PV Design:
Advancements In Solar Electric Design and Equipment

With Christopher LaForge, CMT

Christopher LaForge

IREC Certified Master Trainer

NABCEP Certified Photovoltaic Installation Professional

31 years Operating Great Northern Solar

27 years Training with MREA and other organizations

Emeritus

In accordance with the Department of Labor and Industry's statute 326.0981, Subd. 11,

"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials and Residential Contractors code /1 hour energy** continuing education requirements."

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PV Design:
Advancements In Solar Electric Design and Equipment

Our presentation today will work through:

A review of the current state of development of Solar electric Design and the equipment changes that affect it. Each year the solar field evolves rapidly and with the changes comes additional design challenges. Understanding the best designs and what advantages each design brings to your clients keeps you in the game with the fast-moving solar world. Keeping you up to date is the essence of this session so you can participate in this growing sector of the electrical design and construction field.

We begin with Arrays and will work through wire management, Balance of system (BOS) components, Charge Controllers, Inverters, and storage devices…

Lets begin….

Apollo Tile II

Features and Benefits
The Apollo Tile II system is a versatile solution for power and aesthetics when installed directly on a new or existing tile roof.

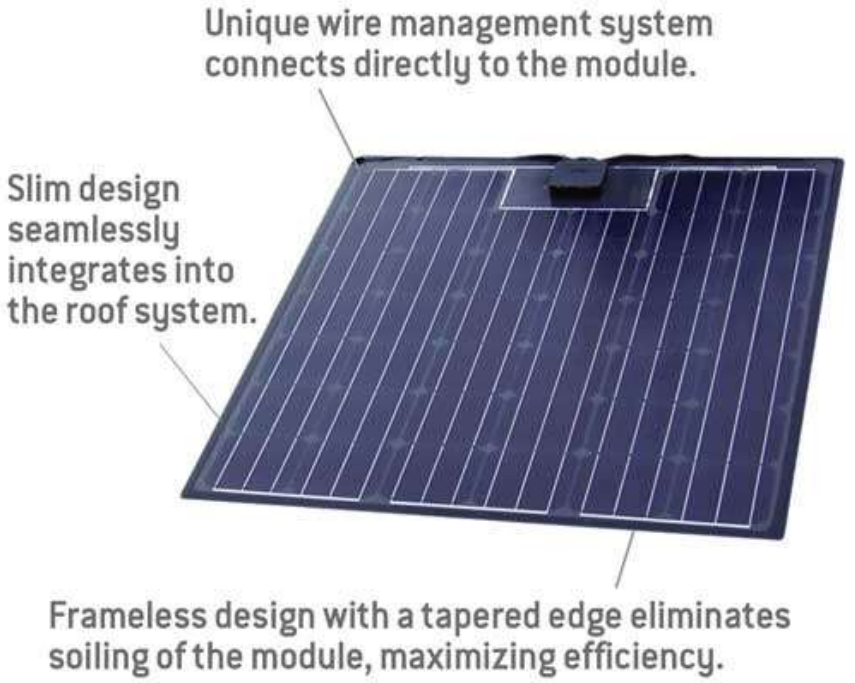
Appearence: Apollo Tile II is designed to match the profile of flat concrete tiles, visually blending into your roof and providing a clean look which a standard rack-mounted system cannot match. An all-black solar laminate combined with a custom colored frame allows the solar tiles to blend with a variety of tile colors.
Mon-Crystal: 14 high-efficiency monocrystalline silicon solar cells provide a power rating of 60 watts per solar tile.
Simplicity: No need to find rafters. Apollo Tile II solar tiles are installed directly into the roof sheathing using standard deck screws.
Weight: No need for structural reinforcements or analysis. At 13 pounds per square foot, the Apollo Tile II system weighs substantially less than a tile roof.
Durable: Even though Apollo Tile II tiles are lightweight, they are designed to be strong. The solar shingles have been tested and rated to withstand 250 pounds per square foot.
Wind Resistant: The Apollo Tile II system achieves the highest wind rating available for roofing materials and can be installed in wind zones of up to 150 miles per hour.
Watertight: Water channels and raised fastener locations provide added protection against water intrusion. With more than 110 years in the roofing industry, you can be assured that CertainTeed knows how to keep water out of your home.

Contractors in the Midwest have begun to use the product “get a roofer” is the current word…

convergence ENERGY LLC

For the last few years we showed this
…Lumeta PowerPly 400
http://www.lumetasolar.com/Installation.aspx

And
the residential
model for asphalt roofs…



This year we See Lumeta Lynx 60 Comp

And Lynx 72

72 CELL
MONOCRYSTALLINE MODULE
360-365W
POWER OUTPUT
RANGE
17.5 kg (38.6 kgs)
MODULE
WEIGHT
18.3%
MAXIMUM EFFICIENCY
Lumeta
Lynx 72

