

Watts Up?



**Tigo**<sup>TM</sup>  
energy

September 2009



# Legal Disclaimer

- INFORMATION IN THIS DOCUMENT IS PROVIDED IN CONNECTION WITH TIGO ENERGY PRODUCT. EXCEPT AS PROVIDED IN TIGO ENERGY'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, TIGO ENERGY ASSUMES NO LIABILITY WHATSOEVER, AND TIGO ENERGY DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO SALES AND/OR USE OF TIGO ENERGY PRODUCTS, INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT, OR OTHER TIGO ENERGY INTELLECTUAL PROPERTY RIGHT.
- Tigo Energy products are not intended for use in medical, life-saving, life-sustaining, critical control or safety systems, or in nuclear facility applications.
- Tigo Energy products may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available upon request.
- Tigo Energy may make changes to dates, specifications, product descriptions, and plans referenced in this document at any time, without notice.
- This document may contain information on products in the design phase of development. The information here is subject to change without notice. Do not finalize a design with this information.
- Designers must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." Tigo Energy reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them.
- Tigo Energy may have patents or pending patent applications, trademarks, copyrights, or other Tigo Energy intellectual property rights that relate to the presented subject matter. The furnishing of documents and other materials and information does not provide any license, express or implied, by estoppel or otherwise, to any such patents, trademarks, copyrights, or other Tigo Energy intellectual property rights.



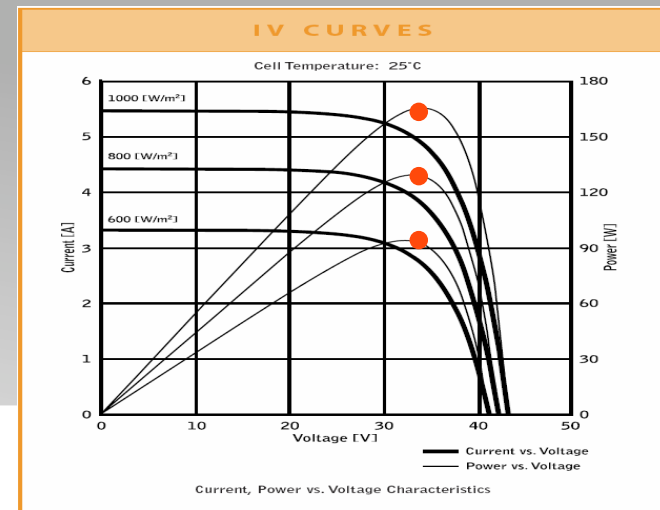
## Our Company

- New Innovation in BoS for PV Installations:
  - Module level data for enhanced MPPT
  - Increased management visibility with panel-level monitoring
    - Ability to pinpoint system issues beyond the inverter
  - Unprecedented level of system safety with Tigo Energy™ PV-Safe
- Enhancing the path to grid parity
  - Reduce cost per kilowatt hour and accelerate payback period
  - Increase rooftops available for installation, ease of installation
- Ramping High-Volume Production
  - Beta since May 2008
- Semiconductor industry methodology
- Venture funding from ...

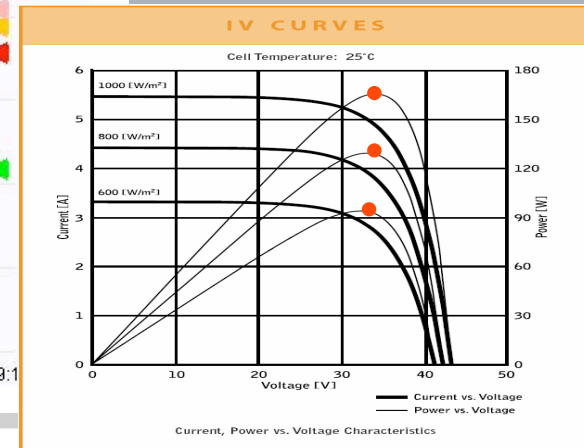
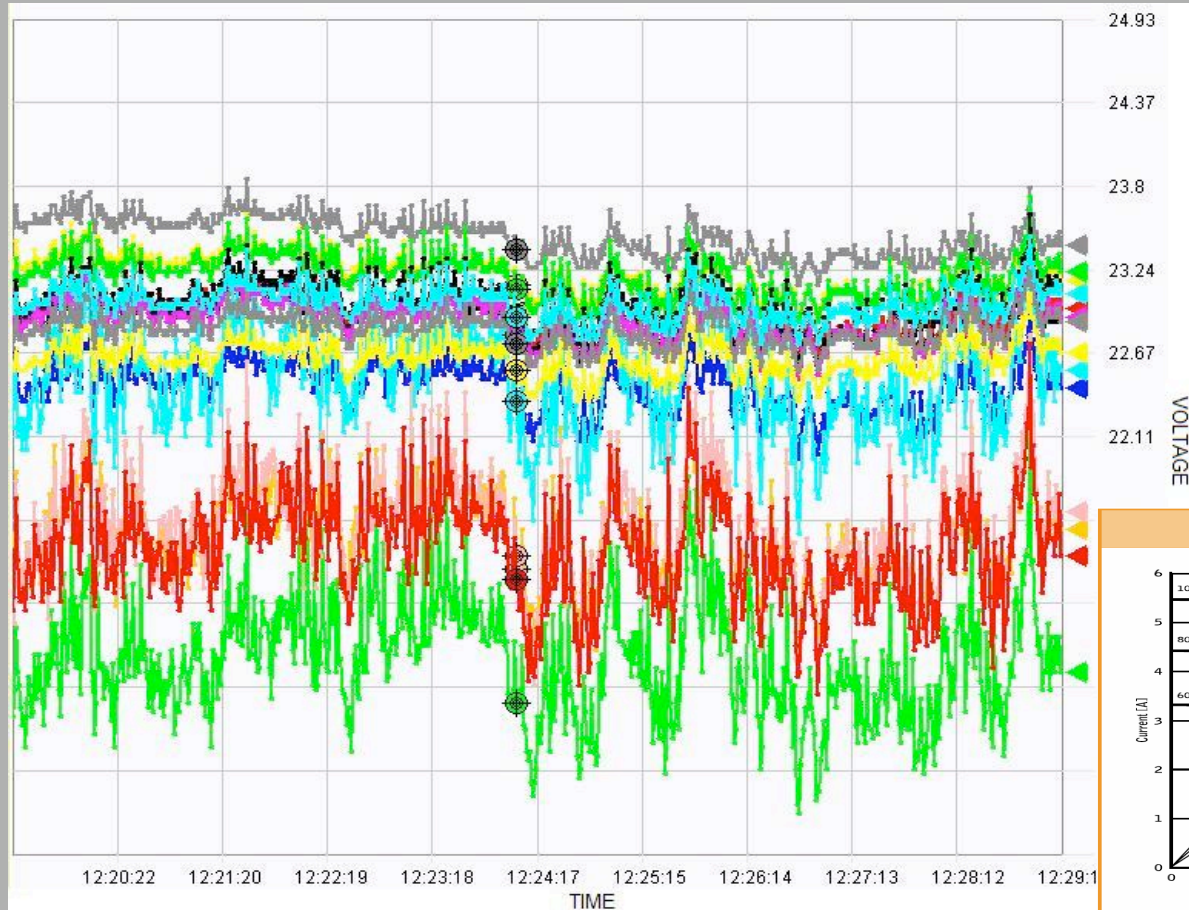


