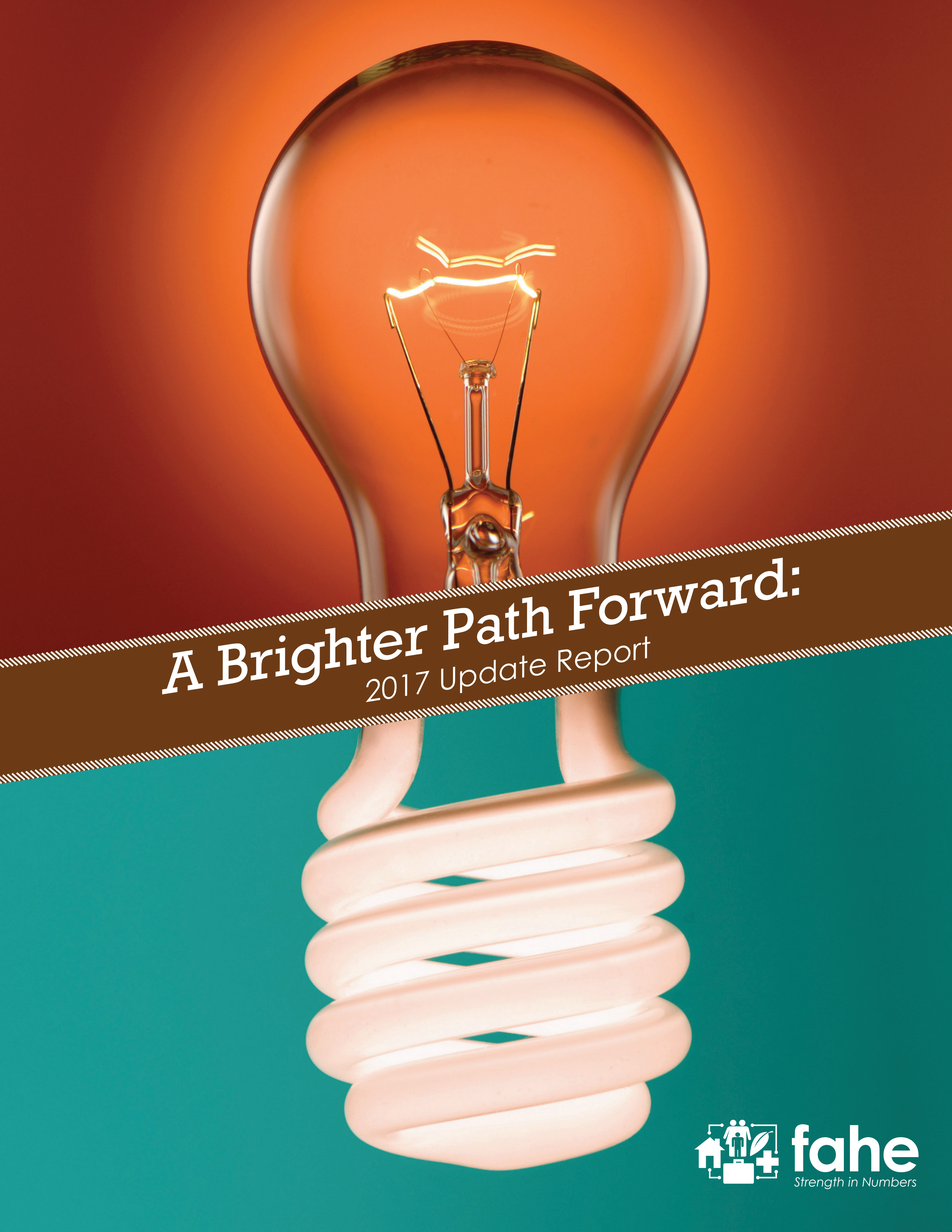

A Brighter Path Forward:

2017 Update Report

fahe

Strength in Numbers

A Brighter Path Forward:
2017 Update Report

by Kathryn Sanders

fahe
Strength in Numbers

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Introduction

This report was undertaken as an update to the 2012 Fahe publication "A Brighter Path Forward: The Intersection of Green Construction and Affordability". Information was primarily gathered from two surveys which were sent out to the Fahe Member Organizations in the spring of 2017. These surveys intended to determine the changes in energy efficient construction practices over the past five years.

Residential sources account for 12% of greenhouse gas emissions in the United States, by both indirect and direct means. Houses use energy directly to heat, cool, light, and other functions. Indirect means related to residential carbon emissions include off-site generation of electricity which is then supplied to houses.

According to the EPA, green building techniques and retrofitting that abide by energy efficient guidelines accomplish the same functions while using less energy which reduces greenhouse gas emissions. Such techniques include improved insulation, more efficient HVAC systems and lighting, using passive strategies for heating and lighting, and using energy efficient appliances.

Fahe Members use many of these strategies in their single family energy efficient designs. In addition to reducing greenhouse gas emissions, these strategies also reduce the homeowners' energy costs. Because of this, low-income households are better able to make payments, which allows the non-profit companies to continue producing these homes.

Barriers

While energy efficient design represents a fairly effective solution to low-income housing, Members reported that there are still barriers that prevent it from being more effective. Cost is the largest barrier to getting the full value for energy efficient units, mostly because of construction but also in having the unit energy rated according to the required standards. Other reasons why Members find energy efficient low-income construction doesn't reach its full potential include lack of desire on the part of the homeowner, difficulties scheduling a rater, and the fact that appraisals don't represent the full value added.

The lack of desire of the homeowner to save money through the energy efficient design is a critical point to understand. Different occupants of these homes may use the appliances and strategies in different ways, based on their family size and dynamic, or based on their priorities. Some inhabitants may prefer to use the more efficient heating and cooling systems to be comfortable throughout the seasons without adjusting the way they dress.

Additional Services

The large majority of Fahe Member Organizations provide Energy Efficient Single Family Housing, but many provide additional services to their clients. The following table indicates other such services and whether or not Members have interest in providing them, if they had the means.

	Already Provide	Would Provide	No Plan to Provide
EE Single Family	80%	15%	5%
EE Multi Family	47.06%	23.53%	29.41%
Weatherization	47.06%	11.76%	41.18%
EE Retrofit & Rehab	35.29%	35.39%	29.41%
Lending for Rehab	11.76%	29.41%	58.82%

Lack of funding and lack of appropriate staff are the main reasons Member organizations cannot provide the additional services they would like to.

