Dewatering Remote Alberta Coal Bed Methane Wells Using Solar Powered Crank Rod Pumps

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Unico® Oil & Gas Division
Background

- Coal Bed Methane (CBM) wells in Alberta
- Well depths vary from 300 to 800 meters
- Low volume dewatering required to hit target gas flow rates
- Well-sites are often remote
- Access is limited by weather conditions
- Electrical service not available
Dewatering CBM Wells by Swabbing

- Wells are dewatered by means of periodic swabbing operations
- Swabbing entails deployment of mobile swabbing rigs to manually pull liquid from the wells
- Water volume during swabbing is roughly 3 barrels per week
Alternative Dewatering Method Sought

- Producer sought a reliable, lower cost, low maintenance alternative to swabbing
Alternative Dewatering Method Sought

- Producer sought a reliable, lower cost, low maintenance alternative to swabbing

One option is solar-powered rod pumping during daylight hours
Evaluate Solar Power

- Analyze historic solar irradiance intensity near Edmonton, Watts/m²
- Determine number of solar panels required to hit liquid production goal based on historic radiance
- Determine effect of daytime-only operation on well flowing pressure and gas flow rate
Investigate Alternatives to Solar Power

- Financial analysis of propane and natural gas (genset operation)
- Lifetime cost of solar power is compellingly low

Financial Analysis Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Code</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Cost Inflation Rate (%)</td>
<td>Ki</td>
<td>3.00%</td>
</tr>
<tr>
<td>Required Discount Rate (%)</td>
<td>Kd</td>
<td>8.00%</td>
</tr>
<tr>
<td>Expected System Life (Years)</td>
<td>Kp</td>
<td>15.0</td>
</tr>
<tr>
<td>Present Value Factor (Years)</td>
<td>Kn</td>
<td>10.5</td>
</tr>
<tr>
<td>Natural Gas Net Present Value</td>
<td>Cgp</td>
<td>$75,958</td>
</tr>
<tr>
<td>Solar Power Net Present Value</td>
<td>Csp</td>
<td>$3,898</td>
</tr>
<tr>
<td>Electric Power Net Present Value</td>
<td>Cep</td>
<td>$12,469</td>
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</table>
Pumping Equipment Selection

- Desktop simulation of pumping system to determine pumping equipment requirements. Assume steel rods:
  - 12 inch pump stroke, 12 SPM
  - 1.25 inch down-hole sucker pump
  - 5/8 or 3/4 inch steel sucker rods (depending upon well depth)
  - Peak liquid production rate ~20 BPD (mid-day)
  - Crank Rod Pump

Predicted Results
## Well Data

<table>
<thead>
<tr>
<th>Field</th>
<th>CBM Near Edmonton, Alberta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump Depths</td>
<td>300 to 800 meters</td>
</tr>
<tr>
<td>Plunger Diameter</td>
<td>1.25 inches</td>
</tr>
<tr>
<td>Rod Diameter</td>
<td>0.625 or 0.75 inches Steel</td>
</tr>
<tr>
<td>Tubing Size</td>
<td>2.375 inches</td>
</tr>
<tr>
<td>Casing Size</td>
<td>4.5 inches</td>
</tr>
<tr>
<td>Tubing Pressure</td>
<td>50 psi</td>
</tr>
<tr>
<td>Casing Pressure</td>
<td>50 psi</td>
</tr>
<tr>
<td>Target Gas Flow</td>
<td>~1,000 – 10,000 m^3/day Range</td>
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<tr>
<td>Target Liquid Flow</td>
<td>1 – 3 BPD With Solar Pump</td>
</tr>
</tbody>
</table>
Surface Pumping Unit

- Small, wellhead mounted CRP® pumping unit
- Crank driven
- 12 inch stroke length
- Direct drive
- Nema 1 enclosure
Example Pumping Unit Installations
Solar Power

- Power is supplied by photo voltaic solar panels
- 5 – 8 dedicated, series connected 170 Watt solar panels per well (exact number of panels depends upon pump depth)
- Daytime operation only
- No battery storage for nighttime operation
- Panel angle is assumed to be fixed for winter operation: approximately latitude +15 degrees
Solar Panel Array
Solar Panel Array
Drive and Controller

- Pumping unit is controlled by inverter drive with Embedded well controls
Controls

- Controller manages solar power and regulates pump speed to maintain pump fill and control pump-off
- Embedded power management controller coupled with mechanical rotary inertia energy storage allow continuous “motoring” power draw from solar panels, maximally utilizing power available from the panels – maximize production with no wasted power
- Solar panels “see” constant power draw rather than cyclic power peaks, thereby greatly reducing the number of solar panels required
Constant Power Draw

