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Designing For Solar: What Every Architect Should Know

Posted on 18. Jan, 2010 by Rebecca Firestone in Off the Grid, Solar

While researching solar technologies, we at Green Compliance Plus heard from solar installers who all seem to think that architects are hard to work with. So, we spoke with Fernando Valenzuela of Alter Systems in Berkeley about how to design a solar-ready home. Note that only about 5-10% of Alter Systems' customers are owner/architect teams. Usually it's the homeowners approaching them directly because they want to "go solar".

So… why are architects hard to work with? "They have a groupthink… they like design, the look, but they don't understand systems. They ask questions like 'why can't we use this roof' without realizing that you can't split up an array. Their projects aren't always quick, either, and rebates that were designed for may be gone by the time the project gets through approval."

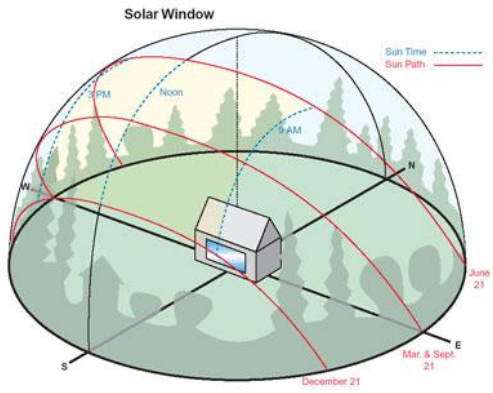
Valenzuela went on to provide various design tips, as well as insights into new technologies, best-of-breed products, the difference between grid-tied and off-grid systems, costs and returns compared with conventional power, financing options, and the importance of grid parity.

Solar Design Tips for Architects

Consider building shape, roof planes, and orientation: With a remodel, people engage with an architect after the house is already built. It's really best to take solar into account and design for it from the start. This may include choosing a lot or site that allows for a good solar orientation. Assuming that you do have some power to determine the shape of the building envelope, just make sure you include a nice un-shaded patch of south facing roof around 20 x 30 feet for your PV arrays. It goes without saying to consider proper solar orientation for the building, of course, if you have the option to do so.

Until recently, a single contiguous area was needed for solar arrays, and many products are still configured to work only if all the panels are installed together as a group. The panels should be tilted for maximum solar angle. Some panels lay flat and others can be tilted up; flat panels are aesthetically preferable and better for the neighbors' attitudes.

Optimize roof tilt: The optimum tilt for the solar panels is your the latitude minus 15 degrees. In California, allow for a south or west facing planar area that is tilted around 20-22 degrees. Utility-scale projects and off-grid systems sometimes use solar tracking devices, but typically residential panels are mounted in a fixed position. The "solar window" is the maximum energy harvesting hours, between 9am and 3pm.



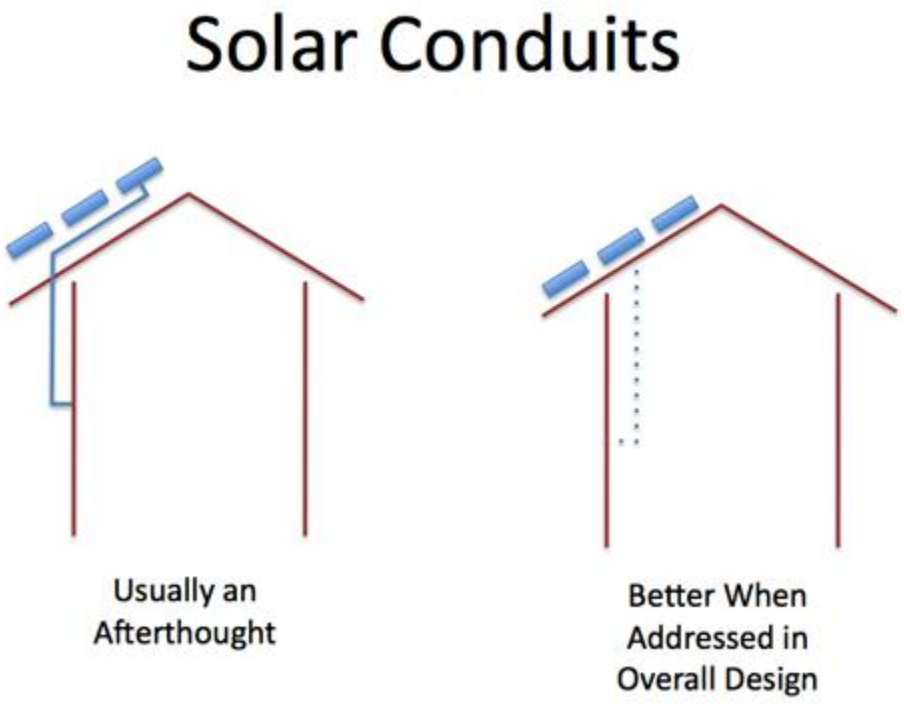
The sun's path across the sky changes according to season.

