

## Low EMF solar systems



**Solar power systems can generate “dirty electricity” and radio frequency radiation, which can cause health effects in sensitized people. We describe which components cause the problems and provide options for how to reduce or eliminate the radiation in your own home.**

*Keywords: solar power, dirty electricity, inverters, interference, EMC, how to*

This article is for homeowners who want to consider their options, whether they already have a solar system or they are about to buy one. It can help the homeowner discuss the issues with a solar contractor. It can also serve as an introduction to this subject for solar contractors.

## **The problem**

Modern solar systems use inverters, charge controllers, converters and other electronics which chops up the flow of electricity tens of thousands of times each second. This is called “dirty electricity.”

The dirty electricity then flows around the solar system. Any kind of wire connected to the system will then act as an antenna radiating the frequencies of the dirty electricity. This is a form of radio frequency EMF (electromagnetic field).

The dirty electricity can turn solar panels, batteries and household wires into radiant sources.

This can cause interference with AM and short wave radio reception, and some people are also affected by it. People who are sensitive to it may have poor sleep, feel irritable and unsettled. A few even have symptoms such as tingling sensations.

Some scientists suggest there are other long term health effects.

For more details, including scientific health studies, look at the articles available through the link at the end of this article.

## **A common misunderstanding**

It is a common misunderstanding that solar panels or batteries themselves generate EMF. They do not. They merely act as conduits for the dirty electricity that comes from other parts of the solar system.

It is like a water faucet. It spews out water, but the water actually comes from somewhere else through the pipe. If you block the pipe, you block the water coming out of the faucet.

It is the same thing with dirty electricity. If you disconnect a solar panel or a battery they will stop radiating, while the rest of the solar system will continue to radiate. If you stop the actual sources of the dirty electricity (such as the inverter) then the whole system becomes inert.

It is crucial to understand this, if you want to understand why the remedies in this article works and avoid trying other ideas that may not bring any improvement.

This misunderstanding is very common – so common that the third season of the popular television series *Better call Saul* made it a centerpoint that batteries are believed to radiate on their own.

## **A simple tool**

Buy a cheap portable AM radio, with an analog dial. The cheaper and simpler the better.

Set the channel selector to the low end of the dial where no station can be heard. This is now an excellent educational tool to “sniff out” radiation from a solar system.

Hold it up against various components of a solar system and listen to the static they create in the radio.

Be aware that this is not a scientific instrument and it won't detect every frequency that the system emits. People who are highly sensitized are often more sensitive than an AM radio.

## **The causes**

In the following we walk through the major components of a typical solar system and describe which of them can cause the dirty electricity. After that we describe what to do about it.

The important components are:

- Solar panels
- Batteries
- Charge controllers
- Inverters
- Optimizers
- Converters
- Wiring

## **The solar panels**

The solar panels convert sunlight to direct-current (DC) electricity. They produce the most electricity when the sun shines directly on them from a clear blue sky. They produce less electricity when it is cloudy or the sun is lower on the horizon. At night they produce no electricity.

Solar panels do not produce any dirty electricity themselves, but can radiate if connected to a source of dirty electricity which backfeeds into the solar panel through the wires.

The exception is solar panels with an attached microinverter. These are sometimes marketed as “AC solar panels.” The problem is the microinverter, not the solar panel itself.

Because of how a solar panel is laid out, with lots of tiny wires spread over the surface, a solar panel is a more effective radiant antenna than ordinary wiring is.

### **The batteries**

Many solar systems do not have batteries. These systems send any surplus electricity out on the grid, and when the house needs more electricity than the solar panels can deliver, it takes the extra electricity from the grid.

Some houses have batteries so they can function during power outages. Other houses are not even connected to the grid at all.

Batteries do not generate dirty electricity by themselves. But batteries can radiate EMF if they are connected to a source of dirty electricity such as a pulsing charge controller. Because of the internal layout of the battery, it is a more effective radiating antenna than ordinary wiring.

Lead-acid type batteries are the best for low-EMF solar systems, as they can use non-pulsing low-EMF charge controllers (see later).

Lithium type batteries must use a pulsing charge controller to taper the charging current. Otherwise the battery may explode. Since pulsing charge controllers produce dirty electricity, it is best to avoid lithium batteries.

### **The charge controller**

The charge controller turns off the electricity when the battery is full. Otherwise the battery will eventually be destroyed. This is the case for any kind of battery.

The simple charge controllers either allow the full current to the battery, or none at all. They do not do any tapering.

