SOLAR AND WIND COMBINATION PRODUCE FLUID FROM 7450 FEET IN PANHANDLE GAS WELL

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WITH ASSISTANCE OF
Stripper Well Consortium Funding

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ABSTRACT

The innovation of using a standard 160D pump jack to lift water from a gas zone at 7450 feet by solar energy only, without storage batteries was presented at this seminar last year. The alternative power source to drive the pump jack motor was expanded to include a wind turbine to take advantage of wind power available in low sunlight conditions. The combination of two sources of clean energy power the unit to run at 6 strokes per minute at wind speeds as low as 11 mph. Sophisticated digital controllers providing power to the unit in "either/or" and "both" modes, is the key to this "one-of-kind" installation. A summary review of the installation and the performance data will be presented.

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. These interests, as expressed last year, remain a valid consideration to justify the expansion of this project to include wind as a source of available power.

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.

The project was guided by recent improvements in solar panel output and more financially attractive solar panel prices. An available pump jack, tuning and rod string were utilized as the foundation equipment that would be required.

The project was designed to use an available American 160 D pump jack with tubing and rods from an abandoned well of about the same depth. Twelve solar panels, with just over 2KW output were used as the sole power source. No storage batteries were included in the design. The pump jack was modified to use a 2 HP, 180 VDC motor as the prime mover. Substantial gear reduction was obtained by inserting a small Cabot gear box between the motor and the pump jack gear box. The stroke length was reduced to 54 inches.. The resulting much slower stroke speeds of 2 SPM 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 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.

SOLAR 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, 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. An additional six solar panels were added to increase the solar output to just over 3 KW, which provided ample power for the 3 HP motor. During the interim, a 3 HP 210 VAC motor was installed and powered by a diesel generator as part of an additional fact finding part of the project to evaluate a more conventional power source. Fluid production was maintained at 18-20 barrels water per month.

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. 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.

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 power consumption. Further improvements to the system increased the stroke speed to 6 SPM and increased the fluid production to about 60 barrels per month.

ADDITION OF WIND POWER

With the solar system operating at near maximum capacity, but only during periods of bright sunlight, the prevailing wind patterns of the panhandle presented the expansion of the project to add a 5KW wind turbine as an additional source of power.

The UNICO engineers began the design of the electronic controls packaging that would permit the pump jack to operate in a wider range of environmental conditions. The design would enable either source of power, solar or wind, or any combination of power sources to power the pump jack to run more hours of the day, or night.

The foundation support for the 30 feet high wind turbine was constructed and the wind turbine was erected on site. At times, the system has functioned as designed. However, the limiting factor to the overall success has been the excessive wind speeds that frequently occur in the panhandle. The turbine is designed to operate between wind speeds of 10 MPH to a maximum 25 MPH. This upper wind speed limit requires an effective braking system that will control the turbine maximum RPM during wind gusts, then allow the turbine to start again after the wind gusts pass. The sophistication of this control feature strongly suggests that independent control modules be designed for the three active functions that must be compatible with each other. A pump jack motor control module is required that performs with either single source of power or any of several variable combinations of solar and wind. A solar control module is required that will provide the optimum output of the solar energy with sufficient sunlight or in times when partial sunlight is all that is available. The turbine control module must constantly monitor the wind speed and adjust the turbine RPM to provide power but not exceed maximum RPM's that would damage the turbine.

At this time, the combination of solar and wind are working together, but not at the automated level that would allow for long time periods without on site supervision and monitoring.

As the result of improving the function and performance of this system, gas rates have already improved by over 50% using a solar and wind 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 solar 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. Increased gas sales suggest a payout for the solar portion in less than 18 months.

The additional costs of the wind turbine system, without the controllers, was about $9,000. While the "add-on" approach to controllers has produced a fully functional system, properly designed modular control systems are still in the development stage.

CONCLUSION

A conventional pump jack utilizing off the shelf down-hole tools was converted to run using solar and wind power as the sole prime power sources. This project was unique in the depth from which fluid was successfully removed and size of equipment required to reach these depths. Some improvements to the controllers for all elements of the system remain. The stroke speed is consistently in the range of 6 SPM when functioning properly. This higher stroke speed will improve the efficiency of the down-hole pump by reducing slippage. The adaptation of standard

equipment to run with solar and wind power will provide the opportunity for removing fluid from stripper oil and gas wells in remote locations, converting all produced hydrocarbons into saleable revenue.

