

The project is one of three single-family homes built by Fluid Construction between 2006 and 2008, each built to an increasingly more robust green building standard. This home was built to LEED-H Silver standards, although the LEED submittal process has not been completed. The home is ENERGY STAR certified.



## Home Built to LEED- H Silver Standards Monmouth County, NJ



*“After having owned and occupied this home built to LEED-H Silver standards for two years, the homeowners stated unequivocally that they would recommend purchasing a home such as this to friends. On a five point scale with 5 being the highest, they rated the day lighting features of the home a 5, the low-flow fixtures a 5, the thermal comfort a 4, the indoor air quality a 5, and their overall satisfaction with the home a 5.”*



**Location of Project:** Monmouth County, NJ

## Overview

This home built to LEED-H Silver standards in Monmouth County, NJ was completed in July of 2008, occupied in November 2008 and is currently home to two adults and two small children. It was built by Fluid Construction as the third in a series of three progressively more energy efficient homes in the area. The home built to LEED-H Silver standards was built on a previously developed site in a residential neighborhood.

## Transportation

The home built to LEED-H Silver standards is within walking distance of the town's downtown area and there is a NJ Transit bus stop nearby. There are also train and ferry services to New York City within seven miles of the home. However, transportation considerations were not a major part of the project.

## Water Consumption and Appliances

The home built to LEED-H Silver standards was outfitted with high-efficiency water fixtures and fittings as well as ENERGY STAR appliances and lighting that have greatly reduced water and energy consumption when compared to a home without these improvements. As for water efficiency, the home is equipped with 1.5 gallons per minute (gpm) low-flow faucets in the kitchen and bathrooms, 2.0 gpm low-flow showerheads, and dual-flush 1.6/0.8 gallons per flush toilets. The homeowners are very pleased with the low flow fixtures and had no complaints, rating their satisfaction as a 5 on a 5-point scale.

All of the major appliances in the home built to LEED-H Silver standards are ENERGY STAR qualified, which use 10-50% less energy than standard appliances. Seventy-five percent of the lighting in the home is also ENERGY STAR certified, which use 75% less energy and produce 75% less heat than conventional lighting systems, which in turn reducing cooling loads. Again, the homeowners were very satisfied with the appliances in the home with the exception of the front-loading washing machine, which often required additional water to ensure adequate cleaning, especially when washing heavily soiled items.

As part of a two-year study, the Rutgers Center for Green Building (RCGB) found that the home built to LEED-H Silver standards used 8% less electricity and 52% less natural gas per square foot per year than a "typical" single family home in the area built

## Project Team

**General Contractor:** *Fluid Construction*

**Architect:** *Debra L. Stoever*

**Energy Consulting Firm:** *MaGrann Associates*

to the International Energy Conservation Code (IECC) 2006. Given that heating constitutes more than 50 percent of an average home's energy use in the Middle-Atlantic Region, the home's reduced natural gas consumption is noteworthy.

## Envelope, Heating and Cooling

The home built to LEED-H Silver standards is outfitted with superior building envelope technologies including a closed-cell spray-applied polyurethane foam insulation system which achieves an R-value of 6 per inch thickness and provides almost-zero air permeability. It uses advanced 2"x 6" wood framing spaced at 24" throughout the house. It is equipped with two super high-efficiency air-conditioning units with a seasonal energy efficiency rating (SEER) of 18, which are about 30% more efficient than the federally mandated SEER 13 units, and a five-zone, fuel-fired hydronic distribution boiler for radiant heat with an annual fuel utilization efficiency (AFUE) rating of 95%, well above the AFUE of 80% required by federal regulation.

The combined building envelope and the superior cooling system help keep temperatures within a comfortable range on even the hottest days of the summer. For example, on the hottest day during the summer of 2009, the home's indoor temperature fluctuated within a range of only 4-5 degrees Fahrenheit. For this reason, the homeowners were very pleased with the thermal comfort of the home, noting that it was unnecessary to adjust the thermostat very often.

