# GETTING TO 0

The Hardisky home—before and after its renewable energy retrofit.


**with Kelly Davidson**
**photos by Tom Hardisky**


**Project Name:** Hardisky Green Energy Home Retrofit

**Designer & Installer:** K.C. Larson Inc. of Williamsport, Pennsylvania

**Location:** Loganton, Pennsylvania—41° N latitude

**Date Commissioned:** April 19, 2010

**Solar Resource:** 4.2 average daily sun-hours

**Average Annual Utility Electricity Offset (PV & SHW Systems):** 17,500 kWh

A net-zero-energy home is an ambitious goal for a newcomer to renewable energy, but that didn't stop Tom Hardisky. Last spring, after years of exploring various options, the wildlife biologist retrofitted his 1991 ranch home in Pennsylvania with solar-electric, solar hot water, and heat pump systems that should offset 100% of his household energy needs. *Home Power* spoke to Tom about his project, motivations, and lessons learned, as well as the process of selecting a system designer and the challenges of navigating all of the available incentives.

*Home Power:* What sparked your interest in renewable energy?

**Tom Hardisky:** When I was in grade school some 30 years ago, my science teacher broke the disturbing news: We will someday run out of fossil fuel. She said that our generation was charged with finding a lasting energy solution without further tapping into our dwindling energy resources. I realized then that by being dependent on a nonrenewable energy supply, we were moving down a disastrous path.

*HP:* So, after all those years, what motivated you to move forward with this project now?

**Tom:** The time was right as far as incentives. In addition, electricity rate caps began expiring at the beginning of 2010 for Pennsylvania electric utility companies. My electric company, Pennsylvania Power and Light, is gradually increasing electric rates. For average PP&L customers, that translates into an increase of approximately 30% in 2010. I anticipate never-ending rate increases—I thought there would be no better time to do this.

The major financial incentive for my retrofit was the Pennsylvania Sunshine Program rebate, which provided 35%

The generation from 40 solar-electric modules offsets the home's electricity use, while eight solar hot water collectors supply the home's hot water and some supplemental space heating.

of the cost of my PV system. The only stipulation is that it could not exceed 10 kW. The combined effect of PV, solar hot water, and heat pump financial incentives actually broadened my vision. I ended up maximizing PV module coverage on my roof *and* investing in solar hot water and heat pump systems.

Income from solar RE credits (SRECs) was an important incentive as well. I have a five-year contract with Sol Systems LLC that pays me $280 per solar-produced megawatt-hour.

In addition, the heat pump qualified for a $400 rebate through my local electric company's E-power Program. And, when I file federal income taxes next year, I will be able to take advantage of an available tax credit. An after-rebate 30% federal tax credit will be an important source of investment return.

***HP:*** **What made you decide to go for net-zero energy for your home?**

**Tom:** I'm a conservationist by nature and profession, so an energy-independent home was logical and always my dream. I wanted an RE system that would meet all of my energy needs, including home heating, hot water, and electricity. I thought maybe I could set an example for other homeowners and help us move toward that lasting renewable solution proposed by my grade-school teacher.

***HP:*** **Once you got serious about the idea, what steps did you take?**

**Tom:** When a PV installation short course was offered by the Honesdale, Pennsylvania-based Sustainable Energy Education Development Support, I jumped at the opportunity to learn more—and possibly complete most of the installation myself. The real value in taking the course was a good education in solar energy system basics—terminology, components, and designs. By the end of the three-day workshop, I realized that having basic plumbing and home wiring skills was not enough for me to take on such a project. This was no weekend project. If I wanted a well-designed, high-quality RE system, I needed professional help.

*HP:* How did you choose a system designer to work with?

**Tom:** At a local Go Green Expo, I spoke to several RE installers. Most installers were very new to the business. Their level of experience seemed to be reflected in the quality of their expo displays and their answers to basic questions, such as, "What renewable energy system options are available?" I found that the most knowledgeable professionals had well-organized, attractive exhibits with informative literature. Designers who placed most of their emphasis on educating me rather than selling their products and services were the type of people I wanted to do business with. Installers who provided free site visits and solar analyses were on my preferred list.

