



A Brighter Path Forward:

The Intersection of Green Construction and Affordability



fahe
Strength in Numbers

A Brighter Path Forward: The Intersection of Green Construction and Affordability

Written by Emma Survis

Edited by Jenna Urusky and Aaron Phelps

Financial support provided by:

- Ford Foundation
- Neighborworks America

Copyright FAHE, 2012



P.O. Box 908 • Berea, KY 40403
859-986-2321 • www.fahe.org

Table of Contents

Executive Summary	2
Energy Efficient Floorplans	5
Utility Savings Analysis	15
Energy Requirements	21
Material Recommendations	25
Savings and Recommendations	33
Appendix	39
Building Performance Institute Determination and Analysis of Utilization of New Knowledge	
Glossary	
Resources	

Executive Summary

For 30 years, FAHE and its Members have been committed to affordable homeownership, meaning lower construction costs to keep payments affordable. ***But as energy costs skyrocket, long-term affordability is threatened for thousands of families.***

Furthermore, residential energy use accounts for 20% of carbon emissions in the US, a pattern which is not sustainable for our environment. Through this research, FAHE endeavors to find a balance between affordability and conservation; where new construction can be environmentally and economically sustainable.

New innovations in green and energy efficient building techniques are paving the way to a brighter future for low-income families. The methods outlined allow for the production of better-built homes that use less energy per month with minimal cost increase to buyers. By following energy efficient building practices, non-profit housing companies are effectively producing a passive way to help families keep their homes.

Choosing energy efficient methods over standard will cost more up front but they save significant money in the long run. The analysis found that homeowners save about \$50.00 - \$75.00 per month and

between \$500.00 and \$900.00 per year. It was found that the additional costs of the energy efficient upgrades will pay for themselves within 5 to 8 years.

The proof of the aforementioned energy savings was collected from data produced by several FAHE members with experience in both green and energy efficient construction methods. These members include People's Self-Help Housing (PSHH), Kentucky Highlands Investment Corporation (KHIC), Frontier Housing, and Community Housing Partners (CHP). The analysis covers combinations of methods of construction, energy consumption, and materials that allow for a reasonable upfront cost and an affordable upkeep of utilities throughout the life of the house.

When homes are cost effective, low-income households are better able to make payments, which in turn allows non-profit companies to continue producing homes. This cycle is an important one not only for the families, but also for their communities and our country as a whole.

Main Concerns

In the pursuit of efficient utilities savings for housing, there are four main areas of concern which have been addressed:

- How effective is sustainable construction vs. standard construction?
- Which internal systems are needed for the greatest savings?
- Which construction materials produce the greatest benefit in utility savings?
- What is the payoff of upfront cost vs. savings over time?
- **Insulation:** blown in dense pack cellulose with open cell polyurethane spray foam insulation at all the rim and head joints and any other areas where there is a crack or opening
- **Mechanical:** high SEER heat pump and ERV, RHEEM or GE Hybrid water heaters are great options, Energy Star appliances and lighting
- **Windows:** operable, non-low-e coated on south side to allow for passive solar heating, protected from the summer sun by overhangs
- **Siding:** Brick veneer siding
- **Foundation:** fully insulated slab or conditioned crawl space

Major Findings

Green technology does not always mean energy efficient and energy efficient technology is not always green. A marriage of the two is often best. By seeking out the greenest option of the energy efficient materials, builders are able to produce a cost saving home while lessening the impact on the environment. It should be noted however that using solely green materials would raise the base cost of the house out of the reach of many potential homeowners.

Using the data provided about building materials and procedures, it was concluded that the following combination produces the best results:

- **Framing:** 2X6 single stud advanced framed wall with energy trusses and 2" of exterior EPS rigid foam insulation
- **Air-sealing:** tape all seams and mastic all ducts

Energy efficient housing is still a growing area, but by following these recommendations, a quality and cost-effective house can be sustainably built.

Next Steps:

FAHE and its Members are working towards identifying an optimal HERS rating, using the plans developed through this research as a starting point. Finding the optimal rating will balance cost with energy savings, which requires further research into the long-term carbon emission savings. Each year the FAHE network provides housing solutions to more than 6,000 families, meaning our potential to have a lasting impact on financial and natural resources is substantial. FAHE will seek new partners to gather the necessary financial and intellectual resources to produce a second edition of this research to go more in-depth based upon these recommendations.



BLOK

010

013

014

015

016

017

018

019

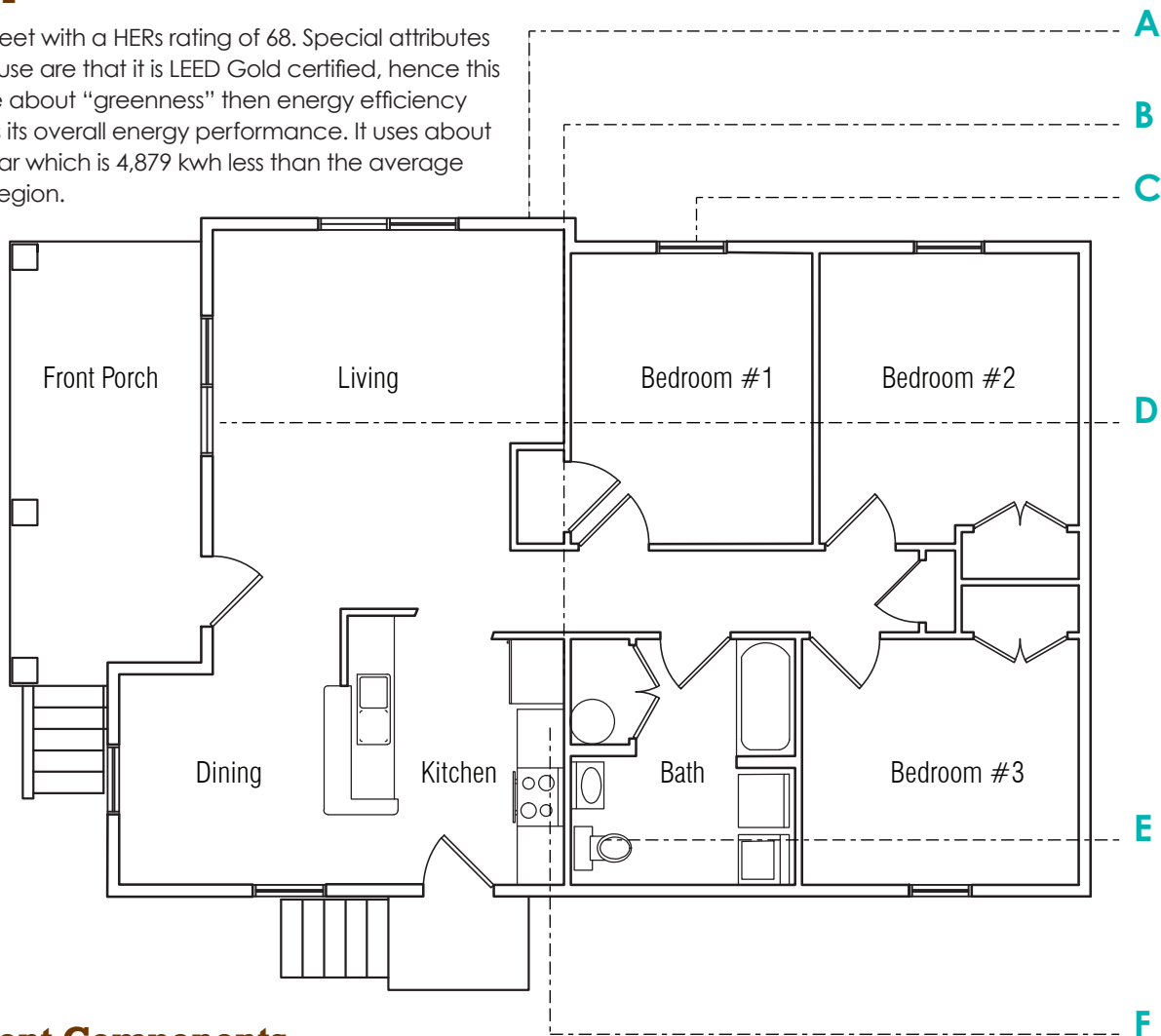
Energy Efficient Floorplans

Energy Efficient Floorplans

The following floor plans for energy efficient homes were collected from various FAHE Members.

House #1

1120 square feet with a HERs rating of 68. Special attributes about this house are that it is LEED Gold certified, hence this house is more about "greenness" than energy efficiency which affects its overall energy performance. It uses about 8,585 kwh/year which is 4,879 kwh less than the average home in this region.



