Micro-turbines
Low Volume/Pressure Gas Usage

Gordon Smith
BP
Micro-Turbine

• What is a Micro-turbine?
  – Small, flex-fuel electrical generator capable of providing standalone or “on grid” power
  – Low emissions
  – Air Cooled
  – Minimal servicing
  – Small footprint
  – No liquid lubricants
  – Minimum moving parts

• Micro-turbine Goals
  – “Self-funding” Economics
  – Highly Reliable – “Start and Forget” Operation
  – Waste Gas Fuel - Low Emissions
  – Tolerance to Harsh Conditions
Micro-Turbine Pilot

- 2007 Pilot Installed in US Remote Field (Jonah)

Pilot Results
- Operating 24/7 for over 14 months, 3 days downtime (99%)
- Successful flash/waste gas test = decreased emissions & better economics
- Elimination of site solar panel/battery costs
- Capstone Brand
  - C30 model
  - 96,000 RPM
  - 30kw (20kw @ elevation) generation – Load following
  - Low fuel gas usage (4scfm at full load, 1800btu gas)
  - 360VAC – 520VAC output

Achievements
- Reduced GHG emissions
- Eliminated pneumatic pumps
- Lower operational costs
- Monetize otherwise vent/combusted gas
Jonah Geographic Location
Severe Winter Conditions
Jonah Field Conditions
Micro-turbine Deployment

- Three deployed; One scheduled; Five budgeted (09)
- 2008 Installations
  - Power large production pads w/ a single Micro-turbine
  - 3 sites, 9 production units, 23 wells
  - Lower installation costs through efficiency and experience

<table>
<thead>
<tr>
<th>Economics</th>
<th>3 Unit Pad</th>
<th>3 Pads (3 Units ea.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation Costs (Loaded)</td>
<td>$300,00 (US)</td>
<td>$900,000 (US)</td>
</tr>
<tr>
<td>Net Gas Savings (mm/scf/yr)</td>
<td>18.4</td>
<td>55.3</td>
</tr>
<tr>
<td>Revenue @ $6 Gas</td>
<td>$110,502</td>
<td>$331,506</td>
</tr>
<tr>
<td>Revenue @ $10 Gas</td>
<td>$184,170</td>
<td>$552,511</td>
</tr>
</tbody>
</table>
Micro-Turbine Future

- Future Plans
  - Test VRU/scroll compressor to recover flash gas
  - Utilize air compressor system to eliminate instrument gas
  - Test waste heat recovery to supplement glycol heat bath
  - Standardize micro-turbines on new production pads
  - Continue to reduce installation costs
  - Construct micro-turbine engineering, installation, and operations technology pack – broaden deployment

Vapor Recovery Unit – To reduce/eliminate tank flash emissions
Questions