SOLAR POWERED PUMP JACK REMOVES SMALL VOLUMES OF FLUID FROM ISOLATED STRIPPER GAS WELL PRODUCING FROM 7450 FEET WITH CONVENTIONAL EQUPMENT

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WITH ASSISTANCE OF
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ABSTRACT

Solar powered pump jacks have been utilized in shallow wells for some time. An American 160D pump jack with 54 inch stroke has been modified to run with a 3HP motor on a conventional rod string and down hole pump producing gas from perforations at 7369-7402 feet with seating nipple at 7450 feet. All power is provided by solar panels without back up battery power. Run times are restricted to bright sun periods. Fluid production volume rates of 2 to 3 barrels per day have been achieved. Fluid is formation water and casing leak invasion water and severely restricts gas flow. Fluid recovery over a long period of time is permissible in this project. Details, photos, and production results will be presented. This project is still on-going and any new data obtained prior to the presentation will be included. This project was partially funded by the Stripper Well Consortium.

INTRODUCTION

As one of many small independent gas and oil producers with an inventory almost exclusively comprised of low volume stripper gas wells, a keen interest exists in new applications of existing technology to remove wellbore fluids and increase gas production, especially those that will fit into the very limited and conservative budget constraint common to many small producers.

Stripper well producers need a simple solution for the removal of small volumes of accumulated well bore fluids from stripper gas wells in remote areas without access to electrical power. Typical solutions suggest either a gas fired motor with a pump jack or periodic trips with a conventional swab rig to remove the small volumes of fluid, both of which are costly and ineffective. Such infrequent swab treatments provide benefit for only a few days before fluid loading restricts increased gas flow to previously lower levels. The choice of using a conventional pump jack is offensively prohibitive in both asset acquisition costs and in deliberately installing equipment that will be severely underutilized and consequently grossly inefficient.

Recent improvements in solar panel output and more financially attractive solar panel prices suggested that a solar powered pump jack would be worthy of evaluation.

A project was designed that would use an available American 160 D pump jack with tubing and rods from an abandoned well of about the same depth. Solar panels would be added as the sole power source and the pump jack would be modified to use a small motor as the prime mover. Substantial gear reduction and a shorter stroke length would permit a 2HP motor to be adequate for this application. The resulting much slower stroke speeds were anticipated and acceptable for this application. The fluid to be recovered consisted of formation water, typically in the range of 1 to 2 barrels per day, and invaded water of unknown quantity from a casing leak. This would permit the fluid to be recovered over a long period of time and would ultimately increase gas sales.

The use of solar modules as the sole source of power would limit pump action to bright sun conditions during daylight hours. However, the ability to consistently remove water over long periods of time would gradually increase daily gas production. No gas will be consumed on the lease as fuel gas for an internal combustion engine. All gas produced would be directed into sales revenue. No expensive and prohibited construction of electrical services to this remote location,, nor monthly electric bills would be necessary. The success in this application will lead to other applications of solar power in remote areas or in environmentally sensitive areas to exhaust gas emissions or unnecessarily adding burdens to the electrical supply infrastructure. Both low volume stripper oil wells and stripper gas wells appear suitable for this application. However, this application is limited to low fluid volume stripper wells and therefore inappropriate for high volume, high water cut oil stripper wells.

A well in the Oklahoma panhandle, producing from a depth of 7450 feet was selected. An earlier casing leak resulted in excessive fluid invasion and restricted the gas production to 4 to 5 mcf/day. Periodic swabbing would recover 20 barrels and increase the gas sales for a few hours. The result of swab treatments indicated that once the invaded fluid was recovered, a much higher rate of gas production could be expected. The successful completion of this project should restore gas production to the range of 20 mcf/day.

EQUIPMENT INSTALLATION

The pump jack was modified for input torque requirements by the addition of a small Cabot gear box, intermediate between the motor and the pump jack gear box. Further modifications were required within the pump jack gear box to insure adequate gear lubrication at stroke speeds of 1 to 3 SPM. The down-hole equipment consisted of 2 3/8 tubing from 7450 feet, with tubing anchor set at 7100 feet, a full string of ¾ inch rods, and ultimately using a 2x1-1/8x12x16 stroke through pump with a 6 ‘ spray metal plunger with a minus .002 clearance.

The solar power was provided by 12 panels of 175 watts, connected in two series of 6 panels, providing a combined output of 9.6 amps in excess of 210 VDC. A 2 HP, 180VDC motor was installed on the pump jack and a controller was added to provide both voltage and amperage constraints. The pump jack was carefully balanced to provide equal amperage loading on both rod lift and counterweight lift portions of a pump cycle. The amperage load was just below the 9.6 amps available. The equipment was installed and operations commenced.