The home was also designed to take full advantage of the seasonal courses of the sun to reduce excessive heating in the summer and utilize the limited sunlight in the winter. The southern face has the most and largest of the windows and glass doors in the house; overhangs were installed over each of the windows to prevent the summer sun from penetrating the home, but allow the winter sun to come in. The homeowners did mention that the sun during the winter was sometimes too much, but were happy with the sun during the summer. They have also planted deciduous trees in the southern yard to help reduce the amount of summer sun that reaches the house.





## Ratings and Awards

Built to USGBC LEED Silver Standards  
ENERGY STAR Certified

## Interior and Operations

Throughout the home built to LEED-H Silver standards, bamboo wood flooring was used and low or no-VOC paints were used throughout the building to reduce toxic off-gassing. An indoor air quality test was conducted at the home that found that all of the VOCs tested for were within the normal range for New Jersey. Indoor air quality is of particular importance to the homeowners and as a result, they use green, environmentally friendly cleaners or natural cleaners with low levels of VOCs nearly all of the time.

The home also uses bamboo flooring throughout the house about which the homeowners expressed some concerns. They did not believe it was holding up to the rigors of daily use by two children as well as they had hoped.

The overall operation of the home built to LEED-H Silver standards requires minimal effort. The heating and cooling systems are controlled by a digital thermostat that is programmable to conform to the occupants' thermal preferences and can be adjusted remotely via the Internet. Overall, the homeowners were satisfied with the capacity to control the heating and cooling systems, though sometimes had difficulties navigating the menus and options of the thermostat.

## Process

### Design

The home built to LEED-H Silver standards was the third progressively more green home built by Fluid Construction in the same area. Prior to this, Fluid Construction worked on homes built to the standard code, but realized the potential benefits of building green. He was able to convince the homeowners of the value of a green design.

### Build

The general contractor was responsible for ensuring the home, as built, met the criteria outlined in the LEED-H checklist.

## Operate

As mentioned above, the home built to LEED-H Silver standards requires minimal active operation on the part of the homeowners. They did mention that they were pleased with how little they had to use their heat and were impressed with how well the home maintained the indoor temperature.

The homeowners did experience extremely low levels of humidity during the winter of 2008/2009 as a building-wide humidifier was not installed at the outset. They had purchased several humidifiers for the bedrooms, but eventually had a home-wide system installed in order to bring the home's humidity up to their desired level.

## Evaluate

As mentioned above, the home built to LEED-H Silver standards was one of three newly built homes in the Monmouth County that was part of a two-year, post-occupancy evaluation conducted by the RCGB. The study included an analysis of monthly electric and natural gas bills as well as quarterly water bills. A full life-cycle costing (LCC) analysis was completed as well as a life cycle environmental impact assessment (LCA). The homeowners were also interviewed twice during the study in order to ascertain user habits and preferences as well as satisfaction levels.

## Finance

A life-cycle cost (LCC) analysis was conducted on the home built to LEED-H Silver standards in order to evaluate whether the energy efficient features included in the design are worthwhile in an economic sense over from the home's construction to its demolition. Considerations of homeowner satisfaction, comfort, or environmental benefits are not taken into account. Again, the REM/RATE model was used to project the home's annual end-use consumption and cost for electricity and natural gas and compared to an average, mid-Atlantic detached single family home built to the IECC 2006 standards.

The home built to LEED-H Silver standards, as designed, was expected to consume 33% less electricity and 49% less natural gas than an average IECC 2006 home and, as mentioned above, actually used 8% less electricity and 52% less natural gas. These increased efficiencies did come at an extra cost. As built, the total initial cost for the appliances, heating and cooling system, windows and insulation of the home built to LEED-H Silver standards was \$17.73/sqft as compared \$11.99/sqft for the average home, a difference of \$5.74/sqft. The largest initial expense was the improved insulation system which accounted for \$6.81/sqft or 8% of the initial costs as opposed to \$2.97/sqft or 25% for the traditional insulation in the IECC 2006 home.

