this objective is to encourage builders and developers to embrace the system engineering principles and efficiency goals of the Building America program.

Habitat affiliates in Baton Rouge, New Orleans, Slidell (LA), Gulf Port (MS), and Mobile (AL) agreed to build two 30% prototypes each. By the end of 2008, four homes will be completed with a fifth under way. The activity of each of these affiliates is described below. An important element of this subtask is introducing the general home building industry in each community to the concepts embodied in the high performance homes. This will be done through workshops as described below.

Initial testing to establish what and how the affiliates were building was finished for all five affiliates. Features of prototypes were finalized and include:

- +75% fluorescent lighting
- ENRGY STAR refrigerator and windows
- Interior AHU closet and return duct
- SEER 14/HSPF 8.5 right-sized heat pump
- Low-E windows (all affiliates selected are using product already)
- RBS decking
- Increased R value of floor insulation on raised-floor houses
- Passive outside air ventilation
- Ducted kitchen and bathroom exhaust fans
- Energy star thermal bypass inspection
- Ducts sealed and tested to verify less than 6 cfm leakage to outside per conditioned square foot

Systems engineering activities were completed for all four Habitat affiliates for their trial prototype houses. Researchers have documented the indoor air quality, energy efficiency, and durability details currently used by the affiliates, and conducted initial testing to establish base line performance. All four affiliates have submitted commitment letters. Here is the 30% Prototype package:

Indoor Air Quality Features

- No Combustion Appliances or Equipment (therefore, no combustion safety risks)
- Low Radon Potential (therefore, no mitigation system)
- Air Sealing and Positive Pressure, Outside-Air Ventilation reduce infiltration
- Interior Air Handler Closet Heating and Cooling Equipment Right-Sized with ACCA Manual J (improves moisture control)
- Mobile and Baton Rouge only: interior duct system
- Baton Rouge only: low VOC paint and formaldehyde free drywall mud

Durability Features

- Air Handler Located Inside (Less harsh environment than attic)
- Water Heater Located In Storage Room (Less harsh environment than attic)
- Face Sealed Siding Provides Continuous Exterior Wall Drainage Plane
- Long Life Fiber Cement Siding
- Ship-Lapped Window and Door Flashing
- Kitchen and Bath Exhaust Fans Ducted to Outside for Humidity Control
- 1'0" Overhangs to Direct Water Away from House
- Baton Rouge and Mobile: Slab Raised 8" Above Finished Grade To Promote Drainage And Protect Siding
- New Orleans and Slidell: Termite Inspection Shield on Foundation Piers

Energy Efficiency Features (In rough order of performance improvement)
(Standard Components: R-30 attic, R-13 walls, Low-E Double Pane Windows)

- At least 75% Fluorescent Lighting
- ENERGY STAR Refrigerator (412 kWh/year)
- High Efficiency Heat Pump (SEER 14, HSPF 8.5 or better) sized using Manual J
- Interior Air Handler Closet (separated from attic by air barrier)
- Air Sealing and Insulation Checklist and Inspection (ENERGY STAR Thermal Bypass Checklist)
- Radiant Barrier Decking
- Sealed Air Distribution Duct System (Qn,out < 0.03)
- Light Colored Exterior Finish
- Insulated Exterior Doors with Double Pane Lites
- Baton Rouge only: Energy Star Ceiling Fans
- Mobile and Baton Rouge only: Interior Duct System

**(Note improvements with multiple benefits are listed in more than one category)*

In July, a Web site for the initiative was launched: www.baihp.org/gulfcoast

Four demonstration homes are currently being completed – one in Mobile, AL, two in Slidell, LA and one in Gulf Port, MS. One more is under construction in Baton Rouge, LA. Activity in New Orleans is currently on hold. Details of progress at each affiliate are included below

Mobile County (AL) HFH Demonstration Project (Subtask 2.1.2)
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 two 30-40% benchmark savings prototypes under BAIHP's supplemental funding for Gulf Coast High Performance Affordable Housing Demonstration Project.

The first prototype was completed in November of 2008. BAIHP presented the project to the general membership of the local chapter of the Air Conditioning Contractors of America (ACCA) in October. A workshop was produced in conjunction with the Home Builders Association of Metro Mobile on November 20. Despite direct mail promotion to over 1700 members of the HBA, attendance was predominately made up of raters and other Habitat affiliates from South Alabama. The workshop agenda and presentation are available on line at www.baihp.org/gulfcoast. The site visit portion of the workshop generated considerable discussion. A press event is planned for January.

Figure 4- 19 *Mobile County Habitat Home*

New Orleans Area HFH Demonstration Project (Subtask 2.1.2)
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 HERS Index of 115. The main problem with the houses was extremely leaky return plenums 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 furnaces. Return plenums were open to the walls of the closet without an air barrier. FSEC discussed methods of securing safe combustion while resolving the infiltration and leaky ducts problem. In 2007, New Orleans HFH committed to building one all-electric ENERGY STAR home and one gas/electric Energy Star home.

Figure 4- 20 *New Orleans Area Habitat 30% Prototypes – both failed the TBIC.*

In January 2008, 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. In the spring of '08, BAIHP conducted training for the construction staff on wall insulation installation and inspection for the thermal bypass checklist. Researchers also identified air sealing problems that need to be resolved before the trial prototype home is constructed. In mid 2008, they committed to building two all electric 30% prototypes. Unfortunately, the homes failed the thermal bypass inspection in October of 2008. Subsequently, BAIHP conducted floor insulation training with the affiliate's construction staff

HFH of Greater Baton Rouge (LA) Demonstration Project (Subtask 2.1.2)
In July 2007, FSEC began analysis of HFH of Greater Baton Rouge site-built homes. The homes being built by this affiliate were already achieving a HERS Index 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 and site would be used, identifying problems, coordinating with sub-contractors and developing solutions on paper. Two homes passed the thermal bypass inspection for ENERGY STAR homes in February, but failed the final testing in March.

Construction of the 30% prototype began in March of '08. The major challenge for this affiliate is locating the air handler in the conditioned space. Numerous sub-contractor meetings were held to discuss the details. Ultimately the strategy was abandoned in the first attempt at building the prototype because the truss layout did not allow adequate space for the supply plenum to enter the attic from the top of the AHU closet. Shortly after this incident, the construction manager was fired and plans to build the prototype were put on hold.

Throughout 2008 there have been a number of management changes and unfortunate circumstances that caused the delay of the construction of a prototype home, but the affiliate began it's third attempt at construction on a 30 % prototype in November of '08 with completion expected in the spring of 2009.

On December 5, in conjunction with the LSU AgCenter's La House and the Capitol District Home Builders Association, BAIHP conducted a workshop worth 4 CEUs. Attendance of ~30 included university students and faculty, raters, non-profit home builders, and for profit production builders.

Slidell (LA) - East Tammany HFH Demonstration Project (Subtask 2.1.2)
This affiliate is striving to bring all homes in line with ENERGY STAR and committed to building two 30% prototype Demonstration houses. In 2007, BAIHP researchers discussed ENERGY STAR requirements with the site supervisor. They 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, through the RESNET partnership, and their utility's builder incentive program to improve their specifications. The initial HERS Index for this affiliate was approximately 95. They began construction of their two 30% prototype houses in September of 2008. They passed the TBIC but needed improvements to their outside air system. Final testing is scheduled for December 18.

Mississippi Gulf Coast Habitat Demonstration Project (Subtask 2.1.2)
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, however the demands of the 2007 Jimmy Carter Work Project precluded progress until 2008. In the spring of 2008, this affiliate was chosen to participate in the pilot phase of the HFHI Partners in Sustainable Building program. After attending training conducted by BAIHP for the pilot affiliates in October, the construction manager contacted BAIHP and committed to building two 30% prototype demonstration homes. The first broke ground in late October and passed the TBIC in late November. Final testing is scheduled for December 17, 2008.

Covington (LA) – West St. Tammany Parrish Habitat
In the fall of 2008, researchers met with the construction manager and conduct an initial evaluation of their homes including duct and whole house air tightness testing. Researchers outlined changes necessary to reach Energy Star and the 30% prototype level. After consideration, the affiliate decided not to proceed with BA partnership at that time.

Foley (AL) – Baldwin County Habitat
In November of 2008, BAIHP researchers met with a HERS rater, Andy Bell, recently hired by the Alabama Association of Habitat Affiliates to work with HFH affiliates around the state. BAIHP and Bell visited the Baldwin County HFH affiliate and conducted testing of a finished house in Foley, just south of Mobile. The house and the duct system were within tightness specifications for building a 30% prototype. The affiliate is interested in participating in the Demonstration project, but will not be stating any new houses until the spring of 2009. If funds are available at that time, the affiliate will be included in the project.

Training and Outreach Activities with Habitat:

In 2007 (BP2), Janet McIlvaine participated in a nationwide conference call on Energy Star attended by 54 HFH construction staffers (May) and presented "Beyond ENERGY STAR" case studies to ~100 attendees at the National HFH conference (October) and also conducted a building science field session in New Orleans Habitat's Musician's Village with Claudette Reichel (LSU).

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

March 2008: Janet McIlvaine led work to produce and submit four HFH case study deliverables to DOE. Case studies on Central Oklahoma HFH and Houston HFH were mentioned under the RESNET partnership. The other two case studies high light the 2007 Jimmy Carter Work Project and Lakeland Habitat. All four are included in Appendix B.

April 2008: McIlvaine was invited to become an Advisory Board member for the Home Depot Foundation collaboration with Habitat for Humanity International – the National Partners in Sustainable Building Program.

May 2008: Case studies were posted on www.BAIHP.org

June 2008: McIlvaine participated in pilot activities for the National Partners in Sustainable Building Program with Habitat International staff, including weekly planning and bi-weekly training conference calls. WSU researchers prepared a presentation on advanced framing and exterior foam sheathing for Habitat regional construction managers.

July 2008: McIlvaine led a conference call for National Partners in Sustainable Building Program pilot activities where she delivered a "Step by Step Guide to Building ENERGY STAR Homes for Habitat Affiliates."

August 2008: Janet participated in planning charrette (and subsequent conference calls) at Habitat International's Atlanta offices for the National Partners in Sustainable Building Program training event.

September 2008: Five separate training sessions were carried out this month – one for the Mobile area ACCA chapter, two for individual Habitat affiliates in New Orleans and Slidell, LA, a regional Habitat International training event in Mobile, AL, and a nationwide HFHI conference call.

ACCA Training (9/9/08): BAIHP presented details related to mechanical systems to the membership of the Baldwin county area ACCA chapter during a general membership meeting. This is the only chapter of ACCA in Alabama. Response was very positive.

The two affiliate training sessions were well attended by construction staff of the partner affiliates. In Slidell (9/17/08) the session included construction staff from two affiliates – East and West St. Tammany. New Orleans (9/18/08) made the training session mandatory for their large construction staff. The majority of the training covered achieving ENERGY STAR build quality, with emphasis given to the elements related to quality assurance during the construction phase – complying with the TBIC, constructing tight ducts and AHU closets, and building a durable shell.

The regional Habitat International training event (9/19/08) was arranged by Habitat International (HFHI) and hosted by our partner affiliate Mobile County HFH. Invitations to all Alabama affiliates and Gulf Coast affiliates in other states were sent out via HFHI. Response was moderate, with an Alabama state HFH attendee, and construction staff from three Alabama and one Mississipi affiliates attending. The training session was for one day and covered basic building science, the ENERGY STAR program, including thermal bypass inspection compliance, and the BAIHP Gulf Coast Affordable Housing packages, with an afternoon session for discussion or blower door and duct blaster demonstrations.

McIlvaine presented "Energy Star Certification Options" to 38 participants on a nationwide conference call training event organized by HFHI. The audio file, step by step guide, and power point presentation are posted on the HFH intranet for access by any Habitat affiliate.

October 2008: McIlvaine co-led a 2.5 day training event at SouthFace Energy Institute in Atlanta for the pilot affiliates in the Partners in Sustainable Building program which provides grant money to Habitat affiliates building Energy Star and Green certified homes. 57 attendees.

November 2008: In November, researchers worked with the Home Builders Association of Metro Mobile and several neighboring HBAs to promote the November 20 workshop. Despite sending a promotional flyer to over 1800 builders and sub contractors, attendance at this free workshop was very low.

Also in November 2008, McIlvaine presented in 2 sessions at the 2nd annual Habitat for Humanity Youth Leadership conference in St. Louis. The 345 attendees from around the country attended the general session panel titled "Building a Sustainable Habitat" and approximately 50 attendees came to a session on implementing high performance practices.

December 2008: In conjunction with the LSU AgCenter's La House and the Capitol District Home Builders Association, BAIHP conducted a workshop worth 4 CEUs. Attendance of ~30 included university students and faculty, raters, non-profit home builders, and for profit production builders.

Also in December '08, McIlvaine participated in a nationwide HFHI conference call on Health and IAQ issues to construction staff from approximately 25 HFH affiliates.

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. Data collection continued throughout 2008.

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. In 2008, this monitoring effort was abandoned due to technical difficulties.

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.

Deer Valley Homes
As a new BAIHP partner, FSEC began analysis of floorplans for this builder in 2008.

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.

In 2008, Staff performed quarterly factory inspection visits, inspected problem homes; developed in-plant quality assurance detailed inspection manuals. In March 2008 NEEM proposed upgrading the standards to higher levels of energy efficiency and presented the higher standards to the industry.

Other activities include updating and distributing a power point CD for factory technical staff. After the meeting with the industry on September 10, 2008 NEEM regional staff from Oregon, Washington, Idaho, and Montana and FSEC staff held a two day meeting in Oregon to discuss research plans for the future. FSEC staff, Dave Chasar, shared research and other FSEC technical assistance projects with the NEEM staff. A Bonneville Power Administration manager, Mark Johnson, also attended the 2 day meeting. NEEM staff updated the list of incentives and contact names of 65 regional utilities.