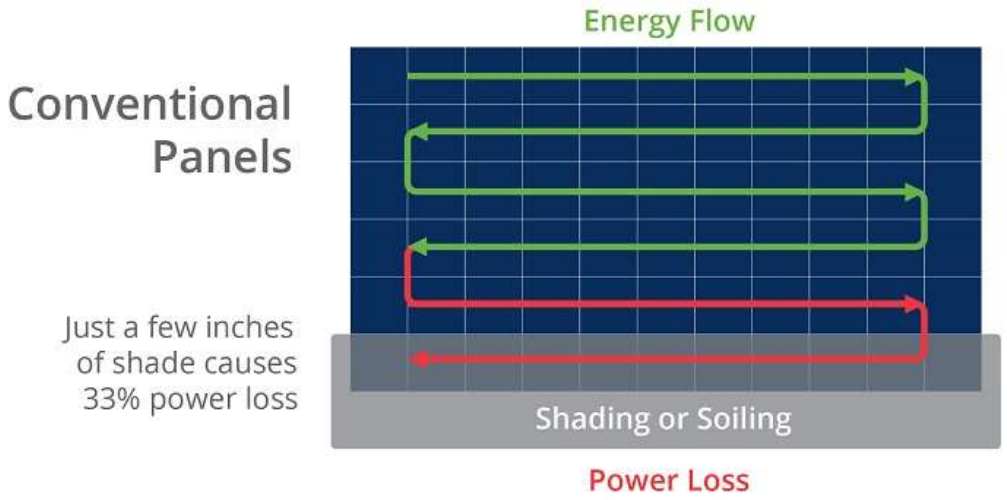
Lumos Solar Continues to provide Frameless glass-on-glass PV modules that create a seamless look…

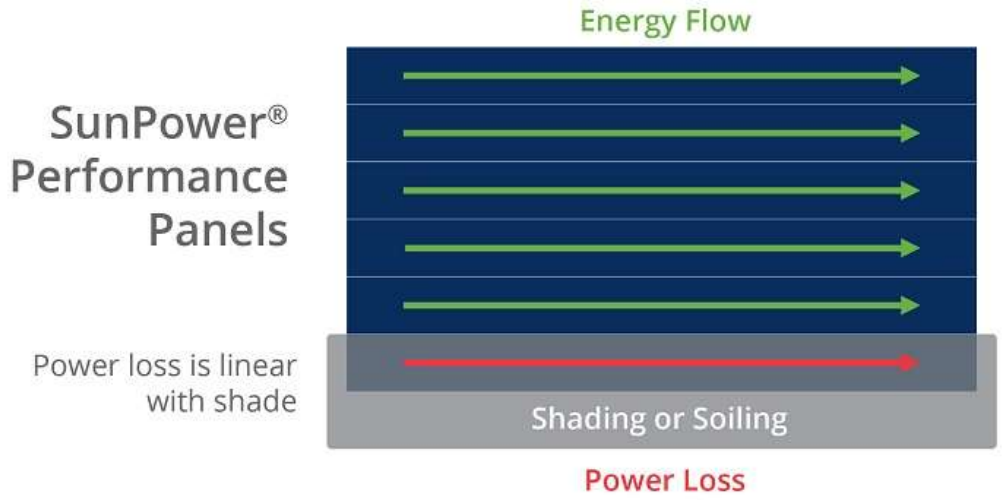
Tesla makes “roofs”!

To date Tesla roofing
Products have not been
Widely available in
The Midwest…

SunPower®

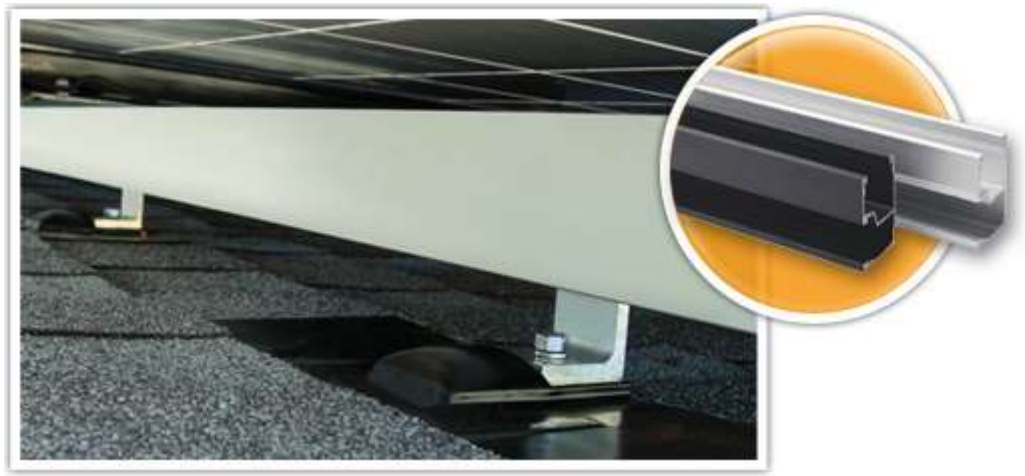
Now offers Performance Series (P-Series) solar panels wrap front contact cells resulting in a panel that offers superior efficiency, power, yield and reliability compared to Conventional Panels.*





The array wire management is starting to be addressed by the rack industry. SnapNrack, Legrand, and Schletter are integrating channels into rack systems to hold PV conductors.

Cablofil and Snake Tray offer wire management solutions that mount on the back of racks. UV-resistant plastic coated stainless steel and crimp connections, like Heyco SunBundler ties, provide long-lasting wire management solution compared to plastic cable ties.



Solar Raceway now makes raceways with PV in mind:

SOLAR RACEWAY®

WIRE MANAGEMENT SYSTEM

https://www.youtube.com/watch?v=meOFpQDMhAQ

Combiner Boxes continue to evolve…

Combiner boxes are changing in significant ways many motivated by new requirements in the National Electric Code …

690.11 mandates that the arc-fault detection device perform several functions in addition to detecting the fault. The device must disconnect inverters, and charge controllers or other “system components within the arcing circuit.” The equipment cannot then automatically restart but must be manually restarted. There also must be a visual indication that the arc-fault device has operated, and it cannot reset automatically.

Section 690.12 requires means to rapidly disconnect “all current-carrying dc conductors of a photovoltaic system from all other conductors in a building or other structure.”

