



Innovative DC Power Management

Lower cost and higher performing PV systems



Optimize PV Systems



Repower PV Systems



DC-Coupled Storage



Monitoring and O&M

About Ampt

Company	Ampt, LLC	
Founded:	2007	
Founder & Chairman:	Doug Schatz Founder and Chairman of Advanced Energy (NASDAQ: AEIS)	
Investors:	Schatz Family Trust Bohemian Investments	
Headquarters:	4850 Innovation Drive Fort Collins, Colorado 80525 United States of America	
Manufacturing Partner:	Sanmina Corporation (NASDAQ: SANM)	
Technology:	DC Power Management & Wireless Communication	
Patents:	31 U.S. & international patents issued; more in process	
Market Position:	#1 optimizer company in large PV systems & energy storage	

Company Vision

Ampt will become synonymous with the way to harvest, control and store the sun's energy.

Core Values

- Integrity
- Customer Focus
- Innovation
- Relentless

Core Focus

- Purpose: Accelerate clean energy revolution
- Our Niche: Optimizing solar energy conversion

Differentiators

- We lower the cost of energy
- Flexible, innovative technology
- Build collaborative relationships

Ampt is a recognized leader in PV power technology

Ampt was founded in 2007 and is headquartered in Fort Collins Colorado. Ampt is established with sales and support in North America, Europe and Japan as well as representation in Asia, Australia, and the Middle East.

World's
#1

Optimizer Company
#1 in Large PV Systems
#1 in Repowering
#1 in PV+Storage

Headquarters



Founded 2007

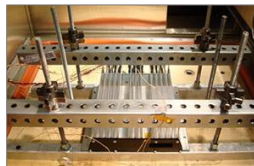
Ampt Japan



Patented Technology



Quality & Reliability



World-Class Manufacturing



Our People



History and Milestones



#1 optimizer company for large-scale PV systems



Repowering Existing Systems

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Delivering Today's Global SOLAR Technology News, Today

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Solar Power Plants | Solar Thermal | Concentrating Solar | Photovoltaic | PV Solar Applications | Energy Storage | Power Electronics | Solar PV Systems

Canadian Solar Deploys Ampt's DC Optimizers in 33 MW Utility Solar Plant

Published on 23 September 2016

33.7 MW
Canada



Ampt LLC, a specialist in power conversion technology, announced the deployment of its DC optimizers in a 33 MW solar photovoltaic (PV) system with [Canadian Solar, Inc.](#) one of the world's largest solar power companies. The project uses Ampt's DC

String Optimizers in one of the largest deployments of DC power optimizers in the world.

The 33 MW installation capped off a six-month evaluation period by Canadian Solar, which began with a smaller demonstration project. Following the successful demonstration, Canadian Solar selected Ampt's String Optimizer as it consistently outperformed other designs while costing less.

When compared to other options, Ampt String Optimizers delivered superior value. Ampt's patented technology puts voltage and current limits on the output of each optimizer to allow twice the number of PV modules per string and eliminate half of the combiner boxes and associated cable and labor.



PV + Energy Storage

SOLAR BUILDER

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World's largest solar PV peaker power plant uses DC-coupled storage design with Ampt optimizers

JANUARY 28, 2019
BY CHRIS CROWELL



The Lāwai Solar and Energy Storage Project in Hawaii completed this month became the world's largest operational solar PV+storage peaker plant and is responsible for delivering 11% of Kauai's power while providing mission critical grid support during peak demand periods. The completion of this system allows the utility to deliver up to 40% of the island's evening peak power using stored solar energy. This record-breaking record-breaking PV peaker power plant has 28 MW of solar PV and 100 megawatt-hours (MWh) of DC-coupled energy storage.

To meet the demanding operational needs of a clean energy peaker plant while being cost competitive, the project developer chose to use a DC-coupled storage architecture based on Ampt String Optimizers for its cost and performance advantages. DC-coupled energy storage systems charge batteries using energy from the DC solar array rather than the AC grid.

Ampt String Optimizers decreases the total cost of the entire power plant. Ampt's unique features lower the cost of all the power electronics, including the inverter and battery converter, and save in electrical wiring of the PV array.

Moreover, Ampt String Optimizers maximize the performance of the PV system by managing power on each string of PV modules rather than across the whole array at a central point. This increased granularity mitigates system degradation to deliver more lifetime energy. DC coupled storage systems

Awards and Recognition

Frost and Sullivan Awards Recognize Ampt

FROST & SULLIVAN

Customer Value Leadership Award
Solar PV Electronics
Global, 2014

"It's Frost & Sullivan's opinion that Ampt's strength lies in its advanced solutions designed for market architecture change based on its patents and intellectual property (IP) that lowers the system cost and also gets all the benefits of Maximum Power Point Tracking (MPPT) on a more granular level."

FROST & SULLIVAN

Technology Innovation
Solar Inverters
North America, 2012

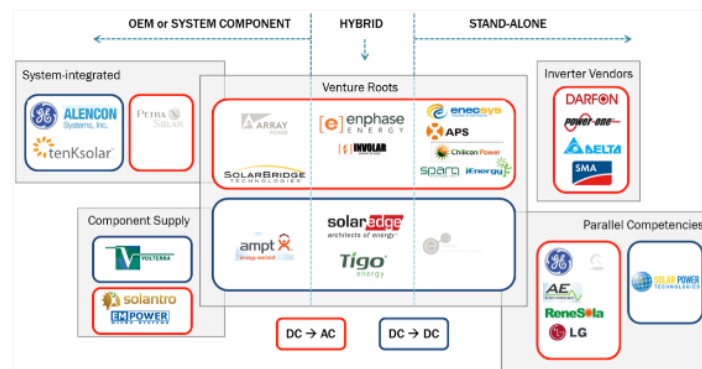
"Ampt has engineered a solution that lowers the capital costs for solar installations while increasing energy harvest using their unique DC/DC power converters that are distributed throughout a PV array. Ampt has been successful in demonstrating its patented and highly reliable technology, and has established partnerships with leading players in the PV market, through the HDPV Alliance to enable an ecosystem of innovators leveraging Ampt technology."