After an extended period of run time without fluid production, it was determined that the pump should be removed for inspection and repair. The pump, with a standard 1 ½ inch bore was removed and found to be packed full of iron sulfide which rendered the pump to be inoperable. It was determined that a smaller bore pump would likely reduce the rod load on the unit. A standard pump with 1 1/8 inch plunger was built, with minimum clearance, and installed. This pump arrangement did lower the rod load and required another sequence of balancing the counterweights to the rod load. The motor shaft of the 2 HP motor failed, probably due to excessive belt tension. A larger shaft diameter was available in a 3 HP 180 VDC, with a maximum amp load of 14 amps. The 3HP motor proved to be a good choice and more than adequate to lift the load. However, the amperage draw of the 3 HP motor exceeded the amperage limit of the controller and resulted in frequent shut downs due to over-amperage.

The controller was removed and returned to manufacturer to modify the controller to operate at maximum amperage of 14 amps to permit higher motor amperage loads. This was done and the unit ran continuously for 3 hours. However, a suspected rod failure occurred which allowed the counterweights to rapidly fall which in turn caused a drastic overspeed on the motor and caused the motor to fail. The motor was repaired and was reinstalled. It was determined that additional amperage output of the solar panels would be beneficial. Six additional panels were ordered and an additional mounting platform was constructed to increase the total solar array to 18 panels in 3 series of 6 panels, for a net output of 236 VDC at 14.6 amps. This would fully power the 3 HP motor. During the interim, a 3 HP 210 VAC motor was installed and powered by a diesel generator.

The anticipated rod repair was unnecessary. The rod string was intact and the pump functional. The motor failure must have been due to other causes not yet identified completely. The diesel generator and 3 HP 208 VAC motor installation proved successful. The welded support frame was anchored and the additional 6 solar panels installed and connected to the original 12 solar panels. The diesel generator was removed and the 3 HP 180 VDC motor was installed and the system began running on daylight solar power. Initial fluid production rates of approximately 1 barrel per day were obtained at the current sunlight levels at 1 ¼ SPM. The pump ran continuously during sun light hours. Optimum run times were 10 AM to 4 PM. Two hours before and two hours after, the pump ran at slower stroke speeds. After two months, we began to experience erratic pump run times. An electrician determined that the brushes were irregularly worn and resulted in poor armature contact. Field adjustments to the brushes restored pump action. New brushes were ordered, and when the electrician went to install them discovered that the controller had shorted out internally. The controller was replaced and the performance was restored. An opportunity occurred to discuss this system with UNICO ENERGY engineers. UNICO specializes in motor controllers for such applications. A meeting was arranged to visit the site for a system inspection and analysis.

A new controller from Sun Pumps in Arizona was installed and production was restored at 1 ¼ SPM. Fluid production was restored to 18-20 barrels water per month. The UNICO ENERGY engineers visited the site in October and evaluated the overall performance and sun energy conversion of the system. The solar module array was performing within specifications. The mechanical configuration of the standard size 160D pump jack with the secondary gear box for torque reduction did indeed consume most of the available lift energy and resulted in an overall low efficiency. However, this condition was predetermined to be an acceptable result of such an ambitious design configuration. The primary justification was the ability to lift fluid from a depth of 7450 feet using conventional equipment with the sole use of solar energy. Overall efficiency was not the primary target. Improving the gas sales over a long period of time was the primary focus of the project.

After the site inspection by UNICO ENERGY, UNICO elected to contribute their time and expertise to improve the overall function and efficiency of the existing system. Their technical staff suggested that we convert the solar output to operate on Alternating Current. Further, they suggested we use a 10 HP 220 VAC, 3 phase motor with a specially designed controller that could be controlled remotely, via cell phone connection, to control motor speed and start and stop times by solar panel output. In addition, their controller provided dynamometer card data and many other diagnostic variables. They also recommended that the drive sheave diameter be increased by two-fold. This provided a stroke speed of over 3 SPM and still operated the system at 2.2 HP consumption. Currently, the performance of the system is limited by a motor speed of 2500 RPM. Other options for further enhancement of the overall system are in the evaluation and implementation stages. Fluid production is now in excess of 35 barrels per month and considered acceptable for limited sunlight hours and typical winter weather conditions. The monthly fluid production should increase during the spring and summer months.

As the result of improving the function and performance of this system, gas rates have already improved by over 30% using a solar powered pump jack in this remote location. Realistic expectations of restoring gas production to the range of 20 MCF/day suggest a successful and exciting conclusion to this project..

ECONOMICS

This project utilized existing equipment available from inventory. Cost to modify the pump jack was $3000. The solar panels and support system costs were approximately $14,000. The controller, with remote communication capabilities, cost was $5,000. The electric motor cost will depend on type and size selected in the $500 to $1,000 range. The total system cost was about $23,000. Compare this with a cost of $10,000 for a gas fired engine and loss of gas sales of $600 per month consumed as fuel gas for the motor, the solar powered pump was a reasonable solution for this well. Gas sales for the month of December 2010 were $704 suggesting payout in less than 18 months.

CONCLUSION

A conventional pump jack utilizing off the shelf down-hole tools was converted to run using solar power as the sole prime power source. This project was unique in the depth from which fluid was successfully removed and size of equipment required to reach these depths. Some improvements remain for implementation that will increase the stroke speed to about 5 SPM and improve the efficiency of the down-hole pump by reducing slippage. The adaptation of standard equipment to run with solar power will provide the opportunity for removing fluid from stripper oil and gas wells in remote locations, converting all produced hydrocarbons into saleable revenue.

