Solar Panels

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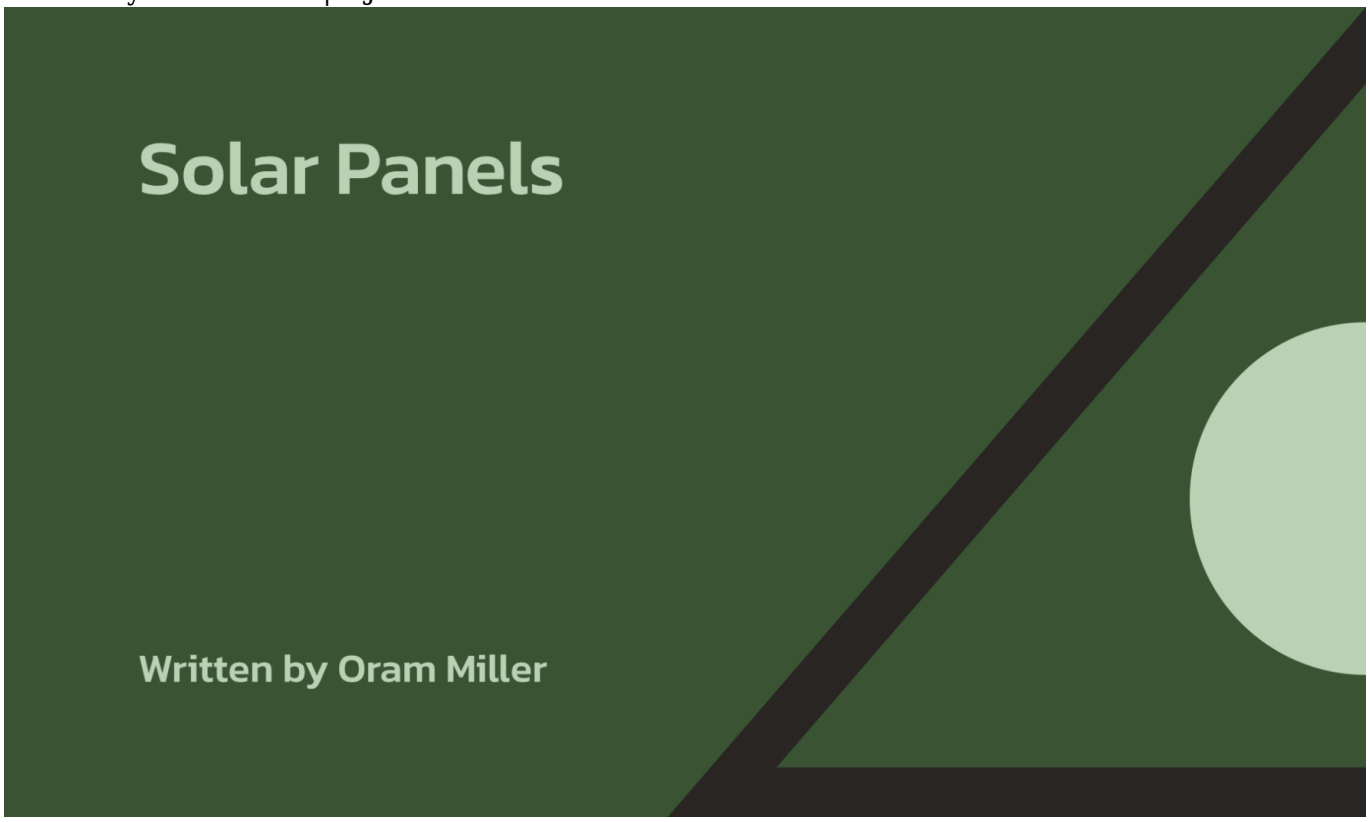

*To read a **Photovoltaic Solar Panels Factsheet** on the Building Biology Institute (BBI) website, click here.*

Introduction to Solar Panels

Most people are under the impression that all EMFs are produced locally around a wireless device or power line. That is normally the case, but when it comes to solar panels and the EMFs associated with them, that is not necessarily true. This is because the primary forms of EMFs associated with solar panels are dirty electricity and radio frequencies (RF), types of EMFs that extend far from the sources that cause them, each in their own way.

