Texas Commission on Environmental Quality
New Technology Research & Development (NTRD) Program
Monthly Project Status Report

Contract Number: 582-11-12630-3264

Grantee: EcoPower Hybrid Systems

Report for the Monthly period: March 2012

Date Submitted: April 11, 2012

Section I. Accomplishments

Provide a bulleted list of project accomplishments as well as a description of their importance to the project.

- Paul-André Lavoie worked with ECS team from February 29, 2012, to March 13, 2012, to complete testing and analysis related to Task 1.

Cell Testing

- All changes made on voltage measurement circuitry shown to be effective. All power testing was completed on every cell. Work related to Task 1 is completed.

Module fabrication

- As mentioned last month, fabrication of all modules has been completed.

Module testing

- Module cycling is completed.
- The use of a battery management system (BMS) to test four modules in serial configuration was a success and permits to catch up on testing schedule. Note that preliminary set-up required to test three or four 4 X 3.2V modules independently to demonstrate capability to complete the crane duty cycle and check for data consistency. As mentioned last month, the advanced BMS configuration allowed the serial testing of the modules for a total energy of 4.3, 4.8 and 5.1 KWh. All technical developments and challenges related to the 51.2V configuration were resolved.
- Cycler code instructions were completed and finally the modules were tested under 3 different duty cycles corresponding to:
    - Intensive rubber tire gantry (RTG) crane operation obtained from direct monitoring to demonstrate cell performance using real operational data.
    - Standardized very severe duty cycle to show limit of technologies.
    - A model duty cycle use for calculation; as real world operation is too complex to extract required parameters.
- This work demonstrated that larger cells could be used even if it is a relatively high power application. Using bigger cells drastically reduces the number of connections required; one 42 Ah cell replaces fifteen cells of 2.8Ah that would be needed to be connected in parallel. To give the order of magnitude at pack level, it represents less than 900 connections versus 13400 connections for smaller cells. It was important to demonstrate that heat generation could be controlled with bigger cells.

- As this is the last monthly report related to task 1, we are presenting how all objectives were achieved. The formal criteria from the original scope of work of the project were formulated as follow:
    - At least 1 (one) tested battery sub-pack that will demonstrate the following characteristics, as compared with lead acid battery technology:
        - At least two times smaller than the lead acid battery accumulator used on the first prototype version.
            - We did preliminary calculations and demonstrate that this higher energy density permitted to reach our objectives of reduction in size to fit smaller cranes and to significantly simplify retrofit when compared with lead acid battery technology requiring crane structure modification and complex installation.
            - From the battery testing performed, we are planning to build a 120 kWh battery pack. This is 3.5 times less capacity of the first Ecocrane prototype and 2.2 times less than the last unit installed in Port of Los Angeles using lead acid battery. The energy density of Li-ion based on LiFePo4 chemistry being 2 times higher than the one of VRLA technology. The reduction in size will represent a reduction of pack size somewhere between 4 and 7 times.
            - Preliminary design shows that the complete new hybrid power plant using Li-ion batteries system will have the same size than conventional genset cabinet to be replaced.
        - Safe regarding thermal run-away in over charge and over discharge.
            - For safety reason, we have researched solutions and focus on technology using LiFePO4 active material as cathode. This technology is safer and resists higher temperature, is not susceptible to thermal runaway in over charge. Overall this technology is recognized as a safer alternative than other technologies but presents a lower energy density. We have demonstrated that Li-ion technology using LiFePO4 invented by Goodenough at University of Texas in Austin represents a safe solution and can be used as energy accumulator in the RTG Crane to be retrofitted at APMT port of Houston.
        - Authorizing recharge current at least two times higher with 80% efficiency.
            - We have demonstrated during our test that all cells could be recharged at C rating of at least 2C; recommendations for charging VRLA batteries is much lower forcing to install much more capacity to manage the power.
        - Presenting a power (kW)/energy (kWh) ratio of at least 5.
            - All cells were tested in power up to peak power of 5C.
        - Designed and sized to have a minimal life expectancy of 7 years or 4 times the one of a lead acid battery for this type of application.
            - We need to install the pack in order to validate this assumption.
            - The final cell to be used is not determined yet and with all lessons learned, we could review our original cell choice for the

final pack. But we are pleased to be able to demonstrate that the safer lithium iron phosphate technology can meet the targeted specifications.

Indicate which part of the Grant Activities as defined in the grant agreement, the above accomplishments are related to:

All these realizations are related to task one of the project.

Section II: Problems/Solutions

Problem(s) Identified: Report anticipated or unanticipated problem(s) encountered and its effect on the progress of the project

- All technical issues are fixed, all testing is completed and objectives of task one are completed.
- Final report is almost completed and will be submitted in the following days.
- We don't know how much time will be required to obtain authorization to proceed for project continuation.

Proposed Solution(s): Report any possible solution(s) to the problem(s) that were considered/encountered

- Deliverable report for task 1 is almost completed and will be supplied in the following days.

Action(s) Conducted and Results: Describe the action(s) taken to resolve the problem(s) and its effect

Section III. Goals and Issues for Succeeding Period:

Provide a brief description of the goal(s) you hope to realize in the coming period and identify any notable challenges that can be foreseen

To obtain authorization to proceed for continuation of the project from TCEQ based on the final report to be submitted.

Date: April 10, 2012

Authorized Project Representative's Signature

NOTE: *Please attach any additional information that you feel should be a part of your report or that may be required to meet the deliverable requirements for tasks completed during this reporting period.*