Community Case Study

Community: Infill and clustered lots, 57 by end of 2007, 51 completed

Builder: Lakeland Habitat for Humanity

Location: Lakeland, FL

Figure 1. Lakeland Habitat builds one and two story homes of approximately 1100 ft^2.

Figure 2. Lakeland Habitat generally builds on infill sites around the city, some large enough for a cluster of homes like this cul-de-sac with six Habitat homes.

Lakeland Habitat for Humanity
Background: Habitat homes are built by a volunteer labor force, except for plumbing, electrical, and mechanical work. The homes are sold to qualifying buyers at 0% interest with a small down payment and the investment of hundreds of hours of "sweat equity" contribution to Habitat's operations. Improving affordability is the primary motivation for including energy efficiency improvements. For Habitat homeowners, utility bills are second only to the mortgage in monthly outlay of cash.

Lakeland Habitat for Humanity adopted an energy efficiency program when Executive Director Claire Twomey joined the affiliate in 2000. The first energy efficient home they built qualified as an Energy Star and won a special $20,000 grant for energy efficiency from the Walt Disney Corporation. BAIHP team member Ken Fonorow (Florida H.E.R.O.) provided plan reviews for the house, specification recommendations, and energy-efficiency testing once the house was completed. Lakeland Habitat has continued to build to these specifications (Table 1), with occasional modifications, since 2000 with technical support from Fonorow and FSEC. FSEC conducts periodic testing and rating of Lakeland Habitat homes (12 houses over the past five years) to verify specifications. Currently Lakeland Habitat plans to build at the rate of 7 to 10 homes /yr at scattered sites throughout the area.

Since that first Energy Star home in 2000, Lakeland Habitat for Humanity has built 51 homes (see Figure 1 and 2) that meet or exceed Energy Star standards. The current specifications save over 30% in whole house energy in comparison to the Building America Benchmark. In addition to energy improvements, Lakeland HFH also incorporates outside air ventilation using an inexpensive, passive strategy that can be implemented by any builder in the hot humid climate.

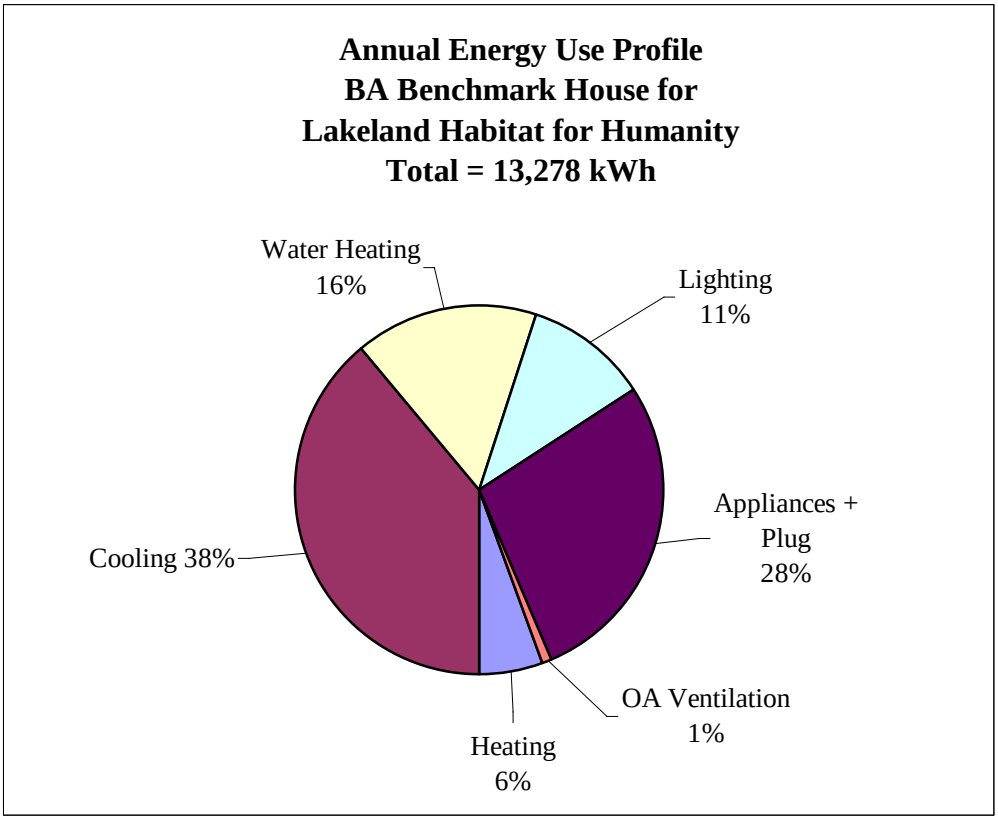
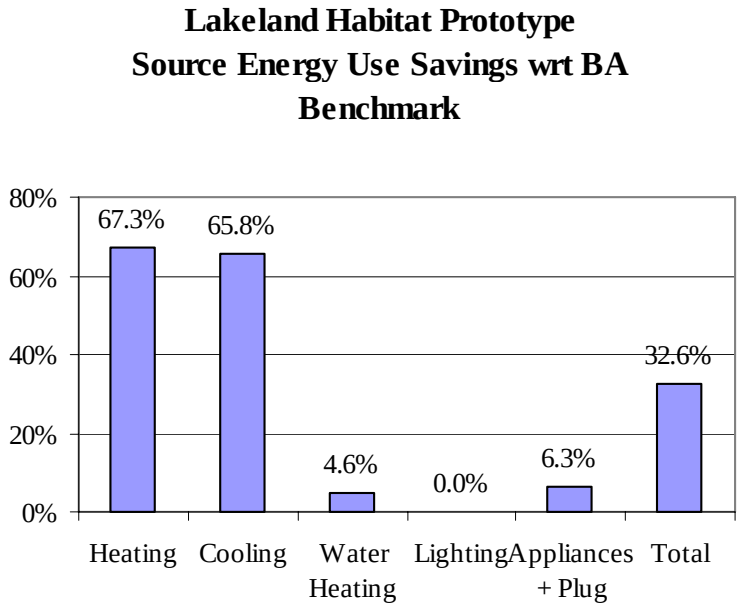


