The Future of

Carter Scott is building and selling whole neighborhoods of affordable spec homes that produce more energy than they consume

BY KEVIN IRETON

On May 30, 2002, the Zoning Board of Appeals in Townsend, Mass., voted unanimously to deny Carter Scott's application for a housing development at Coppersmith Way. Board members were concerned about wetlands and wildlife on the property. They worried about excess nitrogen from septic systems polluting the town's water supply. And they didn't think the town needed any more affordable housing.

Another builder had passed on the land because he thought it would be tough to get five houses on the 30-acre property. Scott filed a plan under the state's 40b affordable-housing laws that called for 41 units, including 35 single-family homes. The 40b law frees a developer from local zoning regulations so long as 25% of the units meet the state's definition of affordable housing.

Jason Cowan, who used to live next to the Coppersmith Way property and who eventually built most of the houses there, admits he was on the fence about the development. "You hear 'affordable housing,' and you think the projects are coming in," Cowan says, meaning public-housing projects—in other words, slums.

The ZBA's refusal to grant a building permit came after a year of meetings. "I was negotiating in good faith," Scott says, "and the rug was pulled out from under me." To keep up payments on the property, Scott got a part-time job selling shoes.

A year and a half later, the Massachusetts Housing Appeals Committee overturned the ZBA's ruling. The ZBA took the case to the state's Superior Court and lost. Scott got his building permit four years after first submitting his plans. At that point, the property he had bought for $280,000 was appraised at $1.8 million. Road construction began at Coppersmith Way in August 2005.

As it turned out, the development Scott built was hardly a slum. It was a proving ground where he learned to build tight, superinsulated houses that run largely on solar power. He sells these homes for the

Housing in America

Tomorrow's neighborhood. *Coppersmith Way is a 41-unit development in Townsend, Mass., where Carter Scott honed his building approach.*

same price as comparably sized houses built to code with no photovoltaic panels on the roof, and he makes money doing it. Scott's company, Transformations Inc., has doubled its revenues every year since 2010.

Building to code wasn't enough

Like many kids, Carter Scott painted houses in the summer to work his way through college. Unlike most kids, though, Scott had 30 employees by the time he finished Northeastern's five-year engineering program in 1987. His company had expanded from painting into remodeling and small additions. Then, as Scott puts it, "I skipped right over building individual houses to building subdivisions."

Scott began his first subdivision in Lexington, Mass., in 1993, and the first house he built was for the director of Northeast Energy Efficiency Partnerships, who wanted an Energy Crafted Home. The Energy Crafted Home Program was a New England-based precursor to Energy Star and encouraged the construction of houses that were substantially more energy efficient than code. That's where Scott started.

By the time he got a building permit for the Coppersmith Way project, Scott was being honored for another development he had just finished a few miles away. He received the Energy Star Builder Achievement Award and was lauded as one of the "leaders in the market who are building the homes of tomorrow today."

Scott admits, "I've always been driven." So in 2005, he was already looking for a way to go beyond Energy Star when he read an article in *Solar Today* about zero-energy communities—whole neighborhoods that run on photovoltaics and produce as much energy as they consume. Scott got so excited that he called the author. "Maybe you should build a zero-energy house first," the man said, "and then build a zero-energy community." That seemed reasonable.

Scott really does want to save the world, or at least his corner of it, by building sustainable houses that don't contribute to global

"**Carter was doing the miraculous,** which is not only thinking about the

warming. At the same time, the number-one goal that he wrote down for Coppersmith Way was "to design and develop in a financially prudent manner." You can't save the world by going bankrupt.

When he started building at Coppersmith Way, Scott admits he wasn't sure he could build a net-zero house, but he was committed to "working toward it in a cost-effective way." Plus, he says, "I wanted things to be repeatable." You also can't save the world by building just one house.

In search of the highest performance at the lowest cost

The basics of getting to zero are pretty well established. First, you reduce the heating and cooling loads of a house as much as possible by building a tight, superinsulated shell. Then you heat and cool with the most efficient equipment you can find. You ventilate the house mechanically to provide fresh air and exhaust stale air. Finally, you generate the necessary energy on site from renewable sources, usually photovoltaic panels.

The details of getting to zero, even today, are much debated. What's the best wall system? What's the best insulation? How tight does the shell need to be? Which heating system? How much ventilation? Eight years ago, the confusion was worse. The only thing people agreed on was that building a net-zero house had to cost more.

