Case Study

Innovative Utility-Scale PV Solar + DC-coupled Storage

Examining the End-to-End Power Conversion Solution used in LATAM's largest PV+storage power plant

Optimize PV Systems

DC-Coupled Storage

Software Controls & Monitoring

Hardware Platforms

- AC coupled solar integration
- Power Converter Station for BESS integration
- Advanced Multiport Power Station
- Static Synchronous Compensator

Software Platforms

- EMS
- SCADA

eks Energy is a leading power conversion system manufacturer focused on grid-friendly energy storage and renewable integration.

Competitive advantages

- AC & DC coupling
- Ample range of Operations
- Fast response
- Open control Platform
- Grid-forming
- Droop and Virtual Synchronous Machine Control

5.3 GW+ Installed

30+ Countries with Deployments

180+ Projects Deployed

20+ Years of Experience

4 GW Per Year Manufacturing Capacity

About the Project

PV Solar + DC-coupled Energy Storage

Location	Andes; Antofagasta; Chile
Model of the plant	Hybrid: PV + Battery
Rated Power at POI	130 MW
Capacity	650 MWh
Inverter and battery converter	eks Energy Advanced Multiport Power Station
String optimizer	Ampt V1475-32-30
Altitude	2700 masl
Construction	2020 – 2023

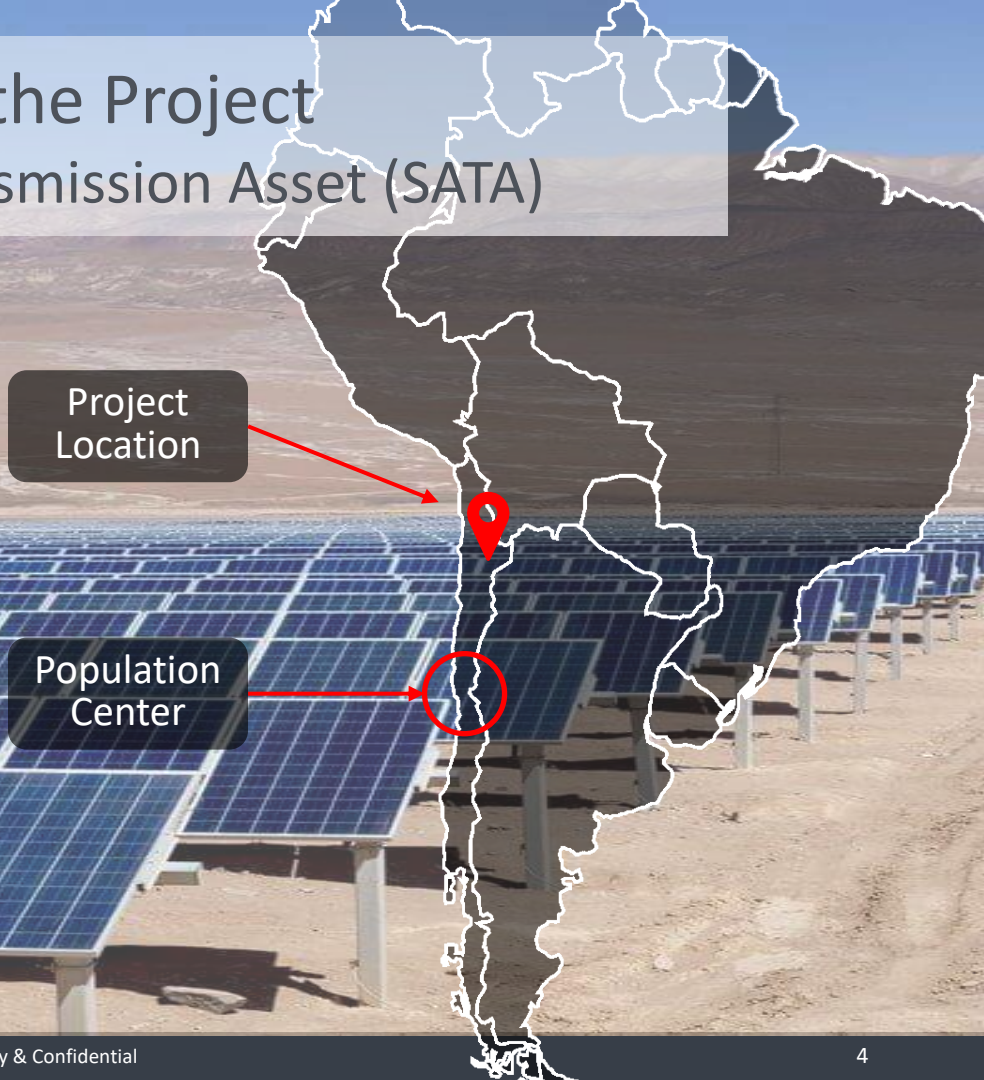
Ampt String Optimizers

eks Energy
Advanced Multiport
Power Station

About the Project

Storage as a Transmission Asset (SATA)

- Energy is produced and stored in one location
- Energy is transmitted to another location when the lines are less congested
- Provides additional operational capacity to existing lines
- Avoids expensive upgrades to the transmission system