Figure 3 (Above) BA Benchmark house estimated annual energy use profile dominated by cooling energy use. (Below) Lakeland Habitat Prototype saving compared to BA Benchmark. Estimated total annual energy use savings of ~34%.



Energy Efficiency Strategy
In the hot humid climate, the dominant energy use in the benchmark house is air conditioning constituting approximately 40% of the total estimated annual energy use. To achieve 30% (Figure 3) whole house energy savings, the principal strategy is to reduce cooling energy use – the largest component of annual energy use. This is done through a combination of sensible cooling load reduction and cooling efficiency improvements.

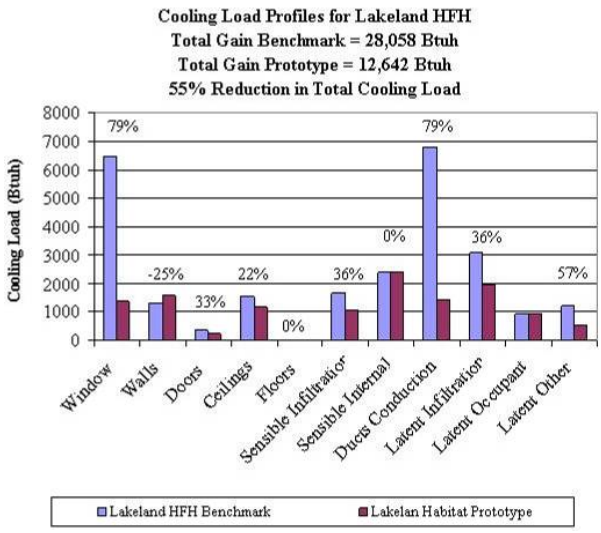


Figure 4 Lakeland Habitat Prototype reduced peak cooling load 55% with savings from source as noted.

To reduce the sensible cooling load in Lakeland HFH's homes, features are selected to address the major components of the load. A review of the peak cooling load (Figure 4, from Manual J system sizing calculation for the Benchmark house) helps analysts and builders prioritize improvements. Notice in the BA Benchmark house (blue) that conductive heat gain to the duct system, window heat gain, and ceiling heat gain are the major envelope related components of the peak cooling load. To minimize these, Lakeland Habitat uses interior ducts and air handler closet, low-E windows with shading where possible, and radiant barrier under the roof decking (Figures 5 and 6). Lakeland Habitat HERS '99 scores range from 88.6 to 91.2 with an average of 89.3 (Figure 7.)