A net present value (NPV) calculation was completed in order to determine the lifetime value of the improved efficiency of the home built to LEED-H Silver standards. The primary analysis assumed a 30-year building lifespan, a discount rate of 7.0% and used a projection for energy prices based on the linear regression equation of historical energy prices from 1992 to present. The price of natural gas projected increase is 2.2% and 4.3% for electricity. Historical energy price data was gathered from U.S. Department of Energy Short Term Energy Outlook. The results found that the NPV of the home built to LEED-H Silver standards was \$0.90/sqft greater than that of the average mid-Atlantic

home. In other words, if the conditions of this analysis hold over the life of the home built to LEED-H Silver standards, the initial investment in energy efficiency improvements will result in a net positive investment when compared with a standard home.

In order to mitigate some of the uncertainty of predicting the future, RCGB also conducted a sensitivity analysis varying the home’s lifespan, the discount rate, and the energy price escalation rate. The energy price escalation rates are derived from the Department of Energy’s Short Term Energy Outlook. Three different energy price scenarios have been calculated. The low projection assumes a 0.0% rate of increase for both natural gas and electricity prices. The medium projection is based on the historical increase in energy prices from 1992-2010. The medium growth natural gas price rate is 2.2% and 1.3% for electricity. The high projection is based on the percentage change over between 2000 and 2010. The high growth natural gas price rate is 4.3% and 3.3% for electricity.

The results are as follows:

Building Lifespan	Energy Price Escalation Rate	Discount Rate		
		5.26%	7.00%	12.00%
15 Years	Low	-\$1.33	-\$1.80	-\$2.80
	Medium	-\$0.69	-\$1.26	-\$2.44
	High	-\$0.17	-\$0.53	-\$1.97
30 Years	Low	\$0.72	-\$0.37	-\$2.26
	Medium	\$2.42	\$0.90	\$1.64
	High	\$5.13	\$2.90	-\$0.71
50 Years	Low	\$1.82	\$0.21	-\$2.15
	Medium	\$4.71	\$2.12	-\$1.42
	High	\$10.32	\$5.62	-\$0.25

## Performance

The RCGB has collected utility bills from the homeowner between November 2008 and October 2010 to assess the building performance. Based on an analysis of those bills, it was found that the home built to LEED-H Silver standards is performing better than expected in terms of natural gas use, but slightly worse than expected in terms of electricity consumption. Based on a building model created using REM/RATE software, the home built to LEED-H Silver standards was expected to use 0.21 therms/sqft/year but in actuality used 0.20 therms/sqft/year—a 5% difference. In terms of electricity, the home was expected to use 2.5 kWh/sqft/year but actually used 3.1 kWh/sqft/year—about 24% higher than anticipated. These numbers differ from those cited above as these are comparing the actual natural gas and electricity consumption of the home built to LEED-H Silver standards with the expected consumption of the home as modeled in REM/RATE while above, the actual use was being compared to a modeled home built to the IECC 2006 standards. More so than natural gas, which has a comparatively limited scope of use (cooking, water heating, and space heating, the last of these being by far the most significant), electricity is used for many purposes that are exclusively linked to user habits and cannot be mitigated or improved by building design. Most notable is the intensity and frequency of electronic use. Further, extraordinary circumstances that demand large amounts of electricity such as home improvements or the addition of new appliances cannot be fully anticipated in the REM/RATE models.

## Lessons and Trade-offs

Overall, the homeowners are very satisfied with their home and have had few issues in the two years that they have resided there. The greater relative expense of the home is evidently offset by the environmental contribution the homeowners feel they are making by living in such a home.



One of the homeowners expressed the increased awareness and environmental responsibility that has grown in every aspect of their lives due to owning a home such as this.

## List of Green Strategies

### Design

- Brownfield and Infill Development
- Water-Efficient Landscape Design
- Low-Flow Faucets And Showerheads
- Dual Flush Toilets
- Closed-Cell Spray-Applied Polyurethane Foam Insulation System
- Low-E, Argon Filled Windows
- Advanced 2X6 24" O.C. Wood Framing
- Daylighting
- High Efficiency HVAC Equipment
- ENERGY STAR® Appliances
- Hydronic Radiant Heating System
- Indirect Fuel-Fired Hot Water Tank

### Build

- Rapidly Renewable Materials: Bamboo Flooring
- Low VOC Paints And Finishes
- Indoor Air Quality Management Plan

### Operate

- Programmable Thermostat
- Green Cleaning

### Evaluate

- Building Performance Evaluation