FLORIDA SOLAR ENERGY CENTER®

CONTRACT REPORT

Building America Industrialized Housing Partnership (BAIHP II)

Final Report – Budget Periods 1-5
April 1, 2006 – November 30, 2010

FSEC-CR-1882-11
March 2, 2011

Submitted to:

U.S. Department of Energy
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A Research Institute of the University of Central Florida

Building America
Industrialized Housing
Partnership
(BAIHP II)

Final Project Report
April 1, 2006 – November 30, 2010
FSEC-CR-1838-10

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ABSTRACT

This report summarizes the work conducted by the Building America Industrialized Housing Partnership (BAIHP - www.baihp.org) during the final budget period (BP5) of our contract, January 1, 2010 to November 30, 2010. Highlights from the four 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 in BP5 was performed in six tasks areas:

Task 1: Building America System Research Management, Documentation and Technical Support
Task 2A: Stage G1A: Integrated Solutions for Specific Climate Regions
Task 2B: Stage G1B: System Performance Evaluations
Task 3: Stage G2: Prototype House Evaluations
Task 4:Stage G3: Initial Community Scale Evaluations
Task 5: Project Closeout, Final Review of BA Communities
Task 6: Other Research Activities

In Task 1, Building America System Research Management, Documentation and Technical Support, BAIHP

- Conducted general project management and coordination activities - coordination with BAIHP researchers, DOE, NETL, DOE national labs, and industry personnel, subcontract deliverable approvals, review and approval of project expenditures, reviewing budgets and related activities
- Submitted final draft of the Hot Humid Climate 40% Milestone Report to NREL (available on BA Project Management Extranet Site). Drafts of case studies for three BAIHP communities were prepared, along with an introduction to the overall report.
- Performed quality assurance and control on partner case studies from the other Building America teams.
- Registered BAIHP completed homes from January through April in the BA Project Database that met at least the Builders Challenge level of E-Scale <= 70. Approximately 80 more homes are ready for entry. *(Note: The Project Database was inoperable for the rest of the budget period.)*

In Task 2A: Stage G1A: Integrated Solution for Specific Climate Regions, BAIHP

- Had no progress to report for this task

In Task 2B: Stage G1B: System Performance Evaluations, BAIHP

- Began construction on two identical new flexible residential test structures to help determine the best retrofit and new home practices. The structures will serve as a control (SBSL2) and experiment (SBSL1) for evaluating energy saving measures.
- Conducted heating and cooling experiments using the SEER 21 system and SEER 13 system connect to the attic ducts (MHLab). A comparison of the energy efficiency (energy use and reduction, savings) of each unit was also completed.

- Gas Technology Institute (GTI) researched efficient hot water and distribution systems
- Continued side-by-side testing on seven solar and conventional hot water heating systems (HWSL)
- Performed collector testing of solar water heating systems (SRCC technical tasks)
- Washington State University (WSU) identified the opportunities and practical challenges involved with incorporating ductless heat pumps into factory built housing
- Continued evaluation of the Nightcool concept

In Task 3: Stage G2: Prototype House Evaluations, BAIHP

- Provided design and technical assistance to partners producing Building America prototypes. Continued instrumented monitoring in prototype home construction projects.
- Supported demonstration home projects for the International Builders' Show

In Task 4: Stage G3: Initial Community Scale Evaluations, BAIHP

- Provided technical assistance to builders that were building communities of 10 or more high performance homes. 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 5: Project Closeout, Final Review of BA Communities, BAIHP

- Performed regressions based on heating and cooling degree days to disaggregate heating and cooling energy use from total use.
- Researchers put the study on hold and awaited approval from the Building America program to begin development of the OMB application process for approval.

In Task 6: Other Research Activities, BAIHP

- Provided technical assistance to Habitat for Humanity International (HFHI)
- Completed regional and national training activities with HFHI (including Habitat affiliates)
- Provided technical assistance to HFH affiliates (completed Gulf Coast High Performance Affordable Housing Demonstration Project report)
- Provided technical assistance to organizations such as local governments and Habitat for Humanity for retrofitting and rehabilitating foreclosed and other existing affordable housing to facilitate deep energy efficiency retrofits.
- Northwest Energy Works (NEW) became the new administrator of the Northwest Energy Efficient Manufactured Home Program (NEEM), a position formerly held by Oregon Department of Energy, and signed contracts with 13 HUD code builders in the Northwest region.

DISCLAIMER

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ACKNOWLEDGEMENTS
This work is sponsored, in large part, by the US Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy, Building Technologies Program under cooperative agreement number DE-FC26-06NT42767. This support does not constitute an endorsement by DOE of the views expressed in this report.

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 final report summarizes the activities of the Building America Industrialized Housing Partnership (BAIHP, www.baihp.org) performed during the entire project period of April 1, 2006 through November 30, 2010 . It describes in greater detail the work performed during the last year of the contract, 1/1/10 through 11/30/10, , with highlights from earlier years which are comprehensively documented in previous project annual reports. Those reports are available online at the following addresses:

- http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1838-10.pdf
- http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1785-09.pdf
- http://www.baihp.org/pubs/pdf/BAIHP-BP2-annualrpt4-28-08.pdf
- http://www.baihp.org/pubs/pdf/BAIHP_II_Yr_1_Report.pdf

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), Gas Technology Institute (GTI), Northwest Energy Works (NEW), Calcs-Plus, and other consultants. Industry partners include housing industry leaders that, together, build 100,000+ homes annually.

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.

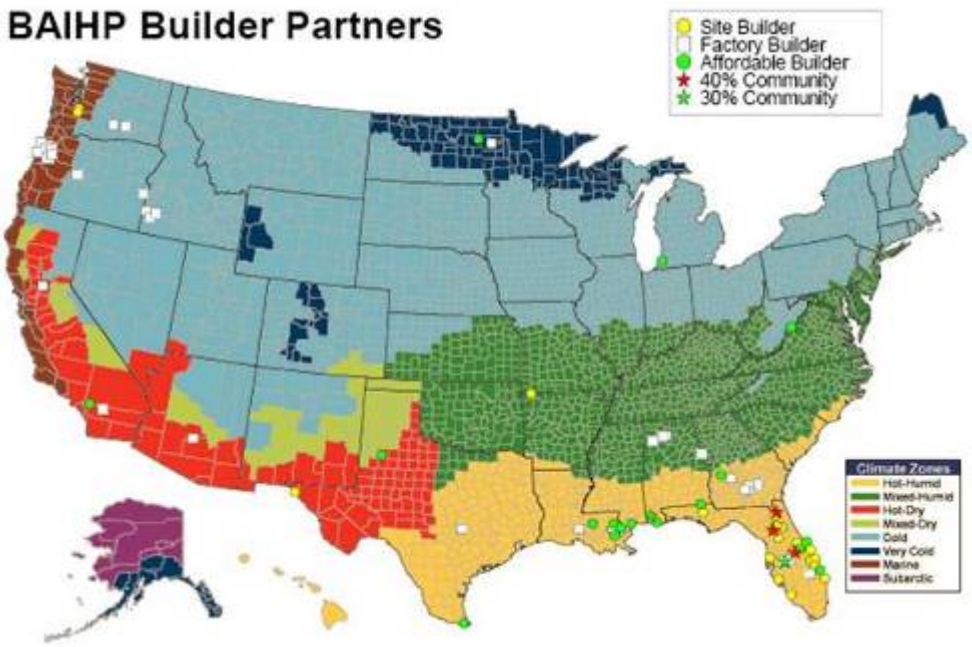

Figure 1-1 *BAIHP Current and Past Industry Partners (See list in Table 1-1 below)*

Industry Partnerships
BAIHP has partners in many stakeholder groups of the U.S. housing market including HUD-Code home manufacturers; modular, multifamily and production site builders; and product and material suppliers (Figure 1-1, Table 1-1). Research organizations and other non-profits have worked with BAIHP to collaborate on field work, ventilation studies, ASHRAE committee work and training.

[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

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 2004-2010*

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, City of Sarasota, and the FL
City of Palm Bay	House Foundation?
	Volusia County
Retrofit Partners	
Alachua County NSP Program	Newtown Housing Trust (Sarasota)
Brevard County NSP Program	Orange County NSP Program
City of Palm Bay NSP Program	Sarasota Office of Housing and Community Development NSP Program
DwellGreen (Sarasota)	Community Housing Trust (Sarasota)
Greg Hardwick Inc. (Orlando)	Volusia County NSP Program
Goodwill (Sarasota)	
King County (Seattle) Housing Authority	

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
KB Home	Springwater Homes
Marc Rutenberg Homes	Stitt Energy Systems
Marquis Construction & Development, Inc	Westmont Homes
Rainier Construction, Inc.	WD Moore Construction
Rock Built Homes	
Developers	
Castle & Cooke	Organum Development (Lily Valley)
Equity Residential (Ft Lewis Army Base and McChord Air Force Base)	Schackow Development / Trunnel Homes
HKW Enterprises	ZCS Development
	Walsh Construction?
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 final budget period (BP5), the BAIHP team conducted activities in six major task areas, as shown below. This represented a change in task numbering from previous budget periods.

Task 1	Building America System Research Management, Documentation and Technical Support
Task 2A	Stage G1A: Integrated Solutions for Specific Climate Regions
Task 2B	Stage G1B: System Performance Evaluations *(formerly Task 1)*
Task 3:	Stage G2: Prototype House Evaluations *(formerly Task 2)*
Task 4:	Stage G3: Initial Community Scale Evaluations *(formerly Task 3)*
Task 5:	Project Closeout, Final Review of BA Communities
Task 6:	Other Research Activities *(Formerly Task 4)*

Task 1: Building America System Research Management, Documentation & Technical Support

Subtask 1.1 Perform Duties as Industry Team Lead

Throughout 2010, researchers worked with the UCF Office of Research on project funding, subcontractor funding, deliverables and related items. Two new subcontractors started during this final budget period – Gas Technology Institute (GTI) and Northwest Energy Works (NEW).

Researchers tracked the cumulative impact of the BAIHP project in 2010. General project management and coordination activities were also conducted - coordination with BAIHP researchers, DOE, NETL, DOE national labs, and industry personnel, subcontract deliverable approvals, review and approval of project expenditures, reviewing budgets and related activities, and adding new material to the BAIHP website: www.baihp.org.

Subrato Chandra announced his retirement from FSEC as of April 2, 2010. On April 5, with the concurrence of N.E.T.L., Philip Fairy assumed responsibilities for managing the BAIHP project.

During Budget Periods 1-5, BAIHP, as a team leader, provided Building America program support and analysis (formerly Subtask 4.3), in the following categories:

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 and 2010, BAIHP continued to submit Builders Challenge applications for GW Robinson, Stalwart Built Homes, Tommy Williams Homes, and LifeStyle Homes (2010 only).

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 1-3). 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.

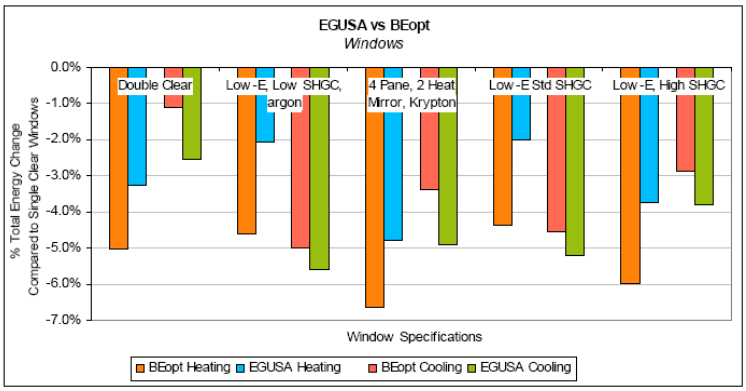

Figure 1-2: *Window analysis shows large heating differences between Energy Gauge USA and BEOpt as well as heating/air conditioning fan energy also showed significant, systematic differences between the software.*

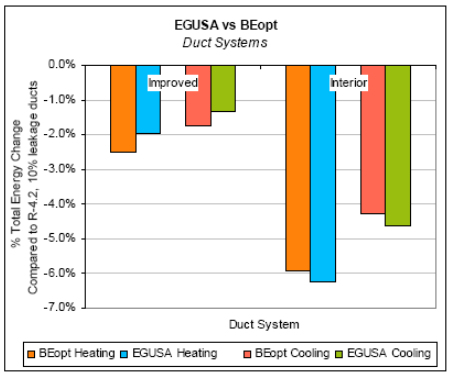

Figure 1-3: *Duct system analysis shows very close agreement on both heating and cooling energy savings.*

Figure 1-2 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

Review of Miscellaneous Electric Loads (MELs) in Residences

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

Subtask 1.2 Perform Duties as Climate Lead
(Formerly 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.

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.

In 2010, work continued on the "Hot Humid Climate 40% Milestone Report", formerly known as the Joule Report. Drafts of case studies for three BAIHP communities were prepared, along with an introduction to the overall report, and final drafts were submitted to DOE in June. BAIHP also performed quality assurance and control on partner case studies from the other Building America teams.

The final draft of the Hot Humid Climate 40% Milestone Report was submitted for DOE peer review in August. Peer review comments were incorporated, and the final report was submitted to NREL in September 2010. The report can be downloaded on the BA Project Management Extranet Site.

Subtask 1.3 Prepare Combined Monthly, Quarterly and Event Reports

The following deliverables were finalized and transmitted:

- Quarterly technical and fiscal reports for 1Q FY10 covering Oct-Dec, 2009
- The BAIHP annual report for BP4 (CY2009) was finalized and transmitted to DOE on Feb 5
- Quarterly technical reports covering January-March, April-June, July-September, and October-November, 2010

Special Events:

January 28 Tommy Williams Homes ZEH – "Ribbon Cutting & Realtor Preview" Gainesville area, North Florida - Approximately 60 attendees. This is Florida's first net-zero energy *production* home. BAIHP researchers (Subrato Chandra, Ken Fonorow, Stephanie Thomas Rees, Karen Sutherland, Kevin Schleith and John Sherwin) attended, assisted in tours for local real estate agents, and answered technical questions about the concept, features, and instrumentation of the home. It is notable that this home was constructed as a speculative venture by the contractor and sold in less than two weeks. Ken Fonorow (FLORIDA H.E.R.O.) and Subrato Chandra presented at the event. Both of them and Subrato Chandra were interviewed for a PBS documentary entitled *ZERO Energy America.* Subrato Chandra was also interviewed by local reporters from channel 20, the Gainesville Sun newspaper, and another local newspaper. A four page *Builder Spotlight* case study about this ZEH was distributed at the Ribbon Cutting. http://baihp.org/casestud/pdf/BAIHP-TWH-ZeroEnergy-02-10.pdf

January 29. Hosted Doug Kosar, GTI, at FSEC. Doug gave a presentation on GTI overview and discussed planned GTI tasks for BAIHP.

January 30 Tommy Williams Homes ZEH – "Grand Open House" Gainesville area, North Florida - Approximately 350+ attendees. FLORIDA H.E.R.O. assisted sales team by answering technical questions at this event which was attended by over 350 people**.**

Subtask 1.4 Update Building America Project Database

In 2010, the homes listed in Table 1-2 for January, February, March, and April were entered into the Building America Project Database. For the rest of the year, the database was not operable for submission of homes. At the end of November, BAIHP has approximately 80 homes ready for entry including those listed below completed from May through the end of November.

Table 1-2 *BAIHP Homes completed in 2010 by month*

Builder	January*	February	March	April	May - July	August	September	October	November
Built Wright									
			BWralph- 2	BWH-Harrison					
Dibros Corporation									
				DBRITT-292-2					
G.W. Robinson									
		GWtrnb-118			GWgw-52				
					GWgw-76				

Builder	January*	February	March	April	May - July	August	September	October	November
					GWgw-79				
HFH									
				HFH-2624					
HKW Enterprises									
				HKW-Villas Model					
Lifestyle Homes									
			LIFE - 474		1615 Marcello	1532 Tralee Bay PV final (no pool)	5297 Royal Paddock Drive		2962 Sereno Pt.
			LIFE - 3384		Job 3037 Sanibel	3692 Pascoli - Final	784 Breakaway Trail		2345 Botanical Circle
			LIFE - 1524		3405 Soft Breeze				1502 Alberton Court
			LIFE - 3405		Job 3045 3725 Tebaldi Final				1579 Bonelli Ct.
			LIFE - 3534		3104 Soft Breeze Final				
			LIFE - 3104		Job 3035 - 3534 Soft Breeze Circle				
					3662 Pascoli Place				
					1415 Primula-final				
					3312 Constellation final				
					3742 Pascoli Place				
					3307 Constellation – Final				
					459 Lighthouse Landin				
					2933 Sereno Pointe Drive-final				
					1152 Tralee Bay –final				
					1574 Bonelli Court resubmit				
Skobel									
	SKOwp-43	SKOwp-42			SKOwop-104				
		SKOwp-45			SKOwop-105				
		SKOwp-56			SKOwop-185				
		SKOwp-57			SKOwop-186				
					SKOwop-187				
					SKOwop-189				
					SKOwop-47				
					SKOwop-48				
					SKOwop-50				
					SKOwop-58				

Builder	January*	February	March	April	May - July	August	September	October	November
					SKOwop-96				
					SKOwop-98				
Southern Heritage Homes									
				SHH-Thompson					
Springwater Homes									
				Spring-1548					
Tommy Williams									
	TWLL-314	TWbm-140	TWbm-180	TWLL-307	TWbm-120	TWbm-113			
	TWLL-298	TWbm-152	TWLL-345		TWbm-126	TWLL-357			
	TWLL-344	TWbm-153	TWLL- 301		TWbm-141	TWLL-326			
	TWLL-315	TWbm-161			TWbm-149				
		TWLL-277			TWbm-162				
		TWLL-304			TWbm-163				
		TWLL-305			TWbm-170				
		TWLL-317			TWbm-172				
		TWLL-358			TWbm-173				
		TWLL-366			TWbm-174				
					TWbm-181				
					TWbm-184				
					TWLL-198				
					TWLL-216				
					TWLL-312				
					TWLL-313				
					TWLL-325				
					TWLL-342				
					TWLL-350				
					TWLL-367				
					TWLL-381				
					TWLL-392				
**Note that houses are tracked using codes that indicate the builder and a specific floor plan, job number, or address.*									

Subtask 1.5 Participate in Working Groups
(Formerly Subtask 4.4 Research Utilization and Subtask 4.5 RESNET Tasks)

Progress reported in 2010:

Building America Working Groups
Ken Fonorow (FL H.E.R.O.) participated in the BA Dehumidification and Ventilation Working Group teleconference in August.

Florida Green Building Coalition (FGBC)
Eric Martin (FSEC) participated in the monthly FGBC Homes Committee conference call on January 25th to help refine version 7 of the Florida Green Home Standard.

Stephanie Thomas-Rees participated in the Florida Green Building Coalition Board of Directors meetings and various sub-committee meetings from January thru November. In March, she participated in Metro Orlando Green Committee Meetings and Volusia Building Industry Association *lunch and learn event* titled "Green Retrofit and Incentives". She also participated in

the Board of Directors Annual meeting and various sub-committee meetings at GreenTrends in Sarasota, June 2-4.

Pacific Northwest Electric Power and Conservation Planning Council's Regional Technical Forum (RTF)

Brady Peeks of Northwest Energy Works is now a board member on the RTF working group. RTF is an advisory committee established in 1999 to develop standards to verify and evaluate conservation savings. RTF members are appointed by the Council and include individuals experienced in conservation program planning, implementation and evaluation. The RTF is also responsible for developing a resource rate discounts for the Bonneville Power Administration. The C&RD program awards rate discounts to customers who have implemented effective energy conservation measures.

At the February meeting, Mr. Peeks discussed with several utility staff members in attendance how HUD-code homes fitted with ductless heat pumps might fit in with utility conservation program efforts. Mr. Peeks also attended the May meeting. In addition, he attended two meetings held in June and updated representatives from several utilities on opportunities to help promote interest in DHP hybrid zonal space conditioning systems in NEEM homes.

At a July sub-committee meeting, Mr. Peeks participated in a discussion on research design for a proposal to monitor ultra-low flow lavatory faucet aerators in a variety of building types to see what kind of deemed energy savings might apply to this measure. The outcome of this monitoring could provide guidance in future specification development for NEEM homes. Subcontract funding to Northwest Energy Works ended in August.

Washington State Labor and Industries (L&I) Factory Assembled Structures Advisory Board (FAS)

As a voting member, Mike Lubliner attended the FAS February meeting to discuss BAIHP coordination on NEEM, Habitat for Humanity, and other related areas. WSU is exploring the possibility of linking L&I alteration permits and NEEM data bases and training inspectors to assist in tracking and improving performance of electrically heated NEEM homes that have heat pumps installed. Currently, a significant number of NEEM homes have low benchmark ratings due to the reliance on electric forced air furnaces. WSU is working with other stakeholders to improve these NEEM homes. WSU is also working with MHCC and L&I IPIA to evaluate factory built “park models”, which have no HUD or state inspection process and are a growing sector of factory built residences.

In May, WSU met with Washington State Labor and Industries FAS to discuss ductless heat pump and solar DHW inspections using HUD-code alteration permit on WSU Energy House. In June, WSU followed-up with Washington State Labor and Industries to discuss ductless heat pump and solar DHW inspections using HUD-code alteration permit on WSU Energy House. WSU is working on re-wiring system to address electrical code issues associated with non-motor rated disconnect switch installed by electrician, and solar tank “pan” plumbing issue.

WSU continued to work with Washington State Department of Labor and Industries (L&I) in September to collect information on heat pump alterations from L&I database. The information

collected was reviewed by both parties in October. This data may be used to recruit homes for potential collaborative research study in 2011.

In October, WSU discussed using data to determine when ENERGY STAR labeled manufactured homes complying with program requirements via the use of a heat pump have actually had the heat pumps installed and inspected by L&I inspectors. Discussions included WSU providing training to L&I inspectors on how to inspect heat pumps for proper airflow, temperature spilt and strip heat lock out, as required in PNW heat pump utility programs. WSU believes these efforts will result in better in-field installations of heat pumps in manufactured homes and provide assurance that claimed savings for heat pump installations are being realized.

Technical Assistance to DOE on Manufactured Housing Industry Issues

WSU has worked with a number of stakeholders in support of DOE's March 2010 ANOPR on manufactured housing and provided comment in conjunction with those from NPCC, NRDC and other stakeholders. In March, WSU provided technical assistance to DOE regarding US Senate bill 1320. The bill concerns manufactured housing replacements.

ASHRAE

BAIHP staff continued active participation in 2010, attending the 2010 Winter and Annual meetings, and participating in the following ASHRAE committees:

ASHRAE 6.3 – Central Forced Air Heating and Cooling Systems

As a voting member, Jim Cummings (FSEC), attended this committee meeting at the 2010 Winter Meeting and will be updating chapter 9 in the HVAC Systems and Equipment. Seminar program that Cummings submitted for the Orlando ASHRAE meeting (subject – Should building cavities be allowed as part of the air distribution system?) was declined. No plans to resubmit. (Note: Mike Lubliner received a round of applause for successfully negotiating the development and approval of the new Standard 193.)

As chair, BAIHP staff convened and participated in research subcommittee meeting in June to update research plan and discuss developing new RTARs on 1) flow measurement in residential systems, 2) high pressure drop duct design issues for ECM in furnace, HP and AC retrofits with ECM motors.

As research project (RP) chair, WSU staff coordinated Project Monitoring Subcommittee (PMS) meeting of RP-1449 (Energy Efficiency and Cost Assessment of Humidity Control Options for Residential Buildings) and approved project deliverables at the ASHRAE 2010 Meetings. WSU provided peer review and comment on reports for tasks 3 and 4. The draft report for task 5 is under review. The project is expected to be completed in 2011.

ASHRAE TC 9.5 – Small Residential and Commercial Buildings

Mike Lubliner became the new programs sub-committee chair for TC9.5. WSU also provided proposals to HVAC sub-committee to evaluate heat pump commissioning.

Planning is underway for Montreal DHP seminar. Seminar will include presentation of flip-flop test results at the WSU energy house, and analysis by BAIHP partners NIST and Ecotope.

ASHRAE 62.2 - Ventilation and Acceptable Indoor Air Quality in Residential Buildings
Throughout the year, WSU staff participated in meetings in support of efforts to align proposed changes to the Manufactured Home Construction and Safety Standards (MHCSS) to ASHRAE 62.2. WSU met with 62.2 committee members, as well as top management at HUD's office of manufactured housing and other stakeholders at NIST. These efforts are consistent with Builder's Challenge Indoor Air Quality Criteria and durability goals.

WSU staff also conducted discussions with 62.2 members and other stakeholders regarding new Washington State ventilation requirements. Specifically, the new requirements specify the need for air inlet vents; 62.2 does not require them.

WSU is also exploring the potential for a new collaboration between Building America and NEEA on requirements for whole house ventilation in code and beyond-code programs with tight envelope requirements.

ASHRAE RP-1449
As research project chair, Mike Lubliner (WSU) coordinated Project Monitoring Subcommittee (PMS) meeting of ASHRAE RP-1449 (Energy Efficiency and Cost Assessment of Humidity Control Options for Residential Buildings) and approved project deliverables at the ASHRAE 2010Winter Meeting in January. In March, WSU provided review and comment on task 3 report - Energy Efficiency and Cost Assessment of Humidity Control Options for Residential Buildings.

In May and June, WSU prepared for and chaired Project Management Subcommittee meeting with Building Science Corporation and others. Peer review of task 4 was completed in June.

WSU filed a no-cost extension in July and discussed RP-1449 activities with Building Science Corporation principal investigator. In September, WSU approved BSC request to ASHRAE for no cost extension as chair of PMS. The current draft report of task 5 simulation plan has been developed and is available per request. In October, WSU began preparation for PMS meeting at ASHRAE winter meeting.

ASHRAE SPC 193
As a voting member, Jim Cummings (FSEC), attended the committee meeting for Standard 193 (a method of testing for air handler air tightness) which went out for public review, received one comment, this comment was resolved, and it has now (as of the January 2010 meeting) been approved for publication at the ASHRAE 2010 Winter Meeting in January.

In September, WSU reported that the request for forum on Std 193 at the ASHRAE annual conference was rejected.

ASHRAE Technical Committee 5.3
In March, WSU worked to address comments from TC5.3 on applicability to VAV systems.

ASHRAE Standard 119 Revision

As a voting member, Jim Cummings (FSEC), attended this committee meeting at the 2010 Winter Meeting and gave a 30-minute Power Point presentation on concerns about the stringency of the Leakage Classes, including insufficient air exchange if ventilation system fails and combustion safety concerns when negative pressure results. While some support was expressed regarding my concerns, the committee voted to not change the content of the standard itself. An Informative Appendix (first draft of this Informative Appendix by Cummings) will be written to express some of these concerns. John Talbott, the Standard 119 chair, agreed to communicate with ASHRAE Standard 62.2 regarding the committee's concerns about IAQ and health/safety. Max Sherman recommended that Cummings prepare requests to ASHRAE Standard 62.2 committee to address specific concerns that I expressed in my presentation.

WSU participated in Standard 119 at the ASHRAE Summer meeting in June.

ACCA

As voting member of the ACCA Quality Installation (QI) committee, WSU participated in the development and review of the final draft of the QI standard, identifying areas for improvement in future drafts, including heat pump sizing in heating climates, and other related airflow and duct leakage testing issues. This effort and discussion of heat pump sizing issues has resulted in discussions within ACCA regarding updating ACCA manual S.

NIST

For the last five years, WSU staff has been providing program design and in-field technical assistance as well as analysis support to the National Institute of Standard's (NIST) study of the air tightness, ventilation and energy use impacts of retrofits on an unoccupied manufactured home, sited at the NIST campus in Gaithersburg, MD.

WSU staff worked with NIST and Energy Conservatory staff to conduct envelope and duct leakage testing on the home, and provided substantial peer-review into two NIST reports on the project: "Air tightness, Ventilation, and Energy Consumption in a Manufactured House: Pre-Retrofit Results," and "Impacts of Air tightening Retrofits on Ventilation Rates and Energy Consumption In a Manufactured Home." Quoting the second report:

> In the project, a manufactured home constructed in 2002 was subjected to a series of air tightening retrofits, including installing house wrap over the exterior walls, sealing a number of leakage sites in the living space floor, tightening the insulated belly layer, and sealing leaks in the air distribution system. These retrofits reduced the whole house leakage, as determined by a fan pressurization test, by about 18% and the duct leakage by about 80%. Whole house infiltration rates were reduced by about one-third, with the specific reduction dependent on weather conditions and how the forced-air system was operating. The energy consumption rate for heating and cooling was reduced by about 10 %.
>
> While the retrofits did improve the air tightness of the house and reduce the energy consumption, the effectiveness of the effort was limited by the challenges of air tightening an existing building.
> In general, it is easier to construct a tight building envelope than to achieve one through retrofits (Hale, Davis et al. 2007). Manufactured homes in particular have the potential for

high levels of air tightness performance given the quality control that can be achieved in the factory.

RESNET

(Note: Additional material is available in the annual reports of Budget Periods 1-4. See links provided in the Introduction of this report).

Building Energy Labeling/National Builders Challenge: In January, Steve Baden and Philip Fairey met with representatives of LENNAR Homes in Washington, DC and discussed a joint marketing project for the National Builders Challenge and the labeling of homes.

On January 12 Steve Baden and Philip Fairey were in Washington, DC and participated in the national forum on the labeling of the energy performance of homes. Representatives of the U.S. Department of Energy, Environmental Protection Agency and Department of Housing and Urban Development also participated.

On January 16 Steve Baden addressed the National Association of Home Builders' Energy Subcommittee providing an update on RESNET.

International Dialog on High Performance Buildings: On January 21-22, Steve Baden and Philip Fairey (all funds for travel were paid by the European Commission) addressed the European Union Energy Performance of Buildings Directive in Amsterdam, the Netherlands. Mr. Baden made presentations on energy policy initiatives in the U.S., RESNET quality assurance procedures, and RESNET training procedures. Mr. Fairey presented RESNET's national building registry and U.S. climate zones. The meeting was attended by the Energy Performance of Building Directive managers of all of the European Union's member states.

Revising RESNET standards and procedures to be compliant with ISO, ANSI and White Certificate Verification Procedures: In March and April, RESNET continued work on revisions of the RESNET Standard to be compliant with all protocols. RESNET has allocated funds in 2010 to put the RESNET Standards in compliance with ANSI procedures and has received a proposal from a contractor to complete this task. A new Chapter Nine was approved and added to the RESNET Standards in March.

Tap Existing Homes Market: In March, RESNET continued work on the development of Chapter Eight of the RESNET Standards on Performance Testing. Chapter Eight will create standards and protocols for work in existing homes.

In April, RESNET's newly revised website was designed to serve as a portal for homeowners looking for qualified contactors, raters and auditors to undertake energy efficiency retrofits of their homes. RESNET has adopted guidelines for qualified contractors to work with raters and auditors to make improvements to existing homes. RESNET has received two applications for Contractor Education and Qualification Providers who will be responsible for training and monitoring contractors.

Revisions to chapter seven of the RESNET Standards, the energy audit standard, were completed. This chapter will be submitted to the RESNET Board of Directors for approval to be sent out for public review.

In anticipation of the Home Star legislation passing Congress, BPI and RESNET have been working to make it as seamless as possible for BPI and RESNET professionals to deliver services under the $6 billon retrofit effort. This cooperation will increase business opportunities and also help to set up the infrastructure to meet the goals of the Home Star program.

The cooperation includes:

- Development by BPI of a RESNET Rater supplemental Training Module for raters to be certified to conduct combustion testing and preparation of a work order.
- Adoption by RESNET and BPI of a protocol for the quality assurance inspection of Silver Star rebates.
- Standards for Professional Development
- Chapter Eight of the RESNET Standards

National Dialog Forums on High Performance Buildings: Steve Baden presented on March 1st at the 2010 Greenprints Conference on "The New ENERGY STAR". Mr. Baden also presented on March 26th at the 2010 Midwest ENERGY STAR Conference.

Building America-Habitat for Humanity Partnership: Continued to recruit raters to volunteer with Habitat at the local level. There are 196 current RESNET rater members who have signed up to volunteer with the Habitat for Humanity Program. Twenty-eight rater members signed up to volunteer from February 13th to March 31st. The Austin Habitat case study was posted on March 30th.
http://resnet.us/rater/partnership/casestudies/Austin.pdf

Additional case studies were also posted in 2010 and are available on the RESNET website:
http://www.resnet.us/rater/casestudies

Develop RESNET National Building Registry: In March, additional registries for raters and quality assurance designees have been added to the scope and there is potential to expand registry to include home energy survey professionals. Work continued on integration of addresses, formatting rater spreadsheet and development of software spreadsheet templates. Energy Logic begun Alpha Testing the registry, and Beta Testing to selected providers were to be completed in the following two months.

As of April, one more update on RESNET National Building Registry needed to be completed before it would be ready for alpha testing. The update was developing the best method for accredited rating providers to enter ENERGY STAR and tax credit information into the registry.

RESNET Technical Committee: WSU staff participated in RESNET technical committee conference calls in March, and provided potential research topics for the RESNET technical committee, including HVAC commissioning and evaluating the current HERS methodologies for comparing fuel types.WSU staff provided comment on RESNET interim combustion safety and scope of work guidelines in April.

Participation in key national forums on high performance buildings:
Steve Baden presented at 2010 Affordable Comfort Conference on April 22nd about "Moving Forward with State, Regional, & National Standards" and on April 23rd about "Selecting the Right Certification for You". Mr. Baden also presented at spring meeting of the National Association of Home Builder's Energy Subcommittee on the number of homes rated and number of home verified for the energy efficient new homes tax credit in 2009.

Recruit RESNET members to volunteer their services to Habitat for Humanity affiliates: Two new Home Energy Raters volunteered their services to Habitat for Humanity in April. This brought the total to 198 rater volunteers for the Habitat for Humanity Program.

Other RESNET Activity: WSU staff participated as members of the RESNET technical committee and Board of Directors, including attending board and committee meetings in Raleigh and New Orleans.

WSU participated in e-mail votes of the RESNET board of directors in September and attended an October meeting of the RESNET board of directors in New Orleans. WSU also participated in e-mail votes of the RESNET Technical Committee and board of directors in November.

Washington State Factory Assembled Structures Advisory (FAS) Board
WSU staff participated in the Washington State Factory Assembled Structure (FAS) board meetings as a voting member, participating 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.

WSU worked with the Washington State Department of Labor and Industries (L&I) to investigate the possibility of linking the L&I alteration permit database with the Northwest Energy Efficient Manufactured Housing Program (NEEM) database, to determine which NEEM electrically heated homes have after-market heat pumps installed. Currently a significant number of NEEM homes have low benchmark ratings due to the reliance on electric forced air furnaces. This data may be used for a potential collaborative research study in 2011.

WSU also discussed providing L&I staff training on inspecting heat pumps for proper airflow, temperature split and strip heat lockout, per Pacific Northwest utility programs. WSU believes these efforts will result in better in-field installations of heat pumps in manufactured homes, and provide assurance that claimed savings for heat pump installations are being realized.

Subtask 1.6 Attend Quarterly Building America Meetings
(Formerly Subtask 4.4 Research Utilization)

FSEC Activity

- Prepared presentation and other material for the February quarterly meeting. However, the meeting was canceled due to bad weather.
- Philip Fairey, Eric Martin and Janet McIlvaine participated in the DOE Building America Residential Buildings Integration Meeting in Denver on July 19-22. Janet McIlvaine presented on retrofit projects that are underway, Eric Martin presented a case study on a

very high efficiency home with an E-Scale score of -2 and Philip Fairey facilitated two technical sessions.

Subtask 1.7 Attend Conferences and Workshops
(Formerly Subtask 4.4 Research Utilization)

FSEC Activity

- Jan 18-19. Subrato Chandra, Stephanie Thomas Rees (FSEC), and Calcs-Plus participated in Building America activities at the International Builders' Show, Las Vegas, NV including staffing of the DOE/HUD/PATH Ask the Experts booth in the exhibit hall
- Jim Cummings attended the January 2010 ASHRAE meeting in Orlando, including three committees as a voting member
- Janet McIlvaine attended a Building America Retrofit Expert Meeting hosted by Building Science Consortium in Boston March 12.
- K. Schleith was guest speaker at the Enchanted Forest in Titusville Florida on 15 June. He spoke on the status of NSP home retrofits in progress with Florida local governments and non-profits see Sub-task 6.2), how the results relate to practical steps home owners can take to improve the energy efficiencies of their homes.
- Stephanie Thomas-Rees attended GreenTrends conference (annual Florida Green Building Coalition) conference June 2-4, 2010.
- Janet McIlvaine, Kevin Schleith, and Karen Sutherland attended the Florida Housing Coalition conference to recruit participation in BAIHP retrofit work.

WSU Activity

- Mike Lubliner met with advisory group members for Subtask 2.2.6 at ASHRAE 2010 Winter Meeting in January; attendees included Ecotope, NIST, WSU, ACCA, Panasonic, LG, Fujitsu, and members of ASHRAE TC 9.5 and RP-1449.
- WSU attended Building Science Corporation's Westford Symposium in August. WSU also met with BAIHP partners Panasonic, DOW, The Energy Conservatory and Walsh Construction, as well as other Building America teams, to discuss current projects and future planning.

GTI Activity

- GTI investigators Paul Glanville and Doug Kosar attended the January ASHRAE conference in Orlando. While attending the meeting and expo in the Orlando area, GTI researchers provided an overview of relevant GTI activities to FSEC, met with key researchers, and toured their water heating and other labs.

Florida H.E.R.O. Activity

- Ken Fonorow attended LEED Field Agent Training Session 3 and a Homes Star Webinar in January.
- In February, Ken Fonorow attended multiple workshop sessions at 2010 RESNET conference.
- In March, he attended the EcoFair in Gainesville Florida and the North Central Florida Builder's Association's Home Show.

- Ken Fonorow attended Builder's Association's of North Central Florida's Spring Parade of Homes show in April.
- In July, Ken Fonorow attended the Southeast Builders Conference in Orlando, Florida.

Subtask 1.8 Host and Participate in Building America Expert Meetings
(Formerly Subtask 4.4 Research Utilization)

In 2010, GTI was tasked with conducting an Experts Meeting (see Table 1-3) themed "Utilities meet High Performance Homes" in 2010. The final meeting topics were to be determined at the February or April Building America Quarterly meeting. However, after the cancellation of both meetings, Ryan Kerr (GTI Task Lead) began discussing the topic, venue and other pertinent information with Building America stakeholders on a one-on-one basis. In August, Ryan Kerr worked with Philip Fairey, Terry Logee, and NREL staff to better integrate Building America's Residential Roadmap development into Expert Meeting agenda. In September, the Experts Meeting was re-titled *Building America Residential Retrofit Roadmap: Delivering Better, Cheaper, and Faster Retrofits through Stakeholder-focused Research* in September.

On November 16th GTI hosted a BAIHP Experts Meeting called "*Building America Program: Delivering Better, Cheaper, and Faster Retrofits through Stakeholder-focused Research*" (Former title "Utilities meet High Performance Homes" changed in September). Industry experts from Building America and energy efficiency programs including U.S. Department of Energy, national laboratories, Building America teams, electric and gas utilities, energy efficiency program contractors, and related organizations gathered at GTI's headquarters in Chicago to identify opportunities that address key barriers to achieving large savings in existing homes, while identifying opportunities for collaboration. The meeting was a success with over 35 participants, a good mix of Building America and energy efficiency program stakeholders. Janet McIlvaine and Karen Sutherland of the BAIHP team were in attendance. On November 15th, GTI hosted an informal dinner for roughly 10 meeting attendees, all were invited. Please see meeting objectives and agenda below. A draft Final Expert Meeting Report will be submitted to FSEC for review December 4th.

Meeting objectives:

- Review Building America's expanded focus on existing homes, including goals and context with other U.S. DOE programs
- Enhance Building America researchers' understanding of energy efficiency program structure and goals
- Identify key shared opportunities and barriers to retrofitting more homes, for more savings
- Characterize important research questions/projects
- Identify opportunities for collaboration, while defining role for Building America and EE programs

Table 1-3 ***BAIHP Experts Meeting Schedule***

Time	Item	Presenter/Facilitator
8:30-9:00	Continental Breakfast	NA
9:00-9:10	Welcome	Bill Liss, Managing Director End Use

		Solutions, GTI
9:10-9:20	Meeting Overview and Objectives	Ryan Kerr, PARR Program Manager, GTI
9:20-9:30	Introductions	NA
9:30-10:00	U.S. Department of Energy Residential Buildings Program: Residential Retrofit Activities	David Lee, Residential Supervisor EERE Building Technologies Program, U.S. DOE
10:00-10:30	Building America Program: Existing Homes Research	Dr. Ren Anderson, Manager Residential Building Research Group, NREL
10:30-11:00	Residential Energy Efficiency Programs: Utility Perspective	Val Jensen, Vice President Marketing and Environmental Programs, ComEd
11:00-11:15	Coffee and Tea Break	
11:15-11:35	Research in Action: Building America and Tennessee Valley Authority partner to perform residential buildings research	Jeff Christian, Director Building Technologies Center, ORNL
11:35-11:40	Breakout Session Assignments	Ryan Kerr
11:40-1:00	Breakout Sessions A: Implementation Tools B: Health, Safety, and Liability Issues C: Measure Guidelines D: Data supporting retrofits	
1:00-1:30	Lunch	
1:30-2:45	Breakout Session Reports and Discussion	TBD
2:45-3:00	Closing Remarks and Next Steps	Ryan Kerr
3:15-4:30	Optional Laboratories Tour (Begins in Auditorium)	Larry Brand, R&D Manager, GTI

Subtask 1.9 Technical Reports and Presentations
(Formerly Subtask 4.4 Research Utilization)

For a full list of BAIHP Documents from 2005 – 2010, please see Appendix A.

2010 Peer Reviewed Papers

Thermal Performance of Exterior Envelopes of Whole Buildings XI International Conference - December 5-9, 2010

FSEC Activity

- D. Chasar, V. VonSchramm, S. Chandra, and J. Sherwin. "Measured Performance of Side-by-side, South Texas Homes." Thermal Performance of Exterior Envelopes of Whole Buildings XI International Conference, December 5-9, 2010.

  This paper highlights the energy and demand savings for cooling and other end uses between 3 side-by-side homes in San Antonio, Texas. In February, presented 20 minute overview of conference paper to FSEC staff at BAIHP meeting.

- J. Sherwin wrote draft case study for peer reviewed paper for Thermal Performance of Exterior Envelopes of Whole Buildings XI International Conference, December 5-9, 2010 in Clearwater, Florida.

  The paper analyzes the performance of four near zero energy homes monitored under the Building America program and was published in ASHRAE Transactions (see below).

WSU Activity

- Lubliner, M.R., Gordon, A.M., & Fuess, C.D. 2010. "Approaching Zero Energy in the Pacific Northwest Marine Climate." Thermal Performance of Exterior Envelopes of Whole Buildings XI International Conference, December 5-9, 2010.

ACEEE Summer Study – Fall 2010

FSEC Activity

- In February, D. Parker began a summary of the feedback research from 2006, updated with comparative performance in 2009 after three years. This will be published at ACEEE this summer (accepted paper).
- Fonorow, K., Jenkins, D., Thomas-Rees, S., and Chandra, S. "Low Cost Interior Duct Systems for High Performance Homes in Hot Climates", ACEEE Summer Study on Energy Efficiency in Buildings, August 15-20, 2010, in Pacific Grove, CA.
- Stephanie Thomas-Rees submitted poster presentation in April titled *"Transforming the New Home Market through High Performance Construction"* for the 2010 ACEEE Summer Study. It was accepted in May.
- (Stephanie Thomas-Rees) Poster presentation was being designed in July and was presented in August, titled "*Three Ways to Sell High Performance Homes"* http://www.baihp.org/media/pdf/ACEEE-Poster.pdf

WSU Activity

- Gordon, A.M., Lubliner, M.R., Blasnik, M., & Kunkle, R.D. (2010, August). Measured vs. Predicted Analysis of Energy Star Modular Permanent Military Housing: Fort Lewis Case Study. Proceedings of the ACEEE 2010 Summer Study on Energy Efficiency in Buildings. August 2010
- Abstract on Discovery Village was accepted for ACEEE Summer Study in January. Paper will include BAIHP technical assistance efforts, technology assessment, and billing analysis on over 400 homes. In February, WSU began the analysis and writing of the first draft, due March 5th. WSU submitted the first draft for peer review in March.
- The abstract to ACEEE 2010 on the Stamets residence, a BAIHP Prototype house in the Marine climate, was accepted in January. In March, however, WSU decided not to submit the paper due to time and resource constraints as well as data issues. WSU will present this paper at an EEBA October 2010 conference.