The more sophisticated charge controllers taper off the current as the battery is getting full. This is more efficient and for some batteries (lithium especially) it prevents the battery from overheating. Unfortunately, this tapering is done by pulsing the current thousands of times a second, i.e. dirty electricity.

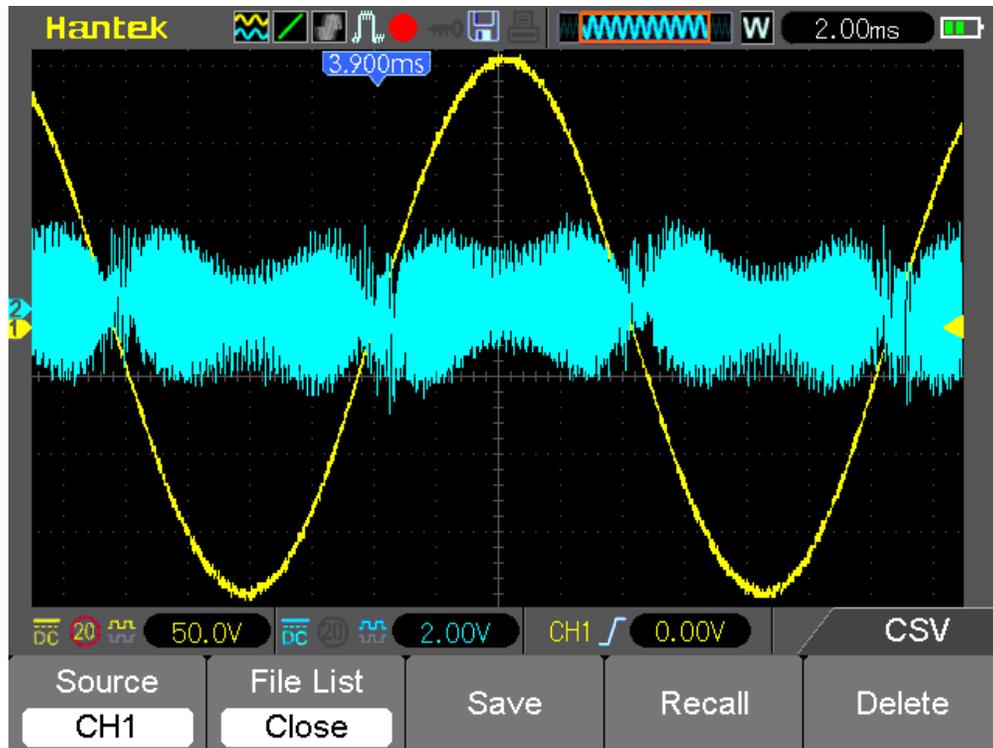
## Inverters

An inverter takes the DC electricity produced by solar panels and batteries and turns it into ordinary AC electricity that comes out of wall sockets and can be sold to the electrical utility.



*Two meters show very high levels of dirty electricity from a high-quality name-brand inverter. (Measured with inverter only, to avoid other possible sources of dirty electricity.)*

Inverters work by chopping up the electricity into pulses and are very powerful sources of dirty electricity. This is the case for all types of inverters (sine wave, square wave, modified square).



*Output from an Exeltech sine wave inverter, showing a powerful 22 kilohertz wave, besides many other frequencies.*

## Optimizers and converters

Some solar systems use optimizers or converters, which change the voltage to make the system more efficient. They change the voltage by chopping the current on and off tens of thousands of times each second. This generates powerful dirty electricity

Some systems have several optimizers/converters, some have just one. Many have none at all.

The more there are of these on the solar system, the more dirty electricity and radiation comes off the wires. They should not be necessary with good system design. The possible financial gain is probably quite modest. They are gimmicks best avoided entirely.

## Wiring

Wiring acts as antennas radiating the frequencies of the dirty electricity. Normal wiring, where the positive/negative or phase/neutral wires are in the same cable are not as effective at radiating as the solar panels, batteries or any wire loops.

## **The remedies**

There are no one-size-fits-all solution to these problems. The remedies depend on the specific situation. It is a lot simpler to design a system to be low-EMF from the start than to modify an existing system.

If there is a person with electrical hypersensitivity (EHS) in the household the requirements are probably more stringent than if the system interferes with a shortwave radio receiver, or if there is just a concern about potential health effects. Some people are so sensitized that it may not be realistic to have a solar system with an inverter on site.

Problems with emissions from solar systems and other electronics are not just a concern for people who are electrically sensitive. Radio amateurs are concerned about interference with their short wave radios. Engineers designing certain types of electronics are also concerned, as these emissions might make sophisticated electronics malfunction.