FROST & SULLIVAN

Product Differentiation Excellence
Solar Inverters
Europe, 2012

"Ampt has come up with a radical product that is expected to revolutionize the Solar Inverter market. Its unique vision of improving the overall performance of the PV system at lower cost has generated a lot of interest in the market. Ampt collaborates with inverter manufacturers, panel manufacturers and other Balance-of-System component suppliers to address the prevailing challenges in the Solar Inverter market. Inverters operating in 'Ampt Mode™' provide optimum performance at up to 50% lesser cost than traditional inverters."

GTM Research Recognizes Ampt as a Top Player



Industry Publications Featuring Ampt



Experienced leadership

Seasoned management team with over 200 years of executive management experience in both public and private companies of which over 60 years is in the Solar PV Industry.



Doug Schatz
Founder & Chairman



Levent Gun
CEO



Aaron Gomolak
CFO



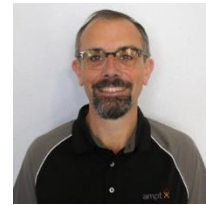
Darryl Parker
VP Sales & Marketing



Anatoli Ledenev
Chief Scientist



Russell Schaeffer
VP Operations



Fernando Tomasel
VP Engineering



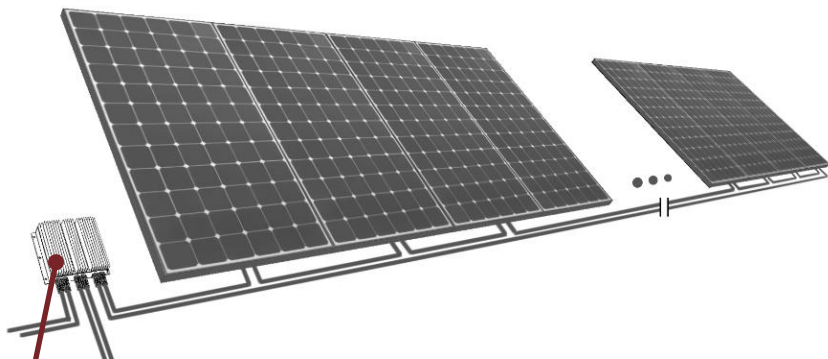
Satcon



Satcon



Ampt String Optimizers Deliver Unmatched Value



Optimize PV Systems



Repower PV Systems



DC-Coupled Storage

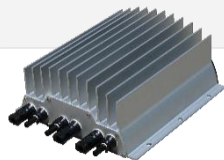


Monitoring and O&M



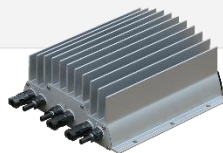
V1500 Series

Max system voltage: 1500 V
Max output power: 27.2 kW



V1000 Series

Max system voltage: 1000 V
Max output power: 11.1 kW



V750 Series

Max system voltage: 750 V
Max output power: 8.7 kW



V600 Series

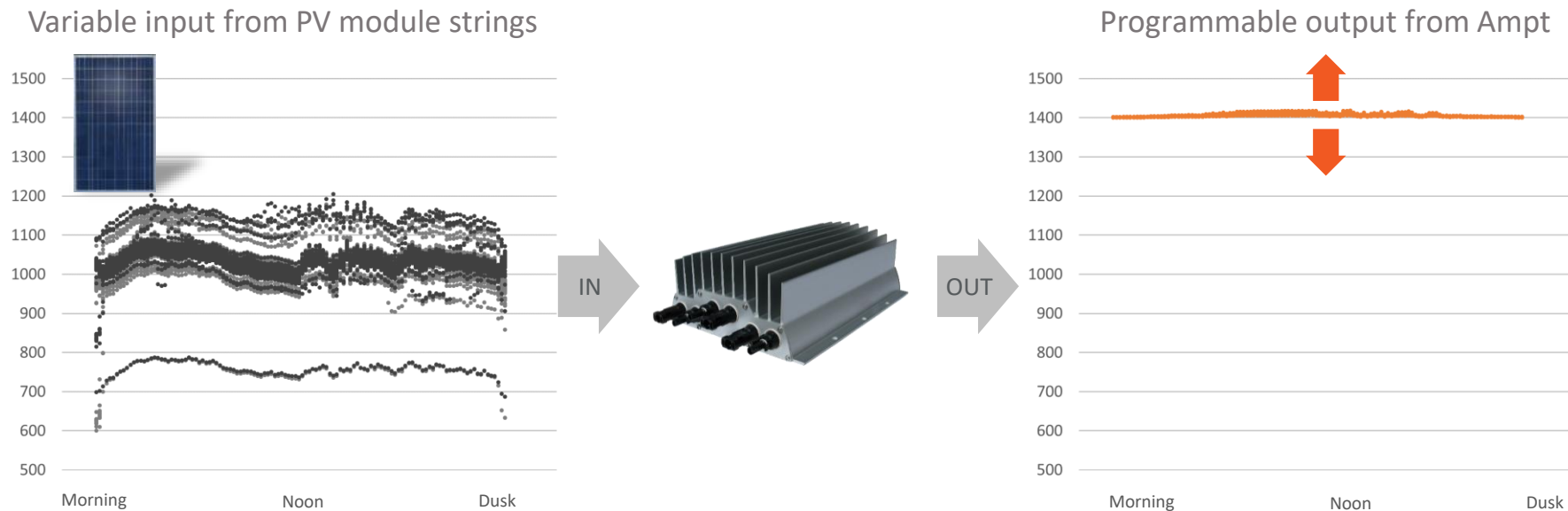
Max system voltage: 600 V
Max output power: 6.7 kW



Ampt CU

Two-way Wireless (RF)
String-level data for O&M

Innovative DC power management



MPP Tracking on each string eliminates mismatch.

Programmable output adapts to meet inverter and energy storage requirements.

