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Technical And Business Solutions For Zero Net-Energy Ready And Zero Net-Energy Homes In The Hot Humid Climate

Florida Solar Energy Center

Eric Martin
Florida Solar Energy Center, martin@fsec.ucf.edu

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Authors

Eric Martin
David Beal
Janet McIlvaine

1679 Clearlake Road
Cocoa, Florida 32922, USA
(321) 638-1000

www.floridaenergycenter.org

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Eric Martin, David Beal, and Janet McIlvaine

Florida Solar Energy Center, University of Central Florida, Cocoa, Florida, 32922, USA
martin@fsec.ucf.edu, david@fsec.ucf.edu, and janet@fsec.ucf.edu

Abstract

The Department of Energy's Challenge Home program provides a standardized platform for application and marketing of Building America innovations in new residential construction and is intended to facilitate delivery of zero net-energy ready and zero net-energy homes that also meet goals for durability, quality, affordability, and comfort. The Building America Partnership for Improved Residential Construction, one of the Building America research team leads, has partnered with several builders in the hot-humid climate, as they work through the process of adopting Challenge Home. This paper serves to identify viable technical pathways to meeting the Challenge Home criteria in this region and illustrate market response to high performance housing. A further objective of the research in general is to identify gaps and barriers in the marketplace related to product availability, labor force capability, code issues, cost effectiveness, and recognizing value in the transaction process – all necessary to ensure adoption on a production scale.

Keywords: Net-zero energy ready homes, net-zero energy homes, labeling program, interior ducts, affordable housing, production builder sales data

1. Introduction

Under the U.S. Department of Energy's (DOE) Building America program, DOE national laboratories and building science research teams conduct cost-shared research together with stakeholders in the home building industry. Researchers work closely with industry partners to optimize residential building energy performance, durability, quality, affordability, and comfort, and bring home building innovations to market. After preliminary research in laboratory scale and prototype houses, whole house solutions are refined and, through research at community-scale, research teams validate the reliability, cost-effectiveness, and marketability of whole-house improvement packages and strategies for new construction and existing homes [1], [2].

The DOE Challenge Home program[2] provides a standardized platform for application and marketing of Building America innovations in new residential construction and is intended to facilitate delivery of "zero net-energy ready" (ZNER) homes. Challenge Home ties together key components of high performance housing including building science, best practices, efficient equipment, high performance enclosure components, and indoor air quality control (Figure1). Challenge Homes are designed, built,

[2] http://www.energy.gov/eere/buildings/doe-challenge-home

and commissioned to be "renewable ready", and a small, grid-tied photovoltaic system (PV) can be easily added at the time of construction, or in the future, to offset most or all of the home's energy use on an annual basis, thereby facilitating true zero net-energy (ZNE) homes. Building America research teams are working with stakeholder partners to document technical pathways to achieve Challenge Home in all climate zones, and the successful business metrics that result from marketing cost effective, high performance homes in general.

Figure 15. Challenge Home required and recommended elements consolidate key concepts for high performance homes.[3]

The Building America Partnership for Improved Residential Construction (BAPIRC), one of the BA research team leads, has partnered with several builders in the Building America hot-humid climate[4], and specifically International Energy Conservation Code Climate Zone 2[5], as they work through the process of adopting Challenge Home. This paper serves to identify viable technical pathways to meeting the Challenge Home criteria in this region. A further objective of the research in general is to identify gaps and barriers in the marketplace related to product availability, labor force capability, code issues, cost effectiveness, and recognizing value in the transaction process - necessary to ensure adoption on a production scale.

The builder partners participating in this cost-shared research include Southeast Volusia County Habitat for Humanity (SEVHFH) near Daytona Beach, Florida and Manatee County Habitat for Humanity (MCHFH) near Tampa, Florida. Both are affiliates of Habitat for Humanity International (HFHI), a non-profit affordable housing organization. Also participating in this research are two small production builder partners, Tommy Williams Homes (TWH), based in Gainesville, Florida, and Lifestyle Homes (LSH) based in Melbourne, FL.

2. Challenge Home specifications and key solutions

Challenge Homes must meet or exceed the projected performance level of the Target Home specifications, which vary by climate, and are more rigorous than the ENERGY STAR 3.0 requirements. This evaluation can be pursued on a prescriptive path or a performance path. The performance path, used by the projects described in this report, requires that a certified home energy rater use approved software

[3] Source: http://www1.eere.energy.gov/buildings/residential/pdfs/ch_zero-net-energy_training_06062013.pdf
[4] https://basc.pnnl.gov/images/building-america-climate-zone-map
[5] https://basc.pnnl.gov/images/iecc-climate-zone-map

to model the house with the Target Home specifications to generate a Target Home Energy Rating System (HERS) Index[6] score, a gauge of whole house efficiency that the project must ultimately achieve as a minimum requirement. This approach allows builders to customize some specifications as long as the end result achieves a HERS Index equivalent or better than the Target. Although house size and characteristics influence the target HERS Index, researchers have found that the Target HERS Index generally falls in the mid to low-50's working for a variety home sizes and types. A typical code compliant home in Florida scores in the low 90's to upper 80's on the HERS Index. The gap of 30-40 in the HERS Index is diminished by many of the mandatory CH requirements (e.g. ENERGY STAR windows) so that after meeting those only a few additional improvements may be needed.

