

Global Photovoltaic Business Magazine

INTERPV

PHOTOVOLTAIC

NOVEMBER, 2009

COVER STORY

GLOBAL PV INDUSTRY 2009 AND BEYOND

ALTHOUGH THE SOLAR PV INDUSTRY GREW SIGNIFICANTLY IN 2007 AND 2008, A NUMBER OF FACTORS HAVE LED TO A PERIOD OF NEGATIVE GROWTH AT THE BEGINNING OF 2009. IN THE MEDIUM TO LONG TERM, HOWEVER, PROSPECTS FOR THE SOLAR INDUSTRY ARE MORE POSITIVE.

VIEWPOINT

Can Asia Become a New Solar Power Hub?

GLOBAL LEADERS IN PV

Konarka Technologies: Converting Light to Energy—Anywhere

POLICY & LEGISLATION

The Price of Policy Risk Mexican Rebellion in LED Solar Street Lighting

GLOBAL MARKET REPORT

Chinese PV Industry: Between Growth and Policy

PRODUCTION & INSPECTION

Energy Meets Quality

CELL & MODULE

Revolutionizing Large-scale PV Projects Capturing Sunlight “Squarely”

COMPONENT & MATERIAL

The Lifeblood of Wafer Manufacturing

Choosing the Right Type of Encapsulation Material

CASE STUDIES

Historic American Eatery Goes Solar for 60th

POWER SYSTEM

Can We Take Control of Energy Resource?

DIRECTORY
Asia

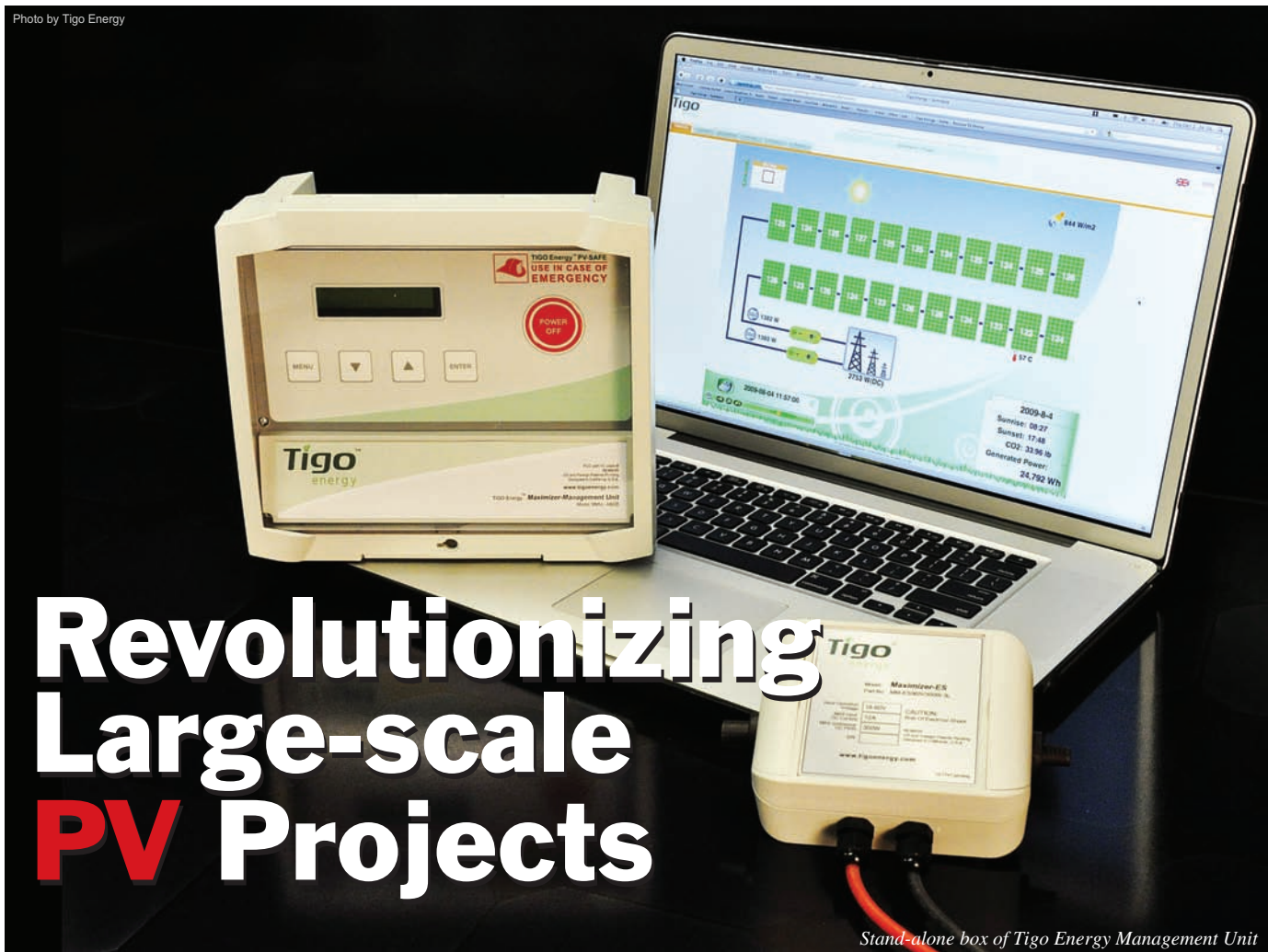
EXPO Solar
International Solar Energy Expo & Conference



