Opportunities for Methane Emissions Reductions in Natural Gas Production

Technology Transfer Workshop
PEMEX & Environmental Protection Agency, USA
April 25, 2006
Villahermosa, Mexico

Agenda

- Reduced Emissions Completions
  - Methane Losses
  - Methane Recovery
  - Is Recovery Profitable?
  - Industry Experience
  - Discussion Questions
- Smart Automation Well Venting
  - Methane Losses
  - Methane Recovery
  - Is Recovery Profitable?
  - Industry Experience
  - Discussion Questions
- Project Summaries for Mexico
Mexico Production Sector
Methane Emissions (2000)

Total Production Emissions: 27.8 Bcf

- Storage Tank Venting: 1.7 Bcf
- Meters and Pipeline Leaks: 2.0 Bcf
- Gas Engine Exhaust: 2.3 Bcf
- Dehydrators & Pumps: 3.1 Bcf
- Well Venting and Flaring: 3.3 Bcf
- Pneumatic Devices: 11.5 Bcf
- Other Sources: 4.0 Bcf

Sources: US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively, Oil and Gas Journal, July 12, 2004
Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004
Bcf = billion cubic feet

Methane Losses During Well Completions

- It is necessary to clean out the well bore and formation surrounding perforations
  - After new well completion
    - Completion: installation of permanent wellhead equipment for production of oil and natural gas
  - After well workovers
    - Workover (or cleanup): operations to restore or increase well production
- Operators produce the well to an open pit or tankage to collect sand, cuttings, and reservoir fluids for disposal
- Vent or flare the natural gas produced
  - Venting may lead to dangerous gas buildup
  - Flaring is preferred where there is no fire hazard or nuisance
Wellhead Gas Prices

- Gas prices in Mexico have increased in recent years to over $6 per thousand cubic feet ($6/Mcf)

![Graph of natural gas prices from 1997 to 2003](http://www.eia.doe.gov/emeu/international/gasprice.html)

Source: EIA "Natural Gas Price for Industry" available at http://www.eia.doe.gov/emeu/international/gasprice.html

Methane Recovery: Reduced Emissions Completions (REC)

- REC or Green Completions recover natural gas and condensate produced during well completions or workovers
- Use portable equipment to process gas and condensate suitable for sales
- Send recovered gas through permanent dehydrator and meter to sales line, reducing venting and flaring
- An estimated 25.2 Bcf or $176 million of natural gas can be recovered annually using Green Completions in U.S.
  - 25,000 MMcf from high pressure wells
  - 181 MMcf from low pressure wells
  - 27 MMcf from workovers

MMcf = million cubic feet
Green Completions: Equipment

- Truck- or trailer-mounted equipment to capture produced gas during cleanup
  - Sand trap
  - Three-phase separator
- Use portable desiccant dehydrator for workovers requiring glycol dehydrator maintenance

![Diagram of gas flow](image)

Temporary, Mobile Surface Facilities Schematic
Source: BP

Green Completions: Requirements

- Must have permanent equipment on site before workover or cleanup
  - Piping connection to sales line
  - Dehydrator
  - Lease meter
  - Stock tank
- Sales line gas can be used for fuel and/or for gas lift operations and techniques in low pressure wells
Green Completions: Low Pressure Wells

- Can use portable compressors to start up well when reservoir pressure is low
  - Artificial gas lift to clear fluids
  - Boost gas to sales line
- Higher cost to amortize investment in portable equipment

Is Recovery Profitable?

- U.S. companies report recovering an average of 53% of total gas lost during well completions and workovers
- Estimate an average of 3,000 Mcf\(^1\) of natural gas can be recovered from each green completion
- Estimate 1 to 580 barrels of condensate can be recovered from each green completion

\(^1\)Values for high pressure wells
Green Completions: Benefits

- Reduced methane emissions during completions and workovers
- Sales revenue from recovered gas and condensate
- Improved relations with government agencies and public neighbors
- Improved safety
- Reduced disposal costs

Industry Experience: BP in U.S.