Challenge Home builders must also meet requirements in seven different categories (Table 1).

Table 16. Challenge Home mandatory requirements[7].

Area of Improvement	Mandatory Requirements
1. ENERGY STAR for Homes Baseline	☐ Certified under ENERGY STAR Qualified Homes Version 3.
2. Envelope	☐ Fenestration shall meet or exceed latest ENERGY STAR requirements. ☐ Ceiling, wall, floor, and slab insulation shall meet or exceed 2012 IECC Levels.
3. Duct System	☐ Ducts located within the home's thermal and air barrier boundary.
4. Water Efficiency	☐ Hot water delivery systems shall meet efficient design requirements.
5. Lighting & Appliances	☐ All installed refrigerators, dishwashers, and clothes washers are ENERGY STAR qualified. ☐ 80% of lighting fixtures are ENERGY STAR qualified or ENERGY STAR lamps (bulbs) in minimum of 80% of sockets. ☐ All installed bathroom ventilation and ceiling fans are ENERGY STAR qualified.
6. Indoor Air Quality	☐ EPA Indoor airPLUS Verification Checklist and Construction Specifications.
7. Renewable Ready	☐ EPA Renewable Energy Ready Home Solar Electric Checklist and Specifications. ☐ EPA Renewable Energy Ready Home Solar Thermal Checklist and Specifications.

All seven categories of requirements, except number 3 (ducts located within the home's thermal and air barrier), are related to codes and standards external to the Challenge Home program. These include:

Requirement 1 - ENERGY STAR for New Homes

Requirement 2 – ENERGY STAR labeling standard for fenestration

- 2012 International Energy Conservation Code

Requirement 4 – Invokes Section 3.3 of the EPA WaterSense Single Family New Home Specifications

Requirement 5 – ENERGY STAR labeling standards for appliances, lighting, and ceiling, bathroom, and kitchen vent fans

Requirement 6 - Environmental Protection Agency (EPA) Indoor airPLUS

[6] RESNET Mortgage Industry National Home Energy Rating Standards govern the calculation method for the Home Energy Rating System Index. On the HERS Index, lower scores indicate lower net energy consumption.

[7] Adapted from: http://www.energy.gov/sites/prod/files/2013/11/f5/doe_challenge_home_requirementsv3.pdf

Requirement 7 – EPA Renewable Energy Ready Home standards for solar electric and solar thermal technologies.

There is no standard or single methodology to meet the interior duct requirement. It has long been a recommendation by Building America and many in the home performance industry. Many factors influence the complexity of meeting this requirement in any given home including building geometry and the builder's typical construction processes. Constructing a duct system fully inside the conditioned space may involve altering standard construction processes, which is often more challenging than altering specifications. BAPIRC has achieved success with a variety of approaches [3], and an additional approach is described herein.

2.1 Manatee County Habitat for Humanity (MCHFH)

For over 15 years, MCHFH built wood-framed homes using the most economical products available with the objective of producing very affordably priced housing. According to Bruce Winter, Construction Supervisor for MCHFH, the start of a new development, Hope Landing, provided MCHFH with an opportunity to re-think how they were building homes with an additional objective of producing homes that are more affordable to live in on a monthly basis. Working with their architectural firm and a certified home energy rater they chose to move away from their conventional wood-framed, low-cost construction model to a highly energy efficient, sustainable and safer home. These decisions aligned with the organization's mission to build homes that are not only affordable to purchase but also affordable to live in.

MCHFH reviewed programs including ENERGY STAR for Homes and the DOE Builders Challenge which subsequently became the Challenge Home program. They also reviewed new building methods and materials that could be handled by their volunteer labor force without sacrificing the cost effectiveness necessary to meet their financial goals. In the end, MCHFH developed a new design - a duplex floor plan (Figure 2), and changed almost all of their construction methods and products. A bold decision requiring extensive planning and preparation.

Figure 2. Example of MCHFH new duplex design.

About a year before construction began, MCHFH construction staff held meetings with volunteer crew leaders to discuss the new construction methods. A Build Book was developed with selected crew leaders detailing over 45 building steps in the new construction process. Quality check sheets were developed to verify that work met specifications before being turned over to the next crews to ensure repeatability and uniformity in construction regardless of crew and volunteer turn over. Ongoing training sessions and on-the-job training bring new volunteers up to competency levels in the construction techniques.