About the Project

Advancing Renewable Energy in the Andes Region

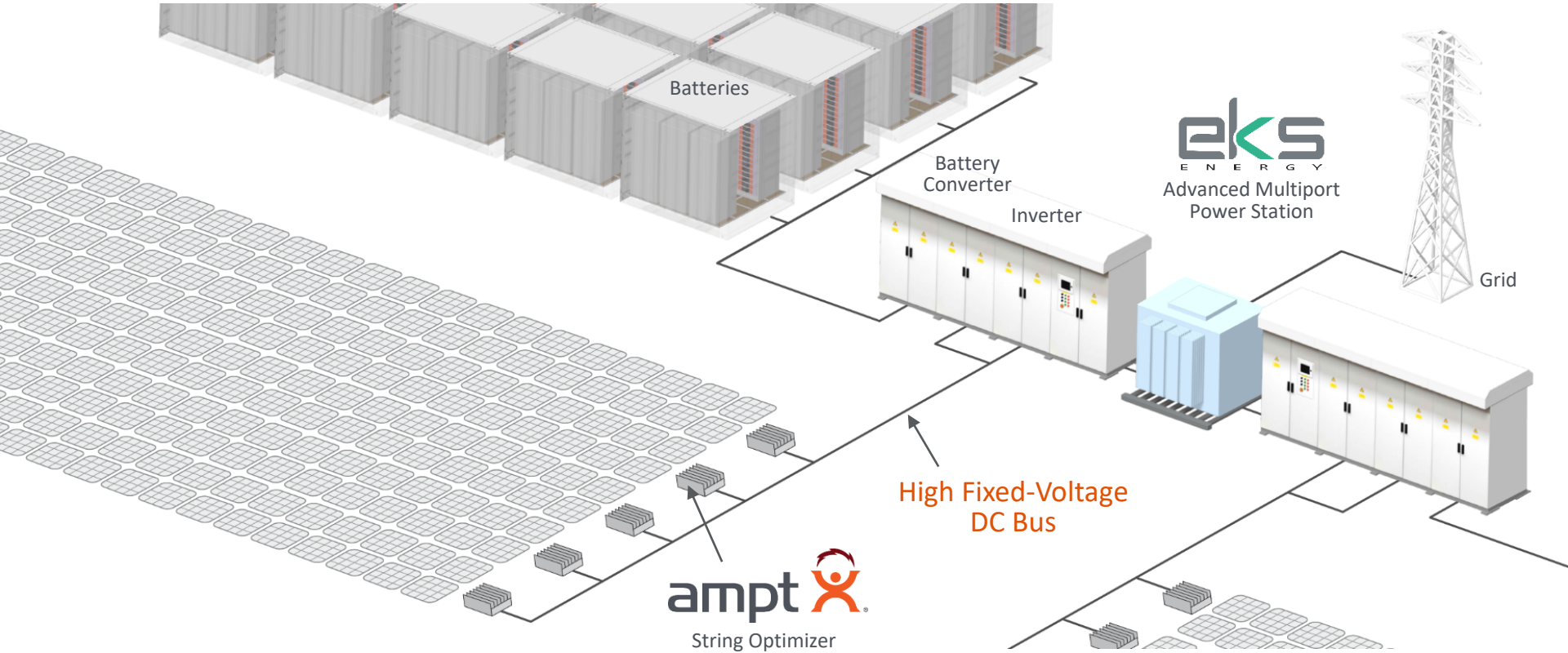
Objectives

1. Clean Energy Adoption
2. Environmental Stewardship
3. Social Responsibility
4. Technological Advancement
5. Cost-Effective Solution

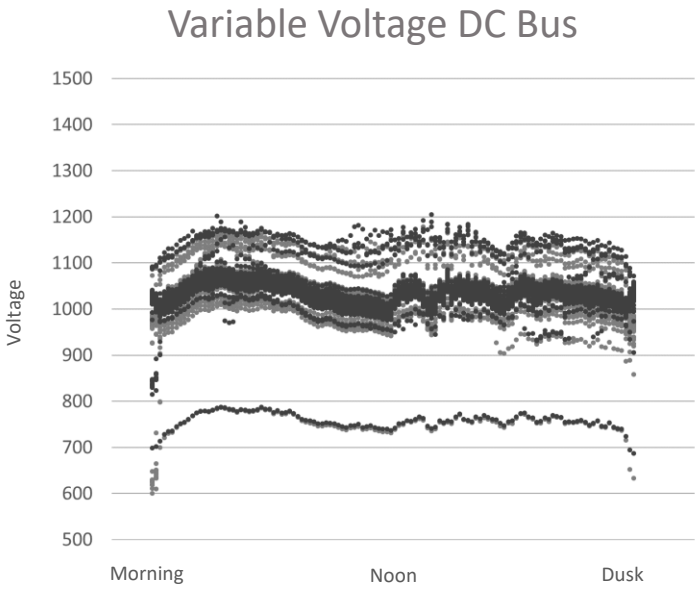
Results

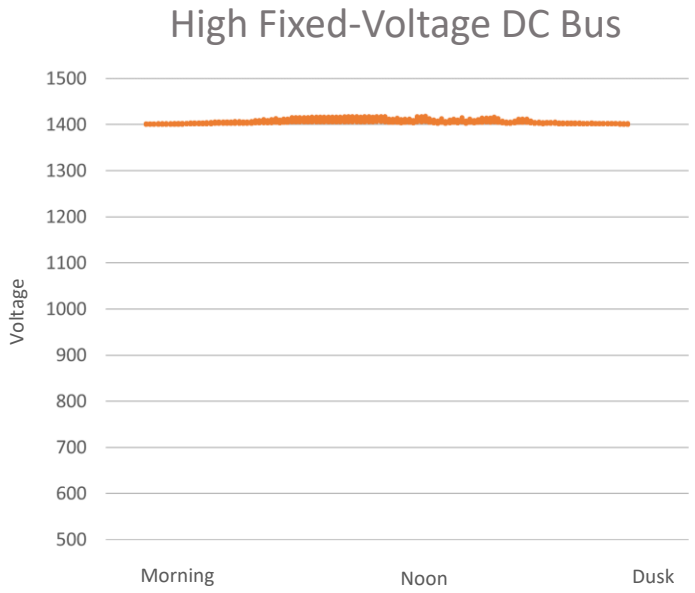
- ☑ PV solar plant reduces carbon emissions
- ☑ Reduces reliance on fossil fuels
- ☑ Local economic growth & engagement
- ☑ Hybrid PV + Storage solution
- ☑ Cost-Effective Solution