Innovative HVAC system

On March 18, NEEM staff, and a Daikin Mini-split representative, and plant engineering and sales staff met to discuss ductless mini-split heat pumps as a heating system option

for Energy Star homes. The Daikin representative toured the plant during production. Electrical and mechanical plant staff discussed the installation in the plant. It was agreed to pursue installing a system in a model home.

Home Shows
NEEM staffed a booth at the Salem, Oregon, regional home show from February 27 – March 2. and at the Idaho home show. NEEM handed out 42 awards to the manufactures for highest production and highest % of production and to the top three retailers in seven states –four Northwest and California, Utah, and Nevada. NEEM staff judged the best energy efficient home at the show and handed out an award to the manufacturer and retailer.

NEEMgreen
In March of 2008 NEEM staff developed a NEEMgreen program, a green building program for manufactured homes. As a part of the NEEMgreen home, the higher energy standards for the Energy Star manufactured home program was incorporated. NEEM staff presented NEEMgreen to the industry regional marketing Board of Directors, NW Pride, in May 2008. At that same meeting with the industry, NEEM staff also presented higher energy standards for the regional Energy Star manufactured home program. The Board of Directors of NW pride voted to approve the NEEMgreen program as part of their efforts to improve the image of manufactured homes and deliver their Advanced Home to the market. NEEM staff presented NEEMgreen program to the Oregon manufactured housing industry, Oregon Manufactured Housing Assoc. Board of Directors on June 5, 2008. NEEMgreen was presented to the Marlette staff in Hermiston OR on July 23. NEEMgreen was presented to the Golden West staff in Albany OR on August 28. NEEMgreen was presented to Liberty on September 8, 2008. Golden West is building the first five NEEMgreen homes beginning in October, 2008.

Figure 4- 25 *NEEM Logo*

Association meetings and industry meetings
In May NEEM staff traveled to Reno, Nevada to the Utah, Idaho, and Nevada manufactured home association annual meeting to present the Energy Star program and meet with Nevada utilities. NEEM staff gave two presentations on best installation practices and hosted a roundtable on energy at the meeting. NEEM staff also field tested 2 Energy Star home sited in Reno as a part of the 86 home field study.

Training and plant certification
NEEM staff presented to installation training sessions in Montana, Idaho and Oregon and to manufactured home associations and to utilities. NEEM staff from Oregon and Idaho taught at certified installer classes. The classes are cosponsored by the Oregon

Manufactured Housing Association, the Idaho Manufactured Housing Association and foundation equipment suppliers. NEEM staff traveled to Woodland, California, for quarterly reviews at the Skyline and Silvercrest plants and met with Fleetwood of CA to discuss becoming their certifier for Energy Star homes.

Higher Energy Standards
On August 5, 2008, NEEM staff contacted suppliers and window manufacturers to set up conference calls to discuss the spec change. After NEEM staff held a conference call with window manufacturers to discuss the window spec change U=0.35 to U=.32, NEEM held a meeting with the manufactured home industry on September 10, 2008. Each of the 17 plants has 1 vote and the majority passes or fails the measures. Voting was held after the September 10th meeting. Votes will be tallied in late October 2008. A cost benefit analysis to the consumer with the energy upgrades was presented at the meeting. Seven regional plants were present at the meeting. The spec change includes the following new measures:

Vaulted ceiling R-40 U=0.029 required
Wall R-21 w no trade off U=0.52 required
U=0.32 area weighted average required
Lighting 50 % fixture CFL's required
90% AFUE gas furnace required

National Numbers
NEEM plants produce approximately 65% -75% of the nation's Energy Star manufactured homes. The 2007 NEEM totals are 3,786 Energy Star homes built. Because of the current national mortgage crisis and the slow down in the building industry, the future looks unsure. For the eight months included in this report, 2,138 homes were built, whereas for the same period in 2007 2,524 homes were built.

ENERGY STAR homes produced February 1, 2008 to September 30, 2008	
Northwest Energy Efficient Manufactured Homes	
ENERGY STAR Gas	500
ENERGY STAR Electric	1,638
Total	2,138

Past Reports
In 2007, 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 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.

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

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.

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

Throughout 2008, BAIHP continued participated in the Builders Challenge initiative and produced E-Scale criteria. FSEC's Deputy Director Philip Fairey accompanied DOE Secretary Bodman on a tour o the prototype home at January's 2008 International Builders' Show, to which the first E-Scale was affixed. BAIHP also evaluated the consistency for Building America benchmark software results and assisted the EnergyGauge USA development team on Builders Challenge items, as well as with Builders challenge program guidelines and implementation of report forms in software. The team also reviewed BOPS prepared by NREL and provided feedback – BOPS weren't meeting Builders Challenge for some homes in various climates.

GW Robinson, a Building America partner in Gainesville, Fla., met the 40% Joule goal in March 2008, and a case study was sent to NREL and DOE as part of the DOE peer review process.

Review of Miscellaneous Electric Loads (MELs) in Residences

FSEC researchers Danny Parker and Philip Fairey developed new algorithms for calculating the miscellaneous electric loads for ceiling fans, dishwashers and clothes washers. These algorithms will be vetted and eventually planned for inclusion in HERS and Building America benchmark calculations.

We have worked with NREL to incorporate the research done by TIAX for U.S. DOE to revise the estimating procedures used for miscellaneous electric end uses in homes. The following areas are being addressed:

- Absolute ranking of end uses and incorporation of TIAX findings into procedures
- Ceiling fans
- Dishwashers
- Clothes washers
- Televisions
- Energy Feedback and Controls

Progress on this task was reported on during the July DOE meeting. A final report will be composed in December 2008.

"Wind Washing" Retrofit Solutions in Two-Story Florida Homes

In Budget Period 3, FSEC is assisting DOE in evaluating the potential benefits of retrofits of existing, but recently constructed homes to improve air tightness and insulation in houses with complex architecture (e.g., houses with attic spaces over first-floor portions that abut the second story, creating potential breaches of the thermal and air boundaries). FSEC is working on the search, selection and scheduling of field assessments to be performed in 32 homes which can characterize wind washing failures of air and thermal boundary, and currently has a list of more than 15 homes which have been volunteered for this project. Testing includes a blower door test, air boundary location, pressure mapping, infiltration testing, infrared scans of house surfaces, and visual inspections. Repairs to restore the air and thermal boundaries will be implemented in 8 homes. A retrofit plan will be developed for each potential repair home. The retrofit plan could

include installing air/thermal barriers at the perimeter of the between-floors cavity, replacing missing batts, applying expansive foam, or securing rigid panels (possibly board insulation) over second story insulation batts facing into attic spaces. The retrofit costs will be paid from project funds. AC energy use and space conditions will be monitored (15 minute data) before and after repairs (6-8 month monitoring period) to document cooling energy savings. This project will characterize the extent and magnitude of the energy and moisture consequences of these thermal and air barrier failures in a hot and humid climate, and evaluate the energy conservation potential of wind washing retrofit programs.

Staff have developed a draft field inspection and testing protocol, which will provide the framework for characterizing air and thermal boundary failures in two-story homes, calibrated instrumentation to be used in field assessments, and performed inspections and testing in five 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.

In 2008, BAIHP completed benchmarking analysis and sales analysis of GW Robinson and Tommy Williams Homes in Gainesville, Fla. GW Robinson met the 40% Joule goal and work was completed on an initial case study report that was transmitted to NREL and DOE.

4.5 Documentation, Resource Development and Related Activities

In the research utilization area we published two magazine articles and nine conference papers. We wrote several contract reports and participated in several press interviews. We served in numerous professional societies and organizations and delivered over 50 presentations and training seminars. Details available in Appendix A and published articles and papers are listed below

Magazine Articles

Parker, D., Hoak, D. and Jamie Cummings - Article on Energy Feedback , Home Energy , July/August 2008 .

Lubliner, M.; Gordon, A. "Q and A – Zero Energy Manufactured Homes." Home Power Magazine. Fall 2008.

Publications with Presentations at the Conference

Chandra, S., Parker D., Sherwin, J., et al "An Overview of Building America Industrialized Housing Partnership (BAIHP) Activities in Hot-Humid Climates", Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

Chandra, S. "Energy Efficient High Performance New Housing in the United States: Building America Examples from Hot, Humid Florida", IAHS congress - Kolkata, India, November 3-7, 2008.

Hoak, D., Parker, D., Hermelink, A., "How Energy Efficient are Modern Dishwashers", Proceedings of ACEEE 2008 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Asilomar, CA, August 2008.

Lubliner, M. et.al. "Moving Ducts Inside: Big Builders, Scientists Find Common Ground." Proceedings: ACEEE 2008 Summer Study. American Council for an Energy Efficient Economy. Asilomar, CA, August, 2008.

Moyer, N. "Using Thermography in the Evaluation of the NightCool Nocturnal Radiation Cooling Concept." Proceedings- InfraMation conference , Reno, NV. November 2008.

Moyer, N. et al. "Research Results From A Few Alternate Methods of Interior Duct Systems in Factory Built Housing Located In The Hot Humid Climate" , Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

Parker, D., Sherwin, J., Hermelink, A., "*NightCool*: A Nocturnal Radiation Cooling Concept", Proceedings of ACEEE 2008 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Asilomar, CA, August 2008.

Thomas-Rees, S. et al. "Green and High Performance Factory Crafted Housing", Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

Vieira, R., Parker, D., Gu, L. and M. Wichers " Energy Impacts of Various Residential Mechanical Ventilation Strategies", Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

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

A project review meeting was conducted on February 12, 2008. The purpose of the meeting was to present project plans and progress to DOE and partners and to seek input from them. Mr. Bill Haslebacher from N.E.T.L., BAIHP project officer, represented DOE at the meeting. Participants expressed satisfaction with the project.

4.6 RESNET activities

Promotion of High Energy Performance Homes
On June 17, 2008, RESNET co-sponsored with the Natural Resources Defense Council a round table of environmental organizations on improving building energy performance. The roundtable featured presentations by Philip Fairey and Steve Baden on the importance of residential energy efficiency to meeting the nation's climate and energy policy goals.

The following policy principals were presented to the environmental organizations:

- The federal government should increase transparency in building energy efficiency and promote energy efficiency improvements at the time of sale or change of occupancy, including requiring uniform labeling of the energy efficiency of all buildings at the time of sale or change of occupancy.

- The federal government should support (and to the degree possible require) the adoption, implementation and effective enforcement by states and local jurisdictions of energy codes that meet or exceed the minimum requirements of the most recent version of the IECC, ASHRAE 90.1 or other relevant model energy code.

- Building energy codes should be strengthened to maximize energy efficiency and minimize energy costs over the useful life of a building such that the total costs of buildings are minimized over at least a 30-year lifetime.

- The federal government should adopt policies that set goals for and spur the rapid development of net zero energy buildings in the market by 2020.

- Net zero energy buildings should serve as the ultimate benchmark goal for future upgrades of building energy codes.

- The federal government should identify the barriers to improving the energy efficiency of existing buildings and adopt policies to overcome these barriers, including, at a minimum, mandatory labeling, tax credits and other incentives, and mandatory requirements applicable to obtaining financing from entities related to the federal government.

As a result of the roundtable the environmental organizations agreed to work with RESNET and the other energy efficiency organizations on adopting a set of common principals for the incoming Congress and Presidential Administration.

Fannie Mae Energy Efficient Mortgage Initiative
With the current stresses upon homeowners caused by spiraling energy costs and the housing market crisis, now is the time to reconsider the Energy Mortgage. As a result of the housing bill passed by Congress and signed by President Bush in July, there will be a

new waive of Americans who will be refinancing their mortgage loans. This waive will be caused by hard strapped homeowners seeking the reliefs contained in the legislation from the threat of mortgage foreclosures.

Congress recognized this under-utilized mortgage optionopportunity. A provision to improve and promote energy efficient mortgages was included in the enacted housing legislation. The bipartisan language was put forward by Senators Jeff Bingaman and Pete Domenici, chair and ranking member of the Senate Energy Committee.

The language states that energy efficient mortgages could play an important role in a national effort to make homes more energy efficient. Residential housing accounts for about 22 percent of all energy use, and a similar percentage of greenhouse gas emissions. Many Federal agencies and some banks already offer such mortgages, and Fannie Mae and Freddie Mac are authorized to purchase them. So, rather than creating a new mortgage product, the provision directs Federal agencies to identify barriers that have prevented widespread adoption of such mortgages; give recommendations to Congress to alleviate obstacles if found, and authorizes a public education and marketing campaign for these mortgages.
Since enactment of the legislation RESNET has been working with Fannie Mae on development of a more effective energy efficient mortgage package.

To date Fannie Mae has agreed on the following steps:

- Focus on improving energy performance of existing homes
- Tie financing to home energy rating
- Demonstrate homes that are rated and are energy efficient decreases risk of foreclosure and improves the loan's performance through national analysis. RESNET is working with Fannie Mae on this analysis. RESNET is collecting address information from providers on the addresses of homes that were rated since 2002.

Number of Homes Certified for Federal Tax Credit for Energy Efficient Homes Surges in 2007
RESNET has completed the survey of rating providers on the number of homes that their raters certified for the federal tax credit in 2007. The survey found that in 2007, 23,702 homes were certified by RESNET certified raters for the tax credit. This is almost a tripling of the number of homes that were certified in 2006. What is most remarkable about this surge of homes certified for the tax credit, is that it took place during the slowdown of the housing market. In 2007 the homes that were certified for the tax credit represented 3% of all homes built.

