BUILDING AMERICA FIELD TEST PLAN
DRAFT – FEBRUARY 20, 2008

NREL / Building Science Consortium
Coastal Habitats
Hilton Head, South Carolina
Hot Humid Climate Region, 40% Energy Savings Level
Gate 2: Prototype House Evaluation
Expected Test Date: March 13-23, 2008

Description: Coastal Habitats is constructing a series of Building America homes at the Bryant Park community in Hilton Head, SC. Based on analysis by Building Science Corporation (BSC), the homes will reach 30%+ source energy savings compared to the Building America (BA) Benchmark through the use of air-tight spray foam insulation, low-e windows, and high efficiency mechanical systems. The Molly plan proposed here for detailed testing will also have solar domestic hot water (SDHW), resulting in projected source energy savings of 46% over the BA Benchmark. The test house will be at lot 8. An elevation drawing of the Molly is shown in Figure 1, the community layout is shown in Figure 2, and a schematic of the SDHW system is shown in Figure 3. The key specifications are listed in Table 1. The preliminary BSC analysis results are summarized in Tables 2 and 3.

Figure 1: Molly test house front elevation.

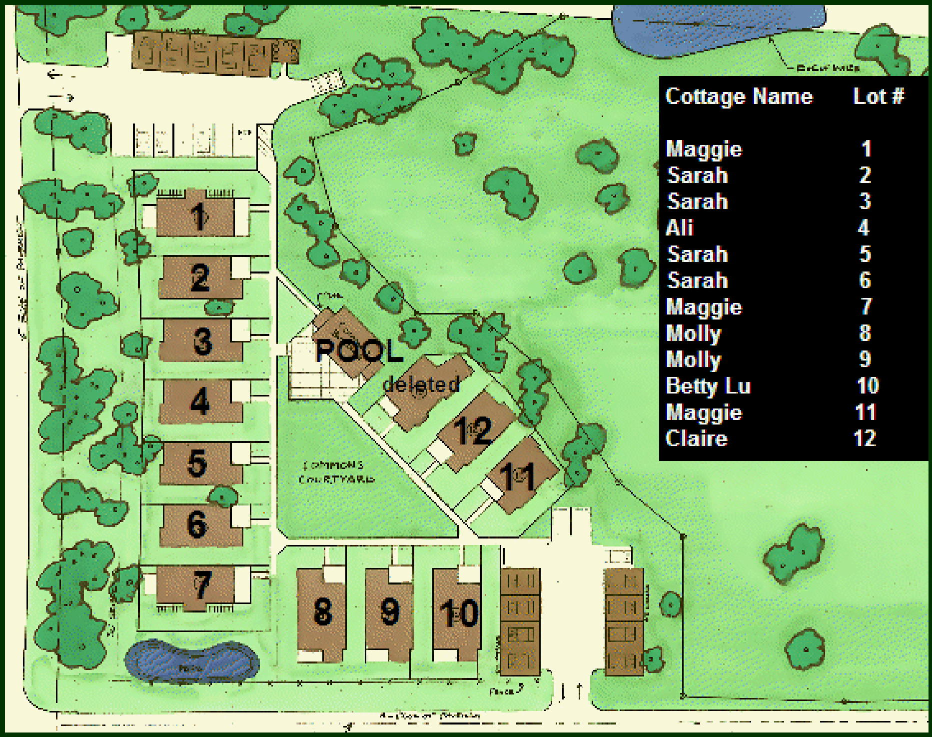

Figure 2: Bryant Park Cottages Site Plan

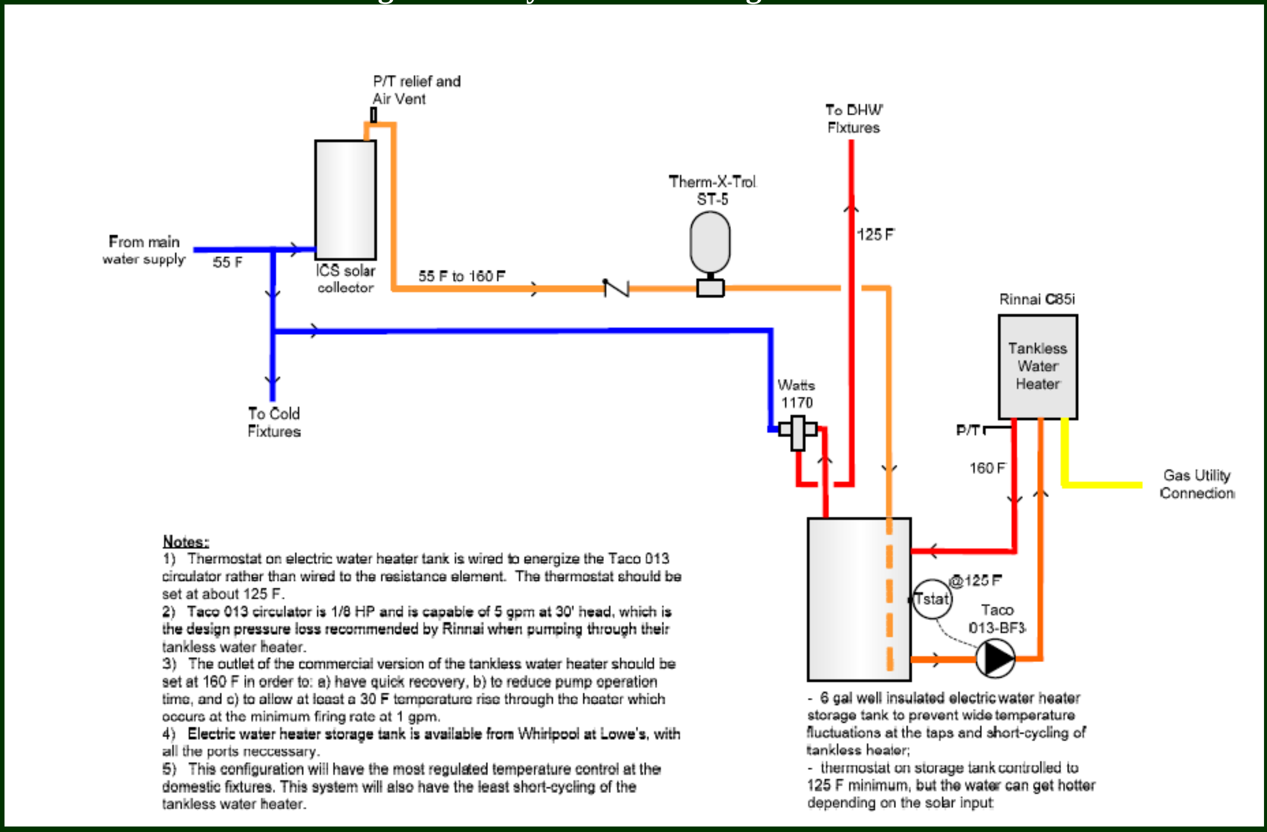

Figure 3. Schematic of the water heating system, in a hybrid configuration designed to avoid shortcomings of integrating a tankless hot water heater with solar pre-heat.

