North Dakota Renewable Energy Program
Status Report

Recipient: Packet Digital LLC
Contract Number: R-040-051
Report for time period of: August 1, 2019 - November 30, 2019

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Description of Project
Packet Digital LLC, Nishati, and the U.S. Naval Research Laboratory (NRL) are collaborating to develop and commercialize transportable solar power generation modules capable of delivering up to 1kW, when setup in parallel, for remote military installations, emergency shelters and camps. The end product will eliminate the fuel requirement and noise and will reduce the life cycle cost of standard electromechanical power generation.

Project Tasks
Please describe the progress on all project tasks achieved during the reporting period:

Objective 1: Refine PSG1 electronic design to simplify manufacturing and assembly process.

- Task 1 – Refine the electronic board designs to reduce the amount of wiring and interconnect needed.
    - Several iterations of design refinement were done in progression. Each iteration was subjected to test and evaluation for continuous design improvement. Potential improvements were identified and implemented in the subsequent iteration.
- Task 2 – Assemble the electronics and perform laboratory tests to verify functionality.
    - Electronics from all of the phases of the design refinement were successfully assembled, tested, and functionally verified.

Objective 2: Refine PSG1 custom enclosure.

- Task 1 – Refine overall enclosure design to make the assembly process easier and less expensive.
    - Enclosure design refinement was done according to the schedule that has been planned.
    - The first iteration of design refinement was sent for fabrication. This allows us to test the refinement and to evaluate the quality of work of the enclosure as well.
    - Communication with vendor regarding the fabricated enclosure, encompassing fine tuning plan on moving forward, as well as feedback on the fabrication quality.
    - The latest enclosure design refinement is ongoing and will be fabricated using the same vendor.
- Task 2 – Add more protection features to better withstand the MIL-STD tests.
    - Multiple gaskets have been designed separately to be installed into the enclosure to provide extra protection to the electronics from dust and water intrusion.
    - Initial water intrusion tests were done to locate weak spots for subsequent reinforcement.
    - Vibration reducing damper has been designed and will be added into the enclosure to provide more protection to the electronics from shocks and vibrations.
- Task 3 – Survey and evaluate plastic injection mold options for the front panel.
    - Several companies have been contacted for injection molding service to make the enclosure.
    - The cost of the mold for injection molding is extremely high (about $150k) due to the size of the enclosure.
    - Due to the relatively large size of the enclosure, injection molding is prone to warping and bending of the final product.
    - Considering the high cost of mold and the risk of deformity of the final product, injection molding will not be pursued for PSG1 enclosure at this time.

Objective 3: Design modification of PSG-C1000 to make it lighter.

- Task 1 – Survey and evaluate economical options for lighter energy storage that will work for PSG-C1000.
    - Different lithium ion batteries, capacitor, and supercapacitor have been surveyed for cost, weight, and applicability.
    - Lithium ion batteries and supercapacitors cost substantially more than capacitors with no significant benefit in term of the PSG-C1000 use case.
    - Lithium ion batteries come with added fire hazard risks and operation limitations that require additional protection circuit, making the design unnecessarily more complex and ultimately more expensive.
- Task 2 – Modify current PSG-C1000 electronic design to support the selected new energy storage.
    - Capacitor was selected as the energy storage medium and custom capacitor bank circuits were added.
    - Design modification was done to accommodate the capacitor banks.
    - A new PSG-C1000 was built using the selected energy storage medium. With capacitor banks as the energy storage medium, PSG-C1000 design is now less complex and it is a lot lighter. More than 26% weight reduction was achieved with this new design.

Objective 4: System integration and field test -- This objective is scheduled to start in January 2020.

- Task 1 – Electronic assembly into the custom enclosure and integration with solar panel.
- Task 2 – Conduct field test.

Objective 5: FCC compliance testing

- Task 1 – Identify FCC accredited testing laboratory to work with and proceed with the testing.
    - Several certified test laboratories have been contacted for FCC compliance test quotes and availability.
    - Considering the cost as well as Packet Digital's previous FCC testing experience, Nebraska Center for Excellence in Electronics (NCEE) Labs was selected as the test facility for this FCC compliance test.
    - Initial FCC compliance test was performed during the week of Thanksgiving Day, unfortunately the radio frequency (RF) emission from PSG1 was beyond the permitted limit, and therefore PSG1 did not pass the test.
- Task 2 – Contingency plan, in the unlikely event that FCC test fails, Packet Digital will perform design refinement and re-test.
    - Contingency plan is currently ongoing. Electronic design modification is currently being done to reduce the amount of RF emission from PSG1.
    - We will also acquire a spectrum analyzer and a broadband antenna to help us investigate and check the RF emission while modifying and optimizing the electronic design.