Reference Projects



Reference Projects

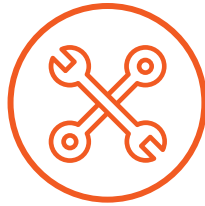


Reference Projects





Optimize PV Systems



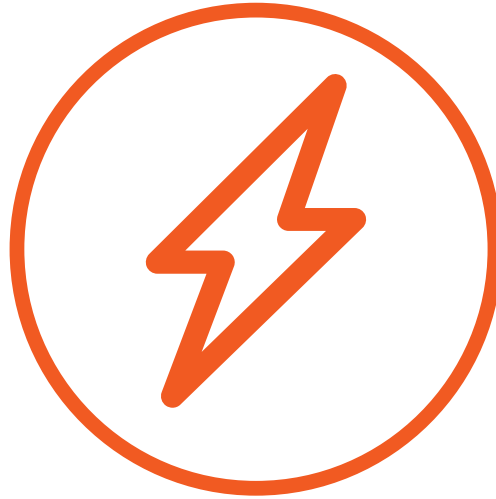
Repower PV Systems



DC-Coupled Storage

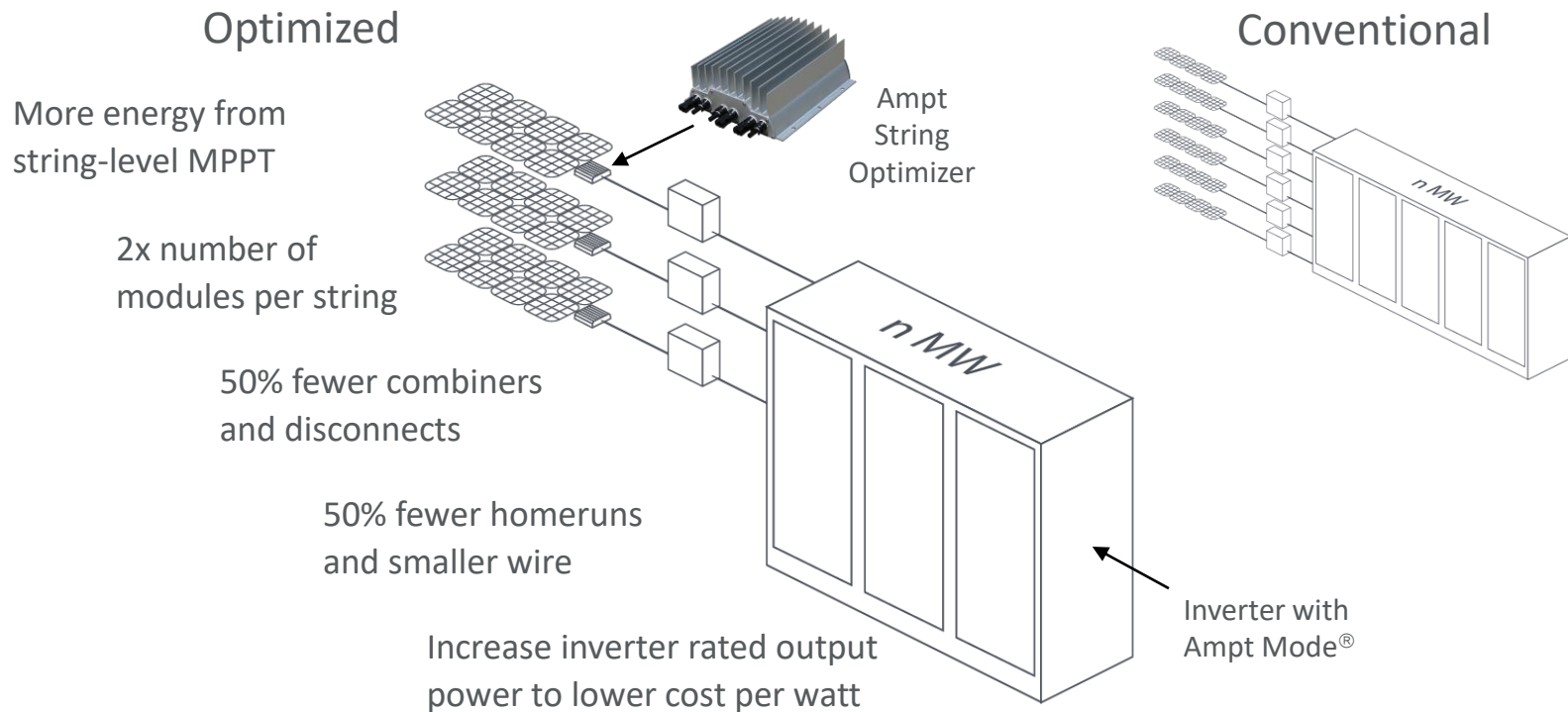


Monitoring and O&M



Optimize PV Systems

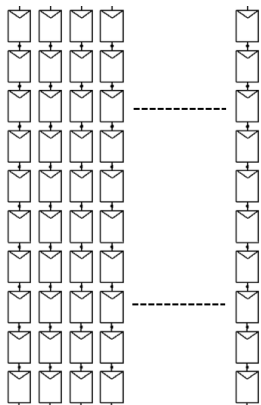
Advantage of Optimized vs. Conventional Designs



More Energy Through Mismatch Correction

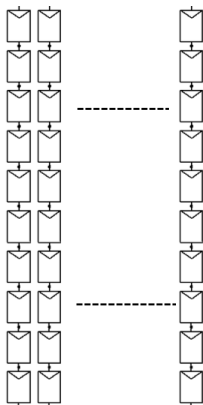
Central Inverters

1000's of Modules per MPP Tracker



Large String Inverters

100's of Modules per MPP Tracker



Ampt String Optimizers

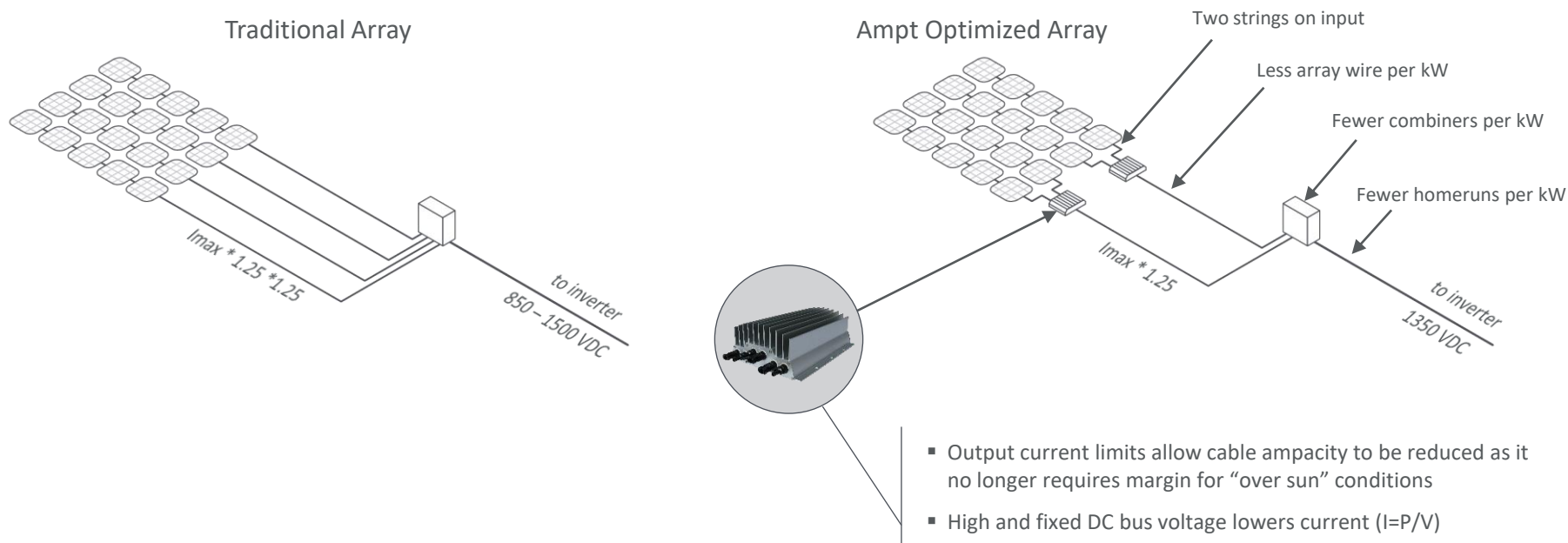
10 - 30 Modules per MPP Tracker (72 cell)



