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Life Cycle Cost Analysis of a Green Home: A Case Study

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Abstract

Due to an increasing consumption and depletion of energy sources, the US government has formulated various policies for reducing electricity and natural gas consumption. These policies help not only to reduce the energy consumption but also help to reduce greenhouse gas emissions. In addition to this, home designers, homebuilders, and homeowners need to be aware of homeowner practices that affect the energy consumption of residential buildings. Some of these are; use of energy efficient appliances, energy efficient home designs and remodels that use good ventilation and insulation, and use of solar-powered appliances. This research study explored the cost benefit of manufacturing green homes through a case study. Data for this study was gathered from Picerne Military housing. Picerne Military housing constructs and maintains military housing at Ft. Rucker Army Airfield in Daleville Alabama. By using LEED for Green home building standard Picerne has been able to reduce the energy use in the military housing by 15% since taking over management and construction from the military. All of Picerne's housing is built to the LEEDs silver standard. There is a positive cost benefit to building homes to green standard if the builder uses technology that is not so new that the cost overcomes the energy savings. The researcher concluded that building a green home is a positive cost benefit to a potential home builder. The operation and maintenance cost of the home will be reduced for the homeowner as long as the home designer does not over do the green aspects of the home.

Keywords: Green Homes, Cost/Benefit analysis, Energy Use

Introduction

Buildings and structures play an important role in meeting human needs. They provide shelter and can provide healthy environments. They are important components of sustainable communities. However, buildings can also provide unhealthy conditions and stress the environments in which they are built. Buildings consume land, require excavation for construction, can modify wildlife habitats, change rainwater runoff patterns, change landscapes and require other materials. They also absorb and radiate heat, need paving for pedestrians and vehicles and, most importantly,

consume resource including energy. Energy consumption varies with the building size, design and climate conditions (Capehart, Turner, & Kennedy, 2008).

In the U.S. buildings represent 39% of primary energy use, 70% of electrical consumption, 12% of potable water use, and 136 million tons of construction waste annually. If there were a way to reduce electrical demand by only 10%, most of the new electrical generating facilities scheduled for construction in the U.S. over the next 10 years would not be required. The carbon associated with the energy use in U.S. buildings constitutes 8% of the current global emissions, equal to the total emissions of Japan and the United Kingdom combined (Capehart, Turner, & Kennedy, 2008).

Research Methodology

Building a green home should have a positive cost benefit to the home builder or at the very least be cost neutral over the life of the home. In building a green home the builder should not spend more over the life of home for the operation and maintenance of the systems that are part of the home. The main research approach was to conduct data analysis on Green home systems and to interview home builders for military housing.

Using Data from Military Housing

Fort Rucker is a U.S. Army post located in Dale County, Alabama. The post is the primary flight training base for Army Aviation and is the home of the United States Army Aviation Center of Excellence. As of the 2000 census, there were 6,053 people, 1,399 households, and 1,347 families residing on the base. In April 2006 Fort Rucker signed a contract with Picerne Military Housing. Picerne has similar contracts at Aberdeen Proving Ground, Fort Bragg, Fort Meade, Fort Polk, Fort Riley, Fort Sill, and Randolph Pointe. Picerne manages approximately 1,500 homes located on Fort Rucker. Since the contracts start in 2006 Picerne has built over 725 new homes on Fort Rucker. Picerne also manages approximately 750 existing homes located on Ft. Rucker. Picerne makes sustainability a priority. Picerne Military Housing is a member of the United States Green Building Council. They also employ staff with LEED credentials.