Energy Efficient Components

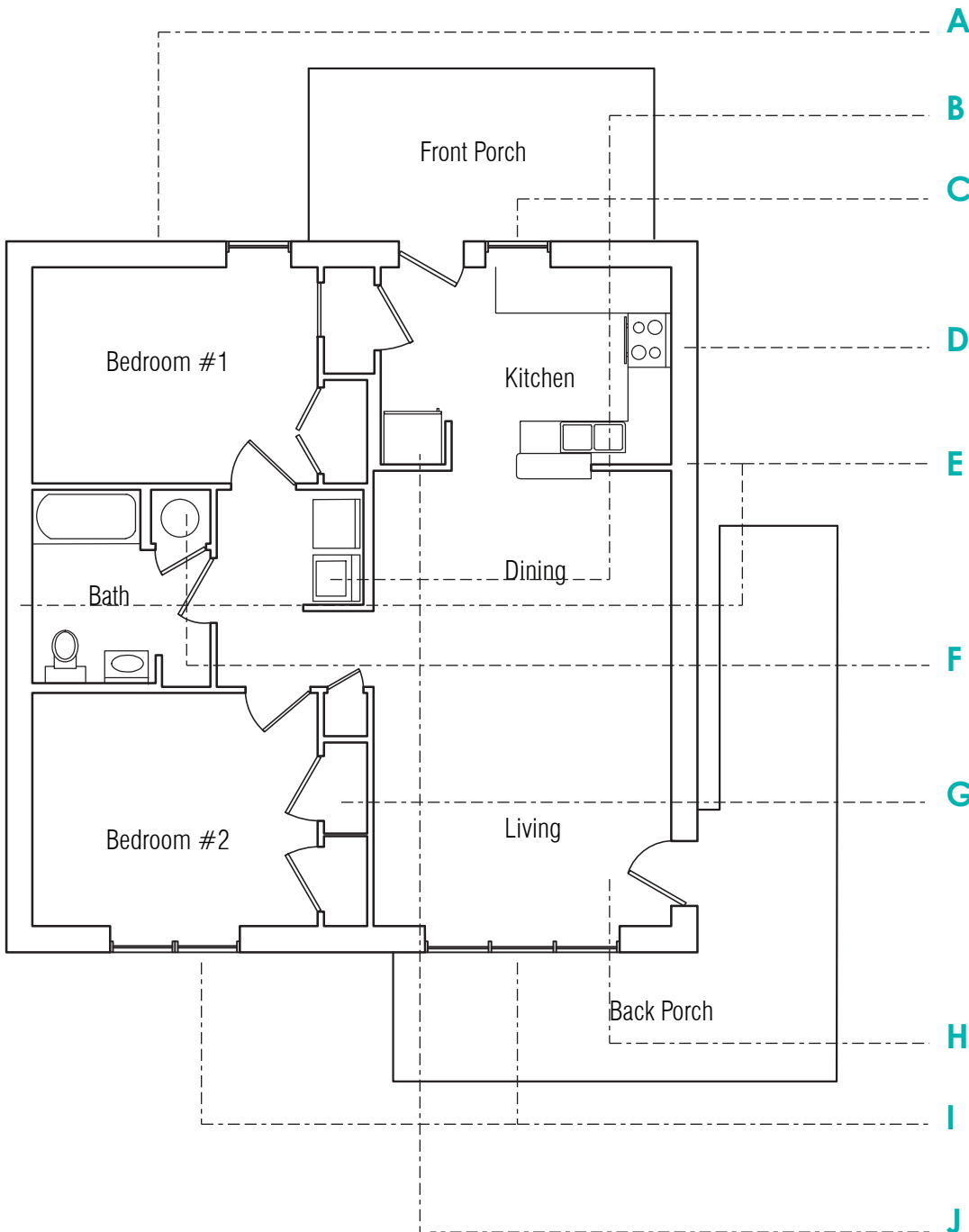
- A** 2x6 framed walls with R-19 fiberglass batt insulation
- B** Water wall: one wall that incorporates all water systems to minimize piping and plumbing requirements
- C** Double pane windows with a U-value of 0.30
- D** Only windows on east and west sides are well protected to minimize unwanted heat gain from those directions with maximized windows on north and south
- E** Low flow fixtures
- F** Energy Star appliances

Savings:
@ \$0.1167/kwh
\$47.45/month

House #2

902 square feet with a HERs rating of 24. Special attributes about this house are the use of photovoltaic panels, passive solar heating from southern windows, 14" thick double stud walls, and triple pane windows. It uses about 3,517 kwh/year which is 9,947 kwh less than the average home in this region.

Savings:
@ \$0.1167/kwh
\$96.73/month

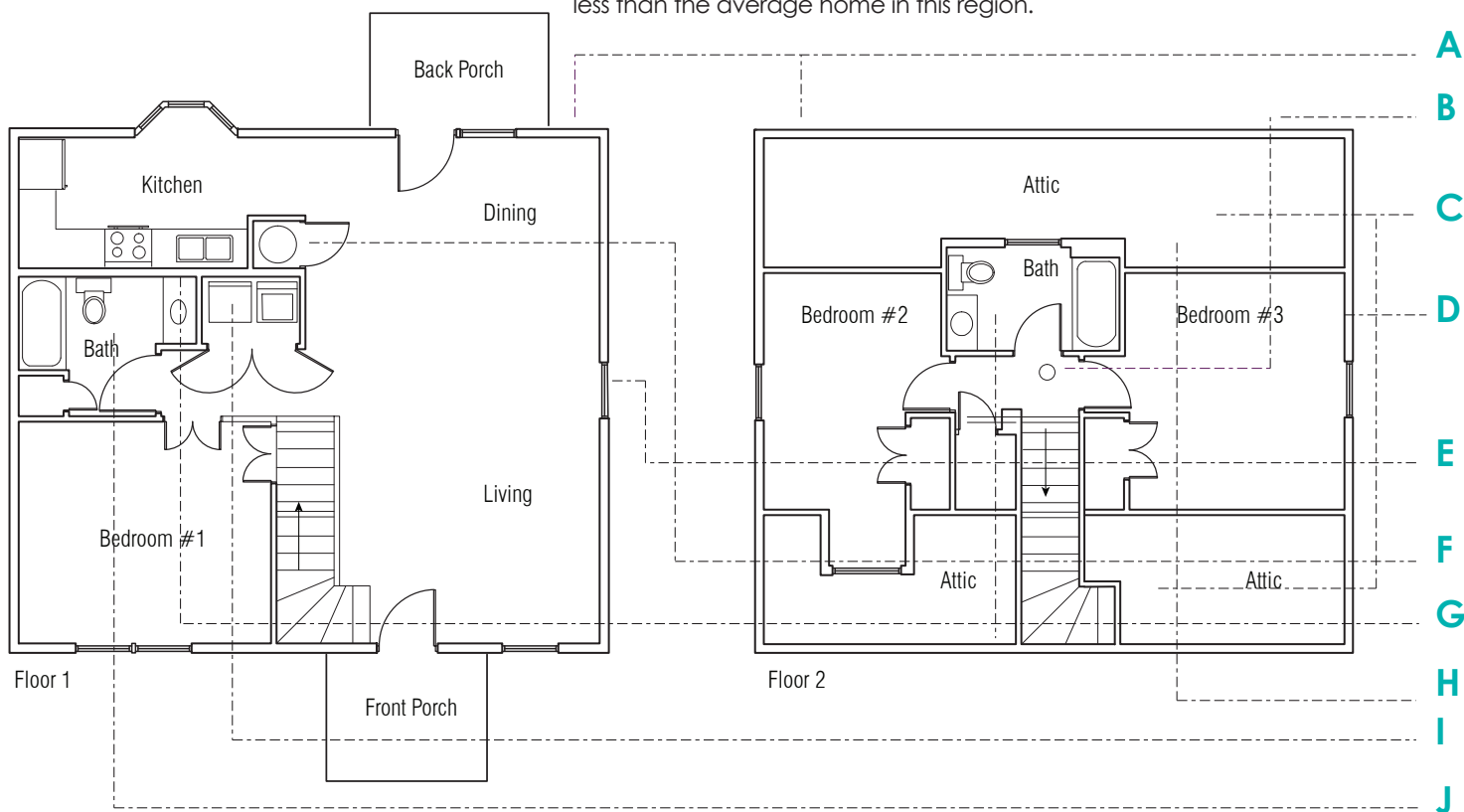


Energy Efficient Components

- A** R-10 rigid insulation on exterior of entire wall
- B** Condensing dryer, recycles heat to be used again, no loss of air to outside
- C** Triple pane windows with a U-value of 0.19
- D** 2x4 double stud walls with R-55 dense pack cellulose insulation, tightly air sealed with energy trusses
- E** No windows on East or West walls to minimize direct heat gain from those directions
- F** Heat pump water heater
- G** HVAC system run over closets and laundry so that it is not visible but in conditioned space
- H** Continuously insulated slab construction
- I** Triple pane windows with a U-value of 0.19 with no low-e coating on south side to allow for solar heating in winter
- J** Energy Star appliances = \$47.45/month

House #3

1301 square feet with a HERs rating of 56. Special attributes about this house are the use of geothermal heat, two-story design, solar tubes, and a fully insulated attic space. It uses about 10,227.71 kwh/year which is 3,236.29 kwh less than the average home in this region.