Habitat for Humanity
The recent organizational changes with Habitat for Humanity International, RESNET and the FSEC Building America team has revised our original work agreement. The FSEC Building America staff agreed to support the RESNET-Habitat partnership by writing a 1 page case study summarizing activity between each volunteer rater and their affiliate. The

case study will be made available to all parties in pdf format and posted on the BAIHP website and possibly on the Building America website. In a message Claudia received from Janet McIlvaine today, Janet said she plans to have at least 6 case studies completed before the RESNET Conference in February.

Every month RESNET Notes includes an article encouraging raters to volunteer their services to Habitat affiliates in their area. They contact Claudia who sends them a statement that they must sign agreeing to provide all of their rating services to the affiliates at no cost. At that point they are recognized with a special logo beside the rater's name on our web site.

Since April, 2008 when Claudia re-contacted the list of raters who had expressed interest to David Beal along with the promotion in RESNET Notes, we now have 55 confirmed volunteers.

RESNET will continue to work with FSEC Building America staff to make the process for raters to volunteer their services to Habitat affiliates as seamless as possible.

RESNET Adopts Residential Energy Efficiency Policy Initiatives
One of key challenges to new President and Congress will be to crafting policies to address the nation's energy and climate change challenges.

To assist in this process the RESNET Board of Directors adopted a set of initiatives to tap the potential of residential energy efficiency.

RESNET used the set of principles adopted by the G8 as the foundation for the recommendations and vetted them with a wide variety of energy efficiency and environmental organizations.

At its Fall 2008 Board Meeting the RESNET Board of Directors adopted the following policy initiatives to recommend to the new President and Congress:

- Time of Sale Energy Assessments
- Financing of Energy Improvements of Existing Homes
- Utility Energy Efficiency Portfolio Standards With a Building Energy Efficiency "Carve Out"
- Performance-Based Federal Tax Incentives
- Energy Retrofit Emergency Fund
- Building Codes to be based on total cost over 30 year period
- Adopt Policy that Sets the Goal of Having Net Zero Energy Homes as the Standard of Construction by 2030
- Foster Development of Residential Energy Service Companies (ESCos)
- Revise Mortgage Financing Underwriting Guidelines to Factor the Energy Performance of a Home in the Mortgage Loan

ISO Standard 163 Technical Advisory Group

In August RESNET recruited the RESNET International Initiatives Technical Advisory Group (TAG) to provide input on the development of ISO TC163 WG3. The members of the TAG are posted on the RESNET web site at www.resnet.us/hotnews/taskforce/international

RESNET prepared a briefing paper on the issues involved with the development of the ISO TC163 WG3 and distributed to the TAG.

RESNET hosted the first meeting of the TAG on August 19, 2008 as a special session at the American Council for an Energy Efficient Economy's Summer Study on Energy Efficiency in Buildings in Pacific Grove, California. Good input was received as a result of the working session.

Because most of the TAG was not able to attend the session in Pacific Grove, RESNET is seeking comments from TAG members until September 15, 2008. After the deadline RESNET staff will compile the comments and forward to Philip Fairey for his consideration prior to the Delft meeting.

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

APPENDIX A – Publications, presentations, and related activities conducted by BAIHP researchers in Budget Period 3 (2/1/08-12/31/08)

BAIHP researchers participated in significant activities in the following areas

- **Magazine and Journal Articles**
- **Publications with Presentations at the Conference**
- **Reports w/o presentations**
- **Videos and Press Interviews**
- **Presentations without Publications**
- **Service to Professional Society, Professional Organizations and Non Profits**
- **Briefings and Recognitions**

Details are provided below for each category

Magazine and Journal Articles

Parker, D., Hoak, D. and Jamie Cummings - Article on Energy Feedback , Home Energy , July/August 2008 .

Lubliner, M.; Gordon, A. "Q and A – Zero Energy Manufactured Homes." Home Power Magazine. Fall 2008.

Publications with Presentations at the Conference

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Parker, D., Sherwin, J., Hermelink, A., "*NightCool*: A Nocturnal Radiation Cooling Concept", Proceedings of ACEEE 2008 Summer Study on Energy Efficiency in

Buildings, American Council for an Energy Efficient Economy, Asilomar, CA, August 2008.

Thomas-Rees, S. et al. "Green and High Performance Factory Crafted Housing", Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

Vieira, R., Parker, D., Gu, L. and M. Wichers " Energy Impacts of Various Residential Mechanical Ventilation Strategies", Proceedings- 16th symposium on Improving Building Systems in Hot-Humid Climates, Plano, Tx. Dec 15-17, 2008

Reports w/o presentations

McIlvaine, J. Produced and submitted four HFH Case Studies to DOE including the Jimmy Carter Work Project and affiliate case studies for Central Oklahoma, Houston TX, and Lakeland FL. March 2008. Online at http://www.baihp.org/habitat/index.htm and included in appendix B of this report.

Parker, D., " Very Low Energy Homes in the United States: Perspectives on Performance from Measured Data", Prepared for the *National Academy of Sciences* and submitted to *Energy & Buildings*, August 2008.

Parker D. and J.R. Sherwin "Evaluation of the *NightCool* Nocturnal Radiation Cooling Concept: Annual Performance Assessment in Scale Test Buildings" Stage Gate 1B report ,March 2008

Quality Installation Verification Protocols Committee. Protocols for Verifying HVAC Systems to the ACCA Quality Installation Standard. Air Conditioning Contractors of America. Arlington, VA. 2008.

ASHRAE Proposed Standards 193P Subcommittee (M. Lubliner, chair) – "Method of Test for determining the air-leakage rate of HVAC equipment – final draft for ballot and then to Standards Council.

ASHRAE Guideline 24-2008 Ventilation and Indoor Air Quality in Low-Rise Residential Buildings Standard 62.2 technical Subcommittee (M. Lubliner, co-author) – Published Fall 2008.

BAIHP-II Annual Report for Budget Period 2 (April 2008) *12.2 MB*
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.

ALL papers and reports (except for magazine and society publications) are available on the web at **http://www.baihp.org/pubs/index.htm**

Videos and Press Interviews:

Builders Challenge Video: As part of the U.S. Department of Energy's (DOE) Builders Challenge a DVD is being developed. On September 17, 18 and 19, 2008, nine separate interviews were conducted with the BAIHP team. Two of these interviews were with homeowners in energy efficient homes, four were with

home builders participating in the Builders Challenge (G.W. Robinson Builders, Tommy Williams Homes, Richard Schackow and Castle & Cooke)and two were with BAIHP team members Subrato Chandra and Ken Fonorow (FL Hero).

Stephanie Thomas-Rees conducted telephone interview with Builder Architect publication about FSEC/Building America Program and general strategies for high performance, energy efficient and environmentally friendly construction.

David Hoak assisted Orlando Fox 35 with information and interview time related to a story on gas mileage improvements on April 17, 2008. From this material, two segments were made and broadcasted by FOX 35 over a two week period.

The NBC segment from the NBC affiliate in Miami, on improving automobile mileage, featuring Danny Parker, aired in February, 2008: http://video.nbc6.net/player/?id=214993 Given the high national gasoline prices, the segment aired widely around the U.S.

Presentations without Publications (E*xcludes numerous presentations at the Building America team meetings*)

Steve Baden

EEBA conference, October 2008
NAHB Energy Subcommittee Meeting - San Diego, CA - September 22
Green Real Estate Conference - Denver, CO - July 16

David Beal

August 17, 2008: In conjunction with the Gulf Coast Affordable Housing Project did partner training with East and West St. Tammany (LA) HFH affiliates, emphasizing ENERGY STAR and the QC needed.

August 18, 2008: In conjunction with the Gulf Coast Affordable Housing Project did partner training with New Orleans (LA) HFH affiliates, emphasizing ENERGY STAR and the QC needed.

Subrato Chandra

one hour seminar on high performance homes on Nov. 18 in Cocoa Beach, FL at a retreat for purchasing managers of the TOUSA group, who builds homes in FL and other hot humid climates as well as hot-dry climates and Colorado http://www.tousa.com/tousa_homes.html In 2009 they are planning to adopt Energy Star homes in several of their communities.

overview presentation on BAIHP to CPS Energy personnel and collaborators in San Antonio , Tx on October 3, 2008

presentation at the Sarasota County Renewable Energy Forum. Presentation Title – Towards Zero Energy Homes September 11, 2008 Venice, FL

BAIHP overview presentation at the Gainesville Regional Utilities Conference July 11, 2008 Gainesville, FL

served as a panelist on April 9, 2008 at the UCF summit on Global Climate Change and Health. 10 min presentation on FSEC and BAIHP.

talk on Mechanical Ventilation at the Greenprints 2008 conference in Atlanta, GA hosted by Southface on March 14, 2008.

Building America 101 session hosted by the Gainesville Regional Utilities (GRU) at the GRU headquarters in Gainesville, FL on March 19, 2008

Presentation on FSEC Buildings Research to two groups of NZ visitors to FSEC on 2/11/08

David Chasar

Presentation on monitoring homes to log energy use and indoor conditions to CPS Energy personnel and collaborators in San Antonio , Tx on October 3, 2008

Philip Fairey

presentation at the third meeting of ISO TC163 WG3 on Energy Performance of Buildings occured in Delft, Netherlands, on October 27-28, 2008.

participated in the 2nd meeting of ISO TC163 WG3 in Nanjing, China on April 14th. Purpose of Travel: U.S. representative on ISO Technical Committee 163, Working Group 3 on Energy Performance of Buildings, supporting the DOE EERE Building Technologies Program in this effort.

traveled to Delft, Netherlands on February 26, 2008 to attend ISO TC163 WG3 meeting and a meeting of an ad hoc working group between ISO TC163 and TC205 to determine areas of work responsibility for calculations of energy performance of buildings.

Ken Fonorow

Presented at RESNET hosted webinar on meeting Builders Challenge, December 2008

presentation on ways builders can get to Builders Challenge at the EEBA conference, October 22-24, 2008.

presentation on meeting builders challenge at the Gainesville Regional Utilities Conference July 11, 2008 Gainesville, FL

Thomas Hewes

Presentations and distribution of a power point training CD for 12 factories from March thru November

presentation of Eco-rated to the industry regional marketing Board of Directors, NW Pride, in May 2008.

presentation of Eco-rated to the Oregon manufactured housing industry, Oregon Manufactured Housing Assoc. Board of Directors on June 5, 2008

presentation of Eco-rated to the Marlette Homes in Hermiston OR on July 23, Golden West Homes in Albany OR on August 28,.Liberty Homes on September 8, 2008.

presentation on best installation practices and Energy star manufactured home program in Reno, May 2008, Nevada to the Utah, Idaho, and Nevada manufactured home association annual meeting and to Nevada utilities.

presentation installation training sessions(15 total) in Montana, Idaho and Oregon and to manufactured home associations and to utilities all year long. The classes are cosponsored by the Oregon Manufactured Housing Association, the Idaho Manufactured Housing Association and foundation equipment suppliers

presentation to manufactured home industry of higher energy standards on September 10th including cost benefit analysis to the consumer .

David Hoak

spoke to a group of 250 FP&L Energy Auditors at the FPL 2008 Business & Residential Product Expo. David covered various devices that the auditors could discuss with consumers to identify standby loads and minimize the impact of Miscellaneous Electronic Loads (MEL's) on May 13-14, 2008

spoke to the Green Building team at the Greater Orlando HBA monthly meeting. The attendees were provided information about foam insulation and unvented attics. May 19, 2008

presentation on The Energy Detective and reducing MELs at the Building America 101 session hosted by the Gainesville Regional Utilities (GRU) at the GRU headquarters in Gainesville, FL on March 19, 2008

Eric Martin

Florida Green Home Designation Workshop
Flagler County HBA
Oct 3, 2008
Bunnell, FL

LEED for Homes Field Agent Workshop
Florida Solar Energy Center
Oct 1, 2008
Cocoa, FL

Florida Green Home Designation Workshop
Pre-Conference Workshop for Gainesville Regional Utilities
Building Efficient Sustainable Training Symposium
July 9, 2008
Gainesville, FL
http://www.regonline.com/builder/site/Default.aspx?eventid=603000

Florida Green Home Designation Workshop
Pre-Conference Workshop for Florida Home Builders Association
South East Builders Conference
July 30, 2008
Orlando, FL
http://www.sebcshow.com/

Florida Green Home Designation Workshop
Florida Solar Energy Center
August 6, 2008
Cocoa, FL

Florida Green Home Designation Workshop
Florida Solar Energy Center
May 1, 2008
Cocoa, FL

Florida Green Home Designation Workshop
Extension Office
April 23, 2008
Immokalee, FL

LEED for Homes Field Agent Workshop
Florida Solar Energy Center
Apr 9, 2008
Cocoa, FL

Stalwart Built Homes Builder Training
Building America / LEED for Homes – classroom and field training

Apr 1-2, 2008
Panama City, FL

overview of green and high performance building programs at the Lake County HBA. March 2008.
overview of green and high performance building programs and techniques at a Brevard County builder / HVAC contractor forum, March 2008.

overview of green and high performance building techniques and programs at the Brevard HBA during a green showcase event, February 2008.

Janet McIlvaine

July 10, 2008: Led a conference call for National Partners in Sustainable Building Program pilot activities where she delivered a "Step by Step Guide to Building ENERGY STAR Homes for Habitat Affiliates."

August 2008: Participated in planning charrette (and subsequent conference calls) at Habitat International's Atlanta offices for the National Partners in Sustainable Building Program training event.

September 9, 2008: Conducted workshop for Mobile (AL) Area ACCA chapter on building to ENERGY STAR and beyond, with content geared towards mechanical systems.

