

Solar Power

Questions Answered

Richard Stubbs

© Richard Stubbs 2003. All rights reserved.

Introduction	2
<i>Disclaimer</i>	<i>2</i>
How does a solar panel work?	3
<i>How is light turned into electricity?</i>	<i>3</i>
<i>How much power?</i>	<i>3</i>
What can I do with the power?	4
<i>What sort of power is it?</i>	<i>4</i>
<i>I'm on the mains. Can't I have solar power then?</i>	<i>5</i>
<i>So what if I'm not on the mains?</i>	<i>6</i>
How do I design a system?	7
<i>Optimise my loads?</i>	<i>7</i>
<i>Done that, what next?</i>	<i>8</i>
<i>Now then, what size does the battery need to be?</i>	<i>9</i>
<i>I'm getting the hang of this, can I do the controller and inverter?</i>	<i>10</i>
How do I attach it all together?	11
<i>What goes where?</i>	<i>11</i>
<i>How is it wired up?</i>	<i>12</i>
Where do I go for more help?	12
<i>Example Wiring Diagrams</i>	<i>13</i>

Introduction

Solar power – how does it all work? This short eBook tries to answer the most common questions I was asked during my years as a renewable energy engineer.

When I first started installing solar power systems I was amazed. It just seemed like magic to me. Now I understand how solar power is used, but I still have to stop and marvel when I see electrical power apparently falling out of the sky.

Years of designing self-contained solar power systems took me all around the world, from the Scottish islands to the Amazon basin. Solar power can be made to work anywhere in the world.

I'm not going to go into great technical detail because there's no need. Light gets converted to electrical power whether you understand the quantum physics or not. I've just tried to give you all the answers you need in a way that anyone can understand.

There's more information on my website which you'll find at <http://www.solar-power-answers.co.uk>

Please feel free to make as many copies of this eBook as you like and give them to your friends and colleagues. All I ask is that you keep it intact and do not delete or modify any of the hyperlinks.

Disclaimer

Every care has been taken to ensure that the information contained in the eBook is correct. However, it is based on personal experience and may not be applicable to every situation. No responsibility is accepted for any loss suffered, either directly or indirectly, as a result of the information contained in this eBook.

How does a solar panel work?

That's a big question, let's split it into a few smaller ones.

How is light turned into electricity?

It's just another form of energy conversion. Really it's no different to burning wood; energy from the sun is turned into chemical energy in the wood. Burning the wood converts chemical energy to heat energy.

When the sun shines on a solar panel, the photovoltaic effect converts the light energy to electrical energy. The power from the solar panel is proportional to the amount of light shining on it, that is if the light gets twice as bright, you get twice as much power.

How much power?

Well, in direct sunshine at midday, the power reaching the surface of the earth from the sun is a bit more than 1000 Watts per square metre.

Hang on, a thousand what's per who?

I suppose it's bound to get a bit technical. A Watt is a measure of power. It's used for light bulbs. A 100 Watt light bulb uses 100 Watts of power. A square metre is just that, a square 1 metre by 1 metre.

So there's enough power for 10 light bulbs on every square metre?

No. Well, yes but only when it's really sunny and even then you can't get at it all. Remember that the light has to be converted into electricity. Quite a lot of it is lost in this process; some is reflected away and some makes the solar panel hot. Very hot. So all in all between 10% and 15% of the light is converted to electricity, that is 100 or 150 Watts per square metre in full sunlight.

But what if it's not sunny?

Good question. It doesn't really have to be sunny, there's always some sunlight during the daytime, that's how come solar power can work in Britain. If you mean "what about when it's dark", then that takes us onto the next question.

What can I do with the power?

Well, before you ask that question, you really need to know the answer to this one:

What sort of power is it?

In case you didn't know, solar panels don't generate what we call "mains electricity". Mains is 230 Volts AC (117 Volts in the USA), while solar panels generate about 12 Volts DC.

AC/DC – that's a heavy metal band isn't it?

Er, yes, but they're not the same without Bon Scott are they? AC stands for Alternating Current and DC stands for Direct Current. The important differences are that the voltage of an AC source can be changed by using a transformer, whilst DC can't. On the other hand DC can charge a battery whilst AC can't. That's why mains is always AC and car electrical systems are always DC.

So I can't make solar power into mains with a transformer?

No, you need something called an "inverter". But you can charge a battery.

I'm on the mains. Can't I have solar power then?

Of course you can, don't worry. You can connect solar panels to the mains using a "synchronous inverter", and sell the extra power to the electricity company. The government may even give you a grant for doing it.

What's a synchronous inverter?

It's an electronic device that turns DC into AC and matches it to the incoming mains. Then, when there is extra power, it turns your meter backwards.

I'll have one, where do I get it?

Don't ask me, I do *self-contained* systems remember? Have a look at my [links page](#) to find specialists who can tell you more. Ask me another question.

So what if I'm not on the mains?

You might not live in the middle of nowhere but that still doesn't mean you can get the mains. You might need power for a caravan or boat, or a holiday home overseas. Maybe your garage is the other side of the main road and you can't bury a cable. The questions are the same.

What if it's not sunny?

I reckon you know the answer by now. Charge a battery, that's what. Then, when the sun's not shining or you need more power than the solar panels are producing it can come from the battery. If you do it right, during the day the battery will charge up again.

But I want mains, not battery power, don't I?

I don't know, do you? You can get a lot of 12 Volt appliances now, so you might not need mains. Truck accessory people and the like sell them. Have a look at my [recommended suppliers](#) for links. If you really do need 230 Volts AC you can use an "inverter".

That's the thing that sells electricity isn't it?

