Key Issues for Small Producers: Agenda

- Determining the appropriate emission reduction technologies
- Economic barriers to implementing technologies and practices
- Biggest opportunities for emissions reductions:
  - Pneumatic devices
  - Dehydrators
  - Compressor Rod Packing
Production in Montana

- In 2007, there were about 7,000 gas production wells producing 115 Bcf of dry gas.

- That same year, about 4 Bcf of gas was estimated to be vented or flared.

- At $5.72\text{ per Mcf}$, that equals about $22$ million of lost revenue due to venting and flaring.

How much revenue are you losing?


Where are your opportunities for emissions reductions?

- Storage Tank Venting: 5 Bcf
- Well Venting and Flaring: 7 Bcf
- Meters and Pipeline Leaks: 8 Bcf
- Compressor Fugitives, Venting, and Exhaust: 12 Bcf
- Dehydrators and Pumps: 12 Bcf
- Other Sources: 7 Bcf
- Pneumatic Devices: 43 Bcf
- Offshore Operations: 29 Bcf


Note: Natural Gas STAR reductions from gathering and boosting operations are reflected in the production sector.
Economic Barriers to Implementation

- Current and future gas prices
- Payback criteria and project feasibility

Additional Barriers to Implementation

- Lack of man-power
- Engaging management
- Lack of information

Pneumatic Devices

Source: EnCana
What is the Problem?

- Pneumatic devices are major source of methane emissions from the natural gas industry

- Pneumatic devices used throughout the natural gas industry
  - Over 630,000 in production sector
  - About 13,000 in processing sector
  - About 83,000 in transmission sector

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Location of Pneumatic Devices at Production Sites

- SOV = Shut-off Valve (Unit Isolation)
- LC = Level Control (Separator, Contactor, Flash Tank Separator, TEG Regenerator)
- TC = Temperature Control (Regenerator Fuel Gas)
- FC = Flow Control (TEG Circulation, Compressor Bypass)
- PC = Pressure Control (FTS Pressure, Compressor Suction/Discharge)
Methane Emissions

- As part of normal operations, pneumatic devices release natural gas to atmosphere
- High-bleed devices bleed in excess of 6 cf/hour
  - Equates to >50 Mcf/year
  - Typical high-bleed pneumatic devices bleed an average of 140 Mcf/year
- Actual bleed rate is largely dependent on device’s design

Pneumatic Device Schematic

- Process Flow
- Regulator
- Regulated Gas Supply
- Weak Signal Bleed (Continuous)
- Strong Signal Vent (Intermittent)
- Weak Pneumatic Signal (3 to 15 psi)
- Strong Pneumatic Signal
- Valve Actuator
- Control Valve

psi = pounds per square inch
How Can Methane Emissions be Recovered?

- **Option 1**: Replace high-bleed devices with low-bleed devices

- **Option 2**: Retrofit controller with bleed reduction kits
  - Field experience shows that up to 80% of all high-bleed devices can be replaced or retrofitted with low-bleed equipment

- **Option 3**: Maintenance aimed at reducing losses

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Economics of Replacement & Retrofitting

<table>
<thead>
<tr>
<th>Implementation¹</th>
<th>Replace at End of Life</th>
<th>Retrofit</th>
<th>Early Replacements</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Level Control⁴</td>
<td>Pressure Control</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>150 – 250²</td>
<td>189</td>
<td>41</td>
</tr>
<tr>
<td>Annual Gas Savings (Mcf)</td>
<td>50 – 200</td>
<td>131</td>
<td>184</td>
</tr>
<tr>
<td>Annual Value of Saved Gas ($)³</td>
<td>350 – 1400</td>
<td>917</td>
<td>1,288</td>
</tr>
<tr>
<td>IRR (%)</td>
<td>138 – 933</td>
<td>&gt;450</td>
<td>&gt;3,100</td>
</tr>
<tr>
<td>Payback (months)</td>
<td>2 – 9</td>
<td>3</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

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1 - All data based on partners’ experiences. See Lessons Learned for more information
2 - Range of incremental costs of low-bleed over high bleed equipment
3 - Gas price is assumed to be $7/Mcf
4 – Large nozzle to small
Dehydrators

- Methane Losses
- Methane Recovery
- Is Methane Recovery Profitable?
- Partner Experience

Glycol Dehydrators Emit?