September30, 2008: Nationwide HFHI conference call on "Energy Star Certification Options". The audio file, step by step guide, and power point presentation are posted on the HFH intranet for access by any Habitat affiliate.

October 7-9, 2008: Co-led 2.5 day training event at SouthFace Energy Institute in Atlanta for the pilot affiliates in the Partners in Sustainable Building program which provides grant money to Habitat affiliates building Energy Star and Green certified homes.

November 8, 2008: Presented in 2 sessions at the 2nd annual Habitat for Humanity Youth Leadership conference in St. Louis.

December 3, 2008: Participated in a nationwide HFHI conference call on Health and IAQ issues

McIlvaine/Beal

September 19, 2008: One day training session at HFHI's Regional Habitat International training event covering ENERGY STAR and beyond with an afternoon blower door and duct blaster demonstration

November 20, 2008: Half day "Gulf Coast Affordable Housing" workshop with partner Mobile County HFH, and the Home Builders Association of Metro Mobile and several neighboring HBAs

December 8, 2008: One day "Gulf Coast Affordable Housing" workshop with partners Baton Rouge HFH, LSU AgCenter, and the Capitol District Home Builders Association, worth 4 CEUs.

Danny Parker

presentation at the Emerging Technologies Conference in San Diego, CA in October 2008 on the research status of zero energy homes after ten years of work at U.S. DOE.

Stephanie Thomas-Rees

presentation on FSEC/BAIHP to the Tile Roofing Institute at their winter Forum in Orlando, FL November 6. Presentation title “FSEC Overview and BAIHP Activities”.

WSU; Lubliner, Hales, Gordon, Howard

April 2008: Made presentation on Fort Lewis (“Going Modular with Energy Star”) at Affordable Comfort annual conference. Audience included FSEC BAIHP staff. Presentation can be viewed at www.affordablecomfort.org/images/Events/26/Courses/958/PRAC8_Lubliner.pdf

April 2008: Made presentation at NFPA-501 meeting in SF on proposed standards. All energy proposals were accepted unanimously by committee for 2008 standard. The proposals made IECC 2006 Uo values requirements for the standards.

May 2008: Planned, coordinated and facilitated meeting between Federation of American Scientists (FAS) and HUD-code stakeholders. Attendees included key satff at HUD, EPA, NFPA. NRDC and FSEC.

July 2008: Made presentation on advanced framing and exterior foam sheathing to Habitat for Humanity construction managers.

August 2008: Made presentation on BAIHP HUD-code related research at ACEEE Summer Study Informal Session

October 2008: Presented BAIHP research efforts in Center for Disease Control meeting "Healthy Factory Built Structures" in DC and discussed with NIST.

October 2008: Made 3 BAIHP presentations at Habitat for Humanity Mainstream Green Conference http://www.habitatwa.org/mainstreamgreen

December 2008: Made presentation on air leakage control and ventilation at Habitat for Humanity of King Co. construction manager meeting

Service to Professional Society, Professional Organizations and Non Profits

ACCA (Air Conditioning Contractors of America)

Mike Lubliner participated as a voting member of the committee for the development of the final Air Conditioning Contractors of America (ACCA) Quality Installation (QI) verification standard

ACEEE (American Council for an Energy Efficient Economy)

Subrato Chandra served as co panel leader for ACEEE 2008 summer conference for panel 1 on Residential Building Technologies.

ASHRAE (American Society of Heating, Refrigeration and Air-Conditioning Engineers)
Philip Fairey serves as a voting member of ASHRAE 62.2
Mike Lubliner and David Hales are active in 62.2, SPC 193P, TC 6.3 and TC 9.5

EEBA (Energy & Environmental Building Organization)
Neil Moyer serves on the board of directors and various committees

FGBC (Florida Green Building Coalition)
Stephanie Thomas- Rees and Rob Vieira serve as board members

Habitat for Humanity International
Janet McIlvaine serves as an Advisory Board member for the Home Depot Foundation collaboration with Habitat for Humanity International – the National Partners in Sustainable Building Program.

ISO (International Standards Organization)
Philip Fairey serves as the U.S. representative to the International Standards Organization (ISO) Technical Committee 163, Working Group 3 on Energy Performance of Buildings.

Metro Orlando Home Builders Association (HBA)
Stephanie Thomas – Rees and David Hoak are active on the Green Homes Steering committee, Green Parade of Homes committee and other educational activities

NFPA
Mike Lubliner is an active participant on the NFPA 501 technical committee.

RESNET
Philip Fairey serves as the president. Steve Baden is the executive director. Ken Fonorow is a member of the board of directors. Neil Moyer and Mike Lubliner serve on committees

Briefings and Recognitions

Philip Fairey accompanied Secretary Bodman and Assistant Secretary Karsner on tour of the International Builders Show home at which the first Builders Challenge e-Scale was affixed by Secretary Bodman on February 14, 2008.

Subrato Chandra briefed Secretary Bodman and Assistant Secretary Karsner about the Building America program at the DOE booth at the International Builders Show in Orlando on February 14, 2008.

Subrato Chandra received letter of recognition from U.S. DOE Assistant Secretary, Mr. Andrew Karsner – March 26, 2008

APPENDIX B –Habitat for Humanity Case Studies

March 29, 2008

Building America U.S. Department of Energy

Research that Works
www.buildingamerica.gov

RESNET Partnership with Habitat for Humanity: Oklahoma City

Since 1995, The **U.S. Department of Energy's Building America** program has been providing technical assistance to Habitat for Humanity International and local Habitat affiliates interested in building energy efficient homes. Building America researchers help Habitat identify energy improvements that:

- are proven to be cost effective,
- are readily available in the market place,
- are appropriate for Habitat's volunteer construction crews, and
- do not place an additional maintenance burden on the homeowner.

Building America recommends that Habitat affiliates striving to build high efficiency homes work with a certified home energy rater. In 2005, **RESNET-certified home energy raters** began a volunteer effort with Habitat affiliates. Each volunteer rater provides a free rating to a Habitat affiliate in their community, including infiltration and duct testing, and they make recommendations on next steps for increasing energy efficiency. RESNET members participating in this program have a "Volunteer Energy Rater" emblem (*shown at right*) in RESNET's online directory of certified raters at: http://www.resnet.us/directory/raters_builders.aspx

Central Oklahoma Habitat for Humanity (COHFH)
For some RESNET volunteers, the offer goes beyond the first free rating. Oklahoma Gas and Electric's Positive Energy Home Program™ provides pro-bono home energy ratings, tax credit calculations, and a donation of $2000 per house for energy efficient improvements to Central Oklahoma Habitat (COHFH) in Oklahoma City. In Oklahoma, a state tax credit of $4,000 is awarded to builders of new homes less than 2,000 square feet that are 40% or more above the 2003 International Energy Conservation Code. COHFH is entitled to this tax credit, however, as a non-profit organization, they do not use the tax credit. Instead, they sell the tax credit at the rate of 85 cents on the dollar generating $3,400 to further offset the cost of energy efficiency improvements including:

COHFH Heating and Cooling System

- Geothermal Heat Pump - Tranquility 20 Systems Donated By ClimateMaster (COHFH Pays For Installation And Drilling)
- Room-by-room Manual J Calculation
- Blower Door Infiltration Testing To Ensure Estimated Natural Infiltration Rate Of 0.35 Air Changes Per Hour Or Less
- Ducts Sealed With Mastic And Tested To Ensure Leakage </= 5 Cfm Per 100 Square Feet Of Conditioned Space

COHFH Enclosure

- 2x4 Frame construction, slab on grade with R-5 perimeter insulation
- Spray foam insulation in Wall (~R-13) with R-4 exterior rigid insulation
- Spray foam insulation at Roof deck (~R-19) in unvented attic
- Low-E, double pane, vinyl frame windows (SHGC=/< 0.4 U-Value =/< 0.35)

COHFH Lighting – 100% Compact Fluorescent Bulbs *(note: only 20% can be counted for Energy Star certification purposes)*

COHFH HERS Index ranges from 56-58 (85 or less required to meet Energy Star)

RESNET
Residential Energy Services Network
www.natresnet.org

OG&E

Steve Sullivan, Coordinator
Builder & Developer Programs
OG&E - Electric Services
Phone 405-553-3393
sullivsr@oge.com

Through the RESNET-Building America-Habitat Partnership, RESNET-certified raters provide one pro-bono Energy Star rating to a Habitat affiliate in their community. Look for the "Volunteer Energy Rater" emblem above in RESNET's online rater directory at: www.resnet.us/directory/raters_builders.aspx

Central Oklahoma HFH Contact
Ann Felton (405) 232-4828

Building America U.S. Department of Energy Research Toward Zero Energy Homes

For more information on Building America's Partnership with Habitat for Humanity, see www.baihp.org/habitat

Note – this back page is the same for all of the Habitat case studies produced in BP3. It is only included once to save space.

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

Research and Development of Buildings

Our nation's buildings consume more energy than any other sector of the U.S. economy, including transportation and industry. Fortunately, the opportunities to reduce building energy use—and the associated environmental impacts—are significant.

DOE's Building Technologies Program works to improve the energy efficiency of our nation's buildings through innovative new technologies and better building practices. The program focuses on two key areas:

- **Emerging Technologies**
  Research and development of the next generation of energy-efficient components, materials, and equipment
- **Technology Integration**
  Integration of new technologies with innovative building methods to optimize building performance and savings

For more information contact
EERE Information Center
1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov

U.S. Department of Energy
Energy Efficiency and Renewable Energy

An electronic copy of this publication is available on the Building America Web site at **www.buildingamerica.gov**

Visit our Web sites at:

www.buildingamerica.gov | **www.pathnet.org** | **www.energystar.gov**

Building America U.S. Department of Energy

PATH

Building America Program
George S. James • New Construction • 202-586-9472 • fax: 202-586-8134 • e-mail: George.James@ee.doe.gov
Terry Logee • Existing Homes • 202-586-1689 • fax: 202-586-4617 • e-mail: terry.logee@ee.doe.gov
Lew Pratsch • Integrated Onsite Power • 202-586-1512 • fax: 202-586-8185 • e-mail: Lew.Pratsch@hq.doe.gov
Building America Program • Office of Building Technologies, EE-2J • U.S. Department of Energy • 1000 Independence Avenue, S.W. • Washington, D.C. 20585-0121 • **www.buildingamerica.gov**

Building Industry Research Alliance (BIRA)
Robert Hammon • ConSol • 7407 Tam O'Shanter Drive #200 • Stockton, CA 95210-3370 • 209-473-5000 • fax: 209-474-0817 • e-mail: Rob@consol.ws • **www.bira.ws**

Building Science Consortium (BSC)
Betsy Pettit • Building Science Consortium (BSC) • 70 Main Street • Westford, MA 01886 • 978-589-5100 • fax: 978-589-5103 • e-mail: Betsy@buildingscience.com • **www.buildingscience.com**

Consortium for Advanced Residential Buildings (CARB)
Steven Winter • Steven Winter Associates, Inc. • 50 Washington Street • Norwalk, CT 06854 • 203-857-0200 • fax: 203-852-0741 • e-mail: swinter@swinter.com • **www.carb-swa.com**

Davis Energy Group
David Springer • Davis Energy Group • 123 C Street • Davis, CA 95616 • 530-753-1100 • fax: 530-753-4125 • e-mail: springer@davisenergy.com • deg@davisenergy.com • **www.davisenergy.com/index.html**

IBACOS Consortium
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Industrialized Housing Partnership (IHP)
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Oak Ridge National Laboratory
Pat M. Love • P.O. Box 2008 • One Bethel Valley Road • Oak Ridge, TN 37831 • 865-574-4346 • fax: 865-574-9331 • e-mail: lovepm@ornl.gov • **www.ornl.gov**

Pacific Northwest National Laboratory
Michael C. Baechler • 620 Southwest 5th, Suite 810 • Portland, OR 97204 • 503-417-7553 • fax: 503-417-2175 • e-mail: michael.baechler@pnl.gov • **www.pnl.gov**

Building America Liaison to Habitat for Humanity
Janet McIlvaine • Florida Solar Energy Center • 1679 Clearlake Road • Cocoa, FL 32922 • 321-638-1434 • fax: 321-638-1010 • e-mail: janet@fsec.ucf.edu • **www.baihp.org/habitat**

Produced for the U.S. Department of Energy (DOE) by Florida Solar Energy Center and the National Renewable Energy Laboratory.
FSEC-BAIHP-10

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

March 29, 2008

Building AMERICA SM
U.S. Department of Energy

Research that Works
www.buildingamerica.gov

Habitat for Humanity in Houston, Texas: Building Energy Efficient Homes for Over a Decade

Since 1995, The **U.S. Department of Energy's Building America** program has provided technical assistance to Habitat for Humanity International and local Habitat affiliates interested in building energy efficient homes. Building America researchers help Habitat identify energy improvements that:

- are proven to be cost effective,
- are readily available in the market place,
- are appropriate for Habitat's volunteer construction crews, and
- do not place a maintenance burden on the homeowner.

Houston Habitat for Humanity

Building America began working with Houston Habitat in 1996 on the award-winning *Energy Affordable Home* program. In 1997, Building America certified the first Energy Star Habitat home, followed by a 100-home community of Energy Star homes in 1998. Houston Habitat has built more Energy Star homes than any other Habitat affiliate (300+) and was recognized with an Energy Star Homes Builder of the Year Special Recognition Award in 1999 and the Affordable Home Builder of the Year Award in 2006.

For three years, Houston Habitat has been receiving free home energy ratings from DPIS Engineering to certify their Energy Star homes (see specifications below.) Brannon King, DPIS Vice President, notes that three more Habitat affiliates have come to them for Energy Star ratings as a result of Houston Habitat's leadership.

