U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES PROGRAM

Test Plan: Environmental, Energy and Moisture Monitoring for Winchester/ Camberley Homes' NCTH

Mixed Humid Climate

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July 2011

Building America® U.S. Department of Energy

Prepared by the NAHB Research Center
For the U.S. Department of Energy Building Technologies Program

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Energy Usage and Moisture Monitoring Test Plan for a High Performance House with Winchester/Camberley Homes Mixed-Humid Climate

Prepared for:

Building America

Building Technologies Program

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U.S. Department of Energy

Prepared by:

NAHB Research Center

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Upper Marlboro, MD 20774

July 2011

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Contents

List of Figures

List of Tables

Definitions

DOE	Department of Energy
HPH	High Performance Home
IAQ	Indoor Air Quality
IECC	International Energy Conservation Code 2009
MC	Moisture Content
OSB	Oriented Strand Board, typically used as wall and roof sheathing
R&D	Research and Development
RH	Relative Humidity
WHI	Winchester Homes, Inc. and Camberley Homes

Executive Summary

Winchester/Camberley Homes is partnering with the NAHB Research Center on a new construction test home (NCTH) in Silver Spring, MD in the mixed humid climate. The Building America goals for this test home are twofold: 1) to develop and implement optimized framing, air sealing, and insulation systems that increase the wall insulation level by 30% and improve air sealing effectiveness with minimized cost increases, and 2) integrate the envelope and space conditioning systems into a high performing home design that can be constructed on a production basis using quality management practices. As a BA test home, this home will be evaluated to detail energy use as well as wall moisture performance.

1 Energy and Moisture Performance of HPH

1.1 Introduction

Major changes to residential construction methods can be accompanied by an absence of focused design details, product specifications, and quality installation techniques. This is a significant concern for production builders where any changes to the house design can be costly. In addition, these details are needed so that the work force is trained for the product(s) and to mitigate warranty issues that may result long after a house has been purchased and occupied. Furthermore, increasing consumer expectations are resulting in the need to meet claims of energy efficiency with realized savings and are complimented by stated benefits such as indoor comfort and good indoor air quality.

One major change to residential wall construction is increasing insulation and air sealing in high performance homes. As a result, many builders have experienced wall moisture issues in homes that were considered to meet Energy Star levels of performance such that an investigation and test of example homes is underway[1]. Issues of moisture levels on and in sheathing in heating climates in walls with higher levels of permeable insulation have been raised throughout Building America research activities as well as other sources. As an example, walls in the mixed humid climate will have a moisture drive to the inside during cooling season with the drive reversing in the heating season, indicating that walls should be designed to dry in either direction. Highly insulated and well sealed wall cavities can result in less water vapor being introduced into the cavity but also less opportunity for drying since the diffusion characteristics of the individual layers plays a much larger role in the moisture performance of the wall system. Higher levels of cavity insulation have also been linked to colder (non-insulating) sheathing temperatures. Changes in the wall system design to increase the thermal performance coupled with use of new materials with different diffusion and moisture handling characteristics will result in changes with how the wall system responds to water vapor moving through exterior wall cavities. Furthermore, many builders who install costly hardwood finishes are concerned with the humidity levels in the home through the heating season and often install mechanical humidifying equipment that may exacerbate wall moisture problems.

This test plan provides a methodology to characterize the performance of a new construction test home (NCTH) related to energy usage, indoor environmental conditions, thermal comfort, and wall cavity response to interior and exterior thermal and moisture drives. The data obtained through this monitoring effort is expected to provide empirical evidence of the wall system moisture performance throughout multiple seasons and changing indoor environmental and HVAC operating conditions. This data will be combined with energy consumption data and ventilation data to provide an overall characterization of the whole house energy and moisture performance that can then be used to compare with models that predict such results.

1.2 Background

Under the Building America Program, production builder Winchester Homes Inc.'s (WHI) Camberley Homes subsidiary teamed with the NAHB Research Center through the NAHB Research Center Industry Partnership to design and construct a new single family detached home that uses 30% less energy than a comparable house that meets the 2009 International Energy

[1] Current Building America research includes wall moisture performance in High Performance homes and wall systems.

Conservation Code (IECC). With technical support from the NAHB Research Center, the builder selected design elements, technologies, and construction methods that minimize cost increases while achieving substantive energy savings and maintaining whole-building performance metrics of durability, comfort, and suitable indoor air quality. The design is a commercially viable energy efficiency solution package for the mixed-humid climate that addresses Building America and builder partner energy efficiency and cost goals.[2]

The builder planned the 3-story, 4,441 finished square foot house to be tightly air sealed with a single zone natural gas furnace and split system air-conditioner serving all floors including the finished below grade basement. To ensure moisture control and good indoor air quality, controlled mechanical ventilation is required in this tight house. Ventilation is delivered through fresh air distribution and filtration supplied by a supply-only, central-fan-integrated design in which outdoor air is ducted to the return side of the central HVAC system. This supply side ventilation system is complimented by automatically controlled exhaust bath fans. The ventilation system is capable of meeting ASHRAE 62.2 ventilation levels. The fresh air supply is conditioned when the HVAC system is operational and includes a motorized damper and electronic control tied to the house thermostat.

1.3 Relevance to Building America's Goals

With support from DOE and the Research Center, WHI developed a market-ready energy solution that improves the energy efficiency of new homes in a mixed humid climate zone, while increasing comfort, safety, durability, and marketability.[3] The solution package is expected to be incorporated in the new home designs for WHI's Camberley division (nearly 100 homes planned) with the first set of homes being constructed at the Poplar Run subdivision in Silver Spring, Maryland. In addition, many of the nation's leading production builders are actively building new home communities in the Washington, DC, area and the project location of this Building America High Performance Home (HPH) will help builders and sales associates better understand the market appeal of the model and its energy efficiency features.

