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Abstract:

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Formation of Lead-acid Batteries for Off-grid Solar Power Applications

There are presently over one billion people without electricity service that represent the potential market for alternative energy through off-grid solar photovoltaic systems. These systems rely on cheap, reliable, low-maintenance lead-acid batteries to shift the daytime electricity generation to the morning, evening, and night-time loads. Formation is a charging process by which manufacturers electrochemically activate the battery. This time and energy intensive process can be accomplished with several different formation methods such as: tank, container, submerged container, and circulated electrolyte. Formation of batteries for the off-grid solar market is especially challenging because they may be placed into immediate discharge service. While conventional markets such as transportation or uninterruptible power supply can provide a high-voltage, long-overcharge because of their strong charging systems, such a strong initial charge is generally not available in off-grid solar systems. Consequently, battery performance may be less than expected by the off-grid client if conventional formation practices are applied.

The purpose of this research project is to experimentally evaluate the aforementioned four different formation methods to conclusively determine which is best suited for the off-grid solar market. Within each method, batteries will be formed to three levels: under-formed, normal-formed, and over-formed, based on electrochemistry and industry best-practices. This will result in 12 formation variations. Eight experimental battery samples for each variation, totaling 96 samples, will be manufactured by Surrette Battery Company while the formation characteristics of time, voltage, current, energy, and temperature are measured. The samples will then undergo laboratory charge/discharge cycling that is representative of both solar storage and deep discharge operation. This experimental research will create new knowledge of optimal formation techniques for lead-acid batteries intended for off-grid solar systems. Additionally, it will identify to battery manufacturers which formation method is most efficient and effective on the basis of minimizing their manufacturing time and energy, while maximizing battery performance as received by the client.

This poster will present the experimental framework developed to perform this research project. A test apparatus was designed to measure and record the formation energy of each of the four methods, and cycling algorithms were written to mimic the two different charge/discharge cycles subjected to the batteries. DC current and voltage will be measured using shunts, and voltage dividers, respectively, and recorded using a data logger. AC current

and voltage will be measured using current transformers, and voltage taps, respectively, and recorded using the same data logger in conjunction with an AC power meter.

The described test apparatus was recently validated through lab-scale testing where an Arbin BT2000 power-cycler connected to a 230 volt AC power line represented the formation charger, while Surrette CS15 lead-acid cells were used to represent the batteries undergoing formation in DC. Having completed the validation process, the apparatus can now be applied with confidence to the Surrette factory-scale environment, which uses up to 600 volt AC on four separate formation lines.