As construction at Hope Landing began, a 3rd party Energy Rater conducted inspection visits, which provided an important quality control mechanism. Any time a change or correction was required, it was reported to the architect and to the volunteer author of the Build Book section for update. In the end, MCHFH prepared a new homeowners and maintenance manual called "The What and Why of How We Build and How to Care for Your Home" to help buyers understand the features and operation of their new home.

Although this transformation originated before MCHFH decided to build its first Challenge Home, it provides an excellent example of how to navigate the transition from building code-compliant homes to building high performance homes. The Build Book in particular informs the whole construction team. It provides construction objectives, detailed process guidance, and quality assurance check points. A document like the Build Book along with construction drawings of unfamiliar details and subcontractor scopes of work can support problem solving at the job site.

2.1.1 MCHFH Meeting Challenge Home Mandatory Requirements: Prior to considering Challenge Home, MCHFH had already evolved their construction to achieve ENERGY STAR for Homes v3.1, thereby meeting Challenge Home Requirement 1. Their new construction method included R-23 insulated concrete form (ICF) walls (Figure 3) and R-21 open cell spray foam applied to the underside of the roof deck to create an unvented attic. The duct system installed in the unvented attic meets Challenge Home Requirement 3, Interior Ducts. While the R-21 roof does not meet the prescriptive IECC 2012 requirement, the combined effect of the wall and roof deck insulation effectively produces a total enclosure meeting Challenge Home Requirement 2 (Envelope) through the program's allowable "total UA method".

Figure 3. MCHFH ICF exterior wall under construction.

The other Challenge Home Mandatory envelope requirement is ENERGY STAR labeled fenestration. MCHFH's standard window had a solar heat gain coefficient (SHGC) of 0.28, very narrowly missing the ENERGY STAR criteria for the hot-humid climate which is 0.27. The Department of Energy granted MCHFH an exemption for this requirement on one of their completed houses. For future homes, MCHFH has changed specifications to regionally qualified ENERGY STAR windows.

To meet Challenge Home Mandatory Requirement 4, Water Efficiency, MCHFH changed the plumbing design by locating insulated pipes under the slab foundation (Figure 4) rather than in the interior walls and the attic. This allowed shorter, more direct runs, minimizing water wasted while waiting for hot water. The criterion specifies less than 0.5 gallons of water in the piping/manifold between the water heater and any fixture.

Figure 4. Insulated pipes under the slab foundation.

The EPA Indoor airPLUS program referred to in Challenge Home Requirement 6 has criteria dealing with attached garages that in this case do not apply since there is no garage. It also calls for, among other things, humidity control capability in Climate zones 1, 2, and parts of 3. MCHFH achieves this requirement using a thermostat with built in humidistat associated with their ducted "mini-split" mechanical system.

Utilizing solar rebate incentives from Florida Power and light, MCHFH equipped this particular home with a 40 ft^2 direct circulation, drain-back solar water heater and a 2.5 kW PV array with micro-inverters (Figure 5). Use of solar components automatically fulfills Challenge Home Requirement 7, Renewable Ready. While not all the homes in Hope Landing are equipped with solar components this builder meets the Renewable Readiness standards for solar thermal and PV in all the other homes by prepping for future installation.

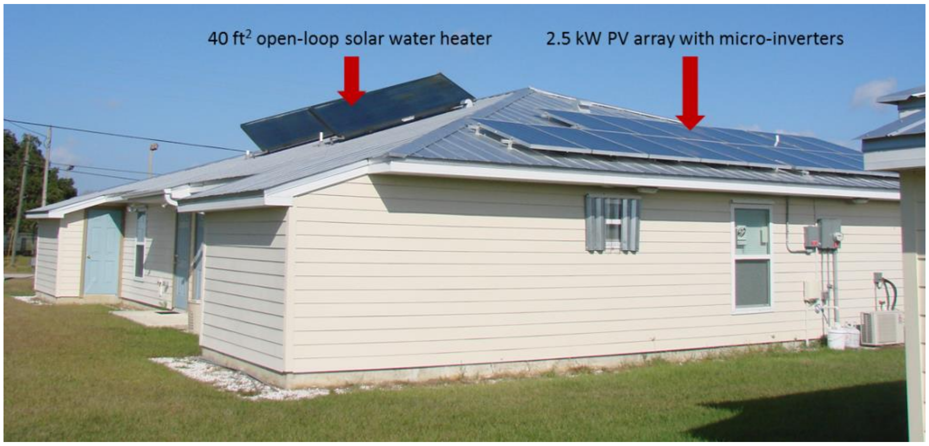

Figure 5. Solar thermal and solar PV panels.

The builder does not include a dishwasher in standard construction. The refrigerator, clothes washer, lighting, exhaust fans, and ceiling fans are all ENERGY STAR labeled products satisfying Mandatory Requirement 5. Table 2 summarizes the energy related specifications MCHFH incorporated into their first Challenge Home.