GTI Activity

- During the course of the year, GTI investigator Ryan Kerr will serve as Panel Leader for Residential Building Technologies for the 2010 ACEEE Summer Study on Energy

Efficiency in Buildings. In this capacity, Kerr will select, review and introduce papers and presentations concerning research pertinent to the Building America program.

- In March, he received and reviewed draft papers in March and sent draft papers out for review.
- Drafts will be returned to authors for final editing in the middle of April. Kerr will continually evaluate opportunities to leverage this role to enhance BA research activities.
- During April, Ryan oversaw the review process for draft papers and approved all final ACEEE conference papers in May.
- As of June, the final session presentation schedule is available on ACEEE's website: http://www.aceee.org/conf/10ss/index.htm#schedule.
- As of July, the final session presentation schedule was available on ACEEE's website: http://www.aceee.org/conf/10ss/index.htm#schedule.
- The 2010 ACEEE Summer Study on Energy Efficiency in Buildings took place from August 15 – 20. The conference was attended by more than 1,000 building science professionals, the largest ever. Mr. Kerr would like to thank BAIHP, the U.S. DOE and NETL for supporting the conference and its participants.

Florida H.E.R.O. Activity

- In April, Ken Fonorow and Stephanie Thomas- Rees prepared peer reviewed paper titled "Low cost interior duct systems for high performance homes in hot climates" which was accepted for 2010 ACEEE summer study conference in Pacific Grove, CA and finalized in May.
- Ken Fonorow, BAIHP research partner (FL HERO), prepared for presentations in July and presented a paper, *"Low Cost Interior Duct Systems for High Performance Homes in Hot Climates,"* in August on building ducts in the conditioned space. It is available on the website at http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-451-10.pdf

2010 American Control Conference, ACC – July 2010

FSEC Activity

- Camilo Gil completed preliminary version of the paper "An Optimal Control Approach for Determination of the Heat Loss Coefficient in a Domestic Water Heating System" in February and completed final version in March. Researcher will present paper at 2010 American Control Conference, ACC, June 30-July 2, 2010, Baltimore, MD. Paper will show first results of the research.
- Previously unreported peer reviewed paper: Gil, C., Haralambous, M., Qu, Z., and Simaan, M., "An Optimal Control Approach for Determination of the Heat Loss Coefficient in a Domestic Water Heating System", American Control Conference, June 30 - July 2, 2010, Marriott Waterfront, Baltimore, MD.

Symposium on Improving Building Systems in Hot and Humid Climates - Fall 2010

FSEC Activity

- Withers, C. and Cummings, J. "Opportunities for Energy Conservation and Improved Comfort From Wind Washing Retrofits in Two-Story Homes – Part I", Seventeenth

Symposium on Improving Building Systems in Hot and Humid Climates, August 24, 2010, in Austin, TX. http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-449-10.pdf

- •Withers, C. and Cummings, J. "Opportunities for Energy Conservation and Improved Comfort From Wind Washing Retrofits in Two-Story Homes – Part II", Seventeenth Symposium on Improving Building Systems in Hot and Humid Climates, August 24, 2010, in Austin, TX. http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-450-10.pdf
- McIlvaine, J., Sutherland, K., Schleith, K., and Chandra, S., "Exploring Cost-Effective, High Performance Residential Retrofits for Affordable Housing in the Hot Humid Climate", Seventeenth Symposium on Improving Building Systems in Hot and Humid Climates, August 24-26, 2010, in Austin, TX. http://www.baihp.org/pubs/pdf/PF-448-10.pdf

ASHRAE Transactions

FSEC Activity

- The following was completed and submitted for publication: Sherwin, J., D. Parker, C. Colon, and E. Martin. Performance of Four Near Zero Energy Homes: Lessons Learned. ASHRAE Transactions (2010 vol 116 part 2).

The Energy and Environmental Building Alliance (EEBA)

WSU Activity

- Presentation as part of the BA track at the EEBA annual conference in October 2010 in Portland, OR. Data analysis for the Stamets residence including radiant zone hydronic heating with electric resistance and ground source heat pumps.
- Presentation in October at the EEBA in Portland, Oregon on hydronic radiant heating system at the Stamets residence.

2011 International Builders' Show *(preparation)*

FSEC and Florida H.E.R.O. Activity

- Ongoing coordination of combined program submittals for (#12716) "Capturing the New Home Market with Zero Energy Homes" and paper authored by Walt Staheli and Ken Fonorow titled (#12428) "A Builder's Guide to Constructing a Net Zero Energy Home".

FGBC Magazine

FSEC Activity

- (Stephanie Thomas-Rees) In August, an article was written and published (cover story) in FGBC Magazine titled "Staying Ahead of the Curve with Zero Energy"

Technical Reports to DOE

Monitoring Plans Submitted to NREL

FSEC Activity

- In February, Dave Chasar submitted monitoring plan details for 4 homes for documentation of cost share funding.

FSEC Contract Reports

Parker, D., Fairey, P. and Hendron, R. "Updated Miscellaneous Electricity Loads and Appliance Energy Usage Profiles for Use in Home Energy Ratings, the Building America Benchmark Procedures and Related Calculations." Report number: FSEC-CR-1837-10. Florida Solar Energy Center. January 2010. http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1837-10.pdf

This task report for former BAIHP *Subtask 4.3 BA Program Support- MELs Review area* details *work* over the last year with NREL to incorporate the research done by TIAX for U.S. DOE to revise the estimating procedures used for miscellaneous electric end uses in homes. The following areas are being addressed:

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

Cummings, James B., Charles R. Withers, Jr., and Ian L. LaHiff. "Investigating Solutions to Wind Washing Issues in 2-Story. Florida Homes; Phase 1." Report Number: FSEC-CR-1842-09. Florida Solar Energy Center, December 31, 2009. http://fsec.ucf.edu/en/publications/pdf/fsec-cr-1842-09.pdf

This final report for former BAIHP *Subtask 4.3 BA Program Support- Wind Washing area* describes initial investigation of solutions implemented to eliminate wind washing effects and Issues in two-story Florida Homes.

Cummings, Jamie, Danny Parker, and Karen Sutherland. "Evaluation of Bias Issues within Regression-Based Inverse Modeling Methods Against Climate and Building Characteristics Using Synthetic Data." Report Number: FSEC-CR-1863-10. Florida Solar Energy Center, July 2010. http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1863-10.pdf

Colon, C. and Parker, D. "Side by Side Testing of Water Heating Systems Results from 2009-2010 Testing." Report Number: CR-1856-10. Florida Solar Energy Center, June 2010. http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1856-10.pdf

A full project report for Subtask 2.2.4 Solar Water Heating – System Evaluations details the first year of the data collection and assessment

McIlvaine, J. and Beal, D. "Gulf Coast High Performance Affordable Housing Demonstration Project." Report Number: CR-1791-09. Florida Solar Energy Center, August 1, 2010. http://www.baihp.org/pubs/pdf/Gulf%20Coast%20Final%20Report.pdf

Please see section 6.1 BAIHP with Habitat for Humanity for a summary of the results.

Martin, E. and D. Daniel, eds. "Building America Stage Gate 3 – Hot Humid Climate 40% Milestone Report." National Renewable Energy Laboratory, September 2010. (The report can be downloaded on the BA Project Management Extranet Site)

Technical Presentations *(in chronological order)*

FSEC Activity

- D. Parker made a presentation to the *Metal Construction Association* (MCA) annual meeting in Naples, Florida on the NightCool cooling system on 25 January. Approximately 60 members were in attendance. There is large interest in MCA working with DOE to demonstrate the NightCool technology in full scale homes.
- Eric Martin presented the 2-day Florida Green Home Certification Training workshop to 12 individuals in Jacksonville, FL on Jan 26-27.
- J. McIlvaine. "2011 Energy Star Program." Alabama Association of Habitat Affiliates *Green and Blue Conference*. 1.5 hours, ~25 attendees. January 28, 2010.
- J. McIlvaine. "Gulf Coast High Performance Affordable Housing Demonstration Project" Alabama Association of Habitat Affiliates *Green and Blue Conference*. 1.5 hours, ~40 attendees. January 28, 2010.
- Subrato Chandra made a brief presentation on the Tommy Williams Zero Energy Home #1 at the FSEC Policy Advisory Board meeting on Feb 19
- Stephanie Thomas-Rees submitted paper titled *"Capturing the New Home Market with Zero Energy Homes"* 2/19/10 for speaking opportunity at the 2011 International Builders' Show
- Stephanie Thomas-Rees presented *"Green Home Program Comparisons and the Builders Challenge Program"* to the Volusia Building Industry Association to approximated 60 attendees on 2/20/10.
- Stephanie Thomas-Rees gave a 15 minute interview to WNZF AM 1550, "Solar Fit" Segment (aired Saturday March 27) about the Building America Program and the Builders Challenge Energy Smart E-Scale.
- Janet McIlvaine conducted two day training with Habitat for Humanity International staff in Dallas for Habitat International Weatherization Pilot program. Day 1 classroom and site visit. Day 2 weatherization of 1995 Habitat built house. March 18-19. Approximately 35 attendees.
- Janet McIlvaine presented building science concepts (30 minutes) to staff and retrofit contractors participating in Brevard County (FL) Neighborhood Stabilization Program activities. March 30. Approximately 25 attendees.
- Danny Parker made three presentations to the *Affordable Comfort Inc*. annual meeting in Austin, Texas:
    - *Cool roofs and radiant barriers*
    - *Long term opportunities in deep retrofits in American homes*

- *Principles for Zero Energy Homes*

- Eric Martin presented the 2-day Florida Green Home Certification Training workshop to 21 individuals in Cocoa, FL on Apr 27-28.
- Danny Parker made a presentation to the *ACEEE Hot Water Forum* annual meeting in Ontario, CA – *Hot Water Systems Laboratory: Findings from First Year of Research* (May 20, 2010)
- Stephanie Thomas-Rees attended and presented session at the 17th Annual Southern Building Show & Conference, Atlanta, GA, May 13-15, 2010 entitled "Zero Energy Homes to Boost Your Profits." She also participated in "Ask the Experts" Panel.
- Janet McIlvaine and David Beal presented a one and one half day workshop in conjunction with Habitat for Humanity International and host affiliate HFH of Broward CO. BAIHP researchers presented information on efficient and sustainable building, including how to achieve ENERGY STAR (both 2006 and 2011 programs) and Builders Challenge. Approximately 30 attendees from affiliates around Florida attended the workshop.
- Janet McIlvaine participated in HFHI's National Construction Leadership Conference in Baltimore. Approximately 40 construction managers and staff attended a session on 2011 ENERGY STAR standards. A second session on DOE's Builders Challenge program and a new green program decision-making tool under development by Steven Winter Associates had a similar level of attendance. BAIHP also contributed to a 1-day post-conference intensive on energy efficient retrofits.
- Kevin Schleith was guest speaker at the Enchanted Forest in Titusville Florida on 15 July. He spoke on the status of NSP home retrofits for the local counties, how the results of energy efficiencies relate to local home owners, and what they can do to improve the energy efficiencies of their homes.
- Janet McIlvaine presented preliminary findings of BAIHP Subtask 6.2 Deep Retrofits in Existing Affordable Homes at the 2010 Residential Buildings Energy Efficiency Meeting, held July 20-22 in Denver, Colorado and sponsored by the U.S. Department of Energy's Building America Program.
- Eric Martin delivered a training for inspectors for the EPA WaterSense New Homes Program and a training for inspectors for the Florida Green Building Coalition Green Home Standard in August.
- David Beal and Janet McIlvaine presented two workshops to Habitat for Humanity Florida's 2010 State Conference on September 24 and 25. Workshops covered the new ENERGY STAR 3.0 and how it will affect the affiliates attempting to build houses in compliance. Attendance was approximately 25 people on Friday's session, mostly construction personnel from Florida affiliates. Approximately 15 people attended Saturday's session.

Florida H.E.R.O. Activity

- Ken Fonorow (Florida H.E.R.O.) presented "Insiders Tips on the U.S. Department of Energy's Builders Challenge – Building and Differentiating High Performance Homes in a Competitive Marketplace" with Edward Pollock, U.S. Dept. of Energy and James Lyons, Newport Partners, LLC at RESNET Conference in February.
- In March, Ken Fonorow prepared for presentation for ducts in conditioned space at the 2010 Affordable Comfort Institute conference to be held in Austin Texas.

- In April, Ken Fonorow (Florida H.E.R.O) presented "Ducts in Conditioned Space at the 2010 ACI conference to be held in Austin Texas.
- Ken Fonorow (Florida H.E.R.O.) presented and participated in round table discussion at The USGBC Heart of Florida Chapter & Green Drinks workshop on "North Central Florida's Energy Future" in April.
- (Ken Fonorow) Santa Fe College Gainesville, FL - *Green Building Training for Professionals* – instructor in May
- (Ken Fonorow) Santa Fe College Gainesville, FL - *Green Building Training for Professionals* – instructor in June

Calcs-Plus Activity

- Dennis Stroer moderated a session (substitution for J. McIlvaine) at RESNET on Habitat for Humanity Sustainable Initiatives in February.

Northwest Energy Works Activity

- Northwest Energy Works presented information about the NEEM program and the Eco-rated certification requirements to a group of utilities at a meeting hosted by Bonneville Power Administration (BPA). At the meeting's conclusion, BPA expressed the desire to develop a purchased upgrade program with the industry to obtain 100 percent of HUD-code homes produced in the region built at the current NEEM-specified efficiency levels or better, with possible additional incentives for homes built to a new high performance specification, yet to be developed.
- NEW held a seminar/reception with the industry on incorporating ductless mini-split heat pumps in homes. NEW, the Oregon manufactured Housing Assoc. and Heat Pump Store, a ductless heat pump (DHP) contractor, sponsored a four-hour seminar at a shop showroom in Independence, Oregon. DHP seminar announcements were sent out and twenty-four industry GMs, production managers and plant engineers attended. In addition Cadet manufacturing attended and displayed and presented their zonal heaters, part of a hybrid system using DHP with zonal electric backup for secondary zones in the house. Other attendees included 2 staff representing Bonneville Power Administration and a designer/retailer who has committed to sell homes with DHP.
- NEW staff and Jeff Pratt of the Heat Pump Store (DHP) trained Homebuilders NW staff on DHP installation in the factory. A Mitsubishi 1.25 ton DHP was installed and commissioned in the factory. Homebuilder NW staff installed the indoor unit and hung the outdoor unit on a bracket attached to the house. Jeff Pratt then flared the copper refrigerant lines, filled the lines with nitrogen, pulled a vacuum, and turned on the system. The whole training took 5 hours start to finish. The two-step process began in April when NEW designed the backup system, directed Homebuilders NW staff in running the electrical wire for the DHP system, located the indoor head, and decided on the location of the outdoor unit. A step-by-step DHP installation process is being developed by NEW for use in all the plants.
- NEW presented information about NEEM Eco-rated home certification and manufactured home end-of-life decommissioning opportunities and challenges at the National Housing Conference & MacArthur Foundation's full-day roundtable event in Portland, "Manufactured Housing – Affordable Housing Already in Our Communities," in the session, "In Support of Green Homes – Replacement Strategies for Inefficient

Homes." At this event, experts in manufactured housing cooperative legislation and technical assistance providers from across the country discussed lessons learned around forming manufactured housing cooperatives and supporting conversions to resident-owned communities and purchasing Eco-rated homes.
- At a regional conference in Goldendale, WA NEW presented analysis of 2009 NEEM home data that shows the program delivering homes with a "fleet average" Uo value that meets the requirements of the ENERGY STAR Homes program. NEEM program stakeholders attended the regional conference included representatives from Bonneville Power Administration, the Energy Trust of Oregon, and several regional utilities.

Subtask 1.10 Review Draft Best Practice Case Studies
(Formerly Subtask 4.4 Research Utilization)

In March of 2010, Subrato Chandra provided comments on attic air sealing best practices guide prepared by the Building Science Corp.

Subtask 1.11 Peer Review Activities for Stage Gates
(Formerly Subtask 4.4 Research Utilization)

No activity reported in 2010.

Task 2A: Stage G1A: Integrated Solutions for Specific Climates

Subtask 2.1 Perform Duties as Technical Lead

No progress reported in 2010.

Task 2B: Stage G1B: System Performance Evaluations

Subtask 2.2 Subsystems Research Projects

For Systems Research activities from previous budget periods, please refer to Task 1 in the annual reports mentioned in the Introduction section of this report.

Systems Research conducted in the final BAIHP budget period is summarized in Subtasks 2.2.1 – 2.2.7 below.

Subtask 2.2.1 Side-By-Side Lab Homes: Prototype (SBSL1) and Control (SBSL2):
(Formerly Subtask 2.3 (BP4) Lab Homes in Hot-Humid and Mixed-Humid Climates)

FSEC Lab Homes

Two identical new flexible residential test structures (see Figure 2-1) were designed and constructed 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 1960 - 1970s residence, with appliance and HVAC efficiency typical minimum current practice, typical for some home change-outs 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. Design and construction costs for the homes were paid by the state of Florida through the Florida Energy Systems Consortium.

Figure 2-1: *Conceptual design for side-by-side lab homes at FSEC*

Figure 2-2. *Construction site*

An architect, Mike Houston, was hired and construction drawings began development in 2009. In winter of 2010, drawings were prepared. Shading analysis was performed for determining issues if homes are situated east and west of one another with 65' between them. Minimal early morning and late evening shading was determined to be acceptable.

Final drawings were completed and a request of bids was distributed in April. Contractor bids for the construction funded under FESC funding were opened on June 11, 2010. The lowest bid for State of Florida University of Central Florida Flexible Residential Test Structure FI 10FSEC01 was from Jordan Development and Construction LLC for just under $300,000 (see Table 2-1).

Table 2-1 *Contractor bids*

PRE QUALIFIED BIDDER	PRICE ($)	PROPERLY SIGNED	BID GUARANTEE RECEIVED	SUBCONTRACTOR LIST INCLUDED
BRC Builders	$496,188.00	N	N	Y
C&D Construction, Inc.	$357,900.00	Y	Y	Y
Jordan Development & Construction, LLC	$297,900.00	Y	Y	Y
Life Style Homes Builders, Inc.	$378,990.00	N	Y	Y

The contract was issued in July 2010 for the contractor, and a draft schedule was composed. The FSEC team finalized a below ground instrumentation plan. Construction on the side-by-side label homes began in August (Figure 2-2). Utilities were run to the site. Each site was filled to the same height leveling the same dirt for both pads. The west site was lower than the east site,

but both were brought to the same height with the same mix of dirt. Only one oak and one pine tree needed to be removed. The slab was poured, the concrete block walls were constructed, the rafters were installed and plywood sheathing of the roof was mostly completed in September (see Figures 2-3 to 2-8).

Figure 2-3. *Well is dug using water.*

Figure 2-4. *PVC rod with thermocouples tied to it is lowered into hole.*

Figure 2-5. *FSEC's John Sherwin measures for exact depth placement. Yellow strings mark top of slab.*

Figure 2-6. *Rafters were placed on the East house by hand. West house shown without rafters in background.*

Figure 2-7. *Rafter design allows for a walkway above insulation level for easier attic walking for experiment changes.*

Figure 2-8. *September 30 photos shows plywood sheathing near completion. Dutch hip roof design allows for overhang on all four sides while providing an attic ridge area as well.*

Ground instrumentation was installed by six staff members with the assistance of a local well digging crew to help facilitate the ten-foot and twenty-foot holes on September 1. Ground heat transfer is still not fully understood and model accuracy is difficult to verify, thus we want to measure the ground heat transfer thoroughly. Water was reached at the eight-foot level the day of instrumentation in the homes. All thermocouples were 22AWG type T, butt-welded and coated with thermal epoxy. They were attached to 3/8" PVC dowels for the ten and twenty foot length holes. Table 2-2 below describes the locations.

Table 2-2 *Under Slab Temperature Measurements*

Type	Quantity	0’	1’	2’	5’	10’	20’	Moisture at 5’	Location
A	3	✓	✓	✓	✓	✓	✓	✓	Center of homes and midway between homes
B	6	✓	✓	✓	✓	✓	✓		Footer midway on east and west sides and two-feet out from home
C	12	✓	✓	✓	✓	✓			Corners of home and midway on North and South side footers
D	12	✓	✓	✓					Eight feet in from each corner in both directions and eight feet in from midway edge points on North and South sides

Construction continued on the side-by-side homes in October 2010. Roofs were shingled, front porch posts were constructed, and HVAC ductwork was installed (see Figure 2-9). The houses are designed to be able to locate the air handler in either of three locations: garage, attic, interior. The air handler will start in the garage, a typical location for Central Florida existing homes. Ductwork is run in the attic. Sensors were placed in the walls prior to drywall installation, ductwork was completed, and HVAC systems were installed in November. Drywall was also completed and painting begun. The houses were completed in 2010 (see Figures 2-10a-b).

Figure 2-9. *Typical new construction ductwork was installed –flexible duct coming from one small fiberglass trunk.*

Figure 2-10a *Overhead picture of completed test structures on the Southwest section of FSEC campus.*

Figure 2-10b *Finished test structures.*

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 was 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 and 2010.

Subtask 2.2.2 Lab House with SEER 21 Heat Pump Evaluation (MHLab)

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 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 was 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 was 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.

The reporting year began with continuing sensor installments and preparing for running heating season experiments. Heating experiments using the SEER 21 system and SEER 13 system connected to the attic ducts began at the end of January and continued until April when they were suspended until December when weather was more suitable for additional heating data. In December, more SEER21 attic system data was acquired before starting new experiments with SEER 21 and SEER13 connected to the indoor duct system. Overall thirty-one days of data were obtained for SEER13 attic system, eight days for the SEER13 indoor system, thirty-two days for the SEER 21 attic system, and thirteen days for the SEER 21 indoor system. Data collected during 2010 for the SEER 13 and SEER21 attic duct systems indicate about 14% heating energy savings (about 2.1kWh/day) for a day that averages about 54 degrees F outdoors. Heating data collection will continue into 2011.

Due to mild winters, there were several days when no heating occurred. These periods were targeted to conduct sensor calibrations and prepare for the coming cooling season experiments. Cooling season experiments began in May and continued for the following six months. Six different experiments were conducted and they were: SEER 13 attic duct system, SEER13 indoor duct system, SEER 21 attic duct system, SEER 21 indoor duct system, SEER 21 attic duct system with relative humidity control, and SEER 21 indoor duct system with relative humidity control.

The SEER 21 experiments with relative humidity control used the manufacture's control method of cooling based on meeting temperature set point and implementing a special low capacity and low airflow rate for better dehumidification if a specified relative humidity is not met. The system will not allow the set point to drop more than one degree below specified set point.

Normal operation of the SEER 21 system (no RH control) resulted in reasonable indoor relative humidity levels averaging around 50%-53% RH. An RH control of 45% was used so there would be adequate opportunity to observe the RH control in action.

Some results from comparisons of the daily energy use between the different cooling equipment and duct systems are shown in the tables below. The summary is based on the least-squares linear regression analysis of daily cooling energy versus the daily average temperature difference (out-in). SEER 21 (45%) refers to the SEER 21 system using the relative humidity control option set to 45%.

Table 2-3 shows predicted daily cooling energy use and the reduction in energy compared to the SEER13 attic system. Prediction is made at 82°F (typical summer day) based on the best-fit equations shown in the plot further below titled "Daily Cooling Energy vs. dT".

Table 2-3 *Predicted daily cooling energy use and energy reduction compared to SEER 13 attic system*

	SEER 13 attic	SEER 21 attic	SEER 21 (45%) attic	SEER 21 in	SEER 21 (45%) in
kWh/day @ 82°F	25.642	17.011	17.653	14.158	14.595
Savings vs. SEER13 attic (kWh/day)	-	8.631	7.989	11.484	11.047
Savings vs. SEER13 attic (%)	-	33.7%	31.2%	44.8%	43.1%

Table 2-4 compares predicted daily energy use and savings from switching from attic ducts to indoor ducts of the same SEER system (SEER 13 attic vs. SEER 13 in and SEER 21 attic vs. SEER 21 in). Both SEER systems show a daily reduction in cooling energy of about 2.9 kWh by going from the attic duct to indoor duct system.

Table 2-4 *Predicted daily energy use and savings from switching from attic ducts to indoor ducts of the same SEER system (SEER 13 attic vs. SEER 13 in and SEER 21 attic vs. SEER 21 in)*

	SEER 13 attic	SEER 21 attic	SEER 13 in	SEER 21 in
kWh/day @ 82°F	25.642	17.011	22.766	14.158
Savings attic duct vs. in duct of same SEER system (kWh/day)	2.876	2.853		
Savings attic duct vs. in duct of same SEER system (%)	11.2 %	16.8 %		

The predicted energy savings can vary depending upon the temperature difference selected for analysis. A deeper analysis based on typical meteorological year (TMY) data representative of Florida climate will be used for a predicted annual cooling savings for each day of the year and reported in a final technical report.

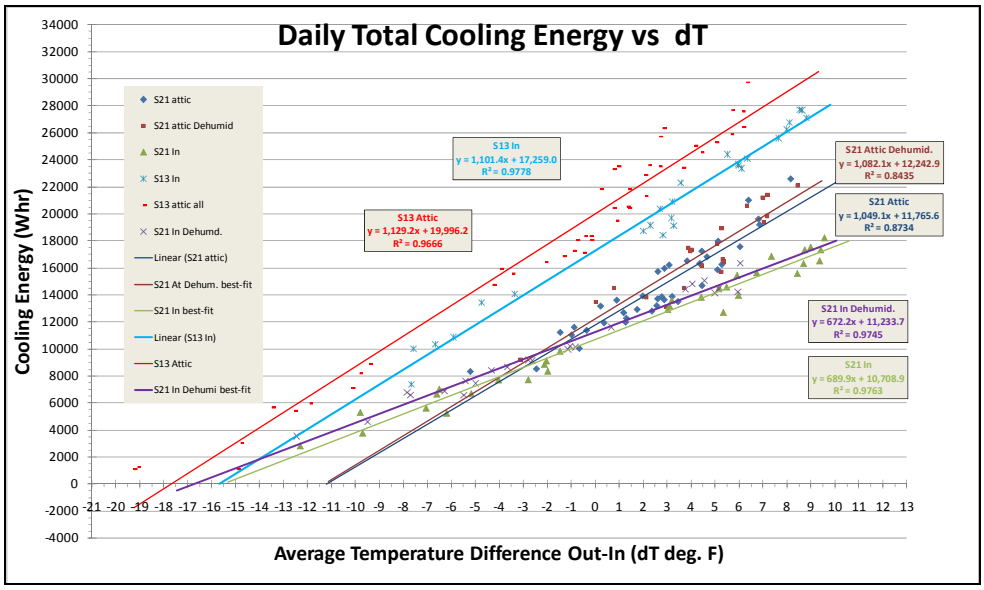

Figure 2-11: *Daily total cooling energy and daily average temperature difference between outdoors and indoors*

Figure 2-11 shows the daily total cooling energy and daily average temperature difference between outdoors and indoors. A least-squares linear regression analysis was used to develop the linear equations suitable for comparing the six different cooling experiments.

Cooling Energy Comparisons Seasonal Summary: Based on the daily cooling linear equations and an outdoor temperature of 82 degrees F, the following savings are predicted:

When Using the Indoor Duct System

- SEER 21 with RH control (45% set point) saves 35.9% compared to the SEER 13 unit.
- SEER 21 with no RH control saves 37.8% compared to the SEER 13 unit.
- SEER 21 with no RH control saves 3.0% compared to the SEER 21 unit with RH control.

When Using the Attic Duct System

- SEER 21 with RH control (45% set point) saves 31.2% compared to the SEER 13 unit.
- SEER 21 with no RH control saves 33.7% compared to the SEER 13 unit.
- SEER 21 with no RH control saves 3.6% compared to the SEER 21 with RH control.

Energy Savings from Switching from Attic to Indoor Duct System

- For the SEER 21 system, switching from the attic duct system to the indoor duct system saves 17.3% when employing RH control (45% set point). Conversely, it can also be stated that switching from the indoor duct system to the attic duct system increases cooling energy use by 20.9%.
- For the SEER 21 system (no RH control active), switching from the attic duct system to the indoor duct system saves 16.8%. Conversely, it can also be stated that switching from the indoor duct system to the attic duct system increases cooling energy use by 20.2%.

- For the SEER 13 system, switching from the attic duct system to the indoor duct system saves 11.2%. Conversely, it can also be stated that switching from the indoor duct system to the attic duct system increases cooling energy use by 12.6%.
- It is reasonable that the energy penalty associated with using the attic duct system would be much greater for the SEER 21 system compared to the SEER 13 system, because the SEER 21 system run time is nearly twice as great with the SEER 21 unit compared to the SEER 13 unit (72% of the time for the SEER 21 system versus 38% for the SEER 13 system during hot and humid weather). Therefore, conductive heat transfer from the attic to the duct interior operates for nearly twice the length of time for the SEER 21 unit.
- It is also reasonable that the energy penalty associated with using the attic duct system would be even greater when the SEER 21 system is in RH control mode (compared to without RH control) because the average supply air temperature is colder (compared to when the RH control is deactivated). The SEER 21 system runtime with RH control is slightly shorter than the SEER 21 system with standard control, but this may be due to the considerably hotter weather when the SEER system with standard control was operating.
- Note that most of the losses associated with the attic duct system are conductive losses, because there are no return leaks, air leakage of the supply ducts represents only 1.5% of the system air flow, and the AHUs and returns are in the conditioned space. It is assumed that duct losses from the indoor duct system are relatively small, and that nearly all of the energy lost from the indoor ductwork finds its way back into the conditioned space.

Peak Cooling Demand Reduction: The cooling peak demand reduction is often evaluated by comparing the hourly energy use during a peak cooling period. The peak period used for evaluation was the Florida Power and Light utility peak period from 4pm-5pm. The plot below uses a composite of several days that shows the average cooling energy used for each hour for the SEER 13 and SEER 21 connected to the indoor duct system. This method is accurate when a group of very hot days (with peak conditions similar to design conditions) is available for each of the experiments being run. It is also important that the outdoor conditions such as temperature, solar energy, wind and rain are also similar.

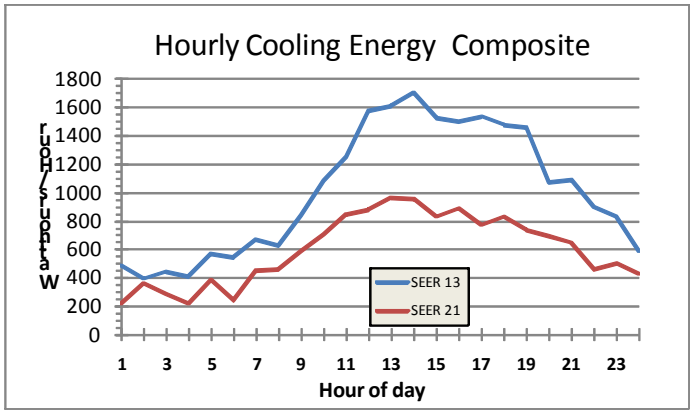

Figure 2-12: *Peak demand profile for two groups of hot summer days representing SEER 12 and SEER 21*

In Figure 2-12 above, the peak demand profile is shown for two groups of hot summer days representing SEER 13 and SEER 21, each using indoor ducts. A group of several very hot days

for all six experiments was not available, so another method of evaluation was done. The other method for determining peak demand and peak demand savings is a peak-hour regression method. Hours from 2 PM to 7 PM are selected from a group of 6 to 9 hotter than average summer days for each experimental configuration. The cooling energy consumption for each hour is plotted versus the outdoor temperature for that hour. The figure below shows the peak-hour regression analysis for the same two experiments shown in the composite graph above. The linear equation is then used to predict what the peak hour energy use would be for a chosen dT (outdoor – indoor temperature).

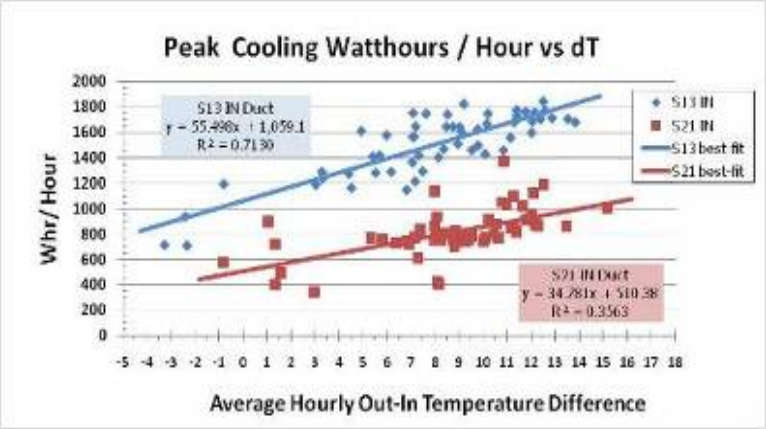

Figure 2-13: *Least-squares best-fit regression analysis for the hours of 2 PM to 7 PM from hot summer days for SEER 13 with indoor ducts and SEER 21 with indoor ducts*

Figure 2-13 above shows Least-squares best-fit regression analysis for the hours of 2 PM to 7 PM from hot summer days for SEER 13 with indoor ducts and SEER 21 with indoor ducts. The hourly regression method evaluates the peak cooling energy reduction reasonably well during the peak period. Figure 2-14 illustrates a comparison between the composite and peak-hour regression methods. The composite method results in a peak cooling reduction of 49.8% and the peak-hour regression method results in a 48.7% cooling peak reduction, a difference of 1.1 percentage points. Figure 2-14 shows almost identical peak hour (4-5 PM) electrical demand from the two different analysis methods. Lines produced by best-fit regression method used the delta-T from the composite to calculate Wh/hr shown in the plot.

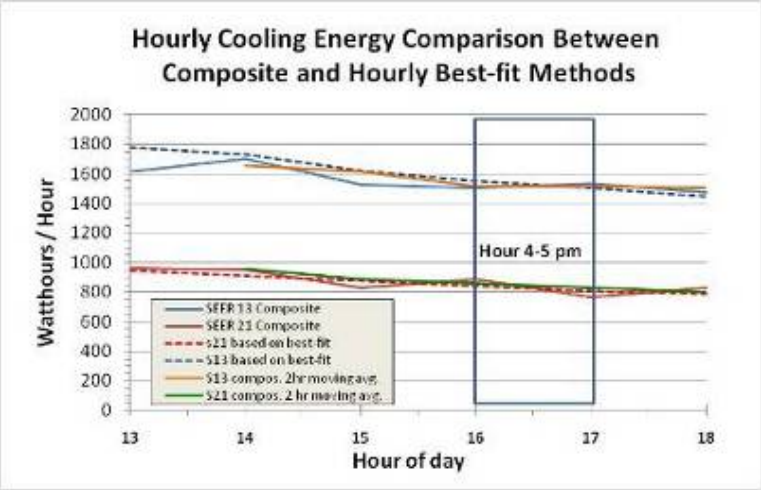

Figure 2-14: *Comparison of composite and regression methods (for SEER 13 and SEER 21 with indoor ducts)*

Figure 2-14 shows almost identical peak hour (4-5 PM) electrical demand from the two different analysis methods. Lines produced by best-fit regression method used the delta-T from the composite to calculate Wh/hr shown in the plot.

Results for peak cooling energy are provided below:
When Using the Indoor Duct System

- SEER 21 with RH control (45% set point) produces 37.2% peak demand reduction compared to the SEER 13 unit.
- SEER 21 with no RH control produces 45.0% peak demand reduction compared to the SEER 13 unit.
- SEER 21 with no RH control produces 12.5% peak demand reduction compared to the SEER 21 unit with RH control.

When Using the Attic Duct System

- SEER 21 with RH control (45% set point) produces 19.6% peak demand reduction compared to the SEER 13 unit.
- SEER 21 with no RH control produces 22.7% peak demand reduction compared to the SEER 13 unit.
- SEER 21 with no RH control produces 3.9% peak demand reduction compared to the SEER 21 unit with RH control active.
- Use of the attic duct system cuts the peak demand reduction in half compared to use of the indoor duct system.

Demand Savings from Switching From Attic to Indoor Duct System

- For the SEER 21 system (when employing RH control at 45% set point), switching from the attic duct system to the indoor duct system reduces peak demand by 32.8%. Conversely, it can also be stated that switching from the indoor duct system to the attic duct system increases cooling peak demand by 48.8%.
- For the SEER 21 system (no RH control active), switching from the attic duct system to

the indoor duct system reduces peak demand by 38.8%. Conversely, it can also be stated that switching from the indoor duct system to the attic duct system increases cooling peak demand by 63.4%.

- For the SEER 13 system, switching from the attic duct system to the indoor duct system reduces peak demand by 14.1%. Conversely, it can also be stated that switching from the indoor duct system to the attic duct system increases cooling peak demand by 16.4%.
- One can clearly see that ductwork located in a hot attic dramatically impacts the energy efficiency of the SEER 21 system.
- Note that most of the losses associated with the attic duct system are conductive losses, because there are no return leaks and only 1.5% air leakage of the supply ducts. It is assumed that duct losses from the indoor duct system are relatively small, and that nearly all of the energy lost from the indoor ducts finds its way back into the conditioned space.

For the SEER 13 unit, the increase in peak electrical demand during the hottest hours produced by switching from the indoor to attic ducts was a substantial 16.4%. This results almost entirely from conductive heat gain from the supply ductwork to the hot attic, since the supply ductwork is essentially airtight.

For the SEER 21 unit, the magnitude of the increase in peak demand (when switching from indoor to attic ducts) is remarkable; 48.8% for the SEER 21 unit with 45% RH control and 63.4% for the SEER 21 unit without RH control activated. These large increases in peak demand result from two factors. First, the SEER 21 AHU is running 100% of the time during peak hours compared to only about 50% for the SEER 13 AHU, so conductive heat gains are nearly twice as large. Second, the additional load produced by the conductive gains through the supply duct walls pushes the SEER 21 unit into higher capacity operation where the system energy efficiency is considerably reduced.

Based solely on the EER ratings of the two units the expected peak demand reduction would be 9.2%, assuming that both systems were operating at full capacity during the peak demand period. Since the SEER 21 unit, when using the indoor duct system, reduces peak demand by about 45% during a hot afternoon averaging 94^{o}F (17 degrees delta-T), the question then arises, how can the peak demand reduction produced by the SEER 21 unit compared to the SEER 13 unit be 5 times greater than indicated by the EER ratings?

Over-Sizing of the SEER 21 System is a Key Element of the SEER 21 System Performance: The answer appears to lie with the heat pump capacity relative to peak cooling load. The SEER 13 and SEER 21 heat pumps have rated capacity of 35,400 and 35,000 Btu/h, respectively. The MH Lab design cooling load, when using the indoor duct system, appears to be about18 kBtu/h. Therefore, even on hot summer afternoons the SEER 21 unit is only operating at about 50% of full capacity. Therefore, the SEER 21 unit can operate at or just above its minimum capacity (14 kBtu/h) during the hours of peak demand. In future experiments, it would useful to run additional configurations with SEER 21 systems of various capacities, to identify the seasonal and peak demand impacts of various equipment-capacity-to-building-load factors.

Indoor Ductwork is a Key Element of the SEER 21 System Performance: With indoor ducts, the SEER 21 unit reduces peak demand by 45%. By contrast, the SEER 21 unit reduces peak demand by only 22.7% compared to the SEER 13 unit when using attic ducts. (Note that the roof of the MH Lab house is medium color tan asphalt shingle, so the roof and attic become very hot on hot summer afternoons.) Therefore, heat gain from the hot attic (by conduction) into the supply ducts substantially diminishes the net energy efficiency of the SEER 21 system because cold supply air is in the ductwork much longer. This fact points to the importance of the thermal environment of the supply ductwork. Obviously, locating the ducts inside the house eliminates almost all of those efficiency losses. Lowering the temperature of the attic is another alternative. This can be achieved by means of a tile roof, a white metal roof, certain types of vented colored metal roof, and by means of a radiant barrier. It can be said, therefore, that use of indoor ductwork produces an optimal circumstance for the operation of variable capacity cooling systems. Alternatively, taking steps to reduce the attic temperature could also yield a significantly improved thermal environment for the SEER 21 system compared to a hot asphalt shingle roofing system.

It would be useful to run additional experiments with the tan asphalt shingle roof covered by a white tarpaulin (or similar), to identify the seasonal and peak demand reduction benefits of a cooler attic space. It would also be useful to more fully investigate the impact of sizing the cooling capacity. A more comprehensive evaluation of sizing impacts upon SEER 21 efficiency would be instructive to retrofit work.

Subtask 2.2.3 Efficient Hot Water and Distribution Systems (HWDS) Research

This subtask was new to BAIHP in 2010. Following the enactment of Energy Star ® for residential hot water heaters and the continued emphasis by utilities, regulators, and industry on increasing the efficiency of water heating, several major water heater manufacturers have released integrated electric heat pump water heaters (HPWH) into the market in 2010. These products "upgrade" ambient enthalpy to heat water with certified Energy Factors (EF) that meet the current Energy Star ® criteria of a 2.0 or above EF. Recent energy conservation standards rulemaking by DOE will essentially require that all electric storage water heaters above 55 gallons utilize heat pump technology to meet NAECA minimum efficiency levels to be implemented in 2015.

The three integrated HPWHs tested in this study, pictured in Figure 2-15, represent the current domestic offerings by the major manufacturers and are the only current class of electric Energy Star ® residential water heaters. At first glance, these HPWH products seem similar to one another and one might conclude that they yield the same performance and efficiency. The three units tested vary in: refrigerant used, compressor size, evaporator fan size, amount of onboard electric resistance heat, condenser design, storage tank size, number and type of appliance (control) settings, and other factors that influence performance.

Broken down by the product class category (e.g. gas-fired tankless, electric resistance storage), residential water heaters generally behave similarly across manufacturer offerings. Despite slight variations in design, one can predict the efficiency and performance across a product category with reasonable accuracy. Such an effort is currently underway in a Gas Technology Institute (GTI) led effort, sponsored by the California Energy Commission, to develop numerical modeling tools to accurately predict the efficiency and performance of gas-fired water heaters across product classes. These component level models developed will be integrated with a hot water distribution simulation program, to provide simulation tools for both generation and distribution of hot water at the whole-house level. This complementary HPWH evaluation of the three HPWHs by GTI (see Figure 2-15), under the Florida Solar Energy Center (FSEC) led Building America (BA) Industrialized Housing Partnership (IHP) Team supported by the Department of Energy (DOE), will aid in the development of electric HPWH models for these and other simulation modeling tools.

Figure 2-15: *HPWHs in this Study*

By design, HPWHs are inherently more complex than typical gas-fired or electric resistance water heaters. The heat pump portion alone brings considerable complexity, with performance and efficiency depending on the heat content of heat reservoirs at both the evaporator (ambient conditions) and the condenser (stored hot water). As ambient temperatures are cooler or drier or as the stored water temperature is hotter, the performance and efficiency of the heat pump will degrade. In addition to factors affecting the heat pump, all three HPWHs tested are "hybrids" in that they have electric resistance heating elements in addition to the heat pump, used for either backup heat or primary heat, depending on the appliance setting (control mode). The HPWHs have numerous appliance settings, which vary by the degree of heat provided by the heat pump versus electric resistance elements. Appliance settings which allow use of both heating methods utilize proprietary control mode algorithms to decide when heat pump heating is insufficient under certain operating conditions or hot water draw patterns. Differences in physical design and operational strategies compound the difficulty in generating meaningful experimental datasets to aid the development of generic HPWH models for these whole-house modeling tools.

