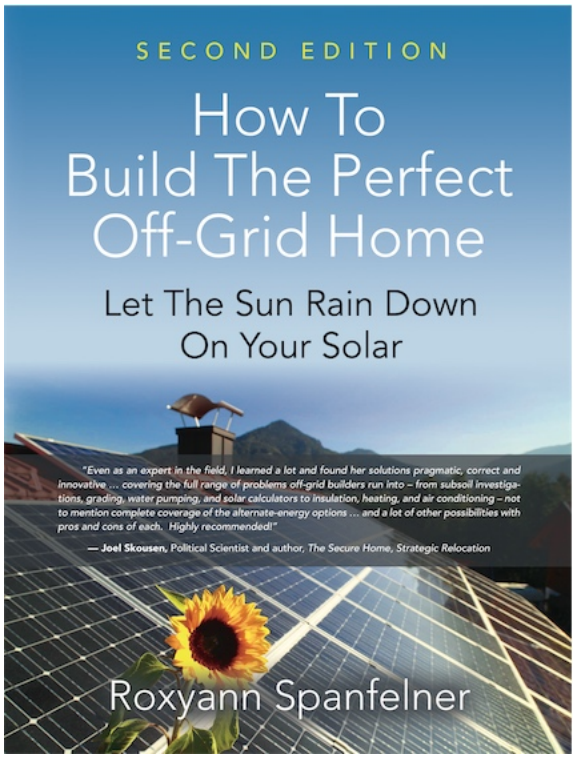


Let The Sun Rain Down On Your Solar solidifies abstract ideas and dreams into concrete form explaining How To Build And Power A Perfect Off-Grid Home. How? Spanfelner, who built a remote off-grid home with husband Gary 9 years ago, offers practical advice to navigate the complex, perplexing process – simplifying it with step-by-step instructions.

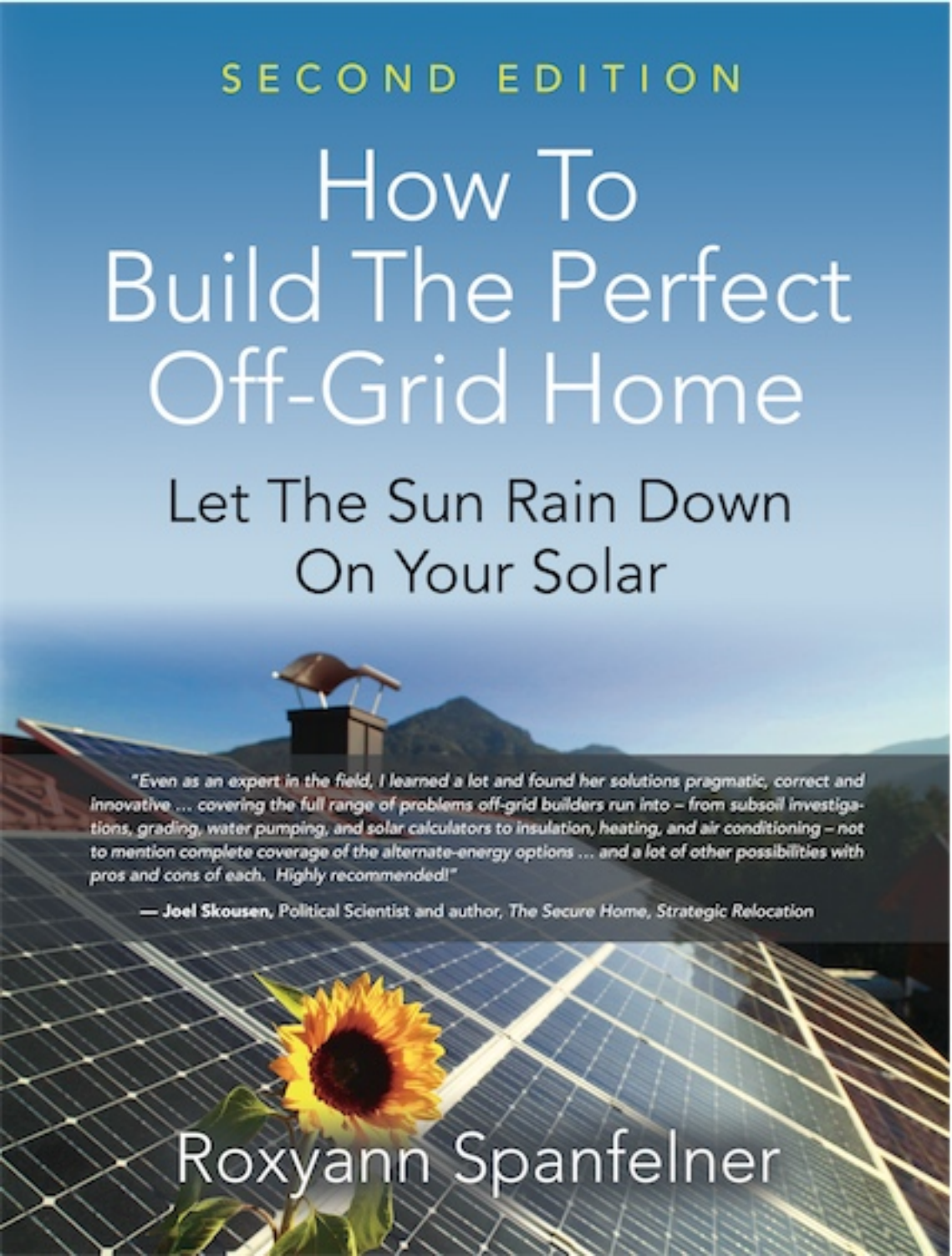
HOW TO BUILD THE PERFECT OFF-GRID HOME:
Let The Sun Rain Down

by ROXYANN SPANFELNER

SECOND EDITION

How To Build The Perfect Off-Grid Home

Let The Sun Rain Down On Your Solar



"Even as an expert in the field, I learned a lot and found her solutions pragmatic, correct and innovative … covering the full range of problems off-grid builders run into – from subsoil investigations, grading, water pumping, and solar calculators to insulation, heating, and air conditioning – not to mention complete coverage of the alternate-energy options … and a lot of other possibilities with pros and cons of each. Highly recommended!"

— **Joel Skousen,** Political Scientist and author, *The Secure Home, Strategic Relocation*

Roxyann Spanfelner

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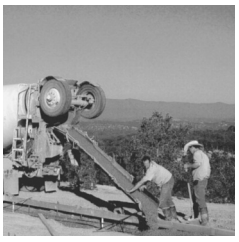




PREFACE





THE ONLY THING TO FEAR IS FEAR ITSELF

Congratulations, now that you've bought this book, you've taken your first major step toward fulfilling your off-grid aspirations. With it in hand, you surely already have a list of ideas swimming around in your brain about how to get started. So it's time to solidify those abstract ideas into concrete form.

But where do you start? First of all, put at the top of your list: never lose heart. Why? Because if you do, you've lost the battle (if not the war) before you ever get to the "lock and load" phase of your dream. I know it's overwhelming at times, and discouragement and self-doubt can set you adrift, eroding that path leading to your heart's desire. Still, in fairness to your fears, a myriad of details *do* need to be addressed to build that tailor-made off-grid system that not only fills your personal needs, but, equally important, also is sculpted to not stretch your pocketbook (or your mind) to the breaking point. But that's where this book comes in. It lights your path, aiding in deciphering the best direction for *you* to take. At the same time, it calls out to you, "Hey! There's something out there for everyone, even me!"

What does that mean? Well before you delve into this book with the preconceived view that because of its title, *How to Build the Perfect Off-Grid Home* only approaches an energy-efficient lifestyle from that narrowed focal point, please don't be misled. Let me assure you that while it certainly does deliver on that primary premise with a detailed ground-up start-to-finish guide for what I term "the new generation of off-gridders," between these pages one also finds valued answers for all kinds of questions for everything in between, be it a small cabinesque off-grid experience or a deluxe version offering seamless transition from grid-tied apron strings to gridlessness (or what I term a personal private utility company) bliss. Though it sounds pie in the sky, you'll see it's easily doable—with a little guidance.

As I said, there is something for everyone inside these pages. If you're not quite ready for a complete gridless makeover, you'll find a vast range of highly energy-efficient options (such as windows, insulation, unique heating and cooling options, and tips to utilize passive energy to maximize air flow, to name just a few) to help make retrofitting your existing home easier.

Here's one simple, cost-little, energy-efficient example of what you'll find. When it comes down to it, either on- or off-grid, new home construction or a retrofit project, my husband, Gary, believes that insulation is the key to successful efficacy. In other words, if you're advised a specific insulation quantity is sufficient, why squeak by on passable approvals? Add more or double up when feasible. You won't be sorry. That's what we did. And since many insulation options are cheap, your investment does double time: you spend less while creating a rock-solid energy-hoarding defense.

Whether you want just a taste test or a sit-down, off-grid lifestyle feast, it's within your grasp. How? As you're absorbing (as we did) the logistical "whys, hows, where at, and when" questions, first define a cornerstone base plan and stay focused on the key elements I list below and expand on in greater detail inside.

1. **Capital expenditures**
   - Trim your budget where you can. Self-sufficiency is affordable for every pocketbook if you temper an unrealistic wish list with pocketbook affordability.
   - Plan ahead. System design changes can be costly. (As those suffered when your firstborn college junior breaks the news: "I'm switching majors this semester.") Ouch. But at least in youth, fairly forgivable.
   - Educate yourself on products, system approaches, and contractors.
   - Have a nailed-down contract (found inside) that includes everything you want —and more if you can get it for the same price.
   - Talk to the experts and visit in-place or in-process projects.
   - If yours is a grid-tied setup, follow the same concepts above.

