

## **Sample Tigo Energy Installation Sites**

Below is a list of installations that you will be able to see. Please read the brief description of these to find interesting anomalies that we have detected as well as how to navigate the software.

### **Sacramento, California, USA**

This residential installation has two identical strings of 11 200Wp multi-crystalline modules connected to separate 2kW inverters. The installation was made in early January, 2009 and grid tied on Jan 27, 2009. The upper string has been monitored in a traditional configuration since the time of installation. On July 29, the Tigo Energy Module Maximizers were added to the lower string of the system and development work was done to run experiments and make small algorithm improvements. Because this is using a standard (un-optimized) US version inverter with an isolation transformer, these Tigo Energy string results will be about 2.0% less efficient than a new installation primarily because of the extra boost stage already present in the inverter. During the weekend of Sept 4-6 (and periodically thereafter) shade experiments were made to showcase the benefits of the Maximizer. Partial shade was applied equally to the last three panels in each string. In the “summary” view, select September 5, 2009 to see that both the shaded and un-shaded modules in the bottom (Tigo Energy) string provide significantly more power output than those on the string without the Tigo equipment.

### **Berkeley, California, USA**

The system is another large rooftop system which is perfectly co-planar (on line-leveled mounting rack) with no shade. We instrumented 17 170W modules in one string connected to a central inverter. We also placed string current, temperature and irradiance sensors elsewhere. Data is available from June 12, 2008 through October 03, 2008 when we had the first generation Maximizers on the array (monitoring only). It is also the R&D graphing UI. We randomly selected a string to instrument and it turned out to have a module which was malfunctioning (panel 13) – you can see one of the diodes is permanently active thus reducing the output of the module to 2/3 of its potential. If you look at June 17, 2008, “every second” frequency from 11am to 1pm you will be able to see the distribution of the modules in full summer sun with no clouds in the middle of the day. Toggle the view of panel 13 off by clicking on the blue square next to “Voltage\_13” on the legend to the right and you will get a better view of the rest of the modules in the string. You will note an average distribution around 13% which is caused only by temperature, dust and module degradation mismatch. In this scenario we can return about 6-7% additional energy output – before fixing the malfunctioning module.

### **Northern Italy**

This installation was made earlier this year and is a side-by-side comparison between two strings of 12 each 175Wp modules similarly positioned in an awning mounted installation. The UI is similar our production view similar to what you see with your system. One string has the full Tigo Maximizer solution (MM-EP) and is shown in the module level view on the “summary” and “energy” pages. We are monitoring the power output on an adjacent string which is shown next to the lower meter icon on the “summary” page and by viewing “power meter string” on the

“energy” page. In this installation the 12 modules with the Tigo Energy Maximizer built by Manufacturer “A” while the modules in the standard string are from Manufacturer “B” (both are 175Wp rated multi-crystalline silicon modules). The historic data from this system showed the modules from “B” consistently outperforming those from “A” by 5%. You can see after installing the Tigo Energy Maximizer, the modules from Manufacturer “A” outperform the others most of the time. To view a normalized comparison of the strings from the “energy” page, select “power meter string” in the legend on the left – then hold down the shift-key and select “LMU normalized”. This will display both data sets on the graph to the right and allow for a direct comparison. Data is available for the month of March, 2009.

### **Santa Cruz, California, USA**

This was one of the first installations made by Tigo Energy – data is available from May 27, 2008 through June 01, 2009. In this large commercial rooftop installation (3 years old), twenty-six (26) 125W modules connected to a string inverter were instrumented. The data is presented differently than on today’s commercial systems – it is a graphing application which can give a per-second view (voltage, current, temperature, irradiance) of all the modules that are being monitoring. This version of the Maximizer is ONLY MONITORING – there is no fixing of the module output. The default view is voltage output readings of each panel. Any value may be viewed or eliminated by clicking on the colored box next to the parameter in the legend to the left of the graph. The interesting aspect is to see the performance of a system at the module level in a well architected (no shade) typical commercial application. This is a very effective tool to demonstrate that module mismatch does occur even in “perfect” systems due to environmental issues other than shade. It also serves as a foundation for us to more accurately predict the magnitude of impact of each issue – we were able to add shade, clean panels, etc. to isolate the impact. We are also able to look at the effects of clouds – for example, if you select June 14, 2008, “every second” frequency from 11am to 1pm you will be able to see the array instability when small cumulous clouds pass over the modules (ex. starting at 11:27am). In these installations the amount of projected energy gain we can return with the latest version of our Maximizer is roughly half of the average distribution percentage (of voltage) from the best to worst modules in the string. When you see a distribution of 12%, we can return 5-6% additional energy output during that time period. The distribution percentage at any given point in time can be read from the mouse-over cursor when placed on the graph.