Before privatization, Military Housing did not meter utility services. This led to over use by military families who had no incentive to reduce utility use. Since privatization has occurred the Army and its privatization partners have worked to reduce the amount of utilities used on installations. LiveArmyGreen is the United States and its privatized partner's communication program for Soldiers and their Families to gain a better understanding of the Office of the Secretary of Defense and the Department of the Army's utility policy through education about utility consumption at Army installations as well as conservation education in the form of energy savings tips, programs, and events. The LiveArmyGreen program develops a Basic Allowance for Housing. The Program sets a baseline utility usage level for utilities in Military Housing. The baseline is developed from the historical data base on the type, size and location of the house. If a resident uses more than the allowable utility usage they pay for the additional usage. If the resident uses less than the allowable usage the received rebate rewards for their conservation.

Since Picerne has 750 homes that existed previously and 750 homes built with Green standards an analysis of the utility usage in the existing homes and the new homes can be compared to this research. The cost of the Green standards should easily be tracked. The authors interviewed the staff at Picerne and detail all the Green standards used in their new military housing, and compare that data to the characteristics and energy use of the existing military housing homes not built to those same green standards.

Cost Analysis of Green Homes

Additional research was conducted to develop a spreadsheet that compares the cost associated with building an ordinary home versus a Green home using LEED for homes rating criteria. The spreadsheet computed the initial cost, the operating cost for zero through thirty years, and calculate the total cost for an ordinary home and a green home.

This study focused on the following specific list of features; Design and Planning, Site Management, Insulation, HVAC Design and Installation, Water Usage Efficiency, Efficient Hot Water Distribution, Pipe Insulation, Advanced Lighting Packages, Environmentally Preferable Materials, Air Filtering, Landscaping, Surface Water Management, Windows, and Appliances. Maintenance and operating cost for green homes systems were analyzed by deriving the cost of purchase and the operation and replacement for major systems a home over a 30 year life.

Data Analysis and Results

For this research project, the primary data collection was through interviews with personnel employed at Picerne Military Housing. A cost benefit analysis of energy star rated appliances over a 30 year life of a house was performed to determine energy use and replacement of appliances versus non energy star rated appliances. Additional research was also done to investigate the cost and payoff per SEER rating on heat pump units.

What are the reasons to build a home to the LEED standards (USGBC, 2007)? The following were some of the reasons:

1. Lower utility bills
2. Government tax incentives and rebates for energy and water savings
3. A healthier, more comfortable environment for occupants
4. Reductions in landfill waste
5. Increased building durability for lower maintenance costs
6. Decreased carbon footprint, which means a better green image
7. Increased property and resale value

What exactly does a LEED home certification entail? There are 136 possible LEED home points. There are 18 prerequisites, 8 credit categories and 5 project phases. The LEED for homes certification levels are as follows (USGBC, 2007).

1. LEED Certified 45-59 points
2. LEED Silver 60-74 points
3. LEED Gold 75-89 points
4. LEED Platinum 90-136 points

The (USGBC) United States Green Building Council has established a list of five steps to participate in the LEED for Homes program (USGBC, 2007).

1. Contact a LEED for Homes Provider and join the program
2. Identify a project team and set the plan
3. Build the home to the stated goals
4. Certify the project as a LEED home
5. Market and sell the LEED home

During the interview with Picerne, the following highlighted areas are the green building standards that Picerne incorporates in their design process (J. Scott, personal communication, February 15, 2013). There are 18 prerequisites that a LEED home project must meet, to begin with (USGBC, 2007).

Picerne states that they improved the efficiency of homes by a15 percent reduction in energy usage (J. Scott, personal communication, February 15, 2013). Prior to Picerne taking over the Ft. Rucker Military Housing all of the houses were not on individual metering devices. All metering was done on a neighborhood by neighborhood basis with monitoring taking place on master meters. Currently, all houses in the Military housing have meters and each neighborhood has a master meter. Consumption for every neighborhood is down 15 percent since Picerne took ownership of military housing (J. Scott, personal communication, February 28, 2013). Part of the savings can be attributed to the use of the LEEDS silver designs. However, part of the savings can be attributed to energy management programs that have since come into effect on the post.