2. **Define your comfort zone**.
   - Know what you absolutely need to live comfortably *and* what you can live without. Factor in what you can realistically afford, and with this formula everything else falls in line. It also tells you whether it's full speed ahead or your savings require some "grain-fed" beefing up beforehand.

3. **Have some hard cash flow.**
   - Save money for your project rather than borrow or cash in a low-earning portfolio investment with the thought in mind that an alternative-power investment can deliver a far better return rate.

RETROFITTING IS GOOD, AND ON-GRID IS NOT A DIRTY WORD . . . ESPECIALLY WHEN THE METER SPINS BACKWARD

But what if, for now, staying on grid makes the best sense for you? Spinning the meter counterclockwise is appealing, especially with the availability of state and federal incentives. But since it's so confusing with program "candy" varying state to state, I describe how you find the latest detailed, specific state-to-state kickback answers, on and off grid. Retrofit rebates and tax advantages are also listed.

Other useful retrofit-related materials found on hand (other than a few revealed above) are formulas calculating current home wattage use, along with an extensive appliance watt-usage chart so you'll find what current wattage (mainly older) appliances eat up. An entire section exhibits how many appliances can be used more efficiently. Couple that with learning the electricity in watts you consume and how and where you use them may surprise you. If nothing else, it arms a fully educated you (crafting changes if need be) to set up a realistic grid-tied system with enough wattage to spin you backward. (Translation: This means credit on your utility bill.) What? If that happens you're operating fully off-grid. Lovely.

GRID-TIED SYSTEMS

Since I don't cover within these pages the nuts and bolts of grid-tied systems, I'll offer a few thoughts right here. First, is it worth the outlay? Yes, it is. The best way to prove this briefly is via one model: in 2001, our friend and his wife installed a 7-kilowatt solar panel system (though most 4- to 5-kilowatt off-grid stand-alone systems operate quite nicely thank you). However, he felt it vital due to space constraints to limit array installation to a partly shaded area (you'll make like choices for array placement).

And the book depicts many placement, mounting, and positioning routes.

- **Cost-effectiveness.** How efficient was this system? It paid for itself in seven years, and each year's utility bills have averaged annually a $300 to $400 credit. Still, our friend mentions here in California, unless operating commercially, credits aren't cumulative, so if you think you'll stash hard-earned cash credits, think again. Annually your bill rolls back to a big fat zero. (It could be worse, right?)

  Other concerns according to our friend (a savvy individual who with the now 12-year-old, self-installed and -maintained grid-tied system under his belt also boasts a ground-up DIY off-grid home project well under way) is that though systems should pay off in five to seven years, you must check specific state net metering laws. Moreover, while some local municipalities "kindly favor" residential setups, others do not.

- **Lower component costs and newer technology.** Read on. In our friend's own extensively researched opinion, grid-tied and off-grid setup component costs (he's well-versed in both) have lowered markedly in the last few years, citing buys at $3 per watt, installed, and stellar panels buyable for $1 per watt.

  As both a doctor of internal medicine and an electrical engineer who, as I said, handles his own installations and upgrades, he professes today's systems (on or off-grid) to be easy to install due to the current micro-inverter built in every solar panel that provides each its own encapsulated inverter. This allows for what he terms "plug and play" technology. That sounds like DIY capability. *Really?* Though we didn't venture there, I've devoted sections forthwith sketching prudent DIY possibilities.

  Also an advocate of the latest cost-effective approaches to prepackaged, prewired power panels and packaged alternative-power systems, he sited OutBack as just one such firm now offering them but said other independent choices exist as well. I concur for, as you'll read, we saved money on our wall construction by using preassembled components, thereby cutting our labor costs significantly. However, that is not to say that we and our contractors didn't double-check modules where need be. Keep this in mind for prewired or prepackaged solar panels and electronic components.

- **Cost of bringing power to new-home grid-tied construction.** While this new, more affordable technology offers better and better future options for both on- and off-grid setups, in a grid-tied new construction home, factor in this food for thought: the cost of tying in to the grid. Bringing power even a short distance to your building site (if not already in place or included in the great purchase price) is expensive. How much depends on how far to the nearest hookup (that can be measured in dollars per foot). *Holy moly*. Yes—from tens of thousands of dollars for short distances to hundreds of thousands for long hauls. Believe me, I know. Our 3-mile jaunt to grid-tied "safety" was conservatively estimated at $250,000 to $300,000, give or take 50 grand. That's right. We could have set up an entire off-grid community—*another* thing you'll read about in this book.

MOVING FORWARD INCREMENTALLY TO AN OFF-GRID EXPERIENCE: YOU'LL BE GRAVITATING IN THE RIGHT DIRECTION

Finally, while I certainly don't think setting up an entire off-grid community is what you plan to do on your own, you obviously must like the idea of self-sufficiency. So don't wait—get started. True, perhaps you need to save a little more money or are unsure about venturing into unknown off-grid territory, so here are a couple of good investments I suggest to get your feet wet.

For starters, how about a tiny woodland fixer-upper cabin where "running water" is a bubbling brook

outside your door? (In the meantime, while you're looking perhaps an old friend will share his retreat until yours is found.) Or maybe you've had your eye on a gorgeous little piece of dirt-cheap, bare-ground getaway property. You can camp there or park your RV (be it ever so humble) on it. All that's left is to hoist a satellite dish —you need only buy and hook up a receiver, pay about $5 more a month on your bill, and the luxury of the Western Movie Channel is yours! Coupled with a tiny array and battery setup or a Honda 2000 generator (like we used) and you're set. You can watch the latest news or make a cup of coffee and watch the wildlife. I'll capture that simple off-grid RV joy for you as I introduce you to our adventure and how it began for us. No matter where *your* off-grid trek begins, once you venture down that road, it will have you coming back for more.

INTRODUCTION





WHERE IT ALL BEGAN

Though we didn't have a clue at the time, our off-grid journey had already begun one warm April afternoon in 1989. Gary and I had been dating for about six months, and life was good. That day we'd driven to his cattle ranch, called the West Ranch (so named by Gary during his youth), for a barbecue. I should've guessed something was up when he parked his old pickup at the base of our favorite hilltop picnic spot instead of wheeling on up the steep grade. But my thoughts were focused on one thing only: sharing the afternoon ahead with him.

So when he said to sit tight and wait while he went up to check wind conditions on the often-gusty hilltop, I didn't question his logic. I merely smiled and said OK, as I watched him gather up a shovel and fire extinguisher before heading uphill and out of sight. Gary soon hollered down to come on up, reporting calm and perfect weather topside. With picnic basket in hand, I hurried up, pausing at the top to drink in the breathtaking view. It was a crystal-clear day, and both Mt. Lassen and Mt. Shasta were plainly visible 150 miles distant, in all their snowcapped glory. Behind me, Gary had put the finishing touches on a shallow pit he'd dug for the occasion and was fitting it with a grill top for our steaks. Remembering a card for him that I'd left in the truck, I quickly turned on my heels to go back for it, rushing past him and a mighty oak on my left.

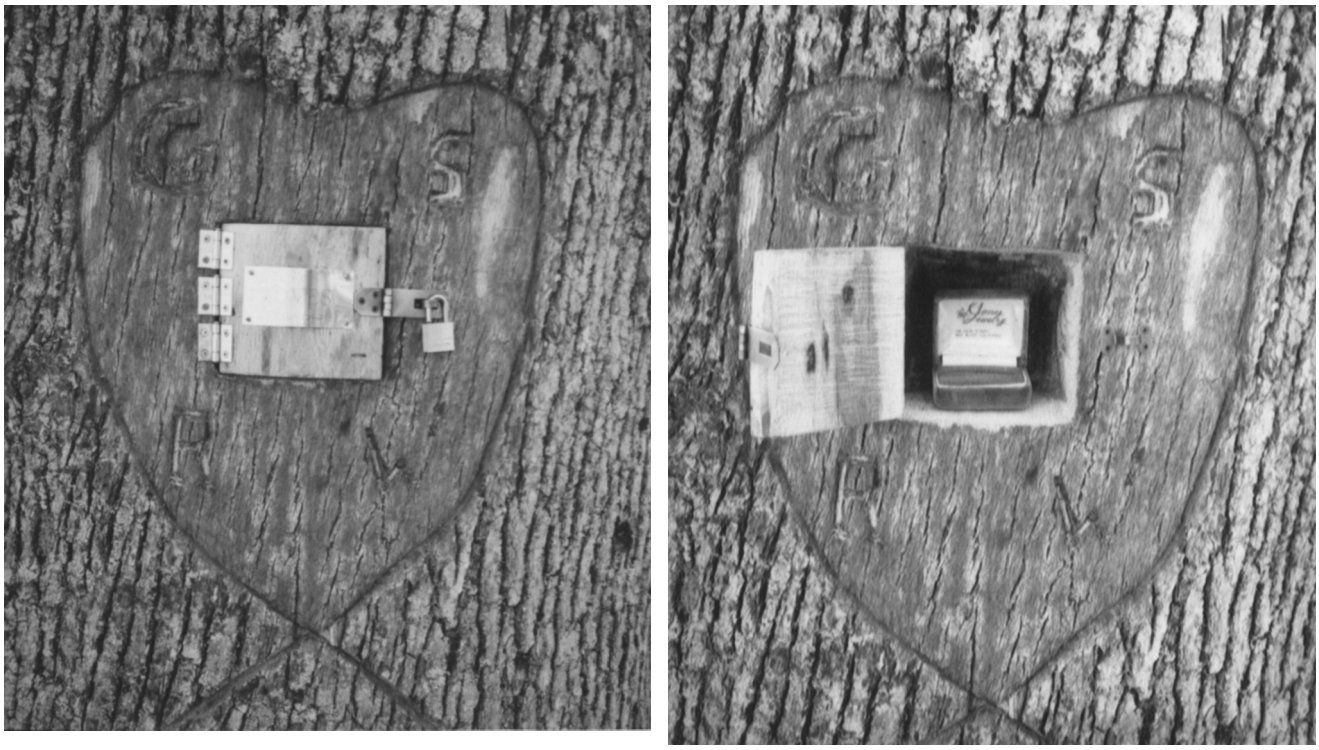
His "Hey there!" halted me, and as I turned my head, he nodded toward the tree and asked with a little smile, "Don't you notice anything?"