Smart PV + DC-coupled Storage Solution



Our Solution Uses a High Fixed-Voltage DC Bus

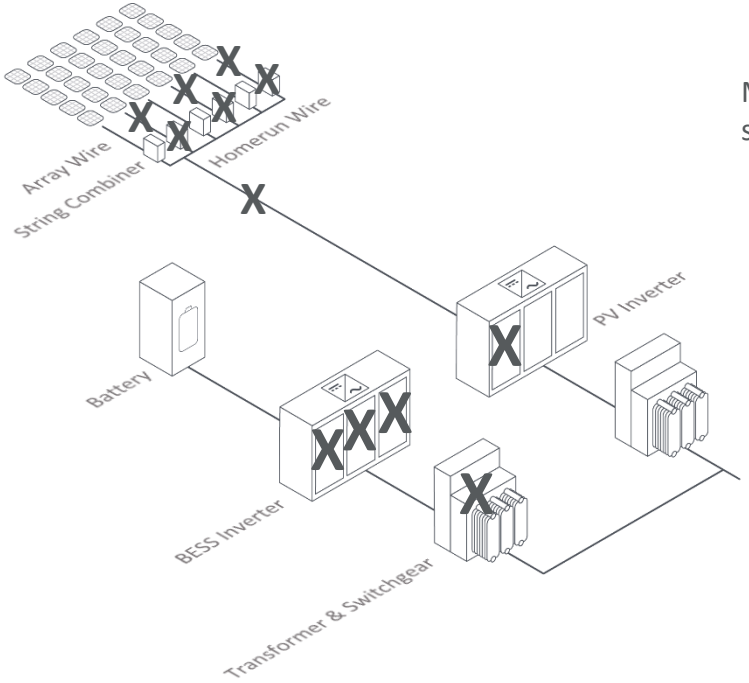




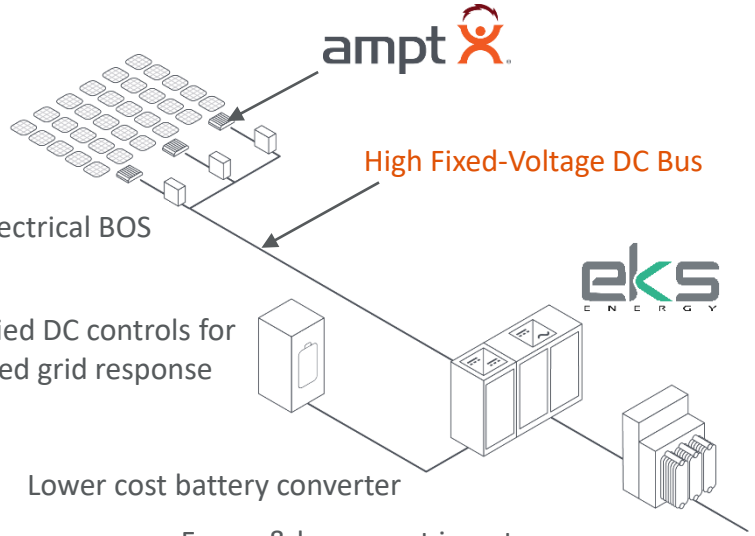
Higher Voltage Enables Lower Current and Lower Cost

Our Solution Advantage

AC-Coupled Storage



Fixed DC-Coupled Storage



Lower Cost & Higher Performance

Higher Voltage, Higher Power Density Inverter

Advanced Multiport Power Station

		Variable Voltage	High Fixed-Voltage	
DC (PV array)				
Max DC voltage	Vdc	1500	1550	
Voltage range at full power	Vdc	850 - 1500	1350	(Programmable)
Rated input voltage	Vdc	850	1350	Higher
Rated input current	A	6400	6400	
AC (Grid)				
Nominal AC voltage	Vac	600	850	Higher
Rated output current	A	2080	2080	
Rated AC power	MVA	2.0	2.8	40% ⬆

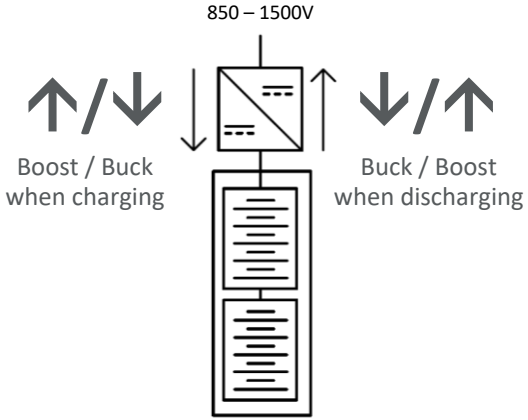
Deploy fewer inverters at a lower cost per watt