One focus of the field test will be the 50 gallon 32 ft^2 integrated collector-storage (ICS) solar hot water system, which will be coupled with a tankless water heater. A potential problem when using solar preheat with a tankless gas water heater is that the preheated water can be in a temperature range too low for use as hot water, but too high to be heated by the tankless water heater to a suitable temperature at its minimum firing rate. This issue is addressed in the design developed by BSC and illustrated in Figure 2. Mains water will first flow through the TCT ProgressiveTube® collector then into a small storage tank where the hot water will be topped off as needed by a pumped loop to the tankless water heater. Hot water is not provided directly by the tankless water heater. A larger than normal pump (6 gpm) is used to ensure that the water provided by the tankless heater is maintained near the 120ºF setpoint. A mixing valve will be installed on the outlet of the domestic water heater to prevent overheated water from going to fixtures when the solar collector heats the storage tank about 120ºF. This design should also avoid the possibility of hot water draws that are not met because the flow rate is too low for the tankless water heater.

We will also evaluate the performance of a next generation ventilation controller being developed by BSC and Lipidex Corporation. This controller will combine the operation of a separate exhaust ventilation fan with Central Fan Integrated Supply (CFIS) ventilation. The purpose of this coupling is to lower the ventilation costs and meet the recommendations of ASHRAE 62.2 by operating the ventilation fan instead of the CFIS when heating or cooling are not called for.

Table 1: Molly test house characteristics.