PV KOREA
Int'l Photovoltaic Power Expo Korea

February 3(Wed)~5(Fri) 2010
KINTEX, KOREA
WWW.EXPOSOLAR.ORG

CELL & MODULE PRODUCT SPOTLIGHT | USA |



During the past year, there has been great buzz around Balance of Systems (BOS) products which apply module or string level Maximum Power Point Tracking (MPPT) in photovoltaic systems by deploying power electronics at the module. Both micro-inverters and DC-side optimizers claim greater returns by ridding the system of the effects of mismatch in a series-connected string of modules. In residential applications where systems are small, shade is abundant, and consumers are open

to new technology, the distributed BOS solutions can demonstrate strong value and are included in system designs with increased frequency. With partial array shading, incremental power output can approach 20% while the additional cost of a distributed MPPT system is minimal at small system sizes. The question remains however: are these solutions appropriate for utility-scale projects? Does the optimal site selection and carefully matched panel layout eliminate the benefits of such technology?

CELL & MODULE PRODUCT SPOTLIGHT | USA |

When evaluating the variety of current and future solutions for distributed MPPT, it becomes immediately clear that there are distinct differences in regards to where the DC-to-AC inversion takes place, the MPPT methods, and system visibility. The degree to which each solution lends it to increased financial gains in large-scale systems is highly variable so a one-size-fits-all conclusion is not appropriate. Each approach must be independently analyzed in the context of a specific project. During the course of product development, Tigo Energy has taken the needs of those that finance, build, operate and maintain large-scale projects and implemented technology which will maximize financial returns by revolutionizing the way large systems are managed, operated and maintained.

The Tigo Energy™ Maximizer solution can deliver significant added financial benefits for large-scale systems that include not only additional power output but also significant operational efficiencies. The upside begins during installation as advanced system debug tools virtually eliminate manual troubleshooting. The system's increased energy harvesting quickly covers the cap-ex impact of adding the solution. Meanwhile, long-term panel-level system management tools offer unprecedented visibility, analysis for keeping the system at peak performance, and an insurance policy that future problems will be quickly identified and corrected.

The Upside from Additional Power Harvest

With the help of several solar veterans, early in the company's history, Tigo Energy set out to quantify the degree of mismatch through the life cycle of a project that is due primarily to environmental factors. While the experts at the time asserted that good system design would eliminate shade while high-quality module

The Tigo Energy™ Maximizer solution can deliver significant added financial benefits for large-scale systems that include not only additional power output but also significant operational efficiencies.