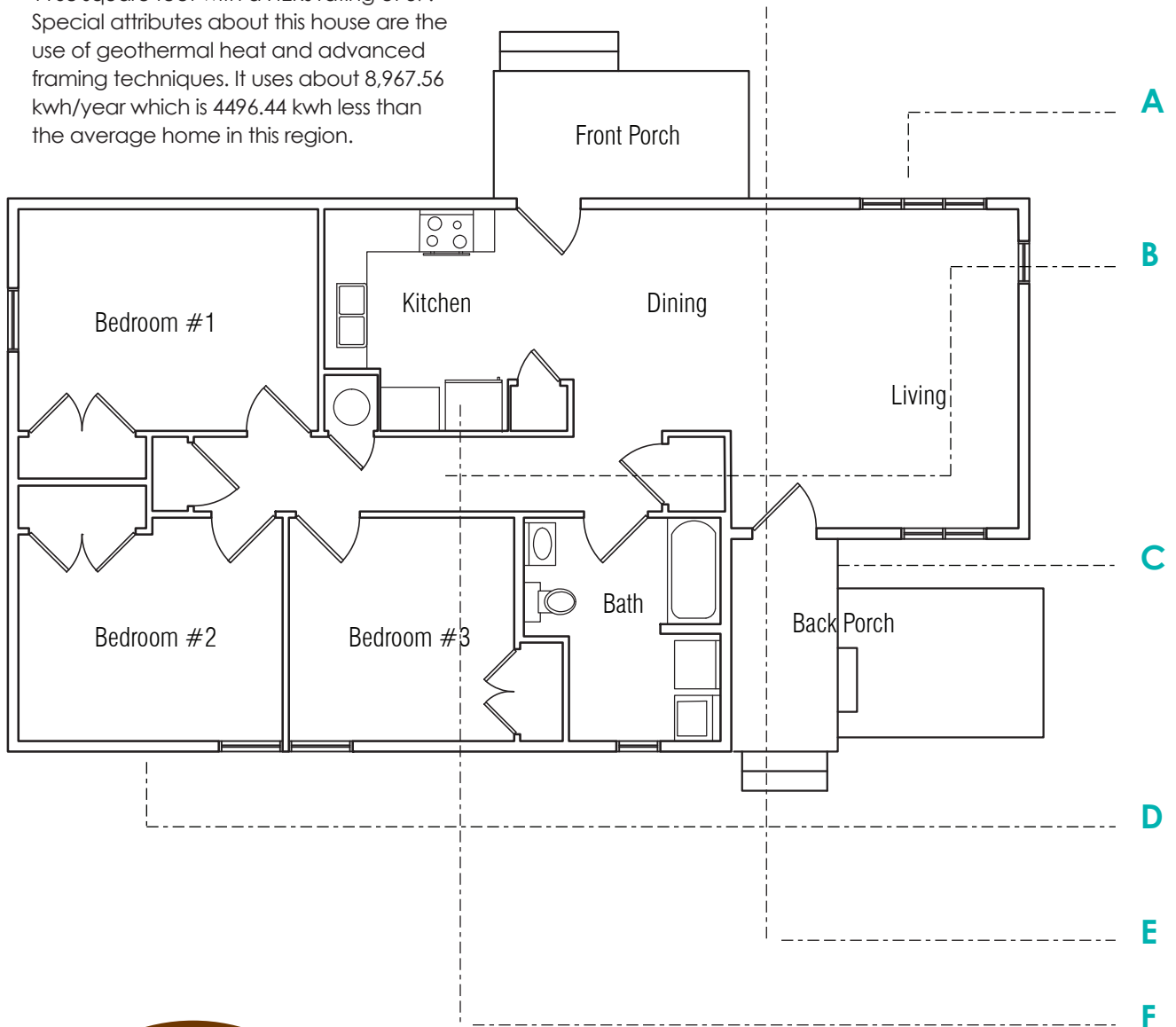
Energy Efficient Components

- A** Two story construction which allows for less surface area than an equal sized one-story home.
- B** Solar tube to allow light into the hallway where lights are often left on.
- C** Conditioned attic spaces which allows all the mechanical systems to be in the attic and conditioned space at the same time
- D** 2x6 advanced framing wall construction with R-26 closed cell spray foam, tightly air sealed
- E** Double pane windows with a U-value of 0.30
- F** Electric water heater supplemented by the waste heat generated by the geothermal heat pump
- G** Stacking of rooms requiring water systems to minimize piping and plumbing requirements
- H** Geothermal unit and pump
- I** Energy Star appliances
- J** Automatic bathroom fan with light to lessen load on HVAC system

Savings:
@ \$0.1167/kwh
\$31.47/month

House #4

1108 square feet with a HERs rating of 57. Special attributes about this house are the use of geothermal heat and advanced framing techniques. It uses about 8,967.56 kwh/year which is 4496.44 kwh less than the average home in this region.



Savings:
@ \$0.1167/kwh
\$43.73/month

Energy Efficient Components

- A** Double pane windows with a U-value of 0.30
- B** Lowered ceiling in hallway to allow for duct-work to be unexposed but in conditioned space of house
- C** Conditioned crawl space - R11.1 insulated foundation walls
- D** 2x6 advanced framing wall construction with R-19 fiberglass batt walls, tightly air sealed
- E** Geothermal heat pump
- F** Energy Star appliances

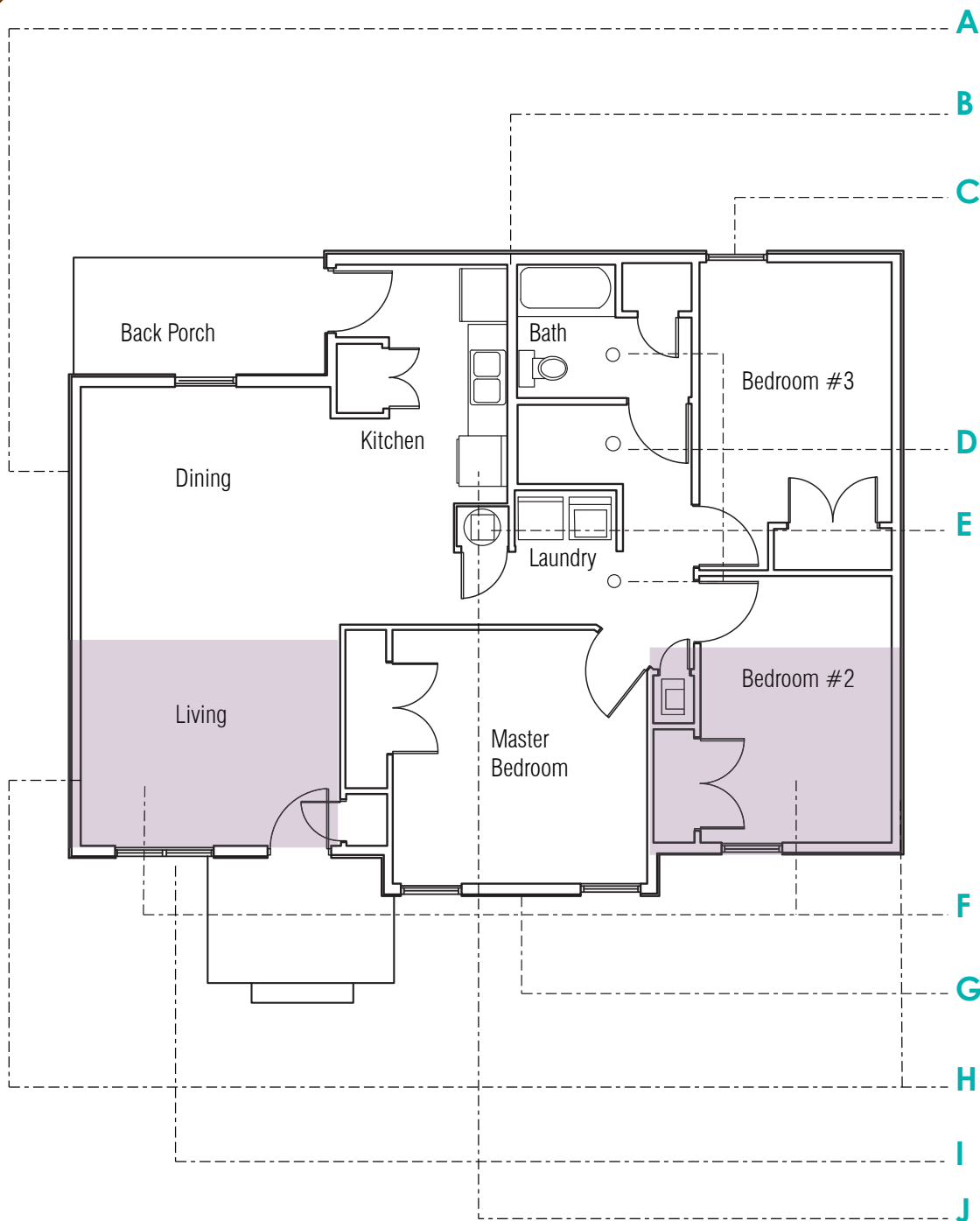
Savings:
@ \$0.1167/kwh
\$73.78/month

House #5

1209 square feet with a HERs rating of 33. Special attributes about this house are the three solar tubes used to light the laundry and bathroom, the use of a solar water heater, and the use of geothermal heat. It uses about 5,333.65 kwh/year which is 8,130.35 Kwh less than the average home in this region.

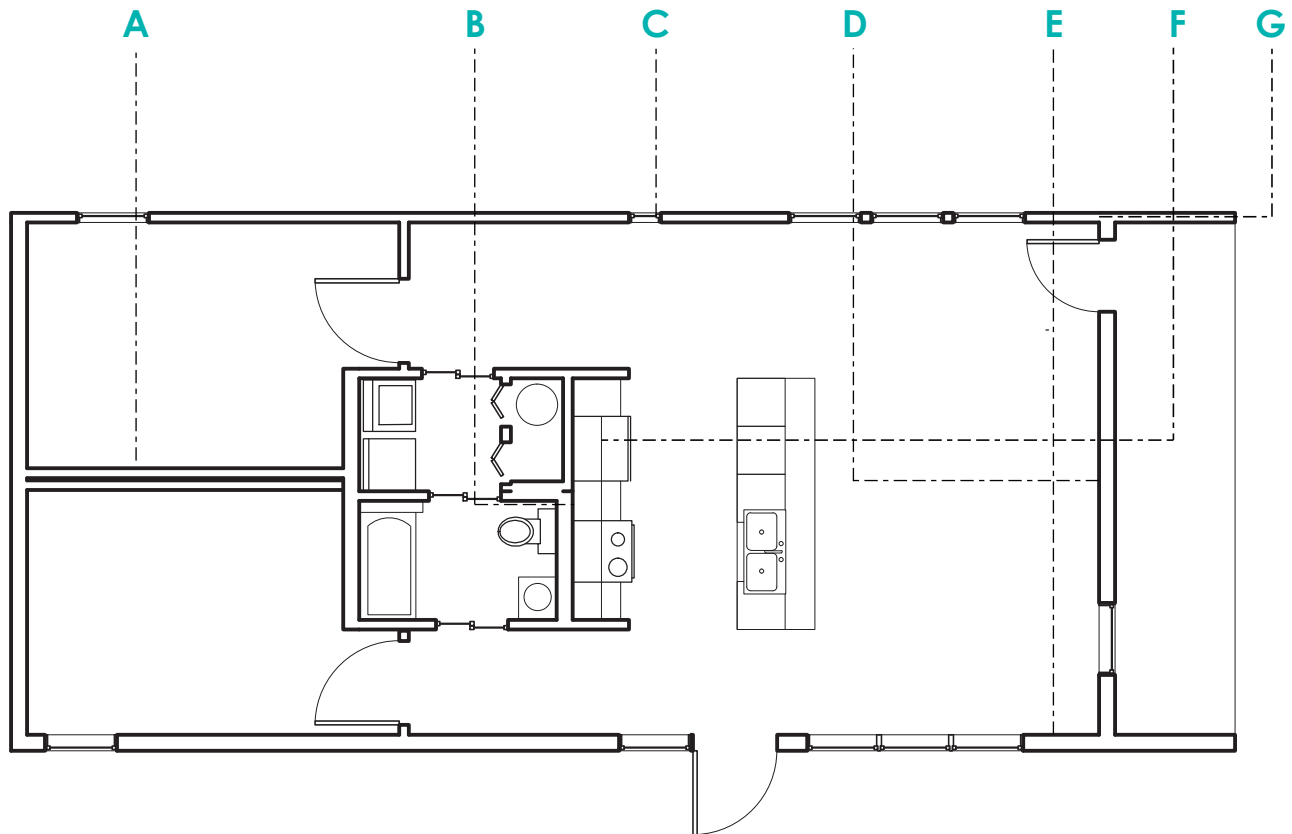
Energy Efficient Components

- A** R-10 rigid insulation on exterior of foundation wall
- B** Water wall: one wall that incorporates all water systems to minimize piping and plumbing requirements
- C** Double pane windows with a U-value of 0.30
- D** Solar tubes used to light the laundry and bathroom
- E** Solar water heater with electrical component
- F** Slab construction with rigid foam in two areas on the south side of the house to maximize the benefit from passive solar heating
- G** 2x6 advanced framing wall construction with R-26 closed cell spray foam tightly air sealed
- H** No windows on East or West walls to minimize direct heat gain from those directions
- I** Multiple south-facing windows to maximize passive solar in the winter (overhang of roof protects windows in summer)
- J** Energy Star appliances