Lower Cost, Higher Efficiency Battery Converter

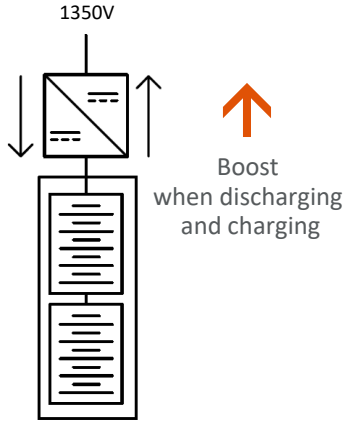
Advanced Multiport Power Station

eks ENERGY

Variable Voltage



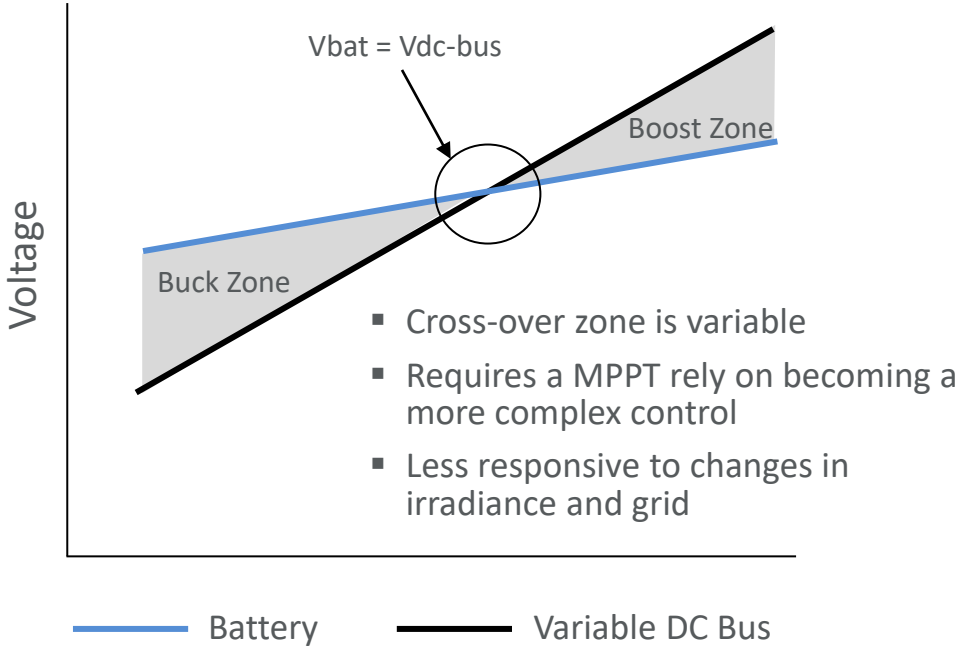
High Fixed-Voltage



- 50% less circuitry
- Higher power density
- Higher efficiency (+0.5 – 0.8%)

Simplified DC Controls for Improved Grid Response

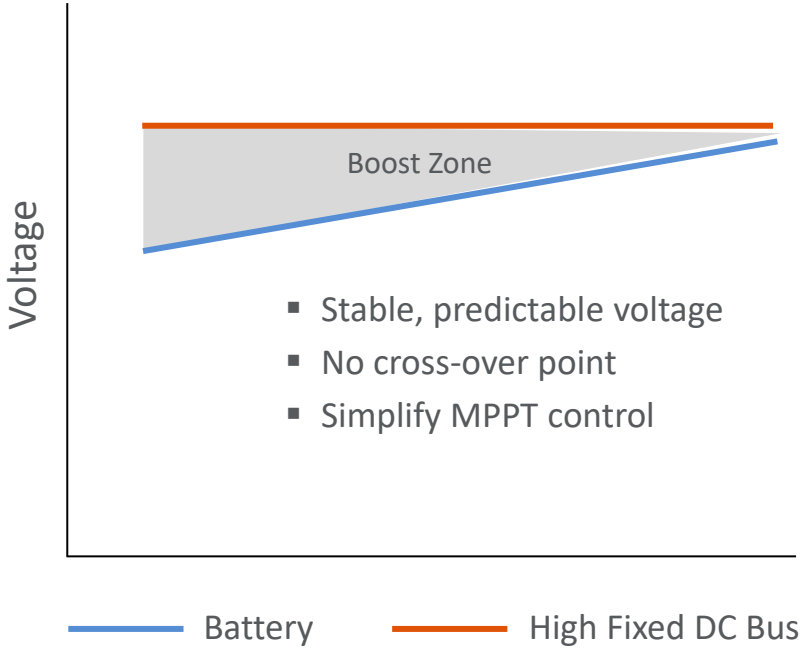
Variable Voltage



- Cross-over zone is variable
- Requires a MPPT rely on becoming a more complex control
- Less responsive to changes in irradiance and grid

