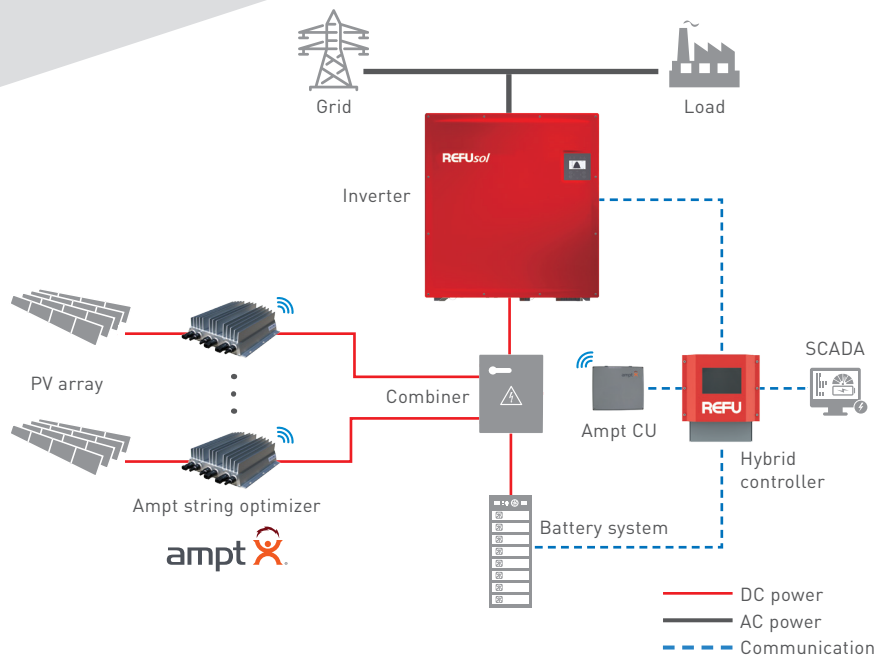


DC-COUPLED STORAGE SOLUTION

Highly efficient, scalable and flexible



- Gain maximum value from PV plants with high DC:AC ratios
- Reduce system cost and complexity
- Add storage with no changes to the existing interconnection agreement
- Achieve highest system and conversion efficiencies

REFU and Ampt have partnered to bring you an optimized DC-coupled storage solution that lowers system cost while maximizing production revenue throughout the PV system lifetime. This solution delivers the system cost and performance advantages of Ampt string optimizers along with the high-efficiency and wide operating range of REFUsol inverters. These components are controlled by the REFU HC-20 hybrid controller with advanced algorithms to create a flexible and optimized DC-coupled storage solution.

While each of these components are uniquely beneficial in PV systems, REFU and Ampt have partnered to provide customers with a DC-coupled storage solution that is designed to simplify the system installation and minimize the amount of hardware required.

Our solution gives system designers maximum design flexibility as the components can be either grouped centrally or distributed throughout the plant and allows them to add storage to already planned or installed systems without changing the AC characteristics of the PV system.

Our technology further enhances DC-coupled storage by providing a simple, cost-effective approach for both new and existing PV systems. With the joint REFU-Ampt solution, you will be a step ahead of other approaches available in the market today.

TARGET APPLICATIONS

UTILITY-SCALE SOLAR + STORAGE

- Ramp rate control
- Capacity firming
- Recapture clipped energy
- PV energy time shifting

COMMERCIAL BEHIND-THE-METER SOLAR + STORAGE

- PV self-consumption
- Demand charge reduction/peak shaving
- Time-of-use energy cost management

ISOLATED SOLAR + STORAGE / MICROGRIDS

- Spinning reserve management
- Step load capacity provision
- Genset runtime optimization
- Recapture curtailed PV energy

COMPONENTS

REFU^{sol} INVERTER

REFU^{sol} inverters feature natural convection cooling and REFU's patented UltraEta[®] topology to ensure highest reliability and performance. In DC-coupled storage applications, the wide DC voltage range and high efficiency even at low battery voltages ensure flexible storage design and maximum system output.

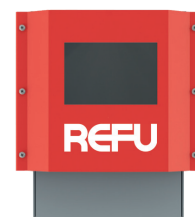
- Deliver more energy – even at low battery voltages
- High flexibility in terms of battery type and capacity
- Reduce cabling cost and losses
- Place the units either centrally or distributed throughout the array



REFU HYBRID CONTROLLER

The REFU HC-20 hybrid controller features advanced algorithms to capture more energy by managing the power flow between grid, PV array and battery. The REFU hybrid controller uses standard communication protocols and interfaces, making it easy and fast to integrate with third-party BMS, EMS or SCADA systems.