More Energy

Smaller MPP zones = better correction for mismatch

Ampt String Stretch® Technology Allows 2x Longer Strings



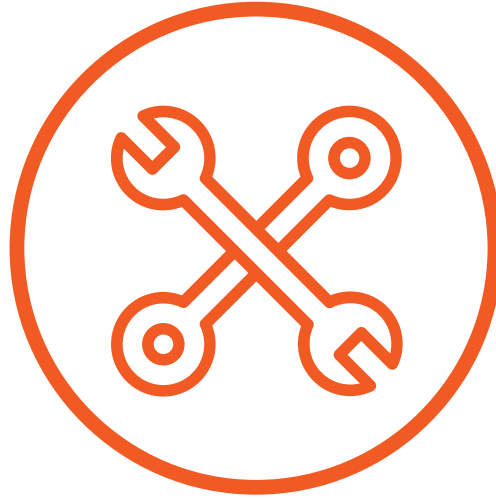
50% fewer combiners and less cabling to save on cost

Lower Cost Inverter with Ampt Mode®



	Standard	Ampt Mode®
DC electrical		
Max array input voltage	1500 V	1500 V
Input voltage range	850 - 1500 V	1350 V Fixed
Rated input voltage	850 V	1350 V Higher
Max operating input current	3200 A	3200 A
AC electrical		
Rated output voltage	600 V	800 V Higher
Rated output current	2300 A	2300 A
Rated output power	2400 kW	3200 kW 33% ↑

Increasing inverter rated output power lowers cost per watt



Repower PV Systems

Repower Existing PV Systems

Improve System Performance

More energy with dual MPPT

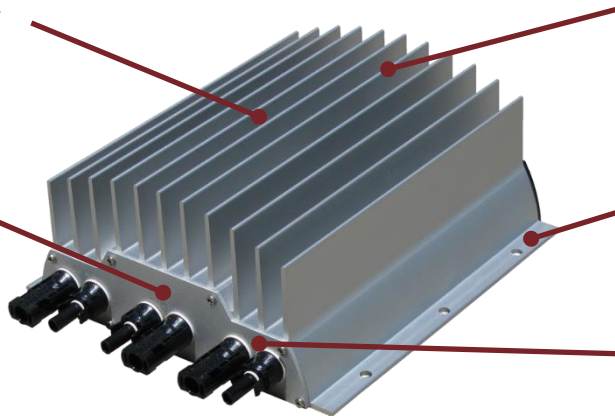
Ampt delivers full available power at voltage set by existing inverter
(no communications required)

Low Cost Solution

Enhanced O&M with string-level data via optional wireless communication

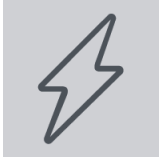
Mounts easily

Low cost retrofit uses existing cables and half the number of combiner circuits



3 Ways to Repower Systems with Ampt

Recover Energy



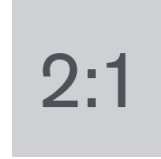
Recover energy lost from mismatch and degradation to increase production.

Upgrade Inverters



Upgrade inverters over time as each one ends its lifecycle with the newest inverter technology

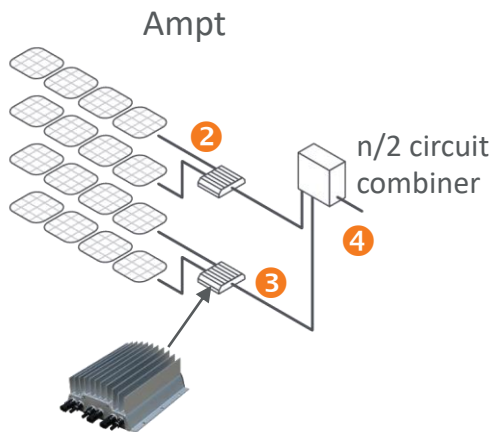
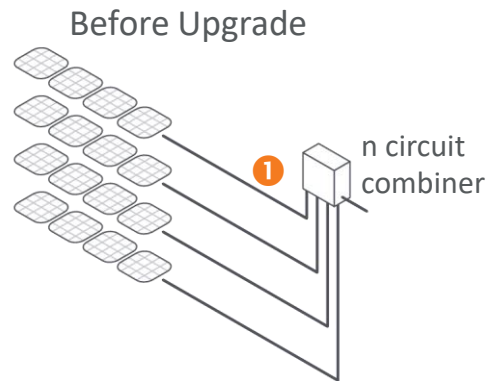
Expand to High DC/AC Ratio



Expand array size mixing new and legacy modules without overloading inverter to increase revenue



