Photovoltaic Electrical Systems

Electromagnetic Exposure Issues & Overview of Configurations

Summary

Photovoltaic (PV) power generation systems as well as other alternative energy producing systems (e.g. wind generators and gas power, on-site generators) are not recommended for people who are experiencing electromagnetic sensitivity and especially for people displaying the symptoms of Electromagnetic Hyper-Sensitivity (EHS). Asymptomatic people are cautioned to evaluate all the pros and cons before moving ahead, especially as pertains to the generation of unwanted EMF radiations and effectiveness of filtration options offered by various system purveyors for dealing with these unwanted radiation
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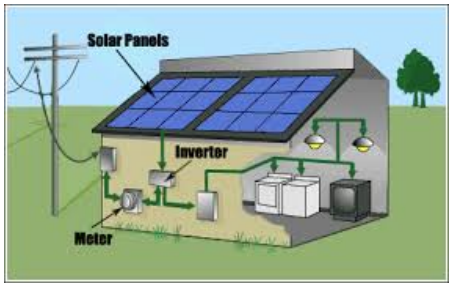


Technical Issues Associated with PV Systems

Alternative energy producing systems create ElectroMagnetic Interference (EMI), popularly termed Dirty Electricity (DE) which is broadcast in the air in the vicinity of the inverter and charge controller (if battery backup is part of the system) and is also carried to the living space by the electrical wiring of the building.

With multiple power source systems (e.g. power grid, a PV system, on-site generator), this noise can be amplified by system configuration. Resolution by installing after-market controls is difficult.

There are after-market DE filters (known as Resistance-Capacitance Filters) which can diminish this noise. These filters are installed in parallel by plugging them into electrical outlets. However, the efficiency of noise reduction varies depending on PV equipment brand and model and on the electrical system characteristics in the building served by the system. Since EHS symptoms can be frequency specific, what works for one individual may not work for another.

Testing of Resistance-Capacitance filters has shown that while these filters do eliminate some DE frequencies, this is accompanied by generation of new DE frequencies.

In-Line or Pi filters (also known as Capacitance-Inductance filters) appear to be the most effective filter. However, they are placed in series with the problematic PV source supplying electricity to the house, so they must be able to handle the full amperage of the source. This makes the filter more expensive and requires an electrician for installation.

Be aware that add-on filters that were not part of the original equipment are at risk of being removed by PV service personnel who do not understand their function and may be suspicious that they are responsible for the service problem they are trouble-shooting. You will need to be vigilant during service calls to make sure your add-on filters are not disconnected.

Filtration of DE is a very technical and complex topic. PV equipment manufacturers' filters are designed for their specific system and would be the most efficient filtration for the noise that system creates. The two manufacturers we talked to were not filtering for biological benefit, but rather against interference with other electronics. They were totally unaware of the need for advanced DE filtration to protect people. The awareness of these manufacturers is probably representative of the industry as a whole. The issue of EMI (DE) generation by PV systems was reported at an IEEE conference 22-25 Nov 2016 in the paper–

Electromagnetic interference in photovoltaic system and mitigation of conducted noise at DC side. https://ieeexplore.ieee.org/document/7848138

Noise caused by inverter has spread to the disturbance both conducted and radiated emissions. In addition, the EMI can be transferred from one mode to another mode; this means that conducted EMI can be transferred to radiated EMI and vice versa.

Additional research is found in the paper: ***EMC Evaluation of Off-Grid and Grid-Tied Photovoltaic Systems…*** at: https://www.researchgate.net/publication/312332845_EMC_Evaluation_of_Off-Grid_and_Grid-Tied_Photovoltaic_Systems_for_the_Brazilian_Scenario

…concerning emissions of radiated and conducted electromagnetic disturbances on mains DC and AC lines. Current standards and tests showed that some frequency spectrum bands such from 150 kHz to 5MHz it is the more affected by conducted disturbances and from 30MHz to 200MHz it is the more affected by radiated disturbances, by the two main types of photovoltaic generation systems: Grid-Tied and Off-Grid applications. The concern is….