Figure 5 Interior air handler, return plenum, and supply duct chase.

Figure 6 Low-E windows are enhanced by two foot overhangs, porches, and site shading.

Twomey explains it in layman's terms, "Mostly its small things, like caulking and adding a radiant barrier. The radiant barrier is like thick, flexible aluminum foil. It is very inexpensive; we just buy it in big rolls. You staple it to the inside of the roof between the rafters. It brings down the temperature in the attic by up to 40 degrees." Radiant barrier research has been shown to reduce heat gain through the ceiling by an average of 20 degrees, reducing the air conditioning load." "Generally, research in the Southeast has shown that roof mounted radiant barriers can reduce ceiling heat flux by 25 - 50% with annual cooling electricity savings of 7%-10% (Parker, et al. 2001.) Occasionally, Lakeland Habitat builds a home with ducts in the attic rather than in the conditioned space. In those instances, the radiant barrier provides the added benefit of reducing conductive heat gains and losses to the ducts – reducing the cooling load.

In addition to these features that diminish the major envelope related components of the peak cooling load (Figure 3), volunteers make extensive air sealing efforts before the drywall is installed to reduce latent and sensible heat gain from

infiltration, two other components of the cooling load. There is also an Energy Star refrigerator which generates less heat than a standard unit – this reduces the category labeled "sensible internal" which includes the heat generated by appliances like the refrigerator, dishwasher, and dryer. Exhaust fans in the kitchen and bathroom help to reduce the latent (moisture) load generated by breathing, cooking, bathing, and washing clothes.

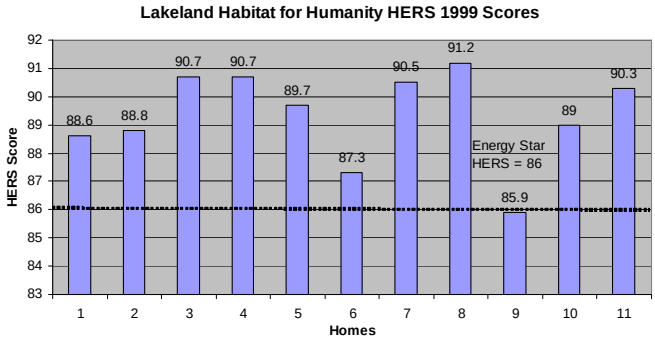


Figure 7 HERS '99 Scores for a sample of Lakeland Habitat homes (average = 89.3)

Table 1 Lakeland Habitat Key Energy Saving Features HERS 99 scores range from 88.6 to 91.2 with an average of 89.3 (Figure 7)	
Roof/Ceiling	Radiant barrier, R-30 ceiling insulation, standard vented attic.
Windows	Double pane, vinyl frame, low-E windows, 24-inch overhangs, site shading and east-west orientation (when possible) to limit direct solar gain
Air Distribution System	Interior air handler closet and ducts in conditioned space (furred down duct chase) with joints and seams sealed with water-based mastic and fiberglass mesh, randomly tested to ensure duct leakage below 6%
Water Heating	Water-heater timers
Ventilation	Passive outside air ventilation ducted to the return side of the air handler with a filter-backed intake grill mounted in the soffit (at back door or porch). Ducted exhaust fans in the kitchen and bathroom(s) to improve indoor humidity control.
Cooling/Heating	14 SEER heat pump (SEER 13 until 12/2005)
Whole House Air Tightness	Extensive air sealing of building envelope after dry in. Random tests for whole house air tightness. In 2007 began implementing the Energy Star Thermal Bypass Inspection Checklist.
Appliances	Energy Star refrigerator

Quality Assurance

As a quality assurance measure, Lakeland Habitat conducts testing in a random sample of the houses it builds to measure whole house and duct system air tightness "All of our houses come out to less than 6% duct leakage said Twomey." The average measured Qn,out in the 11 Lakeland homes tested since 2001 is 0.037 with a maximum of 0.061 (Figure 8). Leakage in typical new construction in Florida homes can be as high as 15% (Cummings, et al. 2002) but average about 6% (Swami, et al. 2006.)

In the Building America program, researchers have repeatedly seen that one indicator of success is having a champion for energy efficiency, durability, and indoor air quality. The most effective champions are decision makers with the power to halt construction if targets are not being met. Thus an important quality assurance technique is having a well-informed "champion" who will provide oversight to the various construction process details needed to reach a targeted energy performance such as 30% whole house energy savings.