# Problem Statement Summary

- Mesh PV module arrays (serial/parallel) power output not optimized per module
- Weaker modules drag down chain, temperature and soil major offenders
- “Non ideal” power source
- Safety hazard
- More factors resulting in less than optimal power production



# PV Module – Output Variance

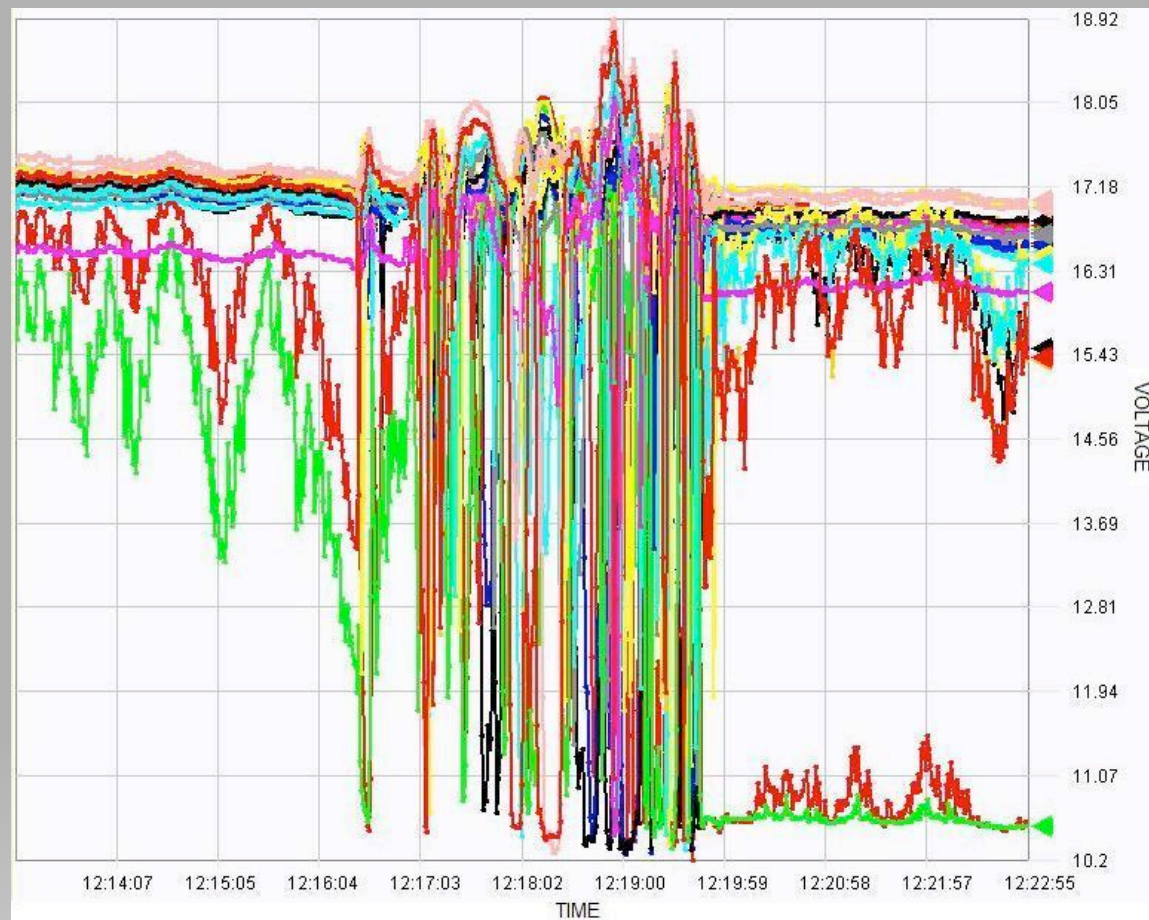


Berkeley California: Even without shade ... module output varies greatly



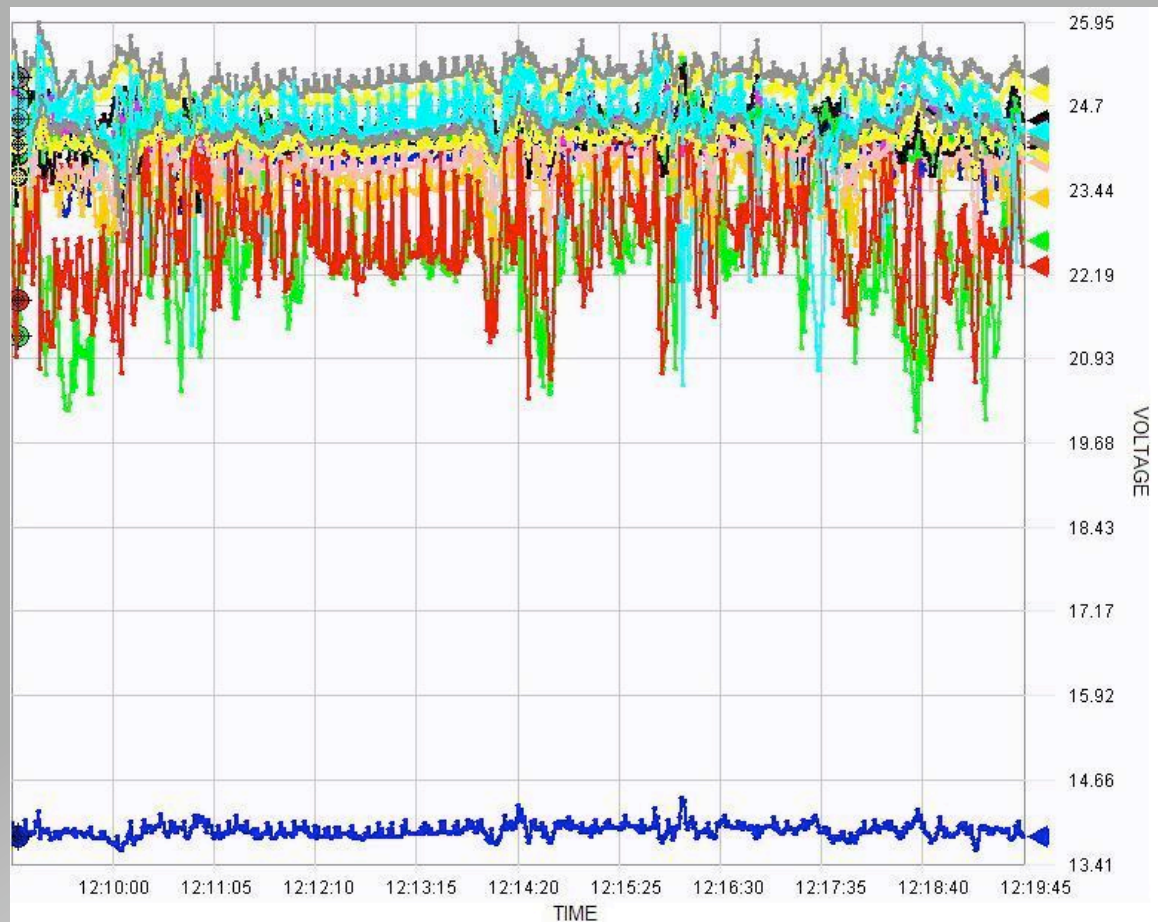


## Cloud Effect – Voltage Response



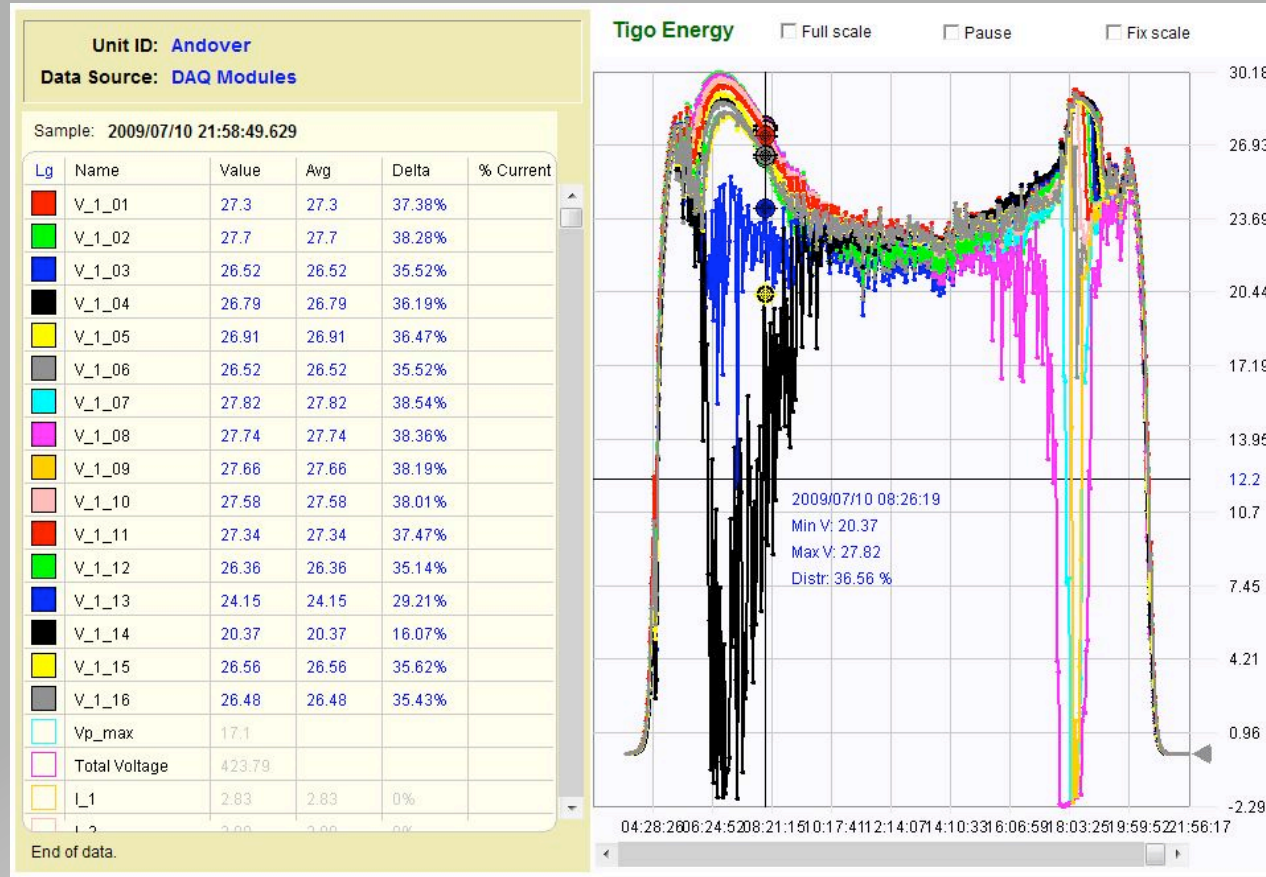
Single input MPPT can't stabilize the array during changing light

