Producer and Processor Partner Reported Opportunities

Lessons Learned from Natural Gas STAR

Producers and Processors Technology Transfer Workshop

Western Gas Resources and EPA’s Natural Gas STAR Program
Gillette and Rock Springs, WY
May 9 & 11, 2006
Producer and Processor Partner Reported Opportunities: Agenda

- Production Sector Emissions
- Processing Sector Emissions
- Top Partner Reported Opportunities (PROs)
- Gas Prices and Methane Savings
- Other Opportunities
- Discussion Questions
Methane Losses from the Natural Gas Industry

- Production: 148 Bcf
- Transmission & Storage: 101 Bcf
- Distribution: 68 Bcf
- Processing: 36 Bcf
- Oil Downstream: 2 Bcf

- Emissions
- Reductions
Production Sector Emissions

The production sector has several large methane emission sources that can be targeted for reductions:

- Storage Tank Venting: 9 Bcf
- Meters and Pipeline Leaks: 10 Bcf
- Gas Engine Exhaust: 12 Bcf
- Dehydrators and Pumps: 17 Bcf
- Well Venting and Flaring: 18 Bcf
- Pneumatic Devices: 61 Bcf
- Other Sources: 21 Bcf

Methane Savings: Vapor Recovery

- Vapor recovery can capture up to 95% of hydrocarbon vapors from tanks.
- Recovered vapors have higher heat content than pipeline quality natural gas.
- Recovered vapors are more valuable than natural gas and have multiple uses:
  - Re-inject into sales pipeline
  - Use as on-site fuel
  - Send to processing plants for recovering valuable natural gas liquids
Types of Vapor Recovery Units

- Conventional vapor recovery units (VRUs)
  - Use rotary compressor to suck vapors out of atmospheric pressure storage tanks
  - Require electrical power or engine driver
- Venturi ejector vapor recovery units (EVRU™) or Vapor Jet
  - Use Venturi jet ejectors in place of rotary compressors
  - Contain no moving parts
  - EVRU™ requires source of high pressure gas and intermediate pressure system
  - Vapor Jet requires high pressure water motive
Conventional Vapor Recovery Unit

Source: Evans & Nelson (1968)
Venturi Jet Ejector*

- Pressure Indicator
- Temperature Indicator
- Flow Safety Valve
- High-Pressure Motive Gas (~850 psig)
- Low-Pressure Vent Gas from Tanks (0.10 to 0.30 psig)
- Discharge Gas (~40 psia)
- Suction Pressure (-0.05 to 0 psig)

*EVRU™ Patented by COMM Engineering
Adapted from SRI/USEPA-GHG-VR-19
psig = pound per square inch, gauge
psia = pounds per square inch, atmospheric
Vapor Recovery with Ejector

- **Gas to Sales**: 6,200 Mcf/day
- **Net Recovery**: 281 Mcf/day
- **Gas**: 5,000 Mcf/day
- **Fuel**: (19 Mcf/day incremental)
- **LP Separator**: 900 Mcf/day
- **Compressor**: 40 psig
- **Ejector**: 300 Mcf/day
- **Oil & Gas Well**: 5,000 barrels/day
- **Crude Oil Stock Tank**: 900 Mcf/day
- **Oil to Sales**: @ 1000 psig

**Ratio Motive / Vent = 3**

= 900/300
Vapor Jet System*

*Patented by Hy-Bon Engineering
Vapor Jet System*

- Utilizes produced water in closed loop system to effect gas gathering from tanks
- Small centrifugal pump forces water into Venturi jet, creating vacuum effect
- Limited to gas volumes of 77 Mcf / day and discharge pressure of 40 psig

*Patented by Hy-Bon Engineering
Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
  - Crude oil stock tank
  - Flash tank, heater/treater, water skimmer vents
  - Gas pneumatic controllers and pumps
- Outlet for recovered gas
  - Access to low pressure gas pipeline, compressor suction, or on-site fuel system
- Tank batteries not subject to air regulations
Quantify Volume of Losses

- Estimate losses from chart based on oil characteristics, pressure, and temperature at each location (± 50%)
- Estimate emissions using the E&P Tank Model (± 20%)
- Measure losses using recording manometer and well tester or ultrasonic meter over several cycles (± 5%)
  - This is the best approach for facility design
Estimated Volume of Tank Vapors

Vapor Vented from Tanks, cubic foot / barrel

Gas/Oil Ratio

Pressure of Vessel Dumping to Tank (Psig)

API Gravities

40° API and Over

30° API to 39° API

Under 30° API

°API = API gravity
What is the Recovered Gas Worth?