Coming back, I glanced at the tree and then stopped cold and burst into tears. Through bleary eyes, I struggled to focus on the huge heart carved deep into the oak's trunk with our initials inside. In the heart's center, Gary had cut a small lockbox and attached a padlocked, hinged door with a brass plaque on front engraved with "LOVES." I read the words, "G.S. LOVES R.W."

When he asked, "Will you marry me?" all I could do was nod dumbly. And when he handed me a tiny key to the padlock and said quietly, "Your ring is inside. Do you want to open it?" I nodded even harder.

Later, as the sun set over the champagne barbecue dinner he'd prepared, we listened to turkeys gobbling on the property's border a mile to the south on Elder Creek. As if on cue, the coyotes chimed in, calling back and forth in the distance as though heralding the news of our engagement.

While not yet imagining we'd actually live there, over the next 20 years we'd often drive to the West Ranch, always spending time enjoying what one friend calls "engagement hill" or what many others term "windy hill." However, from the beginning, to us it's just been "our hill."

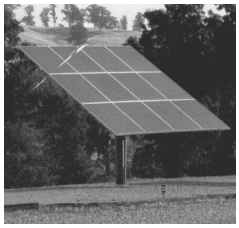
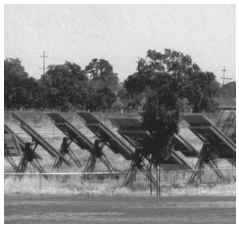


April 14, 1989. This is where my husband proposed to me and where our journey to off-grid living began. Notice that the ring box is empty—I already had it on my finger when Gary took this photo!

As you'll find out in the pages ahead, our hill on the West Ranch took on a new meaning we couldn't have dreamed possible as we began building our off-grid home three years ago near that spot. And it was only after we'd finished our project and moved into our home there that longtime friend Mike McFadyen presented us with a branding iron he'd forged of our heart-carved oak tree as a housewarming gift. As he handed it to Gary, he explained that in his mind, our ranch has always been the "Oak Heart Ranch." It seemed a fitting name, especially now that our home *is* where the "heart" is. So we seared the brand on some steaks, and Oak Heart Ranch was born.

During the course of the book, you'll come to see that our hearts are also carved into this landscape, here to stay, in every way, alongside the old oak tree where it all began.

CHAPTER 5


THE PROS AND CONS OF SOLAR AND WIND

As we set forth on our off-grid journey, we had a couple of major decisions to make regarding our power source *or* sources. Right off the bat, being blessed with a climate where the sun shines even throughout the winter, we knew solar power was a feasible probability for building the groundwork of our power system design. But what about when the sun wasn't shining? During those times we still wanted to power our home without the use of a generator if possible. In short, we wanted to investigate combining it all with a hybrid system—utilizing both sun and wind for our benefit. And as I've mentioned, we have plenty of wind, especially in sunless, stormy winter months when it would be most needed.

The beauty of sun and wind is we (and everyone on Earth if they so desired) can reap both resources endlessly in the greediest fashion without diminishing either, meaning no one complains and everyone feels warm inside. Super. However, we made our final design decisions (as with everything) only after completing a lot of research and weighing the pros and cons. Beyond the obvious advantages of being environmentally friendly and a free nontaxable, constantly renewing fuel source that offers self-sufficiency and total independence (need I continue?), more advantages and disadvantages exist for both power options. Below I put before you our thorough good/bad list evaluation of solar and wind systems.

SOLAR ADVANTAGES

I'll start with solar system advantages. Before we got into the nuts and bolts of our system design, we needed to delve into the power method basics and the widely used alternative-power solutions: solar was atop our list, with wind taking a close second. Yes, we live in "sunny California," the biggest agricultural producing state in the Union. Not only does our climate grow foods prolifically, but it also offers a great market for solar "harvesting" as well since it provides a near year-round daily reliable power source. If you are also lucky like us and have the advantage of living in a sunny climate, solar is an all but invincible option for the following six reasons.

First: Adding Solar Power Later Is Relatively Easy

We figured initially, solar arrays would account for about a quarter of our total power expenditures. And, if we found we needed more later, adding panels to an existing system is relatively easy and cost effective if you make proper provisions during setup and have batteries powerful enough to utilize any added solar (or wind) power. With this big up-front investment, the right PV (photovoltaic) module choice is critical.

Second: Improving Technology Translates to Affordability and Dependability

Your quest for the perfect PV module may be easier than you think. Because solar technology is improving, becoming more efficient, competitive, and affordable with each passing year, it's becoming hard to find bad manufacturers. So overall, expect module quality to be universally first rate. Ultimately we purchased 24 Evergreen "Spruce Line" 195W modules (totaling two pole-mounted arrays, 12 modules each; four strings in a series of three), the highest power and efficiency and tolerance available in 2009. But whatever manufacturer you buy from, if modules come with a 20- to 25-year performance warranty, you should be assured long, trouble-free ownership. In fact, they can have useful life spans (according to *Got Sun? Go Solar*) that will likely exceed 60 years! Following are some other things to look for when solar panel shopping that Evergreen offers:

- 98 percent of rated power guaranteed for 180 and 190W product; 100 percent guaranteed for 195W product
- 5-year workmanship and 25-year power warranty
- Installation versatility with an extensive range of mounting options
- Higher strength with wind and snow loads guaranteed to 80 lbs./ft. squared
- Qualified to all major industry certifications and regulatory standards
- Cardboard-free packaging for minimal on-site waste and disposal cost

Though your alternative power contractor will undoubtedly guide you in wattage and panel options, when you begin shopping, keep in mind the old stereotype adage that buying bigger delivers more bang for your buck. It translates directly to PV modules because each brand is sold by how many watts (most are in the 100–200 watt range now) it delivers under a standardized test. With higher wattage modules, you can buy fewer while at the same time minimizing bolting and wiring requirements. This appealed to us for another primary reason as well: it simplified the system.

A SHOPPING TIP: SOLAR PANEL EFFICIENCY RATING

Before you've shopped 'til you've dropped and finally think you've found just the right solar panel, first check the solar panel efficiency rating coupled with the negative tolerance rating. This is critical because according to the "Learn How to Build Solar Panel" administration (learnhowtobuildsolarpanels.com) that pairs with "Earth4Energy," these combined ratings measure the panel's true effectiveness. Obviously you know that the higher the efficiency rating, the more electricity a panel can produce from the sun. It's simple and straightforward. But what if alone, the efficiency rating is not all you need to know? Here are a couple of details some dealers may not pass on to you.

Number one, the solar panel efficiency rating is meaningless without the negative tolerance rating factored into it. For example, a dealer is offering panels with an extremely high efficiency rating at a competitive price. It sounds great. However if you check the panel specs, you may find a negative tolerance rating (or the minimum warranted power rating) of 15 percent. Poof! The panel you just bought rated at 240 watts of power, drops to a 204-watt maximum. So research beyond the efficiency rating and pass on anything with a more than 5-percent negative tolerance.

Second, don't trust the solar panel efficiency rating on newer technology panels that come with low, introductory warranties. The market is bursting with new products, and solar manufacturers are "rolling out" cheaper ways to develop thin solar cells in various shapes and sizes. While that's terrific, don't get swept away by glam products with brief warranties. The solar industry standard warranty is 25 years, even on newer thin-panel technology. If a dealer tries selling you panels with anything less, take a walk.

Third, avoid manufacturers who advertise high solar panel efficiency ratings coupled with rapid energy returns or payoffs. This gimmick suggests high quality and that buyers will earn their money back the minute sunshine hits their panel. But a rapid energy return indicates the reverse: use of a cheaper manufacturing process. That means lower quality and a higher negative tolerance rating.

Third: Versatility in Construction and Solar Mounting Options

Module Construction Options

Not only are solar modules becoming cost effective and dependable, variable construction offers some choices for you. While single-crystal and polycrystalline constructed modules with fully framed aluminum and tempered glass covers are industry standard and deliver the most wattage with the smallest surface area, there is another Amorphous silicon module to consider. In both cases, the key ingredient is silicon (Si), which is the seventh-most common element in the universe (yes, the universe). Though the Amorphous requires from 30 to 50 percent greater surface area to harvest the same wattage, before you begin throwing rocks at the idea, these panels can be built without glass covers for an unbreakable option. Additional trade-offs to the space-hogging downside are they have a slight edge in low light (but a big one in partial shading) and experience less voltage drop at higher temperatures.

SOLAR CELL MAKEUP—THE GREENNESS OF SAND
But How Can Cells Built from Mere Sand Function?

Very little manufactured products are as "green" as the photovoltaic (PV) cell. The dark parts of the module are made from silica, the same as found in computer chips. Or as Austin Powers would say, "It's sand, baby, sand." And he'd be groovin' because silica is a principal component of plain beach sand, although much today comes as a mining by-product. In addition, extremely recyclable glass covers the modules (more silica) and most frames are aluminum—probably all our crushed soda and beer cans reincarnate. That's it, other than a little plastic (mostly recycled as well) that's used for sealing back covers and in junction boxes.