The Winchester/Camberley model test home, as built with both the optional finished basement and third floor is 30% over the Building America B10 Benchmark. The preliminary energy simulations included both a cost optimization and source energy savings analyses. Through optimization, BEopt produces a set of options that provide the highest energy savings for the lowest investment costs, within the limits of the software and cost data. Figure 1 graphically depicts the simulation results.

[2] *Commercially Viable Energy Efficiency Solution Package*, NAHB Research Center, December 2010.
[3] http://www1.eere.energy.gov/buildings/building_america/program_goals.html

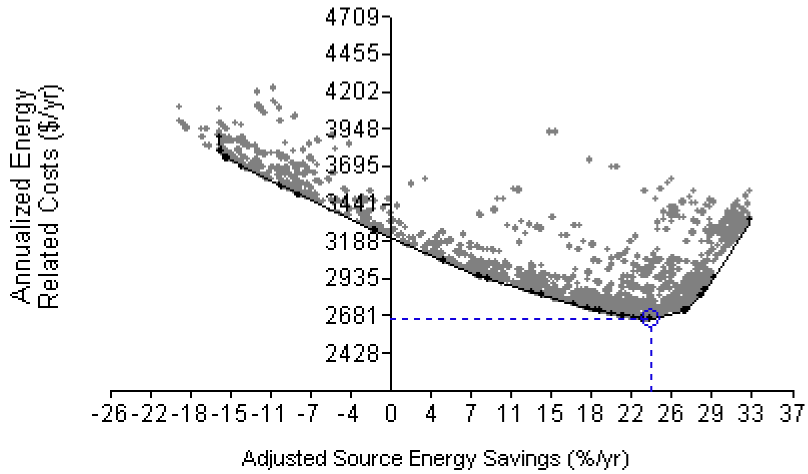


Figure 1. BEopt simulation results

The "swoosh" shape of the graph indicates that the minimum annualized energy cost occurs at source energy savings of approximately 24% (indicted by blue dotted lines). Before reaching the minimum cost point, investment in energy savings measures decreases annualized energy costs (mortgage plus utilities) at a roughly linear rate. Just beyond the minimum (after about 27% source energy savings), additional energy savings are attainable, but the investment needed to attain incremental efficiency gains rises sharply. For example, meeting the project goals of 30% energy savings requires an approximately 10% higher annualized energy cost than would reaching 27% savings. The results indicate that, for this home design in the Washington, DC, area, the maximum practical energy savings for production builders is near the 30% level. Attaining higher energy savings requires a better understanding and experience with new technologies, construction methods, and the benefits of efficiency investments.

The second simulation analysis consisted of preliminary source energy savings estimates. Although the test home is anticipated to reduce the home's energy consumption by 30% over the B10 Benchmark, the as-built design (which will serve as a model home and, as such, includes nearly 2,000 s.f. of optional conditioned space) is subject to a size penalty that reduces overall projected savings. Because of the additional conditioned space, the Building America program administers a penalty (which is manifested in a source energy reduction for the B10 Benchmark design). Figure 2 shows source energy use for the B10 Benchmark and the final house design. The size penalty reduces theoretical source energy savings (SES) by about 7%.

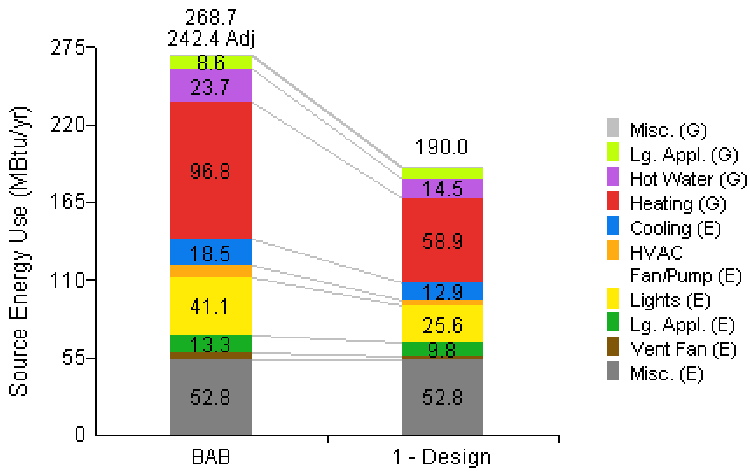


Figure 2. Source energy savings for energy efficient design compared to the B10 Benchmark
(Adjusted source energy use includes a penalty for the energy efficient design's additional square footage.)

The preliminary cost savings, which are not subject to a size penalty, are estimated to be about $1,100 per year. Components of the savings are depicted in Figure 3.

