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Publisher
John Wages
publisher@permaculturedesignmagazine.com

Senior Editor
John Wages
editor@permaculturedesignmagazine.com

Editorial Guild
Rhonda Baird Keith Johnson

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Permaculture is a holistic system of DESIGN, based on direct observation of nature, learning from traditional knowledge, and the findings of modern science. Embodying a philosophy of positive action and grassroots education, Permaculture aims to restructure society by returning control of resources for living: food, water, shelter, and the means of livelihood, to ordinary people in their communities, as the only antidote to centralized power. For 30 years Pc has combined top-down thinking with bottom-up action to make a world of difference in over 100 countries. We are everywhere.

Solar Success in the Midwest

Woodrow Bessler, Darrell Boggess, Anne Hedin & Terry Usrey

THE SOUTHERN INDIANA RENEWABLE ENERGY Network began in 2008 with a mission to promote the adoption and use of renewable energy. Then, as now, Bloomington and Monroe County, IN, had a thriving sustainability and environmentally conscious community with volunteers and groups focused on important issues including local food production, alternative transportation, forest protection, and green building practices. However, no one was carrying the banner of clean, renewable energy. That void accompanied a growing awareness of the state's extreme dependence on coal for power production, and its consequences. Pollution from coal-fired power plants accounted for $100 billion in US health costs and 13,000 premature deaths annually in 2010 (1). In 2013, 84% of Indiana's net electricity generation came from coal—equivalent to 8.23 tons (7.5 metric tons) of coal per Hoosier per year. (2)

...SIREN has presented dozens of Going Solar programs to hundreds of prospective owners....

The group was organized with an acronym (SIREN) that appropriately spoke to the urgency of the climate and energy crisis. Dozens of interested and motivated people were willing to work to advocate for a clean energy future, but they lacked an action plan. Various organizational approaches were explored, including forming an energy producing cooperative or a membership-powered 501(c)3 with a board of directors and elected officers. Ultimately, SIREN became a project in the Center for Sustainable Living, an existing local nonprofit, and evolved into a core group of individuals in a steering committee with a larger group of interested businesses and individual supporters.

Early activities focused on providing formal PV training and barn-raising style solar installation events. By the end of 2008, the county's first three systems were up and running—at a cost per watt of $10. Later, SIREN ran a community-wide energy efficiency contest with a PV system as grand prize. In 2011, the current priority on providing education emerged when Earth Care, a local interfaith group that had been focusing on energy conservation, asked SIREN to present a public program describing the performance, cost, availability, and carbon reduction of renewable energy.

Solar growth spurt

When that program launched in May 2011, nearly 100 people attended to hear the message of keynote speaker, Indiana Nobel laureate Elinor Ostrom: we can't wait for politicians to act. She provided leadership by acting herself. A solar contractor said the Ostroms' garage roof could hold about 30 panels and asked her how many panels she wanted. Ostrom said, "Fill it up." Others followed.

This collaboration showed that a major barrier to renewable energy adoption in the Midwest was lack of information explaining the technology and its trend to lower cost. Subsequently, SIREN has presented dozens of Going Solar programs to hundreds of prospective solar owners, mostly in Monroe County, and provides personal consulting upon request. Perhaps as a consequence of this ongoing education, Indiana's approximately 500 solar owners are not evenly distributed through the state's 92 counties. SIREN has catalogued nearly 200 homes, government buildings, churches, schools, and businesses in Monroe County that use solar energy as of January 2015 (3). A few use it for space and water heating, but the majority harvest the sun using photovoltaic (PV) panels that generate electricity—the application that this article describes.

To thank Earth Care for hosting the first Going Solar program, SIREN teamed with Hoosier Interfaith Power and Light in 2013 to help six faith communities get solar arrays averaging 20 kW for less than $3/W. All the congregations have reduced their electricity consumption by more than 25%; some have reduced it by more than half. An additional eight congregations throughout the state are preparing to go solar now.

Barn-raising style solar panel installation im 2010. Photo by Terry Usrey.

