FINAL REPORT

POWER POD, RELIABLE POWER FOR REMOTE LOCATIONS

EVERGREEN ENERGY TECHNOLOGIES INC.

June 9, 2012

Attached are the Final Financial Report and Final Outcomes Report for the above project. Evergreen wishes to thank CCEMC for its contribution to the success of this work. We believe that the support from CCEMC has been instrumental in moving us from developmental to commercial status. Additionally, we believe that our technology has the potential to make a significant impact on GHG emissions in Alberta.

Darryl West,
Evergreen Energy Technologies Inc.

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FINAL FINANCIAL REPORT

The first three tables summarize project spending by task, time period and category. Of significance:

- The Market Demand Evaluation task was under spent by $29,100. As explained in the Final Outcomes Report, Evergreen was not able to add significant knowledge to the subject of natural gas venting from pneumatic devices at wellsites. This information apparently does not exist either within industry, or within government.
- Expenditures planned for the Jan-Mar 11 and the Apr-Sep 11 periods were partly deferred to the Oct 11- Mar 12 period because it took longer than expected to finalize test sites with industry operators.

The last table summarizes project contribution by time period.

June 9, 2012

PROJECT SPENDING, $ by task			
	ACTUAL	ESTIMATE	OVERSPEND (UNDERSPEND)
Field Testing	267065	260000	7065
Market Dem. Eval.	10900	40000	-29100
Total	277966	300000	-22034

PROJECT SPENDING, $ by time period			
	ACTUAL	ESTIMATE	OVERSPEND (UNDERSPEND)
Jul-Sep 10	77297	77297	0
Oct-Dec 10	44787	44787	0
Jan-Mar 11	46421	55000	-8579
Apr-Sep 11	37207	83000	-45793
Oct 11-Mar 12	72253	39916	32337
Total	277966	300000	-22034

PROJECT SPENDING, $ by category			
	ACTUAL	ESTIMATE	OVERSPEND (UNDERSPEND)
Salaries	140866	130563	10303
Supplies	66737	80459	-13722
Travel	34005	54229	-20223
Capital	0	10000	-10000
Sub Contracts	540	0	540
Other/ Admin	35818	24749	11069
Total	277966	300000	-22034

PROJECT CONTRIBUTION, $ by time period			
	EVERGREEN	CCEMC	TOTAL
Jul-Sep 10	77297	0	77297
Oct-Dec 10	-7996	52784	44787
Jan-Mar 11	27392	19029	46421
Apr-Sep 11	14518	22690	37207
Oct 11-Mar 12	56185	16068	72253
Final claim*	-14514	14514	0
Holdback*	-13898	13898	0
Total	138983	138983	277966

*Anticipated

FINAL OUTCOMES REPORT

BACKGROUND (extracted from Evergreen's CCEMC application)

Evergreen's Power Pod technology addresses a significant oil and gas industry problem: the use of gas-venting pneumatic devices results in lost revenue and high GHG emissions. Pneumatic pumps, a significant part of the problem, are used to inject methanol into many gas production facilities to prevent hydrate formation. Pneumatic pumps use the pressure energy of produced gas to operate the pump, then vent directly to the atmosphere. Potential combustion energy is wasted, and the vented gas stream is largely methane, a high impact GHG. Additionally, some sour gas wells use bottled propane as the pressure source, significantly more costly than produced natural gas.

Electric injection pumps driven by solar energy have been used successfully in the US, but the low solar flux in Canadian winters results in low reliability here. In recent years, Direct Methanol Fuel Cells have become commercially available. DMFC cells are reasonably efficient, and consume methanol, a fuel readily available at field locations. These considerations led Evergreen to combine DMFC and Solar as a hybrid power source. The solar cell provides power when it can, and is backed up by the fuel cell during times of low solar flux. Evergreen's Power Pod is a completely new approach that can be used to replace pneumatic devices at well sites. Electricity is generated in a hybrid combination of DMFC and Solar, stored in batteries, and used to power an electronically controlled solenoid injection pump, as well as other equipment. The equipment is contained in a climate-controlled enclosure to ensure operability in extreme weather.