House #6

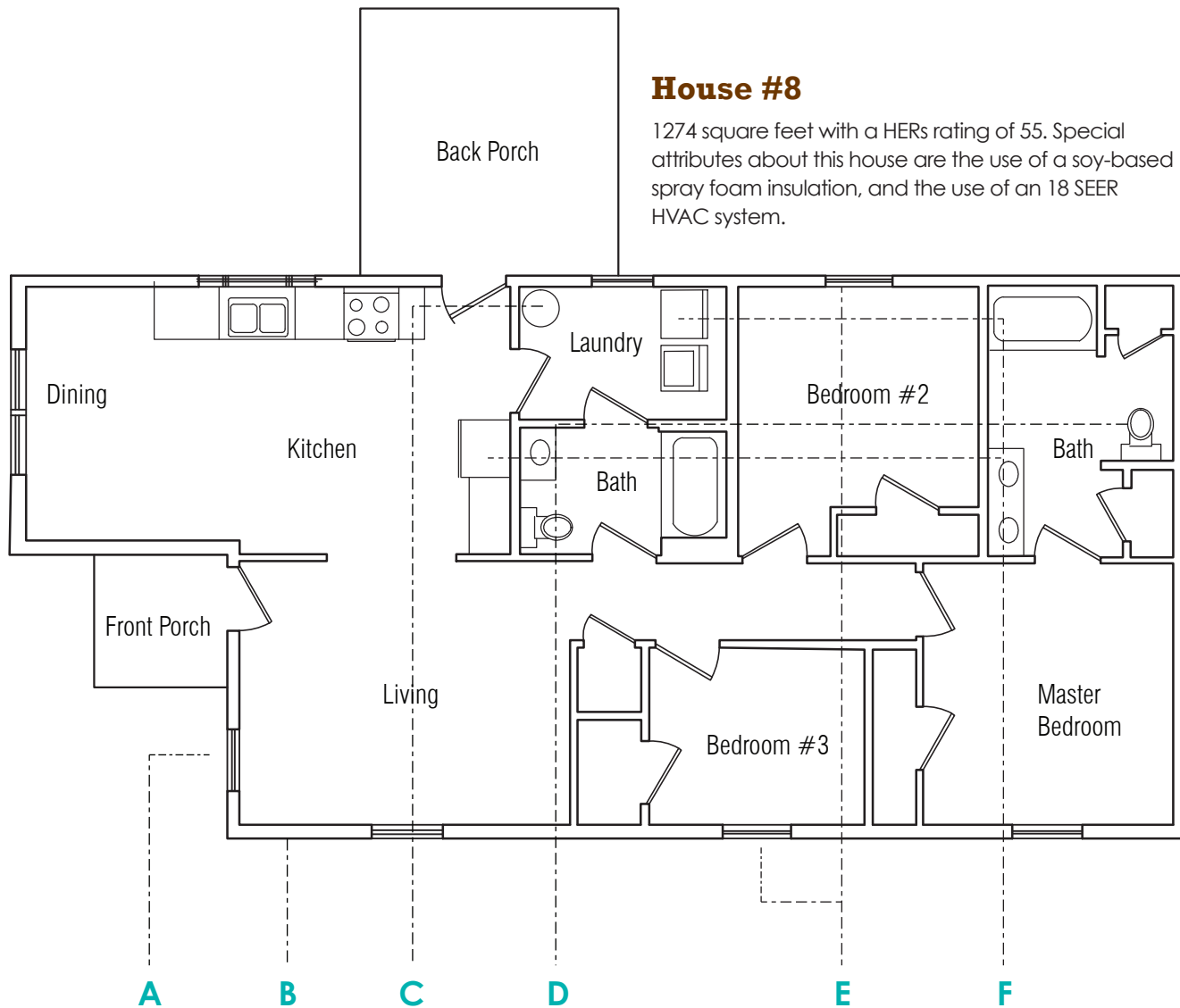
1035 square feet with a HERs rating of 52. Special attributes about this house are that it is a modular house that will be constructed in a factory and then placed on site and that it uses the SIP wall system. It uses about 7,955 kwh/year which is 6409 Kwh less than the average home in this region.



Savings:
@ \$0.0947/kwh
\$50.57/month

Energy Efficient Components

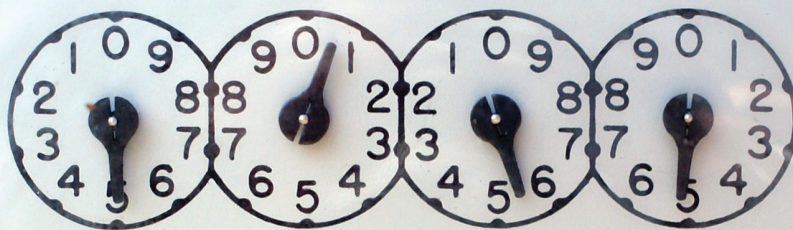
- A** Constructed in two modular pieces that can easily be transported and then placed together on site.
- B** Water wall: one wall that incorporates all water systems to minimize piping and plumbing requirements
- C** Double pane windows with a U-value of 0.26-0.29
- D** SIP wall panel. system with an R-value of 32.9, tightly air sealed
- E** No specific orientation, preferably this would be oriented with the long sides to the north and south as that will create minimal East and West exposure
- F** Energy Star appliances
- G** Spray foam insulation on rim and head joints in walls



Energy Efficient Components

- A** Double pane windows with a U-value of 0.30
- B** R-30 Agribalance foam insulated 2x6 walls tightly air sealed
- C** Rheem Marathon water heater
- D** Low flow fixtures
- E** Maximum window exposure to North and South with minimum exposure to East and West to limit unwanted heat gain
- F** Energy Star appliances

KILOWATT HOURS



240v
3w

K_h 3.6

Utility Savings Analysis: Energy Efficient vs. Traditional Construction

Utility Savings Analysis: Energy Efficient vs. Traditional Construction

The first thing to consider to determine savings when comparing green or energy efficient houses with those that simply meet the Kentucky Residential Code or the Kentucky Housing Corporation Design Standards is that ***green and energy efficient have two very different definitions.***

Green refers to reducing the environmental impact of the house and making it non-harmful to the environment. While green includes addressing energy efficiency, that is only one of the components. Green is also about choosing sustainable materials and building in regard to the surrounding landscape. On the other hand, energy efficient refers to cutting down on the amount of energy a home uses and thus on the cost of utilities. So, while both are important in the context of efficiency and environmental impact, it must be realized that a home can be green without being energy efficient and a home can be energy efficient without being green. Based on the assertion that this report deals with utility savings and low-income housing created by FAHE Members, it would seem that energy efficient housing is the more pertinent path. (See Table 1 for comparison of energy efficient requirements.)

The goal of this analysis is to determine the utility savings gained from constructing an energy efficient house rather than one that simply meets code. I have collected information and data from several partners of FAHE including People's Self-Help Housing (PSHH), Kentucky Highlands Investment Corporation (KHIC), Frontier Housing, and Community Housing Partners (CHP). All of these groups have been working on both green and energy efficient housing design with the conclusion that energy efficiency is the more attainable and logical goal when working with low-income housing. While using green practices and materials when possible is highly recommended and encouraged, the cost of building green often makes the endeavor impractical. Energy efficient techniques and materials, however, come at a very low cost for the benefits they deliver. Unanimously at the top of the charts



is air-sealing which can drastically reduce air leakage in the house, reducing the heating and cooling loads of the house, and comes at the very low cost of some building tape and careful construction.

The course of this analysis compares single-family homes built to code to single-family energy efficient homes. The results indicate a higher initial cost to buying an energy efficient home but a lower monthly energy bill. The energy bill is so much lower in fact, that even with a higher mortgage, the total bill per month is still \$25.00-\$75.00 less. Thus, energy efficient homes will save the owner money over the life of the home in terms of cost-savings as well as durability. Furthermore this report compares the different materials and practices used on these energy-efficient homes in the hopes of determining the most cost-effective, energy-efficient options available. It becomes more evident through this analysis that the most energy-efficient option is not necessarily the most green.

When analyzing the final data, it is important to recognize the many variables that have affected the information and have an impact on its understanding. The amount of kilowatt hours (kWh) used by the homes is an average, as the use of the home actually determines the amount of kWh used. For example, a family with two young kids vs. a family with two teenage kids, vs. a couple with no kids will use the same house in very different ways in terms of energy usage. All cost information is also very variable. Energy efficient and traditional built houses are comprised of roughly the same square footage in the same town in order to guarantee as close of a comparison as possible. However, mortgages vary, the cost per kWh of energy most likely will be different next year than it is right now, home prices can change rapidly, and material costs are not static. Material characteristics and effectiveness, however, are some of the only constant components and thus should be prioritized above cost.