Furthermore, standard single-crystalline and polycrystalline panels—whether arranged in arrays, shingles, or thin-film (amorphous) noncrystalline kinds—are all silicon. And being a semiconductor of electricity, silicon allows current to flow through it. That's good news for solar energy creation. But just how does sun fit in?

Inside each panel are solar cells that produce 0.5 or so volts and connect in series to attain desired voltage. Without delving deeply into proton and electron blending and movement, just be happy knowing when one electron makes it to the right place at the right time, the sun does its magic: a light photon of just the right energy and wavelength zaps that electron, driving him with an energy bolt to a prime spot where he's picked up by one of the cell's "n-side" negative surface conductors and gets whisked through the circuit. This is the door key, and a bazillion electrons stampede out behind him, like a panic-stricken throng exiting a burning theater. Once they've served you, perking coffee or baking lasagna, the dog-tired electrons get "recycled" back to the circuits "p-side," resting until the next sun photon makes them rise and shine. (Now you know why solar panels have positive and negative terminals.)

A Large Variety of Mounting Options

The outstanding "array" of module mounting choices offers flexible and tempting advantages for easily integrating solar into your off-grid design. I'll start with the standard rail assembly method (rooftop or pole top-ground mounts) made of precut, extruded aluminum rails with adjustable top and bottom slots for variable size modules and rafter spans. Tilt-up leg hardware is fitted to optimize vertical orientation for solar exposure.

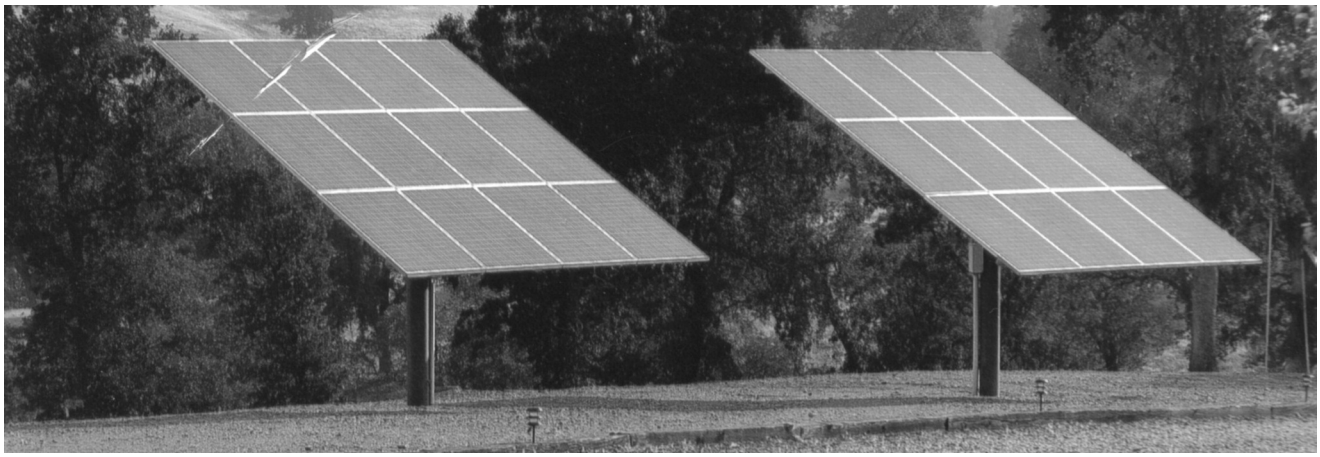
Roof Mounts

Rail attachments for solar roof mounts are the most common option available. Considered the most cost-effective (and unless you have extreme wind conditions like we do), it may also be the most structurally sound locale. Plus, if you have a lot of roof space, a large number of panels can tie into one integrated system. Installation is usually done with roof-bolted standoffs, waterproofed with a flashing (just like standard roof venting) that can be either caulked or fit with a no-caulk rubber insert. Each row of PV modules will lie over a pair of rails and a splice bar attaches to the topmost rail and a ground wire to the lower flanking standoff for PV module hookup. In addition, modules are equipped with a junction box (J-box) that mounts on the rooftop too, providing protected space to convert the multi-contact (MC) connector cables quickly and easily to conventional wiring before dropping down to the inverter level.

However, if you are planning a Spanish tile (barrel tile) roof, this is an exception to roof-mounting solar arrays for obvious reasons. Tile roofs are hard to walk on without breaking tiles, let alone trying to bolt a network of solar panels to it, so the rule of thumb is to stay off the tile roof altogether—and put your array somewhere else. If for some reason you just have to cover those gorgeous Spanish tiles, check out Professional Solar Products' Tile Trac, the best Spanish tile–mounting hardware package (www.prosolar.com). According to *Got Sun*? *Go Solar*, it puts no weight on the tile, attaches firmly to rafters, and penetrates the tile at the highest point to avoid leakage. It's neither fun nor fast, but it is expensive.

Pole Mounts

While roof-mounted PV arrays are the most popular, cost effective, and neatly out-of-the-way choice, if your roof is not designed to handle a panel system's heavy load, look into other options. On that note, pole mounting (often on steel) is highly adjustable and one of the best solar panel–mounting options available. And while roof-mounted panels cannot attain 100 percent solar coverage, pole-mounted systems can be



We used pole mounts not just because they are highly adjustable and one of the best options available, but also because we had to factor in the wind. We built ours strong and can depend on our arrays to be virtually unshakable in even the highest winds.

Our arrays needed a strong anchoring point to make them stand up to strong wind gusts. That began with a 5-foot-deep hole enclosed in three levels of steel gridwork, followed by 10 yards of concrete to hold the 10-inch-diameter poles snugly in place.

Rod works on our steel pole base of 10-inch poles while Brian (almost hidden in the hole) works on the grid. Eight of the 13 feet of the pole length are visible.

installed in the best possible position by pinpointing the best solar coverage area to be had. In our case, because of our 100-plus-mph winds, a roof-mounted system would likely become damaged, shake loose, and cause leakage. So we chose pole-mounted PV arrays (they use the same rail mounting system) and, because we had larger modules, an engineered pipe framework. Here again your installer will suggest the best options for your needs, but UniRac maker of Solarmount (www.unirac.com) and Direct Power and Water (DPW) (www.directpower.com) are two quality mounting-system manufacturers.

Though pole-top mounts hang the array from the top of a single (usually 4- to 6-inch) steel pipe, our high-wind area required heavy engineering, and we built ours to withstand the worst "northerly" gales with a 10-inch-diameter steel pole mounting for each 12-panel array rack. (Pole mount systems usually have a safety maximum of six to eight modules unlike roof-mount systems.) Buried 5 feet deep and enclosed in three levels of steel grid work and 10 yards of concrete, the 8-foot tall poles are rock solid.

Tracking Mounts

There are two types of solar trackers available: active and passive. The advantage is that solar trackers can produce more power in a day (30–40 percent in summer; 10–15 percent in winter) than fixed arrays because they automatically point the array to a perpendicular line with the sun, tracking it from east to west every day—if working properly. The active tracker uses a special sensor and is motorized. Usually custom built, they take up to three months to manufacture and cost several thousand dollars. One drawback is they are prone to failure, which causes the array to "stick" in one place until you fix it. If you're not all that handy and still want to capitalize on power, passive trackers use the sun's heat to move liquid from side to side inside the tracker, allowing gravity to move it without motors, gears, or control failure worries.

Tracking mounts were really hot in the 1990s, but the fuzz has rubbed off the peach since then: PV module costs have dropped by half since then, while tracking mounts have gone up—and then there are those fix-it expenses. Top it off with none of the rebate programs giving credits for the pricey trackers and you have three solid reasons to go with a fixed (zero-maintenance) mount, and can put that extra cash into additional modules if you want a power boost. Hate to rub it in (not true—I really love to pound it into the dust), but simplicity wins out again!

An example of a track-mounted solar array.

Ground Mounts

Sometimes when your roof is too weak and pole mounting won't work for you, it's best to use ground mounts. Although the supporting leg mounts are not as adjustable as pole mounts, if you have the ground space, you can lay out large numbers of tied panels in one place. The only downside is the structural expense of steel supports, concrete structures, and galvanized footings that can cost more than the panels themselves.

Integrated Photovoltaics (PVs)

Uni-Solar has some unique amorphous options that are incorporated into the roof. It has a shingle product called Power Shingle that intertwines within conventional asphalt shingles without any bulky panels or heavy framework. The company also offers the EnerGen system from CertainTeed that uses thin-film photovoltaic laminates that seamlessly integrate with traditional asphalt roofing shingles. You may want to look into the roll-out adhesive peel-and-stick solar cell product for metal rooftops as well. New options are evolving as I write. Investigate and always before buying (when possible) inquire into other off-grid installations for efficiency.

Fourth: No Moving Parts—Ease of Maintenance Translates to Longer Life

Off-grid solar cell maintenance (aside from battery upkeep) is very low. There are no moving parts, unless you have trackers or a pole-mount system like ours that we need only adjust by simply repositioning a few bolts and manually tilting the arrays two times a year. Because of this, your panels will have a very long life, quietly collecting energy for many years beyond (40-plus years) the 20- to 25-year warranties that manufacturers unhesitatingly offer. So, with a well-designed system, you only need a bit of house and yard work to keep solar power at a maximum.

Here's how: give your solar panels the "white glove" treatment. Why? Dusty panels decrease solar output. If you live in a low-dust climate with periodic rainfall and your panels are on the roof, squeegee them down with mild, soapy water every few months. Do this more often if you live in dusty locales like Arizona. You may be able to rig up an extended squeegee or mop and garden hose to avoid getting on the roof. We hose off our pole-mounted arrays with only water, and it works fine. Also check for bird droppings, leaves, and other debris that could fall on your roof, and perform a "shade-clear analysis" every few years and trim trees as needed.