Table 2-5: *Results Summary*

Test Parameter	Efficiency Effect	Performance Effect
Appliance (Control) Setting	• Directly proportional to percentage of heat input from the heat pump. • All-resistance operation results in EFs below that of conventional electric resistance water heaters. • Two of three HPWHs rely almost exclusively on higher-efficiency heat pump heat in Hybrid mode.	• Hot water capacity increases with resistance heat usage. • Large variation in storage tank and delivered water temperatures between manufacturers.
Thermostat Setting	• The HPWH using R-410a requires increased resistance heat for set point temperatures above 120°F, leading to a substantially lower EF at a these	• Two of the three HPWHs actually have a reduced First Hour Rating with a lower set point due to

Test Parameter	Efficiency Effect	Performance Effect
	higher thermostat settings.	onboard controls.
Hot Water Draw Pattern	• All HPWHs performed most efficiently as undersized, with 100 gallons/day versus 64 and 30 gallons/day for "non-standard" (non-DOE) draw patterns. • In Hybrid mode, heat pump energy consumption as a relative percentage of total energy consumption is unchanged for two of three HPWHs over all draw patterns. • As 'more realistic' draws spread demand throughout a 24 period, compared to standard (DOE) draw patterns, heat pump run times increase by up to 69%.	• "Non-standard" (more realistic) draw patterns result in large swings in delivered water temperatures for all HPWHs tested.
Ambient Enthalpy and Water Main Temperature	• As expected, the heat pump operates most efficiently in hot & humid ambient conditions and when the stored water in the tank bottom is cooler. Efficiency improves under 'realistic' versus standard draw patterns for both hot & humid and cold & dry tests in 5 of six cases. This is not consistently observed at standard ambient conditions with a standard (135°F) thermostat setting. • Similar to variation of hot water draw patterns, two of three HPWHs are unchanged in the fraction of heating provided by the heat pump over varying ambient and water main conditions.	• One of the three HPWHs, with the smallest compressor and evaporator fan, requires extended operation (> 6 hours) to reach steady state heat pump operation. • Cooling effect is between 0.25 and 0.5 tons of cooling, with latent fraction reaching 2 - 4% (R-134a) and 27% (R-410a) under the hot & humid test condition, the difference primarily due to refrigerant selection resulting in a lower evaporator-side air temperature.

The three units were put through a 16-test matrix, whereby the following influences on HPWH performance and efficiency were targeted: appliance setting, hot water draw pattern (including over/under sizing), ambient enthalpy, water main temperature, and thermostat setpoint. Tests both determined hourly capacity and daily efficiency, through the First Hour Rating and 24 Hour Simulated Use tests, similar to those of the current standard rating methods of test. These parameters are varied over the test matrix, utilizing an environmental chamber to maintain a hot and humid condition of 90°F/65% RH and cold condition of 50°F/70% RH for several of the tests in that matrix. Throughout testing, energy consumption is measured at the individual component level (e.g. upper resistance element). Finally extended static chamber testing with monitoring of all moisture and heat flows is performed to quantify the space cooling effect of the HPWHs.

Subtask 2.2.4 Solar Water Heating – System Evaluations (HWSL)
(Formerly Subtask 1.11 Related Systems Research: Solar Water Heating)

HWS Laboratory Phase I (March 2009 –May 2010)

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 2-16) was 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 2-17), and the tank and tankless systems were procured and plumbed inside the test shed (Figures 2-18 and 2-19).

Figure 2-16: *The FSEC DHW Test Facility*

Figure 2-17: *The solar collectors are mounted on a nearby roof mock up, with the ICS system in the rear top*

Figure 2-18: *One half of the tanks inside the test shed.*

Figure 2-19: *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 2-20).

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 2-20: *Average daily COP's, gallons, weighted inlet and outlet temperatures in Infomonitors summary page shown for December 6, 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 2-6).

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 (2-21) 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 2-6 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.

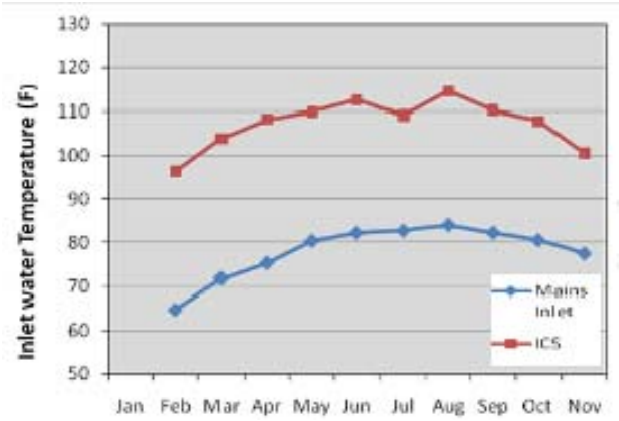

Figure 2-21: *Avg. inlet water temperature by month for standard and ICS system.*

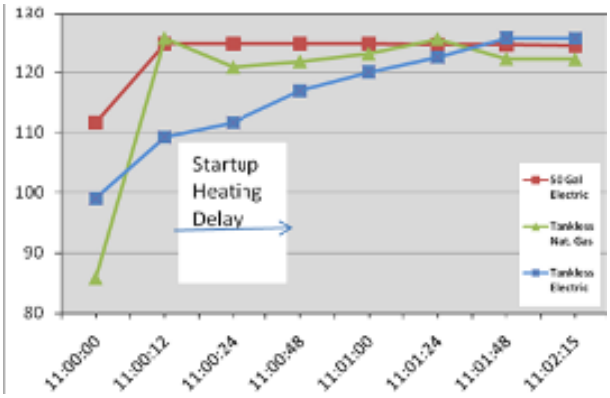

Figure 2-22: *Delivery temperature lag seen in tankless water heaters upon startup*

Table 2-6: *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

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 2-7 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 2-22). 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 2-7) 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 2-23). 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.

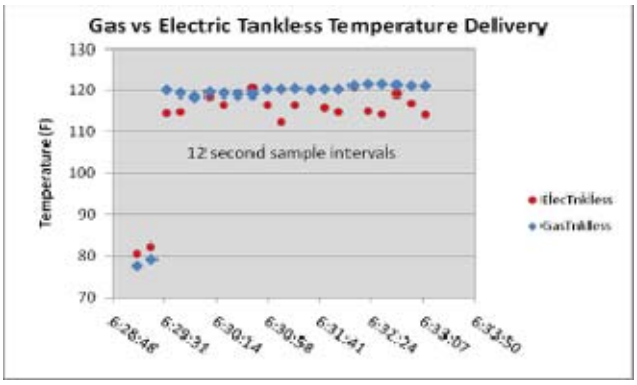

Figure 2-23: *Comparative stability of storage versus tankless system delivery temperature*

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.

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 2-24). 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.

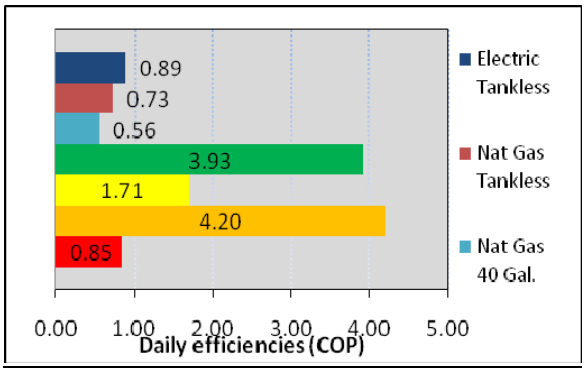

Figure 2-24: *Comparative average COP of tested systems over ten month period*

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 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 Figure 2-25. However, when the efficiency is averaged for December 1- 17, 2009, the differential controlled system has a slight advantage as shown in figure 2-26.

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 2-25: *Daily average efficiency for solar flat plate systems shown as equal (4.41) for the period of March 1st thru December 17, 2009.*

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 2-26: *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*

Daily Electric Consumption

Daily electric consumption for five systems can be compared on Figure 2-27 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.

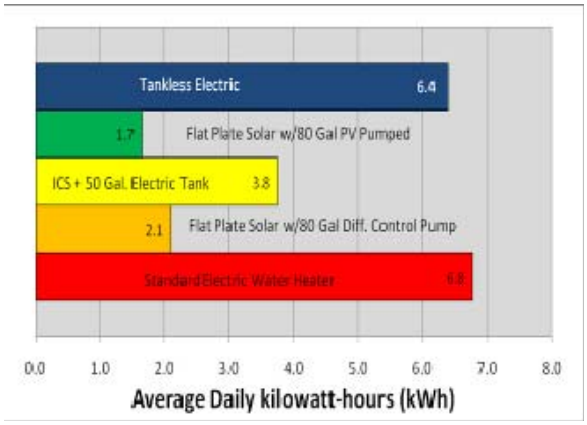

Figure 2-27: *Daily average electricity use for water heating*

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 2-28). 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.

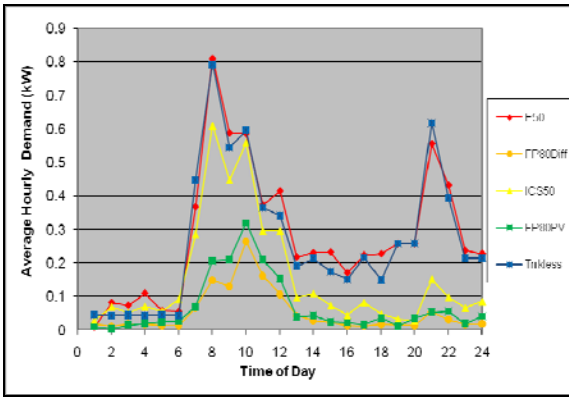

Figure 2-28: *Impact of water heating systems on electrical load shape over ten month period.*

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 2-29). 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%

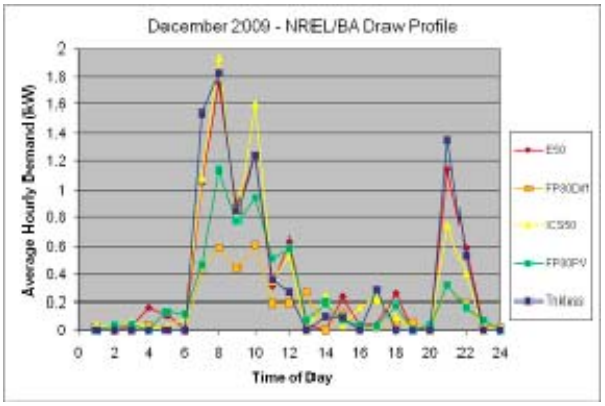

Figure 2-29: *Impact of water heating systems on electrical load shape obtained in December by using NREL/BA draw profile.*

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 2-7: *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	120..8	121.0	124.3	124.4	124.4	122.4	125.9	122.3	120.6	117.1

Summary Table 2-7: *Monthly Performance at HWS Facility – 2009*

	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Plate										
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

Hot Water System Laboratory - Summary of Results (May 2009-April 2010)

The overall combined average daily efficiency for the period of May 2009 thru April 2010 (see Figure 2-30), using both *ASHRAE 90.2* and NREL/BA hot water draw schedules, are shown in the figure at right. Parasitic energy was included in the calculations for the two systems that have auxiliary energy requirements: the controllers in the natural gas tankless and the differential activated pump in the solar system. Results from testing indicated that daily efficiency for these systems was generally below the published energy factor ratings. This difference in efficiency was expected since the testing procedures were not the same.

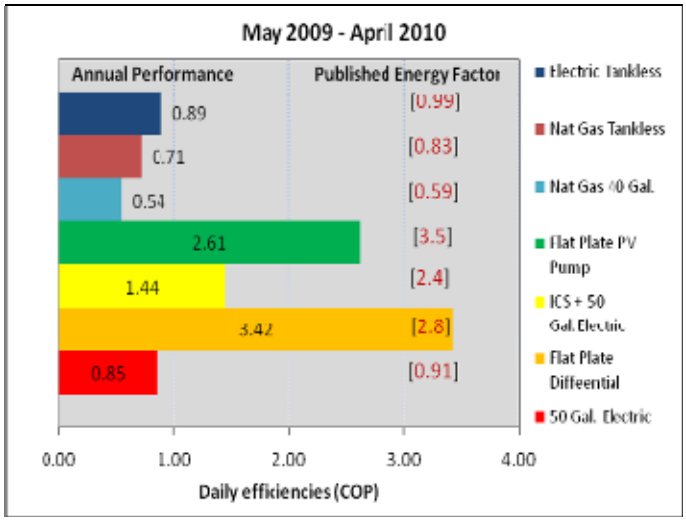

Figure 2-30: *Combined average daily efficiency for the period of May 2009 thru April 2010*

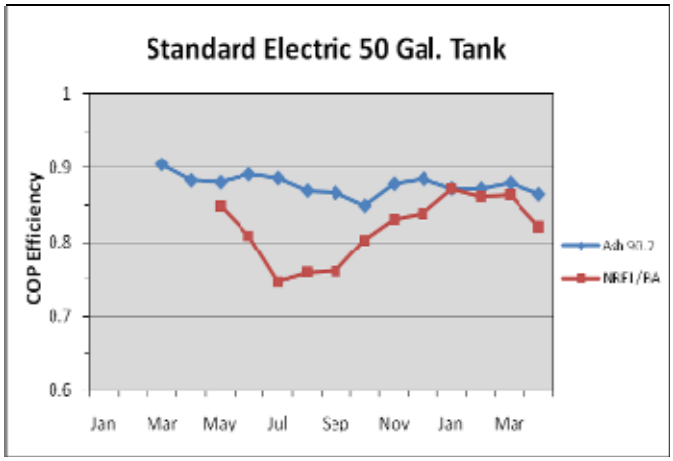

Figure 2-31: *Effects of patterns and efficiency penalty by month between March 2009 and April 2010 on the electric baseline system*

The differential flat plate solar systems displayed higher efficiencies than its solar energy factor (SEF) rating. The PV-pumped system also yielded very good performance. As expected, the solar systems surpassed the other types of heaters regardless of the hot water draw schedule. The highest average daily efficiency for this period (COP = 3.42) was demonstrated by the flat plate solar system utilizing a differential controller and AC pump. During the first eight months of testing, the PV pump system showed the highest overall efficiencies. However, during cloudy days and the winter period, the differential controlled flat plate solar system clearly exhibited the highest performance of all systems exceeding efficiencies by the PV pumped system due to its stronger circulation flow rate capabilities.

As previously mentioned, all systems were submitted to alternating draw schedules each month. The coefficient of performance (COP) figure above (Figure 2-31) displays the effects of patterns and efficiency penalty by month between March 2009 and April 2010 on the electric baseline system. One of the reasons for the lower than expected baseline electric system efficiency was the lower volume of hot water used under the NREL/BA hot water schedule. This lower consumption, along with higher inlet water temperatures in Florida, reduces the amount of energy provided during summer draws. Thus, standby losses become a higher percentage of energy use as compared to the total energy delivered, resulting in lower daily efficiencies.

Daily Electric Consumption

Daily electric consumption for five electric systems was compared for the period of May 2009 through April 2010. A complete one-year data set was recorded with both alternate draws. The plot at right (Figure 2-32) indicates a 0.3 kWh average daily reduction for the tankless electric when compared to the standard electric baseline system. Solar thermal systems demonstrated large daily electric reductions of between 5.5 and 3.5 kWh/day. The ICS system also managed to save approximately2.5 kWh/day.

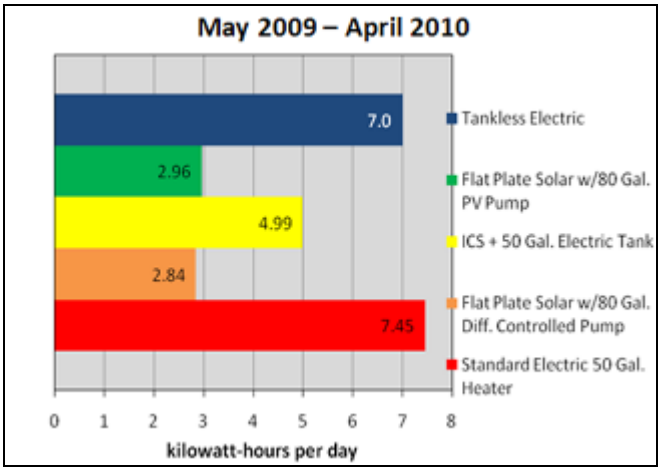

Figure 2-32: *Combined average daily efficiency for the period of May 2009 thru April 2010*

Draw Schedule Dependent Results

Further analysis of individual data was performed to determine the average daily energy consumption by draw pattern. Based on the results, researchers determined the draw-dependent energy savings percentages compared to the electric and gas reference systems, as shown in Table 2-8. The table also illustrates the change between ASHRAE 90.2 and NREL/BA draw schedules. Most systems exhibited lower performance with the NREL/BA profile. The negative impact was most pronounced in the ICS/50 system since ICS systems work best in summer when water heating loads are lower and more poorly in winter when water heating loads are larger. The NREL/BA profile, on the other hand, correctly shows that winter water heating loads are greater.

Table 2-8: *Draw-dependent energy savings percentages compared to electric and gas reference systems*

	ASHRAE 90.2 (savings %)	**NREL/BA (savings %)**	**Change (penalty %)**
Solar Flat Plate Differential w/80 gal. tank	62.7%	61.2%	-1.5%
ICS w /50 gal. tank	39.2%	26.3%	-13.0%
Solar Flat Plate PV pumped w/80 gal. tank	60.7%	59.4%	-1.4%
Tankless Electric	6.9%	5.0%	-1.9%

Natural gas tankless systems reduced natural gas consumption when compared to the standard upright vented water heater. Contrary to electric based systems, the tankless natural gas unit displayed a slight energy reduction under the NREL/BA draw profile due to the lack of small draws during early hours on the schedule (see Table 2-9).

Table 2-9 *Draw-dependent energy savings percentages for tankless natural gas compared gas reference system*

	ASHRAE 90.2 (savings %)	**NREL/BA (savings %)**	**Change (penalty %)**
Tankless Nat. Gas	23.5%	26.9%	+3.4

Time of Day Analysis- Site vs Source Energy

Time of day analysis of gas consumption of the two natural gas (NG) water heaters was analyzed, including a comparison of source and site energy generation to the differential controlled electric assisted solar system. Results indicated that the electric assisted solar system can outpace (and offset) gas water heaters when source energy analysis is taken into consideration. The relationship between natural gas systems and the differential controlled solar system site energy (left plot) and source energies (plot at right) can be observed in Figure 2-33 and figure 2-34. Site to source conversion multipliers were used to generate the source plot (Me = 3.365, Mg= 1.095).

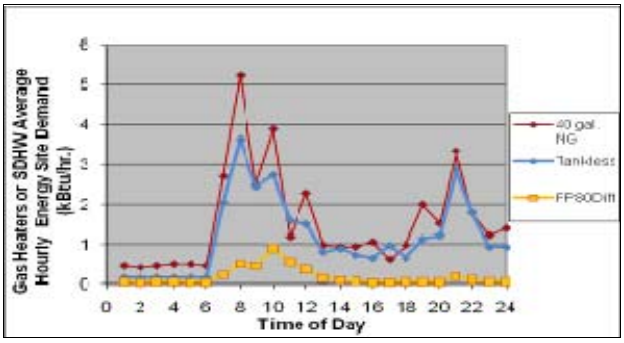

Figure 2-33

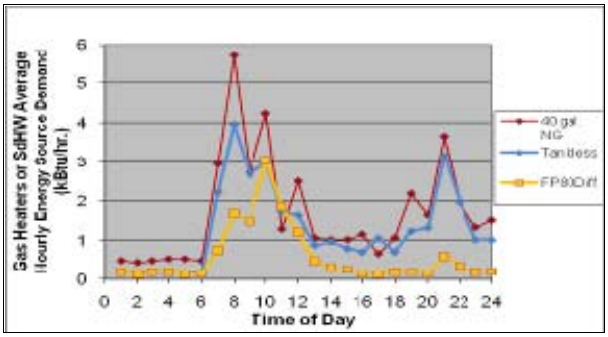

Figure 2-34

Winter Peak Demand

During January, the electric 50-gallon reference hot water system at the HWS Laboratory experienced the highest 15-minute peak demand of 1.1 kWh on January 4th at 6:45 AM. At that same time the integrated collector system (ICS) feeding a 50 gallon tank experienced a slightly higher peak of 2%. Similar average morning increased demand of up to 5% were found overall for the ICS/50 gallon during the month of January. The winter peak day demand of all electric water heaters can be seen in Figure 2-35.

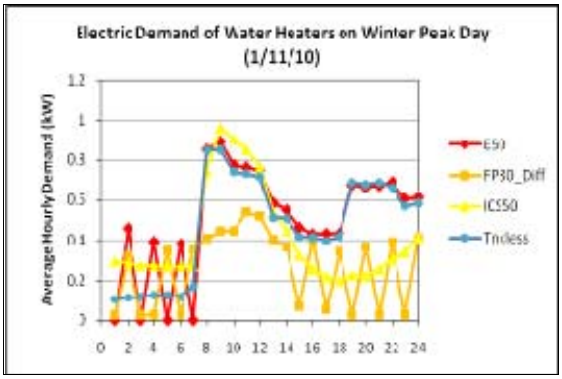

Figure 2-35: *Impact of water heating systems o*

Solar Flat Plate Photovoltaic Pump System Failure

Figure 2-36: *Pump impeller chamber*

On January 7, 2010 the photovoltaic pumped solar water heating system experienced a pumping failure resulting in an air lock which prevented the direct pump from circulating. It was concluded that the failure was attributed to the constant pressure loss of the flow regulators due to simultaneous hot water draw (ASHRAE schedule) and further pressure loss added by flow through the freeze valve in early morning hours. Freeze valves provided flat plate protection during consecutive early cold temperatures experienced in Florida (27 deg F Low) during early January. Check valve damage was found after failed efforts of re-establishing hot water loop circulation. A new check valve was installed in addition to a new direct current pump replacing what appeared to be an inconsistent (damaged) original pump due to repeated overheat (steam) temperatures. An inspection of the pump impeller chamber (Figure 2-36) also revealed that mineral deposits may prevent optimal pumping, adding additional flow resistance to the pump.

Ground Temperature Measurements

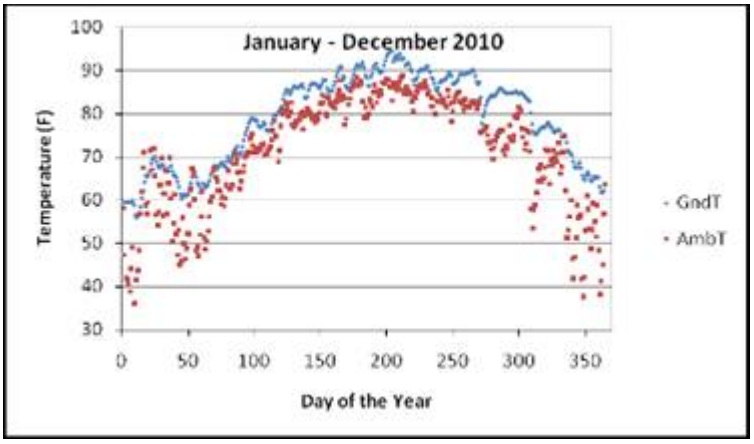

Figure 2-37: *Average daily ambient temperature against ground temperature measurement at 19 in. depth (2010)*

Ground temperature measurement capability was added to the HWS Infomonitors WebGet data base beginning on January 7th (4:00 PM). The ground temperature sensor was buried in-ground south of the HWS building at 19 inches of depth. The sensor has provided valuable measurements that can be used in the heat loss calculation of underground piping systems. Figure 2-37 plots the average daily ambient temperature against the ground temperature measurement at 19 in. depth during 2010.

Average Daily Consumption of Water Heating Systems

The average daily energy consumption (electric and natural gas) demonstrated for the period of March 1, 2009 and April 30, 2010 can be examined on the second column of Table 2-10. The average daily energy consumption of 7.45 kWh/day was measured from the standard electric 50 gallon water heater. For analysis purposes, this daily average value is considered to be a baseline to which all other electric systems are compared. As expected, the highest energy reductions are demonstrated by the solar thermal systems, in particular flat plate collectors. Surprisingly, the flat plate solar systems does not appear to be affected substantially by the NREL/BA draw profile schedule resulting in average daily difference of only 200 watt-hours per day or less.

Table 2-10. *Average Daily energy Consumption for Hot Water Systems (May 1, 2009 – Apr 30, 2010)*

System	Daily Average Consumption All data days (N=365)	Daily Average Consumption ASHRAE 90.2 Draws (N=166)	Daily Average Consumption NREL/BA Draws (N=174)
Standard Electric 50 gal. Tank	7.45 kWh/day	7.88 kWh/day	7.07 kWh/day
Solar Flat Plate Differential w/80 gal. tank	2.84 kWh/day	2.94 kWh/day	2.74 kWh/day
ICS w /50 gal. tank	4.99 kWh/day	4.79 kWh/day	5.21 kWh/day
Solar Flat Plate PV pumped w/80 gal.	2.96 kWh/day	3.09 kWh/day	2.87 kWh/day
Tankless Electric	7.00 kW/day	7.34 kW/day	6.71 kW/day
Nat. Gas 40 gal. tank	39.08 cu. ft/day (Nat. Gas)	39.95 cu. ft/day (Nat. Gas)	38.32 cu. ft/day (Nat. Gas)
Tankless Nat. Gas	29.2 cu. ft/day (Nat. Gas)	30.56 cu. ft/day (Nat. Gas)	28.01 cu. ft/day (Nat. Gas)

However, further analysis performed by separating the alternate draw event periods for ASHRAE90.2 and NREL/BA profiles, reveals conclusive notes on overall energy savings. The lower average daily electric consumption of the reference standard 50 gallon electric system obtained from those days, utilizing the NREL/BA draw schedule, implies that actual energy savings appears to be less than those obtained from the ASHRAE 90.2 schedule. Based on the dependent draw profile results, an average demand reduction as compared to the standard electric reference system was calculated. Results are shown in Tables 2-11 and 2-12 for all solar systems which utilize electric auxiliary and also for the tankless electric. As expected from the results shown, any of these systems provides an energy reduction when compared to the electric reference standard 50 gallon heater. However, the ICS/50 gallon system demonstrated that it is affected the most by draw profile, showing the highest difference in energy savings.

Table 2-11: *Average daily electric reduction for solar systems and tankless electric as compared to the standard reference electric 50 gallon water heater under two hot water draw profiles.*

	ASHRAE 90.2	NREL/BA	Change
Solar Flat Plate Differential w/80 gal. tank	62.65%	61.17%	-1.48%
ICS w /50 gal. tank	39.21%	26.29%	-12.92%
Solar Flat Plate PV pumped w/80 gal. tank	60.73%	59.37%	-1.36%
Tankless Electric	6.86%	5.00%	-1.86%

Table 2-12: *Average daily natural gas reduction for the tankless system as compared to the standard reference 40 gallon(NG) water heater under two hot water draw profiles.*

	ASHRAE 90.2	NREL/BA	Change
Tankless Nat. Gas	23.51%	26.92%	+3.41

A full project report on the first year of the data collection and assessment titled "*Side by Side Testing of Water Heating Systems Results from 2009-2010 Testing*" was published and released: http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1856-10.pdf

HWS Laboratory Phase II (July –November 2010)

Researchers at FSEC continue to evaluate new water heating technology in the HWS laboratory. During summer 2010 a 50-gallon heat pump water heater was purchased, replacing the electric tankless water heater in Phase I. Similarly, a list of changes to the HWS Laboratory configuration was made available in consultation with all interested parties (NREL, FSEC, industry). Power and natural gas (NG) to the hot water systems in the HWS laboratory was temporarily interrupted (shut-off) while the laboratory went through re-configuration. The tankless electric was removed and replaced with a new commercially available heat pump water heater (Figure 2-41).

Figure 2-41:*Commercially available heat pump water heater*

On May 26th, the 10-watt photovoltaic which runs the dc pump on the flat panel solar water heater was replaced with a 20-watt module. To investigate the ability of a larger power source with the existing dc pump and their ability improve efficiency during cloudy days. Prior to installation, the new 20-watt module was tested using FSEC's flash PV simulator, then exposed for a week to outdoor elements. The 20-watt module was tested again a week later to investigate on initial degradation of polycrystalline modules or if any premature failure. The 10-watt module that has been used for testing during our last 1.5 years was also sent to the simulator to document any power production degradation. This module previously tested when it arrived in new condition on august 2008. Both of these modules are of crystalline material composition and do not appear to have any significant degradation so far. Ultimately, the PV pumped system was changed to include a larger (40 watt) photovoltaic power and new dc pump, replacing the 10 watt PV/pump system in phase I.

After consultation with the manufacturer (Ivan Labs), a plan to increase hot water circulation during low solar radiation was formulated. Pump current will be increased via a larger photovoltaic module (40 watts); however this method requires careful and further electronic component addition (multi-series diodes) to limit the maximum voltage input to the pump (20V) during high solar radiation.

The ICS collector system also underwent configuration changes, now a single top tank element configuration in the 50-gallon tank. However the adjustment of the top element proved difficult to achieve a 120 °F setpoint. Ultimately, the thermostat was left at the best setting possible, but output temperatures exceeded 128 °F on most days.

During July the direct-current (dc) circulation pump on the PV solar flat plate systems was replaced with a new 20-watt model in hopes to achieve better response during cloudy days. On August 12th, a second crystalline photovoltaic module was added in parallel to increase power to the 20 watt pump. Pump current has been increased by doubling the photovoltaic modules (now 40 watts). A series of diodes (three per string) was added to the PV pump circuit to limit the

voltage applied to the pump as per manufacturer recommendations. The string of diodes effectively measured a drop of 2.2 volts keeping safe operating conditions to the pump (20 volts limit). The PV pumped system continues to lead in the efficiency race as expected; however it is too early to tell if the intended goal has been achieved because of the limited overcast (cloudy) days during August. The heat pump water heater efficiency continues to show its ability to heat water in hot/humid favorable conditions and has demonstrating almost three-fold efficiency (COP=2.6, August) compared to the standard electric water heater.

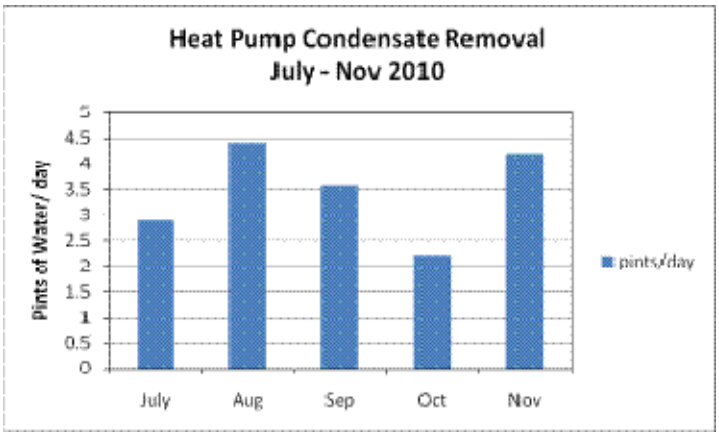

Figure 2-42

During summer months (July-September), the heat pump water heater showed an average efficiency of 2.6.; however this efficiency was achieved under "garage-like" hot temperature conditions that are favorable to this technology. A tipping bucket was added to the heat pump water heater to measure its moisture removal capabilities. During the last two weeks of August, the heat pump was able to remove about 4.6 pints of water on a daily basis (Figure 2-42).

Table 2-13: *Electric Based Water Heaters System Performance: July 1 – Nov 30, 2010*

DHW System	kWh/day	COP Efficiency
Standard 50 gal. electric	6.66	0.87
80 gal. Diff. Flat Plate	1.97	2.91
ICS w/50 gal. electric (single element)	3.56	1.86
80 gal. PV Pump (40 W) Flat Plate	1.62	4.39
Heat Pump Water Heater	2.46	2.25

Average Daily Consumption for Electric Based Systems

The average daily electric consumption for water heating systems during the period of July-November 2010 is summarized in Table 2-13. In November 2010, data indicated that the differential A/C pump solar system has now surpassed the improved 40-watt PV pumped system efficiency.

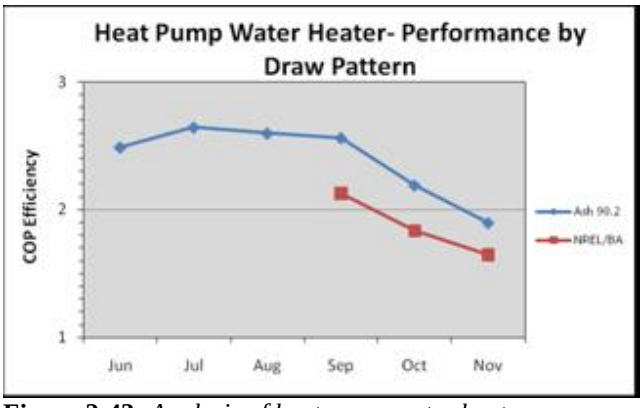

Figure 2-43: *Analysis of heat pump water heater performance*

During November, the heat pump water heater also showed a slight decrease in efficiency (1.85 COP) compared to previous four months where it had maintain efficiencies above 2.0. The heat pump operation still demonstrated a 50.5% electric reduction for the month of November (4.7 vs 9.5 kWh/day on average). Analysis of the heat pump water heater performance based on draw profile can be seen in Figure 2-43.

Tankless Gas Water Heater Maintenance

The instantaneous gas (tankless) water heater was flushed with vinegar in a closed pumped circulation loop for two hours. The system saw an increase of 5.9% the day after the flush procedure, however this increase gradually diminished over the next three days to the previous efficiencies measured prior to the flush procedure. The effects of flushing with vinegar and the residue of internal heat exchanger mineral deposits and corrosion can be observed in Figure 2-44.

Figure 2-44: *Effects of flushing with vinegar and the Residue of internal heat exchanger mineral deposits and corrosion*

Electric tank wrap insulation

Tank wrap insulation research activities took place between October and November to identify current available products in the market including testing for potential energy reductions. A typical R-11 fiberglass blanket product with outer vinyl layer was tested on the electric reference 50 gallon water heater. Electric consumption data was analyzed over three days before and after blanket installation on the water heater. Data indicated that a 3.01% efficiency increase was achieved. The most significant flaw of commercial products appeared to be related to the one-size (height) of blankets available, which is usually 48 inches. The blanket size dimensions are not enough to cover a tall water heater in the 57 inch height category. The blanket leaves a partial bottom area of the tank uncovered. The infrared picture (Figure 2-45) reveals heat being lost through some of bottom plate element access area. If the blanket is pulled up to cover the top plate of the tank entirely, the bottom area is further compromised.

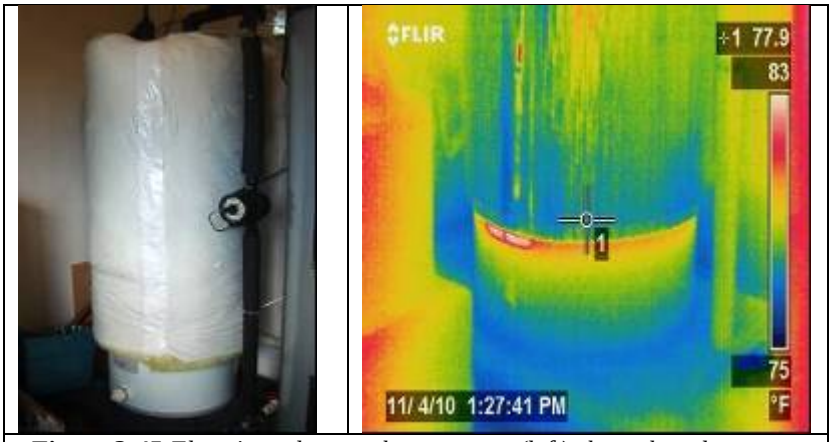

Figure 2-45 *Electric tank water heater wrap (left) shows heat loss (right, yellow with "1") in the partially exposed bottom of the tank.*

GTI Collaboration: A teleconference took place on January 19th with members of Gas Technology Institute (GTI) to review hot water testing activities in the HWS Lab and GTI labs. Details related to ongoing testing procedures including upcoming heat pump water heaters (GTI) were discussed. FSEC also reviewed GTI's three testing water draw profiles which vary in time sequence. GTI's draw profiles used for testing target 30, 64 and 100 gallons per day (gpd).

ICS Modeling Improvement Effort: A complementary effort, Camilo Gil, a UCF graduate student worked in the HWS Lab subtask researching the time-varying heat loss coefficient for modeling integrated collector storage (ICS) solar water heaters in simulation programs such as Energy Gauge USA and TRNSYS. Currently, these programs use a constant heat loss coefficient over the entire year. The ICS system in the HWS Lab was instrumented with a network of sensors during the manufacturing process. Temperature data from the sensors were collected to investigate the system performance and help with the research of the time-varying heat loss coefficient that will improve the simulation results. Recent work on this task examined temperature profile of the various tubes within the integrated collector during cold weather as shown in Figure 2-38.

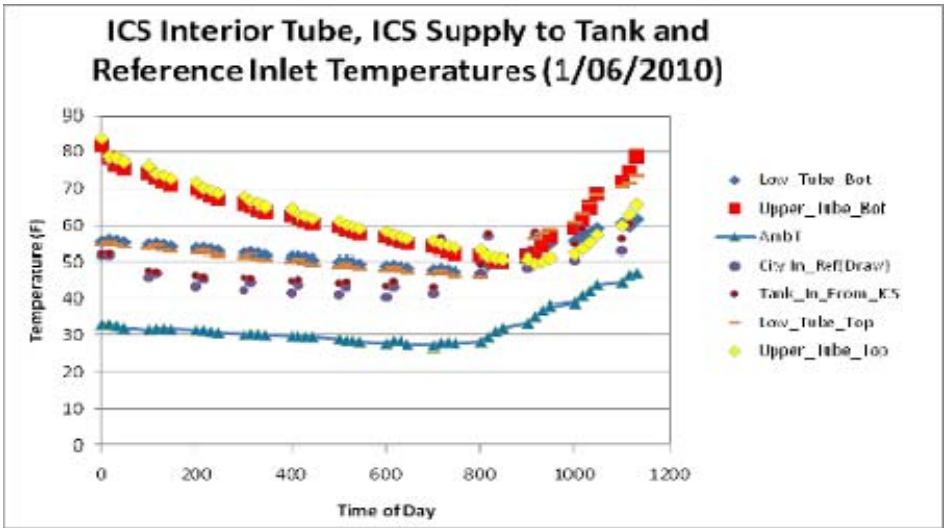

Figure 2-38: *Temperature profile of various tubes within integrated collector during cold weather*

Gil completed the final version of the paper "An Optimal Control Approach for Determination of the Heat Loss Coefficient in a Domestic Water Heating System". It was presented at 2010 American Control Conference (noted under Task 1). ACC, June 30-July 2, 2010, Baltimore, MD. Researcher also completed the preliminary determination and validation of the heat loss coefficient in an ICS system. Gil, completed his thesis on this topic titled "An Optimal Control Approach for Determination of the Heat Loss Coefficient in an ICS Solar Domestic Water Heating System." It is available from the University of Central Florida.

Subtask 2.2.5 Solar Water Heating – SRCC Technical Tasks
(Formerly Subtask 1.12 Full Scale Testing of Innovative Condenser Fan)

BP1, BP2, 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

BP4 and BP5

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.

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

From January 2010 through August 2010 the FSEC test group continued with its improvement

plan. A major milestone was reached in June with the release of the new collector test stand. This test stand incorporated all the improved sensors, data loggers, and computer software developed in the last year. This test stand is now the standard for the collector test facility. Plans continue with the conversion of the old test stands to this new standard.

In addition to the collector test application a new application was developed to improve the efficiency and integrity of storing, retrieving, and analyzing the data. Not only is collector data more accessible but also calibration data and software revision control information required for the quality management are now readily available. This new analysis software greatly improves the efficiency of generating the information required for the test reports.

The following summarizes the accomplishments since January 1, 2010 through August 31, 2010.

- 12 Interim Tests completed
- 10 Interim Test Reports completed
- 9 Performance Testing completed
- 7 Full Reports completed

Subtask 2.2.6 Ductless Heat Pump – Pacific NW Utility Collaborative

The WSU Energy House was used to conduct a pilot research experiment to evaluate new ductless heat pump technology. Weekly to bi-weekly "flip-flop testing" was conducted in winter/spring of 2010 to help evaluate the following research questions:

1) What is energy performance of a ductless heat pump (DHP) benchmarked against a ducted electric furnace (EF)?
2) How well do the DHP or EF maintain acceptable indoor temperature for thermal comfort?

During the experiment, performance of a ductless heat pump (25 SEER/12 HSPF, 16,000 Btu/hr) was compared against that of an electric furnace (the home's ducted heat pump system operated in strip heat mode to mimic a furnace). The thermostat was configured to run the blower only when the electric furnace was in heating.

The ductless heat pump was located in the main living area of the home. The ducted system and tended to provide more heat to the periphery. Flip-flop tests were conducted from February through May 13. Every one to two weeks the system thermostats were adjusted to heat the entire house with either the ductless heat pump (flip) or central ducted furnace (flop). To monitor system performance, electrical energy consumption of both the ductless heat pump and electric furnace was recorded. Temperature sensors were installed both outside and in every indoor zone to observe the effects of running the different heating systems on thermal comfort.

Figure 2-46 provides an indication of the increased efficiency of the DHP as compared to the EF. It should be noted that heat pump COP and heating output are reduced at lower ambient temperatures than those found during this study (outside temperatures were typically 35°F or higher).

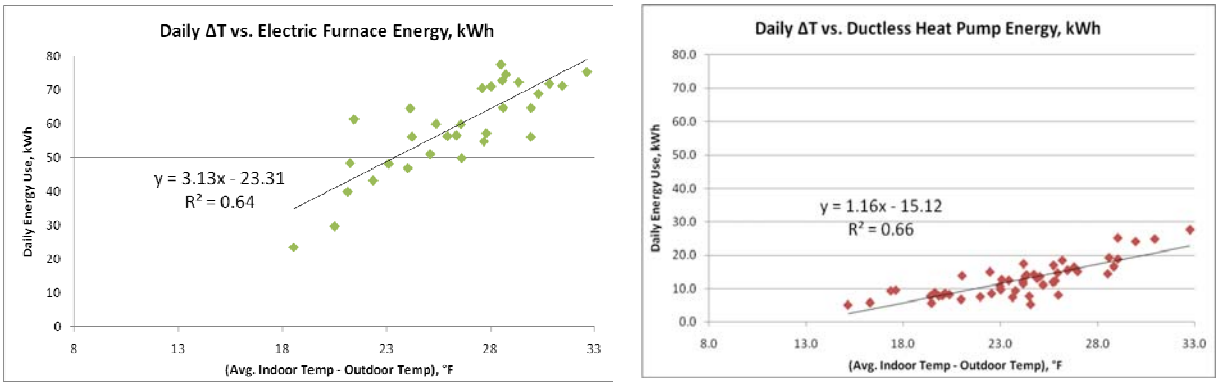

Figure 2-46 *Flip/Flop regression analysis, WSU Energy House Ductless Heat Pump Study*

Dividing the slope of the ER furnace fit by the DHP fit will give an estimate for the DHP's COP for the period of operation. The estimate for this study is a COP of 2.7. Given the directly measured and manufacturer reported COP, this number is slightly lower than may be expected, and can be explained by higher return air temperatures and higher demand on the unit than specified by the manufacturer. Nevertheless, the calculated COP of 2.7 for the ductless heat pump represents substantial savings.