Table 2. Summary of MCHFH Challenge Home energy related specifications.

COMPONENT/PARAMETER	DESCRIPTION
Challenge Home HERS Index score (Challenge Home Target = 60)	53 without PV 23 with PV
Design	1148 ft^2, 3 Bedroom, 2 Bath duplex
Envelope	
Whole House air tightness	Tightly sealed house, ACH50 = 1.02
Foundation	Slab-on-grade R-0
Wall type and insulation	R-23 Insulated concrete form walls R-11 partition wall between duplex dwellings
Windows	Double-pane, low-e, vinyl windows. U = 0.32, SHGC = 0.28*
Roof Finish, Attic configuration, and insulation	Galvalum metal roof with R-21 open cell, spray-foam insulation at underside of roof deck to create an unvented attic
Equipment, Appliances, and Lighting	
Mechanical equipment	SEER 16 HSPF 10 "Mini-split" Heat Pump with compact duct system; central fan integrated supply ventilation
Air distribution system materials	R-6 flex ducts sealed with water based mastic and fiberglass mesh.
Air distribution system air tightness	CFM25,total = 90 cfm (Qn, total=0.08) CFM25,out = 13.5 cfm (Qn, out=0.01)
Air distribution system location	Ducts and mini-split air handler in unvented attic
Lighting and Appliances	100% ENERGY STAR® CFL's, ceiling fans,

	refrigerator, and clothes washer. Dishwasher not provided.
Renewable Energy	
Water Heating	Flat plate, drain-back, 40 ft^2 solar water heater with 80 gallons of storage
Photovoltaics	2.5 kW PV system

*Challenge Home Exemption granted for this home

2.2 South East Volusia HFH (SEVHFH)

Southeast Volusia County Habitat for Humanity (SEVHFH) has a long-standing relationship with Building America. SEVHFH originally partnered with Building America as part of the Building America Industrialized Housing Partnership (BAIHP - the predecessor to BAPIRC) in 2009. Since then SEVHFH has consistently built houses that meet or exceed ENERGY STAR criteria, including the latest ENERGY STAR standard in Florida, Version 3.1. SEVHFH was also an early adopter of the Builders Challenge. With this history it was a natural step for SEVHFH to build a Challenge Home.

In contrast to the MCHFH methods, SEVHFH's standard practice embraces typical central Florida building techniques, with an emphasis on volunteer friendliness and readily available products and labor. Their slab-on-grade, single-family homes (Figure 6) have wood-frame walls and a vented attic with blown-in insulation. SEVHFH's Challenge Home did not replace any of these "conventional" building materials. Their simple yet efficient homes are a sterling example of affordable housing built affordably, while being affordable to live in.

Figure 6. SEVHFH Challenge Home

This Challenge Home provides an excellent model for any central Florida builder because the Challenge Home Target HERS Index is achieved by combining a package of envelope and equipment specifications that are moderately better than typical regional practices with the addition of a solar water heater that takes advantage of utility incentives. A similar path could be used by many central Florida builders to achieve the target Challenge Home HERS Index without major changes in structural systems, components, or equipment.

2.2.1 SEVHFH Meeting Challenge Home Mandatory Requirements: As with MCHFH, SEVHFH had already evolved their construction to achieve ENERGY STAR for Homes v3.1, thereby meeting Challenge Home Requirement 1. The conventional 2x4 walls have R-13 RESNET Grade 1 batt insulation with an added layer of R-3 rigid insulation over the exterior sheathing. The attic insulation of R-38 is becoming a regional standard. These insulation levels comply with IECC 2012, and by utilizing windows that achieve the ENERGY STAR standard, met Challenge Home Requirement 2. Utilizing ENERGY STAR appliances, lighting, and fans throughout the house enabled the affiliate to meet Challenge Home Requirement 5.

Two of the main things that distinguish the SEVHFH house from typical market rate production homes are the small footprint and lack of garage. Because of the small, compact floor plan, no changes were needed to pass the hot water distribution test which limits stand-by hot loses at the fixture farthest from the water heater to 0.5 gallons, and therefore enabled SEVHFH to achieve Challenge Home Requirement 4. Also, like MCHFH the home does not have a garage and related provisions of the ENERGY STAR Indoor airPLUS, and Challenge Home Requirement 6 do not apply. SEVHFH utilized a thermidistat to achieve the humidity control requirement.