Combiner Boxes continue to evolve - but harness can remove much of the combiners' work…

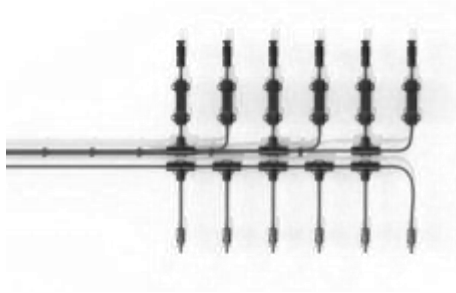
interconnect system™

interconnect system™

inline fuse

harness

Maximize the current rating of the DC combiner fuse holders and reduce the number of DC combiner boxes on site. By using a Shoals Harness that incorporates Shoals In-Line fuse, installers can pre-combine strings before the combiner box.



branch connectors

A method of combining multiple wires without the need for in-field splice. This patented device helps increase efficiency on site while reducing the amount of wire and number of combiner boxes needed.

bla

The BLA (Big Lead Assembly®) takes the component harness to a whole new level. Making use of the Shoals In-Line fuse and wire welding manufacturing process, we can offer a site that is free of DC string combiners, all of the load is combined in the large conductors that typically run between the string combiner and the inverter. No need to trench for DC feeders or hang string combiner boxes. And when booted with BAC connector, the entire array is plug-and-play, plug in the panel strings, plug into the inverter.

dc feeders

Shoals can supply the larger conductors that run from the string combiner to the inverter or re-combiner, cut to length and outfitted with any style lug required on site. It can also be ordered with the BAC connector so there is never any need to torque check which reduces O&M time and costs.

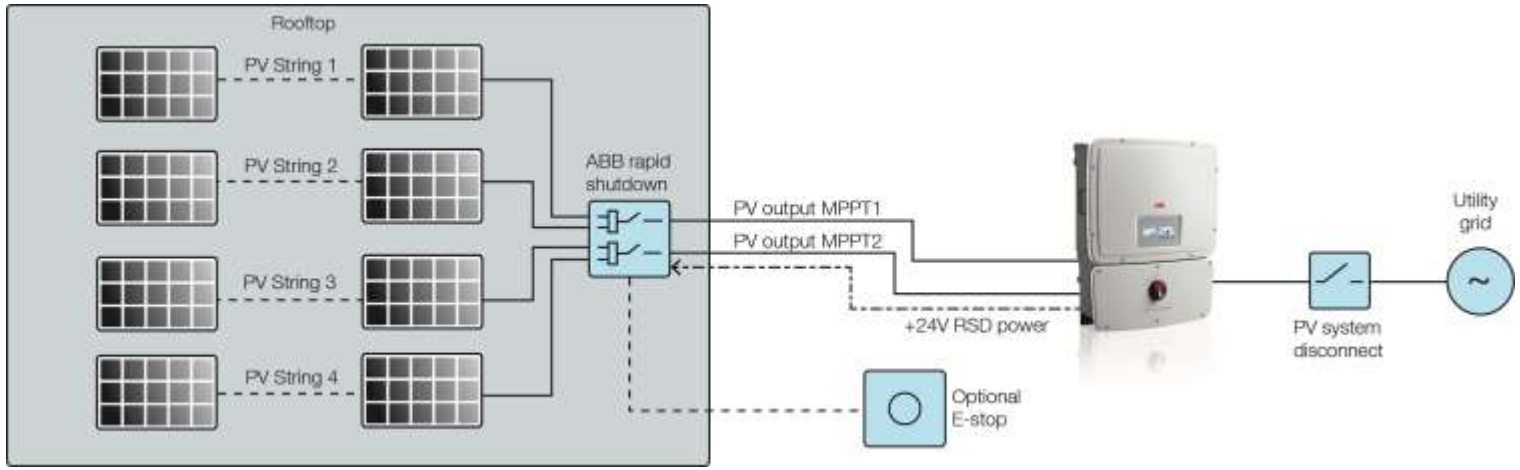
Solutions for rapid shut-down
are the law for venues adopting the 2017 NEC…

Very exciting!

Combiner Boxes now offer integral disconnecting means… MidNite Solar's offers a hard wired remote called the "Birdhouse" to be located at the service entrance… while this is the one solution that can work with battery based systems to rapidly shut down the entire DC system it does not comply with the 2019 requirements for Module level RDS.

ABB Power and productivity for a better world™

The ABB Rapid Shutdown system requires no extra conduit; minimizing additional material cost and associated labor. Shutdown occurs at the rooftop box when utility power is lost or when the PV system's AC disconnect switch is opened. In jurisdictions requiring a dedicated activation switch, an optional emergency stop-button is available – this will be incorporating MLPE to meet the 2019 requirements…



INNOVATIVE SOLAR INC.

Rapid Shutdown® 600v with Capacitor Discharge in Steel Enclosure UL1741

These will not meet the 2019 NEC ML RSD requirements…

Rapid Shutdown® 1000v in Steel Enclosure UL1741

Innovations in Monitoring:
System Monitoring for various size PV systems
And …a bit on data collection for Site Assessments and O&M

Courtesy AMtec Solar

String-level granularity - This Prominence series smart combiner from AMtec Solar provides string-level monitoring for 16 source circuits and includes an optional wireless Modhopper.

Monitoring for Residential and small Commercial systems is most often completed at the inverter level with data logging hardware and software provided by the Inverter manufacturer. These systems are cost effective for this scale of installation but provide little granularity.

