FLORIDA SOLAR ENERGY CENTER®

CONTRACT REPORT

Building America Industrialized Housing Partnership (BAIHP II)

Annual Report – Budget Period 4 (BP4)
January 01, 2009 – December 31, 2009

FSEC-CR-1838-10
February 2010

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A Research Institute of the University of Central Florida

Building America
Industrialized Housing
Partnership
(BAIHP II)

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ABSTRACT

This annual report summarizes the work conducted by the Building America Industrialized Housing Partnership (BAIHP - www.baihp.org) during the fourth budget period (BP4) of our contract, January 1, 2009 to December 31, 2009. Highlights from the three previous budget periods are included for context.

BAIHP is led by the Florida Solar Energy Center (FSEC) of the University of Central Florida. With over 50 Industry Partners including factory and site builders, work was performed in four task areas:

Task 1: System Evaluations
Task 2: Prototype House Evaluations
Task 3: Community Scale Evaluations
Task 4: Post- Phase 3 Activities

As of the end of Budget Period 4 (December 2009), BAIHP worked with partners to improve the efficiency of over 192,500 industrialized homes generating energy savings of over $18.9 million *annually* for the owners/occupants.

In Task 1, System Evaluations, BAIHP

- Measured a 20% savings in heating and cooling energy use from a retrofit of an interior duct system in FSEC's Manufactured Housing Lab (MHLab)
- Worked with Building Science Corp. to test an innovative mechanical system in FSEC's MHLab that can operate as an air-conditioner or dehumidifier depending on the load
- Conducted a field study with commercially available energy feedback devices, documented a 7% savings, and identified opportunities for improvement
- Evaluated performance of seven water heating systems (three solar, four conventional) for two draw patterns (ASHRAE 90.2 and NREL/BA) imposed per month
- Nearly completed preparations for the evaluation of a SEER 22 heat pump in the MHLab

In Task 2, Prototype House Evaluations, BAIHP worked toward achieving DOE multiyear Joule targets with more than 20 Industry Partners in the Hot-Humid and Marine climate zones. This activity included four zero or near zero energy homes (ZEH or NZEH respectively). Other prototypes achieve between 40% and 60%+ whole house source energy savings on the Building America benchmark.

In Task 3, Community Scale Evaluations, BAIHP worked toward achieving DOE multiyear Joule targets with over 10 Industry Partners in the Hot-Humid and Marine climate zones. The majority of these partners have committed to building whole communities to a HERS Index of 60 or lower and including the Builders Challenge Quality Criteria.

In Task 4, Post Phase 3 Activities in new construction, BAIHP, in partnership with seven Habitat for Humanity affiliates, completed a significant affordable housing demonstration project in the Gulf Coast region with 10 Prototypes achieving between 30% and 45% whole house source energy savings on the Building America benchmark. BAIHP also provided technical assistance in the construction of over 1200 manufactured homes that met Energy Star certification criteria

in the Northwest or qualified as ECO-rated homes which requires efficiency beyond Energy Star levels and green features. Researchers fostered growth of the Builders Challenge program, collaborated with the National Renewable Energy Laboratory on their Building Energy Optimization (BEOpt) software, and conducted an extensive analysis of miscellaneous electric loads (MELs).

In 2009, BAIHP's Project Management Plan was revised to include a new element: Builders Challenge Level Retrofits in Existing Homes. Researchers worked with local government partners in four Florida counties to evaluate deep retrofit opportunities with the goal of achieving HERS Index scores of 70 and the Builders Challenge Quality Criteria in ten homes. BAIHP began building relationships within the remodeling and renovation industry and evaluated potential improvement from correcting thermal bypasses in existing homes ("Wind washing").

BAIHP Research Utilization activities in 2009 included service on technical committees and boards, participation in technical working groups, collaboration with industry organizations and peers, production of web materials, publications and presentations needed to communicate research findings to stakeholders, and training for key target audiences.

Project management tasks included reporting to DOE, contract management, staffing activities, project management planning for 2010. BAIHP sub-contractors' annual reports and sample case studies are included in the appendices.

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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.

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

INTRODUCTION

This annual report summarizes the activities of the Building America Industrialized Housing Partnership (BAIHP, www.baihp.org) for the fourth budget period (BP4) spanning January 1, 2009 through December 31, 2009. To provide context and a full representation of BAIHP's work, summaries of significant work completed in budget periods one (BP1 April 2006-February 2007), two (BP2 March 2007-January 2008), and three (BP3 February 2008-December 2008) 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 and existing American homes whether site-built or factory-built.

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 (Florida H.E.R.O.), Residential Energy Services Network (RESNET), Calcs-Plus, and 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 100% 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. In 2009, as the home building industry slowed, the BAIHP Project Management Plan was revised to include initial research activities in existing homes. In all of this work, BAIHP employs the Building America (BA) systems engineering principles to simultaneously enhance energy efficiency, comfort, durability, indoor air quality, 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 nationwide 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, using factory built components

Manufactured homes built to the national HUD Code are one of the most affordable types of single-family detached housing available anywhere in the world, generally costing less than $41/ft^{2} [1] 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. Many HUD Code home producers offer modular homes as well which are built to local codes and take advantage of many factory production benefits.

As of the end of Budget Period 4 (December 2009), BAIHP worked with partners to improve the efficiency of over 192,500 industrialized homes generating energy savings of over $18.9 million *annually* for the owners/occupants.

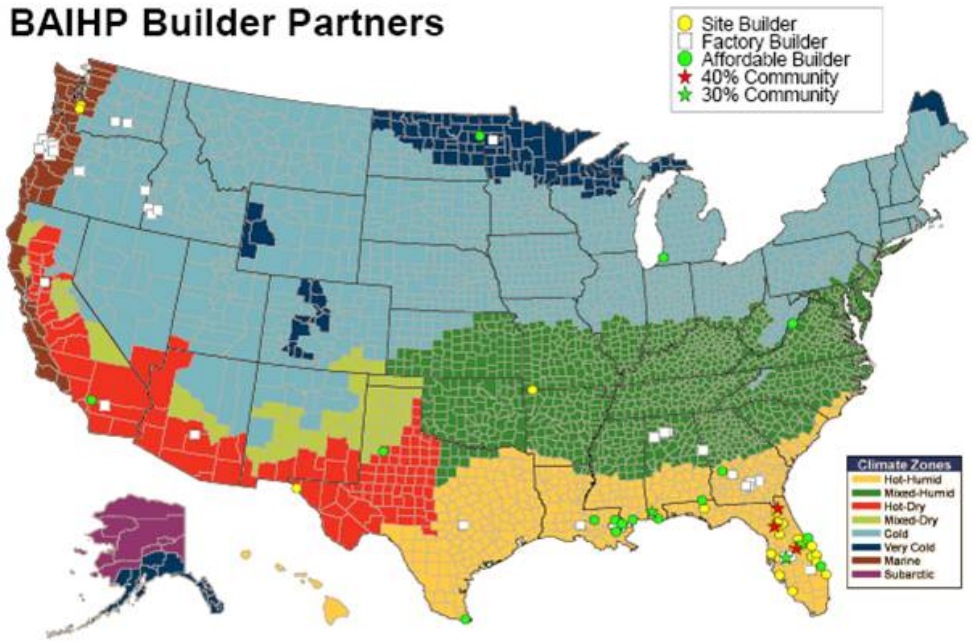

Figure 1-1 *BAIHP Builder Partners 2004-2009.See list in Table 1-1 below As of the end of December 2009: Total # homes improved: Over 192,500. Total energy saved: Over $18.9 million annually*

Industry Partnerships
BAIHP has partners in many stakeholder groups of the U.S. housing market including

[1] U.S. Commerce Department, Census Bureau, Construction Industry Reports Online, "Cost & Size Comparisons for New Manufactured Homes and New Single Family Site Built Homes." http://www.census.gov/const/mhs/sitebuiltvsmh.pdf

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 1-1 lists BAIHP Industry Partners from the past five years. Links to these partners' websites are available on our website from the "Partners" page at http://www.baihp.org/partners/index.htm . The geographic distribution of our partners is depicted on the map in Figure 1-1.

Table 1-1 *BAIHP Industry Partners 2004-2009*

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	Royal Concrete Concepts
Moduline Industries	Stalwart Built Homes
Production Builders	
Castle & Cooke	On Top of the World
Disney Imagineering	Pringle Development
Holiday Builders	Skobel Development
GMD Construction	Southern Heritage Homes
G.W. Robinson Builders	Tommy Williams Homes
LifeStyle Homes	
Affordable Housing Builders	
Atlantic Housing	Habitat for Humanity International
City of Brighton (FL) Housing Department	Habitat for Humanity, Alabama State Office
Brownsville Affordable Housing Corporation	Habitat for Humanity, Washington State Office
ICI Homes	Habitat for Humanity Affiliates (various locations)
Florida Local Government Partners - Deep Retrofits in Foreclosed Homes	
Alachua County	Orange County
Brevard County	Sarasota County and City of Sarasota
City of Palm Bay	Volusia County
Custom Builders	
Built Wright Custom 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.	WD Moore Construction
Developers	
Castle & Cooke	Organum Development (Lily Valley)
Equity Residential (Ft Lewis Army Base and McChord Air Force Base)	Schakow Development / Trunnel Homes
HKW Enterprises	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
CPS Energy	RESNET
Federation of America Scientists	Structural Engineering and Inspections, Inc.
Florida Green Building Coalition	Structural Insulated Panel Association
Florida Solar Energy Research and Education Foundation	Stevens Associates (Home Ventilation Institute)
IBACOS	University of Georgia, Tifton Campus
LSU AgCenter LA House	Washington Manufactured Housing Assoc.
Northwest Energy Efficient Manufactured Housing Program (NEEM)	

In the fourth budget period (BP4) 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

A detailed account of the activity in each of these task areas follows this introduction.

Task 1: System Evaluations

Subtask 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[2]). 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[3]). 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 a high side discharge supply register that uses the interior wall cavities as a conduit that connects to the floor trunks. Southern Energy Homes took a radical departure from the standard manufacturer duct system approach. A single soffit located within the conditioned space at the marriage line provides the space to aesthetically place the duct system. Both manufacturers are working on the elimination of the crossover duct as a field installed process. (Figure 1-2 through Figure 1-5)

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

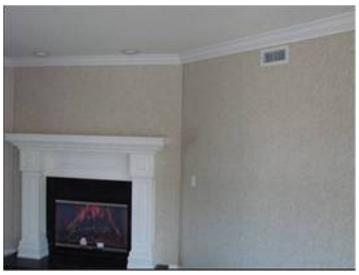

Figure 1-3: *Interior view of prototype house with high side discharge outlet.*

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

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

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

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[2] Cummings, J., J. Tooley, N. Moyer "Investigation of Air Distribution System Leakage and Its Impacts in Central Florida Homes" Florida Solar Energy Center, Rpt: FSEC-CR-397-91, Jun. 01, 1991

[3] Moyer, N., Beal, D., Chasar, D., McIlvaine, J., Withers, C., and Chandra, S., "Moisture Problems in Manufactured Housing: Probable Cause and Cures" Reprinted by permission from ASHRAE, Conference Proceedings IAQ 2001, ©2001 American Society of Heating, Refrigerating & Air Conditioning Engineers, Inc.

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[4]).

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).

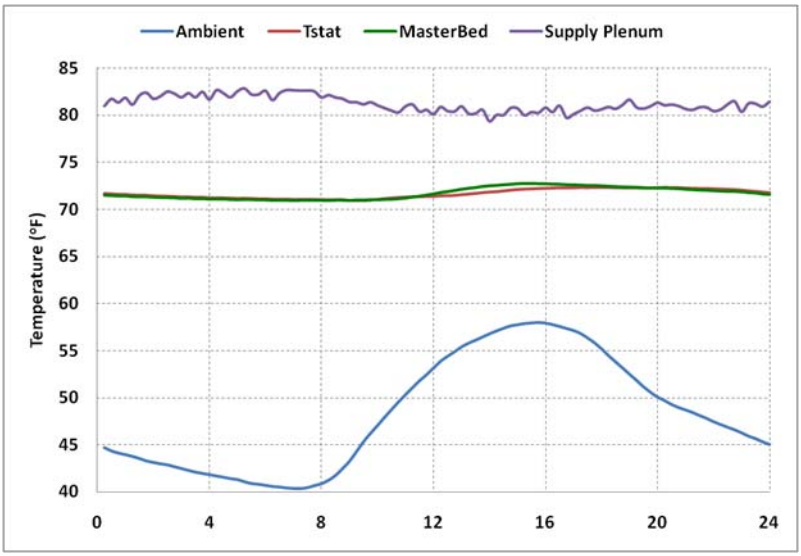

Figure 1-6 *Southern Energy Interior Duct Prototype: an hourly temperature profile of the supply plenum, thermostat, master bedroom and ambient. Data from November 8, 2007 to April 14, 2008.*

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. Monitoring of this home continued through summer of 2009. Data will be analyzed and reported in 2010.

[4] Moyer, N., Stroer, D., Hoak, D., McIlvaine, J., and Chandra, S., "Research Results from a Few Alternate Methods of Interior Duct Systems in Factory Built Housing Located In the Hot Humid Climate", Sixteenth Symposium on Improving Building Systems in Hot and Humid Climates, December 15-17, 2008, Dallas, TX.

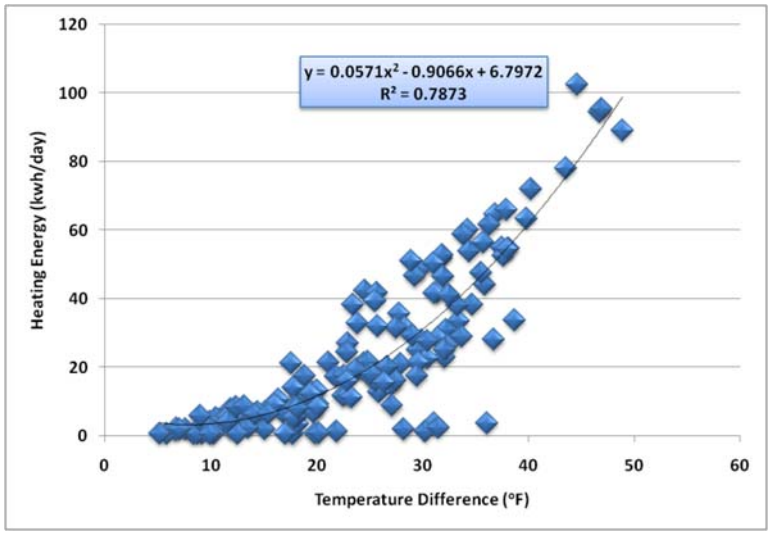

Figure 1-7: *Southern Energy Interior Duct Prototype: Heating energy versus temperature difference between inside and outside*

For the Cavalier Homes' high side discharge 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 cannot occur and none was detected during inspection (Moyer et al. 2008).

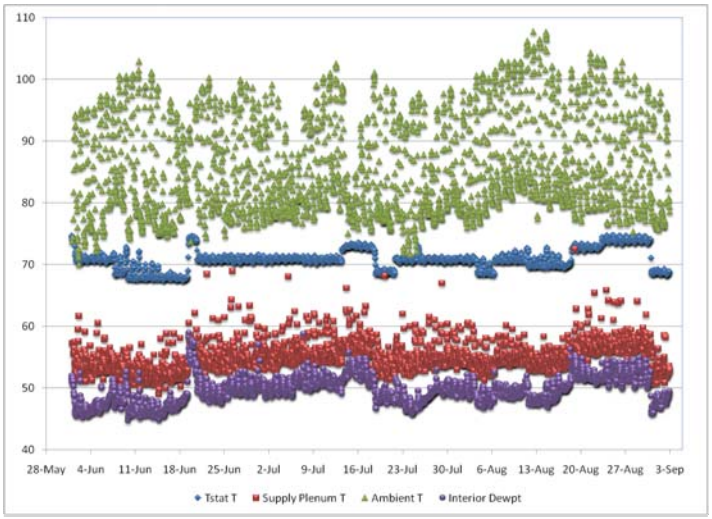

Figure 1-8: *Cavalier Homes - High Side Discharge Prototype: temperatures and dew point conditions on an hourly average 6/1/07 to 9/2/07*

Data reported for the Cavalier prototype was collected from June 1, 2008, through September 2, 2008. Figure 1-9 shows the energy usage plot for 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[5]). 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.

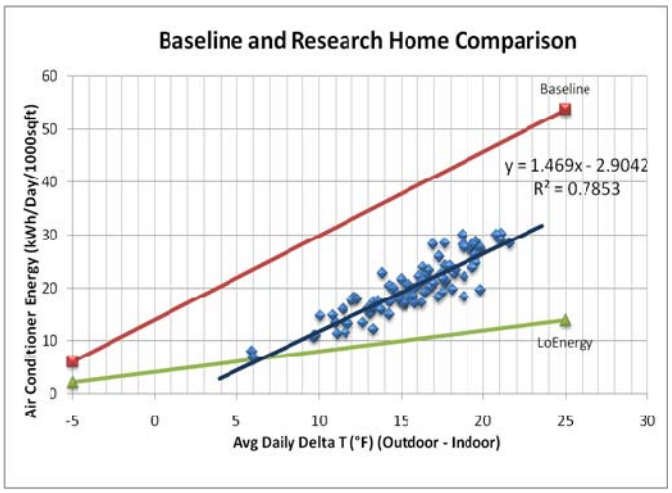

Figure 1-9: *Cavalier Homes High Side Discharge Prototype: daily energy usage verses average daily temperature difference across envelope*

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 1-10 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 cooling savings of about 18% by simply moving the ducts within the conditioned space. This corresponds to annual whole house energy savings of about 5.5%. These savings, however, are relative to the magnitude of the home's conditoining load. At the time of this experiment, the MHLab was

[5] Chasar, D., Chandra, S., Parker, D., Sherwin, S., Beal, D., Hoak, D., Moyer, N., and McIlvaine, J. "Cooling Performance Assessment of Building America Homes" , Fifteenth Symposium on Improving Building Systems in Hot and Humid Climates. July 24-26, 2006 Orlando, FL.

comparable to Energy Star homes (2006 guidelines) in the hot-humid climate with a HERS Index of 87. Cooling energy use makes up about 25% of the total annual energy use. The savings potential of interior ducts for homes that have already achieved higher performance through other envelope and equipment efficiencies is diminished because the conditioning loads are diminished. For example, researchers modeled the MHLab with characteristics similar to 30-40% prototypes that produced a HERS Index of 64. In this scenario, cooling energy use makes up only 15% of the total annual energy use and moving the ducts inside the conditoined space generates an estimated savings of 14%. This equates to a whole house energy savings of about 2.5%.

While interior ducts are widely considered to be a fundamental component of high performance housing, their construction does require change in construction processes. For this reason, partners are often reluctant to include this efficiency improvement in the first prototype effort, when it would result in the greatest whole house energy savings. When interior ducts come under consideration later in the partnership, the expected savings are diminished due to the reduction in overall conditioning load. While the energy savings are thus diminished, there are multiple benefits from locating ducts in the conditioned space and BAIHP researchers are of the opinion that these are sufficient to justify the pursuit of interior ducts with our partners. These include the

- Longevity of this detail (which extends to the life of the house)
- Reduction of pressure imbalances that result from duct leakage to and from unconditioned spaces
- Enhanced comfort from elimination of hot and cold “blows” at system start up
- Aesthetic enhancement if duct chases are well integrated into the interior design
- Relatively low cost (estimated at $0.40 to $0.90 per square foot).

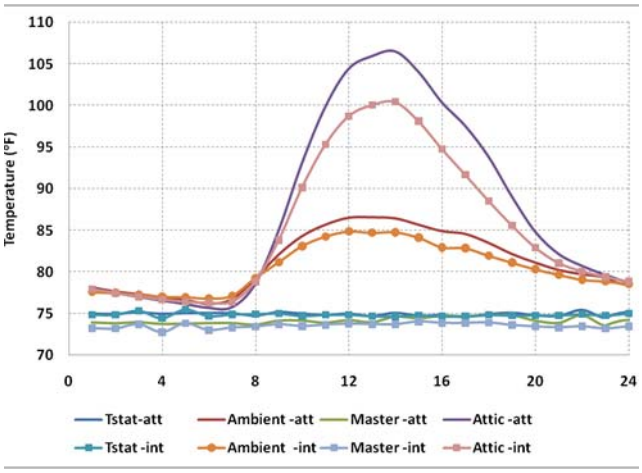

Figure 1-10: *MHLab Interior Duct retrofit: Average Hourly Temperature Profiles, Attic and Interior Locations*

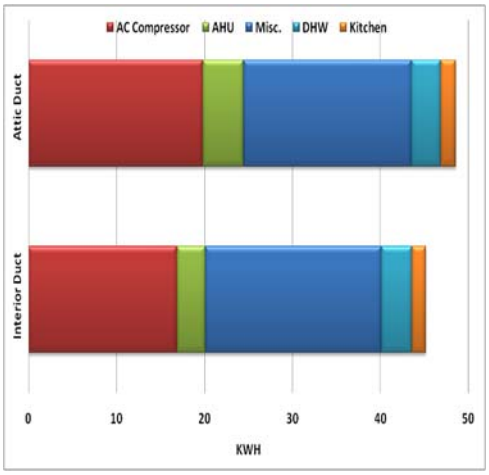

Figure 1-11: *MHLab Average Daily Energy Usage pre and post-interior duct retrofit*

Subtask 1.2 Factory Integrated HVAC/DHW Systems

BAIHP industry partner 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.

Subtask 1.3 Ventilation and Dehumidification

In 2007, Calcs-Plus lead an effort to develop a way to connect dehumidifiers and ventilation systems for hot humid climates to avoid simultaneous running of a/c compressor and dehumidifier. This system is documented in Chandra, et al. (2008) available online at: http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-439-09.pdf A system developed to this purpose was installed in the Gen-X prototype house in Siesta Key, FL in 2008 (see show homes section in Subtask 2.2).

The following efforts were also conducted under this subtask:

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- 14*: The FSEC Manufactured Housing Lab*

Figure 1- 15: *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, data collection, and equipment troubleshooting were performed by FSEC. Good data was collected at one min intervals and put on the FSEC web system for access by BSC. The ACDM system performed well after troubleshooting was completed.

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. In 2009, BSC's AAON prototype HVAC was restarted and set to cycle between cooling and heating modes on a daily basis according to Armin Rudd's experiment plan. Monitoring of the AAON system was completed in BP4. BSC (Armin Rudd) should be contacted for further details.

Humidity Liability Evaluation of ASHRAE 62.2

The other major BP1 project conducted in the MHLab was to evaluate the humidity liability of ASHRAE62.2 level of mechanical ventilation (*ASHRAE62.2, 2004*). In 2004 ventilation experiments conducted with less than 62.2 levels of ventilation during the peak summertime showed good dehumidification performance for all ventilation and dehumidification systems tested (Moyer et al. 2004[6]). During the period between November 2006 and February 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 cubic feet per minute (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 four 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.

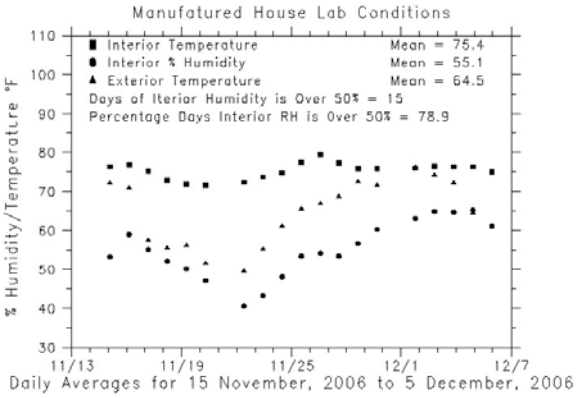

Figure 1-16: *Interior and exterior conditions at the MHLab under ASHRAE 62.2 ventilation (46cfm continuous for this house)*

6 Moyer, N., Chasar, D., Hoak, D., and Chandra, S. "Assessing Six Residential Ventilation Techniques in Hot and Humid Climates," Proceedings of ACEEE 2004 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, DC, August 2004.

Medical literature (Arlian et al. 1982[7]) 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 four bedrooms) and the run time vent rate was only 32 cfm. See Figure 1-17 below.

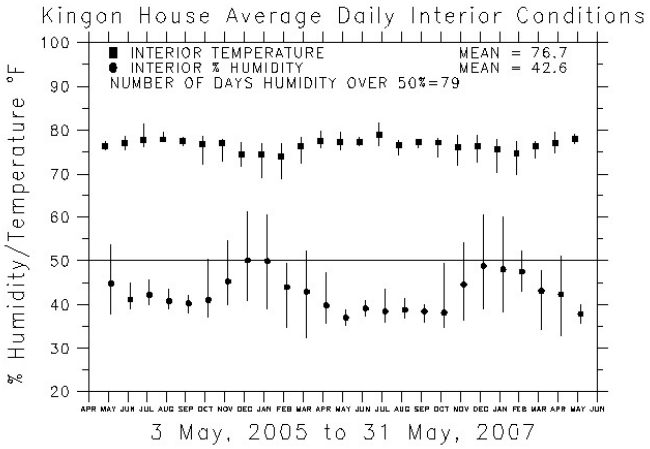

Figure 1-17: *Interior T and RH for an occupied house in Ft. Myers, FL*

For this house, the percentage of days that the interior RH was above 50% was only 11% of the time during this approximate two-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.

In 2009, MHLab refitting continued for future hot water and ventilation testing. Data collection results are available at http://www.infomonitors.com/mhl/ .

[7] Arlian LG, Bernstein IL, Gallagher JS. The prevalence of house dust mites dermatophagoides spp. and associated environmental conditions in homes in Ohio. J Allergy Clin Immunol 1982; 69:527-532.

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.

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. 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 two 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 as seen in the "Reduction" column in Table 1-2 and Figure 1-19.

Table 1-2 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*

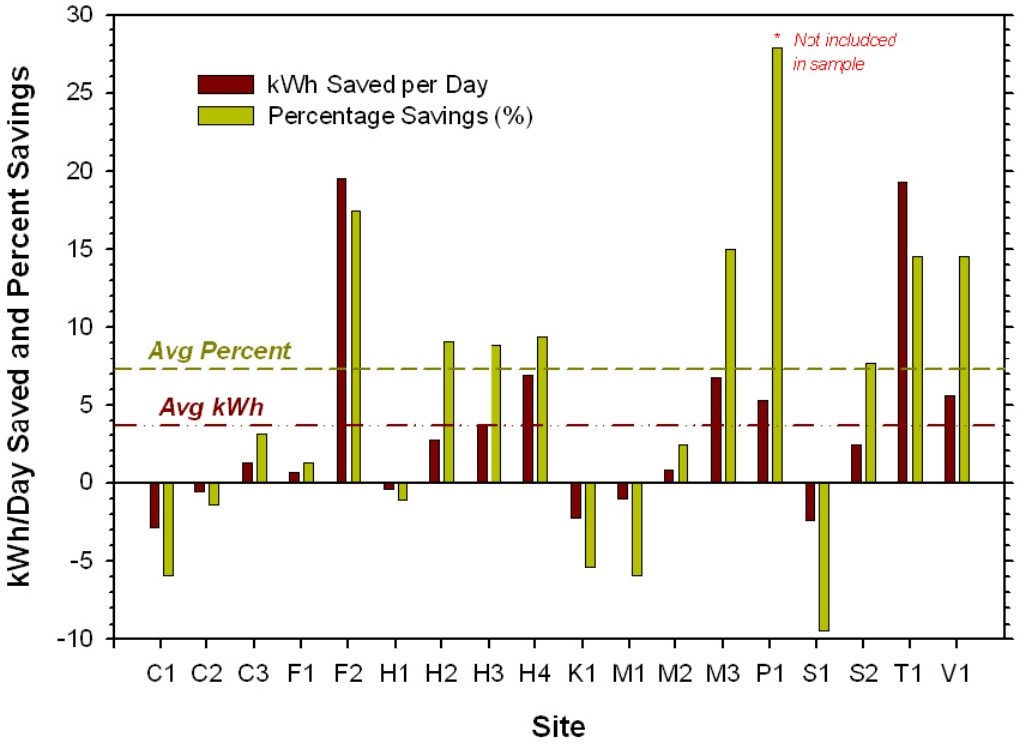

Figure 1-19: *Average daily energy savings*

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% as shown in Figure 1-19. 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 also contacted other researchers who are engaged in a similar test for Pacific Gas and Electric. At 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.

In early 2009, we arranged to obtain two test systems for the *GreenSwitch* pilot. Contact was made with Seth Frader-Thomson with Energy Hub-a new home automation technology. We also worked with Tom Foley with DreamWatts on their web-based control system with an intelligent thermostat and various control modules and obtained a single system to test. A contributed version of the DreamWatts hardware was acquired with the intent of using the device within one of the anticipated Building America constructed lab homes.

In September of 2009, we installed *GreenSwitch* in two Gainesville Near Zero Energy Homes. Experiences were documented with this technology in a detailed evaluation. Although installation was relatively trouble free, we found fundamental problems with thermostat compatibility, aesthetic issues with wall switch plates (both color compatibility as well as switch mounting plate thickness) and difficulties with three-way switches around each home. The system also had an inadequate user's manual for the overall system.

Beyond this effort, we are also evaluating the following areas to reduce plug load energy use: 1) Continue to collect data on the performance of the *GreenSwitch* systems as installed in Gainesville and remedy problems to the extent possible, 2) Obtain two Energy Hub systems for installation in two test buildings, albeit without main house measurement current transducers. These will be evaluated later to gain experience with the system and 3) Installation of *Dreamwatts broad-band control* system still awaiting a laboratory test building for evaluation.

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 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.

Royal Concrete Concepts

Royal Concrete Concepts (RCC) produces innovative concrete modules for both residential and commercial markets throughout Florida. RCC operated a midsize, unenclosed production operation in West Palm Beach. The plant consisted of four production "lines" supported by various uncovered storage areas and small enclosed stockrooms. The plant could produce a maximum of four modules per day. To meet increasing demand, RCC developed a new high-volume plant in nearby Okeechobee. The new plant has 10 unenclosed production lines capable of producing 10 modules per day, increasing production capacity by 2.5 times. The new operation is 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 has 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.

Subtask 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 as part of our technical assistance to partners building prototypes and 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 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 (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[8]).

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 in BP2, BP3, or BP4.

Subtask 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

[8] Parker, D., Sonne, J., and Sherwin, J., "Flexible Roofing Facility: 2004 Summer Test Results," Prepared for U.S. Department of Energy Building Technologies Program, July 2005.

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 (Figure 1-21). 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.

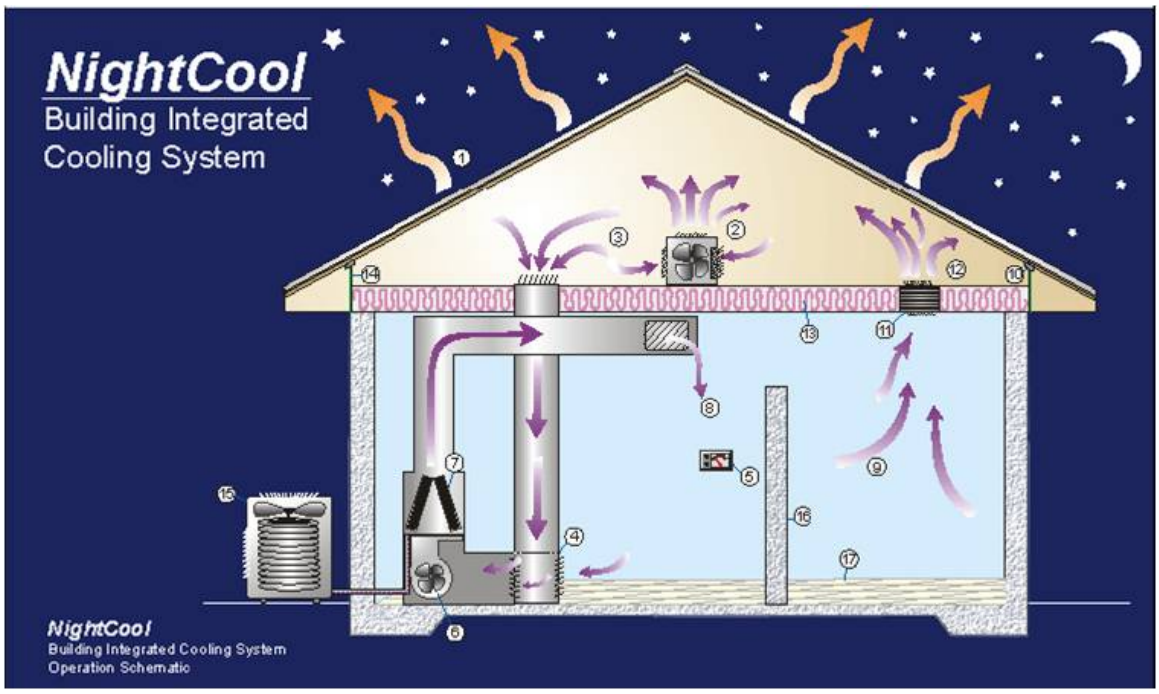

Figure 1- 21 *NightCool Operation Schematic*

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 1-24). 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 1-23 and 1-25).

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

Figure 1- 23: *NightCool Shed with White Metal Roof*

Figure 1- 24: *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 (Figure 1-26). 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 eight-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 two Btu/Wh after June. In any case, this level of performance compared favorably to an EER for the vapor compression air conditioner of about nine Btu/Wh. This level of performance also exceeds the performance of any air source equipment currently available.

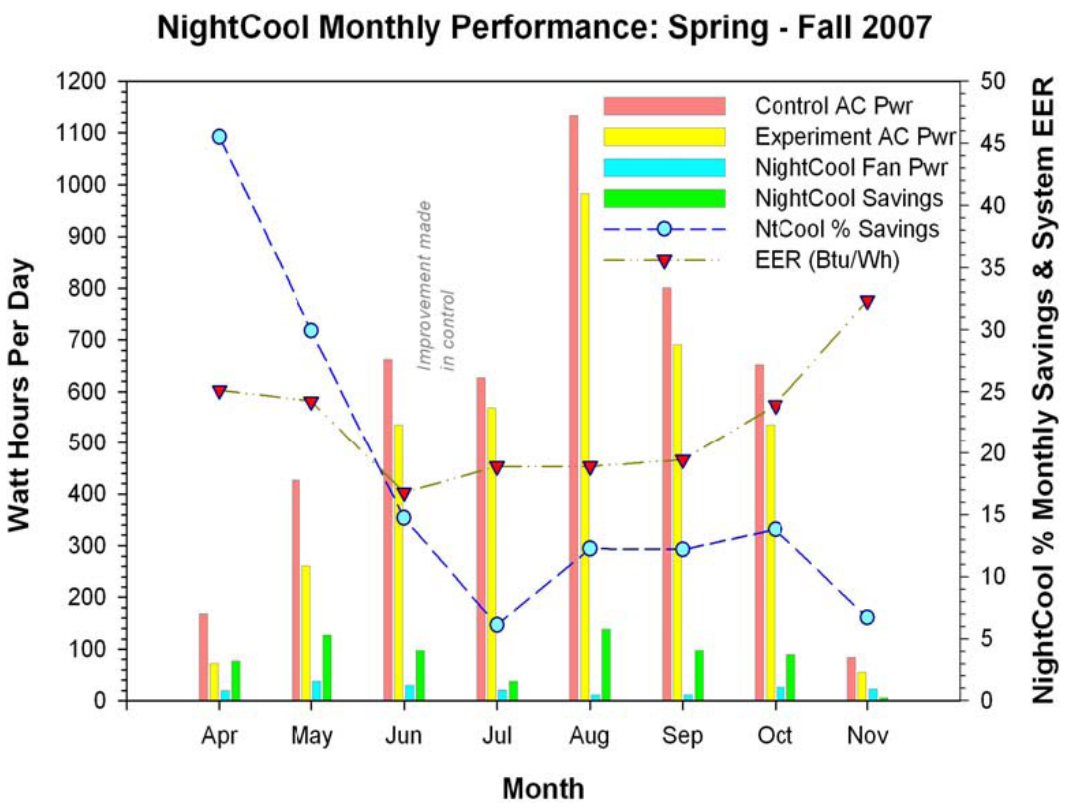

Figure 1- 26 *Performance under standard operating conditions in 2007 shows 15% savings in the NightCool test unit compared to conventional construction over the eight month cooling season.*

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 six-hour operating period, this would produce about 0.2 ton-hours of sensible cooling or two 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-existent 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% versus 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 1-3: *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. Average monthly savings are shown in Table 1-3. 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 versus 3.0 kWh/day). In September, savings in the *NightCool* building were not as low as the August 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.

Throughout 2009, we continued our evaluation of the Nightcool concept. Tests were completed of the Nightcool system in spring conditions in Central Florida which would typify late summer conditions in much of the U.S. Cooling needs were nearly zero during the month, but the NightCool building showed superior dehumidification. In February 2009, average interior humidity in the NightCool building averaged 16% lower than the control (54% versus 70%).

Cooling needs were rising during April through June, with the Nightcool building showing 22% lower energy use (14.9 kWh versus 19.0 kWh) for April, 17% lower energy use (53.2 kWh versus 64.0 kWh) May and 5% lower energy use (72.0 kWh versus 75.3 kWh) in June. A new schedule was implemented in June with 60% lower internal heat gains as would prevail in a low energy home. Relative humidity control has been consistently better in the Nightcool building during autumn/winter and reflects a large difference as we head into summer. However, we expected this difference to diminish as air conditioning increased in the control.

We continued experiments examining how internal gains and window solar gains influenced the savings achieved from Nightcool. The experiments served as validation points for simulation models used in Building America which must accurately evaluate these influences.

Over the summer of 2009, tests were completed of the Nightcool system in summer in Central Florida which is hotter than most conditions in much of the U.S. Cooling needs were high during the period. In June, we began a new schedule with 60% lower internal heat gains as would prevail in a low energy home. This was expected to cause savings to be lower since less there is less nighttime internal heat to be abated. Later, in August, we switched to a daytime thermostat set up to 85 F as often done in homes not occupied from 9 AM – 5 PM. This change, on the other hand, would be expected to somewhat increase Nightcool savings as more of the cooling load is moved to the non-daytime hours.

Monthly cooling energy use in kWh are reported below (Table 1-4) for the cooling systems (including Nightcool fans for the experimental facility):

Table 1-4: *2009 NightCool Data*

Month	Control AC	NightCool	Experiment	% Savings
July	70.0	65.4	Low int gains	7%
August	72.2	67.9	Low int gains	6%
September	55.3	48.8	Low gains+tstat	12%

These data would indicate that the Nightcool concept will show lower savings with decreased internal gain levels, but higher savings levels with a daytime thermostat setup. The project data for Nightcool is on-line on the INFOMONITORS site: http://infomonitors.com/ntc/

Relative humidity control has been better in the Nightcool building during autumn/winter. However, we have seen this difference diminish in summer with increased air conditioning. The NightCool building showed similarly low interior humidity levels over the period (34% in both).

In the autumn and winter of 2010 we will continue experiments examining how a thermostat setup can influence the savings achieved from Nightcool and to see how the lower internal gains

and thermostat setup will influence the previously demonstrated ability of the Nightcool system to better control interior humidity levels during months with low space conditioning. The experiments will also serve as validation points for simulation models used in Building America which must accurately evaluate these influences.

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 .

The *NightCool* 2009 report is also available at: http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1835-09.pdf

Subtask 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.

Subtask 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 (Figure 1-27) has been 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.

Three solar collectors were installed in 2008 (Figure 1-28), and the tank and tankless systems were procured and plumbed inside the test shed (Figures 1-29 and 1-30).

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

Figure 1-28: *The solar collectors are mounted on a nearby roof mock up, 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.*

The comparisons are based on performance under standardized hot water use schedules. Simultaneous hot water draws take place for seven hot water heating systems on a daily basis at the HWS facility. The HWS building serves as unconditioned housing to the systems listed below:

- Standard dual element residential 50 gallon electric tank
- Solar flat plate collector (40 ft^2) connected to a single element 80 gallon storage tank with temperature differential controlled pump – direct loop circulation
- Integrated Collector System (ICS, 32 ft^2) connected in series to a standard 50 gallon water heater tank.
- Solar Flat Plate collector (40 ft^2) connected to a single element 80 gallon storage tank with photovoltaic pump – direct loop circulation
- Standard residential 40-gallon natural gas water heater tank
- Natural Gas tankless water heater
- Electric tankless water heater

Three of the seven are FSEC certified solar systems, and most common residential type installed systems installed in the state – all direct type and not suitable for freezing climates. A standard 50 gallon residential water heater with an energy factor (EF) rating of 0.91 is used as baseline. Similarly, the differential controlled flat plate system is also considered a reference solar system and would remain as baseline in future testing. Although testing was begun during February 2009, March 1st was considered the official starting date for simultaneous testing, where all adjustments to the controls and data acquisition were finalized. As of the end of December 2009, the HWS Laboratory has collected ten months of data which is stored in our data base system (GET v. 4.0) and easily accessed through our www.infomonitors.com/HWS website.

The website default page displays a summary report of the previous day's data, but also provides a link access to over 90 channels of detailed data. In addition to displaying energy values and gallons used, the report format also summarizes weighted inlet and outlet temperature averages and daily system efficiencies (shown on Figure 1-31).

Daily Efficiencies (COP)	* parasitic energy included	
ELECTRIC TANK 50GAL	0.87	
80-GAL DIFF. FLAT PLATE *	2.26	
ICS W/50 GAL. ELECTRIC	0.98	
80-GAL PV PUMP FLAT PLATE	1.10	
40 GAL NAT. GAS TANK	0.51	
TANKLESS NAT. GAS *	0.71	
TANKLESS ELECTRIC *	0.88	
Total Daily Gallons	**gal.**	
ELECTRIC TANK 50 GAL	63.8	
80 GAL DIFF. FLAT PLATE	63.3	
ICS W/50 GAL. ELECTRIC	63.5	
80 GAL PV PUMP FLAT PLATE	63.5	
40 GAL NAT. GAS TANK	64.9	
TANKLESS GAS	65.7	
TANKLESS ELECTRIC	63.5	
Draw-weighted Inlet Tempratures	**deg. F**	
ELECTRIC TANK 50 GAL	67.8	
SOLAR DIFF 80 GAL	68.3	
PREHEATED ICS 50 GAL	76.8	
SOLAR PV 80 GAL	68.6	
NATURAL GAS 40 GAL	67.5	
NATRUAL GAS TANKLESS	68.4	
ELECTRIC TANKLESS	68.4	
Draw-weighted Outlet Tempratures	**deg. F**	
ELECTRIC TANK 50 GAL	121.4	
SOLAR DIFF 80 GAL	122.2	
MIX VALVE PRE-HEATED 50 GAL	122.6	
MIX VALVE SOLAR PV 80 GAL	123.4	
NATURAL GAS 40 GAL	123.4	
NATURAL GAS TANKLESS	118.2	
ELECTRIC TANKLESS	115.0	

Figure 1-31: *Average daily COP's, gallons, weighted inlet and outlet temperatures in Infomonitors summary page shown for December 6th , 2009. Review data at www.infomonitors.com/HWS*

Testing Plan, Hot Water Draw Schedule and Initial Results

During the summer of 2008, an analysis was performed to determine a suitable hot water draw pattern for testing. In consultation with the National Renewable Energy Laboratory (NREL), a decision was made to alternate between ASHRAE 90.2 and a draw schedule that better represents a typical family hot water usage. A new hot water draw schedule was created, which we to refer to as the NREL/BA draw profile. The hot water draw profile was developed from Building America source documentation with the addition of hot water loads changing on a monthly basis (Table 1-5).

Table 1-5: *NREL/BA draw schedule*

Month	NREL/BA Schedule Daily Hot Water Draw (gallons)
January	67.2 (max. draw)
February	66.4
March	66.4
April	63.8
May	54.6
June	48.4
July	42.2 (min. draw)
August	44.0
September	44.9
October	47.5
November	53.7
December	59.0

The decision to adjust the quantity of daily hot water draws on a monthly basis was due to the degree of mains inlet temperature variations observed in central Florida throughout the year Figure (1-32) and from data showing this trend from a monitoring study done in 1983. The plot also shows the ability of an integrated collector system (ICS), configured in series, raising water temperatures into its standard 50 gallon heater. The NREL/BA draw profile was officially implemented for testing at the HWS Lab during the latter part of May 2009. Rotations between the two draw schedules were carried every two weeks for each month. The NREL/BA monthly hot water draw values are listed on Table 1-5 at right. The draw schedule represents a realistic family draw pattern as opposed to the hourly events adopted in ASHRAE 90.2 with a constant of 64.3 gallons per day throughout the year.