Though an added expense, you can also pay a monthly (or flat up-front) fee for a monitoring service or system. (We have a wall-mounted system, so we can easily monitor the system ourselves for free.) Either way, monitoring systems make troubleshooting easier and performance issues less stressful. The following are some examples:

- A solar system is expected to produce a guaranteed amount of power each month. A solar-monitoring system tells you if your system is offline or not performing as expected and can run diagnostic tests.
- Monitoring systems can also be educational, showing power and CO_2 savings and even "dollars" saved.
- Depending on the type, you can monitor information from the Web, from a wall-mounted device, or even from your smart phone.

Fifth: Home Equity and Property Tax Exclusions

The advantage of a solar system of any size is that, while you can take it with you when you move, it will increase the resale value of your home if you leave it in place. Plus, in California there is Section 73 property tax exclusion for solar energy systems. Check that great DSIRE website (www.dsireusa.org/incentives) or contact your tax specialist for state-to-state exclusions.

Sixth: Federal Tax Credits

Now, finally, financial incentives are available to off-gridders! Before 2009, residential tax credits of any kind for non-grid-tied systems peaked at a meager $2,000. But because there is a federal investment tax credit (ITC) created by the Emergency Economic Stabilization Act of 2008, residential consumers can take a whopping 30 percent ITC off the total installed cost of a solar system. The ITC can be used for equipment installed from October 3, 2008, through December 31, 2016. Yet again, our situation was providential. Though our alternative-power system was supposed to be finished in late summer of 2008 (making us ineligible), it was finally completed in late February 2009, proving that God is always one step

ahead of us and giving way more than we ask—even financially! The law was so new, our accountant had to attend a spring seminar to learn restrictions and tax codes for alternative power.

SOLAR DISADVANTAGES

Yes, solar does have disadvantages. Sorry to rain on your parade, but obviously as the Grammy-nominated song (written for country singer Lynn Anderson) by the late, great singer-songwriter Joe South goes: *"I never promised you a rose garden, along with the sunshine there's got to be a little rain sometime . . ."*

All alternative energy systems, including solar, have kinks. That's why we considered adding wind energy. Obviously, on the darkest days when there is no sun, that hum (I've come to love) from the solar power coming into the invertors and through the charge controllers is missing, and the wattage reading of incoming power is dismal by comparison.

Back to the Carbon Footprint Thing—Using the Generator

Without much incoming energy, an off-grid system relies on battery backup and a powerful generator. This is a disadvantage because it forces us to use fuel, though our diesel-powered 20-kilowatt generator (burning roughly 3/4 gallon per hour) is efficient. Moreover, determining when to turn it on is key. During rainy periods, we monitor more closely our battery percentage on the wall-mounted TriMetric panel box in our laundry room. Only when batteries drain to 70 percent do we manually (automatically programmed to go on at 48 percent in emergencies) turn on the generator using a switch on the side of the TriMetric panel. This provides a good median point, giving the sun a chance to come out or issue some brightness to boost power, but at the same time not waiting so long that the generator takes many hours to recharge the system. By this I mean we found if we let the batteries go to 60 percent or lower, it's harder on them and the generator needs to run longer, causing more wear and fuel usage to bring a "full" power reading to the panel box. This practice will extend battery life by conserving battery cycles. (See the section on batteries later in the chapter for more information about battery life cycles.)

Location and Area

Though few places on the globe exist where solar is not useful in some capacity, as areas reach farther above or below the equator belt, sunray-striking power diminishes. Direct hits to the midsection are what supply the most sunshine hours. So factor in your geographic location and climate; it could be a disadvantage in that you'll require more solar panels than you thought to get adequate power. Also dense tree cover and adjacent structures reduce sun exposure.

In addition, supplying enough solar to power an entire household takes a large, unobstructed area that is relatively flat or angled in a favorable direction. Figure you need sunlight to strike modules at least 5 hours a day to make them viable.

Roof Considerations

As I've touched on in the advantages of roof mounts, roofing itself needs careful consideration before solar arrays are installed there. Repairs and roof replacement are expensive and labor intensive. The system must be removed and reinstalled if major roof work is needed. If you know you want roof mounts, make sure your roof supports are properly engineered to support the weight before you begin and consider the best solar mounting (briefly outlined above) option.

Appearance

Let's face it; appearance matters across the board, and solar panels are no exception. In my humble opinion, they just don't enhance a roofline's appeal, and some roof types have limited plusses to solar array installation anyway. My tile roof example is one: it's a difficult (and costly) means of covering a gorgeous edifice and will not maximize solar efficiency to boot!

The Thin-Film Disadvantage of Solar Energy

To back up my claim, if the appearance disadvantages wasn't important, all the latest thin film photovoltaics, flexible PV, and the emergence of PV shingles would not be so popular. But what you may not know is some thin-film production requires copper, indium, gallium, and selenium (CIGS); indium is difficult to obtain, and some in the industry fear that supplies will be depleted in less than 10 years at the current consumption rate. Costs for this rare element will also likely rise sharply if these fears prove to be true.

While thin-film solar is still much less expensive than silicon solar to produce, it has yet to reach even the poor efficiency levels of those modules. However, as technology evolves, solutions are sure to be on future horizons. In the meantime, be cautious and research thin-film options carefully.

Lead and Sulfuric Acid in the Battery Bank

Something else you may not be aware of is the bank of deep-cycle, lead acid batteries an off-grid solar system requires. While solar comes with 20- to 25-year warranties, batteries don't and on average may need replacing every 5 to 8 years. Yikes! In addition, a lead acid battery contains both lead and sulfuric acid, which is toxic to air, soil, and water, and highly poisonous to marine life. Lead is also a serious health risk to children, so lead batteries, if handled improperly, pose a grave environmental disadvantage to solar energy use.

However, on the upside, 98 percent of these materials are recoverable when recycled, and facilities are in place that do so. To best guard your huge investment (our four batteries cost about $3,300 each) and our atmosphere, you need to get the longest life possible out of your batteries and then retire them to a recycling facility at the end of their lifespan. The good news is there are ways to *triple* a battery's lifespan with some basic purchase, setup, and maintenance tips we used, and I'll outline them for you later in this chapter and offer more in-depth battery facts in Chapter 6 as well.

Cadmium

Cadmium is used in some semiconductive applications, such as solar cells, and is a known carcinogenic agent or worse. It poses a number of dangerous health threats depending on length and method (inhalation, ingestion, or absorption) of exposure. Though this is an obvious disadvantage, cadmium causes no health risk while contained within the cell. Years from now, however, attention to dismantling the batteries and disposing the cadmium at proper facilities will be necessary to prevent exposure and leaching of cadmium into soil or groundwater.

Initial Costs and Maintenance—and Saving for a Rainy Day

Now on to the last thing any contractor wants to talk about. That's right. Money. Costs can be a big downside to any alternative power system. How much all this was going to cost us was probably the *first* question we asked Bill Haase about solar energy. That answer is not easily nailed down, because it is based on individual needs, consumption, and the size of your pocketbook. But rest assured the outlay will be substantial. Still, as I've mentioned in earlier chapters, proper design, forethought, and keeping things simple can limit costs greatly.

That said, the solar market understands this disadvantage, and coupled with the drive of increased demand, advances toward increased efficiency and reduced raw material expenses will make solar power more reasonably priced. And don't forget that 30-percent tax credit!

Furthermore, there will come a day when you will have to perform maintenance on your system, replace or add components (such as batteries), and that will not be cheap either. For us, saving for that rainy day was the answer. While saving is always good, it's often hard to do. To make it easier, we set up a savings account specifically for alternative-power expenses. We add to it regularly so cash backup is "painlessly" on hand.

WIND POWER ADVANTAGES

Availability

The first thing to consider before ever harnessing wind is simply this: do you have enough? If so, *then* start thinking about throwing a saddle over it and riding it. Talk about the best of both worlds for us, not only did we have that abundant California sunshine, but we also positioned our house site so that we almost always have a breeze. Even now, glancing up from my laptop out the dining room windows, I see our pole-mounted flag gently waving, though it's a blistering hot August morning and probably still as a stick down in the valley just 30 minutes away. Moreover, in cloudy winter months, that flag "rides the wind," whipping straight out and horizontal to the ground 95 percent of the time. Perfect! A wind machine—even with "no sun, no hum"—might just mean our generator sits silent more often.

Even so, wind power isn't for everyone, so loosening the saddle cinch a bit, we first weighed wind's many advantages and disadvantages before incorporating wind into our alternate-power formula. And you'll want to apply some formal wind measurement means for your area (found later in the chapter) before deciding on turbine installation, like we did.

Vastly Improved Wind-Power Technology

Over the past 10 years, residential wind turbines have radically improved their ability to convert wind to electricity largely because we as consumers are hungry to gobble a piece of this invisible wind pie. Newer designs use innovative materials and technologies to generate even more power with less wind than ever before. A variety of sizes, styles, and wattages are now offered to power your off-grid home, whether it operates alone, or as a hybrid system like we were debating.

24-Hour Production Advantage

Unlike sunshine-reliant solar energy, wind machines generate power on sunny and cloudy days *or* all night long. In short, wind (if you have it) is a potential around-the-clock power source. This means lessened battery backup or generator reliance at those times.