Battery Variable DC Bus

High Fixed-Voltage



- Stable, predictable voltage
- No cross-over point
- Simplify MPPT control

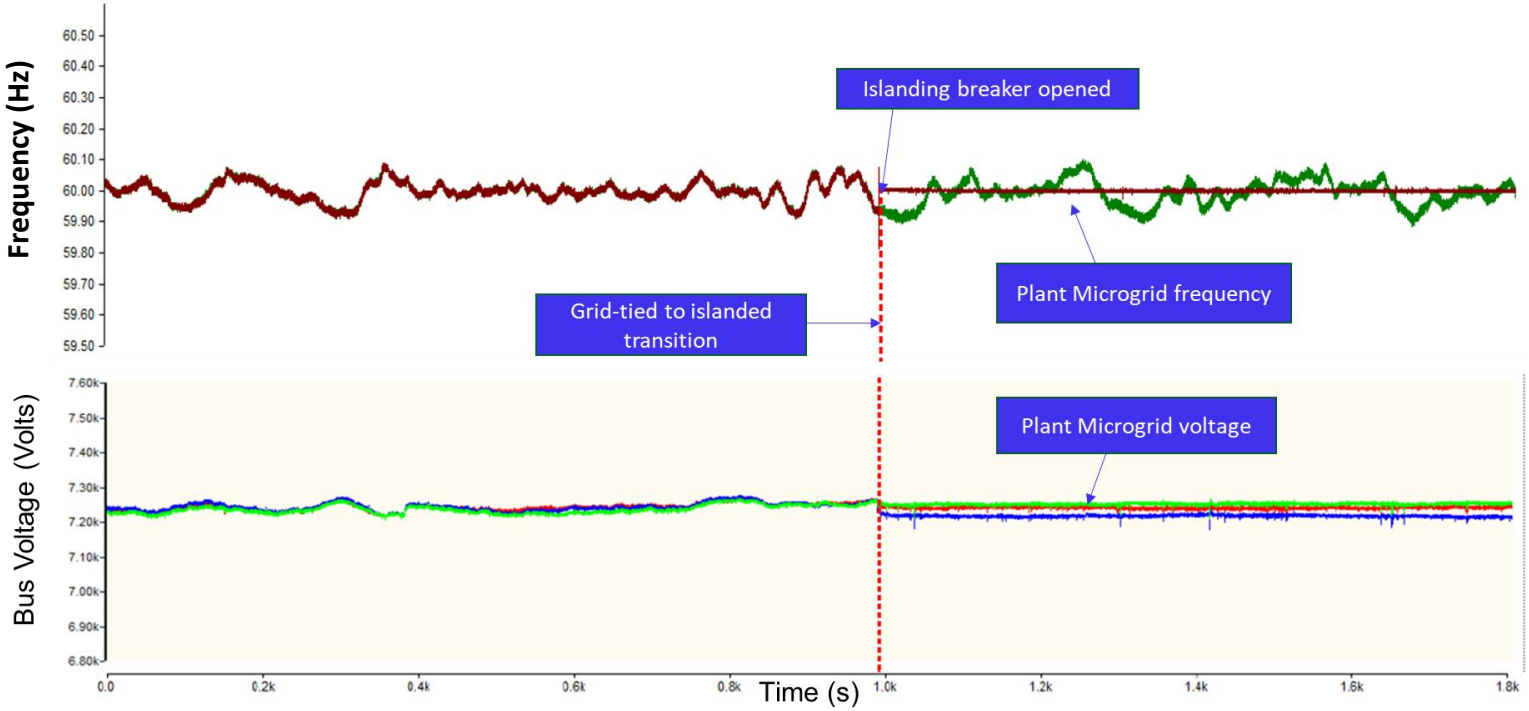
Battery High Fixed DC Bus

GFM: All Functions/Manageability of Traditional Power Plants

Feature	GFM	GFL
Voltage and Frequency ride through capabilities	●	◑
Reactive power support	●	●
Frequency control capabilities	●	●
Virtual inertia	●	○
Islanding operation	●	○
System restart	●	◑
Black start	●	○

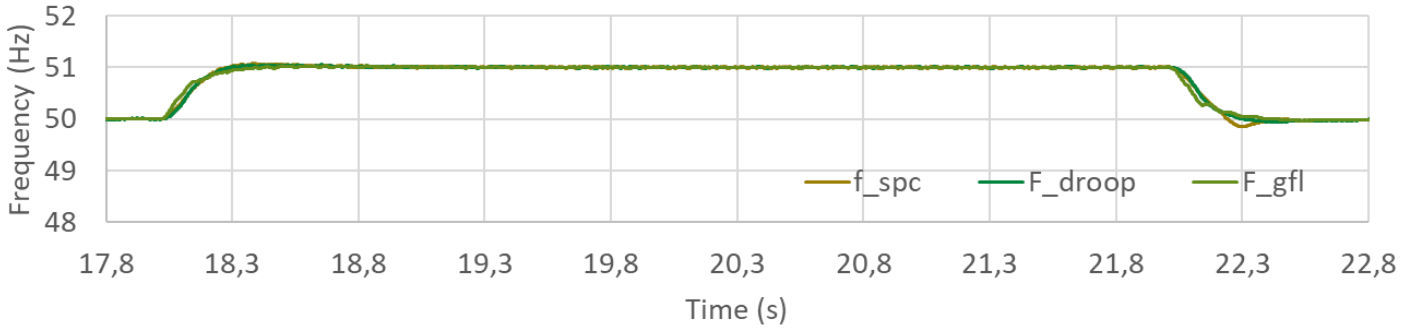
Grid-forming mode offers standalone and high and low inertia grid operation

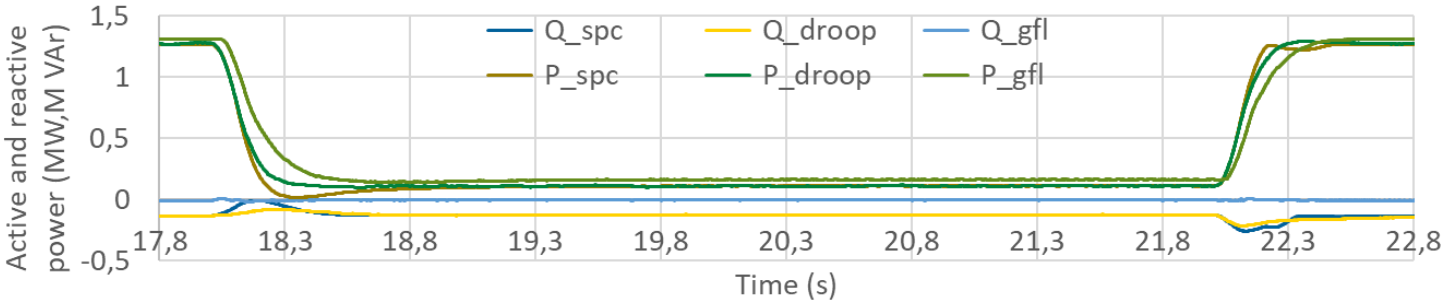
Plant Grid-Tied to Islanded



Smooth transition between grid-tied and islanded mode operation

Control Strategies





GFM optimized energy system improves grid stability

Founded in 2007

Award Winning Technology

DC Power Management
Products & Software

Market Leadership

World's
#1
Optimizer Company
#1 in Large PV Systems
#1 in PV+Storage
#1 in Repowering