Deploy on Existing Wiring, Combiners & Inverter

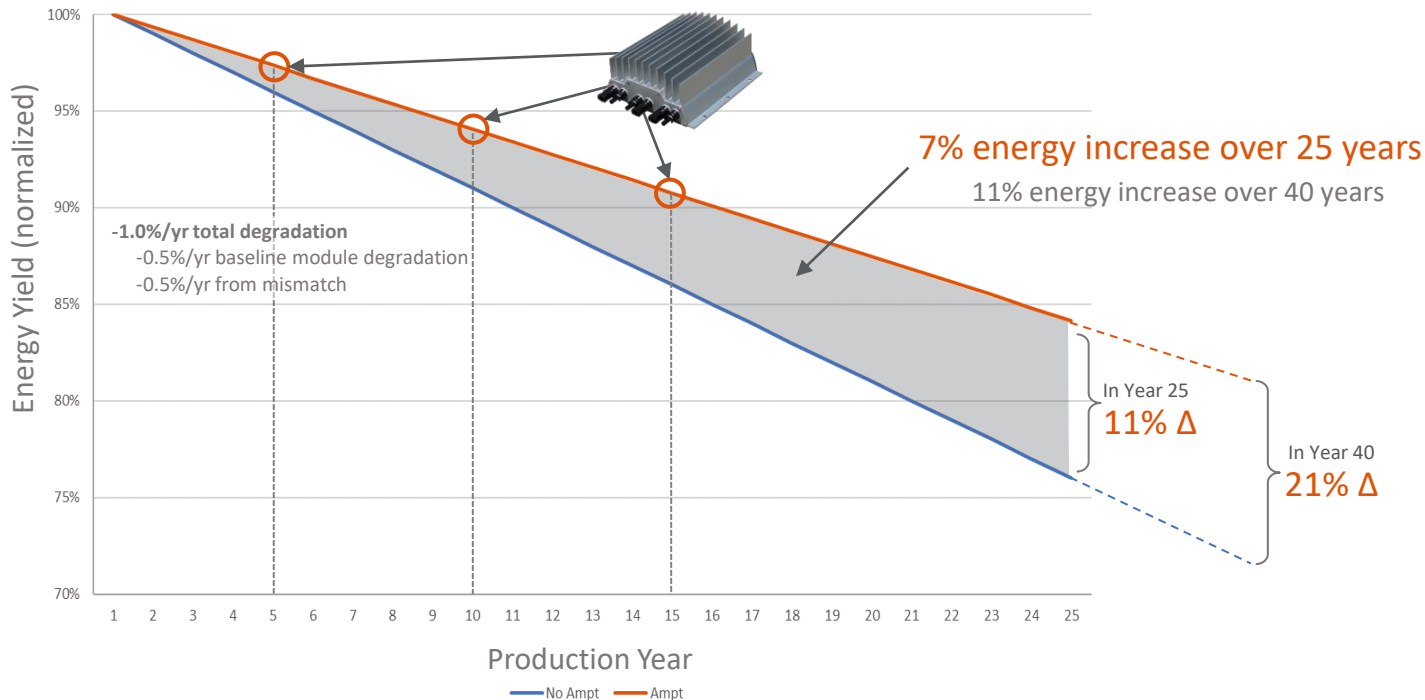


- 1 Disconnect strings from combiner
- 2 Connect one string to each Ampt input using existing cables
- 3 Connect Ampt output to combiner
- 4 Set inverter to constant or narrow-range voltage operation

Simple drop-in use for low-cost installation



String optimizers recover ~33% of annual losses



Repowering date determined by value of energy and degree of degradation



Upgrade Inverters

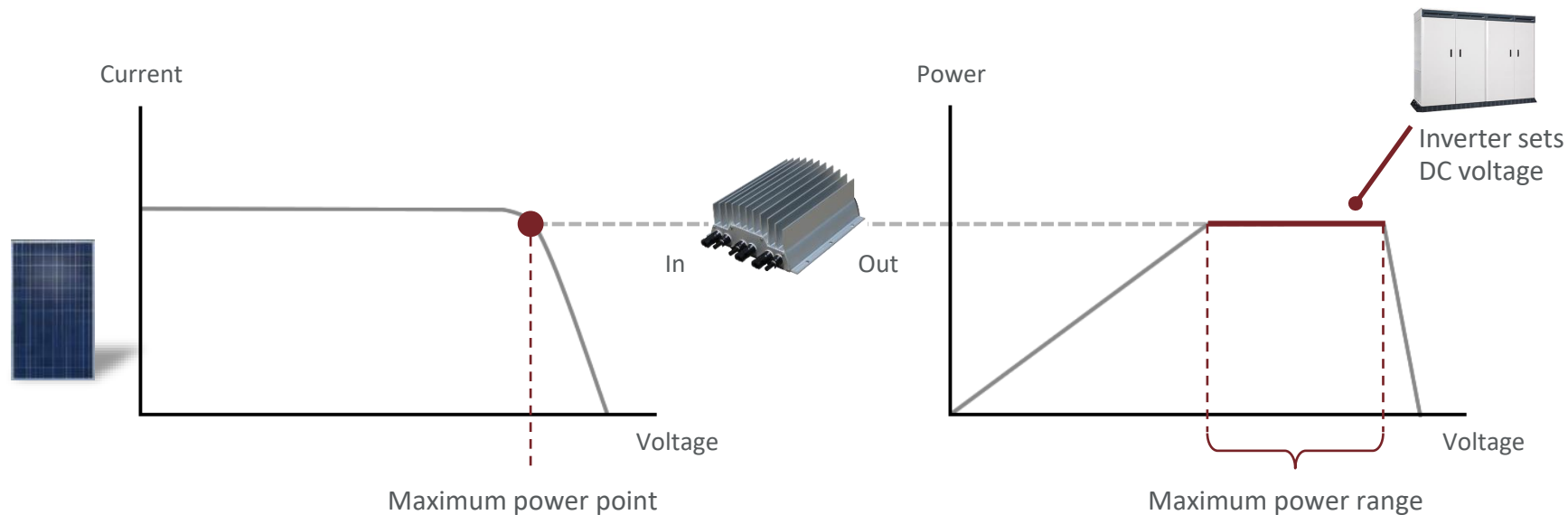


As each inverter ends lifecycle:

- Replace legacy inverters with the newest inverter technology
- Use 1000-volt inverters at full rated power in 600-volt systems
- Use 1500-volt inverters at full rated power in 1000-volt systems

Ampt avoids costly re-wiring and re-trenching while lowering the cost of replacement inverters

Optimizer delivers full available power at the voltage set by inverter



Ampt optimizers serve as an “adapter” between legacy arrays and modern inverters



Use Modern Inverters as Low-Cost Replacements

1000-volt inverter



	Standard	With Ampt
Maximum system voltage	1000	600
Input voltage at full power	480 – 850	550
Output power	500kW	500kW