Prior to Picerne taking over military housing; individual houses were not metered. So there was no way to tell which house was using what amount of electricity. Now Houses are grouped into houses with similar sizes and locations. If Picerne has houses on streets A, B, and C it groups all of the three bedroom houses on each street together, and the same for streets B and C. It groups all the 4 bedrooms the same way, as well as the five bedroom houses. It takes all the like houses and records their energy use. Picerne discards the maximum and minimum energy usages in all groups. Then average the remaining energy usage rates. That becomes the energy usage baseline for that month. Residents who use more than the baseline are asked to pay an overage rate and residents who come in under the baseline share in the savings (J. Scott, personal communication, February 28, 2013).

Energy Star Homes and Appliances

One of the largest prerequisites to building a LEED home is the Energy Star prerequisite. Energy Star homes is a program that was introduced by the EPA so it's owners can save money on utility bills, provide better indoor air quality, and protect the environment. Features typical in Energy Star homes are Efficient Walls and Windows, Efficient Air Ducts, Efficient Equipment, and Efficient Lighting and Appliances. Energy use cost grows over the life of the appliances at .026% increase per year which is the average calculated for electricity between 1980 and 2006. Gas price is calculated to rise to .038% per year. The replacement rate for appliances is at 10 or 12 years for water heaters, 15 years for refrigerators, 15 years for dish washers, and 10 years for clothes washers. As chart 4 shows there is a benefit to buying energy star appliances over the lifetime of a home's operation.

Data for the Table 1 was obtained by pricing the equipment at Lowes.com. The energy usage over the life of the appliances was obtained from the manufacturer energy usage sheet for each appliance. Installation cost where obtained from Means.

Table 1: Initial cost, maintenance cost, and operation cost for standard appliances versus Energy Star appliances

	Initial Cost	Install Cost	year1 OPER	10yr O&M	15yr O&M	30yr O&M
Appliances						
water heaters						
electric (80 gal) 12yr	$760	$415	$508	$6,899	$11,543	$26,278
Nat gas (50 gal) 12yr*	$700	$345	$272	$4,292	$7,486	$18,078
hp elect (80 gal) 10yr*	$2,000	$415	$201	$7,095	$8,467	$18,663
Refrigerators						
15.6 cft top	$404.10	$55	$48	$1,000	$1,787	$3,527

freeze						
15.6 cft top freeze*	$549	$55	$39	$1,043	$1,914	$3,559
Dishwashers						
24" built in	$450	$208	$50	$1,221	$2,221	$4,213
24" built in*	$469	$208	$30	$1,015	$1,897	$3,375
clothes washers						
3.4 cft top load	$499	$143	$50	$1,847	$2,189	$4,807
3.4 cft top load*	$544	$143	$15	$1,543	$1,645	$3,420

SEER ratings for HVAC

SEER is the Seasonal Energy Efficiency Ratio used to classify HVAC equipment. The higher number, the more efficient the system is at converting electricity into cooling power. SEER 10 was the standard, however, 13 is the most common available now. Pricing data was obtained for residential sizes that are common and their SEER rating. Using a 20 year life for the cost savings calculated for an increase in SEER value shown in Table 2. The table illustrates the utility cost savings to upgrade SEER value and the money that can be saved by upgrading along with the cost of the unit. For example, an upgrade for upgrading a 2 ton 10 SEER unit to a 2 ton 13 SEER unit saves someone $4,820 over a 20 year life on utility cost. The 20 year life was chosen because 18 years is the average life of a heat pump unit.

Data for each of the HVAC system where obtained at HVACexpress.com which is a good tool to evaluate quick price differentials on HVAC equipment. The numbers it gives will be the just rough order of magnitude. The installation cost where done using Means. The yearly operational cost came from HVACOPOST.com which has energy usage calculator for the zone of the country, equipment size, electric rate, SEER rating, a square foot of house, and cooling hours.