ACKNOWLEDGEMENTS

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UNICO ENERGY: Joseph Glover, Paul Vanderheyden, and Mike Lucas, with technical assistance from the home office, provided field site analysis and significant improvements to the overall function and performance of the solar pump system and its future improvements.

PHOTOS

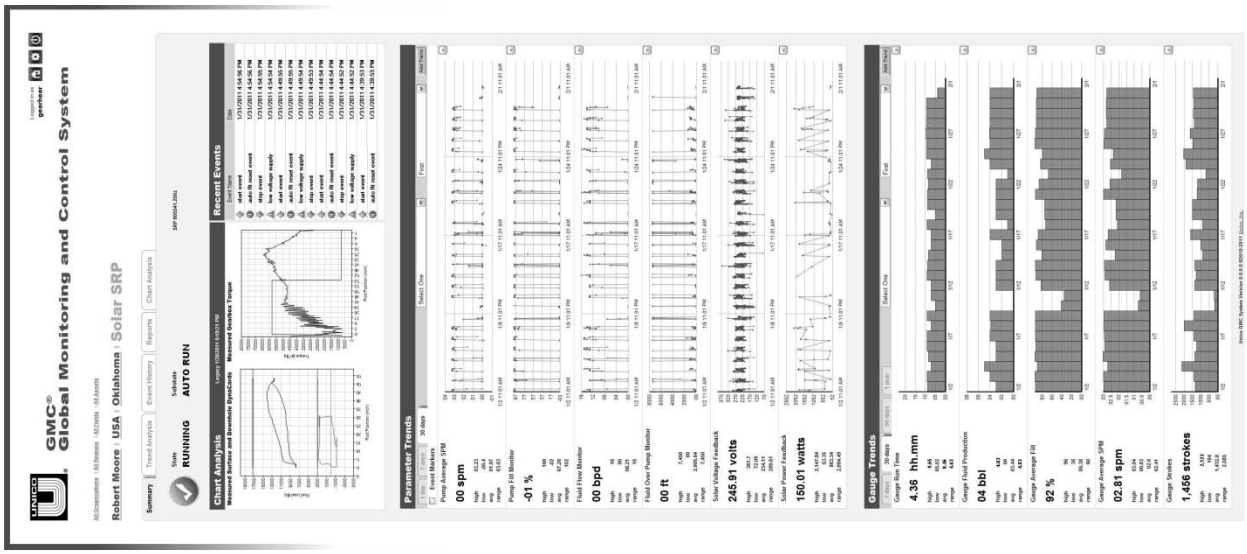
INITIAL 12 SOLAR PANELS WITH 2 KW OUTPUT

FINAL INSTALLATION WITH 18 SOLAR PANELS WITH 3KW OUTPUT

INSTALLATION OF 10 HP 220 VAC, 3 PHASE MOTOR WITH ACTUAL PUMP POWER REQUIREMENT OF LESS THAN 3 HP.

