Musings of an Energy Nerd
Contemplating residential energy use

JUST TWO MINISPLITS HEAT AND COOL THE WHOLE HOUSE

Carter Scott has built 18 homes in Massachusetts without any heat in the bedrooms

POSTED ON AUG 17 2012 BY **MARTIN HOLLADAY, GBA ADVISOR**

Carter Scott was one of the first builders bold enough to build a cold-climate home heated by only two ductless minisplit units (one in the downstairs living room, and one in the upstairs hallway). Skeptics predicted that the unheated bedrooms would be cold and uncomfortable. Yet Scott was confident that the home's excellent thermal envelope — with high-R walls, triple-glazed windows, and low levels of air leakage — would keep the homeowners comfortable even when the bedroom doors were closed.

Scott owns a construction company called Transformations in Townsend, Massachusetts. He built his pioneering two-minisplit house in Townsend in 2008; the inclusion of a 5.7-kW roof-mounted photovoltaic array made it into a zero-energy house.

The skeptics' "cold bedroom" predictions were unfounded. "We have since built several houses in which the upstairs minisplit unit isn't even being used until the outdoor temperature drops below 20 degrees," Scott said. "Typically the response from homeowners is, 'Wow, these houses have even indoor temperatures' and 'these houses are quiet.' And the fact that there are no utility bill makes people excited."

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Carter Scott's first zero-energy house. From the outside, the only clue that this home is unusual is the large photovoltaic array on the south-facing roof. The entire home is heated by two Mitsubishi ductless minisplit units.

Carter Scott's first net-zero energy house

A ductless minisplit is a type of air-source heat pump that can provide space heating as well as air conditioning. Most of the ductless minisplits sold in the U.S. are manufactured in Japan or South Korea; the best known brands are Daikin, Fujitsu, and Mitsubishi.

The first zero-energy house built by Scott's company, Transformations, was designed by architect Ben Nickerson. Dubbed the Needham model, it was built at 18 Coppersmith Way in Townsend in 2008. Here are the home's specifications:

Area: 1,232 square feet
Basement insulation: Basement is unconditioned; basement ceiling is insulated with 3" of closed cell spray foam plus R-30 fiberglass batts (total R-50)
Wall framing: 12-inch-thick double-stud walls
Wall insulation: Flash and fill: 3" closed-cell spray foam plus 9" cellulose (R-50)
Sloped ceiling insulation: Flash and fill: 5" closed-cell spray foam plus 13" cellulose (R-64)
Windows: Paradigm triple-pane krypton-filled low-e windows
Siding: Vinyl
Design heat load: 10,500 Btu/h
Space heating: Two Mitsubishi Mr. Slim ductless minisplit units (one 12,000 Btuh unit downstairs, and one 9,000 Btuh unit upstairs); installed cost, $5,250
Mechanical ventilation: Lifebreath 155 ECM energy-recovery ventilator
Domestic hot water: Sun Drum solar thermal system with electric resistance backup
PV system: 5.7-kW roof-mounted array (Evergreen Solar PV modules) and Fronius IG 5100 inverter (cost before incentives: $33,000)

In 2009, this home won the second prize ($15,000) in a utility-sponsored contest called the Zero Energy Challenge. The home has since received plenty of media attention, including attention from GBA; see, for example:

The Zero Energy Challenge Winner
Heating a Tight, Well-Insulated House, and
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Consultants from Building Science Corporation help refine the specifications

Scott gave a presentation on his recent projects at the Sixteenth Annual Westford Symposium on Building Science in Westford, Massachusetts, on July 30, 2012. Scott is currently working with the DOE's Building America program, and the program hooked him up with energy consultants from the Building Science Corporation. He's now building homes at several locations around Massachusetts.

In Devens, Massachusetts, Scott will build 8 superinsulated single-family homes with prices starting at about $330,000 (not including PV).

In Easthampton, Scott is building 33 new superinsulated homes at a development called Easthampton Meadow. The homes will range in size from two-bedroom homes to four-bedroom homes, and will be priced at $284,000 to $330,000 (not including PV).

The Easthampton homes will have all of Scott's usual features — thick R-40 walls, R-60 ceilings, triple-glazed windows, ductless minisplit heating systems — bringing the homes to HERS 40 without PV. If a homeowner wants to buy a PV system — an available option — any of the homes can reach HERS 0 (or less).

When the temperature is below zero, Mitsubishi ductless minsplits still perform

For Carter Scott, heating a house measuring 1,700 to 2,000 square feet with two ductless minisplits is no longer an experimental method. It's standard operating procedure — one he's used on 18 houses.

Although he has considered using Fujitsu or Daikin minisplit units, Scott continues to specify units from Mitsubishi. He usually specifies the

MUZ-FE12NA outdoor unit and the MSZ-FE12NA indoor unit; this pairing is rated at 12,000 Btu/h. Even at an outdoor temperature of 0°F, these units can put out 10,000 Btu/h of space heat at a COP of 1.8. Mitsubishi minisplits will still deliver heat when the outdoor temperature drops to -13°F.

Scott pays his HVAC contractor less than $6,000 to install two minisplit units in one of his homes.

After Scott heard that the owner of a home he had built (a custom home in Princeton, Massachusetts) had turned off the upstairs heating unit because the downstairs unit adequately heated the whole house, he decided to try an experiment. At his next house, Scott installed just one ductless minisplit. "We thought that maybe we could just use one unit downstairs. But I didn't think of cooling. The cooling didn't rise to the second floor, and the house was hot upstairs in the summer. We went back to the house and installed a minisplit unit upstairs. So if you want AC on the second floor, you need an AC unit up there."