- Capital investment about $1.4 million on portable three-phase separators, sand traps, and tanks
- Used Green Completions on 106 wells
- Total natural gas recovered: about 350 MMcf per year
- Total condensate recovered: about 6,700 barrels per year
Industry Experience: BP in U.S.

- Total value of natural gas and condensate recovered: about $840,000\textsuperscript{1,2} per year
- Investment recovered in just over 2 years

\textsuperscript{1}Value of natural gas at $1.99 per thousand cubic feet
\textsuperscript{2}Value of condensate at $22 per barrel

Weatherford Durango Experience

- Successfully completed pilot project in the Fruitland coal formations in Durango, Colorado, U.S.
  - Well depth: 2,700 to 3,200 feet
  - Pore pressure: estimated at 80 pounds per square inch gauge (psig)
  - Well type: coal bed methane
  - Hole size: 5 ½ inches
  - Number of wells: 3 well pilots
- Captured 2 million cubic feet of gas which was sold by the operator
Weatherford Portable Equipment

Weatherford Green Completions

- Use pipeline gas with proprietary foaming agent as compressible fluid to initiate cleanout
- System includes
  - Wet screw compressor when well pressure is less than 80 pounds per square inch gauge (psig)
  - Booster compressor, three-phase separator and sand trap
- Estimate cleanup pressure of 300 to 400 psig at a well depth of 8,000 feet
- Suggest use in all kinds of completion and workover cleanup operations
Discussion Questions

- To what extent are you implementing this opportunity?
- Can you suggest other approaches for reducing well completion venting?
- How could this opportunity be improved upon or altered for use in your operation?
- What are the barriers (technological, economic, lack of information, regulatory, focus, manpower, etc.) that are preventing you from implementing this practice?

Methane Losses: Well Blowdowns

- Accumulation of liquid hydrocarbons or water in the well bores reduces, and can halt, production
- Common “blow down” practices to temporarily restore production can vent 80 to 1,600 Mcf per year\(^1\) to the atmosphere per well

\(^1\)Mobil Big Piney Case Study 1997
What is the Problem?

- Conventional plunger lift systems use gas pressure buildups to repeatedly lift columns of fluid out of well
- Fixed timer cycles may not match reservoir performance
  - Cycle too frequently (high plunger velocity)
    - Plunger not fully loaded
  - Cycle too late (low plunger velocity)
    - Shut-in pressure cannot lift fluid to top
    - May have to vent to atmosphere to lift plunger

Source: Weatherford

Conventional Plunger Lift Operations

- Manual, on-site adjustments tune plunger cycle time to well’s parameters
  - Not performed regularly
  - Do not account for gathering line pressure fluctuations, declining well performance, plunger wear
- Requires manual venting to atmosphere when plunger lift is overloaded
Smart Automation Well Venting

- Automation can enhance the performance of plunger lifts by monitoring wellhead parameters such as:
  - Tubing and casing pressure
  - Flow rate
  - Plunger travel time
- Using this information, the system is able to optimize plunger operations
  - To minimize well venting to atmosphere
  - Recover more gas
  - Further reduce methane emissions

Methane Recovery: How Smart Automation Reduces Methane Emissions

- Smart automation continuously varies plunger cycles to match key reservoir performance indicators
  - Well flow rate
    - Measuring pressure
  - Successful plunger cycle
    - Measuring plunger travel time
- Plunger lift automation allows producer to vent well to atmosphere less frequently
Automated Controllers

- Low-voltage; solar recharged battery power
- Monitor well parameters
- Adjust plunger cycling

Remote well management
- Continuous data logging
- Remote data transmission
- Receive remote instructions
- Monitor other equipment

Plunger Lift Cycle
Methane Savings

- Methane emissions savings is a secondary benefit
  - Optimized plunger cycling to remove liquids increases well production by 10 to 20%\(^1\)
  - Additional 10%\(^1\) production increase from avoided venting
- 500 Mcf per year methane emissions savings for average U.S. well

\(^1\)Reported by Weatherford

Other Benefits

- Reduced manpower cost per well
- Continuously optimized production conditions
- Remotely identify potentially unsafe operating conditions
- Monitor and log other well site equipment
  - Glycol dehydrator
  - Compressor
  - Stock tank
  - Vapor recovery unit
Is Recovery Profitable?