In the data collection tables that follow, there are some mutual points and processes that can be compared effectively between the different homes and the different members designing and building these homes. As energy usage data continues to be collected on many of these "model" homes, the effectiveness of each of the energy efficient

choices will become much clearer. Currently the cost to build the home versus the appraised value of the home is one of the biggest price gaps in the construction of these homes. Most of the Members feel that this gap will decrease as the construction process of these energy efficient homes becomes more standardized and understood. These homes are still in the early stages of being perfected and already their benefits and savings are obvious and extensive. As we continue to develop better "greener" materials and as these materials become more widespread in their use, the cost will continue to decrease. And as the construction of these homes becomes more widespread and common place, the labor cost will decrease. Even at this early stage, however, there are major advantages and profits to be gained from building and buying energy efficient homes. Their worth will only increase in time and there is no doubt they will soon not be a choice, but a necessity.

Table 1: Energy Efficient Homes Comparison

Company	Sq. Ft.	Insulation	Air Exchange Rate	Windows	HERs Rating	Wall Construction	Cost/ Appraisal	Siding	kWh/ year
People's Self-Help Housing									
1	1120 (3 bed-1 bath)	R-19 Fiberglass batt walls – R-38 loose fill cellulose ceiling	410 CFM50	Double pane – U = 0.3	68	2x6 advanced framing	\$106,875/ \$91,000	Fiber cement	8,585
2	902 (2 bed-1 bath)	R-55 dense pack cellulose walls – R-96 loose fill cellulose ceiling	190 CFM50	Triple pane – U= 0.19	24	2x4 double stud	\$135,000/ \$90,000	Vinyl	3,517
3	1301 (3 bed-2 bath)	R-27 wall and R-40 ceiling open-cell spray foam	300 CFM50	Double pane – U = 0.3	56	2x6 framing	\$118,566/ \$95,000	Vinyl	10,227.71
4	1108 (3 bed-1 bath)	R-19 fiberglass batt walls – R-38 loose fill cellulose ceiling	438 CFM50	Double pane – U = 0.3	57	2x6 advanced framing	\$91,554/ \$88,000	Vinyl	8,967.56
5	1209 (3 be-2 bath)	R-26 closed cell spray foam walls – R-50 loose fill cellulose ceiling	522 CFM50	Double pane – U = 0.3	33	2x6 advanced framing	\$132,876/ \$90,000	Vinyl	5,333.65
Kentucky Highlands Investment Corporation									
6	1035 (2 bed-1 bath)	R32.9 SIP walls – R-41 fiberglass ceiling	646.922 CFM50	Double pane – U = 0.26-0.29	52	SIPs	\$111,000/ \$75,000	Vinyl	7,955
7	1259 (3 bed-2 bath)	R-56.48 high density fiberglass walls - R-62.96 blown in high density fiberglass and loose fill cellulose ceiling	95 CFM50	Triple pane – U =0.16	0 (est.)	2x4 double stud	\$160,000/ \$100,000	Fiber cement	3,902
Frontier Housing									
8	1274 (3 bed-2 bath)	R-30 Agribalance foam walls, R- cellulose ceiling		Double pane – U = 0.3	55	2x6 framing	\$130,000/ \$117,000	Fiber cement	
9	1172 (3 bed-2 bath)	R- fiberglass batt walls – R- loose fill cellulose in ceiling		Double pane – U = 0.3	35	2x6 framing, every stud caulked	\$112,500	Vinyl	



Energy Requirements

Energy Requirements

A basic goal targeted by several groups is the ***Energy Star 3 standard as well as a HERS rating of 50.***



Kentucky Building Code

According to the 101.2.6 Energy section of the code, provisions of the International Energy Conservation Code (IECC) shall apply to all matters concerning energy efficiency. The IECC determines requirements by climate zone of which Kentucky and almost the entire region that FAHE serves is in climate zone 4. In climate zone 4, the IECC requires a fenestration U-factor of at least 0.35 and skylight U-factor of 0.60 with no specified SHGC. The ceiling R-value must be at least R-38 and the wood frame wall R-value must be at least R-13. The R-value of the basement walls must be at least 10/13 which means it must have a continuous interior or exterior insulated sheathing of R-10 or an R-13 cavity insulation. Slab R-value of R-10 at a depth of 2 ft. and a floor R-value of R-19.

Kentucky Housing Corporation (KHC)

KHC requires a heat pump system of minimum SEER¹ of 13.00 and a minimum HSPF² of 7.7. Fuel oil and gas fired furnaces and boilers must have an AFUE³ of 90% or better. Refer to the Kentucky Building Code for insulation value and window requirements.

Energy Star Version 3

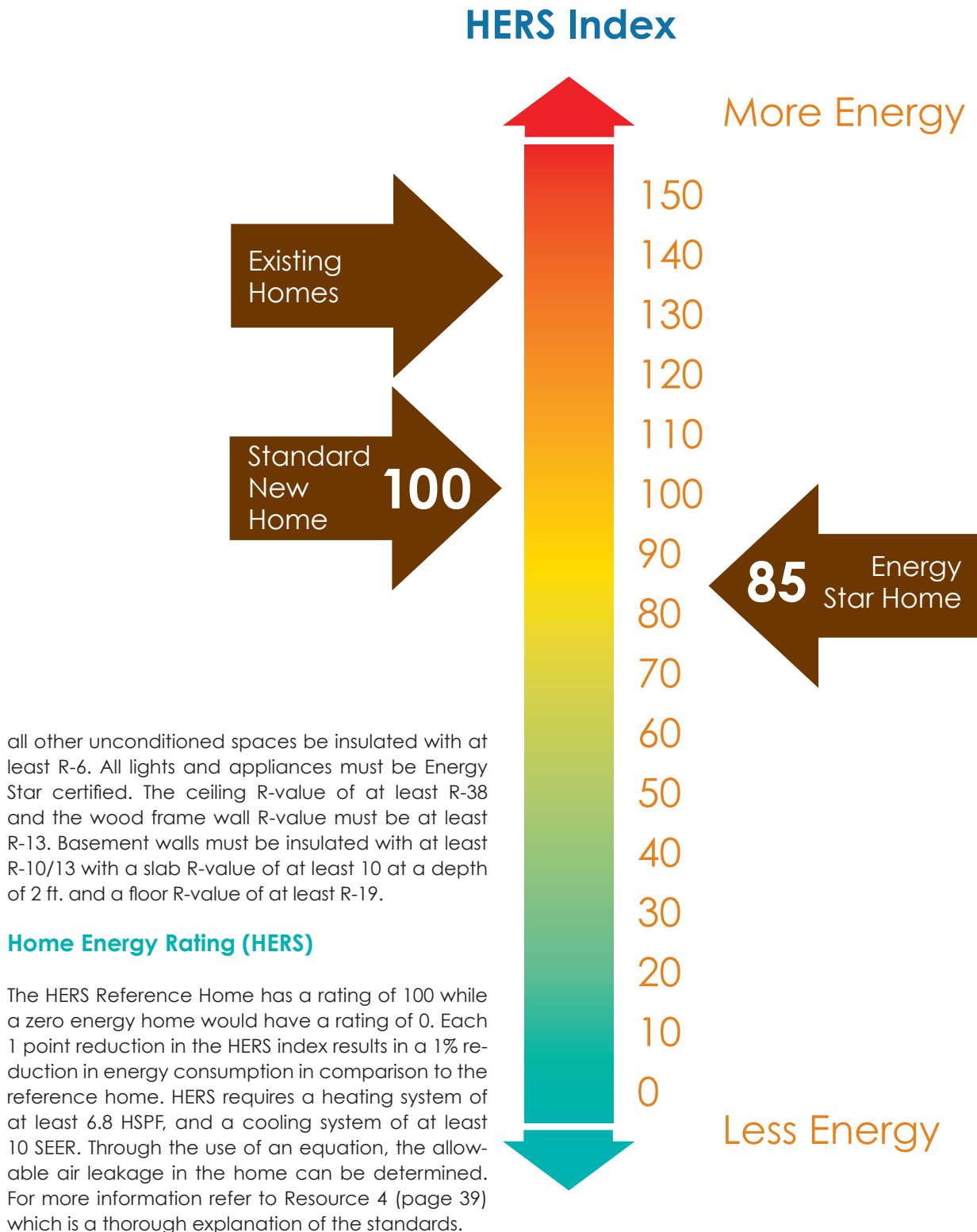
The most stringent energy requirements of the three, this is the agreed upon jumping off point for many of the Members. Energy Star requires an air-source heat pump ≥ 8.2 HSPF, 14.5 SEER and 12 EER⁴ with an infiltration rate of ≤ 5 ACH50. Window U-factor must be at least 0.32. It requires supply ducts in unconditioned attics to be insulated with at least R-8 and ducts in

¹SEER – Seasonal Energy Efficiency Ratio

²HSPF – Heating Seasonal Performance Factor

³AFUE – Annual Fuel Utilization Efficiency

⁴EER – Energy Efficiency Ratio





Material Recommendations

Material Recommendations

In looking at all of the data from these homes, there are several materials and procedures for building that I would recommend for future building ventures in terms of providing long-lasting, durable, energy efficient homes that save the home-buyer money through the lifespan of the home and provide for a worthwhile investment. ***The most important concept to bear in mind is that homes work as a system.***

For example, insulating a home that is not well air-sealed is not going to be effective in terms of energy. Taping seams to air-seal the home is one of the top priorities for any new construction and has been adopted by most FAHE Members as well as other groups constructing energy efficient homes. It is important to consider energy efficiency in every aspect of the construction process as that is the only way to construct a home that will perform effectively and efficiently.