Assuming that you design includes panels that are built directly into the roof, your roof tilt will determine the panel tilt. “Not too steep, either, ” says Valenzuela. A 30 degree roof tilt is too steep – it’s much harder, and more dangerous, to install the panels. “It works your abs and butt!” laughed Valenzuela. And it’s not exactly “green design” when crews get injured, is it?

The roof tilt also depends on whether you have a grid-tied or an off-grid system, according to Valenzuela.

- Grid tied should be your latitude minus 15 degrees. Grid-tied systems are optimized for summer, because that’s when you’ll get the most energy out of the system, and thus you’ll get more money back at the end of each year.
- Off grid, on the other hand, should ideally be your latitude plus 15 degrees. For off-grid you maximize for winter, because you need the system working even in the worst-case scenarios so that you’re not left in the dark. Basically you want to make sure the system will produce in the winter months.

Allow space for conduits: If solar power is an afterthought, then you may have a visible exterior conduit, which can be less aesthetic than building it into the wall. If you put the conduit under the sheetrock it won’t even show on the outside. But even if you’re not installing solar today, you can accommodate future solar in the design.



Left, a typical retrofit requires routing the conduits wherever you can. Right, allowing a place for solar conduits that's built into the house allows flexibility for future solar.

Be careful with vent placement. “Don’t put vent pipes in the middle of a rooftop solar array. If the pipes stick up too far, they’ll get in the way of the PV panels.”

Make the roofing strong. Roofing should be 2 x 6 or 2 x 10 at 16″ on center for strength. Modern codes want 2 x 4 at 24″ across to conserve materials. If the span is too long, however, this doesn't account for the weight of the people walking on it to do things like install solar panels. For this purpose, spans over 8 feet need thicker rafters. "We do a lot of retrofits," says Valenzuela. "Old buildings in Berkeley for example are often 2 x 4 at 24 off center. For these, we may have to put in a brace."

Keep basic sizing guidelines in mind. The amount of surface area you need for your PV panels depends on how effective the panels themselves are, and how much power the house requires. A rule of thumb might be 500-600 SF of roof (or other area) for the solar array to generate 5 – 7 kW. This covers a lot of places, even desert climates. "Even in the hotter parts of California, with heavy air-conditioning loads, it's not too far off base," according to Valenzuela.

Understand the racking systems. It's good to understand how racking systems operate. "No roof penetrations" are needed. In the future, each panel may come with an independent energy panels with built-in inverters. Innovations include reduced installation time and cost.

Process

Choosing Your Solar Companies: A solar systems company is essentially a contractor/consultant who supplies, specifies, and installs systems. "If your client wants solar power for heating, cooling, electricity, or water heating, then you as the architect will need to establish a good relationship with a company that you can rely on to supply a well-designed system that is appropriate for the programmatic requirements of the home."

"Try to work with a few solar systems companies that you know well, to get standard products and sizes for components. But don't rely on just one company, because some companies are over-scheduled right now and orders are going unfulfilled."

How Long Does It Take? Allow a month turnaround including all permits and paperwork such as rebates.

Customer Experience: So what happens when someone comes to you and says they're ready to go solar? Here's what your clients can expect.