1500-volt inverter



	Standard	With Ampt
Maximum system voltage	1500	1000
Input voltage at full power	850 – 1250	950
Output power	1MW	1MW

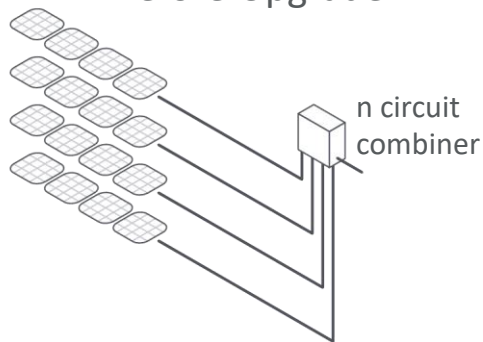
Ampt works with both central and string inverters



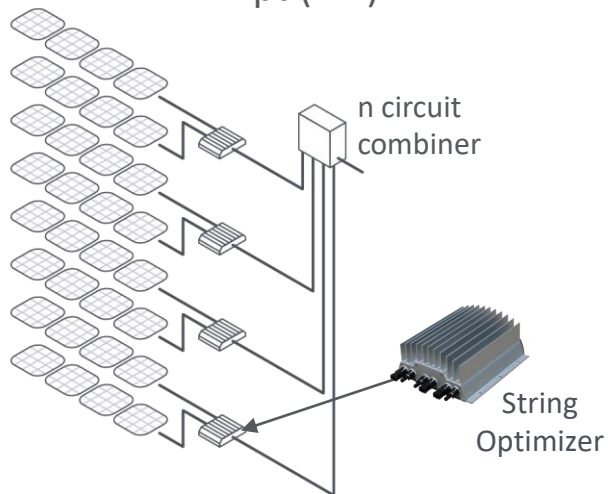
2:1

Expand to High DC Ratio

Before Upgrade



Ampt (2:1)



Existing Inverter

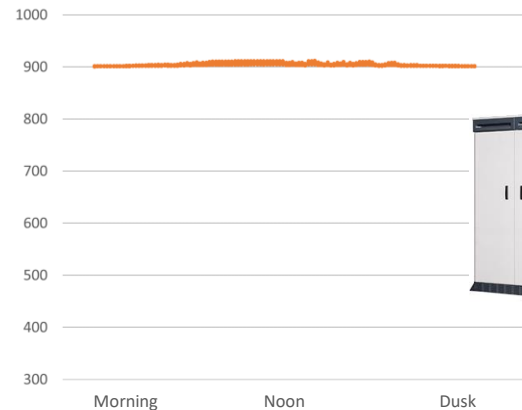
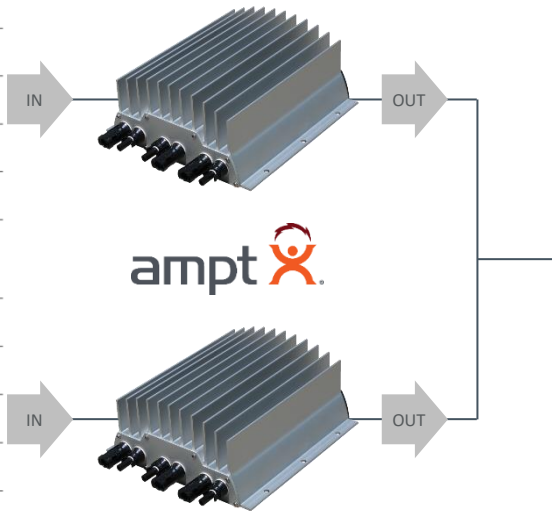
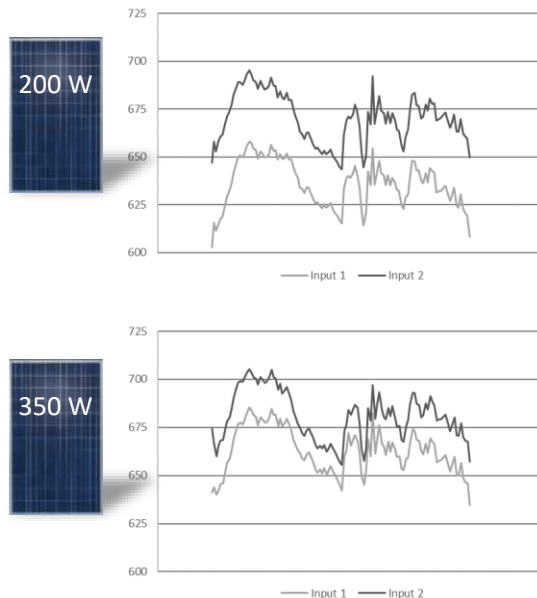


- Add higher power modules to existing strings
- Add new strings to existing combiners
- Save 50% on EBOS when adding new sub-arrays

- Protects existing inverter from exceeding DC loading limits
- Eliminate mismatch losses between strings