Insulation

While building green is not necessarily the primary objective in constructing low-income housing, there is room for some green choices in the design of energy efficient housing. One of these options is in the insulation material. In looking at insulation comparisons in Table 3, while fiberglass may be the most inexpensive option, cellulose is in close contest in terms of cost and offers a much greener option that has nearly the same R-value per square inch as fiberglass. Furthermore, the use of an exterior rigid board insulation or structurally insulated sheathing (SIS) system is highly recommended. The use of the exterior insulation helps with the air-sealing of the house as well as provides for greater insulation at a much thinner profile than that of increasing the thickness of the wall to increase the amount of insulation. And finally,

while spray foam is not a green option and is much more expensive, I would highly recommend its use to seal the rim and head joists of all walls as well as any areas that need to be air-sealed such as outlets. In terms of the spray foam option, there are two listed in the comparison table, open-cell and closed cell. Closed cell has a much higher density and thus uses a blowing agent with an extremely high embodied energy. Open cell foam has a lower density and uses water as its blowing agent which makes it a much more sustainable, "green" product. Closed cell foam also acts as a vapor and water barrier whereas open cell foam allows for vapor to move through it. Therefore open cell foam is the best option for housing because it allows moisture through the insulation whereas closed cell foam would trap moisture, creating moisture build up and mold and mildew growth in the walls.

Siding

While vinyl is without a doubt the most cost-effective option, because of its material make-up and lack of aesthetic appeal it is not the best option even for low-income housing. While its cost is appealing, it actually has about half the life-span of some of the more expensive options, so in the long term, the more expensive options will be more durable and long-lasting as well as providing greater aesthetic



(top left) Taping seams to air-seal a home has been adopted by most FAHE members as well as other groups constructing energy efficient homes. **(top right)** Duct work run through conditioned space. **(bottom left)** Spray foam insulation can be used to seal any areas that need to be air-sealed, such as outlets. **(bottom right)** Fourteen-inch thick walls filled with cellulose insulation.

appeal. Fiber cement is a much greener material that is being used by many of the Members that seems to be, in general, well-recommended. Its material costs run about as much as installed vinyl but because it is more durable, the payback is better. One untapped resource has potential, especially for this climate, is seamless steel siding. While it is also expensive, a little more so than even fiber cement, it has many added benefits. Seamless steel siding is very durable, will most likely last the lifetime of the home, and is custom fit to the house, meaning there are no seams in the siding and thus no unwanted air transfer through the siding. But the best option in my estimation is brick veneer siding. While it can get expensive—according to Members in this area it runs about \$7.00/sq. ft. including installation, which is about the same cost, or cheaper, than the purchase and installation of fiber cement or HardiBoard® siding—it is more durable, lasts longer, adds insulation value, and is a very attractive option. According to studies done in Virginia and Illinois, brick veneer siding results in 35% energy savings, 32% decrease in fire insurance rates, and a 5%-10% increase in resale value.

Framing

While thermal bridging is a concern with a 2x6 single stud wall, there are more alternatives than just the double stud wall. While using advanced framing techniques may not rid the wall of thermal bridges, it does decrease the number of studs in the wall as well as offers a somewhat “green” aspect, as it decreases material use and waste. Therefore, in looking at the amount of material used and the extra labor involved in creating a double stud, much thicker wall, it would seem that simply using standard 2x6 construction with the supplement of advanced framing techniques is a better option. Additionally, the extra insulation and R-value provided by the thicker double stud wall can be countered by using exterior insulation which can give the wall a high R-value, but with a much thinner and more cost-effective profile. Furthermore, the use of exterior insulation is effective at eliminating thermal bridges in the standard 2x6 wall.

Mechanical

All duct work and mechanical systems should be run in conditioned space as the difference in air temperature inside the ducts and in the outside air is more often than

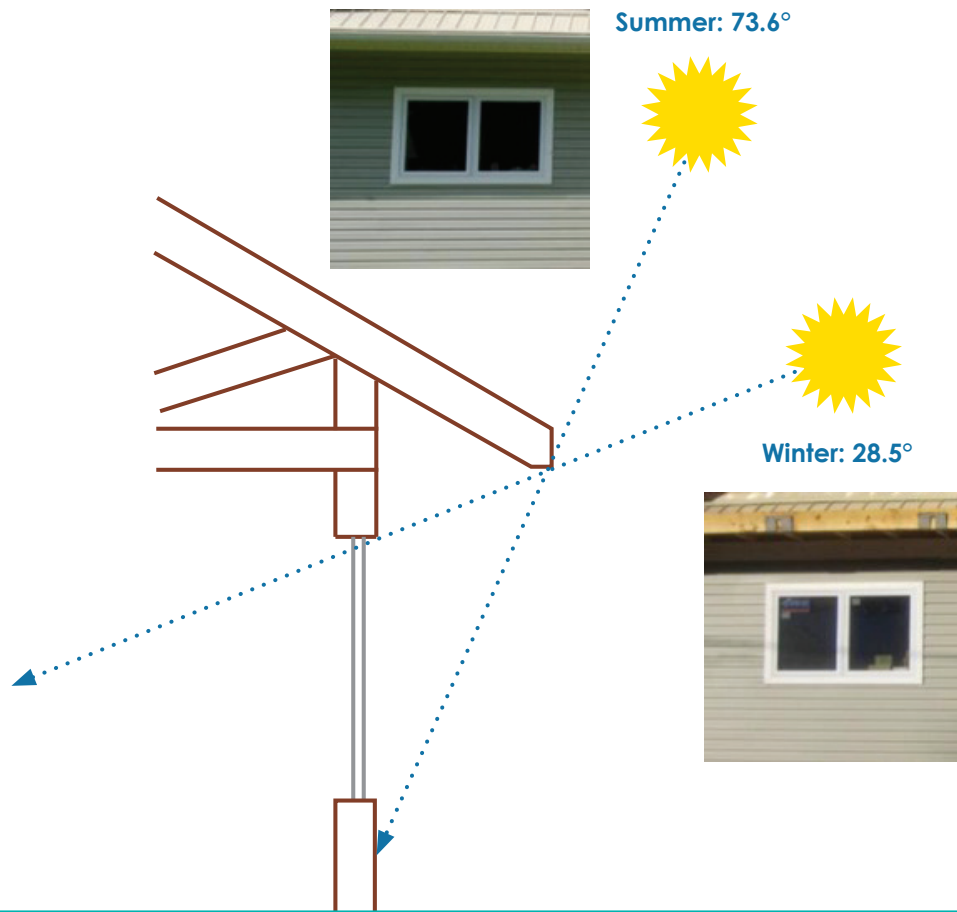
not at two extremes which results in lower efficiency as well as the possibility of condensation in the ducts. Properly sealing the ducts is important as any gaps result in air leakage and consequently energy loss. Using sealed crawl spaces is also a very effective measure for increasing the energy efficiency of the home because it allows for all the plumbing and mechanical systems in the crawl spaces to be in conditioned spaces which is, as stated above, highly recommended to be most efficient. There is also the option of putting the crawl space access hatch inside the home. Normally the hatch is installed outside and is often the origin of most air leakage into a conditioned crawl space. Putting it inside eliminates the need to insulate the hatch as it would simply be connecting two conditioned spaces. However, it also requires finding a fairly large floor area to give up for the hatch.

Once the houses are tightly air-sealed, it is very important to ensure that there is a healthy supply of fresh air. This can be easily accomplished through the use of an energy recovery ventilator (ERV) which exchanges air between outside and inside. This system is complemented by a heat pump, which in a very tightly sealed house can be sized very small and still be able to easily handle the heating and cooling loads. It is important to properly size the heat pump, because an oversized heat pump is extremely inefficient. One of the crucial purposes of air conditioning in a climate like Kentucky's is to dehumidify the air, but if the air is cooled too quickly by an oversized heat pump then the air cools off without actually becoming less humid. This is an issue not only for the comfort of the occupants but for the well-being of the house as mold and mildew growth will result from a space that is not properly dehumidified.

Windows

General consensus from the Members is that windows, while important aspects of the energy efficiency of a home, are still just a component of the overall building system. A good window will not save a leaky house. The Kentucky Building Code requires a fenestration U-factor of at least 0.35, but as you can see in the home comparisons between the different Members (Table 1), most are using double pane windows of at least $U=0.30$. Most windows these days have a low-e coating and an important fact to consider when using passive solar on the southern side

FIGURE 1



of a house—as PSHH did on their solar home—is that the windows must be allowed to collect heat, which means they must either not have a low-e coating or they must be a “high solar gain low-e window.” In order for passive solar heating to work correctly, these windows must also be protected with an overhang that blocks the summer sun but allows direct sunlight in the winter to collect heat. The summer equinox angle that must be protected against is 73.6° and the winter equinox angle that must be allowed to penetrate is 28.5° (See Figure 1). Another important feature of windows that is often overlooked is operability. Operable windows allow for natural ventilation on days when being completely sealed off is not entirely necessary. Using natural ventilation on days when it is tolerable will greatly reduce the energy load on the house.