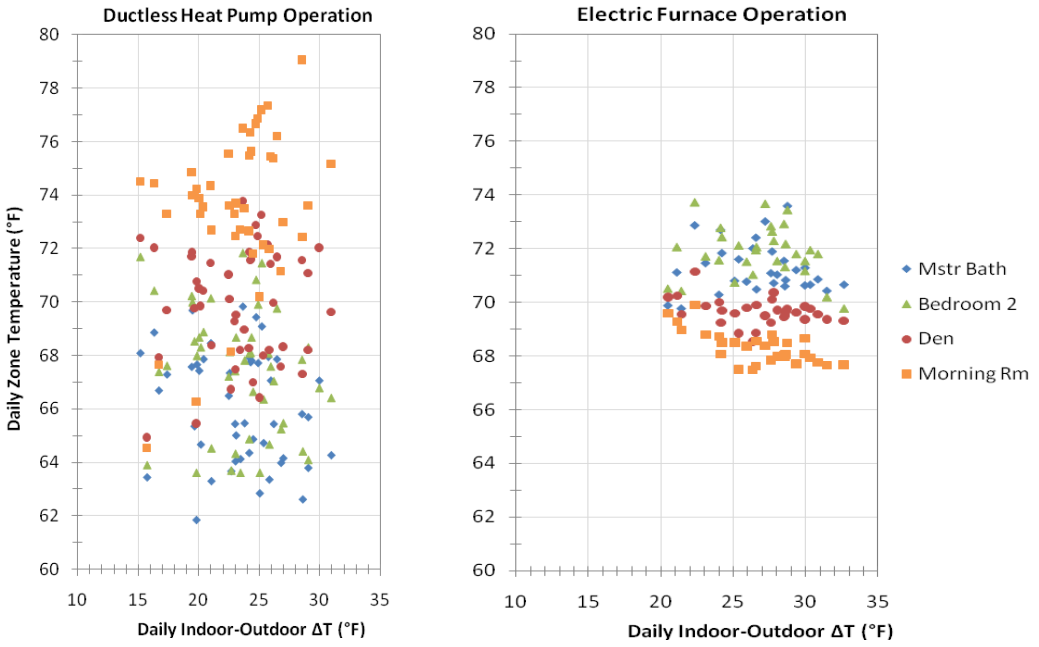

Figure 2-47 *Scatter plot of four average daily zone temperatures vs. outdoor temperatures*

Figure 2-47 provides an assessment of how four of the most interesting zone temperatures vary with respect to outside temperatures (only four zones are plotted for readability). The daily average zone temperature is plotted versus the daily average indoor-outdoor ΔT. For the testing period of this experiment, the weeks in which the furnace operated always had ΔT's greater than 20°F. In contrast, the ductless heat pump periods of operation occurred in some warmer weather where the ΔT was as little as 15°F. The plots clearly demonstrate a wide scatter in indoor temperature with the DHP in use.

Ongoing field research is proposed to continue to investigate the following current and new related research questions:

1) What is energy performance of a ductless, mini-split heat pump (DHP) benchmarked against a centrally ducted electric furnace (EF) and/or ducted heat pump?
2) How much of the electric furnace can be displaced with DHP and/or central heat pump?
3) How well do the DHP or EF maintain acceptable indoor temperature for thermal comfort?
4) What are the pros and cons of various approaches to DHP air distribution mixing that improve thermal comfort and reduce back-up electric resistance heat?

Ductless heat pump advisory group
WSU developed a ductless heat pump lab testing advisory team, including representatives from manufacturers, ACCA, ASHRAE members, national laboratories, NIST, and other Building America Teams. WSU met with individual advisory group members met at the ASHRAE 2010 Winter and annual meetings, to discuss ongoing research efforts in the Pacific Northwest, including the WSU Energy House, Pacific Northwest ductless heat pump field and lab testing, and development of homeowner, builder and contractor guides for ductless heat pumps.

Subtask 2.2.7 NightCool Experimental Facility (NCEF)
(Formerly 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 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.

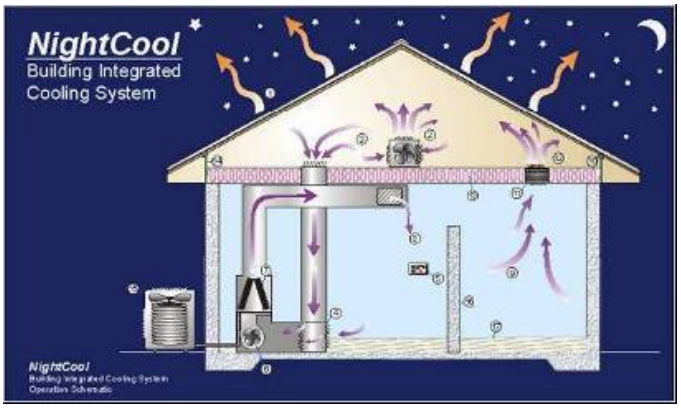

Figure 2-48 *NightCool Operation Schematic*

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 2-48). 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 2-49: *Conventional Shed with Dark Shingle Roof*

Figure 2-50: *NightCool Shed with White Metal Roof*

Figure 2-51: *Conventional Shed with Vented Attic and R-30 Fiberglass*

Figure 2-52: *Exposed Metal Roof in NightCool Attic*

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 2-49 and Figure 1-51). 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 2-50 and 2-51).

In 2007, *NightCool* performance was evaluated under standard operating conditions during a full Florida cooling season, from April to November (Figure 2-53). 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.

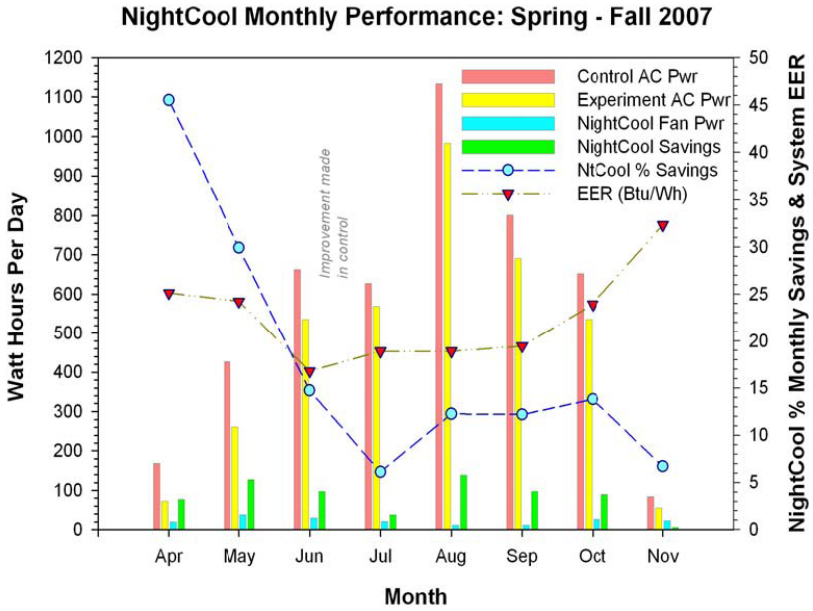

Figure 2-53 *Performance under standard operating conditions in 2007 shows 15% savings in the NightCool test unit compared to conventional construction over the eight month cooling season.*

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.

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 2-14. 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

Table 2-14: *Average Annual Savings Generated Monthly by NightCool Concept in 2008*

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

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 is reported below (Table 2-15) for the cooling systems (including Nightcool fans for the experimental facility):

Table 2-15: *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).

Evaluation of the Nightcool concept continued in 2010. There was no need for cooling at the Nightcool buildings during the months of January thru April. Although the Nightcool building kept more even temperatures from January thru May, it was not possible to compare interior moisture levels which were not comparable due to problems with the control system.

Cooling needs built up rapidly during the month of May while hardware related problems were experienced: the Nightcool activation control relays failed in the early month leading to a prolong period where the AC overcooled the space. This issue was repaired by 7 May. However, this problem was then followed by the failure of the auxiliary AC unit in the Control Building. Both problems were resolved by 24 May 2010.

In June, the systems ran satisfactorily. The Nightcool system reduced cooling use in the very hot month by about 9%: 2.70 kWh per day with 41% interior humidity in the experimental building against 2.95 kWh in the control with 42% humidity. Tests were completed of the Nightcool system in early and late summer in Central Florida which is much warmer and more wet than most conditions in much of the U.S. Carpet was added to both test building floors at midsummer.

The systems ran satisfactorily during September and October. The Nightcool system reduced cooling use in September by about 8%: 2.29 kWh per day with 42% interior humidity in the experimental building against 2.48 kWh in the control with 40% humidity. In October, cooling use was reduced by about 18%: 1.00 kWh per day with 44% interior humidity in the experimental building against 1.21 kWh in the control with 46% humidity. The beginning of November was the end of the cooling season and the experiments for the Nightcool system in 2010.

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

Task 3: Stage G2: Prototype House Evaluations

(Formerly Task 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.

This section describes activity with BAIHP partners working toward Building America prototypes using the following general systems engineering approach:

- 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.

BAIHP progress under Task 3 includes many Industry Partners. Each is briefly described below. Table 3-1 summarizes the status of each Industry Partner's prototype activity in the following subtask areas:

Subtask 3.1 Identify Development Opportunities for Prototype Houses
Subtask 3.2 Produce Prototype House Designs and Test Plans
Subtask 3.3. Support Prototype House Construction
Subtask 3.4 Test Prototype Houses
Subtask 3.5 Produce Prototype Case Studies
Subtask 3.6 Quality Assurance Documentation

The table is divided into the following prototype categories:

Long Term Monitoring of Prototypes
Zero and Near Zero Prototypes
Builders Challenge Prototypes

Table 3-1 BAIHP Prototype Homes	Partner Status	In Design	Under Constr.	Test Monitor	Case Study	QA Docs
	3.1	3.2	3.3	3.4	3.5	3.6
Long Term Monitoring of Prototypes (January – November)						
Chandra Residence **(Discontinued in March)**	O ongoing	0	0	1	0	NA
Chasar Residence	Ongoing	0	0	1	0	NA
Atlantic Housing Partners – Cambridge Cove 2	Ongoing	0	0	2	0	Ongoing
CPS Energy / Woodside Homes	Ongoing	0	0	3	0	Ongoing
Garst Residence	Ongoing	0	0	1	1	Ongoing
Stamets Residence	Ongoing	0	0	1	1	Ongoing
GW Robinson ZEH 2010 – Garison Way	*(Formerly in Zero and Near Zero Energy Prototype Homes section)*					
January	Ongoing	1	1	0	0	Ongoing
February – March	Ongoing	1	1	1	0	Ongoing
April	Ongoing	0	1	1	1	Ongoing
May – June	Ongoing	0	0	1	1	Ongoing
July	Ongoing	0	1	1	0	None
August	Ongoing	0	0	1	1	Ongoing
September	Report Unavailable					
October	Ongoing	0	0	1	1	Ongoing
November	*FSEC support for this endeavor was moved to another contract*					
Parker Residence						
August – October	Ongoing	0	0	1	0	None
Schackow Development NZEH 1 and NZEH 2	*(Formerly in Zero and Near Zero Energy Prototype Homes section)*					
January – February	Ongoing	0	1	2	1	Ongoing
March	-	-	-	-	-	-
April - July	Ongoing	0	1	2	1	Ongoing
August	Report Unavailable					
September	Ongoing	0	1	2	1	Ongoing
October - November	Ongoing	0	0	2	1	Ongoing
Springwater Homes	*(Formerly in Builders Challenge Level Prototypes section)*					
January -March	Ongoing	1	1	0	0	Ongoing
April - June	Ongoing	1	0	1	0	Ongoing
July - November	Ongoing	0	0	1	0	Ongoing

Table 3-1 BAIHP Prototype Homes	Partner Status	In Design	Under Constr.	Test Monitor	Case Study	QA Docs
	3.1	3.2	3.3	3.4	3.5	3.6
Stalwart Built Home NZEH	*(Formerly in Zero and Near Zero Energy Prototype Homes section)*					
January - November	Ongoing	0	0	1	0	Done
Tommy Williams Homes - ZEH1 – Longleaf	*(Formerly in Zero and Near Zero Energy Prototype Homes section)*					
January	Ongoing	0	1	1	1	Ongoing
February - October	Ongoing	0	0	1	1	Ongoing
November	*Site no longer funded under the BAIHP contract activities*					
Tommy Williams Homes ZEH2 – Belmont	*(Formerly in Zero and Near Zero Energy Prototype Homes section)*					
January	Ongoing	1	1	0	Ongoing	Ongoing
February - March	Ongoing	1	1	1	1	Ongoing
April	Ongoing	0	1	1	1	Ongoing
May - October	Ongoing	0	0	1	1	Ongoing
November	*Site no longer funded under the BAIHP contract activities*					
Zero and Near Zero Energy Prototype Homes						
Florida Showcase Green Envirohome						
January - November	Ongoing	0	1	0	0	Ongoing
KB IBS 2011 Show Home						
May - June	Starting	1	0	0	0	NA
July - September	Starting	0	1	0	0	NA
October	Starting	0	0	1	0	NA
November	Ongoing	0	0	1	0	NA
LifeStyle Homes – Model in Viera, Florida						
January	-	-	-	-	-	-
February - July	Ongoing	1	1	0	0	Ongoing
August	Ongoing	0	0	1	0	Ongoing
September	Ongoing	0	0	0	0	Ongoing
October	Ongoing	1	1	0	0	Ongoing
November	Ongoing	0	0	1	1	Ongoing
Stalwart Built Homes – New Orleans						
January - March	Ongoing	2	0	0	0	NA
April	Ongoing		2	0	0	NA

Table 3-1 BAIHP Prototype Homes	Partner Status	In Design	Under Constr.	Test Monitor	Case Study	QA Docs
	3.1	3.2	3.3	3.4	3.5	3.6
May	Ongoing		2	0	0	Ongoing
June - July	Ongoing		2	1	0	Ongoing
August - November	Ongoing	0	0	2	0	Ongoing
Tampa ZEH (Rutenberg Residence)						
January - February	-	-	-	-	-	-
March - May	Ongoing	1	0	0	0	NA
June - August	Ongoing	1	1	0	0	0
September - November	No activity*					
Builders Challenge Level Prototypes						
Palm Harbor Homes						
January - June	Ongoing	0	3	0	0	Ongoing
July - September	Ongoing	0	0	0	0	Ongoing
October	No activity reported for this month.					
November	Ongoing	0	0	0	0	Ongoing
Palm Harbor and Nationwide IBS Show homes 2010						
January	Ongoing	0	0	3	3	Ongoing
February - March	-	-	-	-	-	-
Completed						
Stalwart Built Homes/GE (Marine)						
January - September	Ongoing	0	0	0	0	NA
October - November	Subtask removed due to no activity					
Developing High Performance Prototype Partnerships						
University of Georgia						
January - March	Ongoing	1	0	0	0	None
Habitat for Humanity	Please see Sub-task 6.1 for Habitat Prototypes.					
Existing Home Prototypes	Please see Sub-task 6.2for Retrofit Prototypes.					
Note: Additional description of WSU partnerships may be found in Appendix C.						

Summaries of current and past BAIHP prototype partnerships are given below in alphabetical order. Sub-contractor WSU is monitoring several prototype homes - the Garst home (http://www.infomonitors.com/ws2) and the Stamets homes are described above.

Other monitoring activity is described in Appendix C - Washington State University Annual Report.

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 seeking rebates for energy efficiency and renewable energy use. This long-time BAIHP partner (previously known as Sandspur Housing) has provided $100,000 in funding since 2007, a portion of which funds FSEC assistance with commercial renewable energy system and the remainder cost shared with Building America.

Figure 3-1: *Cambridge I Development with Site for Cambridge II Development below.*

In 2008, BAIHP conducted an energy audit of Cambridge I (Figure 3-1), a 200-unit Atlantic development completed in 2002, to characterize energy use in the apartments and common areas. Atlantic Housing received assistance with sealed attic design, pool efficiency, outdoor lighting, water heating options and HVAC design. A detailed HVAC review resulted in sizing reductions of 1-ton per unit for the Cambridge II and subsequent developments.

Estimates of common area energy use and PV bid specs were developed for Cambridge II and seven other Atlantic developments during 2008 and 2009 and three more were completed in 2010. Net metering agreements with various Florida utilities were negotiated with BAIHP assistance.

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. 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.

Atlantic currently builds projects primarily with low income housing credits which limit total cost of rent plus utilities to specified amounts. A new method of calculating utility allowances was implemented by Florida Housing Finance Corporation in March 2010 causing renewed interest in reducing tenant-paid utility costs. FSEC applied to FGFC as an allowance provider and was accepted. BAIHP analysis determined that Atlantic's all-electric project design yielded better allowances than the gas+electric combination. One development was completed in 2010 and several more are nearing completion with projected HERS of 57 to 63. Specifications include: SEER 15 heat pump, tight ducts, Low-E windows, attic radiant barrier, heat pump water heater, 70-80% CFLs and Energy Star appliances. Allowance calculations are performed using home energy rating software (EnergyGauge) and, once established through Florida Housing, should become a viable new niche for the home energy rating industry. We will continue to work with Atlantic targeting cost effective efficiency upgrades implemented through utility allowance calculations.

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 6.2 - Deep Retrofits on Existing Affordable 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 continued in 2009 and 2010. Built Wright Custom Homes accepted the Builders Challenge in 2010 and committed to building all future homes to an E-Scale of 60 or less. Subcontract funding to Florida H.E.R.O. ended in August. Therefore, no further progress for this partner was reported in 2010.

Chandra Residence – Orlando, Florida

In 2010, monitoring of the Chandra residence (former FSEC researcher) obtained savings data on the solar water heater and temperature in the garage. Monitoring of house temperatures and air conditioner energy use also continued during the year; however, all monitoring was discontinued in March.

Chasar home, Cocoa, FL

The Chasar home (an FSEC researcher) in Cocoa, FL has provided measured performance since 2000 for a 1992 code minimum home. Measurements currently include energy use, ambient,

indoor and attic temperature and RH, as well as water heater performance. In 2007, the soffits were sealed to create an unvented attic space and the envelope and ducts were retested for air tightness. The home had a white metal roof retrofitted in 2005. Monitoring of the solar water heating system installed in 1999 began in 2010 and the existing CR10 datalogger was replaced with a new CR1000 datalogger.

BAIHP has monitored the Chasar home (a BAIHP researcher) 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 an unvented 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.

In 2010, the existing CR10 logger was replaced with a CR1000 datalogger. New power meters were added in August, and collected channels were adjusted accordingly. Additional activities included finalization of solar water heating installation and weather station monitoring channels, installation of a cellular modem to test this method of data transfer on the CR1000, and revision of logger programming for proper water heater performance measurements. Monitoring of key systems and whole house package (pre and post retrofit) will be evaluated and compared.

CPS Energy – Woodside Homes, San Antonio

CPS Energy in San Antonio, Texas is the largest municipally owned energy company providing both natural gas and electric service to 320,000 and 700,000 customers respectively. CPS 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, built to standard practice, serves as a control. 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.

In response to an invitation by CPS Energy, BAIHP provided monitoring and other technical assistance to support the development of 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 was the first field experiment for BAIHP using the new generation Campbell CR1000 datalogger, which provides advanced programming and communications capabilities. Data analysis highlights include:

- 6 to 8 kW (62 to 83%) demand reductions on hottest day during utility peak period
- Peak air conditioning loads reduced 1.2 to 2.9kW (28 to 68%) during same period
- 55 to 77% cooling energy savings in improved homes
- 2.4kW grid-tied photovoltaic array provided 25-30% of total electric energy needs during most months & offset 100 % of annual HVAC energy consumption

Measured data for these homes is available at http://infomonitors.com/CP1/, http://infomonitors.com/CP2/, and http://infomonitors.com/CP3/

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 and media event.

CPS has discussed plans to expand its collaboration with BAIHP into existing home retrofits targeting 30 to 50% savings. Dr. Valerie vonSchramm, senior research program manager with CPS, visited FSEC in October 2009 to present analysis of a large sample of customer billing data and discuss future projects with FSEC researchers.

An $85,000 proposal for continued monitoring of the side-by-side homes and new monitoring of two geothermal heat pump (GHP) systems was suspended in 2010 as CPS reevaluated near-term energy research strategies. Fresh discussions on a similar contract are anticipated in 2011 to include geothermal heat pump and retrofit research cost-shared with the Building America project.

BAIHP researchers continue to evaluate gas meters on the Woodside homes with regression analysis to pinpoint inaccuracies of the whole house meters compared to sub-meters. A comparison and analysis of the heating performance of all three homes was also completed, including, an evaluation of measured versus billed gas usage based on the paper billing of the homes. Instrumentation will remain in all three homes until March 2011.

A case study on the measured performance of these homes was published at Thermal Performance of the Exterior Envelopes of Whole Buildings XI International Conference, December 5-9, 2010, Clearwater Beach, Florida. It is available on the BAIHP website: http://www.baihp.org/pubs/pdf/3cps-homes_B11.pdf

<u>David Axel Home, Oviedo, FL</u>
During 2005 -2006, BAIHP provided feedback on house construction and combustion appliances for Dave Axel home. A site visit was made (Figure 3-2) 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 3-2: *Construction Detail HVAC Equipment Installed*

<u>David Weekley Homes</u>
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 and HVAC system design for nine houses in 2006 and 2007.

East Bay Development Group (EBDC)

Figure 3-3: *Planned Development in East Bay, FL*

BAIHP provided assistance to several builders and manufacturers participating in the East Bay Project (Figures 3-3 and 3-4). 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%.

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.

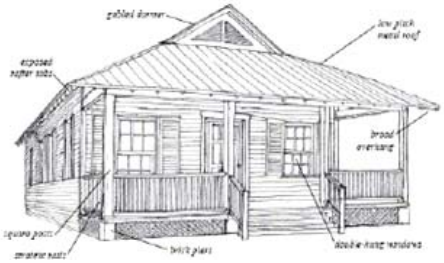

Figure 3-4: *Planned Development in East Bay, FL*

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

In 2008 the East Bay project was moth balled due to the severe decline in new home construction activity in Florida. No further developments were reported in 2009 and 2010.

Dog Park, Ruskin, FL

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. No activity was reported in 2010.

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 3-5) 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 3-5: *Homes with solar hot water and BIPV on detached garage (not installed yet)*

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 3-6). 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. 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 continued to collaborate with this partner; however this project did not result in a Building America prototype. No activity was reported in 2010.

Figure 3-6: *FAS Emergency HUD Code Home for Mississippi*

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 3-7), 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. However, this home did not progress beyond the design stage.

Figure 3-7: *Elevation for Ferrier Builders prototype home in Dallas, TX*

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 3-8). 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. No activity was reported in 2010. Their website is http://www.rheudasilfarms.com/

Figure 3-8: *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 since 2007.

Florida 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. HVAC design was completed in 2008. 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. As of January 2010, the home was nearly complete, and in June 2010, a wind turbine and solar air conditioners were installed. Once completed, and 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.

Garst Residence

The Garst residence (Figure 3-9) 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.

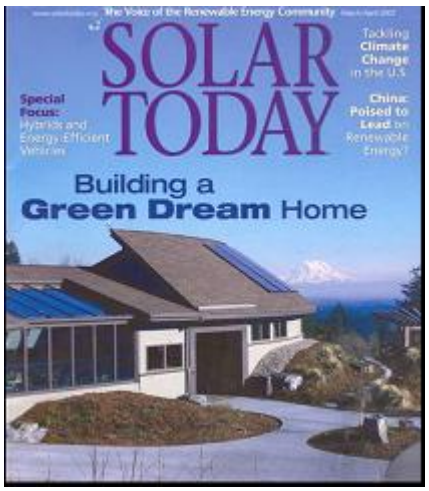

Figure 3-9: *Garst Residence – Olympia, WA, as featured in Solar Today.*

Home construction began in summer of 2005, and was completed in May of 2006. The Garst residence was featured on the cover of Solar Today magazine, and 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 (Figure 3-10). From March 2008 through February 2009, performance was measured at 4538 kWh or 1008 kWh per kW of installed PV. Of the total PV production, roughly 47% was used by the house, and 53% returned to the utility. For the same months in 2009-2010, with the additional 2.2 kW of PV, performance was measured at 7765kWh, or 1158 kWh per kW of installed PV.

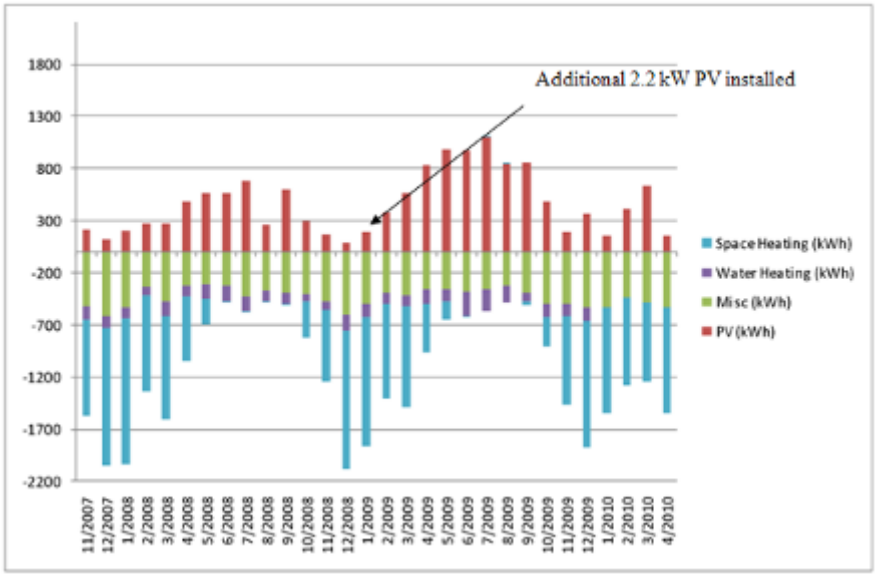

Figure 3-10 *Garst Residence, monthly energy use, including PV to grid, November 2007-April 2010*

As noted in Subtask 1.9 above, WSU staff developed a paper on the Garst residence that was presented at the Buildings XI conference. A full 2010 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. A Preliminary analysis was conducted that considered improvements to G.W. Robinson's current standard specifications, as delineated in Table 3-2 below.

Table 3-2: *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

Construction on the home began and was completed in 2010. Florida H.E.R.O. and BAIHP conducted ongoing meetings and conference calls to finalize the solar systems and component

specifications. Various parametric analyses were also conducted to determine PV system size as a function of various envelope and appliance and water heating options was also performed. The builder decided to purchase and install the photovoltaic system in-house in order to reduce costs associated with third-party contracting of the renewable energy. It is notable that this builder was able to purchase the all-inclusive PV system for $3.65 per watt and a final installed cost of $4.25 per watt by managing the installation in-house.

The home achieved an impressive E-Scale of -3. Final testing, commissioning and registration were completed including Builders Challenge certification and initial installation of monitoring equipment. Preliminary data was achieved at the site.

A *Builder Spotlight* case study of this partner and their first zero energy home is available online at http://www.baihp.org/casestud/pdf/BuildersChallengeSpotlight_GWRobinsonZEH.pdf.

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.

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 3-11) 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 3-11: *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 wind washing 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. No further progress was reported in 2010.

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 since 2008.

Louisiana State University AgCenter's La House

In 2008 BAIHP installed monitoring equipment in the Louisiana House (also known as the LA House – see Figure 3-12) 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 took over the monitoring effort in 2010.

Figure 3-12: *Louisiana State University's Louisiana House demonstration home*

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. No activities reported in 2010.

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 3-13) 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 3-13: *Weather tight and insulated crawlspace*

Marquis Construction also completed two all SIP homes (Figure 3-14) that FSEC tested (Figure 3-15) 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 reported since 2008.

Figure 3-14: *Back view of Marquis Construction home in Dade City, FL*

Figure 3-15: *Testing Marquis Construction home in Dade City, FL (HERS Index 62)*

International Builder's Show – Show Homes (BP1 – BP5) *(Formerly Subtask 2.2 International Builder's 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 (NAHB) 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 Building America systems engineering principles to tens of thousands of attendees annually, including builders and the general public.

These show homes are great opportunities to solicit builders to integrate more energy efficient and higher 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.

BAIHP has provided technical assistance to identify specifications needed to reach performance targets,

Summaries of the IBS Show Homes from each year are included below, starting with the most recent year. Brief case studies for all of these show homes are available at http://www.baihp.org/casestud/index.htm

2011 International Builders' Show[2] – Show Home by KB Home
The publisher Hanley Wood is the primary sponsor for this show home, located in Windermere, FL, which is the 13th in Builder Magazine's Concept Home series of homes annually showcased at the International Builders' Show. The home is built by KB Home, and was created with Martha Stewart. Goals for the project included achieving an E-Scale of 0, and LEED for Homes Platinum. Design was ongoing as of May 2010. A preliminary design/rating meeting was conducted for LEED certification in June. Eric Martin and Stephanie Thomas-Rees attended.

FSEC continued to provide support on solar system design and ventilation system design in July 2010. A site visit of the home in Windermere, FL was conducted, and the shell was 90% complete. A preliminary site visit was also conducted for LEED certification in July, and Stephanie Thomas-Rees attended. In August, a pre-drywall visual inspection was conducted including thermal bypass. FSEC prepared the home during construction for the installation of data monitoring equipment at some point in the future after the conclusion of the IBS Show and just before occupancy.

In fall of 2010 final documentation and inspections were completed for certifications including Builders Challenge (Maximized Energy Efficient Home), Energy Star, WaterSense, LEED for Homes Platinum, and Environments for Living Green. Promotional activities to highlight the homes energy performance during the IBS Show began in November 2010.

[22] The 2011 International Builders Show took place after the end of the reporting period; however, technical assistance was provided during the final Budget Period.

2011 International Builders' Show – Show Homes by Palm Harbor Homes
BAIHP provided technical assistance to Palm Harbor Homes for two modular homes in the 2011 IBS Show Village. Similar to the past 5 years, involvement included design specifications for ensuring the two homes met the Builders Challenge and also assisted with the Florida Green Building Coalition certifications. Builder Spotlight handouts for the two homes, Treasure Sands and Cabana (Figure 3-16) are online at: http://www.baihp.org/casestud/ph_homes2011/index.htm

Figure 3-16: *Treasures Sands Home (left) and Cabana Home (right) by Palm Harbor Homes*

2010 IBS Show Homes
BAIHP researchers assisted two BA Partners, Palm Harbor Homes (PHH) and Nationwide Homes, in their participation at the IBS in Las Vegas 1/15/2010 – 1/19/2010. Involvement included design specifications for ensuring the (3) homes showcased met Builders Challenge and also assisted with the NAHB Green Home Program certifications. *Builder Spotlight* handouts were also developed for the (3) homes, La Linda, Highlander and Osprey (Figure 3-17). These are online at: http://baihp.org/casestud/ph_homes2010/index.htm (Previous year technical support led to the activity at the beginning of this year (see 2009 BAIHP annual report)

BAIHP subcontractor Calcs-Plus consulted with builders as the 2010 IBS Show homes were assembled in parking lot of Las Vegas Convention Center. Insulation and equipment installation was verified and a meeting was conducted with NAHB personnel to assist the homes rating procedures for green programs and Building America Builders Challenge compliance.

Figure 3-17: *2010 IBS Show Homes built by Palm Harbor Homes: La Linda Home (left) and Highlander "Traditional" Home (center). The Osprey –"EcoCottage" (right) was built by Nationwide Custom 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: the Deschutes "Quiet Living" Home and the Tularosa "Media Enhanced" Home (Figure 3-18). 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, and verifying current equipment certification. 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.

Figure 3-18: *2009 International Builders' Show Homes built by Palm Harbor Homes: the Tularosa – Media Enhanced home (left) and the Deschutes Quiet Living home(right)*

2008 PHH Professional Builder Show Village Homes
FSEC and Calcs-Plus researchers assisted Palm Harbor Homes (PHH) on the design of the "Green" (Figure 3-19) and the "Comfortably Affordable" (Figure 3-20) 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.

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 3-19: *Glen Cairn – PHH "Comfortably Affordable" 2008 IBS Show Home*

Figure 3-20: *Bimini II – PHH Green Show Home – 2008 IBS*

2008 Vision House

The Vision House Orlando, a 2008 IBS show home, was built in Lake County (Figure 3-21). 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.

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.

Figure 3-21: *Vision House 2008*

2008 The New American Home (Figures 3-22 and 3-23)

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 3-22: *2008 The New American Home*

Figure 3-23: *Solar water heater on TNAH 2008*

2008 Tradewinds Home (Figure 3-24)

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 3-24: *7,316 square foot 'Tradewinds' home for 2007 IBS Builder Magazine*

Figure 3-25: *3,397 sq. ft. Palm Harbor Homes, the Bellaire – GenX*

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 (Figures3-25 and 3-26) and a tri-plex unit (Figure 3-27). We attended sponsor meetings ensuring that donated products met objectives of Energy Star rated and FGBC green certified homes for the show. FSEC's PV Division also assisted in our involvement and helped procure donated renewable energy products like 3.25 kWp BP Solar PV System, GridPoint Inverter and Battery-Based Backup Power & Energy Management equipment and a solar domestic hot water system for the single family home, GenX.

During BP2, FSEC and Calcs-Plus coordinated the relocation of GenX to Siesta Key in Sarasota, FL (Sarasota County) (Figure 3-26). They assisted in the re-install and re-certifications for Energy Star, FGBC and renewable permits.

Figure 3-26: ***Palm Harbor*** *Homes, the Bellaire GenX relocated to Siesta Key in Sarasota, FL*

The three unit town home, called the EchoBoomer (Figure 3-27), 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
http://www.baihp.org/casestud/ph_homes2007/pdf/echoboomer.pdf

Figure 3-27: *EchoBoomer Town Homes*

2007 The New American Home (TNAH)
Each year the National Association of Home Builders also demonstrates site built housing. 2007 New America Home (Figures 3-28 and 3-29) 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 3-28: *TNAH (with the Renewed American Home roof in background)*

Figure 3-29: *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 3-30: *2,865 sq. ft. Palm Harbor Homes, the Bellaire –Move up Buyer*

The Bellaire Model (Figure 3-30) 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.

LifeStyle Zero Energy Home (ZEH)

LifeStyle Homes in Melbourne, Florida became a BAIHP partner in late 2008 (see more details in Task 4). After learning about the Zero Energy Home concept in 2009, LifeStyle decided to aim for that goal. In 2010, BAIHP worked with the PV division and PV contractor to initiate the module and system verification process and determine the submittal of the required documentation for this process. Final configuration, system and modules were identified and submitted through the approval process. BAIHP also began a development evaluation of FGBC Green Home certification. However, it was cancelled due to time constraints by the builder.

LifeStyle Homes' First Net Zero Energy Home was completed in August 2010, and final testing on the PV system was accomplished in September. Final HERS Index was -6 and Annual Energy Cost (without pool) was -$146. This home has been sold, but occupancy will not occur until 2011. Until then, it will be used as a model center.

A case study is available on the BAIHP website:
http://www.baihp.org/casestud/pdf/LifeStyle-ZEH.pdf

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

BAIHP staff assisted Palm Harbor Homes in Plant City Florida in 2008 to 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, BAIHP 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.

Since 2006, the BAIHP team has provided design recommendations and analysis for PHH homes displayed at the International Builders' Shows (see http://www.baihp.org/casestud/index.htm). All of these homes have met the U.S. DOE's Builders Challenge requirements since the program was started. Since 2009 these homes have included a runtime ventilation strategy with compressor-activated motorized damper.

In 2008, BAIHP evaluated the plans for and pre-rated three new models to meet Energy Star and FGBC standards and conducted IR scans of two model center homes – one with BASF foam and one with standard insulation. Periodic inspections of the buildings were conducted as well in an effort to incorporate TBC into the plant production of these modular homes. In addition to these five homes, BAIHP also reviewed FEMA home plans and specs to ensure Energy Star ratings and qualification for Builders Challenge.

In 2009, BAIHP continued to assist Palm Harbor Homes in Plant City, FL to develop modular homes for Builders Challenge and Energy Star and to verify in-plant Thermal Bypass Checklist. 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.

BAIHP provided assistance in early 2010 for several homes that would be Energy Star, Builder's Challenge, and FGBC green certified. As of November 2010, the plant moved to using the Systems Building Research Alliance (SBRA) to certify both HUD code and modular homes for Energy Star and NAHB Green as this program is specifically geared for manufactured housing producers. FSEC will provide assistance as needed with the transition.

PATH Concept Homes

In BP1, BAIHP performed benchmark analysis for the 2007 Path Concept Home (see Figure 3-32) 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 3-31). 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 3-31: *2008 PATH HUD Concept Home near Charleston, SC.*

Figure 3-32: *2007 PATH concept home in Omaha, NE.*

Parker Residence

In August 2010, BAIHP began monitoring the energy consumption of an existing 1960's style Florida residence that have had a series of "deep" retrofits installed. These modifications include photovoltaics, solar hot water heating, energy efficient window replacements, and exterior wall insulation. In addition to monitoring electrical energy consumption, the monitoring effort examines the 4.9 kW PV system performance, hot water use patterns, and interior comfort conditions.

Installation of wiring, configuration and assembly of monitoring equipment (datalogger and peripherals, electric energy consumption transducers) was completed. This effort included sensors for verification of photovoltaic system and solar hot water system performance. Additional sensors were installed for HVAC performance monitoring and interior comfort.

Activities for October included the continued instrumentation and wiring of sensors to monitor/characterize the previously stated parameters. . In November, operation of the ductless heat pump began. Continuous data acquisition also began. Early evidence suggests that comfort conditions can be met without running the central natural gas furnace for supplemental heating or circulation. Early data also showed the home's two refrigerators are performing poorly and using 3 kWh each with one of these slated for replacement within the project. Data from this site is available online at http://logger.fsec.ucf.edu/dpr/

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 3-33). 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. No activity reported in 2010.

Figure 3-33: *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 3-34).

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 and there were no further developments in 2010.

Figure 3-34: *The Grand Emerald by Royal Concrete in Pt. St. Lucie, FL was Florida's first LEED certified home.*

Schackow Development Homes (and formerly Trunnel Homes)

Schackow Development is developing a community of 27 energy efficient homes called Forest Creek in Gainesville, FL.E-Scales are 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 Florida H.E.R.O. 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. We further 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 3-35) 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 and 2010. Average daily net energy use in July of 2009, 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.

In 2010, total house electricity use was very low: 13.2 kWh/day. Average daily net energy use over the year, including solar production, was approximately 5.2 kWh/day with the PV system providing 61% of electrical needs (8.1 kWh/day).

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— lower than expectations, but likely reflecting the west facing PV array and shading in the morning and afternoons from trees proximate to the site.

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 somewhat 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 in 2010. Not counting solar production, total home power use in over the year averaged only 28.8 kWh/day, less than half the energy typically used in most Central Florida homes during that time of year. Average daily net energy use over the year (including 11.2 kWh/day solar production) has been about 17.5 kWh /day with 38% of the annual electrical loads provided by the PV system.

Figure 3-35: *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 was presented at the Thermal Performance of Exterior Envelopes of Whole Buildings XI International Conference in 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 in the BP4 annual report under Subtask 1.1 Improved Duct Systems. No progress was reported in 2010.

Springwater Homes

In 2010, BAIHP initiated work with this new Builders Challenge builder located in Rockledge Florida. Work included meetings with Springwater Homes to discuss and define Builders Challenge criteria and review initial design analysis. Work in progress on the model home was discussed and included selection of the HVAC system, HVAC Manual J and D development and other home components critical to Builders Challenge Quality Criteria. FSEC continued working with builder to identify future home improvements and define customer base for energy efficient homes. In April, we also continued development of LEED for Homes certification for model home. Other tasks included continued discussions with builder on LEED elements, refining and review of LEED for Homes checklist and selection of elements which will comprise the LEED project, and continued collection of documentation and materials for LEED checklist.

Figure 3-36 Springwater model Home, Rockledge, FL

Figure 3-37 Springwater Home included a solar water heating system

Completion of home checklist has determined that this house will meet LEED Silver certification standards. The home (Figure 3-26 and 3-37) received final approval for LEED silver certification in May 2010. Eric Martin has been working with the team to provide quality assurance for LEED for Homes certification on this first house. FSEC continue assistance efforts by modeling different energy efficiencies to determine the best suitable mix for each customer's lifestyle.

FSEC has been monitoring the performance of the model since March, 2010. This home site is outfitted with ultra high efficiency heat pump (Nutone , SEER 21) and a Honeywell outside air damper control to provide fresh air intake.

Online data for the house: http://.infomonitors.com/spw/

Stalwart Built Homes – New Orleans

In 2009, Stalwart Built Homes requested input on the redevelopment plans of Pontchartrain Park in New Orleans, a historical neighborhood to include 100 new modular Hurricane Katrina replacement homes.

Design reviews continued throughout 2009 and into 2010, including design for a sealed crawlspace. The first two prototype homes went into production early in 2010 and FSEC visited the factory and the site to provide construction support and quality control. The project had a large media event showcasing the first two homes in May in conjunction with project partner GE. In addition, Thermal Bypass Inspection, infrared scans and other quality control activities were completed in conjunction with a locally based energy rater.

Final energy rating and performance testing was performed later in 2010, and performance testing was repeated on the Pierce residence to address high total duct leakage. Work continued to document items for LEED Platinum certification, which was awarded in December 2010.

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.

Figure 3-38: *Stalwart NZEH in Calloway, FL*

In 2008, Stalwart Homes constructed their first Near Zero Energy Home (NZEH) Prototype (see Figure 3-38). 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/.

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 3-39). 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.

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.

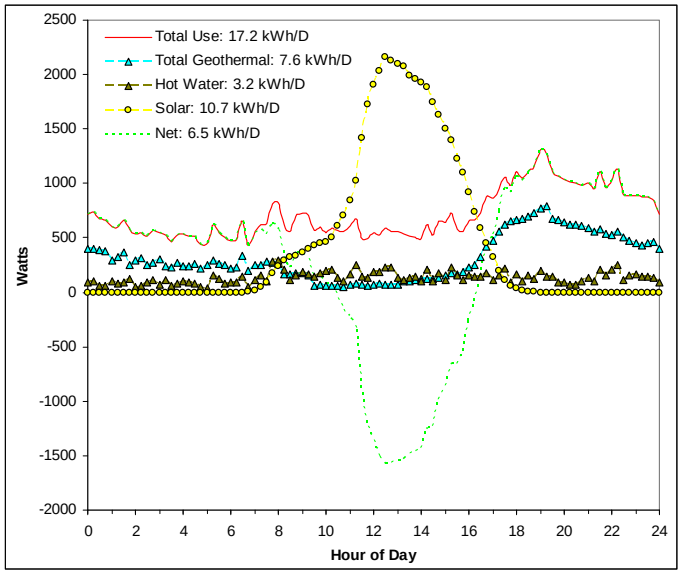

Figure 3-39: Stalwart NZEH average 24-hour electrical demand, September – December 2008

Occupancy characteristics have changed over the monitoring period. 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. Later in 2009, the home was rented, and has changed occupancy a few times. Automated monitoring and data archival continued in 2009 and 2010 despite change in use.

Stamets Residence

The Stamets residence (Figure 3-39) 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 ENERGY STAR windows, lighting and appliances, HRV and HEPA filtration, a heat pump water heater, condensing dryer, Seisco tankless hot water heaters, and a .74 AFUE propane fireplace (rarely used).

Figure 3-39 – *Stamets Residence, Olympia, WA*

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.

In late 2008, a ground source heat pump was installed. Savings from the heat pump are estimated at 10,000 kWh per year, at a cost of $16,000.

Monitoring of the home took place from June 2006 through December 2009. Figure 3-40 shows total home electrical use (excepting a hot tub).