- Produced gas is saturated with water, which must be removed for gas transmission
- Glycol dehydrators are the most common equipment to remove water from gas
  - 36,000 dehydration units in natural gas production, gathering, and boosting
  - Most use triethylene glycol (TEG)
- Glycol dehydrators create emissions
  - Methane, Volatile Organic Compounds (VOCs), Hazardous Air Pollutants (HAPs) from reboiler vent
  - Methane from pneumatic controllers

Source: GasTech

Source: www.prideofthehill.com
Basic Glycol Dehydrator System Process Diagram

Methane Recovery

- Optimize glycol circulation rates
- Flash tank separator (FTS) installation
- Electric Pumps

Source: Kimray Inc.
Optimizing Glycol Circulation Rate

- Gas pressure and flow at wellhead dehydrators generally declines over time
  - Glycol circulation rates are often set at a maximum circulation rate
- Glycol overcirculation results in more methane emissions without significant reduction in gas moisture content
  - Partners found circulation rates two to three times higher than necessary
  - Methane emissions are directly proportional to circulation
- Lessons Learned study: optimize circulation rates

Installing Flash Tank Separator (FTS)

- Methane that flashes from rich glycol in an energy-exchange pump can be captured using an FTS
- Many small units are not using an FTS

<table>
<thead>
<tr>
<th>MMcf/day processed</th>
<th>With FTS</th>
<th>Without FTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>1-5</td>
<td>90%</td>
<td>10%</td>
</tr>
<tr>
<td>&gt;5</td>
<td>80%</td>
<td>20%</td>
</tr>
</tbody>
</table>

MMcf = Million cubic feet
Source: API
Methane Recovery

- Recovers about 90% of methane emissions
- Reduces VOCs by 10 to 90%
- Must have an outlet for low pressure gas
  - Fuel
  - Compressor suction
  - Vapor recovery unit

Flash Tank Costs

- Lessons Learned study provides guidelines for scoping costs, savings and economics
- Capital and installation costs:
  - Capital costs range from $3,300 to $6,700 per flash tank
  - Installation costs range from $1,200 to $3,000 per flash tank
- Negligible Operational & Maintenance (O&M) costs
Electric Pump Eliminates Motive Gas

- **Glycol Contactor**
  - **Inlet Wet Gas**
  - **Gas Driver**
  - **Electric Motor Driven Pump**
  - **Lean TEG**
  - **Glycol Reboiler/Regenerator**
  - **Rich TEG**
  - **Dry Sales Gas**
  - **Water/Methane/VOCs/HAPs To Atmosphere**
  - **Fuel Gas**

Overall Benefits

- Financial return on investment through gas savings
- Increased operational efficiency
- Reduced O&M costs (fuel gas, glycol make-up)
- Reduced compliance costs (HAPs, BTEX)
- Similar footprint as gas assist pump
Is Recovery Profitable?

Three Options for Minimizing Glycol Dehydrator Emissions

<table>
<thead>
<tr>
<th>Option</th>
<th>Capital Costs</th>
<th>Annual O&amp;M Costs</th>
<th>Emissions Savings</th>
<th>Payback Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize Circulation Rate</td>
<td>Negligible</td>
<td>Negligible</td>
<td>394 to 39,420 Mcf/year</td>
<td>Immediate</td>
</tr>
<tr>
<td>Install Flash Tank</td>
<td>$6,500 to $18,800</td>
<td>Negligible</td>
<td>1,191 to 10,643 Mcf/year</td>
<td>4 to 11 months</td>
</tr>
<tr>
<td>Install Electric Pump</td>
<td>$1,400 to $13,000</td>
<td>$165 to $6,500</td>
<td>360 to 36,000 Mcf/year</td>
<td>&lt; 1 month to several years</td>
</tr>
</tbody>
</table>

1 – Gas price of $7/Mcf

Partner Experience (Shell)

✓ Installed flash tank separators on 106 dehydrators over 8 years

✓ Project cost = $15,000- $30,000 per FTS

✓ Annual Emissions reductions = 216 MMcf

✓ Annual Value Savings: $3.00/Mcf x 216 MMcf = $648,000

✓ 3 year pay-back period
Reciprocating Compressors

- Methane Losses from Rod Packing
- Implementing Proper Seals
- Rod Packing Replacement Economics
- Low Emission Packing

Methane Losses from Reciprocating Compressors

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cubic feet per hour (cf/hour) in large compressors at processing plants or gathering and booster stations
  - Worn packing has been reported to leak up to 15 times more gas than a newly installed packing
Reciprocating Compressor Rod Packing

- A series of flexible rings fit around the shaft to prevent leakage.
- Leakage may still occur through nose gasket, between packing cups, around the rings, and between rings and shaft.