Table 2: Insulation Comparison

Type	Installation method	R-value per inch	Raw Materials	Cost	Pros	Cons
Agribalance	Spray foam	R-4.45	Polyisomeric isocyanate, resin, urethane and vegetable oils	\$1.65-\$2.05 per sq. ft.;	Resistant to fungi/microbes, made of 20% renewables, no effect on indoor air quality	High embodied energy, dust can be an irritant
Cotton	Batt	3.5"=R-13 5.5"=R-19	90% post-consumer recycled fibers	\$0.88-\$1.87 per sq. ft.	Renewable, plant-based, 70% recycled	Can absorb moisture
Cellulose	Loose-fill, wall spray, dense pack	R-3.6-4.0	Recycled newspaper	\$0.50-\$0.81 per sq. ft.	30% less energy than fiberglass, 75% recycled	Can absorb moisture, can settle
Fiberglass	Batts, loose-fill, semi-rigid board	R-3.14-4.30	Silica sand, limestone, boron, recycled glass, resin	\$0.25-\$0.90 per sq. ft.	Silica is abundant, 40% recycled (max.)	High embodied energy, re-releases irritants, may release formaldehyde
Closed cell polyurethane	Spray foam	R-5.8-6.8	Fossil fuels	\$0.70-\$1.00 per board ft.	No HCFC ⁵ , doesn't settle, prevents air leakage, 33% soy available.	High embodied energy, not recyclable, petrochemicals
Open cell polyurethane	Spray foam	R-3.6-3.8	Fossil fuels, soy	\$0.44-\$0.65 per sq. ft.	No HCFC, doesn't settle, prevents air leakage, 33% soy available	High embodied energy, not recyclable, petrochemicals
Structural Insulated Panels (SIP)	Pre-assembled	4.5"=R14.4 12.5"=R45.9	OSB and EPS foam	\$3.50 per sq. ft. (6.5")	Little waste, prevents air leakage, recyclable	High embodied energy, often contains formaldehyde
EPS Geofoam (expanded polystyrene)	Rigid board	R-3.85-5	Petroleum or nat. gas, propane	\$0.40-\$1.12 per sq. ft.	No HCFC, recyclable	High embodied energy, petrochemicals, contains toxins
XPS foam (extruded polystyrene)	Rigid board	R-5	Polystyrene crystals	\$0.54-\$1.12 per sq. ft.	More moisture resistant than EPS, recyclable	High embodied energy, petrochemicals, contains toxins
Polyiso (Polisocyanurate)	Rigid board	R-5.6=8	MDI, polyester polyol, pentane	\$0.70-\$1.01 per sq. ft.	No HCFC	High embodied energy, non-recyclable, petrochemicals

⁵hydrochlorofluorocarbons

Table 3: Siding Comparison

Type of Siding	Cost	Expected Product Life	Pros	Cons	"Greenness"
Fiber cement	\$5.00-\$9.00/sq. ft. (incl. installation)	50 years	Termite resistant, water resistant, non-combustible, very durable, easy maintenance	High dust content, more expensive, slower installation time	Long lasting, low maintenance, high embodied energy
Vinyl	\$2.00-\$7.00/sq. ft. (incl. installation)	25 years	Most inexpensive, impact-resistant, strong, rigid, easy maintenance	Petroleum based, can trap moisture, high embodied energy	Made from polyvinyl chloride (PVC) – won't degrade, long-lasting, little maintenance
Brick veneer	\$6.00-\$12.00/sq. ft. (incl. installation)	75+ years	Maintenance free, thermal mass, sound and thermal insulation	More expensive	Very durable, minimal waste, natural ingredients, recyclable, low embodied energy
Aluminum	\$2.50-\$3.50/sq. ft.	20-50 years	Does not rot, easy maintenance, ideal for wet climates, moderate price	Tends to chalk, fade, and dent, conducts electricity, high embodied energy	Recyclable
Seamless steel	\$7.00-\$8.00/sq. ft.	20-50 years	No seams=no unwanted air transfer, good longevity, recyclable, resistant to bugs and mold, very durable	Can rust if exposed, expensive, has to be installed professionally, high embodied energy	Recyclable, long-lasting, little maintenance
Cypress siding	\$2.00/linear ft.	25-75+ years	Has natural preservative oil, extremely durable, resistant to moisture, decay, and bugs	Requires sealant that needs reapplication every 3-5 years, can fade over time	Renewable resource

Table 4: Framing Comparison

Type of Framing	Spacing	Cost/ linear foot
2x4 single stud wall	16" O.C.	\$0.25
2x 4 double stud wall	16" O.C.	\$0.50
2 x 6 single stud wall	24" O.C.	\$0.40
SIP wall	—	\$3.20 - \$4.30 per sq. ft. depending on thickness

A close-up photograph of a clear glass jar filled with numerous silver-colored coins. The jar is being held gently by two hands, with fingers visible at the bottom and sides. A small, white, rectangular piece of paper is stuck to the front of the jar, featuring the word "SAVINGS" written in a bold, black, handwritten-style font. The coins inside the jar are stacked and overlapping, with some showing the word "AUSTRALIA" and a map of the continent. The background is a solid, vibrant pink color.

SAVINGS

Savings and Recommendations

Savings and Recommendations

The comparisons in Table 5 show conclusively that an energy efficient home, while costing more up front and in mortgage payments, **saves significant money in the long-run.**

Savings

The first savings to pay attention to are the savings on the energy bill; about \$50.00-\$75.00 per month and between \$500.00 and \$900.00 per year. Then, taking these energy savings per year, I divided that into the difference in cost between the energy efficient home and the traditionally built home. This number is the number of years it takes to pay the difference in cost between the two houses with the savings acquired by the lowered energy bill. Basically, the energy efficient home will pay for itself within 5-8 years. However, while it is important to understand that the house will pay for itself in a very short time, it is more important to understand that the energy efficient home also results in instant savings for the homeowner. Furthermore, every month, even though the mortgage on the energy efficient house is higher than that on the traditional home, the energy savings are so high that the occupant can expect to be saving between \$30.00 and \$60.00 a month. Therefore, paying extra money up front on an energy efficient home results in substantial savings throughout the lifetime of the home.

For instance in Table 5, the house in Vanceburg costs \$135,000 while the energy efficient house is listed at \$132,276. It must be noted that \$132,276 is the cost to build, not the cost to the homeowner which was actually \$90,000 and still the homeowner is saving \$62.92 per month. If the cost of the house reflected the actual cost to the homeowner, the savings would have been extremely significant at \$220.92 per month. These are immensely substantial savings that resist contention. Based on the savings for the homeowner, there is no reason not to build with energy efficient practices, materials, and systems.

Recommendations

Developing energy efficient construction best practices is at an early stage, and there is a definite learning curve involved, but the only way to get better is to keep building. There are multiple ways to get similar results, whether you choose a 2x4 double stud wall, a 2x6 single stud wall with exterior insulation, or whether you choose fiber cement or brick siding. However, after reviewing the data and research, I have compiled the best options and listed them below:

- **Framing:** 2X6 single stud advanced framed wall with energy trusses and 2" of exterior EPS rigid foam insulation
- **Air-sealing:** tape all seams and mastic all ducts
- **Insulation:** blown in dense pack cellulose (could be fiberglass, though cellulose is the "greener" option) with open cell polyurethane spray foam insulation at all the rim and head joints and any other areas where there is a crack or opening
- **Mechanical:** high SEER heat pump and ERV, RHEEM or GE Hybrid water heaters are great options, Energy Star appliances and lighting.
- **Windows:** operable, non-low-e coated on south side to allow for passive solar heating, protected from the summer sun by overhangs (see Figure 1).
- **Siding:** Brick veneer siding
- **Foundation:** fully insulated slab or conditioned crawl space

Table 5: Utility Savings: Energy Efficient vs. Traditional

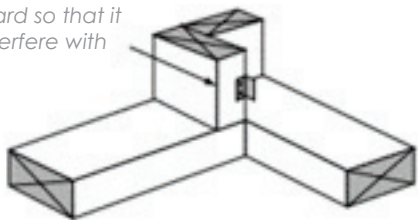
Location	Type of house	Square footage	Cost of house	Energy use/yr.	Energy bill/yr.	Savings/yr.	Savings/mo.	Payback time	Monthly mortgage payment	Total bill: mortgage and energy/month	Total bill savings/month
Monticello	Typical	1,008	\$95,900	14,364 kWh	\$1359.12				\$335.00	\$448.26	
House 6	Energy efficient	1,035	\$100,000	7,955 kWh	\$891.10	\$557.95	\$46.50	7.35 years	\$349.00	\$423.26	\$25.00
Morehead	Typical	1,200	\$115,000	13,464 kWh	\$1571.25				\$420.00	\$550.94	
	Energy efficient	1,274	\$130,000						\$454.00		
	Typical	1,190	\$85,000	13,464 kWh	\$1571.25				\$340.00	\$470.94	
	Energy efficient	1,172	\$112,500						\$393.00		
Vanceburg	Typical	1,248	\$130,000	13,464 kWh	\$1571.25				\$454.00	\$585.00	
House 5	Energy efficient	1,209	\$135,276	5,333.65 kWh	\$601.00	\$848.05	\$70.67	6.22 years	\$472.00	\$522.08	\$62.92

These are not by any means the only options. There are many different combinations of materials and practices that can result in an energy efficient home. Starting with the basics such as air-sealing and good insulation will improve energy efficiency immensely. As energy efficiency becomes more of a standard practice, the cost to build will go down as well as the material and mechanical costs. As shown by the data, the energy savings are already significant and will only increase as the process standardizes.

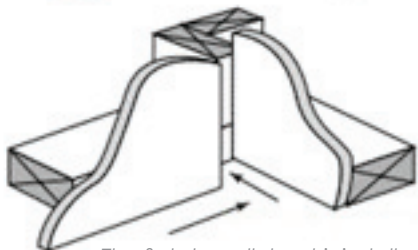
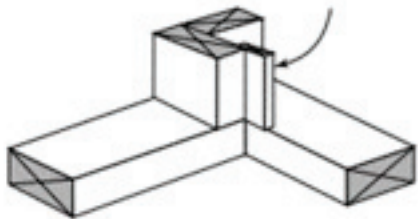
Tightly sealing a home comes at little cost and results in considerable savings in the HVAC system since the tighter the house, the smaller the HVAC system can be. Small changes like this that are carefully done are all that is required to make the transition from ordinary to extraordinary. Advanced framing, which simply involves creating a framing plan to ensure windows and doors are placed appropriately to avoid material waste, spacing studs 24" O.C. to reduce material use, using two-stud corner framing

FIGURE 2:
"Inside Two-Stud" Corners

Position clip support for gypsum board so that it does not interfere with trim nailing

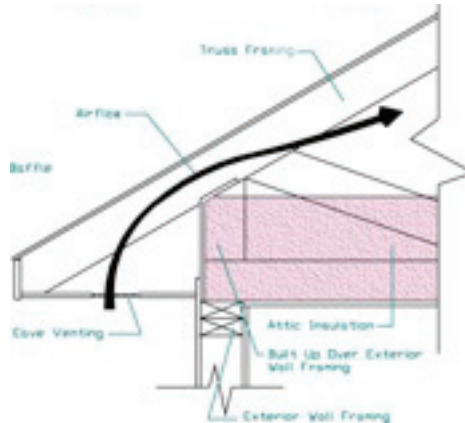


Backer support for gypsum board



The first drywall sheet is installed against side with clip or backer

FIGURE 3:
Raised Heel Conventional Truss



(Figure 2), and using energy trusses (Figure 3) is a simple step in the direction of energy efficiency. It also pays to choose operable windows placed on opposite sides of the house to allow for natural ventilation through the space. Properly sizing overhangs to protect windows from unwanted summer sun and to allow in warming winter sun is essential to using windows to their full advantage. Windows should be limited or eliminated on the east and west and maximized on the north and south. Finally, high-quality insulation is very important. When using a single stud wall, using an exterior insulation eliminates the problem of thermal bridging and thus greatly improves the energy efficiency of the home. Effectively sealing any cracks in the building envelope such as at the rim and head joints with open cell spray foam insulation is also a valuable practice. While it is not a very "green" product, it is the best option for the task and used in moderation in this scenario. The choice of insulation can vary though using closed cell spray foam or XPS is not recommended, as both are extremely harmful to the environment without offering significantly better R-values than less harmful products such as open-cell spray foam and EPS.

