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Solar Monitoring Systems Help Drive Home Photovoltaic Efficiencies

Myriad considerations influence what elements should be woven into a given solar installation

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Unfortunately, many owners find that, over time, inefficiencies creep into their solar systems. In turn, an owner can become disappointed with the system's performance, question the return on investment and grow frustrated with the false promise of a "green" energy solution.

However, solar monitoring technology can serve as a system owner's insurance against potential inefficiency issues. Guaranteeing that the owner is aware of and satisfied with the system's performance through an accurate monitoring structure helps ensure a long, happy relationship between owner and machine. As such, the solar monitoring system is one of the most critical aspects of a solar design and should be addressed early in the design process.

Determining the communication infrastructure's configuration is of paramount importance. Ease of use, data accuracy and timeliness of information all play into an owner's comfort level. Does the owner prefer a simple stand-alone monitoring system with an on-site display, without the fuss of worrying about an Internet connection? Or, does the owner want Web-enabled access to the system's information to take advantage of features such as remote monitoring and automatic performance alarming?

There are many questions to be answered when selecting a solar monitoring system, but one element is definite: The better the fit, the higher the satisfaction level. This article offers descriptions of common system configurations and potential features available for residential and commercial PV systems.

Residential monitoring

Ensuring that the overall system works properly with a monitoring system is important when discussing the system design with a solar system provider. When selecting inverters and monitoring systems, compatibility has to be ensured - a task normally performed by the solar installer. It is therefore important for the homeowner to select an installer that has this experience.

Although it is a good idea to ask some basic questions - such as whether the monitoring system can handle multiple inverters - in general, there are two main types of residential solar monitoring system configurations to consider: direct and remote.

Local inverter monitoring is typically the lowest-cost solution because it requires the least amount of equipment. A simple display, usually mounted near the solar array, gives the owner instantaneous AC output, as well as the cumulative daily and lifetime solar production of the system in kilowatt hours. The display may also include DC voltage, AC voltage, DC amperage and other information, depending on the type of inverter system used.

Most inverter manufacturers also provide software that can be installed on a local PC. The PC connection can either be wired or wireless. Both wired and wireless systems provide instantaneous performance information, historical data regarding the system's performance and important failure alerts. The main drawback to these solutions is that the PC has to be powered on at all times.

Monitoring a solar system remotely requires a more complicated installation, but it can provide a more convenient method of tracking a solar array's performance. The lowest-cost remote monitoring solutions replace the PC with a data logger that connects directly to the inverter, sometimes referred to as inverter-direct monitoring. The data logger performs the same tasks as the PC in the local monitoring case, but with much lower power consumption.

One advantage of inverter-direct monitoring is the ability to read fault codes that, in the case of a failure, indicate why the equipment is not operating properly.

With a remote monitoring configuration, a system's performance information is sent through an Internet connection and is usually accessible anywhere through an interactive Web interface. Some systems even allow access to performance information through a Web-enabled phone.

The advantage of such a system is that the user does not have to be at home to access the system's current and historical performance information, and notifications can be sent to any Web-enabled device, in case of a system failure.

A remote monitoring system may send information from the solar array in one of two ways: in real time or in batches. For matters such as system faults, real-time communication provides instantaneous reports, making immediate remedies a possibility. Other information, such as long-term statistics and trends, may be sent in batches on a pre-set schedule (hourly or daily, for instance). Some systems allow the user to choose when the information is transmitted, while others come with these functions pre-set.

Optional features

In addition to deciding whether to monitor the system directly or remotely, a solar owner will also want to consider a few optional features, such as load meters, weather stations and revenue-grade energy meters. The added functionality achieved with these extras could further boost confidence and overall satisfaction with the solar system.

Revenue-grade energy meters. A solar system's inverters are not required to perform energy metering, and even if metering is included, there are no requirements for accuracy. But if a solar owner wants to take advantage of the benefits of performance-based incentives, such as the California Solar Initiative, it is always better to have a separate revenue-grade energy meter.

This meter is not the utility meter, but a separate meter that tracks only the solar generation. This allows the owner to participate in renewable energy credit tracking and trading activities. Another benefit of having a separate energy meter is that it is inverter-independent.

Load meters. Many customers expect that the solar monitoring system is also monitoring the load of the facility. That is typically not a part of a basic system, but could be added as an option.

Weather stations. In order to track ongoing performance, irradiance and temperature sensors should be added to a monitoring configuration. The actual power produced will be monitored by the inverter or the separate energy meter, and then irradiation and temperature will be monitored by the weather station. The monitoring system can then compare actual power production versus expected solar generation in real time and report back anomalies to the user - a feature sometimes called performance alarming.

Installation issues

Some residential solar installers have found that the labor cost of installing a monitoring system is not justified by its potential benefits. If the installer does not have the proper training or equipment, that may be true.