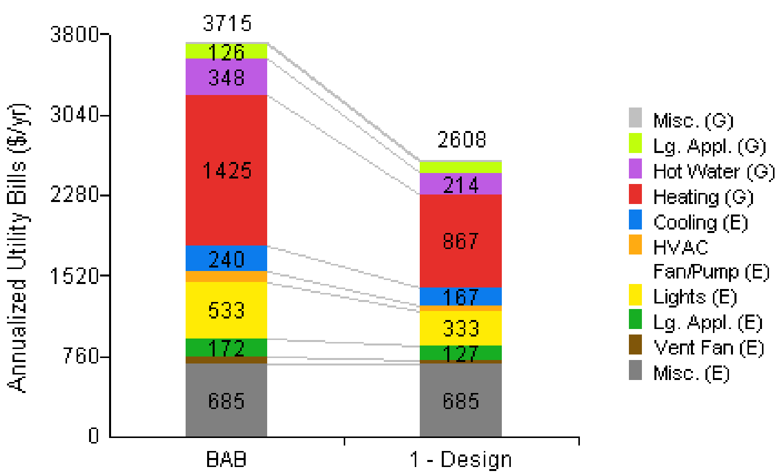


Figure 3. Annualized utility bill comparison for B10 Benchmark and energy efficient design

For a house having the same energy efficiency solution package but that does not include the 700 s.f. above-grade finished attic space nor the 1,300 s.f. finished basement, a 30% source energy savings (with a 1% size penalty) is predicted. Results are shown in Figure 4 and Figure 5.

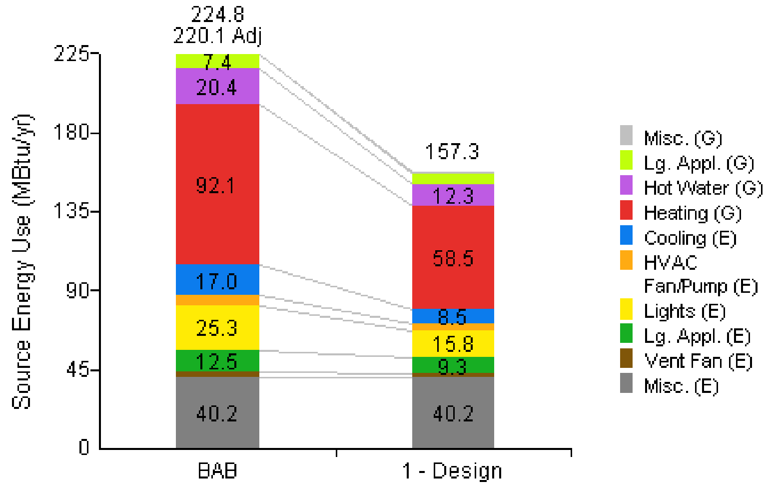


Figure 4. Source energy use for B10 Benchmark and Energy Efficient Design
(for house without 3rd floor bedroom and finished attic)

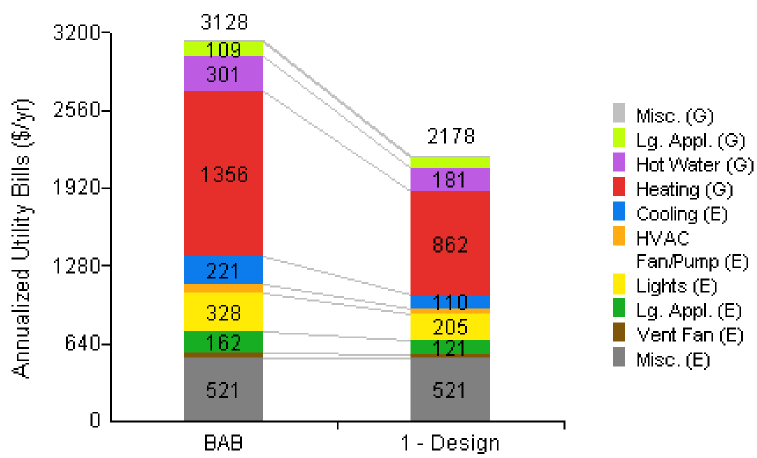


Figure 5. Annual utility bills
(for house without above-grade finished space)

1.4 Cost Effectiveness

Initial cost estimates for the energy efficiency features are anticipated to be available from the builder but were initially estimated in a solution package described in a December 2010 report[4]. Table 1 summarizes the options selected and the preliminary cost of each. Comparing the third and last columns underscores the discrepancy between BEopt's (version 1.0.1) cost library and realistic, regional costs that were discovered by the NAHB Research Center (see Supporting Research section for a discussion). Therefore, the builder's estimated incremental costs (above the standard practice) were input into the BEopt software to provide results with which the researchers had a high level of confidence. For the package of energy efficiency solutions, the estimated incremental cost to the builder is $9,763. Because accurate costs are essential to providing meaningful BEopt results, costs will continue to be refined throughout the project. Based on original estimates for the upgrades and energy savings, a payback period of less than

[4] Commercially Viable Energy Efficiency Solution Package, Mixed-Humid Climate, NAHB Research Center for the Building America Program, December, 2010.

ten years appears reasonable. The results from this test house and further analysis will provide confirmation of the cost effectiveness for these upgrades.