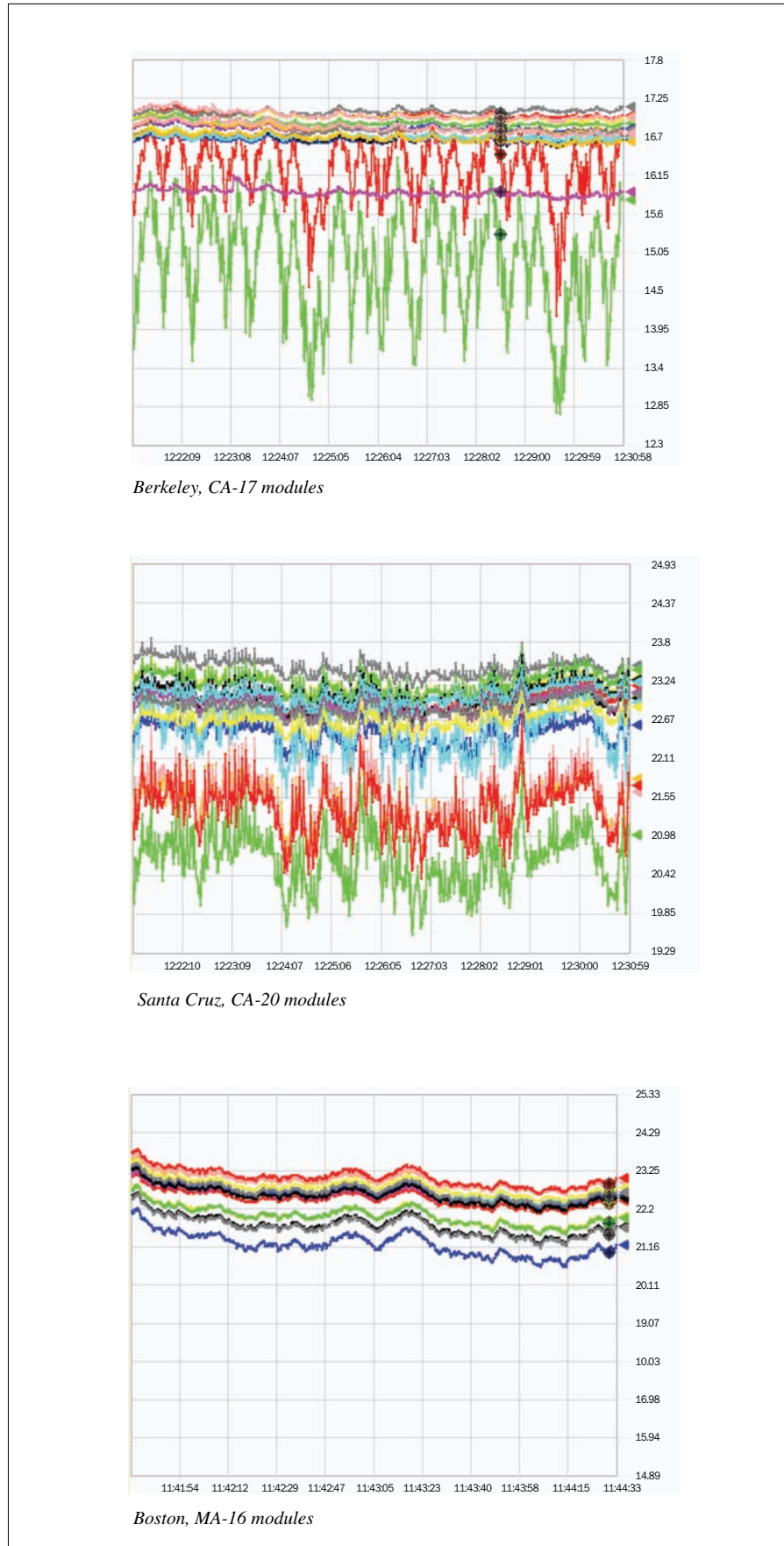


Figure 1. Panel distribution within a string-time (in seconds) vs. output voltage (Source: Tigo Energy)