\[\text{Leakage from Idle/Pressurized Compressors} \]

<table>
<thead>
<tr>
<th>Packing Type</th>
<th>Bronze</th>
<th>Bronze/Steel</th>
<th>Bronze/Teflon</th>
<th>Teflon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak Rate (cf/hour)</td>
<td>70</td>
<td>63</td>
<td>150</td>
<td>24</td>
</tr>
</tbody>
</table>

\[\text{Leakage from Running Compressors} \]

<table>
<thead>
<tr>
<th>Packing Type</th>
<th>Bronze</th>
<th>Bronze/Steel</th>
<th>Bronze/Teflon</th>
<th>Teflon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak Rate (cf/hour)</td>
<td>99</td>
<td>63</td>
<td>150</td>
<td>24</td>
</tr>
</tbody>
</table>

Methane Losses from Rod Packing

- Emission from Running Compressor: 99 cf/hour-packing
- Emission from Idle/Pressurized Compressor: 145 cf/hour-packing
- Leakage from Idle Compressor Packing Cup: 79 cf/hour-packing
- Leakage from Idle Compressor Distance Piece: 34 cf/hour-packing

Table: Leakage from Rod Packing at Natural Gas Transmission Compressor Stations

- PRCI/ GRI/ EPA Cost Effective Leak Mitigation at Natural Gas Transmission Compressor Stations
Steps to Determine Economic Replacement

- Measure rod packing leakage
  - When new packing installed – after worn-in
  - Periodically afterwards
- Determine cost of packing replacement
- Calculate economic leak reduction
- Replace packing when leak reduction expected will pay back cost

Cost of Rod Packing Replacement

- Assess costs of replacements
  - A set of rings: $675 to $1,080
    (with cups and case) $2,025 to $3,375
  - Rods: $2,430 to $13,500
    Special coatings such as ceramic, tungsten carbide, or chromium can increase rod costs

Source: CECO
Calculate Economic Leak Reduction

- Determine economic replacement threshold
  - Partners can determine economic threshold for all replacements
  - This is a capital recovery economic calculation

Economic Replacement Threshold (cf/hour) = \( \frac{CR \times DF \times 1,000}{(H \times GP)} \)

Where:
- \( CR = \) Cost of replacement ($)
- \( DF = \) Discount factor at interest \( i \)
- \( H = \) Hours of compressor operation per year
- \( GP = \) Gas price ($/thousand cubic feet)

Example: Payback calculations for new rings and rod replacement

CR = $1,620 for rings + $9,450 for rod
= $11,070
H = 8,000 hours per year
GP = $7/Mcf

DF @ \( i = 10\% \) and \( n = 1 \) year
\( DF = \frac{0.1(1+0.1)^1}{(1+0.1)^1 - 1} = \frac{0.1(1.1)}{1.1 - 1} = \frac{0.11}{0.1} = 1.1 \)

DF @ \( i = 10\% \) and \( n = 2 \) years
\( DF = \frac{0.1(1+0.1)^2}{(1+0.1)^2 - 1} = \frac{0.1(1.21)}{1.21 - 1} = \frac{0.121}{0.21} = 0.576 \)

One year payback
\[ ER = \frac{11,070 \times 1.1 \times 1,000}{8,000 \times 7} = 217 \text{ scf per hour} \]
Is Rod Packing Replacement Profitable?

- Replace packing when leak reduction expected will pay back cost
- “leak reduction expected” is the difference between current leak rate and leak rate with new rings

<table>
<thead>
<tr>
<th></th>
<th>Rings Only</th>
<th>Rod and Rings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rings:</td>
<td>$1,620</td>
<td>Rings: $1,620</td>
</tr>
<tr>
<td>Rod:</td>
<td>$0</td>
<td>Rod: $9,450</td>
</tr>
<tr>
<td>Gas:</td>
<td>$7/Mcf</td>
<td>Gas: $7/Mcf</td>
</tr>
<tr>
<td>Operating:</td>
<td>8,000 hours/year</td>
<td>Operating: 8,000 hours/year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Leak Reduction Expected (cf/hour)</th>
<th>Payback (months)</th>
<th>Payback (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>32</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>22</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>17</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

Based on 10% interest rate

Industry Experience – Occidental

- Occidental upgraded compressor rod packing at its Elk Hills facility in southern California
- Savings 145 MMcf/yr
- Payback in under 3 years
Discussion Questions

- What industry experiences do you have applying these technologies and practices?
- What are your limitations on applying these technologies and practices?
- Actual costs and benefits