Building America
U.S. Department of Energy
Research Toward Zero Energy Homes

HOME PERFORMANCE WITH ENERGY STAR

Case Study:

HartmanBaldwin Design/Build
Pasadena, CA

Building shell leakage was cut by 45% and duct leakage was cut by 91% in this Home Performance with ENERGY STAR retrofit by HartmanBaldwin in Pasadena, California

High-End Architect and Construction Company's Questions lead to Building Science

Since 1979 HartmanBaldwin Design/Build, a fully integrated architecture and construction company, has been remodeling for high-end clientele and has earned more than 40 local and national awards for design/build excellence. Through all these projects, founding partners Bill Baldwin and Devon Hartman have been driven by the same question: How do we know that the beautiful buildings we create are durable, sustainable, and energy efficient?

Building science, which is the foundation for Home Performance with ENERGY STAR, provided the answer.

"A few years ago when we discovered building science, it was like Christmas for us," said Hartman. "We found out about the science of building through the CBPCA [California Building Performance Contractors Association] in California. We took some classes by Rick Chitwood, a wonderful friend and mentor, and we discovered the answers we had been looking for over 30 years."

The CBPCA is currently the only organization in California providing contractor training for Home Performance with ENERGY STAR. The training is funded primarily by Pacific Gas and Electric, Southern California Edison, and Sacramento Municipal Utility District according to Pat Colburn, director of CBPCA's Support Services.

Home Performance with ENERGY STAR, a national program from the EPA and DOE, promotes a comprehensive, whole-house approach to making energy-efficiency improvements. The program is available in cities where a local sponsor (typically a utility company, state agency, or local association promoting energy efficiency) has agreed to partner with ENERGY STAR. The local sponsor recruits home improvement contractors and trains them to perform comprehensive home assessments and best-practice improvements based on whole-house building science.

Unlike typical home energy audit programs, a goal of Home Performance with ENERGY STAR is to turn recommendations into improved homes. Participating contractors complete the needed renovations or team with other participating contractors who can. Upon project completion, the contractor assesses the home's performance again to document that improvements were properly installed to achieve the promised energy savings. All participating contractors are subject to quality assurance reviews by the third-party sponsor.

BUILDER PROFILE

HartmanBaldwin Design/Build

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Founded: 1979

Employees: 45

Featured Project: Three bedroom, two and a quarter baths

Home Built: 1959

Square Footage: 2,402 sq. ft.

Awards: HartmanBaldwin has been the recipient of more than 40 local and national awards for design/build excellence. These include the Gold Nugget award from the Pacific Coast Building Conference and the Grand Prize Design award from Remodeling Magazine.

"Once we discovered building science, we [HartmanBaldwin staff] became as knowledgeable as possible, got as many certifications as possible, took every class we could find. We are now certified or accredited by BPI, CHEERS, LEED, and Build It Green."

Devon Hartman, president and co-founder of HartmanBaldwin

(top) Holes in 52 can (recessed) lights caused significant air leakage.

(bottom) Batt insulation above the office had been moved and not repositioned to provide adequate ceiling coverage.

What makes Home Performance with ENERGY STAR Contractors different?

Knowing what energy-efficiency improvements to make to a home and how they can work together requires special expertise. Home Performance contractors are equipped with specialized training and diagnostic tools to determine how your home is performing, and can assist you in achieving your goals, whether it's improving comfort, cutting energy costs, or protecting the environment.

For information about Home Performance with ENERGY STAR training in California, visit www.cbpca.org

"Our signature training is called the Green Home Energy Upgrade. It is a 9-day course divided into three 3-day segments or levels. At the end of the third level, our participants can take the written test from the Building Performance Institute (BPI)," said Coburn. All four BPI specialty written tests are offered on the third day of level three. Participants can be certified in one or all of these specialty areas: Building Analyst Professional, Envelope Professional, Heating Professional, and Air Conditioning/Heat Pump Professional.

The Process—A Home Performance with ENERGY STAR Retrofit from Start to Finish

Homeowner Jamie McCoy is not only thrilled by the results of her Home Performance with ENERGY STAR retrofit, which was completed over a year ago, but she is thrilled by the process HartmanBaldwin followed. "Everything in remodeling or construction seemed so imperfect and immeasurable to me…[HartmanBaldwin] did a duct blaster test and other tests, and then used numbers and measurements. [The results] were so verifiable. I thought, 'this is great.'"

Although McCoy originally contacted HartmanBaldwin to remodel her kitchen, she changed her mind and signed up for a whole-house energy retrofit. "After learning about home performance, I decided to do this first and do my kitchen later," says McCoy. "It feels good to know I can make my home more energy efficient."