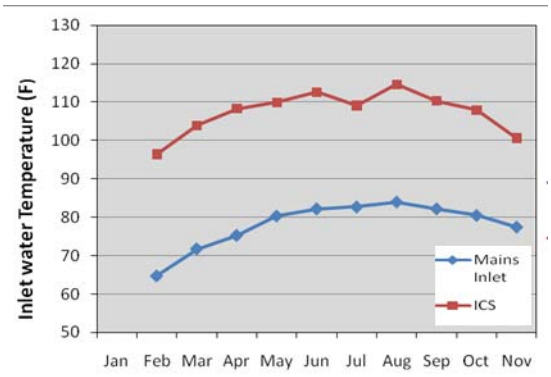

Figure 1-32: *Avg. inlet water temperature by month for standard and ICS system.*

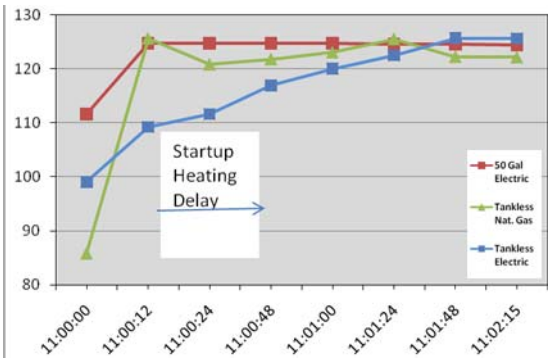

Figure 1-33: *Delivery temperature lag seen in tankless water heaters upon startup*

During late February, all water heating systems were set to deliver a target output temperature of 120°F target. In fact, the combined hot water temperature delivered by all systems through mid November 2009 averaged 119.8°F (from Table 1-6 shown at the end of this section). However, to control higher temperatures generated by the solar systems, a mixing valve was utilized on the three systems to limit hot water temperatures to the desired target. Furthermore, lower averaged values of hot water temperature were obtained from the tankless systems. This is due to the lag associated with startup firing exhibited by the tankless designs. As a result the tankless gas system was set to 122°F via its own electronic controls while the tankless electric was set in increments until the delivery temperature averaged the desired test setting. During January 2009, hot water output delivery was observed to compare the startup delivery temperature of the reference standard electric tank against the tankless heaters (Figure 1-33). Twelve second sample data taken during a routine morning draw (11:00 AM) is plotted and can be observed from its initial startup (standby) until it is stabilized. Data suggests that longer delays at startup by a system to heat water to 120°F under demand can contribute to energy and water resources wasted. In June 2009, the tankless electric unit was replaced by the manufacturer with a current production model. This unit performed better at startup indicating that the manufacturer has addressed the issue. However, other issues with thermostat set point are beginning to re-appear as is evident in the summary table (Table 1-6) showing a slight decline in averaged delivery temperatures since it was replaced in June (116.2°F delivered) to 115.7°F in November. The new unit also shows a high degree of temperature variation during operation and is evident in the plot at right (Figure 1-34). The tankless electric temperature regulation is compared against the tankless gas which exhibits much better regulation performance. We also noted, using infrared thermography that the tankless electric system has substantial heat losses through the heat transfer jacket which adversely impact the performance of the system such that its advantage over the conventional storage electric system is not pronounced.

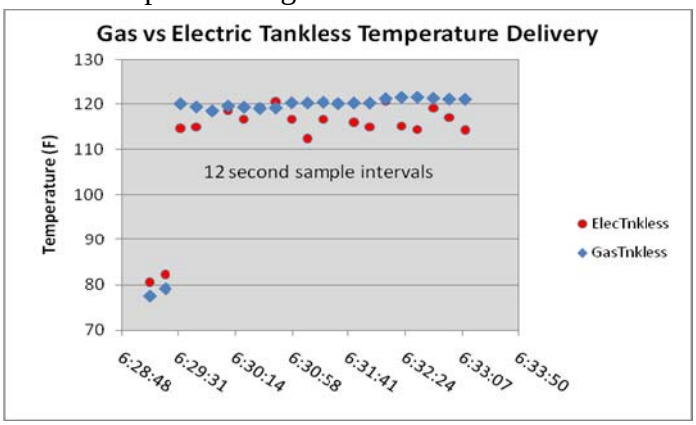

Figure 1-34: *Comparative stability of storage versus tankless system delivery temperature*

Impact of pipe insulation

Between March 3rd and 10th, FSEC staff applied insulation (R-2) to all piping located inside the HWS building. An evaluation of the impact of piping insulation was performed for similar matched data prior to and after insulation. While we found that for the measured performance at the outlet of the water heater that performance did not vary much with pipe insulation, we found a dramatic impact on the two solar systems which circulated during the day. A summary of the fundamental findings:

- The average daily operating COP of the flat plate differential system increased from 5.54 to 8.30 by the insulation, corresponding to an increase in solar fraction relative to the reference electric resistance system of 83.8% to 89.3%.

- The average daily operating COP of the flat plate PV pumped system increased from 3.69 to 6.06, corresponding to an increase in solar fraction relative to the reference electric resistance system of 75.6% to 85.3%.
- The average daily operating COP of the ICS system increased from 1.86 to 2.12, corresponding to an increase in solar fraction relative to the reference electric resistance system of 51.5% to 58.4%.

Thus, the data shows during February/March conditions that pipe insulation exerts between a 5 and 10% influence on achieved solar fraction-- highly significant given its low cost. *It should also be noted that the exterior pipe sections* were already insulated for the solar systems and this influence is solely from insulating the segment of the piping inside the test lab interior. We further conclude that improvements to pipe insulation technology could provide significant improvements to solar system performance, particularly under winter conditions.

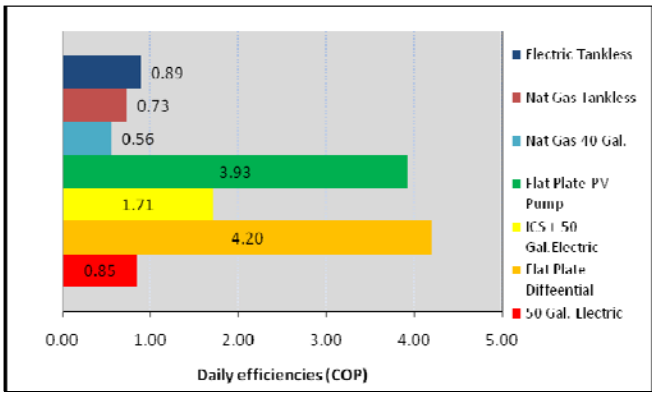

Figure 1-35: *Comparative average COP of tested systems over ten month period*

Summary of Results (through December 2009)

Between the period of March 1 and December 31st 2009, the overall combined efficiency using both ASHRAE 90.2 and NREL/BA draw patterns can be observed in the bar chart at right (Figure 1-35). Parasitic energy is included in the calculations for those systems that have auxiliary energy requirements such as controllers in the natural gas tankless and differential activated pump in the solar system. Not surprisingly, results from testing indicate that daily efficiency for these systems is below the published energy factor ratings.

Daily Efficiencies (COP)	* parasitic energy included	
ELECTRIC TANK 50GAL	0.85	
80-GAL DIFF. FLAT PLATE *	4.41	
ICS W/50 GAL. ELECTRIC	1.75	
80-GAL PV PUMP FLAT PLATE	4.41	
40 GAL NAT. GAS TANK	0.57	
TANKLESS NAT. GAS *	0.73	
TANKLESS ELECTRIC *	0.89	

Figure 1-36: *Daily average efficiency for solar flat plate systems shown as equal (4.41) for the period of March 1st thru December 17, 2009.*

A primary reason is that the reduced amount of hot water utilized during the past eight months under the NREL/BA schedule yields a lower average daily efficiency on standard systems when compared to the ASHRAE 90.2 (64.3 gpd). As expected, the solar differential and PV pumped systems surpass all other water heating systems with the highest average daily efficiencies for this period (COP of 4.4 and 3.93 respectively). Although initial

Daily Efficiencies (COP)	* parasitic energy included	
ELECTRIC TANK 50GAL	0.88	
80-GAL DIFF. FLAT PLATE *	2.54	
ICS W/50 GAL. ELECTRIC	1.10	
80-GAL PV PUMP FLAT PLATE	1.39	
40 GAL NAT. GAS TANK	0.53	
TANKLESS NAT. GAS *	0.70	
TANKLESS ELECTRIC *	0.90	

Figure 1-37: *Daily average efficiency for solar flat plate systems for the period of December 1-17, 2009 clearly shows an advantage for the stronger pump head capacity of the differential controlled system*

results indicated that the PV pumped solar flat plate had achieved the highest overall efficiency, it has been noticed that during cloudy days the differential controlled flat plate solar system has the advantage. Data for those days suggest that a large photovoltaic module might improve efficiency for the passive solar system during mild or cloudy weather. Average efficiency numbers for both the solar differential and PV pumped system appear to be the same from March 1st – December 17th 2009 (4.41) as shown in figure1-36. However, when the efficiency is averaged for December 1- 17, 2009, the differential controlled system has a slight advantage as shown in figure 1-37.

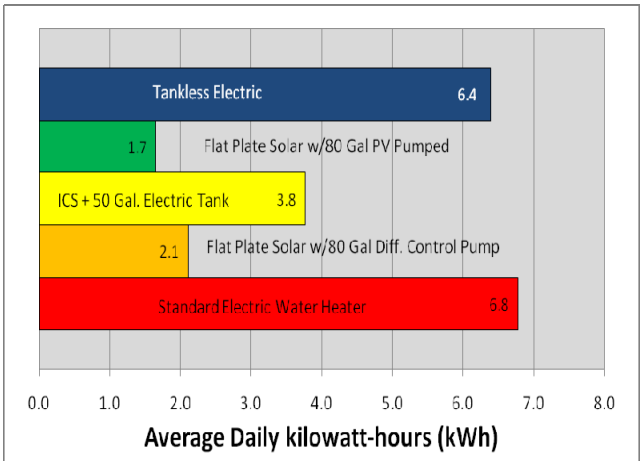

Figure 1-38: *Daily average electricity use for water heating*

Daily Electric Consumption

Daily electric consumption for five systems can be compared on Figure 1-38 at right. The plot indicates a 0.4 kWh daily reduction for the tankless electric when compared to the standard electric baseline system. Solar systems clearly demonstrate large daily electric reductions between 5.1 and 3.0 kWh per day. However, most of the data has been generated from summer and fall conditions and higher daily energy consumption is expected for all systems during the upcoming winter season.

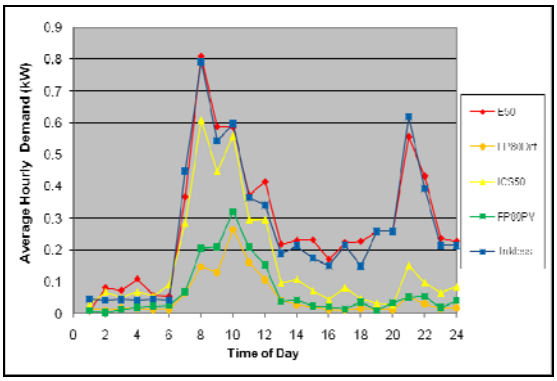

Figure 1-39: *Impact of water heating systems on electrical load shape over ten month period.*

Time of day Electric Demand Analysis

Electric demand for five systems was also being analyzed for the period between March and December 2009 to determine impact on time-of-day-peak loads (Figure 1-39). The plot reveals a drastic peak load reduction of flat plate solar systems when compared to the standard baseline electric—particularly during the critical 7-8 AM hour. Morning Peak demand reduction by the two solar flat plate systems appears to be reduced on average by 78%. The flat plate solar systems now appear to have shifted the peak by two hours (10:00 AM). Peak demand reduction for the ICS solar systems amounts to 25%. Demand for all solar thermal systems in the afternoon appears flat and limited to 0.15 kWh or below.

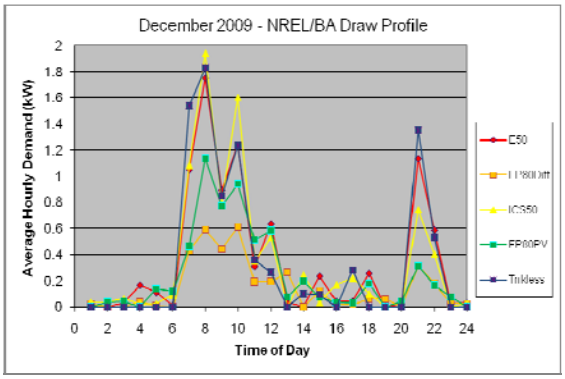

Figure 1-40: *Impact of water heating systems on electrical load shape obtained in December by using NREL/BA draw profile.*

The highest average peak demand during the study has been observed during the NREL/BA

hot water draw events for the period of December 17 to 31st (Figure 1-40). The twin peak over this period is more evident and not masked by the profile of the ASHRAE 90.2 schedule. The morning peak is again observed at 8:00AM for the standard 50 gallon electric system, tankless and ICS systems. The differential controlled and PV pumped flat plate solar systems managed to reduce peak by 66% and 35% respectively. However the ICS in series with 50 gallon tank and tankless electric shows signs of a peak increase of 10.8% and 4.3% respectively. At night, the tankless electric also shows an average peak increment of 18.8% for the 9:00 PM hour. However, the ICS system manages to reduce peak by 34% at this time. Both flat plate solar systems reduce peak equally by 72% at 9:00 PM compared to the electric baseline.

It must be emphasized that these peak impacts will be influenced by the time period chosen for the data aggregation. Thus, the impacts of the tankless electric system may be greater when the data is averaged on a 15-minute basis, or even on a 5-minute basis. We also fully expect, from monitoring done during the shakedown last February, that the true system peaks will be set in January morning hours during cold snaps in early 2010 with the NREL/BA draw profile which is higher in winter. Future project reports will more fully document these important impacts as data are collected.

Summary Table 1-6: *Monthly Performance at HWS Facility – 2009*

	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Electricity Usage– kWh/day										
Electric Tank	9.18	8.80	8.01	6.48	5.80	5.81	5.62	5.65	5.94	7.32
80 Gal Diff Flat Plate	2.57	1.95	1.44	1.35	0.88	1.01	0.74	1.08	1.44	2.11
ICS w/50 Gal Electric	5.75	4.65	3.76	3.13	2.31	2.72	2.01	2.60	3.03	4.60
80 Gal PV Pump Flat Plate	3.43	2.13	1.42	0.98	0.22	0.39	0.04	0.57	2.13	1.66
Tankless Electric	8.63	8.97	8.80	7.65	4.90	4.86	4.75	4.87	5.16	6.38
Natural Gas Usage – therms/day										
50 Gal Nat Gas Heater	0.472	0.510	0.431	0.331	0.277	0.244	0.181*	0.225*	0.289	0.399
Nat Gas Tankless Heater	0.317	0.428	0.287	0.236	0.224	0.219	0.216	0.225	0.233	0.302
Weather Conditions										
Solar (W/m^2)	181.4	211.0	241.0	241.0	247.0	250.0	229.0	199.1	176.3	171.0
Outdoor Temp	61.0	67.7	72.2	79.4	83.6	83.1	84.8	81.8	78.8	75.0
Shed Temp	69.0	74.2	78.5	84.1	88.0	87.2	89.0	86.6	84.3	80.2
Daily Efficiencies COP										
Electric Tank 50 Gal	0.89	0.90	0.88	0.86	0.85	0.81	0.82	0.82	0.82	0.87
80 Gal Diff Flat Plate	3.39	4.27	5.20	4.70	6.57	5.51	7.92	5.29	4.28	3.65
ICS W/50 Gal Electric	1.55	1.82	2.01	1.99	2.37	1.96	2.62	1.71	1.61	1.53
80-Gal PV Pump Flat Plate	2.48	3.92	5.54	6.66	26.61	13.55	133.24	9.35	2.52	3.83
40 Gal Nat Gas Tank	0.55	0.54	0.54	0.54	0.54	0.65	0.80*	0.69*	0.58	0.54
Tankless Nat Gas	0.80	0.76	0.77	0.77	0.75	0.73	0.71	0.69	0.69	0.70
Tankless Electric	0.89	0.89	0.89	0.89	0.92	0.90	0.91	0.89	0.88	0.90
Total Daily Gallons – gals/day										
Electric Tank 50 Gal	59.1	64.0	63.5	57.6	53.2	51.7	53.1	50.9	51.3	60.8
80 Gal Diff Flat Plate	59.0	63.3	62.8	56.9	53.0	51.6	52.9	50.2	50.2	60.4
ICS W/50 Gal Electric	59.6	63.4	62.4	56.8	52.8	51.8	52.1	50.2	50.4	60.5
80-Gal PV Pump Flat Plate	59.6	63.0	63.1	57.5	53.7	52.0	53.2	50.8	50.7	60.5
40 Gal Nat Gas Tank	59.5	64.2	63.8	57.7	51.7	54.9	55.5	53.6	51.2	60.7
Tankless Nat Gas	59.8	62.9	64.5	59.4	56.9	55.2	55.7	53.5	50.8	63.6
Tankless Electric	59.4	63.7	63.0	56.7	53.2	51.8	53.5	51.7	52.2	61.0
Draw-Weighted Inlet Temps										
Electric Tank 50 Gal	64.8	71.9	75.4	80.5	82.4	82.8	84.2	82.4	80.7	77.6
80 Gal Diff Flat Plate	64.9	71.9	75.4	80.4	82.3	82.8	84.1	82.4	80.7	77.6
ICS W/50 Gal Electric	96.4	103.9	108.3	109.9	112.6	109.1	114.6	110.3	107.9	100.6
80-Gal PV Pump Flat Plate	64.7	71.5	75.2	80.2	82.0	82.5	83.7	82.0	80.3	77.3
40 Gal Nat Gas Tank	64.1	71.7	75.4	80.7	82.4	83.0	84.3	82.3	80.5	77.3
Tankless Nat Gas	64.8	71.9	75.	80.4	82.4	82.8	84.1	82.4	80.6	77.6
Tankless Electric	64.7	71.7	75.3	80.0	81.8	82.4	83.7	81.9	80.2	77.3
Draw-Weighted Outlet Temps										
Electric Tank 50 Gal	121.3	119.5	121.0	120.1	120.2	119.9	119.4	119.4	119.3	120.1
80 Gal Diff Flat Plate	119.2	119.1	120.6	121.1	122.5	121.5	123.1	120.6	120.6	119.1
ICS W/50 Gal Electric	121.5	119.9	121.7	121.2	120.9	120.5	120.7	120.4	120.4	120.4
80-Gal PV Pump Flat Plate	120..8	121.0	124.3	124.4	124.4	122.4	125.9	122.3	120.6	117.1
40 Gal Nat Gas Tank	117.4	119.1	120.3	118.0	117.6	117.8	116.2	117.7	118.0	119.1
Tankless Nat Gas	116.4	117.7	117.5	117.8	118.3	118.2	118.1	118.2	117.0	118.6
Tankless Electric	117.5	117.5	126.2	128.8	116.2	116.7	116.5	116.1	115.8	115.7

Subtask 1.12 Full Scale Testing of Innovative Condenser Fan (BP1, BP2, and BP3)

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 was 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 was installed and a full summer of baseline data made 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 four years ago. Data in the MHLab since the change out 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. No further activity was reported in 2009

Subtask 1.12 Solar Water Heating – SRCC Technical Tasks (BP4)

Beginning in July 2009, the FSEC test group conducted testing outdoors whenever the weather was suitable. Testing was completed on one collector. The SRCC Technical Director attended a meeting in San Francisco concerning certification of concentrating solar collectors. The SRCC Concentrating Collector Subcommittee hopes to submit a final draft of Standard 600 to the Standards Committee for consideration at their meeting on September 3.

Many changes have occurred at FSEC to improve the efficiency of our activity. Previous reports have discussed the performance test platform improvements which have provided throughput improvements. Those improvements have shown a consistent change in performance testing cycle time from 12 weeks a collector to five weeks a collector. Procedure improvement and labor hour increases have improved the report writing significantly since July 1.

The following summarizes the accomplishments since July 1, 2009 through October 31, 2009.

- Interim Report - completed 10
- Full Report - completed 8
- Performance Testing - completed 4

LabVIEW application for collector testing is moving in the right direction. The system validation is planned for December, 2009.

Third Mobile Platform to Production consisted of new platform installed, sensors wired, computer and display installed, power systems installed, wind system installed and plumbing and flow meter on platform installed. Validation of the new calibration techniques has begun. Release to production is expected in January, 2010.

Subtask 1.13 Self Drying R Concrete Wall

Royal Concrete Concepts is a producer of concrete modular buildings and concrete tilt-up wall panels. Their newest facility in Okeechobee, FL has 18 production lines and incorporates concrete technology that achieves a structural strength of 8,000psi in 28 days and resists impact of a 2x4 up to 84 mph. As shown in Figures 1-41 and 1-42, wall structural framework inside of wall panels prevents a constant insulation thickness across the wall. Royal Concrete Concepts entered into discussions with FSEC to test their wall panel to determine an accurate R-value.

Figure 1- 41: *Royal concrete concepts modular section*

Figure 1- 42: *Structure & chase details*

In December of 2008, BAIHP researchers visited the Royal Concrete plant in Okeechobee, FL. The group met with the plant manager, and discussed techniques to evaluate the current design including use of Oak Ridge hot box facility, FSEC Building Lab Facility, and instrumentation of whole buildings. In 2009, BAIHP researchers began preparing the FSEC Building Science lab so that the removable wall section could be easily accessed. They also discussed the potential R-value benefit of using the Elamix concrete additive with Nova Chemical. In May of 2009, the FSEC Building Science Lab removable wall frame was delivered to Royal Concrete Concepts to examine for test wall preparation, and the team began to develop an instrumentation and experimental plan. This task was put on hold in 2009 due to resource constraints on the part of the industry partner, and so that the budget could accommodate higher priority tasks. Further activity is delayed until 2010.

Subtask 1.14 Press On Insulation Clip

BAIHP was approved to pursue this systems level research task in 2009; however it was deleted due to intellectual property issues.

Task 2: Prototype House Evaluations and Involvement

Subtask 2.1 Prototype House Involvement and Evaluations

In this section we document our efforts in providing design and technical assistance to partners producing Building America prototypes. 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 for the International Builders' Show (Figure 2-1).

Figure 2-1: *2009 IBS show home built by Palm Harbor Homes*

Subtask 2.1.1 Prototype Homes

This section describes activity with BAIHP partners working toward Building America prototypes. BAIHP's general systems engineering technical assistance approach is summarized here:

- Begin with a review of partners' standard practices including designs, specifications, scopes of work, construction procedures, quality control, whole house infiltration and duct leakage in recently completed homes, and other relevant criteria.
- Model standard or typical designs in detailed hourly energy use 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
- After the first prototype, discuss refinements and strategy for producing a community of BA houses.
- Lastly, BAIHP often works with an industry partner to develop language for marketing materials that will communicate the benefits of the features in their BA project

Armed Forces Foundation (AFF)

In December 2006, the Armed Forces Federation initiated discussions with FSEC along with other organizations to assist with a pilot project to provide accessible housing to injured veterans. They requested that DOE programs provide technical and financial support for the integration of solar energy and energy efficiency in two planned homes in Arizona and North Carolina. FSEC solicited Palm Harbor Homes, a Building America industry 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. In 2008, BAIHP conducted an energy audit of Cambridge I, a 200-unit Atlantic development (See Figure 2-2) completed in 2002, to characterize energy use in the apartments and common areas. 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 which was completed in 2008.

Estimates of common area energy use and PV bid specs were developed for Cambridge II and seven other Atlantic developments during 2008 and 2009. Net metering agreements with various Florida utilities were negotiated with BAIHP assistance.

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

Throughout 2009, the BAIHP team continued contract support for the purchase and installation of PV arrays and provided assistance with utility interconnect agreements for eight Atlantic projects. This included PV array-sizing energy estimates for each Atlantic multi-family project.

A detailed water heater comparison study was performed at Atlantic's request to provide firm savings estimates. Two 3-bedroom units in the Cambridge Cove II apartment complex were

instrumented to measure the savings of a tankless gas water heater (EF 0.82) over a tank-type gas water heater (EF 0.62) typically used by Atlantic Housing in their developments.. Initial analysis of data from the summer of 2009 shows a savings of 20% for the tankless water heater over the typical gas tank design. Data is available for review at http://infomonitors.com/CC2/ Tankless gas water heaters have advantages over tank varieties that will simplify installation and will be an important component in reaching the Builders Challenge level in future Atlantic developments.

A 12-unit building planned for an upcoming Atlantic development was analyzed for cost-effective strategies to reach HERS indices of 70 and 60. A comparison of side-by-side structures is planned to demonstrate the savings of an improved apartment complex over standard building practice. BAIHP recommendations for reaching a HERS index of 70 in these 12, 3-bedroom apartments include the use of fluorescent lighting, Energy Star appliances, tankless gas water heaters and SEER 14 cooling equipment.

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. In 2009, BAIHP evaluated a prototype home built by Brevard County Housing that scored a HERS Index of 80. The home featured metal framing with spray foam insulation, exterior rigid insulation, SEER 14 heat pump, metal roof, and an unvented attic with spray foam roof deck insulation. BAIHP made recommendations for improving the appliances, lighting, and duct leakage in future efforts. This partner is also working with BAIHP on high performance retrofits to existing affordable housing. See Subtask 4.3 - Builders Challenge Level Existing Homes.

Built Wright Custom Homes

Formerly known as Wright & Van Custom Homes, this partner was introduced to the BA systems approach in 2008 and is based in Trenton, FL. They were provided with multiple design reviews and received tax credit certification. This builder's first BA home met Builders Challenge with an E-Scale score of 70. Ongoing consultations continue in 2009.

CPS Energy – Woodside Homes, San Antonio

CPS Energy, the municipal electric and gas utility in San Antonio, TX, began a partnership with Woodside Homes in 2008 to build and test three side-by-side homes with identical floor plans of approximately 2,000 sq. ft. One home serves as a control and was built to standard practice. The second home is energy efficient with a HERS Index of 54, and the third home utilizes solar power with a 2.4 kW PV array and a HERS Index of 37. Data collection for these homes is available at http://infomonitors.com/CP1/, http://infomonitors.com/CP2/, and http://infomonitors.com/CP3/

In response to an invitation by CPS Energy, BAIHP provides monitoring and other technical assistance– the results of which may lead to utility incentives for energy efficient and solar

homes in CPS territory. Energy performance in the homes is monitored through 20 to 25 channels of data including indoor, attic and outdoor temperature and RH, major electric and natural gas end uses, detailed gas water heater performance, and photovoltaic array energy output. This is the first field experiment for BAIHP using the new generation Campbell CR1000 datalogger, which provides advanced programming and communications capabilities. Initial results from September 2009 when all three homes were occupied show a 72% and 60% savings in air conditioning energy in the two improved homes over the control home.

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. Additional visits followed in November to pre-wire the homes, March to install equipment and June to make adjustments to the instrumentation. This included the March 2009 grand opening event attended by the media.

BAIHP collaboration with CPS may expand into existing home retrofits in the future. CPS is willing to retrofit up to 20 homes in 2010 with BAIHP assistance targeting 30 to 50% savings. Dr. Valerie vonSchramm, senior research program manager with CPS, visited FSEC in October 2009 to discuss these two projects with researchers.

David Axel Home, Oviedo, FL

During 2005 -2006, BAIHP provided feedback on house construction and combustion appliances for Dave Axel home. A site visit was made (Figure 2-3) 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 was planning to build 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 (Figures 2-4 and 2-5). This 2600-home development has adopted its own code, East Bay Code, which 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%.

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

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

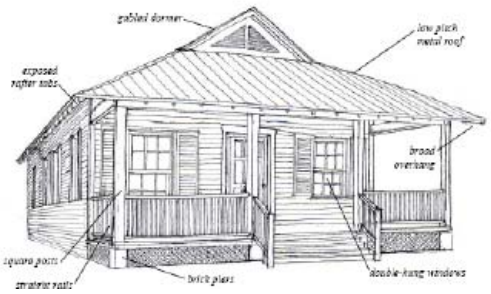

Figure 2-5: *Planned Development in East Bay, FL*

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

In 2008 the East Bay project was moth balled due to the severe decline in new home construction activity in Florida. No further developments were reported this year.

<u>Dog Park, Ruskin, FL</u>

This project (and industry partner) was new to BAIHP in 2008. The Building America industry partner is Structural Engineering and Inspections, Inc. (SEI) located in Lutz, FL. SEI is 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 that the owner wishes to preserve. Both owner and architect have been very cooperative. The owner is a veterinarian who donated adjacent land to the city for a public dog park. This project is to be the new caretaker's home. The existing home was damaged by termites and has been dissembled by a local boys' ranch and removed from the property.

The home is currently in the design stage, and construction may begin in 2010. In June of this year, BAIHP provided photovoltaic and solar thermal system specifications to the architect to include in the contractor bid package, and a conference call was facilitated to finalize the design of the home. Owner and architect are currently evaluating possible construction contractors for the project. The home was featured in FSEC's Achieving Zero Energy Homes Webinar Series. In fall 2009 BAIHP stopped active technical support of this project as the owner was unsure he could finance the project any longer to BAIHP expectations.

Federation of American Scientists, Houston, TX

In 2007, BAIHP assisted the Federation of American Scientists with analysis and technical support for 5,000 affordable modular/HUD code homes being procured by the state of Mississippi with funding from FEMA (Figure 2-6). BAIHP conducted analysis of three manufactured housing designs and revealed that all three, assuming duct and whole house leakage levels met specifications, achieved Energy Star. Although BAIHP offered to conduct field testing in the initial batch of these homes, the manufacturing schedule could not accommodate this work.

Figure 2-6: *FAS Emergency HUD Code Home for Mississippi*

The Federation of American Scientists also received assistance from BAIHP in the construction of a prototype home during BP1. The project location is in Houston, TX and is known as Rasbach House. We continue to collaborate with this partner; however this project did not result in a Building America prototype. Please see section 4.4 for further partnership activity.

Ferrier Builders/Rheudasil Farms

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. In 2007, BAIHP performed Energy Gauge simulations and prepared a report for the Hartsell Zero-energy concept home (see Figure 2-7), redesigned by GGO Architects for Ferrier Custom homes of Ft. Worth, TX. The home included a crawlspace foundation and SEER 17 Daikin ductless air conditioning.

Figure 2-7: *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 (see Figure 2-8). A site visit and discussions were conducted on December 16, 2008, and in 2009 Rheudasil Farms was welcomed as a new BAIHP partner. Rheudasil Farms is a gated, eco-friendly community in Flower Mound, Texas that is bringing low impact living right to your doorstep. Following Low Impact Development practices that preserve the natural features of the property, all homes will meet the highest standards of sustainability, incorporating the latest in green building technologies and aim to meet Builders Challenge Quality Criteria. The developer is diligently working on Sales and Marketing and once he has sold two lots he will begin construction on the Development Phase. Their website http://www.rheudasilfarms.com/

Figure 2-8: *Rheudasil Farms Conceptual Site Plan*

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 since 2007.

Garst Residence

The Garst residence (Figure 2-9) is a 2400 ft.^{2} home built in Olympia, Washington, designed to benchmark at 55% whole house site and 68% whole house source savings. The Northwest Energy Star qualified home features a ground source heat pump supplying domestic hot water and heat to an R-15 radiant slab, Energy Star lighting and appliances, solar sunspace, central energy recovery ventilation with air filtration, a tankless hot water heater for the master bath, and hybrid Icynene™/loose fill R-49 ceiling insulation.

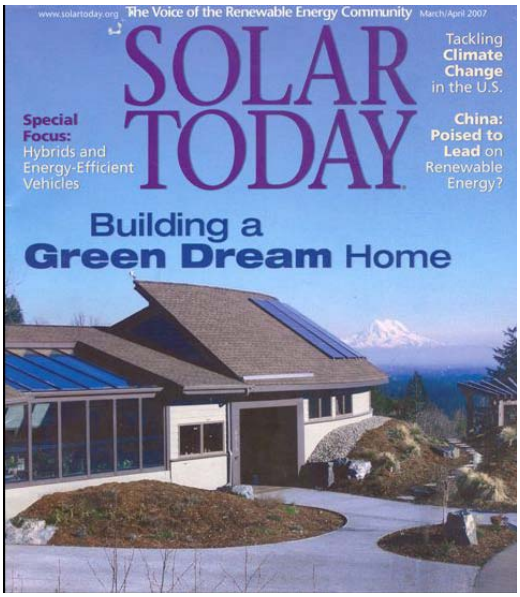

Figure 2-9: *Garst Residence – Olympia, WA, as featured in Solar Today.*

Home construction began in summer of 2005, and was completed in May of 2006. The Garst residence was featured in a Building America Best Practices Case Study, "High-Performance Home Technologies: Solar Thermal & Photovoltaic Systems," written by Pacific Northwest National Laboratory and Oak Ridge National Laboratory in 2007.

Data instrumentation of the home was completed in January 2007. Connection to the WEBGET system, data collection and analysis began in 2007, and continued through 2008 and 2009. Table 2-1 provides a monthly breakdown of energy use and total PV production along with GSHP space, water heating and other misc loads.

Table 2-1: *Garst Residence PV Performance*

Characteristic	**Annual Electricity Use (kWh)**
Benchmark Total Energy Use	25182
Garst: (simulation w/o PV)	12027
Garst (monitored)	12704*
Garst (simulation w/PV)	7787
Garst (monitored)	8237**
Garst Savings: Simulated w/o PV	13155
Garst Savings: Simulated w/PV	16945

* compare to 12898 kWh utility data noted above; discrepancy between these numbers was due to data loss

** compare to 8451 kWh utility data noted above; discrepancy also due to data loss.

Initially, the home included a 4.5 kW photovoltaic array; an additional 2.2 KW (a roughly 50% increase) was installed in early 2009. In 2008, total electric use (without PV) was 12898 kWh; total use after total PV was 8451 kWh. The photovoltaic system is performing well at 4444 kWh, (987 kWh per kW of installed PV.) Once all of 2009's utility data is available, a comparison between performance of the home with the initial amount of PV and the additional 2.2 KW will be possible. WSU will provide that comparison in a BTECC paper, to be completed in winter of 2010 and presented in December of 2010.

As part of the Stagegate effort, *EGUSA Version 2.8* was used to evaluate the source energy savings of the net zero energy home design and compared to the monitored energy use for a year's worth of end load data.

While there seems to be overall agreement, a number of factors need to be considered when comparing the predicted versus measured energy use:

- Net of PV power produced was roughly: 3800 kWh simulated; 4900 kWh measured with 2100 to home and 2800 to grid (for 4.5kW system in year 2008.)
- Measured space heating was 6786 kWh while simulation estimated 4320.
- Measured DHW was 1394 kWh while simulation estimated 909 kWh.
- Measured "Other" non space and DHW use was 5021 while simulation estimated 6114 kWh

The initial 4.5 KW PV array delivered 2113 kWh/year to the house, and 2841 kWh/year to the utility. The forthcoming BTECC paper will include an updated assessment of this house to grid ratio following installation of the additional PV.

In 2008, total miscellaneous loads were 4956 kWh. BAIHP staff decided to install a logger on Garst's media center to determine its impact on these loads. Monitoring indicated that the media center used 566 kWh per year, approximately 350 kWh of which was in standby mode, associated with the TIVO and cable boxes. Each of these devices draws 20 watts; neither can be shut down without requiring significant subsequent startup time. WSU are working with the homeowner and the local media center retailer to use timers to offset this problem, turning on at a time appropriate to anticipate this ramp-up. Garst rarely uses the TIVO and will shut it off most of the time.

After the data logging equipment is removed, the plan is to install a TED 5000, allowing Garst and BA to conduct on-going monitoring of these loads. Previous attempts to use a TED 2000 were unsuccessful, due to multiple meters and PV net metering. The TED 5000 should resolve these issues (see http://www.theenergydetective.com/ted-5000-features.html for features of TED 5000.)

After a few months, Garst decided to turn off the ducted ventilation system and rely only on the spot exhaust ventilation system because:

- The envelope was not as tight as anticipated (around 4.0 ACH@50PA.)
- They perceive no added value in air tempering, filtering and mixing.
- No significant humidity levels observed with two occupants.
- Central air handler with filter and ERV fans uses almost 300 watts when running
- Noise of the ERV and air handler

From 2007 - 2009, BAIHP staff have been analyzing and optimizing the performance of 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. Weekly average COP results for predominantly water heating are shown in Figure 2-10. COP is determined assuming

a range of eight to 12 GPM on the earth loop (dark blue) and (red). The measured operating flow rate was found to be around ten GPM. In both cases, the COP includes the energy of compressor and all system pumps, but does not include standby losses of storage tanks and distribution systems or cycling losses. Analysis of COP estimates suggest highest COP during winter months, when space heating is the predominate load, and lowest COP during water heating only mode. The radiant floor system started up in the beginning of Oct 2008. COP tends to track with radiant floor pump run-time (green), earth temperature difference (purple) and weekly energy GSHP consumption (light blue).

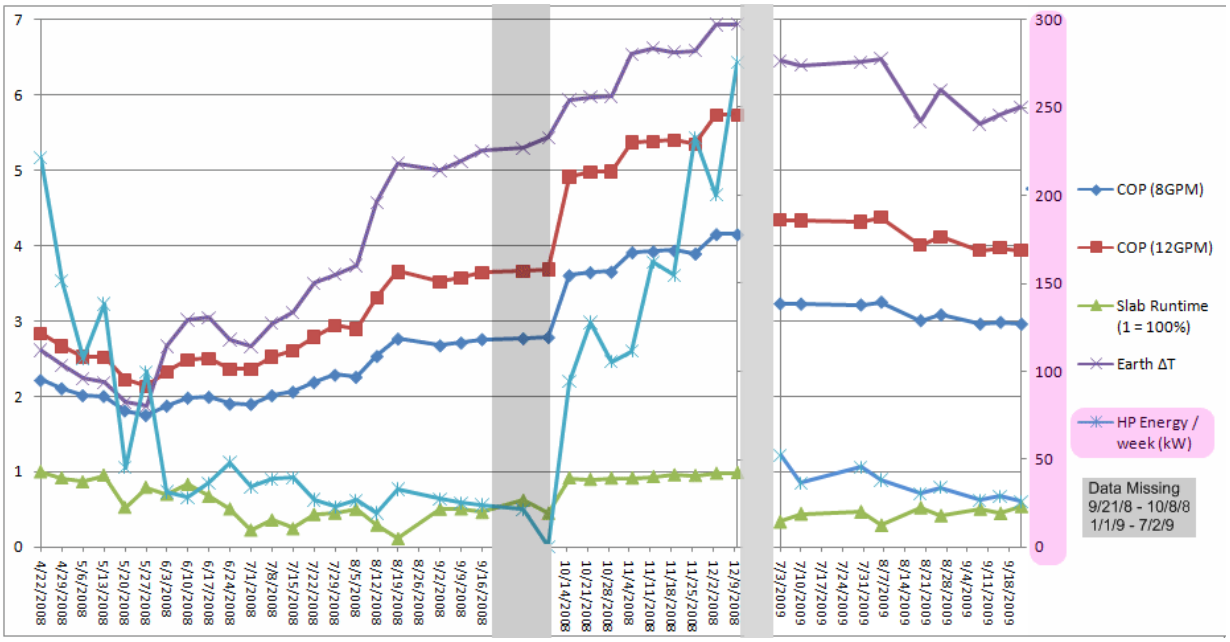

Figure 2-10: *Garst residence, ground source heat pump COP*

The Garst Stagegate report can be found at:
http://www.baihp.org/PUBS/pdf/BAIHP-WSU-zelonedom.pdf.

BAIHP staff members are in the process of evaluating COP performance during the space heating season, where it tends to be to be higher, due to lower slab water heating temperature requirements.

BAIHP staff members have evaluated 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 2-11, 636 kWh/year is provided from the sunspace during the heating season. Whenever the sunspace exceeds the house temperature, the supply fan operates. The heating benefit to the house is indicated in blue, and the supply fan energy used (48 kWh/year) is indicated in red. During the non-heating months an exhaust fan is used to remove heat from the sunspace (shown in green); this fan used 84 kWh/year.

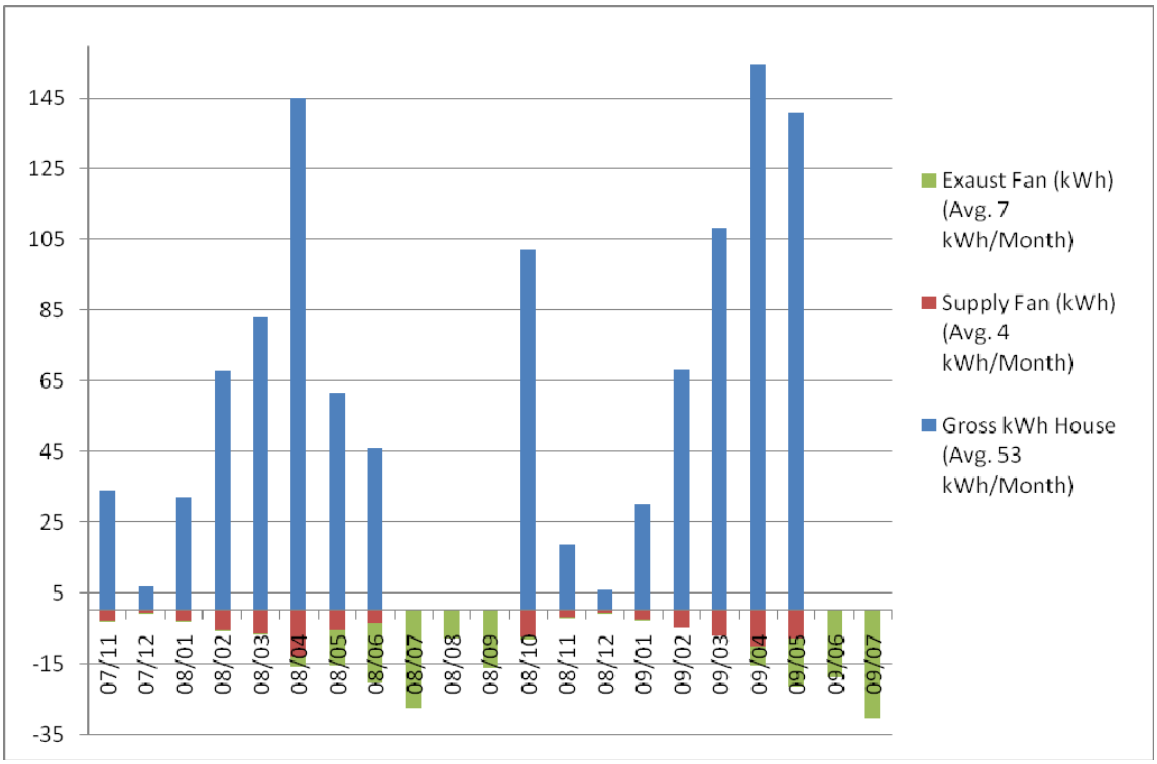

Figure 2-11: *Garst residence, monthly solar sunspace operation*

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. However, construction was never started.

No activity with this partner since 2007.

G.W. Robinson Builders, Inc. ZEH Prototype in 2010

In December of 2009, partner G.W. Robinson Builders, Inc. initiated discussion of building a 2,500 sq. ft. zero energy prototype home in 2010. Preliminary analysis is under way considering

improvements to G.W. Robinson's current standard specifications as delineated in Table 2-2 below.

Table 2-2: *Improvement Package Considerations for G.W. Robinson Zero Energy Home*

G.W. Robinson Builders Standard Specifications (40% Benchmark Savings)		**Improvements under Consideration for Zero Energy Prototype Home**
R13 Insulation - 2x4 Walls		same
R30 Insulation Ceilings		R38 Insulation Ceilings
87.5% CFL's		100% CFL's
15 SEER Straight Cool with Gas Furnace 95% Efficiency		Heat Pump - 16 SEER with 9.5 HSPF
80% carpet 20% tile		50% carpet 50% tile and/or wood floor
Energy Star Dishwasher		Energy Star refrig, washer, dryer, ceiling fan
Electric Range		same
Tankless Water Heater		Solar Water Heater or same
Ducts in attic - 3%leakage		Ducts in conditioned space or same

It appears that a 6 kW PV system will be needed to make this home a ZEH.

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, and Florida Green Home certification 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 sq. ft., 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 (Figure 2-12) 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 2-12: *Holiday Builders Green Showcase Home*

In January of 2009, we analyzed Builders

Challenge packages, performed HVAC load calculations, and performed HVAC duct design for additional floor plans. Due to market conditions, the builder chose not to pursue achieving Builders Challenge at this time, but continues to utilize knowledge gained through their partnership with BAIHP to constructed Energy Star and Florida Green Building Coalition certified homes.

A screening inspection was performed on a Holiday Builder model under construction before drywall to evaluate the potential for windwashing for the home and other completed models. The BAIHP team found good construction practices in the inspected model, with plywood applied over kneewall and second-story floor space area adjacent to attic space.

Homes by Point

This Building America industry 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. In 2009, final ratings and FGBC certificates were delivered for these homes, which achieved HERS indexes of 76 and 72.

No activity with this builder since early 2009.

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 or 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.

Through BAIHP's partnership with the LSU AgCenter LaHouse staff, Louisiana System Built Homes (LASBH) is planning a BC prototype home beginning in Nov 2009. It will include HVAC in the conditioned space, high efficiency heat pump, outside air ventilation with dehumidification, improved flashing details, spray foam floor insulation, with a painted on vapor barrier. LaHouse staff will continue to provide technical assistance to this partner.

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 industry 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 (Figure 2-13) that serves as a return for the whole house. During 2006 – 2008 BAIHP was involved with PV, lighting and whole house indoor air quality design recommendations.

Figure 2-13: *Weather tight and insulated crawlspace*

Marquis Construction also completed two all SIP homes (Figure 2-14) that FSEC tested (Figure 2-15) and submitted energy rating files to Calcs-Plus for tax credit and rating. The homes HERS Indexes were 62 and 68. Throughout 2008, BAIHP continued to work with this builder and assist in energy rating testing and inspections for the homes. No further activity was reported in 2009.

Figure 2-14: *Back view of Marquis Construction home in Dade City, FL*

Figure 2-15: *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. No activity since early 2008.

Palm Harbor Homes

FSEC staff assisted Palm Harbor Homes in Plant City Florida in 2008 to help them develop a standard package of features that, when combined with some customer-selected options, would

enable all homes to comply with green building standards. Assistance was provided to HWC Engineering (PHH 3rd party inspector) with incorporation of a Thermal Bypass Checklist and review for possible use of a 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.

The BAIHP team also completed analysis of the homes built by this partner for the 2008 and 2009 International Builders' Shows 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. See 2009 IBS show homes in section 2.2.

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. (2008 work for Plant City)

In addition to these five homes, 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. (2008 work for Plant City)

In 2009, FSEC continued its assistance with Palm Harbor Homes in Plant City, FL to develop modular homes for Builders Challenge and E-Star and to verify in-plant TBC for an Energy Star home sold to a customer. A field evaluation of thermal bypass inspections and application procedure of foam insulation on walls, ceilings, and floors were completed. Future Energy Star homes will have TBC incorporated in plant production along with checklists for various green programs (FGBC, NAHB). FSEC also assisted with plans for a 57 unit affordable development for Westshore in Tampa, FL to meet Builders Challenge. Preliminary HERS scores ranged from 56 to 59. More information on Palm Harbor Homes' activity during Budget Periods 1, 2, and 3 in Section 4.2 HUD Code Energy Star Homes.