Most suppliers can interface with the wide range of inverters and also get to string level granularity

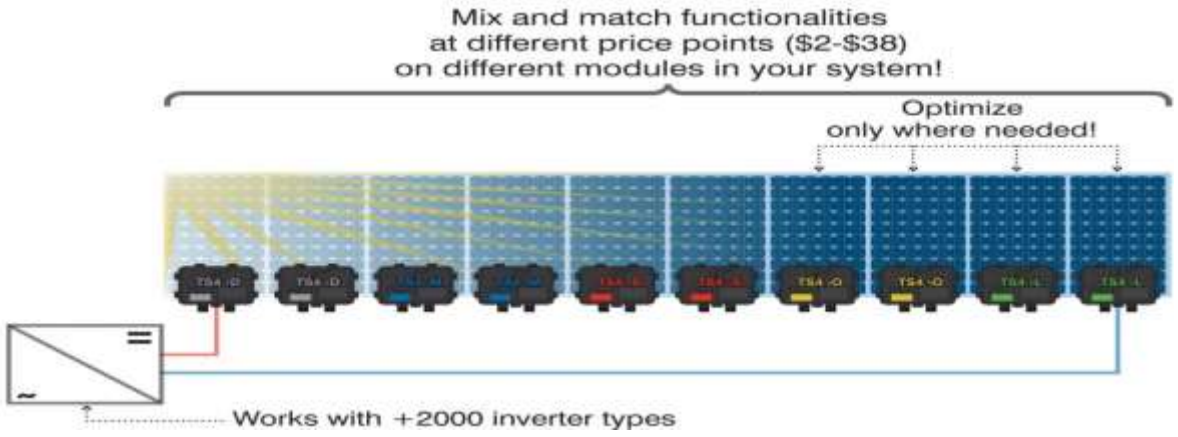
Some Combiner Boxes (like AmTec in the previous slide) offer string level monitoring in conjunction with compatible 3rd party monitoring companies…

Most providers offer “weather station” data collection features to aid in analysis and troubleshooting…

Tigo TS4 – allows for module level monitoring in addition to the other features…

“Tigo TS4 ” the TS4-S,F, O and L will meet NEC 2019 with appropriate inverters

Rapid shutdown at the Module…



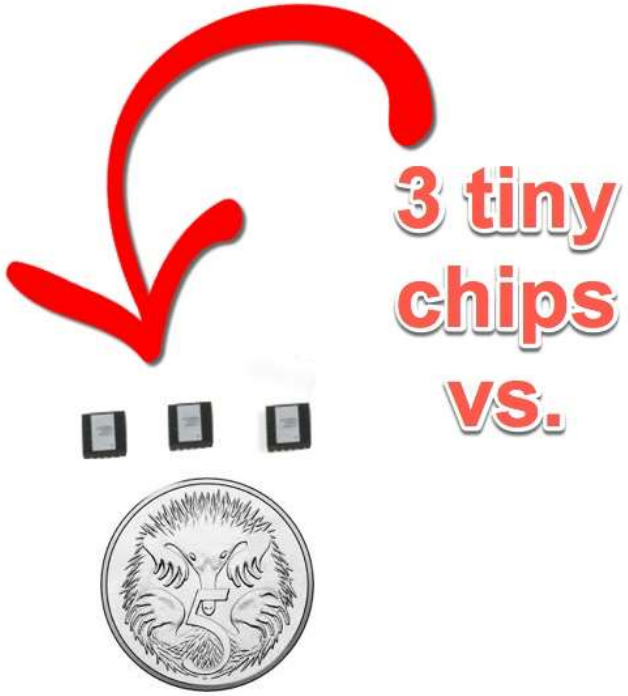
30% Longer Strings

Smart Modules Enable 30% Longer Strings

Germany’s SMA Solar Technology AG will acquire a 27% stake in the Los Gatos, California-based Tigo Energy, Inc., in a $20 million capital increase deal. As part of the agreement, SMA has secured for 30 months exclusive rights for worldwide sales of Tigo Energy’s new TS4 Retrofit product platform for module optimization.

Code changes in the 2017 edition are driving Module level power electronics forward:

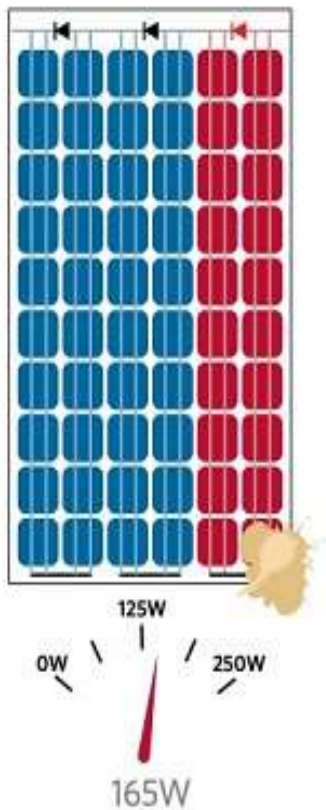
Maxim Integrated – revamps the module diode design….