The first houses at Coppersmith Way were built with 2x6 studs on 24-in. centers, insulated with cellulose and 1 in. of rigid foam over the sheathing. With 3.45kw photovoltaic systems on the roofs, they earned HERS scores of about 40. That was decidedly better than the Energy Star threshold of 85, but still well short of the zero Scott was aiming for.

HERS stands for home-energy rating system. It is an index for grading a home's energy use on a scale of 0 to 100, with 100 representing the energy use of the exact same house built to the standards of the 2006 International Energy Conservation Code and 0 representing a "net-zero" house that produces (via renewable sources) as much energy as it consumes. In Scott's quest to find the sweet spot where affordability and zero energy meet, determining the HERS index was a crucial tool, but it was only half of the equation.

The other important index was the real-estate market. Scott sold five houses in the first 18 months. They ranged in size from 2000 sq. ft. to 2300 sq. ft., and sold for between $389,900 and $419,900. In the same time period, he also sold two 900-sq.-ft. affordable, deed-restricted condos for $168,000 and a 1000-sq.-ft. deed-restricted house for $195,200.

Experimenting improves houses

Most production builders make money the way Ford makes cars: by building the same thing, in the same way, again and again. In addition, builders in general have a well-deserved reputation for resisting change. They want to build in the same way again and again because they already know how to do it, and they know it works, all of which makes Scott that much more unusual. At Coppersmith Way, Scott was building every house differently.

After trying 2x6 walls with 1 in. of foam on the outside, he tried 4 in. of foam. Then he shifted to 12-in.-thick double-stud walls. He tried cellulose insulation, then spray foam. He switched from double-pane vinyl windows to triple pane.

Scott paid to have each new house tested by a HERS rater and made decisions about how to build the next house based on the score of the previous one. At the same time, he was watching the costs closely. Triple-pane windows added about $700 in marginal costs on a typical house. Double-stud walls added $1920. Extra insulation: $6000. To sell these homes at market rates, Scott couldn't pass along the extra costs to the buyers.

By eliminating the interior window trim and instead finishing the flared window wells with drywall, Scott found he could save more than $1000 on a typical house. The big opportunity for cost-cutting on a superinsulated house, though, lies with a simplified heating system. First, Scott would have to figure out which heating system to use.

Minisplits pay for extra insulation

With a small house and a tight, superinsulated shell, the heating load is small, around 10,000 to 15,000 Btu/hour. Even the smallest boiler or furnace, at 50,000 to 80,000 Btu/hour, is overkill. In fact, a couple of hair dryers would do the job.

Scott initially heated his homes with a high-efficiency gas-fired water heater and a small air handler. For cooling, he added a 14-SEER air conditioner. The total cost for heating and cooling was about $14,000. Then he tried a ground-source heat pump. He liked the idea of using the earth as a heat source and of generating both heating and air-conditioning from a single unit. At $22,000, though, the system was expensive.

The solution to Scott's heating-and-cooling challenge turned out to be the ductless minisplit. In recent years, Japanese and Korean manufacturers have improved the efficiency of these small air-source heat pumps so dramatically that they can work in New England's cold winters. The two-part system includes a compressor that sits outside, connected by copper tubing to a wall-mounted blower. Looking like a big room air conditioner that's been stepped on, the blower unit is not the prettiest wall decoration. To Scott, though, minisplits are beautiful.

To heat and cool his typical houses, Scott began installing one minisplit on the first floor and one on the second for a total cost of around $5250. That's $8750 less than his previous heating system (and $16,750 less than the ground-source heat pump). It more than makes up the cost of superinsulation.

For ventilation, Scott has installed energy-recovery ventilators (ERVs) whenever customers wanted them and were willing to pay the additional costs. His most affordable homes, though, rely on exhaust-only ventilation from a Panasonic fan ($250, installed) in each bathroom, set to run continuously at 30 cfm (the switch boosts it to full power for showers). At an average of 1.0 air changes per hour at 50 Pa, Scott's homes are tight, but not obsessively so; most of the air-sealing comes from spray foam. He knows the necessary makeup air will find its way in.

Incentives and tax credits defray the cost of PVs

The small, 3.45kw PV systems on Scott's first houses at Coppersmith Way cost nearly engineering as he was changing the systems, but also managing to do a spec home where **he could make the prices work.”**

—BETSY PETTIT, ARCHITECT

$23,000 installed. However, determining the actual cost of any PV system these days is a challenge.