How Solar Panels Are Designed

Solar panels, also known as photovoltaic or PV systems, have two components. The first is an array of panels mounted on brackets under open skies (with no trees or buildings nearby) on rooftops or on the ground. These arrays produce low voltage DC electricity from sunlight striking panels containing minerals that convert sunlight to electricity. Those panels themselves do not produce significant amounts of EMFs that we consider to be harmful to most people.

That electricity then travels down wires in a metal conduit usually at 24 Volts DC (Direct Current) to the second component, a box called a string inverter mounted next to the main breaker panel. The job of the inverter is to convert that low voltage 24 Volt DC electricity to a form of electricity usable for powering lights and appliances, which is 120 Volts AC (Alternating Current). The inverter takes

the electricity created by the solar panels and sends it at 120 Volts into the main breaker panel. From there, if you do not have a battery back-up system (see below), that electricity goes directly to your electric utility through a process known as “net metering”.

A newer alternative design to a string inverter is micro-inverters mounted underneath each solar panel on the roof (or ground). In that case, low voltage DC electricity produced by each panel is converted to 120 Volts AC right at each panel, and that 120 Volt AC electricity is collected and sent in the metal conduit down from the roof directly to the main breaker panel at the side of the building.

Micro-inverters were invented to avoid the reduction in electricity production by the whole array when a tree casts a shadow on even one of the solar panels. As the sun moves across the sky in the late afternoon, the electricity production of one panel could reduce by, for instance, 50%. With string inverters, unfortunately, the production of the entire array of panels is then reduced by 50% even if the other panels continue to be in full sunshine.

Micro-inverters, on the other hand, allow each panel to operate independently. That means, if one of twelve panels has a shadow on it reducing its output by 50%, the remaining panels, which still have full sunshine, continue to produce full electricity (to the extent that they can depending upon the decreasing angle of the sun as it moves across the afternoon sky). The most prominent brand of micro-inverter on the market today is Enphase.

A second popular solar inverter today is SolarEdge HD Wave with DC Optimizers. This is a string inverter mounted on the side of a house next to the main electrical panel, however, DC Optimizers form a network of low voltage cables connected from the inverter up to each panel on the roof that manages their electricity production in such a way that each solar panel is independent. That way, shadow covering one panel will not reduce the output of other panels still in full sunshine, just as micro-inverters do.

That is why Enphase and SolarEdge HD Wave are two of the most popular brands of solar inverters on the market today.

In either case, electricity from a micro-inverter or any string inverter is then usable by the electric grid. If you are a customer who does not have a battery back-up system, you cannot use that electricity directly nor in a power outage. However, if you are a customer with a battery back-up system, you can now also access this electricity directly from the panels and batteries while the power from the grid is available as well as during an outage.

You can either own your own equipment and store that electricity or sell it back to your electric utility through net metering. These arrangements can get complicated and are beyond the scope of this article, but essentially electricity produced by solar panels is either used directly by the homeowner when the sun is out and it is not cloudy, or stored in batteries for use when it is cloudy and at night. Or, electricity produced by panels is sold back to the utility, in which case the homeowner continues to get electricity from the utility but at a fixed rate over the term of a lease, usually twenty years, and that customer does not experience electricity price increases (during the duration of the lease) that other utility customers can and do experience.

What Types of EMFs Are Produced by Solar

Panels?

If electricity comes down from the roof on wires in metal conduits as low voltage DC to a string inverter on the side of the building, there are no significant magnetic or electric EMFs that enter the house from the rooftop panels nor from along the route of the conduit.

If, on the other hand, electricity comes down from the roof as 120 Volt AC electricity from Enphase micro-inverters, there would still not be significant magnetic or electric EMFs coming into the house from that conduit. This is because a magnetic field would be avoided due to the fact that the AC current traveling down from micro-inverters on the hot wire in the conduit would be equal to the current flowing back up to them on the neutral wire within the same conduit. This phenomenon is explained in the next paragraph.