McCoy's 2,402-square-foot home in Pasadena, California, was custom built by a previous owner in 1959. This single-story three-bedroom, two-bath home uses all-electric heating and cooling.

Conducting a Comprehensive Energy Audit

HartmanBaldwin charges on average $700 for a complete test, and this test follows Home Performance with ENERGY STAR guidelines. Andrew Durben, a senior building analyst at HartmanBaldwin, led the team that conducted blower door tests to determine air leakage; used infrared cameras to show heat and air infiltration areas; checked for insulation levels and gaps in the attic/ceiling, walls, and floor; studied the types and conditions of the windows; studied details of the mechanical heating and cooling systems; checked for signs of moisture infiltration; measured moisture levels; and documented ventilation needs.

One test result proved particularly interesting. "I did the duct blaster test a couple of times," said Durben. "I thought I must be doing something wrong because I wasn't getting any reading. Finally, I crawled under the house to see. The bottom of the return plenum had completely rusted out."

McCoy adds, "I have had repairmen here countless times for things, and no one ever mentioned to me that the ducts were rusted through and sitting in the dirt."

Making Recommendations

With the energy audit complete, Durben reviewed the results with McCoy and provided a detailed proposal with specific prices. McCoy agreed to most of the recommendations. "It was not an inexpensive project, but it feels good to know it was money well spent," said McCoy.

Although McCoy did not investigate federal, state, and local rebates and financial incentives for her Home Performance with ENERGY STAR retrofit, these do exist. The Database of State Incentives for Renewables and Efficiency (DSIRE) can be accessed at www.dsireusa.org. This site provides a comprehensive source of information on state, local, utility, and federal incentives and policies that promote renewable energy and energy efficiency. Established in 1995, DSIRE is an ongoing project of the North Carolina Solar Center and the Interstate Renewable Energy Council funded by the U.S. Department of Energy.

Doing the Home Performance with ENERGY STAR Retrofit

The HartmanBaldwin team organized the retrofit into two areas: completely sealing the building shell and installing a new HVAC system.

Initial tests and visual inspections showed the building shell had major air leakage. "We conducted a blower door test," explains Durben, "The recommended ventilation for her house based on BPI [Building Performance Institute] standards is 159 square inches; her house tested at 13,523 cfm_{50}, that is equivalent to a 742-square-inch hole in the building shell."

To address this leakage problem, the team started with sealing the attic. They removed the existing R-13 batt insulation from the attic's floor, which was performing at an R-5 due to its poor installation and condition. Then, they sealed the interior wall cavities that were open to the attic. "These cavities allow hot or cold air from the attic to come down inside the interior wall cavities," says Durben.

Through an electrical safety check, the team discovered numerous electrical code violations, which were subsequently fixed in order to then properly seal the attic's surface area. A significant air leakage problem came from the 52 non-insulated, non-airtight recessed (can) lights that allowed for conditioned air to escape up to the attic. They built air-tight boxes over each light with adequate space for fire safety, and then buried these in new blown-in cellulose at 10 to 12 inches in height for a new R-38 value.

To determine the appropriate loading order for retrofit work, many variables are taken into consideration. In this case, a poorly insulated attic in southern California reaches average temperatures of 140°F in the summer. The temperature differential between the 75°F interior house temperature and the 140°F attic causes the cooler air of the house to be sucked up into a leaky attic. Therefore, since the temperature differential between the walls at 75°F and the outside temperature at 100°F is not as significant, replacing windows and wall insulation wasn't as high in priority as properly insulating the attic when determining the most cost-effective improvements.

As Durben explains: "When you look at an old home, everyone assumes that the windows are the first thing to address, but if you have 300 square feet of glass and you replace it, you go from R-1 to R-3 [which is the typical R value for new windows]. For a fraction of the cost, you can take the 2,000-square-feet of ceiling surface area and increase it from R-6 or R-10 to R-38 at the place where it really matters—in the attic."

The team did replace several jalousie (louvered) windows that showed significant leakage.

After completing the air sealing in the attic, the team tackled the crawlspace. They removed the rusted-through ducts and debris; inspected and repaired electrical, plumbing, and gas issues; installed a vapor barrier and ventilation fan, and sealed all the vents. They also sealed all major floor penetrations, including electrical, plumbing water, waste pipes, and tub and shower access areas.