## PV System

Forty Schüco 210-watt modules were installed on Schüco ezRails, which were attached to the standing seam roof's metal pans using nonpenetrating S-5! clamps. The air gap provided by the racking system helps air flow between the modules and metal roof, keeping the modules cooler and improving the system's overall efficiency. The four strings of 10 modules are wired to two Fronius 4,000 W inverters (20 modules per inverter), which are located next to the main service panel in the basement. In the first three months of operation, the system has produced 3,615 kWh, slightly exceeding PVWatts' estimate of 3,430 kWh.

## PV Tech Specs

### Overview

**System type:** 8.4 kW batteryless grid-tied PV

**Location:** Loganton, Pennsylvania; 41°N latitude

**Date commissioned:** April 2010

**Solar resource:** 4.2 average daily sun-hours

**Annual production estimate:** 9,750 kWh

**Utility electricity offset to date:** 100% (before a new heat pump system)

### Equipment

**Modules:** 40 Schüco, SMAU-1 210 modules, 210 W STC, 26.3 Vmp, 7.98 Imp, 33.7 Voc, 8.35 Isc

**Array:** Four 10-module series strings, 8,400 W STC total (263 Vmp; each string: 7.98 Imp, 337 Voc, 8.35 Isc)

**Array combiner box:** 6- by 6-inch box

**Array DC disconnect:** 30 A Square D-3 pole disconnect, HU361

**Array installation:** Schüco ezRail and S-5! seam clamps; azimuth 220° (approximately SW), tilt 15°

**Inverters:** Two Fronius IG 4000, 500 VDC maximum input, 150–450 VDC MPPT operating range, 4,000 W AC, 240 VAC output

**System performance metering:** Two kWh production meters


**Two Fronius grid-tied inverters make up the balance of the home's photovoltaic system.**

*HP:* Why did you decide to work with the designer you ultimately selected?

**Tom:** Because of the questions *they* asked *me*. The best question they asked was, "What are your energy and overall project objectives?" The K.C. Larson staff also answered all of my technical questions, and they were very receptive to allowing me to reduce costs by completing some project tasks on my own.