~3 GW
shipped

15+
countries with deployments

Gold Winner for Pioneer in New Technology - Storage

Top Ten Energy Storage Solutions Provider

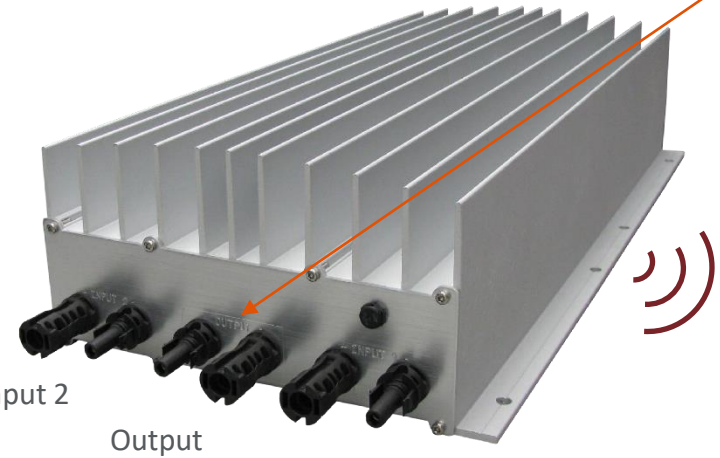
Top Product in Power Electronics

Top Product of the Year

Ampt String Optimizer

High Fixed Voltage Output

Lowers System CapEx



String-Level Data

Improved O&M

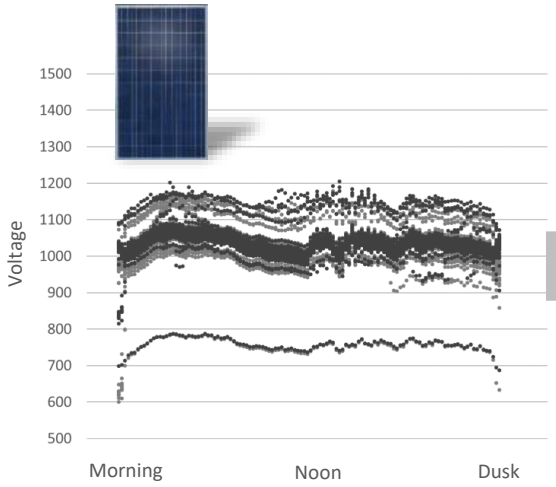
Ampt Communication Unit

Maximum Power Point Tracking

Increases Lifetime Energy Yield

String Optimizer Enables High Fixed-Voltage

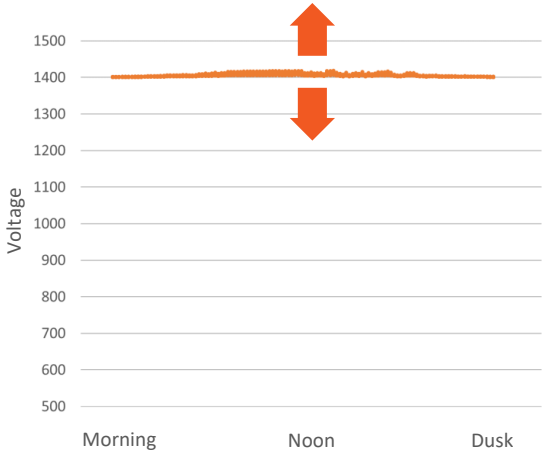
Variable input from PV module strings



IN

OUT

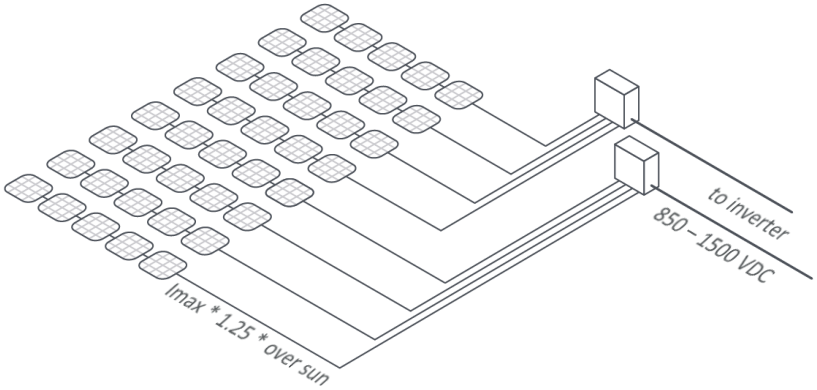
Programmable output from Ampt



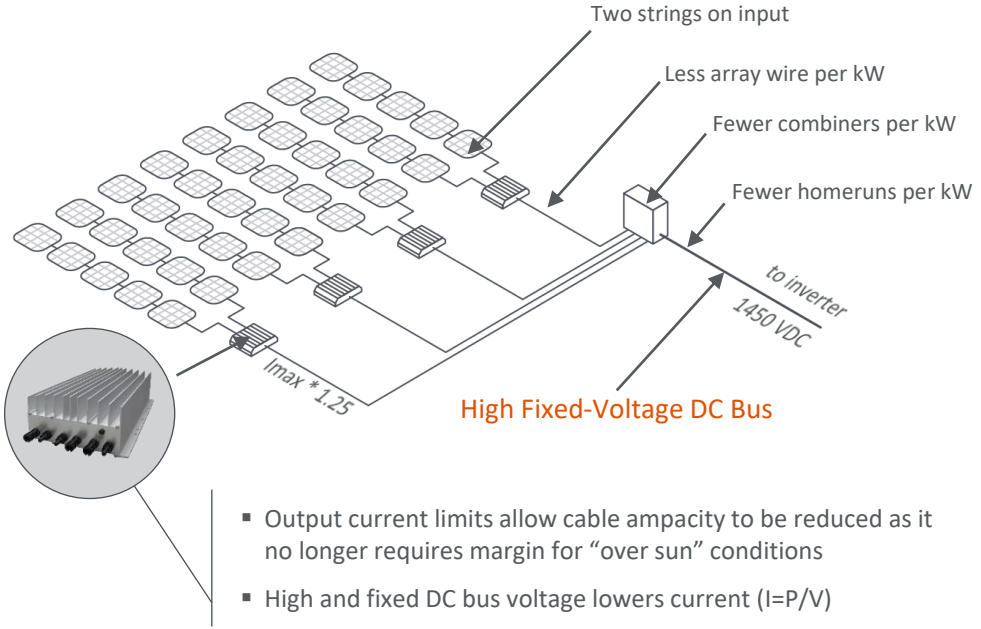
MPP Tracking on each string eliminates voltage mismatch.
Programmable output delivers high fixed-voltage output.