Those first systems each qualified for a $16,000 rebate from the Massachusetts Technology Collaborative, a $2000 federal tax credit, and a $1000 state tax credit, which explains how Scott managed to throw in a $23,000 extra on a market-rate spec house.

Unfortunately, these small systems don’t generate enough electricity annually to offset usage. The homeowners get a smaller electric bill, but they still get a bill. For Scott to reach his goal of building a net-zero house, he had to install a bigger PV system, but that would make the house too expensive to sell in his market. What to do?

Help came from two sources. On Oct. 3, 2008, President George W. Bush signed into law what was then referred to as “the bailout bill.” One of its three parts was the Energy Improvement and Extension Act of 2008, which included a provision that removed the $2000 limit on the tax credit for residential PV systems. After that, the federal tax credit was 30% of the installed cost, regardless of how big the system was (effective through Dec. 31, 2016).

Scott calls the lifting of this limit “the first game changer” that helped him to fund bigger PV systems and to get his homes to zero energy. “We figured out that we could have homeowners get the tax credit and hand it over to us the next tax season,” he says.

The second game changer came in 2010 when Massachusetts implemented a market-based incentive program to drive adoption of residential PV systems. It’s called the Renewable Portfolio Standard Solar Carve-Out Program, and its workings are as convoluted as its name.

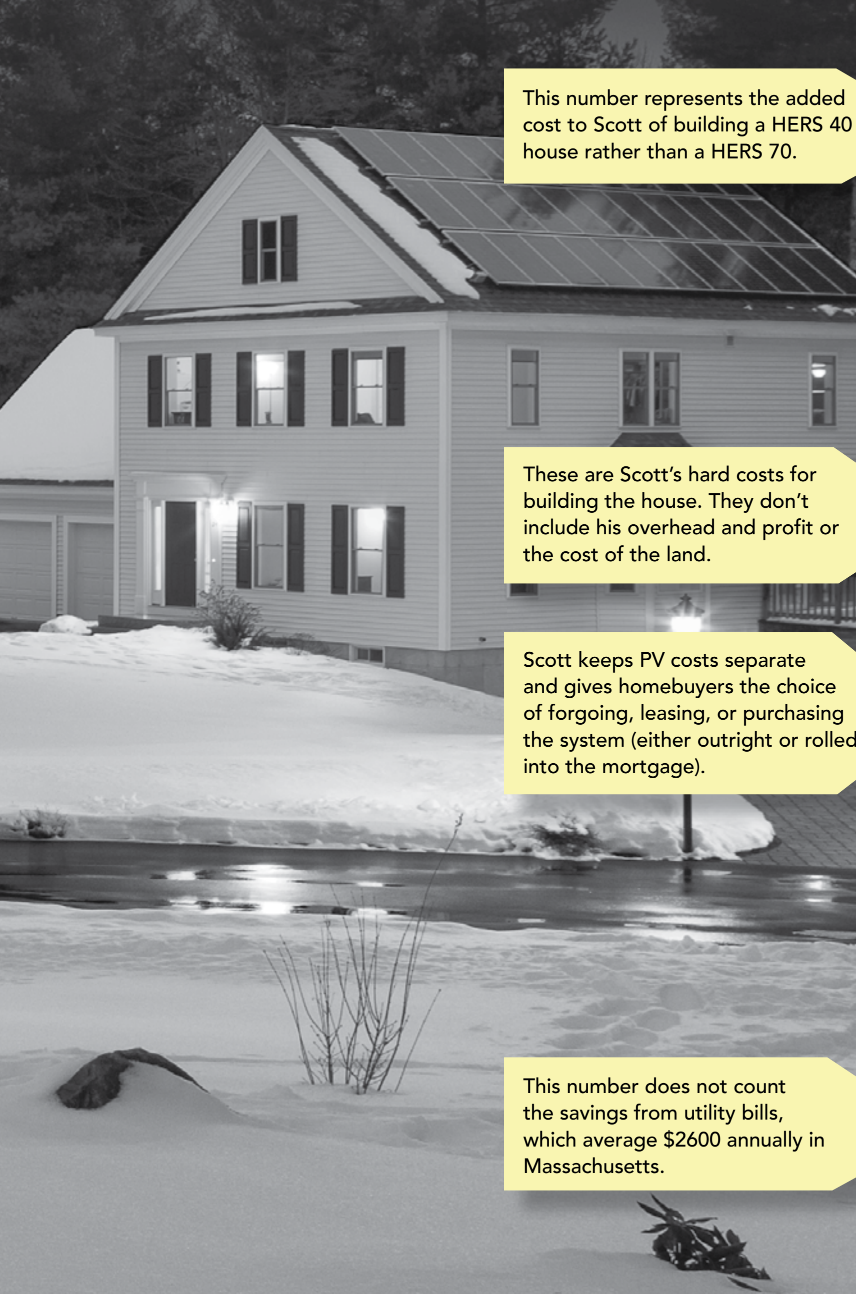
To promote clean energy, some states, Massachusetts among them, have passed laws that require electric utilities to produce a certain amount of energy from renewable sources. One way that utilities meet this requirement is by paying a fee to homeowners with PV panels on their roof so that the utility company can take credit for the power generated by these systems. The medium of exchange for this transaction is a solar renewable-energy credit, or SREC. For every 1000kwh