A prototype was built in 2008/2009 and operated successfully under a variety of laboratory conditions, however suitability for unattended continuous operation in remote Canadian oilfield situations needs to be confirmed.

The reason for developing the technology is to provide a means for economically reducing the GHG impact of gas well operation in Alberta. Using an example of a well with a pneumatic pump operating at 10 strokes per minute to inject methanol, conversion to a Power Pod based electric injection system would save 400 mscf/yr of natural gas, and reduce GHG emissions by 171 tonnes/yr CO2e, a reduction in both energy use and emissions of over 99%.

There are over 100,000 gas wells in Alberta, with about 10,000 new wells typically added each year. Based on the proponents experience in the industry, most are equipped with pneumatic pumps. Some wells, however, operate without pneumatic pumps, some operate at lower injection rates than the example so Power Pod may not be an economic choice, and some wells may require less injection on a seasonal basis. While there is uncertainty regarding the number and operating rates of pneumatic pumps in Alberta, it is possible to make an initial estimate of the province-wide GHG impact at this time. Proponent has been involved in the manufacture of well site facilities for nearly 20 years, and has visited a number of wells throughout the province. Additionally, a methanol distributor has been interviewed (methanol delivery to field locations is directly related to use of pneumatic pumps and associated GHG emissions). While this data is anecdotal and fragmented, proponent believes that at least 20% or over 20,000 wells (predominantly the larger ones) representing 3 to 6 megatonnes/yr of CO_2e could profitably use Power Pod, and this would represent about 50% of the CO_2e arising from pneumatic pumps today. At 3 to 6 megatonnes/yr, the reduction would represents about 3% of Alberta's GHG emissions, and is similar to the expected reduction from Alberta's $2 billion CCS program.

PROJECT OBJECTIVES

The work undertaken in this project addresses two objectives:

- Develop a design for the Power Pod that is suitable for unattended continuous operation in remote Canadian oilfield situations.
- Better define the demand for Power Pod technology.

PLANNED TASKS

In order to meet the objectives, two tasks were undertaken: Field Testing and Market Demand Evaluation. The approach to Field Testing was to install six Power Pod units at well locations that represented a variety of climate and operating conditions. These installations were instrumented to measure and record key performance variables in order to improve the design. The approach to Market Demand Evaluation was to survey potential users to better understand the requirements for individual installations as well as the total market. Completion of this CCEMC project would allow Evergreen to commercialize the technology.

KEY FINDINGS:

Field Testing:

The results from the winter 2010/2011 testing season were not particularly conclusive in that only 2 units were operating in the field. Results from the winter 2011/2012 season were much more useful. Sources of information included instrumentation within the test units, as well as visits to the sites in order to talk to site personnel, and to observe the units in operation. A more detailed discussion of the Field Testing program is given in Attachment A. The primary finding was that the initial design of the units needed to be improved in several respects:

- Insulation of the Fuel Cell chamber was insufficient. Temperatures dropped below freezing in extreme weather
- Design of the Fuel Cell exhaust tube was inadequate. The tip of the exhaust tube would freeze closed in cold weather, causing the fuel cell to shut down.
- In the opinion of some operators, storing the fuel supply outside the enclosure represented a risk for spillage or theft.
- In the opinion of some operators, additional room inside the cabinet for customer options (electronics, additional batteries, etc) was desirable.

These findings were used to develop a new design that responds to the needs of field operators, and meets Evergreens objective: a power source that is suitable for unattended continuous operation in remote Canadian situations.

- The Fuel Cell chamber was redesigned, and insulation value was raised to R10.
- A heated, thermostatically controlled exhaust tube was designed and tested
- A new cabinet design provided room for fuel storage inside the cabinet
- Additional cabinet space was provided to meet unique customer needs.

Market Demand Evaluation:

Originally, the CCEMC Project application envisioned that the technology would be used to replace wellsite pneumatic devices with electrical devices, with Power Pod being the source of electrical power. The reduction in use of pneumatics was estimated to be economically attractive to operators, and would reduce venting of natural gas to the atmosphere.