SEVHFH also participates in Florida Power and Light's Residential Solar Water Heating Program for Low Income New Construction, which enabled them to install a solar thermal system at no cost. Inclusion of solar water heating satisfies Challenge Home Requirement 7 (solar thermal). When this incentive is not available, a heat pump water heater is often installed by the affiliate. Occasionally the affiliate builds in neighborhoods with natural gas and installs an instantaneous gas water heater. Both of these improved hot water systems are gaining momentum in the market. When used, they would allow SEVHFH's homes to meet the Target HERS Index more easily. Additionally, Challenge Home exempts builders from several aspects of Requirement 7 related to providing infrastructure for future solar water heating systems per the EPA Renewable Ready Solar Thermal checklist as long as their water heaters meet the stringent efficiency requirement of the ENERGY STAR labeling program. To comply with the solar electric aspects of Challenge Home Requirement 7 SEVHFH installed a conduit running from the power distribution panel to a junction box mounted on the exterior south wall to facilitate wiring exterior inverters that may be installed in the future (Figure 7). The panel has several blank spaces to accommodate a future circuit breaker for the PV input as required by the program.

Figure 7. SEVHFH ran conduit from the electrical panel to a junction box (Seen high on the wall) to facilitate future installation of a solar electric system.

The main change needed to achieve Challenge Home compliance by SEVHFH was Challenge Home Requirement 3, Interior Ducts. A foamed sealed attic like that used by MCHFH was rejected because of the first cost exceeded budget limitations. The idea of a “fur-down” approach for interior ducts, that creates a duct chase below the ceiling plane [4], was also rejected because of code-mandated ceiling height requirements that are difficult to meet with the standard 8’ ceiling height. Instead, SEVHFH’s Challenge Home used an innovative interior duct system design. SEVHFH Construction Director, Ray Allnutt, worked very closely with the mechanical contractor to envision, design, and execute a creative “fur up” or “raised ceiling” strategy. This innovative approach included a modified truss design to accommodate a duct chase above the ceiling plane. While the general approach is not new, the method developed by Allnutt represents a significant improvement in technical execution.

Figure 8 shows the duct system layout. In this home, the framing for the chase is formed by truss members (2x4’s) in a modified truss design that creates a chase through the center of the house (Figure 9). The modification in the truss design is offset from the central king post to reduce the structural impact of the modification. Accurate sizing of the chase and the ducts using exact dimensions is critical to successful assembly.

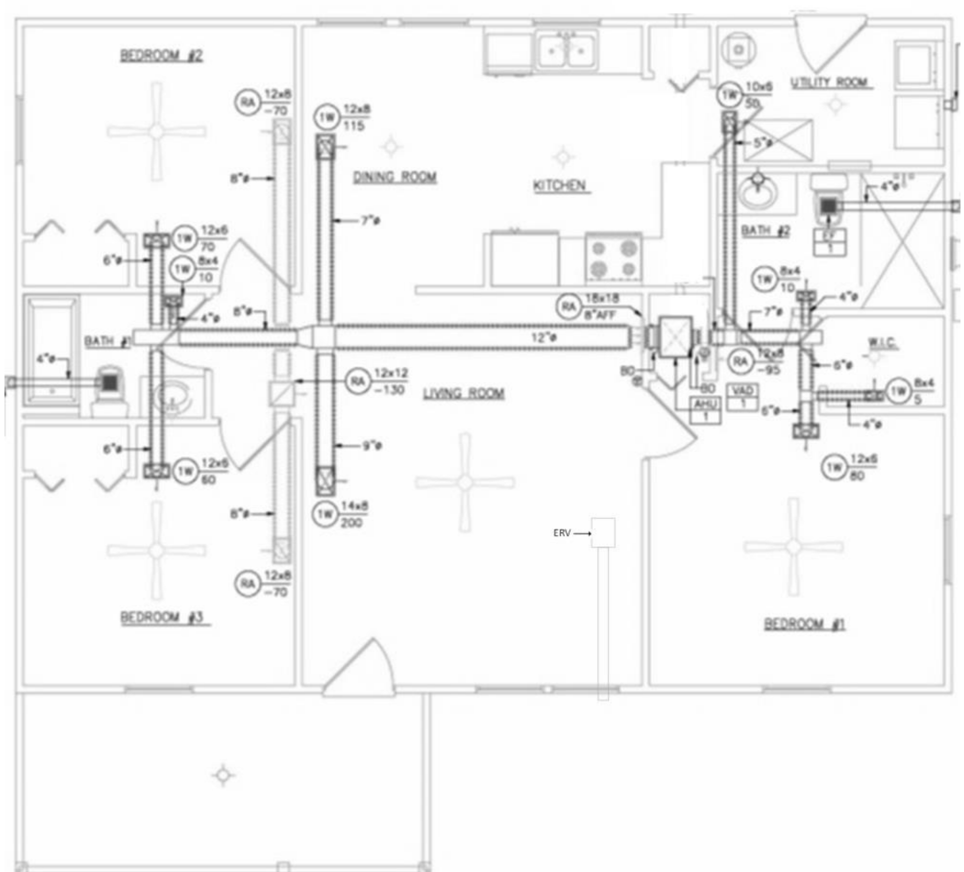

Figure 8. SEVHFH layout for interior duct system.