Whenever we have AC current flowing on a wire in one direction, there is a magnetic flux field circling around that hot wire in a clockwise direction. However, when we have the same amount of current traveling back a second wire, called the neutral, in the opposite direction right next to the first wire, then the magnetic field of the second wire, which circulates around that second wire in a counter-clockwise direction, cancels the magnetic field circling around the first wire the other way. The two criteria we follow to avoid magnetic fields in circuits are therefore met: the two wires are side by side in the same path and the current loads on each wire are equal such that the two rotating magnetic flux fields are the same size and therefore they almost fully cancel each other. This is discussed in detail in my Article on Magnetic Field EMFs in the second section entitled, “How AC Magnetic Field EMFs Are Created”.

There would also not be any electric field EMFs from a wire carrying 120 Volts inside this metal conduit from Enphase micro-inverters because the conduit would be grounded at one end and it would be continuous along its entire route. When that is the case, that metal sheathing would contain electric fields produced by voltage on the hot conductor inside of it. This is discussed in detail in my Article on Electric Field EMFs.

In this way, two of the major EMFs we deal with are taken care of by the use of metal conduit containing hot and neutral wires with balanced current loads coming down from panels. (This is only even a consideration when 120 Volt AC electricity comes down from Enphase micro-inverters located under solar panels.) Again, when the electricity coming down the hot wire in the conduit is low voltage DC current to a string inverter on the side of the house, then that form of electricity does not have significant magnetic nor electric fields in the first place because it is low voltage DC electricity, not line voltage (120 Volts) AC electricity.

Of course, there would be a magnetic field coming through the wall from the string inverter itself on the side of the house, as is the case with any “point source” of magnetic fields, such as a transformer, motor or breaker panel. This magnetic field from a string inverter, however, would drop off quickly within a few feet, just as with other point sources.

In the case of an inverter, the magnetic field would also not be present at all at night after the sun goes down and the inverter stops producing electricity. Since a string inverter is usually mounted next to the main breaker panel, this is an area of the house that already has high indoor magnetic fields extending a few feet into living space from the main electric panel and electric utility meter. We advise that clients not sit, sleep or stand in the part of a room where the main electrical panel is mounted, and that would also go for a string inverter mounted on the exterior wall next to that equipment.

Radio Frequency EMFs from Solar Panels

Thus, the first two types of EMFs we deal with, magnetic and electric fields, are not usually a problem with solar panel/PV systems.

It turns out that the other two types of EMFs that we deal with, namely radio frequencies and particularly dirty electricity, end up being the main types of EMFs that we encounter from solar panel/PV systems.

Radio frequencies come into play when you "net meter" with your electric utility, regardless of whether you lease your panels from a company or purchase and own them yourself. When you net meter, the electricity produced by your solar panels is all sent to your electric utility, but if the amount of electricity you produce on a monthly basis by the panels on your roof exceeds the amount of electricity you consume, you are providing a net amount of electricity each month to the utility. You either are not charged for the electricity you use, and in some contracts you actually receive a check from the utility (such as when you own the equipment on your roof and house). At the least, your rates do not increase.

Again, the details of such arrangements are learned in your particular case by contacting your electric utility and the various companies in your area that provide leases where they net meter with the local electric utility. The leasing company can install their equipment on your roof and side of your house, including Enphase micro-inverters and SolarEdge HD Wave string inverters. In that case, they own the equipment, they obtain all permits, they apply for rebates that you receive, and they get paid by the electric utility for extra electricity produced by their panels above and beyond what you use, but at least your rates are locked in for the duration of the lease. Contact local solar contractors for the details.

Solar companies that install their own equipment on your house must know on an ongoing basis how much electricity their panels are producing. This information is nowadays sent to the company wirelessly from a transmitter inside their inverter or from a transmitting electric meter that the solar company installs on the side of your house. When micro-inverters are used on your roof, a transmitter is usually located in the combiner/interface box (see below). These transmitters usually send data to a nearby cell tower at a regular interval, such as once to four times an hour, or more regularly than that.

As an alternative, in those parts of a city where cell service is weak, some contractors will install a non-transmitting electric meter that conveys its data to your router using an Ethernet cable to your router. The information is then sent over the Internet to their home office. At one time, Sunrun allowed its customers to do this using a Locus L-Gate 100 non-transmitting electric meter that uses an Ethernet cable to connect to the router inside your home. At least that was the case in 2016 on a house here in Los Angeles (Verango was the local leasing company, which is no longer in business, while Sunrun was the vendor that installed and owns the equipment, including the Locus meter). Sunrun is still in business and may continue to offer the Locus L-Gate 100 non-transmitting meter for their equipment if requested by you, the customer, instead of a wireless electric meter.