A January 2011 discussion with a representative group of industry experts indicated that operators normally do not gather information on natural gas usage and venting from pneumatic devices at wellsites. Contacts with ERCB indicated that companies were not obliged to collect this data. This led Evergreen to conclude that the original plan to use a consultant for the study was not feasible. CCEMC and Evergreen agreed to drop the consultant study from the scope of the Market Demand Evaluation task. Evergreen undertook to continue to seek information from individual operators where it was available, but it was understood that results would be directional and not comprehensive.

Little new information was gained from operators during the course of site visits that would either confirm or dispute Evergreens assessment in the initial CCEMC application. Evergreen continues to view this as a significant but undefined market.

While Evergreen was not successful in better defining the market for Power Pod as a substitute for gas venting pneumatics, discussions with potential users both within and outside the oil and gas industry indicated other applications:

Wellsites use electrical power for a number of purposes (e.g. SCADA, telecom, chemical injection pumps). Frequently these needs are met by solar cells, but typically solar systems are unsatisfactory during winter. Evergreen has made commercial sales to operators for the purpose of providing reliability to existing solar-based systems.

Mining and petroleum operators are required to collect environmental data at locations that are remote and off-grid. Commercial sales have been made to resource extraction companies for this purpose.

Commercial sales have been made for security surveillance purposes.

CONCLUSIONS:

- Field Testing: The Power Pod system is capable of providing reliable power for unattended continuous applications in remote Canadian situations
- Market Demand Evaluation: Initial sales confirm that a market for the technology exists, primarily within the resource extraction industry.
- GHG Reduction: The GHG reduction potential for Power Pod technology falls into two main categories:

  1) Solar Expansion: Solar power alone is not reliable enough for most applications in Northern areas especially during winter. This has resulted in operators spending extra time and expense in maintaining these remote sites. Also, facility designers sometimes disregard solar as an option due to these concerns, opting for the less-environmentally-friendly generators. The GHG reduction potential in this case is related to the replacement of GHG-emitting power generation (TEGs, etc), by instead using hybrid solar and fuel cell (Power Pod). Effectively by partnering with solar, we are allowing solar to expand its current territory further northwards, and also for year-round use.

  2) Zero-emissions Well-Site:

  Modern well-site production facilities use electric power for SCADA control and communication, but pneumatic devices to actually perform the work (valve actuators, level controllers, injection pumps etc). These devices vent GHG gases to the atmosphere. By developing a reliable hybrid electric power supply, we are providing the opportunity for these facilities to convert to electric power only, potentially eliminating 100% of these "normal emissions" and keeping the gas in the sales pipeline as a bonus.
- Commercialization: 18 units have been sold to date, and Evergreen believes that manufacturing Power Pod units in Alberta can be a profitable venture.

June 9, 2012

Date: May 21, 2012
Attn: Trial Participants
Re: Power Pod Field Trial Update Report

INTRODUCTION:

This document is intended to serve as a discussion of preliminary results achieved in the on-going field trial of Evergreen's Power Pod systems at a variety of field locations from July 2011 to date.

The Power Pod is a system designed to allow the use of a Direct Methanol Fuel Cell power generator (EFOY Pro by SFC Energy) in remote off-grid locations under typical Canadian conditions year-round. Typically hybridized with solar power, it provides automatic back-up power whenever the solar fails. Units are available at max output of 600, 1600, and 2200 watt-hour per day, for 12V or 24V nominal voltage systems.


Encana Resthaven


Encana Cutbank

DATA:

Data was collected by two methods. The first is continuous (hourly) automatic recording by data-logging computer of the fuel cell's internal operating parameters and an external power meter on the solar output. The second method is manual recording (once per site visit, 3-6 weeks) of some of the fuel cell parameters and also of the external power meters (solar, fuel cell, user load, and others depending on the unit).

Detailed manual datasheets, and calculated results with graphs are available (attached). The automatic data has not been fully processed yet.