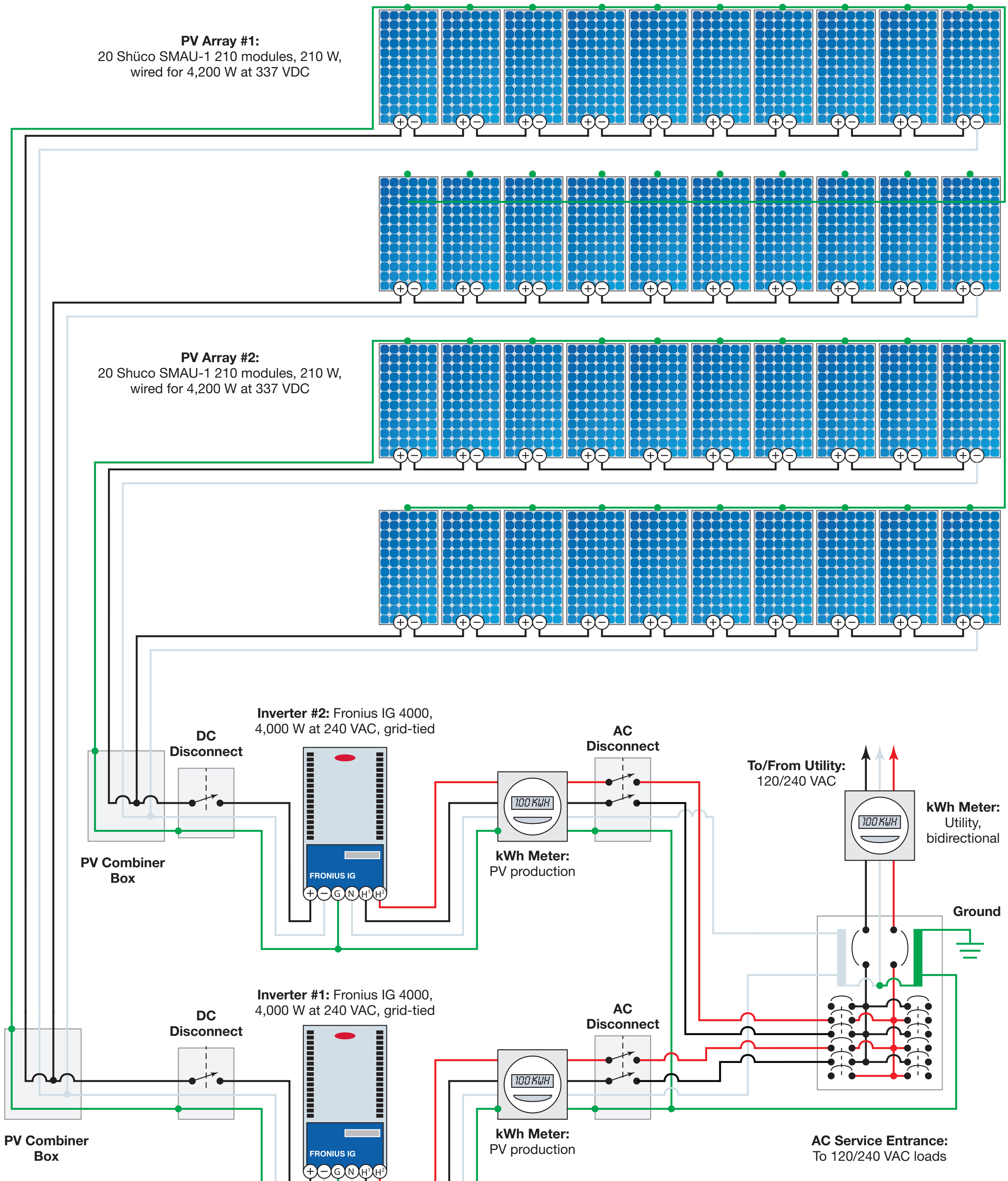
*HP:* What modifications did you make to your home prior to installation?

**Tom:** My existing asphalt shingle roof was 18 years old but in good repair. However, the installers asked me to consider having a standing-seam metal roof installed because it would last the life of the PV system. They also asked me to specify a light color to decrease heat buildup during the summer months.

Prior to the roof installation, I relocated the plumbing roof vent pipes and exhaust ducts from the south side of the roof to the north side. That left the entire south-facing roof free of obstacles, maximizing roof space for the PV array.

The installer also recommended that I replace my 18-year-old electric water heater, so I installed a new, more efficient, 50-gallon water heater to minimize the chance of future problems. I also sealed air leaks. I installed new basement windows with a much higher R-value, insulated the attic with fiberglass blanket insulation, and caulked and added 2-inch foam insulation along the perimeter of the basement to decrease heat loss and air infiltration.

# Hardisky Grid-Tied PV System




**Note:** All numbers are rated, manufacturers' specifications, or nominal unless otherwise specified.

## Solar Thermal System & Space Heating System

The SHW and space heating system consists of eight collectors heating two 120-gallon tanks for heat storage that supplement the winter space-heating load. The heat is delivered to the home through a ceiling-mounted fan coil unit in the basement. In operation, the hot water is pumped from the solar storage tanks through the coils in the fan coil unit, and the fan distributes heat to the basement—with the goal of heating the basement to 75° F-plus during the daylight hours. Natural convection carries the heat upstairs.

To control the seasonal overproduction during the summer, this system has isolation valves that allow five collectors to be covered and one storage tank to be taken out of production in the summer when the heat isn't needed, leaving three collectors uncovered and a single tank supply in operation for the SHW load. By isolating the one tank in this system, the SHW has a quicker recovery at the expense of less heat storage for extended periods of cloudy weather or extra-large loads. However, three collectors can more than adequately heat a 120-gallon tank in the summer.