Construction Manager Mike Owen notes that concern for long-term affordability and durability drive Houston Habitat's effort to build energy-efficient high performance homes. Owen says, "If we can make a house more affordable month to month, it effectively increases the home owner's income. And the attention to details in an energy efficient home enhance durability, especially the air sealing details which keep infiltration and moisture intrusion under control."

The Bottom Line

Owen estimates the cost of building Energy Star homes to be about $600 per house for higher efficiency air conditioning, better windows, extra foam, caulking, and insulation, and some additional staff time for quality control. This cost is offset by utility rebates, Owen explains, "We get about $600 to $800 per house for participating in our utility's builder incentive program for efficiency. If I can build an energy-efficient home and, at the end of the day, the net cost is $0 or I make money on it, why wouldn't I do that?"

RESNET
Residential Energy Services Network
www.natresnet.org

Brannon King
(281) 351-0048
www.dpis.com
DPIS Engineering, LLC

VOLUNTEER ENERGY RATER
Habitat for Humanity
RESNET

Through the RESNET-Building America-Habitat Partnership, RESNET-certified raters provide one pro-bono Energy Star rating to a Habitat affiliate in their community. Look for the "Volunteer Energy Rater" emblem above in RESNET's online rater directory at: www.resnet.us/directory/raters_builders.aspx

Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

For more information on Building America's Partnership with Habitat for Humanity, see www.baihp.org/habitat

Systems and Appliances

- SEER 14 AC (straight cool) with dual stage compressor
- 80% AFUE Gas Furnaces (or Heat Pump)
- Every duct system tested to ensure leakage does not 6 cfm per 100 ft2 of conditioned space
- Passive Outside Air ventilation to return plenum
- Whirlpool Energy Star Refrigerator
- Energy Star Ceiling Fans

Enclosure

- 2x4 Frame construction with R13 insulation with R4 rigid insulation
- R-30 Ceiling insulation with radiant barrier
- Low-E, double pane, aluminum frame windows (SHGC= 0.37; U-Value = 0.51)
- Tankless Water Heaters

HERS Index Average = 82 (85 or less required for Energy Star)

March 29, 2008

Building AMERICA SM
U.S. Department of Energy

Research that Works
www.buildingamerica.gov

Habitat for Humanity in Lakeland, Florida: High Performance Houses since 2000

Since 1995, The U.S. Department of Energy's Building America program has been providing technical assistance to Habitat for Humanity International and local Habitat affiliates interested in building energy efficient homes. Building America researchers help Habitat identify energy improvements that:

- are proven to be cost effective
- are readily available in the market place
- are appropriate for Habitat's volunteer construction crews
- do not place a maintenance burden on the homeowner

Lakeland Habitat's Commitment

In 2000, Lakeland Habitat for Humanity worked with Florida H.E.R.O., a Building America sub-contractor, to build its first high performance home. Since the completion of this first home, which won a special $20,000 grant from the Walt Disney Corporation, Lakeland HFH has built about 60 homes that exceed Energy Star requirements by 20-30%. In 2007, they built their first LEED Certified Green Home. Their standard practice (see bulleted list below) saves about 30% in whole house source energy use compared to the Building America Benchmark. The construction management team works with volunteers and the mechanical contractor to ensure the energy efficiency package is implemented in every house. Building America conducts the Thermal Bypass Inspection and tests the duct system.

The Whole Picture

Designing, detailing, and building high performance housing requires the cooperation of decision makers, construction managers, sub-contractors, and crews. The package of high performance features in all Lakeland Habitat homes includes components for occupant health, safety, and indoor air quality; moisture control for durability; energy efficiency, and comfort (see bulleted lists below.) The components of the package work together, although each is an effective step toward improved long-term performance.

The Bottom Line

Lakeland Habitat estimates the first cost of the package to be $1500. Annually, this adds $50 to a 30 year, 0% mortgage (typical financing terms for Habitat.) Estimated annual energy savings of about $150 create positive cash flow in the first year of occupancy. For a more in-depth case study of these homes, see "Lakeland Habitat" at www.baihp.org/habitat.

Occupant Health, Safety, and Indoor Air Quality

- All electric homes – no combustion safety risks.
- *Air Flow Control:* Ducts are meticulously sealed to prevent unintentional air flow between the duct system and unconditioned spaces
- *Ventilation:* Ducted, filtered, and dampered passive outside air ventilation system with air flow of ~25 cfm. *(System not appropriate outside hot-humid climate.)*
- *Relative Humidity:* Kitchens and bathroom exhaust fans are ducted to the outside to remove humidity generated by cooking and bathing.

Moisture Control for Improved Durability

- Controlling relative humidity levels reduces wear and tear on the air handler
- Continuous exterior air barrier (house wrap sealed at the edges and seams) keeps humid outside air away from components of the building envelope

Energy Efficiency and Comfort

- SEER 14, HSPF 8+ Heat Pump with duct system sealed with mastic and tested
- Interior air handler closet with ducted central return
- Double pane, vinyl frame, low-E windows
- Existing shade trees preserved when possible (see photo, above right)
- Radiant Barrier below roof decking, R-30 Ceiling insulation, R-13 Wall Insulation
- Thermal Bypass Inspection and blower door test on every house
- Water heater timer, Energy Star Refrigerator, 20% CFL Lighting
- Tight ducts, reduced infiltration, and controlled relative humidity all improve comfort
- Right sized air conditioning coils (Manual J) further improves humidity control

Lakeland Habitat for Humanity home.

Wall insulation installed with no gaps or compression.

Return plenum with ventilation duct. ~25cfm of outside air enters return plenum when air handler is operating

Lakeland Habitat for Humanity Contact:
Claire Twomey
Executive Director
1317 George Jenkins Blvd
Lakeland, FL 33815-1367
ctwomey@habitatoflakeland.org

For more information on Building America's Partnership with Habitat for Humanity, see www.baihp.org/habitat

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Building Technologies Program
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

March 29, 2008

Building AMERICA SM
U.S. Department of Energy

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Habitat for Humanity – Building America Partnership: Jimmy Carter Work Project 1997-2007

Since 1995, The U.S. Department of Energy's Building America program has been providing technical assistance to Habitat for Humanity International and local Habitat affiliates interested in building energy efficient homes. Building America researchers help Habitat identify energy improvements that:

- are proven to be cost effective
- are readily available in the market place
- are appropriate for Habitat's volunteer construction crews
- do not place a maintenance burden on the homeowner

Jimmy Carter Work Project (JCWP)

Former President Jimmy Carter and his wife Rosalyn have a long history with Habitat for Humanity, a non-profit affordable housing provider that sells homes at zero interest and no profit to qualified buyers. Every year, President and Mrs. Carter work on a a special project with Habitat to draw attention to the need for affordable housing. The Carter's have selected domestic sites from the Blue Ridge Mountains to the shores of Lake Michigan and the streets of Harlem, from Florida across the Gulf Coast to Georgia, Alabama, and Texas and west to Los Angeles, the 2007 site. Building America has supported Habitat at many of the sites (*see list, right*) helping Habitat affiliates implement energy efficiency strategies that make affordable housing more affordable to live in.

Energy Star and Beyond

Recognizing this link between energy efficiency and long term affordability, Habitat for Humanity has embraced construction of Energy Star Homes as a Best Practice. Since 1997, hundreds of Energy Star homes have been built during the JCWP. However, in 2007, things got decidedly *greener*. These 30 dwellings (8 duplexes and 14 multi-family units) are the first Carter Project houses to be LEED Certified. Global Green USA and Gaia Development worked with the Habitat affiliate to identify and implement the green package which includes photovoltaic solar electric systems, designed and installed by GRID Alternatives (*see photo at right.*) Building America worked with Habitat and Alternative Energy Systems (a certified California Home Energy Rater) to certify the 2007 JCWP houses as Energy Star – a LEED prerequisite and important part of green building because it saves energy, conserves natural resources, and reduces air pollution – continuing the decade-long partnership between Building America and Habitat for Humanity.

2007 JCWP Green Features

- LEED Certified at the Gold Level (Pending)
- Close To Transit And Community Amenities
- Ducted Fresh Air Intakes and Exhaust
- Low Water Use Plumbing Fixtures
- Drought-Tolerant, Native landscaping
- On-site Storm water Management Systems
- Non-toxic Paints And Finishes
- See more at: http://www.jcwpla.org/jcwpla/

2007 JCWP Energy Features

- 95% AFUE Gas Furnace, No Air Conditioning
- Tankless Gas Water Heater
- Duct Systems Tested To Ensure Leakage Below 6% of Rated Air Flow
- R-19 Floor, R-13 Wall, and R-38 Ceiling Insulation
- Energy Star Refrigerator and Energy Star Ceiling Fans
- Low-E, double pane, vinyl frame windows (SHGC= 0.30; U-Value = 0.35)
- Blower Door Test to Ensure Infiltration (SLA) below 1.5
- 1.3 - 2.1 kW solar electric systems (PV Modules and Inverters)
- Average Improvement over California Energy Code = 32% (15% required to qualify for Energy Star in California)

Photo by GRID Alternatives.

Former President Jimmy Carter, center, at 2007 JCWP site in Los Angeles.

Carter Project Homes Supported/Rated by Building America		
Year	Site	Houses
1997	Lee County, KY	3 Energy Stars
1998	Houston, TX	100 Energy Stars
2000	Americus, GA New York City, NY	23 Energy Stars Volunteer Training
2003	LaGrange, GA Anniston, AL	22 Energy Stars 35 Near Energy Stars
2005	Benton Harbor, MI	23 Energy Stars
2007	Los Angeles	30 Energy Stars
		236 Total

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Building AMERICA U.S. Department of Energy Research Toward Zero Energy Homes

For more information on Building America's Partnership with Habitat for Humanity, see www.baihp.org/habitat

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Building Technologies Program
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

APPENDIX C – Washington State University Annual Report

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

Contract # DE-FC36-99G010478

January 2008 – October 2008

Michael Lubliner
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Task Area 2 – Test House Evaluations

Garst Residence

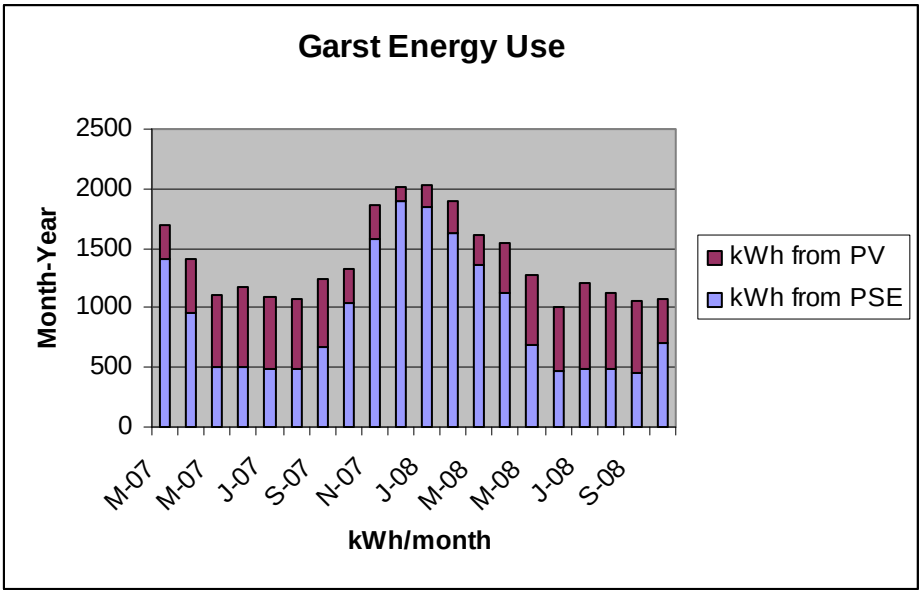

Figure 1 – Garst residence, monthly energy use, including PV to grid

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. Figure 1 provides a monthly breakdown of energy use and PV production.

Total electric use (before PV) was 12704 kWh/year; total use after total PV was 7750 kWh/year. The photovoltaic system is performing well at 4954 kWh/year or 1086 kWh/year per kW of installed PV. Of the total PV production, 2113 kWh/year was used by the house, and 2841 kWh/year returned to the utility. BAIHP staff are in the process of comparing this metered usage to the modeling predictions as part of the final report and presentation in February 2009. This report will update information used in the PNNL Building America Best Practice Case Study.

BAIHP staff and FSEC coordinated during the design, field testing and monitoring stages of this project. Field testing indicated significant leakage at windows and resulted in a higher than anticipated envelope leakage of 4.9 ACH_{50}.

Based on blower door field testing, energy use monitoring and IAQ perception, the Garsts decided to make the following changes to the operation of their home in 2007-08:

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, BAIHP staff began the process of analyzing and optimizing well pump performance for the ground source heat pump. BAIHP staff collected one minute data on ground source heat temperature and flow to determine per cycle space and hot water COP. Preliminary daily average COP results for predominantly water heating are shown in Figure 2. COP is determining with (blue) and without (red) the GSHP pumping energy included. BAIHP staff are in the process of evaluating COP performance during the space heating season, which is expected to be higher, due to lower slab water heating temperature requirements.