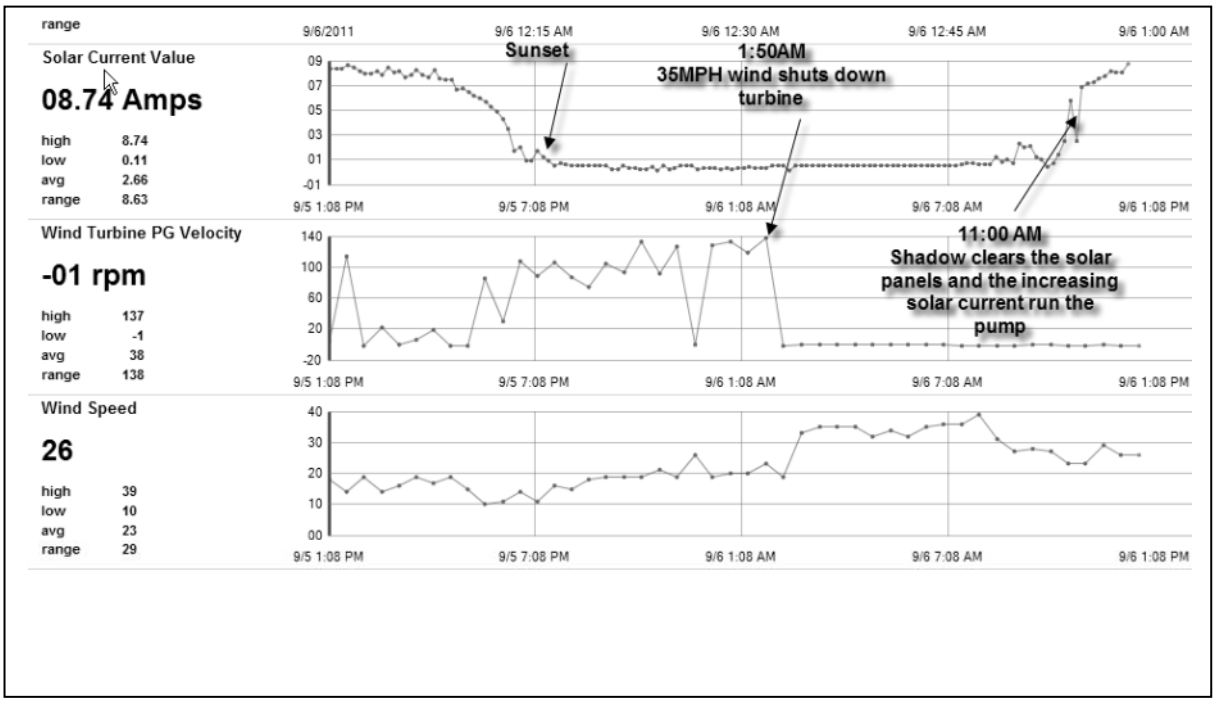
UNICO SOLAR CONTROLLER WITH DC TO AC CONVERTERS

5 KW WIND TURBINE WORKING IN CONJUNCTION WITH 3 KW SOLAR PANELS



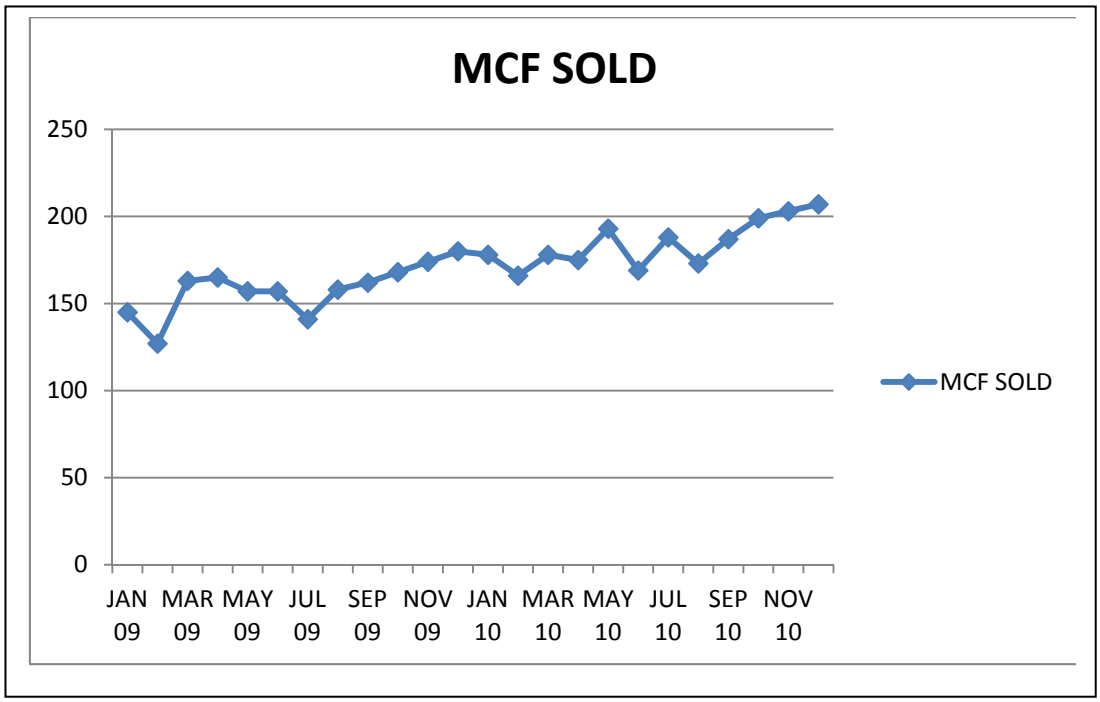
SAMPLE OF DATA AVAILABLE ON WEB SITE DAILY

COMBINATION OF WIND AND SOLAR CONTROLLERS WITH BRAKE



COMPOSITE OF WIND AND SOLAR FUNCTIONS OVERNIGHT

ADJUSTING SOLAR PANELS TO WINTER SUN ANGLE



GAS PRODUCTION WITH BENEFIT OF SOLAR POWER ONLY