## SHW Tech Specs

### Overview

System type: Closed-loop, antifreeze solar hot water

Annual production estimate: 26,597,631 Btu total

Average annual electricity offset: 7,795 kWh

Estimated percentage of hot water produced annually: 75%

### Equipment

Collectors: 8, Schüco, Slim V

Collector installation: Ground mount on concrete pad, portrait-oriented Schüco exFlatroof TH angle and safety cross kit. Azimuth at 220°; tilt at 40°

Heat-transfer fluid: Propylene glycol

Pump controller: Schüco, Solar Pump Station, GL-30, #PS-1.3

Hydronic heater: Beacon/Morris, HB136A hydronic heater; 35,900 Btu with speed controller

### Storage

Tanks: 2, Rheem, #120HE-1, 120 gal.

Heat exchanger: Exterior wraparound; vented for leak detection

Backup DHW: Whirlpool Energy Smart, 50 gal. electric water heater

### Production

Summer mode: 3 collectors for 3 months: 3,449,673+/- Btu

Heating-season mode: 8 collectors for 9 months: 23,147,958+/- Btu

Average annual energy offset: 7,795 kWh

**The balance of system components of the solar hot water system.**

Since the system was installed, I've identified additional sources of heat loss as well—namely basement doors, the electric service entrance, and other unsealed foundation wall openings/cracks. I'm in the process of completing these improvements.

### *HP:* Did you make lifestyle or energy use adjustments?

**Tom:** Although I made no major lifestyle changes, I am now much more conscious of my use of energy. Turning off unnecessary lighting was always a routine. However, soon after project completion, I found myself trying to figure out why my house used 6 to 8 kWh overnight—even when the heating or air conditioning was not running. I discovered that the outside security lighting was responsible for about 5 kWh each night.

My habits with respect to hot water usage have changed. During the warm months, I produce much more hot water than I can use. I used to wash my white clothes in warm water. Now, I always use hot water. When I need a bucket of water for cleaning or rinsing, I reach for the hot water faucet.

### *HP:* What was the home's initial energy profile, and how did it change?

**Tom:** Prior to my solar system installation, I had an 18-year-old electric water heater, no central air-conditioning, and forced-air oil heat. Annual heating oil charges were about $880, and my annual electric bill exceeded $900. My annual electric consumption over the past two years averaged 5,344 kWh.