DATA ANALYSIS AND DISCUSSION:

General trends in the data confirm that the EFOY Pro fuel cell put out most energy during the same period of time that the solar put out the least (Dec-Jan), with corresponding changes in fuel usage. This confirms the nature of the fuel cell control algorithm, which is to back-up other sources of power such as solar by monitoring battery voltage, with setpoints to turn on at a voltage that is lower than the solar is supposed to maintain.

The specific fuel consumption is 1100 watt-hours per litre as reported by the manufacturer. Recorded data seems to verify that this figure is reasonably accurate, although there is some variation to be expected, based on “antifreeze mode” that would continue to use some fuel even if / when the load is turned off. Based on the measurements, for a typical 8W user load plus 2W tube heater only (compared to trial unit with 10W of extra parasitic loads), the fuel usage could be expected to be about 50% of that recorded, or 0.15L/D winter average. This would mean that a 28L cartridge should last 4 months of winter.

The average user load (power used by the operator’s normal equipment at the site i.e. SCADA, etc) was unexpectedly quite variable. For example at one site it jumped from 5W to 15W later in the trial period. It may be that there was more frequent communication (higher radio load), or possibly some SCADA devices may generate additional heat loss in colder ambient conditions. The Power Pod system responded automatically to any variation in load without incident.

It should be noted that in addition to the user load recorded, there were also additional parasitic loads caused by the data-logging equipment (computer and power meters, for the Power Pod trial units only) and also the exhaust tube heater / fan that are part of the Power Pod system. These extra loads were only recorded on some units (not all) but they would be expected to be consistent across all units. The data-logging system consumed about 10W steady, while the heater/fan used from 0-8W (averaging 1-2W during cold weather). The effect can be seen on some of the graphs where the user load or fuel cell output goes slightly negative – this is due to the parasitic meter load. The data-logging load is actually much higher than the average user load in some cases, which means that for a production model without data-logging, the smallest Power Pod model should be more than enough.

Some of the existing solar power systems would show negative current flow during some site visits (flowing from the batteries to the panels). The cause is not known exactly, but it is suspected that the solar charge controller is not properly functioning (supposed to prevent current loss at night / low light). This may also explain negative values on some charts.

CHALLENGES & LESSONS LEARNED:

The data-logging computer was very problematic and difficult to troubleshoot. Several site visits revealed a data-logging failure of varying intensity from partial to total. The amount of data recorded was very small relative to the storage space available, but the Windows operating system still had occasional virtual memory errors that could sometimes interrupt the running data-logging programs in between site visits. Various steps were taken to solve or work around the issue including changing the memory settings, data sampling frequency, swapping the hardware, and even reducing time between site visits. At some sites these steps seemed to work, but not at others. As a result the automatically-collected (hourly) data is not fully-continuous, but the manually-recorded data is fine (must still account for meter-rollover events and meter-reset on power failure).

The Power Pod system has worked very well during the trial so far, coming to the rescue repeatedly by turning on at low voltage which indicated the solar was already failing (allowing the batteries to decline below normal settings). There have also been a few EFOY Pro / Power Pod failures (or "learning opportunities" as we prefer to call them).

One solar panel installation (Devon Ferrier well-site) was modified by field operations in a manner that was not intended by Evergreen. The panel was mounted vertically (but came angle-mounted, which they altered) and also was located underneath a pipe-rack such that it is always subject to partial shading. This shading is expected to become worse during the summer. Based on data collected it appears that the solar output is not sufficient, so the fuel cell must do more work at this site than would be normal. In a way this is a good extreme test site because of this installation error, but Evergreen still recommends that it should be remedied in the spring - perhaps with a second solar panel.

The first failure (Devon Ferrier well-site) was simply due to running out of fuel. Contributing factors include the under-sized solar (previously mentioned), using the small 10L size fuel cartridge, and being caught un-prepared for a sudden increase in fuel consumption in November when the weather abruptly changed and solar failed. This was resolved by removing and warming-up the EFOY Pro unit, and also upgrading to a 28L size fuel cartridge with adapter. NOTE: our newest design also allows for the addition of a DuoCartSwitch (DCS) device to allow up to (2) 28L fuel cartridges to be connected together, fully draining one before automatically switching to the next. This could make changing fuel a once-per-year event for some typical sites.

