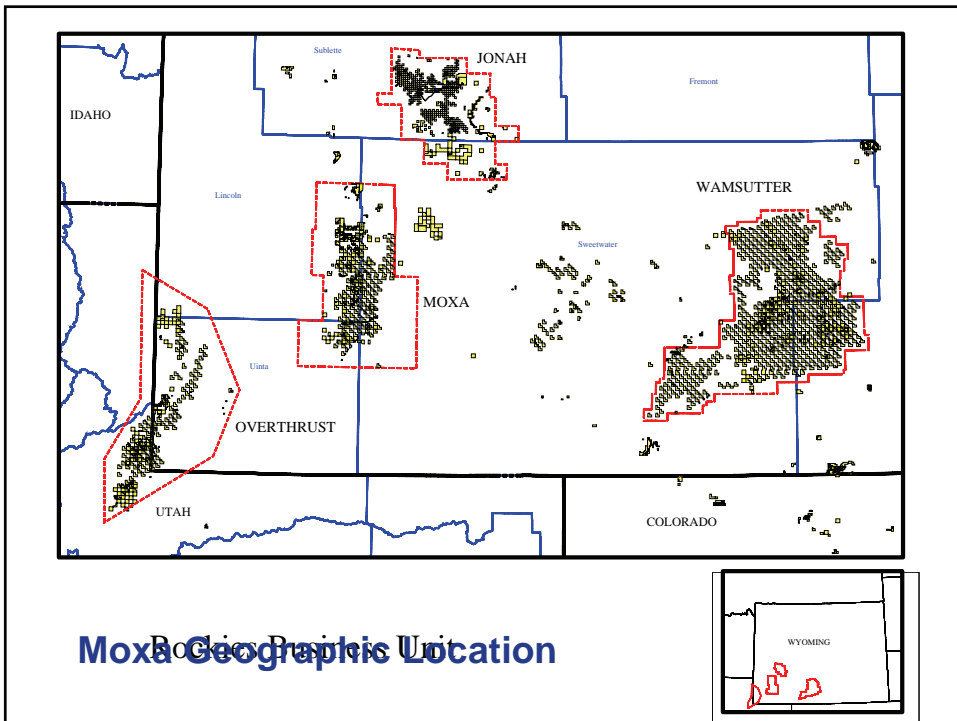
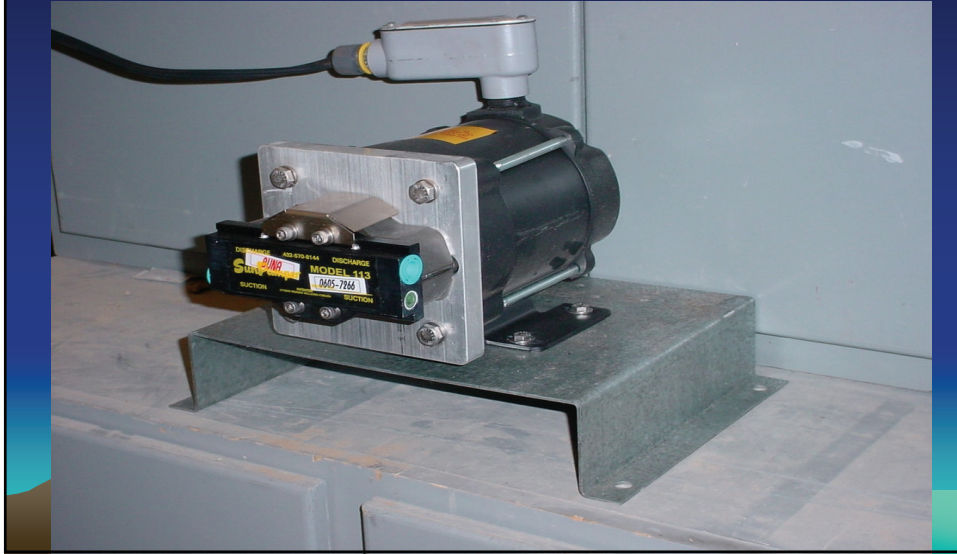


Moxa Success with Solar Pumps



Challenge:

- Mitigate hydrates.
- Reduce GHG emissions.
- Lower Methanol consumption.
- Increase reliability

Pre-solar

- In the past we used two different styles of pumps: Western and Texsteam
- These pumps would use an average of 6-8 gallons of methanol a day
- Working off a gas supply from the separator, they would also vent to the atmosphere.



