Toward Zero Energy at Home
A Personal Example


LISA SHEPPERD

Danny Parker sits on the roof of his remodeled home with white metal roof, solar hot water heater, and 4.92 kW PV system.

In 1988, my wife, Lisa, and I moved into our new home in Cocoa Beach, Florida, and I began a new life working as a researcher at the Florida Solar Energy Center (FSEC). My work focus with FSEC over the last 22 years has been on finding ways to dramatically improve the energy efficiency of homes in the United States, and particularly those in Florida's challenging hot-humid climate. Given FSEC's emphasis on practical empirical research, we have learned a lot about how to reduce residential energy consumption using a variety of technologies. This includes techniques such as reducing duct losses, insulated solar control windows and white roofs. Over time through full scale testing, we were able to learn what techniques really worked. But a question came up: What if we combined all these techniques and used them together?

In 1991, I and Jim Dunlop (one of FSEC's most experienced photovoltaics researchers) began simulation work to see if it might be possible to design extremely efficient homes and match them with residential photovoltaics to realize an imagined Holy Grail—houses that produced as much energy as they used. In 1998, we accomplished that goal with an early zero energy home (before the moniker existed). That house received a lot of attention, but the question always came up. How many more houses were there like that? And could what we did be done with any existing home?

Personally, I have always considered being a hypocrite one of life's worst fates. Thus, for our own home—which had not even ceiling insulation when we moved in—we began improvements as soon as we could, to try to decrease energy use. Those improvements have spanned a 20-year period that has included two additions to the family, adding 500 square feet to the home, and a host of other changes, both helpful and unhelpful, in our quest to walk our talk. As you will see, we succeeded. Twenty years later, zero energy existing homes appear imminently possible—at least from my doorstep. And the fact that I've done it means that anyone can.

Figure 1 shows the annotated 20-year history of electricity use at our Cocoa Beach home. Monthly recorded kWh, as well as the 12-month moving average, are shown. Figure 1 also shows the various retrofits and changes that we made to the building and to the family. For the costs see "How Much Did It Cost?" Some of these changes reduced energy use. Some, of course, increased consumption. The photo shows the south face of the house during the retrofit with its PV system in January, 2009.

In 2009, the 4.9kW PV system produced 6,542 kWh, which was 99% of our electrical consumption. Toward the end of the year, I added another 800 watts, and I hope to be a net electricity producer this year. Our annual natural gas use in 2009 was 155 therms for heating, hot water, cooking, and clothes dryer, but true zero is the next target.

HOW MUCH DID IT COST?

White metal roof	$4000
Sealed ducts/insulation	$400
PV pumped pool	$3,600
Ventilation fans	$500
Whole house fan	$300
CFLs everywhere	$400
Solar hot water:	$2,000
TED/Isole:	$500
PV:	$30,000
less tax credit	- $9,000
less state rebate (possibly)	- $16,000
TOTAL (over 20 yrs)	**~$32,000**
Savings per year vs. average use	**~$2,600**

THE GOOD STUFF

We may not reach the true zero *Steve-Greenberg-Green-Zone* ("A Deeper Shade of Green" *San Francisco Chronicle*, 22 June 2008), but without getting too eccentric, we have been able to achieve satisfying savings. We have done a lot of stuff to make the loads lower, most of which are summarized in Figure 1:

- After adding ceiling insulation, we first coated the shingle roof, which dramatically reduced cooling loads, but which we no longer recommend due to the potential for moisture damage. (See "Saving Cooling with Reflective Roof Coatings," *HE* May/June '94.) Later, we remodeled and installed a white metal reflective roof, which has maintained its reflectance very well over the last ten years with no problems at all.

- We replaced the very poor existing refrigerator with the most efficient model available of the same size. (See "Refrigerator Replacement: A Florida Case Study," *HE* Jan/Feb, '93.)
- We sealed the existing duct system (which was quite leaky).
- We removed all carpet and replaced it with tile flooring—free cooling.
- We installed a whole-house fan to be able to cool the house during cool spring and autumn evenings. (See "Florida Cooling, the Natural Way," *HE* Nov/Dec, '91.) and added low-sone (ultra quiet Fantech FR150) fans to the kitchen and both bathrooms (wonderful).
- We changed all possible end uses (heating, hot water, range, dryer) to natural gas to reduce source energy and the associated carbon-footprint.
- We installed a solar hot water (PV-pumped) flat-plate collector (AET-40), with tankless gas—which is turned off in summer—backup, as well as a PV-powered ½ hp DC pool pump (ETA Engineering 90 Volt DC pump) to eliminate electric pool pumping. The pump runs as long as the sun is up each day from a dedicated 500 watts of PV.
- We changed all the lights in the house to CFLs (except for the lights in the closets, which are 25W incandescents) and installed a sun tunnel and skylights to provide daylight to the interior kitchen and bathrooms.
- We installed high-efficiency ceiling fans on manual off switches that allow fans to be easily deactivated.
- We purchased a high-efficiency dishwasher (Bosch SHX98M09; EF = 1.14).
- We purchased a high-efficiency Kenmore 2706 clothes washer (MEF = 2).
- We put the home office peripherals on an Isole (Wattstopper IDP-3050) occupancy-controlled power strip, selected an efficient home TV (Sony Bravia 37-inch LCD) based on low power consumption (130 watts), and placed phantom loads on power strips for the entertainment center and garage rechargables.
- We installed a real-time electricity use feedback (TED) device.
- And finally, we installed a 4.92kW grid-tied PV system, which produces about 20 kWh per day.