Table 1. Preliminary Estimated Costs of Energy Efficiency Options

Group Name	Category Name	BEopt's Incremental Capital Cost	Current Option Name	Ref Option Name	Builder's Incremental Capital Cost
Building	Orientation	$0	Southwest	Same as Prototype	
	Neighbors	$0	at 20ft	None	
Operation	Heating Set Point	$0	71 F		
	Cooling Set Point	$0	76 F		
	Misc Electric Loads	$0	1	4599 kWh	
	Misc Gas Loads	$0	1	11 therms	
	Misc Hot Water Load	$0	Benchmark	70.0 gal/day	
	Natural Ventilation	$0	Benchmark		
Walls	Wood Stud[F]	$2,047	R23 blown 2x6 24"	R13 batts 2x4 16"o.c.	$3,088
	Exterior Finish	$0	Gray Vinyl Siding	Abs=0.60 Emiss=0.90	
	Interzonal Walls	$322	R-23 blown 2x6 24"	R13 batts 2x4 16"o.c.	
Ceilings/Roofs	Unfinished Attic	$97	Ceiling R49 FG Blown	R38 Ceiling SLA=0.00333	$100
	Roofing Material	$0	Asphalt Shgls. Med.	Abs=0.75 Emiss=0.90	
	Radiant Barrier	$0	None		
Foundation/Flo	Finished Basement[C]	$0	R-13 2x4 at 24"	8-ft R10 Rigid	
	Exposed Floor	$0	20% Exposed	None	
Thermal Mass	Floor Mass	$0	Wood Surface		
	Ext Wall Mass	$0	1/2" Drywall		
	Partition Wall Mass	$0	1/2" Drywall		
	Ceiling Mass	$0	1/2" Ceiling Drywall		
Windows & Sh	Window Areas	$0	Camberley A; 554 sf	416 sf; 25%/side	
	Window Type	$0	U-.31 SHGC-.28	U-0.35 SHGC 0.35	
	Interior Shading	$0	Benchmark	Benchmark (0.70)	
	Eaves	$0	1 ft	2 ft	
Airflow	Infiltration	$1,918	NGBS 1.3ACH50; elastomeric seal[A]	SLA=0.00036	$1,910
	Mechanical Vent.[B]	$0	Supply 100%: A-62.2	Exhaust 100% 84 WH cfm	$600
Major Applianc	Refrigerator	$200	EnergyStar S-by-S	Standard (669 kWh)	$200
	Cooking Range	$0	Gas Conventional	Gas (33 therms)	
	Dishwasher	$0	EnergyStar	Standard (204 kWh)	
	Clothes Washer	$270	EnergyStar	Standard (90 kWh)	$270
	Clothes Dryer	$0	Gas	Gas (46 therms 100 kWh)	
Lighting	Lighting	($35)	100% Fluorescent/CFL	Liv 2893 Grg 0 Ext 685 kWh	$126
Space Conditio	Air Conditioner	($261)	SEER 15	SEER 13 (11.09 EER)	$1,014
	Furnace[E]	$604	Gas AFUE 92.5%	Gas AFUE 78%	($859)
	Ducts[D]	$0	In Finished Space	Uninsulated ducts	$2,414
	Ceiling Fans	$0	Benchmark		
Water Heating	Water Heater	$900	Gas Tankless Cond.	Gas 50 gal 0.57 EF	$900
	Distribution	$0	Trunk&Branch PEX	R-0 TrunkBranch Copper	
	Solar DHW	$0	None		
	SDHW Azimuth	$0	Back Roof	None	
	SDHW Tilt	$0	Roof Pitch	None	
Power Generat	PV System	$0	0 kW		
	PV Azimuth	$0	Back Roof	None	
	PV Tilt	$0	Roof Pitch	None	
HVAC Sizing	Cooling Capacity	$0	3.5 tons	3.0 tons	
	Heating Capacity	$0	60kBtu/hr	70 kBtu/hr	
Total Incremental Capital Cost		$6,062			$9,763

This test plan will outline the effort to document the post-construction performance and energy savings. Other monitoring goals include the effect on comfort (as described by room temperatures, temperature gradation between floors, and relative humidity), and durability (based on moisture and temperature conditions in the wall cavities). The importance of this monitoring effort lies in its relevance to both the builder and the Building America Program. For the builder, the monitoring results will help redefine the test home into a production design so as to move forward with confidence that the investment in the energy efficiency features is an achievable, reliable and marketable approach for future house designs. For the Building America Program, the monitoring effort will add empirical data that these specific advanced design features can be successfully and cost effectively implemented by production builders in this climate.

1.5 Trade-Offs and Benefits

Many of the energy efficiency features incorporated into the home design are new to the builder and trade contractors. Many of the features require a learning curve that will subsequently be evaluated for success and opportunities for improvement as the testing results emerge. In addition, the consumer comfort, defined in terms of the interior operating conditions, is vital to the ongoing implementation of the advanced features and construction methods. The monitoring effort will allow time for documentation of the energy use, the specific operation of the HVAC system and the wall cavity moisture response through numerous seasons and interior conditions. The high performance home is the builder's model home, thus, the house will see considerable traffic from consumers which creates a showcase demonstration HPH for mainstream energy efficient new construction as the builder has placed the energy efficiency features on numerous displays and videos within the model. The house will likely see usage extremes to the high and low ends of usage for various systems (e.g. lighting in a model is typically higher whereas hot water usage is typically lower than an occupied home). The model home presents the opportunity to inform and educate about the energy efficiency features.

2 Experiment

2.2 Research Questions

Use of this High Performance Home for testing and evaluation is critical in addressing the following research questions:

- Based on the redesigned single-zone duct air delivery system, how consistent are the interior temperatures on the four levels of the home and how do these temperatures change throughout the day during summer peak cooling days and winter peak heating days?
- Is the measured energy use for heating and cooling consistent with modeled estimates given similar ambient weather conditions?
- Are the HVAC elements – furnace, compressor, thermostat, humidifier, and fresh air supply damper operating as designed and in an optimal manner?
- How do the wall cavity environmental conditions change with seasonal interior and exterior conditions and are the sheathing moisture characteristics within expected swings?
- How do the wall cavity moisture characteristics compare with modeled results in WUFI software?

- Is there anecdotal evidence of the marketplace response to the costs, features, and interior conditions of the house from the builder, potential buyers, trades or manufacturer partners?