Updated Material

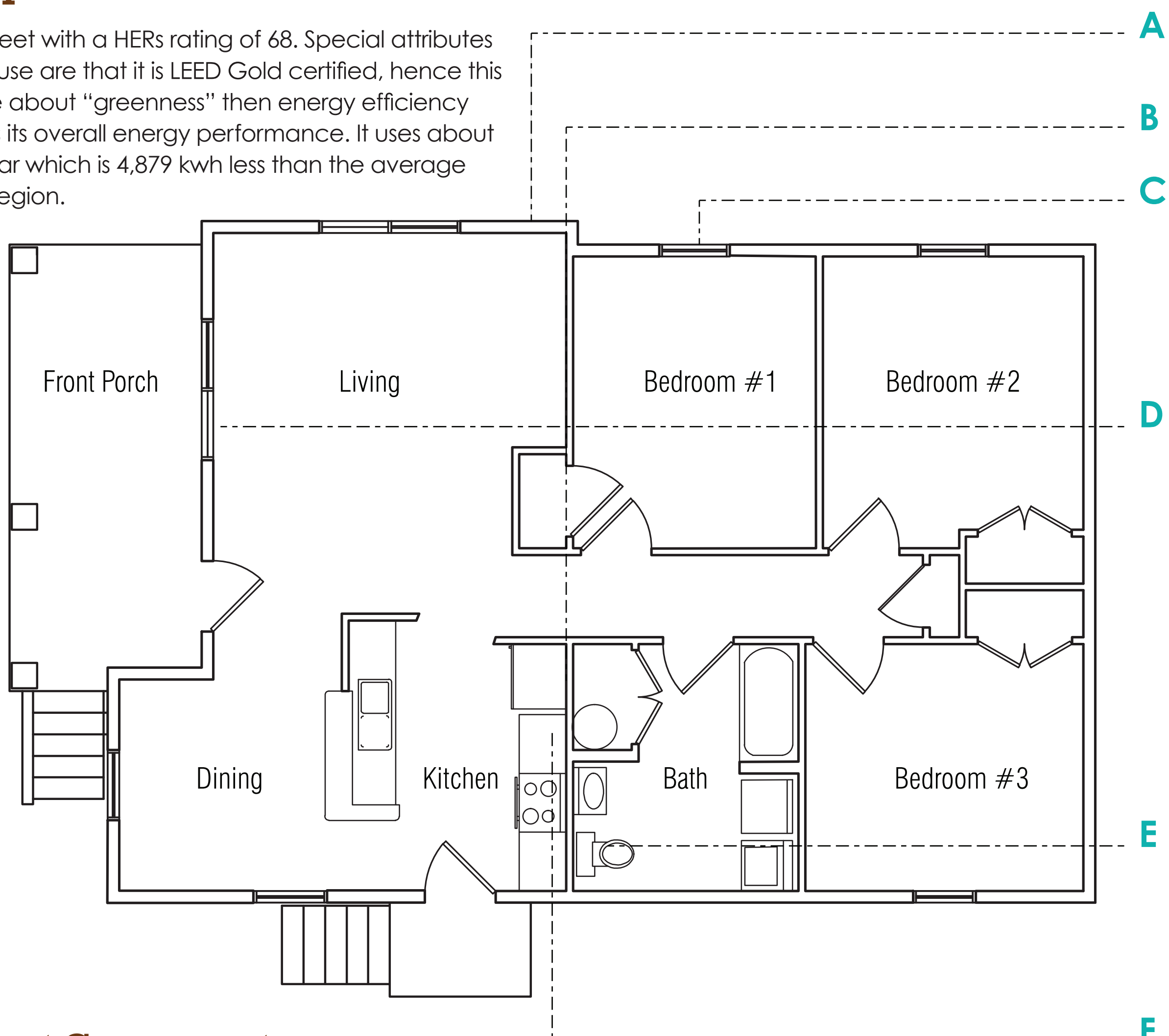
Energy Efficient Floorplans

Energy Efficient Floorplans: 2012

The following floor plans for energy efficient homes were collected from various Fahe Members in 2012 for the initial publication of "A Brighter Path Forward".

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" then 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

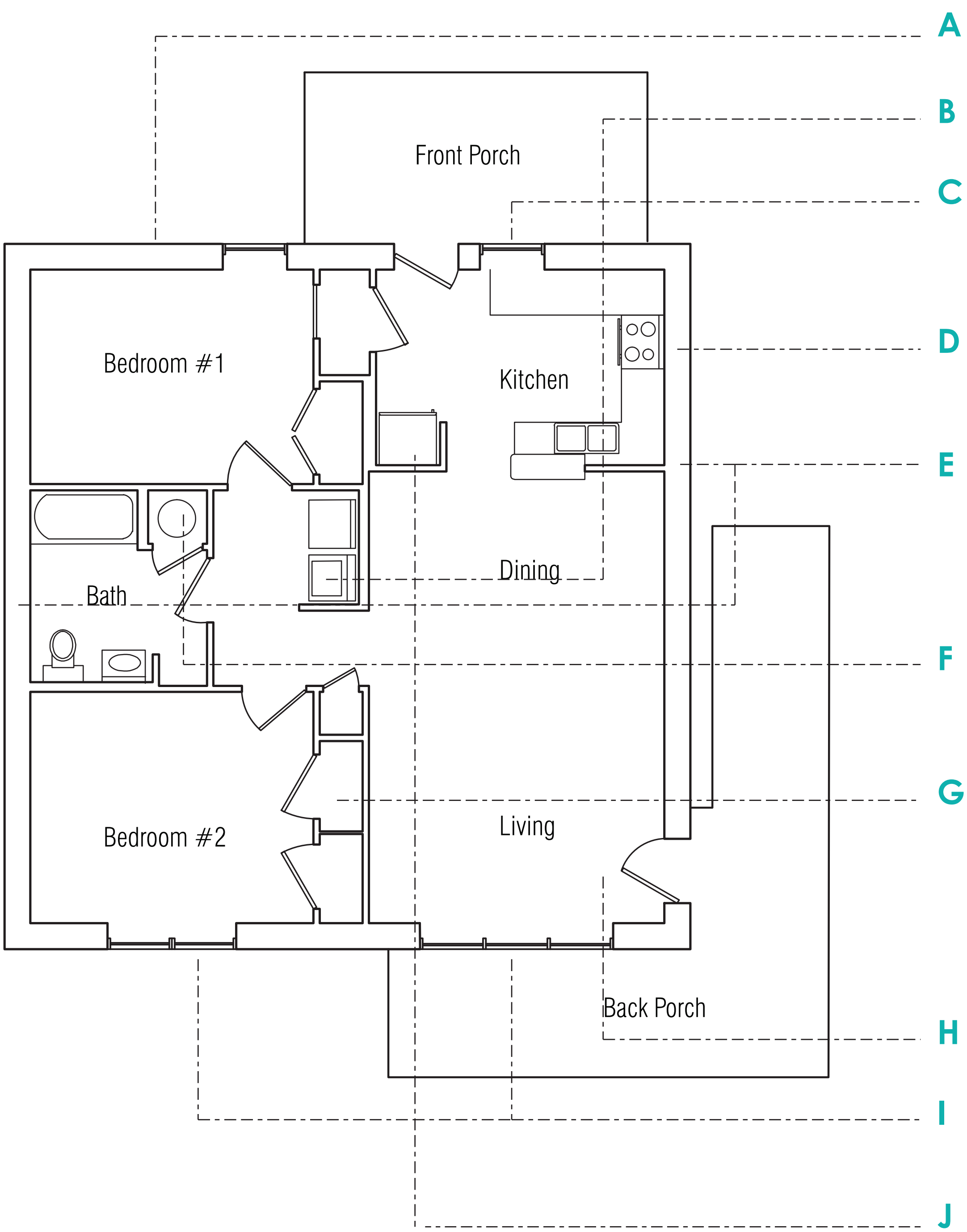
F Energy Star appliances

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

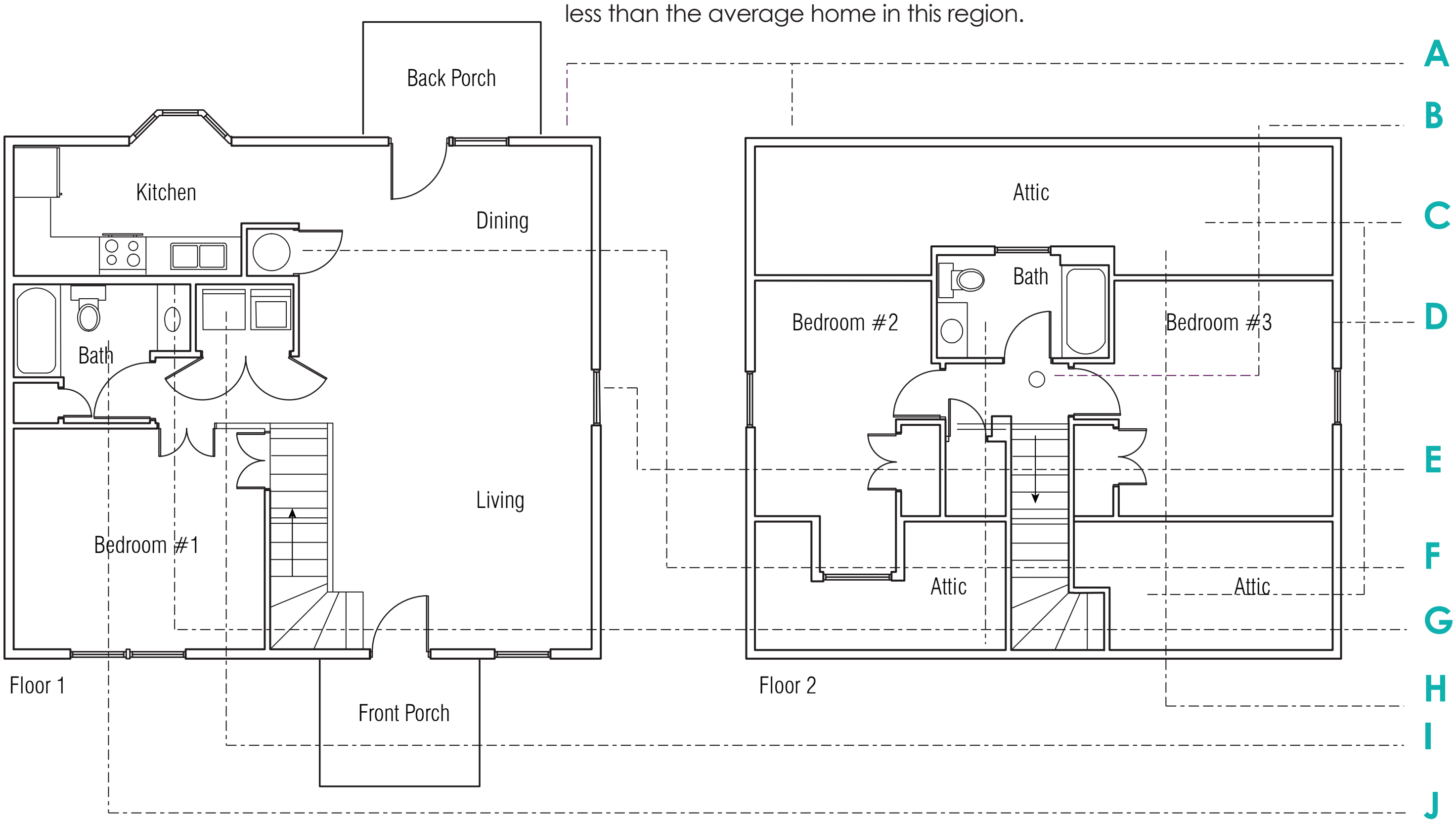
H Continuously insulated slab construction