## PV Module Malfunction



Difficult to find operational issues in the array.

# Co-planarity



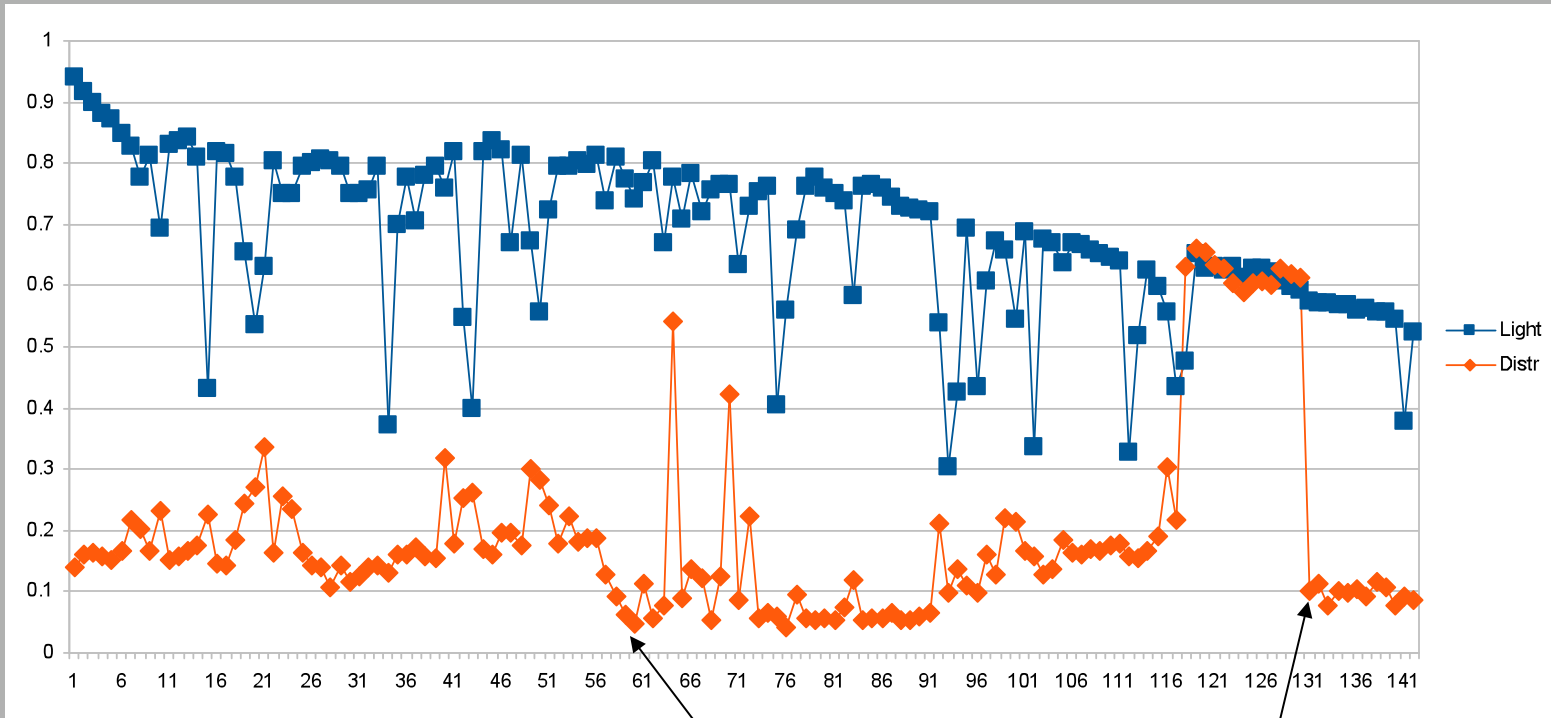
Boston, MA – slight architectural issues



# Soiling Trends

Data from Santa Cruz commercial installation

- June 7 to Oct 28, 2008
- soiling patterns triple module distribution over 6-8 weeks



System Cleaning

Partial Cleaning

# Solar Safety Concerns

PV Safety

- Emergency services agencies expressing concern
  - 400-600 Volt – high shock risk
  - Water from fire hose is conductive
  - Mechanical disconnects don't stop electricity at PV module when sun is shining
  - Limited roof space to cut venting holes
- Municipal restrictions could further raise cost of installation
  - Expensive quick-release racks
  - Walkways between strings reducing available roof space



