Oil & Gas Industry
Electric Power For
Upstream Operations

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Overview of Presentation

• Background on Oil & Gas Industry
• Upstream Activities
• Power Requirements
• Available Technologies
• Industry Drivers To Go To Electric Power
VIDEO
Fracking History

- 1862: Battle of Fredericksburg
- 1866: Colonel Edward Roberts, Patent 59936 “Torpedo”
- 1868: Nitroglycerin replaced black power in the Torpedo
- 1949: First hydraulic fracturing performed in Duncan Oklahoma
- 1980s: Shale developments started using hydraulic fracturing
Upstream Facilities – Typical 3 Well Wellpad

Note all of the solar panels and battery boxes
Upstream Facilities – 4 Gas Separators

Note all of the electrical devices requiring power
Upstream Facilities – Metering Computers

Note the solar panes and batteries for the wellpad computer systems.
Upstream Facilities – Typical Tank Battery
Upstream Facilities – 12 Well Gas Facility

Note that this facility does not have electrical equipment.
Upstream Facilities – 24 Well Condensate Facility

Note the solar panes, cable tray, and other electrical components
Note that there are no electrical components in this picture.
Average Power Requirements

- Instrumentation
  - 1 well: 35 W
  - 5 wells: 175 W
  - 10 wells: 270 W

- Air Compressor: 330 W

- Chemical Pump: 7 W

- Downhole Pump (10 hp): 7460 W

- Electric Actuator: 2 W
Fuel System For Fuel Cell

- Drip Pot to remove "free" water
- Filter to remove drops of water
- Dryer to remove moisture
Inside The Fuel Cell
## Fuel Cell Costs (Test Unit)

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Cell w/ Stand</td>
<td>$19,820</td>
</tr>
<tr>
<td>Fuel Gas System</td>
<td>$1,977</td>
</tr>
<tr>
<td>Battery System</td>
<td>$822</td>
</tr>
<tr>
<td><strong>Total Installed Cost</strong></td>
<td><strong>$22,797</strong></td>
</tr>
</tbody>
</table>
Fuel Cell Positives

• Initial Operation Has Been Excellent
• Good Remote Tracking By Manufacturer
• Great Help From Manufacturer With Initial Setup
• Very Low Fuel Consumption (137 scfd for 500 W unit)
• Using Fuel Cell As Battery Charger Is The Right Approach To Handle “Startup” Power Spikes
• Can Run 24-hours Per Day
Fuel Cell Negatives

- High Initial Cost
- High Annual Cost
- One Producer Has Approximately 50 Fuel Cells
  - They Are Replacing Fuel Cells When They Have Issues
  - Difficult To Repair
  - Operators Can Not Perform Field Repairs
  - Yearly Maintenance Is High
  - Catalyst Bundle Replacement Is High (12-18 mo)
Thermoelectric Generator (TEG)

- Typically Used For:
  - Low Power Service
  - Remote Locations Where Grid Power Is Not Available
- Low Fuel Emissions (If Run On Natural Gas)
- Zero Fuel Emissions (If Run On Waste Heat Alone)
- Can Be Run:
  - Directly Power Load
  - Battery Charging Mode
Thermoelectric Generator – Typical Installation
Thermoelectric Generator – Exterior Picture
Thermoelectric Generator – Interior Picture
Thermoelectric Generator Positives

• These Units Have Extensive Field Applications In The Oil & Gas Industry:
  – Using Some To Supplement Solar
  – Using Hundreds Of TEGs
• Easy To Maintain/Fix By Field Operators
• Low Initial Cost
• Low Annual Cost
• Can Run 24-hours Per Day
Thermoelectric Generator Negatives

- TEGs Consume A Medium Amount Of Fuel When Powered By Natural Gas (Approximately 10 Times That Of A Comparably Rated Fuel Cell)
Solar Package

• Typically Used For:
  – Low Power Service
  – Remote Locations Where Grid Power Is Not Available

• Zero Hydrocarbon Emissions

• Can Be Run:
  – Battery Charging Mode
Solar Package – ROC
Power Options

- Grid
- Engine Driven Generator (Natural Gas)
- Micro Turbine (Pressure Drop or Natural Gas)
- Fuel Cell (Natural Gas)
- Thermoelectric Generator (Natural Gas)
- Wind Generator
- Solar
Waste Heat Recovery

• Weather
  – Freezing Weather

• Pressure Drop
  – Joule-Thomson Valve
  – Turboexpander

• General Heating
  – Line Heater
  – Heater Treater
Waste Heat Recovery
Burning or Emitting Fossil Fuels

VS

Clean Electric Power
Diesel or Natural Gas Engines

VS

Electric Motors
Questions?