- Value depends on heat content of gas
- Value depends on how gas is used
  - On-site fuel
    - Valued in terms of fuel that is replaced
  - Natural gas pipeline
    - Measured by the higher price for rich (higher heat content) gas
  - Gas processing plant
    - Measured by value of natural gas liquids and methane, which can be separated
## Value of Natural Gas Liquids

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Btu/gallon</td>
<td>MMBtu/gallon</td>
<td>$/gallon</td>
<td>$/MMBtu $=3/2</td>
</tr>
<tr>
<td>Methane</td>
<td>59,755</td>
<td>0.06</td>
<td>0.43</td>
<td>7.15</td>
</tr>
<tr>
<td>Ethane</td>
<td>74,010</td>
<td>0.07</td>
<td>0.64</td>
<td>9.14</td>
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<tr>
<td>Propane</td>
<td>91,740</td>
<td>0.09</td>
<td>0.98</td>
<td>10.89</td>
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<tr>
<td>n Butane</td>
<td>103,787</td>
<td>0.10</td>
<td>1.32</td>
<td>13.20</td>
</tr>
<tr>
<td>iso Butane</td>
<td>100,176</td>
<td>0.10</td>
<td>1.42</td>
<td>14.20</td>
</tr>
<tr>
<td>Pentanes+</td>
<td>105,000</td>
<td>0.11</td>
<td>1.50</td>
<td>13.63</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Btu/cf</td>
<td>MMBtu/Mcf</td>
<td>$/Mcf</td>
<td>$/MMBtu</td>
<td>Vapor Composition</td>
<td>Mixture Value ($/Mcf) $=8*10</td>
<td></td>
</tr>
<tr>
<td>Methane</td>
<td>1,012</td>
<td>1.01</td>
<td>$ 7.22</td>
<td>7.15</td>
<td>82%</td>
<td>0.83</td>
<td>$ 5.93</td>
</tr>
<tr>
<td>Ethane</td>
<td>1,773</td>
<td>1.77</td>
<td>$ 16.18</td>
<td>9.14</td>
<td>8%</td>
<td>0.14</td>
<td>$ 1.28</td>
</tr>
<tr>
<td>Propane</td>
<td>2,524</td>
<td>2.52</td>
<td>$ 27.44</td>
<td>10.89</td>
<td>4%</td>
<td>0.10</td>
<td>$ 1.09</td>
</tr>
<tr>
<td>n Butane</td>
<td>3,271</td>
<td>3.27</td>
<td>$ 43.16</td>
<td>13.20</td>
<td>3%</td>
<td>0.10</td>
<td>$ 1.32</td>
</tr>
<tr>
<td>iso Butane</td>
<td>3,261</td>
<td>3.26</td>
<td>$ 46.29</td>
<td>14.20</td>
<td>1%</td>
<td>0.03</td>
<td>$ 0.43</td>
</tr>
<tr>
<td>Pentanes+</td>
<td>4,380</td>
<td>4.38</td>
<td>$ 59.70</td>
<td>13.63</td>
<td>2%</td>
<td>0.09</td>
<td>$ 1.32</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,289</td>
<td>$11.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1  Natural Gas Price assumed at $7.15/MMBtu as on Mar 16, 2006 at Henry Hub
2  Prices of Individual NGL components are from Platts Oilgram for Mont Belvieu, TX, January 11,2006
3  Other natural gas liquids information obtained from Oil and Gas Journal, Refining Report, March 19, 2001, p-83

Btu = British Thermal Units, MMBtu = Million British Thermal Units
# Is Recovery Profitable?