In addition to DE, another issue that plagues alternate power systems with more than one generator is unwanted grounding system current flow that is likely to generate objectionable AC magnetic fields in the home. The potential health effects of pulsing magnetic fields are amplified in such conditions.

Unwanted current flow and the attendant AC fields are not correctable by DE filtration. Grounding problems are of two types:

1. Electrical system grounding errors in your house or even neighboring houses. Current on the electrical grounding system will cause broadly distributed magnetic fields that accentuate the effect of Dirty Electricity already on the wiring (i.e. DE from the PV system, personal electronic equipment and DE that enters your electrical system from the utility system). Grounding errors are time consuming to mitigate. Ground currents from neighbors are not within your control.
2. Multiple generating sources in a building complicate grounding, therefore, grounding errors are more likely. For example, utility electricity source and one or more alternative power sources like a PV system and/or a generator.

Moving forward, it is important for the Institute for Building Biology & Ecology and people it serves to expect more from some manufacturers in terms of DE filtration than they are currently delivering as standard product. This will be accomplished by consumers asking informed questions about DE generation and the effectiveness of DE reduction by built-in filtration methods. Companies will design solutions based on customer demand; if no one demands safer products then it is unlikely that manufacturer research & development will address this issue.

As for grounding errors, that is in the realm of electrical codes. Electrical codes typically deal only with fire and personal shock issues, not Dirty Electricity or objectionable current flow on the grounding system. Some electricians have been introduced to these issues through the Building Biology Institute, but unless electrical codes and electrician education are changed to reflect these problems we are in an uphill battle.

It is valuable to note that PV systems do not require a "Smart" Meter. Any style of utility meter, analog or digital, that measures electricity usage will work. The PV grid-tie inverter connects to the power panel and the utility meter connects on the other side. A smart meter emits bursts of pulsed microwave radiation all the time. The World Health organization (WHO) ruled this type of radiation a possible human carcinogen (May 31, 2011).

The American Academy of Environmental Medicine, an organization representing environmental medicine MDs, released a letter on Jan 25, 2012 to the Public Utilities Commission of California speaking to wireless radiation. The most important passage is this: *Chronic exposure to **wireless radio frequency radiation** is a preventable environmental hazard that is sufficiently well documented to warrant immediate preventative public health action."* (https://www.aaemonline.org/emf_rf_position.php)

Health Issues Associated with DE

More than ten years ago it was estimated that 3% of the US population was electro sensitive and up to 35% had symptoms of Electromagnetic Hyper-Sensitivity (EHS). Today these figures are surely higher with the ever increasing proliferation of electronic devices with power-switching non-linear loads producing DE, and the almost universal use of wireless technologies.

Is DE a health hazard? While research and case studies to date have not been extensive, there is growing sufficient evidence that high frequency voltage transients can produce negative biological effects. Here is some of this evidence:

- **Cance**r – *American Journal of Industrial Medicine*, 51(8): 579-586, 2008
- **Diabetes** – *Bioelectromagnetics*, 25(3): 160-166, 2001; *Proceedings from the International Conference of Childhood Leukemia*, London, September 6-10, 2004; *Electromagnetic Biology & Medicine*, 25: 259-268, 2006; *Electromagnetic Biology & Medicine,* 27: *135-146, 2008*
- **Neurotransmitter levels** – *Electromagnetic Biology & Medicine* (online), Informa Healthcare, January 18, 2013
- **Asthma** – *Archives of Pediatrics & Adolescent Medicine*, 165(10): 945-950, 2011
- **Multiple Sclerosis** – *Proceedings from the International Conference of Childhood Leukemia*, London, September 6-10, 2004; *Electromagnetic Biology & Medicine*, 25: 259-268, 2006
- **Headaches** – *Proceedings from the International Conference of Childhood Leukemia*, London, September 6-10, 2004
- **Improved Teacher Well-being and Student Behavior** – *Science of the Total Environment*, April 21, 2008; *Proceedings from the 3rd International Workshop on the Biological Effects of Electromagnetic Fields*, Kos, Greece, October 4-8, 2004
- **Childhood Leukemia** – *Medical Hypothesis*, 56(3): 290-295, 2001
- **Attention Deficit Disorder** – *Journal of Developmental and Behavioral Pediatrics*, 32(8): 634, 2011
- **Amyotrophic Lateral Sclerosis (ALS)** – *Medical Hypothesis*, 74(6): 1086-1087, 2010
- **Symptoms of Electromagnetic Hypersensitivity (EHS)** – *Proceedings from World Health Organization Workshop on Electrical Hypersensitivity*, Prague, Czech Republic, October 25-26, 2004; *Science of the Total Environment, November 1*, 2011