<http://www.ktvu.com/video/14491729/index.html>





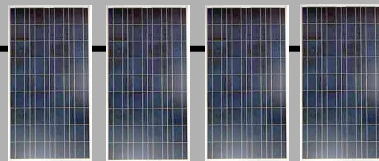
# The Tigo Energy™ Maximizer Solution



# Tigo Energy™ Maximizer System



modules type 1



modules type 2



Tigo Energy Module  
Maximizer at each  
PV module



Tigo Energy™ Management Unit

- Improved power efficiency up to 20%
  - Dynamic module balancing
  - Significantly decrease system aging degradation
- Reduced cost and ease of installation
- Hazard mitigation
- Extended system uptime
- Significantly improved Inverter reliability



Tigo Energy™ Data Center for Remote  
monitoring & Control

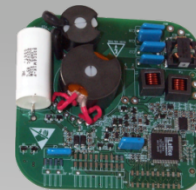




# Tigo Energy Product Components

(not to scale)

- Tigo Energy Intelligent Data Center  
*one server (or hosted partition) per customer*
- Tigo Energy MaxiManager software applications  
*Panel level performance monitoring, alerting, real time maintenance tool, project planning, remote system control*
- Tigo Energy Maximizer Management Unit  
*one per project - LMU control and gateway to Data Center*  
*Can be integrated into power conditioner*  
*Stand-alone version can monitor any PV system or inverter*
- Tigo Energy Module Maximizer  
*one per module or grouping of modules*  
*Serial and parallel versions*
- Inverter from Partners  
*one per project up to 500kW - Versions from 2.5kW to 500kW capacity*  
*DC/AC conversion function*





# Tigo Energy™ Maximizer Solution

## MORE

- ✓ Energy Output
- ✓ System Visibility
- ✓ PV Safety





### Utility Scale – well placed systems with little shade

- Up to 8% incremental energy output
- Most output of any distributed MPPT system
  - Harvests practically 100% of the available energy from the array
  - Including DC/DC conversion, parallel or microinverters
- Output gains grow over time with environmental mismatch
  - Lesser gains for new (matched) systems

### Residential – sub-optimal orientation & shade

- Up to 20% incremental energy output
- Minimizes effect of shade & other mismatch on system
- Enables greater utilization of available roof-top
  - Sub-optimal placement doesn't drag down string



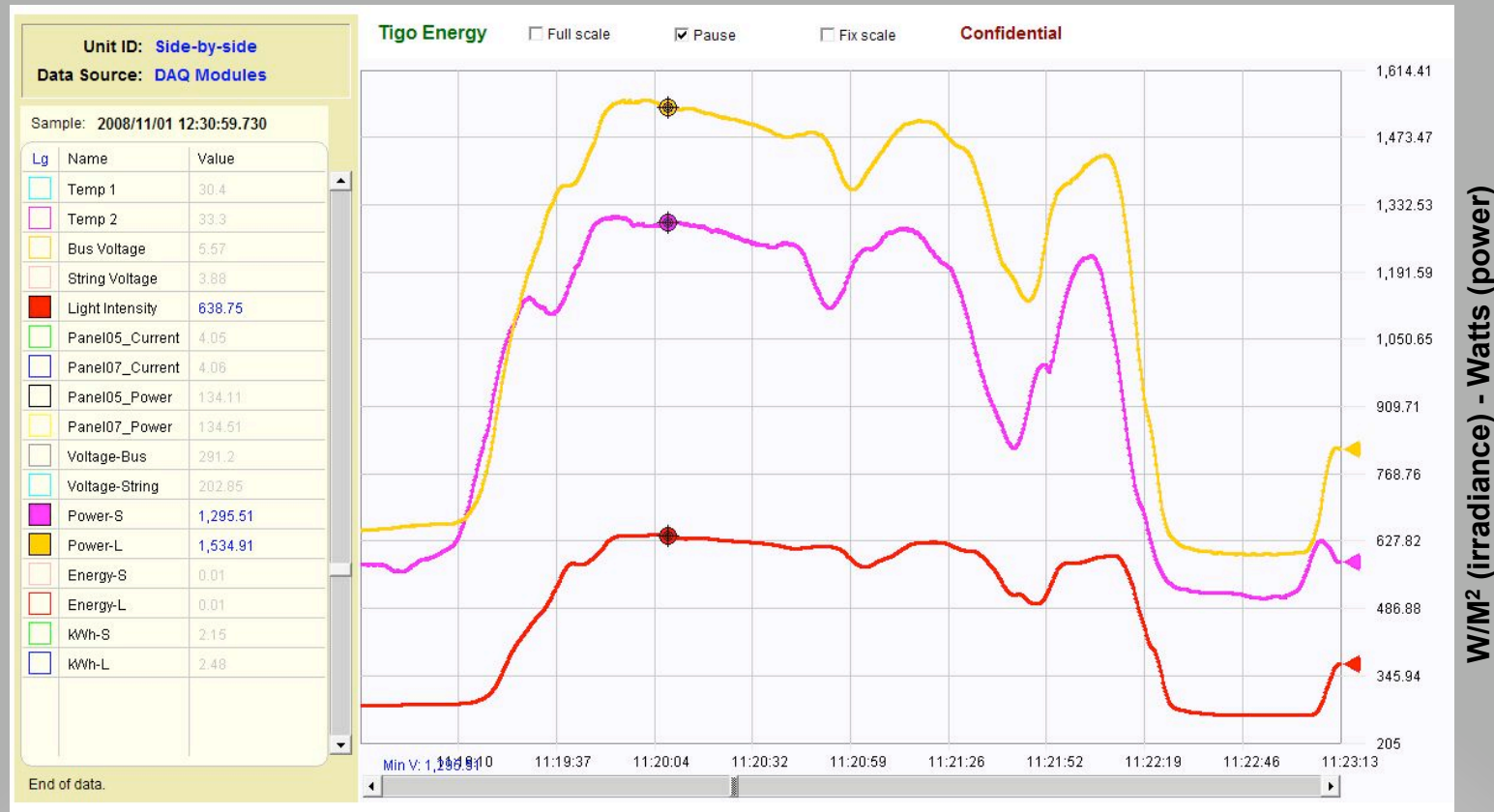
**Always equal or better than string/central MPPT, even in optimal conditions**