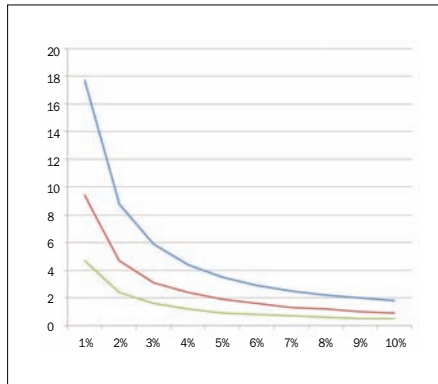


Figure 2. ROI graph for a typical 2009 retrofit project in Southern Germany
(Source: Tigo Energy)

manufacturers would bin their product output to a very tight performance distribution, Tigo Energy's founders believed it was critical to look primarily at the issues facing large systems. Issues such as soiling, clouds, uneven thermals, and long-term materials degradation were deemed outside of the architects' control and, thus, worthy of closer scrutiny. The Tigo team deployed an early version of the Maximizer which unobtrusively monitored each module in randomly selected strings of many large-scale, well architected systems. Additional current sensors were placed on all strings in the systems to understand additional string mismatch within the array. Each system was over one-year old so that life cycle effects could be observed. Figure 1 shows typical findings as represented by three different installations from both coasts of the U.S. Each graph plots the voltage of each module in a series-connected string over time at one second intervals. Within the string, voltage is linearly proportional to power as current is constant within. In large-scale systems, it is not uncommon to find a variance of 12%-15% from the best to the worst performing modules.

Similar to other solutions, the Tigo Energy Maximizer implements MPPT at the module level, thus eliminating the impact of underperforming modules on the best performers in the string. However, the Tigo solution does this with unprecedented efficiency, experiencing conversion losses well below 1%. In a well architected and regularly maintained system Tigo Energy equipment may typically return up to 6% incremental power by harvesting practically 100% of the energy lost from environmental causes of mismatch. Financial estimates indicate that an increase of 6% harvest can increase the project IRR by 20 basis points often providing 30%-40% increase in returns. By potentially offsetting today's increased cost of capital, the Tigo Energy solution can transform non-viable

projects into profitable operation.

It should be noted that immediately after the project has been constructed, there is typically little mismatch in the system and returns can be as low as 1%. However, even in this initial state, the Tigo Energy solution will yield the highest return of any distributed MPPT system due to the efficiency of the module maximizer. As the inevitable environmental mismatch quickly occurs within the project (heat, dust, clouds, module degradation, and, etc.), incremental gains of higher magnitude result. Figure 2 depicts an ROI graph for a typical 2009 retrofit project in Southern Germany, considering ONLY the value of incremental energy output. For a new installation, module integrated solutions offer a much lower capital investment and thus a much faster break-even point. Additional cap-ex savings and accelerated payback are available by reducing BOS costs from stringing and combining, or selecting an optimized inverter, such as those from Kaco New Energy, GmbH.

Bringing Up a New Installation

During the installation of a large power plant, there is often suboptimal performance from certain sectors or inverters due to loose connections, Dead-on-Arrival (DOA) components, or improper installation. The complex debugging and optimization of a new installation often takes significant technician time due to the need to address inverters and measure modules in order to identify and fix the issues. Meanwhile, the system activation gets delayed or the project is brought online with suboptimal results. The Tigo Energy solution includes a communication capability at each module that reports real-time performance every few seconds to a database. This information can be viewed from a management console accessible from any web-connected personal computer or mobile device. With the Tigo Energy system, all aspects of the power plant can be viewed through the remote console and issues immediately identified for correction, allowing acceleration of the payback of the system. The streamlined system design also assists the EPC with greater layout flexibility, reduced BOS components (combining), and faster installation.

