Extreme Solar: Towards 24-7 Renewable Energy

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Project Description

- The purpose of the Extreme Solar project is to build a solar panel integrated with batteries that uses standard DC-AC micro inverters normally used with solar panels alone.
- The batteries are charged with excess solar and discharged during the evening or when additional power is required.
- The combined system was tested in a realistic environment of the desert southwest. Charge/Discharge data were collected, along with failure data and proof of concept demonstrated

System design concept

- Compared to the common AC coupled system (Fig.1), the "Panel-Converter-Battery" (Fig. 2) acts as a 'PV emulator' so that the solar panel and the battery can be operated with any inverter that has a peak power tracker.
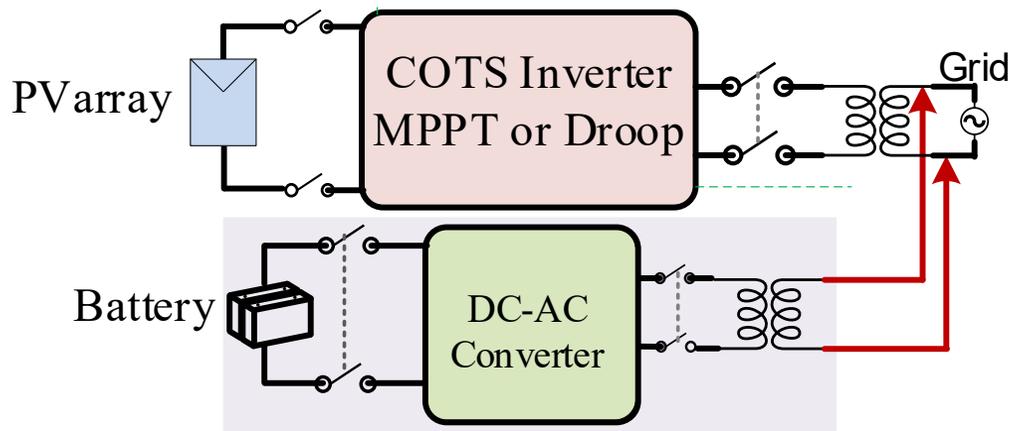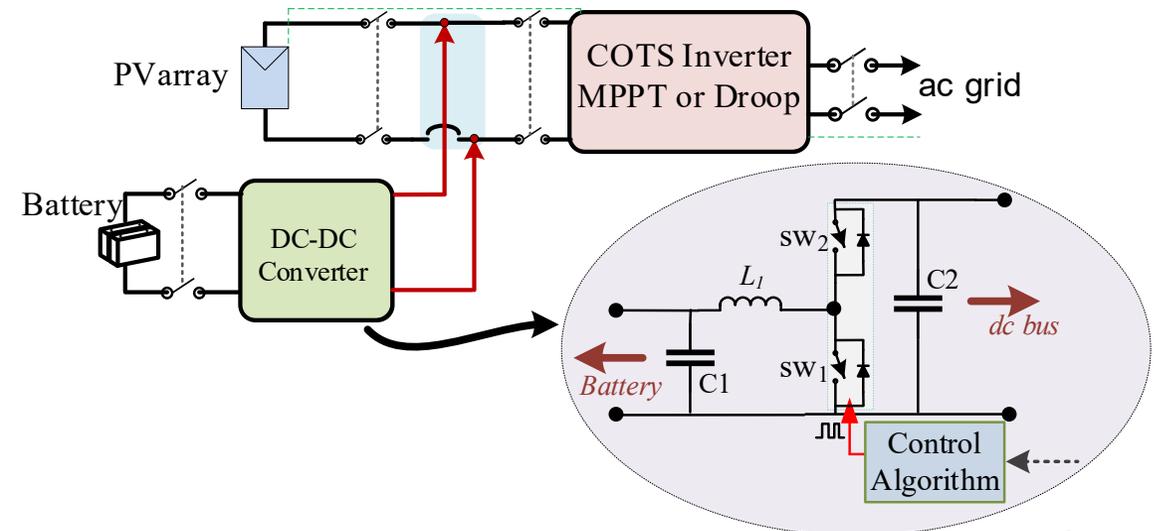
Fig.1 Common AC coupled system

Fig. 2 Proposed Solar-PV Energy Storage System

Accomplishments for Year-1

- Two proof-of-concept battery-solar systems were tested in NMSU (Fig. 3). The systems used off-the-shelf, DC-DC converters that did not allow solar power to be partitioned between the battery and the inverter.
- The data acquisition system was developed and tested

Accomplishments for Year-2

- A new DC-DC converter was implemented and tested in the lab (Fig. 4). The converter allows solar power to be partitioned between the batteries and the inverter.
- The basic charge-discharge control algorithm was tested and refined.
- New battery cells were developed that use a gel electrolyte that can operate in a temperature range of -10ºC to 50ºC.