In the absence of or in addition to a champion who is directly involved with construction, quality control procedures (such as duct testing) provide a check point which has to be passed before

construction proceeds. Building America periodically conducts on-site training with Lakeland Habitat to help site supervisors understand the performance targets.

Clair Twomey, Lakeland Habitat's Executive Director and energy-efficiency champion, explains how testing is used as a quality control check point to thwart common job site hazards and the morale payoff of passing the testing. "We had one house that we had tested and the duct leakage score was terrible. Our air conditioning contractor used two crews - one to install and one to come back to do the sealing. On this house they never came back to do the sealing. We would not have known this if we had not tested the house," said Twomey. "Testing is very critical to ensure good results. And it's very rewarding to the volunteers and construction staff when the house scores high and they know they've done it right."

The Building America Program through FSEC currently conducts the testing at no cost to the Lakeland affiliate and provides other information as needed. "Their biggest contribution," says Twomey, "is just being available for me to call. When we did the steel houses, I called Janet (McIlvaine with the Building America Industrialized Housing Partnership) and she was extremely helpful. She provided a detail for installing the rigid insulation on the steel framing that helped code officials accept the new construction type. We look to Building America for information, even information on things like getting into pilot programs and grant programs to do new houses."

Added Benefits

In addition to the energy improvements described, Lakeland Habitat homes have the benefit of improved indoor air quality, durability, and comfort. Excellent indoor air quality in energy-efficient houses is the result of sealed combustion (when gas is used) heating and water heating, sealing the duct system, providing filtered outside air ventilation, installing ducted kitchen and bath exhaust fans to remove moisture generated by cooking and bathing, and providing adequate return air pathways from all bedrooms. Careful attention to sealing the house's continuous air barrier by caulking and filling any cracks and penetrations in the walls, floors, and ceilings improves energy efficiency while it also keeps out insects and pollen. Properly sealing the ducts reduces the risk of condensation in and around ducts also, a source of mold and rot. And looking

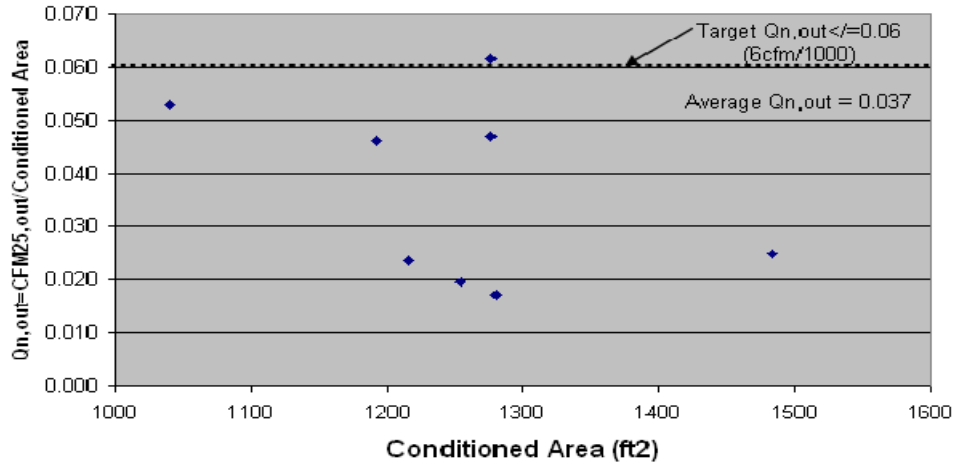


Figure 8 Duct leakage in 11 Lakeland Habitat homes show excellent air tightness.

at the big picture, more energy-efficient homes decrease both pollution and US dependence on foreign energy.

Volunteers

Lakeland Habitat's buyers love the energy efficiency of their new homes, convincing volunteers that these changes in construction practice are a good thing can sometimes be a challenge. "Some of these volunteers had been with the affiliate for years when I arrived and change is a challenge for most people." said Twomey. "For example when we started putting ductwork in conditioned space, volunteers started saying 'why do we have to do that?' and 'my house doesn't have that.'" Twomey sent two people, her construction supervisor and a volunteer site supervisor, to a one-day workshop on energy-efficient and green construction. "Our staff person came to us from a for-profit construction company. It takes time to show people that this (energy-efficient construction) really does work. The workshop training really helped convince him of the value of some of these measures."