PATH Concept Homes

In BP1, BAIHP performed benchmark analysis for the 2007 Path Concept Home (see Figure 2-17) 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 (see Figure 2-16). 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, Earth Craft and NAHB Green.

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

Figure 2-16: *2008 PATH HUD Concept Home near Charleston, SC.*

Figure 2-17: *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. This home scored a HERS 94. Rainier's first BA home completed construction November 1, 2008 and the residents, Tom and Lynda Oyler are occupying the home (see Figure 2-18). During construction 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 completed home was conducted November 2008 resulting in HERS Index of 65 and qualifying for Energy Star tax credit, Builder's Challenge (E-Scale=65) and Florida Green Building Coalition (FGBC) Green Home. BAIHP continues to monitor systems and owner satisfaction/dissatisfaction. The home is occupied, and during the 2nd quarter BAIHP assisted with minor performance issues relating to the tankless water heating systems.

Figure 2-18: *Oyler Residence completed, photo taken January 2009*

Royal Concrete Concepts (RCC), Okeechobee, FL

Royal Concrete Concepts is a producer of concrete modular buildings and concrete tilt-up wall panels. 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 a panelized home in Pt. St. Lucie, FL (see Figure 2-19).

Figure 2-19: *The Grand Emerald by Royal Concrete in Pt. St. Lucie, FL was Florida's first LEED certified home.*

This home became the first certified USGBC LEED Home in Florida in 2007. Other features of this prototype design are good R-values, tight envelope with balanced mechanical ventilation, and ducts in conditioned space.

In 2008, BAIHP researchers visited Royal Concrete to explore future work with advanced concrete wall panels. However significant progress was not made during 2009 (see also Subtask 1.13).

Schackow Development and Trunnel Homes

Schackow Development is developing a community of 27 energy efficient homes called Forest Creek in Gainesville, FL with E-Scales below 60 for all homes. There are currently four homes completed including the community's first 2-story home. BAIHP assisted with the development of detailed specifications, evaluation of systems and simulation of various program elements for two near zero energy homes (NZEH) prototypes whose construction began in June 2007.

FSEC and FLHero staff assisted the 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 (NZEH #1 and NZEH#2 – Figure 2-20) were completed in 2008, with extensive monitoring equipment installed. The NZEH #1 was completed and occupied in 2008, whereas the NZEH #2 also completed in 2008 was not sold and occupied until April 2009. Each home was equipped with a TED energy feedback device to help the owners monitor the performance of their homes. Monitoring continues for both homes. Current results for these homes are available at http://infomonitors.com/zeg/ and http://infomonitors.com/nzg/

In 2008, the results from the first completed NZEH #1 were 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 56 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 months.

Impressive results also ensued during August and September. During these hot, humid summer months, the NZEH#1 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 provided more than 90% of the water heating needs with back up electrical production needed only occasionally (0.2 kWh/day). Air conditioning consumption averaged only 3.8 kWh per day—remarkably low considering the 21 kWh/day average for a/c only for typical housing in this month.

Similar findings were reported in 2009. Average daily net energy use in July, including solar production, was approximately 4.7 kWh/day with the PV system providing 61% of electrical needs. Average daily net energy use from July through September, including solar production, was only about 6.3 kWh /day with the PV system providing 55% of electrical needs.

The solar water heating system provided over 95% of the water heating needs with back up electrical never needed during the three month period. Solar photovoltaic (PV) output from the west facing 3.15 kW array averaged 7.9 kWh/day over the three month period— some lower than expectations, but likely reflecting the west facing PV array and shading in the morning and afternoons from trees.

April of 2009 was the first month of occupancy in the second completed near zero energy home (NZEH #2). While it was initially planned to be a zero energy home (ZEH), site shading and less than expected equipment efficiencies lowered the whole house performance throughout the year. Early evaluation of the ground source heat pump system (GSHP) showed very poor performance (COP typically is around 1.5 or less), partly due to the high pump power. The cooling system also did not perform well. To mitigate these issues, a defective expansion valve was replaced on the cooling system with much better subsequent performance. An oversized well pump was also replaced with a suitably sized more efficient pump, but unfortunately there was no significant improvement in performance.

Despite these challenges, the overall energy performance of the home has been above average compared to other homes in the area. Not counting solar production, total home power use in September averaged only 27.9 kWh/day, less than half the energy typically used in most Central Florida homes this time of year.

Figure 2-20: NZEH #1 and #2 Prototype Home, Gainesville, FL

While Trunnel Construction constructed the NZEH#1 and #2, they are no longer active in this community. Innovative Home Builders of North Florida is the builder that completed the third and fourth home in 2009. These most recent homes will also be certified under the Florida Green Building Coalition's (FGBC) Green Home Standard.

Schroeders Homes, NZEH

In June 2007, BAIHP accepted and welcomed Schroeders Homes as a BAIHP partner who built a near 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.

In 2009, the automated Infomonitors data acquisition system for the high efficient Schroeder's home continued to collect data. A preliminary 10-month billing analysis was initiated to validate data taken at the site and compare it to the actual electric utility (Florida Power and Light – FPL) billing. This high performance ~1,450 ft2 home features a dual-oriented photovoltaic and solar water heating system. The house has a HERS index of 24. The thermal envelope consists of concrete walls (R-7.8), a vented attic with R-38 insulation, and radiant barrier decking with a shingle roof. It is occupied by a family of six, and data is available from summer 2008. Online data for the house is located on the following website: http://infomonitors.com/sch/

During August 2009, a presentation was given at the BIRA Expert Solar Meeting (August 19, 2009) in Vancouver, Washington. Performance of the Schroeder's home was covered as part of four Near Zero Energy Homes (NZEH) presented. The presentation covered a summary of lessons learned from monitoring the four NZEH's including PV performance, indoor conditions, summary of equipment technology, overall PV system efficiencies and air conditioning performance (winter and summer periods) for each home. (30 min.)

September of 2009, we assisted Calcs-Plus with a service call to troubleshoot a communication problem with data logging equipment. Data acquisition was interrupted at the North Port, FL NZEH site due to a GFCI outlet power interruption and compounded by a phone line service failure, but data acquisition was restored by the end of the month. During September the data acquisition was also upgraded with a new set of current sensors to record the power fed back into the grid by the PV system. This data will be validated against utility net meter records on the customer billing data base from Florida Power and Light (FPL).

During October, data acquisition at the North Port (SCH), FL home continued and ended on November 17th 2009. The data acquisition system was removed on December 15, 2009. Data

results and lessons learned from this site were submitted to be arranged into a paper, with a draft due in January 2010. The paper is to be presented by J. Sherwin, primary author, at a builder's symposium conference in Clearwater, FL on December 2010.

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 with this partner since BP2.

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 high performance, energy efficient, sustainable modular homes for the southeast. Homes are built via partnerships with modular manufacturers and builders. Stalwart strives for all homes to be LEED certified and attain very high levels of efficiency. Beginning in 2006 BAIHP participated in several meetings that discussed the strategies Stalwart Homes was considering to implement into the modular process, including but not limited to ground source heat pumps and solar water heating. BAIHP staff visited and inspected a few pre-production prototypes to recommend building enclosure improvements prior to the first true prototype being manufactured.

In 2008, Stalwart Homes constructed their first Near Zero Energy Home (NZEH) Prototype (see Figure 2-21). The 1371 sq. ft., 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 Arabi, GA and was delivered to the Callaway Corners Community in Callaway, FL. BAIHP assisted in photovoltaic and mechanical system design and specification. We also performed in-plant and on-site inspections and performance testing for quality control including thermal bypass compliance for Energy Star, Builders Challenge and USGBC LEED for Homes certification. The home earned an E-Scale of 26 and became the first LEED Platinum home in Florida. BAIHP also installed monitoring equipment for the two-story high performance PV home (Nashville model) and data continues to be collected. Data is available at http://infomonitors.com/zep/.

Figure 2-21: *Stalwart NZEH in Calloway, FL*

In early 2009, a preliminary performance evaluation was completed on the NZEH. Findings reported that based on four months of monitoring, the PV system produced about 62% of the electricity used on site (Figure 2-22). When a full year of energy used was approximated from the four months of monitored data, results showed that the home could achieve a source savings of approximately 87% compared to the BA Benchmark home.

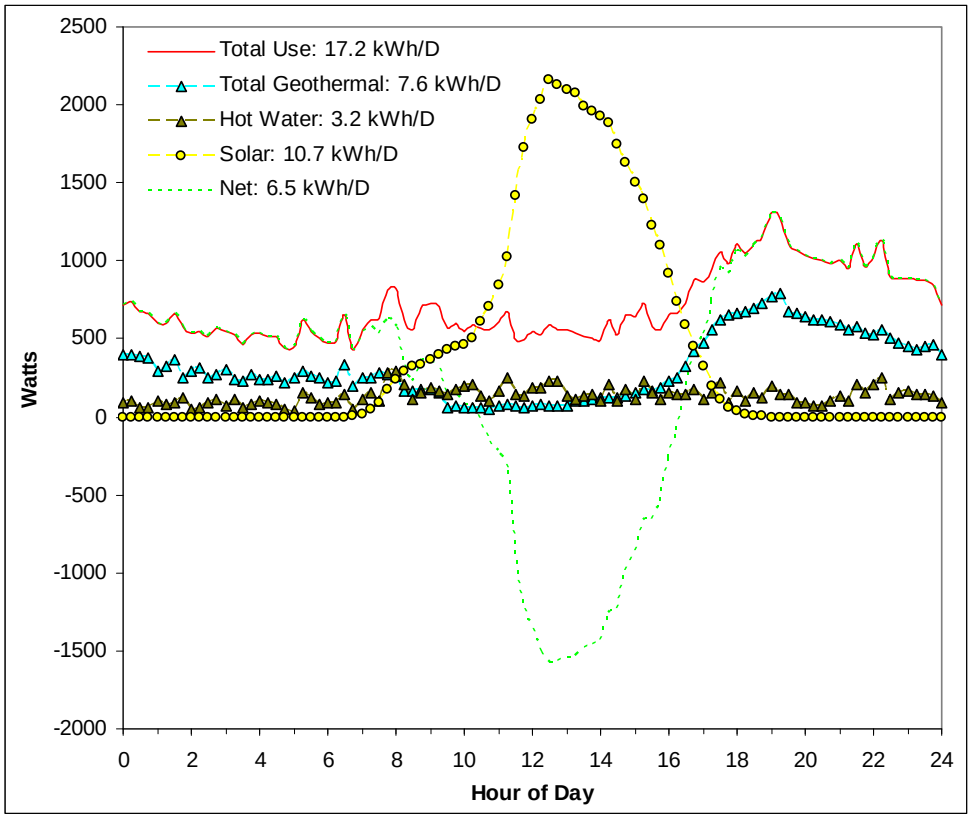

Figure 2-22: Stalwart NZEH average 24-hour electrical demand, September – December 2008

Average cooling energy use averaged 7.6 kWh/day, considerably more than simulated. However, performance ratings and simulations of geothermal equipment do not include energy use of

pump components. Also, monitored data show that the soil conductivity in the area may not allow for maintenance of ideal ground loop temperatures. Estimation of operating efficiency for the geothermal system using monitored data showed 7.4 EER with an average entering fluid temperature of 89F, while the performance rating of the equipment shows 18.3 EER with an average entering fluid temperature of 77F. However, the occupant reported being very pleased with the even temperature conditions and low energy bills.

When data collection began in August of 2008, the home was occupied by one person; however in 2009 the house was vacated by the homeowner and leased to a developer for conversion to a model home. Data collection has continued despite change in use.

Stamets Residence

The Stamets residence (Figure 2-23) is a custom home, constructed in 2005-06 in Shelton, Washington with retrofit improvements in 2008 designed to achieve a 50-60% Building America benchmark. The monitoring results for this home including PV performance are described fully in WSU's 2009 Annual Report in Appendix C.

Figure 2-23: *Stamets Home in Shelton, WA*

Tommy Williams Homes ZEH1 Longleaf Prototype

In 2009, Tommy Williams confirmed its plans to build a Net Zero Energy Home with a HERS index of 0, the first ZEH for this production builder and the first true net zero energy home for a production builder in Florida. Continued analysis, design and communication efforts have been completed on this planned E-Scale 0 home. Groundbreaking for this home took place in February 2009 and William Haslebacher from NETL was in attendance along with realtors, county personnel and BAIHP staff.

In September, Tommy Williams led a team meeting with several BAIHP team members, including FSEC's expert solar and instrumentation team. In addition, the project's superintendent, sales and marketing personnel, HVAC contractor, plumber, electrician, framers and solar contractor attended and participated in a Q & A session at the ZEH currently under construction. The primary goal and objective is to minimize the need to alter or redo work due to a lack of knowledge or the requirements of the integrative systems. Multiple site visits and photographic documentation of progress were performed. BAIHP also filmed segments of construction for the "Achieving Net Zero Energy Green Homes" webinar highlighting measures related to the Builders Challenge Quality Criteria Checklist.

The TW ZEH1 will host 30 Sunpower 225 panels and 64 sq. ft. of solar hot water, all on the south facing roof (Figure 2-24). This 2,250 sq. ft, three bedroom 2.5 bath all-electric home will include an innovative approach to construction of interior duct chases (Figure 2-25). Construction is scheduled to be completed in Spring 2010. The one page specification sheet is located on BAIHP's website http://baihp.org/casestud/pdf/BAIHP-18_TommyWilliams_ZEH.pdf .Tommy Williams also wishes to seek Florida Green Building Coalition Green Home certifications, which BAIHP is assisting. Tommy Williams maintains a

link on their website dedicated to zero energy homes
at http://www.tommywilliamshomes.com/energy-efficiency/news.aspx .

Figure 2-24: *South (top) and North (bottom) Façades of Tommy Williams Homes' first ZEH*

Figure 2-25: *Ducts in Conditioned Space (top) and Ken Fonorow of Florida HERO with Signage(bottom)*

Tommy Williams also produced a handout for their Parade of Homes which was held in October 2009. There were also some media highlights in the local paper (See Appendix B).

The ribbon cutting for this model ZEH1 is scheduled for January 28, 2010. Based on the sureness of this home, TW has decided to start a second ZEH in their Belmont community. Groundbreaking for this home was held on November 12, 2009.

University of Georgia

In 2009, the University of Georgia, UGA, proposed to design and build a low energy farm house. The Future Farmstead home and office are the program's centerpiece. The program site is on the Tifton campus of UGA and next to the Georgia Agricultural museum. The location was selected because of its excellent research, educational and outreach potential. Over 40,000 cars pass by this site each day and hundreds of school children and teachers visit the Georgia Agricultural museum each day of the school year. The lab/home is expected to also receive this level of traffic.

"We envision the Future Farmstead home and office to be net zero or better, energy and people efficient. We want this grid-connected home to focus on passive design and energy efficiency strategies first, and bring in solar power and heating to insure we reach at least net zero in energy consumption.

This 2,500-3,000 sq ft working model lab/home will have graduate students living in and working on this project, overseen by many faculty engaged in the program. As a research and outreach project, the house will be monitored, updated and the information made available through electronic and print media. We plan to have the home incorporate the best technologies of today and the near future - eco-friendly, and specifically designed to take advantage of its rural setting."

The Building America team will be providing technical assistance for this endeavor. In August of 2009, John Sherwin attended the 2009 BioEnergy conference (8/11/09 – 8/12/09) sponsored by the University of Georgia to give a presentation on the essentials of a zero energy home success. During the conference a meeting was held to discuss design details with the University of Georgia personnel on the future farmstead. The project is still in the design phase as of 2009.

Walt Disney Imagineering

In 2009, an analysis was conducted on generic plans submitted by Walt Disney Imagineering. The plans represent housing architecture that may be built in conceptual communities. BAIHP initiated the development of sample energy conservation packages for two floor plans that will potentially be used in a planned residential development focusing on environmental responsibility. Improvement packages to achieve E-Scale of 60, 40, and 0 were developed and submitted for review with builders, along with comparisons to current and past code-minimum performance. A meeting with the developer was held in December 2009 to discuss opportunities for partnership with the local utility on incentives for distributed generation and conservation efforts.

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 or 2009.

ZCS Development, Rockledge, FL

ZCS Development is developing a 100 unit subdivision named Sierra Lakes (Figure 2-26) in Rockledge, FL that includes all steel (Figure 2-27) 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 was collected in 2007 for the Wesley model.

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 2-26: *Sierra Lakes, Wesley Model*

Figure 2-27: *Steel trusses produced on site*

Florida H.E.R.O. Activity

In addition to activities described above and in Subtask 3.1, the following partnership activities were conducted by FLHero:

- *Anderson Construction & Design* – Keystone, FL – Ongoing consultations in 2009. E-Scale of 57 on first Builders Challenge home. Partnership activities completed in 2009.
- *Bedsaul Development* - Gainesville, FL - Design Review & provided consultation to develop specifications for future homes achieving the tax credit level of performance. No partnership activity since 2008.
- *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. No partnership activity since 2008.
- *Custom Homes* - Florida, Georgia and Texas - Multiple design reviews, recommendations, consultations & commissioning. Ongoing consultations in 2009.
- *Dibros Corporation* – Town of Tioga, FL – Ongoing consultations in 2009. Completed one Builders Challenge house. Partnership activities completed in 2009.
- *Emerald Ventures – Gainesville, FL – Introduced to BA* systems approach and provided initial design review. No partnership activity since 2008.
- *Florida Certified Contractors (mentioned in 2008 as Davis Custom Homes)* – Gainesville, FL – Beginning in 2008, Florida HERO provided technical assistance while modular

housing plant in North Florida area was being constructed. Plant was completed in 2009 and Florida HERO continued to provide ongoing consultations to review/develop component specifications. Conducted performance and diagnostic testing to identify opportunities to enhance the operational efficiency of the product. Manufacture's goal is to meet the Builders Challenge.

- *Ivan Solback Company* – Gainesville, FL – Ongoing consultations in 2009 and all other partnership activities completed in 2009.
- *Kimble/Brown Enterprises* – Gainesville, FL – Ongoing consultations and all other partnership activities completed in 2009.
- *Norfleet Construction* – Newberry, FL – Design review, TBIC and commissioning. First BA home achieved HERS score of 67 and qualified for federal tax credit. No partnership activity since 2008.
- *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. No partnership activity since 2008.
- *Schackow Development & Innovative Home Builders* – High Springs, FL - Ongoing consultations in 2009. Received commitment to build future homes to an E-Scale of 60 or less. Completed two homes by end of 2009.
- *Schackow Development & Trunnel Homes* – 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. Completed Zero Energy Home (ZEH) in 2008.
- *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). Ongoing consultations in 2009.
- *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. Ongoing consultations in 2009.
- *Spray Foam Houston LLC* – Texas – Ongoing consultations and troubleshooting in 2009.
- *Sutton Family Homes* – Newberry, FL – Introduced BA systems approach, provided design review and recommendations. Prepared Manual J, D and FL Energy Code form. No partnership activity since 2008.
- *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. No partnership activity since 2008.

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

- *AllWallSystem* – LaCrosse, FL
- *Brighton Housing Department* – Brighton, FL

- *Daybreak Equity Corporation* – Ocala, FL
- *Edinborough Development Corp.* – Gainesville, FL
- *Irvin Construction Company, Inc.* – Ocala, FL
- *Real Building* – St. Petersburg, FL
- *Smoak Construction of Central Florida* – Williston, FL
- *Vernon Investments Group* – Gainesville, FL (affordable housing)
- *Weeks Construction* – Gainesville, FL

Other Prototype Design Assistance:

- HVAC design was completed in 2008 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 achieve NZEH status and utilize, among other high performance building techniques and equipment, unique small capacity DC air conditioners that are powered by dedicated PV systems. In 2009, we performed a thermal bypass inspection on the Envirohome, and the house successfully passed the check list with only minor suggestions made to the owners/builders. A pre-drywall inspection and mid-point duct test were also conducted for general quality control purposes, and towards certification for Energy Star, Builders Challenge, and LEED for Homes. The home is expected to be completed in early 2010 after final testing and inspection. The home will be open to the public as an educational resource. . Through a partnership with the UCF Stormwater Management Academy, this home is also striving for zero storm water runoff status through the use of green roof sections, rainwater collection, and site infiltration strategies.
- ICI Homes, a builder in Kissimmee, FL, became a BAIHP partner in late 2007, but this partnership did not result in a Building America prototype.
- 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 was planned. No partnership activity since 2007.
- 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. No partnership activity since 2007.
- Calcs-Plus performed HVAC load calculations and Energy Gauge file conversions for two houses from Cambridge Homes in 2007. No partnership activity since 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. No partnership activity since 2007.
- 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.
- In February 2009, following up a December 2008 visit to GL Homes, a large production builder in South Florida, simulations were conducted to bring a prototype to HERS 60. However, this builder did not pursue the BA partnership.

- 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.
- WD Moore Construction -Based in Keystone Heights, Florida, this builder's goal is to achieve the Builders Challenge. Ongoing consultations continued in 2009.

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 (Figure 2-28) 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.

Figure 2-28: *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 2000. The monitored data provides an example of performance for a mid-90s code minimum home and includes energy use, indoor conditions and attic conditions. In 2007, the soffits were sealed to create a sealed attic space, and the envelope and ducts were retested for air tightness. The home had a white metal roof retrofitted in 2005 and a garage temperature sensor was added in 2008. As of September 2009, we are planning to monitor the solar water heating system to assess long-term performance of the system installed in 1999. The old CR10 logger will be replaced with a new CR1000 datalogger to improve data collection and gain more experience with the new logger system.

Hoak Home

BAIHP monitored this three-story, 4,250 square foot BAIHP researcher home in Longwood, Florida near Orlando for several years (2004-2009). 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 could be cooled with a much smaller air conditioner than is needed by most homes of this size in the hot and humid Florida climate. Two heat pump water heating systems were evaluated in this house. Monitoring was discontinued in late 2009. LSU AgCenter's

LaHouse

In 2008 BAIHP installed monitoring equipment in the Louisiana House (also known as the LA House – see Figure 2-29) demonstration home (http://www.louisianahouse.org/) on the LSU campus under the direction of Professor Claudette Reichel. LA House staff purchased the equipment in consultation with BAIHP. The house was completed in 2009 and instrumentation continued during several site visits. During construction, irreparable damage was done to multiple components of the monitoring system including severed wires, destroyed labels, and removal of sensors. Researchers have endeavored to salvage a set of useful elements from what remains and LSU will take over the monitoring effort in 2010.

Figure 2-29: *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) and the Stamets homes are described above. Monitoring activity with prototypes built by Scott Homes and a modular prototype in Ft. Lewis, WA are described in Appendix C - Washington State University Annual Report and in Subtask 3.2 – Marine Community Scale Developments.

Subtask 2.1.2 Gulf Coast Affordable High Performance Prototype Homes

In 2009, Subtask 2.1.2 was incorporated into Subtask 4.1 because all of the participating builders were Habitat for Humanity affiliates. Please see Task 4.1 for progress on this project.

Subtask 2.2 International Builders' Show – Show Homes

Overview

Since 2005, BAIHP has provided technical assistance including HVAC design assistance, green consultation and Energy Star certification to many homes in the National Association of Home Builders International Builders' Shows in Orlando and Las Vegas, including the outdoor show home exhibits and the National Association of Home Builder's show case homes built off site. Design activities for these show homes usually begin at least twelve months in advance. These homes demonstrate the

Figure 2-30: *The 2008 New American Home*

latest technology and products to tens of thousands of attendees annually, including builders and the general public. Product manufacturers use these projects as marketing avenues for displaying new products or even showcasing how-to guides for installation of products.

These show homes are great opportunities to solicit builders to integrate more energy efficient and improved performance strategies in their homes as certifications and energy ratings can allow for a marketing edge. In addition, BAIHP helped several builders of the outdoor exhibit show homes after the homes were relocated to permanent sites. BAIHP assisted in recertifying those homes for green, Energy Star and renewable credits and certifications.

In preparation for the 2010 IBS, discussions began in 2009 regarding BAIHP participation. BAIHP has continued technical assistance with the builder and product sponsors and attended the sponsor meeting in September. BAIHP has assisted with duct and equipment sizing and offered recommendations to the builders. Construction is underway and completion expected by December 2009.

Preparations for the 2009 IBS show homes began early in 2008. BAIHP provided technical assistance such as 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.

In 2009 BAIHP provided assistance to the following homes:

- Three 2010 IBS Show Homes – Two in partnership with Palm Harbor Homes and one in partnership with Nationwide Custom Homes.
- ***Two 2009 PHH Professional Builder Show Village Homes –*** compiled high performance data sheets for both homes that involved Building America support. Evaluated both Building America supported show homes for NAHB Green Home and Builders Challenge. Assisted builder with green and Builders Challenge certification and energy efficient strategies at the show in Las Vegas, NV.

In 2008 BAIHP provided assistance to two 2008 PHH Professional Builder Show Village Homes and the 2008 New American Home (see Figure 2-30).

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.

Summaries of a sample of the IBS Show Homes are included below. Brief case studies for all of these show homes are available at http://www.baihp.org/casestud/index.htm

2010 IBS Show Homes

For the 2010 International Builders' Show, held again in Las Vegas, BAIHP has provided technical assistance to Palm Harbor Homes and Nationwide Custom Homes for three show homes (Figures 2-31 and 2-32). The HERS Indices for all three are expected to be in the 60's.

Figure 2-31: *Osprey –"EcoCottage" by*

Figure 2-32: *La Linda Home (left) and Highlander "Traditional" Home (right) by Palm Harbor Homes*

2009 PHH Professional Builder Show Village Homes

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

Figure 2-33: *Tularosa – Media Enhanced (2009 International Builders Show Home)*

Figure 2-34: *The Deschutes Quiet Living (2009 International Builder's Show Home)*

FSEC assisted Palm Harbor Homes (PHH) on the design of the Deschutes "Quiet Living" (Figure 2-34) and Tularosa "Media Enhanced" Homes (Figure 2-33). Both homes included energy efficiency, indoor air quality and noise reduction features, and other green building certifications. Palm Harbor Homes is a continuing participant in the Builders Challenge. The Tularosa was tested at the show met Builders Challenge certification with an E-Scale of 60.

FL HERO provided on-site technical assistance, conducted performance tests, and developed ratings for the two show homes. They also submitted the final project file for registration as ES/BC homes.

2008 PHH Professional Builder Show Village Homes

FSEC and Calcs-Plus researchers assisted Palm Harbor Homes (PHH) on the design of the "Green" (Figure 2-36) and the "Comfortably Affordable" (Figure 2-35) 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 2-35: *Glen Cairn – PHH "Comfortably Affordable" Show Home*

The Glen Cairn "Comfortably Affordable" home was acquired by Stalwart Built Homes and was relocated to the Florida panhandle to serve as a sales model for the Waterview at Inlet Beach community (www.WaterviewFlorida.com).

Figure 2-36: *Bimini II – PHH Green Show home*

2008 Vision House

The Vision House Orlando, a 2008 IBS show home, was built in Lake County (Figure 2-37). 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 2-37: *Vision House 2008*

The 6694 sq. ft. home is constructed of SIPS and contains four 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 (Figures 2-38 and 2-39)

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: AAC 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 2-38: *2008 The New American Home*

Figure 2-39: *Solar water heater on TNAH 2008*

2008 Tradewinds Home (Figure 2-40)

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 2-40: *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 (Figures 2-41 and 2-42) and a tri-plex unit (Figure 2-43). 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 2-41: *3,397 sq. ft. Palm Harbor Homes, the Bellaire – GenX*

Figure 2-42: ***Palm Harbor*** *Homes, the Bellaire GenX relocated to Siesta Key in Sarasota, FL*

During BP2, FSEC and Calcs-Plus coordinated the relocation of GenX to Siesta Key in Sarasota, FL (Sarasota County) (Figure 2-42). They assisted in the re-install and re-certifications for Energy Star, FGBC and renewable permits.

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

Data sheets for these two homes can be found on the web at:
http://www.baihp.org/casestud/ph_homes2007/pdf/genx.pdf

Figure 2-43: *EchoBoomer Town Homes*

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

2007 The New American Home (TNAH)

Each year the National Association of Home Builders also demonstrates site built housing. 2007 New America Home (Figures 2-44 and 2-45) 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)

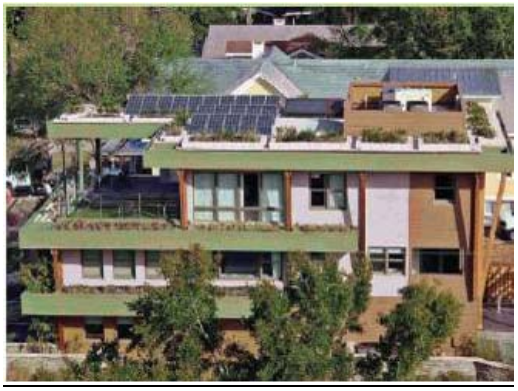

Figure 2-44 *TNAH (with the Renewed American Home roof in background)*

Figure 2-45 *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, four 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 industry 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

Figure 2-46: *2,865 sq. ft. Palm Harbor Homes, the Bellaire –Move up Buyer*

The Bellaire Model (Figure 2-46) 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.

Subtask 2.3 (BP4) Lab Homes in Hot-Humid and Mixed-Humid Climates

FSEC Lab Homes

Two identical new test structures (right-Figure 2-47) are being designed to be built at FSEC's Cocoa campus to help determine the best retrofit and new home practices. The structures will serve as a control and experiment for evaluating energy saving measures. The buildings are designed to allow ready change-out window systems, as well as equipment and appliances. The initial configuration will replicate the envelope efficiency of a typical 1960s residence, with appliance and HVAC efficiency typical for a home from that era on the market today. The homes will be monitored consistent with a lab home monitoring plan being developed by the National Renewable Energy Laboratory and Building America teams. An architect was hired and construction drawings are being developed. Construction is planned for 2010.

Figure 2-47: *Conceptual design for side-by-side lab homes at FSEC*

G.W. Robinson Builders Lab Home

In 2009, this builder expressed an interest in constructing a lab home that would have a HERS 40 performance level without renewables and that would incorporate additional energy conservation measures not analyzed by the HERS methodology (Nightcool, feedback, automated load shedding etc). BAIHP hosted G.W. Robinson personnel at FSEC in February to discuss various options. The builder provided a plan and identified a lot in Garison Way subdivision for this home; however, shading issues present at the originally designated lot required identification of a different lot for the lab home. Design and solar access studies were conducted. In July, G.W. Robinson homes informed BAIHP that they were not interested in pursuing the lab home due to poor economic conditions. However, in November they have decided they would like to proceed with building their first net zero energy home and possibly "plus net zero energy home", meaning HERS -10. Analysis has begun to examine improving their prototype home specifications in order to maximize effectiveness of photovoltaic and solar hot water systems.

Redbrick Homes

In 2009, Jim Cheeks of Redbrick Homes in Atlanta expressed an interest in building a lab home. BAIHP participated in an initial meeting with this builder and SouthFace in March 2009. No further activity occurred in 2009.

Subtask 2.3 (BP3) 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 the 2008 budget period, FSEC 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 four IBACOS sites were active in 2008. We also collected data for the two ORNL zero energy Habitat homes in Tennessee in 2008 and 2009.

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 Scott Homes, 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 communities (Figures 3-1, 3-2, 3-3, and 3-4) of 10 or more high performance homes. We have 16 community scale projects in the hot-humid and marine climates as listed in Table 3-1.

Table 3-1 Community Scale Projects by Climate
**Note, italics indicate industry partners committed to building all homes to HERS 60 or less.*

Proj. No	Builder/ Project Title	Location	BA Benchmark Savings	Homes / Units	Status	Partnership Status
Subtask 3.1 Hot Humid Climate Communities						
*1**	*GW Robinson Builders*	*Gainesville, FL*	*40%*	*200*	*62 Built*	*Active*
*2**	*Tommy Williams Homes*	*Gainesville, FL*	*40%*	*200*	*36 Built*	*Active*
3	Castle & Cooke	Oakland Park, Winter Garden, FL	40%	10	10 Built	Active
*4**	*Skobel Development*	*Willow Oak Plantation, Gainesville, FL*	*40%*	*30*	*9 Built*	*Active*
*5**	*Lifestyle Homes*	*Melbourne, FL*	*40%*	*20*	*5 Built*	Active
6	Brownsville Affordable Homeownership Corp	Brownsville, TX	40%	66	13 registered with BC	Active
*7**	*HKW Development*	*Gainesville, FL*	*40%*	*TBD*	*1 Built*	Active
*8**	*Schackow Realty and Development*	*Gainesville, FL*	*40%*	*24*	*4 Built*	Active
9	Stalwart Built Homes	New Orleans, LA	40%	424	Site Work	Active
10	On Top of the World	Ocala, FL	Bldrs Chlng			Complete
11	Pringle Development	Eustis, FL	Bldrs Chlng			Complete
Subtask 3.2 Marine Climate Communities						
With #9	Stalwart Built Homes / GE	Cascadia, Tacoma, WA	50%	6,500	Site Work	Active
12	Fort Lewis Army Base	Ft. Lewis, WA	~30% meets or exceeds Energy Star;	383	complete	Complete
13	Fort Lewis Army Base	Ft. Lewis, WA Discovery Cove	Meets or exceeds Energy Star;	34 units	34 units complete	Complete
14	Fort Lewis Army Base	Ft. Lewis, WA Town Center Phase 1	TBD	63 units	Design	Active
15	McChord Air Force Base	Tacoma, WA	Exceeds Energy Star	32	Site Work	Active
16	Scott Homes	Olympia, WA	50%	NA	21 complete	Active

As BAIHP industry partners build and refine their prototype homes, researchers begin discussing the transition from prototyping to production. Whereas the prototype effort engages the partner's staff and subcontractors, the industry partners must take ownership of the new specifications and process and integrate them fully throughout their business to successfully build a community of high performance homes. The industry partners must determine when they are ready to expand a prototyping effort into a community scale project. The transition involves everything from purchasing to warranty services. To facilitate this transition, BAIHP provides staff and sub-contractor training, marketing development support, and third party verification of all technical requirements.

This section describes BAIHP work done in partnership with builders that are building high-performance communities.

As the nationwide slowdown in new home construction continued in 2009, BAIHP community scale production was also reduced as indicated in Table 3-2.

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

	2007	2008 (through November)	2009
Hot-humid Climates (site built and IBS show homes)	284	118	84
Marine Climates (modular)	151	0	0
Habitat for Humanity (all climates)	35	47	21
HUD code (NEEM homes)	3,718	2,926	1,246 (through September)

Even in the face of this slow market in 2009, BAIHP secured commitment from six Florida industry partners to build all homes to an E-Scale score of 60 or less. They are achieving a standard met by fewer than one in every 1,000 new homes built in Florida since 2007. Their combined annual production is around 100 houses. Five of the industry partners are located in the Gainesville area: G.W. Robinson, Tommy Williams Homes, Skobel Development, Schackow Realty and Development, and H.K.W. Enterprises Inc. The sixth, LifeStyle Homes of Melbourne, builds along Florida's Space Coast in Brevard County. An FSEC press release titled "New Home Sales Robust for Some Energy Efficiency Florida Builders" is included in Appendix B. These industry partners are shown in italics in Table 3-1 above. Partnership activity with each of these and our other Hot Humid Climate community builders are described below.

Subtask 3.1 Hot Humid Climate Communities
(Note: Community Project numbers correspond to Table 3-1 above that lists all of our community scale projects.)

Community Projects 1 and 2: G.W. Robinson Builders and Tommy Williams Homes, Gainesville, Florida (*Please also see Subtask 2.1 G.W. Robinson Builders, Inc. ZEH Prototype in 2010 and Tommy Williams Homes Zero and Near Zero Energy Homes)*

Work continues with both Tommy Williams Homes and G.W. Robinson Builders through the efforts of BAIHP subcontractor, Florida Home Energy Rating Organization (FLHERO). *In 2009, both industry partners committed to building all their homes to a HERS 60 or lower.*

FLHERO conducts design reviews, develops Manual J's and D's for each home, conducts site visits for quality assurance and completion of the Thermal Bypass Inspection Checklist, commissions homes, performs diagnostic tests and provides recommendations and tax credit reports. In addition, BAIHP is working with Tommy Williams Homes (Figure 3-1) to improve the performance of homes even further. Since late 2008, they have included tankless gas water heaters and radiant barriers as standard items.

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

In addition, in April 2007 BAIHP held a public event honoring GW Robinson Builders and Tommy Williams Homes. Both the City of Gainesville and Alachua County named this day as "Building America Day." Steve Chalk (Figure 3-5) from the DOE presented a Certificate of Recognition to both these builders.

Figure 3-5: *GW Robinson presented with a certificate by Steve Chalk, Deputy Assistant Secretary from the DOE*

In 2009, we received commitments from Tommy Williams Homes (Belmont, Longleaf & Custom in Gainesville and Newberry, FL) and G.W. Robinson (Turnberry, Garison Way, Gainesville, FL) to build future homes to an E-scale of 60 or less. BAIHP continues to support both industry partners' participation in the Builders Challenge program.

The GW Robinson staff was assisted in finalizing the approach selected to meet the NAHB Green Homes standard at the Gold level. Consultations and site visits for QA were provided. On-site technical assistance was provided to Tommy Williams' Belmont, Longleaf, and Custom

divisions in Gainesville and Newberry, FL, including ongoing site visits for QA. Multiple homes were also commissioned.

Several high performance homes were constructed in 2009 by both Tommy Williams Homes and G.W. Robinson builders in the Gainesville, FL area that all have a HERS Index of less than 60. BAIHP successfully designed and deployed a low cost (approximately $0.40 / sq. ft. of floor area) interior duct system for these homes. Shaded areas in the plan below (Figure 3-6, left) denote areas where ceiling sheetrock is first installed, before interior walls are constructed (Figure 3-6, right). Then the supply ductwork is installed using hard ducts whenever possible. Special drywall supply boots are field constructed to reduce the sheetrock plenum size. Next the ductwork is framed in and the house is readied for the second and final visit of the drywall crew. A key to low costs is elimination of all return duct work in one story homes using over the door transom returns from bedrooms. A series of Net-Zero Energy "ready made" home plans have been developed.

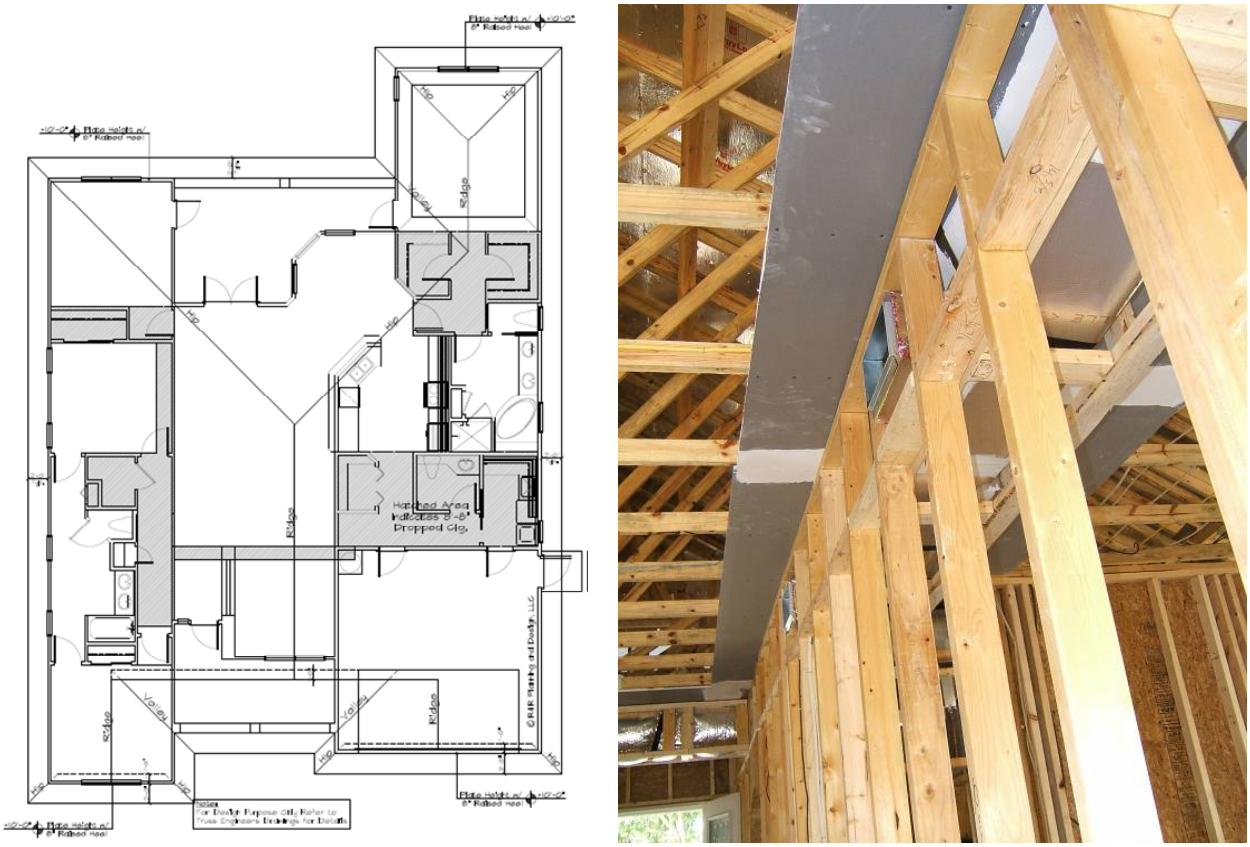

Figure 3-6: *Innovative interior duct system design shown in plan at left (shaded areas) and under construction at right. Note that the ceiling of the duct chase that forms the attic air barrier is installed above the top plates, significantly reducing the number of drywall joints that need to be sealed. This detail resulted from a collaboration between Ken Fonorow of FL HERO and the sub-contractors involved in the construction of the chase.*

Among the numerous advantages of well designed and constructed interior duct systems are – improved energy efficiency and indoor air quality from eliminating duct leakage to the outside and conductive heat gains and losses through the duct wall. These effects reduce the load on the mechanical system and improve comfort through faster pull down rates in hot summers due to

elimination of hot air and cold air blows at equipment startup. Overall indoor air quality is improved due to elimination of duct leaks which often drive uncontrolled air exchange between conditioned and unconditioned spaces such as attics, wall cavities, garages, and vented crawlspaces. Interior duct chases have been used by BAIHP industry partners to improve aesthetics through variation of ceiling heights and creation of alcoves. It is also a long lasting measure that can last the life of the dwelling.

A detailed G.W. Robinson Builders Case Study is included in Appendix B and available online here: http://www.baihp.org/casestud/pdf/GWcasestudy40_4-4-08-2.pdf

A detailed Tommy Williams Homes Case Study is also included in Appendix B.

Community Project 3: Castle & Cooke - Oakland Park, Orlando, FL
BAIHP have continued to work with Castle & Cooke developers on 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 3-7: *Oakland Park, Winter Garden, FL built by Castle & Cooke*

In 2008, construction on all ten homes was completed (Figures 3-7 and 3-8). The homes range from 1819-2340 sq. ft. and HERS Index ranged from 59-65. All ten include passive outside air ventilation (Figure 3-9). While the majority of the homes are single family, four 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.

Figure 3-8: *Completed Castle & Cooke Home*

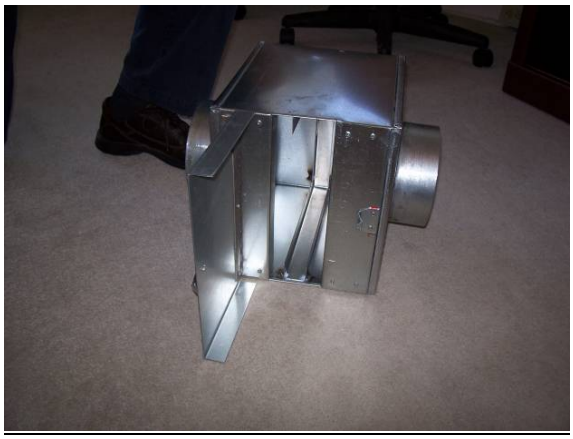

Figure 3-9: *Custom designed outside air filter box installed in each house*

Interior conditions were monitored in a sample of homes for a period during the summer of 2008 (Figure 3-10). 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.

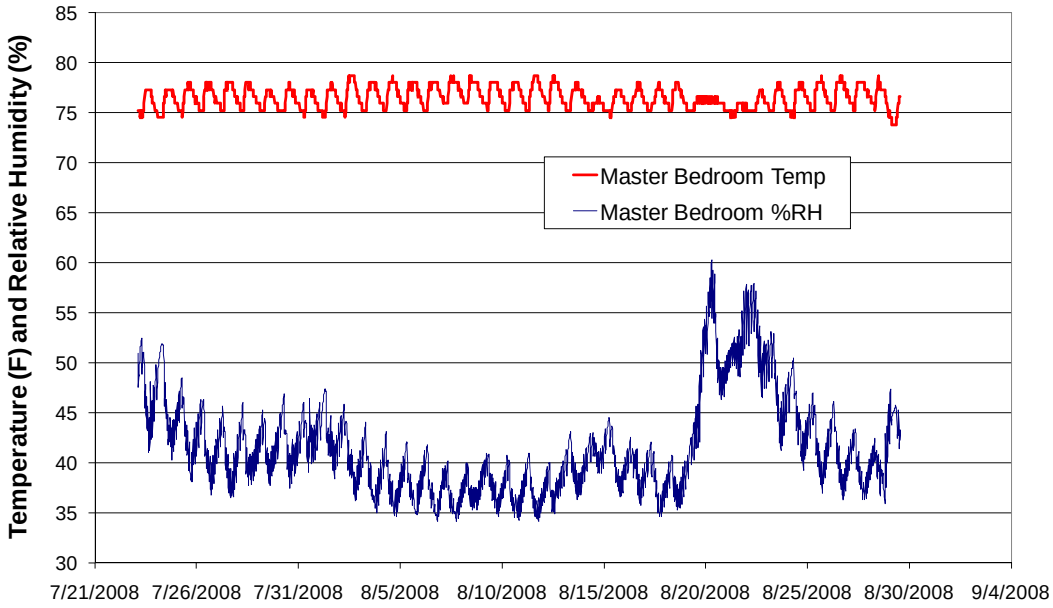

Figure 3-10*: Monitored data from unoccupied Oakland Park home showing excellent summer comfort conditions. Rise in relative humidity beginning 8/20 caused by Tropical Storm Fay, which brought historic rainfall to the Central Florida area, along with three consecutive overcast days with no sun.*

In May of 2009, the BAIHP team began working with this developer to draft a case study of the first ten Builder's Challenge homes that were completed in the Oakland Park Community. This case study will be included in the 40% Hot-Humid Climate Joule Report scheduled for completion in 2010.