Energy Output

System Visibility

PV Safety



Measured side-by-side results: ~16% incremental power output

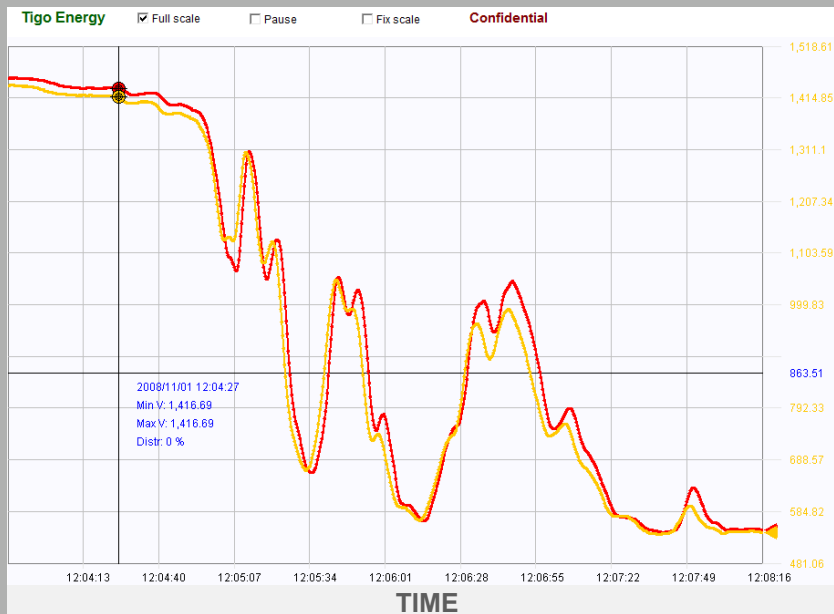




Energy Output

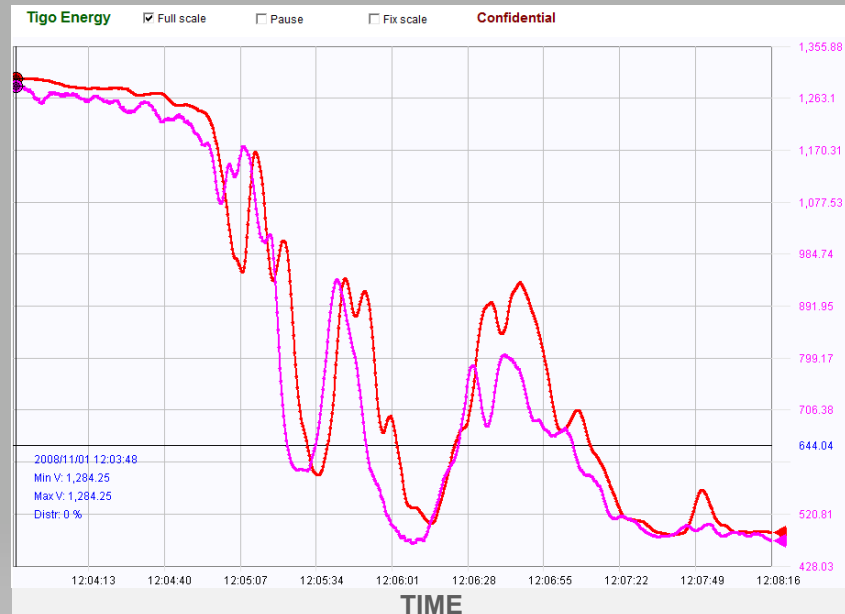
System Visibility

PV Safety



The Tigo Energy Solution

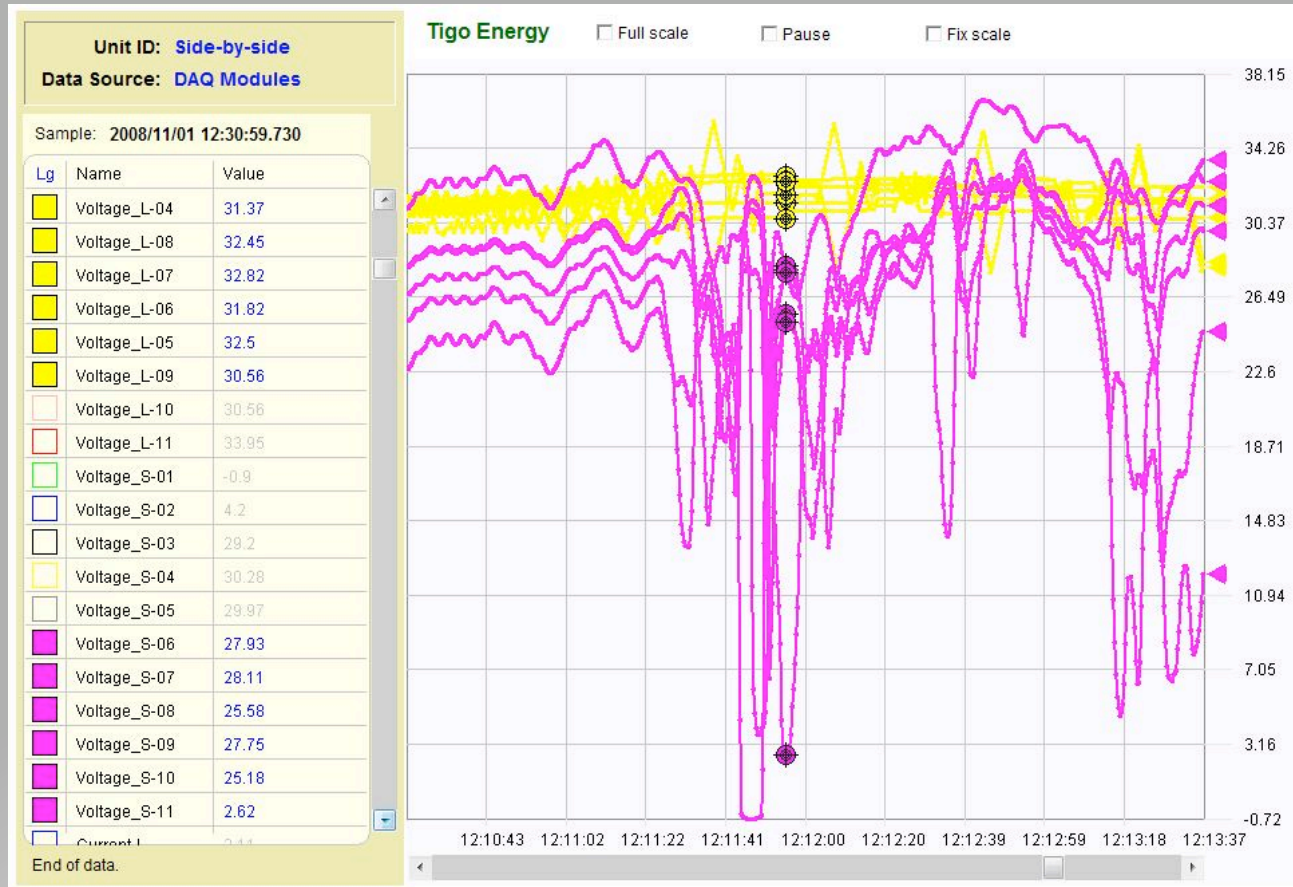
- Irradiance
- Tigo Energy power production
- Traditional string power production