Mix new and legacy modules on the same inverter

MPPT eliminates mismatch between strings

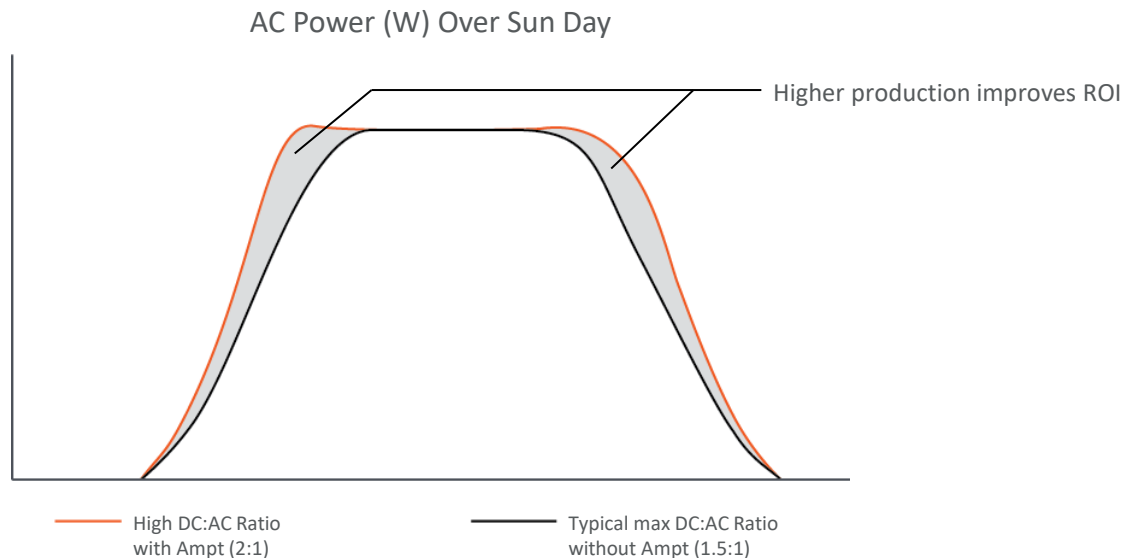


Each string delivers full available power at a higher and narrow DC bus voltage



2:1

Higher DC/AC Ratio Delivers More Energy



With Ampt, deploy high DC/AC ratio systems without overloading existing combiner boxes, cables, or inverters

Ampt Repowering Solution Delivers a High Return on Investment



15-30% return on investment

- Typical return projected over the system life

Maximized annual project revenue

- Generate more energy over the system life

Lowest cost upgrade option

- Use existing wires & combiners
- Use existing inverters

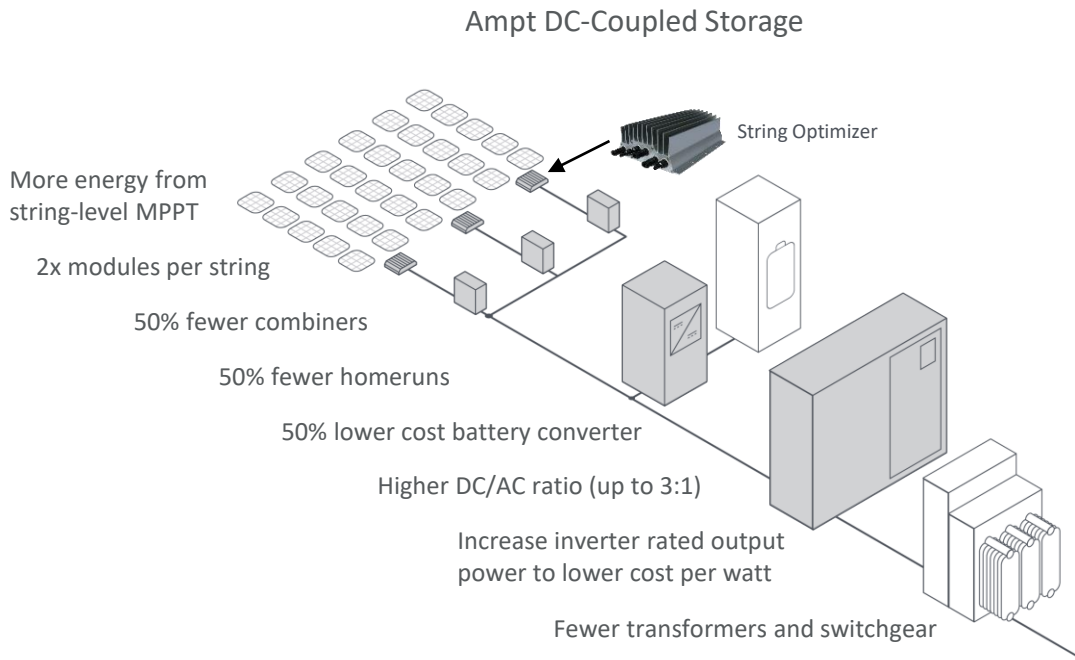
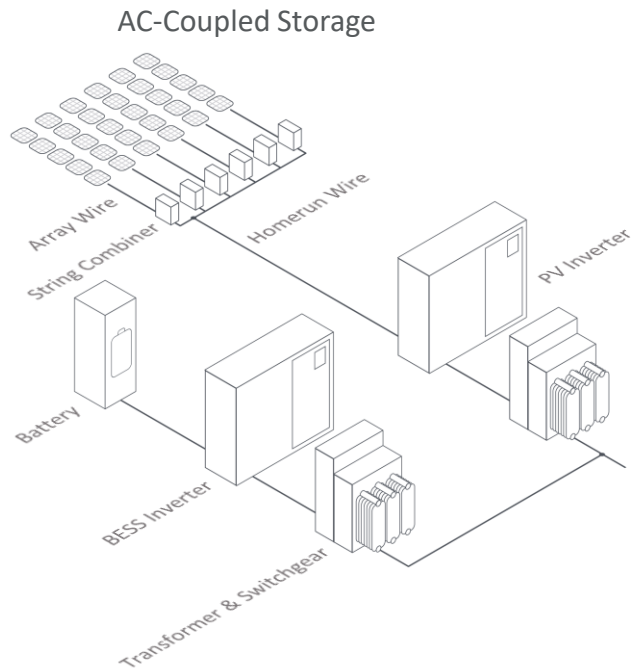
Future-proof inverter replacement

- Upgrade with low-cost, modern string or central inverters
- No re-wiring or re-trenching



DC-Coupled Storage

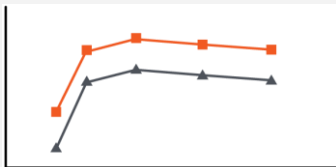
Ampt DC-Coupled Cost Advantage



Lower Cost & Higher Performance

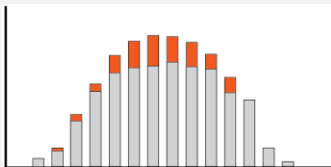
Ampt DC-Coupled Performance Advantage

Storage Roundtrip Efficiency



Achieve higher roundtrip storage efficiency while increasing the operating efficiency of the inverter and battery converter.

Curtailment Harvest



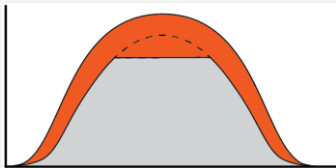
Capture array power that would normally be lost by charging the battery during periods of AC power curtailment.

Mismatch Recovery



Deliver more energy by recovering mismatch losses from various sources with string-level maximum power point tracking (MPPT).

Clipped Energy Harvest



Charge the battery when the PV inverter is clipping output power. Ampt enhances this benefit with higher DC/AC ratios (up to 3:1).