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

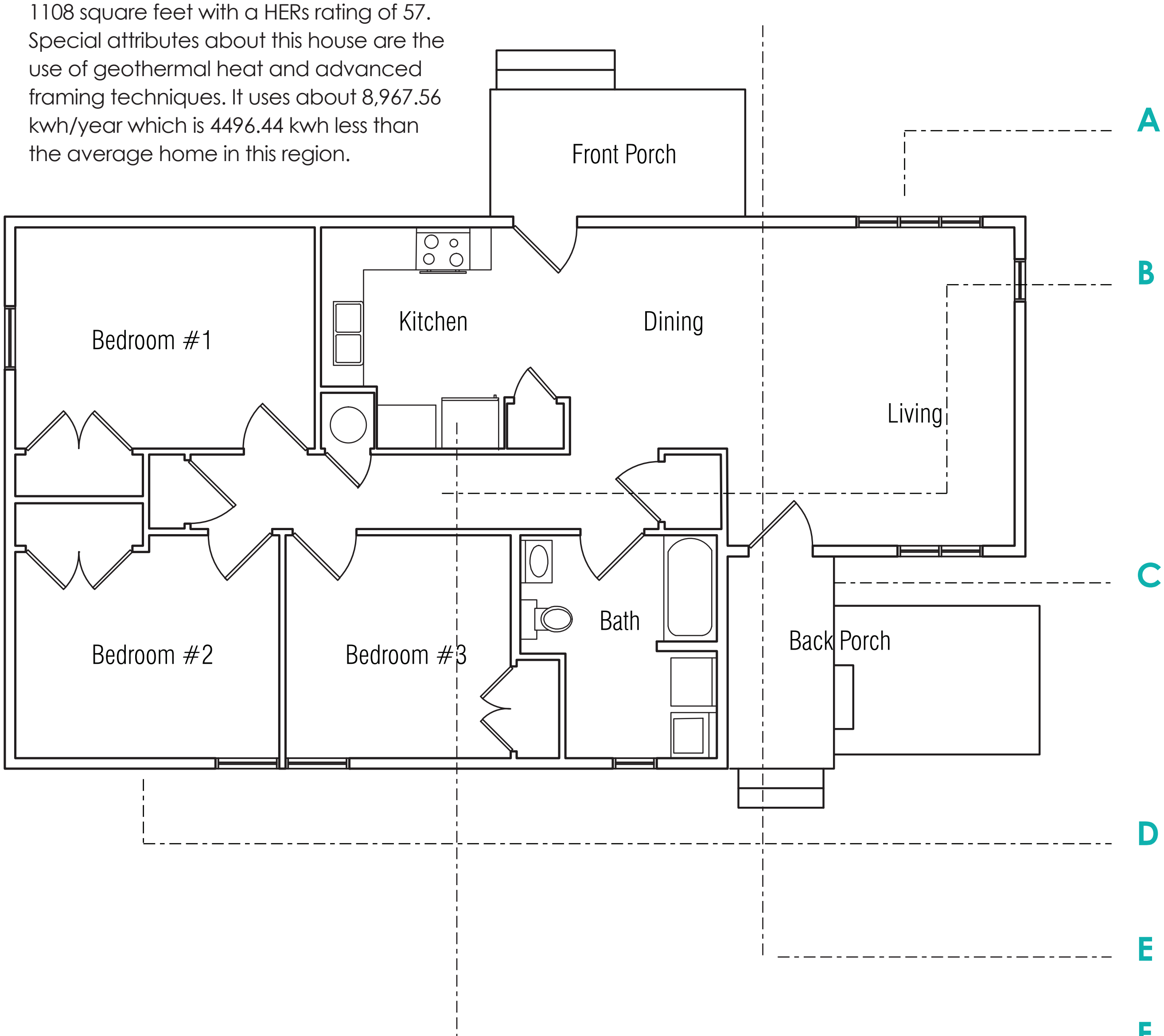
I Energy Star appliances

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

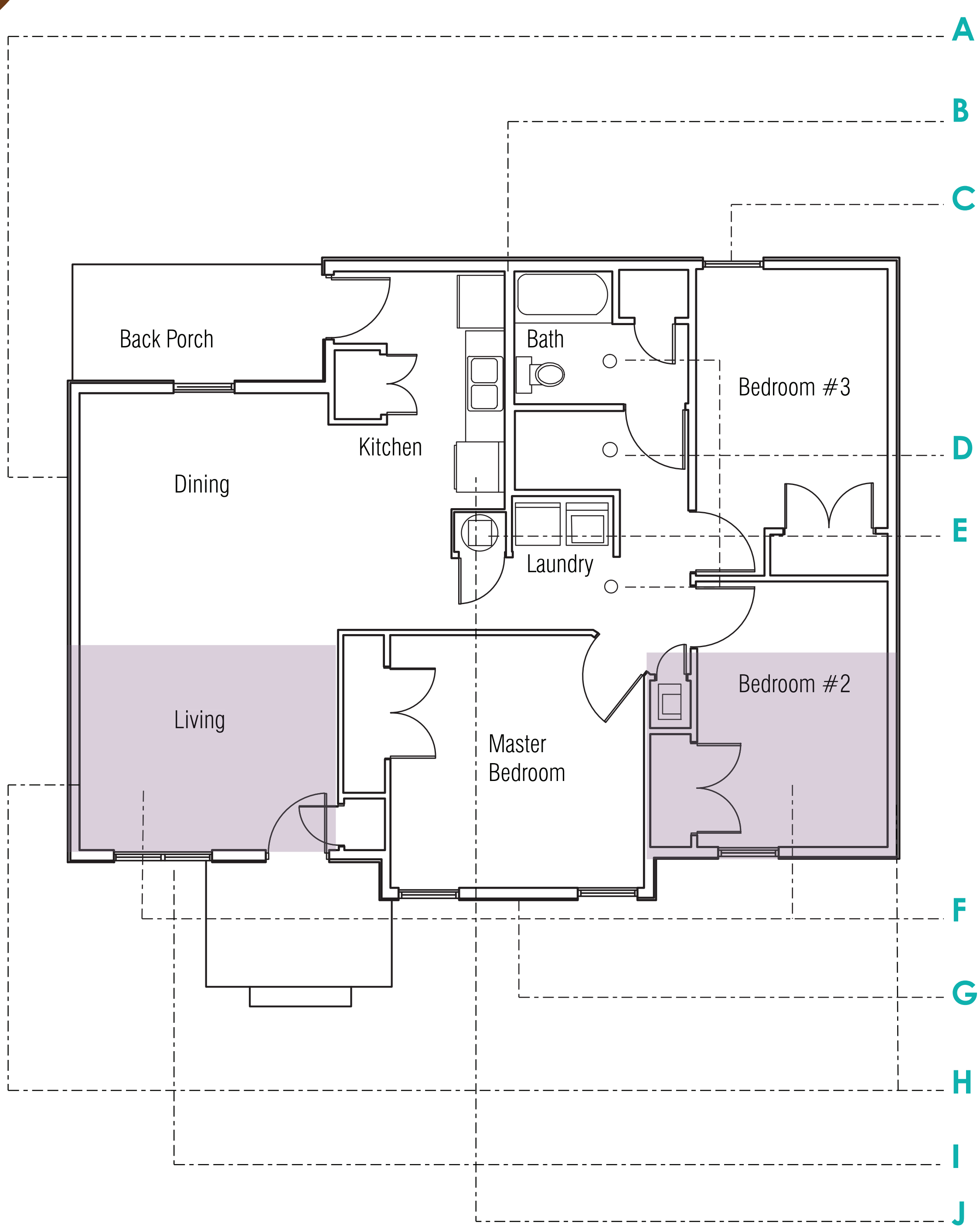
Savings:
@ $0.1167/kwh
$73.78/month

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.