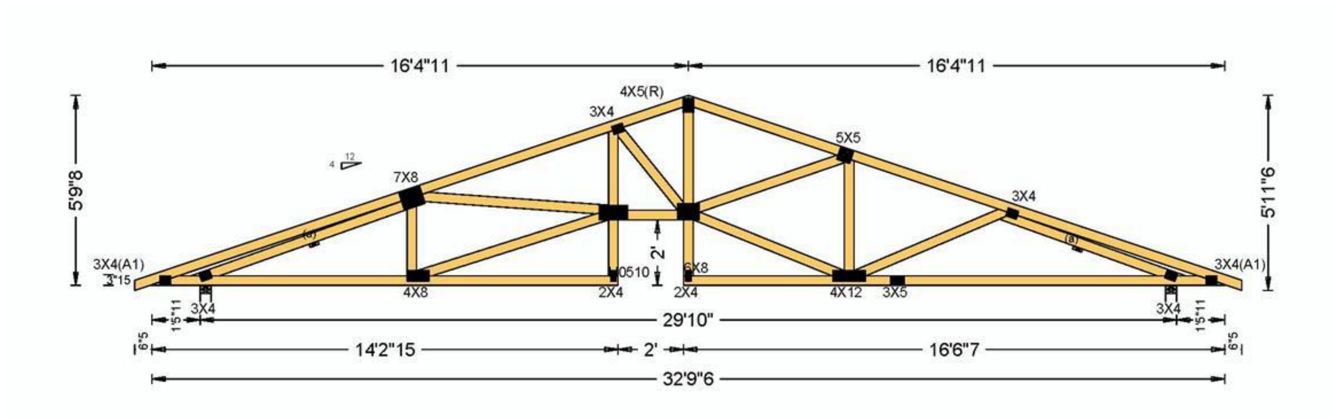

Figure 9. Truss modification design to create interior duct chase.

The technical challenges of building a duct chase, whether fur-down or fur-up, are establishing a continuous, sealed air barrier between the chase and the surrounding unconditioned spaces (including building cavities) and adequately insulating the chase. Conventionally, drywall or other sheet goods are used to create the air barrier. Air sealing details must address all joints, edges, and penetrations in the air barrier. Where the chase extends into rooms through interior walls, the air sealing must isolate the chase from the wall cavities to remain truly in conditioned space. Regarding insulation, the tops of fur-down chases are aligned with the ceiling plane; hence, attic insulation forms the thermal barrier for fur-down chases. Alternatively, fur-up chases rise above the ceiling plane, requiring a different insulation strategy. Insulating the top and vertical sides of the chase is similar to insulating tray ceilings and knee walls. Typically built with 2 x 4's, it's very challenging to achieve insulation levels similar to the rest of the attic on these surfaces as mandated by IECC 2012.

SEVHFH's decision to build a fur-up chase was influenced by the availability of free materials through Habitat for Humanity International's "Gifts in Kind" Program, which partners with DOW and others. DOW provides free rigid foam insulation products to affiliates upon request. DOW Styrofoam provides insulation of R-5 per inch. SEVHFH was already taking advantage of this partnership by using ½" DOW Styrofoam on the exterior of their houses. They requested 2" thick, Square Edge, "unskinned"[8] Styrofoam Insulation from DOW, and utilized it to form the air barrier (and part of the thermal barrier) for their fur-up chase. In total, SEVHFH achieved an R-33 insulation level on the sides and the top of their fur-up duct chase by using a double layer of 2" Styrofoam, installed to the inside of the chase structure, resulting in R-20. Then the top and sides of the chase were wrapped in R-13 fiberglass batts that are sized to fit into the 24" truss bays (Figure 10).

[8] The Styrofoam used does not have a thin plastic facing found in some versions. That film constitutes a vapor flow retarder. By using the un-faced product, the chase assembly is 'vapor open" allowing moisture to flow in both directions.

Figure 10. SEVHFH lined the inside of their fur up chase with rigid foam insulation, and then wrapped the top and sides with batt insulation for a total of R-33.

The edges and seams of the first layer of Styrofoam were sealed with a construction adhesive specifically designed for foam. The seams in the second layer of Styrofoam are staggered (with respect to the first layer) to further impede air exchange between the chase and the surrounding attic space and sealed in a similar manner. Through this careful attention to detail, the major challenge of creating a continuous sealed air barrier was conquered. The structure to support the duct system is installed to the inside of the chase. This is an important detail that eliminates leakage paths around the structural element. Careful detailing proved effective as evidenced in the duct leakage test which showed no leakage to the surrounding attic. Runout chases to serve rooms throughout the house branch off the main chase. Dead wood installed between trusses provided attachment surfaces for the foam top and sides. This ensures that all run out ducts are fully within the conditioned space. The air handler is also in conditioned space, housed within an interior closet (Figure 11). Table 3 summarizes the energy related specifications SEVHFH incorporated into their first Challenge Home.