Figure 9 Wall insulation installed with no voids or gaps by volunteers at Lakeland Habitat.

Energy-efficient construction can be a very good fit with volunteers who often exercise more attention to detail that fast working professionals. They are not as attached to typical construction practices as experienced professionals and they will take their time with air sealing and insulation details as is evident manifest in the excellent quality of insulation installation shown in Figure 9. Often Habitat's volunteers do not have a background in construction, so they must be trained. Training volunteers to follow energy efficiency guidelines like properly installing house wrap takes no more time than teaching the typical practices. But many of the features make no difference in the volunteer process – an important consideration. It takes exactly the same amount of time to install a low-E window as a standard window.

Dollars and Sense

Energy savings are great, but do Energy Star homes cost Habitat homebuyers more up front? Not at Lakeland HFH. According to Twomey, "People talk about payback periods with energy-efficiency measures. But our homes essentially have instant payback. We work with the owners to make sure the mortgage is affordable no matter what. They get a 0% interest mortgage and we determine how long the mortgage is, for example 20, 25, or 30 years depending on what they can afford monthly. So if there is a slight increase in cost to cover the cost of energy-efficiency improvements, we can just adjust the length of the home owner's mortgage, so that they have a monthly mortgage they can afford. And because it's energy efficient, they can afford to keep it."

Twomey notes, "We estimate it costs about $1500 more per house to build to [this performance level.]. For commercial builders, time is money. But Habitat uses volunteers, so labor costs are not such a factor."

A $1500 increase in a 30 year mortgage at 0% interest represents about a $50 increase in annual mortgage payment (Table 2) which is a cost of about $4 monthly for Lakeland Habitat's energy

efficiency package. While the BA Bench mark analysis shows a savings of $463 annually ($1437-$975/year), savings in comparison to specifications for typical Habitat construction are lower at an estimated $182 annually or about $15 monthly (Table 3). This yields an average monthly positive cash flow of about $11 - from the first month of occupancy. While the added mortgage cost will stay stable for the life of the mortgage, the energy savings value will rise with energy rates.

The real story however lays not in the simulated energy savings but in the realized energy savings that Twomey reports. “We reviewed the utility bills for our first house for five years and compared it to a house with the same square footage and same family size that was built 6 months earlier without the energy-efficiency changes. Utility savings were 60%.” Occupant density probably plays a major role in the difference between the simulated savings and this real world example of savings. Each of these three bedroom Lakeland Habitat homes had seven occupants – three more than the standard simulation assumption of four (number of bedrooms plus one.)

Even more compelling are the savings in comparison to the energy use of the homes that Lakeland Habitat’s buyers are moving out of. Twomey noted that, depending on what they are moving from, some homeowners will see even bigger energy bill savings compared to their previous budget. “Some of our homeowners are coming from old rental homes where they were paying $400 or $500 per month in utility bills. There is very little utility bill assistance here. If you can’t afford it, the utility company will shut off your utilities. I’ve seen home owners who are using their ovens to heat their homes because they can’t afford to have the heat on,” said Twomey.

Fonorow echoes the thoughts of many energy-conscious Habitat affiliates, “We need to think of affordability not just in terms of how much it costs to buy the home but also in terms of how much it costs the family to run the home once they’re in it.” Fonorow noted that the Census Bureau did a study a few years ago and found the average low-income person spends 18% of their income on their utility bill. He showed what impact that would have if translated to a middle-income salary (U.S. Census, 2005.) “If you made $50,000 a year, that would equal $800 a month for utilities.” By building homes that reduce energy consumption, Lakeland Habitat is putting money into the monthly household budget of every family they partner with.

Table 2 Specifications adopted by Lakeland Habitat for Humanity to achieve 30% BA Benchmark savings compared to Typical Local Practice specifications.