Minimizing System Degradation

When projecting the financial returns of a large-scale system, models predict an annual degradation percentage and then deduct this amount from the total energy generated. This factoring accounts for the reduction of efficiency of the photovoltaic materials over time, but also acknowledges the statistical reality of undetected component failures that remain in the system for the duration of the project lifetime. Operators of multi-megawatt systems know that after several years there are non-functional components in the system. However, as they don't know how many or where they

Lowest cost and highest reliability are key elements of the system design and electronics architecture since the Maximizers come with a warranty which matches that of the modules.

are, the payback and method of finding these are not clear.

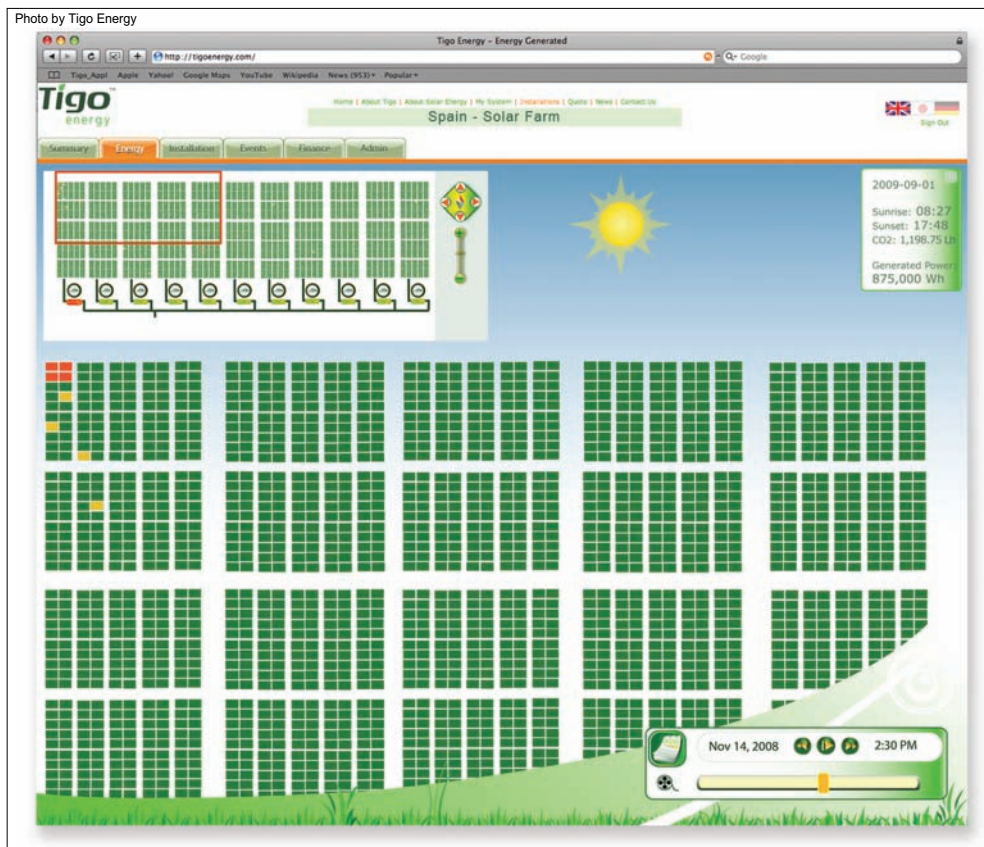
The Tigo Energy Maximizer System reduces the pace of annual project degradation by over half the typical projected value. For example, if the project financial projections assume a 0.5% annual degradation, use of the Tigo Energy system can decrease this to below 0.2%. This is done in two ways. First, by identifying severely degraded or non-functional components for replacement, the system can be kept much closer to peak-rated output. In conventional systems, defective or degraded module identification is too costly so they are left in the system in a suboptimal state. Second, system degradation is further reduced by limiting the impact that more rapidly degrading modules have on those that are performing optimally. Because modules in a traditional system are connected in a series, and underperforming modules limit the current in the string, there is interdependence between them. Furthermore, in a large mesh connection where strings are connected in parallel, underperforming strings limit the voltage of those performing optimally and further reduce system output. In this system, it is the modules degrading fastest which determine the overall system output.