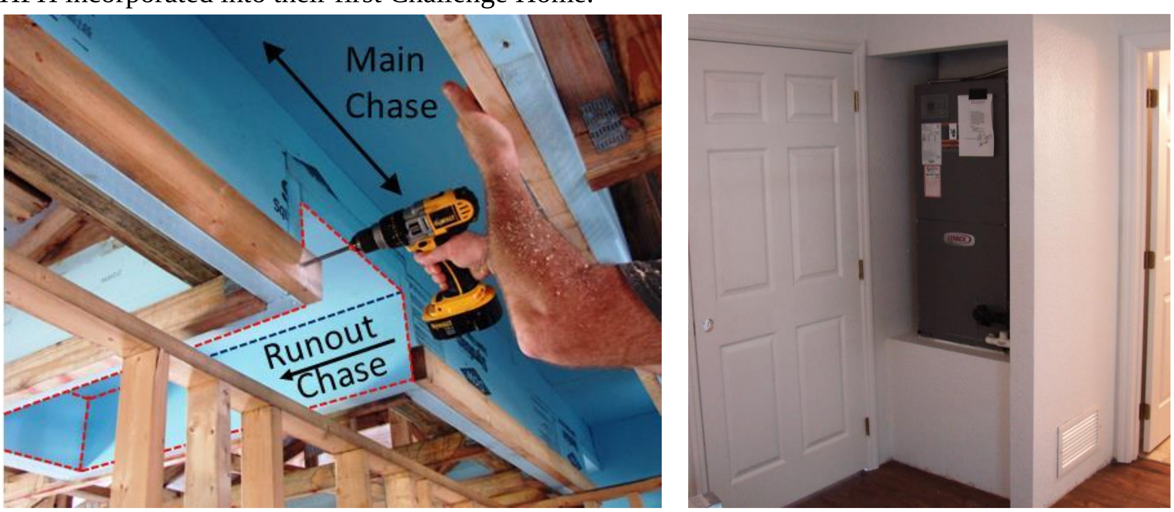

Figure 11. Left photo shows intersection of runout chase with main chase. Right photo shows interior air handler closet.

Table 3. Summary of SEVHFH Challenge Home energy related specifications.

COMPONENT/PARAMETER	DESCRIPTION

Challenge Home HERS Index score (Challenge Home Target = 59)	49
Design	1250 ft^2, 3 Bedroom, 2 Bath single family home
Envelope	
Whole House air tightness	Well sealed house, ACH50 = 4.00
Foundation	Slab-on-grade R-0
Wall type and insulation	R-13 frame walls with R-3 exterior rigid insulation
Windows	ENERGY STAR labeled Double-pane, low-e, vinyl windows. U = 0.33, SHGC = 0.18
Roof Finish, Attic configuration, and insulation	Light color shingle roof with RBS roof deck over vented attic with R-38 blown insulation
Equipment, Appliances, and Lighting	
Mechanical equipment	SEER 15/HSPF 8 Heat Pump; energy recovery ventilator (ERV) provides balanced ventilation
Air distribution system materials	R-4.3 duct board sealed with water based mastic and fiberglass mesh.
Air distribution system air tightness	CFM25,total = 39 cfm (Qn, total=0.03) CFM25,out = 0 cfm (Qn, out=0.0)
Air distribution system location	Ducts in a "fur-up" chase created with modified trusses; air hander closet in conditioned space
Lighting and Appliances	100% ENERGY STAR®CFL's, ceiling fans, refrigerator, dishwasher, and clothes washer.
Renewable Energy	
Water Heating	Flat plate, open loop, 40 ft^2l solar water heater with 80 gallons of storage
Photovoltaics	Renewable ready

3. Cost effectiveness and marketability of ZNER and ZNE homes

The Challenge Homes described in this report are both built by Habitat for Humanity affiliates. Habitat for Humanity International's (HFHI) vision involves "a world where everyone has a decent place to live", and their mission "brings people together to build homes, communities, and hope." To fulfill those goals many affiliates have realized that building the least expensive home generally does not result in the least expensive home to live in. HFHI has many partners at the national and local level that donate goods and services to the affiliates. In addition, some of the affiliate's sub-contractors donate or discount labor and materials.