Table 2 : 20 year life for the cost savings calculated for an increase in SEER

Hp ton/SEER	Equip cost	install cost	yearly op cost	Delta over 20 years SEER to SEER
1.5 ton 10 SEER			$632	
1.5 ton 13 SEER	$2,147	$435	$451	$3620
1.5 ton 14 SEER	$2,320	$435	$421	$600
1.5 ton 15 SEER	$2,771	$435	$395	$520
2 ton 10 SEER			$843	
2 ton 13 SEER	$2,232	$460	$602	$4820
2 ton 14 SEER	$2,391	$460	$562	$800
2 ton 15 SEER	$3,076	$460	$527	$700
2 ton 16 SEER	$3,668	$460	$496	$620
2.5 ton 10 SEER			$1,053	
2.5 ton 13 SEER	$2,457	$485	$752	$6,020
2.5 ton 14 SEER	$2,562	$485	$702	$1,000
2.5 ton 15 SEER	$3,306	$485	$658	$880
3 ton 10 SEER			$1,264	
3 ton 13 SEER	$2,531	$555	$903	$7220

3 ton 14 SEER	$2,694	$555	$843	$1200
3 ton 15 SEER	$3,585	$555	$790	$1060
3 ton 16 SEER	$4,180	$555	$743	$940

Conclusions and Recommendations

The researcher concluded that building a green home is a positive cost benefit to a potential home builder. The operation and maintenance cost of the home will be reduced for the homeowner as long as the home designer does not over do the green aspects of the home. The main findings of this study are as follows:

The initial cost for building a home to a green standard is higher than building a traditional non-green home. Many green home options are cost neutral. Additional higher efficiency systems will cost the builder more upfront cost. Some green systems can cost as much as 2.5 times the cost of non-green systems. The worst case scenario the researcher found was to compare an Energy Star heat pump water heater where the initial purchase price is $2000 compared to the regular water heater's cost of $760.

The life cycle cost of building a green home will be much less than building a standard home. Still referring to the water heaters selected the life cycle cost of the water heater for the green appliance is $18,663 while the life cycle cost of the standard water heater is $26,278. The maintenance cost for the system will be slightly more for the green appliance due to it having a higher frequency of replacement.

On the same water heater, it can be determined that even though the initial cost is 2.5% more than the standard water heater. The energy savings over the 30 year life of the home would be $7,615 just for the water heater. Also from interviews with Picerne military housing, they showed a 15% energy savings by building homes to the LEEDs silver standard.

The most important part of building a Green home is the design and planning phase. If care is taken during the design and planning phase there are no additional cost to building a green home compared to building any other home. Simple design planning for the site stewardship, landscaping, surface water management, site selection, and site orientation can all be done in the early stages of the build and have no effect on the initial coat of the home. These attributes while costing little could save the home owner much in the way of energy savings over the life of the home. Insulating to green standards will be a little more upfront cost to the home owner. But these cost over the life of the home will pay for themselves.

HVAC design is one of the key aspects of designing a green home. In order for the Air-conditioning equipment to operate at its optimum rate, it must be sized correctly. SEER is the Seasonal Energy Efficiency Ratio used to classify HVAC equipment. The higher number, the more efficient the system is at converting electricity into cooling power. The SEER ratings are the way designers and HVAC specialist present to the homeowners how efficient the HVAC unit will be. But at this time the higher the SEER rating the more the unit will cost at initial purchase. As shown in Table 2 if a homeowner were to purchase a 2 ton SEER 14 over a 2 ton 13 SEER; the homeowner would spend $159.00 dollars up front, but the energy savings over the life of the unit would be $800.00. If the homeowner were to install a 2 ton SEER 15 over the 2 ton SEER 14 the homeowner

would spend $685.00 up front and save $700.00 over the life of the unit. Finally, if a homeowner were to install a 2 ton SEER 16 over the 2 ton SEER 15 the homeowner would spend $592.00 up front and save $620.00 over the life of the unit. As the SEER rating goes up the percent of cost savings declines very rapidly.

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