2.3 Technical Approach

The package of energy efficiency solutions in this NCTH results in predicted energy savings of 30% over a theoretical 2010 Building America Benchmark home (B10 Benchmark) that meets the minimum requirements of the 2009 International Energy Conservation Code. The predicted savings are based on a preliminary energy simulation of WHI's NCTH using BEopt. To document the efficiency of the high performance construction features, a plan to monitor energy usage, conditions within select wall cavities, and indoor air conditions (temperature and relative humidity) was devised. Table 2 covers a brief description of the test methods employed and purposes.

The layout of the temperature/RH/MC sensors is detailed in Appendix A.

Table 2. Test and Monitoring Parameter Description

Parameter of Interest	Test Method	Purpose
House infiltration rate	Blower door test and diagnostic evaluation	• After Drywall - assess primary leakage paths and remediate • At Construction Completion - provide overall infiltration rate and locate remaining major leakage paths
HVAC duct tightness and overall duct system performance	Duct Blaster test; Air handler and diffuser flow rates, Room pressure differentials	• Duct System Rough-In – assess leakage and remediate; repeat tests • At Construction Completion – characterize overall air delivery system
Ventilation system performance	Balometer and hot wire anemometer measurements	• At Construction Completion – measure supply ventilation air flow rate and exhaust fan flow rates. Measure house depressurization during exhaust fan operation
Whole House Electric	Energy transducer and recording devices	• Record whole house electricity use • Identify a demand profile
Space Conditioning equipment	Energy transducer and recording devices	• Document the operation of the HVAC system relative to interior setpoints and exterior ambient drivers
Indoor Environment	Temperature/Relative Humidity (RH) sensors • 5 sensors in conditioned area of the house located on each floor • 1 sensor located in supply duct • 1 sensor outside • Periodic surface temperature measurements	• Analyze the operation of the HVAC system relative to interior and exterior temperature and humidity drives • Document the operation of the supply ventilation system • Analyze temperature stratification through the 4 level home • During peak conditioning periods, document the interior surface temperatures (perform the same tests on a standard wall system by the builder in the same development) • Assess ventilation performance

Parameter of Interest	Test Method	Purpose
Wall Cavity Environment	Temperature/ RH/ Moisture Content (MC) • Sensors placed in wall cavities of basement, first, second, and third floors, and roof	• Monitor wall cavity conditions and sheathing moisture content in high thermal value wall system with elastomeric air seal • Characterize the diurnal and seasonal moisture performance • Provide data for comparison with moisture models
Other	TBD	• Additional short term tests or monitoring devices may be added based on ongoing measured data inspections, and/or field performance reported by builder staff or consumers

2.4 Measurements

Based on Table 2 above, the individual short-term tests and longer-term monitoring will provide the following general performance characteristics of the High Performance Home design: HVAC system capability to maintain the desired indoor environment relative to the overall system design including duct layout and system size, Energy use of the space conditioning equipment relative to the ambient drives and internal loads, and Wall cavity and sheathing environmental conditions relative to exterior and interior drives across seasons.

The measurements used to achieve these research goals are described in Table 2. The data will be processed seasonally with partial data available for the cooling season 2011, the heating season 2012 and the cooling season 2012.

2.5 Equipment and Communications

Table 3 outlines the measurement parameters and the equipment needed to obtain accurate and reliable measurements.

Table 3. Research Measurements and Equipment

Measurement	Equipment	Test Type
Infiltration Rate	Blower door apparatus	Short-term characterization test
Duct Loss	Duct blaster apparatus	Short-term characterization test
Air Handler and duct flow rates	Trueflow® grid, balometer, hot wire anemometer	Short-term characterization test
Temperature, Humidity, Moisture Content	Omnisense S-900 wireless sensor	Long-term monitoring
Electric energy	Watt Node transducers and associated current transformer sizes	Long-term monitoring
Gas valve on-time	Low-current switch	Long-term monitoring
Data Recording - Temperature/Humidity/MC	Omnisense Gateway connected to protected website	Long-term monitoring

Measurement	Equipment	Test Type
Data Recording – Energy, runtime, etc.	Campbell Scientific data logger, modem	Long-term monitoring

Short-term characterization tests outlined in Table 3 above include infiltration, duct loss, and flow rates. Long-term monitoring will include sensors that record temperature, relative humidity, and moisture content are intended to be located within specific exterior wall cavities of the HPH prior to insulation and drywall installation (See Appendix A for location plan). These sensors measure 2 ½" x 1 ½" x 2 ½" and are installed with stainless steel screws fastened directly to the wall sheathing. The sensor shape places the temperature and RH measurement two inches from the sheathing surface. The moisture content is measured based on the conductivity of the sheathing and calibrated based on the sheathing temperature. Sensors are equipped with a long-lived battery fueled wireless transmitter capable of a transmission range of up to 100 meters. A receiver/modem located within the home receives and uploads data at pre-programmed intervals to a central server via an internet connection. Figure 6 shows an example of an installed sensor.

Figure 6. OmniSensors Installed in Wall Cavities

3 Analysis

All data streams from long-term monitoring equipment will be analyzed and summarized either by totals or averages for a given period or season. Various data streams will be reported together such as interior, exterior, and wall cavity environmental conditions and sheathing moisture content. Heating and cooling energy use will be reported based on interior and exterior environmental conditions.

Wall cavity moisture measurements will be used to compare with models of wall systems developed with WUFI software. HVAC energy will be used to compare with energy models developed with BEopt or other modeling software estimates and calibrated to the internal loading conditions measured for the analysis period.