However, highly trained installers should be able to set up monitoring systems in a cost-effective manner. Knowing what potential problems might be faced and asking the right questions will go a long way toward avoiding frustration and, ultimately, higher installation costs.

The most common issue for residential installations is the Internet connection. Depending on the in-home equipment, the installer may have to add routers, switches or gaming adapters in order to connect the solar monitoring system to the Internet. Most installers have limited or no experience with the configuration of these devices, and many do not even carry a laptop. Simple tasks, such as crimping RJ-45 connectors on a newly installed Ethernet cable, can lead to hours of troubleshooting if not performed properly.

Additionally, the task of installing an energy meter with external current transformers requires the electrician to understand the basics of energy metering. Knowing how to identify each phase properly and matching the current transformers with the voltage measurements will make the job much easier.

For instance, all current transformers have to be installed in the same direction. But in too many installations, the installer misses this important step, leading to incorrect energy metering and subsequent losses of rebate dollars. Performing a few simple checks after the installation is complete reduces the risk of a faulty installation.

Finally, installations that include the task of pulling RS-485 wires are subject to two major mistakes. First, RS-485 is polarity-sensitive. Anytime the polarity is wrong, it will bring down the RS-485 network. Secondly, an RS-485 network has to be installed in a topology called daisy-chain, as opposed to a star topology, due to the risk for impedance mismatch.

Commercial systems

Commercial solar systems are typically defined as those larger than 10 kW. But until a system reaches a size greater than 30 kW, it will function much like a residential system. Owners can choose from either direct or remote monitoring and can add features such as weather stations and load meters. However, there are some differences between residential and larger commercial solar systems.

One of the first questions addressed when considering a commercial installation is who owns the system. Although many business owners opt to host their own solar systems, some choose third-party ownership. In a third-party arrangement, one entity hosts the solar system on its building, while the other owns and manages the system.

These arrangements are ideal for companies that either cannot take ad-

vantage of federal or state tax credits and benefits (such as schools, municipalities, nonprofits or government agencies) or those that would rather not be burdened with the responsibility of solar system ownership.

Another type of third-party arrangement is the power purchase agreement (PPA). In this setup, the system owner sells the power produced by the solar system back to the host for a specified period of time. In most cases, the power price starts at retail and then increases by a set percentage every year, giving the host a predictable rate structure for the power produced by the system.

Generally, two types of design philosophies preside over small to medium solar systems (10 kW to 75 kW): string inverters or central inverters. Central inverters work by managing all of the solar modules in an array as an aggregate, viewing the entire system as one single source of energy.

With one of these systems, nonuniform changes in irradiance, temperature or shading can create uneven energy generation across multiple strings. The larger the system, the greater the chance that individual dips in module performance will go unnoticed.

Central inverter systems can be augmented by sub-array monitoring for intermediate-level performance measuring or by string-level monitoring for the highest level of granularity. Alternatively, an owner can opt to have on-site personnel manually monitor the system. Either of these options will improve the performance of a central inverter system. A key advantage of these systems is that there are fewer components that can fail, resulting in lower maintenance requirements.

String inverters can allow system owners to monitor many points of data, including ground-faults, solar panel dropouts and drops in efficiency, with a high level of accuracy. System operators can then dispatch maintenance crews to quickly remedy the problem, limiting downtime and maintaining a steady stream of energy production.

Although the majority of larger solar systems (those over 100 kW) are designed around the central inverter model, string-level monitoring can offer advantages for these installations. Consider that each string typically holds up to 3 kW of power, or about as much as a typical residential system in total. On a 500 kW system, a typical size system for a retail store such as Costco, Wal-Mart or Macy's, there could be 150 to 200 strings, with each string capable of generating more than 6 MWh of electrical energy per year. That is a lot of energy coming from many independent parts.

Without string-level monitoring, it is likely that non-functioning strings will go unnoticed for some time, resulting in potential monetary losses that could exceed the investment cost of string-level monitoring.

Commercial installation issues

The monitoring system for a commercial solar array has to be designed up front because of the many potential variations in location, distance, Internet connection types, number of inverters and number of data points being monitored.

In addition to the issues outlined in the residential section, commercial installations may be subject to challenges such as wireless communication problems over long distances, which can be especially difficult if the installer lacks knowledge of wireless systems. With the growing number of wireless devices, a site survey should be performed in order to eliminate most problems.

The most common installation issue in a large solar monitoring system is the termination of the communication wires. It is important to avoid selecting the wrong wire type, such as a solid Cat5 cable. Stranded wire is generally recommended in the RS-485 networks, because these wires do not break as easily.

Another issue that can be prevented through proper engineering is the distribution of control power to the various sensors in the system. When distributing 24 VDC power over longer distances, voltage drops must be considered in design calculations.

In order to troubleshoot issues with a solar monitoring system, a few basic tools are required, such as a multi-meter, laptop and cable tester. For the advanced user, an RS-485 adapter and appropriate software could resolve communication issues on the local device network.

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