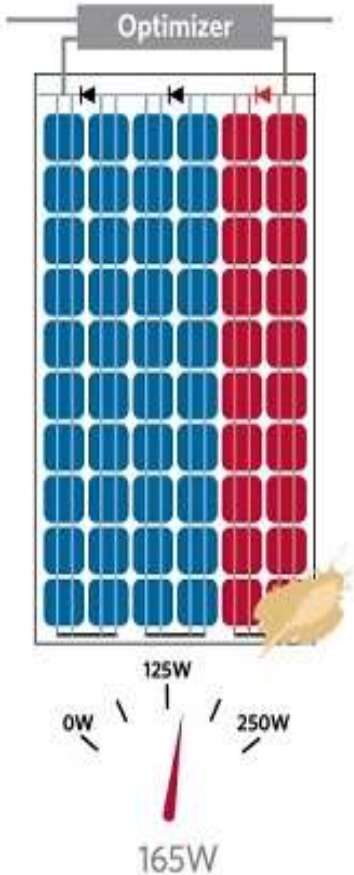
maxim integrated™

maxim integrated™

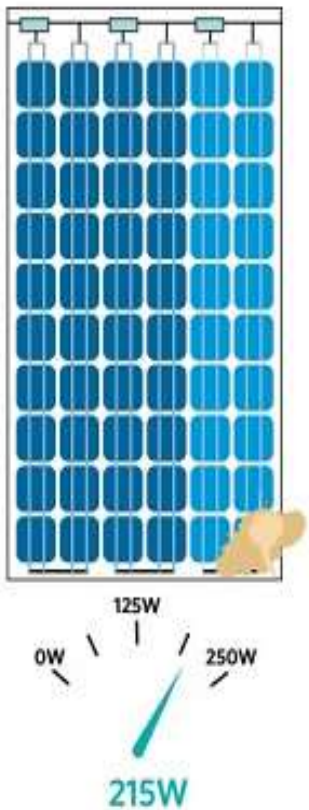
Conventional Panel



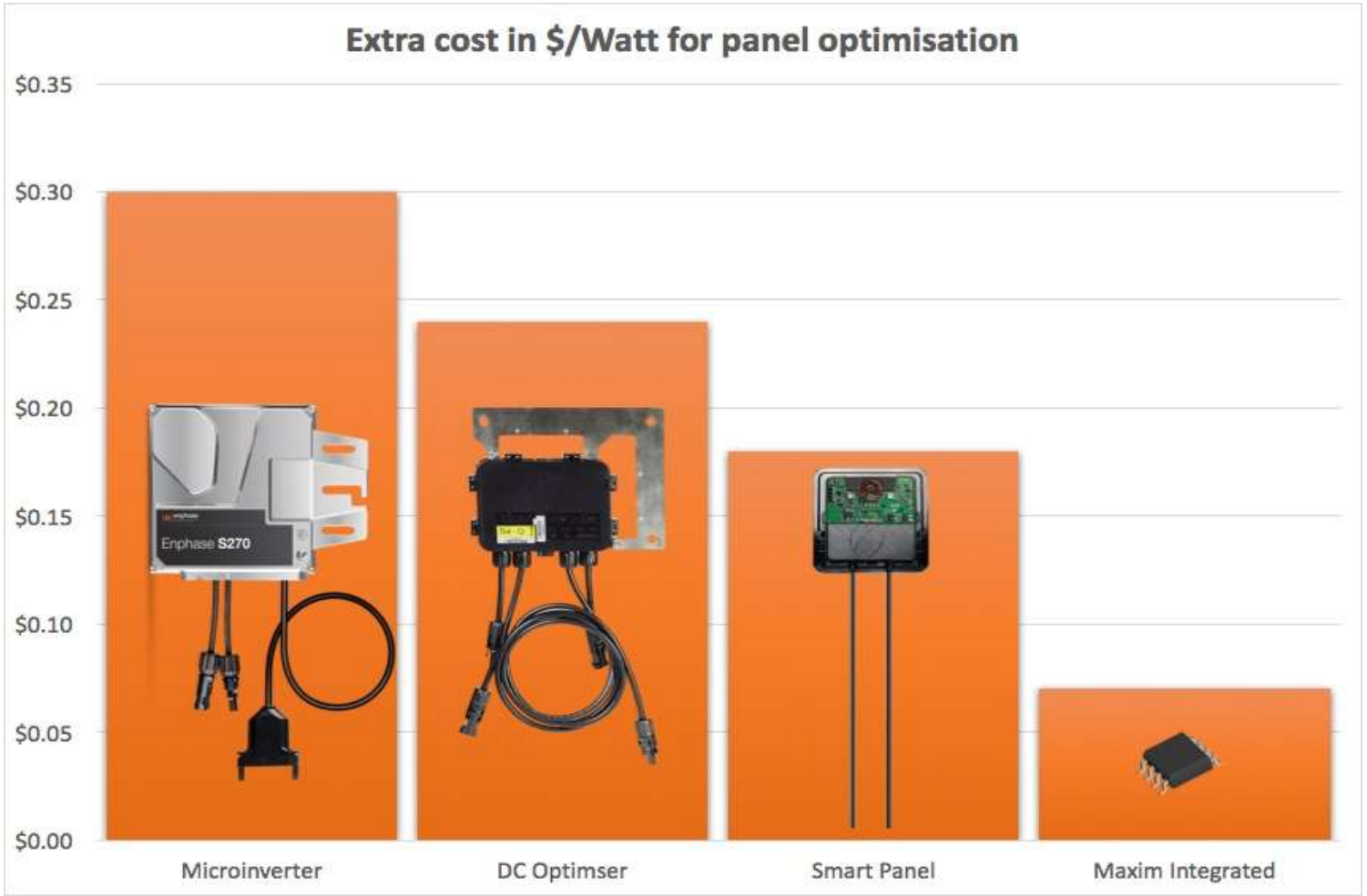
Panel Optimizer Module



Solar Cell Optimizer



Maxim is working with the industry in the SunSpec Alliance to create an open-standard solution enabling compatibility amongst a wide variety of inverters and modules. This approach will provide the industry with flexibility to use best-in-class building blocks rather than proprietary vertical power solutions. The Maxim implementation will be the lowest cost PLC-based optimized/shutdown solution in the market.



SUNPOWER®

SunPower Panels Bypass Individual Cells

On their illustration, Maxim Integrated describe their technology as a solar cell optimizer. And it is certainly true that it optimizes solar cells. However, it would be more accurate to call it cell-string optimization, as it works on that level and not on individual cells.