## Financial Analysis for a conventional VRU Project

<table>
<thead>
<tr>
<th>Peak Capacity (Mcf / day)</th>
<th>Installation &amp; Capital Costs(^1) ($ / year)</th>
<th>O &amp; M Costs ($ / year)</th>
<th>Value of Gas(^2) ($ / year)</th>
<th>Annual Savings ($ / year)</th>
<th>Simple Payback (months)</th>
<th>Return on Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>26,470</td>
<td>5,250</td>
<td>51,465</td>
<td>46,215</td>
<td>7</td>
<td>175%</td>
</tr>
<tr>
<td>50</td>
<td>34,125</td>
<td>6,000</td>
<td>102,930</td>
<td>96,930</td>
<td>5</td>
<td>284%</td>
</tr>
<tr>
<td>100</td>
<td>41,125</td>
<td>7,200</td>
<td>205,860</td>
<td>198,660</td>
<td>3</td>
<td>483%</td>
</tr>
<tr>
<td>200</td>
<td>55,125</td>
<td>8,400</td>
<td>411,720</td>
<td>403,320</td>
<td>2</td>
<td>732%</td>
</tr>
<tr>
<td>500</td>
<td>77,000</td>
<td>12,000</td>
<td>1,029,300</td>
<td>1,017,300</td>
<td>1</td>
<td>1321%</td>
</tr>
</tbody>
</table>

\(^1\) Unit Cost plus estimated installation at 75% of unit cost

\(^2\) $11.28 \times 1/2 \text{ capacity} \times 365, \text{ Assumed price includes Btu enriched gas} (1.289 \text{ MMBtu/Mcf})
Vapor Recovery Installations

8 Units capturing ~ 2MMSCFD
Vapor Recovery Installations
Processing Sector Emissions

The processing sector emits less methane, but still has several large emission sources:

- Reciprocating Compressors: 17 Bcf
- Gas Engine Exhaust: 7 Bcf
- Centrifugal Compressors: 6 Bcf
- Blowdowns: 2 Bcf
- Plant Fugitives: 2 Bcf
- Dehydrators and Pumps: 1 Bcf
- Other Sources: 1 Bcf

Highly Implemented PROs

- The Gas STAR program has identified 42 production sector PROs and 29 processing sector PROs.
- Ten “top” PROs from each sector: PROs most reported by Gas STAR partners in production and processing sectors, all target major emissions sources, responsible for over 65% of all emission reductions in the production and processing sectors.
## Production and Processing Top PROs

<table>
<thead>
<tr>
<th>Top PROs</th>
<th>Sector</th>
<th>Payback</th>
<th>Methane Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install flares</td>
<td>Production: x, Processing: x</td>
<td>None</td>
<td>2,000 Mcf/yr</td>
</tr>
<tr>
<td>Install vapor recovery units</td>
<td></td>
<td>1-3 yr</td>
<td>4,900 Mcf/yr</td>
</tr>
<tr>
<td>Install plunger lifts</td>
<td></td>
<td>&lt;1 yr</td>
<td>4,700 Mcf/yr</td>
</tr>
<tr>
<td>Install instrument air systems</td>
<td></td>
<td>&lt;1 yr</td>
<td>20,000 Mcf/yr</td>
</tr>
<tr>
<td>Eliminate unnecessary equipment and/or systems</td>
<td></td>
<td>&lt;1 yr</td>
<td>2,000 Mcf/yr</td>
</tr>
<tr>
<td>Perform green completions</td>
<td></td>
<td>1-3 yr</td>
<td>7,000 Mcf/yr</td>
</tr>
<tr>
<td>Conduct leak surveys</td>
<td></td>
<td>1-3 yr</td>
<td>4,000 Mcf/yr</td>
</tr>
<tr>
<td>Install electric compressors</td>
<td></td>
<td>&gt;10 yr</td>
<td>6,440 Mcf/yr</td>
</tr>
<tr>
<td>Consolidate crude oil production and water storage tanks</td>
<td></td>
<td>1-3 yr</td>
<td>4,200 Mcf/yr</td>
</tr>
<tr>
<td>Alter blowdown piping</td>
<td></td>
<td>1-3 yr</td>
<td>1,000 Mcf/yr</td>
</tr>
<tr>
<td>Use hot taps for in-service pipeline connections</td>
<td></td>
<td>1-3 yr</td>
<td>24,400 Mcf/yr</td>
</tr>
<tr>
<td>Redesign blowdown systems and alter ESD practices</td>
<td></td>
<td>1-3 yr</td>
<td>2,000 Mcf/yr</td>
</tr>
<tr>
<td>Rerouting of glycol skimmer gas</td>
<td></td>
<td>&lt;1 yr</td>
<td>7,600 Mcf/yr</td>
</tr>
<tr>
<td>Shut down compressors</td>
<td></td>
<td>&lt;1 yr</td>
<td>5,000 Mcf/yr</td>
</tr>
<tr>
<td>Replace gas starters with air</td>
<td></td>
<td>&lt;1 yr</td>
<td>1,300 Mcf/yr</td>
</tr>
<tr>
<td>Replace glycol dehydration units with methanol injection</td>
<td></td>
<td>&lt;1 yr</td>
<td>800 Mcf/yr</td>
</tr>
</tbody>
</table>