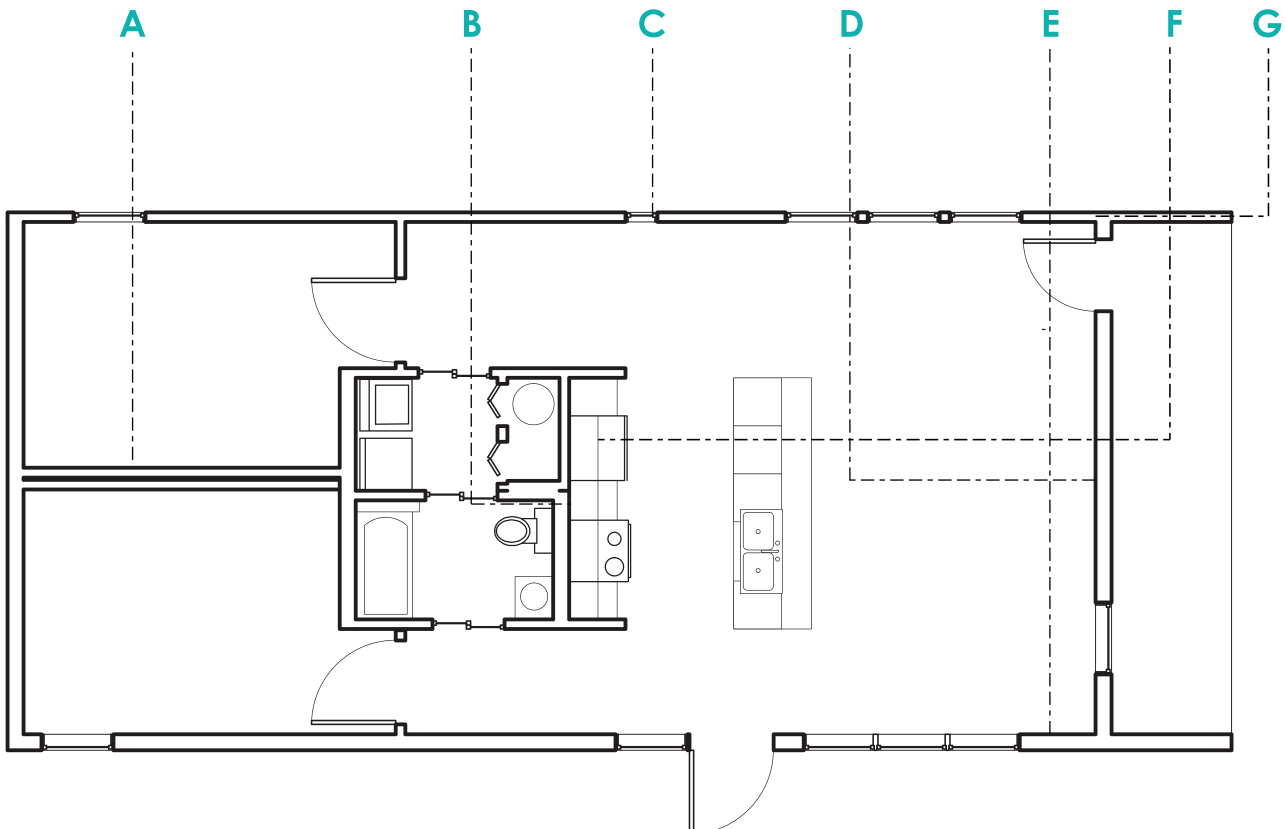
Energy Efficient Components

- **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

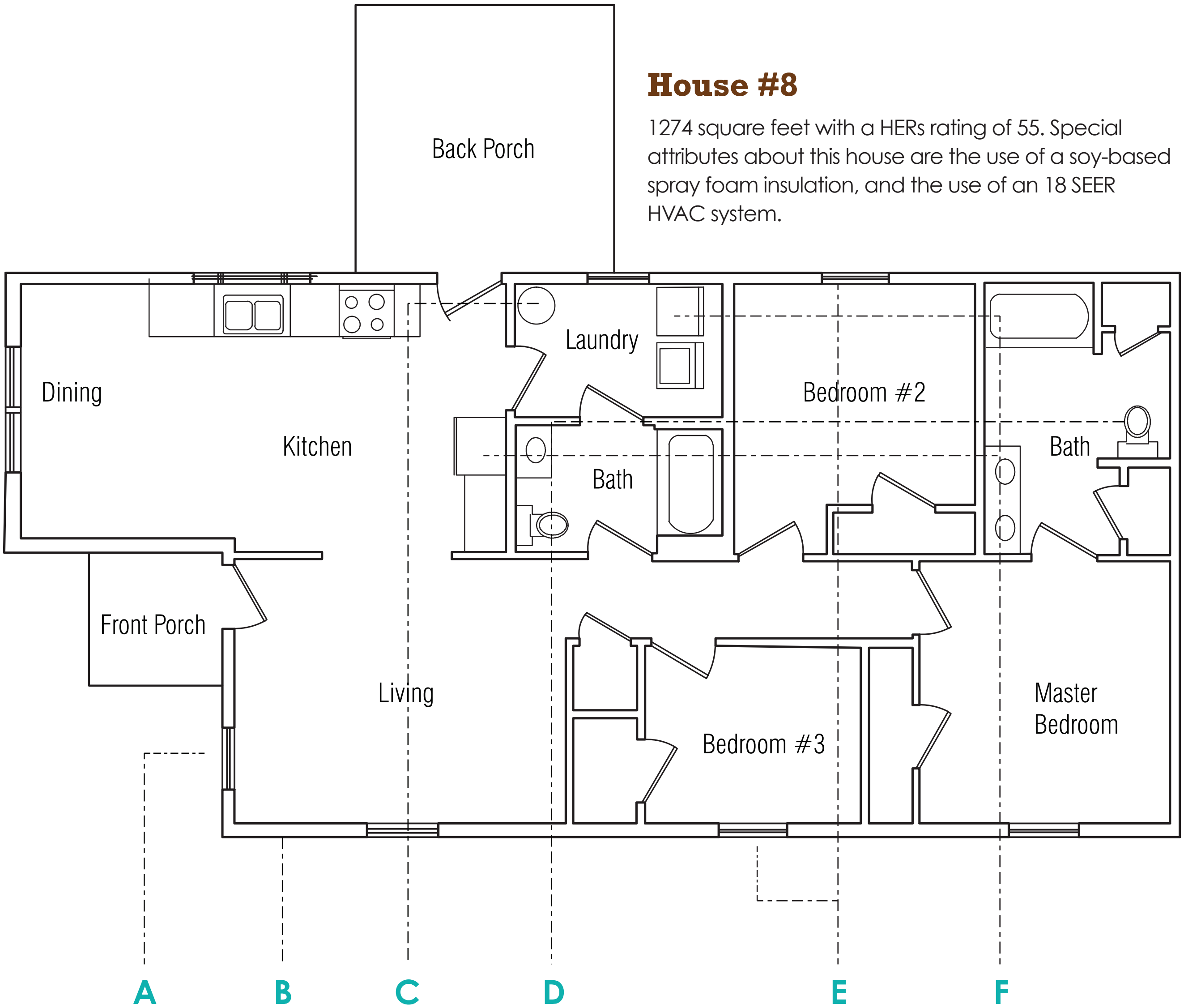
1035 square feet with a HERs rating of 52. Special attributes about this house are that it is a modular house that will be constructed in a factory and then placed on site and that it uses the SIP wall system. It uses about 7,955 kwh/year which is 6409 Kwh less than the average home in this region.



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



House #8

1274 square feet with a HERs rating of 55. Special attributes about this house are the use of a soy-based spray foam insulation, and the use of an 18 SEER HVAC system.