	Building America Version
Building envelope	
Ceiling	R-34 cathedralized attic
Walls	R-20 Icynene + 1" R-1.25 XPS
Foundation	Slab on grade exposed
Windows	Spectrally Selective LoE2 U=~0.32, SHGC=~0.33
Skylights	Spectrally Selective LoE2 U=~0.48, SHGC=~0.33
Infiltration	2.5 sq in leakage area per 100 sf envelope
Mechanical systems	
Heat	8.5 HSPF air source heat pump with AHU in conditioned space
Cooling	16 SEER air source heat pump with AHU in conditioned space
DHW	0.82 EF propane instantaneous water heater with solar preheat; 50 gallon 32 ft^2 integrated collector-storage (ICS) solar system; TCT ProgressiveTube® collector
Ducts	R-4.2 flex runouts in dropped ceiling or in floor joists
Leakage	none to outside (5% or less)
Ventilation	CFIS coupled with extra ventilation fan - Next generation controller
Dehumidification	Aprilaire 1700 coupled with HVAC supply plenum

Table 2: Predicted Annual Site Energy Comparison

	Annual Site Energy			
	BA Benchmark		**BA Prototype**	
End-Use	kWh	therms	kWh	therms
Space Heating	3036	0	1033	0
Space Cooling	4770	0	1489	0
DHW	0	196	0	95
Lighting*	1610		545	
Appliances + Plug	4240	126	3790	126
OA Ventilation**	41		57	
Total Usage	13697	322	6914	221
Site Generation	0	0	0	0
Net Energy Use	13697	322	6914	221

Table 3: Predicted Annual Source Energy Comparison

	Estimated Annual Source Energy		Source Energy Savings	
			Percent of End-Use	Percent of Total
	Benchmark	**Proto**	**Proto savings**	**Proto savings**
End-Use	10^6 BTU/yr	10^6 BTU/yr		
Space Heating	33	11	**66%**	**12%**
Space Cooling	51	16	**69%**	**20%**
DHW	20	10	**52%**	**6%**
Lighting*	17	6	**66%**	**6%**
Appliances + Plug	59	54	**8%**	**3%**
OA Ventilation**	0	1	**-39%**	**0%**
Total Usage	181	97	**46%**	**46%**
Site Generation	0	0		0%
Net Energy Use	181	97	46%	46%

Research Questions:

1. What are the basic air leakage and flow characteristics of each house measured using a blower door, duct blaster, and flow hood? (Short term testing)
2. What is the hourly air infiltration of each house during the spring season, with and without the air handlers operating? With the outside air duct sealed and unsealed? (Short term testing)

3. Is the maximum room-to-room pressure differential below the design goal of 3 Pa? (Short term testing)
4. What is the projected fraction of total hot water load met by the solar hot water system? (Short-term testing and simulation) What is the actual fraction? (Long-term monitoring) What is the economic value of the solar hot water system in terms of annual energy cost savings? (Simulation)
5. What is the overall energy factor (EF) of the DHW system with solar hot water inter-tie using the small storage tank to moderate temperature fluctuations and eliminate short-cycling of the tankless water heater? (Short-term testing) How much does the storage tank reduce the EF of the tankless water heater? What is the difference in annual energy use for the installed hot water system compared to a stand-alone tankless propane water heater using Benchmark operating conditions and TMY2 weather conditions for Savannah, GA? (Short term testing and simulation)
6. Is there potential for unstable hot water supply temperatures when the hot water tank, the 6 gpm pump, and the mixing valve are removed from the system or de-activated? If so, across what combinations of flow rate and solar water heater delivery temperature does the problem occur (note: define test matrix with inlet water temperature controlled between 70ºF and 120ºF at 10ºF increments and flow rates from approximately 0.5 (sink) to 2.5 gpm (shower))? (Short-term testing) How large are the temperature fluctuations, and over what time period to they occur? (Short-term testing) How frequently are these conditions expected to occur assuming Benchmark event schedules and the expected solar hot water outlet temperature using TMY2 weather data? (Simulation) Does the addition of the tank and pump avoid or mitigate the problem? (Short-term testing) What alternative solutions are available, and how does the annual energy use for those approaches compare to the tested system design? (Simulation)
7. Is there potential for low flow hot water draws to be unmet by the tankless system when the solar system, the hot water tank, the 6 gpm pump, and the mixing valve are removed from the system or de-activated? (Short-term testing) How frequently are such low flow rates expected to occur assuming Benchmark event schedules? (Simulation) If it assumed that occupants will increase the flow rate as necessary to ensure hot water delivery, what is the increase in annual energy use caused by this effect? (Simulation) Does the addition of the tank and pump avoid or mitigate the problem? (Short-term testing)
8. What is the difference in air exchange and energy consumption with the Enhanced System Ventilation Controller in various settings (balanced vs. unbalanced and intermittent vs. continuous)? (Short-term testing) What is the projected energy savings of the enhanced ventilation controller compared to a continuous exhaust fan with the same nominal flow rate per ASHRAE Standard 62.2? Compared to a central-fan integrated supply ventilation system with the same average flow rate? (Simulation)
9. How uniformly distributed is outside air when using the Enhanced System Ventilation Controller to energize the air handler for 10 minutes every hour, and energizing a single-point exhaust fan the rest of the time? (Short-term testing)
10. What are the air distribution characteristics of the CFIS, the stand-alone exhaust ventilation fan and the two combined using the intended control strategy during actual weather conditions? Are the decay curves sufficiently stable to accurately calculate reciprocal age-of-air? (Short-term testing)
11. How repeatable are the reciprocal age-of-air measurements under significantly different weather conditions at night an during the day? (Short-term testing)