Updated results will be presented in April at the SWPSC seminar.

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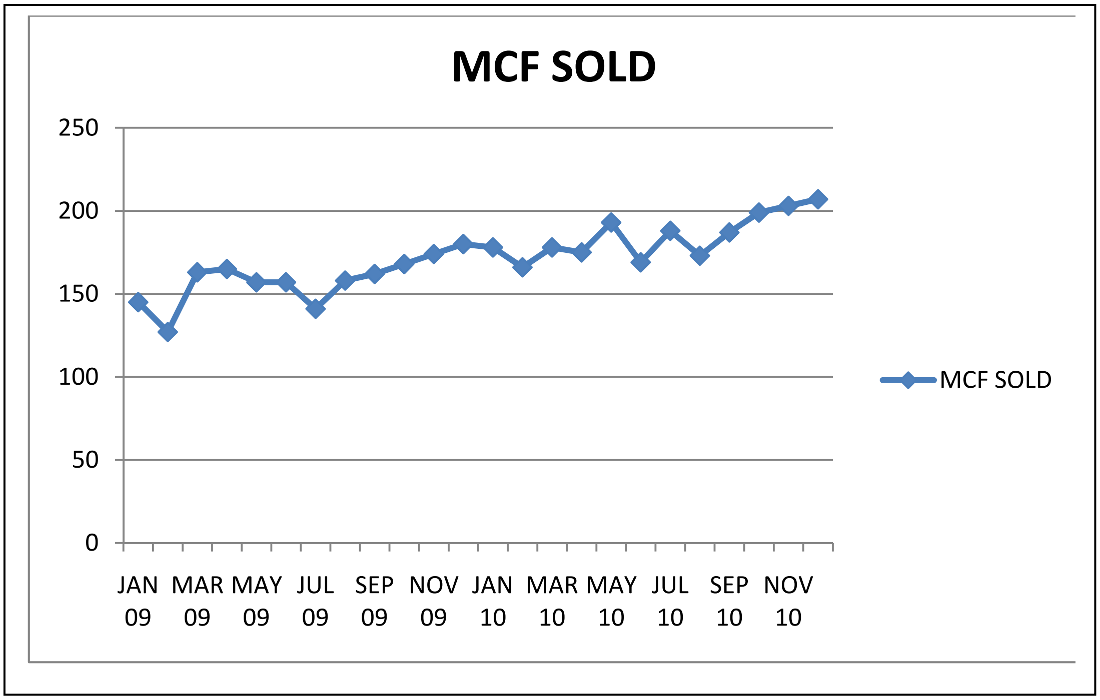
Initial installation of 12 solar panels

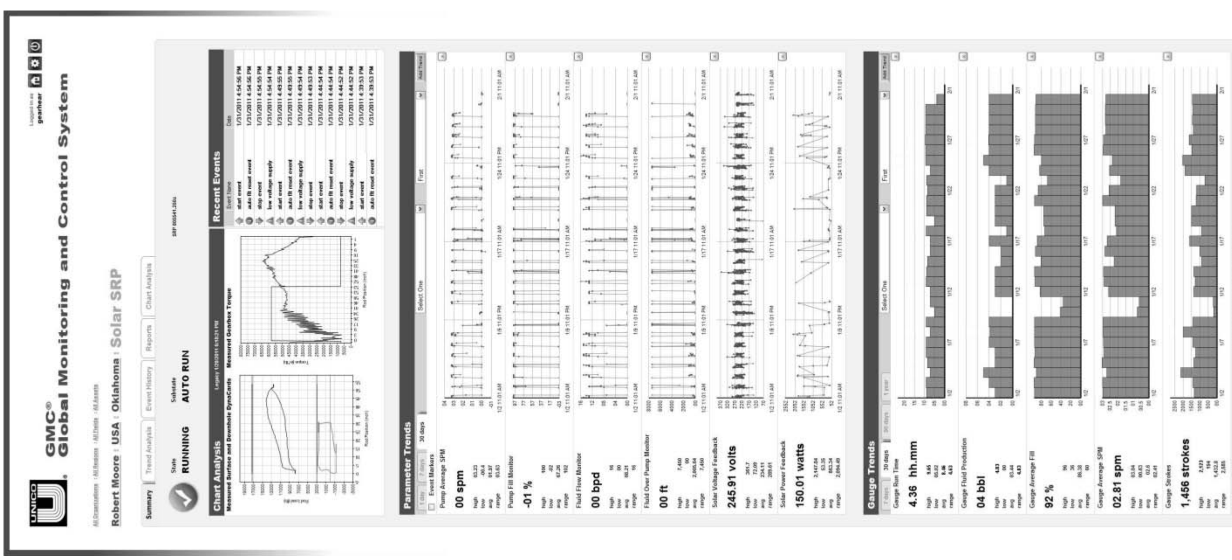
Final installation of 18 solar panels

Installation of 10HP 220 VAC, 3 phase motor
(Actual power requirement uses 2.2HP)

UNICO controller and DC to AC converter

Adjusting panels to the winter angle for more direct sunlight





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