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

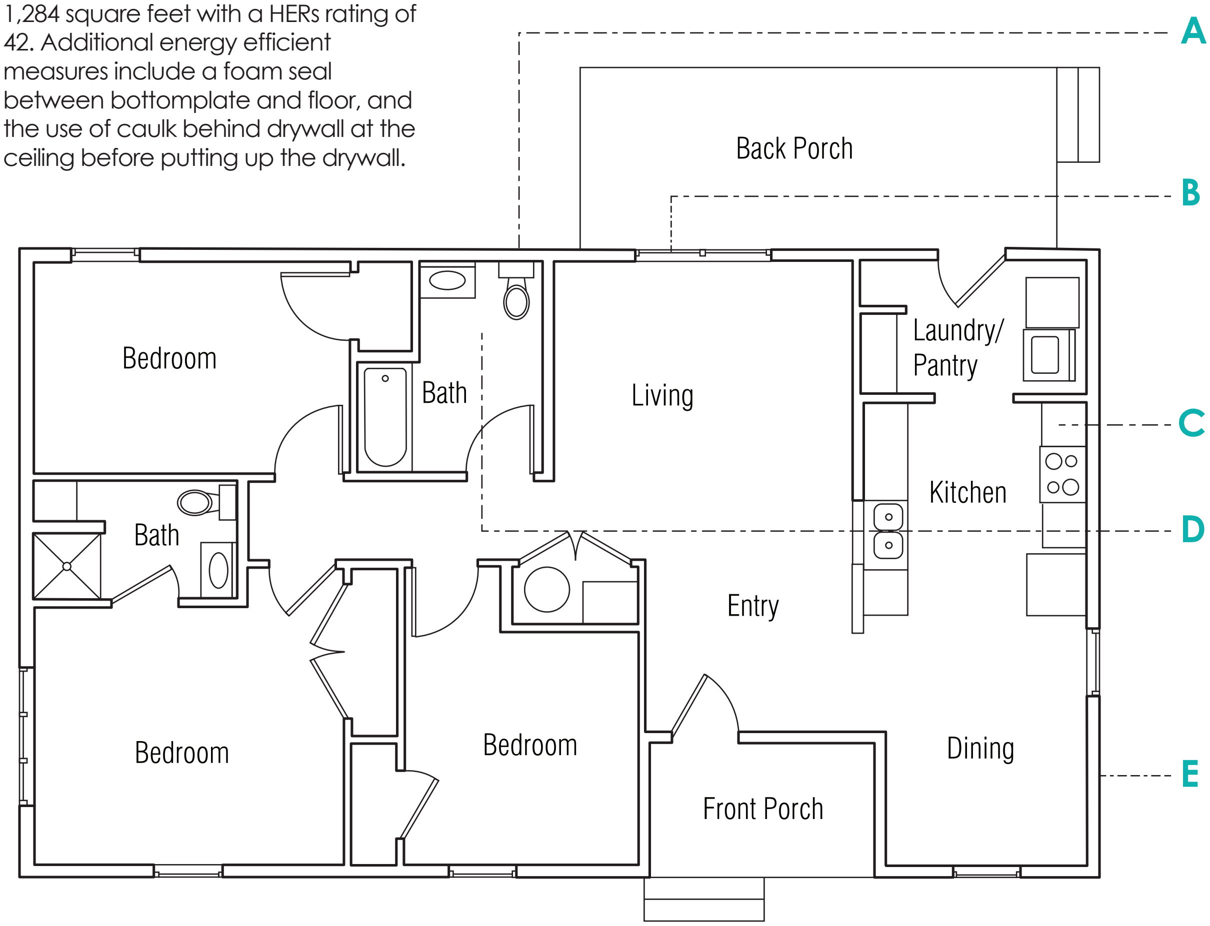
F Energy Star appliances

Energy Efficient Floorplans: 2017

The following floor plans for energy efficient homes were collected from People's Self Help Housing in 2017.

House #1

1,284 square feet with a HERs rating of 42. Additional energy efficient measures include a foam seal between bottomplate and floor, and the use of caulk behind drywall at the ceiling before putting up the drywall.



Energy Efficient Components

A 2x6 framed walls, advanced framing of exterior walls with R-19 faced fiberglass insulation

B All vinyl windows, U factor of 0.30, solar heat gain coefficient of 0.22

C Energy Star rated appliances and exhaust fans

D low-flow plumbing fixitures, insulated hot water lines

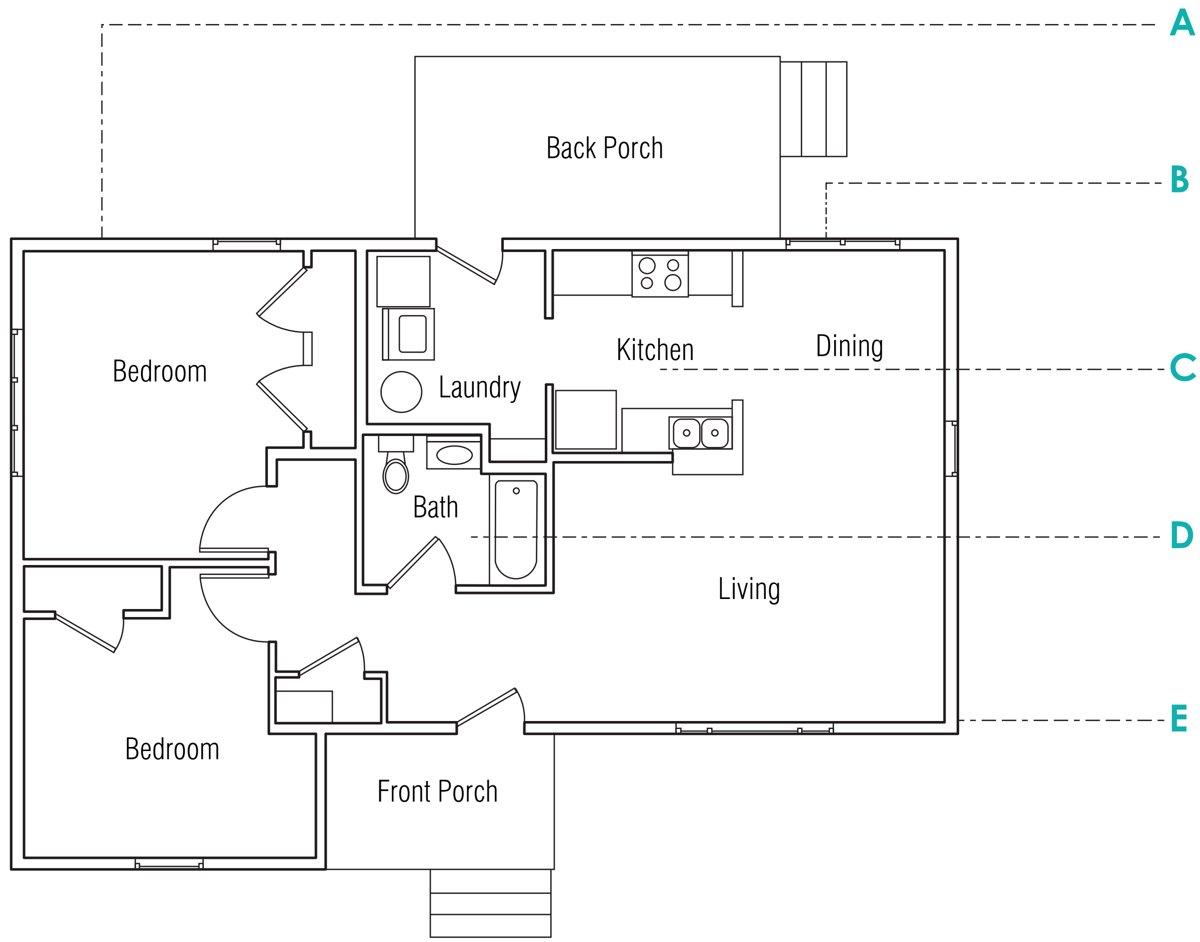
E ZIP- R4 exterior wall sheathing

Savings: $136.42/month

Updated Material

House #2

1,008 square feet with a HERs rating of 38. Additional energy efficient measures include a foam seal between bottomplate and floor, and the use of caulk behind drywall at the ceiling before putting up the drywall.



A 2x6 framed walls, advanced framing of exterior walls with R-19 faced fiberglass insulation