Carter Scott. *As president of Transformations Inc., Scott does what many builders across the country deemed impossible.*

Formula for a high-performance, low-cost spec house

Scott improves the energy use of his homes from a baseline HERS score of 70 (what Massachusetts calls a "stretch code") down to a HERS 40 with minimal added cost. He then adds a PV system to reduce the home's HERS score down to 0 or lower. The numbers here are for a three-bedroom, 1716-sq.-ft. house.

You won't be able to duplicate Scott's numbers exactly, unless you're a developer who can negotiate volume discounts and you live in Massachusetts, which has the most progressive energy incentives in the country. But in a cold, wet climate, his approach is still likely to be the least-expensive route to a net-zero house.



This number represents the added cost to Scott of building a HERS 40 house rather than a HERS 70.

These are Scott's hard costs for building the house. They don't include his overhead and profit or the cost of the land.

Scott keeps PV costs separate and gives homebuyers the choice of forgoing, leasing, or purchasing the system (either outright or rolled into the mortgage).

This number does not count the savings from utility bills, which average $2600 annually in Massachusetts.

STEP 1: REDUCE ENERGY USE

Critical details

- 2 in. rigid foam under basement slab, R-10
- 3½ in. high-density spray foam on basement walls, R-20
- 6 in. closed-cell spray foam on rim joists, R-36
- 12-in.-thick double-stud walls, 2x4s 16 in. on center
- Wall insulation: 12 in. low-density spray foam, R-46
- Attic insulation (ceiling): 18 in. cellulose (with poly vapor barrier), R-63
- Triple-pane, argon-filled vinyl windows, R-5
- Heating/air-conditioning: 2 Mitsubishi ductless minisplits
- Ventilation: 3 Panasonic WhisperGreen exhaust fans
- Hot water: Navien instantaneous gas water heater

Cost increase of critical details $14,771

Savings/trade-offs/rebates

No insulation in first-floor joists $1210
No wood window trim.. $1050
No traditional heating and cooling system................. $5500
Energy Star Tier 3 rebate $4550
Total savings $12,310
Net cost increase .... $14,771 – $12,310 = $2461
Net cost increase/sq. ft. ...... $2461 ÷ 1716 sq. ft. = $1.43

Construction costs/sq. ft.

HERS 70 construction costs .... $101/sq. ft.
Net cost increase/sq. ft. .... $1.43/sq. ft.
HERS 40 construction costs..... $101 + $1.43 = **$102.43/sq. ft.**

STEP 2: ADD RENEWABLE ENERGY

Costs

8kw PV system.. $40,000

Savings

Federal tax credit, 30% of system cost $12,000
State tax credit $1000
Adjusted cost of PV $27,000
Solar renewable-energy credits
(10-year return) .... $20,000 to $40,000

Cost of PV system after 10 years .... $7000 to $0

"One thing that worries me about Carter is that **he always has a need to move to what's next."**

—BEN NICKERSON, ARCHITECT

a system generates, the homeowners are issued 1 SREC. The mechanics of how SRECs are bought and sold is complicated, and their value fluctuates. In Massachusetts, the SRECs from a 10kw system can generate $24,000 or more over a 10-year period.

Yeah, but will the walls rot?

You might think that attracting the attention of the country's foremost building scientists would be flattering, but what if they want to monitor your houses to see if the bedrooms are too cold and the walls are rotting?

Betsy Pettit, Joe Lstiburek, and others at Building Science Corp. (BSC) outside of Boston are longtime participants in the Department of Energy's Building America program. They work with builders around the country, encouraging them to go beyond code. In particular, Pettit says, their mantra has been to encourage a trade-off: "Improve the enclosure, and you can downsize your mechanical equipment." When she heard about a builder in her own backyard who was "already on the path," she was shocked.