- Cyclic power peaks are eliminated in favor of speed modulation with transference of power in/out of rotary inertia
- Hybrid energy storage
Response to Variable Irradiance

- Pump torque is continuously adjusted to maximize power draw (pumping speed) for the given irradiance (brightness), Watts/m²

- As irradiance changes (for example, if a cloud passes over), the pump will rapidly adjust speed, thus continually maximizing production while also preventing the solar panel from “crashing”
Solar Panel Peak Power Point

• MPPT “maximum peak power point tracking” algorithm continuously adjusts operating voltage to maintain maximum power draw as solar panel characteristics change – especially temperature
Remote Telemetry and Data Collection

- Diagnostic Data are collected remotely via cell phone modems
- Data are stored on web-accessible system
- Data include such things as surface & down-hole dynamometer plots, estimated liquid production rate, Well Reports, etc.
- To improve reliability and robustness, all data, including surface and down-hole dynamometer plots, are collected without the use of any external sensors
Results

- Liquid production increased from ~3 barrels/week to ~2 BPD
- Liquid production peaking at approximately 25 BPD (instantaneous) at 13 SPM
- Gas production increased and stabilized
Gas Production of Representative Well

- **Gas Flow, E3m3**
- **Periodic Swabbing**
- **Install Solar Pump**

**Graph Details:**
- **Individual Wells**
- Created: 10/19/2010 7:29:12 AM
- **Facility:** 06/06-33-04
- **Start:** 1/1/2010
- **End:** 10/18/2010

*Graph shows gas production and pressure changes over time.*
Example Daily Parameter Trend

- **Motor Power**: 0.47 hp
- **Solar Current**: 0.22 amps
- **Solar Power**: 52.92 watts
- **Solar Voltage**: 230.09 volts
- **Pump Speed**: 0.00 spm
- **Pump Fill**: 100%
- **Pump Flow**: 0 bpd

**Trend Peaks**:
- **Solar Power (Peak 1100 Watts)**
- **Pumping Speed (Peak 14 SPM)**
- **Pump Fill**
- **Production Rate (Peak 25 BPD)**

- **Sunrise**
- **Sunset**
### 30 Day Parameter Trend

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>High</th>
<th>Low</th>
<th>Avg</th>
<th>Range</th>
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<tbody>
<tr>
<td>Motor Power</td>
<td>hp</td>
<td>0.00</td>
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<td></td>
<td></td>
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<tr>
<td>Solar Current</td>
<td>amps</td>
<td>0.46</td>
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<tr>
<td>Solar Power</td>
<td>watts</td>
<td>36.14</td>
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<tr>
<td>Solar Voltage</td>
<td>volts</td>
<td>78.56</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pump Speed</td>
<td>rpm</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump Fill</td>
<td>%</td>
<td>-1</td>
<td></td>
<td></td>
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</tbody>
</table>

**Peak Parameter:** 14 SPM
90 Day Parameter Trend
1 Year Parameter Trend

Parameter Trends

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>High</th>
<th>Low</th>
<th>Avg</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Power</td>
<td>hp</td>
<td>5.00</td>
<td>-2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Current</td>
<td>amps</td>
<td>5.00</td>
<td>-2.5</td>
<td></td>
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</tr>
<tr>
<td>Solar Power</td>
<td>watts</td>
<td>1,000</td>
<td>250</td>
<td>500</td>
<td>750</td>
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<tr>
<td>Solar Voltage</td>
<td>volts</td>
<td>300</td>
<td>100</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>Pump Speed</td>
<td>spm</td>
<td>200</td>
<td>-10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Pump Fill</td>
<td>%</td>
<td>-1</td>
<td>10</td>
<td>0</td>
<td></td>
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</tbody>
</table>

Feb. 27 - Mar. 2, 2011
90 Day Daily “Gauge” Trend

**Gauge Trends**

- **Gauge Run Time**
  - 05.39 hh.mm
  - high: 08.05
  - low: 00
  - avg: 03.03
  - range: 08.05

- **Gauge Fluid Production**
  - 02 bbl
  - high: 04
  - low: 00
  - avg: 01.02
  - range: 04

- **Gauge Average Fill**
  - 98%
  - high: 99
  - low: 00
  - avg: 80.12
  - range: 99

- **Gauge Average SPM**
  - 08.88 spm
  - high: 12.25
  - low: 00
  - avg: 07.94
  - range: 12.25
Dynamometer Diagnostic Trends

- Down-hole Dynamometer used for pump speed control
- No externally mounted sensors required
Next Generation Pumping Unit
Thank You – Questions?
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