Home Geography—We Have Space Advantage

If wind power is for you and you have enough area for a wind machine, you're set. Because a wind generator rotates with the wind it isn't, unlike solar, affected by your home's orientation. And although it takes up less physical space to produce similar amounts of energy, you need room around it. We had the advantage of having enough land to safely locate a tower on which turbines (600-watt size and up) need to be placed. To avoid tower issues, you may consider one or more small wind-turbine mounts (500 watts or less) on a barn or sturdy structure. But let me offer a rule of thumb about mounting distance: keep even these smaller models off your roof and away from your house where noise and vibration from spinning blades are out of your earshot so you don't go out of your mind.

There are two other critical details to keep you of sound mind. First, the turbine should be far enough away from your living area and neighboring property lines to avoid structural damages or injuries if the tower fell or part or all of the turbine flew off (picture that: yikes!) in gale winds or a sudden strong downdraft or "microburst" (All of which prove you *can* get too much of a good thing). As a reference; *Got Sun? Go Solar* suggests a distance of 15 rotor diameters (an 11-foot propeller translates to at least 165 feet) from your house or any neighbors' structures or fences.

Second, the tower height needs to be unobstructed so wind has a direct pathway at least 30 feet above the tallest structure or tree for a 300-foot radius, according to *Got Sun? Go Solar*. This clearing minimizes air turbulence that increases wear and tear on the turbine (this turbine turbulence can be compared to the shuddering and bucking that airplanes experience in similar encounters) and significantly reduces wind force. This is not good—though granted, it's not as bad as a wind-wrenched, careening turbine propeller.

Wind Turbines Can Last a Lifetime . . . with a Little Maintenance

Bergey Windpower Company based in Norman, Oklahoma (405-364-4212 to call direct and get a *live* person), claims its wind turbines are "maintenance free" because of their simplistic design involving only three moving parts. However, Britton Rife from Bergey's Sales and Customer Service Department told me that the company recommends inspections at 30 days after commissioning, 180 days after commissioning, and then every two years after that. According to Rife, Bergey Windpower is the oldest and most experienced manufacturer of residential-sized wind turbines in the world. Rife says, "Bergey wind turbines have a 30–50 year lifespan, and we have many systems that have been in place for 25-plus years." He added that while its other models carry a five-year warranty, "our 10-kilowatt turbine has the longest warranty in the industry, 10 years."

Another company, Wind Analytics based in Brooklyn, New York, backs up Bergey's low-to-no-maintenance claims. When asked how difficult residential tower-mounted turbines are to maintain, operations manager Camilla MacLean replied, "Turbines are designed to be basically maintenance free and have a 20-year life." She added that an "annual visual inspection of the equipment by the installer is probably a good idea."

Maintaining a residential wind machine, in my estimation, falls into two categories: preserving maximum efficiency and safeguarding the system. Because modern turbines have fewer moving parts and are designed to operate for up to 120,000 hours, or on average 15 years (some like Bergey can claim 25 years and even longer), they require low maintenance and can last forever if repaired properly. This doesn't mean that you install one and forget it's there.

Climate conditions, mainly the rigors of wind turbulence, factor highly into system distress. Turbines need regular inspections and safety checks, as the manufacturers suggested above. And though you do not have to oil and lubricate Bergey turbines, which also have permanent magnet brushless alternators (negating the need to replace worn brushes), Mr. Rife said that grease should be added to the Excel model's sealed bearings using a micro-needle every 8–15 years. He adds that you should also watch for signs of grease migration.

Stick to an Easy Maintenance Checklist to Keep the Wind Turbine Shipshape

The following are some basic guidelines to use in your checklist:

1. During your inspections, check guy wire tension and condition of anchoring system. Any corrosion and loose or missing bolts or fasteners must be dealt with immediately, particularly on the tower and around rotor blades to prevent unchecked vibration damage.
2. Check rotor blade for erosion or cracking. Depending on material used (likely a fiberglass composite today), periodic blade replacement for cracks may be needed. Sometimes, however, only the leading blade edge requires retaping (according to Bergey, typically after 10 years) to ensure optimal wind flow over the surface.
3. Inspect the tail pivot bearings, surge arrestors, and grounding connections, and remove dust from heat sinks on fan-cooled electronics. You also need to ensure that the fan is operating properly.
4. With better design, further safety inspections for icing on rotor blades in colder climates have almost become unnecessary, but periodic monitoring doesn't hurt. In the past, frozen chunks flying off blades as projectiles could damage the turbine (or bystanders), but in newer models, ice simply slows down their rotation until it harmlessly melts, sliding straight down to the tower base.
5. Listen for unusual noises. After about 10 years, expect the rotor blades, gearbox, and bearings to wear and possibly need changing. A decrease in efficiency or increased mechanical noise usually draws attention to your need for a professional service call. What does that cost? Figure a gearbox or generator will run about 15 to 20 percent ($3,000 to $4,000 for a $20,000 setup) of the original turbine cost.
6. Get a service contract and extend it. Make sure that the cost of your system setup includes service (which can usually be extended) for a set period. If you want to set aside some money monthly or

yearly, repairs and maintenance annually break down to about 2 to 2.5 percent of original costs ($400 to $500 for a $20,000 system) or about .01 cent per kilowatt hour.

7. Still, with these simple checks in place, monitoring your own system for obvious problems (e.g., damaged rotor blades) with visual inspections, by listening for noise, and keeping records on its energy generation is easy. Treat it as you would your vehicle, and in the same way, proper service and maintenance will extend your turbine's life.

Tax Credit Advantages

Yes, the same 30 percent investment tax credit is available for small wind turbine systems as for solar setups for equipment installed from October 3, 2008, to December 31, 2016, through the Emergency Economic Stabilization Act of 2008. It applies to a small business, farm, or residence. To qualify, units must have a 100-kilowatt capacity or less. Also check the DSIRE website (www.dsireusa.org) for any local or state incentives and consult the American Wind Energy Association (www.awea.org) that not only explains existing legislation, but also tracks additional measures in the works.

WIND POWER DISADVANTAGES

Consistent and Predictable Wind Is Required

The biggest disadvantage to wind power is, as I've established earlier, that you have to have enough wind and it must be consistent and dependable. And keep in mind that this never-ending free resource isn't found everywhere (some things are too good to be true—especially if you live in the southeastern United States, as seen on the map on the back cover) and can be inconsistent to boot. In many areas of our great country, the wind level force near ground level is as useless to turn a wind machine as a swishing bull's tail is for budging pesky flies off his rump.

Still, ensuring that you have wind enough to justify the time and expense of installing a wind machine is not really hard. First check out a few websites. The map provides an overview of average annual wind power. At a glance [greens showing under 5 m/s (meters per second — 1 m/s equals 2.24 mph) annual winds while browns to purples show 6.5–9.0 m/s annual winds)], you can see wind patterns. Just click on your state to get detailed specifics for your exact area. As is evident, the Southeast is not a good wind bet, while the upper Midwest (6.5 m/s and greater at 80 meters) offers great harvesting potential. The higher Northeast and Northwest and all along the Rocky Mountains are also good sources. Note that the far Northern California area has brown and orange coloration dots as well.

But there are some other lean and mean wind statistics sources to use for your specific region. In my opinion, "My Solar & Wind Estimator" (solar-estimate.org) is a fast, phenomenal source that comes highly recommended by NREL. Mentioned previously in Chapter 4 (to help calculate baseloads easily), this website was originally partnered with and funded by the California Energy Commission in 2000. First it walks you through simple input steps beginning with your ZIP code, and then asks for your current utility company, whether the estimate is for a residence or business, and your energy system type, such as solar power or wind turbine. From there you'll be asked to input one of the following three options based on your utility bill:

1. A typical monthly bill amount
2. Annual kilowatt consumption
3. A typical seasonal bill amount for summer, winter, spring, and fall

In a few nanoseconds, the website issues a wind rating in your area and a specific m/s and annual wind average. It also estimates your turbine size, cost, electricity rate in dollars per kilowatt, and monthly electric usage. It goes still further, providing a detailed net cost and savings benefit by year and cumulatively over the years. For more information, you can email the site at help@solar-estimate.org.

These measures do not offer an exact science for pinpointing wind velocity at your little house on the prairie or your lofty mountain chalet. If you're a stickler, you may want to purchase an anemometer, place it as close to your planned tower location and height as possible, and monitor its readings for a few months. To help interpret and extrapolate gathered data to arrive at wind speeds, you may find the Iowa Energy Center's *Wind Energy Manual* found at www.energy.iastate.edu/renewable/wind/wem-index.htm helpful. Better yet, if copious manual reading is not for you, get input from your well-informed installer.

That said, while Gary would have liked to install an anemometer, if only to have documented proof of our vast wind power, we didn't have time to collect months of data. We needed to make design decisions quickly, and perhaps you do too. The good news is that, while determining wind potential and predictability is key to an optimally functioning system, you shouldn't have to sort through reams of data and resort to pricey equipment to monitor wind power, and frankly we didn't think going to extreme lengths was necessary. And like we did, you should have a good idea on your own (and your installer can further advise you) whether your wind power is adequate. I'll add, like everything else in our alternative-power design, we kept our approach to wind power rating simple with this basis: wind blows here even on the seemingly stillest of summer days, and in winter months it's downright scary. In other words, it soothed us in summer but aggravated the heck out of us much of the rest of the time.

Off-Grid Configurations Provide Less Power Than Grid-Tied Setups

When you begin researching wind turbine setups, I don't recommend comparing grid-tied systems to your off-grid wind turbine's setup because energy-production levels differ—and you will put yourself at a disadvantage when calculating expected system generation. Why? A grid-tied system flat out produces more power and can be likened to a shot that's administered directly into the vein versus swallowing the same medicine in a lower-dose pill form. The pill has much farther to travel to be absorbed, and on the way, its effectiveness is diminished.