12. What are the pros and cons of using the room mixing fans in the outside-air distribution test protocol? (a) How much does the age-of-air vary within a room during the decay test, when there is no mixing? (b) How much do the room mixing fans change the amount of room-to-room variation in age-of-air? Does the shape of the decay curve vary within a room when there is no mixing? (Short-term testing)
13. What is relationship between outdoor weather conditions (temperature, wind speed, wind direction) and interzonal airflows for the test house? How large are the errors introduced into the reciprocal age-of-air calculations by the actual weather conditions during each test? (Short-term testing)
14. What is the predicted annual energy use of the dehumidifier? (Simulation) How frequently would the indoor relative humidity exceed 60% for more than 4 hours without the dehumidifier? (Simulation) What is the moisture removal rate of the dehumidifier compared to the heat pump over the course of a year? (Long term monitoring) What is the relative humidity in different parts of the house under various weather conditions? (Long-term monitoring)
15. What is the projected annual energy savings of the test house compared to the Benchmark, Regional Standard Practice, and Builder Standard Practice? (Simulation)
16. What is the energy use of the test house under occupied conditions? (Long term monitoring) How does the actual energy use compare to the simulations when actual weather and operating conditions are used? (Simulation)

Preliminary Time Frame: The first building should be available for testing on March 13, 2008.

Day #1 (March 13)	Arrive at site and meet with Coastal Habitats representative for keys to house. Transport equipment from NREL to test house.
Days #1-10	TBD testing of the system.
Day #10	End test and transport equipment back to NREL.

Requested Action Items for Team and Builder:

1. Let NREL know with as much advance notice as possible when this house will be available for testing.
2. Have the house fully finished prior to testing if possible.
3. Install instrumentation and additional piping to DHW system in accordance with Figure 4.
4. Have any building commissioning activities deemed necessary by the team performed prior to testing (i.e., balance air distribution system).
5. Conduct full battery of performance testing including. This includes blower door, duct blaster, HVAC static pressures, register flows, and ventilation measurements.
6. Inform NREL test engineer if builder or sales personnel require access to the house while testing is underway.

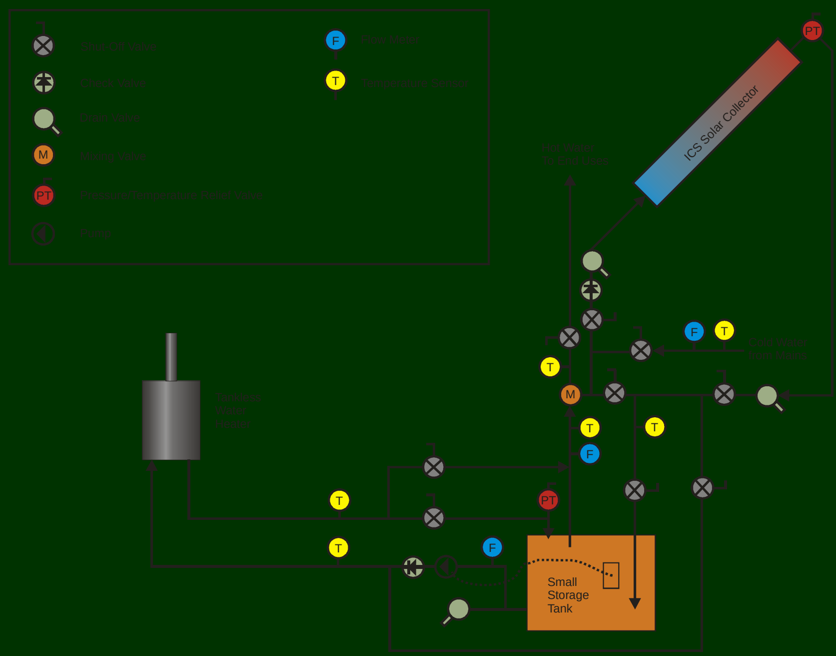

Figure 4. Locations of flow meters, temperature sensors, and bypass loops.