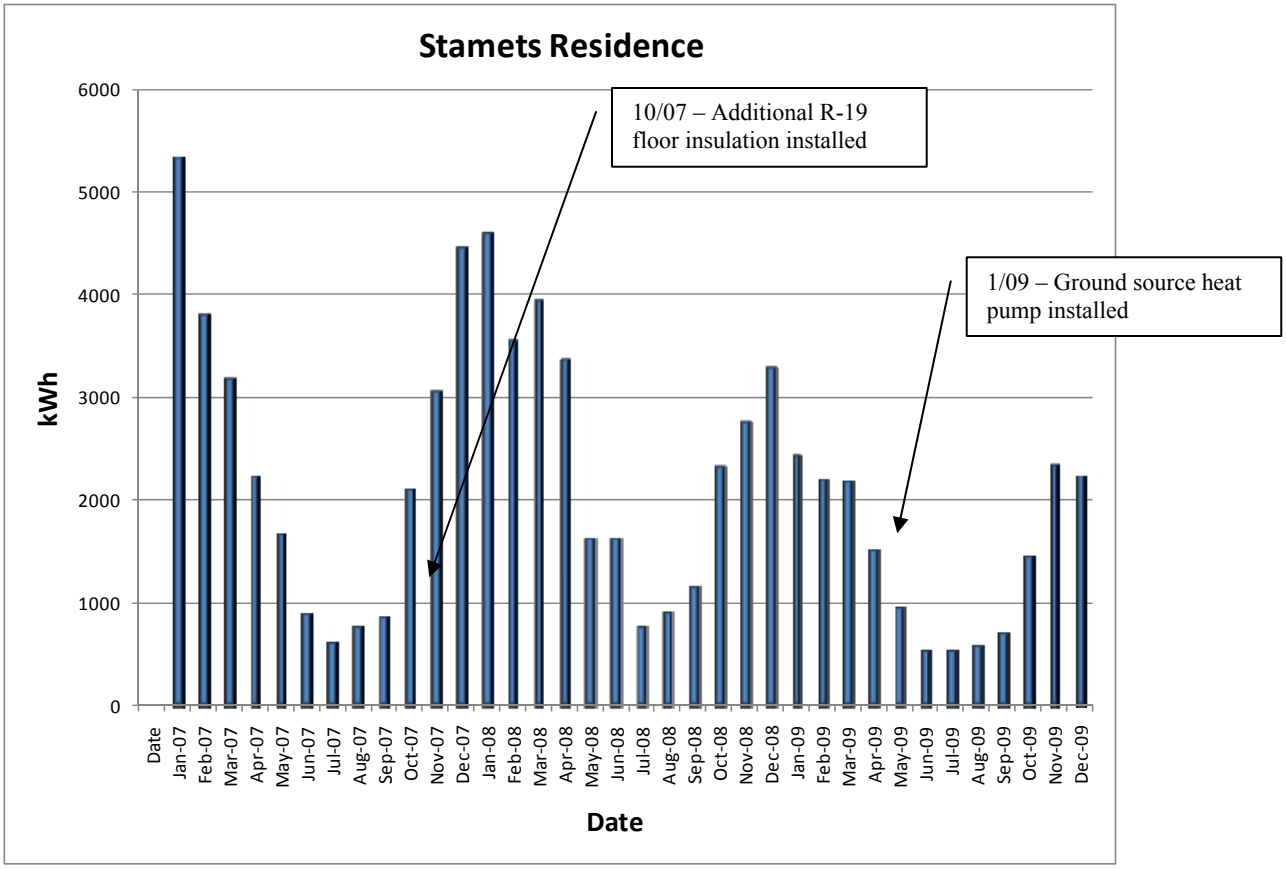

Figure 3-40 – Stamets residence, electrical use

As noted in Subtask 1.9, BAIHP staff gave a presentation on the Stamets residence to the EEBA national conference as part of the track "The Green in Radiant Zone Heating." WSU's full 2010 Annual Report is available in Appendix C.

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 of 2009, 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 3-41). 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 3-42). Construction is scheduled to be completed in Spring 2010. The one page fact 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 3-41: *South (top) and North (bottom) Façades of Tommy Williams Homes' first ZEH*

Figure 3-42: *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.

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

Ongoing consultations continued among builder's representatives, FSEC and Florida H.E.R.O in 2010. Construction on the prototype house was completed in January and was instrumented to monitor and verify energy performance. Florida H.E.R.O. performed final testing, commissioning, and rating on the Longleaf ZEH. This Builders Challenge certified home achieved an impressive E-Scale of -2 and sold at asking price in less than one month. It was also selected for the 2010 Aurora Awards in which Tommy Williams and Energy Smart Home Plans

were awarded Auroras in five categories, including a Grand Aurora. As of October, this site is no longer funded under the BAIHP contract activities.

Case study is available on the BAIHP website:
http://www.baihp.org/casestud/pdf/BA_BuildersChallengeSpotlight_TW_ZEH.pdf

Tommy Williams Homes ZEH2 Belmont Prototype

In 2010, Tommy Williams Homes developed an innovative new homes initiative by offering to pay for home buyers electric bills for the first year of occupancy. This BC builder also introduced a new home in the Belmont community, the second ZEH by a production builder in the State of Florida. Florida H.E.R.O and FSEC representatives provided Tommy Williams Homes with ongoing consultations and technical assistance for this project. The home greatly exceeds the Builders Challenge level of performance including all quality criteria and a HERS Index of -1. It was sold at the end of September, and monitoring equipment has been removed. As of October 2010, the Belmont ZEH was no longer funded under BAIHP contract activities.

Tampa ZEH – Rutenberg Residence

BAIHP subcontractor, Florida H.E.R.O., met with Alfonso Castaneira, Sr. Executive Producer from ZeroEnergy America and Jeff Smith with JW Smith Architecture/Planning to discuss our involvement with the proposed ZEH to be built by Marc Rutenberg.

Assistance was requested by Zero Energy America and Rutenberg Homes to advise and provide technical support for their Production Quality zero energy homes project located in Palm Harbor, FL and partially sponsored by the state of Florida's Renewable Energy Technologies Grants Program established by the Florida Renewable Energy Technologies & Energy Efficiency Act (Senate Bill 888). FSEC helped with this by providing technical assistance through Ken Fonorow/FL HERO and conducted an energy analysis on design drawings to date. Analysis was in progress in 2010.

BAIHP participated in a conference call in May 2010 with Mark Rutenberg and Alfonso Castaneira (ZEA) about our scope and the preliminary specifications for the zero energy home planned. Florida H.E.R.O. had ongoing meetings and communications with Marc Rutenberg, builder, his staff and material component system suppliers in 2010. Completed preliminary Manual J and began analysis. Attended ground-breaking on June 25 and met with various material component system representatives. Subcontract funding to Florida H.E.R.O. ended in August 2010.

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 was still in the design phase as of 2009. In 2010, work on this project was largely halted pending delays in architectural design by the University of Georgia.

Walt Disney Imagineering

In 2009, an analysis was conducted on generic plans submitted by Walt Disney Imagineering. The plans represent housing architecture that is eventually planned to be built in conceptual communities in Central Florida. BAIHP developed sample energy conservation packages for two floor plans to achieve E-Scale of 60, 40, and 0 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.

BAIHP researchers conducted a range of analysis in 2010 for this partner. In March, FSEC staff and representatives from Disney Imagineering met with Building America and DOE leadership to discuss a partnership involving Disney's plans to continue the build out of the Celebration community along with offering retrofit strategies to existing residents. FSEC staff conducted retrofit analysis for sample homes ranging in size, construction type, and construction vintage and presented the cost/benefit analysis of various retrofit strategies to the partner.

In April, FSEC concluded preliminary retrofit analysis and it was agreed to involve architectural and construction team members in retrofit package development activities. Disney Imagineering has begun planning for a charrette to develop design constraints for new construction and retrofit. FSEC assisted the partner with development design objectives that will be used to guide activities during a community charrette, which is still in the planning stages. No further activities were reported in 2010.

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 since 2008.

ZCS Development, Rockledge, FL

ZCS Development is developing a 100 unit subdivision named Sierra Lakes (Figure 3-43) in Rockledge, FL that includes all steel (Figure 3-44) 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 3-43: *Sierra Lakes, Wesley Model*

Figure 3-44: *Steel trusses produced on site*

Additional Prototype Activity

Habitat for Humanity High Performance : Please see Subtask 6.1.
Existing Homes High Performance Prototypes: Please see Subtask 6.2
Manufactured Housing High Performance Prototypes: Please see Subtask 6.4.

Task 4: Stage G3: Initial Community Scale Evaluations

(Formerly Task 3. Community Scale Developments)

Under Task 4, BAIHP provides technical assistance to partners moving from the prototypes stage into community scale (10 or more homes) application of high performance concepts. See Subtask 1.4 for a list of homes produced under Task 4 by the 2010 community scale partners. Partnership activity falls into the following six subtask areas:

Subtask 4.1 Identify Development Opportunities for Prototype Houses
Subtask 4.2 Produce Prototype House Designs and Test Plans
Subtask 4.3 Support Prototype House Construction
Subtask 4.4 Test Prototype Houses
Subtask 4.5 Produce Prototype Case Studies
Subtask 4.6 Quality Assurance Documentation

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.

As the nationwide slowdown in new home construction continued in 2010, BAIHP community scale production was also reduced in comparison to previous budget periods. Even in the face of this slow market, several of BAIHP's Industry Partners continued to build homes to an E-Scale score of 60 or less as indicated under Subtask 4.3 and 4.4 for the "HERS Index 60 or Lower Communities" in Table 4-1 below.

Progress of current and past community scale Industry Partners is briefly described below Table 4-1.

Table 4-1 BAIHP 2010 Community Partnerships	**Partner Status**	**In Design**	**Under Constr.**	**Select Testing**	**Case Study**	**QA Docs**
	4.1	**4.2**	**4.3**	**4.4**	**4.5**	**4.6**
40% Joule Report Case Study Communities						
Brownsville Affordable Homeownership Corporation						
January-March	Ongoing	Complete	Complete	29	1	Ongoing
2009 Community April - June	Ongoing	Complete	29 Complete	21 Complete and 8 in progress	1	Ongoing
2010 Community	Ongoing	44	4	4	0	Ongoing

Table 4-1 BAIHP 2010 Community Partnerships	Partner Status	In Design	Under Constr.	Select Testing	Case Study	QA Docs
	4.1	4.2	4.3	4.4	4.5	4.6
April - June						
July	Ongoing	Complete	5	29	1	Ongoing
August - November	Ongoing	Complete	6	6	1	Ongoing
Castle and Cooke Winter Garden, Florida						
January - November	Complete	Complete	Complete	Complete (10 houses)	1	Ongoing
Tommy Williams Homes, Gainesville, FL	See activity below under "HERS Index 60 or Lower Communities					
HERS Index 60 or Lower Communities						
Built-Wright Homes Trenton, FL						
January - April	Ongoing	0	1	0	0	Ongoing
May	Partnership activities were completed in April					
G.W. Robinson Builder Gainesville, FL						
January	Ongoing	2	2	0	0	Ongoing
February	Ongoing	0	2	0	0	Ongoing
March	Ongoing	0	0	2	0	Ongoing
April	Ongoing	7	0	0	0	Ongoing
May	Ongoing	8	1	0	0	Ongoing
June	Ongoing	0	1	0	0	Ongoing
July - August	Ongoing	1	1	0	0	Ongoing
September - November	No activity*					
Innovative Home Builders High Springs, FL						
January	Ongoing	0	2	0	0	Ongoing
February	Ongoing	0	1	1	1	Ongoing
March	Ongoing	0	1	0	1	Ongoing
April	Ongoing	0	1	0	0	Ongoing
May - June	No report					
July - August	Ongoing	0	0	0	0	0
September - November	No activity*					
Lifestyle Homes						
January	Ongoing	2	11	3	0	Ongoing
February	Ongoing	3	8	3	0	Ongoing

Table 4-1 BAIHP 2010 Community Partnerships	Partner Status	In Design	Under Constr.	Select Testing	Case Study	QA Docs
	4.1	4.2	4.3	4.4	4.5	4.6
March	Ongoing	2	8	3	0	Ongoing
April	Ongoing	2	7	4	0	Ongoing
May	Ongoing	3	6	3	1	Ongoing
June	Ongoing	6	3	3	1	Ongoing
July	Ongoing	6	5	0	0	Ongoing
August	Ongoing	8	6	0	0	Ongoing
September	Ongoing	6	8	0	0	Ongoing
October	Ongoing	0	10	0	0	Ongoing
November	Ongoing	Complete	11	2	2	Ongoing
Skobel Development						
January	Ongoing	1	1	0	0	Ongoing
February	Ongoing	0	6	4	0	Ongoing
March	Ongoing	8	6	0	0	Ongoing
April	Ongoing	6	6	2	0	Ongoing
May	Ongoing	12	6	0	0	Ongoing
June	Ongoing	0	12	6	0	Ongoing
July - August	Ongoing	13	12	0	0	Ongoing
September - November	No activity*					
Tommy Williams Homes – Belmont and Longleaf						
January	Ongoing	2	2	2	0	Ongoing
February	Ongoing	0	22	2	0	Ongoing
March	Ongoing	1	20	1	0	Ongoing
April	Ongoing	4	15	6	0	Ongoing
May	Ongoing	4	18	4	1	Ongoing
June	Ongoing	3	9	8	0	Ongoing
July	Ongoing	0	6	3	0	Ongoing
August	Ongoing	0	3	3	0	Ongoing
September - November	No activity*					
Other High Performance Community Partnerships						
Disney Imagineering Orlando, Florida	Ongoing					
January - March	Ongoing	Multiple	0	0	0	NA

Table 4-1 BAIHP 2010 Community Partnerships	Partner Status	In Design	Under Constr.	Select Testing	Case Study	QA Docs
	4.1	4.2	4.3	4.4	4.5	4.6
April - November	Ongoing	0	0	0	0	NA
Fort Lewis						
January - April	Ongoing	157	63	2	1	Ongoing
May	Ongoing	70	157	2	1	Ongoing
June - November	Ongoing	0	157	2	1	Ongoing
McChord AFB						
January - April	Ongoing	0	30	2	0	Ongoing
May - November	Ongoing	62	30	8	0	Ongoing
Rock Built Homes						
March (new)	New	1	0	0	0	NA
April - June	Partnership activity suspended due to financing issues.					
Salishan – Walsh Construction						
July	No report this month					
August - November	Ongoing	90	60+	Ongoing	0	0
Scott Homes						
January - August	Ongoing	8	4	1	1	Ongoing
September - November	Ongoing	8	0	1	1	Ongoing
Spain & Cooper						
January - February	-	-	-	-	-	-
March	Ongoing	1	0	0	0	NA
April	Ongoing	1	0	0	0	0
May-June	No partnership activity					
July - August	Ongoing	1	1	0	0	0
September - November	No activity*					
Stalwart Built Homes Pontchartrain Park, Louisiana						
January - February	Ongoing	2	0	0	0	NA
March - June	Ongoing	0	2	0	0	NA
July - November	Ongoing	0	0	2	0	Ongoing
Stalwart Built Homes Washington	Partnership did not progress.					

* Subcontract funding to Florida H.E.R.O. ended in August. No further activity with these partners will be reported.

Table 4-1 BAIHP 2010 Community Partnerships	Partner Status	In Design	Under Constr.	Select Testing	Case Study	QA Docs
	4.1	4.2	4.3	4.4	4.5	4.6
Note: Additional description of WSU partnerships may be found in Appendix C.						

Industry Partners producing high performance homes at the community scale during Budget Period 5 are briefly described below in alphabetical order. Previous community scale activity is described in the annual reports for Budget Periods 1-4 (see Introduction for links.) Please note that a portion of progress with Tommy Williams Homes has been included in the description of activity with Industry Partner G.W. Robinson.

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 13 Prototype Gate 2 homes. BAHC also signed up for the Builders Challenge as Pioneer Builders.

Of the thirteen Prototype Gate 2 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).

In 2010, BAHC completed their 2009 Phase 2 build-out of 29 houses. Final testing and ratings were completed for 24 of the 29 homes. All homes were registered with the ENERGY STAR Program and the Builders Challenge. The remaining five houses were not certified due to lack of homeowner cooperation; they were not interested in participating in final testing.

BAHC plans for Phase 3 construction were projected to be 48 houses, and the first six houses were registered with ENERGY STAR and Builders Challenge during 2010. BAIHP researchers noted a significant improvement in the uniformity of the houses across the three builders building for this partner. BAHC's goals were WHSES at 40% or higher and 100% Builders Challenge compliance.

Although BAHC's desire to participate in Building America's new community goal of 50% WHSES remains undetermined at this time, further communications with this partner outlining a gas and electric path to 50% WHSES is expected.

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 ensure 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.

Case study is available on the BAIHP website:
http://www.baihp.org/casestud/pdf/08-Brownsville-CaseStudy-Feb-09.pdf

A new case study on BAHC was finalized in 2010 and included in the "Hot Humid Climate 40% Milestone Report". This report can be downloaded on the BA Project Management Extranet Site.

Castle & Cooke - Oakland Park, Orlando, FL

BAIHP worked with Castle & Cooke 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 Builders Challenge with an estimated 40% savings over the 2009 BA benchmark. The scope also incorporated FGBC certification and high performance features including unvented attics, ducts in conditioned spaces, high efficiency HVAC equipment and mechanical ventilation.

Figure 4-1: *Oakland Park, Winter Garden, FL built by Castle & Cooke*

In 2008, construction on all ten homes was completed (Figures 4-1 and 4-2). The homes range from 1819-2340 sq. ft. and E-Scale ranged from 59-65. All ten include outside air ventilation (Figure 4-3). 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. Future homes in the development will be built by other builders as the housing market stabilizes. These builders may also choose to partner with Building America.

Figure 4-2: *Completed Castle & Cooke Home*

Figure 4-3: *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 4-4). 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.

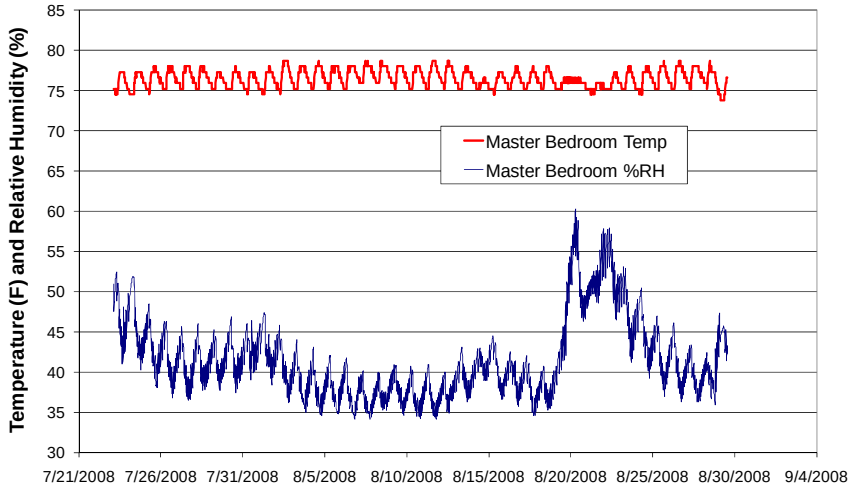

Figure 4-4: *Monitored data from unoccupied Oakland Park home showing excellent summer comfort conditions. Rise in relative humidity beginning 8/20 caused by Tropical Storm Fay, which brought historic rainfall to the Central Florida area, along with three consecutive overcast days with no sun.*

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. In 2010, the case study was finalized and included in the "Hot Humid Climate 40% Milestone Report" (available for download on the BA Project Management Extranet Site).

Fort Lewis Army Base, Town Center (Figure 4-5) – Fort Lewis, WA

Figure 4-5 – *Town Center, Fort Lewis*

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 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 .90 AFUE furnaces, efficient windows, and ENERGY STAR appliances and lighting.

WSU staff worked with Equity on plans for a new 220 unit development at Fort Lewis named Town Center, modular built row houses in clusters of 8-12 (2 story modular with 1 story site-built garage.) Phase 1, with 63 units, began construction in late 2009, and was completed in 2010. While WSU staff testing found substantial total leakage numbers (between 7% and 11% of conditioned floor area), the ducts being located within the envelope meant that leakage to the exterior was negligible (between 1% and 2% of conditioned floor area). Tested envelope leakage was less than 4 $ACH_{50.}$

For Phase 2 (the remaining 157 units, with commercial space on the first floor) which began construction in fall of 2010, WSU staff lobbied to incorporate Building America demonstration technologies, and championed development of alternative ENERGY STAR paths for electric resistance heating, offering additional practical approaches for affordable housing constructed to ENERGY STAR performance levels.

In the end, Equity chose to use ductless heat pumps along with backup electric resistance heat. WSU and Equity plan to evaluate use of the ductless heat pumps in 2011 with PNNL support.

G.W. Robinson Builders, Gainesville, Florida *(Summary includes some material for Tommy Williams Homes. Please also see Task 3 G.W. Robinson ZEH 2010 Prototype and Tommy Williams Homes Zero and Near Zero Energy Homes)*

Figure 4-6: *GW Robinson presented with a certificate by Steve Chalk, Deputy Assistant Secretary from the DOE*

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, 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.

In 2010, Florida H.E.R.O. continued to work with G.W.

Robinson Builders in the following high performance communities: Garison Way and Turnberry Lake subdivisions. This Industry Partner continued to meet the goal of building all of their homes to an E-Scale of 60 or less, averaging in the mid 50's. Ongoing consultations, commissioning of multiple homes, site surveys for QA, and design reviews were completed. Subcontract funding to Florida H.E.R.O. ended in August, and no further progress was reported.

Florida HERO 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.

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 4-6) from the DOE presented a Certificate of Recognition to both these builders.

In 2009 BAIHP worked with by both Tommy Williams Homes and G.W. Robinson Builders in to successfully design and implement a low cost (approximately $0.40 / sq. ft. of floor area) interior duct system approach. This procedure was been adopted by several other BAIHP partners in 2010. Refer to the shaded areas in the plan below (Figure 4-7, left) which denote areas where ceiling sheetrock is first installed, before interior walls are constructed (Figure 4-7, 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.

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.

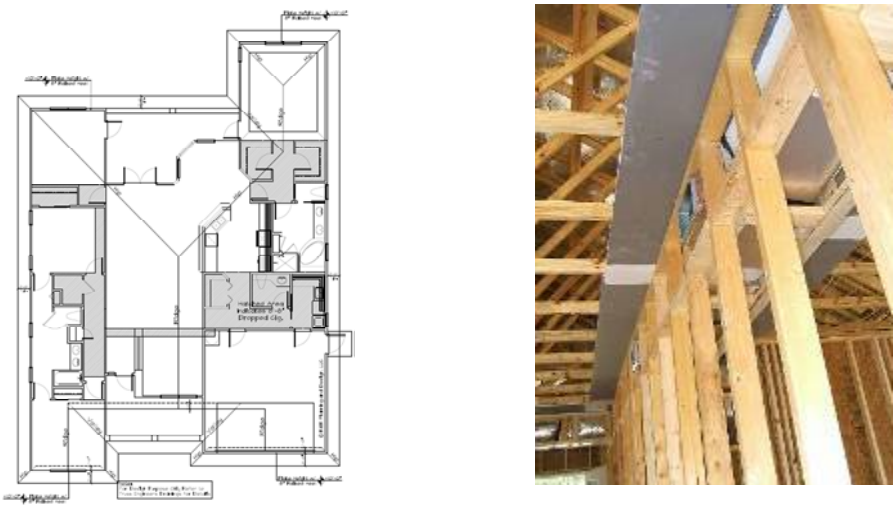

Figure 4-7: *Innovative interior duct system design shown in plan at left (shaded areas) and under construction at right. Note that the ceiling of the duct chase that forms the attic air barrier is installed above the top plates, significantly reducing the number of drywall joints that need to be sealed. This detail resulted from a collaboration between Ken Fonorow of FL HERO and the sub-contractors involved in the construction of the chase.*

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

See more about Tommy Williams Homes' activity with BAIHP below.

Innovative Home Builders

Since 2009, Florida H.E.R.O has been working with this BC builder (located in High Springs, Florida) when he took over construction at the high performance Forest Creek subdivision. Florida H.E.R.O. has been involved since the inception of this project in 2007. This builder continues to meet the goal of building all of their homes to an E-Scale of 60 or less- Ongoing consultations in 2009 and 2010.

In 2010, a site visit was conducted to inspect the installed interior duct system in 2010. A thermal bypass inspection checklist was also completed, including a site visit for QA and photographic documentation of progress. Commissioning and final testing were completed in February.

Florida H.E.R.O. conducted an air handler closet pressurization study in February in Innovative Homes' Forest Creek-Lot 19 (INV-fc-19). The purpose of this study was to measure the impact of the installation of a 12"x12" through the wall transom connecting an air handler closet to the home. Typically an air handler closet will operate under a significant negative pressure. The air pathway provided resulted in a neutrally pressurized air handler closed while the system was operational. The inexpensive approach appears to accomplish the goal of eliminating the introduction of outside air through unattended penetrations. Subcontract funding to Florida H.E.R.O. ended in August 2010, and no further progress was reported.

Lifestyle Homes

Lifestyle Homes, a family owned business, was interested in improving performance and distinguishing 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 4-8). 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 4-8: *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 4-9). 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 4-9: *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 4-10).

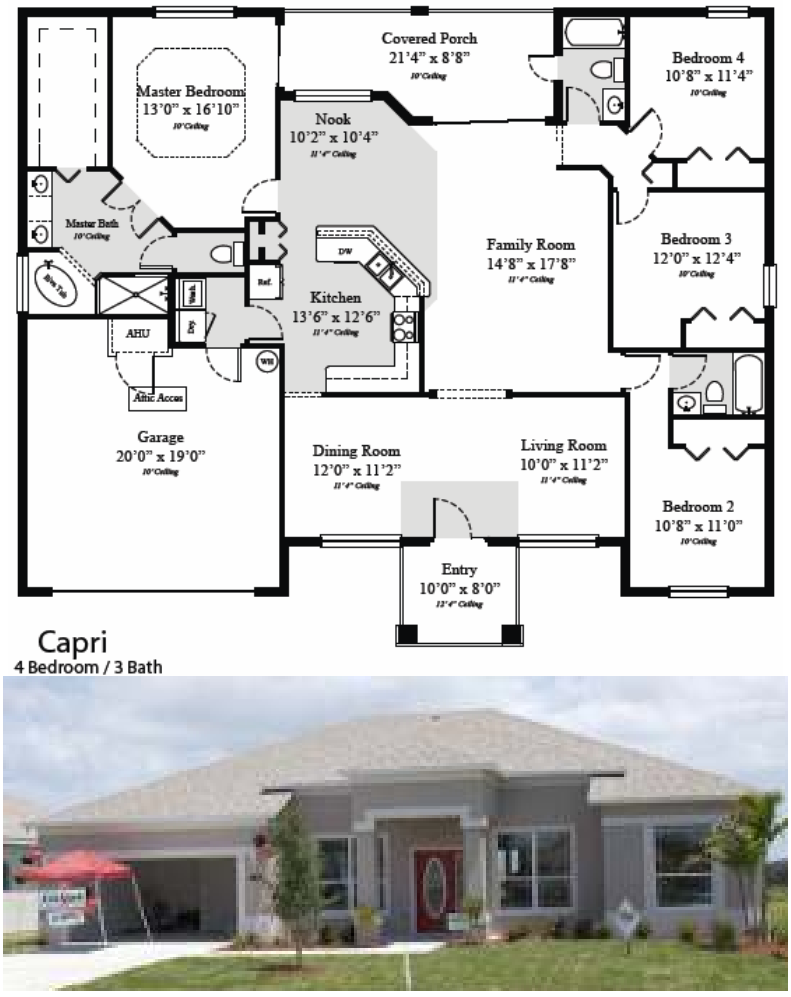

Figure 4-10: *Lifestyle Homes Capri Model*

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 4-2 shows LifeStyle Homes' standard (pre-Builder's Challenge) construction characteristics and the Builders Challenge improvements.

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.

Table 4-2: *LifeStyle Homes Typical Characteristics*		
Attribute	***Pre Builder's Challenge***	***Builder's Challenge***
Bedrooms/Bath	4 / 3	
Floor Area (sq. ft.)	2054	
Orientation	East *(for worst case modeling)*	
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 to floor ratio	16.7%	
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

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 4-11) 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 4-11 *Interior AHU closet in garage*

While sales in the construction industry declined, LifeStyle increased its sales from 2008 to 2009 by 92%. Fifty homes were sold in 2009.

In 2010, BAIHP continued to work with Lifestyle Homes in the development and analysis of Builders Challenge homes under construction. Mid-point and final testing was conducted on 21 completed homes to verify Builders Criteria. Thermal by-pass inspections were also performed.

Further analysis was underway in July and September to determine if energy efficiencies and their associated costs could be enhanced with different levels of home components (i.e. SEER 14 vs. SEER 15; R-38 ceiling insulation vs. spray foam attic). Analysis continued to determine if energy efficiencies and their associated costs can be enhanced with different levels of home components (i.e. SEER 14 vs. SEER 15; R-38 ceiling insulation vs. spray foam attic). Results of this study are expected to produce a series of cost and energy efficiency parameters that could be used to determine suitable energy options for future home development.

LifeStyle continues to improve their insulation techniques. The rear of their homes where the ceiling meets the exterior porch ceiling is effectively being blocked to prevent spillage of the blown in insulation. The bonus rooms are now being insulated with open cell foam spray on the raised floor over the garage as well as the knee walls.

A four-page case study on LifeStyle Homes was also completed in 2010. It is available on the BAIHP website: http://www.baihp.org/casestud/pdf/BuildersChallenge_LifeStyle-Homes.pdf

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 have been coordinating with Equity and the HVAC contractor to provide training on heat pump commissioning, and additional training for duct sealing for new HVAC staff.

In 2010, WSU continued to coordinate with Equity and HVAC contractor on Phase 1 of Wescott Village, which included 32 homes in phase 1. WSU provided training on heat pump commissioning and duct sealing, as well as quality assurance throughout the construction process. Field testing identified multiple areas for improvement, including duct system design and leakage levels, heat pump controls, and floor insulation details. Through numerous field visits, WSU worked with Equity and the HVAC contractor to address these issues; by late spring the performance testing results showed substantial improvement.

WSU also began discussions with Equity on a new 62 home site built project called Cascade Village, using lessons learned at Westcott village to achieve higher benchmark savings. In 2010 WSU staff worked with Equity and architects on the design of up to 850 new homes as part of the Grow the Army (GTA) privatized military family housing. The first 250 homes will be built in 2011.

Rock Built Homes

In 2010, Rock Built Homes made plans to build ten homes that would meet Builders Challenge criteria. This partner was assisted by a local gas company representative to conduct their Energy Star compliance and home energy testing. Calcs-Plus completed the HVAC load calculation followed by a site visit to other homes under construction to review typical installation with builder and provided suggestions for the design to HVAC contractor. In March of 2010, this builder submitted for permitting, and coordinated with FSEC in order to design their homes as cost effectively as possible and still meet BC criteria. However, builders funding for this project expired in May of 2010.

Salishan - Walsh Construction

In late 2009, WSU began working with Walsh Construction, Tacoma Public Utilities, the Tacoma Housing Authority and consultant O'Brien and Company on Phase 7 of the Salishan development (. The development, which began construction in late 2009, and was completed in late 2010, is composed of 91 low-income housing units, and is the first federal Hope VI project to achieve LEED Platinum. (Figure 4-12)

Figure 4-12 – *Salishan 7 (L) and foam sheathing detail on demonstration unit*

WSU and Walsh Construction coordinated the plans for the last four units to demonstrate advanced technologies, including ductless heat pumps, exterior foam sheathing and Panasonic ERVs and Dupont's liquid applied house wrap. WSU is also working with partners Tacoma Public Utilities and Tacoma Housing Authority to plan long term billing analysis; utility data would be collected via new gateway meters with BA support in 2011-12.

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 Task 3. Two more houses were completed in 2009, and work continued 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.*

Scott Homes Olympia, WA

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

Since 2008, BAIHP staff has provided design and on-site technical assistance to the 11 unit Woodard Lane Co-Housing project. 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. Phase 1 construction was completed in 2009; the HERS index on these homes ranges from 54-64 for these units. The units were not fully occupied until April of 2010, so a full year's utility bill assessment was not possible. For the months April through October (largely non-heating), average energy use per building (4 units each) was on average 53 MMBTUs; roughly 4.8 MMBTUs per occupant (based on 8 adults and 3 children per building).

WSU staff met with Woodard Lane Co-housing residents and Scott Homes staff to solicit feedback on the buildings and present questions about certain features and mechanical operations. A majority of comments referenced elements of the homes required by code, or reflected a misunderstanding in the operations of equipment. Major concerns included:

- Several residents expressed concern over the noise of the bathroom fan when operating at maximum setting, revealing misunderstandings about the use of the whole-house ventilation system.
- In a similar vein, several residents complained about the cold air coming in from ventilation ports positioned at the top of certain window frames, reflecting a misunderstanding that the ports cannot be closed, regardless of conditions. These comments also seemed to reflect a greater sensitivity to temperature and sound resulting from greater insulation and a tighter building envelope.

- One resident noted the room housing the back door was consistently colder than the adjacent rooms and suspected that the door was not perfectly installed (see Figure 4-13, below)

The feedback emphasizes the need for proper education and technical assistance for new residents of highly efficient homes. WSU and Scott Homes are planning to meet implement a resident survey in 2011.

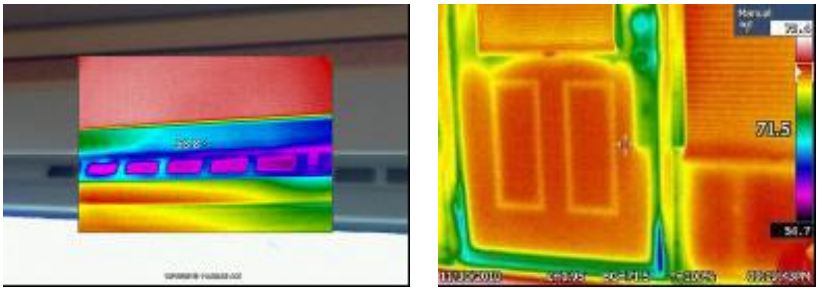

Figure 4-13 – *Air inlet vents (L) and possible air leakage around door, Woodard Lane, Olympia, WA*

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

Skobel Development

Florida H.E.R.O. has been working with this BC builder since 2007 and 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. *Also in 2009, FLHERO received a commitment from this partner to build future homes to an E-Scale of 60 or less*. This high performance standard continued in 2010. Activities in BP5 included final testing/commissioning of multiple homes, ongoing consultations, site surveys for QA, and multiple thermal bypass inspections (TBICs). Subcontract funding to Florida H.E.R.O. ended in August of 2010. See Subtask 1.4 for a list of homes completed by this community partner.

Spain & Cooper Construction

(Willowcroft, Greystone and Custom Homes) Florida H.E.R.O. has been working with this builder since 1998. This high performance builder's commitment was one of the first to implement the method of installing ductwork beneath the ceiling plane. In 2009, design review, TBIC, Tax Credit and Site visits for QA were completed. Technical support and assistance was also provided for a high performance home with unvented attic. This builder was introduced the BA Builders Challenge, and a commitment to accept the Challenge was received. Ongoing consultations continued in 2009.

In 2010, consultations with builder were conducted to review preliminary plans for a new home that will have an unvented attic. The design review was completed in April. Subcontract funding to Florida H.E.R.O. ended in August 2010, and no further progress for this partner was reported.

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 4-14) and becoming a part of the Stalwart Builders Guild, offer the product to consumers.

Figure 4-14: *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. (*See Task 3 - Stalwart Built Homes New Orleans and NZEH Prototype sections for 2010 progress with this partner*)

Stalwart Homes/GE Marine

Late in 2009, Stalwart homes requested support for placement of homes in the Cascadia community in Washington State. While designs were being conceptualized, the relationship between Stalwart and Cascadia dissolved, and no activity was conducted in 2010.

Tommy Williams Homes – Belmont and Longleaf subdivisions

Florida H.E.R.O. continued to work with this builder/developer in these high performance communities in 2010. This BC builder continues to meet the goal of building all of their homes to an E-Scale of 60 or less, averaging in the mid 50's. Ongoing consultations included design reviews, code compliance forms, duct design, commissioning, site visits for QA, thermal bypass inspections, and completion of multiple tax credit calculations for multiple homes. Subcontract funding to Florida H.E.R.O. ended in August 2010.

A case study on Tommy Williams Homes was finalized in 2010 and included in the "Hot Humid Climate 40% Milestone Report". This report can be downloaded on the BA Project Management Extranet Site.

Task 5: Project Closeout, Final Review of BA Communities

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 was to investigate whether program goals were 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, and 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.

During parts of 2009, BA Researchers attempted to recruit participants who own qualifying *study* homes (homes built in partnership with BA) and *control* homes (homes of similar size and age not built in partnership with BA). Working with the builders who are already 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 planed 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 identified and targeted approximately 50 candidate study homes built by each builder (100 total homes), estimating 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.). 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.

Via partnerships developed with local utilities and homeowner associations, information that briefly described 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. Despite offering participating homeowners a small stipend, response from this initial mailing was poor, and only two interview/audits were conducted in November 2009, including deployment of HOBO dataloggers to record interior temperature and humidity. Without OMB approval of the study, follow up on the initial recruitment as well as additional attempts at recruitment could not be conducted. Researchers thought it best to delay the full study until OMB issues could be resolved.

Researchers were able to acquire utility bills from identified potential participants, and began a preliminary analysis in late 2009. Regressions based on heating and cooling degree days were performed to disaggregate heating and cooling energy use from total use. It was expected that results from this preliminary analysis along with results from interviews/audits of the two participants could act as a "pilot" and become part of the OMB approval process. Researchers put the study on hold and awaited approval from the Building America program to begin development of the OMB application process for approval.

Task 6: Other Research Activities

Subtask 6.1 Building America Partnership with Habitat for Humanity (HFH)

(Formerly in Subtask 4.1)

Figure 6-1: *Typical US Habitat for Humanity home; average costs $60,000*

In BP1-BP5, BAIHP continued its decade-long partnership with affordable housing builder Habitat for Humanity (HFH) International (based in Americus and Atlanta, GA) and Habitat's network of local affiliates across the country (Figure 6-1). Partnership activity falls into three main categories:

- Technical assistance to Habitat for Humanity International (HFHI)
- Regional and national training activities with HFHI (including Habitat affiliates)
- Technical assistance to Habitat for Humanity affiliates (including Gulf Coast Recovery)

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

Technical Assistance to Habitat International (HFHI)

HFHI Existing Homes Initiatives

In 2010, BAIHP (FSEC, WSU, RESNET) provided support to HFHI and HFH affiliates with the goal of increasing the volume of high performance existing and affordable homes.

Weatherization Pilot: HFHI entered into a partnership with Exelon in Dallas, Chicago, and Philadelphia to implement a pilot shallow retrofit program dubbed a "weatherization" pilot though there was no connection with the DOE Weatherization program. BAIHP supported the Dallas site with classroom and hands on training and the pilot implementation in two homes.

Neighborhood Stabilization Program: HFHI was also awarded over $137 million under the second round of the Neighborhood Stabilization Program (NSP2) in February of 2010. The money will be used for retrofit projects California, Florida, New York, Texas, and Wisconsin. BAIHP conducted a conference call with the Florida Habitat NSP2 affiliates explaining the technical assistance and BA goals for retrofit activities (see related activity under Subtask 6.2).

DOE Weatherization Award: HFHI submitted a proposal to DOE under the Weatherization program in 2009. In 2010, they were awarded funds to begin a weatherization program in approximately 25 locations nationwide. BAIHP provided multiple reviews of the intended scope of work and audit procedure, based in part on work conducted under the Exelon pilot mentioned above. Work is expected to commence in 2011.

HFHI New Homes Initiatives

In 2010, BAIHP (FSEC, WSU, RESNET) continued to provide support to HFHI programs and initiatives for new construction as described below. In addition to discussion of programmatic direction, researchers provided information on new standards for Energy Star labeled products, the Version 2.5 and 3.0 Energy Star for New Homes Standard, the Builders Challenge, and other building science topics.

FSEC researchers supported Sustainability Specialists at State Support Organizations (SSOs) in Alabama (Andy Bell) and Texas (Mike Lopez). Since July 2010, Ed Brown, formerly under sub-contract with WSU to provide technical assistance to HFH affiliates in Washington State, works for Habitat International providing similar assistance throughout the region.WSU staff conducted a conference call with Mr. Brown in August to discuss ways in which they could continue to coordinate activities and how those activities would be reported.

Partners in Sustainable Building Grant Program: In August of 2010, BAIHP researchers assisted Tiffani Irwin of the HFHI Partners in Sustainable Building grant program with potential methods of assessing energy savings for the Energy Star (Figure 6.2), Builders Challenge, and green certified houses built by Habitat affiliates under this program. Further discussions concluded with a plan to conduct utility bill analysis in 2011 in a sample of homes in the grant program which began in 2008.

Figure 6-2: *RESNET Grade 1 insulation and attic ventilation baffles required for Energy Star certification, East St. Tammany HFH in Slidell, LA*

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.

HFHI 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

(Note: training activities with Habitat for Humanity in previous years are detailed in the annual reports for Budget Periods 1-4. Links to these documents are provided in the Introduction of this report. See Subtask 1.9 for other 2010 Habitat conferences and workshops.)

Training with Habitat for Humanity during Budget Periods 1-5 targeted construction personnel and consisted of nationwide conference calls (concurrent viewing of a prepared presentation), building science sessions national and regional HFH conferences, on site training at high profile events such as the Jimmy and Rosalyn Carter Work Projects, and regional training events lasting one to five days that combine classroom and hands-on training. In 2010, BAIHP researchers provided the following technical training to HFH affiliates:

January 2010 - FSEC provided training on behalf of HFHI at the Alabama Association of Habitat Affiliates conference in Auburn, Alabama.

February 2010 - BAIHP moderated a Habitat session at the RESNET conference to encourage raters to join the RESNET-Building America-Habitat partnership. WSU assisted Habitat SSO volunteer researcher to develop presentation to discuss ductless heat pump technologies, and attended presentation to construction managers.

March 2010 - FSEC researchers participated in a National Weatherization Pilot project in Dallas (one of the three pilot cities). The event kicked off with a one-day training including classroom and field exercise followed by a Level 1 Weatherization (shallow retrofit) in an existing home that the affiliate built in 1995.

April 2010 - FSEC researchers participated in a national shallow retrofit pilot event in Dallas one of the three pilot cities in the Exelon partnership. Two homes were weatherized with volunteers from the sponsor organization, Exelon, a nationwide gas and electric utility. Researchers worked with staff and volunteers to implement Habitat International's Level 1 Weatherization (shallow retrofit) improvements in a home built by the Dallas Habitat affiliate in 1995.

April 2010 - WSU worked with Ed Brown (Washington Habitat State Support Organization) in April to develop a presentation for the Affordable Comfort Institute conference, conducting billing analysis, REM/Rate simulations and occupant survey data evaluation. A presentation was made in April.

In September, WSU was working with Brown to develop a presentation about changes in the Northwest Energy Star program for affiliates participating in the Partners in Sustainable Building Program.

In October, WSU worked with Ed Brown of Habitat International to develop and present an ENERGY STAR Version 3 presentation to affiliates participating in the Partners in Sustainable Building Program.

Technical Guidance Publications
In August 2010, BAIHP revised and distributed a draft of the technical guidance paper "Affiliate Steps Toward Energy Star" based on the requirements of Version 3 of the Energy Star for New Homes Standard. It was also posted on the BAIHP website:
http://www.fsec.ucf.edu/en/publications/pdf/FSEC-FS-47-10.pdf

BAIHP-RESNET Partnership with Habitat for Humanity International
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 6-3. 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 6-3: *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.

In 2010, there were 196 RESNET rater members who signed up to volunteer with the Habitat for Humanity affiliates at the local level. Over the course of the partnership, over 200 RESNET members have participated in the partnership between Habitat, Building America, and RESNET volunteers.

BAIHP researchers pledged to produce short case studies of volunteer raters in RESNET's national service project with Habitat for Humanity. In 2010, these following case studies were posted to the BAIHP web site:

- Austin Habitat for Humanity (Austin, Texas)
- Indian River Habitat for Humanity, (Vero Beach, Florida)
- Orlando Habitat for Humanity (Orlando, Florida)
- South Sarasota Habitat for Humanity (Venice, Florida)

http://www.baihp.org/habitat/index.htm

Long Term Instrumentation and Monitoring Habitat for Humanity Projects (BP1-BP4)

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 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 and 2010, 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. More detailed information of previous collaboration with Habitat for

Humanity can be found in the annual reports from Budget Periods 1-4. Links are provided in the Introduction of this report.

Local Habitat for Humanity Affiliates (alphabetical by state)

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.

California, 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.

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

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, Habitat for Humanity of Jacksonville (FL) HabiJax
FSEC served as LEED for Homes Provider and completed 3rd party quality control activities for a LEED Certified Home in January 2010.

Florida, Highlands County Habitat for Humanity, Sebring, FL
In July 2010, BAIHP researchers traveled to inspect two of the finished houses this affiliate builds. The affiliate uses SIPS panels, including the roof. The affiliate was interested in how their houses compared to others and how close to ENERGY STAR their standard build was. BAIHP tested their houses and is generating a list of recommendations to achieve ENERGY STAR as a start, and plan on helping the affiliate achieve compliance with the 2011 ENERGY STAR program.

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.

BAIHP produced two home energy ratings for this affiliate in 2010. HERS Indices were very close to 70. Another home energy rating was completed for the affiliate and resulted in a HERS Index very close to 60. In March, BAIHP conducted final testing in one home and discussed the Builders Challenge with the construction manager. Final testing for two homes was completed in April.

The affiliate is very close to a HERS Index of 70 and decided to pursue the Builders Challenge. BAIHP worked with this Habitat partner to identify quality criteria requirements for a Builders Challenge level home. As of October 2010, this partner was moved to another contract focused on Builders Challenge level of performance.

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, Jackson County Habitat for Humanity, Marianna, FL
FSEC served as LEED for Homes Provider and completed 3rd party quality control activities in March 2010 for a LEED Gold Home.