Figure 1. How big should your PV system be?
Measure in kilowatts and kilowatt hours:
A kilowatt (kW) = 1,000 W
A kilowatt hour (kWh) = 1,000 W for one hour
In 10 hours, a 100 W light bulb uses 1,000 W-hours or 1 kWh AC
In 4 hours of full sun, a 250 W DC solar panel makes 1,000 W-hours or 1 kWh
If you want to generate 100% of your electricity:
Total up your annual consumption (example: 12,000 kWh / year)
Four 250 W panels (a 1 kW system) will produce 1,200 kWh in a year.
Forty panels (a 10 kW system) will produce 12,000 kWh / year.
If you follow a 50-50 strategy:
Replace half of your annual kWh with solar PV (20 panels, a 5 kW system).
Try to reduce the rest with energy efficiency and conservation. Reducing household energy use by 100 kWh a month has the same effect as buying four 250 W solar panels that produce 1,200 kWh a year.

Siting, sizing, and paying for a PV system

Three factors usually determines PV system size: present electricity usage, available space, and budget. The first question solar installers ask is "how much electricity do you use?" In response, most people say something like "our bill is $120 per month." While cost is important, knowing the total number of kilowatt hours (kWh) you use annually is essential for properly sizing a solar system. Utility companies use kWh as their billing unit, so you can get this number from your bill. In 2013, the national average for residential energy consumption was 10,908 kWh annually (the examples below round that up to 12,000 kWh for simplicity) (4). Your energy usage will vary depending on the home's size, number of occupants, and climate. Sizing for a business depends on both current usage and any near- and long-term expansion plans.

Full sun exposure is most important for PV siting, and orientation to the sun is a close second. Panels that generate approximately 1,000 kWh per year when facing south will generate 800 kWh when facing east or west. Figure 1 presents two different strategies for calculating the size and cost of a PV system. They are based on two assumptions: that your system will face south and that you select a 250 W panel. If roof space is limited, consider panels with the same footprint (about 3' x 5') but a higher capacity (up to 300 W; 275 W is becoming the new norm). They are a little more expensive, but the extra energy they generate will pay for themselves over time.

Incentives: tax credits, SRECs, and grants

Many factors affect the installed cost of a PV system, from product selection to the difficulty of the job to the contractor's travel time. Table 1 approximates the current cost of three sample roof-mounted, grid-tied configurations. The addition of batteries to make the system independent of the grid, while possible, would add significant expense as well as a maintenance burden. (The panels themselves are virtually maintenance-free.) Fortunately, a 30% federal tax credit offsets a portion of the cost, as shown.

The federal tax credit is set to expire on December 31, 2016, unless Congress extends it. Your state may offer additional incentives; if so, they will be listed in the Database of State Incentives for Renewables & Efficiency (5). To give an idea of how fast solar costs have fallen, a PV system would cost less in 2015 even without a tax credit than it did in 2011 with the tax credit. An investment in renewable energy is an appreciating asset that increases in value as utility rates go up. It is like buying 30+ years of electricity, upfront, at a fixed price!

Solar Renewable Energy Credits (SRECs) are a financial incentive offered by some states with a renewable energy standard (RES). Indiana has no RES, but residents can participate in Ohio's SREC program and possibly that of Illinois in 2016. By registering with a clearinghouse, a solar owner can claim one SREC for every 1,000 kWh generated; the SREC is sold through a broker, who then pays the owner. Ohio out-of-state SREC prices have varied between $30 and $50, providing 3 to 5 cents/kWh income to solar owners. SRECs can increase the return on investment by half when electric rates are near 10 cents/kWh.

The Rural Energy for America Program (REAP) provides financial assistance to agricultural producers and rural small businesses to 1) purchase, install, and construct renewable energy systems, 2) make energy efficiency improvements to non-residential buildings and facilities, 3) use renewable technologies that reduce energy consumption, or 4) participate in energy audits and renewable energy development assistance.

Eligible renewable energy projects include wind, solar, biomass, geothermal, and hydrogen derived from biomass or water using wind, solar, or geothermal energy sources.

REAP grants are limited to 25% of a proposed project's cost, and the loan guarantee limit is $25 million. The combined amount of a grant and loan guarantee must be at least $5,000 (with the grant portion at least $1,500) and may not exceed 75% of the project's cost. A minimum of 20% of the funds available for these incentives will be dedicated to grants of $20,000 or less.