AND NOW FOR THE BAD STUFF

These are things we had to compromise on, since existing homes present special challenges. It can be more energy efficient to make do than to retrofit, but in a perfect world, these things would be different:

- Crummy single-glazed awning windows that are really leaky.
- Mostly uninsulated concrete block walls that get very cold in winter and hot in summer.
- 10-SEER A/C with a standard blower that operates more like 8-SEER.
- Sealed duct system that is still located in the attic, leading to lots of conductive losses.
- Digital video recorders that draw 25 Watts and cannot be turned off without defeating the programmable recording capability. This is scandalous and federal regulation is needed.
- A clothes dryer that, while modern, has a Stone Age efficiency. Luckily this is changing, at least for electric clothes dryers. See the new Bosch EcoLogixx 7 clothes dryer, which uses both a heat exchanger and heat pump source to drop dryer power in half.

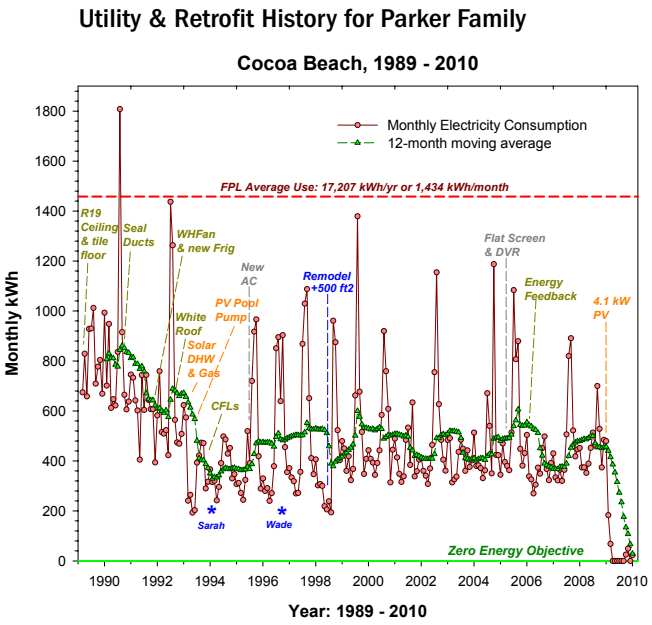

Figure 1. Utility records and annotated retrofit history for Parker household over twenty years.

THE FUTURE

The cold snap of winter, 2009–2010 gave me religion concerning the heating and cooling loads from my walls and drafty windows. I have some nice thermographs telling that tale, but take my word for it. By 2011, I hope to insulate the walls and replace the windows.

With that done, I expect to see gas use to drop by 40–60 therms, and shed another 1,000 kWh of annual electricity. I plan to add a SEER 26 Fujitsu mini-split heat pump (Fujitsu 9 RLS), and hope to use it for both heating and cooling. That will effectively ditch the duct system, the furnace, and the standard A/C. If things get really good, I might use power production excess to charge a plug-in hybrid. It will be interesting to see how this story ends up. I'll keep you posted.

In any case, I am already really quite proud of what we have done with our home. When we moved in, the house didn't even have ceiling insulation. Statistics show that with a family of four in a home built before 1960 with a pool, the average use in Florida should be about 20,000 kWh/year. Yet, we have transformed such an average dwelling to a zero energy home. Thus the zero energy homes we research at FSEC and in DOE's Building America program are hardly pipe dreams. They are available to anyone who is willing to make the investment and effort.

—Danny Parker

Danny Parker *is principal research scientist at the Florida Solar Energy Center where he works within DOE's Building America program. He has enjoyed participating in low energy home research since 1978.*

>> For more information:

To read the full San Francisco Chronicle article about Steve Greenberg's home, go to: http://articles.sfgate.com/2008-06-22/living/17164413_1_lawrence-berkeley-national-laboratory-electric-car-solar-powered-car