B All vinyl windows, U factor of 0.30, solar heat gain coefficient of 0.22

C Energy Star rated appliances and exhaust fans

D low-flow plumbing fixutures, insulated hot water lines

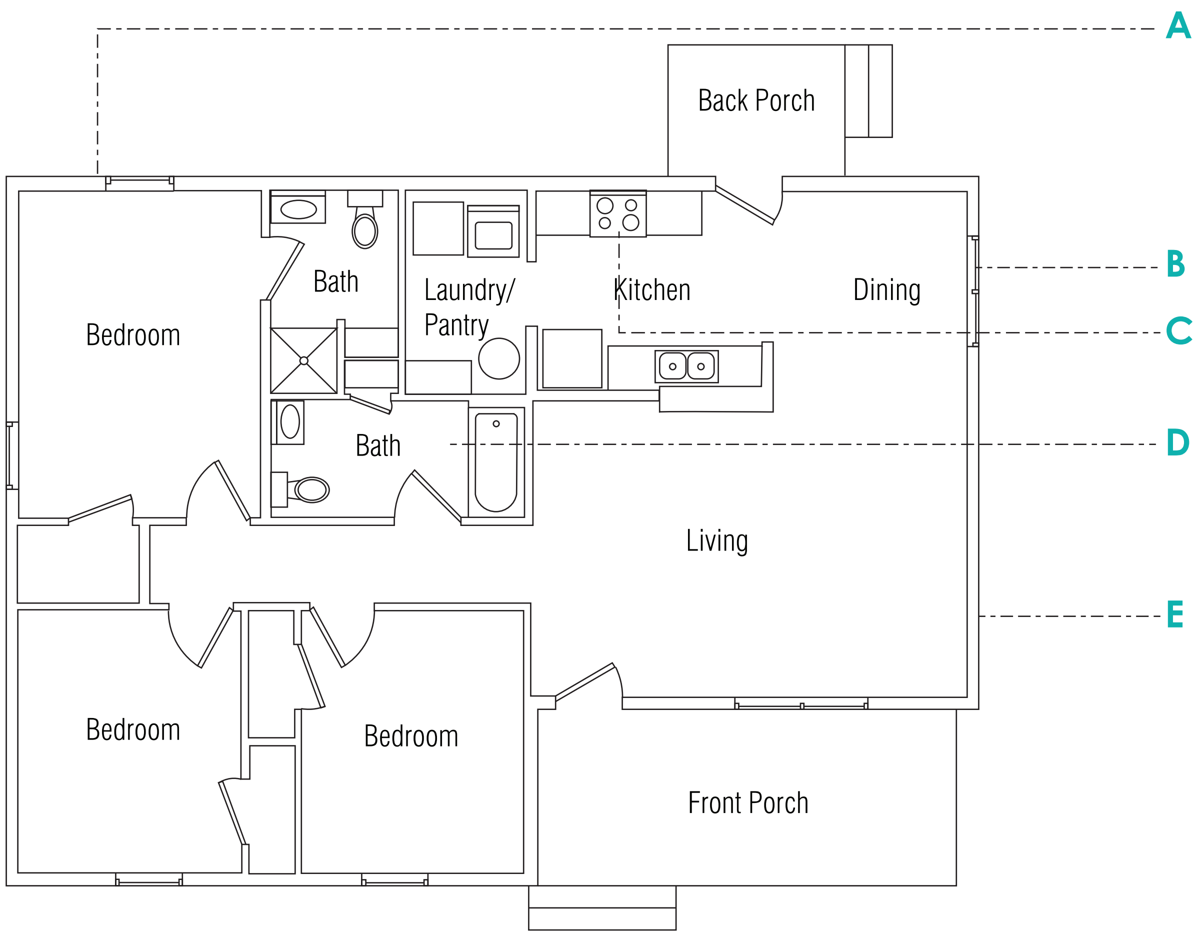
E ZIP- R4 exterior wall sheathing

Savings:
$119.08/month

Updated Material

House #3

1,248 square feet with a HERs rating of 42. Additional energy efficient measures include a foam seal between bottomplate and floor, and the use of caulk behind drywall at the ceiling before putting up the drywall.



A 2x6 framed walls, advanced framing of exterior walls with R-19 faced fiberglass insulation

B All vinyl windows, U factor of 0.30, solar heat gain coefficient of 0.22

C Energy Star rated appliances and exhaust fans

D low-flow plumbing fixutures, insulated hot water lines

E ZIP- R4 exterior wall sheathing

Savings:
$115.67/month

Updated Material

Table 1: Energy Efficient Homes Comparison - 2012 Homes

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	

Table 2: Energy Efficient Homes Comparison - 2017 Homes

Company	Sq. Ft.	Insulation	Air Exchange Rate	Windows	HERs Rating	Wall Construction	Cost/ Appraisal	Siding
People's Self-Help Housing								
1	1248 (3 bed-2 bath)	R -19 faced Fiber Glass Batt walls, R - 48 blown in cellulose in ceiling	520 CFM50	Vinyl - U = ,3	49	2x6 advanced framing 24" o.c.	$116,543/ $95,000	ZIP - R4
2	1008 (2 bed-1 bath)	R -19 faced Fiber Glass Batt walls, R - 48 blown in cellulose in ceiling	305 CFM50	Vinyl - U = ,3	38	2x6 advanced framing 24" o.c.	$116,641/ $92,000	ZIP - R4
3	1284 (3 bed-2 bath)	R -19 faced Fiber Glass Batt walls, R - 48 blown in cellulose in ceiling	317 CFM50	Vinyl - U = ,3	42	2x6 advanced framing 24" o.c.	$129,187/ $98,000	ZIP - R4
Frontier Housing								
8	1092 (3 bed-2 bath)	R -20 Fiber Glass Batt walls, blown in R - 52 in ceiling	740 CFM50	Double pane with low-e and argon		2x6 wood framing	gap = $12,321.38	Vinyl
9	1174 (3 bed-2 bath)	R -20 Fiber Glass Batt walls, blown in R - 52 in ceiling		Double pane with low-e and argon		2x6 wood framing	gap = $7,754.53	Vinyl
9	1104 (3 bed-2 bath)	R -20 Fiber Glass Batt walls, blown in R - 52 in ceiling		Double pane with low-e and argon		2x6 wood framing	TBD	Vinyl

Cost vs. Savings

There was a wide discrepancy between Members regarding the comparison of the cost of energy efficient products to the savings. One important factor noted regarding the payback is the client's operations and the way they live in the house. Payback is typically long-term and primarily seen by the homeowner, not the developer. Over the life of the home, the savings offset the initial cost of energy efficient products and practices. Rising cost of materials needed to achieve desired standards is increasing the payback period. Air sealing is a cheaper practice that produces an immediate payback, while solar measures have a much longer payback period.

While different combinations of products can be used to construct similarly performing houses, from the second table, it appears that Member organizations have determined specific practices they find successful and use them in most of their floor plans. In 2012, there was a wider variety of combinations of windows, insulation, and wall construction within each organization. The 2017 floor plans from People's Self Help Housing are more similar to eachother than the plans from PSHH from 2012 were.

In comparing the plans from PSHH from 2012 and 2017, it can be seen that savings have significantly increased while construction costs have remained about the same.

KHIC shared reflections on the two plans they had included in the 2012 publication, #6 and #7, and the lessons learned from those designs. One significant realization was the cost vs.savings debate in several aspects of the house. #6 was a modular home, and though buyers loved the openness and its energy efficient measures, the cost of the structural complexity and cabinetry were not reflected in the appraisal. The box-style modular construction also proved more limiting in design than pods and panels have found to be. The plan for House #7 in the 2012 book has not been used much recently but was reworked to address more efficient uses of space from hallways. It also presented the idea that roof and exterior details may add curb appeal but they do not add space or generate savings that justify the additional cost. Buyers would prefer that the finances behind those details were redirected to the interior of the house and increase the amount of living space.

KHIC has also noted the importance of minimizing penetrations into the thermal envelope. One measure by which this is accomplished is by putting attic access in the ceiling of the front porch rather than the living space when possible.

Updated Material

Requirements and Standards

Requirements and Standards

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 SEER[1] of 13.00 and a minimum HSPF[2] of 7.7. Fuel oil and gas fired furnaces and boilers must have an AFUE[3] 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 EER[4] with an infiltration rate of ≤5ACH50. 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 all other unconditioned spaces be insulated with at least R-6. All lights and appliances must be Energy Star certified. The ceiling R-value of at least R-38 and the wood frame wall R-value must be at least R-13. Basement walls must be insulated with at least R-10/13 with a slab R-value of at least 10 at a depth of 2 ft. and a floor R-value of at least R-19.

Primary and Secondary Standards

Based on results of the survey conducted in 2017, most Members primaily adhere to the Energy Star Standards. Some comply with the Energy Start with EPA WaterSense & EPA Indoor airPLUS while others build to Kentucky Housing Corporation Standards. A few build to the EarthCraft specifications while few primarily build according to the standards of Green Communities or the standards of the 2012 IECC code

LEED and NAHB Green are secondary standards for all of the organizations surveyed.