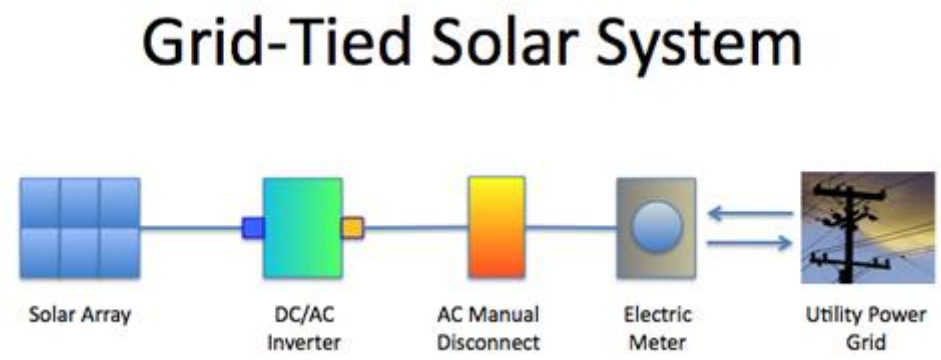
1. *Site evaluation.* The solar consultant will most likely want to visit the house to inspect the roof area, shading, and electrical box. Some houses just aren't suitable for solar. "Usually it's a mounting problem," says Valenzuela. A general rule of thumb for say a 1,200 – 2,000 SF house is to have flat or south facing roof around 20 x 30. Using micro-inverters helps reduce the amount of roof area that you need (read on for more information).
2. *Proposal.* Assuming the house will support a solar system, the owner gets a price proposal. "I have to ask why they're doing it to figure out if it's off-grid, grid-tied, or hybrid system. If they sign off, the paperwork starts."
3. *Permits and Rebates.* Local permits for installing a solar system can take as little as a day or up to around 2 weeks depending on locale. The paperwork for tax rebate programs takes 2-3 weeks.
4. *Installation.* Alter Systems takes 2 days to install, but schedules for 4 days to allow for contingencies such as rain. The owners or occupants can continue to use the home and live in the home while the installation is ongoing.

Grid-Tied and Off-Grid Systems

One basic decision the owners must make is whether to tie their new solar arrays int the power grid. Grid-tied and off-grid systems are totally different animals in some important ways, but as solar power gains mainstream acceptance, it must also be able to integrate smoothly into mainstream infrastructures as well.

- **Off-Grid** systems are the classic "1.0″ of solar renewable energy. Although they tend to be associated in the U.S. with environmental activism, survivalist movements, and early-adopting technology buffs, they're also essential in parts of the world where a centralized power infrastructure either doesn't exist or isn't reliable.
- **Grid-Tied** systems are mainly intended to reduce or eliminate energy bills, as in Net Zero homes. It's a more mainstream market than either the early adopters or the green contingent. A main motivation is likely to be cost savings.

Although grid-tied systems are a newer concept, they are likely to be the wave of the future in industrialized countries. The components of a grid-tied solar system are the panel arrays, a power inverter to convert the direct current generated by the panels into the alternating current used by household appliances, a manual power disconnect, and of course the utility company's usual infrastructure: the meter and switch box.



A grid-tied system is simple and straightforward. There is no need to store power onsite. Power generated is fed directly back into the grid, and home power needs are drawn also directly from the grid.

An off-grid system has more components, because of the onsite power storage requirement. In an off-grid system, the solar arrays feed into a combiner box which balances the inputs from each array. The combiner box combines or branches together the PV arrays/modules and then takes all the power through one set of leads to the charge controller. The controller makes sure your battery is charged correctly, and prevent over-charging.

The advantage to this type of off-grid configuration is the ease with which you can add supplemental power-generation systems such as microhydro or wind turbines. The goal of an off-grid system is to keep the batteries fully charged at all times. If there's a grid tie-in, the battery won't "sell" back to the grid unless it is already fully charged.

Which configuration you choose for your solar system depends on the reason why you're going solar in the first place. Homeowners typically adopt a grid-tied system to save on energy bills, reduce their carbon footprint, and perhaps to show off to their neighbors. Valenzuela cites an estimate from the Journal of Assessors and Appraisers that for each dollar you can shave off your annual home operating costs, you add $20 to the property value.

According to Valenzuela, based on his experiences with his own customers, homeowners might choose off-grid because they're in a remote area, and either it's too expensive to bring the grid out there, or it exists but is not completely unreliable. "Some people do it because they hate public utility companies just on principle," notes Valenzuela. "They're also more likely to be DIY types who are comfortable assembling their own systems," he adds.