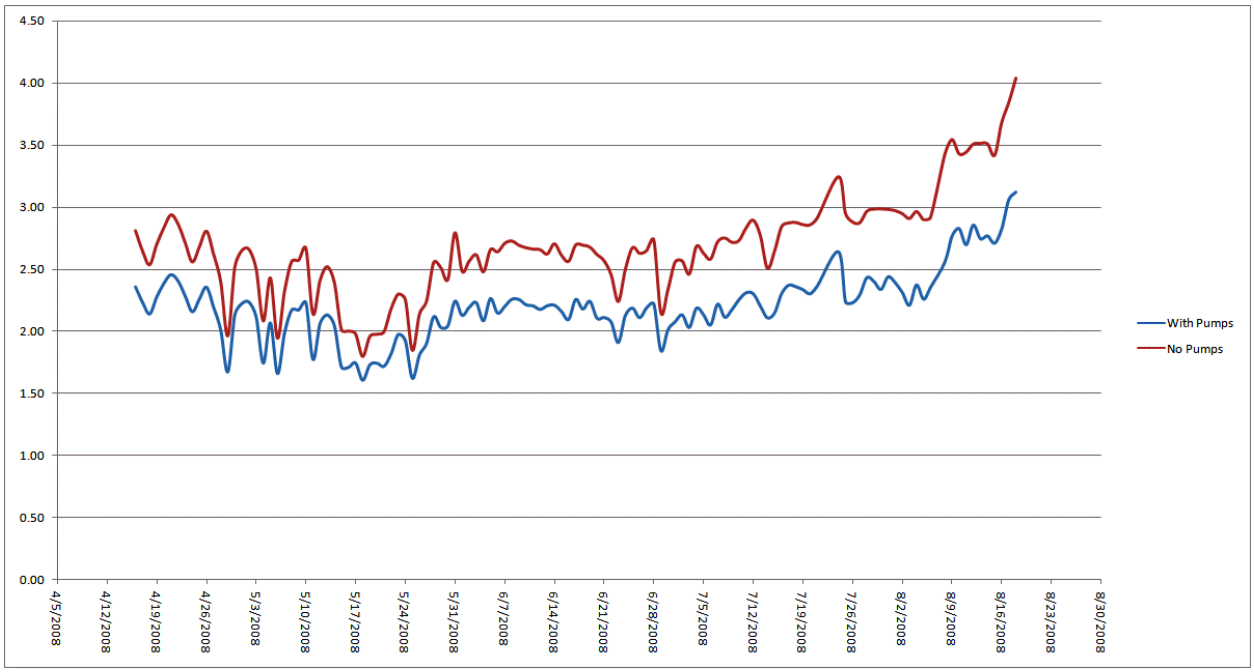

Figure 2 – Garst residence, ground source heat pump COP

Detailed heat pump data can be found at: \\energy.wsu.edu\oly\Shared\IND\Build America\Build America\Garst\COPCalc20080903.xls

BAIHP staff are evaluating using the home's sunspace to provide solar gain benefits to the house during the heating season via a 90 CFM thermostat controlled exhaust fan. As shown in Figure 3, warm air (red) is delivered to house on two consecutive mild days in October (outside temperatures in yellow). As fan turns on (purple), sunspace drops to temperatures (green) above outside and below house temp (blue), providing solar gains to home.

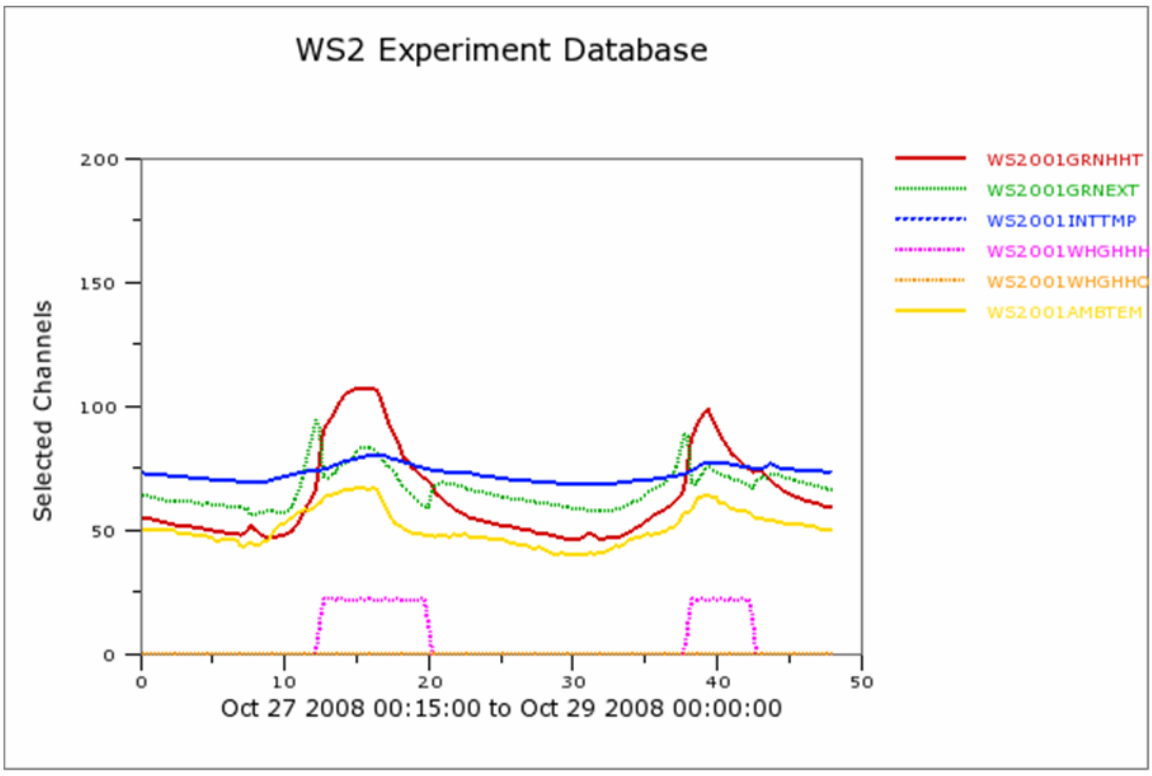

Figure 3 – Garst residence, solar sunspace operation on sunny fall day

Scott Homes

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. Figure 4 provides the combo mechanical system diagram.

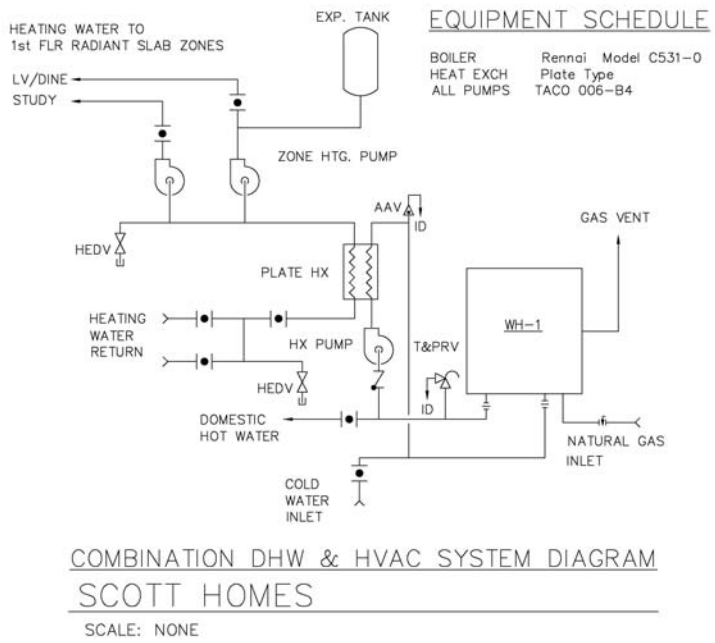

Figure 4 – Scott Homes, combo space/DHW system mechanical drawing

Since 2005, BAIHP staff have worked with Scott Homes on 20 homes built in Washington's south Puget Sound; 17 of these homes qualified for Energy Star certification, 13 qualified for the federal tax credit for new homes. BAIHP has focused efforts on elements in the homes' specifications that were a barrier to compliance with ENERGY STAR, tax credit, and high Building America metrics, including heating fuel choice and air sealing detail (the 17 Energy Star Homes' average air leakage is 2.75 ACH50, and two of the most recently qualified homes achieved 1.5 ACH_{50}.

Since 2007 BAIHP staff have tested 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.

BAIHP staff have deployed HOBO dataloggers in one of the homes (Salvi Residence) to collect zone temperature/RH and HVAC performance data. Monitoring of the homes' supplementary electric resistance heat in the upstairs bedrooms is underway during the 2008-09 heating season. Overall annual monthly gas and electricity use was 24 MMBTU electric and 46 MMBTU gas as shown in figure 5. There is reasonable agreement with REM simulation preliminary estimates of 71 MMBTU/year; additional investigations are underway during the 2008-09 heating season.

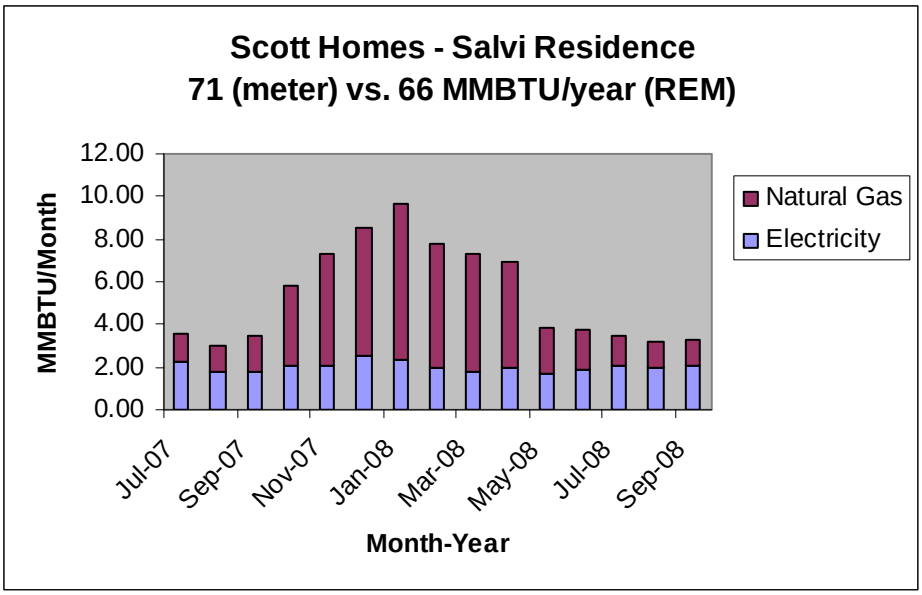

Figure 5 - Scott Homes, gas and electric utility usage (07-08)

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, Seisco tankless electric boiler and Seisco tankless back-up water heater. 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. Figure 6 illustrates end load electrical total usage, for space heating, water usage and other usage for two years.

Stamets Electric Use July 2006 - July 2008 kWh/yr

Year	Total	Floor Heat (1a)	Ceiling Heat	Total Heat (1b)	HPWH DHW	Tankless DHW	Total DHW (2)	Other	Hot Tub (3)
2006-07	32656	20,230	1,058	21,288	1,717	2,546	4,262	5,819	1,307
2007-08	32750	18,217	1,711	19,928	2,235	1,734	3,969	6,203	2,699
Avg 06-08	32703	19224	1384	20608	1976	2140	4116	6011	2003

(1a) T-stat raised F in12/07 (1b) R19 floor + R30 ceiling added summer 2007

(2) HPWH off in summer 2006-07, on in 2008 (3) Hot tub installed in Feb 07

Figure 6 – Stamets Residence, electric end load usage (07-08)

The total overall electricity use was roughly 32,000 kWh per year, with roughly 2/3 of that electric resistance being space heating.

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.

BAIHP staff are coordinating the design and installation of the ground source heat pump and PV system in fall 2008. Monitoring is underway to evaluate the energy impact of these improvements. Based on the performance of the Garst GSHP system, the installation of the Stamets GSHP system is expected to reduce the space and water heating by at least 10,000 -13,000 kWh in 2009, to under 20,000 kWh/year. Figure 7a shows the radiant floor heating zonal pumping system in the mechanical room; figure 7b shows the radiant floor heating piping (prior to installation of floor insulation.)

Figure 7a & 7b – Stamets Residence, Radiant Floor Zonal Heating System

The overall mechanical system drawing is shown in figure 8.

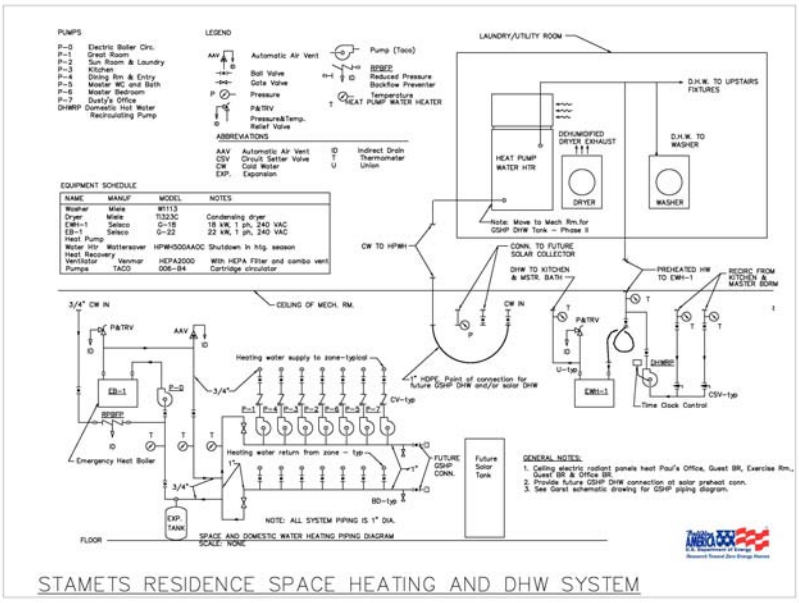

Figure 8 – Stamets Residence, Mechanical System Drawing (noting GSHP installation of fall 2008)

Preliminary results from a flip flop test conducted on the utility room heat pump water heater in the summers of 2007 and 2008 suggest that the heat pump water heater saved 446 kWh in overall DHW use. The HPWH operated in resistance mode in the summer of 2007, compressor mode in summer of 2008. The use of the HPWH in summer of 2008 significantly reduced the tankless electric DHW usage for that period. In addition, the HPWH cooled down the utility room, and utilized waste heat from the condensing dryer during laundry cycles, while taking advantage of solar gains from the south facing windows.

