# Application Note: Monitoring Performance of PV Strings

**Description of Application** - As the financial and environmental costs of non-renewable sources of energy continue increasing, many commercial, industrial and government facility owners are exploring the use of renewable energy solutions (solar, wind, geothermal…etc) for meeting their growing energy needs. The A89DC-08 Solar Current Monitor from Obvius is designed to monitor the real time performance of solar photovoltaic systems to allow building owners to maximize the return on investment of these systems.

**Background** - While renewable energy is a concept that has been around for many years, the real-time measurement and verification of the performance of renewable energy systems has been rather limited. A typical commercial solar application consists of four levels to convert the DC power of solar panels into energy usable in a typical facility. The four levels consist of:

- Photovoltaic cells – these cells convert the energy from the solar radiation into a DC current. A typical solar cell produces 200 watts of power under ideal conditions
- Combiner box(es) – the output from multiple PV cells (strings) are combined to produce a single DC output. The combiner box is used to minimize wiring costs and losses.
- Inverter – the inverter converts the direct current (DC) output of the PV cells into usable alternating current (AC). The power from the inverter is used directly by the building and excess power may be sold to the utility
- Net meter – the net meter records the amount of power from the PV array and the utility to determine a "net" bill for the owner. If the output of the solar array exceeds the needs of the building, the owner receives a credit from the utility.

All of these points signify vulnerability and potential losses in efficiency for a solar application.

Traditionally a solar system would incorporate just one point of measurement to verify the amount of electricity generated by the system. Typically this job is done by a net meter, a bi-directional meter that nets out differences in locally generated power and power provided by the utility, ultimately giving a net gain or loss for the system as a whole which is provided from the utility on a monthly basis. Such a system gives little clarity as to issues that may arise within a typical solar application. For instance, the solar cells will typically come with a factory predetermined efficiency that can be attained only under ideal conditions. If the system fails to perform to expectations, it can be difficult to correct the problems without timely and accurate performance data. So the following questions arise:

- How can you better monitor the efficiencies of your solar application?
- What other factors contribute to the productivity of the solar cells?
- How can this data be used to maximize performance?
- Where are the losses occurring? (i.e. panel, combiner, inverter, little bit of each)

**How can you better monitor the efficiencies of solar applications?**

The best means for monitoring the efficiencies of commercial solar applications is to attain critical operating performance data in a timely manner, giving greater clarity as to the operation of the system as a whole. The SCM is an 8 channel Modbus RTU based direct current monitor specifically designed for solar installations. Each channel can monitor up to 50 Amps, and maintains an accuracy of half a percent. By integrating the Obvius A89DC-08 Solar Current Monitor (SCM) to the existing A8812 Acquisuite subsystem, users have near real time access to direct current generation per array; giving users the most direct reading of their cells efficiencies. Through partnerships with combiner and weather station manufacturers such as Amtec Solar, Cooper, SolarBos, and Sunlink, Obvius has made the process of integrating such a device as seamless as possible. By placing the SCM in line with the terminal blocks of the combiner, users can simply install a "smart combiner" box giving them timely information with virtually the same installation time as with a standard combiner box. Additionally, partnering with inverter manufacturers such as SMA and Fronius simplifies ever more sophisticated monitoring of solar-based power generation. Combining SCM's with wireless ModHopper transceivers and AcquiSuites provides a complete monitoring solution for the PV cells, the inverter(s) and other metering and monitoring equipment such as weather stations or net meters.

By providing users with real time average generation capacities of each active channel, the module can generate alarms based upon user selectable thresholds. For example, if one cell on an array were to be generating less than the current average of the overall installation by a user selectable percentage, an alarm would be activated notifying the user. By using this now readily available data, users are able to circumvent days, sometimes weeks of losses in their solar arrays generation capabilities through proactive maintenance and monitoring.

**What other factors contribute to the productivity of the solar cells?**

One of the most obvious variables to affect solar systems is weather; however this is also one of the most misunderstood. The typical mind set is that a solar system will perform at its peak in a hot and sunny environment. While the sun is an obviously significant factor, the ideal temperature is somewhat contradictory to the standard line of thinking.

Maximum performance of a typical solar cell occurs under sunny conditions with lower temperatures.

So the question becomes, how do you measure these weather related variables? Obvius has experience gathering data from weather stations, giving building managers/owners real time access to all pertinent meteorological data. By integrating the acquired weather station data in unison with the SCM, users are given a truly comprehensive monitoring package for solar arrays. The AcquiSuite can monitor Modbus weather stations which incorporate a variety of meteorological sensors including wind speed and direction, various ambient temperature sensors, and a solar radiation sensor.

**How can this data be used to maximize performance?**

As mentioned above, photovoltaic cells are rated by the manufacturer for efficiency of conversion of the available irradiance, typically measured in watts per meter$^2$.

Combining the information from the SCM's and weather stations, the user can model the actual output of the solar array as compared to the rating from the manufacturer.

As previously mentioned the power output of a solar system is highly dependent on the cell temperature. Traditionally users of weather stations would use a combination of weather-related variables to determine the temperature of the solar cells; often relying on a combination of wind speed & direction and ambient temperature to determine the cooling/heating effect on the cells. To simplify this process, Obvius has incorporated a line of wireless temperature sensors that can be attached directly to the cells themselves, eliminating the need for complicated comparisons.

**Where are the losses occurring?**

As discussed above, the SCM can provide users with insight as to the losses caused by the process of converting solar energy into usable energy. The question now becomes: *How do you identify the cause of these losses so you can potentially rectify them in a proactive manner?*

Begin by looking at the individual levels of the solar system and identify how the Obvius line of renewable products can be used to monitor such a system. On the panel level, the SCM is able to monitor the real time efficiencies of all the arrays attached to the device. It does so by performing real time averaging over the 8 connected channels, and sending an alarm notification if one of the channels were to drop below a user determined percentage of the other cells. So for example if one array was dust-covered or had a broken wire or connection, the SCM would notify the user of the location of the error.

To ensure the efficiencies of the combiner, the SCM takes in the individual current readings of the inputs of the arrays prior to the combiner process. After the combiner process, the direct current travels to the inverter to be converted into a usable alternating current. By partnering with manufacturers of inverters such as PVPowered, SMA, and Fronius, Obvius can extract direct readings of the incoming and outgoing current of the inverter. Thus verifying the efficiency of the inverter and the net meter as the outgoing current from the inverter represents the expected readings of the net meter.

By partnering with multiple companies, Obvius has gained the ability to be vertically integrated throughout the solar generation process. When used in conjunction, the Obvius line of renewable products can provide wireless transmission of all monitored data points, historical data gathering, and M&V for virtually any solar photovoltaic application.