Community Project 4: Skobel Development

FLHERO made a preliminary consultation with Alex Skobel, President, who is 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. In addition, we performed TBIC on this partner's first BA home. In 2009, FL HERO continued its consultations with Skobel which resulted in the production of Builders Challenge level homes. We also worked with an HVAC contractor to resolve leakage and setup issues. *In 2009, FLHERO received a commitment from this partner to build future homes to an E-Scale of 60 or less.*

Community Project 5: Lifestyle Homes

Lifestyle Homes, a family owned partnership, was looking for a path to distinguish themselves from other builders located in Brevard county, Florida. One of the founding partners, Larry Hufford, had a strong desire to push the energy efficiency component into their designs. In the summer of 2008 they became a BAIHP partner and planned to build such a community in Melbourne, FL. We provided them options to build homes that exceeded the Builder's Challenge goals; in fact the HERS Index was less than 60 (Figure 3-11). Construction on their first Building America Builder's Challenge home was completed in April 2009 with a HERS Index of 60. The BAIHP team participated in Lifestyle Homes Open House, celebrating the first Builder's Challenge home in Brevard County. Since then, four more houses have been completed and 14 more are in various stages of completion – and all are presold. *LifeStyle Homes has committed to building all their homes to a HERS Index of 60 or less.*

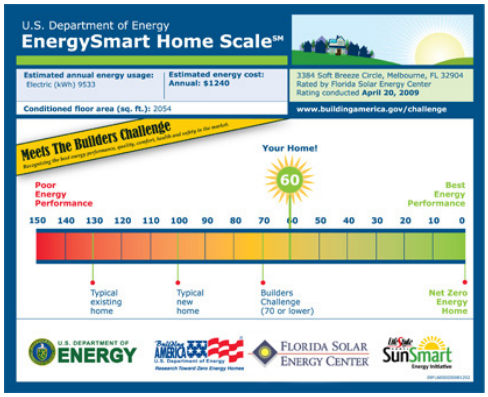

Figure 3-11: *E-Scale Label for Lifestyle Homes' First Builders Challenge Home*

Preliminary work

Initial energy analysis of plans indicated that the homes had a HERS Index of approximately 100 or a home built to meet the Florida Energy code. BAIHP team submitted a few possible solutions that would lower the energy use and incorporate solar use solutions. Additionally we worked with the builder on marketing and systems plans, including possible energy upgrades and features. The resulting marketing plan included the development of the SunSmart[SM] program (Figure 3-12). SunSmart[SM] is an exclusive combination of better building techniques and higher-performance components that will deliver higher quality, more durable homes and substantially reduce electrical bills families have to pay to live in them comfortably.

Figure 3-12: *SunSmart is a new Builders Challenge product line offered by Lifestyle Homes*

Construction Details

The standard Lifestyle Home is a single story, slab on grade, concrete block home meeting the Florida Energy Code. Insulation consisted of R30 in the attic and R5 foil insulation in walls.

Windows were single pane clear with a metal frame. The air conditioning system met the minimum requirements at SEER 13 with the air handler located in the garage and the duct work in the attic space. Duct leakage was minimal, but not considered to be air tight. Water heating accomplished with an electric 40-50 gallon tank. The HERS Index approaching the 100 mark. *(Note that after we began working with LifeStyle Homes, the Florida Energy Code increased efficiency 15%.)*

Lifestyle has about 20 different design layouts, varying in size from 1650 square feet (single story) to over 3200 square feet (two-story). A typical design is the Capri model (2054 square feet) which is a four bedroom, three bath home (Figure 3-13).

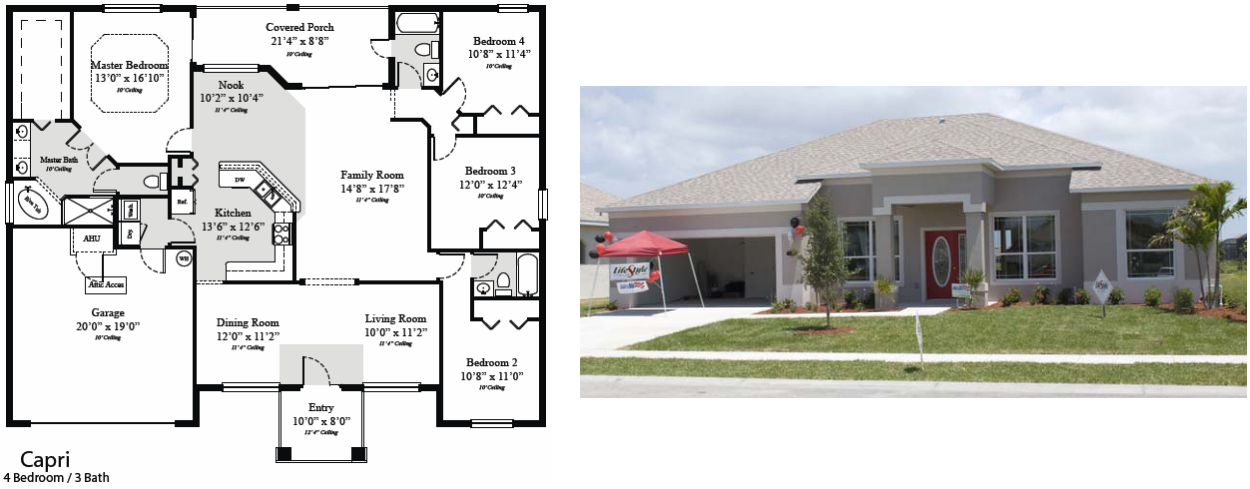

Figure 3-13: *Lifestyle Homes Capri Model*

This is the first Builder's Challenge home in Brevard County during their open house in April 2009. It has a HERS index of 60. The following Table 3-3 shows LifeStyle Homes' standard (pre-Builder's Challenge) construction characteristics and the Builders Challenge improvements.

Table 3-3: *LifeStyle Homes Typical Characteristics*		
Attribute	***Pre Builder's Challenge***	***Builder's Challenge***
Bedrooms/Bath	4 / 3	
Floor Area (sq. ft.)	2054	
Worst Case Orientation	East	
Attic	Passive 1:300 Venting	PV Powered Attic Fans with proper air sealing at all penetrations in ceiling air barrier
Roof Type	Shingle (medium)	
Floor/Foundation	Slab on grade, -R0	
CBS Walls	R5 Foil Layer	R7 – Double Foil Layer on double battens – provides more room for electrical boxes – no broken blocks
Framed Walls	R11 – Grade II or III	R13 – Grade I
Ceiling	R30	R38 – Grade I including knee walls & tray ceilings
Glazing/Frame	Single / metal	Dbl Low-E / metal
U-value	1.2	0.60
SHGC	0.8	0.35
Window / floor ratio	0.167	
Fluorescent Lights (%)	10%	100%
Doors	Insulated	
Cooling System	HP, SEER 14, 48 kBtu	HP, SEER 14, 34 kBtu
Heating System	HP, HSPF 8.0, 34.7 kBtu	HP, HSPF 8.2, 20.4 kBtu
Thermostat	Programmable	
Supply Duct	Attic	
Return Duct	Attic	
Air Handler	Garage	Interior
Duct Leakage	Qn=0.06	Qn < 0.03
Ventilation	None	50 cfm
Water Heater	40 gal Electric - EF=0.92	80 gal Electric - EF=0.92
Solar DHW	N/A	Active Solar – PV pump
Estimated Natural Infiltration	ach = 0.30	ach = 0.15
HERS Index	98	60

Energy features of the Lifestyle SunSmart homes include the use of solar equipment for attic ventilation and water heating.

The PV powered attic ventilation fans provide increased air movement through the attic space when the temperatures are the most extreme. The fan speed varies proportional to the solar radiation. The thermal bypass inspection ensures that the ceiling air barrier is continuous to prevent accidental depressurization of the living space.

The properly installed insulation (no gaps, voids or compression - grade I) in the walls and attic ensure a good thermal barrier.

Some other issues being addressed by Lifestyle homes as part of their efforts with the BAIHP are air quality, home durability and equipment reliability. As part of this effort,
a significant health and safety factor that has been incorporated into the Lifestyle homes is the placement of the AHU closet (Figure 3-14) built as part of conditioned space. While located in the garage, this space is air sealed and insulated with a pressure relief to the conditioned. This is

accomplished with either a jump duct or pass through opening, depending on the layout of house. This precludes the possibility of garage or attic air from being drawn into the space by the slight leakage of the air handler unit.

Some of other features include; extensive air sealing with long life caulk and foam, placement of drainage planes, joints and connections and attention to window & door openings.

And to round out the healthy interior environment, outside air is pulled into the base of the air handler unit. This air is pulled through a filter grill assembly located in the ceiling of rear porch for easy maintenance.

The result is improved health, safety, durability, comfort and energy efficiency.

Figure 3-14 *Interior AHU closet in garage*

In September 2009, the BAIHP team met with Lifestyle Homes to discuss plans for future development. The partner expressed interest in building a near zero energy home as a model. We provided input to the builder on different Zero Energy Home (ZEH) and Near Zero Energy Home (NZEH) approaches and provided energy gauge inputs for multiple PV types and sizes.

Community Project 6: Brownsville Affordable Housing Corporation

Brownsville Affordable Homeownership Corporation (BAHC) is a non-profit developer sponsored by the City of Brownsville TX through their receipt of U.S. Department of Housing and Urban Development's (HUD) Housing Opportunities Made Equal (HOME) program funding. BAHC contacted Building America Industrialized Housing Partnership in late 2007. Gate 1 activities resulted in an improvement package designed to qualify BAHC homes for the Builders Challenge. In 2008 BAHC built several prototype Gate 2 homes. BAHC also signed up for the Builders Challenge as Pioneer Builders.

Of the thirteen homes built by BAHC in 2008's Phase I, nine met or exceeded the Building America 40% Whole House Source Energy savings (WHSE) Benchmark while qualifying for Energy Star and the Builders Challenge (with Builders Challenge Quality Criteria exemptions). Phase II's 26 houses are to be finished in 2009. Currently (November, 2009) four Phase II homes are tested and registered with both Energy Star and Builders Challenge programs; bringing the community's number of homes to 13. The remaining Phase II homes are pending completion of testing and registration. BAHC's intent is to make all future homes meet the BA 40% WHSE and qualify for Energy Star and the Builders Challenge without exemptions to the Builders Challenge Quality Criteria.

BAHC has adopted a standard package consisting of:

- SEER 16 A/C with strip heat
- RBS roof decking
- R-44 attic insulation
- SHGC 0.22 Energy Star windows
- 100% tile floor

- over 85% florescent lighting
- In September of 2009 BAHC decided to include an Energy Star refrigerator as a standard feature in all their homes.

The inclusion of an Energy Star refrigerator will serve to further increase the WHSE and insure that all homes built to the standard package will exceed the 40% WHSE Benchmark and provide a buffer for Builders Challenge program compliance.

BAIHP had some difficulties bringing this project to fruition. BAHC's function as a non-profit arm of the City of Brownsville causes several layers of bureaucracy between BAIHP researchers and the actual contractors who build the houses. As an example of the problems this caused, none of Phase I's houses have an identical package of improvements. Getting a uniform package of improvements deployed in the field proved to be quite challenging. Contractor resistance to change, contractor turn-over and general lack of clear lines of communications all played a role in inhibiting the rapid and thorough adoption of BAIHP recommendations. BAIHP researchers have made good progress in implementing a standard package, Phase II homes all have a uniform package, but there is still room for improvement thorough the deployment of checklists and better documentation on BAHC house plans outlining the expected energy and durability improvements desired by Building America and the Builders Challenge.

Community Project 7: HKW Enterprises

HKW has built ten homes to the Building America Goal. The partner builds multifamily units in Gainesville, Florida with an average HERS Index of 73. BAIHP commissioned multiple homes, completed TBIC and created multiple tax credit reports for HKW. *This partner also made a commitment in 2009 to build future homes to an E-Scale of 60 or less (The Villas modular homes)*. Ongoing consultations continue with this builder.

Community Project 8: Schackow Development

Schackow Development is producing a community of 27 energy efficient homes called Forest Creek in Gainesville, FL with E-Scales below 60 for all homes. There are currently four homes completed. The initial homes in this community were two near zero energy homes (NZEH) prototypes completed in 2008, described in detail in Subtask 2.1. Two more houses were completed in 2009, and work is expected to continue for this community in 2010. *Schackow is one of the six BAIHP industry partners that has committed to building all their homes to a HERS Index of 60 or less.*

Community Project 9: 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 (Figure 3-15) and becoming a part of the Stalwart Builders Guild, offer the product to consumers.

Figure 3-15: *Eric Martin leads a Stalwart Builders Guild training*

Several 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 general designs call for the following specifications: high-performance envelopes, unvented attics with ducts in conditioned space, vented crawlspaces with spray foam insulation in the floor, ground source heat pumps with desuperheaters for water heating, supplemental dehumidification, and high efficiency lighting and appliances.

BAIHP provided a great deal of support beginning in 2006 to a community in the Florida Panhandle called Callaway Corners. Design review and mechanical system design was performed on several different models. Due to various market factors, the high performance specifications were not employed on all homes within the community, although most of the quality control / quality assurance plan was carried out utilizing locally based energy raters. BAIHP visited the community to provide training to builders and subcontractors and participate in quality control activities. Recommendations were made to the builders and developer to improve future performance.

In 2009, Stalwart Built Homes requested input on the redevelopment plans of Pontchartrain Park in New Orleans, a historical neighborhood including 100 new homes. Groundbreaking for three models is slated for early 2010 with the goal of achieving LEED certification and E-Scale less than 60 on all homes. BAIHP design support continued throughout 2009 for this partner in developing prototype homes for communities in New Orleans. Late in 2009, Stalwart also requested support for placement of homes in the Cascadia community in Washington State. Designs are still being conceptualized, and support is expected to be provided in 2010.

Community Project 10: 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. 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. No activity was reported in 2009.

Community Project 11: Pringle Development

This over-55 age restricted community builder located in Mt. Dora, Florida became a BAIHP partner in March 2007. Florida Hero worked with this partner to build homes in two subdivisions, Lakes of Mount Dora and Heritage Park in Eustis, FL, to Building America Goals. Pringle Development achieved an average HERS Index of 77 and completed their first home that qualifies for the federal tax credit. In October 2007, FL Hero introduced the BA Builders Challenge and received a commitment to accept the challenge. However, Pringle did not implement the outside air vent strategy or bring the air handler out of the garage in 2008, so despite building homes to a HERS Index less than 70 level they have not yet received a builders challenge certificate. Throughout 2009, Florida Hero continued to provide multiple design reviews, make ongoing site visits for QA and completion of the TBIC, provide commissioning of multiple homes, and assist this partner with the resolution of mechanical systems issues. Florida Hero also reviewed 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. Partnership activities were completed in 2009.

Subtask 3.2 Marine Climate Multi-family Communities

Washington State University (WSU), a BAIHP subcontractor, has provided technical assistance to several community-scale projects in Washington State including work at Ft. Lewis Army Base, McChord Air Force Base housing, and with Scott Homes in Olympia.

Community Project 12: Fort Lewis Army Base, Phase 1, 2, and 3 – Fort Lewis, WA

Since 2005, over 500 energy efficient modular homes have been built at Fort Lewis Army Base in Washington State. BAIHP staff members are working with Building America industry partners at the Oregon Department of Energy (ODOE), Idaho Energy Division, Champion Homes, and Guerdon Homes, in coordination with builder Equity Residential, in an effort to build energy efficient modular homes at the base. These factory-built homes are constructed to Northwest Energy Star Homes standards and feature 0.90 AFUE gas furnaces, efficient windows, and Energy Star appliances and lighting.

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. There was no construction activity in 2008, however work began again in 2009. Phase 1, 2, and 3 Fort Lewis homes benchmark at around the 30% level.

Community Project 13: Fort Lewis Army Base, Discovery Cove – Fort Lewis, WA

In 2008, Guerdon Homes of Idaho was awarded the contract to construct the final 34 units at the Miller Hill development, using the same floor plans as the earlier Discovery Village, constructed by Champion Homes of Oregon (see Figure 3-16). WSU BAIHP staff provided significant technical assistance on design, training, and in-field testing and coordinated with IED on in-plant quality assurance. The homes used tankless water heaters as a result of a previous demonstration at the Discovery Village development.

The two biggest learning curves for Guerdon in finishing this project were reducing duct leakage and maintaining acceptable insulation levels in the attic space. Guerdon HVAC staff were barely meeting Northwest Energy Star criteria for total duct leakage (6% of CFA at CFM_{50}) for the first half dozen homes. With onsite technical assistance provided by WSU staff, Guerdon staff were able to reduce the duct leakage rate significantly to as low as 2% of CFA. Interstate travel and inadvertent compression created by other trades seriously degraded the ability of the attic insulation to perform to specifications for the first few homes at Miller Hill. With some coaching from WSU staff, these problems were addressed, and the insulation was brought in line with Energy Star requirements.

The floor plans used at Miller Hill benchmark between 30-40% depending on the tightness of the envelope and ducts. Note that these benchmarks are without the tankless water heater used in the Miller Hill development. Homes benchmark up to 8% higher with the tankless systems.

Figure 3-16: *Guerdon duplex (Madison) – Fort Lewis*

In 2009, WSU contracted with Blasnik and Associates, who developed a preliminary billing analysis for Fort Lewis as part of a proposed abstract (underway) for ACEEE 2010. The paper will compare Discovery Village homes' Madison Duplex electric and gas utility bills to Energy Gauge modeling and will also document project findings. A preliminary assessment suggests reasonable agreement. Figure 3-17 suggests a mean electric usage for 89 homes with complete data at a Normalized Annual Consumption (NAC) of 8711 kWh/year. Complete analysis results can be found at http://energy.wsu.edu/BAIHP-WSU/Ftlewis_gas_and_electric_usage_summary.xls .

Electric Usage from Utility Bills – kWh ('08-'09)			
Variable	**# Homes**	**Mean**	std dev
Total Use (NAC)	89	8,711	2,956
Baseload	89	7,421	3,049
"Heating" Use	89	967	1,091
"Cooling" Use	89	324	457
Gas Usage – Therms (08-09)			
Variable	**# Homes**	**Mean**	std dev
Total Use (NAC)	265	**484**	127
Heating Use	265	**285**	94
Baseload	265	**198**	85
T-ref (bal point)	265	**56.9**	3.7
R-squared	265	**0.91**	0.07
CV(NAC)%	265	**4.7%**	2.4%

Figure 3-17: *Fort Lewis billing analysis, preliminary results*

After a year of data has been collected from Miller Hill, additional analysis will be conducted to compare the hot water use from the tankless water heaters at Miller Creek (EF=0.85) with that of the power vented tank units at Discovery Village (EF=.61). Additional field testing will be conducted in 2010, including pressure diagnostics and infrared scanning to compare homes built by Guerdon with those previously conducted in Champion units at Discovery Village.

Community Project 14: Fort Lewis Army Base, Town Center – Fort Lewis, WA

In 2009, BAIHP worked with Equity Residential to plan for a new 220 unit development at Fort Lewis named Town Center. These homes will be modular row houses in clusters of eight to twelve units (two story modular with one story site-built garage.) More details including a site plan and floor plans are included in WSU's complete annual report, see Appendix C. Phase 1, beginning construction and siting in late 2009, will be 63 units.

The two-story, single wide design afforded the opportunity to include all ductwork within the conditioned space. Efforts in 2010 will include in-plant and on-site quality assurance and technical assistance.

Community Project 15: McChord Air Force Base, Tacoma, WA

At McChord Air Force Base in Tacoma Washington, Equity Residential began constructing homes in the Wescott Hills development in 2009. These are 32, single family homes intended for officers and the base commander, and range in size from 2200-3500 ft.^{2}. The homes will be Energy Star (as required by the Department of Defense), all electric (with commissioned heat pumps) and an improved lighting package. BAIHP staff members are coordinating with Equity and the HVAC contractor to provide training on heat pump commissioning, and additional training for duct sealing for new HVAC staff.

After Wescott Hill, the Cascade Village development will begin construction in September through December 2010. WSU staff will work with Equity to include some additional, beyond Energy Star technologies in a demonstration at Cascade Village.

Because the Department of Defense specifies Energy Star homes for military family housing, it has been difficult to get Equity to build beyond Energy Star unless there are other compelling benefits (for example, no additional first cost or reduced maintenance costs -both of which are Equity's responsibilities). This challenge suggests an opportunity for DOE to engage with the Department of Defense to specify higher efficiency levels for this type of housing (consistent with Building America research, demonstration and deployment goals).

Community Project 16: Scott Homes Olympia, WA

Scott Homes is a production and custom home builder in Olympia, Washington emphasizing green and energy efficient construction techniques (Figures 3-18 and 3-19). 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 3-18: *Brotherton 13th Ave Bungalows by Scott Homes, Olympia, WA*

Figure 3-19: *Infrared Image of Brotherton 13th Ave Bungalows*

Since 2005, BAIHP staff have worked with this partner on 24 homes built in Washington's south Puget Sound; 21 of these homes qualified for Energy Star certification, 15 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. Through 2008, Scott Homes' Energy Star Homes' average air leakage was 2.75 ACH_{50}, with two homes achieving 1.5 ACH_{50}. Complete SIP non-custom homes continue to show this high level of performance.

Since 2007, BAIHP staff provided technical assistance on three Bungalow homes built by Scott in Olympia. These homes were designed to meet the 40% BA benchmark savings level as well as qualify as Northwest Energy Star Homes and the federal tax credit. They include gas tankless combo systems, radiant floors, SIP walls, Energy Star lighting and appliances, HRVs and the Energy Detective (TED) energy monitor.

BAIHP staff deployed HOBO dataloggers in one of the homes (Salvi Residence) to collect zone temperature and relative humidity and HVAC performance data. WSU staff worked with the local utility, Puget Sound Energy, to provide 15-minute data for electric use and hourly data for gas use.

Monitoring of the homes' supplementary electric resistance heat in the upstairs bedrooms took place 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 3-20. There is reasonable agreement with REM simulation preliminary estimates of 71 MMBTU/year over two heating seasons. The final Stagegate presentation is planned for 2010 and will include benchmarking, regression analysis on gas and electric use, an assessment of indoor temperature and RH, HRV performance, and occupant satisfaction. Higher combo-system energy performance can be achieved by condensing tankless water heater (EF=0.96) as compared to the non-condensing tankless water heater used (EF=0.84). Consequently, Scott is planning the use of these higher efficiency units in new BAIHP projects.

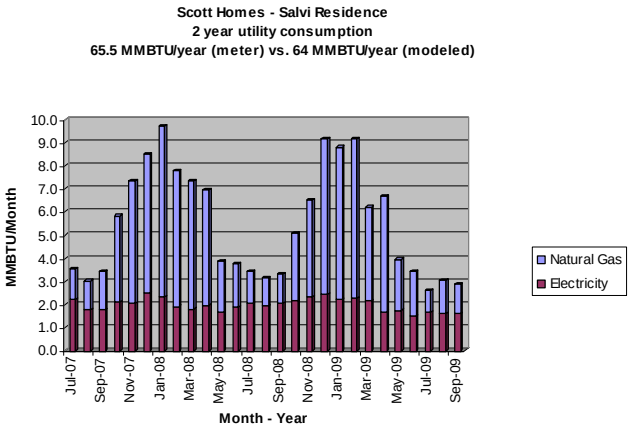

Figure 3-20*: Scott Homes, gas and electric utility usage (2007-2009)*

At the 2009 Energy Value Housing Awards (EVHA), Scott Homes' was given the Builder of the Year award. This was their first time entering a submission. See article in the 2009 EVHA magazine (http://www.nahbrc.com/evha/2009-evha-mag.pdf):

> *EVHA judges described Scott Homes as "doing it all very well but constantly looking for ways to improve." There were discussions about how the company "flawlessly and seamlessly" incorporates energy efficiency and green aspects into its construction while doing "a really good job of improving its process and incorporating what it is learning."*

The increased visibility from the award led to a tour of Scott Homes for WA state senators and staff as well as BAIHP staff. During the tour, Scott Homes pressed for the need to have energy efficiency recognized as an added value during the appraisal process.

Scott Homes is working closely with WSU and BAIHP partner SIPA to further document these current projects and to plan future projects that will include both test homes and community projects.

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

Subtask 3.3 Post Occupancy Evaluation of Building America versus 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. Further delays were encountered due to Office of Management and Budget regulations as well as budget prioritization.

BA Researchers are currently recruiting 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 industry partners in the BA program and their sales representatives, researchers identified a group of candidate study homes that met minimum qualifications for participation early in 2009. Researchers plan 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 met the minimum qualifications for participation were also identified. This process was conducted with cooperation from an area Realtor with extensive local industry knowledge. Researchers expected a 50% participation rate, and expected 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 was also important to identify comparable homes in terms of heating fuel for analysis purposes, which included an even mix of heat pumps and gas furnaces.

During 2009 researchers acquired utility bills from identified potential participants and began a preliminary analysis. Regressions based on heating and cooling degree days were performed to disaggregate heating and cooling energy use from total use. Interviews with homeowners and audits of home features planned after official recruitment of participants will be used to qualify the analysis.Via partnerships with local utilities and homeowner associations, information that briefly describes the research study began being mailed to potential participants late in 2009 to inform them of the opportunity to participate. This information includes a brief overview of the research methodology, along with the benefits of the research. Two interview/audits were conducted in November 2009, and HOBO dataloggers were deployed to record interior temperature and humidity. Researchers expect to continue recruitment activities through the 2nd quarter of 2010, and will continue to collect data, including utility bills, until final analysis is conducted in late 2011.

Task 4. Post - Phase 3 Activities

Subtask 4.1. Habitat for Humanity (HFH) Partnership

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

In 2009, BAIHP continued its decade-long partnership with affordable housing builder HFH International (based in Americus and Atlanta, GA) and Habitat's network of local affiliates across the country (Figure 4-1). Partnership activity falls into three main categories:

- Technical assistance to Habitat International including regional and national training activities
- Research in support of DOE goals
- Technical assistance to Habitat for Humanity affiliates (including Gulf Coast Recovery) – 90 house registered with HERS Provider (BP1-BP4)
- Gulf Coast High Performance Affordable Housing Demonstration Project – 10 houses completed, 3 others attempted (formerly subtask 2.1.2) (Figure 4-2)

An overview of the BAIHP and HFH partnership and case studies can be viewed online: http://www.baihp.org/habitat/

Figure 4-2: *RESNET Grade 1 insulation and attic ventilation baffles in High Performance Gulf Coast Affordable Demonstration house built by East St. Tammany HFH in Slidell, LA*

Technical Assistance to Habitat International (HFHI)

Partners in Sustainable Building Program Launch: In 2009, Habitat International completed the pilot phase of its Partners in Sustainable Building program which is funded by a $30 million grant from the Home Depot Foundation. The program provided 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. HFHI has included the Builders Challenge in the higher, green tier of the program. The national rollout of the program proceeded in the spring and summer of 2009. BAIHP provided training on reaching and exceeding Energy Star as well as general building science to the affiliates in the rollout via several nationwide conference calls.

In 2008, HFHI launched the pilot phase of the Partners in Sustainable Building program, funded under a $30 million donation from the Home Depot foundation. BAIHP sat on the program advisory board, contributed to the technical content of the program, and co-led a 2.5 day training event (57 attendees) at SouthFace Energy Institute in Atlanta for the pilot affiliates. BAIHP directly assisted several of the pilot affiliates in Mobile (AL), Valdosta (GA), Tampa (FL), and Gulf Port (MS) with the selection of energy efficiency measures.

SHOP Grant Support
In 2009, BAIHP developed a fact file on Energy Star rated products and equipment for the HFHI coordinator of the HUD SHOP grant sub-awards to Habitat affiliates. While SHOP grant funds are restricted to use for site related improvements, such as roads and utility access lines, there is new language that requires recipients to include Energy Star certified products and equipment in home built on improved sites. The homes must also be certified under the Energy Star criteria for New Homes program. Because of these new requirements, many affiliates using SHOP grant funds for site development in 2009 will be producing homes with HERS Index scores close to the Builders Challenge level in 2010. Affiliates will include Energy Star rated lighting, appliances, fans, and other equipment in their Energy Star package.

Regional and National Training Activities with HFHI:
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).She also conducted a building science field session in New Orleans Habitat's Musician's Village with Claudette Reichel (LSU).

In 2008, activities included a one day regional training event in September arranged by HFH International and hosted by our partner affiliate Mobile County HFH, a nationwide conference call training event organized by HFHI "Energy Star Certification Options" to 38 participants, two sessions at the 2nd annual Habitat for Humanity Youth Leadership conference in St. Louis including a panel discussion for the 345 attendees titled "Building a Sustainable Habitat," and a nationwide HFHI conference call on Health and IAQ issues to construction staff from approximately 25 HFH affiliates.

In October 2008, 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.

February 2009, Janet McIlvaine served as a "subject matter expert" February 9-11, 2009, for Habitat for Humanity International – National Leadership Training Event in Mobile, Alabama. This hands-on workshop was conducted on three Mobile County Habitat's job sites. Discussions and training included establishing a whole house barrier and drainage plane, window and door flashing, insulation installation, outside air ventilation, Energy Star for Homes criteria, mechanical ventilation for various climate zones, and a testing demonstration. 46 attendees

Also in 2009, BAIHP co-presented a two-day workshop at the National Habitat Conference in Ft. Worth that included a half day of field work with the local affiliate. BAIHP participated in HFHI's second annual Youth Conference as a panelist on affordable green building and in a session on practical green building. Other training activities with HFHI included a nationwide conference call on Indoor Air Quality issues and strategies and several conference calls open to the more than 100 Habitat affiliates participating in the Partners in Sustainable Building program.

BAIHP-Habitat-RESNET Partnership
In an effort to increase the availability of technical assistance to HFH's 1600+ local affiliates, BAIHP works with RESNET to develop a network of volunteer HERS raters. RESNET has been instrumental in the formation and management of this network.

Details are available to volunteer HERS raters and Habitat affiliates on RESNET's website: http://www.natresnet.org/rater/partnership/default.htm

Volunteer raters are recognized on RESNET's website with the emblem shown in Figure 4-3. RESNET wrote an article in Home Energy Magazine about the partnership in February '09. Since inception of the partnership in 2007, RESNET periodically promotes the partnership in their newsletter "What's New at RESNET"

Figure 4-3: *Habitat Volunteer Energy Rater Logo*

In 2007, BAIHP participated in a "rater roundtable" nationwide conference call to introduce RESNET members to the partnership. Two Habitat affiliates participated in the call.

In 2008, BAIHP committed to producing one-page case studies of selected RESNET-Habitat partnerships for the joint use of RESNET, the RESNET volunteer, Habitat, and Building America. Case studies are available on the BAIHP website.

In 2009, the network of RESNET volunteers continued to expand. BAIHP produced three case studies profiling RESNET volunteer raters (available at www.baihp.org/habitat). Researchers also teamed up with David Lee of the EPA Energy Star for Homes program to deliver a session introducing raters to the Habitat partnership at the national RESNET conference. RESNET is working with Habitat for Humanity International to develop several sessions on the Habitat's sustainable building initiatives at the 2010 RESNET Building Performance Conference.

Long Term Instrumentation and Monitoring Habitat for Humanity Projects

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 2009.

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.

Technical Assistance to Habitat for Humanity Local Affiliates

In addition to the support provided to HFH International, BAIHP provides technical assistance directly to Habitat affiliates at the local level including design, specifications, scopes of work, performance testing and sustainable construction techniques. Over the years, BAIHP has worked with affiliates in Florida, the Pacific Northwest, Alabama, Georgia, California, Texas, North Carolina, Tennessee, Kentucky, Ohio, Washington D.C., Pennsylvania, New York, Michigan, Louisiana, and Mississippi.

In 2008, 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.

In 2009, BAIHP continued work with local HFH affiliates in Florida and the Pacific Northwest region. Note that the BAIHP activities with Gulf Coast Habitat affiliates are described at the end of this section.

Florida, Lakeland (FL) Habitat for Humanity

BAIHP began work with Lakeland Habitat for Humanity in 2000 when the affiliate adopted Energy Star as standard practice. Since then, the affiliate has built over 50 Energy Star homes. 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.

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

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. Five homes were tested and rated by BAIHP in BP1. BAIHP continued to perform testing, TBIC inspections, and EnergyGauge calculations for this affiliate throughout BP2, BP3, and BP4. In 2007, Lakeland HFH passed the TBIC in its homes with ease because of its thorough pursuit of Energy Star and 30% BA Benchmark savings homes In BP3, BAIHP conducted thermal bypass inspections at 11 of the affiliate's homes, including duct performance and house tightness testing in these residences followed by analysis using EnergyGauge USA.

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 next steps. The affiliate continued to build the 30% package delineated in Table 4-1 below and decided to strive for the Builders Challenge in 2009. This affiliate is also a recipient of HUD SHOP grant funds which now require Energy Star certification and inclusion of Energy Star products. Researchers worked with the affiliate toward the Builders Challenge goal in 2009.

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 (Figure 4-4) 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 ran a feature story on Lakeland Habitat based on this case study.

Florida, Lake-Sumter County HFH- Florida H.E.R.O. provided technical assistance to this affiliate for their first Energy Star certified home in April of 2009. The home earned an E-Scale score of 73. Ongoing consultations continued in 2009 on the introduction of outside air in a controlled manner.

Florida, Southeast Volusia County Habitat, New Smyrna Beach, FL: In September 2009, BAIHP tested a home built to SE Volusia County HFH's standard construction specifications. The testing showed that the affiliate has good sub-contractors, insulation installed to Grade 1 standards, and a very tight house with duct leakage below Qn = 0.03. The house achieved a HERS Index of 77, qualifying it for Florida's new Energy Star standard (effective 6/1/09). Researchers reviewed the affiliate's new plans and made minor recommendations to bring the

plans into line with the Builders Challenge Quality Criteria. As of 12/25/09 the affiliate has finished two houses built to Builders Challenge compliance, one of which has been tested and registered with Builders Challenge. The house had a HERS Index of 66 with a Benchmark of 43.2% WHSES. Testing of the second house will be carried out early in 2010. Future houses' efficiency will be further increased by the incorporation of a SEER 15 heat pump (currently SEER 14), and where feasible, gas instantaneous water heaters.

Florida, Hillsborough Habitat, Tampa, FL BAIHP provided technical assistance to Hillsborough County HFH in 2007 during the planning of a 25 home development. Support included a conference call with FGBC, HFHI, HCHFH and RESNET to go over the improvement package and what needed to be done for Energy Star, FGBC and LEED for Homes certifications. BAIHP analysis showed that the improvement package would produce homes with a HERS Index of around 78 depending on the specific plan. In 2009, BAIHP revisited the affiliate and certified two homes to assist the affiliate with the Energy Star requirement of a grant. The homes both had HERS Index scores of 62.

Florida, Sarasota Habitat, Sarasota
BAIHP met with staff at this affiliate in July to discuss their "Re-Habitat" initiative in existing homes. Researchers performed a test-out audit in one renovated home which scored a HERS Index of 122. The "as found" condition of the home was not conducive to conducting a test-in audit prior to renovation. Researchers have done audits on two other existing homes for this partner with HERS Index scores of 148 and 117. The affiliate's improvement package for the house will bring the HERS Index down from 117 to 71. Researchers made recommendations for achieving the Builders Challenge in the home and will conduct a test-out audit on the home when renovations are complete. The house scoring a 148 HERS Index is still under consideration.

Prior to BP4, BAIHP has provided technical assistance to dozens of Habitat affiliates, some of which are described below.

Alabama, 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, 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 of 2008.

Florida, 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.

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.

Florida, Orlando Habitat, 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, ten different improvements were analyzed and presented in several packages that were all designed to qualify the homes for Energy Star. After BAIHP technical assistance, this found a rater to provide pro-bono services through the BAIHP-Habitat-RESNET partnership.

Florida, Pinellas County Habitat
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.

Florida, South 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. 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. In BP4, Calcs Plus continued work with affiliate on a set of high performance town homes.

2007 Jimmy Carter Work Project, Los Angeles

BAIHP provided assistance in the 2007 Jimmy Carter Work Project in Los Angeles where 100 LEED-certified dwellings with PV (Figure 4-5) were being 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 4-5: *Former President Jimmy Carter with solar panels on the site of Habitat's 2007 Jimmy Carter Work Project in Los Angeles.*

Normally, Building America would provide onsite 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

2005 Jimmy Carter Work Project

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 (Figure 4-6).

Figure 4-6: *JCWP-CBA House built by Lansing (MI) Habitat for Humanity*

WSU Technical Assistance to Habitat for Humanity

BAIHP staff at WSU continued to work with Ed Brown, a staff member of Habitat for Humanity International's Washington State Support Office to certify homes for Energy Star and northwest performance testing standards as well as HERS ratings.

WSU also continued work directly with Washington State Habitat affiliates to qualify over 210 homes to Northwest Energy Star standards (including 45 in the period November 2008-October 2009), and are continuing to provide technical assistance and outreach to other Northwest Habitat affiliates, including:

Washington, King County Habitat, Seattle: Conducted three design charrettes and follow up for communities including Rainier Vista (Figure 4-7) and Megan's Meadow, as well as providing general technical assistance and design consultation. This affiliate and WSU staff worked together to evaluate Energy Complete, a new Owens Corning air sealing system, which facilitates the use of airtight drywall (see Figure 4-7, right) in a prototype home. The home also included blown-in fiberglass walls and foam sheathing.

Figure 4-7: *Rainier Vista development, King County Habitat for Humanity (Seattle) (left), Owens Corning Energy Complete demonstration (right)*

Pierce County Habitat: Conducted phone charrette on Larabee Terrace, development (Figures 4-8) of twelve units including one BA Prototype with a gas combination space heating and water heating system, Broan Smart Sense ventilation controls, foam sheathed walls, and PV. The predicted HERS index is 49. Blower door testing indicated envelope leakage ranging from 3.2 to 6.5 ACH_{50} for homes in the development; the demonstration home tested at 3.9 ACH50.

Figure 4-8: *Building America Habitat Prototype built by Pierce County Habitat in the Larabee Terrace development, predicted HERS Index 62.*

Please see the full WSU Annual Report in Appendix C for further detail on their technical assistance to Habitat affiliates.

<u>Washington Habitat Technical Assistance prior to BP4:</u>

In 2007, BAIHP staff members at WSU 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

Figure 4-9: *Habitat for Humanity 15 home Community Cottage project – Olympia, WA*

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 (Figure 4-9) and Tacoma. WSU staff met with Tacoma Public Utilities and BAIHP industry 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 industry partners Panasonic and Broan on a ventilation study of two of 15 homes being built by Tacoma HFH.

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.

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 (Figure 4-10) 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. In 2009, Subtask 2.1.2 was combined with Subtask 4.1 because all of the participants were Habitat affiliates though researchers worked to recruit other affordable builders to the demonstration project. Other Gulf Coast activities are described next.

Figure 4-10: *Raising Walls at a Gulf Coast Habitat Build*

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

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 homes – Figure 4-11) and Baton Rouge, LA (15 homes). 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, EnergyGauge USA 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 4-11: *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 (see Figure 4-12).

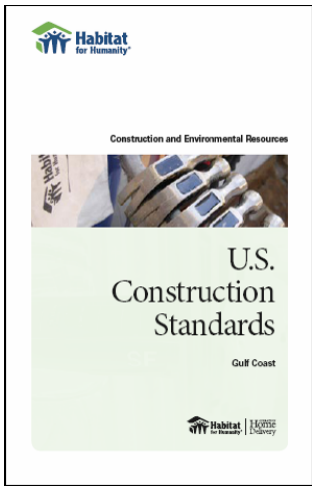

Figure 4-12: *HFHI's Construction Standards which were released November 2006*

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 (formerly Subtask 2.1.2)

The primary objectives of the *Gulf Coast High Performance Affordable Demonstration Project* were to encourage high performance re-building in areas affected by hurricanes Katrina and Rita and to demonstrate that it could be done in the challenging affordable housing sector. BAIHP worked with seven Habitat for Humanity affiliates in the Gulf Coast region to build a total of ten prototype homes achieving between 30% and 45% savings on the BA Benchmark (see map, Figure 4-13). In 2008, four prototypes were completed in Slidell (2), Mobile, and Gulf Port. In 2009, six more prototypes were completed in Covington (2), Gulf Port, Mobile, and Foley (2).

Figure 4-13: *Locations and number of the Gulf Coast Affordable High Performance Prototype Homes are indicated by the blue markers. Yellow markers show new partnerships, and red markers indicate partners that started but did not complete a prototype.*

Through hands-on involvement in the design, construction, and testing of prototype Habitat houses, BAIHP taught the systems engineering process to construction managers while mitigating the risk typically associated with changing specifications.

To ensure project replicability, BAIHP concentrated on strategies that builders can adapt to many different styles of homes. The elements of the package are summarized below. Note that some features provided multiple benefits as is common in the BA systems engineering experience.

Indoor Air Quality Features

- Extensive air sealing to reduce infiltration of hot, humid outside air
- Passive, run-time outside air ventilation
- Interior air handler closet
- HVAC equipment right-sized with ACCA Manual J (improves moisture control)

Durability Features

- Long life fiber cement siding over house wrap (sealed at edges and seams) drainage plane
- Ship-lapped window and door flashing
- Kitchen and bath exhaust fans ducted to outside for humidity control

Energy Efficiency Features

- At least 75% Fluorescent Lighting
- Energy Star Refrigerator (412 kWh/year)
- High Efficiency Heat Pump (SEER 14, HSPF 8.2 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
- Energy Star Ceiling Fans if ceiling fans used
- Standard specifications already included R-30 attic and R-13 wall insulation and double pane low-E windows

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

Researchers are still collecting data that show the costs this package of improvements can be delivered for. This task is proving surprisingly difficult considering funding is linked to providing cost data. As of December 1, 2009 Gulfport has reported inability to provide any cost data for the second prototype, Foley AL is still preparing data for both houses they built. Compiling the existing data and standardizing it into BA format will be finished late 2009.

Two partners exceeded 40% BA Benchmark savings by adding a water heating improvement to the above package. Mobile County Habitat installed an electric heat pump water heater. Baldwin County Habitat installed a solar water heater.

Researchers conducted three one-day workshops for builders and affordable housing providers to encourage and train others to adopt BA practices and the high performance package in the demonstration houses. Workshops were held in Mobile, Baton Rouge, and Covington. A morning classroom session was followed up with an afternoon site visit. Site visits were to prototype homes where researchers demonstrated the testing procedures, and a home under construction where researchers discussed the thermal bypass inspection and other detailing. The project was also presented to a broad audience at a regional energy efficiency conference, Re-Energize produced by the Gulf Coast Energy Network, and to the members of the Mobile Area ACCA chapter.

In July of 2008, a Web site for the initiative was launched: www.baihp.org/gulfcoast. In addition to an introduction to the project, visitors to the website can access presentation materials from the Mobile workshop. Other project materials will be added to the site as they become available.

Mobile County (AL) HFH Demonstration Project (Formerly Part of 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 showed the homes achieving a HERS Index of 95 and benchmark savings of 13%. In an effort to bring specifications in line with Energy Star for all their homes, the affiliate agreed to build two 30-40% benchmark savings prototypes.

The first prototype (Figure 4-14, left) was completed in November of 2008 with a BA Benchmark Source Energy Savings of 31% and a HERS Index of 69. Given the ease with which the affiliate incorporated the package of improvements to their build, the affiliate has adopted the BA package for all future construction.

BAIHP presented the Mobile Prototype 1 project to the general membership of the local chapter of the Air Conditioning Contractors of America (ACCA), and a workshop was produced in conjunction with the Home Builders Association of Metro Mobile on November 20, 2008. Despite direct mail promotion to over 1700 members of the HBA, attendance was predominately made up of local raters and other Habitat affiliates from south Alabama and the Florida panhandle. 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 second high-performance affordable prototype was completed in 2009 (Figure 4-14, right) that includes an Energy STAR heat pump (SEER 15), and an electric heat pump water heater with a COP of 2.3 to the previous prototype package to produce a BA Benchmark savings of 43.8% and a HERS Index of 59. Ratings on the house were completed by a local rater and will also be certified green by a local green building program. The affiliate is a participant in Habitat International's Partners in Sustainable Building program which provides a $5,000 grant for green certified homes to offset increased first cost of the home.

Figure 4-14 *Mobile County Habitat 30% Prototype (left)and 40% Prototype (right).*

New Orleans Area HFH Demonstration Project (Formerly Part of Subtask 2.1.2)
BAIHP performed multiple design reviews, provided energy efficiency and general building science technical assistance and tested homes for Energy Star thermal bypass compliance for this affiliate. Their 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 was located in an interior closet that was open to the attic to provide combustion air for the atmospheric combustion gas furnaces. Return plenums were open to the walls of the closet with no attempt to create 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 4-15 *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. Also in 2008, the affiliate switched to all radiant barrier roof 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 needed to be resolved before the trial prototype home was constructed. In mid 2008, they committed to building two all electric 30% prototypes using the improvement package developed by BAIHP.

The affiliate began construction on the side-by-side prototype homes shown in the above photograph (Figure 4-15). Unfortunately, the homes both failed the thermal bypass inspection in October of 2008. In particular, the floor insulation was severely compromised. Guidance on correcting the failed items was provided to the construction staff, and BAIHP conducted floor insulation training with the affiliate's construction staff. Near the end of 2008, a large portion of the construction staff left the affiliate which brought our partnership activity to a stand-still. It was anticipated that the affiliate would resume participation in the demonstration in 2009; however no further progress was made despite attempts to re-energize the partnership with the new staff members.

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. In January of 2008, 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 of 2008, but failed the final testing in March of that year.