Objective 6: MIL-STD testing and certification -- This objective is scheduled to start in February 2020.

- Task 1 – Identify MIL-STD accredited testing laboratory to work with.
- Task 2 – Build four identical systems and proceed with the testing.
- Task 3 – Contingency plan, in the event that any of the MIL-STD tests fail, Packet Digital will perform the necessary design reinforcement and re-test.

Objective 7: Looking into potential new design to support further hybridization with gasoline/diesel power generator -- This objective is scheduled to start in February 2020.

- Task 1 – Perform market survey to investigate the potential market demand for such a hybrid system.
- Task 2 – Perform initial design architecture, capturing general functionalities of the hybrid system.

Deliverables

Please describe the progress on project deliverables, as stated in your contract, achieved during the reporting period:

- Report on the improvement in electronic design to simplify manufacturing and assembly process.
    - Several iterations of design optimization have been done, resulting in a substantial reduction of the printed circuit boards (PCBs) needed in the product. The total number of PCBs in PSG1 was reduced by more than 30%, allowing simpler and faster manufacturing and assembly of the product.
    - Wiring and interconnects design were optimized, allowing less cabling (more than 34% reduction), cleaner look, and more importantly, making assembly easier and faster.
    - Every single iteration of design improvement was tested and passed the functionality check.

- Report on the improvement in custom enclosure to simplify manufacturing and assembly process.
    - Changes on both the front and back of the enclosure panels have been made to accommodate the new printed circuit board designs.
    - Improvement includes but not limited to:
        - The original standoff locations have been repositioned in a way that will not obstruct the assembly process, especially for the wiring installation.

        - Creation of guidance pegs to facilitate mounting and potting of the display. Original design in Phase I requires the assembler to manually drill mounting holes, which not only takes time and is prone to accident, but also can potentially cause leakage and let water into the PSG1.
        - Removal of screw holes for mounting PSG1 onto the Expedition 570 solar panel support beam. Clamping collars are used instead of screws, removing the need to drill holes on the solar panel support beam.
    - Other improvements are still ongoing.
    - Outsourcing the fabrication of the enclosure to overseas. This resulted in more than 40% reduction in the total cost of building PSG1.

- Report on the weight reduction of PSG-C1000 inverter module.
    - Several options for energy storage have been looked into with respect to the final application of the PSG-C1000. Lithium ion battery, capacitor and supercapacitor were the candidates for the energy storage. Upon evaluating the cost, operability, and use case of the PSG-C1000, custom capacitor banks were selected as the energy storage.
    - The goal for Phase II was to reduce the weight of PSG-C1000 to <25lbs. The weight of PSG-C1000 is now 22lbs, a substantial reduction from its original weight of 30lbs in Phase I.

- Report on the FCC and MIL-STD compliance of the product.
    - Initial FCC test was done during the week of Thanksgiving Day at the NCEE Labs. Further design refinement to reduce electromagnetic interference (EMI) is needed and is currently ongoing.

Budget

Project Associated Expense	NDIC Share	NRL Share	Total
Total Personnel Cost	$389,898.60[1]	$500,000.00	$889,898.60
Software and Materials	$110,101.40[2]	$0.00	$110,101.40
Total	$500,000.00	$500,000.00	$1,000,000.00

[1] Direct personnel costs plus indirect overhead and G&A
[2] Direct materials costs plus G&A

Expenditures
Expenditures for the project to date are shown in the table below. Supporting documentation is provided as a separate attachment.

EXPENDITURES FOR INTERIM 2 REPORTING PERIOD ONLY				
Project Expense	**NDIC**	**Packet Digital**	**NRL**	**Total**
Total Personnel Costs	$93,848.86	$0.00	$0.00	$93,848.86
Software/Materials/Subs	$4,723.09	$0.00	$0.00	$4,723.09
Total	$99,405.58	$0.00	$0.00	$99,405.58

CUMULATIVE EXPENDITURES				
Project Expense	**NDIC**	**Packet Digital**	**NRL**	**Total**
Total Personnel Costs	$138,271.60	$0.00	$130,329.46	$268,601.06
Software/Materials/Subs	$4,871.60	$0.00	$27,979.21	$32,850.81
Total	$143,143.20	$0.00	$158,308.67	$301,451.87