So how does this translate to off-grid configuration disadvantages? By design, all wind turbines initially generate three-phase alternating current (AC) by spinning three pairs of magnets around three wire coils. On off-grid turbines designed for battery-based systems (factory configured for either 12-, 24- or 48-volt operation), the AC is converted to DC either within the turbine itself or inside the charge controller. On the other hand, according to *Got Sun? Go Solar*, direct grid-tied operating turbines (operating at 94-percent efficiency) deliver high-voltage DC (150–350 volts for the Windy Boy 1800U inverter, and 250–550 volts for the 2500U) that is converted immediately to grid-compatible AC within the inverter. Holy moly! So without argument, direct grid-tied systems are more efficient because they require none of off-grid's power-conversion travels whereas DC electrical energy moves to chemical energy inside batteries and then back out again into electrical energy before going through its final transformation when DC is switched to AC by the inverter.

All said and done, it doesn't mean an off-grid wind turbine isn't a phenomenal power source. But examine closely only off-grid systems that operate as hybrid types or, what I deem the gutsy ones, a solely wind-powered stand-alone system.

Some Maintenance Disadvantages Exist

While not frequent, cases do exist where wind turbine maintenance can be difficult and costly. Some larger tower-mounted wind turbines require cranes or even a helicopter (though Camilla MacLean of Wind Analytics said air installation is only required if the turbine is going where a truck can't go) to install and maintain. And this may need doing every one to two years depending on maintenance issues. However, Rife at Bergey said, "For locations where crane access is not possible, we have a tilt-up guyed lattice tower for the Excel 10-kilowatt turbine that can be installed without a crane. You use a winch and gin pole to install the tower, and it is available in 60, 80, and 100 feet."

WIND SPEED MATH

Ever been in or near the driving force of hurricane winds? The power is as unbelievably frightening as it is awesome. However, to get that kind of power from your wind machine, you don't need a ground-leveling disaster. To begin the mathematical equation, wind speed and the power it generates are not of equal measure. Using this example from *Got Sun? Go Solar*, a 30-mph wind is not just half again greater than a 20-mph wind; it's nearly 3.4 times more powerful.

What? It's the "cube" factor concept at work: the force of the wind increases as the cube of the wind speed, so while 20 x 20 x 20 = 8,000; 30 x 30 x 30 = 27,000. Further, you can attain wind force in watts per square meter (W/m^2) by multiplying either product by 0.05472. Not only is that easy to follow, the same (W/ms^2) equation works for solar radiation, so the energy each generates can be pretty closely contrasted. To make it fair and balanced according to *Got Sun? Go Solar*, the sunlight hitting Earth—or your solar array—at mid-latitudes in the middle of a summer's day is equal to a steady 22–23 mph wind speed, or about 600 watts per square meter.

While that sounds famous, keep in mind that both solar and wind turbines (though not commonly efficiency measured due the widely varying sweep areas) harvest only about 12 to 15 percent of that power. And by the meter, solar is more constant than a steady high wind in most regions. This may factor into decisions to use (or not use) wind if your spot is iffy. But if your locale averages 10-mph-plus wind speeds, you can safely wager a paying investment. Because if the wind is blowing, nothing—be it rain or shine or sleet or snow . . . kind of like the proverbial mailman—can deter your wind turbine from its appointed round.

Generating Power Can Be Noisy

Out of sight is not always out of mind. A frequently mentioned disadvantage of generating wind power is noise. This is the humming sound (in commercial models, it is somewhat similar to a small jet engine) generated from the spinning blades. Smaller wind machines typically used for residential applications aren't a problem. Unless you have the always contentious Hatfields or McCoys as close neighbors, noise is usually only a problem in larger turbine systems; as blade size increases, noise levels rise proportionately. However, most people considering larger wind turbines have larger plots of land, far enough off the beaten track (wildlife make good neighbors) that the whirring racket isn't a factor.

Tower Height Can Be a Problem

For larger wind turbines to operate optimally, they must be tower mounted and the tower must be high enough to catch a consistent wind source unobstructed. When I first spoke to the Bergey manufacturers (about its 10-kilowatt wind turbine), the representative recommended an 80- to 100-foot tower, though that can be lessened, as we planned, with a hillside mount. While California allows towers of 65 feet on parcels of 1–5 acres and at least 80 feet on 5 or more acres, many states restrict tower heights to less than half of that, which severely limits power-producing potential. Check your state regulations and, if need be, find a lofty hilltop location to offset this constraint because tower height is key in your wind power design since there is a lot more wind current way up there. For example, have you ever watched an eagle (or buzzard) soar and circle far overhead without a single wing flap for long periods even on a seemingly still and hot summer day? That's because they know something we may not: it's possible to literally float along in the firmaments above on steady, less-turbulent air currents found at higher altitudes rather than relying on gusty or chaotic breezes found at earthly levels. Even DOE statistics typically chart wind power density (though it varies geographically) at 50 meters (1645 feet) to be double that at 10 meters (33 feet). Outstanding! That considered, however, even a rural residential mega-tower is both impractical and unnecessary, but it clearly illustrates height relevancy. Most wind turbines will start power spinning at 6 to 7 mph (cut-in wind speed) but won't begin generating serious energy below 8 or 9 mph. According to *Got Sun? Go Solar,* this affords enough wind to keep batteries charged for battery backup systems like ours, unlike grid-tied setups that need annual average wind speeds of at least 10 mph.

Towers Can Be Expensive

Another drawback to towers is that they can be costly to manufacture and engineer. Most turbine manufacturers offer tower kits sized specifically for each of their turbines, and those manufacturers that don't sell them will make excellent recommendations. This is not a sales gimmick. Listen to their advice about what it takes to hold up these "wind catchers." In the highest of winds, lateral thrust is exponentially unbelievable and nothing you want to leave to chance experimentation. Keep in mind also that your tower and its foundation will most likely require a local building department permit and inspection, and you will have to comply with those codes and regulations. When paying, comfort yourself with the knowledge that, by utilizing professional engineering done with expert precision, your turbine won't end up in Oz.

Types of Towers

For residential applications, towers come in four basic types: guyed-pipe, guyed-lattice, freestanding lattice, and tubular monopole.

1. **Guyed-pipe tower.** The cheapest and probably the most common and easiest to set up, this type of tower is made from standard off-the-shelf galvanized steel tubing sections, making it sleek and streamlined. Hinged at the base, these towers can be erected with the turbine already attached. The major drawback: because you cannot climb it, you must lower it for periodic inspections.
2. **Guyed-lattice tower.** This model is three-sided and uniform dimensionally (about 18-inch sides) from top to bottom. Like guyed-pipe models, they must have a series of guy-wire (we call them "trip-wire") supports. They can be assembled standing by section or on the ground with a hinged base that tilts up into position.
3. **Freestanding lattice tower.** The tower type we considered, the freestanding lattice tower, is broad at the base and tapers toward the top. Though more expensive than the guyed-wire type, this type has no "trip-wire" requirements. In our case, Bill Haase suggested that we consider a climbable, pre-engineered, windmill steel frame tower that he had available (great if you can procure one) with a center sliding extension (to service turbine) that also has a platform on top. The four legs, as would be our pole-mounted solar arrays, would be concreted in place. In general, like guyed-lattice towers, freestanding versions can be built in place or assembled horizontally before going vertical.
4. **Tubular monopole.** A fourth freestanding tower type, offered by Bergey for its 10-kilowatt turbine, is the tubular monopole tower. These towers look like the solid, tapered steel towers holding communications equipment or lights above highway exit ramps. Though expensive and requiring crane erection, they're solid, attractive, and a space-saving option.

Money Is Always a Disadvantage

Excluding what insurance companies term a major "act of God" (physical damage from sources beyond your control, including severe storms), maintenance issues and expense over many years are minimal and lower the overall cost of owning a wind system. Still, the initial cost of installing a wind generator system (as with a solar system) can be a hard pill to swallow. Over time, however, this reliable electricity source—if you research proper installation and local wind currents—will generate enough power to more than make up for the up-front outlay of your hard-earned cash. Don't forget to couple that with the 30-percent federal income tax credit available through 2016. To find more helpful information about home wind-energy projects, go to the excellent Beating High Energy Costs website at www.howtosaveelectricity.net. It offers a free newsletter and lots of wind and solar energy tips, including costs and how long the system will take to "pay for itself." The site even delves into how to buy a residential wind machine or, if you're one of the few who is really experienced in such matters (I do not use the term "experienced" lightly), how to lower costs significantly by building one yourself. And don't forget the detailed financials offered at the My Solar & Wind Estimator website (solar-estimate.org).

A Wind System Requires More Research Than a Solar System

Although to our surprise, and maybe yours too, there is very little difference between wind and solar systems in terms of components. Wind/battery and solar/battery systems are set up in the same way. The key difference (aside from that of the power-generating source) and disadvantage is that wind systems require more intense study, largely due to the feast of turbine options laid upon your table. From there, add in wide-ranging wind-variable conditions from region to region and you've got a bellyful before you even finish the "first course."

With our off-grid power stakes being so high (even with our consistent wind), we only considered a wind turbine as a solar supplement, never as a stand-alone method for powering our home simply because of the complex dynamics involved in choosing a wind system that we could rely on solely to do it all power wise. However, by now you know we are big advocates of backup systems, and the idea of wind combined with solar brought confidence that we could combine the best of both worlds into an all-encompassing system.