That's a synchronous inverter, this is a bit different. Instead of being connected to the solar panels, a stand-alone inverter is connected to the battery. It does the same sort of thing except it generates its own "mains" power. Solar power answers has a page all about [inverters](#).

So, a solar panel, a car battery and one of these inverter things then?

If you like, but it won't work very well or for very long. You see, there probably won't be the right amount of power, and the battery won't last very long. To understand more, let me show you how to design a solar power system.

How do I design a system?

Well, you start at the beginning. Actually that's not strictly true, really you start at the end, by optimising your loads. Then you size the battery and solar array, then the controller and inverter. Finally you decide where all the things are going and size the cable.

Optimise my loads?

Yes; before you start designing you need to know that you're designing the right thing. That's what optimising your loads is all about.

So I should start weighing things?

No, not those sort of loads. The load on the system is the amount of power it will have to supply, averaged over time. So optimising your loads is about reducing the number of appliances you have, reducing the time you use them for and picking the appliances with the lowest power consumption.

Why would I want less appliances?

It's like this; every extra Watt of electricity or every extra hour that something's on for is an extra bit of solar panel, an extra bit of battery, an extra bit of controller and maybe an extra bit of inverter. These things aren't cheap; the way to make an affordable solar power system is to do a good job of optimising your loads.

Ok, how do I do it then?

I've done it for you, sort of. There is a pop-up calculator which does the calculations for you on my [design page](#). Keep trying until you get the smallest possible answer.

Done that, what next?

You need to size the array.

Size the array? What's that?

The array. That's the term used for a number of solar panels connected together. There is a maximum practical size for a solar panel so it's normal to connect more than one together for big systems.

Is there another calculator?

Yup, on the [same page](#). Beware though, it's an approximation for the UK only. If I could predict the weather like that I'd be a millionaire.

I need an array the size of Birmingham. What did I do wrong?

That's what I mean about optimising your loads. Reduce your expectations and do it again. Keep doing this until either you realise you can't solar power a blast furnace or you get a sensible answer.

Now then, what size does the battery need to be?

Well that all depends on how many days holdover you want.

Speak English man. What's holdover?

Simple, it's the amount of time that a fully charged battery would be able to power the system without the solar panels. That's your decision.

Great. How do I decide?

It's 3. Well, not necessarily; for critical medical applications it's at least 7, but for you 3 will do. Don't ask why.

And there's a calculator?

Just like before, at Solar power answers there's a [battery sizing](#) calculator.

It says I need 200 Amp hours of battery, so my 500 Amp car battery will do won't it?

A common mistake that, mostly made by the sellers of car batteries. The output of the calculator is in Amp hours. A 200 Amp hour battery can provide 200 Amps for 1 hour, 1 Amp for 200 Hours or anything that adds up to the same. The number on a car battery is cold-cranking amps. A 500 Amp battery can provide 500 Amps for 30 seconds on a cold day. Different altogether. Anyway, what you need is a deep-cycle battery or at the least a leisure battery.

Not a car battery? They're cheap you know.

I didn't believe this myself so I tried it. Take it from me, you'll be lucky if a car battery lasts a month. In a car it's always on charge so it will last for years. In a solar power system it gets discharged daily and will break. Nope, a deep-cycle battery's what you want.

I'm getting the hang of this, can I do the controller and inverter?

That's the next thing. Lucky it's easy, because there's no calculators.

No calculators?

No, sorry, but I'm sure you'll manage. Let's do the controller first.

Do I really need one?

Yes. Well, almost certainly. The only time you don't need one is if you've got a really big battery relative to the size of the solar panel or array.

How do I work it out?

On the back of the panels there is a rating for the *short circuit current*. Multiply this by the number of panels in parallel and that's the rating of your controller in Amps.

I haven't got the panels yet have I?

Oh no so you haven't. You'll have to approximate then. Divide the rated output (in Watts) by 16. That will give you about the right answer. If the total is less than 10% of the battery capacity you may be alright without a controller if it's not going to be left unattended for long periods and you're not using sealed batteries. I wouldn't recommend it though.

What about the inverter?

Even easier. Add up the Wattage of all the mains appliances that will be on at once. That's your answer.

How do I attach it all together?

Get an electrician. Seriously, you need to have a certain amount of electrical knowledge before you start. If you have, then read the instructions before you start and I'll take no responsibility if you set your house on fire. First you have to decide where to put things.

What goes where?

The solar panels need to face the south, or the north if you're south of the equator.

Can I mount them flat?

No, because you'll have to keep cleaning them. Tilt them at about your angle of latitude, or at least 10 degrees.

And the batteries?

Protected from the elements, but well ventilated. They produce hydrogen gas when charging and it's highly flammable.

And the electronics?

Nice and close, preferably indoors. You need to keep the cables as short as possible.

Why do the cables need to be short?

Because they're low voltage cables remember. If you half the voltage then you double the current, so our current is about 20 times what it would be if it was mains.

Why do I care about the current?

Because it determines the thickness of the cables and that determines the cost. Once again there's a [calculator](#) which will help.

How is it wired up?

Pretty much the same as the mains really. The 12 Volt stuff will need thicker cable than you would imagine; use the calculator to get an idea. Earth the battery negative and make sure that the 12 Volt and 230 Volt wiring is kept completely separate.

Why is that so important?

To make sure that you can never have 230 Volts on the 12 Volt circuit, that's why. You could get a nasty shock.

What fittings do I use?

Some mains fittings, some special ones. Look at the [wiring page](#) for more information.

Can you give me an idea?

Of course, look at the sample wiring diagrams on the next page.

Where do I go for more help?

Where do you think, <http://www.solar-power-answers.co.uk> of course.

Example Wiring Diagrams
12 Volt lighting only system.