The International Institute for Building Biology & Ecology believes that harm from electromagnetic radiation does not need to be conclusively proven for action to be taken. This means that in the absence of scientific consensus the Precautionary Principle needs to be invoked where scientific investigations have found a plausible risk. It is at this point that the public health should be protected with biologically-based radiation exposure standards.

Remember that DE occurs in an intermediate range (2 kHz – 100 kHz) between the lower power frequencies (called ELF) and the higher radio frequencies (called RF). The International Agency for Research on Cancer (IARC) has classified both of these—ELF magnetic fields (2001) and RF microwave fields (2011)—as Group 2B Possible Human Carcinogens.

It is interesting that in its conclusion the *World Health Organization* (WHO) *Environmental Health Criteria 238—Extremely Low Frequency Fields (2007)* stated:

> *"Acute biological effects have been established for exposure to ELF electric and magnetic fields in the frequency range up to 100 kHz that may have adverse consequences on health."*
>
> *(This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the International Commission of Non-Ionizing Radiation Protection, the International Labour Organization, or the World Health Organization.)*

Residential Alternative Energy Systems

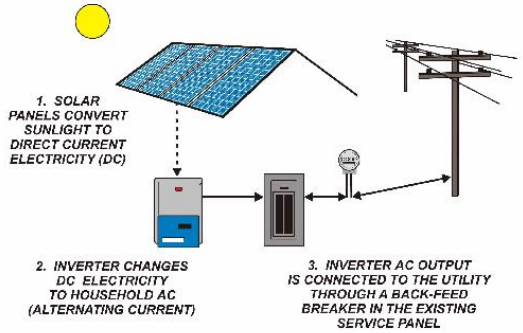
As more research is forthcoming, the International Institute for Building Biology & Ecology believes it will add to and confirm with more certitude that dirty electricity presents a health hazard, and government and industry should take steps to help mitigate this type of electromagnetic radiation.

Types of Solar Electricity Generation Systems[1]

[Also called Photo Voltaic (PV) Systems]

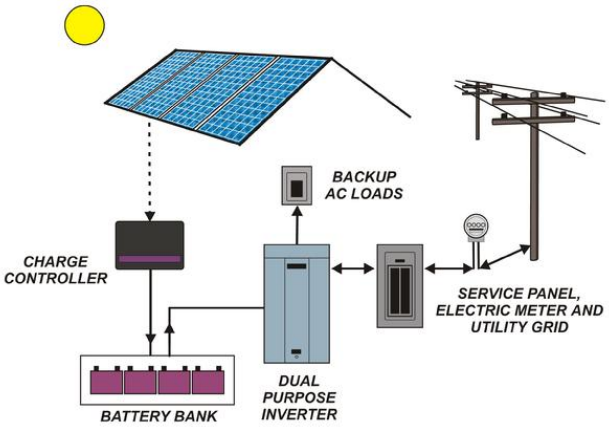
1. GRID-TIE (BATTERY FREE)

The simplest and most cost effective PV design for most sites is the "Grid-Tie" (sometimes referred to as intertied or utility-interactive) system. This system does not provide backup power during a power outage (even if the sun is shining). Power you generate in excess of your usage at any moment is fed back into your utility's electrical grid and offsets the cost of the power you consume when the PV system is not generating. The inverter shown in the picture is the primary source of DE.