Two SEER 14, HSPF 8.0 1½-ton heat pumps were installed. Two were installed because the house is long, and they wanted to use smaller units and keep the duct runs as short as possible. "It is more energy efficient to do two small systems and also more comfortable because we are heating and cooling the air at a slower rate," say Durben. "SEER 13 is the lowest you can buy in California. What we have discovered is that adding high-efficiency equipment alone is not cost effective. It is easy to sell your customers more expensive high-SEER equipment. It is harder to make sure you get the duct system installed just right, that it is tight, and that you keep the duct runs as short as possible."

(top) The bottom of the furnace's return plenum was completely rusted out.

(bottom) Unidentified debris covered the duct insulation in the crawlspace.

More than half of the over 66 million single-family homes in the United States were constructed before modern energy codes existed. Many of these homes have no wall insulation, high levels of air infiltration, inefficient heating and air conditioning, and inefficient water heaters and appliances. In fact, over 40% of households report at least some winter drafts, and 62% complain of a room that is too warm in the summer.

Home Performance with ENERGY STAR website

Through 2008 more than 50,000 existing homes have been improved through Home Performance with ENERGY STAR, with 12,000 homes improved in 2008 alone. There are more than 25 program sponsors and 750 participating contractors.

Jonathan Passe, EPA Communications Coordinator for ENERGY STAR Residential Programs

High moisture content was found in the soil of the crawlspace which had no vapor barrier covering.

Key Energy-Saving Features

- Duct blaster showed duct leakage cut from 800 cfm to 62/70 cfm
- Blower door test showed whole house air leakage cut from 13,523 cfm_{50} to 7400 cfm_{50}
- Air conditioning reduced from 8 to 3 tons
- Electric bills cut in half
- Laid mylar vapor barrier over the crawlspace dirt floor and added a ventilation fan; all floor penetrations sealed
- Increased attic insulation from sloppy R-5 batt to R-38 blown cellulose
- Built air-tight boxes around 52 noninsulated, non air-tight recessed can lights in ceiling
- Extensive attic air sealing
- Replaced leaking windows
- Installed two new SEER 14, HSPF 8.0 1½-ton heat pumps
- Replaced rusted out metal ducts with R-8 insulated plastic flex duct configured for short duct runs

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The team installed plastic flex duct with R-8 insulation and lined the crawlspace floor with a Mylar vapor barrier. In the new design, each supply duct run is a home run to the supply plenum to ensure the correct amount of air could be delivered at the right speed to each room. This is important explains Durben because "Too much air or too little air in the room is going to be uncomfortable, and you need the air delivered at the right speed."

Conducting Follow-up Testing

The original blower door testing showed significant leakage at an interpolated reading of 13,523 cfm_{50}, which is 742 square inches. After sealing the home, leakage was reduced to 7,400 cfm_{50} or 406 square inches.

The first system's duct leakage measured 800 cfm, and the second was too leaky to test. The post-test numbers started at about 100 cfm. They conducted smoke tests and did additional sealing and ended up with post-retrofit duct leakage of 70 cfm at 25 pascals of pressure in the living area and 62 cfm 25 Pa in the bedrooms.

"This home originally had eight tons of air conditioning equipment, and today it has 3 tons. In the traditional home, an HVAC system is designed so that one ton of capacity will cool or heat about 400 square feet. In this home, we were able to cool 800 square feet with every ton of air conditioning," says Durben.

The homeowner's reduced energy bills and increased comfort may be the real follow-up test. "I just recently got the real apples to apples bill for July. It was exactly half what I paid the year before in July," says McCoy. She is as enthusiastic about how the house feels. "I am like a commercial for them. I so believe in what they did. I had my niece visiting here two weeks ago from New York. I hadn't told her anything about the retrofit. It was a very hot day, and we had been out outside. We came in and were sitting in the dining room and she said to me, 'You know it is so comfortable in here.' And she meant the temperature. That is how this house is. It is comfortable now, and before it was hot."

The Bottom Line

For Devon Hartman and his staff, building science makes the difference. "We can now, with existing technology and off-the-shelf materials, assess a person's home, retrofit it, and reduce energy, reduce greenhouse gases, and attack some of the most important problems in sustainable building today. Right now. That's what's exciting…. Now we have the testing equipment to identify issues, fix the problem, retest to prove that we fixed the problem, and move on with a great feeling of satisfaction."

To find your state sponsor for Home Performance with ENERGY STAR, go to **www.energystar.gov** Then, click on *Home Performance with ENERGY STAR*. From here, click on the link labeled "contractors participating in a locally sponsored Home Performance with ENERGY STAR Program." Or, Google: *Home Performance with ENERGY STAR Locations.*

For more information about Home Performance with ENERGY STAR, visit **www.energystar.gov/homeperformance**