Analytics to Lower Cost of System Maintenance

To enable the MPPT and control of each module, the Maximizer senses current, voltage and temperature at all the modules every few seconds and returns this value to the Tigo Energy Management Unit (either a stand-alone box or integrated into an optimized inverter). While this data is used to calculate the optimal operating point for each module, it is also sent through an internet communications gateway to a central server. The Tigo Energy MaxiManager software suite includes advanced analytics which look for anomalies, degradation patterns, and regularly occurring issues. The management console provides performance monitoring with module level granularity, problem alerts, maintenance reports (exactly where the issues are and when it makes financial sense to fix them),

CELL & MODULE PRODUCT SPOTLIGHT | USA |





Performance monitoring with modules

and macro analysis relative to other large-scale systems in the owners' or operators' portfolio.

With this dataset, the project can be kept at peak operation throughout its life cycle. By understanding the performance levels of each system component, maintenance can be quickly and effectively performed. Regular "blanket" maintenance no longer is necessary, in favor of targeted actions with high return. On-demand maintenance reports help crews directly target problem areas which greatly reduces time in the field and O&M costs. Due to the Tigo Energy System, they can arrive at the site with exactly the right replacement components and tools to get the job done quickly.

Each subsequent project can be managed the same way through a single, centralized site. Over time, the macro analytics can help refine and optimize the design and development of new projects since the system operator has the knowledge of exactly which components provide the most energy output in a given geography.

Theft & Safety

As Tigo Energy places a small amount of electronics on each module, there are many additional functions that can be deployed to enhance the system performance or cost of ownership. Two examples of these features are theft protection and Tigo Energy™, PV-Safe. Regardless of the time of day, the system can detect whether the

modules are connected properly. Should a module unexpectedly be disconnected from the system, a user-programmable alert or alarm will be activated. Furthermore, during operating hours, the Maximizer can stop the flow of energy onto the system cables when issued the command to do so by the system operator. This can be done either from the management console (only with administrator rights) or on-site by pressing the PV-Safe button on the Management Unit. When this feature is used along with the standard DC disconnect at the inverter, the system or subsection can be completely free of high voltage for safe maintenance or emergency services. While the sun is shining, today's large-scale systems will always have high voltage present (as much as 1 kV) in the array and cabling to the inverter regardless of whether the inverter is functioning. Including these capabilities in the large project design not only may reduce the direct costs of operation, but can also many times lower the personal injury and property insurance rates paid by system owners and operators.

Optimal Solutions for Better Performance

When taking a holistic view of construction and operational costs of a large-scale PV system, project developers can find that deploying the Tigo Energy solution will greatly enhance the life cycle payback

of the system. The system provides investors and financiers with the security of knowing how the project is performing with clarity through its useful life. The value extends well beyond the incremental power harvest from applying MPPT at each module.

The Tigo Energy system is unique as it has the smallest on-module electronics footprint, most efficient MPPT and DC conversion, works optimally with inverters from the industry's leading manufacturers, and provides a comprehensive web-based software management tool. The lowest cost and the highest reliability are key elements of the system design and electronics architecture since the Maximizers come with a warranty which matches that of the modules.

Large-scale PV project developers, EPCs and investors can evaluate any of these systems and draw educated conclusions relative to their particular project characteristics. One approach that is often considered is to retrofit an existing installation. Most existing installations have output data collected at each inverter and frequently have underperforming sectors of the project relative to the others. By implementing a test deployment on the lowest performing sector, the full impact of the Maximizer solution can be assessed as well as please investors with greater performance upsides. 