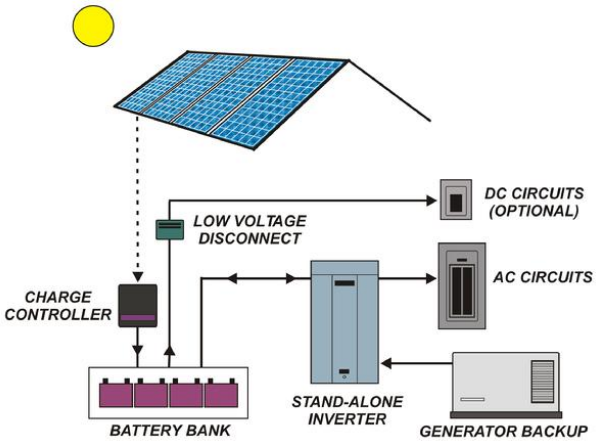
2. GRID-TIE WITH BATTERY BACKUP

The Grid-Tie With Battery Backup system also feeds back unused electricity produced to the electric utility grid as with system #1. But this system has the added ability to store energy in an on site battery bank for use in the dark hours or for use during a utility service interruption. During a service interruption the batteries provide power to a few selected or critical applications like the refrigerator, freezer, some lights, phones, alarm system. With this benefit comes increased complexity, cost and maintenance requirements. The battery charge controller shown in the picture is another source of DE.



3. STAND-ALONE or OFF-GRID

A building with this system is not connected to the utility electrical grid. The Off-Grid or Stand-Alone PV System incorporates a much large amount of battery storage than system #2 so there is enough capacity to provide power for a certain number of days (and nights) in a row when sun is not available. The array of solar panels must be large enough to power all energy needs at the site and recharge the batteries at the same time. Most Off-Grid systems also have more than just PV generation and could include Wind and/or Hydro power. A hydrocarbon powered generator (natural gas, propane, gasoline or diesel) is often used for emergency backup power and to recharge the batteries when needed.



[1] All images courtesy of Aladdin Solar, LLC serving areas of Minnesota

Types of Inverters Used in Photovoltaic Systems

The type of inverter is determined by the generation objectives of the PV system. Inverters can be divided into three broad types listed below.

Inverters are typically a single box containing the required components to meet the objective and located near the main electrical panel in home or alternatively near the solar panels typically on the roof in most home installations.

Stand Alone Inverter
This inverter is used in isolated systems (not connected to the utility grid) where the inverter draws DC energy from batteries charged by photovoltaic arrays. Many stand-alone inverters also incorporate integral battery chargers to replenish the battery from an AC source such as a fossil fuel powered generator.

Grid-tie Inverter
This is the most prevalent PV system on residential homes. This inverter is specifically designed to match phase and frequency with utility-supplied grid power. Additionally, grid-tie inverters are designed to shut down automatically upon loss of utility supply primarily for reasons of safety for utility workers. This PV system will not provide backup power during utility outages.

Inverter Location

Traditionally, the inverters has been located at one point in the system, usually near the circuit breaker panel. A more recent development is the micro-inverter which is located below each solar panel. Low voltage DC from the panel goes into the micro-inverter and is converted to 120/240 volt AC. This arrangement reduce the magnitude of current to be transmitted and allows the panels to be further away from the house. The 120/240 volts is then sent to the circuit breaker panel where it is tied into the utility grid. Of interest with the roof located micro-inverter approach is the ability to avoid having a single point inverter in a location that exposes some area of the house to the unwanted radiations emanating from the inverter.

However, newer solar panels produce higher voltage, so the PV panels can now be located away from the house without using micro-inverters. Because of this PV panels can be ground mounted away from the building where there is the best sun exposure independent of building location.

With the ability to have remote location of the PV Panels, all the electronics (including the inverter) can be moved away from the house to lesson the inherent EMFs. Additionally, in the event of a house fire, roof mounted PV panels are a shock hazard and may prevent the firemen from chopping holes in the roof. With PV panels on the roof the firemen may let the house burn until the roof falls in then pour water through the roof hole.

Battery Backup Systems Need Another Inverter

This inverter is designed to draw energy from a bank of on-site electricity storage batteries, convert the DC to AC which is exactly matched to the phase and frequency of the utility grid so that excess energy can be exported to the utility grid. These inverter produce their own DE. This is in addition to DE produced by the inverters used to convert the solar panel DC to AC.

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