A total of $12.3 million in grants and $56.4 million in loans were awarded in 2014. Application deadlines for 2015 are April 30 and June 30. More information and application forms are available online (6).

Table 1. The Cost of Solar Varies with Complexity and Power

PV system type:	Simple 4 kW	Complex 4 kW	8 kW
Cost per watt	$3.50/W	$4/W	$3.25/W
Installed cost	$14,000	$16,000	$26,000
Tax credit (30%)	($4,200)	($4,800)	($7,800)
Net cost	**$9,800**	**$11,200**	**$18,200**

A greenhouse with green power

Susan Welsand, the Chile Woman, has run a permaculture-based nursery business for 23 years. (7) In May 2011, a tornado blew through her property in Bloomington. It sucked potted chiles and tomatillos right out of her greenhouse, disrupting operations halfway through the 8-week window allowed by law for interstate shipping. When the crisis was over, she looked around and realized that she had an opportunity.

"I had always wanted to have solar power. It was my AP physics project in high school. When I bought my land, it was heavily wooded, so I gave up the idea," Welsand says. "After the tornado, there was a large opening right by the greenhouse. I missed the trees, but then I realized, maybe I can have solar now."

...these people were already environmentally conscious; going solar made them more so.

She saved up for a year (she doesn't believe in taking on debt) and applied for grants, but by winter, the only time she had to do the research, they had all been given out. However, Green America responded to her inquiry by nominating her for a People and Planet award, which she won. The prize contributed $5,000 toward the cost of the system.

Welsand installed a 5.2 kW ground-mounted PV system, grid-tied and eligible for net metering. Because its angle and tilt can be adjusted for optimal exposure to the sun in every season, it generates up to 20% more output than a fixed roof-mounted system. Since completion in January 2013, it has provided all the electricity needed for the greenhouse. Welsand says, "Chile peppers need very high temperatures to germinate. Last winter we had brutal cold in early February, just when I was starting my peppers, and it was cloudy so I was not getting any solar gain in the greenhouse. I had to keep the greenhouse at 85°F (29°C), which uses a lot of power. Then in the warmer months, the ventilation fans have to run constantly, and we've had darn hot summers."

Ground-mounted systems cost more than roof-mounted ones anyway, and Welsand's panels cost more than the average because of site-specific challenges. The installer had to dig a trench through limestone (and some days, ice) to lay conduit for the wires to the meter. In addition, the meter location was changed from the house to a shop belonging to the business to consolidate expenses for tax purposes, with attendant rewiring in both locations.

Despite the extra expense, Welsand says, "The solar panel

The Chile Woman proudly displays her ground-mounted, 20-panel PV system. It can be adjusted seasonally for best sun exposure. Photo by Luiz Andre Bispo de Jesus.

investment makes a lot of economic sense for a small business. There is a 30% tax credit right off the top along with a five-year accelerated depreciation schedule, and it is a win-win because you are going to need the power anyway. The initial capital investment can be beneficial financially over a long period of time. This system was rated for a 15-year payback period, but if we continue to have the type of weather we had last year, it's going to be more like ten years."

Solar as a permaculture solution

In 2013, we asked the SIREN community how going solar had affected their attitudes and behavior. Here is what we heard from a dozen people who wrote back.

Attitude first—these people were already environmentally conscious; going solar made them more so. One person wrote, "Even before I had solar panels, I got in the habit of reducing my carbon footprint as much as possible. Now I pay much more attention to my lifestyle and its consequences." Another person, European by birth, wrote, "I grew up more sustainably than an American, so I squander little. With the solar panels, I've become even more adamant about not wasting, as power has become personal."

These themes recurred repeatedly. Gaining a measure of control over their supply of electrical power increased their sense of personal power. Monitoring power generation on the PV system dashboard and watching the utility meter spin backwards are powerful motivators for energy efficiency. Every account we received from solar owners told us about energy efficiency improvements they had made and were planning for the future.

This brings us to practical results. The initial size of residential solar systems ranged from 2 kW to 8 kW, replacing between 50% and 90% of the households' previous usage of grid power. A third of the responding solar owners later added more panels. A few households have reached net zero, the balance point where generation meets demand. Over time, they send as much electricity out to the grid as they draw from it at night and under cloudy skies. Others are closing in on that goal.