Heat Pump Water Heater (HPWH) Summer Flip/Flop Test

	HPWH	Tankless	Total	Flip/Flop
Jul-06	85.7	305.5	391.2	HPWH off
Aug-06	96.2	305.7	401.9	HPWH off
Total	181.9	611.2	793.1	HPWH off
Jul-07	137.8	41.3	179.1	HPWH on
Aug-07	129.8	37.8	167.6	HPWH on
Total	267.6	79.1	346.7	HPWH on
	COP summer flip/flop		2.29	
	kWh summer savings		446.4	

Figure 9 – Stamets Residence, Heat Pump Water Heater flip flop test

Task Area 3 – Community Scale Evaluations
UNICO, Dexter Project

Unico Properties LLC is a real estate investment and operating company. Headquartered in Seattle, Washington, the company owns and operates nearly nine million sq. ft. of premier properties in the western United States. The Dexter project is a four-story multi-family building with interior corridors and combined living/office/storefront on the 1st floor. The project is a first of its type hybrid, with the 1st floor site built, and the rest of the building factory-built at Guerdon Homes of Idaho, and shipped to Seattle. Unico will pay for the utility costs associated with the corridors (HVAC, lighting, motors); renters will pay utility costs for individual units.

Still in the permitting phase, Unico asked BAIHP staff to provide design assistance with the project. Unico had two major goals: achieve LEED Silver certification (as a minimum) and high Building America metrics. Through numerous design charrettes and e-mail exchanges, the BAIHP team, working with Ecotope Inc. (acting as mechanical engineer) made the following recommendations:

- Reduced glazing area
- Triple glazing
- R-21 framing with R-5-7 rigid foam wall sheathing
- Ductless mini-split heat pumps
- Central condensing gas-fired water heater system
- Gas-fired corridor HVAC
- Low flow plumbing fixtures
- Energy Star appliances
- Energy Star lighting
- Exhaust-only ventilation

During the project, a combination of significant budget problems and resistance from the design and construction teams let to a re-evaluation of the improvements suggested by BAIHP and Ecotope:

- The architects were unwilling to alter the look of the building enough to incorporate ductless heat pumps, so the factory built units were heated by electric resistance baseboard heaters. Heat pumps were retained for first floor units.
- The architects were also unwilling to investigate the use of compact fluorescent lighting technology. In addition, there was no lighting designer engaged in the project.
- The developer did not want any central HVAC or DHW systems, so as to maintain the ability to individually meter each unit. Also, in the interest of eliminating one utility cost, they did not want any gas HVAC or DHW. BAIHP and Ecotope then recommended the use of instantaneous electric water heaters; unfortunately, it was determined that they would increase the electrical service size by a factor of 2, which was cost-prohibitive. In the end, the developer decided to use electric storage water heaters.

- Both site and factory contractors complained about the difficulty in incorporating rigid exterior insulation on the project. They sited problems with shipping and connecting the units at the site; siding the units on site was identified as another challenge. Perhaps most importantly, the lack of a fire listing for exterior foam for this building type presents a serious code compliance challenge. BAIHP is exploring need to separately listing assembly for fire code if the foam is non-combustible type. Resolving this issue may lead to the use of exterior foam (combustible and non-) of this type of multi-family housing.
- Exhaust-only ventilation was eliminated as a cost-saving measure. Washington State Ventilation Code allows compliance for buildings over four stories, using only operable windows.
- Triple-glazed windows were eliminated to cut costs.

Of all of the recommendations put forth by BAIHP and Ecotope, only reduced window glazing went into the final design. Window u-factor was also reduced to an area-weighted value of 0.32. It is important to note that without these low-to-no cost improvements to glazing, the project would have met neither LEED Silver certification or Washington State Energy Code.

BAIHP staff have offered to provide training and technical assistance to UNICO in the areas of air leakage control, HVAC commissioning (in-plant and at set-up) and energy feature quality control.

While final results of this project were frustratingly far from the hoped for outcome, the lessons learned for both Unico and BAIHP were valuable:

- Cost-benefit analysis was not part of the contractural agreement between the developer and the architect. As a result, even with the assistance of BAIHP and Ecotope, decisions were made without any evaluation of impact on long-term operating costs to Unico or renters.
- Both the modular and site-construction general contractors had significant resistance to implementing the proposed technologies.
- LEED silver certification was shown to be “greenwashing” – project is still recognized as “green,” though it barely meets WSEC.

Unico is looking to incorporate these lessons as they undertake future projects in Seattle.

Fort Lewis Army Base – Fort Lewis, Washington

Figure 10 –Crawlspace Fan - Fort Lewis Army Base, Washington

Since 2005, 483 energy efficient modular homes have been built at Fort Lewis Army Base in Washington State. BAIHP staff are working with Building America partners Oregon Department of Energy (ODOE), Champion Homes and Equity Residential in an effort to build 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, featuring .90 AFUE furnaces, efficient windows, and ENERGY STAR appliances.

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.

All Fort Lewis homes are mechanically ventilated, controlled by humidistats to operate at 60% relative humidity (see Figure 10.) BAIHP staff are working with Equity to evaluate the effectiveness of this ventilation strategy, compared with the electricity use of fan

operation. Preliminary data suggests fans can be turned off, saving tens of thousands of dollars in electric bills over the life of the home (see Figure 11.) BAIHP staff will advocate not including these fans on remaining Fort Lewis homes.

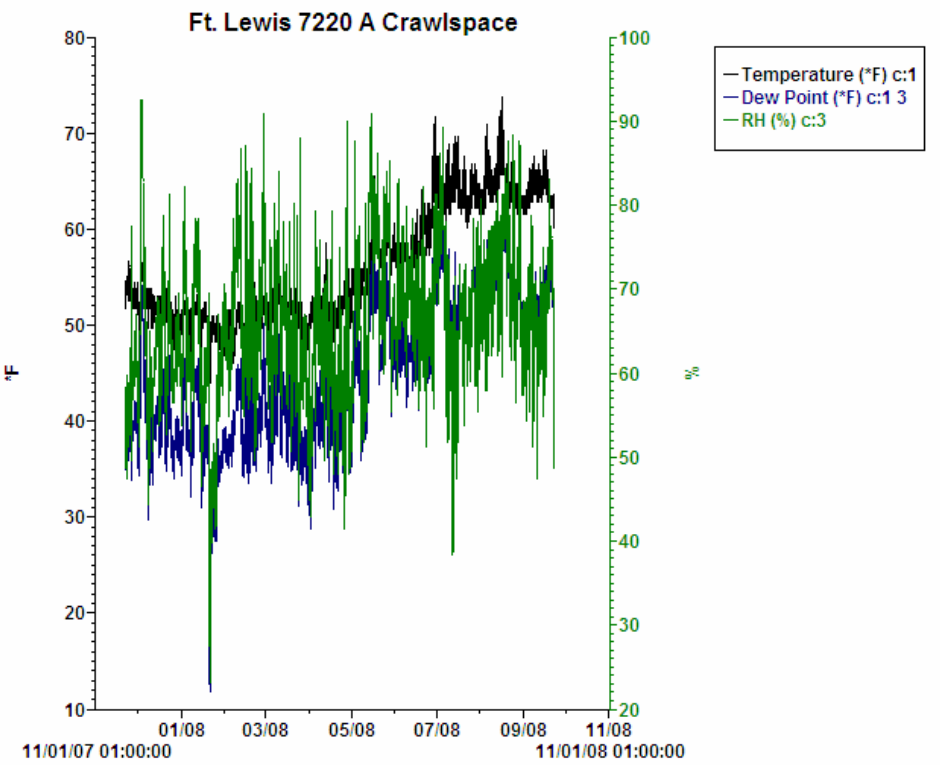

Figure 11 – Fort Lewis, Crawlspace Temperature, Relative Humidity and Dew Point (no crawlspace fans operating)

BAIHP staff are also working with Equity staff and Minol on an effort to conduct a community scale billing analysis of over 300 homes (including the demonstration homes.) In Spring of 2009, an additional 34 more homes will be built at Fort Lewis; BAIHP staff is working with Equity and utility partners to incorporate technologies from the demonstration duplex into these homes. As a result, future utility billing analyses will have a reasonable sample size for both control (Energy Star) and Building America demonstration technologies.

In 2009, BAIHP will work with Equity to plan for a new 220 unit development at Fort Lewis named Town Center, start date to be determined. BAIHP staff hope to incorporate Building America demonstration technologies; ductless heat pumps will also be discussed. BAIHP staff made a presentation on Fort Lewis "Going Modular with Energy Star" at the Affordable Comfort conference in Pittsburgh. The presentation can be found at www.affordablecomfort.org/images/Events/26/Courses/958/PRAC8_Lubliner.pdf

Scott Homes

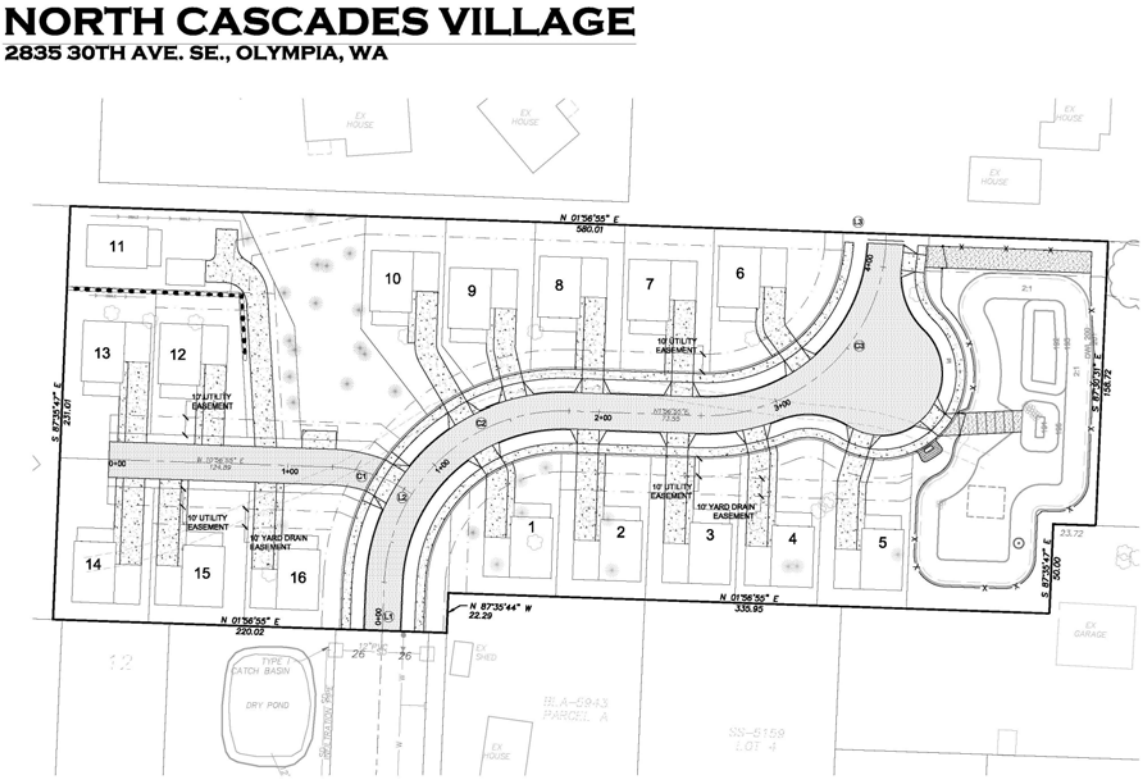

Figure 12 – Scott Homes, North Cascades Village site plan

In addition to coordinating with Scott Homes on their work on individual test homes, BAIHP staff have been working with the builder to design and plan a 16 home solar-ready development called North Cascade Village. The homes are designed to achieve the Building America 50% whole house savings target, and include:

- A Navian tankless, condensing combination radiant floor space/water heating system. This is an improved version of the Scott Homes combination system (see Test Homes Section) with an EF improvement of .85 to .96.
- SIP ceiling, walls
- R-15, fully insulated slab on grade
- 100% E-star lighting and appliances
- .30 u-value windows (Scott is also considering triple pane)
- Non-heat recovery Panasonic, low-wattage exhaust only ventilation (wall air inlet vents in bedroom closets and above refrigerator)
- TED energy monitors

All but two sites have adequate solar access. One model home will be fully equipped with PV and passive solar panels; the other 15 will be built "solar ready." The homes

will be extensively monitored, and connected to the WEBGET system. Construction is scheduled to begin in spring of 2009.

Habitat for Humanity Olympia, WA

Figure 13 – BAIHP booth, HFH Mainstream Green Conference, Tacoma, WA

Over 300 people attended Habitat's Mainstream Green Conference in Tacoma, Washington. BAIHP staff worked with Habitat to develop a building science track for the conference, and enlist presentations from Joe Lstiburek and WSU Energy Program's director. During the conference, BAIHP staff introduced the concept of collecting utility data for future Habitat projects. BAIHP staff also conducted a field visit to Reynolds Park, a nearby 16 unit Habitat project, demonstrating the impact of air sealing details to over 20 Habitat staff.