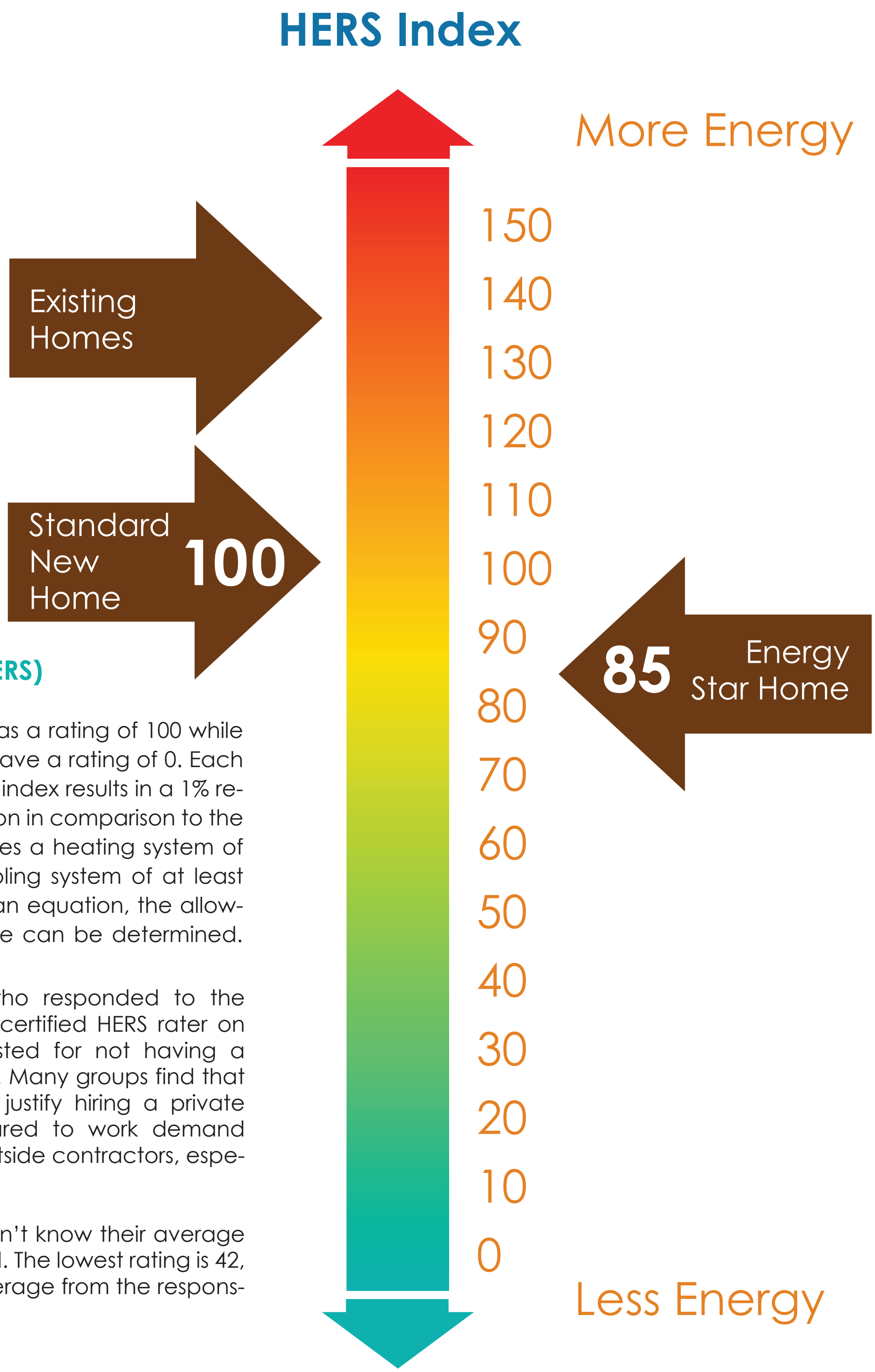
[1]SEER – Seasonal Energy Efficiency Ratio

[2]HSPF – Heating Seasonal Performance Factor

[3]AFUE – Annual Fuel Utilization Efficiency

[4]EER – Energy Efficiency Ratio

Updated Material



Home Energy Rating (HERS)

The HERS Reference Home has a rating of 100 while a zero energy home would have a rating of 0. Each 1 point reduction in the HERS index results in a 1% reduction in energy consumption in comparison to the reference home. HERS requires a heating system of at least 6.8 HSPF, and a cooling system of at least 10 SEER. Through the use of an equation, the allowable air leakage in the home can be determined.

Of the twenty Members who responded to the survey, 80% do not have a certified HERS rater on staff. The primary reason listed for not having a certified rater is the expense. Many groups find that the low demand does not justify hiring a private rater. Training costs compared to work demand have led Members to use outside contractors, especially with small staffs.

40% of those who replied don't know their average HERS Rating, or haven't rated. The lowest rating is 42, the highest is 74, and the average from the responses gathered is 62.7.

Updated Material

Requirements and Standards

BPI

BPI stands for Building Performance Institute, which is a nationally recognized certification system for home performance contractors. They develop national standards for residential energy efficient and weatherization retrofit work and provide a connection between contractors, technicians, training organizations, and programs. There are many different standards and certifications including specializations in Building Science Principles (BSP), Residential Building Envelope - Whole House Air Leakage Control, Infiltration and Duct Leakage.

A large majority of member organizations do not have a staff person with BPI certification. Of the groups who do not have a certified staff person, they stated funding as the primary barrier. The cost of training and obtaining the CEU's isn't justified by the revenue stream or low demand. Another reason for organizations not having a BPI certified staff member is the difficulty of balancing with other staff roles, especially in organizations with very small staffs.

Almost one third of the organizations surveyed do have at least one certified staff person, while 10% previously had a BPI certified staff member but they have not renewed their certification. Those member organizations who do have a certified staff person find it important and helpful in understanding energy efficiency.

BPI certified organizations noted other beneifts of the program including:

- Energy efficiency knowledge
- Ability to correctly inspect, especially rehab work
- Improved HVAC design
- Ability to problem solve building performance problems
- Helps with working through barriers of implementi ng energy efficient design with subcontractors, local code officials, grant funders
- Increases combustion equipment safety

Updated Material

Material Recommendations

Material Recommendations: 2012

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 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

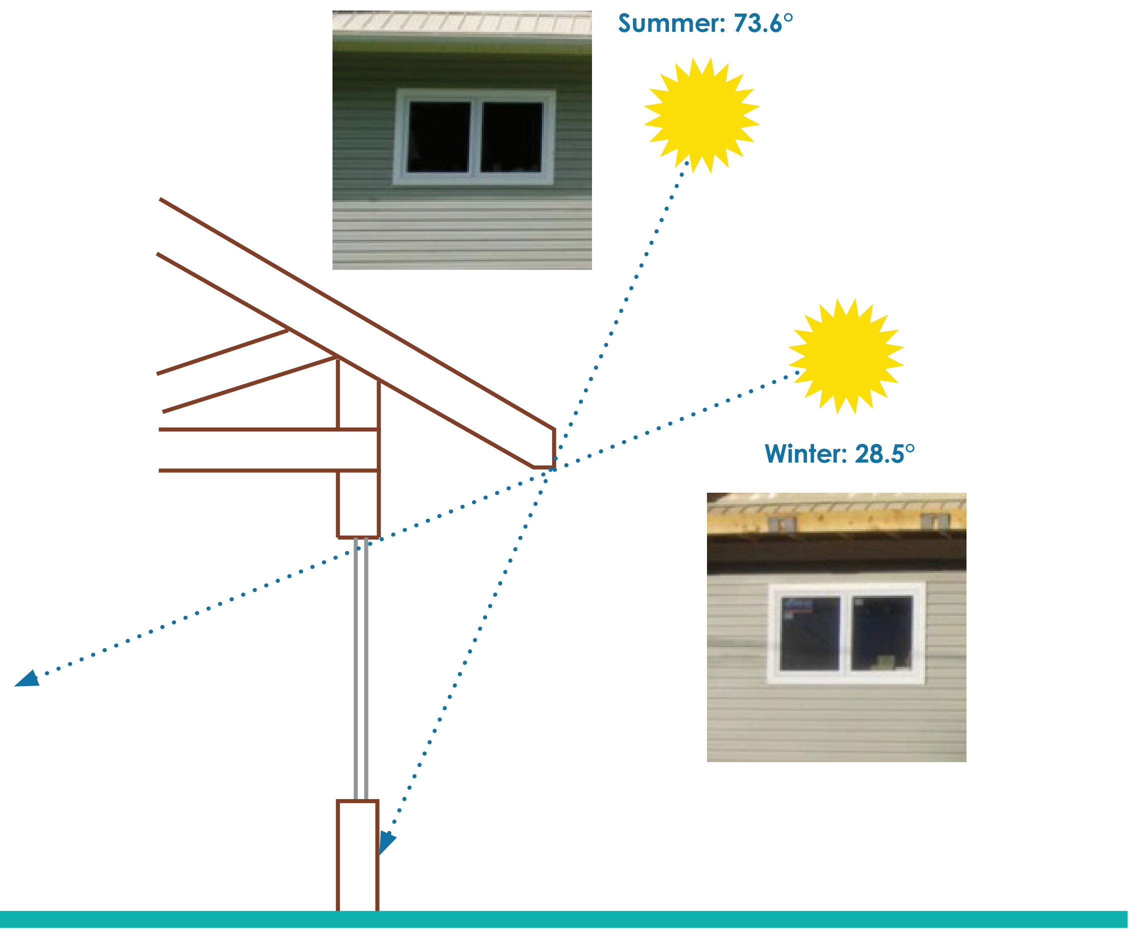
All duct work and mechanical systems should be run in conditioned space as the difference in air temperature inside the ducts and in the outside air is more often than not at two extremes which results in lower efficiency as well as the possibility of condensation in the ducts. Properly sealing the ducts 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.