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 6-4: 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, BP4 and BP5. 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 6-4) 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.
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.

During BP5, FSEC continued to support this affiliate in striving to meet the Builders Challenge. In addition, three houses received midpoint duct testing and inspections.

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. In January 2010, Florida H.E.R.O. was contacted concerning the affiliate's decision to renovate eight homes in lieu of new construction. It was determined that they could provide affordable housing for four times as many families through this approach. FSEC scheduled two existing homes audits with this affiliate in February – please see Subtask 6.2 for more information.

Florida, Oceola County Habitat for Humanity, Kissimmee, FL:
BAIHP researchers met this affiliate's Executive Director during our May 2010 workshop in Ft. Lauderdale, Florida. This is a small affiliate, building 2 to4 houses per year. They build a steel frame house, using no wood at all, a metal roof applied directly to steel trusses, and a non-wood sheathing used on the walls. The affiliate was interested in how their houses compared to others, and how close to ENERGY STAR their standard build was. BAIHP tested one of their houses and generated an estimated HERS index of 84, with a BA WHSES of 28.6%. BAIHP lacked complete information about the windows and other minor detail about the house. BAIHP is generating a list of recommendations to achieve ENERGY STAR as a start, and plan on helping the affiliate achieve compliance with the 2011 ENERGY STAR program.

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.

In April 2010, BAIHP researchers visited with this affiliate to look at their multi-family project, Staghorn Villas (http://habitat-orlando.org/Staghorn-Villas). This project is unusual since most HFH projects are single family housing. The project is availing itself of the RESNET volunteer rater program and is also getting Florida Green Building Coalition done on a volunteer basis. The affiliate has achieved Gold status in that program.

A case study was completed in May and posted on the RESNET website: http://www.resnet.us/rater/casestudies

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 ft2 per unit triplexes. PCHFH desires to make these homes Energy Star compliant. The HERS Indices as tested were Energy Star compliant, 80, 83 and 84 (85 or less is Energy Star certified); improvement recommendations were also made and included comparison of ICFs to CMU block construction techniques. Two of Pinellas County HFH construction supervisors attended training in Gautier, MS.

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

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.

This affiliate is continuing to build houses that qualify for ENERGY STAR and Builders Challenge. In January 2010, the affiliate increased their build specifications and included Builders Challenge QC criteria into their plans. The second BC qualifying house was completed. The house benchmarked at 41.4% with a HERS of 67. The 1233 ft2, 3/2 home features a SEER 14 heat pump, Low-E windows, RBS decking and R-38 attic insulation, ENERGY STAR refrigerator, dishwasher, washing machine, and ceiling fans, and 55% florescent lighting. Both of

the affiliate's BC houses have been registered with the ENERGYSTAR program and the Builders Challenge. This house was the affiliate's last house using this package developed for the Gulf Coast Demonstration Project (available on line at www.baihp.org/gulfcoast); future houses will incorporate SEER 15 heat pumps, and where practical, gas instantaneous water heaters, bringing projected Benchmarks to 50% In February, the affiliate began preparation for a third BC level (or better) home.

Their excellent insulation contractor went out of business in April 2010. A Thermal Bypass Inspection of their new insulation contractor was also carried out. The new contractor is installing RENET Grade 1 insulation, meeting the criteria for the Builders Challenge. A final test of the affiliate's new construction package, which includes R-38 attic, SEER 15 HSPF 8.5 heat pump and all of the features previously adopted, was carried out resulting in a HERS of 61 with WHSES of 46%. This was an all electric house; the affiliate has several houses under construction using instantaneous gas water heaters which will exceed these scores.

In May, a second test of the affiliate's new construction package, which includes R-38 attic, SEER 15 HSPF 8.5 heat pump, and all of the features previously adopted, was carried out, resulting in a HERS of 63 with WHSES of 46%. This was an all electric house; the affiliate has completed a house with gas employing an instantaneous gas water heater. This house had a HERS Index of 58, with a WHSES of 51%

One gas home was registered with both programs in June, with HERS of 57, BA WHSES of 44.3%, or 48.9% if screw-in CFLs are included. A second gas house was not eligible for the Builders Challenge, as construction of the home started long before Builders Challenge existed, had a HERS of 62, BA WHSES of 41.2,or counting screw-in CFLs BA WHSES of 46.6%. Final registration of three of the affiliates' homes for the Builders Challenge was received in July. As of September 2010, two more registrations were pending.

A case study on this affiliate was completed in 2010 and is available on the BAIHP website: http://www.baihp.org/habitat/pdf/NewSmyrna_Case-study.pdf

Florida, Seminole County Habitat for Humanity, Sanford, FL
BAIHP attended a meeting in August 2010 that this affiliate coordinated to assess the feasibility of building first Builders Challenge home in partnership with Seminole State College student American General Contractors (AGC) chapter. This home's goal is also to include LEED-H certification.

Florida, South Sarasota County (Venice, FL) 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.

In May 2010, Calcs-Plus completed final blower door testing and certification of two homes in South Sarasota HFH's multi-family town home project ENERGY STAR. A two-page case study of the RESNET partnership with this affiliate was completed and posted on the BAIHP website: http://www.baihp.org/habitat/pdf/Case%20study%20_South-SarasotaHFH.pdf.

Michigan, 2005 Jimmy Carter Work Project, Various Locations
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 6-5).

Figure 6-5: *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 to work directly with Washington State Habitat affiliates to qualify over 210 homes to Northwest Energy Star standards (including 45 in BP4 November 2008-October 2009). In 2009, WSU provided technical assistance and outreach to other Northwest Habitat affiliates, including:

Washington, South King County Habitat, Seattle: In 2009, WSU conducted three design charrettes and follow up for communities including Rainier Vista (Figure 6-6) 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 6-6: *Rainier Vista development, South King County Habitat for Humanity (Seattle) (left), Owens Corning Energy Complete demonstration (right)*

The affiliate was finishing Highpoint and Rainier Vista developments (four homes in each) in 2010. The homes showed significant attention to air leakage detail (homes tested out at about 3.0 ACH50 on average) but didn't qualify for Energy Star requirements for electrically heated homes (2.5 ACH50.) The first of two LEED qualified Habitat homes was completed in April but did not receive LEED certification (pending landscaping detail). Second home completed drywall.

Technical assistance was provided to affiliate on procurement of single wide HUD code homes in May. Final LEED-H inspections were conducted in June for two homes in Pacific, WA. Pacific 2 achieved blower door results of 2.37 ACH50. Construction techniques include air-tight drywall w/EDPM gaskets + Lessco air-tight electrical box housings. Mechanical system includes N.G. unit heater w/electrical resistance backup + N.G. on-demand DHW. A LEED-H initial points meeting was held for Meagan's Meadow (9 single family dwellings) with LEED Gold targeted. Strategies to include ductless heat pump technology.

As of August 2010, this WSU Habitat partner's Meagan Meadows project was on hold awaiting funding. WSU also met with King County Housing Authority and Habitat staff to discuss opportunities for research at Wonderland Estates Mobile Home Park. The park contains weatherized manufactured homes, with room for additional single wide homes. WSU is working with the housing authority to develop specifications for the single wide homes. A preliminary site visit was conducted at Wonderland with housing authority and Habitat staff.

Washington, Pierce County Habitat, Tacoma
Conducted phone charrette on Larabee Terrace, development (Figures 6-7) 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 6-7: *Building America Habitat Prototype built by Pierce County Habitat in the Larabee Terrace development, predicted HERS Index of 62.*

During BP5, WSU supported the construction of Habitat homes in WA State that are achieving tighter blower door test are the result of greater air-sealing efforts by crews and the employment of air-tight drywall technique. Several affiliates are moving from all-electric heating strategies to either natural gas unit heaters or ductless heat pumps, coupled with back-up resistance type heating in bedroom area.

Activities included certifying all homes to NW Energy Star using combination on demand DHW/in-floor radiant space heating. WSU also coordinated with this affiliate on a new project in May using ductless mini-split heat pumps, SIP roof and foam wall sheathing. Four additional homes were certified in May 2010.

Washington, Clallam County HFH, Port Angeles:
The affiliate is using a modified technical compliance option for Energy Star compliance, using an ERV, R-6.5 exterior foam, and heating with in-floor radiant off of the electric resistance hot water tank. One unit is currently under construction – affiliate will be using air tight drywall to hit target envelope leakage of 3.5 ACH50. The affiliate also paid special attention to air sealing around the code-mandated fire sprinkler system. In February, the affiliate used a modified technical compliance option for Energy Star compliance, using an ERV, R-7.5 exterior foam, and heating with in-floor radiant off of the electric resistance hot water tank. One unit is currently under construction – affiliate will be using air tight drywall to hit target envelope

leakage of 3.5 ACH50. The affiliate also paid special attention to air sealing around the code-mandated fire sprinkler system.

Also in 2010, a fire sprinkler system installed with w/mitigation for air leakage at retractable heads. A Northwest Energy Star inspection and blower door test was conducted and verified on May 17th. Blower door results: 3.08 ACH50.

Washington, Colville County HFH Partners
WSU met with HFH board in January about possibly including Energy Star specifications in a new development, Victory Park (8 units, two per year.) However, the board has not yet made a decision.

Washington, Island County HFH
In February, the affiliate received $180,000 in Housing Trust Fund money in Winter 2010 awards to be used for six units in Building Hope. Will require compliance with Evergreen Sustainable Development Standard Building program to include 2" of XPS insulated sheathing, furring strip w/ screening top and bottom for rain screen detail.

Washington, Mason County HFH (WA)
WSU consulted with this affiliate on an Evergreen Sustainable Development Standard protocol and hardboard requirements for behind tub/shower assemblies. This affiliate elected to pursue Built Green certification as administered by the MBA of Olympia. Space heating includes single head DHP in common area + zonal electric resistance in bedrooms.

The home was verified in June to meet NW Energy Star compliance and achieved blower door tests results of 2.30 ACH50. This is the best test results to date of WA State HFH houses. The affiliate hangs own GWB with an air-tight drywall technique that includes caulking the perimeter of each GWB piece installed.

Washington, South Puget Sound HFH (WA)
This affiliate received $60,000 in Housing Trust Fund money in Winter 2010 awards, for 3 units in Shepherd's Grove. Will require compliance with Evergreen Sustainable Development Standard.

Washington, Spokane HFH
WSU worked with the affiliate to implement Energy Star specifications in future projects. Currently, they are using atmospheric vented gas unit heaters.

Washington, East King County
WSU provided TA to and participated in design charrette with East King County HFH in February 2010. Assistance was in support of La Fortuna development buildings 5 and 7 (first to be built in development). Development will total 8 buildings and total of 41 units. WSU conducted duct blaster test at Snoqualmie Ridge Project. System tested below Energy Star Northwest standards (6% of conditioned floor area at CFM50. and duct blaster testing at Snoqualmie Ridge Project. System tested below Energy Star Northwest standards (6% of conditioned floor area at CFM50.) WSU also provided TA to and participated in a design

charrette and provided assistance in support of La Fortuna development buildings 5 and 7 (first to be built in development). Development will total 8 buildings and total of 41 units.

Also in 2010, the final home was completed in the Snoqualmie Ridge development. Duct blaster tests were conducted at Issaquah Highlands Project on four units in June. All units failed to meet NW Energy Star standard. Subcontractor was called back to perform additional sealing of duct system. Subcontractor reports successful compliance upon self-testing.

Washington, Ellensburg Area HFH/Kittitas County HFH
This affiliate was building their first house to Energy Star NW certification for completion in May '10. Wall composition: Hardie Board over ¼" XPS over ½" OSB over 2x6 cavity filled w/2" closed celled foam+3.5"fiberglass batt insulation. Space heating: 1.5 ton DHP w/ zonal electric in bedrooms. In June, the house was verified to meet NW Energy Star compliance and achieved blower door test results of 3.13 ACH50

Washington, Kitsap County HFH
This Habitat affiliate installed a solar hot water heater system on one home. A previous report indicated that the system was offered to the affiliate at a discount, indicating a payback of about 26 years. However, the affiliate later clarified that the system was, in fact, donated by the vendor.

Washington, Tri-County Partners HFH
In February the affiliate received $180,000 in Housing Trust Fund money in Winter 2010 awards for six units in Tierra Vida Phase 1C. Will require compliance with Evergreen Sustainable Development Standard.

April, this affiliate received Housing Trust Fund money in winter 2010 awards $180,000 for 6 units in Tierra Vida Phase 1C. Will require compliance with Evergreen Sustainable Development Standard. Certifying homes to NW Energy Star and Built Green. No activity was reported in May and June.

Washington, Yakima Valley Partners
In February and March, this affiliate was attempting to form buying group for bulk purchase of Ductless Heat Pump Systems from Portland, OR area Heat Pump Store. Looking to coordinate with Ellensburg, Seattle/South King Co., E. Jefferson Co. and Island Co. Area affiliates.

As of April, attempting to form buying group for bulk purchase of Ductless Heat Pump Systems from Portland, OR area Heat Pump Store, along with Ellensburg, Seattle/South King Co., E. Jefferson Co. and Island Co. Area affiliates. Receiving on-site consultation from Island Co HFH (May 16, 2010) construction manager regarding best practice for XPS insulated sheathing application. Blower door test was performed in May'10 on one home, testing to 6.33 ACH50.

Please see the full WSU Annual Report in Appendix C for further details regarding their 2010 technical assistance to Habitat affiliates.

WSU Technical Assistance to Habitat Affiliates in the Northwest prior to BP4

Figure 6-8: *Habitat for Humanity 15 home Community Cottage project – Olympia, WA*

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 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 6-8) 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

Figure 6-9: *Raising Walls at a Gulf Coast Habitat Build*

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 6-9) 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.

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

Figure 6-10: *Palm Harbor Homes built in Alabama for Oprah Winfrey-HFH partnership*

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 6-10) 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.

Gulf Coast Recovery: 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 6-11).

Figure 6-11: *HFHI's Construction Standards which were released November 2006*

Gulf Coast Recovery: 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 6-12). 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). For a detailed explanation of the project, visit www.baihp.org/gulfcoast.

Figure 6-12: *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)*

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.

In 2009, researchers were still collecting data that showed the costs this package of improvements could be delivered for. This task proved surprisingly difficult considering funding was linked to providing cost data. 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.

As of January 2010, all cost data from the various affiliates involved in this project had been gathered. In addition, Stage Gate cost analysis was underway, with average package prices, including added labor, working out to be approximately $2300. As different affiliates billed for different items, when actual cost data for a particular item is unavailable from the affiliate, the average reported cost (from all affiliates involved) is used in lieu of reported costs. The partner affiliates in Mobile (AL), Foley (AL), and Gulf Port (MS) expressed an interest in continuing BAIHP partnership, without the reimbursement incentive, in their new existing homes initiatives.

FSEC conducted a benchmark cost analysis and Stage Gate analysis in March of 2010. Benchmarking and economic analysis continued thru June. In November, a contract report *Gulf Coast High Performance Affordable Housing Demonstration Project* was completed, available online here: http://www.baihp.org/pubs/pdf/Gulf%20Coast%20Final%20Report.pdf

Nine prototype homes built by five Habitat for Humanity affiliates in Louisiana, Mississippi, and Alabama achieved 30% to 42% whole house source energy savings (based on 2008 BA benchmark) implementing a standard package of improvements with minor modifications when needed. The package of improvements, photographs, and workshop materials based on the prototypes are available on the project webpage here: http://www.baihp.org/gulfcoast/index.htm

Table 6-1 below shows a summary of the successful prototypes' energy use and costs. The range of BA Benchmark WHSES for the successful homes was 30.3% to 43.4% with the HERS Index value ranging from 60 to 73. Three of these houses Benchmarked at or above 40% WHSES, and the remaining houses Benchmarked at or above 30% WHSES. Researchers received expense data showing the incremental cost of $2,334 to $2,780 for 30% WHSES and $3,288 to $6,309 for 40% WHSES for all components of the package. Since none of the participants submitted pricing information for all components, researchers determined an average cost based on the various data points provided. These averages were reported as added estimated costs. Then they were combined with the reported cost data to calculate the total cost of the packages when partners had not provided the actual cost data for a measure. Annual cash flow to the homeowner was calculated by assuming $0.12 /kWh and a 30 year, 7% mortgage.

Table 6-1 *Gulf Coast High Performance Affordable Housing Demonstration Project* Principle Results

House	HERS Index	Total Annual Whole House Source Energy Use				Incremental Cost Information			
		Benchmark (Mbtu)	Prototype (Mbtu)	Savings (Mbtu)	Savings (%)	Reported Cost	Added Estimated Cost*	Total Cost	Annual Cash Flow
Mobile House 1	69	54.01	35.94	18.07	33.5%	$1462	$886.50	$2348.50	$179.63
Mobile House 2	60	46.94	26.57	20.37	43.4%	$3176	$1016.50	$4192.50	$186.93
MSGC House 1	69	57.26	36.37	20.89	36.5%	$1491	$843	$2334	$238.46
MSGC House 2	71	58.14	38.87	19.27	33.1%	N/A	N/A	N/A	N/A
Slidell House 1	71	55.80	37.61	18.19	32.6%	$2408.80	$0	$2408.80	$206.67
Slidell House 2	73	55.80	38.89	16.91	30.3%	$2408.80	$0	$2408.80	$161.84
Foley House 1	68	63.41	41.53	21.88	34.5%	$1670	$1109.50	$2779.50	$231.83
Foley House 2	60	55.11	31.90	23.21	42.1%	$5000	$1308.63	$6308.63	$55.82

Abita House 1	64	69.92	41.94	27.98	40.0%	$3096.34	$191.50	$3287.84	$339.67
* Some partners did not provide cost data for all of the improvement package elements. In these cases, researchers developed estimated costs for the missing items show here as "Added Estimated Cost."									

Gulf Coast Recovery: 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 6-13, 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 6-13 *Mobile County Habitat 30% Prototype (left)and 40% Prototype (right).*

Gulf Coast Recovery: 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.

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.

Figure 6-14 *New Orleans Area Habitat 30% Prototypes – both failed the TBIC.*

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 6-14). 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.

Gulf Coast Recovery: 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 6-15: *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 2008.

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 6-15) 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.

Gulf Coast Recovery: Slidell (LA) - East St. Tammany Parrish HFH Demonstration Project (Formerly 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 6-16) 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 6-16: *East St. Tammany HFH 30% Prototypes in Slidell, Louisiana.*

In addition to building two High Performance Prototypes, the affiliate w a participant in Habitat for Humanity International's "Partners in Sustainability" program funded by Home Depot Foundation. ESTHFH can receive a grant of $3K per house built to ENERGY STAR levels. In February 2010, ESTHFH used BAIHP contributor (also a RESNET "Habitat volunteer" rater) LaGrange Engineering as a field agent to perform envelope and duct testing. BAIHP was able to qualify nine homes for the affiliate as ENERGY STAR, with HERS indices of 74 and 75.

Gulf Coast Recovery: 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 6-17, 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 6-17, right) in May of 2009 with a HERS Index of 71and BA Benchmark of 33.2%.

Figure 6-17: *Mississippi Gulf Coast Habitat high performance affordable prototypes.*

Gulf Coast Recovery: 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 6-18: *West St. Tammany Habitat high performance affordable prototypes.*

In 2009, this affiliate completed two prototype homes (Figure 6-18), 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.

Gulf Coast Recovery: 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 6-19) 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%.

Figure 6-19: *Baldwin County Habitat high performance 30% affordable prototype.*

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%.

Gulf Coast Recovery: Other Gulf Coast Habitat Partnerships

Lafayette, LA HFH - A visit was made to discuss the high performance house package and Energy Star construction. As of 2009, the affiliate was applying for a grant for energy improvements to their housing; however, no further progress was reported in 2010.

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 6.2 Deep Retrofits on Existing Affordable Homes
(Formerly "Builders Challenge Level Existing Homes" in Subtask 4.3. BA Program/Analysis Support)

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)

In 2010, BAIHP continued to work with nine Florida local government and nonprofit partners who received funding under HUD's Neighborhood Stabilization Program. By November 18, 2010, 41 (of 99) post retrofit analyses were completed. Table 6-2 summarizes the status of homes with all ten partners. Following the table, activity with each partner is described.

Table 6-2 High Performance Retrofits in Foreclosed Homes Renovated under HUD Neighborhood Stabilization Funding to Local Government Entities

	Partner Status	Test-In Audit	Pre Retrofit Analysis	Test-Out Audit	Post Retrofit Analysis	Case Study	QA Docs
As of 11/18/2010	Ongoing	99	90	45	41	2	Ongoing

Note: Partnership activity with King County (WA), LifeStyle Homes (FL), Tangelo Park (FL), and Greg Hardwich (FL) are described below but not included in these totals.

The process begins with a "test-in" audit. Then collected data are used to produce a HERS Index for the house "as found." Based on the scope of improvement planned for the house, researchers produce a "projected" HERS Index for the renovated home. Next, researchers develop a package of recommended improvements for bringing the home to a HERS Index of 70, with the goal of achieving 30-50% whole house energy efficiency improvement. Once the retrofits are complete, researchers evaluate the actual efficiency improvement through inspections made during construction, a test-out audit, and final HERS Index rating.

Existing Homes Partnerships (Primarily Renovation of Foreclosed Homes under the HUD Neighborhood Stabilization Program)

Alachua County (FL): In March, Florida H.E.R.O facilitated and participated in meeting with BAIHP researchers and Sean McLendon, Alachua County Sustainability Manager to discuss the potential collaboration of deep retrofits of foreclosed properties. Alachua County has been awarded a $2.9 million grant through the Neighborhood Stabilization Program.

In June, Florida H.E.R.O. and BAIHP began partnership activity with Alachua County, recipient of a $2.9 million grant through the Neighborhood Stabilization Program (NSP1) to purchase and renovate foreclosed homes. The county retained the services of a third party consultant to conduct a walk-through to determine the individual home's viability for retrofit, as well as developing detailed scope of work. The current method of developing specifications for upgrades does not include any testing. Our involvement was requested after the third party had completed their work.

In June, test-in audits and preliminary analysis were performed on four more homes for this partner. We performed our preliminary walk-though audit and conducted performance testing inclusive of blower door and duct blaster on three of homes. On the fourth home, testing was not conducted due to holes in the roof/ceiling and presence of standing water throughout the home. We began analysis of the currently proposed work to develop other cost-effective strategies to improve the home's IAQ and efficiency using the BA Systems Engineering approach.

In July, we performed our preliminary walk-though audit and conducted performance testing inclusive of blower door and duct blaster on seven more homes. In August, Florida H.E.R.O. made ongoing attempts to communicate with project management. In September, Alachua County contracted BAIHP to discuss test-out arrangements for all homes in November and December.

By the conclusion of this contract, pre-retrofit analyses were completed for seven of the homes tested for this partner upon receipt of the scope of work for each. Nearly all of these homes are expected to be deep retrofits, with projected HERS Index reductions of 29%, 33%, 34%, 37%, 46%, and 69%.

Brevard County (FL): January, BAIHP performed a test-out audit on one home and reported findings to our partner. The test-in HERS Index (determined in 2009) was 116. The projected HERS Index after renovations was 83. The actual HERS Index after renovation was 87. Specifications were not met for heat pump HSPF, water heating efficiency (different fuel), and duct leakage (worse after renovation). Whole house infiltration was unexpectedly reduced about 10%. In February, researchers provided input for NSP specifications given to contractors performing the NSP retrofit work. In March, researchers conducted an information session on reaching a HERS Index of 70. Attendees included five of the eight subcontractors who have been selected by this partner for NSP retrofit work and county staff. Highlights of the training include:

1. In-depth discussion about mechanical systems and ventilation as it relates to health and safety
2. Presentation and discussion about what we are finding in the field with some of our other partners and what these subcontractors might expect to find in their retrofit work
3. Presentation using MADDAIR model for a visual on duct leakage, pressures, and combustion safety

Partner was in the process of acquisition in the second quarter of the year. BAIHP met with Brevard County housing officials to discuss their NSP housing project and our support efforts in this process. Brevard County is very receptive to our support role and is now in the process of procuring homes. They have asked us to accompany them and their contractors on their inspections (once the home has been procured) and assist them in determining the best options for energy improvements.

We accompanied Brevard County officials and their contractors to four homes in July, 16 homes in August, and six additional homes in September for a total of 26 homes. Researchers conducted initial test-in audits throughout the quarter to determine baseline HERS and changes based upon planned retrofits. Additional deep retrofit recommendations were also made for improving energy efficiencies to achieve energy improvements to the 30% to 50% level.

In the third quarter, researchers continued working with Brevard County to refine energy efficient targets for NSP purchased homes. Held further discussions of deep retrofits for selected homes and developed a suitable spreadsheet that defines energy components.

Researchers produced final analysis for three homes for this partner in October. The HERS Index dropped by 30%, 35%, and 38%, all testing-out in the low 80s. Qn 25, out of ranged from 0.048 to 0.073 and ACH(50) ranged from 7.08 to 10.55.

Researchers were able to identify areas that would improve the duct leakage, specifically in the return plenum, in all homes. Two of the homes were surprisingly leaky. Infiltration issues were found behind kitchen cabinets in two of these homes, a poorly closing garage door at one, and a poorly fit interior attic hatch. Our partner was very interested in identifying potential infiltration issues as the renovation is in progress for their remaining homes.

One home had significant combustion safety concerns. While the scope of work stated that the HVAC system was to be replaced with a minimum16 SEER heat pump, the contractor deviated from the scope to a furnace fueled by natural gas. The air handler closet appears to have inadequate combustion air. The refrigerant line is devoid of any insulation and is directly under the intake air vent coming from the attic presenting the possibility of condensation and mold growth.

Researchers produced final analysis for two homes for this partner in November. The HERS Index for these homes dropped by 26% and 41%, testing-out with a 77 and a 70. Qn 25, out was 0.09 and 0.06 and ACH(50) was 4.5 and 5.4, respectively.

Although the second of these homes scored a HERS Index of 70, researchers found surprisingly high pressure differences between the bedrooms and main body of the house under normal operating conditions with all doors closed as shown in Table 6-2.

The house was visited a second time to verify the pressure mapping and the results were repeated. Additional pressure mapping was undertaken. Turning on the bathroom exhaust fans made very little change to the pressure differences. The whole house pressure with respect to the outside was negative when the air handler was "on" with interior doors open (see Table 6-2) suggesting that the duct leakage is predominately on the supply side. Pressure measurements in the air handler closet showed that it was not significantly affected by door closure and operation of the air handler did not significantly change the pressure in the AHU closet. Although the duct leakage (Qn 25, out = 0.09) was above specification, it was not excessive. In light of this and the pressure mapping results, duct leakage was ruled out as the driver causing these high pressure differentials.

Several other issues with the mechanical system retrofit were identified.

1. The mechanical system appears to be significantly oversized. A 3 ton unit was installed in this 1100sf home resulting in very high fan flow for the space being served. EnergyGauge USA suggested a 1.5 ton unit. The original unit was a 2 ton. Although the partner included system sizing in the mechanical scope of work, it does not appear that this influenced the final installation.
2. The supply plenum was leaking at the junction with the air handler. This is commonly found in air handler replacement where access to the "back" of the air handler is limited by closet dimensions.
3. Originally the air handler was situated in the garage. The partner made an attempt to enclose it in a closet that would be part of the conditioned space but accessed from a door in the garage. This detail has been successfully adopted by three BAIHP new construction partners. The attempt in this retrofit was a good effort; however, the door into the closet (accessible from the garage) was an interior door without weather-

stripping or a gasketed jamb. It did not effectively separate the closet from the garage. Regardless of this, the walls of the closet were insulated and, other than the supply leak mentioned above, the closet does not appear to significantly be coupled air handler or the return plenum. This was determined by measuring pressure in the closet with the air handler operating.

Researchers advised the partner of possible impacts of these high pressures and the over sizing including comfort and moisture control issues. Several options were presented to correct the problem including system change out, addition of a ducted return in the master bedroom, adjustment of duct size serving the master bedroom (located immediately off the main trunk at the supply plenum), and addition of passive return air pathways from the bedrooms in the form of jump ducts. Passive return air inlet size was estimated for each bedroom.

Table 6-2 Pressure differences measured under normal operating conditions with interior doors closed.

Space	With Respect to	Pressure Difference	Notes
Whole house	Outside	+1.8	Air handler on, exhaust fans off, all interior doors open
Air Handler Closet	Main body	0 pascals	Same as above
Main body	Outside	-14 pascals	Air handler on, exhaust fans off, all interior doors closed
Master Bedroom (w/master bath)	Main body	+57 pascals	Same as above
Bedroom 2	Main body	+44 pascals	Same as above
Bedroom 3	Main body	+38 pascals	Same as above
Air Handler Closet	Outside	-1 pascals	Same as above
Air Handler Closet	Main body	+9 pascals	Same as above

City of Palm Bay, Brevard County (FL): Researchers met with the City officials in charge of NSP1 funding (separate from Brevard County funding) in October and December of 2009. In March, the city provided a commitment letter to partner with BAIHP working towards the HERS Index 70 goal. At the end of March, this partner has not begun acquiring homes yet.

In April, this partner acquired approximately 20 homes and was in the process of selecting the homes which they would like us to analyze. In May researchers performed pre retrofit energy audits on the first three homes for this partner. Test-in simulations were created. One 936 sq ft home built in 1952 which had major infiltration issues (ACH50 = 33.6) had a test-in HERS Index of 158. The other two, slightly larger homes built in the early1970's tested-in at 128 and 116. The partner's scope of work was requested. At the end of June, this partner has purchased over 40 properties with their NSP funding. Focusing on obligating funds for their properties before their deadline, they have not yet produced scopes of work for any of the properties.

In July researcher performed preliminary pre-retrofit energy audit on a planned model home for the City of Palm Bay. This home will be owned and controlled by both the City of Palm Bay and

the Brevard Community College. It will be retrofit with options from multiple contractors and will also feature both low cost and high energy efficient upgrades for display to the public.

Research staff met with city and college representatives and contractors to discuss energy efficient options and provided a demo on the test-in procedures and produced a test-in HERS and annual energy cost. We provided data on energy efficient options and their related HERS annual energy cost improvements. This was reviewed by all parties and was expected to provide the baseline for actual energy efficient retrofits for this home.

In August, we provided this partner with an analysis of the as-found characteristics of the homes with a "typical" deep retrofit package. We suggested packages to yield a HERS Index for each home near or below a 70. As of the conclusion of the BAIHP contract renovation work was incomplete on all homes tested for this partner.

Greater Birmingham Habitat for Humanity (AL): (FSEC researchers with subcontracted HERS Rater Tabetha Reyes of Energy Potentials in Alabama) In April, researchers began work with this new partner with the help of subcontractor, Energy Potentials, in Alabama. Energy Potentials conducted test-in audits. Using that data, BAIHP researchers began analysis for four homes. Analysis for one of these homes was completed and delivered to the partner. The partners proposed package has this home improving from a test-in HERS index of 114 to an 83. We have suggested that with lighter shingles, window tinting, installing crawl space insulation, improving infiltration and duck leakage, and upgrading to a SEER 16 instead of a SEER 14, the home could be improved to a HERS index of 72.

Four more homes were analyzed for this partner in May. All homes had poor infiltration (ACH50 = 22.3, 30.9, 33.7) and large amounts of duct leakage (Qn 25, out = 0.27 and 0.36) and some homes we were unable to test. Test-in HERS indices for these homes were 135, 148, 151, and 153. In June, test-out audits were performed on four of five of these properties.

In July, final analysis was performed on four homes for this partner. Test-in HERS Indices were 115, 143, 144, and 149. Test-out HERS Indices were 92, 92, 82, and 86, respectively, and annual energy cost savings ranged from 25 to 40%.

In August, final post retrofit analysis was completed for the fifth of five homes and analyses for all were submitted to partner. The final home had a HERS Index improvement of 47%, going from a 150 to a 79. Duct repair and infiltration improvement were great contributors to this change. ACH50 dropped from 25 down to 8 and Qn 25, out was not testable before the renovation due to large leaks. Post-retrofit Qn 25, out was 0.06.

King County Habitat for Humanity (Seattle, WA): WSU provided technical assistance at Newport apartments on deep energy retrofits, including infrared testing and HVAC commissioning. Retrofits include dense pack cellulose with foam wall sheathing. Met with King County Habitat to discuss design of roof retrofit, including with hybrid flash and batt system.

In August, WSU met with King County Housing Authority staff at Newport Apartments to investigate the possibilities for deep energy retrofits at this 100 unit (1960s vintage) apartment

complex. Optimization analysis identified over $30,000 in potential savings. Project will have blown in wall insulation plus R4 foam ROXUL sheathing, high performance windows, condensing hot water tank and furnace, and continuous whole house (exhaust only) ventilation. This is the first of many retrofit projects proposed with the Housing Authority for 2011.

King County Housing Authority (Seattle, WA)- WSU met with King County Housing Authority staff at Newport Apartments to investigate the possibilities for deep energy retrofits at this 100 unit (1960s vintage) apartment complex. This is the first of many potential retrofit projects with the Housing Authority for 2011.

The following measures proposed have been implemented:

- blown in wall insulation plus R4 foam ROXUL sheathing
- high performance triple pane windows
- combination condensing hot water tank and furnace,
- continuous whole house (exhaust only) ventilation.

WSU also provided on-site technical assistance, including infrared testing and HVAC commissioning, with BA partner Fluke. This work will continue in 2011 with BA FSEC/WSU support.

Lake Sumter County Habitat for Humanity (FL) (LSCHFH) – Non-NSP funds: In February, BAIHP audited two foreclosure acquired homes for this new partner and developed the initial analysis files. HERS indices were 132 and 111; ACH(50) was 13.0 and 10.0; Qn 25, out was 0.20 and 0.06. The houses have atmospherically vented combustion heaters and water heaters, interior in one home and in small, unvented outside closets in the other. LSCHFH is considering various options for rehabbing these homes. BAIHP has developed recommendations for combustion safety, as well as ENERGY STAR and Builders Challenge levels of energy savings on these rehabs. The partner has decided not to pursue a HERS Index of 70 effort.

Throughout the second quarter, this partner has reviewed our analyses of test-in, partner estimated, and suggestions for a deep retrofit for the two homes audited in April. A change in construction staff has slowed progress with retrofits and partnership activity. Retrofit work was not complete by the conclusion of the BAIHP contract.

Lifestyle Homes (FL): This partner participates with BAIHP in both the Prototype and Communities task as described in Task 3 and Task 4 above. In February, BAIHP agreed to provide technical assistance to LifeStyle Homes as they considered conducting retrofits for a few of their past buyers desiring energy efficiency retrofits. Researchers audited and an existing five-year-old Lifestyle home and produced analysis including economic calculations to determine cost effective retrofit solutions

Mobile County Habitat for Humanity (AL) (MCHFH): In February, BAIHP audited four NSP acquired home for this new partner. All four homes have gas heat and hot water, all homes have interior gas furnaces, and three of them have interior gas hot water heaters. One home has sealed combustion gas appliances, the rest are atmospherically vented.

The homes consist of two that were not testable, a 1323 ft^2 3 bed /1.5 bath (3/1.5) where repairs and replacement was underway, and a 2164 ft2 4/2 that was damaged by Hurricane Katrina. This second house had modern sealed combustion appliances.

Test results of the remaining two houses, a 1464 ft2 3/2 with and ACH 50 of 15 and a Qn 25, out of 0.19, and a 1377 ft2 3/2 with a Qn 25, out of 0.28 and an ACH50 of 22.5 show the need for attention to combustion safety. Recommendations will address combustion safety and energy efficiency, with packages developed to achieve ENERGY STAR and Builders Challenge levels of energy savings. In March, BAIHP initiated discussion to refine energy upgrades, appliance issues and estimated start dates on retrofit work.

In April, this partner reviewed our analyses of test-in, estimated improvement from the original scope of work, and BAIHP suggestions for a deep retrofit for the four homes audited. They were in the process of retrofitting all four homes we evaluated for them. In May, we continued working with partner to evaluate energy efficiency suggestions as a result of the testing done on four retrofit homes. Each home was expected to incorporate suggested retrofits for energy efficiencies. During the summer, the NSP program management instructed the partner to replace the high efficiency gas furnaces already in the homes with electric heat pumps, and to make other choices that were not part of the agreed upon improvement package. No further activity was pursued.

Orange County (FL): In January, BAIHP provided partial analysis for a home audited in December and conducted a test-in audit on a second home.

In May, researchers conducted a test-out on one of Orange County's retrofit homes that was initially tested in January. This 2400 sq ft home, built in 2004, re-tested with a HERS Index of 89 which was 16% more efficient than original test-in. This HERS index dropped from a 98, showing a 9% improvement. Deep retrofits were not achieved on this home due to the budget constraints and the fact that the home was newer and did not require additional work. Installation of a 14 SEER heat pump air conditioner to replace the 12 SEER heat pump was the greatest source of energy improvement but not likely the biggest energy savings work they could have performed for the same expense.

In June, discussion with management revealed that the majority of homes were of recent vintage, five to ten years old. As such, few improvements are needed to bring the properties up to market stand.

In July, researchers provided a test-out to one of the retrofit homes that was completed during the month. Test-out yielded a HERS Index of 83 which was a 22% improvement of the HERS index and a 17% improvement on energy savings. Researchers held further discussions on how to increase energy efficiencies on upcoming retrofits and provided additional analysis to this partner on retrofit energy enhancements. Ultimately, complications with this partner prevented additional research.

Sarasota County, City of Sarasota, and the Florida House Foundation (FL): In January, February, and March, BAIHP continued work begun in 2009 with this partner and other

organizations involved in their NSP work including the Florida House Foundation, the Community Housing Trust, and Newtown Housing Trust. Researchers produced conducted test-in, analysis, and test-out activities in various homes.

The scope of work for house retrofits produced by this partner continues to improve in energy efficiency. In April, Sarasota County and the City of Sarasota, with help from BAIHP researchers, energy raters, and contractors, drafted new energy conservation standards for their NSP2 retrofit work. Highlights included minimums of a SEER 16 for the HVAC and R-38 ceiling insulation where space permits, and a duct test on all homes with a goal of normalized leakage to the outside (Qn 25, out) at a standard test pressure of 25 pascals (with respect to outside) of 6 cfm per 100 square feet of conditioned space or less.

A deep energy retrofit – Central Florida prototype case study was completed and is posted on the BAIHP website: http://www.baihp.org/casestud/pdf/Deep-Energy-Retrofit_Casestudy.pdf

Ownership and management of Sarasota County NSP homes are handled by one or more of the non-profit organizations listed below.

Community Housing Trust (Sarasota) - In February, non-profit partner, Community Housing Trust, began work on a home with proposed HERS Index of 70 – the first that BAIHP has been involved with. They worked with the Florida House to produce a documentary on the process and host a community open house showcasing the energy efficiency and green elements of the home. BAIHP researchers met on site with the general and mechanical contractors to review the elements of the Builders Challenge package, performed duct leakage and house infiltration tests, explained what the tests were measuring and discussed our findings for a segment of the documentary.

In March, researchers performed our fist test-out in Sarasota in a home retrofitted by the Community Housing Trust. The test-in HERS index for this 1967 built home was 167. The partner's proposed package suggested this home would come down to a HERS 76. The partner did actually get to this HERS level, but with tradeoffs. Primarily, better windows were used, while the HVAC was replaced with only a 15 SEER instead of the 16 SEER that was proposed. Presumably the small interior AHU closet was a limiting factor in what unit could be installed. Noteworthy about this retrofit is that the ducts, which had tested in at Qn 25, out = 0.05, had been compromised and tested out at Qn 25, out = 0.10. Similarly -- and possibly related -- although infiltration was markedly improved, it was poorer than expected given the extensive measures taken to the envelope. The general contractor repaired the duct work and requested a second test-out. Final results were Qn 25,out = 0.02.

BAIHP did additional analysis for the home they have chosen to be their first Builder's Challenge level retrofit (Hartsdale), incorporating the county scope of work and cost data. The Florida House foundation is planning a community open house at this location for May 1. FSEC assisted with developing the technical language for the handouts and signage.

In April, the goal of a retrofit to a HERS Index of 70 – the first that BAIHP has been involved with – was met. And the goal was exceeded, with a test-out HERS index of 66. With a test-in

HERS Index of 101, this represents an improvement of 35%. Highlights of the energy savings features for this home included: reduced duct leakage, drywall repair, R-38 attic insulation, light colored singles, serviced mechanical system with programmable thermostat, Energy Star® appliances, heat pump water heater, and 100% CFLs. It also has ducted kitchen and bathroom fans and a ducted, dampered, passive outside air ventilation system.

The community open house showcasing the energy efficiency and green elements of the home was May 15th, in partnership with Florida House, Sarasota Office of Housing and Community Development, Sarasota County Government and others. Researchers worked closely with this partner in developing the technical language & graphics for the handouts and signage. The event was well covered by local media.

Researchers performed test-in audits of three more homes and a second test-out on a home that required duct repair based on the first test-out findings. This home had test-in Qn 25, out = 0.05. Initial test-out results were Qn 25, out = 0.95. The contract was able to address the issue quickly and the final results were an improvement over the original test, with a Qn 25, out = 0.04.

Researchers also performed one test-out audit for this partner in May. The test-in results were: HERS Index = 109, Qn 25, out = 0.04, and ACH(50) = 4.6. Test-out results produce a HERS Index of 79, an improvement of 22%, with Qn 25, out = 0.02 and ACH(50) = 3.8.

In June, researchers performed test-in audits on two more homes for this partner. Test-out audits were conducted for three homes. The simulated annual energy cost savings for these three homes were: 12%, 19%, and 36%. Test-out HERS Indices were: 70, 79 & 97. Pressure mapping on two of these homes showed they were negative house-to-out, with high positive pressure coming from some or all of the bedrooms. Though neither of these homes had combustion appliances, moisture intrusion into the home is a concern. We discussed findings with our partner who agreed to provide air flow via through-the-wall passive returns of the rooms with very high pressures and trim the bottoms of the bedroom doors where pressures were only slightly elevated.

In July, researchers continued efforts to attain cost information for three of the six homes completed with this partner. No new activity had begun, and there were no test-out audits in July. In August, researchers continued to work with this partner to gather cost data for completed retrofits.

Researchers performed three test-out and three test-in audits for this partner in September. Test-in and Test-out HERS Index (followed by percent improvement) were 111 to 95 (14%), 164 to 88 (46%), and 107 to 68 (36%). A second test-out is scheduled for the last of these. The ducts in this home tested more poorly than at test-in, despite the installation of a new mechanical system. (Qn 25, out 0.12 to 0.13). And the infiltration hardly improved (ACH50 11.4 to 9.6) considering the entire envelope was outfitted with new windows. The primary issue impacting both of these tests was a large amount of air infiltrating from the attic directly into the interior air handler closet. Contractors were called back to remove the air handler and reseal the closet.

Test-in audits for the three acquisitions produced HERS Indices of 106, 133, and 193. Qn 25, out for the first two was 0.17 and 0.07 and ACH50 was 7.1 and 24.7, respectively. Mold

prevented testing of the last of these and the HERS Index was generated using program defaults for worst case infiltration and duct leakage which the energy auditor believes is justified basted on appearance of the envelope and the mechanical equipment.

Researchers produced final analysis for two homes for this partner in November. The HERS Index dropped by 28% and 38%, testing-out with a 76 and a 66. Qn 25, out was 0.10 and 0.05 and ACH(50) was 5.3 and 7.0, respectively.

This was the second test-out audit on the second of these homes. The first test-out found high levels of infiltration and duct leakage. The home has an internal, ductless return. At the initial test-out there was poor connection between the top of the new air handler closet and the attic which allowed attic air to flow, uncontrolled into the air handler closet. This affected infiltration too as closet was not well separated from the main body of the home because of a full-length levered door. The large hole was not easily accessible and fixing the problem required temporarily removing the air handler unit. The general contractor had the hole sealed from both the attic and the air hander closet. This measure improved the HERS Index by three points. A summary of the results are as follows.

	HERS	Qn 25, out	ACH(50)
Test-In	107	0.12	11.63
Test-Out #1	69	0.13	9.06
Test-Out #2	66	0.05	7.02

Newtown Housing Trust (Sarasota) - BAIHP worked with another of Sarasota County's non-profit partners, Newtown Housing Trust, to audit an NSP1 acquired home and subsequently developed the rating file. This home had a test-in HERS index of 106. This 1983 built home had extremely tight ducts, Qn 25, out = 0.02. The managing non-profit organization for this home has not been receptive to recommendations from previous audits.