TIPS FOR BUYING A RESIDENTIAL WIND TURBINE

1. **Do your research and consider your options.** At this point after your wind assessment, if you're even toying with thoughts of purchasing a wind turbine, focus first on this: the more you learn before you buy one, the happier you'll be with its operational aftermath. The American Association of Wind Energy maintains a directory of small wind-turbine equipment providers. Start by talking directly with manufacturers that have outlets in close proximity who stand behind their products. They must also have an impeccable reputation for product reliability and client satisfaction, be easily accessible by phone or e-mail, and have long-lasting warranties. For example, American-made Bergey (whose products are now available at Lowe's) fits all these criteria, making it a favored personal choice. Although you shouldn't rely solely on the recommendation of your alternative-power contractor, he can certainly point you to some of the best manufacturer options from his experience, especially if he is a totally independent contractor (like ours was), who has no vested interest in any model or manufacturer.

2. **Ask smart questions.** According to the Beating High Energy Costs website noted above, a good residential turbine company should be able to answer all of these quantifying questions to your satisfaction:

    - "For the turbine you are suggesting for my site, what is the annual energy output in kilowatt-hours given an average wind speed of 10 to 12 mph?"
    - "Are you basing the estimated annual energy output on measurements averaged from other *actual* installations of this turbine or on product-testing data gathered in laboratory settings?"
    - "Using the specific wind assessment for my site, how is the turbine's annual energy output likely to differ in practice from your estimates?"
    - "How long have you been making or selling this turbine? How long has this model been for sale? How has this unit been tested for reliable field performance? What is its warranty, and can it be extended?"
    - "How many of these units have you sold, and can you provide me with contact information of preferably local customers I can visit and discuss the turbine's performance?"
    - "What is the safety and maintenance record for this unit?"
    - "Can you put me in contact with at least a couple of experienced local installers who have experience with your systems?" (If you live in a remote location, this is critical because impeccably credentialed, at your-beck-and-call contractors are as hard to come by as a drip-free, soft-swirl ice cream cone during our area's scorching summers. When I asked the Oklahoma-based Bergey

about installers for our area, the representative spanned the continent from Oklahoma to far Northern California to give me one name instantly: Bill Haase. Crikey! What a relief, as he was already highest on our (very) short list.

3. **Get multiple bids.** Before you select your wind-power installer, follow up with my "bullet item" essentials found in Chapter 2. Foremost among them is to get several bids and make sure that your contractor be highly reputable and close at hand for maintenance and repair. As I've mentioned before, just like with your home-builder's work or your solar installer, check the past clientele of potential wind installers (we were fortunate that Bill Haase can do both) as well.

4. **Do your own research.** Once you gather all your bids, research the recommended turbines on your own. Don't just look at manufacturers' websites. Try to find independent online reviews by individuals who have gone through the process and contact some of them if possible. Even better, don't be afraid to scope out other off-grid wind-energy pioneers in your locale. They will not only be empathetic compadres, they will proudly show off their setups and help answer the questions pouring from your uninformed lips, such as the basics of where they purchased and how they installed their machines. If you're like me, seeing is believing, and you'll be able to quickly tell whether a system is laid out to your liking. On the other hand, Gary could determine, often at a glance, when a setup was all wrong for us so we could, as he put it, "dodge a bullet."

5. **Go to Wind Energy School.** To further educate yourself, one great place to go first is Bergey's "Wind Energy School" website (www.bergey.com/pages/wind_school). It offers an array of unbiased articles, such as "A Primer on Small Wind Systems," "An Off-Grid Primer," and "California Consumer's Guide to Buying a Small Wind System." The site also includes a frequently asked questions section, dealer-training workshops (that also allow customers, educators, and government officials to attend), a "90 Second Expert" on essential points of particular topics, and wind maps.

   Last, but not least, it tells you how to purchase the Alternative Energy Institute (AEI) wind course CD-ROM, "Wind Energy and Wind Turbines" for $25.00. Involved with wind energy since the early 1970s and well respected in the industry both in the United States and internationally, AEI provides on its CD a "tremendous amount of training material on all aspects of large and small wind power, wind characteristics, instrumentation, design of wind turbines, electrical aspects, system performance and siting," according to the Bergey Wind Energy School site. You can order the CD directly from AEI, West Texas A&M University, Box 60248, Canyon, TX 79016; telephone: 806-651-2295; fax: 806-651-2733, aeimail@mailwtamu.edu at www.windenergy.org. This CD may be helpful in laying the groundwork needed to form decisions regarding whether wind power is advantageous or disadvantageous for your energy needs.

Wind Turbine 101

Nowadays, wind machines are popping up all over so you are probably familiar with what one typically looks like: a horizontal axis turbine, with a propeller, a rotor, a generator, and often a tail section. Today's models differ from the multi-bladed windmills of old because the newer machines almost all have three blades. Although some have only two blades, they don't run as smoothly and are slightly inferior at turning wind power into watt power. Although most machines appear similar, each model will offer individualized performance depending on location, size, and the wind speed it is built to handle.

COMPARISON CHART OF POPULAR WIND TURBINES

	Southwest Windpower Whisper 100	Bergey Windpower XL.I	Southwest Windpower Whisper 200	Kingspan KW3 (formerly Proven 7)	Bergey Excel
Rated Power	900 watts	1.0 kW	1.0 kW	2.5 kW	7.5 kW DC 10 kW AC (grid-tie only)
Cut-in wind speed (mph)	7.5	5.6	7.0	3.0	7.0
Rated wind speed (mph)	28	24.6	26	26	31
RPM at rated output	1,500	490	900	300	300
Approximate monthly kWhs at 12 mph (on average)	100	188	158	524	900 DC 1,090 kWh AC (grid-tie only)
Rotor diameter (in feet)	7.0	8.2	9.0	12.2	23.0
Maximum design wind speed (mph)	120	120	120	*	134
Turbine weight (in pounds)	47	75	65	771	1,000

Modified/updated from *Got Sun? Go Solar* (compiled from *Bergey Windpower, Southwest Windpower, Solar Wind Works*, and *Home Power* magazine).

* Designed to class-1 wind standards (defined by National Hurricane Centeras 74–95 mph), the KW3 has a unique downwind mechanical feature so the turbine never stops (see page 140) even in major hurricane-class winds.

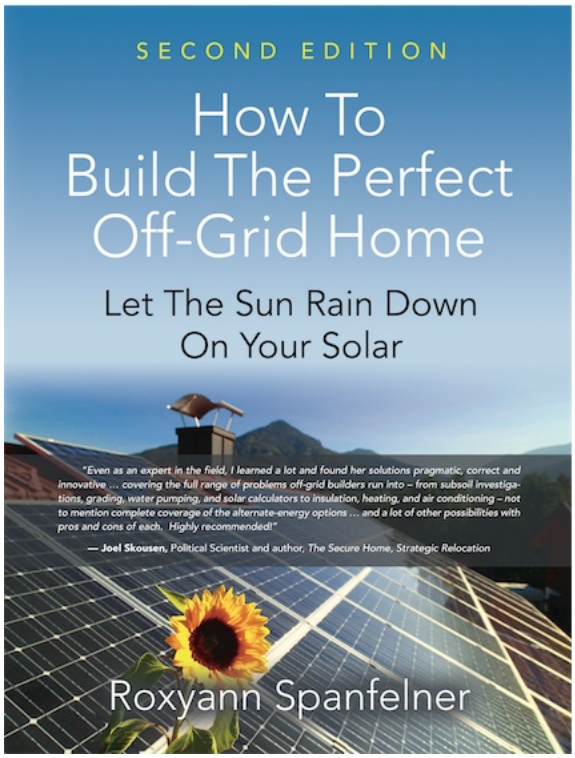
Herein lies the answer to the wind-harnessing "thrill of victory or agony of defeat." First, different machines are intended for use with various wind types. Normally, the "featherweight" classes of wind machine blades are polypropylene, while the big-boy blades—what you need if you have high winds (sidestep polypropylene models for 1,000-watt turbines and up)—are epoxy-coated wood or, better yet, fiberglass. To avoid damage to your venture, install a wind brake mechanism, either mechanical or electrical, to stop the turbine during inordinately bad squalls, which can harm blades, or from frost and ice, which can throw the system off-balance.

Now here are a few turbine-type examples drawn from *Got Sun? Go Solar*. Those with large sweep areas (e.g., Southwest Windpower's Whisper 200) are designed for lighter winds, while other shorter-propeller-blade turbines (Whisper 100) are engineered to take a beating from high hilltop locations (like the spot we chose) even during gale winds. Some deliver the best of both worlds (Proven Energy and

Bergey Windpower), churning away fresh as a daisy while holding on to every petal even in the severest storms but still producing power-packing efficiency in light winds.

While how they handle wind types is chalk to cheese, turbines have diverse cut-in speeds (where some amount of power is generated) and rated wind speeds (meaning where peak execution is met) as well. The useful chart on the previous page, adapted from *Got Sun? Go Solar,* shows these ranges. Further, according to *Got Sun? Go Solar,* although most turbines today start to generate some amount of power at 6–7 mph (again, the cut-in speed), they will not create much useable power under 8–9 mph for a battery-backup system (direct grid ties need an average annual wind speed of no less than 10 mph).

So, what ruler do you measure by when buying? Basically the larger the turbine, the larger the wattage you'll derive. Unfortunately, it takes a larger investment too. My advice here (and *Got Sun? Go Solar* suggests the same) is do what we did with our entire setup: go as big as your pocketbook allows. It gives you more zing, and the big, heavy, slower-moving machines last longer than "tinker-toy" models with smaller price tags.



Let The Sun Rain Down On Your Solar solidifies abstract ideas and dreams into concrete form explaining How To Build And Power A Perfect Off-Grid Home. How? Spanfelner, who built a remote off-grid home with husband Gary 9 years ago, offers practical advice to navigate the complex, perplexing process – simplifying it with step-by-step instructions.

HOW TO BUILD THE PERFECT OFF-GRID HOME:
Let The Sun Rain Down

by ROXYANN SPANFELNER