Summary Project Report

Undertake monitoring and demonstration of prototype PV powered Hybrid/UPS system

Client:

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Background

Instant Solar have developed a battery storage system allowing various pieces of electrical equipment to be powered from Renewable Energy sources and in the event of low battery charge, the system includes a connection for a grid backup supply. Instant Solar approached South West College (SWC), to undertake independent monitoring of the system. This was undertaken at the CREST facilities in CITC in Cavan, funded through the Innovation Voucher scheme and this report details the findings.

Details of product monitoring

The Instant Solar (IS) product was connected to 4 Solar panels (combined output of 2 kW_p @ STC) located on the CITC building in Cavan (55 degrees North). An additional electrical circuit was installed allowing the Instant Solar system to power either 240 V AC or 48 V DC load appliances. During the period of the trial a PC was connected to the system, providing a relatively constant real power AC load of approximately 85 Watts (W).

A monitoring system was installed to record the performance of the equipment. This consisted of a Crompton Integra Ri3 digital metering system, with associated model 256-TTVW Paladin Transducers. Additional secondary items were also monitored, but these were not relevant to this report.

Fig.1 Installed energy storage and monitoring equipment.

The monitoring commenced on the 20th of March 2015 and during the test period no changes, adjustments or manual interventions occurred. Two different battery storage systems were however examined during the test period. The initial tests were carried out using 4 no. industrial lead acid batteries to provide an overall voltage of 48 V. The second test was undertaken using 16 no. Wina WN100AH 3.2V lithium iron phosphate cells to provide an overall voltage of 48 V, with a battery management system for cell equalisation and overcharge protection, housed within a 19" rack system to form an overall battery pack.

The test procedure involved leaving the PC to run twenty four hours a day to provide a constant load on the system. When sunshine was available the PV panels converted this to DC power and this was fed into the Instant Solar Hybrid Energy Storage system, which provided an AC output to power the PC. Any excess DC power was used to charge the batteries. During the night or during periods of limited sunshine the Battery pack supplied the power to the PC. The system was also connected to the electric grid to provide a backup power supply in the event of the battery system not having sufficient energy to power the system. However the grid backup system was not required at any time during the trial period. As detailed previously the internal electrical circuitry within the CREST building was configured to allow a 48 V power source to be supplied should it be required, however this was not used during the trial period, as the trial concentrated on the system performance to power an AC load.

Using the power monitoring equipment mentioned above it was possible to get instantaneous readings for the power being fed into and out of the system; from the PV panels (and grid if utilised), from the batteries, and to the AC load. Once the interval between data recordings was known this could be used to convert the figures into energy figures, in kWh units, for that particular recording period. The energy readings for each recording period were then summated to give the total energy readings for the full duration of the trial period. The efficiency of the system was worked out by dividing the sums of all the outputs, by the sums of all the inputs (from PV panels in this case). The figures for the AC load related to real power, and thus the efficiency is measured in terms of real power, (rather than apparent power).

Tests on Lead acid storage system

The first trial took place with the Instant Solar system connected to 4 no. Sonnenschein GF12 90V industrial lead-acid batteries to provide an overall voltage of 48 V.

The monitoring of this system took place from the 20th of March 2015 to the 29th of May 2015. Data readings were taken every minute (initially this had been set to every 3 minutes). Figures for the total energy from each component were worked out as detailed above and a summary of the results is shown in the table below:

Table 1. Output and consumption data generated during trial of Lead Acid storage system.

Scenario Description	Period investigated	Inputs total (kWh)	outputs total (kWh)	Approx. Efficiency
Lead-acid Battery system	20-3-15 to 29-5-15	200.18	139.76	69.8%

(Efficiency calculations based on 'real power' readings for AC load)

Tests Lithium Iron Phosphate storage system

The second trial took place with the Instant Solar system connected to 16 no. Wina WN100AH 3.2V lithium iron phosphate cells to provide an overall voltage of 48 V, with a battery management system for cell equalisation and overcharge protection, housed within a 19" rack system to form an overall battery pack. The batteries were brought to site fully charged within in the rack system and were easily installed into the existing mounting system. The rack system matched the existing rack containing the hybrid system controls, and like the lead-acid system the overall system was able to fit neatly in a corner of the CREST lab.

Fig.2 $LiFePO_4$ storage system connections.

After the $LiFePO_4$ system was installed it was left running for a period to allow the system time to stabilise, prior to monitoring commencing. The monitoring of this system took place from the 17th of June 2015 to the 26th of June 2015. Data readings were taken every minute. Figures for the total energy from each component were worked out as detailed above and a summary of the results is shown in the table below:

Table 2. Output and consumption data generated during trial of Lithium based storage system.

Scenario Description	Period investigated	Inputs total (kWh)	outputs total (kWh)	Approx. Eff. (using Real power figures)
Lithium-Iron phosphate Battery system	17-6-15 to 26-6-15	25.09	20.24	80.7%

(Efficiency calculations based on 'real power' readings for AC load)

Summary of Results

The Hybrid Energy storage system containing lead-batteries was tested for a period of approximately three months and showed an overall system efficiency of approximately 70%. The Lithium Iron Phosphate ($LiFePO_4$) system was tested for a shorter period and showed an approximate efficiency of 81%. Note that both of these efficiency calculations were based on real power monitoring and the efficiencies would be greater if apparent power had been recorded and used in the efficiency calculations.

Conclusions

Both the lead-acid and Lithium Iron Phosphate ($LiFePO_4$) systems functioned without any issues during the monitoring periods. Both systems operated directly from the power supplied by the PV panels, without the need for the backup AC power supply. The trials indicated that the lithium Iron phosphate system operated with approximately 11% better efficiency during the trials compared to the lead-acid battery system.

Note: Full details of the monitoring data relating to this report is available on request