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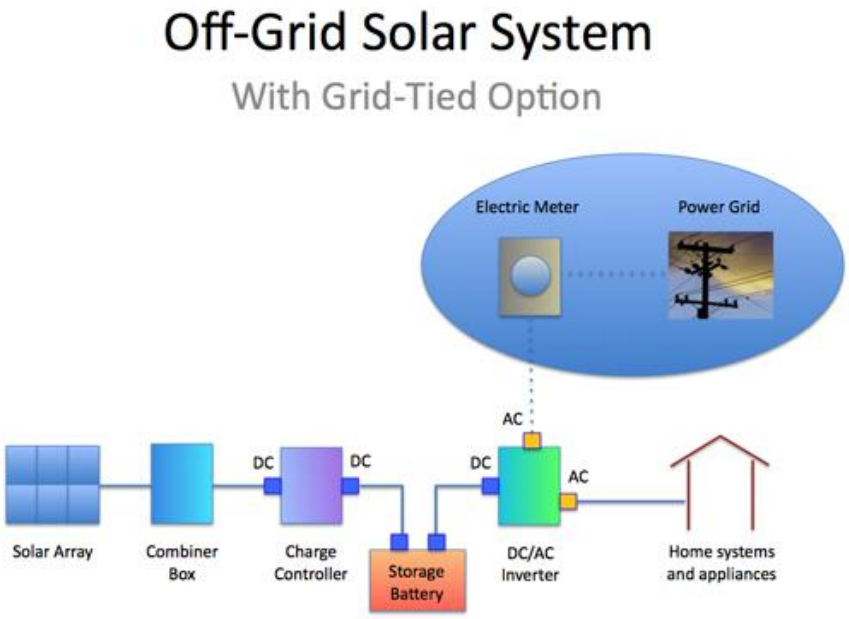
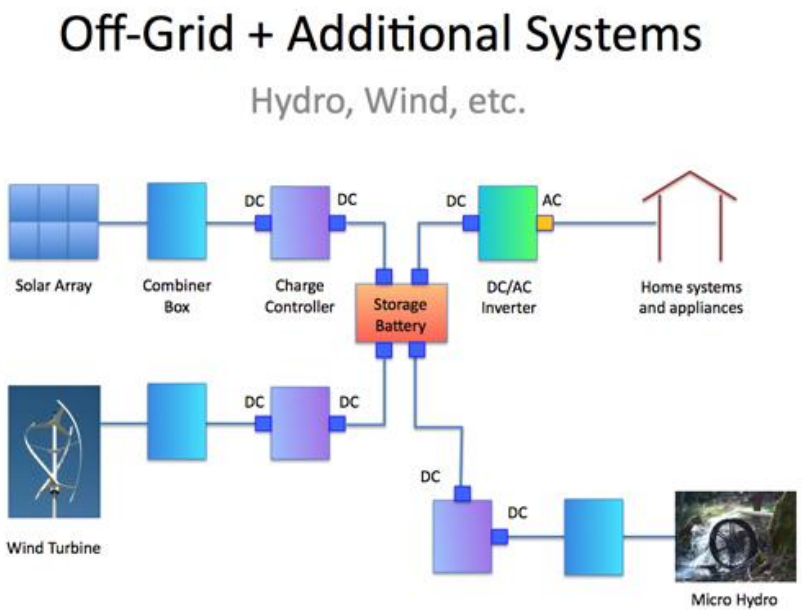


An off-grid system includes an onsite storage battery. It's designed to be self-reliant. The homeowner can add a grid-tie option as shown above.

So what are the pros and cons of each type of solar configuration? Grid-tied systems require less equipment and employ simpler configurations; on the downside, they're limited based on inverter sizes.

With off-grid systems, it's easier to add supplemental renewable-energy systems on the side for things like wind or microhydro.



It's easier to add supplemental power generation systems to an off-grid system with its own battery storage.

Off-Grid for Villages: A typical residential home might need a 6kW system. For sites such as an army base, a remote ranger station, or a farm with multiple buildings, a system called AC coupling can deliver 20 kW or more. Basically it's a way to create your own micro-utility company, and collect power from solar arrays on several buildings, using one central inverter (such as the Sunny Island off-grid inverter from SMA Solar Technology) and a central storage area. "This type of installation is very useful in places like the Caribbean, island countries or places without any infrastructure," says Valenzuela.

Could you implement something like that in a city neighborhood, I wondered? A residential collective of some sort, for people who live in urban areas but still want to have totally independent self-generated power, and who want to pool their money to invest in economies of scale? "You'd have to do all your own wiring," Valenzuela responded. "They'd have to be fairly close together."

Well… with the geek factor in this area of the country, I wouldn't be surprised if it's already happening. After all, if a few homes drop off the grid on a single city block, how would we ever know?

Solar Grid Parity

I didn't even know what this was, but with all the talk about the ROI of solar systems vs. fuel cells vs. high-efficiency but conventional systems, it's a very important concept. Solar grid parity is a tipping point in the energy marketplace when the cost of energy production for solar power will be equal to or less than the cost of generating conventional, fossil fuel-based grid power.

A common comparison is dollars per watt or cost per kWh. U.S. average power prices for last year ranged from 5 – 15 cents per kWh, averaging roughly around 10-11% (businesses were 1 cent cheaper).

This number includes upfront investment in equipment although of course there's debate over how to calculate it and when this momentous day will actually come. 2012 seems to be a common guess, although coincidentally that's also the end of the world, according to the Mayan doomsday calendar).