Other companies, such as Solar City, (now owned by Tesla) has over the years used a string inverter made by Fronius that has a transmitter that sends its data wirelessly four times an hour via a Wi-Fi signal to a gateway wireless device located inside the home. That gateway in turn transfers the data received from the wireless transmitter on the Fronius inverter to the homeowner's router over an Ethernet cable, and from there the data is sent over the Internet to Solar City's home office. Now that Tesla owns Solar City, I do know that Tesla continues to use Wi-Fi for its inverters (I have

measured Wi-Fi signals coming off a Solavari-brand inverter in a Tesla system).

Some electric utilities, such as Los Angeles Department of Water & Power (LA DWP) a municipally-owned electric utility where I live and work want to monitor for themselves data being sent by the meter used by solar companies. DWP therefore requires its net metering customers to have a second meter on the side of their house in addition to their own electric meter for measuring your house's electricity usage. This is in addition to the solar company's transmitting meter (or the Locus L-Gate 100, if you can convince your solar installer to install it). DWP's second meter sends data regularly to DWP's headquarters, using a nearby cell tower (rather than to a nearby smart meter since DWP has not yet installed neighborhood mesh networks of smart meters in their service area–most of their electric meters are still analog meters because they are a municipally-owned electric utility and do not have the budget to install a mesh network of smart electric meters).

LA Department of Water & Power will then also replace your older generation house analog DWP electric meter with an ERT (Encode, Receive, Transmit) digital Itron-brand electric meter that is monitored monthly by a DWP technician who comes to the street outside your house and collects a month's worth of data through a handheld device. I have found that while ERT electric meters installed by DWP on new houses and houses with electrical upgrades do transmit a weak RF signal that is generally not detected beyond a couple of feet from the meter outdoors, and a much smaller distance inside the meter location, DWP's ERT Itron electric meters do not transmit a strong RF signal like a smart meter because it is not part of a smart mesh network, meaning, there are only analog meters on neighboring houses and thus not a mesh network to receive a smart meter RF signal. That is why a tech needs to come to the house once a month to read an ERT meter.

I should also add that you are not allowed to have an analog opt-out electric meter if you have solar panels and you therefore net meter with LA DWP, although LA DWP does not technically have a smart meter network in the first place to opt out of like neighboring Southern California Edison does.

Customers in Southern California of Southern California Edison, on the other hand, do not need a second smart meter if they have solar panels and net meter with Edison. Edison reportedly trusts the data being sent to them by the solar company's meter or inverter. However, Edison customers who net meter due to having solar panels are not allowed to opt out of Edison's smart meter program and are therefore required to have Edison's smart electric meter.

Customers of San Diego Gas & Electric who have solar panels and who net meter are likewise not required to have a second SDG&E electric meter, as that utility also trusts the data being sent to them by the solar company for net metering customers with solar panels. SDG&E, however, also now requires net meter customers to have a smart meter and does not allow them to opt out of their smart meter program.

Dirty Electricity EMFs from Solar Panels

The biggest EMF issue with solar panels, however, is not RF. It is dirty electricity, also known as DE. This form of EMF is comprised of higher frequency transient voltage spikes above 60 cycles per second (Hz), which is the frequency of electricity on typical house wiring. In fact, the fundamental frequency of dirty electricity coming from many solar system inverters is much higher, at 20,000 Hz (or 20 kiloHertz — kHz). That would then have harmonics at 40 kHz, 60 kHz, and so on. This is demonstrated on spectrum analyzer tracings I have obtained on my oscilloscope from inverters at several client's homes that you can see in my article, "Spectrum Analysis and Oscilloscope Tracings of Harmonics from Photovoltaic (PV) Grid-Tied Inverters," accessed here.

