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Custom Power Solar Radian Battery Energy Storage System

Custom Power Solar provides residential energy power systems with energy storage using Outback Power Radian inverters, charge controllers and Energport lithium batteries. These systems can be configured with PV DC solar power inputs or as standalone add-ons to existing solar power systems (AC-coupled). Systems can also include external generator inputs, which can be any AC power source. System configurations are available in 4 and 8kw building blocks which can be stacked up to 80kw, scaled to provide nominally minimum of 2 hours of charge/discharge capacity per configuration. The inverters are GS4048A for 4kw systems, GS8048A for 6 and 8kw systems. Either one or two FM-80 charge controllers are used for 4k and 8kw systems respectively. Charge controllers transfer PV energy from the solar array to the battery storage. The inverters provide power to the home and grid from the batteries. The nominal storage capacities are 10.24kwh for maximum 4kw systems, and 20.48kwh for maximum 8kw systems. System specifications are provided in Appendix A.

Monitoring

Monitoring is provided through Opticsre, which is a software component of the Radian GS Series Inverters provided by Outback with cloud based storage of monitoring data. See www.opticsre.com. Individual cell data and battery temperature is monitored on a minute by minute basis, and transmitted once per day to Custom Power Solar.

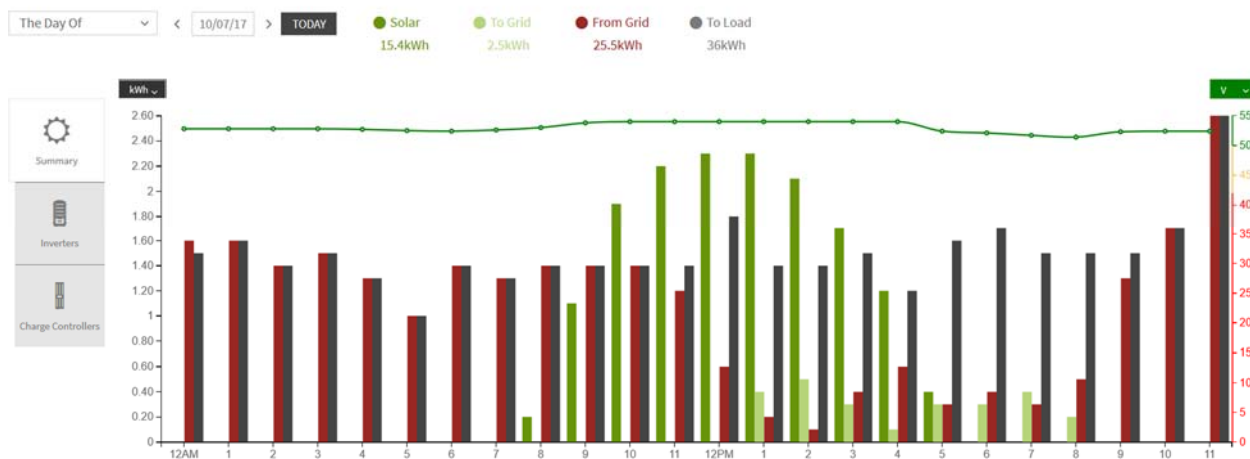


Fig. 1 Example dashboard display

Operation of System with PV Energy and Storage

In the example display (Fig 1), the dark green bars show DC solar energy production on an hourly basis, the light green bars show the AC solar power generated, dark red bars show power drawn from the grid to operate home loads, and black bars show the home loads. The green/yellow line at the top shows the voltage of the battery storage. In this case, storage is providing power to operate loads starting at 5pm. The following day energy from solar power is used to recharge the batteries. Roughly 6kwh was discharged and charged in this example of a 4kw PV system with a 10kwh battery.

This profile is used from May 1 to October 31 of each year. This provides 180 days of charge/discharge cycles per year, or a maximum total of 1080kwh of charge/discharge cycles per year.

SGIP requires 52 days times 2 hours or $3.6 \times 52 \times 2 = 374.4$ kwh of charge/discharge cycles per year.

The data from the system is monitored through the MATE3 microcontroller, which is linked by network cables to the inverter and charge controller. Custom Power Solar provides monitoring of individual cell and battery temperature.

Aggregate 15 minute data is transmitted to cloud storage. Reports are available and can be emailed from the Opticsre site for each system in Excel .xlsx form for each of the 5 quantities above for a minimum of 5 years. Battery individual cell data & temperature are transmitted once per day.

The storage system is nominally kept at 100% of maximum capacity to provide backup power in the event of grid failure during the off peak months from November through April. When operated in charge/discharge cycles, the battery is discharged to 20-40% of full capacity, then recharged back to 100% of full capacity. If necessary, the full 100% of the capacity can be used. These operating parameters have been chosen to maximize the lifetime of the battery and reduce demand on the grid during peak power periods.