4 Expected Results

4.1 Overview

The research and data is expected to provide documentation that the HVAC system design coupled with the advanced framing and insulation system will function as intended, providing the interior comfort levels desired. The builder has made significant investment in the changes to the construction plans that demonstrate major changes to the typical construction process. The architectural and engineering teams have modified numerous details to accommodate thicker wall dimensions, sometimes significantly updating structural interactions and typical wall layouts. The trades have been required to modify large sections of their work scope and the learning curve for mechanics is often steep. This NCTH and the associated data stream will help verify that these efforts are fruitful and cost effective.

The research data is also expected to confirm that the wall system design utilizing high levels of cavity insulation and detailed air sealing will not result in problematic moisture issues within the wall cavity. This specific data will also be added to a larger database of wall cavity moisture performance being concurrently researched through the Building America program.

4.2 Integration Opportunities

This research afforded by the Building America program will lead directly to significant changes to the builder's construction methods and ultimately to large reductions in energy use in their new home designs. Based on these results, the builder will also consider making changes to current home designs – a large commitment and investment, but eventually affecting thousands of new homes.

An important aspect to this NCTH research is the consumer response to the high level of energy efficiency and the added cost of the home. Whereas the builder has incorporated many of these advancements in their higher-end home designs where the added cost is not as large a percentage of the total home cost, the largest benefit will be to understand the consumer demand to accept and purchase these changes as well as the opportunity for the builder to reduce costs as familiarity with the systems by designers, trades, code officials, and builder staff develops.

5 Logistics

5.1 Location

The NCTH is located in Silver Spring, Maryland and is part of the Poplar Run subdivision. The subdivision will eventually site 700 homes, 100 of which are expected to incorporate these advanced high performing designs. Based on the consumer acceptance of these features and systems and based on the performance of the system as measured in this research project, some of the remaining 600 homes may be offered with options to incorporate these advanced designs.

5.2 Contact Info

Partners involved in this project are outlined in Table 4.

Table 4. Key Project Partners

Key Project Partners	Contact Person	Contact Email	Contact Phone
Winchester Homes, Inc.	Randy Melvin	randy.melvin@whihomes.com	301-803-4791
iLevel (Weyerhaeuser)	Jeremy Dummer	jeremy.dummer@weyerhaeuser.com	651-637-0449
Owens Corning	Don Kosanka	don.kosanka@ownescorning.com	419-248-7952
Carrier Enterprise	Tom Windmiller	Thomas.P.Windmiller@carrierenterprise.com	
All Temp (HVAC)	Jeff Green	jeff@alltemphvacinc.com	410-467-3311
NAHB Research Center	Amber Wood Dave Mallay Joe Wiehagen	awood@nahbrc.com dmallay@nahbrc.com jwiehagen@nahbrc.com	301-430-6309 301-430-6209 301-430-6233

5.3 Detailed Timeline

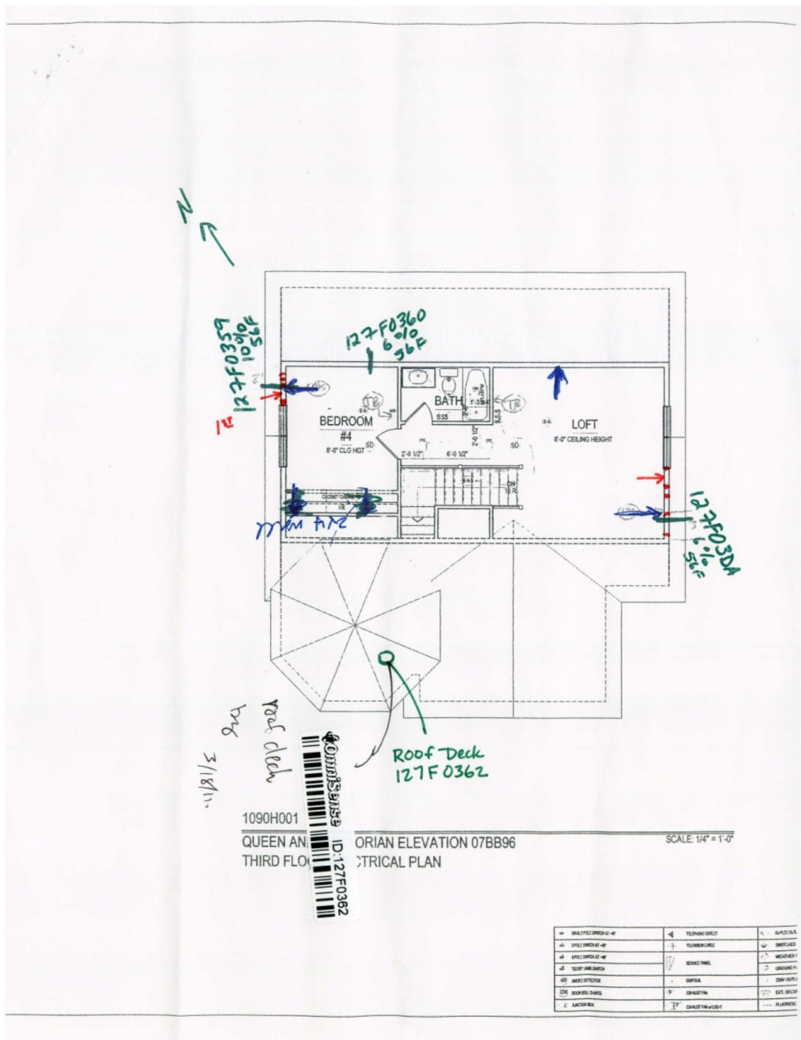
The following Table summarizes the planned project and research timeline.