Finally, it is substantially important to educate homeowners on their energy use and their energy efficient homes. Operable windows are not effective unless they are operated. Geothermal heat doesn't save energy and money if the thermostat is kept at 78°. Education is key to using these homes effectively and making the effort worthwhile.



(Below) The Bonner House is a long term commitment to energy efficiency and affordability. While the home is a bit more expensive to build than a comparable traditional home, the Bonner House, right now, is saving about \$1100 a year in energy costs; savings that will only grow as utility rates continue to rise. And while some of this savings comes from the home's equipment, such as solar panels and a heat pump water heater, the core of the home's efficiency is in its exemplary insulation and air sealing, features that will need no further investment during the home's long life.





OF NEED
T H
E

06

30

40

09

APPALACHIA

Blanket Mtn.
4609 ft.

Highest Pt. in Tenn.
Clingmans Dome
6643 ft.

Gatlinburg
Ski Area

Headquarters
Sugarlands
Motor Center

Elk Mount
Ranger Station

Dollywood

Pigeon Forge
Love Creek
Cascades

Glades

(Closed
in Winter)

New
504

Appendix

Building Performance Institute (BPI)

Determination and Analysis of Utilization of New Knowledge

The three certifications that various FAHE members complete were the Building Analyst Professional, the Envelope Professional, and the Heating Professional. The Building Analyst Professional is the main standard and the other two build off of it.

Building Analyst Professional Minimum Health and Safety Requirements as according to the Technical Standards

- When air sealing, enclosed cavity insulation representing 15% or more of the total building shell area, or sealing of the ducts outside the thermal envelope are recommended, the work scope must include pre and post-installation blower door tests
- Whenever blower door tests are required, the results must be compared to the Building Airflow Standard to verify compliance with ASHRAE 62-89 requirements for ventilation. If natural ventilation is inadequate according to the ASHRAE standard, mechanical ventilation must be installed or recommended as part of the work scope to increase the ventilation to required levels
- A preliminary and post-installation safety inspection of all combustion appliances must be completed whenever changes to the building envelope and/or heating system are part of the work scope
- The combustion appliance safety inspection includes all of the following: carbon monoxide test, draft measurement, spillage evaluation, and worst-case depressurization of the combustion appliance zone
- In homes with natural gas/propane service, the gas line must be inspected thoroughly and all leaks repaired.
- Combustion safety test results must be acted upon appropriately according to the Combustion Safety Action Level Table
- Whenever an appliance fails any of the combustion safety tests, appropriate repairs must be completed or specified in the work scope according to the requirements listed
- Appropriate inspection and diagnostic tests must be included in the work scope when attic insulation and/or ventilation are specified
- Whenever air sealing or other shell tightening measures are recommended, leakage paths to the attic must be given highest priority on the work scope

Heating Professional Minimum Health and Safety Requirements as according to the Technical Standards

- Combustion appliances which fail any combustion safety test, as described in the Building Analyst Professional Standards, must be adjusted, repaired, or replaced; and the problem effectively remedied before proceeding with additional installations.
- When atmospherically vented combustion appliances are removed or replaced with sealed combustion units, a blower door test must be done to verify adequate air exchange across the building shell. Mechanical ventilation must be added, as needed to provide adequate air exchange in compliance with ASHRAE 62-89.

- When a high efficiency appliance, such as a furnace, is installed and no longer requires chimney venting, "orphaned" water heaters must be tested and verified for safe operation.
- In homes with natural gas service, the gas line must be inspected thoroughly and all leaks repaired.
- Forced warm air furnaces must be inspected for flame interference and additional heat exchanger integrity tests must be performed as indicated by the flame interference inspection. Cracked heat exchangers must be replaced.
- Steam distribution system pipes must be insulated in all accessible locations.
- All water heaters must have a pressure and temperature relief valve and a safety discharge pipe. Install a relief valve and discharge pipe if none exists.

Envelope Professional Minimum Health and Safety Requirements as according to the Technical Standards

- Blower door tests must be performed before and after the installation of air sealing, enclosed cavity insulation representing more than 15% of the building shell area, or sealing of ductwork located outside the building envelope.
- If the measured CFM50 is less than the Building Airflow Standard, as set forth in ASHRAE 62-89, mechanical ventilation must be recommended or installed according to the standards.
- When a mechanical ventilation system is installed in a building where combustion appliances are present, a complete post-installation combustion safety diagnostic must be conducted and final conditions must meet minimum safety requirements for draft, spillage, and CAZ depressurization.
- Air sealing measures must be prioritized to reduce the stack effect and inhibit moisture migration into attics or other interstitial spaces.
- Appropriate inspection and diagnostic tests must be performed before and after installation of attic insulation and/or ventilation to ensure an effective air barrier exists between the attic and living space.
- Prior to installing insulation in an existing home, a thorough inspection of the interior and exterior of the home is required to identify areas where installation of insulation may be unsafe. Problems that are identified must be remedied prior to installation.
- Insulation may not be installed where live knob and tube wiring exists.
- Recessed can light fixtures that are not IC-rated, chimneys, and other heat producing obstructions must be baffled with an effective dam prior to insulating the area to maintain minimum clearances to insulation or other combustible products

In order to determine and analysis how members who received their BPI certification in Building Analyst, Envelope Professional and Heating Specialist are utilizing their new knowledge, I sent out a questionnaire as well as conducted one phone interview. Unfortunately few people have responded. I have attached the completed questionnaires and some of the information from the phone interview. While not a majority in the least, the people who have responded seemed to feel that while they knew about the importance of insulating and air-sealing, having tools such as the blower-door test that provide quantifiable information is extremely helpful. This is the type of information that is necessary in order to show people the real benefits

of energy efficient measures as it is actual hard data. Basically, it seems that the training was worthwhile in terms of receiving and learning to use the equipment as well as understanding specific requirements such as the proper amount of fresh air that needs to be introduced into a home. Furthermore, one response included the added benefit of taking this knowledge and applying it to the design stage of building. The knowledge gained from this certification can be applied to renovation as it is intended, but it can also influence how new homes are designed.

From the responses of the BPI certified professionals I spoke with, it would seem that BPI could be a very beneficial and rewarding new line of business. It helps immensely with remodeling as the equipment specifically points out the most important areas to focus on and hence makes every dollar count. The cost to have the energy audit done is the biggest roadblock at the moment for the affordable housing market, figuring out how to make it into a business will be essential for its success. Overall, the BPI certification offers numerous opportunities in the world of energy efficiency. Many people already have homes that simply aren't operating efficiently but are still decent, solid homes. With BPI certification, these homes can be rehabbed and brought to the same standard as new energy-efficient construction. Tearing down well-built old homes to build new ones is not an energy efficient answer, but saving these old homes and making them more energy efficient is.

Next Steps:

- Consider how a BPI house energy audit be funded. The cost to the homeowner does not lend itself to low-income housing owners. Possibly marketing to the median to higher income families in order to develop this into a business.
- Make the benefits (energy bill savings, state and federal incentives, and the Weatherization Assistance Program) well-known to the public
- Collect data on before and after homes to start compiling hard data that can illustrate the savings to both the homeowner and for the possibility of convincing the Appraisal Institute to include energy efficiency in appraisals.
- Continue training professionals; having one in each of the member organizations would be an excellent goal because they are a valuable resource that should be accessible and convenient to each location.

Glossary

Advanced framing:

Techniques using 2x6 wall studs spaced 24" on center (O.C.), using single-top plates in non-load bearing walls, using in-line framing for two story houses, and using energy trusses.

Energy truss:

Also called a "raised heel truss," allows for the insulation in the ceiling to continue at the same thickness all the way to the end of the truss, doesn't come to a triangular point but is built up to allow insulation out to the edge.

Heat pump:

A heat pump uses a small amount of energy to move heat from one location to another, pull heat out of the air to heat and vice versa to cool.

Low-e coating:

Low-e coating is a virtually invisible metallic or metallic oxide layer on the window that reduces the U-factor by suppressing heat flow by radiation.

R-value:

Measure of thermal resistance, the greater the R-value, the greater the thermal resistance.

Thermal bridging:

When a material that is a poor insulator allows for heat to flow through the path of least thermal resistance, i.e. a wood stud is a gap in the insulation in the wall, and acts as a thermal bridge between the inside and outside air temperatures.

U-factor:

Measures the rate of heat transfer through a product, therefore the lower the U-factor, the lower the amount of heat loss and the better the product is at insulating the building.

Resources

1. Smegal, Jonathon and John Straube,
<http://www.buildingscience.com/documents/reports/r-0903-building-america-special-research-project-high-r-walls/view>
2. Listiburek, Joseph,
<http://www.buildingscience.com/documents/published-articles/pa-future-of-framing>
3. <http://www.bpi.org>
4. <http://www.resnet.us/standards/mortgage>