My profession defines dirty electricity as the electric and magnetic field components emanating from circuits and plugged-in cords into living and work space of any frequency above 60 Hz. These higher frequency electric and magnetic fields did not exist before 50 or 60 years ago. They come from such devices as electronic dimmer switches, energy-efficient light bulbs (CLFs, older LEDs, and some halogen fixtures), variable speed motors for furnaces and pool pumps, computers and other electronic equipment, and many solar system inverters (except Enphase and SolarEdge HD Wave). These newer electronic devices, which did not exist more than 50-60 years ago, inject large amounts of dirty electricity onto the electric wires in houses, which unfortunately spreads from house to house through the neighborhood electric utility grid.

Loose connections of hot, neutral and ground wires in outlets, lights switches, other junction boxes and breaker panels as well as loose connections in electric utility grid equipment outside your house can also cause significant amounts of dirty electricity from the micro-arcing or micro-sparking that those loose connections produce. William Holland of My Quiet Home in Arizona and California has been tightening these loose connections in outlets, switch boxes, light fixtures and panels for several years now and notices a significant reduction in the "fuzziness" of the sine wave of the house electricity on his oscilloscope, discussed below, which he sets up in the kitchen along with a plugged-in Stetzer meter when he starts his work to monitor the progress as he tightens circuits. This demonstrates a significant reduction in the dirty electricity for the house when he is done, and electrically hypersensitive clients report noticing the reduction. Contact William on his website or text him at (818) 292-1271.

Read more about dirty electricity in my article, Higher Frequencies of "Dirty Electricity" EMFs.

In fact, dirty electricity is the hardest form of EMF to measure and mitigate. It is indeed emitted from the device that produces it into the surrounding air, such as dimmer switches and solar panel inverters. However, most of the dirty electricity these devices produce travels on electric circuits throughout the house riding on the 60 Hz sine wave of conventional electricity, both downstream on the circuit and upstream on the circuit from the source. That dirty electricity then radiates several feet into living space. It travels primarily on the hot wire, but it can also travel with current on the neutral wire and to a much smaller degree, on the ground wire. DE can then hop from circuit to circuit traveling up the hot wire of the circuit with the dirty electricity source to the panel, then down the hot wire of other circuits throughout the house, emitting through the wall several feet into other rooms. But it does not stop there. Dirty electricity can even travel up the hot wires of the electric utility service cables back to the neighborhood electric utility transformer and pass from that house to neighboring houses that way.

Thus, dirty electricity from your solar panel inverter can and will travel throughout your house, emanating off hot wires in walls and electric cords you plug into outlets, even when lights and appliances are turned off. The electric field component of dirty electricity enters your living space up to six feet from circuits in walls and from plugged-in power cords. It bothers many electrically-sensitive people.

Likewise, you will also have the magnetic field component of dirty electricity radiating into your rooms when current travels on metal paths of the house grounding system, including the incoming metal water service pipe and TV cable, and from grounding paths within the home if you have neutral-to-ground wiring errors. We can repair all of these problems.

Dirty electricity from solar panels is created in the process of converting low voltage DC 24 Volt electricity made by photovoltaic panels up to 120 Volt AC electricity to feed into each house's electrical system. Some brands of inverters are better at making that conversion without producing electronic "noise" than others. Many brands of solar inverters on the market produce high levels of

dirty electricity. We often measure readings of 1800-1900 Graham-Stetzer Units at outlets when we use our Stetzer dirty electricity plug-in meters, with similar readings measured with Greenwave, AlphaLabs and Satic model plug-in meters. I can measure these very high readings in outlets throughout a client's house. High dirty electricity readings from solar panel inverters does drop significantly after dark when the inverter stops producing electricity, whether that inverter is on the client's house or on a neighbor's house (when the client does not have a battery back-up system).

You can also see dirty electricity as "caterpillar fuzz" on the sine wave of AC electricity measured at an outlet with an oscilloscope as well as on a spectrum analyzer. Normally the sine wave of 60 Hz house electricity as seen on an oscilloscope should be clean, in the form of a single undulating wave, but higher frequencies of dirty electricity add "fuzz" to the sine wave. When sources of DE are reduced and removed, including by tightening up outlet, switch and panel wire connections, when dirty solar panels stop functioning for the night, when dirty pool pump motors or electric power tools stop running, and when whole-house and plug-in DE filters are added, that fuzz diminishes significantly on the sine wave on an oscilloscope and higher frequency spikes on the spectrum analyzer flatten out.