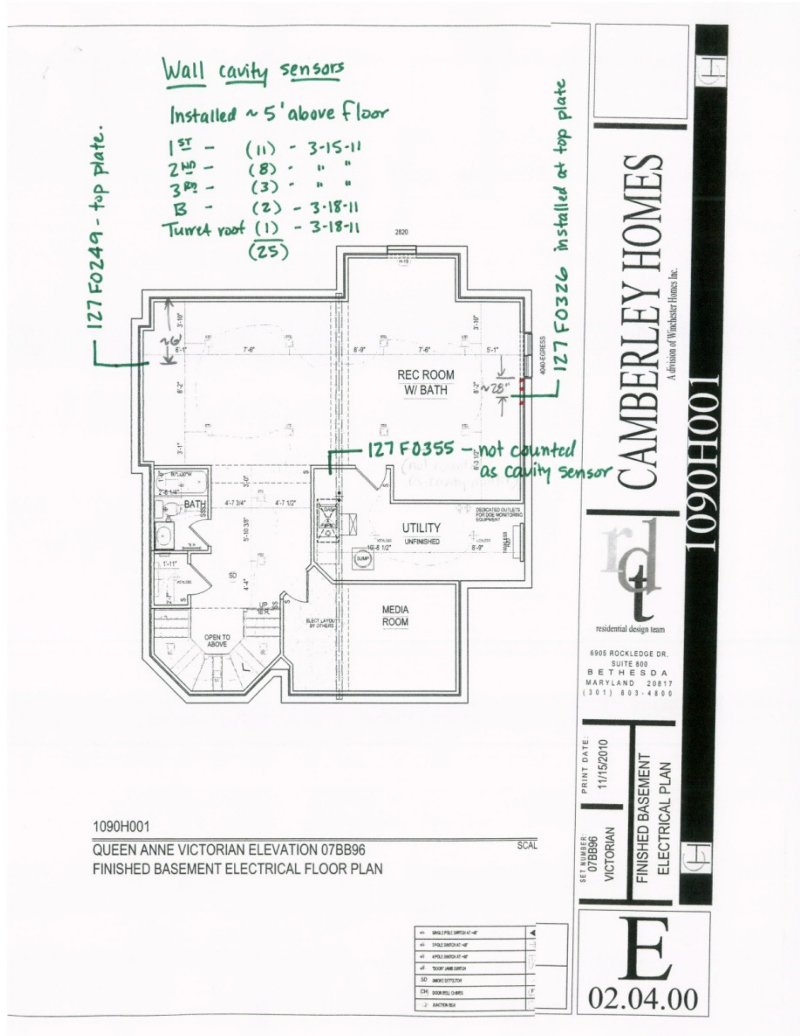
Table 5. Test Plan Overall Schedule

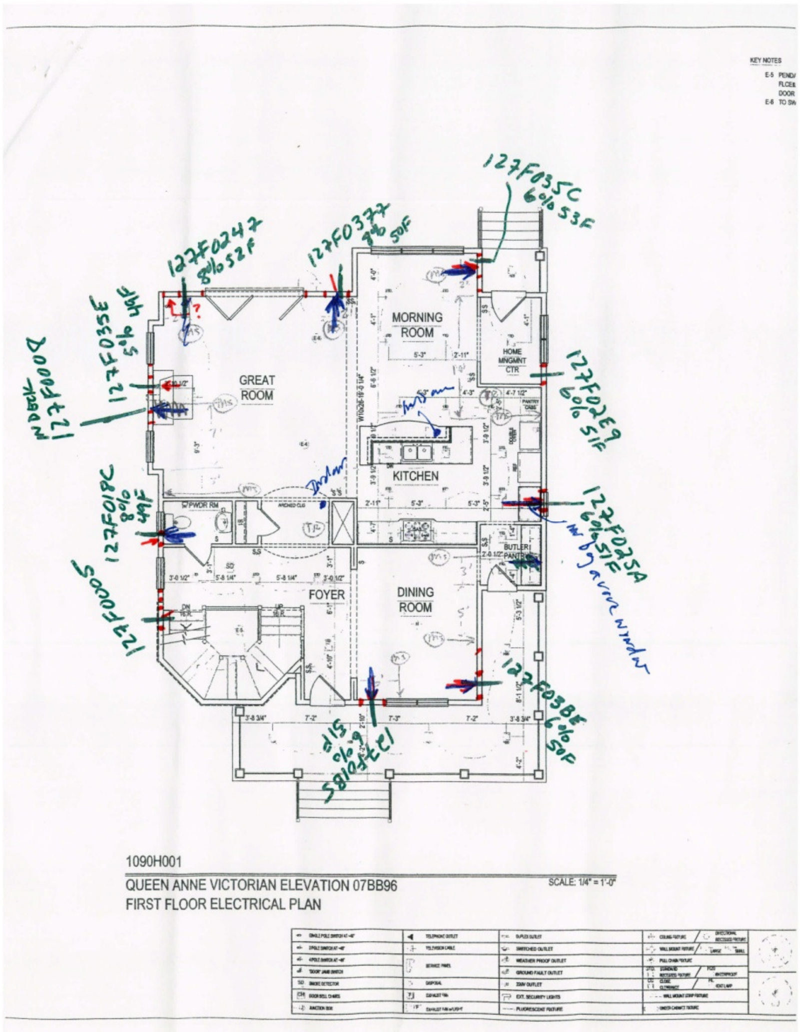
Milestone	Description	Expected Date	Team Member
House completion	Final completion of the house construction and startup of all equipment	June 2011	Winchester Homes, Inc.
HVAC characterization and checkout	Perform the startup of the HVAC system, measure all air handler flows, room pressures, and ventilation system flows	July 2011	Dave Mallay AllTemp will perform the startup checkout
Short-term house characterization testing	Perform the house characterization tests	July 2011	Dave Mallay Joe Wiehagen
Install long-term measurement sensors	Install wall cavity sensors Install energy and environmental sensors	Completed July 2011	Joe Wiehagen Dave Mallay
Install long-term monitoring data recording	Install Omnisense Gateway Install Campbell Scientific data logger, modem	July 2011 July 2011	Joe Wiehagen Dave Mallay