The next failure (Encana Resthaven well-site) initially appeared to be running out of fuel (same error message and time frame as the first) but turned out to be caused by a damaged fuel line between the fuel cartrdge and the EFOY Pro (the armored line permanently attached to the EFOY Pro). This could only be confirmed upon sending the unit back to SFC for tear-down and inspection / repair. Based on the visible markings it seems most likely that the damage was done by the electrician used by Evergreen to originally install the EFOY Pro and wire up the Power Pod unit (prior to field installation), possibly by shorting the metal cable armor across a live battery, partially-melting the plastic tube inside. The unit operated normally during testing prior to original shipment, and again for several months in the field but finally broke in its weakened state. There was no leakage, but the EFOY Pro could not receive fuel needed to operate.

Another failure happened at a few sites (Encana Resthaven and Devon Ferrier) in January when a cold weather snap brought ambient conditions down to -35C for a week or so. The Power Pod and EFOY Pro operated correctly, preventing internal freezing of the exhaust tube. But external ice built up on the outer surface of the Power Pod enclosure (and stand) near the exhaust exit, eventually blocking it over time. Evergreen also used this opportunity to do ambient testing on our latest design (Power Pod type D) in Calgary. We adjusted the projection of the exhaust tube exit and position of the heater, which resulted in no ice collecting at the exhaust (just on the ground). Similar adjustments were made in the field by Evergreen on the Type A units in this study at the next opportunity, with improved results afterwards.

Devon Ferrier External Ice

Encana Resthaven External Ice

Another failure (Devon Ferrier well-site) was caused by a rare firmware bug in the EFOY Pro fuel cell unit. The manufacturer (SFC Energy) had just issued a warning with a new firmware patch, but the unit failed prior to the next site visit a week later. It was actually Evergreen's loaner unit that failed, since the original one had previously been removed for warming-up after the external ice issue from a previous site visit. As a precaution all of the trial units were updated to the latest firmware at the next site visit. NOTE: Firmware patches are easily done in the field using a laptop and software (available on Evergreen's website) or else by an updater device (hardware dongle, available from SFC Energy). Eventually they could even be done remotely by SCADA interface with the EFOY Pro fuel cell itself.

While not a failure, the experience of one particular site (Devon Ferrier Repeater Station) is unique and worth discussing. An EFOY Pro 1600 and (2) 135W solar panels were installed inside/on top of an existing heated non-hazardous building. These were also tied into an existing propane 5060 thermoelectric generator (TEG). At the beginning, operations preferred to leave the TEG running (as before) despite the new fuel cell / solar system. The TEG does not have an adjustable charge controller similar to the solar and fuel cell, so it never actually stops charging when the battery reaches a voltage setpoint, to resume again at a lower setpoint. Since the TEG was continuously charging at high voltage, the solar and fuel cell would never come out of standby mode, and so could not contribute any power (or meaningful data). Evergreen recommended turning off the TEG but this was still under consideration. However, in early March the TEG unit suddenly failed, providing the opportunity for the other equipment to automatically take over without interruption. At the time, the hill-top site was not readily accessable due to heavy un-plowed snow on the road leading up to it, but Evergreen managed to get in on foot. The EFOY Pro fuel cell and solar were working as expected and data was recorded.

Devon Repeater Site

CONCLUSION:

The field trial is still ongoing at this time, with additional data being collected into the spring. Processing of the automatic data is also still underway. In the opinion of Evergreen, the results so far are positive and support the future deployment of more units (of the latest design) on a commercial basis, having incorporated improvements based on the lessons learned from this study.

Latest Version of Power Pod (Type D) with CSA, improved exhaust, DuoCartSwitch, and (2) 28L Fuel Cartridges (61,600 Watt-hours of standby power)

REPORT PREPARED BY:

Darryl West, P.Eng, President, Evergreen Energy Technologies Inc.
10290 Tuscany Hills Way NW, T3L 2G5, Calgary, Alberta, Canada
Mobile: (403) 370-5437 email: darryl.west@evergreen-eti.com
web: www.evergreen-eti.com