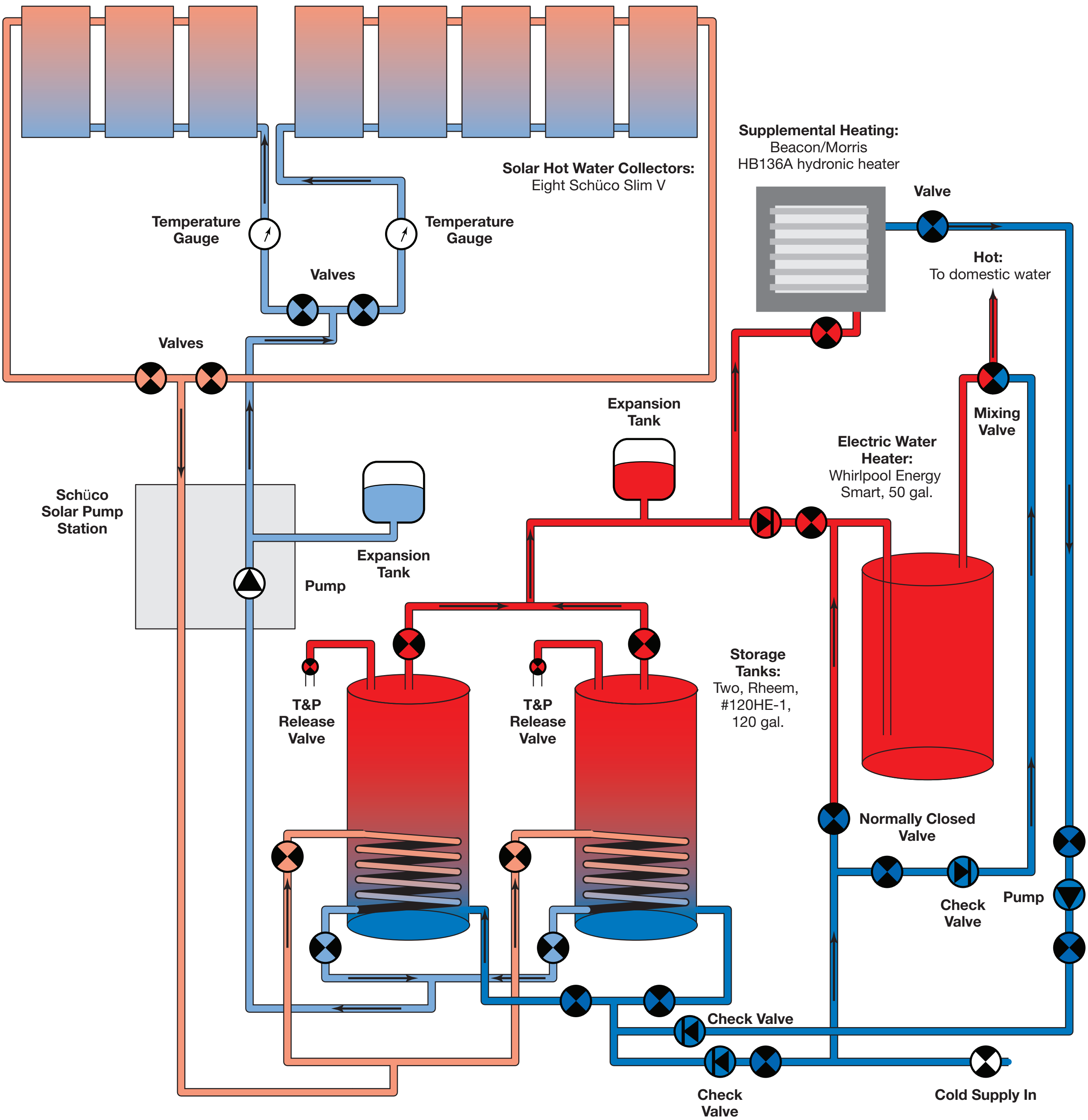
The new heat pump provides central air-conditioning that I did not have before, and I now have a much more efficient electric water heater and electric forced-air heat. Since I did away with the old furnace, I no longer need heating oil.

Overall, my electric consumption increased by 21% since system installation, primarily because of the new electric heat pump, but during the first three months of operation, I had a monthly electric bill of $8.45—the minimum base distribution charge from the electric company.

*HP:* Do the systems need maintenance?

**Tom:** Thus far, there has been minimal system maintenance. Because of excess hot water production, I cover five of the eight solar collectors and close down half of the solar

# Hardisky Domestic SHW System



**The solar fan-coil unit in the basement, which serves to supplement the home's space-heating system.**

**Right: A high-efficiency heat pump replaced the old furnace, providing space heating and cooling.**

thermal system during the summer months. All eight panels will be in operation during the spring, fall, and winter. The maintenance work entails moving panel covers and closing a few ball valves. I'll periodically change filters in my air exchanger, and that's about it for the year.

***HP:*** **What did you learn from the installation process?**

**Tom:** Never underestimate the effects of shading. During the design phase, the folks at K.C. Larson asked me to take my chimney down to the roofline since I had removed the fuel-oil-fired furnace. Although I did not need the existing chimney, I balked. The slight shading that my chimney temporarily casts on my PV modules in the morning seemed insignificant. However, as the sun path changed, I noticed some solar energy loss. Considering the cumulative impact of this partial shading, I decided to lower my chimney to eliminate any shading issues but still leave Saint Nicholas with suitable access.

***HP:*** **Your goal is to produce more energy than you use. Do you think you'll be able to achieve your net-zero target?**

**Tom:** Energy use during the winter months will greatly influence my net-zero status.

The PVWatts calculator estimates my PV system's annual production at 9,750 kWh. If my energy consumption does not increase by more than 82% of last year (5,344 kWh), I should reach net zero.