The starting point is important. One member who installed solar on a new house wrote, "SIREN suggests that new solar users size their system to provide 50% of their needs and try to conserve much of the remaining half. However, given how efficient the house already was, I sized the PV system to generate about 80% of our power... The system was even more proficient than I expected, generating about 92% of our needs in its first year."

If a less efficient house is the starting point, leave room for improvement. This example is closer to the norm: "Our solar system was designed to produce about half of our household energy use. For the past three years, it has reduced our total cost by about half and reduced our energy use by 70%. Other energy-saving strategies included envelope tightening starting with a blower door test; sealing of can lights, chimney, and outer wall holes; and installing LED lights. We are planning more, including replacement of our electric water heater with a natural gas or on-demand system; replacement of the refrigerator with an Energy Star model; replacement of washer and dryer with water- and energy-conserving appliances; adding insulation; and considering a plug-in hybrid when our 2002 Prius needs to be replaced."

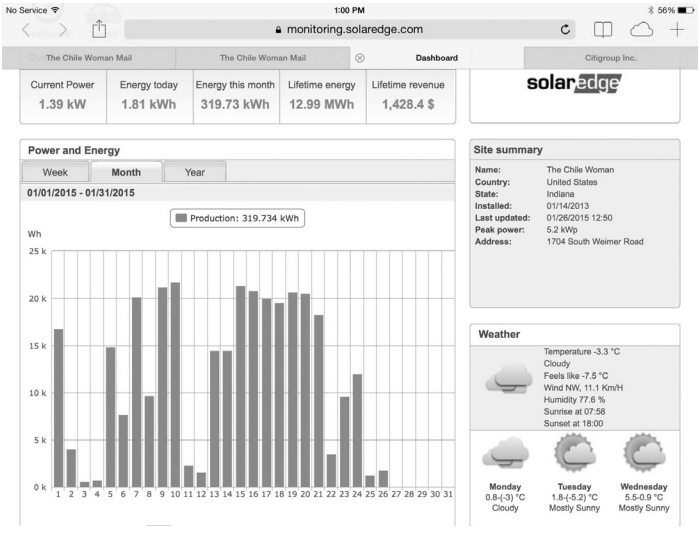
It's easy to overestimate the number of panels you need and underestimate the amount of energy you can conserve. The more energy you save, the less you have to buy or generate. One person replaced a 70s-era refrigerator that used 1,500 kWh annually with an Energy Star appliance that saved 1,000 kWh a year. The new $500 refrigerator cost far less than the number of solar panels it would take to generate 1,000 kWh annually.

One final observation

Like permaculture itself, the adoption of renewable energy encourages and rewards holistic thinking. For solar owners, having some control over the source of their electricity provides the flexibility to develop seasonally adaptive strategies such as those recommended by Peter Bane in the November 2014 issue of this magazine *(PcA #94)*. Many people described their strategies for creating synergies between solar-powered electricity and other energy sources (wood, propane, gas, and geothermal) to get the most results from the least resource.

This is not just about the money. One strategy frequently mentioned is using an electric heat pump instead of a gas furnace on mild winter days. The state still gets 84% of its electricity from coal, which is dirtier than gas, and a heat pump heats less efficiently than a gas furnace in weather below 32°F (0°C). For both these reasons, a heat pump is not the best tool for the job—unless it runs on solar power.

We will end with a quote from a SIREN member who bought her house specifically for its south-facing roof. Before she moved here, she had no idea that Indiana received enough sunlight to make a PV system feasible. Now she is at net zero. She wrote, "I view a solar system as not only an appliance, but as a tool for teaching neighbors and the community how to 'Be the change you want to see in the world.' " Δ



Even on cloudy winter days, PV panels keep generating electricity. Susan Welsand's dashboard shows current and lifetime values for her 5.2 kW system. Image by Susan Welsand.

The authors serve on the SIREN Steering Committee. Woodrow Bessler is an electrical engineer who has worked for organizations as diverse as Kraft and the Indiana University (IU) Cyclotron. Darrell Boggess retired from NSA Crane where he held engineering and management positions. Anne Hedin is an enterprise software marketing professional. Terry Usrey teaches at IU's School of Public and Environmental Affairs.

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