Lower Cost Electrical BOS

Variable Voltage



High Fixed-Voltage

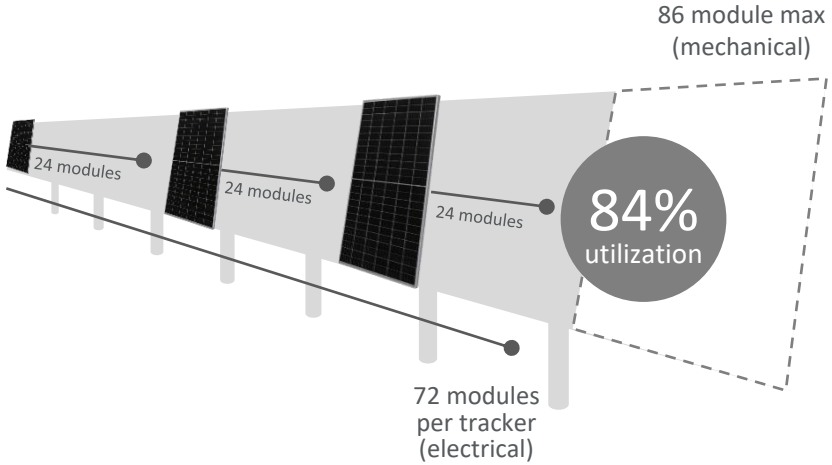


- Output current limits allow cable ampacity to be reduced as it no longer requires margin for “over sun” conditions
- High and fixed DC bus voltage lowers current (I=P/V)

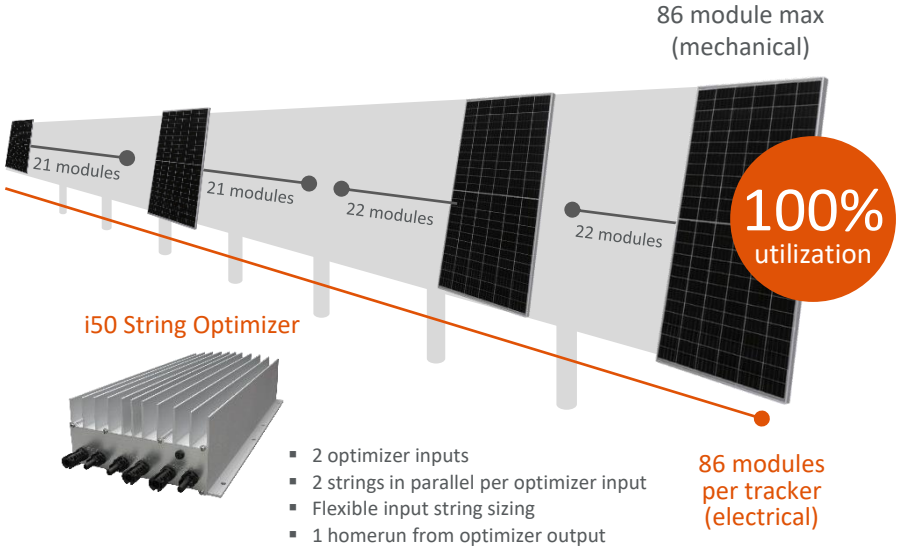
Fewer combiners and less cabling to save on cost

Full Tracker Fit – Fewer Trackers and Lower Costs

Without Ampt



With Ampt



- 2 optimizer inputs
- 2 strings in parallel per optimizer input
- Flexible input string sizing
- 1 homerun from optimizer output

Full tracker fit in a wide temperature range to deploy fewer trackers/MW

Based on 625Wp 156 cell bifacial PV module

Higher DC/AC Ratios with Ampt

The “Ampt Factor”

1.6	X	1.1	X	1.71	=	3.0
DC/AC Ratio		no “oversun” multiplier		1450/850 = 1.71		DC/AC Ratio with Ampt

Inverter max DC/AC Ratio (e.g.; 1.6) without Ampt in the system.

An “oversun” multiplier (e.g.; 1.1) is not required because Ampt has output current limits.

The fixed operating voltage of an inverter deployed with Ampt (e.g.; 1450 VDC) divided by the inverter’s minimum MPP voltage (e.g.; 850 VDC) without Ampt. Operating at a higher and fixed voltage with Ampt lowers current (I=P/V) which allows more power on the inverter.

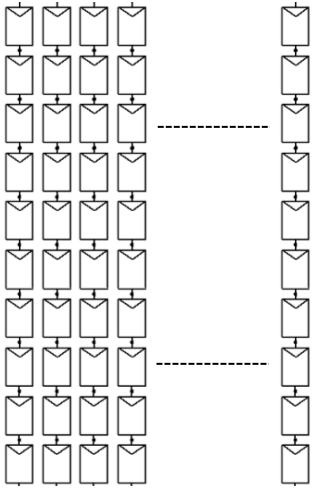
Max DC/AC Ratio of the inverter when deployed with Ampt.