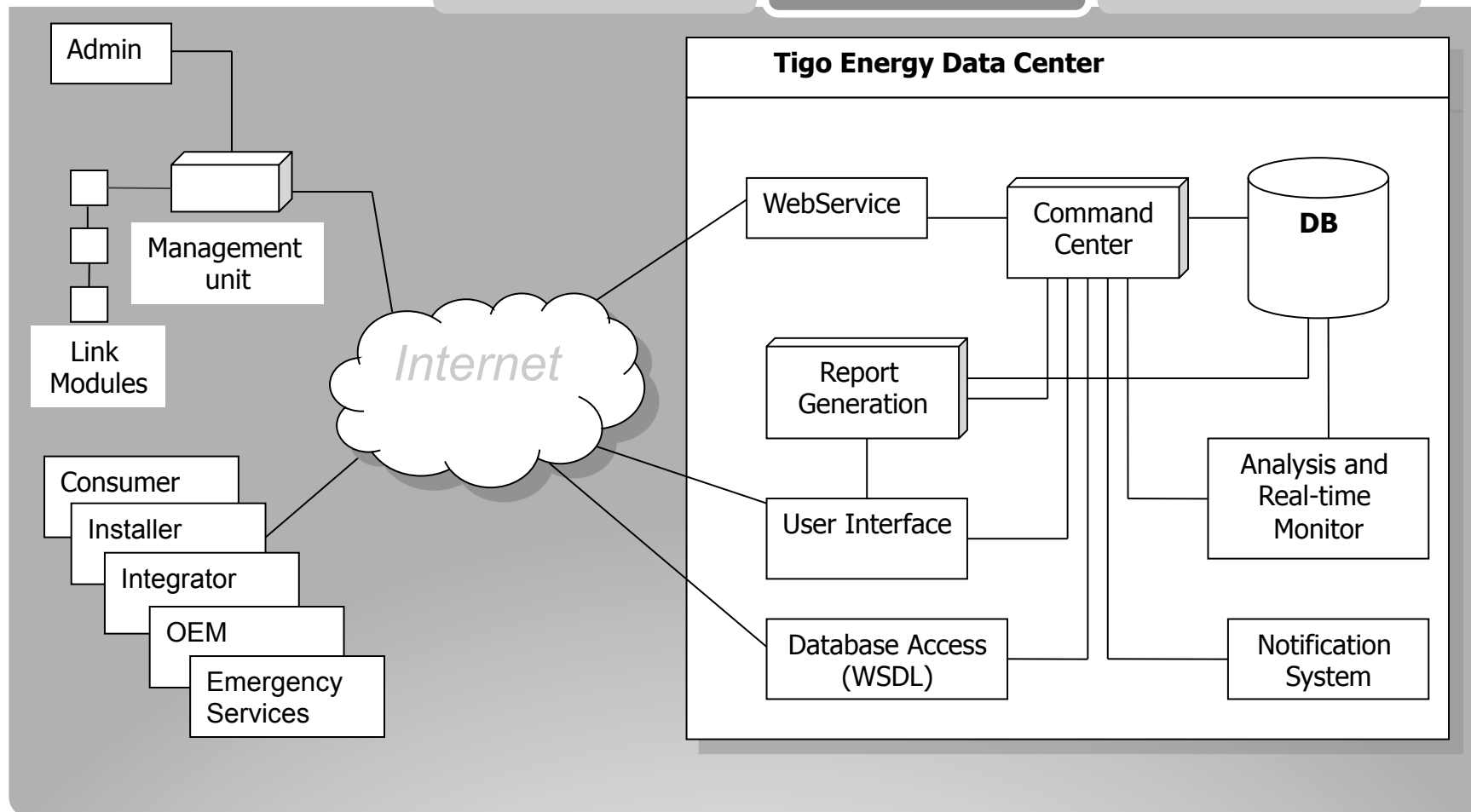
Traditional MPPT

\* Light and power readings not on same scale

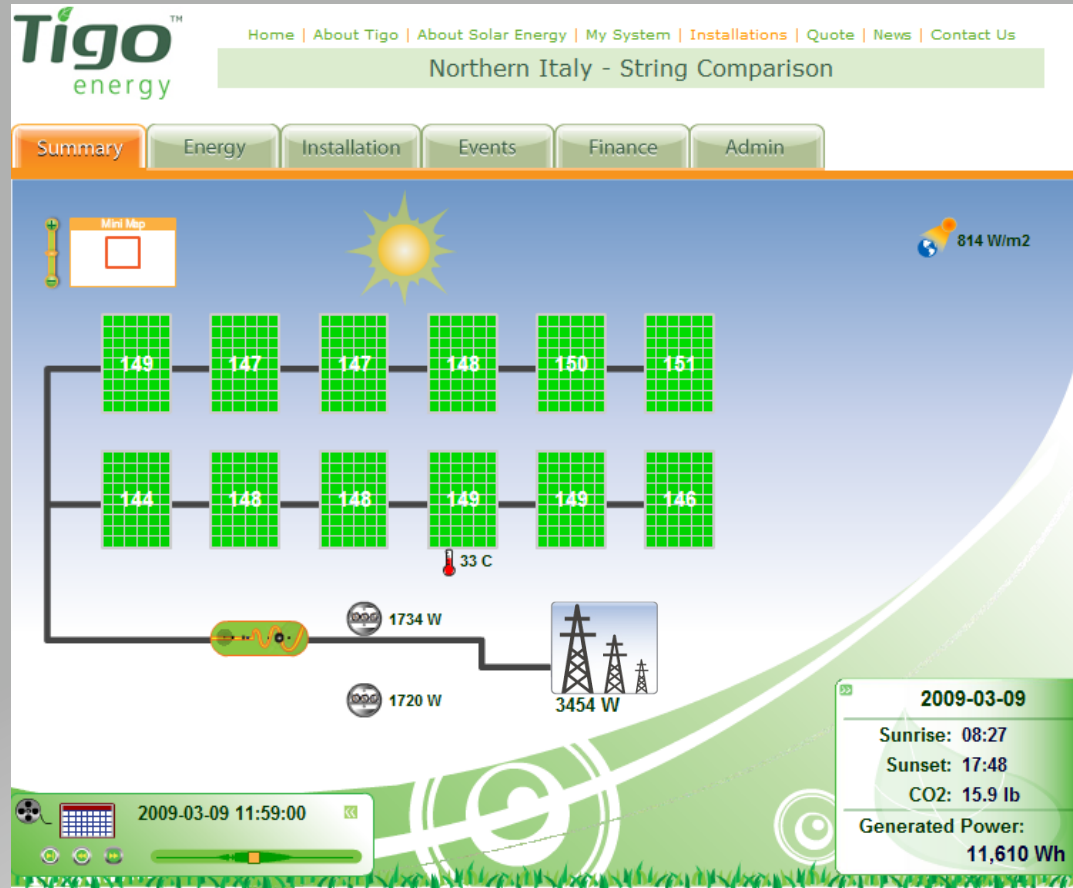
Tigo delivers maximum power output as irradiance changes (ex clouds)



Side-by-side: Comparative Voltage stability



## Data Center Architecture



Visibility to module-level power output





Side by side installation in Italy

## Our Board of Advisors



### Professor Takashi Tomita

- Professor of the University of Tokyo, Research Center of Advanced Science and Technology;
- Member of the Market Strategy Board of the International Electro-technical Commission (IEC);
- Former Executive Director of Sharp and CEO of Sharp Solar



### Gary Gerber

- President & Co-Founder, Sun Light & Power Company;
- President, California Chapter of Solar Energy Industry Association (CalSEIA);
- Pioneer in the fields of solar thermal and solar electric system design with 30 years of experience



### Nathan Zommer, PhD

- Founder, Chairman and CEO, IXYS – a technology leader providing products to improve power conversion efficiency



### Yair Cohen

- Vice President, IDB Group (Israel);
- Senior Executive, Clal Energy;
- Former Brigadier General in the Israel Defense Forces (IDF), heading the IDF's elite technology development unit (8200 Unit)



# Unique Competitive Advantage

- Our Approach
  - Distributed MMPT and power harvesting
  - Module level visibility to the PV solar project
  - NOT a micro inverter or distributed inverter
    - Incremental innovation for PV to make partners more successful
- Our Team
  - Industry leaders in distributed systems, power electronics, process control and PV solar
  - Proven entrepreneurial track record, proven ability to grow established businesses
  - Top tier VC backing
  - Board of Advisors – International team of prominent figures in solar, power electronics, standards, and utilities
- Our IP
  - Strong portfolio of patents filed starting in 2006

Optimizing ALL THREE vectors – power output, costs & reliability



Is your array producing to expectations?



If you suspect that your large scale PV system could be producing more, give us a call. We're so sure we can improve your output that you can pay with a percentage of the increased returns.

[www.tigoenergy.com](http://www.tigoenergy.com)