- Smart automation controller installed cost: about $11,000
  - Conventional plunger lift timer: about $5,000
- Personnel savings: double productivity
- Production increases: 10% to 20% increased production

Savings =

\[(\text{Mcf per year}) \times (10\% \text{ increased production}) \times (\text{gas price}) + (\text{Mcf per year}) \times (1\% \text{ emissions savings}) \times (\text{gas price}) + (\text{personnel hours per year}) \times (0.5) \times (\text{labor rate})\]

$ \text{savings per year}$

Economic Analysis

- Non-discounted savings for average U.S. well =

\[(50,000 \text{ Mcf per year}) \times (10\% \text{ increased production}) \times ($7 \text{ per Mcf}) + (50,000 \text{ Mcf per year}) \times (1\% \text{ emissions savings}) \times ($7 \text{ per Mcf}) + (500 \text{ personnel hours per year}) \times (0.5) \times ($30 \text{ per hour}) - ($11,000) \text{ cost}\]

$35,000 \text{ savings in first year}$

3 month simple payback
U.S. Industry Experience

- BP reported installing plunger lifts with automated control systems on about 2,200 wells
  - 900 Mcf reported annual savings per well
  - $12 million costs including equipment and labor
  - $6 million total annual savings

- Another company shut in mountaintop wells inaccessible during winter
  - Installed automated controls allowed continuous production throughout the year


Project Summary for Mexico

- Reduced Emissions Completions

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Description</td>
<td>Performing a reduced emissions completion on one high pressure well</td>
</tr>
<tr>
<td>Methane Saved</td>
<td>3.3 MMcf per year per well</td>
</tr>
<tr>
<td></td>
<td>(93.5 thousand cubic meters per well)</td>
</tr>
<tr>
<td>Sales Value</td>
<td>$17,300 ($5.25 per Mcf gas)</td>
</tr>
<tr>
<td>Capital and Installation Cost¹</td>
<td>($770) per well per day (rental cost)</td>
</tr>
<tr>
<td>Operating and Maintenance Cost</td>
<td>$10 per well per day</td>
</tr>
<tr>
<td>Payback Period</td>
<td>17 months</td>
</tr>
<tr>
<td>Additional Carbon Market Value</td>
<td>$40,000 ($30 per tonne of CO₂e)</td>
</tr>
</tbody>
</table>

¹One well is completed in about 30 days
**Project Summary for Mexico**

- **Smart Automation Well Venting**

<table>
<thead>
<tr>
<th>Project Description: Install one smart automated well controller on a well to increase production rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Methane Saved:</strong> 500 Mcf per year (14 thousand cubic meters per year)</td>
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<tr>
<td><strong>Sales Value:</strong> $2,600 ($5.25 per Mcf gas)</td>
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<tr>
<td><strong>Capital and Installation Cost:</strong> ($11,000)</td>
</tr>
<tr>
<td><strong>Operating and Maintenance Cost:</strong> ($1,950) per well</td>
</tr>
<tr>
<td><strong>Payback Period:</strong> 60 months</td>
</tr>
<tr>
<td><strong>Additional Carbon Market Value:</strong> $6,000 ($30 per tonne of CO₂e)</td>
</tr>
</tbody>
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**Discussion Questions**

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Reference: Unit Conversions

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Equivalent</th>
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<tbody>
<tr>
<td>1 cubic foot = 0.02832 cubic meters</td>
<td></td>
</tr>
<tr>
<td>Degrees Fahrenheit = (°F – 32) * 5/9 degrees Celsius</td>
<td></td>
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<tr>
<td>1 inch = 2.54 centimeters</td>
<td></td>
</tr>
<tr>
<td>1 mile = 1.6 kilometers</td>
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</tr>
<tr>
<td>14.7 pounds per square foot = 1 atmosphere</td>
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