How Do You Protect Yourself from Dirty Electricity EMFs Caused by Solar Panels?

What is surprising is that I will often measure high DE levels at outlets throughout a house even if solar panels are on a neighbor's house but not atop my client's house. That client needs a whole-house dirty electricity-reduction device, such as the SaticShield Power Perfect Box, to filter out the DE coming into their electrical system from a neighbor's dirty solar inverter. Choose the Super Duty model.

If you are not electrically hypersensitive (EHS) and want to install solar panels, you should install this same Satic Power Perfect Box at your own house. Choose the Super Duty Power Perfect Box when you have solar panels, regardless of what brand of inverter you choose.

I mentioned Enphase and SolarEdge HD Wave with DC Optmizers above as the brands of inverter on the market today that have the lowest DE levels compared to other inverters on the market. They do not produce zero dirty electricity levels, but the way each company has engineered their products makes them low in electronic noise, which we know as dirty electricity.

Sunny Boy in Germany is another inverter manufacturer that has been aware of dirty electricity over the years and is said to have designed their inverters to minimize this effect. Models sold under the SMA label are reportedly similarly low in producing DE.

Dirty Electricity EMFs from Battery Back-up Systems

Another important consideration, however, is whether you add a battery back-up device to your solar panel system. These are made by Tesla, Enphase, SolarEdge and a host of other companies. They manage power use from multiple choices of power and provide back-up power in an outage. They automatically switch between providing power for your electrical loads during the day from either the electricity coming into the home from your electric utility grid or from the electricity being

produced by your solar panels on your roof, or directly from the electricity you have stored into your batteries. Which source provides power to your loads depends upon how much current is being drawn by loads and which source is the most efficient at the time. When power is drawn from the electrical grid, power made by the solar panels will go into the batteries and when the batteries are topped up, the excess electricity from the panels will go to the grid.

The downside is that these combiner/interface devices tend to generate dirty electricity (DE) all the time, day and night, onto your circuits. This is because they are AC coupled. If you install one of these back-up batteries, you will likely be injecting DE onto your electrical wiring 24/7. You will certainly require a whole-house DE-reduction device, such as the SaticShield Power Perfect Box or the PQFilter 1 or 2 contained in an EMFSafeSwitch remote circuit cut-off device (to shut off power to circuits we identify in bedrooms to avoid electric field EMFs where you sleep), along with possible additional plug-in filters in various outlets throughout the house, as needed.

If you install Enphase micro-inverters or a SolarEdge HD Wave inverter and want a back-up batteries, be sure to couple your inverter with the battery back-up made by Enphase (to match with their micro-inverters) or SolarEdge (to match with SolarEdge's string inverter). Do not substitute another back-up battery system, such as the Tesla Powerwall, with your Enphase or SolarEdge inverters because other company's back-up batteries produce dirty electricity and the battery back-up made by SolarEdge does not.

We have been told by a representative of SolarEdge that they design their entire suite of components to operate off of one inverter, using DC-to-DC couplers and MOSFET components to keep overall dirty electricity levels low. Other manufacturers use older IGBT technology, which causes dirty electricity. SolarEdge chooses the components they use to avoid the non health-related problems that dirty electricity (known to engineers as "electromagnetic interference" or EMI) produces, such as audible noise in high quality music speakers, and other electronic-related issues. Similarly, Enphase back-up battery systems have reportedly been cleaner relative to dirty electricity in the past (however, see below regarding DE and their Envoy device).

We are grateful that SolarEdge, and similarly, Enphase, have made the design decisions they have because it means their products produce much less dirty electricity than their competitors, which helps our more sensitive clients to have PV systems without significant dirty electricity (however, see below regarding Enphase's back-up batteries and DE).

I measure elevated dirty electricity levels with every Tesla system that I have measured, both their Solavari brand inverters, which would stop producing dirty electricity at night if a Powerwall battery was not present, and their Powerwall, which operates round the clock through an interface/energy management box.