Engineers refer to it as electromagnetic interference (EMI), and the mitigation work they do as electromagnetic compatibility (EMC).

They have worked on these problems for decades. What is new is that biological systems (humans) can sometimes also be affected, and at levels much lower than what radio amateurs and EMC engineers are concerned about.

The measures listed in the rest of this article almost all come from EMC textbooks (adapted to solar systems). To learn more about these methods see the “Further reading” section at the end.

## **Use a separate power shed**

A power shed can house the batteries, charge controller and inverter. The solar panels can be mounted on the roof of the shed or on a rack next to it.



*Keeping the entire solar system away from the house can help.*

That way all the radiant parts are kept out of the house. There is only a cable going to the house.

This is a much better setup than trying to mitigate a roof-mounted system with the electronics in a utility closet. Distance really helps.

How much distance is needed is unclear. Some highly sensitive people have reported they need at least a hundred yards (meters), though these are the exceptional cases.

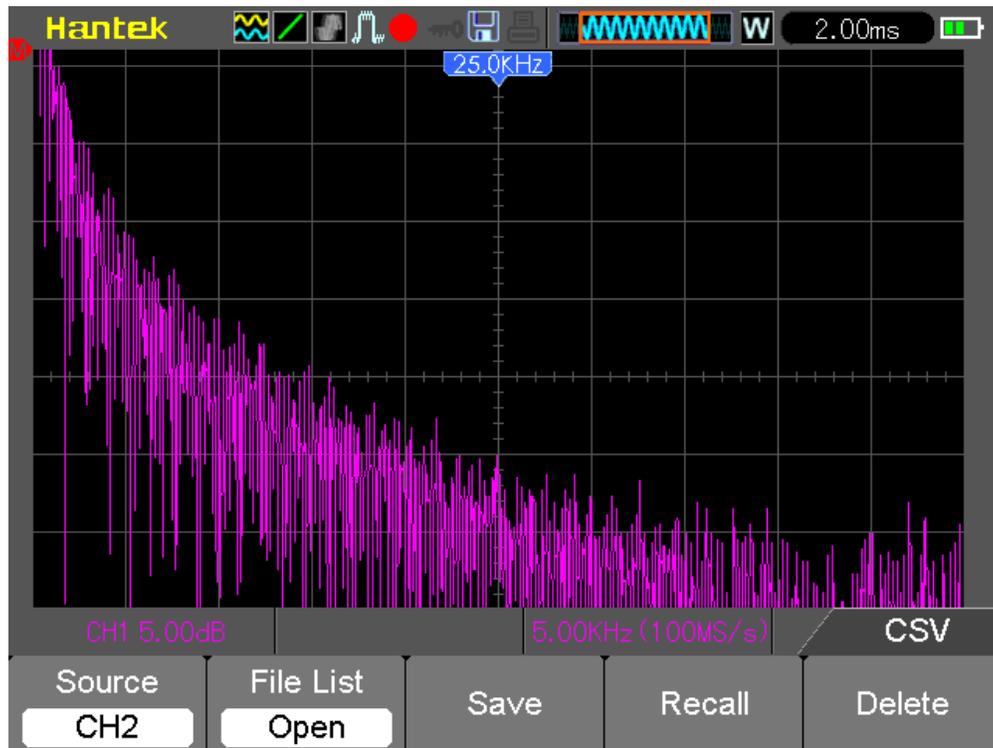
### **Choose a quality sine wave inverter**

The amount of dirty electricity does vary with the brand. The better brands are *somewhat* more concerned about causing interference to radio reception and try to design their inverters with some filtering.

This is what we have heard from radio amateurs. We have not tested this ourselves, and cannot recommend any specific brands

A true sine wave inverter is probably always the best choice, if you must have an inverter. The square wave and modified-wave inverters are probably always worse, as they switch more powerfully and will emit many additional frequencies

(called “harmonics”). They also tend to be more primitive with less concern about interference.



*The wide range of dirty electricity frequencies generated by a square wave inverter. This plot is from a spectrum analyzer.*

Some solar systems use micro inverters. They are much smaller than a regular inverter and can only handle a small wattage. They are typically mounted directly on a solar panel, so a system may have many micro inverters instead of just one.

We recommend never using a micro inverter. Having more sources of EMF and dirty electricity is generally a bad idea. Also since these inverters are so physically small and price sensitive, they may produce more dirty electricity than a well-designed large inverter (we have not tested this).