Energy Gauge USA energy analysis software was used by the affiliates and their energy raters to determine Challenge Home compliance, and used here to estimate annual energy use. The MCHFH Challenge Home is projected to save $949 in annual energy costs at $0.12 per kilowatt, compared to the same home configured to meet Florida code. This includes a projected photovoltaic output of $427 per year. Total cost for the upgraded package was $17,008, increasing the total cost of the home by 23%[9]. However, Florida Power and Light (FPL), the electric utility, provided a low income solar water heating incentive covering the cost of the solar water heating system, and a $2/watt rebate on the photovoltaic

[9] Total costs include soft costs such as architecture, survey, permitting, and certifications. Total costs also include hard costs such as materials and sub-contractor labor. General construction labor is not included, as habitat uses primarily volunteers.

system, reducing the added cost to $7,774, or about 10% of the total cost of the home. The SEVHFH Challenge Home is projected to save $509 in annual energy costs at $0.12 per kilowatt, compared to the same home configured to meet Florida code. Total cost for the upgraded package is approximately $8,300. SEVHFH also received a low income solar water heating incentive from FPL, as well as DOW Styrofoam at no cost, reducing the added cost to approximately $3,000[10].

The economics of Habitat for Humanity's business model vary significantly from market rate housing. A portion of the buyer's down payment comes from building with Habitat's volunteer labor force. Finance terms are 0% interest over 20 to 30 years. These variations and the narrow market niche of affordable housing skew the relevance of their business metrics to market rater builders who pay full price for labor and face rigorous competition. To examine economic implications of Challenge Home in the production builder market, BAPIRC is also working with partners to prototype and document incremental changes necessary to achieve Challenge Home cost effectively in production housing. Tommy Williams Homes (TWH) and Lifestyle Homes (LSH) have been continuous partners in the Building America program since 2004 and 2009 respectively (Figure 12), and are currently in the planning stages for their first Challenge Homes. Their transition from building minimum code homes to building high performance homes is well documented, and their current ZNER designs, with similar levels of performance to Challenge Home and now standard practice for each builder, have been shown to result in net positive annual cash flow for home buyers [1]. This is quantified by showing that the forecasted average monthly energy savings over minimum code exceed the added monthly mortgage cost for the improvement package. The designs also serve as a reliable and cost effective platform with which to deliver ZNE homes, with TWH and LSH selling 9 and 15 zero energy homes since 2010 respectively. In each case, the builders deliver net zero energy by simply adding PV to their standard designs.


Figure 116. TWH (left photo) and LSH (right photo) have each been successful at standardizing ZNER designs, and offer ZNE homes as an option.

Previous work by BAPIRC has discussed the importance of combining effective sales and marketing solutions with technical solutions in order to successfully deliver ZNER and ZNE homes [1]. Market rate builders must translate the benefits and advantages of high performance technical solutions into a marketing campaign that engages buyers bombarded with nearly endless choices. When successful, the approach has been found to lead to robust sales and growth within the marketplace.

Upon adopting a ZNER package as standard in 2009, a year in which the down housing market only generated 25 closings, LSH has increased business nearly 5 times, with 120 closings in 2013. Their

[10] Detailed cost analysis for the SEVHFH home is ongoing.

marketing strategy combines model home displays that show the logic differences behind their construction techniques. They communicate value with case studies of first year cash flow examples.

Before adopting elements of high performance housing as standard in 2006, TWH was only able to claim a 40% market share against a competing builder within the same development. As the TWH package evolved into a ZNER level of performance, they simultaneously developed a print media marketing strategy focused on tangible benefits of high performance homes and model home displays where prospective buyers could see and touch the things that distinguish them in the market. The builder's market share in the same development grew to 84% by the end of 2012. These examples show that new home buyers are able to understand, appreciate, and value homes that optimize performance and economics. Enough time has elapsed that now some of the ZNER homes built by the builders are appearing in the resale market. Data from the resale of 18 TWH homes (vs. 13 from their principal competitor) shows the TWH ZNER homes selling at a $23,000 premium, with an average of 92 days on the market vs. 240. Advancing current ZNER packages to comply with Challenge Home is expected to complement the robust sales these production builders are currently experiencing, and advance the housing market in general one step closer to cost neutral ZNE homes.

4. Conclusions

BAPIRC, one of the Building America research team leads, has partnered with several builders in the hot-humid climate, as they work through the process of adopting Challenge Home. Two HFHI affiliates, MCHFH and SEVHFH, have constructed prototype homes certified under the program. Each used different approaches to meeting the technical specifications. MCHFH transformed their home building process to incorporate a number of advanced and emerging products and materials. SEVHFH adopted a more conventional approach by identifying and implementing adjustments to their existing home building process. In each case, by leveraging various incentives and partnerships, economics were favorable and the end products complemented the mission of the non-profit affordable housing sector.

BAPIRC has also partnered with TWH and LSH, small production builders that have implemented ZNER packages as standard practice, and have used the package as a platform to successfully market upgrades to ZNE. Sales data shows that the optimization of efficiency and performance results in robust sales and on both the new and resale market. It is expected that the DOE Challenge Home program is able to provide the guidance and tools necessary for any builder to recreate the success our partners have experienced.

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