Since he learned his lesson, Scott always includes a minisplit unit on each floor of his two-story homes.

Anyone interested in following in Scott's footsteps needs to remember that the success of his two-minisplit approach depends in part on compact rectangular designs. Stretched-out houses on a single floor, designs with ells, or designs that include a bonus room over the garage aren't amenable to the two-minisplit solution.

On the other end of the spectrum are the one-minisplit homes; examples include Marc Rosenbaum's house in Massachusetts, the Montague Urban Homestead (also in Massachusetts), Larry and Jill Burks' Up Hill House in New York state, and John Semmelhack's house in Charlottesville, Virginia (see Comment #15, below). The best candidates for this approach are flexible homeowners who leave their bedroom doors open during the day and who have no need for second-floor air conditioning.

What about ventilation?

As a builder of spec homes on his way to becoming a production builder, Carter Scott has always focused on affordability. That's why the standard ventilation system included with his homes is a simple exhaust-only system. However, he offers a variety of ventilation options to customers who are willing to pay extra.

"The baseline ventilation system we offer is a Panasonic exhaust fan in each bathroom," said Scott. "They cost us $250 each installed. The next step up — an available option — would be a Panasonic ERV [energy-recovery ventilator] that exhausts and supplies from the same location. That's $500 installed. A little better would be the Fantech VHR 704 HRV with one exhaust location and one supply location. Better than that would be the Fantech SHR 1504 HRV, which could exhaust three bathrooms and supply all of the bedrooms. The next bump up would be the Lifebreath ERV, which is about $2,500."

Subsidies, incentives, and tax credits make PV systems affordable

Before incentives or tax credits, Scott's PV systems cost him about $5 a watt to install. However, all of his customers benefit from at least one type — and in many cases, several types — of tax credit or subsidy. Homeowners who aren't interested in owning a PV array can also take advantage of a variety of leasing options.

In addition to the 30% federal tax credit on photovoltaic installations available to all U.S. taxpayers, Massachusetts homeowners with PV systems can take advantage of Solar Renewable Energy Credits, or SRECs. The mechanics of the SREC market are complicated, and the value of these credits fluctuates. According to Scott, until recently the SREC market valued residential PV production at 50 cents per kWh — meaning that PV system owners could recoup their investment extremely quickly. The market value of SRECs for residential PV systems is now down to only 28 cents per kWh; although that number is lower than it was in the past, it still provides a quick payback to owners of PV systems — often ten years or less.

The Energy Star program in Massachusetts also offers generous incentives to builders like Scott who achieve the Tier 3 level of performance; Scott receives an $8,000 cash incentive for each high-performance house he builds.

"Solar systems are very cost-effective now," says Scott. "When it comes to maintenance, PV is pretty simple. Solar thermal is more problematic than PV."

Propane is sometimes cheaper than natural gas

At one of his zero-energy homes in Townsend, Scott installed an on-demand natural gas water heater; it's the only gas appliance in the house. During their first year in the house, the homeowners only used $50 of natural gas, but were billed $152 — $50 for the gas, and $102 for the service charge of $8.50 a month.

Once Scott realized that the homeowners were paying more for the service charge than they were for fuel, he concluded, "This dog don't hunt." He now avoids hooking up his homes to natural gas lines; he's concluded that most homeowners with a single gas appliance are probably better off buying propane. Even though propane costs more per gallon, propane dealers don't charge a monthly service fee.

Letting go of solar thermal

As Scott continues to aim for high performance at the lowest possible cost, he has tweaked a few of his specifications. These days, Scott is installing more open-cell spray foam in his walls, and less cellulose, for two reasons: the spray foam provides a better air seal, and his insulation contractor offers open-cell foam for the same price as cellulose.

To reduce costs, he has switched from triple-glazed vinyl windows from Paradigm to triple-glazed vinyl windows from Harvey. When I asked Scott about the quality of Harvey windows, his answer made it clear that the windows' best feature was the low price. "The quality of Harvey triple-pane windows is improving," Scott told me. "They now come with a hole midway up the jambs, which we pin to the studs. This keeps them opening and closing above 85 degrees. We are also careful not to put more than 1/2 inch of low-expanding foam to seal around the windows. Harvey will sell me an R-5 window at an unbeatable price. In quantity, I'm getting the windows for just a few dollars more than our old double-pane windows."

In the past, Scott tried a variety of approaches for heating domestic hot water, including solar hot water systems. His favorite water heater is now the Navien 180 on-demand tankless unit fueled by propane or natural gas. "An $8,500 solar hot water system doesn't make any sense compared to the $1,800 Navien. The fuel use cost with the Navien is so low that there really isn't much money to be saved doing anything different."

Ground-source heat pumps are too expensive

Before he discovered ductless minisplit units, Scott built three homes with a ground-source heat pumps (GSHPs). Now that he knows about minisplits, however, he has no intention of installing another GSHP.

When I asked him why, his response was simple. "The first ground-source heat pump system I installed cost $38,000. The second one cost $40,000. The third one had a direct-exchange loop and cost me $22,000," he said. "But I can install two minisplits for less than $6,000. And the whole system efficiencies are about the same, as far as I can tell. Even if the ground-source units have a slightly higher COP, it's not enough to warrant the extra money."

Last week's blog: **"Living Without Electricity Bills."**

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