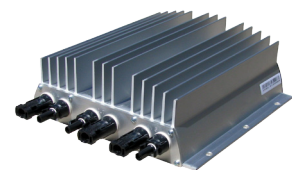
- Third-party integration with Modbus SunSpec
- Easily expand the system in future
- Save data for up to 10 years
- Monitor and configure the system remotely



AMPT DC STRING OPTIMIZER

Ampt DC string optimizers put dual MPP tracking and Ampt's patented String Stretch[®] technology on each string in the PV array to deliver full PV power over the entire battery voltage range. The string optimizers allow for flexible system designs with patented output voltage and current limits and can be installed in parallel to scale charge and PV array power.

- Eliminate the need for a separate battery inverter
- Deliver more energy with higher MPP tracking resolution
- Reduce cost of combining/cabling and associated labor
- Up to 48 modules per string



INVERTERS

REFU ^{sol} model	20K	22K-JP	40K	46K-MV
AC output power (kW)	20	22	40	46
Full power input voltage range (V)	490 ... 850	550 ... 850	490 ... 850	575 ... 850
Maximum input voltage (V)	1,000			
Maximum input current (A)	41.8	44	84	82
Rated output voltage (V)	400	440	400	460
Grid connection	3 Phase / N / PE			
Grid frequency / Frequency range (Hz)	50, 60 / 45 ... 65			
Maximum output current (A)	3 x 29.2	3 x 29	3 x 59	3 x 59
Efficiency (Max / CEC / Euro) (%)	98.2 / - / 97.8	98.2 / 98.0 / -	98.2 / - / 97.8	98.3 / - / 98.1
Dimensions (mm)	535 x 601 x 277	530 x 600 x 270	755 x 820 x 300	755 x 820 x 300
Weight (kg)	38.4	38.4	75.6	75.6
Operating temperature range (°C)	-25 ... +55	-25 ... +60	-25 ... +60	-25 ... +60
Cooling type	Convection			
Protection degree	IP 65			
Compliance	latest certificates available at www.refu-sol.com			

STRING OPTIMIZER

Ampt model	V1000-12
Maximum voltage per input (V) ¹	1,000
Maximum current per input (A) ²	11.5
MPP tracking voltage range (V)	400 ... 850
Number of inputs	2
Output voltage range (V)	0 ... 1,000
Maximum output current (A)	12
Maximum continuous output power (kWdc)	11.4
Efficiency (Max / CEC / Euro) (%)	99.5 / 99.3 / 99.2
Dimensions (mm)	272 x 220 x 100
Weight (kg)	4.8
Operating temperature range (°C)	-40 ... +75
Protection degree	IP 66
Cooling type	Convection
Compliance	ETL to UL 1741; IEC 61000-6-1, 61000-6-3, 62109; CE; FCC Part 15, class A

EXAMPLE LITHIUM-ION BATTERY³

Energy (kWh)	39 ⁴	49	78 ⁴	98	135 ⁴	160	178
Nominal voltage (V)	563	704	563	704	563	666	742
Voltage range (V)	493 ... 634	554 ... 713	493 ... 634	554 ... 713	493 ... 634	582 ... 749	650 ... 835
Maximum charge power per string optimizer (kW) ⁵	6.8	8.4	6.8	8.4	6.8	8.0	8.9
Dimensions (mm)	462 x 600 x 1,654	462 x 600 x 1,950	462 x 600 x 1,654	462 x 600 x 1,950	1,800 x 800 x 2,200		
Approx. weight (kg)	400	500	800	1,000	1,620	1,840	2,005

¹ Voc at coldest design temperature - follow Ampt's design guidelines to determine the number of modules per input and maximum system voltage² Module Imp at standard test condition (STC) - irradiation level of 1000 W/m² at 25°C³ other available on request⁴ only in combination with REFU^{sol} 20K or 40K inverter⁵ at rated battery voltage

REFU ELEKTRONIK GMBH

Setting new benchmarks with sustainable solutions - that's the philosophy of REFU Elektronik, the pioneer of the frequency converter. REFU, founded in 1965, can draw on its long experience and large expertise in power electronics – no matter whether for solar, energy storage or hybrid applications.

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AMPT, LLC

Ampt delivers innovative power conversion technology and communications capabilities that improve the way PV systems are designed. With installations and experience serving markets around the world, Ampt is lowering the cost of solar energy, improving project ROI, and broadening the PV solar market.

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