Accomplishments for Year-3

- A prototype of the complete system with the batteries and the DC-DC converter was implemented
- Extensive charge-discharge testing has been done.
- Retired cells studied by UEP for reliability tracking

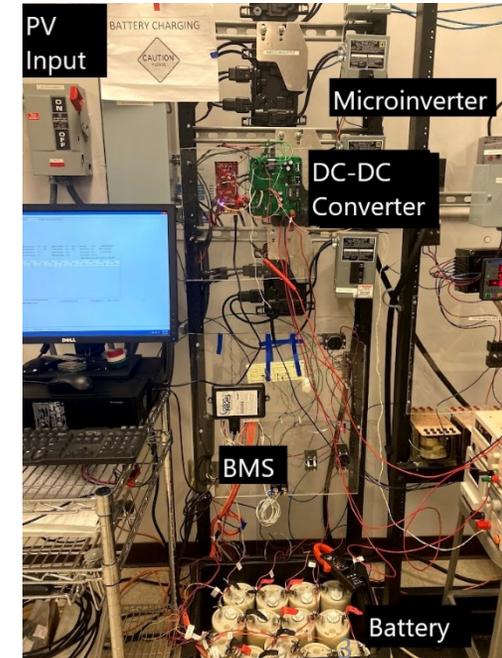Fig. 3: System built on the roof

Fig. 4: Lab setup

Experimental Results

- Extensive testing has done.
- Test results for the battery charging-discharging process are shown in Fig. 5(a) and (b). .
- When the blue curve is above the red curve, batteries are being charged from part of the solar power. When the blue curve is below the orange curve, batteries are being discharged.
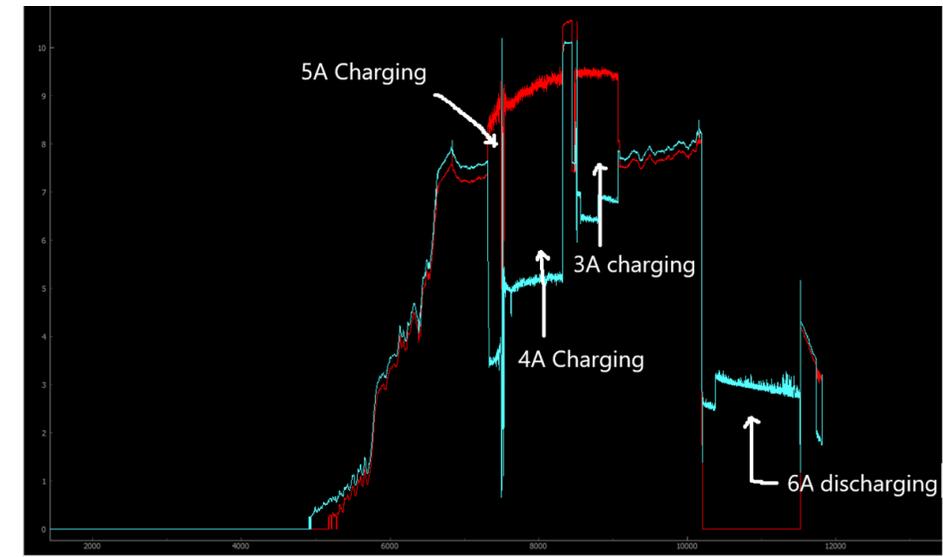- The cell voltages measured through BMS is shown in Fig. 6(a) and total pack current is shown in Fig. 6(b)
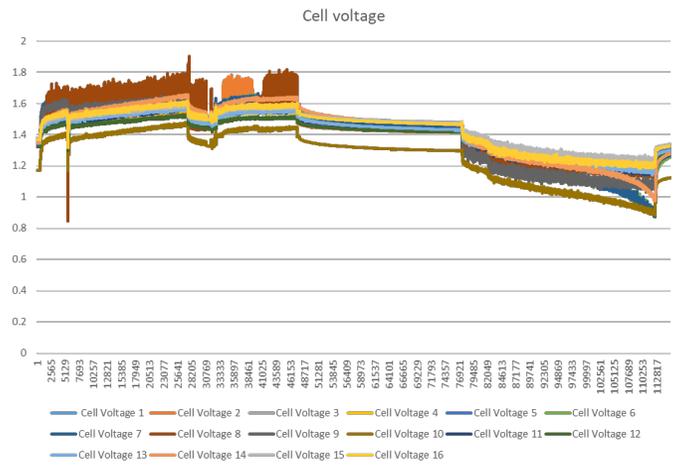