In April, this partner was expressing interest in BAIHP findings and continued to involve us in testing their homes throughout April. We also performed our first test-out audit for this partner. The home tested in with a HERS index of 116. The partner brought this to a HERS 86, but did not employ many of our recommendations. One test-in audit was performed and this was the first town home to become part of the study. In May, we analyzed our first test-in for a town home retrofit, and audited and analyzed a second for this partner. The results for one were HERS Index = 96, Qn 25, out = 0.02, and ACH(50) = 13.2. The results for second was HERS Index = 92, Qn 25, out = 0.06, and ACH(50) = 3.6. Both townhomes are under construction.

We performed one test-out audit on a home for this partner in July. Test-in results were: HERS Index = 120, Qn 25, out = 0.02, and ACH50 = 10.0. Test-out results were HERS Index = 96, Qn 25, out = 0.02, and ACH50 = 8.1. Annual energy cost savings was 15%.

In August, we performed one test-in and two test-out audits for this partner. Test-in HERS Index was 161. A large amount of mold growing all around and in the air handler closet prevented any testing in this home. The partner's scope of work is comprehensive and reflects the new standards this partner has developed for their NSP2 renovations. If the scope is followed, a HERS Index in the low 70's is expected after the retrofit is completed.

The test-out audits were preformed on our first two townhomes to be part of the study. These are newer homes, built in 2004. These townhomes provided little room for improvement because a) the test-in audit showed the homes in fairly good shape and b) many of the home's components were in good shape and not in need of replacement. These homes showed a 7 and 11% improvement in HERS Index. (Test-in of 92 and 96; Test-out of 86 and 85, respectively.) Ducts were an issue for the first of these homes and they were improved from Qn 25, out 0.06 to 0.03. There was notable infiltration improvement on the second of these homes, where ACH50 was reduced from 13.2 to 4.0.

Researchers continued to work with this partner in September to gather cost data for completed retrofits.

Goodwill Manasota (Sarasota NSP Partner)– BAHIP worked with a new partner in Sarasota County to discuss retrofit analysis and energy improvements on NSP homes throughout the quarter. Researchers conducted two test-in energy audits for this partner in July. The first house was a tear down and test-in estimates are HERS 63. The second home is a retrofit of a 1982 house with test-in HERS 108. Proposed partner retrofit improvements result in a HERS Index of 64, a 38% savings in energy cost.

Researchers conducted three energy audits for this partner in August. These homes had already gone through their retrofits and the partner asked us to conduct the energy audit and report the results and recommend additional retrofits. First homes tested out at HERS 88 and additional retrofits were found to reduce this to 80; second home tested out at HERS 79 with no additional retrofits; and the third home tested out at HERS 100 with additional retrofits to reduce this to HERS 99. All additional retrofits were being incorporated into these homes for finalization in September.

In September, researchers conducted three energy audits on three completed homes for this partner. First home was a rebuild for NSP 2 and tested out at HERS 60; the second home was a retrofit and tested out at HERS 66; the third home was a home that had already undergone retrofit and had a HERS of 113, and additional retrofits were found to reduce this to 98. All additional retrofits from last month have been incorporated into the homes and were completed in September.

Habitat for Humanity Sarasota – BAIHP met with staff at this affiliate in July 2009 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. Subsequently, 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 was still under consideration in 2010.

We performed our first test-out audit for this partner in April 2010. This was a major renovation as the living area was reduced to exclude an enclosed porch. The home tested in with a HERS index of 150. The partner brought this to a HERS 82. Researchers performed two test-in audits for this partner in May and two test-outs in June. Activity was suspended due to shifting priorities in the partner organization.

Other Sarasota Retrofit Initiatives: Four Building America staff visited an interesting steel SIPS system retrofit in progress. BAIHP will continue dialog with this partner in the interest of possible Builders Challenge level retrofit. This builder has developed the SIPS system specifically for retrofit applications and is working with a local RESNET certified rater who projects the improved HERS Index for this 1960's vintage home will be below 60, however, BC quality criteria are still under consideration.

Tangelo Park Energy Retrofit Project (FL): In April and May, researchers continued to assist Craig Savage (Building Media) in coordinating a show case deep retrofit project in a +600 home community near a conference site called Tangelo Park. This community would greatly benefit from energy retrofits and would provide a great demonstration "corridor" to the estimated +60,000 building related attendees. BAIHP staff met with Progress Energy (also in April) to request their partnership in optimizing their Home Improvement program incentives. Tangelo Park community was toured in June, and pre and post retrofits currently conducted by developer, Elliot Perry were inspected.

Volusia County (FL): In January, BAIHP received a commitment letter to retrofit 10 homes to the HERS Index 70 level. In February, BAIHP audited three NSP1 acquired homes, developed rating files and presented our partner with analysis and recommendations. Test-in HERS indices were 130, 142, and 184, with the latter having an ACH (50) of 16.0 and a Qn 25, out of 0.36. The partner's current packages bring these indices to 121, 116, and 137. Retrofitting each of these homes to cost-effectively approach HERS 70 appears possible. Further discussion with this partner about our recommendations is planned. This partner has been eager to get our analyses and appears ready to make improvements to their current retrofit scope. In March, researchers held a conference call with this partner to discuss details of our retrofit analyses. We explained mechanical system ventilation health and safety issues and solutions. Following the discussion we revised our analyses to reflect an improved scope of work on their retrofits. Efficiency improvements to their standard scope include: brining ceiling insulation levels to an R-30, installing SEER 15 HVACs with programmable thermostats, replacing windows (when necessary) with double-pane, Low-e, metal frame. (Partner contends vinyl frame windows are too expensive.)

In April, this partner was in the bid selection process for three of the homes we tested. One home was under construction. They acquired one more home they wanted us to audit. Researchers audited and analyzed the fifth home for this partner in May. The test-in HERS index was 114, with a Qn 25, out = .09 and an ACH50 = 10.3. The first four homes audited for this partner are still under construction and expected completion date has been pushed back to August.

Researchers conducted two test-in analyses for this partner in July. Test-in HERS Indices were 163 and 137. Ducts for both were poor, and each had above average infiltration levels. Analyses are still being conducted.

Researchers conducted eight test-in audits, two pre-retrofit analyses, three test-out audits, and two test-out analyses for this partner in August. The two pre-retrofit findings were as follows: HERS Index = 163 and 137; Qn 25, out = 0.19 and 0.26; ACH50 = 7.9 and 9.0, respectively.

In the two homes that were analyzed post-retrofit, HERS Indices improved by 34% and 39%. In the first of these homes, which tested in with a HERS Index of 184, ducts were very poor. Qn 25, out was reduced from 0.36 to 0.21. ACH50 for this home went from 16.0 to 11.1. The second home had a test-in HERS Index of 142. The Qn 25, out was reduced from 0.09 to 0.05 and ACH50 was cut in half, going from 10.1 to 5.5. Both homes had a negative pressure with all the bedroom doors shut and the air handler running. This was significant in the second of these homes.

It is noteworthy that the partner was not aware that a 13 SEER HVAC system was installed in the second of these homes until we reported our findings. Their request for bid specified a minimum 15 SEER. A revision to this analysis may be forthcoming. This has caused our partner to revise their process for assuring contractor work is being done as specified.

Researchers conducted one test-in audit, presented pre-retrofit analysis for eight homes, and one test-out audit for this partner in September. The newly tested-in home yielded a HERS index of 118, a Qn 25, out of .05, and an ACH50 of 4.5. The scope of work suggests this home should see about a 30% improvement in the HERS Index upon completion. For the eight analyses preformed on homes audited in August, five are expected to reach about a 30% or greater improvement in the HERS Index.

The post-retrofit findings for the one completed home was test-in and test-out HERS Index (followed by percent improvement) were 130 to 86 (34%). Qn 25, out went from .08 to .06, and ACH50 was unchanged at 7.5. This home required two test-out audits due to issues with a probable disconnected supply register. Additional findings at the initial test-out were that:

1. The new interior air handler had been installed such that the filter was not removable without damaging trim.
2. Return duct to the main body and to the master bedroom were disconnected. (The master bedroom registered a 6.4 pa positive pressure with regard to the main body, contributing to a slight negative pressure in the main body with reference to outside.)

Researchers performed test-in audits and pre-retrofit analyses for three homes. Test in HERS Indices were 100, 126, and 169 (which had high infiltration issues ACH50 = 13.9). The proposed renovation suggests these to drop to 78, 73, and 82 respectively. We have made recommendations to the partner that would yield HERS Indices of 70, 64, and 74 respectively.

Three homes were renovated and re-tested. One has been analyzed to date. The HERS Index dropped 30%, from 114 to 80. Qn 25, out of .09 was reduced to .06 and ACH(50) of 10.3 dropped to 5.8.

In November, researchers completed analyses for two homes tested-out the prior month. The HERS Index dropped by 25% and 47%, testing-out with 87 and 75. Qn 25, out was 0.18 and 0.05 and ACH(50) was 9.2 and 5.2, respectively. Interestingly, the first home tested poorer in infiltration and in duct leakage upon test-out. Qn 25, out rose from 0.15 to 0.18 and ACH(50) increased from 5.1 to 9.0. There were several wall cavity return ducts. Infiltration could be felt under each sink, holes in the drywall by the second bathroom vanity, above the kitchen range, and from the return air duct (wall cavity) in one of the bedrooms. The utility room supply air vent had been painted shut, though apparently prior to this retrofit.

Retrofit Service Provider, DwellGreen (FL): In May, we conducted an audit on a retrofit completed by a local contractor with assistance from DwellGreen, a Sarasota based audit and retrofit service provider. Researchers used audit data to construct a simulation file and then modeled the pre-retrofit home to compare our predicted savings with DwellGreen's predicted savings. HERS Index pre-retrofit was 131 and post retrofit of 62, a 53% improvement. DwellGreen uses a fast and simple prediction method based on information gathered from DOE and other energy efficiency resources.

In July, researchers conducted another audit on a retrofit completed by a local contractor with assistance from DwellGreen, a Sarasota based audit and retrofit service provider. Researchers used audit data to construct a simulation file and then modeled the pre-retrofit home to compare our predicted savings with DwellGreen's predicted savings. HERS Index pre-retrofit was 120 and post-retrofit of 7, a 94% improvement. This home underwent extensive retrofit and included a 7kW PV system, spray foam sealed attic, Low-E double pane windows and a SEER 15 multi-speed HVAC. DwellGreen uses a fast and simple prediction method based on information gathered from DOE and other energy efficiency resources.

In August, BAIHP staff conducted another audit on a retrofit completed by a local contractor with assistance from DwellGreen. Researchers used audit data to construct a simulation file and then modeled the pre-retrofit home to compare our predicted savings with DwellGreen's predicted savings in July and August. Analysis was still on-going on this home during these months, and the results were planned to be completed in September; however, no further activity was reported.

Market Rate Re-modeling Contractors:

Greg Hardwick Inc. Deep Retrofits (FL): In May, BAIPH researchers introduced Greg Hardwick, Orlando as another potential deep retrofit, zero energy builder prospect for a showcase home at the 2011 International Builders' Show. Researchers were approached by Greg Hardwick to assist in providing technical and testing support on several deep retrofit projects that Greg Hardwick is currently contracted for. These homes had tours conducted highlighting energy efficient and green strategies during the construction at the SEBC 2010. July activity consisted of welcoming Greg Hardwick into the BAIHP program and conducting site visits to both homes

during “de-construction” prior to retrofits for documentation. Greg Hardwick was accepted as new partner. Ongoing consultations with builder representatives and builder’s home energy rater on two homes – McNair and Guinsler residences.

> McNair -Remodel of existing home in Longwood, complete retrofit – minor addition. 2,690sf; Address: 908 Stone Creek Court, Longwood, Florida 32779; E/W exposure, front door facing West-SW; 2-story with existing pool; Complete retrofit of existing 1983 home. Similar to other homes in the neighborhood, this home was tested pre-retrofit and the HERS = 108. Expected post-retrofit HERS = less than 71. The challenge of this home is that the owners had a SEER 17, 4-ton system installed last year as a pre-energy efficient retrofit. With the enhancements, the system is now oversized by 2 tons. The construction is completed and the testing of the home resulted in HERS =62. In August, performed pre-remodel testing, Mid Point Smoke Testing, & Thermal by pass inspection. Guinsler Residence – Performed Mid Point Smoke Testing & Thermal by Pass Inspection. Calcs-Plus re-calculated HVAC load calculations.
>
> Guinsler – Remodel of existing home in Winter Springs, complete retrofit - with addition. Changing from 1,250sf to 2,570sf; Address: 645 Sailfish Road, Winter Springs, Florida 32708; N/S exposure, rear to the south. 1-story with new pool; Complete retrofit of 1978 home; One of a kind, custom; expected HERS = less than 70.

Subtask 6.4 Eco-Rated Northwest Energy Efficient Manufactured (NEEM) Homes
(Formerly Subtask 4.2. Northwest Energy Efficient Manufactured Homes)

This task 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. By January 2010 Northwest Energy Works (NEW) had taken over from the Oregon Department of Energy to administer the Northwest Energy Efficient Manufactured Home Program (NEEM) and signed contracts with 13 HUD code builders in the Northwest region. Marlette, Kit, Homebuilders Northwest, Skyline, Liberty, Fleetwood of Oregon and Golden West Homes signed up and built Eco-rated homes, a NEEM-developed branding program that expands upon ENERGY STAR requirements to deliver a somewhat more energy efficient and environmentally responsible home. NEW certified a total of 20 Eco-rated retailers and seven builders. NEW performed over 28 quarterly factory inspection visits and inspected four problem homes in Oregon and Washington.

NEW and Ecotope, a Seattle consulting firm, wrote and submitted a proposal to the Bonneville Power Administration, BPA, for utility acquisition program to build super efficient home in each of the 13 plants. The proposal seeks to pay a utility incentive to the builder for each home produced, provided the builder agrees to build all of its homes to the NEEM requirements. In the present market, this could mean 3,000 homes per year with all thirteen plants participating. *(See Appendix D for full NEW annual report)*

NEEM Homes Reported in 2010

Energy Star/Eco-rated homes produced January 1 to July 31, 2010	
Energy Star electric/gas	641
ECO-RATED electric/gas	132
Total Homes	773

Also in 2010, WSU continued to work with Habitat affiliates, Washington Habitat SSO, state agencies and other stakeholders in January and February to develop specifications for highly energy efficient manufactured housing built for public housing and Habitat projects. Homes will use Eco-Rated as a baseline, adding R5 foam sheathing and mini-split heat pumps as additional

measures. Also discussed using the specifications for all homes using Housing Trust Fund monies, including Habitat homes, and potential new NEEM MAP program.

In BP1, BP2, and BP3, this task was "Subtask 4.2 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.

ACRONYMS & ABBREVIATIONS

AAC -- Autoclaved Aerated Concrete
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
ANSI – American National Standards Institute
ANOPR – Advance Notice of Proposed Rulemaking
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
BCQC – Builders Challenge Quality Criteria
BEOpt - Building Energy Optimization Tool
BIPV - Building Integrated Photovoltaics
BIRA – Building Industry Research Alliance
BOP – Builder Option Package
BP – Budget Period
BPA – Bonneville Power Administration
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
C&RD – Conservation and Renewables Discount
DHP – Ductless Heat Pump
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
ECM – Electronically Commutated Motor
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
ERV – Energy Recovery Ventilator
E-Scale - EnergySmart Home Scale
ESCos - Energy Service Companies
ESSI - Energy Structures & Systems, Inc.
FAS - Federation of American Scientists
Factory Assembled Structures (Sub-task 1.5)
FEMA – Federal Emergency Management Agency
FESC – Florida Energy Systems Consortium
FGBC - Florida Green Building Coalition
FL H.E.R.O. – Florida Home Energy and Resources Organization
FPL - Florida Power and Light
FRF - Flexible Roof Facility
FSEC – Florida Solar Energy Center
GFCI - Ground-fault Circuit Interrupter
GPD – Gallons Per Day
GRU - Gainesville Regional Utilities
GSHP - Ground source heat pump
GTA – Grow the Army
GTI – Gas Technology Institute
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
HWDS – Hot Water and Distribution System
HWSL – Hot Water Systems Lab
IAHS - International Association for Housing Science
IAQ – Indoor 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
L&I – Labor and Industries
MELs - Miscellaneous Electric Loads
MHCC – Manufactured Housing Consensus Committee
MHCSS – Manufactured Home Construction and Safety Standards
MHLab – Manufactured Housing Lab
MHRA – Manufacture Housing Research Alliance
MMBTU – Million British Thermal Units
NAC – Normalized Annual Consumption
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
NEW – Northwest Energy Works
NFPA – National Fire Protection Agency
NIST - National Institute of Standards and Technology
NPCC – Northeast Power Coordinating Council, Inc.
NRDC – Natural Resources Defense Council
NREL - National Renewable Energy Laboratory
NSP – Neighborhood Stabilization Program
NZEH - Near Zero Energy Home
ODOE – Oregon Department of Energy
OMB – Office of Management and Budget
ORNL – Oak Ridge National Laboratory
PATH - Partnership for Advancing Technology in Housing
PERC - Propane Education & Research Council
PHH – Palm Harbor Homes
PMS – Project Monitoring Sub-Committee
PNNL – Pacific Northwest National Laboratory
PNW – Pacific Northwest
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
RECS – Residential Energy Consumption Survey
RESNET – Residential Energy Services Network

RH – Relative Humidity
RP – Research Project
RTAR – Research and Technical Activities Report
RTF – Regional Technical Forum
SAA - State Administrative Agency
SBCI - United Nation's Sustainable Buildings and Climate Change Initiative
SBIR – Small Business Innovation Research
SBRA – Systems Building Research Alliance
SBSL – Side-by-side Lab
SDHW – Solar Domestic Hot Water
SEBC – Southeast Building Conference
SEER – Seasonal Energy Efficiency Ratio
SEF – Solar Energy Factor
SHOP – Self-Help Homeownership Opportunity Program
SIP – Structural Insulated Panel
SQ. FT. – Square Feet
SSO – State Support Organization
TA – Technical Assistance
TAG - Technical Advisory Group
TBC – Thermal Bypass Checklist
TBIC - Thermal Bypass Inspection Checklist
TED - The Energy Detective
TMY – Typical Meteorological Year
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

Building America Documents 2005 - 2010				
Publication Title	**Link to Publication, if available**	**Technical Topics (please separate with semi-colon)**	**Information For (audience)**	**Information Type**
Low Cost Interior Duct Systems for High Performance Homes in Hot Climates	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-451-10.pdf	Interior ducts; HVAC	Homebuilders; Mechanical Contractors; Designers; Researchers	Technical information and applications
Opportunities for Energy Conservation and Improved Comfort From Wind Washing Retrofits in Two-Story Homes - Part I	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-449-10.pdf			Technical information and applications
Opportunities for Energy Conservation and Improved Comfort From Wind Washing Retrofits in Two-Story Homes - Part II	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-450-10.pdf	Insulation and air sealing; Energy audits	Renovators; Researchers	Technical information and applications
Pilot Evaluation of Energy Savings and Persistence from Residential Energy Demand Feedback Devices in a Hot Climate	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-447-10.pdf	MELs (Misc. Electric Loads)	Researchers	Technical information and applications
Exploring Cost-Effective, High Performance Residential Retrofits for Affordable Housing in at the Hot Humid Climate	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-448-10.pdf	Hot Humid Climate; Retrofit; Energy audits; Energy Performance Goals and Analysis; Retrofit case studies	Researchers	Technical information and applications
Evaluation of Bias Issues within Regression-Based Inverse Modeling Methods Against Climate and Building Characteristics Using Synthetic Data	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1863-10.pdf	Modeling; Retrofit	Researchers	Technical information and applications
Side-by-Side Testing of Water Heating Systems: Results from 2009-2010 Testing	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1856-10.pdf	Appliances: Water Heating: Building America Technical Report	Researchers	Technical information and applications
Updated Miscellaneous Electricity Loads and Appliance Energy Usage Profiles for Use in Home Energy Ratings, the Building America Benchmark Procedures	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1837-10.pdf	Appliances: Energy Performance Goals and Analysis: Building America Technical Reports	Researchers/ Government agencies	Technical information and applications

and Related Calculations				
NightCool: Nocturnal Radiation Cooling Concept Long Term Performance Evaluation	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1835-09.pdf	Building Envelope: Roofs: Building America: Technical Reports	Researchers	Technical information and applications
Investigating Solutions to Wind Washing Issues in 2-Story Florida Homes; Phase 1	http://fsec.ucf.edu/en/publications/pdf/fsec-cr-1842-09.pdf	Insulation and air sealing; Energy audits	Renovators; Researchers	Technical information and applications
Comparison of the ENERGYGAUGE USA and BEopt Building Energy Simulation Programs	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1814-09.pdf	Modeling	Researchers; Government Agencies	Technical information and applications
Interim Report on ISO TC 163 Working Group 3	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1799-09.pdf			Other
Zelonedom Case Study Report: "Approaching" Zero Energy in the Pacific Northwest Marine Climate	http://www.baihp.org/pubs/pdf/BAIHP-WSU-zelonedom.pdf	Marine Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
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			Technical information and applications
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			Technical information and applications
Energy Impacts of Various Residential Mechanical Ventilation Strategies	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-437-09.pdf	Heating, Ventilation, and Air Conditioning: Humidity Control	Researchers	Technical information and applications
Research Results from A Few Alternate Methods of Interior Duct Systems in Factory Built Housing Located In the Hot Humid Climate	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-444-08.pdf			Technical information and applications
Green and High Performance Factory Crafted Housing	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-441-08.pdf			Technical information and applications
An Overview of Building America Industrialized Housing Partnership (BAIHP) Activities in Hot-Humid Climates	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-439-09.pdf			Other

Very Low Energy Homes in the United States: Perspectives on Performance from Measured Data	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-RR-302-08.pdf			Technical information and applications
NightCool: A Nocturnal Radiation Cooling Concept	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1771-08.pdf	Building Envelope: Roofs: Building America: Technical Reports	Researchers	Technical information and applications
How Energy Efficient are Modern Dishwashers?	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1772-08.pdf	Appliances: Building America Technical Reports		Technical information and applications
Evaluation of the *NightCool* Nocturnal Radiation Cooling Concept: *Annual Performance Assessment in Scale Test Buildings* Stage Gate 1B	http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1749-08.pdf	Building Envelope: Roofs: Building America: Technical Reports	Government agencies	Technical information and applications
Using Show Homes (and Sponsorships) to Persuade Commissioning Relevancy and Factory Crafted High Performance Modular Homes	http://fsec.ucf.edu/en/publications/pdf/FSEC-PF-435-08.pdf			Technical information and applications
Pilot Evaluation of Energy Savings from Residential Energy Demand Feedback Devices	http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1742-08.pdf			Technical information and applications
Improved Duct Systems Task Report with StageGate 2 Analysis	http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1738-07.pdf			Technical information and applications
Commissioning of High Performance Residences in Hot, Humid Climates	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-430-07.pdf			Technical information and applications
Zero-Energy Manufactured Home	http://www.baihp.org/pubs/pdf/HomeEnergy07.pdf			Technical information and applications
Experimental Evaluation of the *NightCool* Nocturnal Radiation Cooling Concept: Performance Assessment in Scale Test Buildings	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1692-07.pdf	Building Envelope: Roofs: Building America: Technical Reports	Researchers	Technical information and applications
Zero Energy Manufactured Home Project (ZEMH) Deliverable for task 1.2 Side by Side tests of HUD code Homes	http://www.baihp.org/pubs/deliverables/ZEMH9-27-06.pdf			Technical information and applications

Improving the Accuracy and Speed for Building America Benchmarking	http://www.baihp.org/pubs/deliverables/ImprovingBenchmarkCalcs9-27-06.pdf	Whole Building Design: Benchmarks: Building America: Technical Reports		Technical information and applications
Energy Efficient Renovations of Storm Damaged Residences - Florida Case Studies	http://www.baihp.org/pubs/deliverables/hurricane-retrofits9-13-06.pdf			Technical information and applications
Comparing Apples, Oranges and Grapefruit: An Analysis of Current Building Energy Analysis Standards for Building America, Home Energy Ratings and 2006 International Energy Conservation Code	http://www.baihp.org/pubs/deliverables/BA-HERS-IECC_9-12-06.pdf			Technical information and applications
Energy and Indoor Air Quality Recommendations for Cold Climate Habitat for Humanity Homes	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1647-06.pdf			Technical information and applications
Water Intrusion in Central Florida Homes During Hurricane Jeanne in September 2004	http://www.baihp.org/pubs/deliverables/WaterIntrusionReport8-21-06.pdf			Technical information and applications
Energy and Resource Efficient Communities through Systems Engineering: Building America Case Studies in Gainesville, FL	http://www.baihp.org/pubs/aceee_fonorow/index.pdf	Hot and Humid Climate: Whole Building Design: Systems Engineering: Building America Case Studies-New Construction	Home builders	Technical information and applications
Improved Specifications for Federally Procured Ruggedized Manufactured Homes for Disaster Relief in Hot/Humid Climates	Contract Report submitted to DOE: http://www.baihp.org/pubs/ImproveSpecificHomes/contract_report.pdf Paper published in the Proceedings of the 15th Hot/Humid Symposium http://www.baihp.org/pubs/ImproveSpecificHomes/index.htm SIPA issues News Release about Specifications http://www.sips.org/content/news/			Technical information and applications

Home Much Energy Are We Using? Potential of Residential Energy Demand Feedback Devices	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1665-06.pdf			Technical information and applications
Cooling Performance Assessment of Building America Homes	http://www.baihp.org/pubs/cooling/index.htm	Heating Ventilation, and Air Conditioning: Cooling Systems	Researchers	Technical information and applications
Measured Crawlspace Conditions in a HUD-code Home	http://www.baihp.org/pubs/crawlspace/index.htm			Technical information and applications
Recommendations for High Performance Homes	http://www.baihp.org/casestud/2005recommend/index.htm			General Guides, overviews, and FAQs
Heat and Non-Heat Recovery Ventilation Performance in Energy-Efficient HUD-Code Manufactured Housing	http://www.baihp.org/pubs/heatrecovery/index.htm	Heating, Ventilation, and Air Conditioning	Researchers	Technical information and applications
DOE Peer Review				
High Efficiency Condenser Fans	http://baihp.org/pubs/doe_review/BAIHP-techsys-condenserfan4-29-05.pdf	Building America: Technical Reports	Government agencies	Other
Cool Roofs and Nightcool System	http://baihp.org/pubs/doe_review/BAIHP-techsys-coolroofs4-29-05.pdf	Building Envelope: Roofs: Building America: Technical Reports	Government agencies	Other
EG USA and Info Monitors	http://baihp.org/pubs/doe_review/BAIHP-techsys-EGUSA-Infomon4-29-05.pdf	Building America: Technical Reports	Government agencies	Other
Manufacturing/Construction Productivity	http://baihp.org/pubs/doe_review/BAIHP-techsys-manu-cons-productivity4-28-05.pdf	Building America: Technical Reports	Government agencies	Other
Whole House	http://baihp.org/pubs/doe_review/FSEC-BAIHP-wholehouse_5-18-05.pdf	Building America: Technical Reports	Government agencies	Other
Development of High Efficiency Air Condenser Fans	http://www.baihp.org/pubs/develop/index.htm			Technical information and applications
Theoretical Evaluation of the NightCool Nocturnal Radiation Cooling Concept	http://www.baihp.org/pubs/nightcool/index.htm	Building Envelope: Roofs: Building America: Technical Reports	Researchers	Technical information and applications

Effect of Residential Ventilation Techniques for Hot and Humid Climates on Indoor Concentrations of Volatile Organic Compounds	http://www.baihp.org/pubs/pdf/LBNL-57030-Effect.pdf	Hot and Humid Climate: Heating, Ventilation, and Air Conditioning: Indoor Air Quality	Home Builders	Technical information and applications
Manufactured Home Performance Case Study: A Preliminary Comparison of Zero Energy and Energy Star	http://www.baihp.org/pubs/pdf/ZEMHfinal.pdf	Cold Climate: Construction Type-New: Building America-new construction case studies	Home builders	Technical information and applications
Assessing Six Residential Ventilation Techniques in Hot and Humid Climates	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-378-04.pdf	Hot and Humid Climate: Heating, Ventilation, and Air Conditioning: Indoor Air Quality/Humidity Control	Home builders/researchers	Technical information and applications
Geographic Variation in Potential of Rooftop Residential Photovoltaic Electric Power Production n the United States	http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-380-04/index.htm	Building Envelope: Roofs: Renewable Technologies: Photovoltaics: Building America: Technical Reports	Researchers	Technical information and applications
Cold Climate Case Study; High Efficiency North Dakota Twin Homes	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-PF-416-04.pdf	Cold Climate: Construction Type-New: Building America-new construction case studies	Home builders	Technical information and applications
Energy Star Manufactured Homes: The Plant Certification Process	http://www.baihp.org/pubs/estar-hudcert/index.htm			Technical information and applications
Optimizing Manufactured Housing Energy Use	http://www.baihp.org/pubs/optimize/index.htm			Technical information and applications
Standards for Clean Air Florida Homes	http://www.baihp.org/pubs/standards/index.htm			Technical information and applications
Alleviating Moisture Problems in Hot, Humid Climate Housing	http://www.baihp.org/pubs/alleviate/index.htm			Technical information and applications
Achieving Airtight Ducts in Manufactured Housing	http://www.baihp.org/pubs/airtight_ducts/acknowledge.htm			Technical information and applications
Technical services provided to the HUD Code and modular industry	http://www.baihp.org/pubs/techserv/index.htm			Technical information and applications
Measured and Simulated Cooling Performance Comparison; Insulated Concrete Form Versus Frame Construction	http://www.baihp.org/pubs/insulated/index.htm			Technical information and applications
The Building America Industrialized Housing Partnership (BAIHP)	http://www.baihp.org/pubs/baihp/index.htm			Other

Performance and Impact from Duct Repair and Ventilation Modifications of Two Newly Constructed Manufactured Houses Located in a Hot and Humid Climate	http://www.baihp.org/pubs/repair_impact/index.htm	Hot and Humid Climate: Heating, Ventilation, and Air Conditioning: Humidity Control	Home builders/researchers	Technical information and applications
Moisture Problems in Manufactured Housing: Probable Causes and Cures	http://www.baihp.org/pubs/moistprob/index.htm	Hot and Humid Climate: Existing Homes in Moisture Failure; Heating, Ventilation, and Air Conditioning: Humidity Control; Indoor Air Quality; Foundations	Home builders/researchers	Technical information and applications
Preventing House Dust Mite Allergens in New Housing	http://www.baihp.org/pubs/mites/index.htm			Technical information and applications
Design and Construction of Interior Duct Systems	Brochure: http://www.baihp.org/pubs/pdf/M1-13_1-4.pdf Full Report: http://www.baihp.org/pubs/pdf/interior_ducts.pdf			Technical information and applications
Ventilation in US Manufactured Homes: Requirements, Issues and Recommendations	http://www.baihp.org/pubs/wsu-aivc/index.htm	Heating, Ventilation, and Air Conditioning: Indoor Air Quality	Researchers	Technical information and applications
Evaluation of EnergyGauge USA, A Residential Energy Design Software, Against Monitored Data	http://www.fsec.ucf.edu/en/publications/html/FSEC-CR-1670-00/index.htm			Technical information and applications
Energy Efficient Industrialized Housing Research Summary of FY 1998 Activities (July 1998 - August 1999)	http://www.baihp.org/pubs/pre2000/cr9899/index.htm			Other
Testing and Monitoring of the READ Project House East Lansing, Michigan	http://www.baihp.org/pubs/pre2000/read/index.htm			Technical information and applications
Design/Sizing Methodology and Economic Evaluation of Central-Fan-Integrated Supply Ventilation Systems	http://www.baihp.org/pubs/pre2000/aceee98/index.htm	Heating, Ventilation, and Air Conditioning: Indoor Air Quality	Researchers	Technical information and applications
Building Testing and Monitoring at the Habitat/ SIPA/ APA	http://www.baihp.org/pubs/pre2000/plains/index.htm			Technical information and applications

Project in Plains, GA				
Vented and Sealed Attics in Hot Climates	http://www.baihp.org/pubs/pre2000/sealed/index.htm			Technical information and applications
Trip/Testing of the Seattle Healthy House	http://www.baihp.org/pubs/pre2000/seattle/index.htm			Technical information and applications
Allergy Resistant Housing - Principles and Practice	http://www.baihp.org/pubs/pre2000/allergy/index.htm	Heating, Ventilation, and Air Conditioning: Indoor Air Quality	Home builders/consumers	Technical information and applications
Coquille Indian Reservation: Testing and Monitoring	http://www.baihp.org/pubs/pre2000/coquille/index.htm			Technical information and applications
BAIHP-II Annual Report or Budget Period 4	http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1838-10.pdf	Plans, Roadmaps, and Technical/Progress Reports	Government agencies	Technical information and applications
BAIHP-II Annual Report or Budget Period 3	http://fsec.ucf.edu/en/publications/pdf/FSEC-CR-1785-09.pdf	Plans, Roadmaps, and Technical/Progress Reports	Government agencies	Technical information and applications
BAIHP-II Annual Report or Budget Period 2	http://www.baihp.org/pubs/pdf/BAIHP-BP2-annualrpt4-28-08.pdf	Plans, Roadmaps, and Technical/Progress Reports	Government agencies	Technical information and applications
BAIHP-II Annual Report or Budget Period 1	http://www.baihp.org/pubs/pdf/BAIHP_II_Yr_1_Report.pdf	Plans, Roadmaps, and Technical/Progress Reports	Government agencies	Technical information and applications
BAIHP Annual Report - Final Project Report	http://www.baihp.org/pubs/finalrpt/index.pdf	Plans, Roadmaps, and Technical/Progress Reports	Government agencies	Technical information and applications
BAIHP Annual Report - Sixth Budget Period	http://www.baihp.org/pubs/annualreports/year6/index.pdf	Plans, Roadmaps, and Technical/Progress Reports	Government agencies	Technical information and applications
BAIHP Annual Report - Fifth Budget Period	http://www.baihp.org/pubs/annualreports/year5/index.pdf	Plans, Roadmaps, and Technical/Progress Reports	Government agencies	Technical information and applications
BAIHP Annual Report - Fourth Budget Period	http://www.baihp.org/pubs/annualreports/year4/index.htm	Plans, Roadmaps, and Technical/Progress Reports	Government agencies	Technical information and applications
Palm Harbor Homes - Highland	http://www.baihp.org/casestud/ph_homes2010/pdf/BuildersChallengeSpotlight_Highland.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Palm Harbor Homes - La Linda	http://www.baihp.org/casestud/ph_homes2010/pdf/BuildersChallengeSpotlight_PHH_LaLinda.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Nationwide Homes - Osprey Eco Cottage	http://www.baihp.org/casestud/ph_homes2010/pdf/BuildersChallengeSpotlight_N	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications

	at-Osprey.pdf			
Palm Harbor Homes - Tularosa - "Media Enhanced" Home	http://www.baihp.org/casestud/ph_homes2009/pdf/BAIHPTularosa.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Palm Harbor Homes - Deschutes - "Quiet Living" Home	http://www.baihp.org/casestud/ph_homes2009/pdf/BAIHPDeschutes.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Palm Harbor Homes - Bimini II - "Green" Home	http://www.baihp.org/casestud/ph_homes2008/pdf/PHH_Bimini.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Palm Harbor Homes - Glen Cairn - "Comfortable Home	http://www.baihp.org/casestud/ph_homes2008/pdf/PHH_GlenCairn.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Palm Harbor Homes "GenX" Home	http://www.baihp.org/casestud/ph_homes2007/pdf/genx.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Palm Harbor Homes "EchoBoomer" Town Homes	http://www.baihp.org/casestud/ph_homes2007/pdf/echoboomer.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
The New American Home 2007	http://www.baihp.org/casestud/ph_homes2007/pdf/NewAmericanHome2007.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Palm Harbor Homes' "First Time Buyer" Home	http://www.baihp.org/casestud/ph_homes/pdf/PHH-IBS-handout-FirstTime-Final.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Palm Harbor Homes' "Move-up Buyer" Home	http://www.baihp.org/casestud/ph_homes/pdf/PHH-IBS-handout-MoveUp-FINAL.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
NextGen "Peace of Mind" Show Village Home	http://www.baihp.org/casestud/ph_homes/pdf/PHH-IBS-handout-NEXTGen-FINAL.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications

High Performance Builder Spotlight: LifeStyle Homes Zero Energy Home (ZEH) - St. Croix, Tralee Bay	http://www.baihp.org/casestud/pdf/LifeStyle-ZEH.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
High Performance Residential Retrofits - Florida and Alabama	http://www.baihp.org/casestud/pdf/Residential-Retrofits_Casestudy.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
High Performance Builder Spotlight: G.W. Robinson Homes Zero Energy Home (ZEH) - Kempsford, Garison Way	http://www.baihp.org/casestud/pdf/BuildersChallengeSpotlight_GWRobinsonZEH.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Deep Energy Retrofit - Central Florida Prototype - North Port, Florida	http://www.baihp.org/casestud/pdf/Deep-Energy-Retrofit_Casestudy.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
High Performance Builder Spotlight - Lifestyle Homes - Melbourne, FL	http://www.baihp.org/casestud/pdf/_BuildersChallenge_LifeStyle-Homes.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Tommy Williams Homes - Zero Energy Home Longleaf	http://www.baihp.org/casestud/pdf/BA_BuildersChallengeSpotlight_TWH-ZEH.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
40% Community Case Study - G.W. Robinson Builders	http://www.baihp.org/casestud/pdf/GWcasestudy40_4-4-08-2.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Gulf Coast High Performance Affordable Housing Demonstration Project	http://www.baihp.org/gulfcoast/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Affordable Homes rise to DOE's Builders Challenge in Brownsville, Texas	http://www.baihp.org/casestud/pdf/08-Brownsville-CaseStudy-Feb-09.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Building America Day	http://www.baihp.org/casestud/baday/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Other
G.W. Robinson Builders, Inc.	http://www.baihp.org/casestud/baday/G%20W%20Robinson%20Builders.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications

Tommy Williams Homes	http://www.baihp.org/casestud/baday/Tommy%20Williams%20Homes.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Return Air Pathway Study	http://www.baihp.org/casestud/return_air/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Florida International University's 2005 Solar Decathlon Entry - Washington DC	http://www.baihp.org/casestud/fiu_entry2005/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Metal Roof Retrofit on a Hurricane Damaged Home	http://www.baihp.org/casestud/hdh_roof/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
City of Orlando, Florida	http://www.baihp.org/casestud/orlando/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Cold Climate Case Study; High Efficiency North Dakota Twin Homes	http://www.baihp.org/casestud/ndtwinhomes/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
WCI Communities at Evergrene	http://www.baihp.org/casestud/wci/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
The K-9 Comfort Cottage	http://www.baihp.org/casestud/pethouse/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Cambridge Homes at Baldwin Park	http://www.baihp.org/casestud/cambridge/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Zero Energy Manufactured Home	http://www.baihp.org/casestud/zeroenergy/pdf/zeroenergy.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	General guides, overviews, and FAQs
Six Moisture Home Case Studies				

Just a little south of Houston	http://www.baihp.org/casestud/moisture/pdf/BAIHPcase1.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Just a little north of New Orleans	http://www.baihp.org/casestud/moisture/pdf/BAIHPcase2.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Just outside Kinder, Louisiana	http://www.baihp.org/casestud/moisture/pdf/BAIHPcase3.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
'nother wet wall west of the Gulf	http://www.baihp.org/casestud/moisture/pdf/BAIHPcase4.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Somewhere near Houston	http://www.baihp.org/casestud/moisture/pdf/BAIHPcase5.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Near the beaches of N. Carolina	http://www.baihp.org/casestud/moisture/pdf/BAIHPcase6.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Central Florida Dream Home	http://www.baihp.org/casestud/dream/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
High Efficiency Florida Home - Longwood, Florida	http://www.baihp.org/data/cfres/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Manufactured Home Comparison - Greensboro, North Carolina	http://www.baihp.org/data/ncatu/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Super Good Cents/Natural Choice Program	http://www.baihp.org/casestud/wsu/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	General guides, overviews, and FAQs
Portable Classrooms - Pacific Northwest	http://www.baihp.org/data/portables/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications

Side-by-Side Comparison of Manufactured Homes	http://www.baihp.org/casestud/bossier/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Palm Harbor Homes Partnerships	http://www.baihp.org/casestud/palm/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	General guides, overviews, and FAQs
The Entry Level Homes - Orlando, FL	http://www.baihp.org/casestud/elh/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Health House 1997 - Orlando, FL	http://www.baihp.org/casestud/hh97/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Health House 1996 - New Orleans, LA	http://www.baihp.org/casestud/nohh/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Building America Partnership with Habitat for Humanity Internation's Congress Building America Projects	http://www.baihp.org/casestud/hfh_partner/index.htm	Construction Type-New : Building America-new construction case studies; affordable housing; Habitat for Humanity	Home builders	Technical information and applications
Energy Star Home (Version 1) Examples Developed for Habitat for Humanity	http://www.baihp.org/casestud/HfH_EStar/index.htm	New construction case studies; Goals and Analysis; affordable housing; Habitat for Humanity	Home builders	Technical information and applications
Habitat for Humanity - Plains, GA Structural Insulated Panel Field Project	http://www.baihp.org/casestud/PLAINSHABITAT/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders; Researchers	Technical information and applications
Affiliate Steps toward 2011 ENERGY STAR Homes	http://www.fsec.ucf.edu/en/publications/pdf/FSEC-FS-47-10.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
RESNET Raters Volunteer - Habitat for Humanity - South Sarasota County, Florida	http://www.baihp.org/habitat/pdf/Case%20study%20_South-SarasotaHFH.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Habitat for Humanity - Builders Challenge Houses - New Smyrna Beach, Florida	http://www.baihp.org/habitat/pdf/NewSmyrna_Case-study.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications

Gulf Coast High Performance Affordable Housing Demonstration Project	http://www.baihp.org/gulfcoast/index.htm	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
RESNET Raters Volunteer - Habitat for Humanity with Orlando, Florida	http://www.baihp.org/habitat/pdf/Orlando-HFH-CaseStudy.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
RESNET Raters Volunteer with Habitat for Humanity - Indian River County, Florida	http://www.baihp.org/habitat/pdf/Indian%20River%20HFH_Case%20Study.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
RESNET Raters Volunteer with Habitat for Humanity - Austin, Texas	http://www.baihp.org/habitat/pdf/Casestudy%20_AustinTexas_%20Final.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
RESNET Rater Volunteers with Habitat for Humanity in Greenville, South Carolina	http://www.baihp.org/habitat/pdf/09Greenville-CaseStudyFinal.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
RESNET Rater Volunteers with Habitat for Humanity in Cincinnati, Ohio	http://www.baihp.org/habitat/pdf/09-Cincinnati-CaseStudy_Final2page.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Habitat for Humanity - Building America Partnership: Jimmy Carter Work Project 1997-2007	http://www.baihp.org/habitat/pdf/JCWP07-Case-Study.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Habitat for Humanity: LaGrange, Georgia, 2003 Jimmy Carter Work Project	http://www.baihp.org/casestud/hfh_partner/pdf/HabitatLaGrangeGA1.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Habitat Metro Denver - Perfecting Award-Winning Affordable Homes Using Building America's Integrated Design Approach	http://www.baihp.org/casestud/hfh_partner/pdf/MetroDenverHFH.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies	Home builders	Technical information and applications
Lakeland Habitat for Humanity	http://www.baihp.org/habitat/pdf/ba_bc_lakeland_habitat_hot-humid.pdf Full Case Study: http://www.baihp.org/habitat/pdf/Lakela	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies; affordable housing	Home builders	Technical information and applications

	nd-Habitat-Case-Study.pdf			
RESNET Partnership with Habitat for Humanity: Oklahoma City	http://www.baihp.org/habitat/pdf/Central-Oklahoma-Case-Study.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies; affordable housing	Home builders	Technical information and applications
Habitat for Humanity in Houston, Texas: Building Energy Efficient Homes for Over a Decade	http://www.baihp.org/habitat/pdf/Houston-Case-Study.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies; affordable housing	Home builders	Technical information and applications
Toward Simple Affordable Zero Energy Houses Loudon County Habitat for Humanity	http://www.baihp.org/habitat/pdf/envelopeZEHpaper.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies; affordable housing	Home builders	Technical information and applications
Moses Lake Washington Energy Star Home	http://www.baihp.org/habitat/pdf/Moses_Home.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies; affordable housing	Home builders	Technical information and applications
Building America Technical Assistance to Habitat for Humanity (presentation)	http://www.baihp.org/habitat/pdf/HFH_Building_Science_Gautier_2007.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies; affordable housing	Home builders	Technical information and applications
Building America - Habitat for Humanity Partnership Update July 2007	http://www.baihp.org/habitat/pdf/Building_America_Habitat_Partnership.pdf	Hot and Humid Climate: Construction Type-New : Building America-new construction case studies; affordable housing	Home builders	Technical information and applications
Building America Stage Gate 3 – Hot Humid Climate 40% Milestone Report	Available for download on the BA Project Management Extranet Site	(formerly known as the Joule Report)		

In BP3 and BP4, 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

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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

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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."