Use the “Ampt Factor” to Achieve Higher DC/AC Ratio for longer duration storage

More Energy Through Mismatch Correction

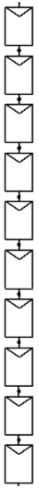
Central Inverter MPPT

3752 Modules per MPPT



String-Level MPPT

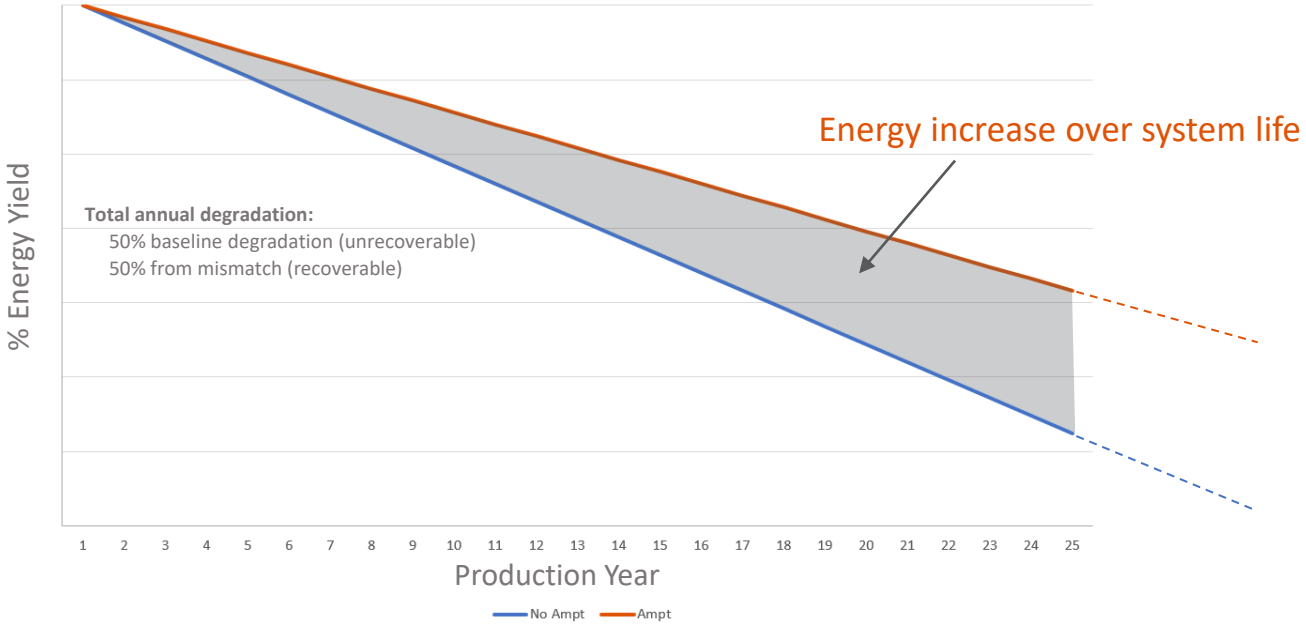
28 Modules per MPPT



More Energy

134x higher resolution MPPT improves performance

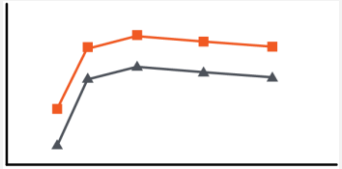
String-Level MPPT Recovers Mismatch Losses



String optimizers recover ~33% of annual losses

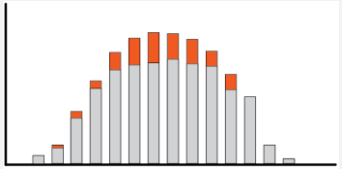
Performance Advantage of our DC-Coupled Solution

Storage Roundtrip Efficiency



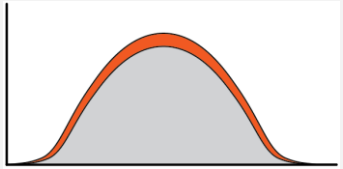
Achieve higher roundtrip storage efficiency while increasing the operating efficiency of the inverter and battery converter.

Curtailment Harvest



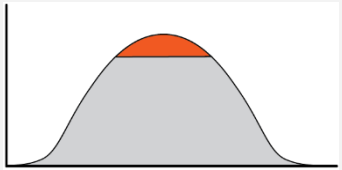
Capture array power that would normally be lost by charging the battery during periods of AC power curtailment.

Mismatch Recovery



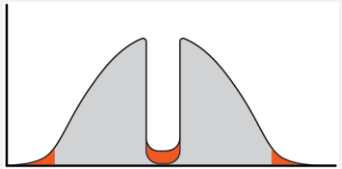
Deliver more energy by recovering mismatch losses from various sources with string-level maximum power point tracking (MPPT).

Clipped Energy Harvest



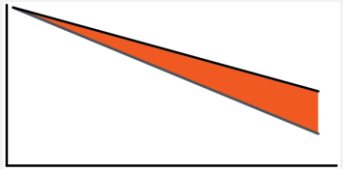
Charge the battery when the PV inverter is clipping output power. Capture array power that would otherwise be lost.

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.

Higher performance compared to AC-coupled solutions

Smart PV + DC-coupled Storage Solution

- Lower total system cost
- Fewer and lower cost inverter & transformer
- Lower cost battery converter
- Decrease EBOS costs
- Increase PV performance
- More efficient energy storage
- Improved O&M
- Simplified DC controls for improved grid response

Advancing Renewable Energy Around the World

Thank You

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