Recently, however, I have become aware that the combiner device that Enphase uses for their back-up batteries has a component within it called Envoy (and reportedly also newly called the Gateway). Unfortunately, my building biology colleague, Eric Windheim, BBEC, EMRS, BBNC of Windheim EMF Solutions in Sacramento, California reports measuring DE from Enphase's Envoy/IQ Gateway. He has videos of this on his oscilloscope in client's houses on his website. I have spoken with a solar installer who says the Envoy is part of the combiner box used with Enphase's back-up batteries, which cannot be used without the Envoy device.

I was also told by the solar installer that California's Title 24 building code requires that rooftop solar panels must be able to be shut off at ground level by firemen in case of a house fire and that for Enphase micro-inverters, that requires the presence of the Envoy device at ground level to shut off the rooftop micro-inverters even if you do not install Enphase's back-up battery system. That

means that Enphase's PV solar systems are no longer devoid of dirty electricity as they were in the past now that the Envoy system needs to be installed as part of it whether you get back-up batteries or not. I will explore this.

For now, if you are electrically sensitive and want to risk installing solar panels even with the possibility that you may react to the low dirty electricity levels that these company's inverters produce, for now only go with SolarEdge HD Wave.

Should You Install Solar Panels?

Whether you should install solar panels on your own house and whether you should add a back-up battery depends upon whether you are electrically hypersensitive (EHS) or not. I have EHS clients who call me up and say they moved into a house with solar panels or had them put on their own house thinking they could tolerate them, and now they cannot be in the house when the solar panels are running. Plugging in Greenwave, Stetzer or other capacitor dirty electricity-reducing plug-in filters does not always help these individuals. Nor do the whole house dirty electricity-reducing devices in every case. For other EHS people, there are those who have been able to use Satic systems with their solar panels with success. It all depends upon the person and their degree of sensitivity.

My advice to electrically hypersensitive, EHS clients is that if they do not already have solar panels and are thinking about installing them, they should reconsider and decide not to do so. I have seen too many EHS people make that decision and then regret it. You can not easily get out of the contract and take a solar/PV system off a house once it is installed once you have signed a lease.

In my opinion, if you are electrically sensitive, don't take a chance with your health. Avoid solar panels altogether to prevent possibly reacting to them once installed. Save on your electricity bills in other ways.

If, on the other hand, you are not that electrically sensitive and want to have solar panels, then only enter into a contract with a company that installs SolarEdge HD Wave inverters. You also want to avoid being locked into equipment that has to send out a wireless signal several times an hour to connect with the home office. Then have an electrician install a whole house Satic DE-reduction system and supplement with plug-in Greenwave filters, if needed (according to your plug-in DE meter).

If you choose to own your own equipment, on the other hand, purchase an inverter from SolarEdge HD Wave or Sunny Boy/SMA and have an electrician install a whole house Satic DE-reduction system. Supplement with plug-in filters as needed.

Important note: Kim Lear of the Greenwave company states, "Greenwave filters and other dirty electricity filters that utilize capacitance technology should NOT be used in buildings being powered by a generator (for example during power outages). If you have a generator to provide electricity during power outages or at other times, make sure to UNPLUG your Greenwave filters while the generator is operating. You can plug them back in when power to the grid has been restored and the generator is no longer running."

Likewise, Adam Leavitt of the Stetzer company states: "Stetzerizer filters should not be used with a generator. The added capacitance from the filters tricks the voltage regulator of a generator into thinking it needs to output higher voltages. This can damage the filters, other electrical devices, and ultimately the generator itself. This shouldn't be a great concern for a short duration (a monthly

test/maintenance cycle, for example), but it would be best to remove filters from home outlets whenever there is a power outage of unknown duration.”

Then be aware that after all these precautions, you are taking a chance that you still could react to the dirty electricity that will still be there to some extent, even if it is filtered with a Satic system.

Finally, remember that solar panels themselves do not emit much in the way of EMFs from their location on your roof, especially at night when the sun is not shining. Therefore, they can be placed on the roof above your bedroom in almost all cases. However, bear in mind that certain highly electrically sensitive people do report that they are still bothered by solar panels on the roof above their bedrooms even at night when they are not operating. I tell these clients that they are well advised to not put solar panels on their house or purchase a home that has them in the first place.