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APPENDIX B –Case Studies

The following case studies were completed in 2010 (website links provided):

Existing Homes
http://www.baihp.org/casestud/pdf/Deep-Energy-Retrofit_Casestudy.pdf
http://www.baihp.org/casestud/pdf/Residential-Retrofits_Casestudy.pdf

High Performance Builder Spotlight
http://www.baihp.org/casestud/pdf/BuildersChallengeSpotlight_GWRobinsonZEH.pdf
http://www.baihp.org/casestud/pdf/LifeStyle-ZEH.pdf
http://www.baihp.org/casestud/pdf/BA_BuildersChallengeSpotlight_TWH-ZEH.pdf
http://www.baihp.org/casestud/pdf/_BuildersChallenge_LifeStyle-Homes.pdf

IBS 2010 Show Homes
http://www.baihp.org/casestud/ph_homes2010/pdf/BuildersChallengeSpotlight_Nat-Osprey.pdf
http://www.baihp.org/casestud/ph_homes2010/pdf/BuildersChallengeSpotlight_Highlander.pdf
http://www.baihp.org/casestud/ph_homes2010/pdf/BuildersChallengeSpotlight_PHH_LaLinda-.pdf

High Performance Habitat for Humanity Homes
http://www.baihp.org/habitat/pdf/NewSmyrna_Case-study.pdf
http://www.baihp.org/habitat/pdf/Casestudy%20_AustinTexas_%20Final.pdf
http://www.baihp.org/habitat/pdf/Indian%20River%20HFH_Case%20Study.pdf
http://www.baihp.org/habitat/pdf/Orlando-HFH-CaseStudy.pdf
http://www.baihp.org/habitat/pdf/Case%20study%20_South-SarasotaHFH.pdf

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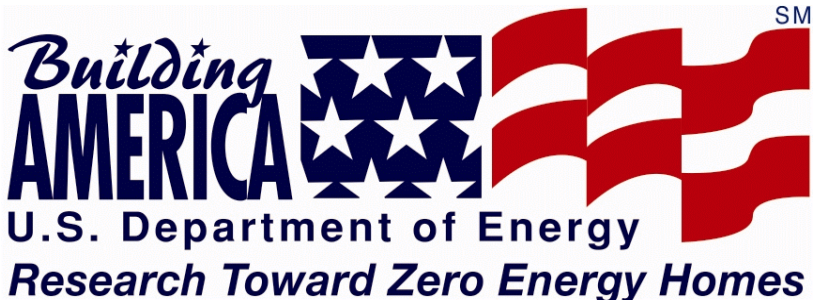
APPENDIX C – Washington State University Annual Report



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

Contract # DE-FC36-99G010478

November 2009 – October 2010

Michael Lubliner
Andy Gordon
Ken Eklund
David Hales
Chris Fuess
Luke Howard
Luke Mattheis

WASHINGTON STATE UNIVERSITY
EXTENSION ENERGY PROGRAM

Subtask 1.5 Participate in Working Groups (RESNET Tasks)

ACCA
As voting member of the ACCA Quality Installation (QI) committee, WSU participated in the development and review of the final draft of the QI standard, identifying areas for improvement in future drafts, including heat pump sizing in heating climates, and other related airflow and duct leakage testing issues. This effort and discussion of heat pump sizing issues has resulted in discussions within ACCA regarding updating ACCA manual S.

ASHRAE

BAIHP staff continued active participation in 2010, attending the 2010 Winter and Annual meetings, and participating in the following ASHRAE committees:

6.3 – Central Forced Air Heating and Cooling Systems
As research project (RP) chair, WSU staff coordinated Project Monitoring Subcommittee (PMS) meeting of RP-1449 (Energy Efficiency and Cost Assessment of Humidity Control Options for Residential Buildings) and approved project deliverables at the ASHRAE 2010 Meetings. WSU provided peer review and comment on reports for tasks 3 and 4. The draft report for task 5 is under review. The project is expected to be completed in 2011.

9.5 – Small Residential and Commercial Buildings.
Mike Lubliner is the new programs sub-committee chair for TC9.5. WSU also provided proposals to HVAC sub-committee to evaluate heat pump commissioning.

Planning is underway for Montreal DHP seminar. Seminar will include presentation of flip-flop test results at the WSU energy house, and analysis by BAIHP partners NIST and Ecotope.

62.2 – Ventilation and Acceptable Indoor Air Quality in Residential Buildings.

Throughout the year, WSU staff participated in meetings in support of efforts to align proposed changes to the Manufactured Home Construction and Safety Standards (MHCSS) to ASHRAE 62.2. WSU met with 62.2 committee members, as well as top management at HUD's office of manufactured housing and other stakeholders at NIST. These efforts are consistent with Builder's Challenge Indoor Air Quality Criteria and durability goals.

WSU staff also conducted discussions with 62.2 members and other stakeholders regarding new Washington State ventilation requirements. Specifically, the new requirements specify the need for air inlet vents; 62.2 does not require them.

WSU is also exploring the potential for a new collaboration between Building America and NEEA on requirements for whole house ventilation in code and beyond-code programs with tight envelope requirements.

NIST

For the last five years, WSU staff have been providing program design and in-field technical assistance as well as analysis support to the National Institute of Standard's (NIST) study of the airtightness, ventilation and energy use impacts of retrofits on an unoccupied manufactured home, sited at the NIST campus in Gaithersburg, MD.

WSU staff worked with NIST and Energy Conservatory staff to conduct envelope and duct leakage testing on the home, and provided substantial peer-review into two NIST reports on the project: "Airtightness, Ventilation, and Energy Consumption in a Manufactured House: Pre-Retrofit Results," and "Impacts of Airtightening Retrofits on Ventilation Rates and Energy Consumption In a Manufactured Home." Quoting the second report:

> In the project, a manufactured home constructed in 2002 was subjected to a series of airtightening retrofits, including installing house wrap over the exterior walls, sealing a number of leakage sites in the living space floor, tightening the insulated belly layer, and sealing leaks in the air distribution system. These retrofits reduced the whole house leakage, as determined by a fan pressurization test, by about 18% and the duct leakage by about 80%. Whole house infiltration rates were reduced by about one-third, with the specific reduction dependent on weather conditions and how the forced-air system was operating. The energy consumption rate for heating and cooling was reduced by about 10 %.
>
> While the retrofits did improve the airtightness of the house and reduce the energy consumption, the effectiveness of the effort was limited by the challenges of airtightening an existing building.
> In general, it is easier to construct a tight building envelope than to achieve one through retrofits (Hale, Davis et al. 2007). Manufactured homes in particular have the potential for high levels of airtightness performance given the quality control that can be achieved in the factory.

RESNET

WSU staff participated as members of the RESNET technical committee and Board of Directors, including attending board and committee meetings in Raleigh and New Orleans.

Washington State Factory Assembled Structures Advisory (FAS) Board

WSU staff participated in the Washington State Factory Assembled Structure (FAS) board meetings as a voting member, participating 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.

WSU is working with the Washington State Department of Labor and Industries (L&I) to investigate the possibility of linking the L&I alteration permit database with the Northwest Energy Efficient Manufactured Housing Program (NEEM) database, to determine which NEEM electrically heated homes have after-market heat pumps installed. Currently a significant number of NEEM homes have low benchmark ratings due to the reliance on electric forced air furnaces. This data may be used for a potential collaborative research study in 2011.

WSU also discussed providing L&I staff training on inspecting heat pumps for proper airflow, temperature split and strip heat lockout, per Pacific Northwest utility programs. WSU believes these efforts will result in better in-field installations of heat pumps in manufactured homes, and provide assurance that claimed savings for heat pump installations are being realized.

Other Technical Assistance

In March, WSU also provided technical assistance to DOE regarding US Senate bill 1320, a bill to provide assistance to owners of manufactured homes constructed before January 1, 1976, to purchase Energy Star-qualified manufactured homes. The bill never came to the Senate floor in the last congress.

Subtask 1.7 Attend Conferences and Workshops

ASHRAE 2010 Winter Meeting – Orlando, Florida
Mike Lubliner met with advisory group members for Subtask 2.2.6 at ASHRAE 2010 Winter Meeting in January; attendees included Ecotope, NIST, WSU, ACCA, Panasonic, LG, Fujitsu, and members of ASHRAE TC 9.5 and RP-1449

WSU attended Building Science Corporation's Westford Symposium in August. WSU also met with BAIHP partners Panasonic, DOW, The Energy Conservatory and Walsh Construction, as well as other Building America teams, to discuss current projects and future planning.

Subtask 1.9 Technical Reports and Presentations

Gordon, A.M., Lubliner, M.R., Blasnik, M., & Kunkle, R.D. (2010, August). Measured vs. Predicted Analysis of Energy Star Modular Permanent Military Housing: Fort Lewis Case Study. Proceedings of the ACEEE 2010 Summer Study on Energy Efficiency in Buildings. August 2010

- Invited paper. Presented at the ACEEE 2010 Summer Study on Energy Efficiency in Buildings, Asilomar, CA.

Howard, L., Lubliner, M. & Matheis, L. 2010. Electric Resistance Zonal Radiant Heating in a Large Custom High Performance home.

- Presentation, given at 2010 EEBA annual conference.

Lubliner, M.R., Gordon, A.M., & Fuess, C.D. 2010. Approaching "Zero Energy" in the Pacific Northwest Marine Climate. Buildings XI Conference; Transactions

- Presented at the ACEEE Buildings XI Conference in Orlando, FLA, December 2010.

Subtask 2.2.6 Ductless Heat Pump – Pacific NW Utility Collaborative

WSU Energy House

The WSU Energy House was used to conduct a pilot research experiment to evaluate new ductless heat pump technology. Weekly to bi-weekly "flip-flop testing" was conducted in winter/spring of 2010 to help evaluate the following research questions:

1) What is energy performance of a ductless heat pump (DHP) benchmarked against a ducted electric furnace (EF)?
2) How well do the DHP or EF maintain acceptable indoor temperature for thermal comfort?

During the experiment, performance of a ductless heat pump (25 SEER/12 HSPF, 16,000 Btu/hr) was compared against that of an electric furnace (the home's ducted heat pump system operated in strip heat mode to mimic a furnace). The thermostat was configured to run the blower only when the electric furnace was in heating.

The ductless heat pump was located in the main living area of the home. The ducted system and tended to provide more heat to the periphery.

Flip-flop tests were conducted from February through May 13. Every one to two weeks the system thermostats were adjusted to heat the entire house with either the ductless heat pump (flip) or central ducted furnace (flop). To monitor system performance, electrical energy consumption of both the ductless heat pump and electric furnace was recorded. Temperature sensors were installed both outside and in every indoor zone to observe the effects of running the different heating systems on thermal comfort.

Figure 1 provides an indication of the increased efficiency of the DHP as compared to the EF. It should be noted that heat pump COP and heating output are reduced at lower ambient temperatures than those found during this study (outside temperatures were typically 35°F or higher).

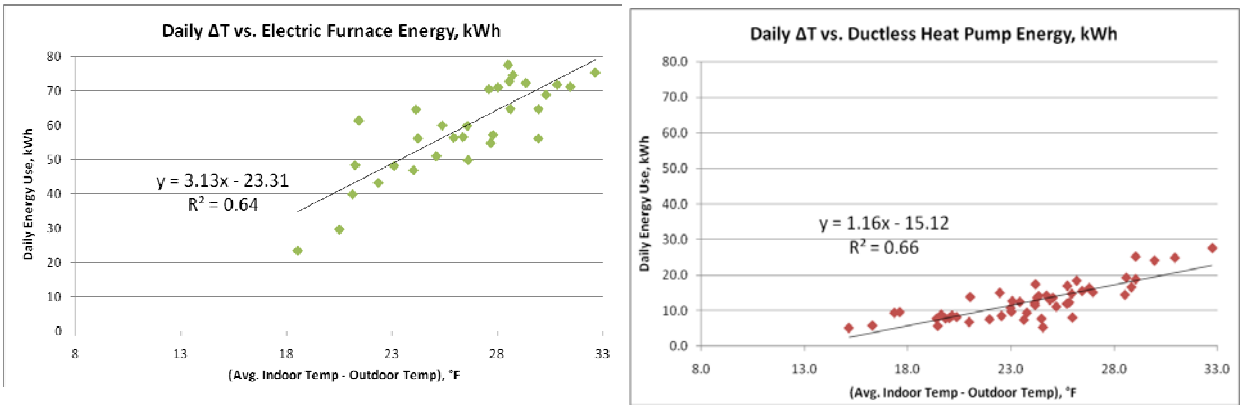


Figure 1 – Flip/Flop regression analysis, WSU Energy House

Dividing the slope of the ER furnace fit by the DHP fit will give an estimate for the DHP's COP for the period of operation. The estimate for this study is a COP of 2.7. Given the directly

measured and manufacturer reported COP, this number is slightly lower than may be expected, and can be explained by higher return air temperatures and higher demand on the unit than specified by the manufacturer. Nevertheless, the calculated COP of 2.7 for the ductless heat pump represents substantial savings.

Figure 2 provides an assessment of how four of the most interesting zone temperatures vary with respect to outside temperatures (only four zones are plotted for readability). The daily average zone temperature is plotted versus the daily average indoor-outdoor ΔT. For the testing period of this experiment, the weeks in which the furnace operated always had ΔT's greater than 20°F. In contrast, the ductless heat pump periods of operation occurred in some warmer weather where the ΔT was as little as 15°F. The plots clearly demonstrate a wide scatter in indoor temperature with the DHP in use.

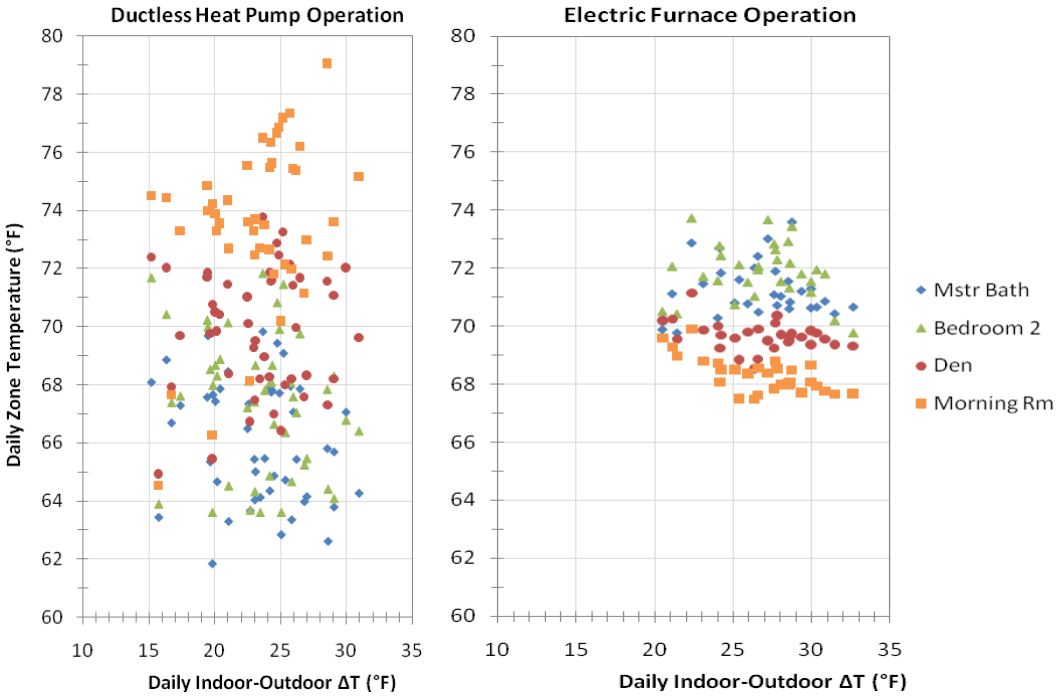


Figure 2 – Scatter plot of four average daily zone temperatures vs. outdoor temperatures

Ongoing field research is proposed to continue to investigate the following current and new related research questions:

1) What is energy performance of a ductless, mini-split heat pump (DHP) benchmarked against a centrally ducted electric furnace (EF) and/or ducted heat pump?
2) How much of the electric furnace can be displaced with DHP and/or central heat pump?
3) How well do the DHP or EF maintain acceptable indoor temperature for thermal comfort?
4) What are the pros and cons of various approaches to DHP air distribution mixing that improve thermal comfort and reduce back-up electric resistance heat?

Ductless heat pump advisory group

WSU developed a ductless heat pump lab testing advisory team, including representatives from manufacturers, ACCA, ASHRAE members, national laboratories, NIST, and other Building America Teams. WSU met with individual advisory group members met at the ASHRAE 2010

Winter and annual meetings, to discuss ongoing research efforts in the Pacific Northwest, including the WSU Energy House, Pacific Northwest ductless heat pump field and lab testing, and development of homeowner, builder and contractor guides for ductless heat pumps.

Task 3: Prototype House Evaluations Monitored Prototypes

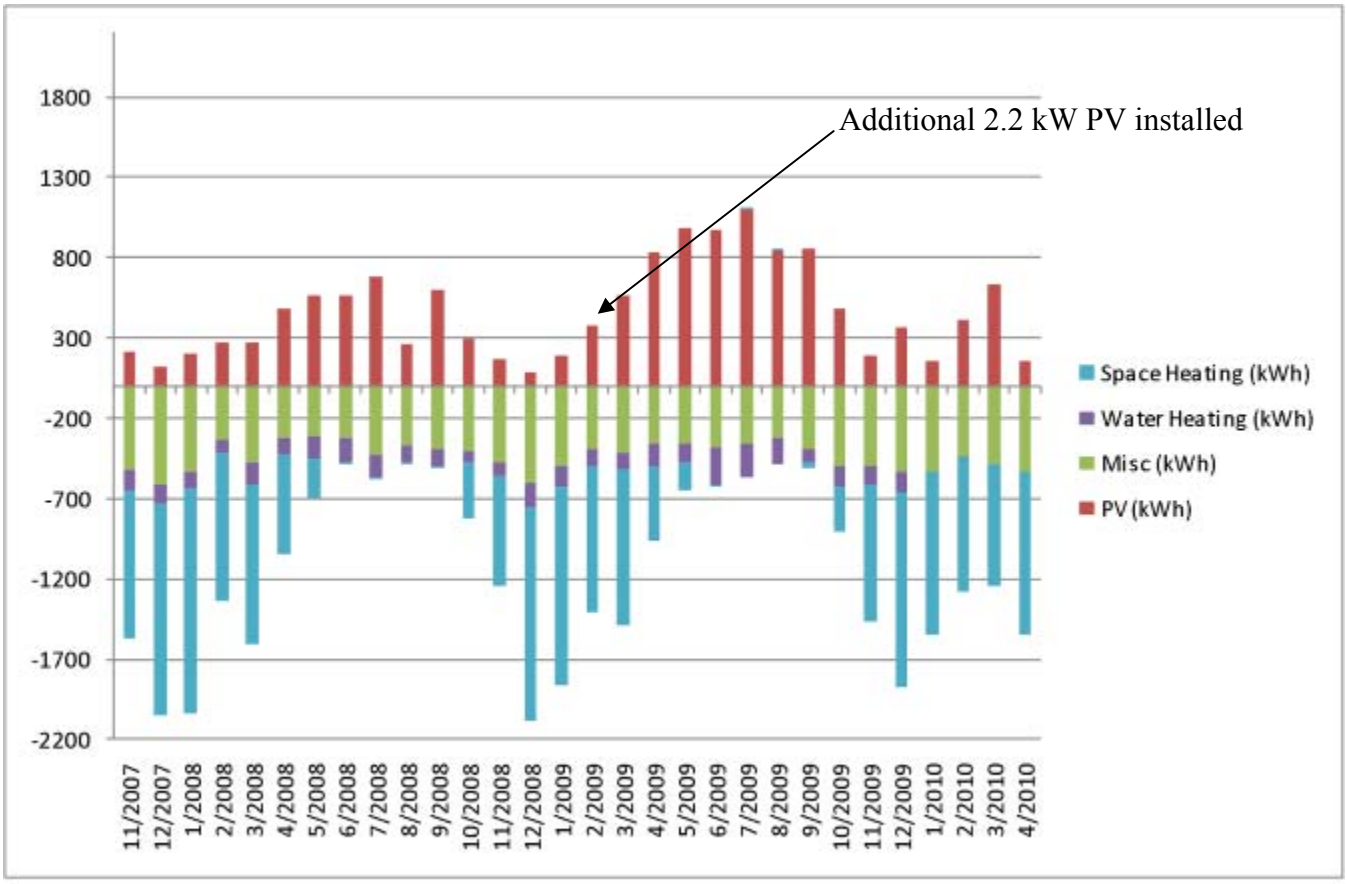
Garst Residence

Figure 4 – Garst Residence, monthly energy use, including PV to grid, November 2007-April 2010

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 on the cover of Solar Today magazine, and 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. From March 2008 through February 2009, performance was measured at 4538 kWh or 1008 kWh per kW of installed PV. Of the total PV production, roughly 47% was used by the house, and 53% returned to the utility.
For the same months in 2009-2010, with the additional 2.2 kW of PV, performance was measured at 7765kWh, or 1158 kWh per kW of installed PV.



As noted in 1.9 above, WSU staff developed a paper on the Garst residence that was presented at the Buildings XI conference.

Stamets Residence

Figure 4 – Stamets Residence, Olympia, WA

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 ENERGY STAR windows, lighting and appliances, HRV and HEPA filtration, a heat pump water heater, condensing dryer, Seisco tankless hot water heaters, 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.

In late 2008, a ground source heat pump was installed. Savings from the heat pump are estimated at 10,000 kWh per year, at a cost of $16,000.

Monitoring of the home took place from June 2006 through December 2009. Figure 5 shows total home electrical use (excepting a hot tub).

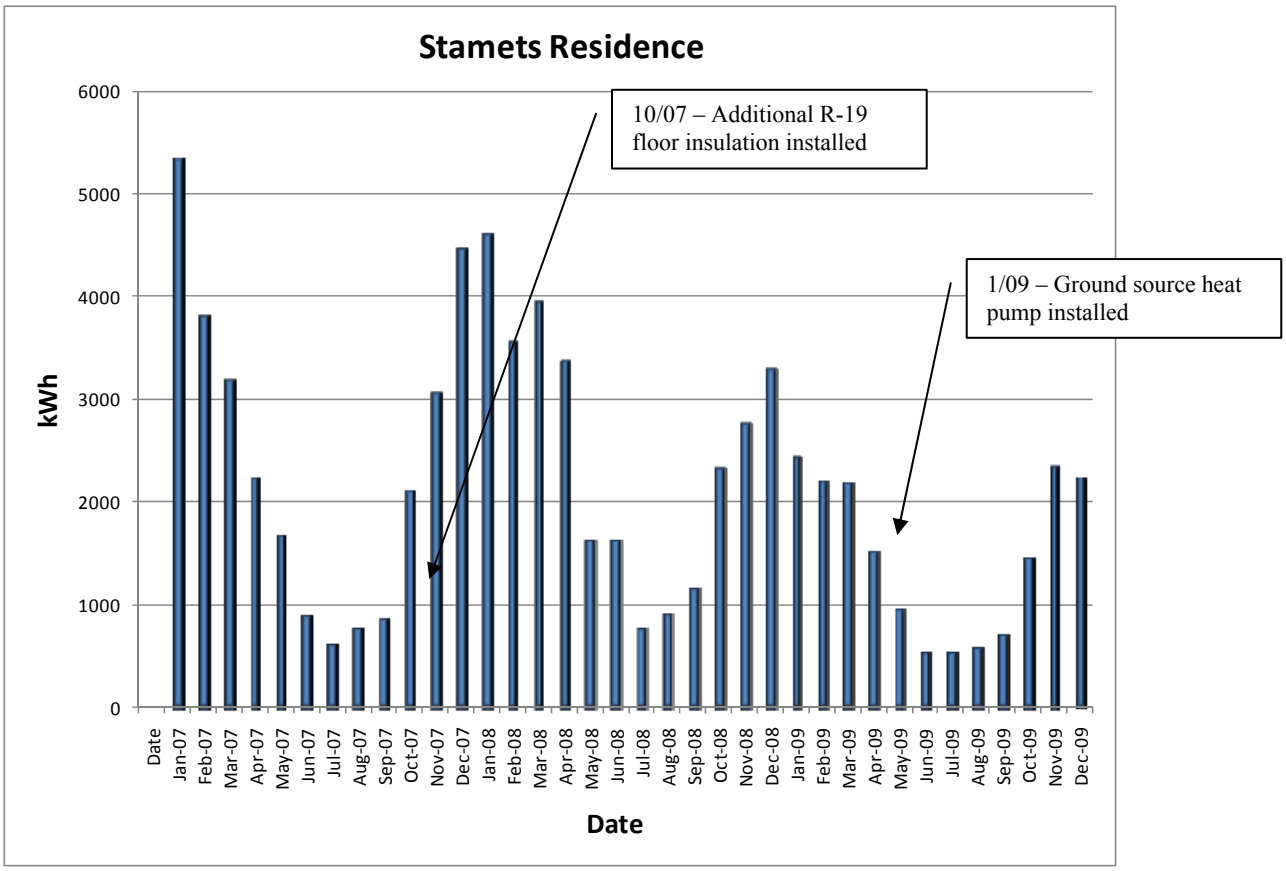


Figure 5 – Stamets residence, electrical use

As noted in 1.9 above, BAIHP staff gave a presentation on the Stamets residence to the EEBA national conference as part of the track "The Green in Radiant Zone Heating."

Task 4: Initial Community Scale Evaluations

Scott Homes

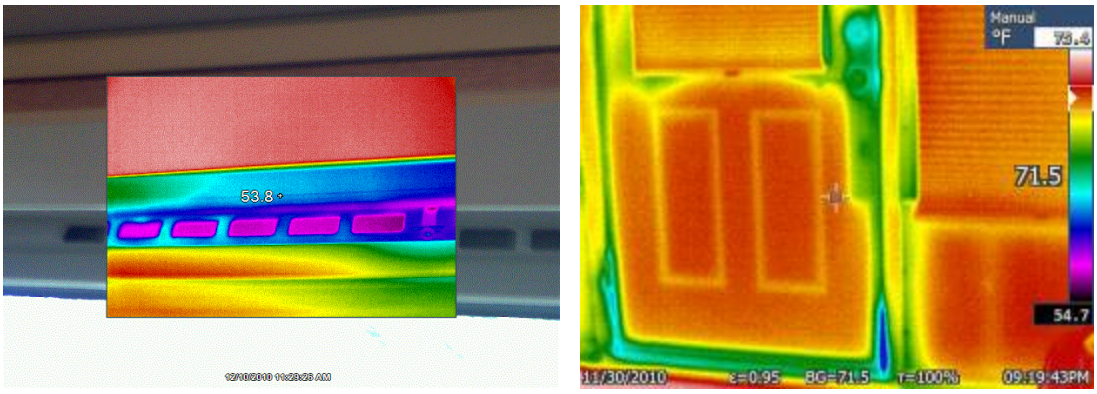


Figure 6 – Air inlet vents (L) and possible air leakage around door, Woodard Lane, Olympia, WA

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

Since 2008, BAIHP staff has provided design and on-site technical assistance to the 11 unit Woodard Lane Co-Housing project. 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. Phase 1 construction was completed in 2009; the HERS index on these homes ranges from 54-64 for these units. The units were not fully occupied until April of 2010, so a full year's utility bill assessment was not possible. For the months April through October (largely non-heating), average energy use per building (4 units each) was on average 53 MMBTUs; roughly 4.8 MMBTUs per occupant (based on 8 adults and 3 children per building).

WSU staff met with Woodard Lane Co-housing residents and Scott Homes staff to solicit feedback on the buildings and present questions about certain features and mechanical operations. A majority of comments referenced elements of the homes required by code, or reflected a misunderstanding in the operations of equipment. Major concerns included:

- Several residents expressed concern over the noise of the bathroom fan when operating at maximum setting, revealing misunderstandings about the use of the whole-house ventilation system.
- In a similar vein, several residents complained about the cold air coming in from ventilation ports positioned at the top of certain window frames, reflecting a misunderstanding that the ports cannot be closed, regardless of conditions. These comments also seemed to reflect a greater sensitivity to temperature and sound resulting from greater insulation and a tighter building envelope.
- One resident noted the room housing the back door was consistently colder than the adjacent rooms and suspected that the door was not perfectly installed (see Figure 6, above),

The feedback emphasizes the need for proper education and technical assistance for new residents of highly efficient homes. WSU and Scott Homes are planning to meet implement a resident survey in 2011.

Fort Lewis

Figure 7 – Town Center, Fort Lewis

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 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 .90 AFUE furnaces, efficient windows, and ENERGY STAR appliances and lighting.

WSU staff worked with Equity on plans for a new 220 unit development at Fort Lewis named Town Center, modular built row houses in clusters of 8-12 (2 story modular with 1 story site-built garage.) Phase 1, with 63 units, began construction in late 2009, and was completed in 2010. While WSU staff testing found substantial total leakage numbers (between 7% and 11% of conditioned floor area), the ducts being located within the envelope meant that leakage to the exterior was negligible (between 1% and 2% of conditioned floor area). Tested envelope leakage was less than 4 ACH_{50}.

For Phase 2 (the remaining 157 units, with commercial space on the first floor) which began construction in fall of 2010, WSU staff lobbied to incorporate Building America demonstration technologies, and championed development of alternative ENERGY STAR paths for electric resistance heating, offering additional practical approaches for affordable housing constructed to ENERGY STAR performance levels.

In the end, Equity chose to use ductless heat pumps, along with backup electric resistance heat. WSU and Equity plan to evaluate use of the ductless heat pumps in 2011, with PNNL support.

McChord Air Force Base

WSU continued to coordinate with Equity and HVAC contractor on Phase 1 of Wescott Village, which included 32 homes in phase 1. WSU provided training on heat pump commissioning and duct sealing, as well as quality assurance throughout the construction process. Field testing identified multiple areas for improvement, including duct system design and leakage levels, heat pump controls, and floor insulation details. Through numerous field visits, WSU worked with

Equity and the HVAC contractor to address these issues; by late spring the performance testing results showed substantial improvement.

WSU also began discussions with Equity on a new 62 home site built project called Cascade Village, using lessons learned at Westcott village to achieve higher benchmark savings. In 2010 WSU staff worked with Equity and architects on the design of up to 850 new homes as part of the Grow the Army (GTA) privatized military family housing. The first 250 homes will be built in 2011.

Salishan

Figure 8 – Salishan 7 (L) and foam sheathing detail on demonstration unit

In late 2009, WSU began working with Walsh Construction, Tacoma Public Utilities, the Tacoma Housing Authority and consultant O'Brien and Company on Phase 7 of the Salishan development. The development, which began construction in late 2009, and was completed in late 2010, is composed of 91 low-income housing units, and is the first federal Hope VI project to achieve LEED Platinum.

WSU and Walsh Construction coordinated the plans for the last four units to demonstrate advanced technologies, including ductless heat pumps, exterior foam sheathing and Panasonic ERVs and Dupont's liquid applied house wrap. WSU is also working with partners Tacoma Public Utilities and Tacoma Housing Authority to plan long term billing analysis; utility data would be collected via new gateway meters with BA support in 2011-12.

Subtask 6.1 Building America Partnership with Habitat for Humanity

WSU staff continued to provide support to Habitat for Humanity International (HFHI) programs and initiatives. WSU worked closely with Ed Brown, Sustainability Specialist for Washington HFH, to provide technical assistance to Washington affiliates. Over the last five years, this close coordination with the state Habitat office has led to over 230 homes certified to Northwest ENERGY STAR standards (including 24 in the period November 2009-October 2010).

Ed Brown left his position in 2010 for a job with Habitat International; WSU staff have continued to work with him to coordinate technical assistance efforts throughout Washington and the region. WSU staff developed a presentation, titled "Energy Modeling vs. Actual Usage in Washington State Habitat for Humanity Homes" in coordination with Brown, that he and Lubliner delivered at the ACI national conference in Austin. WSU staff also developed and co-delivered a presentation with Brown on Energy Star version 3 standards to affiliates participating in the Partners in Sustainable Building Program.

Historically, low-income housing such as that constructed by Habitat affiliates utilize electric resistance heat. In order to comply these homes for the Northwest Energy Star program (and thus obtain access to Housing Trust Fund monies), they would have to construct a home with either advanced framing, or exterior foam, as well as install an HRV and achieve an envelope

leakage rate of 2.5 ACH_{50} or less. Meeting this performance testing requirement has been very difficult, especially when using volunteer crews. In the last two years, the Seattle/South King County affiliate has to construct 60 homes to meet the Energy Star BOP 2 requirements for electrically heated homes. Of these, only 5 met the performance testing requirements. WSU is working with the affiliate to aid in these challenges, including finding alternate compliance paths.

It should be noted that WSU has noted improved envelope leakage numbers in Habitat homes as a result of greater air-sealing efforts by crews and the employment of air-tight drywall technique. Also, several affiliates are moving away from all-electric heating strategies to either natural gas unit heaters or ductless heat pumps, coupled with back-up resistance type heating in bedroom area.

Figure 9 provides a summary of WSU's technical assistance to the Washington Habitat affiliates. Additional, direct technical assistance to the Washington affiliates includes:

- WSU continued to work with Habitat affiliates, Washington Habitat, state agencies and other stakeholders to develop specifications for highly energy efficient manufactured housing built for public housing and Habitat projects. Homes will use EcoRated as a baseline, adding R5 foam sheathing and mini-split heat pumps as additional measures. Also discussed using the specifications for all HFH homes purchased by WA affiliates interested in HUD-code housing. This work is continuing with support from PNNL.

- WSU met with HFH staff and the King County Housing Authority to discuss opportunities for research at Wonderland Estates Mobile Home Park. The park contains weatherized manufactured homes, with room for additional single wide homes. WSU is working with the housing authority to develop specifications for the single wide homes. This work is continuing with support from PNNL.

- In-person and phone charrettes with affiliates, in support of building to beyond Energy Star standards, including La Fortuna development (East King County), Highpoint and Rainier Vista (Seattle/South King County)

- Ongoing third-party inspection and quality assurance, through the Northwest Energy Star program.

In 2011, technical assistance to Habitat will continue through funding from Pacific Northwest National Laboratories.

Affilliate/Project	City	County	BA Partner	# units	Built	BA Technologies
Seattle/South King Co	Tukwila	King	2008-10			
High Point 1 – MF & SF				8	2007-08	Base WSEC
High Point 2a – MF & SF				8	2009-10	BOP2 (electric), Foam walls, HRV, OC Energy Complete
High Point 2b - MF & SF				8	2010	BOP2, Knauf blown-in insulation, HRV
Buffini House - SF				1	2008	Base WSEC
Rainier Vista 1 - MF				12	2009-10	BOP2 Electric Foam walls, HRV,
Rainier Vista 2 - MF				12	2011	Ductless heat pump, foam walls, HRV, triple pane windows
Rainier Vista 3 - MF				4	2011	Ductless heat pump, foam walls, HRV
Pacific - SF				2	2009-10	TCO9 - Combo gas
Tuklilla - SF HUD				1	2009	HUD single
Megan's Meadows				9	On Hold	LEED certified
Tacoma/Pierce County	Tacoma	Pierce	2008-10			
Reynolds Park				16	2008-09	Blower Door, Demo at 2008 conference
Larrimie Terrace				12	2009-10	1 Demo home w/Solar, Smart Sense, Foam
Puyallup Fair 1				1	2008	Blower door, Duct test, Mini-split, foam walls
Puyallup Fair 2				1	2009	Foam walls
Salishan				10	2010	In-floor hydronics, ductless heat pump, SIPS
South Puget Sound HFH	Olympia	Thurston	2007			
TESC				1	2007	ICF, Icynene, HRV, conbo gas, solar ready
Fairview				15	2007-08	ICF, Foam walls, blower door
East King County	Redmond	King	2008-10	5	2007-09	Base WSEC, Estar+ TBD
La Fortuna	Renton	King		11	2010-11	1" exterior foam, ducted furnace
Kitsap County, HFH of	Bremerton	Kitsap	2009-11	11	2007-09	Base WSEC, Estar+ TBD,
Cornerstone				3	2010	under floor radiant system, condensing boiler
Yakima Valley Partners	Yakima	Yakima	2009-10	7	2007-10	Base WSEC
Scattered				3	2010	Exterior foam, and ductless heat pumps, not ENERGY STAR (no incentive)
Tri-County Partners HFH	Richland	Benton	2009-10	2	2007-09	Base WSEC
Santiago Estates				8	2010	Estar with Heat Pump (8.5 HSPF)
Tanglewood				2	2010	ICF, 2" foam exterior, Heat Pump

Figure 9 – Habitat for Humanity, Technical Assistance Summary

Subtask 6.2 Deep Retrofits On Existing Affordable Homes

King County - WSU met with King County Housing Authority staff at Newport Apartments to investigate the possibilities for deep energy retrofits at this 100 unit (1960s vintage) apartment complex. This is the first of many potential retrofit projects with the Housing Authority for 2011.

the following measures proposed have been implemented:

- blown in wall insulation plus R4 foam ROXUL sheathing
- high performance triple pane windows
- combination condensing hot water tank and furnace,
- continuous whole house (exhaust only) ventilation.

WSU also provided on-site technical assistance, including infrared testing and HVAC commissioning, with BA partner Fluke. This work will continue in 2011 with BA FSEC/WSU support.

APPENDIX D – Northwest Energy Works Annual Report

January – July 31.2010, the NEEM team performed the following:

By January 2010 Northwest Energy Works (NEW) had taken over from the Oregon Department of Energy to administer the Northwest Energy Efficient Manufactured Home Program (NEEM) and signed contracts with 13 HUD code builders in the Northwest region. Marlette, Kit, Homebuilders Northwest, Skyline, Liberty, Fleetwood of Oregon and Golden West Homes signed up and built Eco-rated homes, a NEEM-developed branding program that expands upon ENERGY STAR requirements to deliver a somewhat more energy efficient and environmentally responsible home. NEW certified a total of 20 Eco-rated retailers and 7 builders. NEW performed over 28 quarterly factory inspection visits and inspected 4 problem homes in Oregon and Washington.

NEW and Ecotope, a Seattle consulting firm, wrote and submitted a proposal to the Bonneville Power Administration, BPA, for utility acquisition program to build super efficient home in each the 13 plants. The proposal seeks to pay a utility incentive to the builder for each home produced, provided the builder agrees to build all of its homes to the NEEM requirements. In the present market, this could mean 3,000 homes per year with all thirteen plants participating.

An unexpected energy measure is being installed in several plants, because the windows being made available to most of the home manufacturers have improved from U=0.34 to U=0.30, likely in response to the new Energy Star window specifications. NEW is monitoring Greenfiber's change its reported thermal performance values, which means that home manufacturers are now changing bag counts and depth gauges used in their building assemblies.

Northwest Energy Works collaborated with program staff from the Energy Trust of Oregon to help them develop promotional materials in support of their NEEM eco-rated homebuyer incentive program.

NEW developed a design for a hybrid zonal electric heating system based on a ductless mini-split heat pump (DHP) located in the main zone of the home with zonal electric resistance supplemental heat in secondary zones in the house. The resistance heating is intended to augment the DHP's output in extremely cold weather and provide adequate comfort heating to secondary zones when interior doors are closed. The overall system design seeks to optimally balance system first costs with system efficiency and occupant ease of use and comfort. To help facilitate a smooth adoption of DHP systems, NEW partnered with the Jeff Pratt from the region's premier DHP distributor and installer with access to all the leading brands of DHP's and developed an industry a price sheet for DHP equipment and installation services. The price includes all materials, charging the system in the factory and warranty on the installation.

NEW and Jeff Pratt held an introductory design session with the NEEM homebuilders in Mr. Pratt's DHP showroom. The excellent dialog scoped the challenges and opportunities the hybrid zonal system presents to manufactured home builders. The builders at the design session expressed a strong desire to be able to offer the option with a single price, regardless of the siting climate zone, NEW researched equipment availability and found Cadet units with variable

capacity. These units allow the builder to standardize home plans in terms of wiring and unit placement, but the builder can move jumper wires to the appropriate terminals to get the necessary heating output for the climate zone. The NEW-designed system allows homebuilders to price the hybrid DHP heating system as a very close to climate blind option. (Homes shipping to parts of Idaho and Montana do require an extra electric heater in the main zone of the home, because the heating design temperature for these areas is below the effective functioning range of the available DHP equipment.)

One home designer and retailer stepped up to be the first to offer a hybrid DHP to his clients, and NEW sized the DHP and supplemental zonal heating units in accordance with ACCA Manual J for three of his home models in the three northwest climate zones. NEW worked with the retailer's builder, Homebuilders NW, in Salem, OR to get DAPIA approval for the ductless hybrid zonal system. NEW and Jeff Pratt inspected the first Eco-rated home to have a DHP installed at the factory. We located the DHP indoor and outdoor units, specified the electrical wire runs and with plant staff determined the location of refrigerant and condensate lines. Homebuilders Northwest built the first Eco-rated homes with a DHP installed in the plant. NEW and Jeff Pratt trained the factory staff on how to install the DHP unit as the home moves down the production line. The system was installed and commissioned in the factory.

Jeff Pratt of the Heat Pump Store traveled to Milwaukie, OR to confirm that the first home with a factory-installed DHP had traveled successfully, without damage to the DHP. NEW staff trained Homebuilders staff on DHP set up and commissioning with the homeowner present. Jeff Pratt went over the manual for the Mitsubishi 1.25 ton DHP that was installed in the factory. Commissioning involved turning the unit on at the breaker box and instructing the Homebuilders NW staff and homeowner on how the DHP operates. NEW is now providing design assistance to Homebuilders Northwest or any other builder, to help to prepare a DAPIA package with a DHP hybrid system for the northern climate zones. Homebuilder's Northwest plant will be building more homes with DHP and electric zonal supplemental heat in the bedrooms/bathrooms.

NEW staff met with a homebuilder of Fife, WA at the Golden West Plant in Albany. They plan to build both HUD and Modular homes at the Albany, OR facility and want to certify them Eco-rated. NEW staff will certify these homes. Follow up duties include heat loss calculations and making homes comply with Eco-rated specs.

NEW staff provided technical assistance to the Northwest Energy Efficiency Alliance (NEEA) by attending a stakeholder meeting and subsequently drafting proposed revisions to Oregon's one- and two- family dwelling code's energy efficiency provisions. NEEA's objective is to improve the energy efficiency requirements of the 2011 code by 10 to 15 percent, compared to the 2008 code.

NEW staff met with Northwest Energy Efficiency Alliance to discuss a NEW/ Fluid marketing proposal to purchase and install 25 DHP in show homes sited at retail centers around the northwest. Fluid is the regional DHP program project coordinator for NEEA and BPA.

NEW trained staff at Valley Manufactured Housing to leak test duct systems. The training helped plant staff develop and implement process changes to facilitate getting the entire duct system, including the furnace plenum, completed in the floor stations, so each floor can be duct tested before any walls are

set on the floor. NEW staff trained three people to perform the duct leakage tests. While periodic duct tests performed by NEW staff over the years have shown this plant consistently achieving tight ducts, the plant staff will now own this function test and receive immediate feedback on their work.

NEEM Homes Reported in 2010

Energy Star/Eco-rated homes produced January 1 to July 31, 2010	
Energy Star electric/gas	641
ECO-RATED electric/gas	132
Total Homes	773