SunPower, an American company that produces panels with a 25 year product warranty, uses technology that is able to bypass individual shaded cells. According to SunPower's information they appear considerably better at handling shade than Maxim's cell-string optimization. But while they do an excellent job of reducing the effect of shade on individual panels, they won't prevent one shaded panel dragging down the output of others on the same string in the panel array.

Charge Controllers with some Innovations:

While charge controllers have evolved greatly in the last decade only small incremental changes have come in the last few years…

Magnum now Controller Integrates with its full line of Battery-based equipment…

100 A, 200VDC

Schneider Electric (maker of Square D) moves Xantrex into the future with the 600Vdc charge controller and other new offerings…

195 Maximum V OC

865-1032
Xantrex XW - solar charge controller XWMPPT80-600 - 24...48V DC

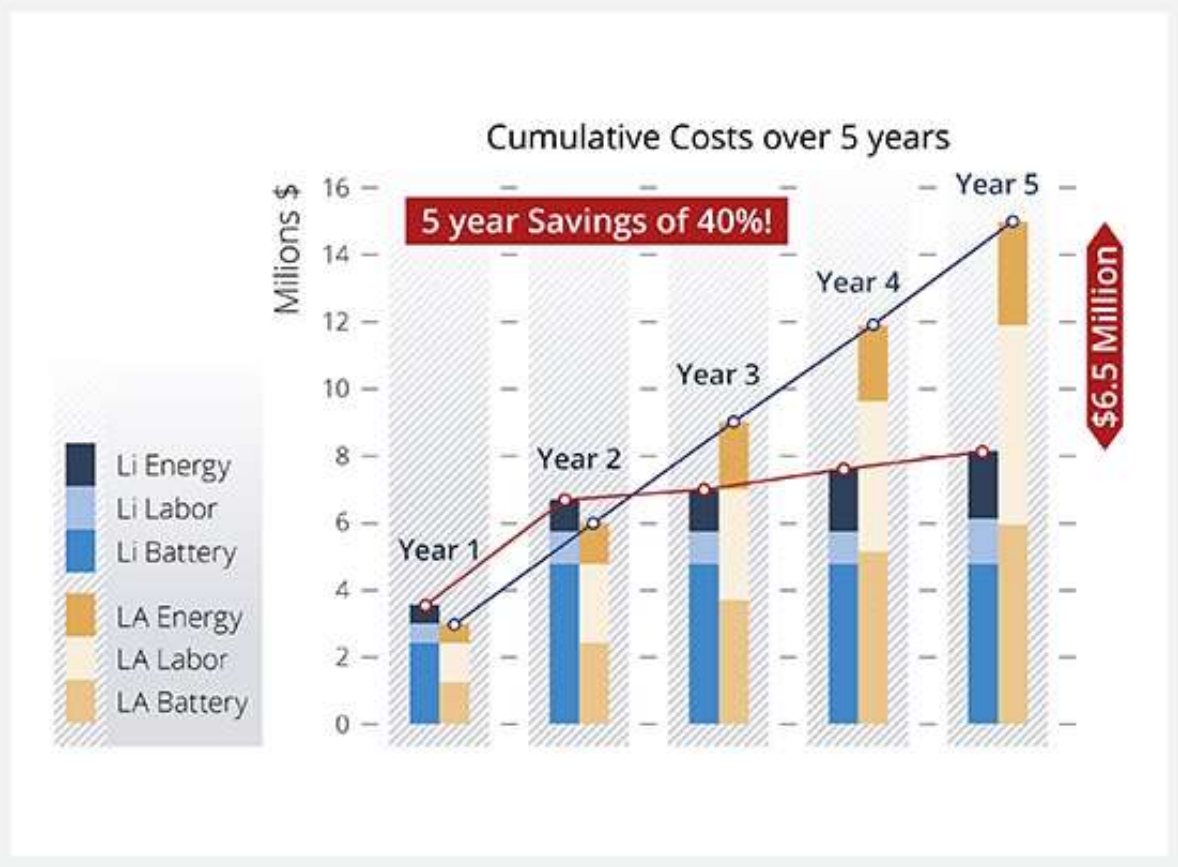
MidNite continues its evolution with 30Amp “Kid” and 600 Vdc Hybrid “SkyBox”

Batteries are now one of the most innovative areas of technology used in the PV field

Flooded Deep-Cycle Lead-Acid (FLA) batteries have dominated the storage area of PV’s for its entire history

The field is ripe for development and the big opportunity with electric vehicles is materializing into what will become many cost competitive alternatives
to FLA batteries

FLUX Power claims to compete with Lead-Acid today…



Flux Power Q1’19 Revenue Increased Ten-Fold to Record $1.84M, Driven by Large Customer Adoption of Lithium-Ion Industrial Batteries

Stone-edge-farm-microgrid-project

Fourteen 25 kWh Aquion M-Line Battery Modules providing approximately 350 kWh of energy storage capacity, connected to a 32 kW solar array using Ideal Power's 30 kW multi-port power conversion system.

The Ideal Power multi-port system architecture enables the direct DC-level connection of solar PV and energy storage in one compact, highly efficient, transformerless package, eliminating the complexities and redundancies of older, AC-coupled systems. Aquion's battery technology is a unique saltwater chemistry made from abundant, nontoxic materials. The batteries are designed for daily deep cycling in long duration (4+ hour charge/discharge) applications, making them ideal for solar installations.