Prediction: "a number of solar companies will hit a long-pursued industry target of $1 per watt by 2012." This "race towards $1 per watt" means that "within a few years solar panels will be able to generate electricity cheaper than the grid in many regions of the world." (Sunnier regions have a bigger solar payoff, not surprisingly.)

Another claim is that we can reach 2012 grid parity in "almost half the US" and he also notes that there are several ways to calculate grid parity.

Even 4 years ago, solar was still pooh-poohed as a boutique technology for wealthy do-gooders or conspicuous consumers. But that was before tax rebates and stimulus dollars made it easier for new owners to "green" their homes. Other factors include improved component efficiency and a wider array of creative financing options such as these options from SunRun to purchase solar power as a service, to lease the equipment to the owner, or to help owners seek solar financing through local municipal programs.

So, is it a sure thing that in 2012 we'll all be putting PG&E out of business? Doubtful, but there's definitely a sense that price parity is coming, it's just a matter of when. For example, higher interest rates could hurt financing, and if grid prices fall, parity won't be reached nearly as soon. For those who prefer to focus on equipment efficiencies, there's a rather geeky engineering article from BP Solar that discusses current and future efficiencies, including emerging new technologies such organic photovoltaics and nanocomposite solar cells.

The $1 per watt number is disputed as overly simplistic on one investor blog: "PV's competiveness with the grid varies wildly based on the region… The idea that module prices need to come down to $1/W for

solar to be competitive is misplaced at best" because "PV is already at or near parity with the grid in a number of markets". This blog also includes a good discussion of calculating the cost of various types of conventional power, including nuclear.

Solar Financing Innovations

For homeowners who want to finance their solar installation, three good sources are:

- Tax rebates
- Municipal funding options through property taxes
- Bank loans

In the second case above, this is a plan being adopted in some localities such as Santa Rosa. Basically, the city obtains the funds for solar installations at a very low interest, say 3%. The city then loans it out to homeowners at a slightly higher but still reasonable rate, say 7%. The owner then pays back the loan in the form of an extra property tax surcharge every year. If the house is sold, the new owner is responsible for continuing those payments as part of the home's property tax bill, and the new owner of course enjoys the reduced energy bills in the meantime.

"Some owners just pay for it with a credit card," said Valenzuela. I can't imagine plunking down $35-$60,000 on my card but then again, I can't imagine watching the national average of television, either. "Every dollar decrease in operating cost adds an extra $20 in property value," said Valenzuela, "but equity is fake money. So, we don't include this increased equity on our cost/benefit analyses that we show customers in our proposals."

New Solar Products

During the course of our conversation, Valenzuela mentioned some of his favorite new solar technologies. In no particular order, here they are.

Solar forced air heaters. These devices are installed on a south-facing wall or roof and are best used as a complement to other heating systems, a boost but not a replacement. They're small and relatively efficient, at least compared to PVs. A single 8-foot panel is enough to heat a small room. They use no fuel and have no moving parts except a fan to draw cold air into the panel and push heated air out directly into the room. They don't work as well on cloudy days, obviously. And you don't even need fancy PVs or heat collectors: here are some ingenious DIY solar air heaters made from recycled aluminum cans.

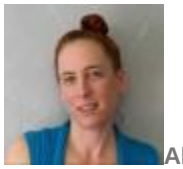
This 8-foot solar wall air heater from ClearDome Solar in San Diego can heat up to 500 SF of residential space.

Micro-Inverters. Green Compliance Plus has mentioned the breakthrough of micro-inverters in a previous post – basically, by having separate inverters for every PV panel in a solar array, you can harvest more energy because shaded panels no longer bring down the performance of the entire array. One maker of micro-inverters is Enphase Energy. Valenzuela waxed almost poetic about Enphase products: “At the recent Green Building Expo, their booth was mobbed while the big players were empty!”

FLEXpower ONE Off-Grid Solution. Valenzuela made special mention of one particular product from OutBack Power called the FLEXpower ONE. He recommended this for total off-grid systems including smaller installations such as boats.

Xantrex XW Grid-Tied Solution. The Xantrex XW from Schneider Electric is recommended for homes that are grid-tied with a battery backup. “It’s not quite as flexible as the OutBack for very small installations, but it’s easier for designers, because it’s a high-quality product and you can scale it up,” says Valenzuela.

But what should architects really know? “Use Enphase!” says Valenzuela.



About the author

Rebecca Firestone has been working in the Bay Area since 1998 as a technical writer, business content developer, architectural filing lady, marketing director, and sorcerer’s apprentice.