**Fig 2. Radian inverter with charge controller, MATE3 monitoring display and battery storage
4kw version with 10kwh storage**

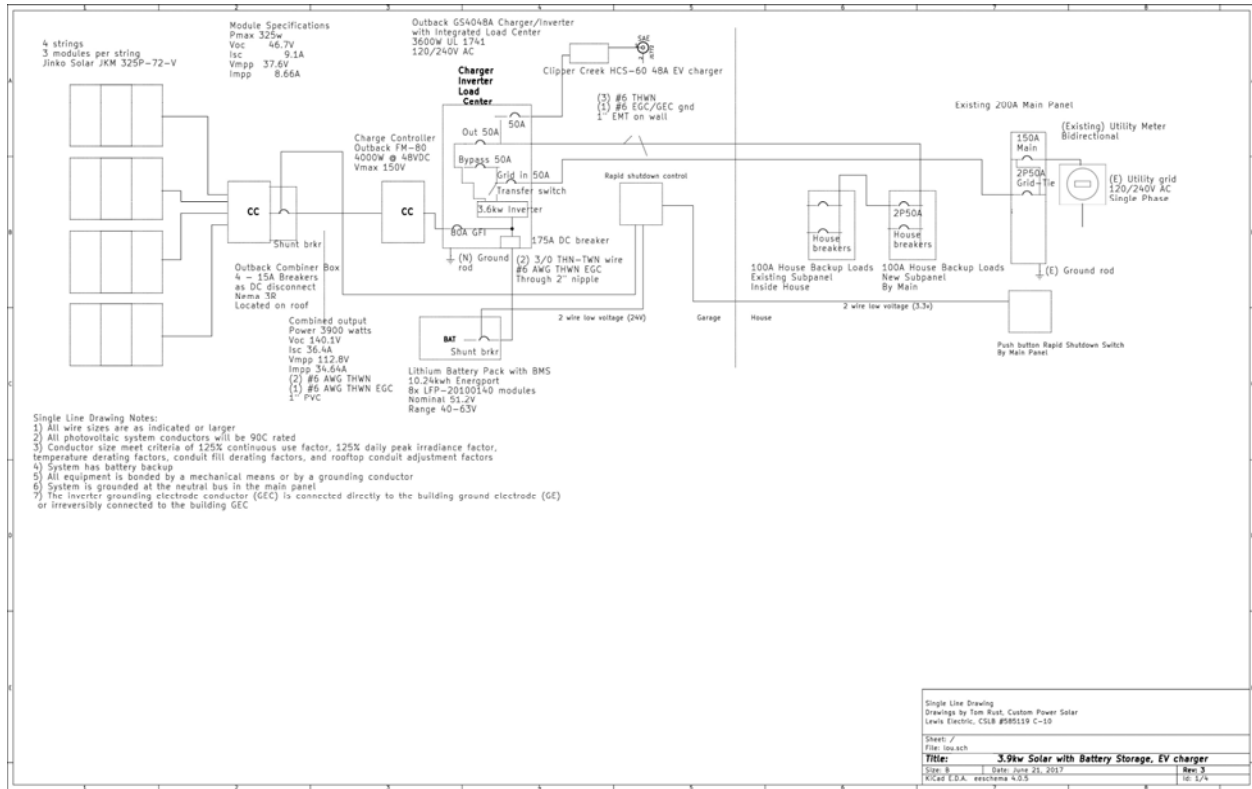


Fig 3. Single Line Drawing example 4kw PV with 10kwh storage

Appendix A

Systems Specifications with Energenport batteries

Radian CPS Battery Energy Storage System Description	4kw	8kw	units
Inverter			
Inverter used	GS4048A	GS8048A	
Continuous power out	4	8	kw AC
Peak power out	10	20	kw AC
Grid-tied max power (pass-through)	12	12	kw AC
Charge Controllers			
FM-80 charge controllers	1	2	
charge controller max power	4.5	9	kw DC
Battery			
Battery nominal capacity	10.24	20.48	kwh
Configuration of battery	16s8p	16s16p	X in series Y cell pairs in parallel

Capacity of each cell pair	1.28	1.28	kwh
Cell pairs per battery	8	16	
Nominal voltage	54	54	V
Nominal capacity	200	400	Ah
Voltage minimum	44.8	44.8	V
Voltage maximum	55.2	55.2	V
Operating V range of inverter min	36	36	V
Operating V range of inverter max	63	63	V
Max charge current	80	160	A
Max discharge current	80	160	A
Battery efficiency PV->battery	98%	98%	DC
Battery efficiency battery->AC	93%	93%	CEC-AC
Round trip efficiency	91%	91%	
Min charge time	2.4	2.4	hr
Min discharge time	2.4	2.4	hr
Power out min charge/discharge time	4	8	kw
Battery capacity times inverter efficiency	9.5232	19.0464	kwh

Appendix B

Construction of Battery Systems

Custom Power Solar assembles their Radian Custom Power Solar Battery Systems from Energport Lithium Iron Phosphate modules as follows:

Energport

The battery systems inside the Custom Power Solar units are assembled from roughly cubic modules that consist of two cell groups, Energport part # LFP-20100140. Each of these modules is nominally 1.28kwh total. The modules are assembled 4 modules to a case with bus cables between modules. The nominal 10.24kwh systems have two cases with 4 modules each, 20.48kwh systems have 4 cases with 4 modules each. Terminals are provided at the ends of the packs. Each module also includes a tap cell so that each cell is monitored and balanced by the BMS. Four temperature sensors are also included. A network monitoring unit provides access to all cell parameters. Units are enclosed in steel cases. The BMS monitors all cells, and maintains all cells to within 0.02V difference from each other. For systems with rapid shutdown, a shunt trip breaker is also provided between the main positive output and the cable to the inverter, which can force instant disconnection of the battery on command.