No matter which inverter you choose, expect it to emit powerful dirty electricity and also radiowaves directly from the box. If you are sensitized to these things, you don't want an inverter inside or on top of your home.

The inverter is probably the biggest issue in any solar system.

## Use low EMF charge controllers

There are a few charge controllers which do not pulse the current as the batteries are getting filled. The ones we are familiar with are:

- ASC (Specialty Concepts)
- Flexcharge
- Sunforce

These controllers are only suitable for lead-acid batteries (flooded, gelled, AGM). They should not be used for lithium type batteries, which must use controllers that taper the current.

We don't know of any commercially available controllers that taper the current without pulsing it. (We know of a custom-built one.)



*Three low-EMF charge controllers: ASC (left), Flexcharge (top) and Sunforce.*

If you need a larger charge controller (more amps) you can use multiple controllers in parallel. Each controls its own set of solar panels.

## **Avoid wire loops**

Many solar systems have a big wire loop around the solar panels. The plus connector of one solar panel is connected to the minus connector on the next panel and so on for several panels. This loop can be quite large, perhaps covering nearly the entire roof.

A wire loop is the same as a coil with just one turn. Coils are used to intentionally produce EMF in electronic systems.

In a rack, each solar panel should have its own cable (with positive and negative) going to a collection box (string combiner).

For large systems, try to have a cable serve a single row only, with the minus routed closely along the positive wire.

As the current moves in opposite directions inside a cable, the fields around the wires will have opposite directions too and thus largely cancel each other out. This is why it is so important that they are as close together as possible. This sort of wiring may require the system to use a lower voltage, such as 12, 24 or 48 volts.

## **Twisted wires**

Twisting the wires can reduce the radiation from them by about 90%. The positive and negative wires for the same DC circuit are simply twisted around each other, with about one twist per two inches (5 centimeters).

It also helps to twist the wires for AC circuits (i.e. phase and neutral). If possible, even do it with the regular household wiring.

Do not twist wires from different circuits together.

## **Steel conduit**

Steel is a good material to shield the types of frequencies generated by solar systems. Ordinary steel electrical conduits will work well (called EMT in America).

## **Smart grounding**

It is a common myth among electricians that to control problems with interference, the solution is to ground as much as possible and wherever possible. This is a crude way to stop electrical shocks (instead of finding the cause) and it can

actually make interference (radiation) worse because it can create loops and unbalanced circuits (net current).

It is good to ground the chassis of the equipment.

Grounding the negative wire and the neutral wires should be done in one place only, which is what the electrical code specifies too, if you read it closely.

People have gotten into trouble when they started “grounding” the negative/neutral wires to various metal around the house, such as metal pipes, steel roofs, steel air ducts and much else. This caused loops and stray electricity (net current), making things much worse.

### **Filters**

You could install a filter on the cable that brings the solar electricity into the house. That will dampen the dirty electricity.

Effective filters are bulky and costly. An expert will need to be consulted to choose the correct filter. It must be chosen for the frequencies to be dampened, and sized for the wire configuration (amperage and phases).

These kinds of filters are commonly used by military and corporate sites with sensitive equipment, such as data centers.

You would need a filter that dampens at least 20 dB, and preferably much more than that.

The Stetzer capacitors (“filters”) should NOT be used. They modify the sine wave of the AC current from the inverter in a way that is likely to eventually damage the inverter. These things are much too primitive.

### **Kill switch**

A standard AC wall switch breaks the phase wire, so current cannot flow on a circuit. However, in a household with dirty electricity, the neutral wire can still carry a low voltage that is modulated with the dirty electricity.



*A kill switch (left) and a regular light switch near a door to a bedroom.*

A solution is to install a kill switch. A kill switch is double-poled and disconnects both the phase and the neutral wires. One or two are typically installed by the door to a bedroom and disconnects all circuits in all the walls of the room.

Besides blocking dirty electricity, a kill switch also lowers the electric field in the room.

### **Community solar**

An alternative to having your own solar system is to sign up for a larger system shared with other households. A whole neighborhood may share such a system instead of each house having their own rooftop solar system.

Such community systems may also serve a larger area, where some households sign up and others do not.

Besides the health benefits, there are other possible advantages with such a setup. It may be cheaper to install one large system in one place, rather than several smaller systems on individual houses. When a roof needs to be replaced, there is no solar system which has to be taken down and reinstalled, which is a major extra expense.

Some utilities offer “100% renewable” plans. That may be the simplest way to go.