Category	Typical Habitat Local Practice	Prototype House	Total Incremental Costs	Amortized Annual Cost (30yr, 0%)	Notes
Thermal Envelope					
Attic radiant barrier	No	Yes			Material donated, extra volunteer labor
TBIC Compliance	No	Yes			Extra volunteer labor
Windows	2-pane Aluminum Clear	2-pane Vinyl Low-E			
HVAC SYSTEM					
Heating System	Elec Resistance	HSPF 8			Recent change
Capacity	NA	NA			
Cooling System	SEER 13	SEER 14			SEER 13 until Dec 2005
Capacity	NA	NA			
Ventilation System	None	Run Time	$300	$1.00	Passive
Air Handler Location	Interior	Interior	$0.00	$0.00	Interior AHU is standard for Habitat – no garages
Duct Location	Attic	Interior			Fur down chases
Duct Leakage	6% to out	4% to out			Standard practice for mechanical contractor
Water Heating					
Water Heater Timer	No	Yes			
Appliances					
Refrigerator	Standard	Energy Star	$0	$0.00	Whirlpool Donation
Lighting	10% CFL	14% CFL	NA	NA	
Cost to Builder			**$1,500**	**$50.00**	**Builder estimate**
Total Energy Efficiency Investment			**$1,500**	**$50**	**No mark up.**
PV SOLAR ELECTRIC			$0	$0	
Total withPV			**$1,500**	**$50**	
REBATES / INCENTIVES			$0	$0	
Total Incremental Cost to Buyer			**$1,500**	**$50**	**$4/month**

Table 3 Energy Savings of a 912 sq. ft. 1 story 3BR, 2 Bath home with specifications typical for the region compared to Lakeland Habitat home with BA specifications meeting the 30% Benchmark savings target. *(Note: Also see the opening paragraph of “Dollars and Sense” above.)*

	Annual Source Energy							Annual Utility Bill Reduction	
		Typical		Estimated Source Energy Savings					
		Regional		Percent of End-Use		Percent of Total		(Use local Utility Rates)	(Use local Utility Rates)
escription	Benchmark	Practice	Prototype House	vs. Benchmark	vs. Typical	vs. Benchmark	vs. Typical		
End Use	**(MBtu/yr)**	**(MBtu/yr)**	**(MBtu/yr)**					**Prototype WRT Benchmark**	**Prototype WRT Typical**
Space Heating	8.6	3.5	2.8	66.9%	18.0%	4.1%	0.6%	$54	$54
Space Cooling	55.8	27.1	17.4	68.7%	35.8%	27.0%	9.1%	$373	$100
DHW	22.5	21.4	21.5	4.6%	-0.7%	0.7%	-0.1%	$11	-$1
Lighting	15.5	15.8	15.5	0.0%	2.3%	0.0%	0.3%	$0	$4
Appliances and MEL	39.5	39.5	37	6.3%	6.3%	1.8%	2.3%	$25	$25
Total Usage	141.9	107.3	94.3	33.6%	12.2%	33.6%	12.2%	$463	$182
Site Generation	0	0	0	0	0	0	0	$0	$0
Net Energy Use	141.9	107.3	94.3	33.6%	12.18%	33.6%	12.2%	$463	$182
Added Annual Mortgage Cost w/o Site Generation. Includes 10% profit.								$50	$50
Net Cash Flow to Consumer w/o Site Gen.								$412	$132
Added Annual Mortgage Cost with Site Gen.								$50	$50
Net Cash Flow to Consumer with Site Gen.								$412	$132

DOE Stage Gate Criteria

Table 4 shows that, in accordance with DOE Building America guidelines, the Lakeland Habitat for Humanity homes achieve the "must meet" criteria for Stage Gate 4.

Table 4 Lakeland Habitat for Humanity (Lakeland, Florida)
Stage Gate 4 "Must Meet" Criteria

Criteria #1 Production home designs must achieve target whole house source energy compared to Building America (Hot-Humid Climate = 30%)			
► Radiant barrier, R-30 ceiling, ► double pane, vinyl, low-e windows ► 14 SEER heat pump, ducts in conditioned space ► ventilation with intake in soffit ► water heater timers ► Energy Star refrigerator.			Benchmark Savings 32%
Criteria #2 Must have a minimum of 5 projects with a minimum of 10 homes per project and a minimum of 5 homes completed by March/April.			
Infill and clustered lots in Lakeland, Florida			Completed / Build out 51 / 57
Criteria #3 Positive annual cash flow from energy savings (compared to BA Benchmark) when first cost (compared to standard practice) is added to mortgage over 30 years at 0% interest (*All Habitat for Humanity homes are financed at 0% interest.)*			
Incremental Cost	Annual Amortized Cost	Annual Energy Savings	Net Annual Savings
$1,500	$50	$463	$412

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