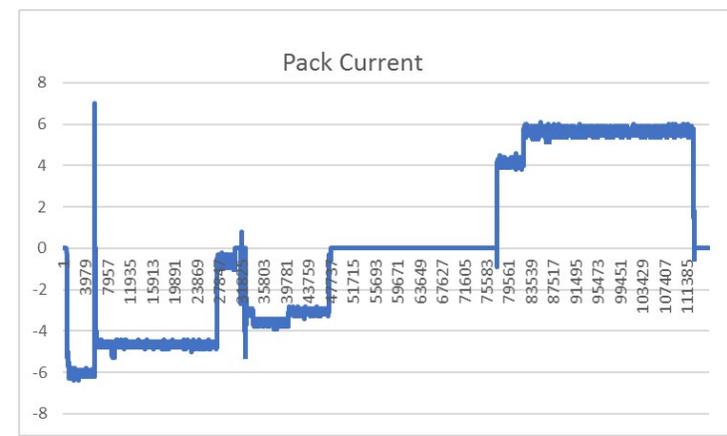
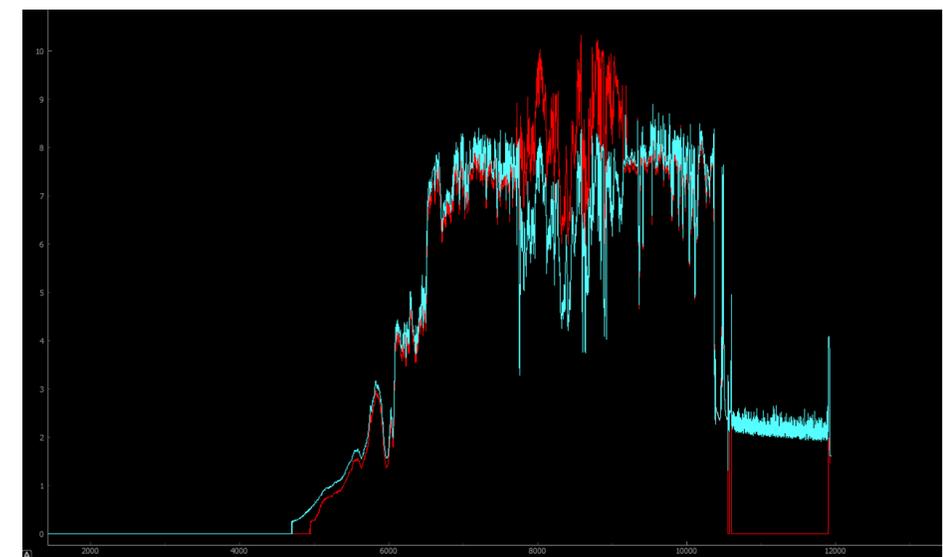Fig. 5(a) Sunny day

Fig. 6(a) Cell voltages

Fig. 6(b) Pack current

Fig. 5(b) Cloudy day

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Summary

- The Zn-MnO2 technology performed well under harsh and realistic conditions.
- UEP has used lessons learned to improve and advance cell design via other projects
- Dc-dc converter control algorithm demonstrated to be effective.
- Proposed conversion scheme allows simple interface to solar panel and grid connection using COTS inverters with any control algorithm(MPPT, droop, etc.)
- Patent: Provisional patent will be submitted as Non-provisional, Oct. 2021: Universal method for battery storage integration: draft Submitted to Sandia National Laboratories for submission.