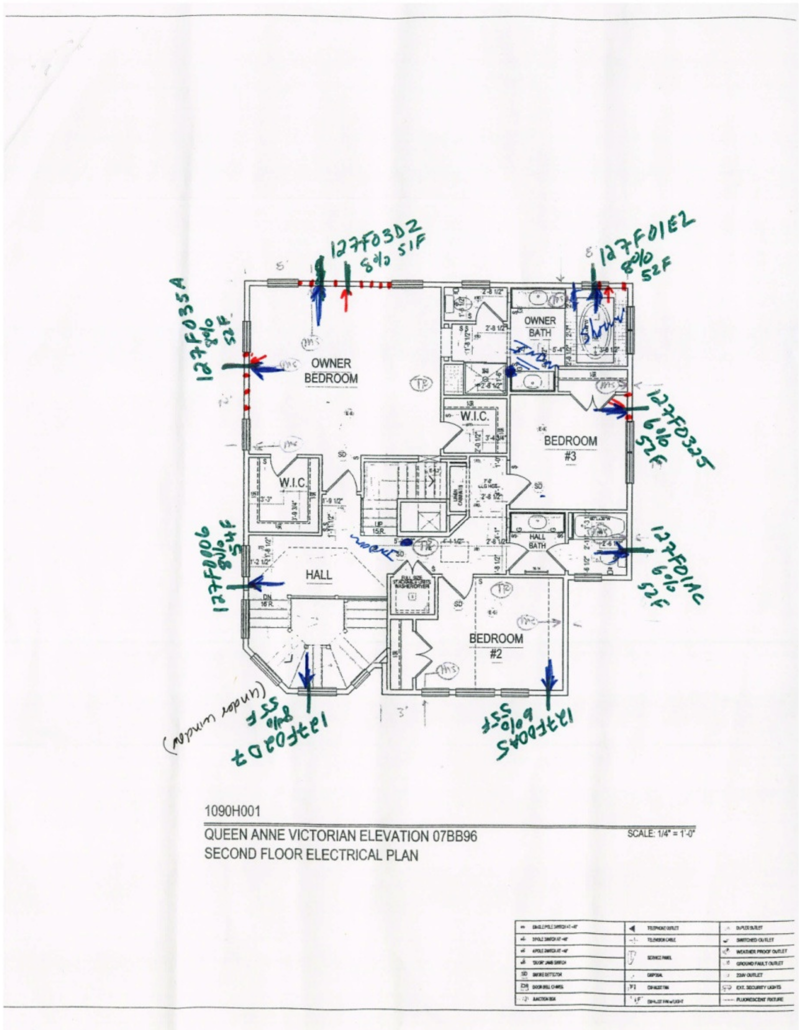
6 Appendix A - Sensor locations

The wall cavity sensors are indicated in the following graphics.




Wall cavity sensors
Installed ~ 5' above floor
1ST - (11) - 3-15-11
2ND - (8) - " "
3RD - (3) - " "
B - (2) - 3-18-11
Turret roof (1) - 3-18-11
(25)
127 F0249 - top plate.
127 F0326 installed at top plate
127 F0355 - not counted as cavity sensor
REC ROOM W/ BATH
UTILITY UNFINISHED
MEDIA ROOM
BATH
OPEN TO ABOVE
1090H001
QUEEN ANNE VICTORIAN ELEVATION 07BB96
FINISHED BASEMENT ELECTRICAL FLOOR PLAN
CAMBERLEY HOMES
A division of Winchester Homes Inc.
1090H001
residential design team
6905 ROCKLEDGE DR.
SUITE 600
BETHESDA
MARYLAND 20817
(301) 803-4800
PRINT DATE 11/15/2010
SET NUMBER: 07BB96 VICTORIAN
FINISHED BASEMENT ELECTRICAL PLAN
E
02.04.00


GREAT ROOM
MORNING ROOM
HOME MNGMNT CTR
KITCHEN
PWDR RM
BUTLER PANTRY
FOYER
DINING ROOM
127F0242 8% 52F
127F0377 8% 50F
127F035C 6% 53F
127F035E 5% 44F
127F0007 Door
127F02E9 6% 51F
127F019C 8% 49F
127F025A 6% 51F
127F0005
127F038E 6% 50F
127F018S 6% 51F
1090H001
QUEEN ANNE VICTORIAN ELEVATION 07BB96
FIRST FLOOR ELECTRICAL PLAN
SCALE: 1/4" = 1'-0"


OWNER BEDROOM
OWNER BATH
W.I.C.
BEDROOM #3
W.I.C.
HALL
HALL BATH
BEDROOM #2
1090H001
QUEEN ANNE VICTORIAN ELEVATION 07BB96
SECOND FLOOR ELECTRICAL PLAN
SCALE: 1/4" = 1'-0"

EERE Information Center
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