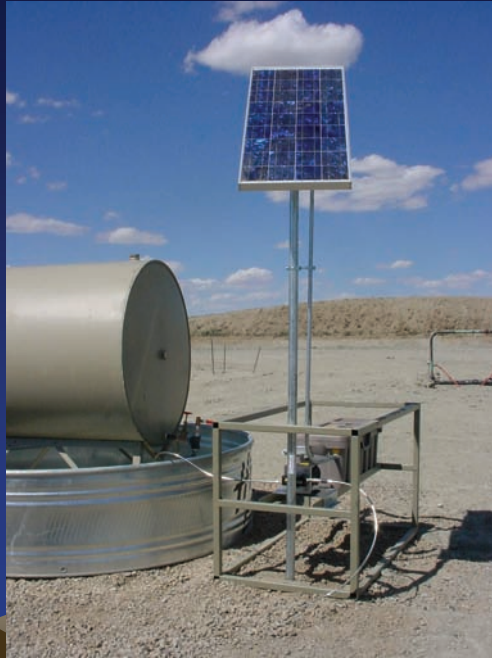


Solar Pump Advantages

- More reliable than diaphragm pumps.
- Reduce methanol usage to an average of 2.5 gallons per day
- Sell vs. vent gas



Solar MeOH Pump



Economics

- 160 solar pumps cost \$500,000.
- Methanol savings pay out is 1.3 years
- Texsteam & Western rate of 6-8 gal/day
- $\$1.5 \text{ gal} \times 160 \text{ pumps} \times 7 \text{ gal/day} = \$613,200 / \text{year}$
- Solar pump rate of 2.5 gal/day
- $\$1.5 \text{ gal} \times 160 \text{ pumps} \times 2.5 \text{ gal/day} = \$219,000 / \text{year}$
- Methanol savings of \$395,000 / year
- 4 wells down at 300 mcf/d for 6 months = \$1.3 M
- ***Solar pumps pay out in less than 3 months in winter conditions.***

Solar Gycol Pump Tests

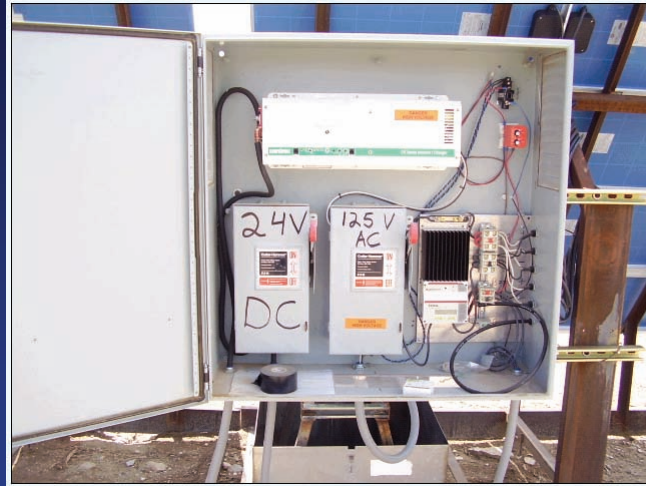
- Currently use heated GW for heat trace at well facilities.
- Fuel gas consumption is 4-13 mcf/d for each diaphragm pump (based on pump curves). Some wellsites have two pumps.
- Target FG savings about 1.2 mmscf/d -- 80% of the 430+ wells @ 8 months/yr run time.



First test

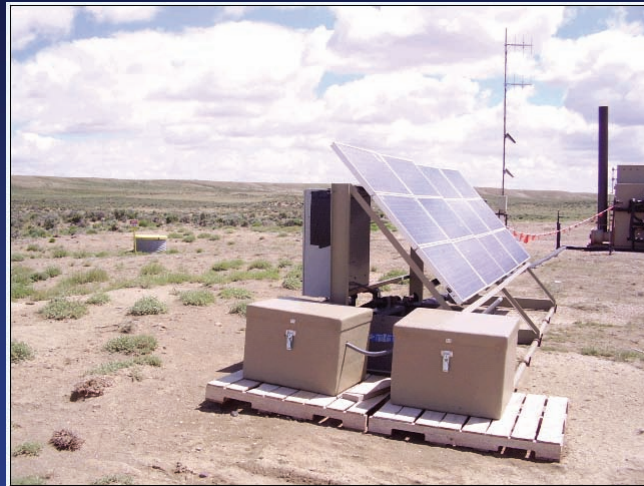
- System composed of solar panel, batteries, 24V to 120 Vac inverter, ½ hp motor and gear pump. Pumping about 3-4 gpm.
- Efficiency is poor taking over 1.2 electrical hp to generate .042 hhp– 3.5% total efficiency.
- Three shut-downs due to low voltage from Dec. 06 through July 07,
- Kept the well from freezing except for a few days during -41F weather in Jan (4gpm)
- Illustrated the need for more efficient pump/motor





Test two

- Using 24 V 1/5 hp brushless DC motor:
 - Eliminates cost of inverter and energy conversion loss
 - No high voltage safety concerns
 - Higher efficiency motor
- On line Feb '07, but several shut down's, reason unknown
- Test run: 0.39 hp to generate .054 hhp, 14% total efficiency, 400% improvement





Final (?) version

- Using 24 V 1/2 hp brushless DC motor, close coupled gear pump:
 - 680 W solar generator
 - 800 A-hr battery
 - 5.5 gpm, 25 psig discharge, 5.5 amps
- 4 month run time, no problems
- Electrical to hydraulic power conversion efficiency >35%, up from 3.4% on the first system.
- Currently concentrating efforts to improve heat transfer,



Backup