### **The radical options**

There are two radical options:

- Shut it down
- DC-only solar (analog solar).

An obvious solution is to simply shut down the solar system and instead rely on grid power. It is sad to have all that money invested in something you can't use, but people have had to do that.

At least it is usually easy to do. Turning off all the breakers for the system will usually make it inert. The exceptions are systems that have optimizers or microinverters mounted on the individual panels. They have to be physically disconnected.

Be aware that if the system has batteries, they will decay if they are not charged regularly. Lead-acid type batteries may only last a couple of months. Lithium-type batteries can last much longer.

The other radical option is to use pure analog DC-only solar. This was common for off-grid solar houses in the early 1990s before inverters became dominant.

Pure DC-only systems are not for everyone, as they have a lot of limitations compared to a typical modern grid-connected solar system.

With a DC-only system:

- You can't sell surplus electricity to the grid
- You have to use batteries
- You have to use DC lamps and appliances
- Power is more limited

Using such a system is a radical change in lifestyle. It is definitely not as convenient as unlimited power from the nearest electrical outlet.

Several people with severe electrical hypersensitivity live with analog DC-only solar, including this writer, but we do not recommend doing it unless you have to.

We have several articles about such systems on the link at the end of this article.

## **Bad ideas**

This is a collection of ideas that may seem good, but are not.

**Stetzer filters.** These are just a capacitor that sits between the phase and neutral wires on AC wires. They force the current and voltage on the wire out of phase, which is really hard on an inverter. It will likely be destroyed within a short time.

**Shielding.** Shielding is usually the first thing people think of. It is better to eliminate the source whenever possible. Shielding the wires using steel conduit can help. It may help to shield the inverter and charge controller, if they are inside the house, but we don't know of anyone who has actually tried. A major concern here is that they may overheat. Shielding the solar panels is not realistic.

**Grounding.** Grounding is for protection against short circuits and lightning, it will not work for dirty electricity and EMF. Inappropriate grounding can make the problems much worse by creating loops and stray electricity.

**Harmonizers, etc.** A number of companies sell pendants and other devices that they claim somehow makes EMF harmless. They do not make any difference on any scientific instrument. The explanations the sellers give on how they supposedly work are very dubious and seems mostly written to confuse the reader. We consider these devices to be purely placebo.

## **How much modification is really needed?**

How many of these measures are really needed? It depends on the situation, both what kind of system is/will-be installed, the layout of the property and the sensitivity levels of the people living there.

There is an interesting case story in the *QST* magazine for radio amateurs (Brock-Fisher, 2016). The problem here was interference with his short wave radio, which was affected by the higher harmonics from the inverter, not the fundamental inverter frequency itself. That made his project a lot easier (and still not easy). Someone who has direct health effects may need much more stringent measures.

Some radio amateurs went with analog DC-only instead (Gauger, 2012).

## **Working with contractors**

The issue of dirty electricity and its potential health effects may be totally new to a solar contractor. New or not, it will probably be received with the same enthusiasm as any company being told their only product, their bread and butter, has a serious flaw.

Solar contractors may be reluctant to install a system that is different from what they are used to. They are comfortable using certain equipment and methods they know work and they know how long time it takes to install. It is natural if they are reluctant to do things differently. If it does not work out, it may reflect on their reputation. And it is harder for them to bid on a contract, so it may work better if they bill by the hour.

Also, you may want to order the important components yourself, so you are sure you get the right equipment.

### **Suggested readings**

Brock-Fisher, Tony. Can home solar power and ham radio coexist?, *QST*, April 2016.

Fink, Dan. Charge controller buyer's guide, *Home Power*, December 2011.

Gauger, Dave. Going totally green: moving your station off the grid may be easier than you thought, *QST*, February 2012.

Gerke, Daryl and Bill Kimmel. *The EDN designer's guide to electromagnetic compatibility* (2005 edition).

KA7OEI. The solar saga – part 1: Avoiding interference (why I did not choose microinverters!), kazoei.blogspot.com, March 2, 2016.

Loftness, Marv. *AC power interference handbook (3<sup>rd</sup> edition)*, American Radio Relay League (ARRL), 2007.

### **More information**

For more articles about dirty electricity from solar systems and the available science on the possible health effects, go to [www.eiwellspring.org/demenu.html](http://www.eiwellspring.org/demenu.html).

For articles about low-EMF solar systems, especially analog DC-only systems, go to [www.eiwellspring.org/offgrid.html](http://www.eiwellspring.org/offgrid.html)

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