Figure 4-16: *Baton Rouge Habitat 30% affordable demonstration house.*

Construction of the 30% prototype began in March of '08. The major challenge for this affiliate was locating the air handler in the conditioned space. Numerous meetings with the HVAC sub-contractor were held to discuss the details. Ultimately the strategy was abandoned in the first attempted prototype because the truss layout had not designed to 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 left the affiliate and plans to build the prototype were put on hold. Throughout 2008 there were a number of management changes that delayed construction of a prototype home, but the affiliate began its third attempt at construction on a 30 % prototype in November of '08

On December 5, 2008, in conjunction with the LSU AgCenter's La House and the Capitol District Home Builders Association, BAIHP conducted a workshop worth four CEUs. Attendance of ~30 included university students and faculty, raters, non-profit home builders, and for profit production builders.

The HFH of Greater Baton Rouge prototype home (Figure 4-16) underwent a Thermal Bypass Inspection in January 2009 and passed the assessment. Work on the home was suspended when the buyer pulled out of Habitat's program early in 2009 and the prototype home is still incomplete.

Slidell (LA) - East Tammany HFH Demonstration Project (Subtask 2.1.2)
In 2007, BAIHP researchers discussed Energy Star requirements with the site supervisor and construction manager at this affiliate. Researchers made suggestions for improving the thermal envelope and air barrier, including a strategy for enclosing the air handler closet at the attic interface. Throughout 2007, the affiliate worked on improving these envelope issues including the air barrier separating the air handler closet from the attic. In January 2008, BAIHP tested several houses and found favorable results. This affiliate also worked with their utility's builder incentive program to improve their specifications. The initial HERS Index for this affiliate was approximately 95. They began construction of two 30% prototype houses (Figure 4-17) in September of 2008. They passed the TBIC but needed improvements to their outside air system. The homes were completed in December of 2008 and were part of the 2008 Jimmy and Rosalind Carter Work Project. Final testing and rating were conducted in January of 2009 with one house at 31.2% WHSES savings on the BA Benchmark and the other just shy of the goal at 29% due to higher duct leakage (Qn = 0.06). HERS Indices were 71 and 73 respectively.

Figure 4-17: *East St. Tammany HFH 30% Prototypes in Slidell, Louisiana.*

Mississippi Gulf Coast Habitat Demonstration Project (Subtask 2.1.2)
FSEC conducted analysis and Thermal Bypass Inspections for HFH of MS Gulf Coast homes in various stages of construction in June 2007. FSEC prepared a detailed report providing guidance on how to correct 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 and other building scientists for the pilot affiliates in October of 2008, the construction manager contacted BAIHP and committed to building two 30% prototype demonstration homes. The first was completed (Figure 4-18, left) in December of 2008 with final inspection, testing and rating in January of 2009. It achieved BA Benchmark savings of 34.9% with a HERS Index of 69. This affiliate completed their second prototype home (Figure 4-18, right) in May of 2009 with a HERS Index of 71and BA Benchmark of 33.2%.

Figure 4-18: *Mississippi Gulf Coast Habitat high performance affordable prototypes.*

Covington (LA) – West St. Tammany Habitat
In the fall of 2008, researchers met with the construction manager and conducted 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.

Figure 4-19: *West St. Tammany Habitat high performance affordable prototypes.*

In 2009, this affiliate completed two prototype homes (Figure 4-19), one slab-on-grade and one pier foundation. Testing on both houses was completed in September. The slab-on-grade house's duct system was too leaky to quality the house for Energy Star (Qn=0.09). However the pier foundation home qualified, benchmarking 40% with a HERS Index of 64. The home has incorporated the BAIHP Gulf Coast Package along with increased attic insulation (R-38), an Energy Star SEER 15 heat pump, and Energy Star lighting package.

BAIHP also partnered with LSU's AgCenter program and West St. Tammany Habitat to present a workshop for home builders on June 23, 2009 in Covington, LA. Louisiana licensed builders participating received two CEUs. Two additional CEUs were available for participating in the site visit portion of the workshop. There were twenty attendees; of 18 reviews submitted 17 were favorable, with one attendee wanting more LEED for Homes material.

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, south of Mobile. The house and the duct system were within tightness specifications for building a 30% prototype. Two prototype homes were completed in 2009 (Figure 4-20) and incorporated a modified package, using a galvalume metal roof instead of radiant barrier decking. Final inspection and testing of the first prototype was completed in June. The home had a HERS of 68 and BA rating of 34.5%.

The affiliate completed construction of their second prototype home in November of 2009. The home features the Gulf Coast Package with increased R-values, a white metal roof, and a solar hot water heater. The home achieved a projected (pending feature confirmation) HERS Index of 54, with a Benchmark of 48%.

Figure 4-20: *Baldwin County Habitat high performance 30% affordable prototype.*

Developing Gulf Coast Habitat Partnerships
Lafayette, LA HFH - A visit was made to discuss the high performance house package and Energy Star construction. The affiliate is applying for a grant for energy improvements to their housing.

Waveland, MS – Bay-Waveland Habitat for Humanity – This Habitat affiliate was selected for Habitat International's Partners in Sustainable Building (described at the beginning of Subtask 4.1) which provides grant money for building Energy Star or green certified homes. Initially, the affiliate could not locate a certified HERS rater locally. BAIHP produced preliminary HERS Index calculations, provided recommendations, and assisted the affiliate with locating local rating support. While we do not anticipate further activity with this affiliate, it serves as an example of the facilitation that BAIHP researchers regularly provide to Habitat affiliates in the early phases of performance improvement.

Subtask 4.2. Northwest Energy Efficient Manufactured Homes
Subtask 4.2 involved working with HUD code manufacturers and Northwest Energy Efficient Manufactured (NEEM) Housing program to improve efficiency and marketability through activities primarily directed toward projects located in marine-cold and hot-humid climates. BAIHP made factory and field visits to test homes and ensure low leakage ducts, promote better equipment efficiencies and solar ready concepts.

In BP1, BP2, and BP3, BAIHP worked with several HUD-code home manufacturers toward Energy Star plant certification. FSEC also 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 Energy Star for HUD-Code New Homes program. The nineteen factories that participated in NEEM produced over 3400 HUD-code Energy Star homes during the second budget period. ODOE continued NEEM activity in BP3 and BP4 (2009). Along with BAIHP, the RTF, Bonneville Power Administration, the Energy Trust of Oregon and Idaho Power Company funded the 87 home field report and billing analysis.

Also in 2009, ODOE staff performed quarterly factory inspection visits for each participating builder, inspected problem homes, developed in-plant quality assurance detailed inspection protocols to support the roll out of the ECO-rated brand, which requires higher than Energy Star levels of energy efficiency in addition to green building features. NEEM staff meets monthly to discuss technical and program issues.

NEEM staff certified five plants as Eco-rated builders and inspected their first homes in the plants. NEEM staff met with several retailers in Oregon, Washington, Idaho and Nevada and certified them as Eco-rated retailers, trained to represent the brand and confirm proper home setup.

Technical support was provided to two manufacturers by ODOE staff in 2009. Assistance focused on evaluating an innovative cross over duct strategy designed to reduce reliability and durability of this important component of the duct system.

ODOE staff and a technical sub-contractor completed the latest periodic random field study of NEEM-certified homes and submitted results to the Regional Technical Forum to validate the energy savings attributed to these homes by utility programs. This is the basis for utility incentive programs in the four northwest states.

Oregon Department of Energy concluded its partnership with BAIHP in 2009 when the NEEM program was transferred to another department. (See Appendix D for the full 2009 ODOE Annual Report)

NEEM Homes Reported in 2009

Energy Star/Eco-rated homes produced January 1 to September 30, 2009	
Energy Star gas	203
Energy Star electric	860
ECO-RATED electric	188
ECO-RATED GAS	32
Total Homes	1283

In BP1, BP2, and BP3, Subtask 4.2 was called HUD Code Energy Star. The following cumulative material describes BAIHP activity with Partners in the HUD Code industry striving to achieve Energy Star. In 2009 (BP4) this work was largely stagnant due to the down turn in the HUD Code housing market.

Deer Valley Homes
FSEC conducted analysis of floor plans for this builder and BAIHP partner in 2008.

Homark Homes
This BAIHP partner and builder produced 20 Energy Star HUD-code homes placed in MN, ND and WI. Researchers tested one home in May 2007 and one in 2008 to comply with the MHRA Energy Star program and tax rebates. In addition, they diagnosed a HUD home with moisture problems. BAIHP has since concluded all partnership activities with this builder.

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. Please see Palm Harbor Homes in Section 2.1 (Hot-Humid Prototypes) for further information.

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.

Subtask 4.3. BA Program / Analysis Support

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 industry partners as of January 2008. Since then several more BAIHP 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 2008, FSEC's Deputy Director Philip Fairey accompanied DOE Secretary Bodman on a tour of the prototype home at January's 2008 International Builders' Show, to which the first E-Scale was affixed. BAIHP evaluated the consistency for Building America benchmark software results and assisted the EnergyGauge USA development team on Builders Challenge items, including program guidelines and implementation of report forms in software. The team also reviewed the Builder Option Packages (BOPs), prepared by NREL and provided feedback since the BOPs were not meeting Builders Challenge for some of the homes in various climates.

In 2009, BAIHP provided poster size E-Scales to several industry partners to highlight their achievement of Builders Challenge in model centers, groundbreaking ceremonies, and open house events. Florida HERO also participated in a Builder's Challenge Webinar sponsored by RESNET to answer questions and introduce raters to the BA Builder's Challenge Program.

The BAIHP team participated in discussions with Builders Challenge staff about marketing strategies and materials including those developed for Lifestyle Homes.

Throughout 2009, BAIHP continued to submit Builders Challenge applications for GW Robinson, Stalwart Built Homes, and Tommy Williams homes.

NREL Collaboration

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 the exchange of benchmark and analysis files with NREL to verify the process of benchmarking and consistency of results. Air conditioning sizing was addressed as an issue. NREL showed that EGUSA appears to cut off energy during hottest peak days, which leads researchers to believe that there is a reduced energy usage for the benchmark. FSEC staff addressed this software code issue.

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

In 2009, a BEOpt Analysis of HUD-Code Manufactured Housing was completed. The preliminary set of simulations in BEOpt was administered to obtain the Geographic variation in U.S. potential of rooftop residential solar hot water production.

The U.S. Department of Energy seeks to make zero energy buildings cost-effective by 2020. This goal requires innovative energy efficiency solutions and sophisticated energy analysis. Energy simulation software such as Energy Gauge USA and BEOpt allow builders to reduce home energy use by the ~70% necessary to make achieving zero net energy use a feasible goal. EnergyGauge USA, created by the Florida Solar Energy Center, and BEOpt, created by the National Renewable Energy Laboratory, use hourly energy simulations to estimate home energy use. Both of these software are used extensively by Building America teams to design both zero energy and low-cost energy efficient residences. Because they are used widely, a study was conducted to compare the two software. A base house in Atlanta, GA was simulated in each software. The base house was then simulated with increased efficiency for many different parameters such as duct leakage and location (Figure 4-21). The savings from each efficiency improvement were compared between the two software. The comparison identified some significant differences between the programs involving window conductance, slab performance, unvented crawlspace performance, air conditioning and heat pump efficiency.

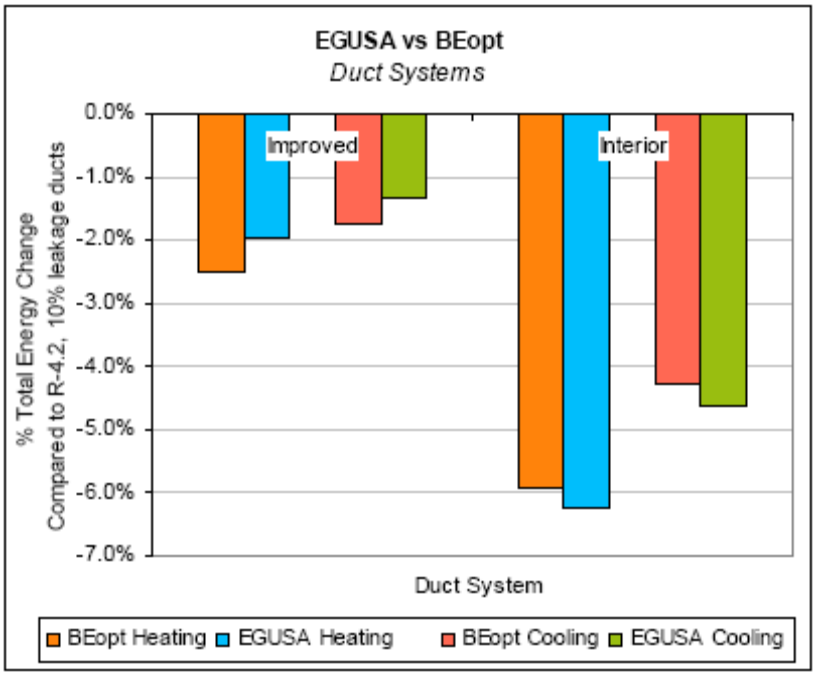

Figure 4-21: *Duct system analysis shows very close agreement on both heating and cooling energy savings.*

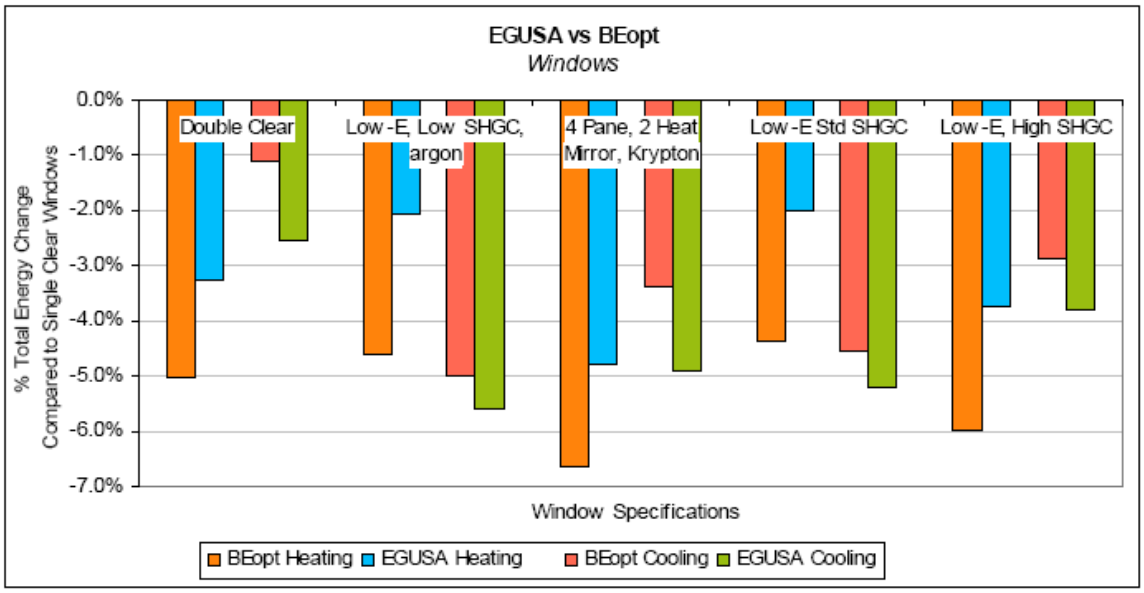

Figure 4-22: *Window analysis shows large heating differences between Energy Gauge USA and BEOpt as well as heating/air conditioning fan energy also showed significant, systematic differences between the software.*

Figure 4-22 Window analysis shows large heating differences between Energy Gauge USA and BEOpt as well as heating/air conditioning fan energy also showed significant, systematic differences between the software. Beyond these discrepancies, some of which should be addressed, most simulations differed only minimally on the magnitude of impact. In general, *BEOpt* and *Energy Gauge USA* were comparable regarding the influence of most energy efficiency improvements.

For further information regarding this comparison, please visit the on-line publications section of the BAIHP website: http://baihp.org/pubs/index.htm

Builders Challenge Level Existing Homes

In 2009, BAIHP worked towards development of Builders Challenge level retrofits on foreclosed homes in partnership with several local governments throughout Florida who are participating in the HUD Neighborhood Stabilization Program (NSP).

Initially, BAIHP researchers developed simulations for four typical homes that might be purchased under NSP funding. We compared each of the homes as they might be found to a minimal resale renovation, a renovation to comply with current code, and a Builders Challenge renovation. This analysis was used to launch our discussions with the local government partners.

We also met with Habitat for Humanity Sarasota, Inc., who has completed many retrofits over the past few years, to help us strengthen our ability to assist our local government partners in their NSP grant work. Specifically, we gathered information about their scope of work, timeline to complete retrofits, specifications on the homes they are considering for retrofit in the Sarasota area, the typical retrofit work being completed on these homes, challenges they are encountering, how much the retrofits are costing, if they are bringing the homes up to any specific codes, if

they are aware of other organizations doing similar work in the area, and if they have interest in partnering with us in future work. In addition, BAIHP met with Donald Hadsell, director of the Office of Housing & Community Development with the City of Sarasota. We discussed existing Sarasota County programs that may fit the research goals of FSEC. Also discussed were several pathways to achieving a HERS Index of 70 and below.

Researchers began partnership activities by conducting energy audits in homes purchased with NSP funds and developing a recommended Builders Challenge package for each.

We audited ten homes in Sarasota County. Three homes in Brevard, one in Orange County, and one in Volusia County. Each partner is committed to striving for the Builders Challenge level of improvement in ten retrofit homes. The audit included a Blower Door test, duct test and full building take-off. A drawing of the floor plan was drafted, and the information gathered was used to generate an energy gauge file and projected rating. Calcs-Plus also met with Kirk Bryson and James Payne, ETC Building System, to learn about their new retrofit project in Sarasota Florida with the intent of investigating their building systems.

In November, BAIHP began discussions with Precision Building Systems, LLC, in Sarasota (FL) who is conducting major renovations in the private sector. The partner has developed an interesting steel SIP system with no obvious major thermal shorts that replace failed exterior frame walls. The interior and exterior finish will be stucco. Concrete block walls are retrofit with two inches of foam panels inside and outside for a well insulated wall system. Precision Building is committed to getting LEED Platinum certification for their first project and has retained Karl White for assistance. The renovated home will be a model/ educational center and perhaps a residence as well. BAIHP will provide recommendations on energy efficient envelopes and mechanical systems to attain an E-Scale of 70 or less as well as meet the Builders Challenge Quality Criteria (BCQC)

Retrofit Lab House with SEER 21 HVAC equipment

Beginning in July of 2009, a schedule and plan for a SEER 21 heat pump versus a SEER 13 heat pump experiments were developed. These experiments will be carried out in the MH Lab. The experimental design includes comparison of the performance of the two heat pump systems when operating with the standard attic duct system and also with the indoor duct system, several levels of duct leakage, and with variable levels of duct insulation. We obtained co-funding from Florida Power and Light ($40k) for these experiments.

BAIHP obtained bids from two HVAC contractors to install two 3-ton heat pumps in the MH Lab. One heat pump was a 13 SEER system and the second was a 21 SEER (iQ Drive) system. We developed first and second drafts of a channel map for the SEER 21 experiments. Installation of the two heat pumps and an investigation of internal load and occupancy schedules for the MH Lab to operate during the SEER 21 experiments began in August. Several FSEC staff participated in a Lab House conference call in late July.

We have also made modifications to the MH Lab in order to be prepared for the SEER 21 experiments. We tested the air tightness of the dampers which separate the attic duct system from the indoor duct system and found that there was sufficient leakage in those dampers to cause

problems for the experiments. A plan was developed to create two separate supply plenums, one for the attic duct system and one for the indoor duct system, to eliminate the damper leakage problem. A duct air tightness test of the attic duct system was performed; actual duct leakage was calculated based on Q25, out a system operating pressure, and actual leakage was found to be approximately 1.5% of system air flow.

When comparing performance with the two duct systems, it will be important that system air flows be similar. We began an examination of supply plenum pressure for both duct systems (attic duct system and indoor duct system) with the objective of creating similar plenum static pressures and similar air flow rates through both duct systems. After making a series of modifications to the supply plenums, air flows are now comparable between the attic and indoor duct systems.

Additional instrumentation has been purchased. A channel map was developed; in total there will be 78 channels of data. Programming of the Campbell Scientific data logger is now partially complete. Initial testing of the two heat pump systems was performed to verify that they were operating at or near specified capacity. The control and cycling behavior of the variable speed (SEER 21) system was examined, and some questions were raised. Initial testing suggests that the AHU fan for the SEER 21 unit operates at seven discrete air flow rates. The system can be controlled based solely on room temperature; an RH control set point can also be selected. An initial examination of the humidity control function of the thermostat and its interaction with the AHU fan and compressor speeds has been performed. With the thermostat set to RH control, system air flow rates can at times modulate to very low speeds and supply air temperature has been observed as low as 41^{o}F. Project staff members contacted Nordyne and arranged for a manufacturer representative to provide training and technical support. A four-hour class was provided by Nutone about installation, operating, and programming features of this variable capacity heat pump system on October 15 at FSEC.

A plan was finalized to modify the gable ends of the MH Lab to allow ready access to the relatively shallow (cramped) attic space on either side of the “marriage” partition, including an exterior platform for easier access to the attic and crawl ways in the attic to facilitate movement. Calibration of a variety of sensors has begun, including power meters, condensate (tipping bucket) flow meters, thermocouples, RH probes, and air velocity sensors.

<u>Review of Miscellaneous Electric Loads (MELs) in Residences</u>
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 were 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 during the July 2008 quarterly Building America meeting.

The scope of this work expanded to include televisions and ceiling fans in 2009. Philip Fairey and Danny Parker co-authored a report on this topic with Bob Hendron at NREL: *Updating Miscellaneous Electricity Loads and Appliance Energy in Home Energy Rating Systems and Building America Benchmark Procedures* (Florida Solar Energy Center,: FSEC-CR-1823-09, Sep. 29, 2009.)

This report addresses the ever increasing percentage of whole house energy use that is attributable to miscellaneous electricity loads (MELs) and major appliances. It builds on earlier U.S. Department of Energy (DOE) reports on the same subject and incorporates the 2005 Residential Energy Consumption Survey (RECS) public use data set to determine how major appliance use is related to the number of bedrooms in existing homes. These data, coupled with existing and proposed DOE appliance testing and labeling standards, are then used to determine a set of baseline lighting and appliance energy end use values for use in the HERS Reference and Building America Benchmark whole house energy analysis procedures. The report makes recommendations for revising the reference standards that are in current use and provides mechanisms for expanding the number and types of lighting and major appliances that are considered to be rated features of a home. The report also provides a section on the potential of energy feedback devices and home energy management systems to reduce home energy use. The full report is available at http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1837-10.pdf

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

FSEC assisted DOE in evaluating energy losses associated with wind washing and the potential benefits of retrofits of existing homes to eliminate wind washing in two-story houses. FSEC participation in this wind washing project began during Budget Period 3 and continued throughout Budget Period 4. Florida Power and Light provided cost-share to this effort. For the purposes of this study, wind washing is defined as uncontrolled air flow into the floor cavity located between the first and second stories when that cavity is open to an attic space located above first-floor portions of the house. Wind washing also occurs when insulation batts on knee walls (within the attic) gap away from the wall board allowing thermally driven air flow against the wall surface. FSEC performed the search, selection, scheduling, and field assessment in 32 two-story homes to characterize wind washing failures. Field assessments included a blower door test, air boundary location, pressure mapping, infiltration testing, AC performance testing, duct leakage measurements, infrared scans of house surfaces, and visual inspections.

Repairs to restore the air and thermal boundaries were implemented in six homes. A retrofit plan was developed for each repair home. The retrofit plans included installing air/thermal barriers at the perimeter of the between-story floor cavities to isolate the floor cavity from the attic space. In all cases, this plan was achieved by applying an open-cell expansive foam (Demilec) to the interface between the open floor cavity and adjacent attic spaces. In some cases, the insulation level of knee walls was identified as being substandard withR11 batts tucked into a dense framework of framing members and an effective R-value on the order of R8. Hence, foam insulation was also applied to the knee wall. The average retrofit cost was $650 per house and was paid from project funds. AC energy use and space conditions were monitored (15-minute data) before and after repairs to document cooling energy and peak demand savings. This project

characterizes the extent and magnitude of the energy and moisture consequences of these thermal and air barrier failures in a hot and humid climate and evaluates the energy conservation potential of wind washing retrofit programs. At the time of this report, analysis is being performed to identify cooling energy savings and peak demand reduction.

The six repair homes were selected from the 32-house testing sample; however, because of the timing of the testing and when the monitoring and repairs needed to be done, the six repair homes were actually drawn from a pool of only 15 homes. Evaluation of the field testing data has revealed that many of the homes with the greatest wind washing potential, and therefore the greatest energy reduction potential, were found in the last 17 homes. Therefore, it is likely that the energy savings found in the six repaired homes most likely under represents the energy savings potential of the larger sample. The following case study was completed on a house that has considerable wind washing potential. However, it was not repaired or monitored because it was tested in the latter 17 houses.

A Wind Washing Case Study

A house that was tested in August 2009 has high wind washing potential. This home is located within a half mile of the Atlantic Ocean, has a vented attic, and has an open floor space orientation east to west which allows the sea breeze to flow through the building cavities. An exterior view of the attic section over the garage on the east side of home is shown in Figures 4-23 and 4-24

Upon inspection in the garage attic, we observed that the floor space between the first and second floors was open to garage attic space and open to west attic space over the master bedroom (Figures 4-25 and 4-26. Evidence of the hot attic air that has flowed into the interstitial floor cavity is shown in Figures 4-27 and 4-28. This infrared image shows evidence of the hot floor space behind the gypsum board wall surface in the stairway. The first story ceiling and second story floor surfaces also have elevated temperatures; infrared imaging indicates floor space surfaces of about 3- 6 degrees F warmer then interior air temperature of 77^{o}F at midday. This heat comes from outdoor air and attic air that are being pushed into interstitial floor cavities, adding considerable load on the AC system. We expect that repair of this uncontrolled air flow (which we term wind washing) will considerably reduce AC energy consumption. The homeowner has indicated willingness to participate in a Phase 2 monitoring and repair in 2010.

Figure 4-23: *East and north side of house with attic over garage adjacent to open floor cavities.*

Figure 4-24: *Infrared image of the house during midday after mostly sunny conditions all morning.*

Figure 4-25: *Open floor cavity area in the east attic. (view looking toward the west into the floor space)*

Figure 4-26: *Open floor cavity area in the west attic. (west side is to the left)*

Figure 4-27: *Infrared image of floor space behind wall.*

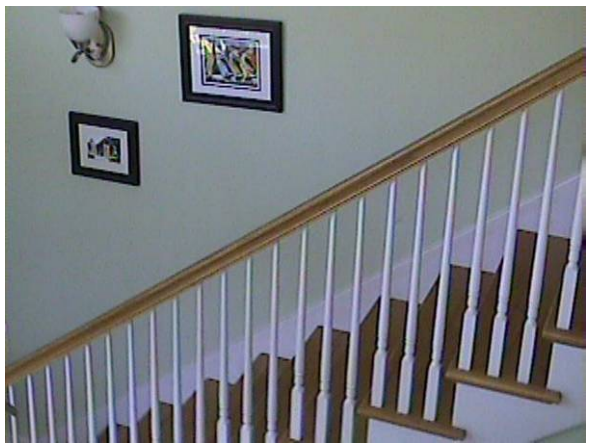

Figure 4-28: *There are conditioned rooms on the other side of this wall.*

Subtask 4.4. Research Utilization

System Research Completion Reports 2006-2009

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.

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.

In 2009, BAIHP began initial work to organize the 40% Hot Humid Climate Joule Report by participating in conference calls and coordinating submission of case study executive summaries from other Building America teams.

1) Service on committees and boards

FSEC Activity

- Metro Orlando Green Home Steering Committee, attended meetings, participated in the Parade of Homes sub-committee for the first Green Parade of Homes, discussed upcoming BAIHP participation in green expo – both in early 2009
- Philip Fairey attended the winter ASHRAE conference where he serves as voting member of ASHRAE SPCC 62.2 and SPCC 140.
- Philip Fairey attended the Building America mechanical ventilation experts group meeting in January of 2009.
- Florida Green Building Coalition Board of Directors: attended monthly meetings, participated on FGBC's new task force (Green Governments, 60x2010) to encourage more governments adopting FGBC Green Government Standard, presented FGBC Green Government Standard to representatives of 17 cities in Volusia County on July 21. Incorporated personalized pre-taped (carbon neutral) messages directed to Volusia County Commissioners from Orange County FL Mayor Crotty and City of Palm Coast Mayor Netts. Stephanie Thomas-Rees participated in FGBC strategic planning session facilitated by an NAHB-RC representative.
- Stephanie Thomas-Rees and David Hoak attended and passed NAHB's Certified Green Professional course.

ODOE Activity

- Presentation of the Eco-rated program to the Northwest Power Planning Council Regional Technical Forum on March 2, 2009.

WSU Activity

- WSU attended the ASHRAE winter meeting and participated in the TC6.3 and 9.5 technical committee meetings. Task 1 report was reviewed by the steering committee for the Latent Cooling Modeling Project.
- Attended RESNET conference as members of technical committee and RESNET board. Also co-presented (with EPA, DOE and HUD staff) on manufactured housing energy rating. WSU participated in RESNET Technical Committee conference calls to discuss improvements to the HERS specifications, including HVAC systems. WSU staff members are facilitating a working group to discuss HUD code labeled housing and RESNET.
- Participated in ASHRAE RP-1449 Research and SPC-193 Standards committees; acted as chairman of both committees.
- Participated in conference calls with AAMA members regarding BEOPT analysis of windows in manufactured housing and followed up with window manufacturers on BAIHP cost data collection.
- Provided PNNL and Chris Early with window, insulation and HVAC manufacturers. Data will be used in EGUSA libraries.
- WSU coordinated a HUD-MHCC energy efficiency task group conference call to discuss proposals to improve installation of insulation and air leakage control, based on BAIHP experiences.
- WSU has signed contracts with Ecotope (provides match for WSU's BAIHP funding) to coordinate research activities on ductless mini-split heat pumps. Field instrumentation of homes in Washington is underway to measure heat pump COP, electric resistance heat, domestic hot water use, and whole house electric use. The contract includes formation of a technical advisory committee including representatives from manufacturers, ACCA, ASHRAE members, national laboratories, and other Building America Teams. Advisory group will meet at ASHRAE 2010 winter meeting. Discussed development of homeowner and contractor guides to mini-split heat pumps with ACCA as potential 2010-11 BAIHP related activity.
- WSU staff met with HUD and EPA in Washington DC in October on AirPlus, ASHRAE 62.2 and MHCC IAQ task force coordination.

Florida HERO Activity

- High Performance Builder Meetings - Gainesville, FL – Coordinated and attended meetings with Subrato Chandra, BA Builders Partners and their staffs including G.W. Robinson Builders, Tommy Williams, Skobel Development, Innovative Homes and Dibros Corp. The primary purpose was to inform and receive feedback with regard to achieving an E-Scale of 60 or less on all future homes that they build. Their formal commitment was discussed.
- Alachua County Deep Retrofits – Coordinated and participated in discussion with the chairman of the Alachua County Commission, Mike Byerly, concerning the deep retrofit of foreclosed homes that the county has given their formal intention to achieve.
- 10,000 Homes Initiative – Alachua County - Reviewed and provided input as requested.
- Sustainable Alachua County - Ongoing meetings and discussions.

2) Participation in Working Groups

FSEC Activity

- Presented FGBC Green Government Standard to representatives of 17 cities in Volusia County on July 21. Incorporated personalized pre-taped (carbon neutral) messages directed to Volusia County Commissioners from Orange County FL Mayor Crotty and City of Palm Coast Mayor Netts.
- Initial meeting of the newly formed ISO TC163 Joint WG4 task groups was hosted by FSEC on October 26-27. Philip Fairey acted as host and participated in the meetings.

ODOE Activity

- ODOE working with manufactured home industry NW Pride to develop a green home program for the northwest. Subsequently, NW Pride adopted Eco-rated as their green home program for the northwest marketing. Regional Technical Forum working group approved saving for Eco-rated homes
- On April 5, 2009 NEEM staff presented the results for the NEEM field study to the Regional Technical Forum.

WSU Activity

- Coordinated with BSC to manage ASHRAE contract on RP-1449 (Energy Efficiency and Cost Assessment of Humidity Control for Residential Buildings.) WSU reviewed and commented on task 2 Research Questions and coordinated comments from other Project Management Subcommittee members.
- As research project chair, provided review and comment on final draft of ASHRAE RP-1449.
- Worked with ASHRAE TC 6.3 & 9.5 chairs to share BAIHP research on ductless mini split heat pumps. Coordinated with NIST on potential phase 3 retrofit (HVAC) of BAIHP's MHLab at FSEC. Also provided technical assistance to NIST on final report for phases one and two.
- WSU researchers participated in meeting of researchers on the 1980s Residential Standards Demonstration Project (RSDP) to evaluate potential research of persistence of energy savings and other building science research questions. Other participants included staff from the Northwest Power and Conservation Council, Bonneville Power Administration, PNL and LBL.

Florida HERO Activity

- UF Department of Urban and Regional Planning, College of Design Construction and Planning: Attended and participated in workshop: Sustainable Development: is Going Green Worth the Green?"
- Building America Project Meeting, Washington, D.C. - Attended meeting. Participated and reported on break-out session "Preliminary Hazard Analysis."

- "Rater Roundtable" at FSEC - Sam Rashkin of EPA reviewed proposed changes of the Energy Star program.
- High Performance Builder Meetings - Gainesville, FL - Coordinated and attended meetings with Subrato Chandra and BA staff with various Builder Partners to discuss making formal commitment to build future homes to an E-Scale of 60 or less.
- Alachua County Deep Retrofits - Coordinated and participated in discussion with chairman of Alachua County Commission concerning deep retrofit of foreclosed homes.
- LEED Field Agent Training - Completed Section 2

3) Collaboration with Federation of American Scientists (FAS), factory built housing industry and other industry stake holders (new category in BP4)

FSEC Activity

- BAIHP met with Sylvester Schmidt, consultant to the Autoclaved Aerated Concrete industry, to discuss future collaborations.
- BAIHP continued collaborations with FAS to develop an initiative on high performance manufactured homes. This effort was in the planning stages as of BP3. FAS participated in a HUD move to IECC in BP4.
- In BP4, BAIHP provided FAS with Habitat for Humanity contacts for a document profiling best practices for high performance affordable homes.
- Hosted Dr. Valerie V. vonSchramm of CPS Energy at FSEC on October 26 and 27. We discussed the Green versus base case affordable home study she is doing in San Antonio and our own BA versus non –BA home study in Gainesville. Also discussed in detail the CPS Energy three side-by-side home study BAIHP is monitoring.
- In BP4, conducted initial Discussions with Florida Local Governments interested in deep retrofits on foreclosed homes as part of the new HUD Neighborhood Stabilization Program (NSP).
  - January conference call with Sarasota County government to explore bringing foreclosed homes up to the Builders Challenge.
  - February visit to Sarasota County to explore bringing foreclosed homes up to the Builders Challenge. County is very interested and have provided a letter to that effect.
  - In February, discussions were begun with other counties.
  - In March, received letters of interest from Orange County, Alachua County, and Brevard County indicating desire for BAIHP technical assistance to explore conducting deep energy retrofits (to Builders Challenge level) on WSU, ODOE and NewPort Partners (a potential new sub-contractor) have obtained additional letters from several other counties throughout the U.S. on this.
  - Throughout the year, continued discussions with local governments on deep energy retrofits (to Builders Challenge level).
  - In July, requested permission to add this work as a subtask to BAIHP Project Management Plan.
  - In September, received permission to add this work to BAIHP Project Management Plan. Please see "Builders Challenge Level Retrofits" in Subtask 4.3.

Energy Systems Engineering BS/MS program

- UCF College of Engineering (COE) is beginning an initiative to offer an Energy Systems Engineering BS/MS program beginning fall of 2010. Subrato Chandra is serving on the college Dean's committee as the FSEC representative.
- In February, Subrato organized a meeting (02/19/09) to obtain input from FSEC faculty and continued discussions to compile a comprehensive list of interested faculty and their interest areas which was subsequently summarized and transmitted to Dr. Kapat, committee chair, in March.
- In April, attended UCF COE symposium on senior design projects showcase.

EPRI Collaborations

- In March, hosted visit from EPRI personnel (Ammi Amarnath and Chris Trueblood) to FSEC. Future collaboration topics were identified for hot water system testing and lab homes.
- In April discussed future FY10 potential collaborations with EPRI personnel (Ammi Amarnath) .

BP4 Other Meetings/ conference calls

- March 6 conference call with Progress Energy in Central Florida to explore their interest in becoming a Builders Challenge partner.
- March meeting with Dr. ElDifrawi and his colleagues on developing a roof integrated solar DHW system and briefed them on past FSEC and other work in this area.
- March conference call with Florida Power and Light Co. serving a major portion of the Florida peninsula to explore their interest in becoming a Builders Challenge partner.
- April meeting with Bill Eggers and others at MSCW Inc., who are performing site development planning and engineering for a large green and solar community (Rybolt Park) in east Orlando, near UCF. They are potentially interested in BAIHP technical assistance.
- In April, BAIHP attended the Kitchen and Bath Industry Show and Conference to research the latest energy efficient appliances, attended an advanced appliance workshop.
- In April, discussed the new GE heat pump water heater with the GE marketing manager Gregg Holladay and possibly testing a unit.
- May conference call with Progress Energy on participation with BAIHP. Their budgets are really tight and they will not be able to participate in the near future.
- In May, hosted USF department of Architecture at FSEC. They are interested in FSEC assistance on Solar Decathlon and Zero Energy Homes.
- May meeting with Jay Fechtel on a passive heat recovery water heater.
- May meeting with Eco-Smart who carry a full line of "Green" products.
- May meeting with Atlantic Housing. Plans were made to analyze one of their future complexes and recommend options to make their apartments Builders Challenge qualified – see more details in Task 2-Prototype Homes under Atlantic Housing.
- Participated in FGBC Systems Built Task Force to devise a standard for FGBC to offer to modular, panelized, factory and/or system built manufacturers.
- In June, attended Florida Home Builders Association educational session "Road to Recovery in Volusia County (Daytona area).

- In June, Neil Moyer Attended EEBA board meeting in Minneapolis MN
- In June and July, Florida H.E.R.O. met with current and potential industry partners in Gainesville (Richard Schackow, Tommy Williams Homes, GW Robinson Builders, Skobel and Town of Tioga) and Ft. Lauderdale area ((volume builder GL Homes) to ascertain their interest levels in beginning or continuing to build high performance All discussions were productive and most of them were interested in building close to or below E-Scale 60 homes.
- July meeting with Florida Power and Light Co. to seek co-funding on retrofit work for the recompete Building America proposal. They were interested. Similar phone discussions with CPS Energy in San Antonio , Texas.
- In July, hosted Jay Moskowitz, CEO of SPD Control Systems at FSEC. They develop controllers for smart windows which become opaque in direct sunlight, clear otherwise.
- In July, attended joint reception at the South Eastern Builders Show between NAHB-RC, USGBC and FGBC to show attendees and constituents that a these three "green" rating organizations are in support of each other and are all after the same common goal of sustainable built environments.
- In October, at the request of builder partner Don Ferrier, performed an analysis of a vented roof over a R-40 SIPS roof. Reported back the meager savings.
- In October, Eric Martin attended a webinar delivered by Newport Partners on the Builders Challenge Program.
- Stephanie Thomas-Rees attended presentation hosted by Environmental and Energy Study Institute (EESI) and the Embassy of Switzerland, *Addressing Climate Change with Energy Efficient Buildings: Best Practices from Switzerland* at the Rayburn House Office Building, in Washington DC.

ODOE Activity

- Throughout the year, working with HUD-Code industry on Eco-rated green home program
- Toured Owens Corning XPS foam plant in Portland. Agreed to work together to promote high performance housing.
- Toured Miranda Home factory, a modular builder.
- In the third quarter ODOE talked to 47 builders over the phone and
- In June, staff met with Ben Walsh construction in Portland, Oregon to discuss a planned 20 home net zero housing project. Homes will qualify for the High Performance Home tax credit program and federal tax credit.
- In August, presented NEEM to USDOE and national labs.
- In September. presented to 100 low income housing advocates at the CFED (Corporation for Enterprise Development) retreat in Seattle.

WSU Activity

- Throughout 2009, supported the National Fire Protection Association's (NFPA) Manufactured Housing Consensus Committee (MHCC) related activities continues, including coordination with DOE, HUD, PNL and other stakeholders
- In March, discussions with FAS staff on monitoring/research plan related to stimulus funding.

- In March, discussions with Structural Insulated Panel Association staff regarding BAIHP activities for 2009 and beyond.
- In May, attended meeting with Washington State Department of Commerce on Housing Trust Fund and Habitat coordination efforts.
- In June, followed up with window, insulation and HVAC manufacturers on BAIHP cost data collection that will be used in EGUSA libraries
- In July, attended meeting with CTED on the Housing Trust Fund and Habitat coordination on Evergreen Sustainability Standards (ESS).
- In July, attended NFPA-MHCC meetings in Washington DC and participated in follow-up conference calls in August.
- In July, attended MHCC meetings in Washington D.C. Coordinated meetings with Chris Early at DOE headquarters.
- In August, attended meeting with Washington State Department of Community, Trade and Economic Development (CTED) and Washington Factory Assembled Structures Group to discuss low-income HUD-code housing projects, including farm worker housing and Habitat coordination.
- September meeting in Washington, D.C. with HUD, EPA and USDOE on developing high performance HUD-code homes, the potential for energy rating/labeling of homes and the status of MHCC proposals on IAQ, durability and energy efficiency.
- In September, at the request of George James of DOE, met with Randy Hedgebeth to discuss his high R-value (claimed R38) steel stud wall system for potential use in future BAIHP high performance homes.
- In September, attended 2009 I'm Home – Innovation in Manufactured Housing retreat in Seattle. Presented on BAIHP HUD code related activities. Repeated presentation at the Manufactured Home Owners Association of America 2009 National Convention in Seattle.(http://energy.wsu.edu/BAIHP-WSU/MH_2009_Home.ppt)
- In September, re-recruited Panasonic as a partner for BAIHP and discussed improved control system designed to limit over ventilation in homes which don't achieve optimum air tightness. WSU will continue to explore using NIST test home to support this effort.
- September discussed with Owens Corning about becoming a BAIHP partner.
- In September, WSU participated in Webinar with USEPA to evaluate Indoor Air Plus program specifications for use in BAIHP future projects.
- September, attended quarterly meeting of the Washington Factory Assembled Structures Group. Discussed state and federal HUD code issues, as well as potential community scale projects. WSU staff provided update to group on HUD code development activities.
- In October, met with HUD and USDOE on Manufactured Home Construction and Safety Standards (MHCSS) energy analysis in Washington DC.
- WSU researchers coordinated with Bonneville Power Administration and others on potential Zero Energy Manufactured Housing documentary.
- In preparation for new Building America Retrofit proposal, conducted conference calls with WA Veteran's Administration, WA Habitat staff and other stakeholders.

4) Publication, Presentation, and Showcasing of Research

- Ongoing activities
  - BAIHP website - www.baihp.org - updated throughout 2009

    - Ten new publications: http://www.baihp.org/pubs/index.htm
    - "Measured Data" page was reorganized. Includes descriptions and data for 16 current and completed studies with links to Infomonitors website where users can access actual project data: http://www.baihp.org/data/index.htm
    - "Case Studies" page - six new items http://www.baihp.org/casestud/index.htm
    - New "Gulf Coast High Performance Affordable Demonstration Project" page http://www.baihp.org/gulfcoast/index.htm
    - New case studies of RESNET member volunteers working with Habitat: http://www.baihp.org/habitat/
  - BAIHP staff participated in presentation development and recording for 12 course webinar series titled *Achieving Zero Energy Green Homes*. The series aired in June, July, and August of 2009 with plans to repeat the series three times in 2010. http://www.fsec.ucf.edu/en/education/cont_ed/bldg/zero.php

- January 2009 - International Builders Show (IBS) in Las Vegas-
  - Presented "Surviving the Crunch -- Perspectives from Energy Efficient Builders in Florida". Speakers are Stephanie Thomas-Rees (BAIHP/FSEC), Subrato Chandra(BAIHP/FSEC), Walt Staheli (BAIHP Partner GW Robinson Builders) and Todd Louis (BAIHP Partner Tommy Williams Homes).
  - assisted at the DOE booth at 2009 IBS and showed different parts of the booth to a TV crew.
  - BAIHP representation at EVHA dinner.
- January 2009 *Builder/Architect* - Stephanie Thomas-Rees was interviewed for story titled "Energy/Air Quality, Using the Best Gives Builders and Edge."
- January 23, 2009. Gulf Coast Energy Network's *Re: Energize* one day conference. Janet McIlvaine presented "*Building America's Gulf Coast Demonstration Houses.*" 150 attendees, 45 minute session.
- In February, BAIHP prepared and transmitted three reports on near zero energy homes (NZEH) for the DOE peer review. Links to these reports:
  - Olympia, WA: www.baihp.org/pubs/pdf/BAIHP-WSU-zelonedom.pdf
  - Callaway, FL: www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1793-09.pdf
  - Gainesville, FL: www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1792-09.pdf
- February 21, 2009, Front page Florida Today newspaper, article titled "What gets hot, for less". The two-page article about BAIHP hot water research activities at the FSEC, including a description of the seven hot water systems currently under study in Subtask 1.11.
- February 18, 2009 RESNET Building Performance Conference. Janet McIlvaine presented with David Lee (EPA Energy Star Program), Advanced Energy, and McGrann Associates. *Energy Star Qualified Homes: Opportunities to Work with Affordable Housing.* 30 attendees. 1.5 hour session.
- March 25-26, 2009 - Subrato Chandra attended Greenprints in Atlanta and presented on "High Performance Modular Housing"
- March 18, 2009 - Subrato Chandra was the dinner keynote speaker in Orlando, FL for the Green Communities conference and made presentation "Making Solar Communities Viable: What will it take?"
- March 2, 2009 - David Hoak and Jeff Sonne represented FSEC at the annual Kennedy Space Center All American Picnic 2009 for family and friends of KSC employees.