With my solar hot water system and more efficient home heating and cooling, I am confident that my systems will produce more energy than I use annually.

**With the combined output of the solar hot water and PV systems, the Hardisky home should be able to reach its annual net-zero energy goals.**

# Q&A

K.C. Larson's Keevin Larson discusses the energy systems for Tom's net-zero home.

**HP: Tom did not set out initially to design a net-zero home, so how did the project evolve to that level?**

**Keevin:** The possibility of a net-zero status arose during the final design of the solar thermal system, but after the PV system design was complete. The roof was to be completely covered with PV modules and all of the available ground space was slated for the thermal collectors. After Tom approved the solar thermal and heat pump designs, it was then I knew the home could be very close to net-zero.

**HP: How do all of the systems work together to achieve the net-zero goal?**

**Keevin:** The air-to-air heat pump system puts out twice as much heat energy as the electricity put into it. Since the PV system generates electricity, it helps offset the heat pump's use during the air-conditioning mode. The heat pump system also contains a backup electric resistance heating element, which is energized if the heat pump cannot provide the needed home-heating capacity. This is when the space-heating mode of the solar thermal system can help supplement the home's space-heating needs. The less the heating element is energized, the more savings.

**HP: What process did you use to design the solar hot water system?**

**Keevin:** We installed a similar but smaller system in early 2009 for another client. This system had five thermal collectors and two 105-gallon solar storage tanks. This system proved the concept of heating the basement mass during the daytime, allowing the heat to radiate up to the first floor during the day and into the evening hours. But that other project's basement has much more heat loss than Tom's basement, so this system will retain a warm temperature within the confines of the basement for a much longer period of time. In other words, fewer Btu of heat are required due to less heat loss and outside infiltration.

**HP: How does the SHW hydronic design optimize efficiency?**

**Keevin:** If the basement temperature is 60°F or above and the temperature in the solar storage tank is at least 75°F, the hydronic heater can still heat the basement with solar. The heater can be advantageous due to the quick delivery of the heat—it raises the space temperature instantly, and this heated air rises up to the first floor.

**HP: What savings does the heat-pump system offer over the old oil-fueled furnace?**

**Keevin:** Tom's furnace used, on average, 355 gallons of No. 2 fuel oil each year. At an average of about $2.25 per gallon, a furnace with 80% efficiency would cost $20.39 per 1 million Btu. If utility electricity cost $0.11 per kWh, the cost to run his heat pump would be about $16.12 per 1 million Btu—a 21% savings.

When the weather gets really cold, below the 35ºF effective capability of the heat pump, the backup electric resistance heat will kick in. This, by definition, has a lower coefficient of performance, and uses more energy. Since it's electric, the PV system will offset at least a portion of that. But considering completed and future weatherization upgrades, the comparative amount of heating the home will require is still unknown.

## Home Heating & Cooling with a Heat Pump

The home's oil-fired hot air furnace was removed and replaced with a new energy efficient heat pump that was connected to the existing ductwork. The ductwork was modified to better balance the system operation. The PV system will offset the electricity required to operate the heat pump. During the heating season, the solar thermal system helps supplement the heat pump to decrease the heating cycles and electricity used, sending solar-heated water to a hydronic heating unit located in the basement.

## Access

Tom Hardisky (disky@tds.net) lives on a 13-acre farm in rural Pennsylvania. He is a wildlife research biologist for the Pennsylvania Game Commission. He has bachelor's degrees in biology and wildlife science, as well as a master's degree in wildlife ecology.

K.C. Larson • www.kclarson.com

Pennsylvania Sunshine Program • www.depweb.state.pa.us • State incentives

Sol Systems • www.solsystemscompany.com • RECs

System Component Manufacturers:

Schüco USA • www.schueco.com • PV modules, SHW collectors

Fronius • www.fronius.com • Inverters

Goodman • www.goodmanmfg.com • Heat pump

Rheem • www.rheem.com • Storage tanks