1 – based on $3/Mcf gas price
Implementation of Top PROs

- These PROs have been proven to reduce emissions economically
- Top PROs target the largest sources of methane emissions in the production sector
- Room for a great deal of further emissions reductions
Emissions Targeted by Top PROs

- BMPs and top PROs target over 75% of production and processing sector emissions

- This means:
  - Partners that report PROs recognize major sources of methane losses and are taking steps to mitigate emissions
  - Partners not practicing all BMPs and top PROs may have further opportunities for methane savings
Gas Prices and Methane Savings

- Economics of implementing new PROs change with gas price
- PRO fact sheets use nominal gas price of $3/Mcf
- Many PROs were reported when gas price <$2

Natural Gas Wellhead Price to 2025

## Other Opportunities

The Gas STAR Program has the following PRO Fact Sheets available

<table>
<thead>
<tr>
<th>Production</th>
<th>Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Compressor</td>
<td>9 Compressor</td>
</tr>
<tr>
<td>6 Dehydrator</td>
<td>5 Dehydrator</td>
</tr>
<tr>
<td>2 Pneumatics/Controls</td>
<td>2 Pneumatics/Controls</td>
</tr>
<tr>
<td>3 Pipelines</td>
<td>2 Pipelines</td>
</tr>
<tr>
<td>5 Tanks</td>
<td>3 Tanks</td>
</tr>
<tr>
<td>6 Valves</td>
<td>6 Valves</td>
</tr>
<tr>
<td>9 Wells</td>
<td>2 Other</td>
</tr>
<tr>
<td>3 Other</td>
<td></td>
</tr>
</tbody>
</table>
## Other PROs with High Potential Savings

<table>
<thead>
<tr>
<th>PRO</th>
<th>Sector</th>
<th>Payback</th>
<th>Methane Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production</td>
<td>Processing</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Rejection Unit Optimization</td>
<td></td>
<td>x</td>
<td>&lt;1 yr</td>
</tr>
<tr>
<td>Install Compressor to Capture Casinghead Gas</td>
<td>x</td>
<td></td>
<td>&lt;1 yr</td>
</tr>
<tr>
<td>Zero Emissions Dehydrators</td>
<td>x</td>
<td>x</td>
<td>&lt;1 yr</td>
</tr>
<tr>
<td>Connect Casing to Vapor Recovery Unit</td>
<td>x</td>
<td></td>
<td>&lt;1 yr</td>
</tr>
<tr>
<td>Inspect &amp; Repair Compressor Station Blowdown Valves</td>
<td>x</td>
<td>x</td>
<td>&lt;1 yr</td>
</tr>
<tr>
<td>Use Ultrasound to Identify Leaks</td>
<td>x</td>
<td>x</td>
<td>&lt;1 yr</td>
</tr>
</tbody>
</table>

1 – based on $3/Mcf gas price

ળ Partners implementing all top PROs have further opportunities for emissions reductions

비용 높은 초기 비용을 지불할 수 있습니다.

 Ł These PROs reduce emissions and with higher gas prices pay back more quickly

비용 높은 초기 비용을 지불할 수 있습니다.
Discussion Questions

- Do you find any of the top PROs to be economically unattractive?
- How do you take into account the price of gas when examining which PROs to implement?
- What are some of the other issues that are preventing you from implementing these practices?