Directions

Jobsite: 625 Spanish Wells Road, Hilton Head, SC 29926

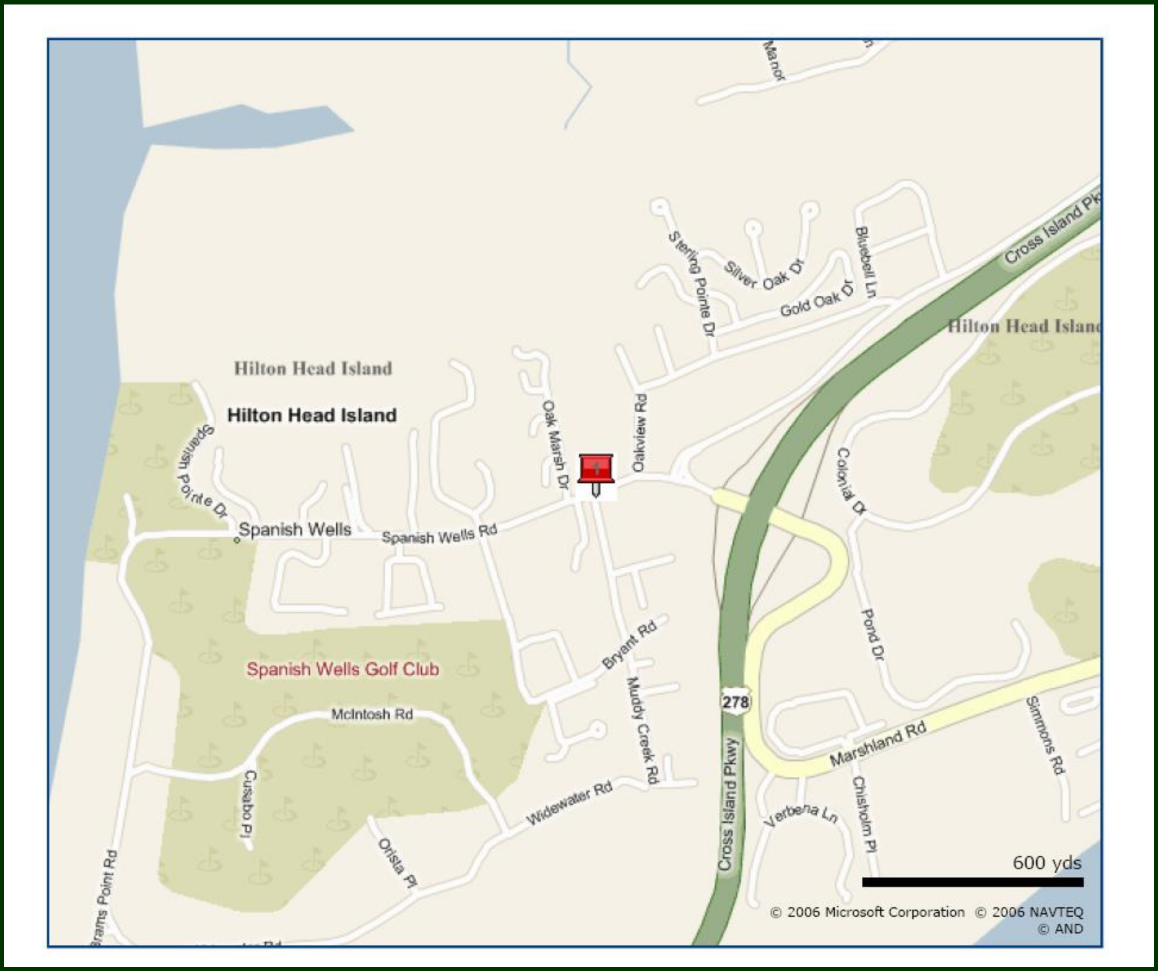

Figure 3: Bryant Park Cottages Site Location

Contacts:

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DEVELOPMENT WEB SITE HTTP://WWW.BRYANTPARKCOTTAGES.COM/

BUILDER WEB SITE HTTP://WWW.COASTALHABITATS.NET/