"Carter was doing the miraculous, which is not only thinking about the engineering as he was changing the systems, but also managing to do a spec home where he could make the prices work," she says. According to Pettit, "Every other builder in the country was crying that we can't possibly do better for the same price … that it's going to cost us too much money." Scientists are a peculiar lot, though. While the folks at BSC were impressed by what Scott was doing, they still wanted proof that it was working.

From a scientific point of view, the best way to build a superinsulated wall is to put 4 in. or so of rigid foam on the outside of the sheathing. This configuration keeps that sheathing warm and reduces the possibility of warm air migrating from inside the house and condensing on the sheathing. With Scott's 12-in.-thick double-stud walls, the sheathing stays cold, which increases the risk of condensation and related moisture problems. In December 2011, researchers from BSC began to collect data from 60 wall sensors installed in one of Scott's houses.

Another area of interest was the effectiveness of the ductless minisplits. In a conventional house, heat from a furnace or boiler is distributed to each room via ducts or pipes. With ductless minisplits, Scott's homes have only one source of heat on each floor, not multiple registers or radiators—and they're pretty small heat sources. Thanks to open floor plans, there was not much question that one minisplit would work on the first floor, but the upstairs was another matter. With a second minisplit installed at the top of the stairwell, researchers wondered if the bedrooms would be warm enough, particularly at night. They installed more sensors, and surveyed homeowners.

Although the monitoring is ongoing, initial findings were released earlier this year in a report to the DOE. Twelve-in.-thick double-stud walls with cellulose insulation and with low-density foam were tested. In the stud bay insulated with cellulose, the moisture content of the sheathing on the north side of the house spiked to 28% in the winter. That's high enough to raise concerns about mold and rot. In the summer, though, it dried out to 8%, and given that cellulose is treated with borates, no one seems too concerned. The walls insulated with spray foam were fine; the moisture content of the sheathing on the north wall peaked at 15%.

As for the performance of the minisplits, temperatures in all rooms remained within 1°F or 2°F of each other, with the bedroom doors open. According to the report, of the eight homeowners surveyed, "all but one reported that the new home is more comfortable than their previous home, and the remaining homeowner rated the house as a 1 (most comfortable) on a five-point scale."

Blowing past zero

It took about two years and 16 houses, but Scott finally built his first zero-energy house in 2008. The 1232-sq.-ft. house was one of the affordable, deed-restricted houses at Coppersmith Way and had a price cap of $195,200. With a 5.7kw PV system on the roof, it earned a HERS score of minus 4 and took second place in the Zero Energy Challenge, sponsored by Massachusetts's investor-owned utilities.

Scott has built more than two dozen houses since then, with zero energy now being the standard, rather than the goal. The PV systems on his roofs have been getting bigger and bigger, as he has set his sights on the next goal. "One thing that worries me about Carter," says architect Ben Nickerson, "is that he always has a need to move to what's next."

This time, "what's next" for Scott turned out to be homes that produce a lot more energy than they consume. In the summer of 2011, Scott started an eight-home subdivision in Devens, Mass., that would prove to be his first zero-energy development. It includes a custom saltbox with an 18kw PV system on the roof. The first two banks refused to finance the house, and the buyers almost walked away.

The problem is that most banks don't know what to make of superinsulated walls or PV systems. Scott has lost sales where the appraiser gave no value whatsoever to the PV system. "Literally," Scott says, "nothing for the PV system. I got a copy of the appraisal." That's what was happening in Devens with the custom saltbox.

Chris Parlee, who eventually bought the house with her husband, Wes, was getting frustrated. She said, "I really do care about being green, but 10kw is good enough." Scott continued to advocate for an 18kw system—at a cost of $100,000.

How did he make it work? Scott lowered the price of the house so that the Parlees could secure a mortgage, and then made a deal with them to install the bigger PV system in exchange for the SRECs it generated. But why, you might wonder, did Scott want such a big PV system?

The Parlees' house is projected to produce 10,200kwh of electricity more than it consumes over the course of a year. According to Scott, "That's enough to power a Nissan Leaf or a Chevy Volt 30,000 miles."

"With the zero-energy home," Scott says, "we were able to go after the 40% of carbon that's associated with the building sector, and that's great. But with these other homes, we can go after the 33% of the carbon that's associated with the transportation sector. That's a really exciting sweet spot." □

Editor at large Kevin Ireton lives in New Milford, Conn. Photos by Trent Bell.