Chapter 11 as of March 2017

https://prezi.com/cnbi98fvg3va/stone-edge-farm-microgrid-project/

SUNVERGE

DC –coupled design, LiOn Battery with Schneider BOS

Continues to be an industry leader in controls and applications of aggregation…

Germany - Sonnen is putting the largest virtual battery of its kind into operation creating the power grid of the future…For the first time, Sonnen is providing balancing power for the energy market by means of residential energy storage systems networked across the whole of Germany. The Sonnen virtual battery, which is now online, is currently the largest of its kind that is able to compensate for fluctuations in the power grid. As a result, German households are now in a position to take over all the tasks of conventional power stations.

sonnen

Until now, it has mainly been CO2-intensive power stations that have been used for this primary balancing power; Sonnen's networked residential energy storage systems are helping accelerate the removal of these power stations from the grid in Germany.

Since each SonnenBatterie has a different state of charge the large number of individual batteries will be aggregated into blocks starting at 1 MW, which are then made available to the energy market. During TenneT's certification of the virtual battery, it had to first discharge one megawatt of power to the grid and then re-charge the same amount back from it within 30 seconds. With the passed test, the virtual battery has qualified for participation in the so-called primary operating reserve market.

San Diego schools take 6.3MWh Green Charge storage systems

US firm Green Charge Networks sold its Green Charge energy storage system to12 school campuses in Poway, in San Diego in the US, with cumulative capacity of 6.3MWh across the sites.

The Poway Unified School District has 37 schools, catering to 36,000 students of all ages. It is the third largest school district in the city. The Green Charge installations have come through Green Charge's Power Efficiency Agreement (PEA), where Green Charge owns and operates the system, and invoices customers for a portion of their energy savings.

Green Charge said the district will save more than US$1.6 million over the term of the 10-year contract.

stem

data
analytics
power

Stem creates innovative solutions that are changing the way energy is distributed and consumed. Stem combines powerful learning software and advanced energy storage, simultaneously helping businesses better manage energy costs while creating a more efficient electrical grid.

Adobe: **Facility type:** Technology offices
Sites: 2
Capacity and power: 162 kW / 180 kWh
10-year savings: $255,600
With Stem's solution, Adobe can achieve more than peak demand management alone from their energy storage system. Through Stem's participation in the California ISO (CAISO)'s Supply-Side Pilot, Adobe became one of the first companies to demonstrate that commercial energy consumers can support the smart grid with energy storage – and get paid to do it.

Micro Inverters are a still a significant player in the grid-intertie market and the manufacturers are responding with more offerings –

Enphase, the first leader in the revived Micro-inverter world,

Micro inverters are ideal for roofs with multiple orientations, starter systems and where shading is unavoidable.

Enphase – IQ7+ & 7x -

Optimized for high powered 96-cell modules
Max Output Power: 320 VA
Recommended PV module input power: 320-460+ W
MPPT Range: 53V – 64V
97.5% CEC Efficiency
Configurable for variable grid profiles like Hawaiian Electric Company (HECO) Rule 14H, California Rule 21, and others

Optimized for high powered 60-cell, 72-cell* modules
Max Output Power: 250 VA (IQ 7) or 295 VA (IQ 7+)
Recommended PV module input power: 235-350+ W (IQ 7) or 235-440+ W (IQ 7+)
MPPT Range: 27V – 37V (IQ 7), 27V – 45V (IQ 7+)
97.5% CEC Efficiency
Configurable for variable grid profiles like Hawaiian Electric Company (HECO) Rule 14H, California Rule 21, and others
* The IQ 7+ Micro is required to support 72-cell modules

Power One:

NOW a “LEGACY” product not offered…

Aurora Micro

Aurora Micro
The Aurora 250 and 310 Watt micro-inverter.
96.5% CEC efficient

String Inverters: Long the inverter of the residential and small commercial market

Innovators include:

SMA

Fronius

SolarEdge

SMA + Tigo

Complying with NEC 2017 requirements for module level shut down…

RAPID SHUTDOWN SYSTEMCOST-EFFECTIVE SYSTEM COMPLIANCE – Until Dec. 31’st 2018

Number of DC inputs	4 strings, 2 in parallel
per channel	
Number of DC inputs	20 A DC
DC operating current per channel	36 A DC

Fronius Symo Advanced

The Fronius Symo Advanced comes with an integrated Power Line Communication (PLC) transmitter based on the SunSpec Rapid Shutdown communication standard. In conjunction with the Tigo TS4-F cover, solar installers get a simple and cost-effective solution for module level shutdown.

The Fronius Primo 10-15 kW complies with NEC 2017 module level shutdown in conjunction with the Tigo TS4-S or O cover.

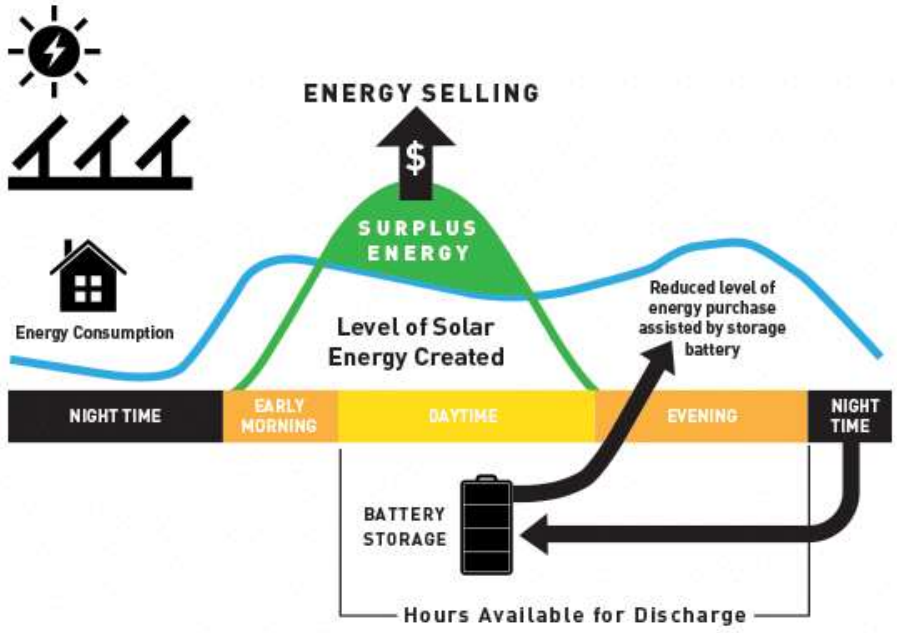
Blueplanet Ultraverter System

AC system
Easy plant design and installation
Highest up-time
Intelligent power balancing mitigates loss from shading or soiling
Low voltage operation
Self-healing system
Compliant with NEC 690.12 rapid shutdown requirements
Wi-Fi as standard data logger interface
Standard 25 year warranty for Blueplanet Ultraverter 250