Low Voltage Harvest



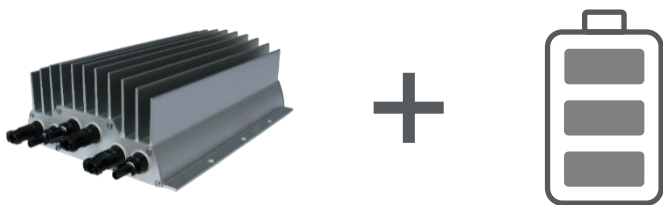
Charge the battery storage system when the array voltage is below the inverter turn on voltage to maximize energy production.

Mitigate Degradation



Recover energy losses caused by variable degradation of PV cell and modules within a system to improve lifetime system performance.

Superior Storage with Ampt



Performance advantage

- Higher roundtrip efficiency
- Capture more energy
- Mitigate degradation

Reduced system cost and complexity

- Lower cost power conversion
- Standard or bi-directional inverter
- Lower cost EBOS

Scalable and flexible

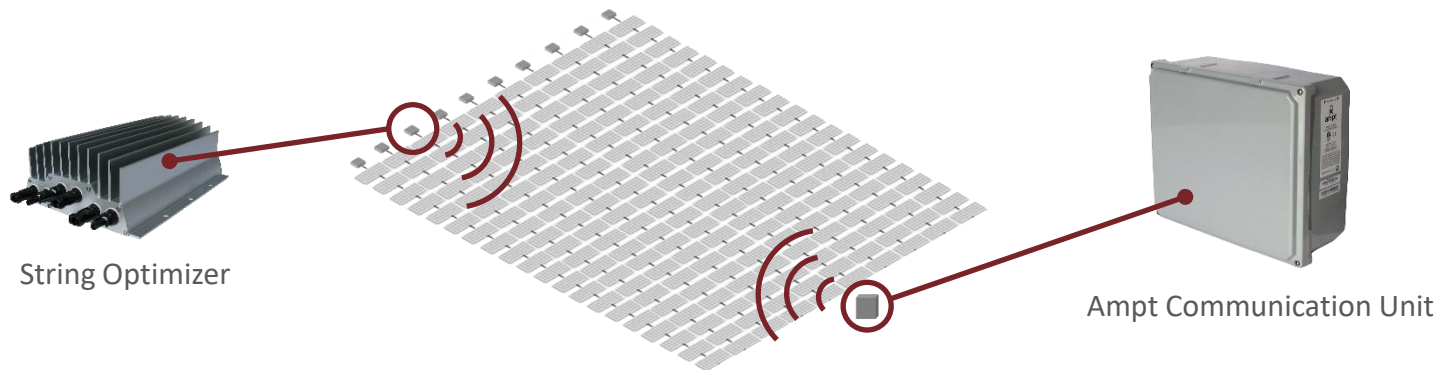
- Micro-grid to large power plants
- Add storage over time with less hardware cost
- Battery technology independent

With Ampt, the PV array is Storage-Ready™ and scalable in the future



Monitoring

Ampt communication technology and software



Monitoring and Service



Installation



Onsite Diagnostics

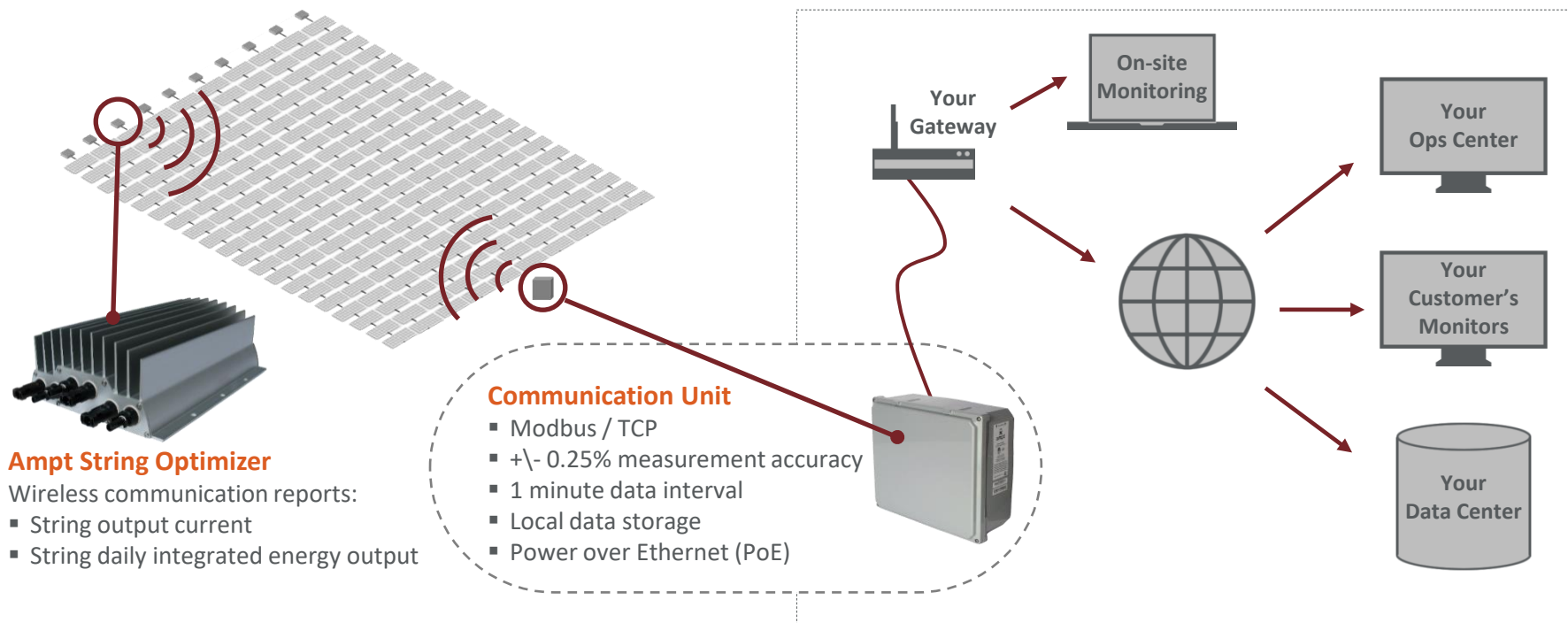


Remote Management



Ampt Support

Optional String-Level Data for Improved O & M





ampt.com



hdpv.org