- In March, a presentation on the Nightcool technology was made in Wes, Austria at *World Sustainable Energy Days* where there is increasing interest in cooling due to changing climatic conditions. A similar presentation will be made next month at the Passive House conference in Frankfurt.
- April 14, 2009 - Subrato Chandra presented at the Metro Orlando HBA meeting on Building America, Builders Challenge and BAIHP. 70 attendees.
- April 28-30, 2009 - Neil Moyer attended Affordable Comfort Conference in Kansas City and presented three sessions: *Mechanical Humidity Control Research Update , Mechanical Solutions for Humidity Control,* and *HUD Code Housing: From Zero Image to Zero Energy*.
- In June, Carlos Colon and Danny Parker presented data on the HWS at the ACEEE Hot Water Forum in Asilomar, California.
- June 11, 2009 - Todd Louis (BAIHP Partner Tommy Williams Homes) and Stephanie Thomas Rees presented GreenTrends Annual Conference in St. Petersburg, FL, *Surviving the Crunch with High Performance Housing,* 60 attendees.
- June 4-6, 2009 – Subrato Chandra and Stephanie Thomas Rees presented at 16th Annual Southern Building Show & Conference in Atlanta, *Greening Your Bottom Line Through Energy Efficiency, Solar Energy And Green Technologies*
- In June, Neil Moyer presented at Mid Florida HBA *IAQ And Moisture Problems/Prevention In Home*.
- July 27, 2009 - NEEM staff presented NEEM and led a four-hour tour of 54 people from USDOE, national labs and code officials through the Fleetwood of Oregon plant in Woodburn, Oregon. The tour was part of a four-day national energy codes conference in Portland Oregon
- July 24, 2009 - made presentation to the FSEC policy advisory board on BAIHP progress and plans for the future.
- July 24-26, 2009 - ODOE staff gave five presentations and manned an information booth at the Sol West Conference in John Day, Oregon including One two-hour workshop presented to 30 residential solar installers on technical specifications, performance estimating, and the ODOE residential and homebuilder tax credit programs. One presentation detailing the Oregon High Performance Home tax credit program. Three presentations to 50 members of the general public regarding the state energy tax credit programs.
- July 11, 2009 - ODOE staff manned a booth at the Oregon Country Fair in Veneta, Oregon and spoke to 40 members of the general public regarding energy efficiency and the state energy tax credit programs.
- August 19, 2009 - Carlos Colon gave two presentations at the BIRA Expert Solar Meeting in Vancouver, Washington. One presentation on the performance of seven water heating systems including efficiency performance obtained from two draw patterns (ASHRAE 90.2 and NREL/BA) imposed per month and the time of day electric load profile for electric systems. (30 min.) Second presentation on the performance of four Near Zero Energy Homes (NZEH) summarizing lessons learned from the monitoring including PV performance, indoor conditions, summary of equipment technology, overall PV system efficiencies and air conditioning performance (winter and summer periods) for each home. (30 min.)
- August 27, 2009 - Stephanie Thomas-Rees gave BAIHP/FSEC presentation to Orlando AIA Committee On the Environment meeting in Orlando, 40 attendees, one hour.

- September 21, 2009 - Stephanie Thomas Rees gave guest lecture on Building America Program and Green Rating Programs to CCE 4813 – Mechanical and Electrical Systems for Buildings for the UCF CECE department class. 18 students.
- September 30, 2009 - Eric Martin presented on interior duct systems during a Builders Challenge session at the EEBA conference in Denver, CO
- September 22, 2009 - Danny Parker gave a two hour presentation on Zero Energy Homes technologies to National Institute of Testing and Standards in Gaithersberg, Maryland on September 22nd: "Zero Energy Homes: Technology Challenges for the Next Decade." There were approximately 20 professional staff from NIST in attendance.
- October 1-2, 2009 - Subrato Chandra and David Hoak participated expert meeting on Home Energy Management at NREL.
- October 29, 2009 - D. Parker and S. Chandra participated in the NIST Zero Energy Buildings workshop. D. Parker made keynote presentation to 75 persons.
- October 21 – FSEC press release issued, after review by DOE, highlighting BAIHP work with six Florida builders that are building all their homes to an E-Scale less than 60. Our analysis shows less than one in 1,000 new homes in Florida attain this level of energy efficiency. Article from press release in FSEC Energy Chronicle *New Home Sales Robust for Some Energy-Efficient Florida Builders* http://blog.floridaenergycenter.org/echronicle/2009/10/

Submitted Abstracts and Proposals for Sessions

- Submitted an education session proposal for IBS 2010 on "Pushing the Envelope – Zero Energy Homes!" to be presented by Subrato Chandra, Stephanie Thomas-Rees and Todd Louis.
- Mike Lubliner submitted abstract on Garst prototype home for BTECC Conference in December 2010.
- Dave Chasar submitted abstract on side-by-side comparison of CPS Energy's Woodside Homes to the Thermal Performance of the Exterior Envelopes of Whole Buildings XI International Conference (2010).
- Stephanie Thomas Rees submitted abstract *Envelope, Equipment and Photovoltaic design considerations in Zero Energy Homes – A Florida Case Study* to Thermal Performance of the Exterior Envelopes of Whole Buildings XI International Conference to be held December 2010.
- Janet McIlvaine, David Beal, and Subrato Chandra - Submitted abstract, *Gulf Coast High Performance Affordable Demonstration Homes: Lessons Learned* to the Thermal Performance of the Exterior Envelopes of Whole Buildings XI International Conference.
- John Sherwin, Danny Parker, Carlos Colon, Eric Martin, and Subrato Chandra submitted abstract *Performance of Four Near Zero Energy Homes: Lessons Learned* to the Thermal Performance of the Exterior Envelopes of Whole Buildings XI International Conference

Training

- February 9-11, 2009 - Janet McIlvaine served as a "subject matter expert" for Habitat for Humanity International - National Leadership Training Event in Mobile, Alabama. This hands-on workshop was conducted on three of Mobile County Habitat's job-sites. 46 attendees.

- April 21, 2009 - Eric Martin trained over 80 attendees on verification principles for the FGBC Florida Green Home Designation Standard
- April 23, 2009 - Eric Martin trained over 30 attendees on verification principles for USGBC LEED for Homes standard
- In April, ODOE staff presented a High Performance Home (HPH) Wall Workshop in Portland to 30 attendees and a class on Solar Thermal engineering to 40 solar contractors in Portland, OR.
- In May, ODOE staff presented a HPH Workshop in Portland at the NW Solar Expo for 30 attendees at six sessions for a total of 180 attendees.
- June 11, 2009 - Eric Martin provided training for 30 attendees at the GreenTrends Conference in St. Petersburg, FL.
- In June, ODOE staff presented three full day HPH Wall and Roof Workshops. These workshops were presented in La Grande to 30 builders, in Hermiston to ten builders and in Hood River to 30 builders.
- August 17-18, 2009 - Eric Martin taught the 2-day FGBC Certifying Agent course to 25 individuals.
- August 20, 2009 - Eric Martin taught the LEED for Homes for Field Agents course to 30 individuals.
- Fall Semester - S. Chandra and C. Gil started co-teaching CCE 4813 – Mechanical and Electrical Systems for Buildings for the UCF CECE department for fall semester 2009. 18 students in this senior level class.
- October 28-29 - Eric Martin taught 2-day FGBC Certifying Agent training course to 15 individuals on in Miami Lakes, FL.
- October 13 - Eric Martin delivered a workshop on Green Construction during a joint meeting of the Brevard Air Conditioning Contractors Association and students/faculty of the HVAC apprenticeship program at Brevard Community College.
- November 19, 2009 –UCF Office of Research held an Energy Efficient Buildings Workshop on the UCF campus with support from BAIHP.

5) Project Management activities

FSEC Activity

Reporting

- Prepared and transmitted the BAIHP annual progress report for Budget Period 3.
- Prepared and transmitted monthly report.
- Prepared and transmitted a quarterly technical report for
  - October, November, and December of 2008
  - January, February, and March of 2009.
  - April, May, and June of 2009
  - July, August, and September of 2009.
- In February, BAIHP presented material from three performance evaluations at the 2009 Building America Peer Review session in Washington, D.C. These are available online:
  - Preliminary Performance Evaluation of a Near Zero Energy Home in Gainesville, Florida: http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1792-09.pdf
  - Preliminary Performance Evaluation of a Near Zero Energy Home in Callaway, Florida: http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1793-09.pdf

    - Zelonedom Case Study Report: "Approaching" Zero Energy in the Pacific Northwest Marine Climate: http://www.baihp.org/pubs/pdf/BAIHP-WSU-zelonedom.pdf
- Assisted in preparing quarterly fiscal report that was transmitted by UCF accountant.
- Monthly updated home counts for the entire BAIHP project.
- Discussions held with NREL and other BA Teams in preparation for compiling a draft of the Hot Humid Climate 40% Joule Milestone report.'
- GW Robinson, a Building America industry 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.
- A one page summary of our work on Gate one for 50% homes in hot-humid climates was prepared and submitted to DOE
- BAIHP annual report compilation began in October.
- Submitted comments on the ventilation section of the BCQC support document to Michael Baechler.
- In September, began working with IBACOS and NREL to clarify the criteria and procedures to be used in preparing the 2010 40% hot-humid Joule report. Conference call was held on Sep 15 and minutes distributed soon thereafter. Presentation made at BA quarterly review meeting Oct 7. Executive summaries of anticipated case studies were submitted in December.
- Janet McIlvaine presented on February 24 progress on Gulf Coast Affordable Housing Demonstration Project at BA quarterly meeting.

Contract Management and Staffing

- Worked throughout the year with UCF Office of Research on project funding, subcontractor funding, deliverables and related items.
- Worked throughout the year to maintain contact with BAIHP Industry partners and worked with each toward goals as described in Tasks 2, 3, and 4.
- Worked throughout the year to respond to requests for information and partnership.
- Welcomed new BAIHP industry partners such as the University of Georgia, Tifton campus "Future Farmstead" project, reported in Sub-task 2.1 Hot Humid Prototypes.
- General project management and coordination activities—coordination with BAIHP researchers, DOE, NETL, LABS and industry personnel, subcontract deliverable approvals, review and approval of project expenditures, reviewing budgets and related activities.
- In March, participated in ribbon cutting at New Smyrna Beach's first FGBC green certified home in Venetian Bay. he home scored a HERS Index of 65. Discussed the Building America Program with Jerry Johnson with The Johnson Group, builder in Venetian Bay.
- Interviewed and hired new staff to expand team capability with emphasis on existing homes including the foreclosure market
    - Hired Karen Sutherland to start on April 17. She has a realtor license and an M.A. and will be assisting BAIHP task leaders on a variety of tasks.
    - In May, participated in search committee meetings and telephone interviews with two candidates for a possible FSEC position to be funded with BAIHP.
    - In June, interviewed at FSEC potential new BAIHP faculty – Stephen Tibbetts

    - In June, recruited Kevin Schleith to become part of the BAIHP team. In June he was paid from non BAIHP state funds.
    - Interviewed Dr. Rodrigo Mora for a BAIHP position on July 2.
    - Recruited student assistants Ashley Tyre and Michal Flynn to work on BAIHP in September
    - In October, hired Danielle Daniel as an editor to lead the compilation of the BAIHP annual report and help on other editorial tasks as needed.
- Participated in the BA quarterly meetings in February, May, August, and October.
- Discussed with NREL and DOE the latest guidance from DOE on bridge funding for the last year of BAIHP.
- Wrote a letter to support Mr. G.W. Robinson's (BAIHP builder partner) nomination to the UF Construction hall of fame.
- S. Chandra attended luncheon at Gainesville HBA on October 22 where BAIHP builder partner G.W. Robinson was inducted in the U. Florida School of Construction Hall of Fame.

Project Management Planning

- Submitted pre-proposal for additional BAIHP work to be conducted with Stimulus funding on March 16, 2009
- Updated the milestones in the project management plan to reflect status as of March 31 and submitted to Mr. Haslebacher.
- Developed and submitted budgets and other paperwork for an additional $325,000 in supplemental funding with input from sub-contractors.
- On April 15, participated in conference call to discuss SRCC funding and what should be funded through BAIHP.
- On May 3rd submitted our FY10 AOP to DOE. On May 18th submitted a prioritized budget per DOE request. On June 27th submitted the revised FY10 AOP. Continued discussions with DOE and proposed new subcontractors -- Gas Technology Institute and Newport partners.
- Hosted visit and presentation by Liza Bowles and Jamie Lyons of Newport Partners at FSEC on June 2, 2009 to discuss future collaboration
- Spent significant time on developing partnerships and cost share funding for proposal to be submitted in response to solicitation FE-FOA-0000099, which is recompeting our BAIHP work.
- Major effort this quarter was on preparing our proposal in response to solicitation DE-FOA-0000099 to continue and expand our Building America work for the next five years. This was uploaded on the due date of August 27th. Obtained co-funding commitments from FPL, CPS Energy and GTI in addition to FSEC co-funding and that from other subcontractors.
- Updated and received approval on revised project management plan for this current year to include the FSEC lab homes and increase the scope of retrofit research activities to include owner occupied or rental affordable homes.

ODOE Activity

- ODOE management of the Northwest Energy Efficient Manufactured Home Program with 18 contracts with factories and 6 contracts with other states and consultants. Annual budget from certification fees approximately 400K
- Management of the Northwest Energy Efficient Manufactured Home Program. Eco-rated contracts signed by Marlette, Kit, and Golden West Homes, Liberty.
- Certified 15 Eco-rated retailers in the Northwest and Utah. Management of the Northwest Energy Efficient Manufactured Home Program. Eco-rated contracts signed by Marlette, Kit, and Golden West Homes, Liberty and Karsten. Maintain Eco-rated website.
- In July ODOE talked to 20 builders over the phone.

WSU Activity

- Planned for BAIHP future activities in new and, when permitted, existing homes.

4.5:RESNET Tasks

Habitat for Humanity
See subtask 4.1 for BAIHP-Habitat-RESNET partnership activities.

International Dialog
RESNET was appointed to be part of the United Nation's Sustainable Buildings and Climate Change Initiative (SBCI). The SBCI is part of the UN's Environment Programme (UNEP), which is responsible for international environmental efforts including climate change. RESNET, the U.S. Green Building Council and the Natural Resources Defense Council are the U.S. representatives of SBCI.

Philip Fairey, David Goldstein and Steve Baden participated in the SBCI's meeting in Washington, D.C. on April 15 – 17, 2009. There were also representatives from Australia, Brazil, Canada, China, France, Germany, Holland, Norway, Singapore, South Africa, and the UK at the meeting. Steve Baden was able to present the RESNET system at the meeting. My presentation was well received and generated much interest in the U.S. rating system. SBCI and the nation representatives were very interested in creating a dialog on harmonizing standards.

The participants in the Washington meeting reached a consensus for a call to action to the nations that will be meeting in Copenhagen to negotiate the successor to the Kyoto treaty. The call to action states that:

- Buildings are responsible for more than 40% of global energy use and one third of global green house emissions
- The current Kyoto Protocol has failed to harness the potential of reducing greenhouse emissions through improve building energy performance
- Countries will not be able to meet their climate change commitments without addressing building energy performance , particularly existing buildings
- The Inter-Governmental Panel on Climate Change report states that the building sector has the greatest potential of any sector for delivering significant emission reductions, using available technologies and provide greenhouse gas emissions reduction at net life-cycle cost benefits rather than net increased costs.

The Call for Action has the following policy recommendations to the national delegates to the Copenhagen negotiations:

- Include as an agenda item at the negotiations the need to prioritize the building sector as fundamental to achieving significant greenhouse gas emissions
- Support the inclusion of measures to encourage investments in building projects (both new and renovation) that reduce emissions in the new global climate change treaty
- Include in the technology transfer framework measures to support capacity building to increase the efficiency in new and existing buildings
- Support the reform of the Clean Development Mechanism (CDM) to effectively encourage investment in increasing building energy performance
- Adopt a mandate to establish working groups to develop specific measures in the protocol for the building sector
- Encourage governments to conduct an inventory of emissions for the nation's building stock and set targets to reduce emissions in existing and new buildings

On May 27 and 28, 2009, Steve Baden, RESNET's executive director attended the invitation-only U.S. Department of Energy's Residential Energy Efficiency Business Model Summit in Washington, D.C. Steve Baden was invited to the summit by Gil Sperling, DOE's director of Weatherization and Intergovernmental Program. Seventy-five energy efficiency experts from across the country participated in the summit. Participants included experts from the following fields: financial institutions; home performance programs; non-profit organizations and trade associations; state energy offices; public utility commissions; program administrators; energy improvement contractors; and government consultants. Representatives of the Environmental Protection Agency, HUD, White House Office of Environmental Quality, and the Senate Energy Committee also participated. The list of participants are posted on http://www.sentech.org/energysummit/documents/2_Participant_Listing.pdf

After listening to presentations about existing business models, the 75 participants were split into groups to discuss how these models address known obstacles to residential energy efficiency, what is or is not working, and whether these models are scalable. I was struck with the level of concurrence on strategies for the future from this diverse group of organizations.

RESNET was contacted by the chair of the European Union's Energy Performance of Buildings Concerted Action Committee (EPBDCA), Eduardo Maldonado, about presenting to the EPBDCA at its meeting in January, 2010. The meeting will continue the dialog on harmonizing the EU and US approaches to rating a labeling a building's energy performance. The meeting will take place on January 21 and 22, 2010 in Amsterdam, Netherlands.

Steve Baden participated in the United Nations Sustainable Buildings and Climate Initiative in Paris, France on September 10 and 11 of 2009. The purpose of the meeting was to come up with a set of building energy performance metrics and baselines to be incorporated into the new international climate change treaty that will be negotiated in Copenhagen, Denmark. RESNET was successful in incorporating residential building performance into the protocol.

While in Paris, Mr. Baden met with Jens Lausten of the International Energy Agency regarding the development of the OECD Sustainable Buildings Network. It was learned that the network was approved by the G8 and that funding was secured for the effort. Mr. Lausten stated that RESNET would most likely be asked to serve on the network's steering committee.

Building Energy Labeling/National Builders Challenge

On March 11 – 13, 2009, RESNET Executive Director Steve Baden participated in the Midwest Energy Star Conference that was sponsored by the Kentucky Home Builders Association in Lexington, Kentucky. There were over 350 attendees at the conference. Mr. Baden presented the keynote address for the conference and presented in three breakout sessions.

On August 24 - 27 Steve Baden was in Washington, DC and had the following meetings: Henry Kelly, U.S. Department of Energy - Provide briefing on RESNET, home energy ratings, and energy modeling software for occupied homes. The Department of Energy is interested in labeling of buildings according to their energy performance and developing an Energy Efficient Mortgage that works. Philip Fairey, David Goldstein and Steve Baden participated in the meeting. It was a productive meeting and all sides agreed to continue a dialog.

Steve Baden and Edward Pollock of the U.S. Department of Energy discussed tying RESNET's standards closer to DOE's E-scale. Steve Baden and Lane Burt of the Natural Resources Defense Council met and discussed calibrating ratings for occupied homes where energy bills are available.

In September, Steve Baden met with representatives of LENNAR Homes about the company's incorporating energy labeling and the E-Scale into its marketing efforts. It was agreed that RESNET and LENNAR would work together in exploring a way to develop standard modeling assumptions to streamline the production of an energy label of a home.

On September 28 Steve Baden presented an update on RESNET and the Builders Challenge at the EEBA Conference. At the Builders Challenge Mr. Baden met with Ed Pollock regarding RESNET's participation in the National Builders Challenge. It was agreed to explore having RESNET adopt the E-Scale.

Occupied Homes Software

In July the Occupied Homes Software Task Force adopted the Process Steps for Modeling Proposed Improvements to Occupied Buildings for which Historical Energy Use Data Exists. The steps are listed below.

Steps:

1. Collect and record measured energy use data and influential variables for the pre-retrofit period. At a minimum, include the following for each month for which energy use data are collected and recorded:
    a. Monthly average outdoor temperature from the weather station (NOAA) most representative of the actual building site

b. Monthly heating degree days (HDD) and cooling degree days (CDD) or cooling degree hours (CDH), as appropriate, from the weather station (NOAA) most representative of the actual building site.

2. Develop a regression model of the pre-retrofit energy use data as a function of the influential variables in accordance with ASHRAE's *Inverse Modeling Toolkit* (ASHRAE 1050 RP) methods. At a minimum, include regression(s) of building energy use data as a function of the local weather data recorded in Step #1.

3. Using the regression model(s) from Step #2, develop a set of weather-normalized energy use data for the typical meteorological year (TMY) weather data set that is most representative of the actual building site.

4. Collect and record all building and energy systems characteristics necessary to accurately construct a building simulation model for the pre-retrofit building. Using these data, develop a complete building simulation model for the building in its pre-retrofit condition.

5. Calibrate the building simulation model developed in Step #4 to the weather-normalized energy use data developed in Step #3.

6. Using the calibrated pre-retrofit simulation model from Step #5 as the basis of comparison, along with the most representative TMY weather data from Step #3, determine projected energy savings from proposed energy conservation and energy efficiency improvements to the building.

As a result of the task force's action RESNET appointed a working group to develop a draft set of guidelines for the process steps for the task force's consideration. The members of the working group are:

- Steve Baden, RESNET
- Michael Blasnik, M. Blasnik and Associates
- Philip Fairey, Florida Solar Energy Center
- Tom Fitzpatrick, Texas Home Energy Raters Organization
- Dave Roberts, NREL
- Rob Salcido, Architectural Energy Corporation
- Greg Thomas, Performance Development SystemsL

The working group conducted its first teleconference on September 4. The group reached a remarkable consensus on a number of key issues:

1. That the effort and task force be renamed the RESNET Occupied Homes Software Task Force. The new name is viewed as a more accurate description of the work.

2. The working group would be divided into three task groups:
   - Weather Data Protocols (headed by Rob Salcido of Architectural Energy Corporation)
   - Inverse Modeling (headed by Michael Blasnik of Conservation Services Group)
   - Calibration Modeling (headed by John McCartney of Performance Systems Development)

As the task groups complete their work it will be shared with the full task force members of review and input.

Discussions of building labels worldwide have pointed out the difference between "asset value" labels, which are based on how a building performs at standard operating conditions and "operational value" labels, which are based on measurements of energy consumption using the operating conditions that are in use at a particular time. Most products, such as cars or appliances, are rated using asset value labels with a standardized operational component—for example, cars are rating by EPA miles per gallon (mpg) but are not resold based on the mpg that the seller actually obtained. But for buildings, analysts generally recognize that both results are useful. These two types of labels are very distinct and different ways of characterizing energy use, with different purposes. There have been much discussion and some misinformation on this subject. To clarify the issue RESNET posted an message on Energy Labeling and Energy Billing Analysis that was written by Philip Fairey of the Florida Solar Energy Center and David Goldstein of the Natural Resources Defense Council. The message is posted at http://www.resnet.us/hotnews/2009-09-04-EnergyLabeling_and_EnergyBillingAnalysis.pdf

Outreach

On April 27 - 30 Steve Baden participated in the 2009 Affordable Comfort Conference in Kansas City, Missouri. Mr. Baden made a presentation at the conference on RESNET's new National Home Energy Audit Standard.

Steve Baden worked with the U.S. Environmental Protection Agency and two South Dakota Indian tribes on a sustainable building demonstration project. The tribe will construct a straw bale home. RESNET coordinated with the project in having the demonstration home energy rated.

ACRONYMS & ABBREVIATIONS

AC – Air Conditioning
ACCA – Air Conditioning Contractors of America
ACDM - Advanced Cooling with Dehumidifier Mode
ACEEE - American Council for an Energy Efficient Economy
ACH – Air Changes Per Hour
ACH50 – Air Changes Per Hour measured at a test pressure of 50 pascals
ACQ - Alkaline Copper Quaternary
AFF - Armed Forces Foundation
AFUE - Annual Fuel Utilization Efficiency
AHU – Air Handling Unit
AAC -- Autoclaved Aerated Concrete
AOP – Annual Operating Plan
ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BA – Building America
BAHC - Brownsville Affordable Homeownership Corporation
BAIHP – Building America Industrialized Housing Partnership
BC – Builders Challenge
BEOpt - Building Energy Optimization Tool
BIPV - Building Integrated Photovoltaics
BOP – Builder Option Package
BP – Budget Period
BSC - Building Science Corp. or Building Science Consortium
Btu – British Thermal Unit
CEU – Continuing Education Unit
CFL – Compact Fluorescent Lamp
CFM – Cubic Feet Per Minute
CLTC - California Lighting Technology Center
CMU – Concrete Masonry Unit
COP - Coefficient of Performance
DHW – Domestic Hot Water
DOE – Department of Energy
DOE-NETL – Department of Energy-National Energy Technology Laboratory
DOT – Department of Transportation
EBDC - East Bay Development Group
EEBA - Energy & Environmental Building Organization
EERE – Energy Efficiency and Renewable Energy
EERs - Energy Efficiency Ratios
EF – Energy Factor
EGUSA – Energy Gauge USA
EPBDCA - Energy Performance of Buildings Concerted Action Committee
E-Scale - EnergySmart Home Scale
ESCos - Energy Service Companies
ESSI - Energy Structures & Systems, Inc.
FAS - Federation of American Scientists

FEMA – Federal Emergency Management Agency
FGBC - Florida Green Building Coalition
FL H.E.R.O. – Florida Home Energy and Resources Organization
FRF - Flexible Roof Facility
FSEC – Florida Solar Energy Center
GPD – Gallons Per Day
GRU - Gainesville Regional Utilities
GSHP - Ground source heat pump system
HBA - Home Builders Association
HCL - Housing Constructability Lab
HEPA - High-Efficiency Particulate Arrestance
HERS – Home Energy Rating System
HFH – Habitat for Humanity
HFHI - Habitat for Humanity International
HGTV – Home and Garden Television
HPWH – Heat Pump Water Heater
HRV - Heat Recovery Ventilator
HSPF - Heating Season Performance Factor
HUD – Housing and Urban Development
HVAC – Heating, Ventilation, and Air conditioning
IAHS - International Association for Housing Science
IAQ – Internal Air Quality
IBACOS – Integrated Building and Construction Solutions
ORNL – Oak Ridge National Laboratory
IBHS - Institute for Business and Home Safety
IBS – International Builders' Show
ICF – Insulating Concrete Form
ICS - Integrated Collector Storage
IPIA - In Plant Inspection Agency
IRB – Institutional Review Board
ISO - International Standards Organization
JCWP – Jimmy Carter Work Project
kWh/year – Kilowatt-Hour Per Year
LASBH – Louisiana System Built Homes
LED – Light Emitting Diode
LEED - Leadership in Energy and Environmental Design
LSU – Louisiana State University
MELs - Miscellaneous Electric Loads
MHLab – Manufactured Housing Lab
MHRA – Manufacture Housing Research Alliance
MMBTU – Million British Thermal Units
N.E.T.L – National Energy Technology Laboratory
NAHB-RC – National Association of Home Builders Research Center
NBS - National Bureau of Standards
NEEM - Northwest Energy Efficient Manufactured Housing Program
NFPA – National Fire Protection Agency

NIST - National Institute of Standards and Technology
NREL - National Renewable Energy Laboratory
NZEH - Near Zero Energy Home
ODOE – Oregon Department of Energy
ORNL – Oak Ridge National Laboratory
PATH - Partnership for Advancing Technology in Housing
PERC - Propane Education & Research Council
PHH – Palm Harbor Homes
PNNL – Pacific Northwest National Laboratory
PV - Photovoltaic
QII - Quality Insulation Installation
Qn,out – Normalized duct leakage to the outside calculated by dividing the measured duct to the outside at a test pressure of 25 pascals (CFM25,out) by the conditioned area of the home
R Value – Resistance (Thermal) Value
RBS – Radiant Barrier System
RCC - Royal Concrete Concepts
RESNET – Residential Energy Services Network
RH – Relative Humidity
SAA - State Administrative Agency
SBCI - United Nation's Sustainable Buildings and Climate Change Initiative
SBIR – Small Business Innovation Research
SDHW – Solar Domestic Hot Water
SEER – Seasonal Energy Efficiency Ratio
SIP – Structural Insulated Panel
SQ. FT. – Square Feet
SRCC - Solar Rating and Certification Corporation
TAG - Technical Advisory Group
TBIC - Thermal Bypass Inspection Checklist
TED - The Energy Detective
TNAH – The New American Home
TW - Tommy Williams Homes
UCF – University of Central Florida
UCFIE – University of Central Florida Industrial Engineering Department
UNEP – United Nations Environment Programme
USGBC – United States Green Building Council
UTSOA - University of Texas at Austin, School of Architecture
VIAQ - Ventilation and Indoor Air Quality
VOC - Volatile Organic Compound
(E-mailed and confirmed – not an abbreviation)
Wh –Watt-Hour
WSEC – Washington State Energy Code
WSU – Washington State University
ZEH - Zero Energy Homes

APPENDIX A – Publications, presentations, and related activities

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

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

Parker, D. "Reflective Walls," *Home Energy Magazine*, May/June 2009.

Parker, D. S. Very low energy homes in the United States: Perspectives on performance from measured data, *Energy and Buildings*, 41(5), May 2009, pp. 512-520.

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

Thomas-Rees, S., Parker, D., & Sherwin, J., "Lessons Learned in Portable Classrooms", *ASHRAE*, May 1, 2009.

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.

Parker, D. S., Sherwin J. R., & Hermelink, A. H, *"NightCool:* An Advanced Cooling Technology for Passivhaus," 13th International Passive House Conference, 17 - 18th April 2009, Frankfurt, Germany.

Parker, D. S., Sherwin, J. R., & Hermelink, A. H. *"NightCool:* An Innovative Nocturnal Radiation Cooling Concept, in Energy Efficient Cooling of Buildings," World Sustainable Energy Days, 25-29 February 2009, Wels, Austria.

Thomas-Rees, S., Chasar, D., Chandra, S., & Stroer, D., "Green and High Performance Factory Crafted Housing", Sixteenth Symposium on Improving Building Systems in Hot and Humid Climates, December 15-17, 2008, in Dallas, TX.

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

Fairey, P. "Interim Report on ISO TC 163 Working Group 3," Annual progress report submitted to *U.S. Department of Energy Building America Program*, April 2009

Lubliner, M., Fuess, C., Gordon, A., & Kingrey, W. "Zelonedom Case Study Report: "Approaching" Zero Energy in the Pacific Northwest Marine Climate," February 2009

Martin, E., Parker, D., Sherwin, J., & Colon, C. "Preliminary Performance Evaluation of a Near Zero Energy Home in Callaway, FL," Final report submitted to *U.S. Department of Energy*, February 2009

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, S., Sherwin, J., Hermelink, A., & Moyer, N. "*NightCool:* Nocturnal Radiation Cooling Concept Long Term Performance Evaluation" submitted to *U.S. Department of Energy*, December 2009

Parker, D. and Cummings, J. "Comparison of the *ENERGYGAUGE* USA and *BEOpt* Building Energy Simulation Programs," Contract Report prepared for *U.S. Department of Energy, Building America Program Office of Energy Efficiency and Renewable Energy*, August 2009

Parker, D., Sherwin, J., Hoak, D., Chandra, S., & Martin, E. "Preliminary Performance Evaluation of a Near Zero Energy Home in Gainesville, FL," Final report submitted to *U.S. Department of Energy*, February 2009

Parker, D. S., Hoak, D., & Cummings J. "Pilot Evaluation of Energy Savings from Residential Energy Demand Feedback Devices" Report submitted to *U.S. Department of Energy*, January 2008.

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

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

Stephanie Thomas-Rees was interviewed for *Builder/Architect* in story titled "Energy/Air Quality, Using the Best Gives Builders and Edge," January 2009 publications both national volumes and regional volumes.

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 occurred 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 two 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 four 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 staff 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 three 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 one 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

HFHI (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 –Case Studies

FLORIDA SOLAR ENERGY CENTER
Creating Energy Independence
PRESS RELEASE
A Research Institute of the University of Central Florida

Contact: Sherri Shields
1679 Clearlake Road
Cocoa, FL 32922
Phone: (321) 638-1019
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sherri@fsec.ucf.edu

For Immediate Release

October 21, 2009

New Home Sales Robust for Some Energy-Efficient Florida Builders

It's no surprise that in today's ailing market, new home sales are down. What *is* surprising is that construction is on the rise for six Florida homebuilders.

In partnership with one of the U.S. Department of Energy's Building America teams, led by the University of Central Florida's Florida Solar Energy Center (FSEC), these successful homebuilders are building super energy-efficient homes. They are achieving a standard met by fewer than one of every 1,000 new homes built in Florida since 2007.

Homes consume about 35 percent of the electricity produced in the United States. Homes are also responsible for more than 20 percent of the U.S. emissions of carbon dioxide, a significant contributor to global warming. Building America's goal is to develop cost-effective solutions that reduce the average energy use of housing by 40 to 100 percent.

Similar to an automobile's miles-per-gallon sticker, energy-efficient homes can have an energy-efficiency rating called the **EnergySmart Home Scale℠ (E-Scale),** which is based on the nationwide Home Energy Rating System's HERS Index. A home with an E-Scale of zero generates as much energy as it consumes on an annual basis. While most existing homes have an E-Scale of 130 or higher, typical new homes in Florida have an E-Scale of about 90.

The six Building America homebuilders are constructing all of their homes – a total of about 100 a year – at an E-Scale of 60 or lower. Each home is also an Energy Star-qualified new home.

Five of the six participating homebuilders are based in Gainesville: G.W. Robinson Builders

Inc., Tommy Williams Homes, Skobel Development, Schackow Realty and Development (Innovative Home Builders of North Florida Inc.), and H.K.W. Enterprises Inc. The sixth, LifeStyle Homes of Melbourne, builds along Florida's Space Coast in Brevard County. Each home is individually certified by Florida Home Energy and Resources Organization (Florida H.E.R.O.), an FSEC subcontractor based in Gainesville or by FSEC.

Ken Fonorow, president of Florida H.E.R.O., is largely responsible for the concentration of participating builders in Gainesville.

"Rethinking how homes are constructed makes good sense," he says. "My goal is to work with developers, builders and homeowners to improve the efficiency, health and durability of homes in the Gainesville area. I hope that others in Florida will see the tremendous value of these homes and want to do the same."

It doesn't cost a lot more to build a more energy-efficient home, particularly when the improvements are financed as part of a mortgage. The improvements produce immediate savings in utility bills, in addition to improved air quality and durability.

"The future of new home construction is energy-efficient, high-quality housing," said Subrato Chandra, FSEC's Building America program director. "The success of these builders encourages me."

In addition to FSEC's six Building America industry partners, 60 other builders in Florida and 417 nationwide have risen to this challenge.

Building America forms research partnerships with all facets of the residential building industry to improve the quality and energy efficiency of homes. The Florida Solar Energy Center, a research institute of the University of Central Florida, is the only university-led Building America team. FSEC researches technologies for highly energy-efficient homes, and also works with builders to help them design, build and sell highly energy-efficient homes.

Researchers and builders work together to select cost-effective improvements. All of the homes have a highly efficient building envelope (better insulation levels, double pane low-e windows and radiant barriers), efficient and well-engineered heating and cooling systems with tight duct systems and controlled outside air ventilation, very efficient water heating systems and compact fluorescent lighting. Energy Star appliances round out the package in many cases.

"Being a part of the Builders Challenge with our new line of Sun Smart homes is our way of doing the right thing for America's energy future," said Lifestyle Homes' Larry Hufford. "I underestimated how many people felt the same way."

For more information, visit www.baihp.org and or www.buildingamerica.gov/challenge.

About FSEC
The Florida Solar Energy Center, a research institute of the University of Central Florida, is

the largest and most active state-supported renewable energy and efficiency institute in the United States. Created by the Florida Legislature in 1975, FSEC's mission is to research energy technologies that enhance Florida's and the nation's economy and environment, and to educate the public, students and practitioners on the results of the research. Working in alternative fuels, hydrogen and fuel cells, photovoltaics, solar thermal technologies, high performance buildings, and education areas, FSEC's 140-member staff helps provide Florida with a future of energy independence and environmental sustainability. FSEC is also responsible for testing and certification of solar systems sold in the state of Florida. For more information about FSEC, please visit www.floridaenergycenter.org, or send your questions to info@fsec.ucf.edu.

G.W. Robinson Builders, Inc., Gainesville, FL – 352-373-1724, www.gwrobinson.com

H.K.W. Enterprises, Inc., Gainesville, FL – 352-377-2240

LifeStyle Homes, Melbourne, FL – 321-727-8188, www.buildingalifestyle.com

Schackow Realty and Development (Innovative Home Builders of North Florida, Inc.) – 386-454-3174, innovativehomebuilders@gmail.com

Skobel Development, Gainesville, FL – 352-224-5545, www.skobel.com

Tommy Williams Homes, Gainesville, FL – 352-331-8180, www.tommywilliamshomes.com

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PR09-10

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

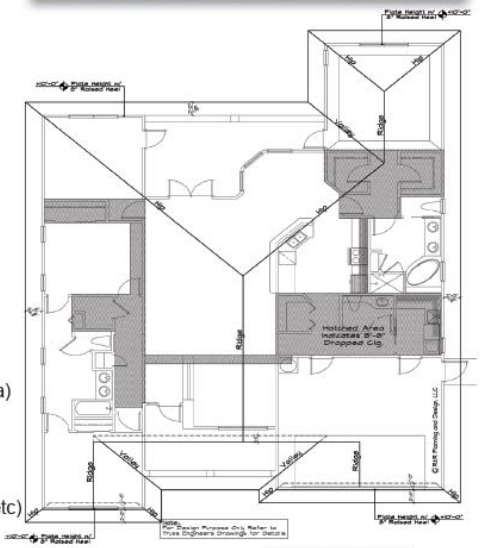
Research that Works
www.buildingamerica.gov

Tommy Williams Zero Energy Home

Gainesville, FL

ZEH Statistics
- 2,250 square feet – 3 bedrooms, 2.5 bathrooms, to be completed spring 2010

Energy Efficiency & Renewable Energy Features
- Builders Challenge Qualified– HERS/E-Scale ≤ 0 (expected)
- R-38 Ceiling Insulation (R-19 knee wall Insulation), Vented attic
- 10" Heel trusses for improved insulation coverage
- R-15 Fiberglass "Spider" Wall Insulation
- Double Pane, Low-e Vinyl Frame Windows (U=0.35, SHGC=0.25)
- ENERGY STAR® Certified Including Thermal Bypass Checklist Compliance
- ACCA Manual D Sized Duct System, Sealed With Mastic At Joints
- Ducts and air handler inside conditioned space
- ACCA Manual J Sized Heating/Cooling Equipment
- High Efficiency Heat Pump (HSPF 9.2, SEER 16)
- 100% Compact Fluorescent Bulbs
- 6.75kWp Sunpower 225 PV System (inverter avg. eff. = 0.97)
- Solar domestic hot water system (64 sq. ft. collector)



Indoor Air Quality & Noise Reduction Features
- Outside Air "Run-time" Ventilation System
  - When furnace or air conditioner compressor is running, creating beneficial positive pressure in the house to minimize intrusion of outside humidity and dust
  - Filtered outside air is mixed with house air in return plenum
  - Passive System - no moving parts to maintain
  - Can be disabled if necessary (such as when there's a fire in the area)
- Ducted exhaust fans in kitchen and bath rooms to remove humid air
- Duct System Air Tightness Tested
- Air Handler and Ducts in Conditioned Space (hatched area of floor plan indicates dropped ceiling for ducts)
- Air Sealing to Reduce Infiltration (outside air, pollen, dust, soil gases, etc)
- FGBC (Florida Green Building Coalition) Certified Home (expected)

Systems Engineering by BAIHP
- Simulation analysis to identify cost effective net zero (annual) energy package
- Scope of work developed for the mechanical and solar contractors

florida H.E.R.O.

Builders Challenge
Recognizing Energy Leadership in Homebuilding

FLORIDA SOLAR ENERGY CENTER
Florida Solar Energy Center leads the Building America Industrialized Housing Partnership Consortium

TOMMY WILLIAMS
HOMES BUILT FOR THE FUTURE

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Building Technologies Program

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

Note – this back page is the same for all of the case studies produced in BP4. It is only included once to save space.

Visit our Web sites at:

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

Building America U.S. Department of Energy

PATH

ENERGY STAR

Building America Program
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Building Industry Research Alliance (BIRA)
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Building Science Consortium (BSC)
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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)
Subrato Chandra • Florida Solar Energy Center • 1679 Clearlake Road • Cocoa, FL 32922 • 321-638-1412 • fax: 321-638-1439 • e-mail: subrato@fsec.ucf.edu • www.baihp.org • IHP provided technical and on-site support for PHH and TNAH '08

National Renewable Energy Laboratory
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Pacific Northwest National Laboratory
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Tommy Williams Homes
Todd Louis • 2563 SW 87th Drive, Suite 10 • Gainesville, Florida 32608 • (352) 331-8180 • (352) 331-8179 fax • e-mail: todd@tommywilliamshomes.com • www.tommywilliamshomes.com

Produced for the U.S. Department of Energy (DOE) by Florida Solar Energy Center and the National Renewable Energy Laboratory.
FSEC-BAIHP-18 October 2009

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

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

Research that Works
www.buildingamerica.gov

Nationwide Custom Homes – Osprey – "EcoCottage"
2010 International Home Builders' Show
Las Vegas, NV

Osprey Statistics
• 513 square feet, 1 bedroom, 1 bath

Energy Efficiency & High Performance Features
- ENERGY STAR, Low E windows (U=0.29, SHGC=0.19)
- R=21 walls, R=19 floors, R=50 ceilings
- 15.5 SEER /8.5 HSPF variable refrigerant, duct less HVAC
- ENERGY STAR appliances
- Tankless water heater
- Extensive use of controlled compact fluorescent & LED lighting
- Expected to meet Builders' Challenge Standards

Indoor Air Quality & Noise Reduction Features
- VOC source control including zero VOC paint
- Outside air ventilation
- Ductless HVAC system
- Air filtration and cleaning system
- Central vacuum system

NATIONWIDE Custom Homes

Other Green Building Features and Certifications
- Low flow faucets & showerheads with supply "runs" no more than 20 feet
- Termite & weather resistant siding
- Resource efficient modular construction & construction waste management
- Expected to meet Bronze level in all sections except lot design, preparation and development per the new NAHB National Green Home Building program
- Non-HCFC refrigerant HVAC system
- PV & Solar Hot Water "ready"
- "Growable" (modules can be added for growing family)
- Builder is Building America Partner and Builders Challenge Participant

FLORIDA SOLAR ENERGY CENTER
Florida Solar Energy Center leads the Building America Industrialized Housing Partnership Consortium

CALCS-PLUS

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Palm Harbor Homes – Highlander – "Traditional" Home
2010 International Home Builders' Show
Las Vegas, NV

Highlander Statistics
• 2,292 square feet, 3 bedroom, 2.5 bath

Energy Efficient & High Performance Features
- ENERGY STAR Low E Windows (U=0.29, SHGC=0.29)
- R=19 walls, R=21 floors, R=38 ceilings
- 15 SEER /8.5 HSPF packaged heat pump
- Duct system performance tested
- ENERGY STAR appliances
- Tankless water heater
- Extensive use of compact fluorescent lighting
- Expected to meet Builders' Challenge Standards with an Energy Smart Home Scale (E-Scale) = 62

Indoor Air Quality & Noise Reduction Features
- VOC source control including zero VOC paint
- Phenol & formaldehyde free insulation
- Outside air ventilation
- Duct system sealed with mastic & fiberglass mesh
- Air filtration and cleaning system
- Central vacuum system

Other Green Building Features and Certifications
- Class 1 (A) fire rated siding
- Earth-friendly pest control with mold preventative
- Resource efficient modular construction & construction waste management
- Expected to meet Bronze level in all sections except lot design, preparation and development per the new NAHB National Green Home Building program
- Non-HCFC refrigerant HVAC system
- California Title 24 compliant
- Builder is Building America Partner and Builders Challenge Participant

Palm Harbor Homes

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

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

Research that Works
www.buildingamerica.gov

Palm Harbor Homes – La Linda Home
2010 International Home Builders' Show
Las Vegas, NV

La Linda Statistics

• 2,140 square feet, 3 bedroom, 2 bath

Energy Efficiency & High Performance Features

- ENERGY STAR, Low E windows (U=0.29, SHGC=0.29)
- R=19 walls, R=21 floors, R=38 ceilings
- 15 SEER /8.5 HSPF packaged heat pump
- Duct system performance tested
- ENERGY STAR appliances
- Tankless water heater
- Extensive use of compact fluorescent lighting
- Z-wave (wireless) technology for remote, energy & access home management
- Expected to meet Builders' Challenge Standards with an Energy Smart Home Scale (E-Scale) = 67

Indoor Air Quality & Noise Reduction Features

- VOC source control including zero VOC paint
- Outside air ventilation
- Duct system sealed with mastic & fiberglass mesh
- Air filtration and cleaning system
- Central vacuum system

Other Green Building Features and Certifications

- Low flow faucets & showerheads
- Class 1 (A) fire rated siding
- Resource efficient modular construction & construction waste management
- Expected to meet Bronze level in all sections except lot design, preparation and development per the new NAHB National Green Home Building program
- Non-HCFC refrigerant HVAC system
- California Title 24 compliant
- Builder is Building America Partner and Builders Challenge Participant

Palm Harbor Homes

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April 23, 2009

Building America SM
U.S. Department of Energy

Research that Works
www.buildingamerica.gov

RESNET Rater Volunteers with Habitat for Humanity in Greenville, South Carolina

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.

Free Home Energy Ratings for Habitat for Humanity Affiliates

In 2007, Building America researchers partnered with RESNET (a national standards making body for building energy efficiency rating systems) whose members are encouraged to volunteer with Habitat for Humanity by providing free home energy ratings to their local Habitat affiliate. Todd Usher, a Volunteer RESNET Member and president of Addison Homes, works with Habitat in Greenville, South Carolina as a way of giving back to the community, networking, and raising awareness of energy efficiency and green building.