BAIHP staff have worked with Washington State Habitat affiliates to qualify over 170 existing homes to Northwest Energy Star standards, and are continuing to provide technical assistance and outreach to other Northwest Habitat affiliates, including:

- BAIHP staff conducted a series of design charrettes with King County Habitat for two multi-family developments and one single family development. Site excavation has started on two of the projects with a total of 24 units; BAIHP provided guidance in understanding and meeting Energy Star certification requirements, as well as product recommendations. The third project, consisting of 15 units, requires certification to the Evergreen Sustainable Development Standard, developed by Washington State to qualify homes for low-income housing funding. BAIHP staff provided guidance on HVAC and ventilation

system strategy; the project will use an inexpensive HRV, and is considering the use of mini-split heat pumps.

- BAIHP staff worked with Building America partners Panasonic and Broan on a ventilation study of two of fifteen homes being built by Tacoma Habitat for Humanity. One home will be outfitted with a full Smart Sense package, donated by Broan; the other will receive a full Whisper Green package, donated by Panasonic. The houses were built in the summer; analysis should be finished in 2009.
-

BAIHP staff trained Ed Brown, a staff member of Washington State Habitat to certify homes for Energy Star and northwest performance testing standards; Mr. Brown is pursuing full RESNET certification as well. Mr. Brown is tasked with assuring that all Habitat homes constructed in 2008-09 will meet both Energy Star and the Evergreen Sustainability Standards.

Subtask 4.5 – Documentation, Resource Development and Related Activities

ASHRAE

BAIHP staff Lubliner and Hales continued active participation in 2008:

- BAIHP staff chaired ASHRAE SPC 193P committee, "Method of Test for Determining the Air Leakage Rate of HVAC Equipment. Committee was convened at January and June ASHRAE meetings. Coordinated improvements to the draft standard with other committee members. The final draft is to go to the committee in November 2008 for approval for public review. The goal is to have the standard adopted by June 2009 at the earliest.

- Attended following ASHRAE committees:
    - TC 6.3 – Central Forced Air Heating and Cooling Systems
        - As chair of research subcommittee, proposed statement of work for latent cooling research project, entitled "RP-1449 – Energy Efficiency and Cost Assessment of Humidity Control Options for Residential Buildings." Project was accepted by ASHRAE and ARTII, and awarded to Building Science Corporation.
    - TC 9.5 – Small Residential and Commercial Buildings
    - 62.2 – Ventilation and Acceptable Indoor Air Quality in Residential Buildings Technical Subcommittee produced Guideline 24- 2008, Ventilation and Indoor Air Quality in Low-Rise Residential Buildings

ACCA

- Attended meetings and participated as a voting member of the committee for the development of the final Air Conditioning Contractors of America (ACCA) Quality Installation (QI) verification standard.

ACEEE

- Published paper and made presentation on moving ducts inside at ACEEE Summer Study; study included BAIHP efforts with Habitat for Humanity (see publications.)

NAHB/IBS

- Participated in Energy Value Housing Awards and USDOE Builder Challenge events; provided public outreach and technical assistance at BA booth at International Builder Show.

NFPA

- Made presentation at NFPA-501 meeting in SF on proposed standards. All energy proposals were accepted unanimously by committee for 2009 standard, and may be the basis for DOE's review of the MHCSS.
- Convened stakeholder meetings to discuss NFPA-501 standard and Building America research. Meetings took place at Federation of American Scientists, ACEEE Summer Study (informal session), Center for Disease Control, and BSC Westford Symposium.

NIST

- Provided review and comment, as well as technical assistance for report NISTR 7478 – "Airtightness, Ventilation, and Energy Consumption in a Manufactured House: Pre-Retrofit Results."
- Followed-up with NIST on proposed modeling research to evaluate EPA IAQ package in future HUD-code and BAIHP homes.
- Met with staff at NIST's Manufacturing Extension Partnership to explore technical assistance to factory built housing clients

Other Activities

- Participated in RESNET technical committee and board meeting, as well as delta Q demonstration at 2008 RESNET conference.
- Conducted peer review of Lean Manufacturing research paper for HUD.
- Attended Alaska Building Science Network annual meeting. Participated in discussions on $300,000,000 of funding to improve efficiency of existing Alaska homes.
- Met with Washington Manufactured Housing Association and other stakeholders on regional HUD-code BAIHP related activities and issues.

Press, References and Publications

ACCA

Quality Installation Verification Protocols Committee. Protocols for Verifying HVAC Systems to the ACCA Quality Installation Standard. Air Conditioning Contractors of America. Arlington, Vir. 2008.

ACEEE

Lubliner, M. et.al. "Moving Ducts Inside: Big Builders, Scientists Find Common Ground." Proceedings: ACEEE 2008 Summer Study. American Council for an Energy Efficient Economy. Washington, 2008.

ASHRAE

ASHRAE Proposed Standards 193P Subcommittee (chair) – "Method of Test for determining the air-leakage rate of HVAC equipment – final draft to Standards Council.
ASHRAE Standard 62.2 technical Subcommittee (co-author) – Published Fall 2008.
ASHRAE Guideline 24- 2008, Ventilation and Indoor Air Quality in Low-Rise Residential Buildings

Magazines

Lubliner, M.; Gordon, A. "Q and A – Zero Energy Manufactured Homes." Home Power Magazine. Fall 2008.

APPENDIX D – Oregon Department of Energy Annual Report

Oregon Department of Energy

Annual Report for Building America Industrialized Housing Partnership

February 2008 – September 2008

Task 2 – Test House Evaluations

Random home field-testing
As part of the continuing quality control process, field studies were performed in 1992-93, 1997-98 and 2001-02, 2005-06. The Northwest Energy Efficiency Manufactured Home (NEEM) program randomly selected recruited homes for an 86 home random field study. F**unding for the field study is being provided by BAIHP, the Regional Technical Forum, Bonneville Power Administration, The Energy Trust of Oregon, and Idaho Power and per home fees. In addition to the heating system house tightness, and ventilation fan tests, billing analysis, a** complete lighting survey was done on all **homes. A draft report should be available in November 2008.**

A billing analysis is also being done and will be compared to 1997 MAP home billing analysis sample. The selection of homes in this study was random, and included 19 of the region's 19 manufacturers building homes in 2006. In-plant duct testing and the field duct test results are being compared as well as overall HVAC performance.

A letter from NEEM staff was sent to each homeowner participating in the study with a summary of their homes test results. A copy of the letter was also sent to each manufacturer. If problems were found during the field visit, NEEM staff immediately sent a letter to the manufacturer and the retailer and followed the progress of the repairs including a possible retest if needed.

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 fixture and bulb types as part of a complete lighting survey

- Collect utility bill releases and perform billing analysis.
- Compile data and publish report

Decommissioning of older mobile homes

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 homes. NEEM staff continues to cooperate with our industry partners and attended Native American and non Native American weatherization conferences and meetings.

Task 3: Community Scale Evaluations:

In late October 2007, ODOE's building inspector, Al Rust, made final inspections on Ft Lewis homes in the Champion plant in Silverton Oregon. The Champion plant closed down and ceased to be a HUD code or modular builder. 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 tested each homes ducts system and sent results for entering into the Energy Star data base.

Ft. Lewis Communities LLC, Equity Housing, Washington State University, and ODOE continue to monitor two test units at Ft. Lewis. Tankless hot water heaters, 94% efficient gas furnaces Panasonic Whisper Green fans. Fans were sized to ASHRAE 62.2 instead of WA VIAQ and were installed in bathrooms replacing the hallway whole house fan. The entire HVAC system in one home was sealed with Aeroseal. The ESTAR lighting fixtures were installed in both units as well as T-8 strip lighting above and below kitchen cabinets.

Ft Lewis Communities LLC released bid documents for Phase 4. NEEM staff is providing technical assistance to other NW HUD and modular plants involved in the bidding process at Ft. Lewis. NEEM maintains a contract for inspection and certification services with Ft Lewis Communities LLC, the contractor to the Army that owns, builds and maintains all Ft Lewis base housing for the next 47 years. ODOE also maintains a contract with WSU Energy programs for certification of Energy Star homes built in Oregon and sited at Ft. Lewis. NEEM staff is waiting for Equity Residential/Ft Lewis Communities LLC to announce the winner for the next phase. Energy Star is in bid specification.

NEEM staff developed a power point for Energy Star modular homes and traveled to NW plants to present the Energy Star Modular program. So far Champion of Idaho and Guerdon of Idaho are the only plants to sign up as Energy Star modular builders after Champion of Oregon closed its doors.

Task 4: Lessons Learned

Subtask 4.2 NEEM Program Support
Staff performed quarterly factory inspection visits, inspected problem homes; developed in-plant quality assurance detailed inspection manuals. In March 2008 NEEM proposed upgrading the standards to higher levels of energy efficiency and presented the higher standards to the industry.

Other activities include updating and distributing a power point CD for factory technical staff. After the meeting with the industry on September 10, 2008 NEEM regional staff from Oregon, Washington, Idaho, and Montana and FSEC staff held a two day meeting in Oregon to discuss research plans for the future. FSEC staff, Dave Chasar, shared research and other FSEC technical assistance projects with the NEEM staff. A Bonneville Power Administration manager, Mark Johnson, also attended the 2 day meeting. NEEM staff updated the list of incentives and contact names of 65 regional utilities.

Innovative HVAC system

On March 18, NEEM staff, and a Diakin Mini-split representative, and plant engineering and sales staff met to discuss ductless mini-split heat pumps as a heating system option for Energy Star homes. The Diakin representative toured the plant during production. Electrical and mechanical plant staff discussed the installation in the plant. It was agreed to pursue installing a system in a model home.

Home Shows

NEEM staffed a booth at the Salem, Oregon, regional home show from February 27 – March 2. and at the Idaho home show. NEEM handed out 42 awards to the manufactures for highest production and highest % of production and to the top three retailers in seven states –four Northwest and California, Utah, and Nevada. NEEM staff judged the best energy efficient home at the show and handed out an award to the manufacturer and retailer.

NEEMgreen

In March of 2008 NEEM staff developed a NEEMgreen program, a green building program for manufactured homes. As a part of the NEEMgreen home, the higher energy standards for the Energy Star manufactured home program was incorporated. NEEM staff presented NEEMgreen to the industry regional marketing Board of Directors, NW Pride, in May 2008. At that same meeting with the industry, NEEM staff also presented higher energy standards for the regional Energy Star manufactured home program. The Board of Directors of NW pride voted to approve the NEEMgreen program as part of their efforts to improve the image of manufactured homes and deliver their Advanced Home to the

market. NEEM staff presented NEEMgreen program to the Oregon manufactured housing industry, Oregon Manufactured Housing Assoc. Board of Directors on June 5, 2008. NEEMgreen was presented to the Marlette staff in Hermiston OR on July 23. NEEMgreen was presented to the Golden West staff in Albany OR on August 28. NEEMgreen was presented to Liberty on September 8, 2008. Golden West is building the first five NEEMgreen homes beginning in October, 2008.

Association meetings and industry meetings

In May NEEM staff traveled to Reno, Nevada to the Utah, Idaho, and Nevada manufactured home association annual meeting to present the Energy Star program and meet with Nevada utilities. NEEM staff gave two presentations on best installation practices and hosted a roundtable on energy at the meeting. NEEM staff also field tested 2 Energy Star home sited in Reno as a part of the 86 home field study.

Training and plant certification

NEEM staff presented to installation training sessions in Montana, Idaho and Oregon and to manufactured home associations and to utilities. NEEM staff from Oregon and Idaho taught at certified installer classes. The classes are cosponsored by the Oregon Manufactured Housing Association, the Idaho Manufactured Housing Association and foundation equipment suppliers. NEEM staff traveled to Woodland, California, for quarterly reviews at the Skyline and Silvercrest plants and met with Fleetwood of CA to discuss becoming their certifier for Energy Star homes.

Higher Energy Standards

On August 5, 2008, NEEM staff contacted suppliers and window manufacturers to set up conference calls to discuss the spec change. After NEEM staff held a conference call with window manufacturers to discuss the window spec change U=0.35 to U=.32, NEEM held a meeting with the manufactured home industry on September 10, 2008. Each of the 17 plants has 1 vote and the majority passes or fails the measures. Voting was held after the September 10th meeting. Votes will be tallied in late October 2008. A cost benefit analysis to the consumer with the energy upgrades was presented at the meeting. Seven regional plants were present at the meeting. The spec change includes the following new measures:
Vaulted ceiling R-40 U=0.029 required
Wall R-21 w no trade off U=0.52 required
U=0.32 area weighted average required
Lighting 50 % fixture CFL’s required
90% AFUE gas furnace required

National Numbers

NEEM plants produce approximately 65% -75% of the nation's Energy Star manufactured homes. The 2007 NEEM totals are 3,786 Energy Star homes built. Because of the current national mortgage crisis and the slow down in the building industry, the future looks unsure. For the eight months included in this report, 2,138 homes were built, whereas for the same period in 2007 2,524 homes were built.

ENERGY STAR homes produced February 1, 2008 to September 30, 2008	
Northwest Energy Efficient Manufactured Homes	
ENERGY STAR Gas	500
ENERGY STAR Electric	1,638
Total	2,138

Subtask 4.5 – Documentation, Resource Development and Related Activities

BAIHP project coordination:

- Meet with the window industry August 5, 2008.
- Meet with the manufactured home industry September 10, 2008
- Attend BAIHP review committee meeting 2/2008

Other BAIHP Partner coordination:

- Coordinated with BAIHP partners at NEEM plants on results of 86 home field study
- 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 five two-day classes for State of Oregon certified installers and local jurisdiction installation inspectors and taught five installer classes in Idaho.