Savings and Recommendations

Savings and Recommendations: 2012

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, the 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 6: 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 mort-gage payment**	**Total bill: mort-gage 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 3:
"Inside Two-Stud" Corners

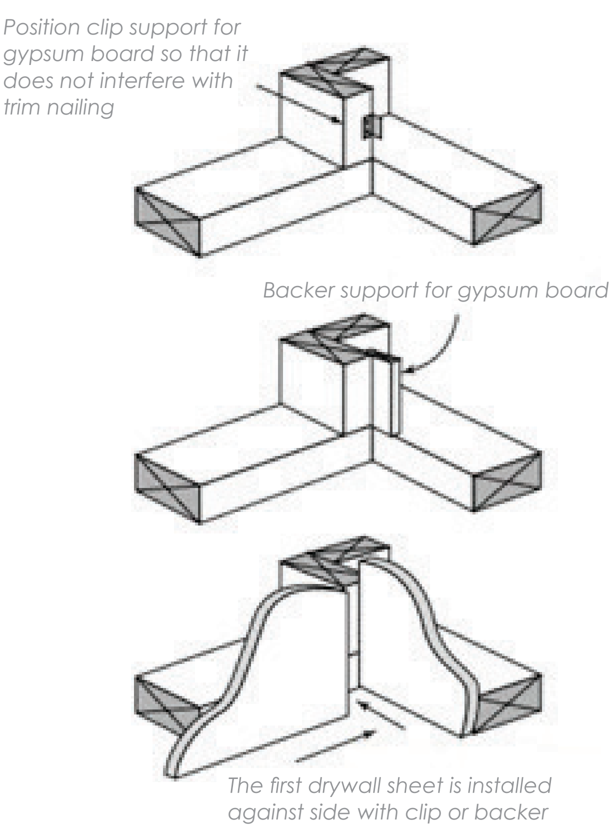
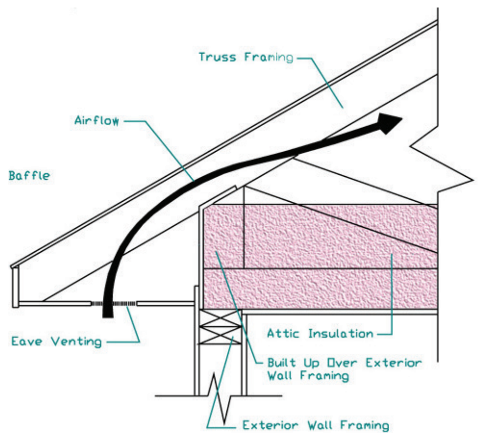


FIGURE 4:
Raised Heel Conventional Truss



(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 78º. Education is key to using these homes effectively and making the effort worthwhile.

Table 3: Insulation Comparison						
Type	**Installation method**	**R-value per inch**	**Raw Materials**	**Cost**	**Pros**	**Cons**
Agribalance	Spray foam	R-4.45	Polyisomeric isocaynate, 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-leases 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 form-aldehyde
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, pet-rochemicals, 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, pet-rochemicals, contains toxins
Polyiso (Polisocyanurate)	Rigid board	R-5.6=8	MDI, polyester polyol, pentane	$0.70-$1.01 per sq. ft.	No HCFC	High embod-ied energy, non-recyclable, petrochemicals

[5]*hydrochloroflurocarbons*

Table 4: 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-combusti-ble, 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 ingredi-ents, 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 em-bodied energy	Recyclable
Seamless steel	$7.00-$8.00/sq. ft.	20-50 years	No seams=no unwanted air transfer, good longev-ity, recyclable, resistant to bugs and mold, very durable	Can rust if exposed, expensive, has to be installed profession-ally, high embodied energy	Recyclable, long-last-ing, 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 reap-plication every 3-5 years, can fade over time	Renewable resource

Table 5: 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

Material Recommendations: 2017

While most of the information regarding material recommendations from the 2012 publication of "A Brighter Path Forward" was confirmed to still be true at the time of this report, there was additional information gathered through the survey that reflected current practices of FAHE's Member organizations.

Appliances are the most commonly used method of achieving energy efficiency. Building materials are the second most common method, according to those surveyed. Construction methods such as framing techniques are a third method. Air sealing is another significant process. Energy Star windows, high efficiency heat pumps, and continuous insulation are additional considerations.

Air Sealing

Many Members discussed the benefits of the relatively low-cost practice of air sealing. Reducing the amount of air that leaks in and out of the house lowers utility costs, is more comfortable, increases the lifespan of the house, and is better for the environment. Air sealing can be achieved bu caulking or weatherstripping and offers quick returns on investment, often one year or less. Caulk window and door frames while weatherstripping seals moving components like the doors and windows inside the frames.

Continuous Insulation

Continuos insulation has become more of a consideration after introduction to the Residential Code in 2009 when the issue of thermal bridging was addressed. These thermal bridges contributed to heat loss in the winter and heat gain in the summer to the extent that cavity insulation proved almost ineffective. Placing the insulation on the outside of the studs reduces heat loss and increases the R-value of the wall system. Additionally, moisture is less likely to condense on the inside face of the sheathing, which presents problems of mold or mildew. Less air infiltration could also present the opportunity for a smaller HVAC system by reducing loads.

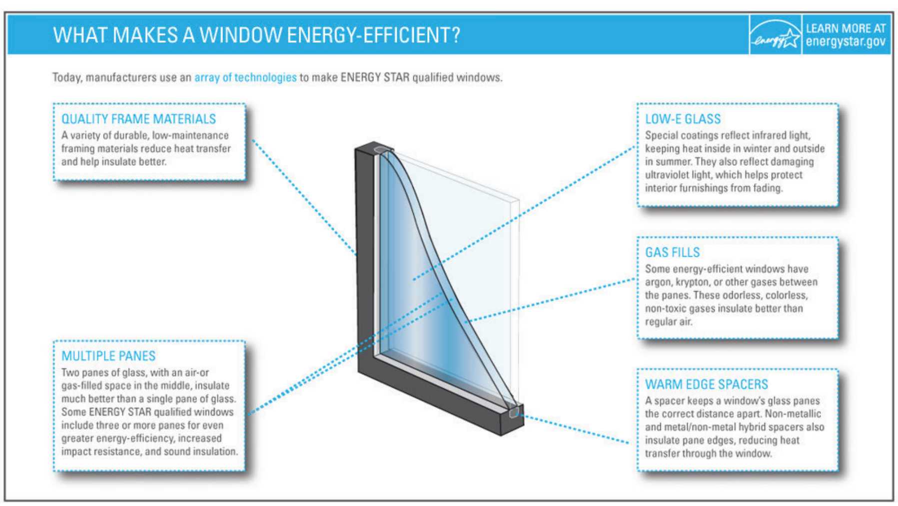


FIGURE 2: EnergyStar Windows

Updated Material

Savings and Recommendations: 2017

Changes in the Past Five Years

Again, the general conclusions from the 2012 publication regarding savings and recommendations accurately represent considerations for today.

A few member organizations who responded to the survey reported that their construction methods have not changed much since the publication of "A Brighter Path Forward" in 2012. Others who did indicate changes in practices noted that there is a more efficient use of materials, increased air sealing, more energy efficient appliances, improved framing styles, increased attention to ventilation, and better insulation. Many of these changes are due to adjustments in EnergyStar guidelines and the code regarding insulation.

Future Considerations

One concern of changing standards in indoor air quality is that increased use of energy recovery ventilators (ERVs) means more equipment for the homeowner to maintain. Many energy efficient houses already have above average amounts of specialized equipment. If this equipment is not simple enough for the average homeowner to operate, the effectiveness of its energy efficiency may be reduced.

Additional Benefits

Other than financial savings, Members see additional reasons to pursue energy efficient construction. Some noted the marketing and PR benefits. Many acknowledged the improvement of health and safety conditions for the residents through proper ventilation and moisture control. Energy efficient housing is more affordable in the long term, for both the homeowner and the environment through reduced carbon emissions and reduced water usage. Reduced long-term maintenance is another benefit.

Effectiveness of Energy Efficiency

Overall, Members find that energy efficient construction is an effective solution to affordable housing for the homeowner. While the developer faces higher construction costs, the long-term affordability and sustainability benefit the homeowner in reduced operating costs.

In order to see these benefits, it is important to use proper practices and methods of energy efficient construction. To make this a most effective solution requires somewhat of a balance of investment and practices. Past a certain extent of energy efficient construction methods and appliances, the investment and cost of construction are too high to be produce savings within a reasonable amount of time.

Updated Material