Usher encouraged Greenville Habitat to consider energy efficient, green building and "house as a system" thinking, and provided them with a baseline evaluation of their energy features – which achieved a HERS Index of 100. He took affiliate leaders from Greenville to visit the Atlanta Habitat affiliate where they build homes that are Energy Star and Earth Craft (green home) certified.

When Greenville Habitat received two free lots with the stipulation that they build Earth Craft green certified homes on each, Usher recommended volunteer-friendly improvements that would take the "path of least resistance" to reaching the Energy Star and Earth Craft standards (see bulleted list below.) Usher points out that volunteers excel at caulking and other air sealing tasks – an important part of gaining control over household air flow and heat loss. After completing their two required houses, Greenville Habitat decided to build all of their houses to this high standard, and they have completed more than 15 houses. HERS indices range from 72 to 84.

RESNET
Residential Energy Services Network
www.natresnet.org

ADDISON HOMES, LLC
Todd Usher
864-848-2667
www.addison-homes.com

Volunteer Energy Rater – Habitat for Humanity – RESNET

Read more about this Partnership:
www.natresnet.org/rater/partnership

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 Air Conditioning
- Sealed and Tested Ducts
- Duct Leakage less than 5%
- Energy Star Refrigerator
- Energy Star Dishwasher
- HVAC Integrated Outside Air Ventilation

Enclosure

- R-38 Ceiling Insulation
- R-13 Wall Insulation
- R-19 Floor Insulation
- Energy Star Windows
- Extensive Air Sealing
- Insulated Exterior Corners

Original HERS Index = 100 (85 or less required for Energy Star)
Improved HERS Index = Ranges from 72 to 84

Durability features

- Erosion control site plan
- Engineered roof framing
- Integrated drainage plane
- 30-year roof shingles
- Posted job site waste management plan
- Kitchen exhaust fan vented to outside
- Alternative termite treatment (borate)
- Review energy operations with homeowner

April 30, 2009

Building AMERICA SM
U.S. Department of Energy

Research that Works
www.buildingamerica.gov

RESNET Rater Volunteers with Habitat for Humanity in Cincinnati, Ohio

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.

Free Home Energy Ratings for Habitat for Humanity Affiliates

In 2007, Building America researchers partnered with RESNET (a national standards making body for building energy efficiency rating systems) whose members are encouraged to volunteer with Habitat for Humanity by providing free home energy ratings to their local Habitat affiliate. RESNET Member, Homes+, Inc. in Cincinnati, Ohio stepped forward to work with TriState Habitat, a single nonprofit corporation merging nine Habitat for Humanity affiliates in Ohio, Indiana, and Kentucky.

Holly Todd, Operations Manager of Homes+ Inc. reports that the house leaders are very competitive and present her with their air sealing details when she arrives to test their homes. Under Construction Director Randy Wilkerson, the Habitat affiliate builds homes to specifications that deliver an average HERS Index of 60.3.

Habitat builds homes with volunteers, including Habitat's home buyers, completing most of the work. Ms Todd notes that hundreds of volunteers learn about energy efficiency, insulation, and air sealing on TriState Habitat's job sites. She will lead TriState Habitat's first Women's Build home which will also be their first Green certified home.

Organizational Commitment

Wilkerson drafted an illustrated "Energy Efficient Home Construction Manual" that details construction procedures for many aspects of their building science approach. Details include moisture management, air sealing, advanced framing, duct sealing, and installing batt insulation, rigid insulation, house wrap, window and door flashing. The manual also describes that building Energy Star homes is a board approved policy.

By assisting this Habitat for Humanity affiliate, Homes+ Inc. is helping to raise expectations of affordable housing performance and giving back to the community in a way that draws on their extensive expertise.

RESNET
Residential Energy Services Network
www.natresnet.org

HOMES +, INC.
Your Professional Connection for Home Testing Services
P.O. Box 43497 • Cincinnati, OH 45243
Barb Yankie: 513-272-2005
Holly L. Todd: 513-477-0130

VOLUNTEER ENERGY RATER
Habitat for Humanity
RESNET

Read more about this Partnership:
www.natresnet.org/rater/partnership

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

- Manual J System sizing
- 90+ AFUE gas furnace
- SEER 13 straight cool
- Programmable Thermostat
- Sealed and tested duct work
- Tankless gas water heater
- Compact fluorescent bulbs

Enclosure

- Advanced Framing with R-19 wall insulation
- ½" exterior rigid insulation with taped house wrap
- Double pane, argon filled, Low-e windows
- Air sealing & thermal bypass checklists
- R-38 blown in ceiling insulation; R-30 floor insulation over unconditioned space

Average HERS Index = 60.3 **Average estimated annual energy savings** = $450

The Gainesville Sun
October 19, 2009 www.gainesville.com

Energy efficiency a star attraction

Homes with green amenities that offer savings over the long haul proving appealing

AARON E. DAVE/STAFF PHOTOGRAPHER

David Cannon, right, of One Stop Painting and Floor Covering climbs a ladder to continue painting a zero-energy home under construction in the Longleaf Village subdivision.

By Anthony Clark
Business editor

Matt and Tiffany Thomas wanted a charming older home in the Duck Pond area or near the University of Florida campus, but the homes they found needed a lot of repairs, and they would have had to put money in reserve for fixes or a new roof.

They then attended a presentation about new energy-efficient homes and were swayed by the savings in monthly utility bills.

"It dawned on us — what were we thinking getting into something older?" Tiffany Thomas said. "It was a relief to be able to find something to provide us with lower electric bills and water bills."

After moving into a new 2,100-square-foot home in the Longleaf Village subdivision last year, she said their utility bills are about the same as in their previous 1,500-square-foot home.

As a Realtor, Thomas said she sees a lot of home

HOMES *on Page 4A*

ENERGY STAR FOR HOMES

A program of the U.S. Department of Energy and Environmental Protection Agency.

Qualifying homes have 85 or lower HERS in hot climates, 80 or lower in temperate zones.

19,917: qualified in Florida.

2,331: in Gainesville.

HERS INDEX

(Home Energy Rating System)

- **Score of 100** equals the energy efficiency of a typical code-built home, determined by independent energy auditor.
- **Score of 50** equals 50 percent more efficiency.
- **More certified energy-efficient homes in Gainesville and the tax credits and rebates available, 4A**

ES: City long at forefront of green building

d from 1A

through the same
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with new energy-effi-
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Williams Homes is
wer high-cost solar
y spending more to
e home more efficient as
n ongoing project to
t a home in Longleaf
s net zero energy, Vice
nt Todd Louis said.
sville has long been at
front of the green
movement.
sville developer Howard
said he built the first
Star home in the state in
-1980s. According to the
program, he has since
) Energy Star homes in
. The latest is a modular
his Villas at 39th
ment off North Main
nd 39th Avenue with a
nergy Rating System
score of 57, meaning it
percent of the energy of
age code-built home.

ARON E. DAYE/STAFF PHOTOGRAPHER

Todd Louis, center, vice president of Tommy Williams Homes, gives Sean McLendon, sustainability program manager with the County Commission, a tour of the new zero-energy home Louis' company is building at the Longleaf Village subdivision on Thursday.

Louis said the Mentone subdivision built in the Kanapaha area more than 10 years ago was the first Energy Star community in the nation. At the time, he was in sales for the developer, Atlantic Designs.

Of 162 homes built and sold in Florida under the Department of Energy's Builders Challenge program, 126 are in Alachua County. Qualifying homes use 70 percent or less of the energy of the average home. Of 65 builders in the state participating in the program, 14 are in Gainesville.

Gainesville has 2,331 Energy Star homes that use 85 percent or less of the energy of an average home.

The Brytan subdivision has three homes certified by the U.S. Green Building Coalition's Leadership in Energy and Environmental Design (LEED) for Homes program with two more pending, and has started a new program that will allow residents to monitor and compare energy and water use. Builders also are guaranteeing energy savings.

Wallace said energy efficiency was not a big selling point for a long time, but energy waste has long been one of his pet peeves.

"The largest energy consumer in our country is still our homes, so this is really important," he said.

His early customers tended to be professors and engineers who understood the science, and people concerned about the environment.

Energy efficiency has become more of a selling point in new homes among more people over the past four years, builders say.

"Since global warming has become so generally understood, coupled with this energy crisis and amplified by the financial crisis, everyone has an awareness that maybe that's something they need to look at," Wallace said.

"For the longest time, it was hard to get people to listen to the energy features," Louis said.

When Tommy Williams, his current employer, held a groundbreaking on its zero-energy home in February, Louis said he was questioned about it nonstop for four hours and that interest continues to be "off the charts."

According to the Department of Energy, eight zero-energy homes have been built, sold and certified so far in the U.S.

As more builders jump on the green bandwagon, the early adopters are doing more to distinguish themselves. G.W. Robinson and Tommy Williams Homes have built more Builders Challenge homes than all the other builders in the rest of the state combined and have committed to building homes that all meet Energy Star standards.

"We have to pay attention to the competition and are keenly aware that everybody has stepped up," Louis said. "It's forced us to continue to improve as well."

Tommy Williams has been offering to pay its customers' first year of utility bills, with about 30 takers so far.

"It's a way of backing up what we're saying, to differentiate ourselves from the 'greenwashing' that's going on from everybody claiming energy-efficient homes because they have one energy product in their home," Louis said.

Tax credits and rebates

- Federal tax credits are available to new home buyers for 30 percent of the cost of geothermal heat pumps, solar panels, solar water heaters, small wind energy systems and fuel cells.
- Home builders are eligible for a $2,000 federal tax credit for a new home that achieves 50 percent energy savings for heating and cooling.
- Producers of new manufactured homes are eligible for a $1,000 federal tax credit for achieving 30 percent energy savings for heating and cooling.

GAINESVILLE REGIONAL UTILITIES REBATES FOR NEW HOMES

- Efficient central air conditioning, up to $550.
- Natural gas tankless water heater, gas furnace, range and dryer, up to $750; or maximum $500 for solar water heater.
- Efficient pool pump, up to $350.

Certified energy efficient homes

DEPARTMENT OF ENERGY BUILDERS CHALLENGE

Qualifying homes have 70 or lower E-Scale.

1,835: certified nationwide (built, sold, occupied and certified).

162: in Florida.

126: of those in Alachua County.

77: by G.W. Robinson Builder.

39: by Tommy Williams Homes.

5: by Skobel Development Inc.

5: by Spain & Cooper Construction.

U.S. GREEN BUILDING COUNCIL'S LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN LEED FOR HOMES PROGRAM

Point system based on number of green amenities in house, property and community, including Energy Star for Homes qualifications.

27: in Florida.

3: in Gainesville, all in the Brytan development.

2: by Tony Sullivan Construction.

1: by Loren Spies Construction.

NATIONAL ASSOCIATION OF HOME BUILDERS RESEARCH CENTER CERTIFIED

- Different levels of green certification based on points for various green amenities and construction practices.
- Starts at 85 percent energy efficiency compared to a typical home for bronze up to 40 percent for emerald.

FLORIDA GREEN BUILDING COALITION CERTIFIED

- Point system based on number of green amenities in house, property and community.
- More than 260 certified in Florida in 2009 through Sept. 17
- One in Gainesville, built by Ivan Solbach Company, with second-highest score in the state.

G.W. Robinson Builders, Inc. Case Study Originally Compiled in 2007, Updated in 2008

Communities (Data as of2009):

CobbleField –	Build out 265 homes, 265 completed
Turnberry Lake –	Build out 186 homes, 100 completed
Garison Way –	Build out 110 homes, 45completed
Total –	Build out 561 homes, 410 completed

(Note: Production numbers updated to reflect progress made in 2009)

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 1 through Figure 4) 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 1: *Cobblefield Home*

Figure 2: *Turnberry Lake Home*

Figure 3: *Cobblefield Site Plan*

Figure 4: *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 1. All of the homes built to these specifications achieve a HERS '99 score of 88.6 or better (HERS Index scores of 68 or lower).

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

All of the homes are individually performance tested as part of a commissioning (quality assurance) process. Simulation analysis shows these homes to be approximately 35% to 41% better than the benchmark with savings in all categories except appliances and plug loads (plotted in Figure 5 for a sample home saving 38.9% overall).

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

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 5 below for air handler cost benefit.

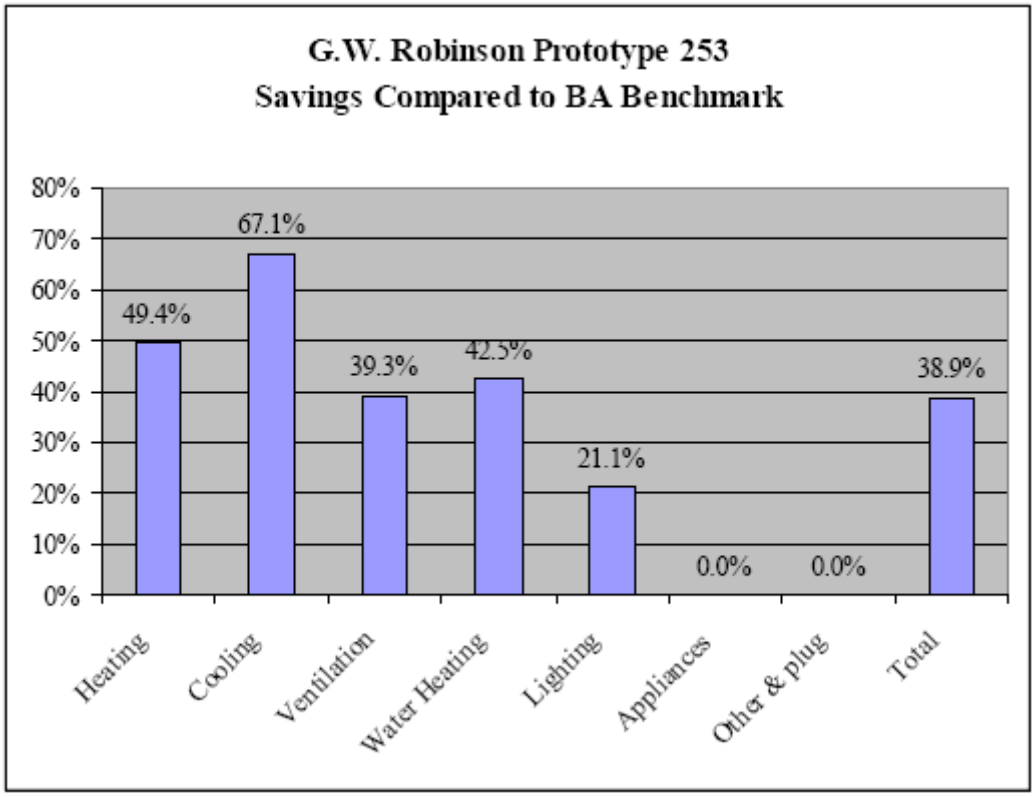

Figure 5 Source energy end use savings

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 6). 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 7 shows the view looking up at the ceiling of the air handler closet before the air handler has been set. The supply trunk line on the right will be attached to the top of the air handler while the return trunk on the left will be connected to the return plenum below the up-flow

Figure 6: *Exterior walls around air handler isolate closet from garage, create valuable conditioned square footage.*

Figure 7: Air barrier in top of air handler *closet created with duct board by the mechanical contractor at the time that the ducts are installed.*

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 7) 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 8). 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).

Figure 8 *Outside air* **ventilation system details**

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.

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 from 2007

Communities:

Longleaf Village: Build out: 275 homes,: 120 Completed
(Additional 275 lots allocated to a non-Building America builder.)

Belmont - Build out: 151 homes 59 Completed
(Additional 40 lots allocated to a non-Building America builder.)

Total *Build out 426, 179 Completed*

(Note: Production numbers updated to reflect progress made in 2009.)

Builder: Tommy Williams Homes

Location: Near Gainesville, FL in Alachua county.

Background

Tommy Williams has been building homes (Figure 9, 10, and 11) 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 9 *Tommy Williams Homes*

Figure 10 *Site plan for Phase 2 in Belmont. Pink sites allocated to Tommy Williams Homes. Sales comparison with non-BA builder (purple sites) included in "Energy Efficiency and Cost Neutrality" below.*

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

Energy features are delineated in Table 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 12).

Figure 11 Floor plan for Tommy Williams Homes' Mattair Model

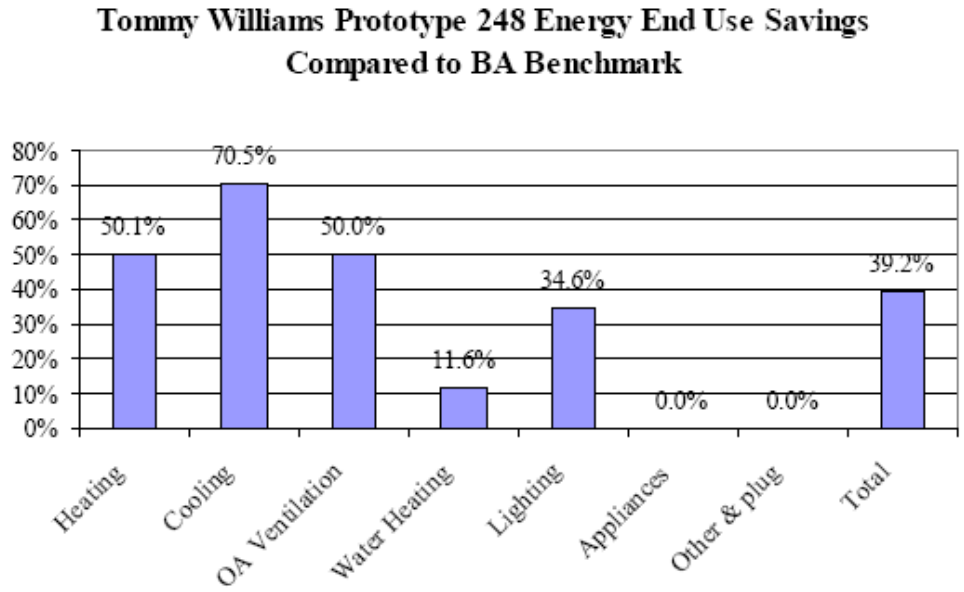

Figure 12 **Estimated annual source energy savings by end use. Note significant reduction in heating and cooling energy use**

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

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

Value Added Innovations

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

Figure 13 Details reduce framing fraction and improve comfort.

Both builders are also using advanced framing techniques that result in lower framing fractions (Figure 13 and Figure 14) 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 14 *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 15.) 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 16.) Outside air is only drawn when the mechanical system is running. It is outfitted with a pressure actuated damper with a manual override.

Figure 15 **Outside air intake boot in porch ceiling at front door**

Figure 16 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 industry partner. One realty company handles all sales. 2005 and 2006 sales data for both builders are shown in Figure 17. 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.

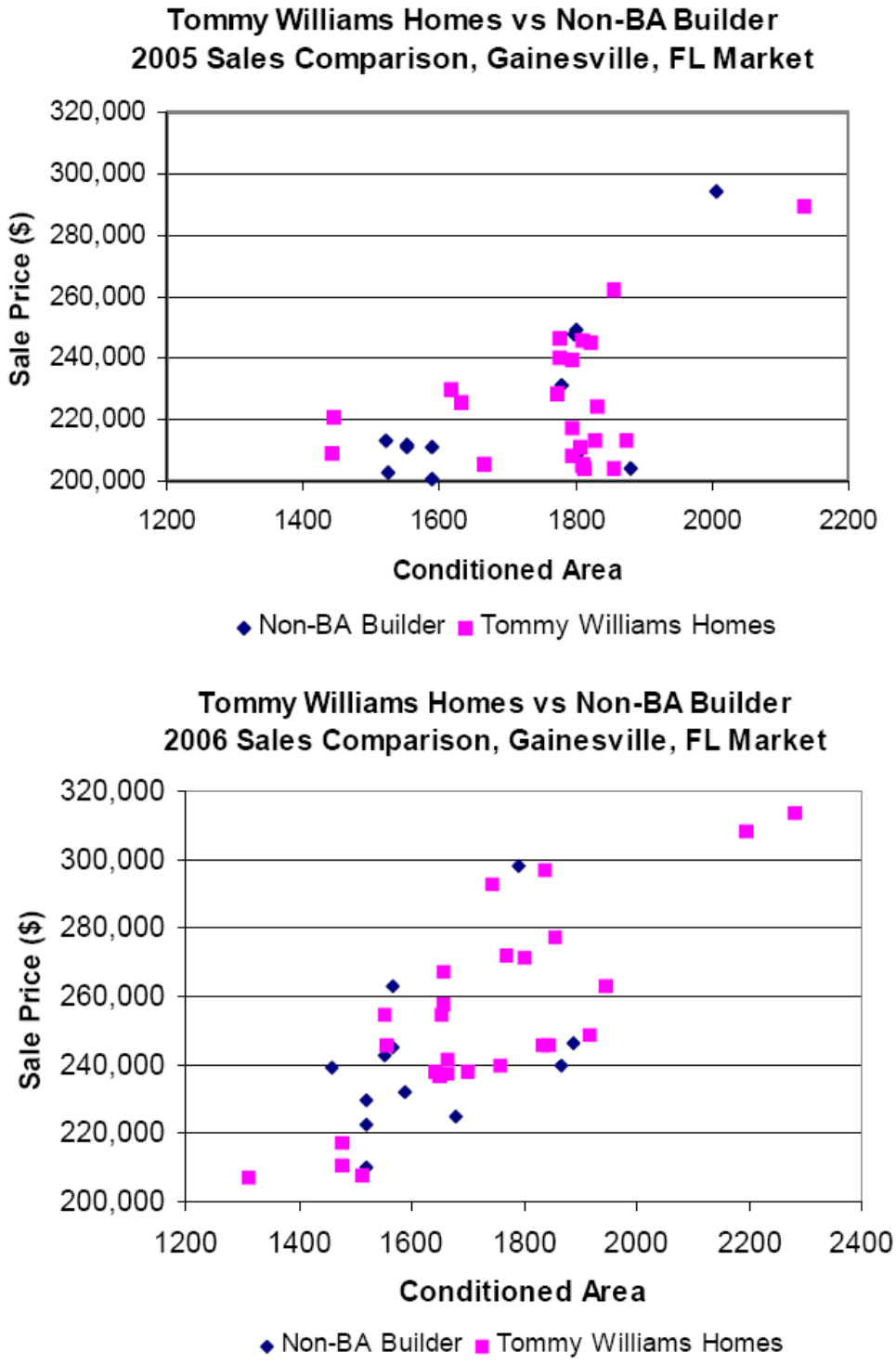

Figure 17 Sales data for Tommy Williams (squares) and non-BA builder in same subdivision (diamond)for 2005 (top) and 2006 (bottom).

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 versus 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.

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

November 2008 – October 2009

Michael Lubliner
Andy Gordon
Todd Currier
David Hales
Chris Fuess
Luke Howard

Task Area 2 – Test House Evaluations

Garst Residence

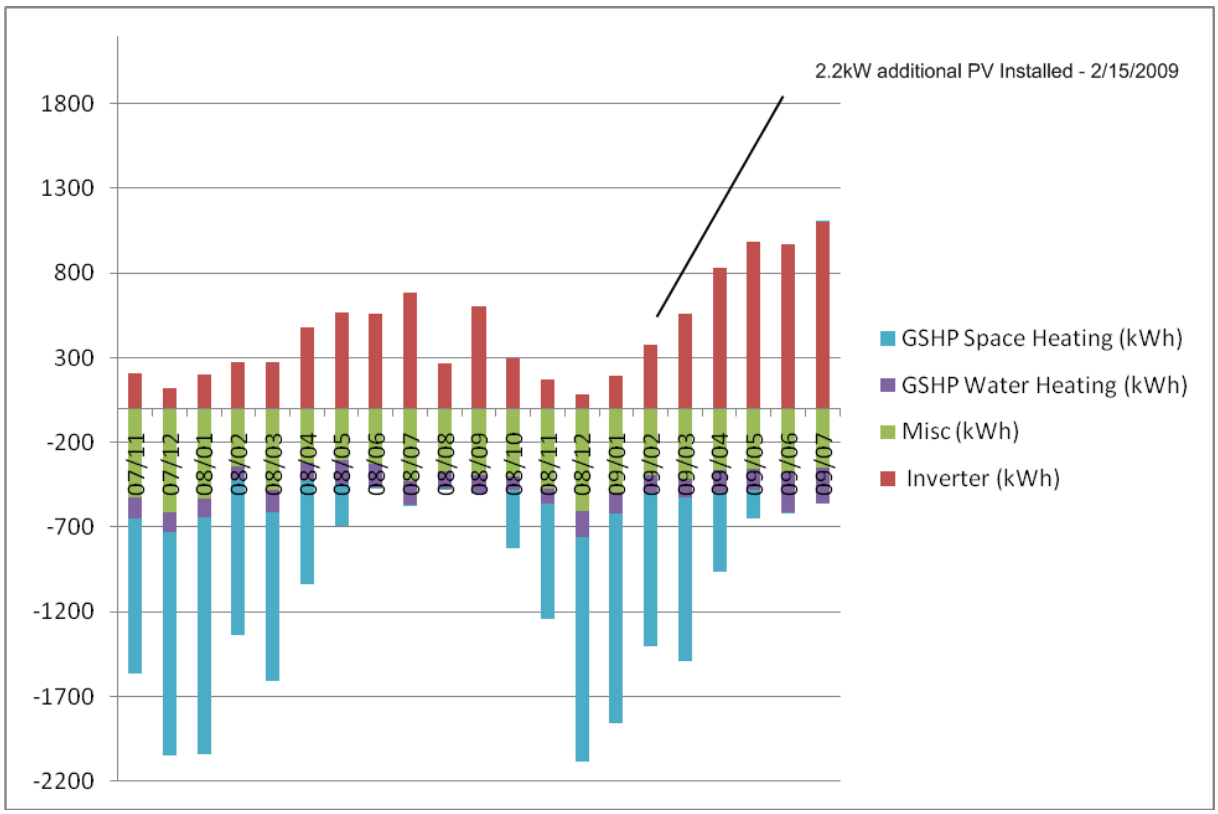

Figure 1 – Garst residence, monthly energy use, including PV to grid, November 2007-July 2009

The Garst residence is a 2400 ft.^{2} home built in Olympia, Washington, designed to benchmark at 55% - 68% whole house site and source savings respectively. The Northwest Energy Star qualified home features a ground source heat pump supplying domestic hot water and heat to an R-15 radiant slab, Energy Star lighting and appliances, solar sunspace, central energy recovery ventilation with air filtration, a tankless hot water heater for the 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. The Garst residence was featured in a Building America Best Practices Case Study, "High-Performance Home Technologies: Solar Thermal & Photovoltaic Systems," written by Pacific Northwest National Laboratory and Oak Ridge National Laboratory in 2007.
Initially, the home included a 4.5 kW photovoltaic array; an additional 2.2 KW (a roughly 50% increase) was installed in early 2009. In 2008, Total electric use (without PV) was 12898 kWh; total use after total PV was 8451 kWh. The photovoltaic system is performing well at 4444 kWh, (987 kWh per kW of installed PV.) Once all of 2009's utility data is available, a comparison between performance of the home with the initial amount of PV and the additional 2.2 KW will be possible; WSU will provide that comparison in a BTECC paper, to be completed in winter of 2010, and presented in December of 2010.

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 total PV production along with GSHP space, water heating and other misc loads.
As part of the Stagegate effort, *EGUSA Version 2.8* was used to evaluate the source energy savings of the net zero energy home design, and compared to the monitored energy use for a year's worth of end load data.

Characteristic	**Annual Electricity Use (kWh)**
Benchmark Total Energy Use	25182
Garst: (simulation w/o PV)	12027
Garst (monitored)	12704*
Garst (simulation w/PV)	7787
Garst (monitored)	8237**
Garst Savings: Simulated w/o PV	13155
Garst Savings: Simulated w/PV	16945

* compare to 12898 kWh utility data noted above; discrepancy between these numbers was due to data loss

** compare to 8451 kWh utility data noted above; discrepancy also due to data loss.

While there seems to be overall agreement, a number of factors need to be considered when comparing the predicted versus measured energy use:

- Net of PV power produced was roughly: 3800 kWh simulated; 4900 kWh measured with 2100 to home and 2800 to grid (for 4.5kW system in year 2008.)
- Measured space heating was 6786 kWh while simulation estimated 4320.
- Measured DHW was 1394 kWh while simulation estimated 909 kWh.
- Measured "Other" non space and DHW use was 5021 while simulation estimated 6114 kWh

The initial 4.5 KW PV array delivered 2113 kWh/year to the house, and 2841 kWh/year to the utility. The forthcoming BTECC paper will include an updated assessment of this house to grid ratio following installation of the additional PV.
In 2008, total miscellaneous loads were 4956 kWh. BAIHP staff decided to install a logger on Garst's media center to determine its impact on these loads. Monitoring indicated that the media center used 566 kWh per year, approximately 350 kWh of which was in standby mode, associated with the TIVO and cable boxes. Each of these devices draw 20 watts; neither can be shut down without requiring significant subsequent startup time. WSU are working with the homeowner and the local media center retailer to use timers to offset this problem, turning on at a time appropriate to anticipate this ramp-up. Garst rarely uses the TIVO and will shut it off most of the time.
After the data logging equipment is removed, the plan is to install a TED 5000, allowing Garst and BA to conduct on-going monitoring of these loads. Previous attempts to use a TED 2000 were unsuccessful, due to multiple meters and PV net metering. The TED 5000 should resolve these issues (see http://www.theenergydetective.com/ted-5000-features.html for features of TED 5000.)

After a few months, Garst decided to turn off the ducted ventilation system and rely only on the spot exhaust ventilation system because:

- The envelope was not as tight as anticipated (around 4.0 ACH@50PA.)

- They perceive no added value in air tempering, filtering and mixing.
- No significant humidity levels observed with 2 occupants.
- Central air handler with filter and ERV fans uses almost 300 watts when running
- Noise of the ERV and air handler

From 2007 - 2009, BAIHP staff have been analyzing and optimizing the performance of 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. Weekly average COP results for predominantly water heating are shown in **Figure 2**. COP is determined assuming a range of 8 to 12 GPM on the earth loop (dark blue) and (red). The measured operating flow rate was found to be around 10 GPM. In both cases, the COP includes the energy of compressor and all system pumps, but does not include standby losses of storage tanks and distribution systems or cycling losses. Analysis of COP estimates suggest highest COP during winter months, when space heating is the predominate load, and lowest COP during water heating only mode. The radiant floor system started up in the beginning of Oct 2008. COP tends to track with radiant floor pump run-time (green), earth temperature difference (purple) and weekly energy GSHP consumption (light blue).

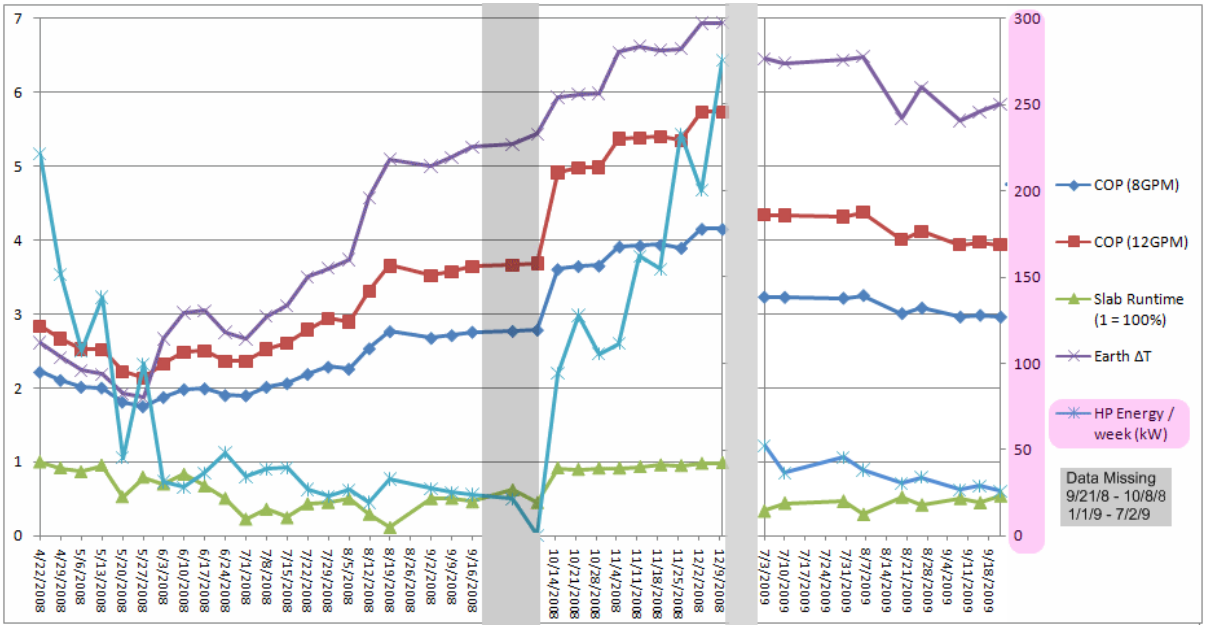

Figure 2 – Garst residence, ground source heat pump COP

Detailed heat pump data can be found at: http://energy.wsu.edu/BAIHP-WSU/COPCalc20080930a.xls

The Garst Stagegate report can be found at: http://www.baihp.org/PUBS/pdf/BAIHP-WSU-zelonedom.pdf.

BAIHP staff are in the process of evaluating COP performance during the space heating season, where it tends to be to be higher, due to lower slab water heating temperature requirements.

BAIHP staff have evaluated 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,** 636 kWh/year is provided from the sunspace during the heating season. Whenever the sunspace exceeds the house temperature, the supply fan operates. The heating benefit to the house is indicated in blue, and the supply fan energy used (48 kWh/year) is indicated in red. During the non-heating months an exhaust fan is used to remove heat from the sunspace (shown in green); this fan used 84 kWh/year.

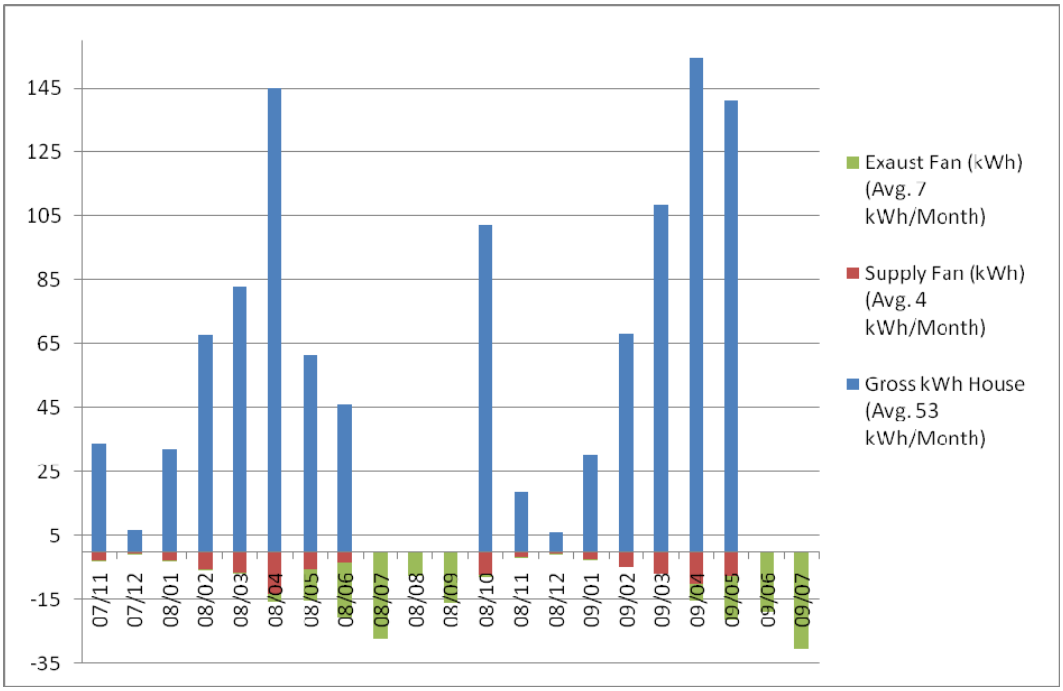

Figure 3 – Garst residence, monthly solar sunspace operation

Scott Homes

Scott Homes is a production and custom home builder in Olympia, Washington, emphasizing green and energy efficient construction techniques. A Building America industry 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.

Since 2005, BAIHP staff have worked with Scott Homes on 24 homes built in Washington's south Puget Sound; 21 of these homes qualified for Energy Star certification, 15 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. Through 2008, Scott Homes' Energy Star Homes' average air leakage was 2.75 ACH_{50}, with two homes achieving 1.5 ACH_{50}; complete SIP non-custom homes continue to show this high level of performance.

Homes that were other than complete SIP construction (largely custom homes) had more of a challenge in maintaining air tightness – the home seen in **Figure 4** was constructed using a hybrid truss roof, and was built over a crawlspace instead of a slab. As the infrared image indicates, the SIP panel connections to the building trusses provide an air leakage pathway not

present in all-SIP construction. The home in question tested at 3.1 ACH_{50}; very good compared with many code and Energy Star homes, but leakier than Scott Homes has come to expect. This problem is being investigated by Scott Homes' quality assurance staff, working with SIPA and WSU.

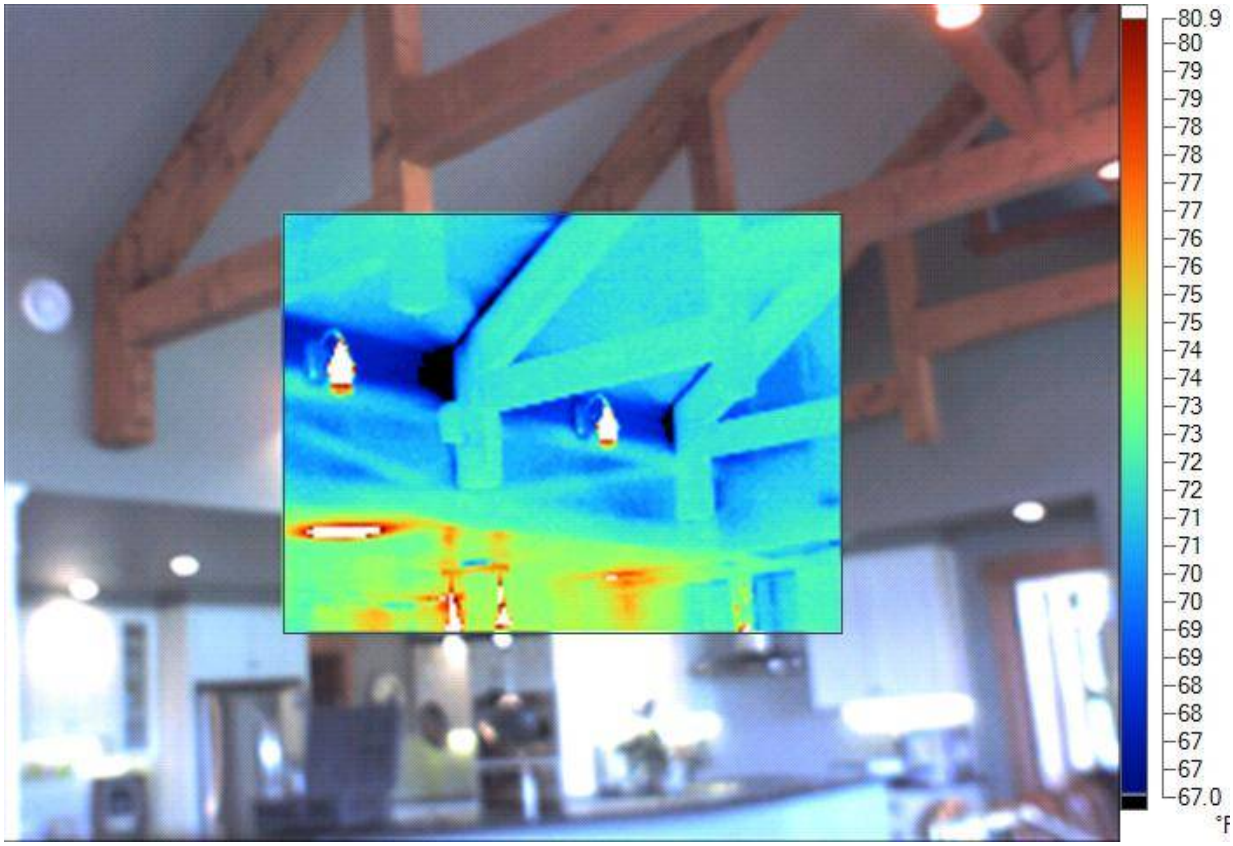

Figure 4 – Air leakage detail, Scott Homes

Since 2007, BAIHP staff have provided technical assistance on three Bungalow homes built by Scott 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. WSU staff worked with the local utility (Puget Sound Energy) to provide 15 minute data for electric use and hourly data for gas use.

Monitoring of the homes' supplementary electric resistance heat in the upstairs bedrooms took place 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, over two heating seasons. The final Stagegate presentation is planned for 2010, and will include benchmarking, regression analysis on gas and electric use, an assessment of indoor temperature and RH, HRV performance, and occupant satisfaction. Higher combo-system energy performance can be achieved

condensing tankless water heater (EF=.96) as compared to the non-condensing tankless water heater used (EF=.84). As a result, Scott is planning the use of these higher efficiency units in new BAIHP projects.

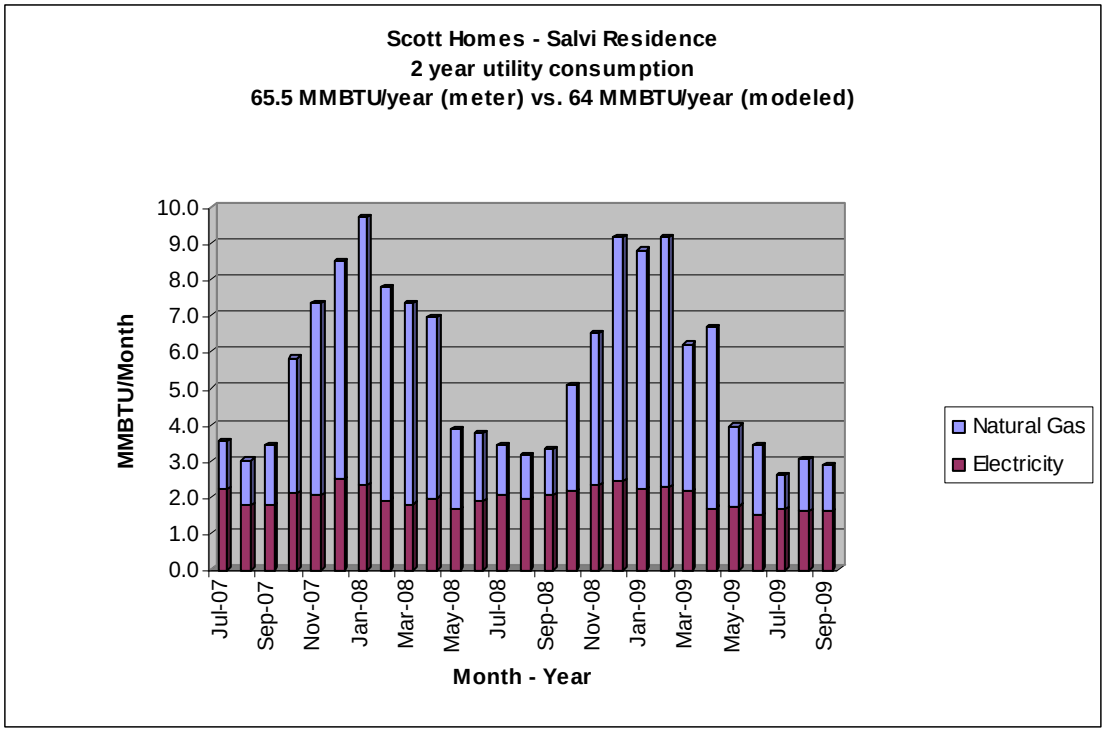

Figure 5 - Scott Homes, gas and electric utility usage (2007-2009)

At the 2009 Energy Value Housing Awards (EVHA), Scott Homes' was given the Builder of the Year award, all the more significant since Scott was a first time entrant. According to the 2009 EVHA magazine (http://www.nahbrc.com/evha/2009-evha-mag.pdf):

EVHA judges described Scott Homes as "doing it all very well but constantly looking for ways to improve." There were discussions about how the company "flawlessly and seamlessly" incorporates energy efficiency and green aspects into its construction while doing "a really good job of improving its process and incorporating what it is learning."

The increased visibility from the award led to a tour of Scott Homes for WA state senators and staff, as well as BAIHP staff. During the tour, Scott Homes pressed for the need to have energy efficiency recognized as an added value during the appraisal process.

Scott Homes is working closely with WSU and BAIHP partner SIPA, to further document these current projects and planning for future projects (both test homes and community projects.)

Stamets Residence

Figure 6a, 6b - Stamets ground source heat pump earth loop charge, and heat pump water heater

The Stamets residence is a 5000 ft.^{2} custom home, constructed in 2005-06 in Shelton, Washington. The home, which is designed to achieve a 50-60% Building America benchmark, features a ground source heat pump (**Figure 6a -** installed at the end of 2008 – monitoring is underway) for hydronic radiant floor and DHW heat, and zonal ceiling radiant heat panels. The home was built with Energy Star windows, lighting and appliances, HRV and HEPA filtration, a heat pump water heater, (**Figure 6b**) condensing dryer, Seisco tankless hot water heaters (separate units for domestic hot water and hydronic heat.), and a .74 AFUE propane fireplace (rarely used). 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 (R-19 in each case). In 2007, an additional R-30 blown insulation was added to the ceiling, for a total of R-49. In addition, R-19 unfaced batt was added to the floor insulation, for a total of R-38. The original plan was to install a field mounted PV array. This PV was to be installed in 2009, but has been delayed due to the desire to procure Silicon Energy PV panels, manufactured in Washington State, in order to take advantage of a significant (.50/kWh) production credit. More information on the credit can be found at http://web.me.com/green_island_trust/Northwest_Solar_Center/Incentive_chart.html.

In 2009, evaluation of the PV mounting system concluded that utilizing the roof of an adjacent building on the property may reduce first costs compared to the original plan to ground-mount the system.