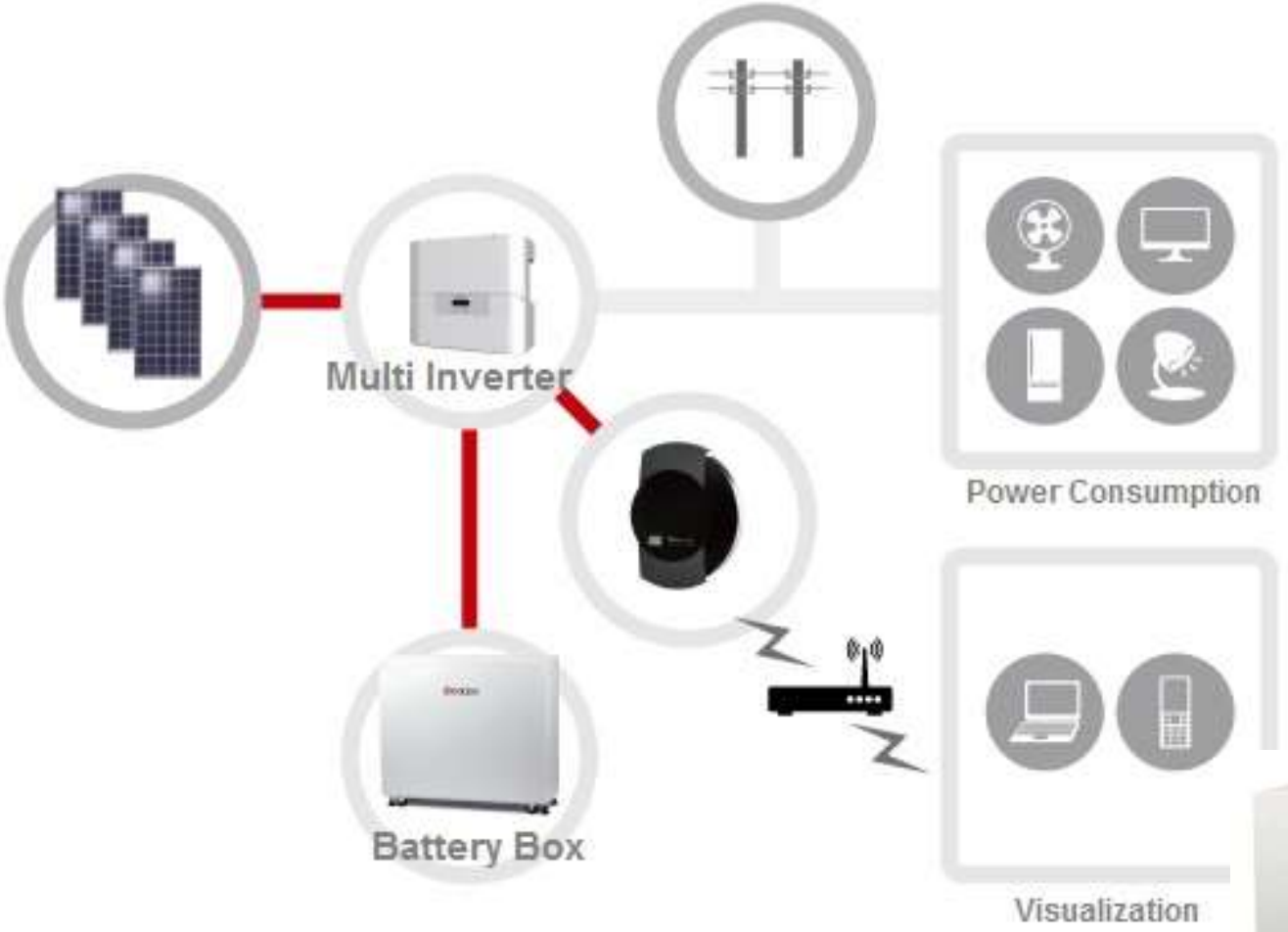
SolarEdge – uses module based power optimizers sending uniform MPPT high voltage to the inverter in a small window – This is the required inverter for using Tesla Powerwall..

The optimizers create a RSD at the module level…

With Energy storage and advanced communications, our systems will become whole building energy management Systems, and with aggregation we will see in my final presentation today on Solar + Storage that the entire utility model will be evolving into an interactive world …



From our Friends at Kyocera



Operation modes

Self consumption mode
Stand alone mode
Charging mode
Discharging mode
Without battery mode

And from our friends at Panasonic we see good designs over seas….

https://www.youtube.com/watch?v=PxBHv40XoFs

There are more competitors to come and the use of Solar + Storage will be the ongoing wave of Renewable Energy development for year to come…

Stay tuned….

Thank you for your interest in renewable energy and creating a rational future…

GREAT NORTHERN SOLAR

IREC
Interstate Renewable Energy Council
CERTIFIED MASTER TRAINER™