Figure 7 illustrates end load electrical total usage, for space and water heating, hot tub and other usage for three years.

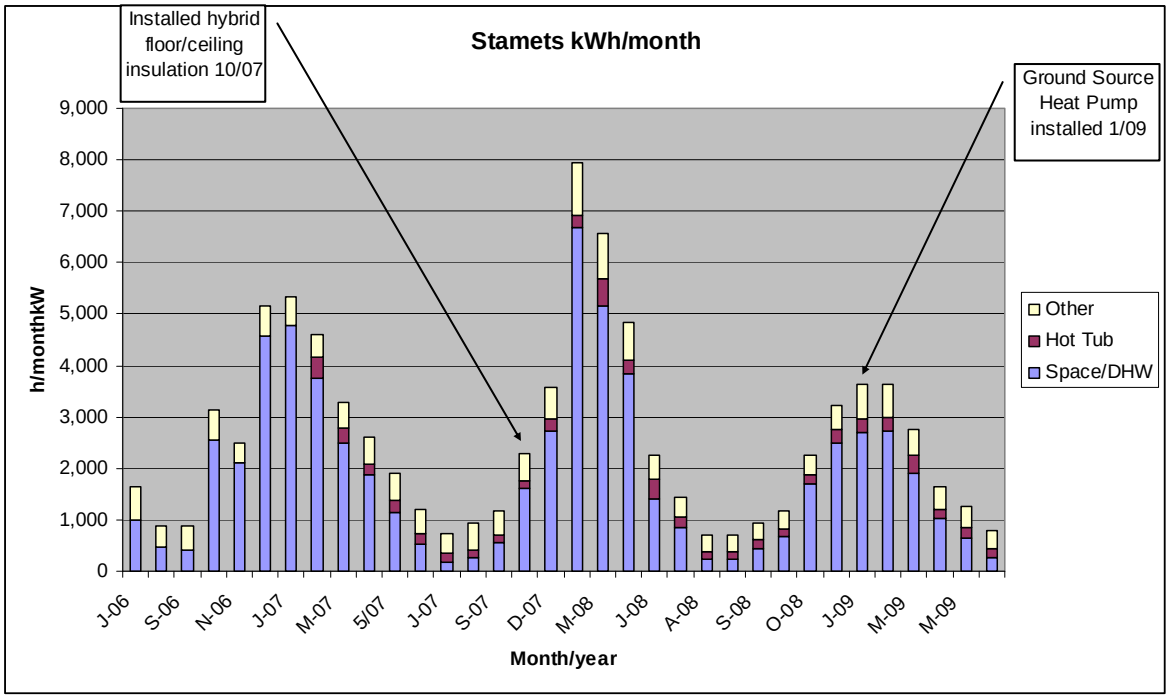

Figure 7 – Stamets Residence, electric end load usage (July 2007-June 2009)

In the first year of occupancy (July 2006- June 2007) the total overall electricity use was roughly 32,000 kWh per year, with roughly 2/3 of that being space heating. Dramatic reductions in space and hot water heating were evident after the installation of the ground source heat pump, since January 2009. An abstract for the 2009 ACEEE Summer Study has been submitted on the Stamets home; this paper will include an analysis of a full year's utility data with the GSHP installed, and compare to modeled energy use, along with an assessment of the HPWH, condensing dryer, HRV and other technologies.

The overall mechanical system drawing is shown in **Figure 8**. This is an updated version of the drawing shown in last year's annual report, which did not include the ground source heat pump.

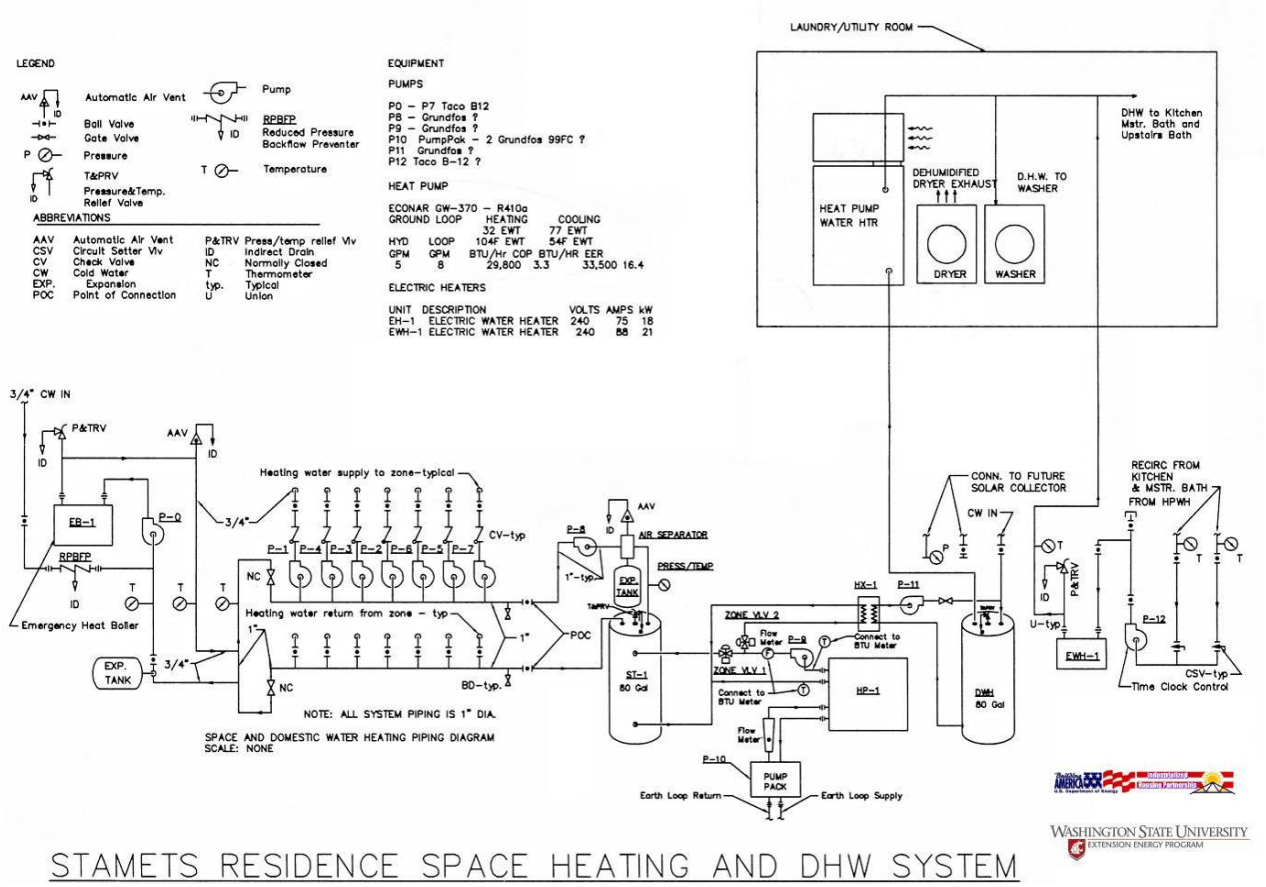

Figure 8 – Stamets Residence, Mechanical System Drawing (noting GSHP installation of fall 2008)

Since installation, BAIHP staff have conducted an evaluation of the heat pump water heater, located in the utility room, particularly as it interacts with the ground source heat pump. Feedback from the occupants suggests the following:

- Dissatisfaction with the cooling of the utility room
- Noise
- Reliability (on at least 3 occasions during the monitoring period, the system has locked)

As a result of these concerns, the heat pump water heater is being removed, and the Seisco water heater shut off, to be used only as backup (if the ground source heat pump fails.) These concerns have wider implications, as Building America investigates the use of heat pump water heaters in conditioned space in Marine climates.

Task Area 3 – Community Scale Evaluations

Equity Residential

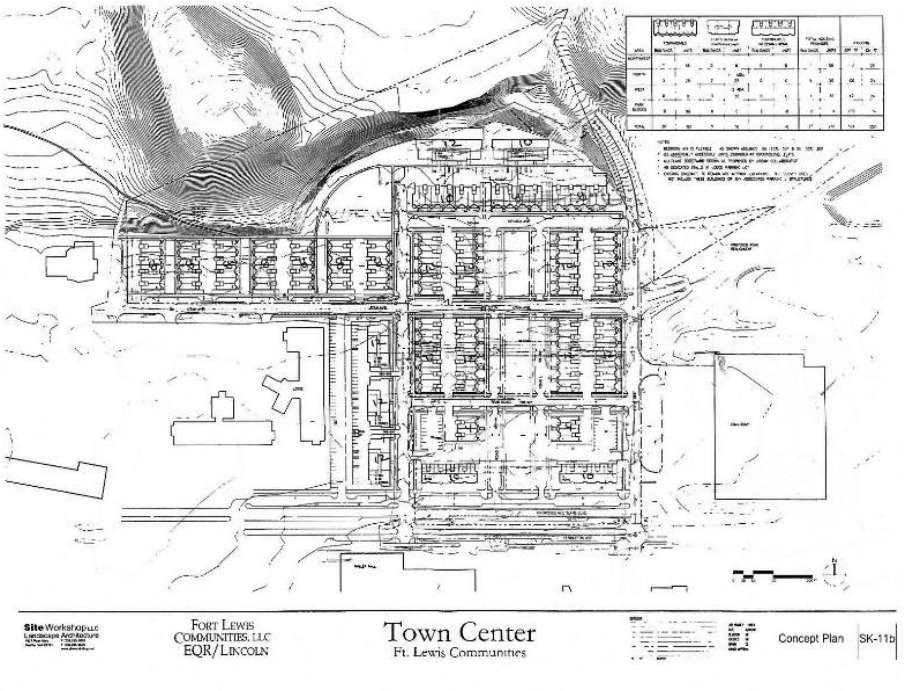

Figure 9 - Town Center site plan, Fort Lewis

Fort Lewis Army Base(Figure 9) – Fort Lewis, Washington

Since 2005, over 500 energy efficient modular homes have been built at Fort Lewis Army Base in Washington State. BAIHP staff are working with Building America industry partners at the Oregon Department of Energy (ODOE), Idaho Energy Division, Champion Homes and Guerdon Homes, in coordination with builder Equity Residential, in an effort to build energy efficient modular homes at the base. These factory-built homes are constructed to Northwest Energy Star Homes standards, featuring 0.90 AFUE furnaces, efficient windows, and Energy Star appliances and lighting.

In 2008, Guerdon Homes of Idaho was awarded the contract to construct the final 34 units at the Miller Hill development, using the same floor plans as the earlier Discovery Village, constructed by Champion Homes of Oregon (see **Figure 10**). WSU BAIHP staff provided significant technical assistance on design, training, and in-field testing, and coordinated with IED on in-plant quality assurance. The homes used tankless water heaters, as a result of a previous demonstration at the Discovery Village development.

The two biggest learning curves for Guerdon in finishing this project were whittling down duct leakage and maintaining acceptable insulation levels in the attic space. Guerdon HVAC staff were just barely meeting Northwest Energy Star criteria for total duct leakage (6% of CFA at CFM_{50}) for the first half dozen homes. With onsite technical assistance, provided by WSU staff, Guerdon staff were able to reduce duct leakage rate significantly, to as low as 2% of CFA. Interstate travel and inadvertent compression caused by other trades seriously degraded the ability of the attic insulation to perform to specifications for the first few homes at Miller Hill. With some coaching from WSU staff, these problems were addressed, and the insulation was brought in line with Energy Star requirements.

The floor plans used at Miller Hill benchmark between 30-40%, depending on tightness of envelope and HVAC (using Energy Gauge 2.8). Note that these benchmarks are without the tankless water heater used in the Miller Hill development; with the tankless systems, the homes benchmark up to 8% higher.

Figure 10 – Guerdon duplex (Madison) – Fort Lewis

WSU contracted with Blasnik and Associates who developed a preliminary billing analysis for Fort Lewis, as part of a proposed abstract (underway) for ACEEE 2010. The paper will compare Discovery Village home's (Madison Duplex) electric and gas utility bills to Energy Gauge modeling, and document project findings. Preliminary assessment suggests reasonable agreement. **Figure 11** suggests mean electric usage for 89 homes with complete data at a Normalized Annual Consumption (NAC) of 8711 kWh/year (download complete analysis: http://energy.wsu.edu/BAIHP-WSU/Ftlewis_gas_and_electric_usage_summary.xls

Electric Usage – kWh (08-09)

Variable	**# Homes**	**Mean**	std dev
Total Use (NAC)	89	8,711	2,956
Baseload	89	7,421	3,049
"Heating" Use	89	967	1,091
"Cooling" Use	89	324	457

Gas Usage – Therms (08-09)

Variable	**# Homes**	**Mean**	std dev
Total Use (NAC)	265	**484**	127
Heating Use	265	**285**	94
Baseload	265	**198**	85
T-ref (bal point)	265	**56.9**	3.7
R-squared	265	**0.91**	0.07
CV(NAC)%	265	**4.7%**	2.4%

Figure 11 - Fort Lewis billing analysis, preliminary results

After a year of data has been collected from Miller Hill, additional analysis will be conducted to compare the hot water use from the tankless water heaters at Miller Creek (EF=.85) with that of the power vented tank units at Discovery Village (EF=.61). Additional field testing will be conducted in 2010, including pressure diagnostics and infrared scanning to compare homes built by Guerdon with those previously conducted in Champion units at Discovery Village.
In 2009, BAIHP worked with Equity to plan for a new 220 unit development at Fort Lewis named Town Center. These will be modular built row houses in clusters of 8-12 (2 story

modular with 1 story site-built garage.) The Town Center site plan is shown in **Figure 9**; floor plans are shown in **Figure 12**. Phase 1, beginning construction and siting in late 2009, will be 63 units. BAIHP staff lobbied to incorporate Building America demonstration technologies, and championed development of alternative Energy Star paths for electric resistance heating. These two new paths offered additional practical approaches to for affordable housing constructed to Energy Star performance levels.

Figure 12 – Town Center floor plan – Fort Lewis

Due to electric transmission issues the final design went back to gas heat and tankless DHW. The two-story, single wide design afforded the opportunity to include all ductwork within the conditioned space. The homes also include tankless water heaters, (**Figure 13)** improved lighting and Energy Star whole house ventilation.

Figure 13 – Noritz tankless water heater – Fort Lewis

Efforts in 2010 will include in-plant and on-site quality assurance and technical assistance.

McChord Air Force Base

At McChord Air Force Base in Tacoma Washington, Equity began constructing homes in the Wescott Hills development in 2009. These are 32, single family homes intended for officers and the base commander, and range in size from 2200-3500 ft.^{2}. The homes will be Energy Star (as required by the Department of Defense), all electric (with commissioned heat pumps) and an

improved lighting package. BAIHP staff are coordinating with Equity and the HVAC contractor to provide training on heat pump commissioning, and additional training for duct sealing for new HVAC staff.
After Wescott Hill, the Cascade Village development will begin construction in September through December 2010. WSU staff will work with Equity to include some additional, beyond Energy Star technologies in a demonstration at Cascade Village.
Because the Department of Defense specifies Energy Star homes for military family housing, it has been difficult to get Equity to build beyond Energy Star, unless there are other compelling benefits (for example, no additional first cost, or reduced maintenance costs (both of which are Equity's responsibilities.) This challenge suggests an opportunity for DOE to engage with the Department of Defense to specify higher efficiency levels for this type of housing (consistent with Building America research, demonstration and deployment goals.)

Scott Homes

Since 2008, BAIHP staff have provided design and on-site technical assistance to the 11 unit Woodard Lane Co-Housing project (**Figure 14**); construction began in 2009. The units, between 950 and 1200 ft.^{2}, are provided with gas hydronic heating, using a condensing boiler/combo (96% efficient) system, Panasonic hybrid ERV/Whisper Green exhaust ventilation system, and solar hot water. WSU will provide field testing during construction, and will monitor home's performance after. The first building had a blower door test of 1.9 ACH_{50} before sheetrock. The units are expected to benchmark around 50%. Projected ratings suggest HERS indexes from 52 to 65, depending on unit location, and how ventilation strategy is modeled. WSU will provide comparable technical assistance during Phase 2, expected to begin in 2010.

Figure 14 - Woodard Lane, Olympia, Washington

From late 2008 and into 2009, BAIHP staff worked with Scott Homes to provide technical assistance and design analysis of a new 18 home development, North Cascade Village. BAIHP assistance included evaluating cost effective envelope improvements and various HVAC options, as well as preliminary development of monitoring plan. Scott was due to break ground in late 2009, but financing issues have delayed construction until 2010.

Habitat for Humanity

Figure 15 – Rainier Vista development, Habitat for Humanity, Seattle Washington (left),Owens Corning Energy Complete demonstration (right)

BAIHP staff have worked with Washington State Habitat affiliates to qualify over 210 homes to Northwest Energy Star standards (including 45 in the period November 2008-October 2009), and are continuing to provide technical assistance and outreach to other Northwest Habitat affiliates, including:

- King County – 3 design charrettes, including Rainier Vista (**Figure 15)** and Megan's Meadow, as well as general technical assistance and design consultation. Also conducted follow-up phone charrettes for Rainier Vista
- Conducted phone charrette with Pierce County Habitat on Larabee Terrace development (**Figures 16 and 17**.) The development will include 12 total units. BAIHP staff are working with Habitat to include additional BA technologies in one demonstration home, including a gas combination space heating and domestic hot water system, Broan Smart Sense ventilation controls, foam sheathed walls, and PV. Per plans, the home achieves a HERS index of 49. Blower door testing indicated envelope leakage ranging from 3.2 to 6.5 ACH_{50} for homes in the development; the demonstration home tested at 3.9 ACH_{50}.

Figure 16 – Larabee Terrace demonstration home


Figure 17 – Larabee Terrace - other community homes

- Conducted field test of 2008 Puyallup Fair demonstration modular home, with a ducted mini-split heat pump. The envelope testing results of 8.0 ACH_{50} failed Energy Star criteria, and were higher than State Energy Code assumptions. Duct leakage to exterior testing of 12% of conditioned floor area was even more disappointing. The experience provided lessons for both systems selection and air sealing for the 2009 Puyallup house. This modular home, which was constructed with gas combination space/hot water heating; had blower door results of 3.2 ACH_{50}.
- Worked with King County Habitat and Owens Corning to evaluate new Energy Complete air sealing system, which facilitates the use of airtight drywall (see **Figure 15,** right). Home also included blown-in fiberglass walls and foam sheathing. Details on the Energy Complete system can be found at http://www.ocenergycomplete.com/

BAIHP continued to work with Ed Brown, a staff member of Washington State Habitat to certify homes for Energy Star and northwest performance testing standards as well as HERS ratings. Figure 16 provides a summary of BAIHP technical assistance to Habitat. Table 1 will be updated quarterly; links to the most current version will be found in WSU's quarterly reports (the most current version is at http://energy.wsu.edu/BAIHP-WSU/WSU_Habitat_Summary-3Q09.xls.

Table 1: WSU Partnerships with Habitat for Humanity

Affilliate/Project	# units	Built	Utility	EStar	HERS	BA Bench %	BA Technologies
Seattle/South King Co HFH Tukwila, WA Partner 2008-09							
High Point 1 - MF & SF	8	07-08	No	No	TBD	TBD	Base WSEC
High Point 2a - MF & SF	2	09-10	No	Yes	TBD	TBD	BOP2 Electric Foam walls, HRV, OC Energy
High Point 2b - MF & SF	8	2010	No	Yes	TBD	TBD	BOP2 Electric Foam walls, HRV
Buffini House - SF	1	2008	No	No	No	No	Base WSEC
Rainier Vista 1 - MF	12	09-10	Yes	Yes	TBD	TBD	BOP2 Electric Foam walls, HRV,
Pacific - SF	2	09-10	TBD	Yes	TBD	TBD	TCO9 - Combo gas
Tuklilla - SF HUD	1	2009	Yes	No	TBD	TBD	HUD single
Rainier Vista 2 - MF	11	10-11	Yes	Yes	60	TBD	Ductless mini-split, Foam walls, NR|HRV

Table 1: WSU Partnerships with Habitat for Humanity							
Affilliate/Project	**# units**	**Built**	**Utility**	**EStar**	**HERS**	**BA Bench %**	**BA Technologies**
Megan Medows - SF	9	2010	Yes	Yes	63	TBD	Panel Wall system, TBD
Tacoma/Pierce County HFH Tacoma, WA Partner 2008-09							
Reynolds Park	16	08-09	Yes	No	TBD	TBD	Blower Door, Demo at 2008 conference
Larrimie Terrace	12	09-10	Yes	Yes	**49**	TBD	1 Demo home w/Solar, Smart Sense, Foam
Puyallup Fair 1	1	2008	No	No	No	TBD	Blower door, Duct test, Mini-split, foam walls
Puyallup Fair 2	1	2009	No	Yes	TBD	TBD	Foam walls ?? TBD
South Puget Sound HFH Olympia, WA (Thurston Cnty) Partner in 2007							
TESC	1	2007	Yes	Yes	TBD	TBD	ICF, Icynene, HRV, conbo gas, solar ready
Fairview	15	07-08	No	No	No	No	ICF, Foam walls, blower door
East King County Redmond, WA Partner 2008-09	5	07-09	Yes	Some	TBD	TBD	Base WSEC, Estar+ TBD
Kitsap County, HFH of Bremerton, WA Partner 2009	4	07-09	Yes	Some	TBD	TBD	Base WSEC, Estar+ TBD
Yakima Valley Partners Yakima, WA Partner 2009	4	07-09	Yes	Some	TBD	TBD	Base WSEC, Estar+ TBD
Tri-County Partners HFH Richland, WA Partner 2009	2	07-09	Yes	Some	TBD	TBD	Base WSEC, Estar+ TBD
Home Depot BAIHP TA:							
Mason County, HFH Shelton, WA Mason County	2	07-09	TBD	Some	TBD	TBD	Base WSEC, Estar+ TBD
Island County, HFH Oak Harbor, WA Island County	2	07-09	TBD	Some	TBD	TBD	Base WSEC, Estar+ TBD
Cowlitz County HFH Longview, WA Cowlitz County	2	07-09'	TBD	Some	TBD	TBD	Base WSEC, Estar+ TBD
Tri-County Partners HFH Tri-cities, WA Benton County	4	07-09	TBD	Some	TBD	TBD	Base WSEC, Estar+ TBD
Spokane, HFH Spokane, WA Spokane County	4	07-09	Yes	Some	TBD	TBD	Base WSEC, Estar+ TBD

Mr. Brown is also coordinating with BAIHP to obtain and analyze utility bills for targeted Habitat homes, as indicated in Table 1 above. WSU and Mr. Brown will make a presentation on the status of this analysis for Habitat homes at the 2010 ACI conference. We will continue to evaluate these bills in 2010 as they become available.

Manufactured Housing

WSU coordinated four meetings with Washington State Habitat for Humanity, Housing Authority of Snohomish County (HASCO), Washington Department of Commerce, Washington Department of Labor and Industries, and other stakeholders. Subject of these meetings was replacing old pre-1980 manufactured housing (estimated at over 90,000 homes in Washington State and over 3 million homes nationally, per 2000 census data) with new efficient Eco-rated NEEM homes in manufactured home communities in King and Snohomish Counties. The specifications developed by the group will use EcoRated as a baseline, adding mini-split heat pumps and, in the case of Habitat, R5 foam sheathing. These specifications will make these NEEM homes the most efficient electrically heated manufactured homes in the Northwest, and may apply to other not for profit organizations proposing HUD-code housing projects paid with Washington's Housing Trust Fund.

WSU's field testing of a non-NEEM Palm Harbor singlewide home purchased by Habitat's South King County affiliate suggested significant potential for improvement (duct and envelope leakage and HVAC system performance) by moving to EcoRated. Continued discussions with Palm Harbor engineers regarding the factory installation of R5 DOW foam wall sheathing/flashing systems. The plan is to have DOW "drop ship" foam and flashing to the plant on behalf of Habitat.

WSU field tested HASCO's first HUD-code home at the Alpine Ridge manufactured home community, indicating significant duct leakage (Qn >12%), which was repaired by manufacturer and dealer. HASCO plans to continue to utilize BAIHP technical assistance on future replacement homes in two of their manufactured housing communities.

Task Area 4 – Post phase-3 activities

Research Utilization

Ductless Heat Pumps

The Pacific Northwest continues to be deeply involved in heat pump research. WSU is attempting to leverage that research in support of BAIHP efforts in the region. Because of historically low electric rates and somewhat favorable climatic conditions (especially in the marine climate areas) heat pumps have been used in a growing number of homes. Based on a growing concern with the inefficiencies of ducted central forced air systems and the obstacles and resistance to bringing ductwork within conditioned space, Northwest electrical utilities have launched a pilot program to incentivize the installation of ductless heat pumps (DHPs) and evaluate their field performance in an extensive research project involving detailed monitoring of over 100 systems throughout the region.

While this research currently focuses on existing electric heated homes, WSU is currently planning to expand this effort into new BAIHP homes, and continues to support lab testing of DHP units with BAIHP partners NEEA and Ecotope. As BAIHP projects have significantly reduced heating and cooling loads with improved building enclosures, DHPs have become an attractive alternative to conventional heating systems. DHPs have been included in several BAIHP prototype homes in the region, with on-going evaluation planned for 2010 and beyond. Preliminary evaluation indicates high performance and reduced cost over conventional split heat pump systems. Available DHP systems using variable speed DC motors with integrated inverters have HSPFs as high as 12 and SEERs of greater than 20, and are competitively priced.

Subtask 4.5 – Documentation, Resource Development and Related Activities
ASHRAE

BAIHP staff Lubliner and Hales continued active participation in 2009:

- Attended the 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." The project was accepted by ASHRAE and ARTII, and awarded to Building Science Corporation in 2009. RP-1449 phases 1 and 2 have been completed by BSC. WSU coordinated the peer review by the RP-1449 project management committee.

TC 9.5 – Small Residential and Commercial Buildings. WSU participated in TC 6.3 meetings at ASHRAE 2009 winter meeting and provided information on Building America to those attending.

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 - WSU participated in ASHRAE 62.2 winter meeting and provided comments on proposed changes made in 2009.

ACCA

- WSU participated as member of the committee that developed the final Air Conditioning Contractors of America (ACCA) Quality Installation (QI) verification standard published in 2009. WSU staff also joined ACCA committee providing comments on updates to the standard in 2009. Comments sought to better align the ACCA standard with Building America's HVAC best installation practices.

- Discussion underway in 2009 with ACCA about developing a homeowner and/or contractors applications guide to mini-spit heat pumps, which may start in 2010, with potential support from PNW and EPRI.

ACEEE

- WSU submitted abstracts for ACEEE Summer Study on Stamets and Fort Lewis projects, and (as noted in sections above) has been conducting data analysis on these projects.

NAHB/IBS

- Participated in Energy Value Housing Awards and USDOE Builder Challenge events; provided public outreach and technical assistance at Building America booth at International Builder Show. As noted above, BAIHP builder Scott Homes won EVHA Builder of the year for the Salvi home, currently being monitored by WSU.

NFPA

- All WSU energy proposals accepted unanimously by committee in 2008 were included in the final 2010 version of the NFPA-501 Manufactured Housing Standard. NFPA-501 has been used in the past to assist HUD in its efforts to improve on the Manufactured Housing Construction and Safety Standards. WSU staff have been involved with these efforts since 1999. The new 2010 edition of NFPA-501 has resulted in improvements in the following areas:

o	Section 4.3 - Lighting & Ventilation	(approved by HUD/MHCC)
o	Section 5.13 - CO detectors	(approved by HUD/MHCC)
o	Section 6.7.1.3 - Weather resistant walls	(TBD at HUD)
o	Section 6.7.3 - SHGC	(TBD at DOE/HUD)
o	Section 8.4 - Condensation control	(TBD at HUD)
o	Section 8.6.1 - Heat Loss	(TBD at DOE/HUD)
o	Section 8.8.3 - Insulation QA	(in MHCC task group)
o	Section 8.5.1.1 - Air leakage Control	(in MHCC task group)
o	Section 8.8.5 - NRFC window testing	(TBD at DOE/HUD)
o	Section 10.14.5 - Duct leakage testing	(approved by HUD/MHCC)
o	Section 10.14.8 - R8 duct insulation	(approved by HUD/MHCC

WSU has encouraged HUD and USDOE to adopt these improvements in future improvements to HUD MHCSS, along with proposals to require Energy Star HVAC, appliances and lighting for any equipment shipped from factory.

- Convened stakeholder meetings with HUD, DOE and EPA in DC and at BSC Westford Symposium to discuss NFPA-501 standards and Building America research.

NIST

- Provided review and comment, as well as technical assistance for a NIST report on air tightness, ventilation, and energy consumption in a manufactured home.
- Followed-up with NIST on proposed phase 3 retrofit involving HVAC upgrades to test lab.

RESNET

- Participated in RESNET technical committee and board conference calls and annual meetings. WSU coordinated and participated in a panel on HUD-code housing with USDOE, HUD and EPA at 2009 RESNET conference. Panel discussions focused on modifying the HUD data plate to provide Builder's Challenge type information as a future improvement to MHCSS.

I'M HOME (Innovations in Manufactured Housing) Retreat/Manufactured Housing Homeowners of America National Convention

- Participated in retreat and convention and presented information on BAIHP HUD-code housing related efforts. Meetings resulted in education of attendees regarding opportunities to early retire old manufactured homes, replacing them with higher efficiency, durable and healthy new homes. Presentation can be found at http://energy.wsu.edu/BAIHP-WSU/MH_2009_Home.ppt

WA State Factory Assembled Structures Advisory Board:

- WSU staff attended WA State Factory Assembled Structure (FAS) board meetings as new voting member in 2009, and participated in quarterly meetings to share information with Washington Manufactured Housing Association, State IPIA and SAA and other stakeholders in support of regional and national HUD-code BAIHP related activities and issues.

Press, References and Publications

ASHRAE

ASHRAE Proposed Standards 193P Subcommittee (chair) – "Method of Test for determining the air-leakage rate of HVAC equipment" – final public review draft.
ASHRAE Standard 62.2 updates – Ventilation and Indoor Air Quality in Low-Rise Residential Buildings

BAIHP

Zelonedom Case Study Report: "Approaching" Zero Energy in the Pacific Northwest Marine Climate – peer-reviewed Stagegate report.

APPENDIX D – Oregon Department of Energy Annual Report

Final Technical Progress Report

BUILDING AMERICA INDUSTRIALIZED HOUSING PARTNERSHIP II

http://www.baihp.org

Period Covered: January 1 through September 30, 2009
Date Submitted: November 17, 2009

DOE HQ program managers: Mr. George James, Mr. Chris Early
DOE Project Officer: Mr. Bill Haslebacher, DOE/ NETL
Cooperative Agreement # ODOE contract 102269
UCF Account Nos.
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Task 2: Prototype House Evaluations:

Subtask 2.1 High Performance Prototype Homes:
Design and Testing Assistance:

Staff continued ongoing efforts to help Parr lumber see how to make the Oregon High Performance Home specifications part of a product offering. Several homes have been built at this level, but Parr has not yet formally incorporated the added efficiency measure, continuous exterior foam, into its product line.

ODOE staff worked with Earth Advantage to develop and deliver a 1-day training workshop for builders on how to build a high performance wall with 2X4 staggered studs/blown cellulose and 2X6 with fiberglass and 1.5 inch exterior foam at the ACI Northwest conference, held in Portland. 85 attended. On February 4-5, Staff delivered 2 presentations at ACI Northwest conference on the Oregon High Performance Home tax credit program. The training then was taken to four locations around Oregon to reach additional audiences.

ODOE staffed a booth and provided a full scale wall and roof assembly that was displayed for 10 days at the Oregon State Fair in Salem, OR. The wall and roof assembly detailed continuous exterior foam insulation, staggered stud construction, air sealing, and high heel truss roof construction and ventilated rain screen construction techniques. ODOE gave presentations to the general public regarding residential high performance home construction and renewable energy systems. The presentations detailed the state tax credit programs and were seen by several hundred people. Several builders contacted ODOE after the event to explore further the possibility of building to the tax credit requirements.

As of the September 30th, 38 tax credit applications have been received for the year and 11 homes located throughout Oregon have been completed and granted tax credits. The Oregon High Performance typically benchmarks at, or around, the 40% level.

Long Term Instrumented Monitoring:
None performed.

Task 3: Community Scale Evaluations:

Subtask 3.2 Marine climate multifamily communities:
Ft. Lewis
ODOE has asked FSEC that the funding and scope of this task be deleted from their work plan, because the Ft Lewis homes are being built in Idaho plant Guerdon not at Champion of Oregon . Washington State University is working with Guerdon

Task 4: Post –Phase 3 Activities

Subtask 4.2 Northwest Energy Efficient Manufactured Homes:

The NEEM team performed the following:

Staff performed quarterly factory inspection visits for each participating builder, inspected problem homes, developed in-plant quality assurance detailed inspection protocols to support the roll out of the ECO-rated brand, which requires higher than Energy Star levels of energy efficiency in addition to green building features. NEEM staff meets monthly to discuss technical and program issues.

NEEM staff certified five plants as Eco-rated builders and inspected their first homes in the plants. NEEM staff met with several retailers in Oregon, Washington, Idaho and Nevada and certified them as Eco-rated retailers, trained to represent the brand and confirm proper home setup.

On September 8-9 NEEM staff presented Eco-rated Homes to 100 people at the CFED annual retreat in Seattle. CFED (Corporation for Enterprise Development) expands economic opportunity by helping Americans start and grow businesses, go to college, own a home, and save for their children's and own economic futures. NEEM staff also helped with a CFED sponsored tour of new Eco-rated homes in Everett, WA purchased by the Snohomish housing authority replacing a pre-1976 home in a park they own. NEEM staff also helped with the tour of the Clayton I-house at the Heritage home sales center in Everett, WA

Staff and technical sub-contractor completed the latest periodic random field study of NEEM-certified homes and submitted results to the Regional Technical Forum to validate the energy savings attributed to these homes by utility programs. This is the basis for utility incentive programs in the four northwest states.

On July 27 NEEM staff presented NEEM and led a 4 hour tour of 54 people from USDOE, national labs and code officials through the Fleetwood of Oregon plant in Woodburn, Oregon. The tour was part of a 4 day national energy codes conference in Portland Oregon.

ODOE Homes Reported in 2009

Energy Star/Eco-rated	homes produced January 1 to September 30, 2009
Energy Star gas	203
Energy Star electric	860
ECO-RATED electric	188
ECO-RATED GAS	32
Total Homes	1283

Subtask 4.3 BA Program / Analysis Support:
Builders Challenge Program Development: Oregon High performance homes (Builder Challenge score 62) are in the pipeline in 2009

Subtask 4.4 Research Utilization:
1) Service on committees and boards
2) Participation in Working Groups
- NW Pride adopted Eco-rated as their green home program for the northwest marketing.
- Regional Technical Forum working group approved savings for Eco-rated homes.

3) Collaboration with FAS and factory built housing industry
- Presented to the 100 low income housing advocates at the CFED retreat in Seattle
- Presented NEEM to USDOE and national labs

4) Publication, Presentation, and Showcasing of Research
5) Project Management activities
- Management of the Northwest Energy Efficient Manufactured Home Program.
- Eco-rated contracts signed by Homebuilders NW, Marlette, Kit, and Golden West Homes, Liberty.

The Oregon Department of Energy has determined that the manufactured home industry no longer needs the Department's support by way of administration of the regional NEEM program. Staff is facilitating the transfer of administrative functions to other program partners with a transition to other program administration occurring by the end of 2009.

Tom Hewes, NEEM program manager and principal investigator for the Building America retired from ODOE on September 30, 2009.

APPENDIX E – RESNET Annual Report

Subtask 4.5 RESNET tasks:

Habitat for Humanity
During February and March of 2009, there was an increase in industry professionals volunteering their services for Habitat. Unfortunately, many of these individuals are not certified raters were not members of RESNET. However, we did add seven new raters from the states of Maryland, Florida, Colorado, New Mexico, Georgia, and Illinois. For the individuals who express interest and are certified raters, we encourage them to join RESNET and apply for the program which is now available on-line.

During the month of March 2009, RESNET received several emails from raters interested in participating in the Habitat for Humanity program as well as responded to numerous phone calls on the subject. We expect that these contacts will result in between 10 and 20 new volunteer raters being approved and posted on the RESNET website in April.
In addition, Janet McIlvaine has been in contact with Claudia Brovick about the case studies that have been completed and how to move forward to get more raters interested in sharing their experiences with Habitat. They will be working together on that effort. We will be posting the latest two case studies on our website.

RESNET is also working with Habitat for Humanity International in having several sessions on the Habitat's sustainable building initiative at the 2010 RESNET Building Performance Conference.

International Dialog
RESNET was appointed to be part of the United Nation's Sustainable Buildings and Climate Change Initiative (SBCI). The SBCI is part of the UN's Environment Programme (UNEP), which is responsible for international environmental efforts including climate change. RESNET, the U.S. Green Building Council and the Natural Resources Defense Council are the U.S. representatives of SBCI.

Philip Fairey, David Goldstein and Steve Baden participated in the SBCI's meeting in Washington, D.C. on April 15 – 17, 2009. There were also representatives from Australia, Brazil, Canada, China, France, Germany, Holland, Norway, Singapore, South Africa, and the UK at the meeting. Steve Baden was able to present the RESNET system at the meeting. My presentation was well received and generated much interest in the U.S. rating system. SBCI and the nation representatives were very interested in creating a dialog on harmonizing standards.

The participants in the Washington meeting reached a consensus for a call to action to the nations that will be meeting in Copenhagen to negotiate the successor to the Kyoto treaty. The call to action states that:

- Buildings are responsible for more than 40% of global energy use and one third of global green house emissions

- The current Kyoto Protocol has failed to harness the potential of reducing greenhouse emissions through improve building energy performance
- Countries will not be able to meet their climate change commitments without addressing building energy performance , particularly existing buildings
- The Inter-Governmental Panel on Climate Change report states that the building sector has the greatest potential of any sector for delivering significant emission reductions, using available technologies and provide greenhouse gas emissions reduction at net life-cycle cost benefits rather than net increased costs.

The Call for Action has the following policy recommendations to the national delegates to the Copenhagen negotiations:

- Include as an agenda item at the negotiations the need to prioritize the building sector as fundamental to achieving significant greenhouse gas emissions
- Support the inclusion of measures to encourage investments in building projects (both new and renovation) that reduce emissions in the new global climate change treaty
- Include in the technology transfer framework measures to support capacity building to increase the efficiency in new and existing buildings
- Support the reform of the Clean Development Mechanism (CDM) to effectively encourage investment in increasing building energy performance
- Adopt a mandate to establish working groups to develop specific measures in the protocol for the building sector
- Encourage governments to conduct an inventory of emissions for the nation's building stock and set targets to reduce emissions in existing and new buildings

On May 27 and 28, 2009, Steve Baden, RESNET's executive director attended the invitation-only U.S. Department of Energy's Residential Energy Efficiency Business Model Summit in Washington, D.C. Steve Baden was invited to the summit by Gil Sperling, DOE's director of Weatherization and Intergovernmental Program. Seventy-five energy efficiency experts from across the country participated in the summit. Participants included experts from the following fields: financial institutions; home performance programs; non-profit organizations and trade associations; state energy offices; public utility commissions; program administrators; energy improvement contractors; and government consultants. Representatives of the Environmental Protection Agency, HUD, White House Office of Environmental Quality, and the Senate Energy Committee also participated. The list of participants are posted on http://www.sentech.org/energysummit/documents/2_Participant_Listing.pdf

After listening to presentations about existing business models, the 75 participants were split into groups to discuss how these models address known obstacles to residential energy efficiency, what is or is not working, and whether these models are scalable. I was struck with the level of concurrence on strategies for the future from this diverse group of organizations.

RESNET was contacted by the chair of the European Union's Energy Performance of Buildings Concerted Action Committee (EPBDCA), Eduardo Maldonado, about presenting to the EPBDCA at its meeting in January, 2010. The meeting will continue the dialog on harmonizing

the EU and US approaches to rating a labeling a building's energy performance. The meeting will take place on January 21 and 22, 2010 in Amsterdam, Netherlands.

Steve Baden participated in the United Nations Sustainable Buildings and Climate Initiative in Paris, France on September 10 and 11 of 2009. The purpose of the meeting was to come up with a set of building energy performance metrics and baselines to be incorporated into the new international climate change treaty that will be negotiated in Copenhagen, Denmark. RESNET was successful in incorporating residential building performance into the protocol.

While in Paris, Mr. Baden met with Jens Lausten of the International Energy Agency regarding the development of the OECD Sustainable Buildings Network. It was learned that the network was approved by the G8 and that funding was secured for the effort. Mr. Lausten stated that RESNET would most likely be asked to serve on the network's steering committee.

Building Energy Labeling/National Builders Challenge

On March 11 – 13, 2009, RESNET Executive Director Steve Baden participated in the Midwest Energy Star Conference that was sponsored by the Kentucky Home Builders Association in Lexington, Kentucky. There were over 350 attendees at the conference. Mr. Baden presented the keynote address for the conference and presented in three breakout sessions.

On August 24 - 27 Steve Baden was in Washington, DC and had the following meetings: Henry Kelly, U.S. Department of Energy - Provide briefing on RESNET, home energy ratings, and energy modeling software for occupied homes. The Department of Energy is interested in labeling of buildings according to their energy performance and developing an Energy Efficient Mortgage that works. Philip Fairey, David Goldstein and Steve Baden participated in the meeting. It was a productive meeting and all sides agreed to continue a dialog.

Steve Baden and Edward Pollock of the U.S. Department of Energy discussed tying RESNET's standards closer to DOE's E-scale. Steve Baden and Lane Burt of the Natural Resources Defense Council met and discussed calibrating ratings for occupied homes where energy bills are available.

In September, Steve Baden met with representatives of LENNAR Homes about the company's incorporating energy labeling and the E-Scale into its marketing efforts. It was agreed that RESNET and LENNAR would work together in exploring a way to develop standard modeling assumptions to streamline the production of an energy label of a home.

On September 28 Steve Baden presented an update on RESNET and the Builders Challenge at the EEBA Conference. At the Builders Challenge Mr. Baden met with Ed Pollock regarding RESNET's participation in the National Builders Challenge. It was agreed to explore having RESNET adopt the E-Scale.

Occupied Homes Software

In July the Occupied Homes Software Task Force adopted the Process Steps for Modeling Proposed Improvements to Occupied Buildings for which Historical Energy Use Data Exists. The steps are listed below.

Steps:
1. Collect and record measured energy use data and influential variables for the pre-retrofit period. At a minimum, include the following for each month for which energy use data are collected and recorded:
a. Monthly average outdoor temperature from the weather station (NOAA) most representative of the actual building site
b. Monthly heating degree days (HDD) and cooling degree days (CDD) or cooling degree hours (CDH), as appropriate, from the weather station (NOAA) most representative of the actual building site.

2. Develop a regression model of the pre-retrofit energy use data as a function of the influential variables in accordance with ASHRAE's *Inverse Modeling Toolkit* (ASHRAE 1050 RP) methods. At a minimum, include regression(s) of building energy use data as a function of the local weather data recorded in Step #1.

3. Using the regression model(s) from Step #2, develop a set of weather-normalized energy use data for the typical meteorological year (TMY) weather data set that is most representative of the actual building site.

4. Collect and record all building and energy systems characteristics necessary to accurately construct a building simulation model for the pre-retrofit building. Using these data, develop a complete building simulation model for the building in its pre-retrofit condition.

5. Calibrate the building simulation model developed in Step #4 to the weather-normalized energy use data developed in Step #3.

6. Using the calibrated pre-retrofit simulation model from Step #5 as the basis of comparison, along with the most representative TMY weather data from Step #3, determine projected energy savings from proposed energy conservation and energy efficiency improvements to the building.

As a result of the task force's action RESNET appointed a working group to develop a draft set of guidelines for the process steps for the task force's consideration. The members of the working group are:
Steve Baden, RESNET
Michael Blasnik, M. Blasnik and Associates
Philip Fairey, Florida Solar Energy Center
Tom Fitzpatrick, Texas Home Energy Raters Organization
Dave Roberts, NREL
Rob Salcido, Architectural Energy Corporation
Greg Thomas, Performance Development SystemsL

The working group conducted its first teleconference on September 4. The group reached a remarkable consensus on a number of key issues:

3. That the effort and task force be renamed the RESNET Occupied Homes Software Task Force. The new name is viewed as a more accurate description of the work.

4. The working group would be divided into three task groups:

- Weather Data Protocols (headed by Rob Salcido of Architectural Energy Corporation)
- Inverse Modeling (headed by Michael Blasnik of Conservation Services Group)
- Calibration Modeling (headed by John McCartney of Performance Systems Development)

As the task groups complete there work it will be shared with the full task force members of review and input.

Discussions of building labels worldwide have pointed out the difference between "asset value" labels, which are based on how a building performs at standard operating conditions and "operational value" labels, which are based on measurements of energy consumption using the operating conditions that are in use at a particular time. Most products, such as cars or appliances, are rated using asset value labels with a standardized operational component—for example, cars are rating by EPA miles per gallon (mpg) but are not resold based on the mpg that the seller actually obtained. But for buildings, analysts generally recognize that both results are useful. These two types of labels are very distinct and different ways of characterizing energy use, with different purposes. There have been much discussion and some misinformation on this subject. To clarify the issue RESNET posted an message on Energy Labeling and Energy Billing Analysis that was written by Philip Fairey of the Florida Solar Energy Center and David Goldstein of the Natural Resources Defense Council. The message is posted at http://www.resnet.us/hotnews/2009-09-EnergyLabeling_and_EnergyBillingAnalysis.pdf

Outreach

On April 27 - 30 Steve Baden participated in the 2009 Affordable Comfort Conference in Kansas City, Missouri. Mr. Baden made a presentation at the conference on RESNET's new National Home Energy Audit Standard.

Steve Baden worked with the U.S. Environmental Protection Agency and two South Dakota Indian tribes on a sustainable building demonstration project. The tribe will construct a straw bale home. RESNET coordinated with the project in having the demonstration home energy rated.