Opportunities for Methane Emissions Reductions in Natural Gas Production

Ministerio de Minas y Energía
Ministerio de Ambiente, Vivienda y Desarrollo Territorial
Occidental Oil & Gas Corporation and Environmental Protection Agency, USA

October 6, 2005
Methane Emissions Reductions: Agenda

• South American Oil and Natural Gas Industry Overview
  – Roger Fernandez, U.S. EPA
• Reduced Emission Completions (Green Completions)
  – Gerald Alberts, Williams
• Smart-Well Automation
  – Don Robinson, ICF Consulting
• Discussion Questions
South American Oil and Natural Gas Industry Overview

Agenda
• South American Oil and Gas Statistics
• Columbian Methane Emissions
• Major Emission Sources
• Emission Reduction Opportunities
South American Oil and Gas Statistics: Production

- Colombia represents 9% of South American production

- Other 561 mboe/d
- Argentina 1,449 mboe/d
- Brazil 1,913 mboe/d
- Venezuela 3,437 mboe/d
- Colombia 705 mboe/d

mboe/d = 1000 barrels of oil equivalent per day
South American Oil and Gas Statistics: Consumption

- Colombia represents 7% of South American consumption
- Argentina 945 mboe/d
- Other 811 mboe/d
- Brazil 2,392 mboe/d
- Venezuela 1,035 mboe/d
- Colombia 371 mboe/d

mboe/d = 1000 barrels of oil equivalent per day

Inventory of Oil and Natural Gas provided by Energy Information Administration (EIA)
Colombian Methane Emissions Estimates

- Oil and gas production contribute 44% of methane emissions

- Production: 2,548 MMcf
- Transmission: 2,241 MMcf
- Distribution: 583 MMcf
- Oil Downstream: 37 MMcf
- Processing: 324 MMcf
<table>
<thead>
<tr>
<th>Production</th>
<th>% of Total Sector Emissions</th>
<th>Transmission</th>
<th>% of Total Sector Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumatic Devices</td>
<td>41%</td>
<td>Reciprocating Compressors</td>
<td>42%</td>
</tr>
<tr>
<td>Well Venting and Flaring</td>
<td>12%</td>
<td>Pneumatic Devices</td>
<td>11%</td>
</tr>
<tr>
<td>Dehydrators and Pumps</td>
<td>9%</td>
<td>Engines</td>
<td>11%</td>
</tr>
<tr>
<td>Gas Engine Exhaust</td>
<td>8%</td>
<td>Centrifugal Compressors</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Processing</strong></td>
<td><strong>% of Total Sector Emissions</strong></td>
<td><strong>Distribution</strong></td>
<td><strong>% of Total Sector Emissions</strong></td>
</tr>
<tr>
<td>Reciprocating Compressors</td>
<td>48%</td>
<td>M&amp;R Stations</td>
<td>25%</td>
</tr>
<tr>
<td>Engines</td>
<td>20%</td>
<td>Unprotected Steel Mains/Services</td>
<td>18%</td>
</tr>
<tr>
<td>Centrifugal Compressors</td>
<td>16%</td>
<td>Regulators</td>
<td>16%</td>
</tr>
<tr>
<td>Blowdowns</td>
<td>6%</td>
<td>Cast Iron Mains</td>
<td>12%</td>
</tr>
</tbody>
</table>

South American Emission Reduction Opportunities

- Significant emissions reductions can be achieved at low cost
Reduced Emission Completions (Green Completions)

Agenda
• Green Completions
• Flowback Skids
• Piceance Well Completions
• Green Completion Economics
• Conclusion
Green Completions

• Technology used to recover gas that is otherwise vented or flared during the completion phase of natural gas well
• At Williams, Green Completion technology is a flowback separator skid leased from Breco
• Flowback skids used to separate sand, water and gas
Breco Flowback Skid

Sand Vessel

Gas Vessel
Flowback Skid – When Is It Used?

• Used after each zone is facture stimulated (frac’d)
• Used when all zones are fractured and waiting for workover rig to drill out plugs for final completion (Up to 10 days)
• When production well is located near gathering system
• Wildcat and step-out wells are not completed with green completion technology
• One Month = time wells at typical 4-well pad are routed to flowback skid
Flowback Skid - Operation

- Sand Vessel separates sand from field gas
- Gas Vessel separates gas from water used for hydrologic frac’ing
  - Gas routed to sales line
- Sand dumps to drill pit manually
- Water dumps to media tanks automatically
  - Water is filtered and reused for future frac jobs
- Flowback skid operates at 20 to 40 psi greater than gas gathering line pressure which is about 260 to 320 psi in Piceance Basin
Flowback Skid – Wellhead Equipment
Flowback Skid – Drilling Pit and Water Tanks
Piceance Well Completions

Well Completion Type = Mechanical Isolation

- Perforate casing prior to Stage 1 – makes fracture stimulation possible
- Frac Stage 1
- Flowback well, first 12 hrs water, afterwards routed to Breco skid
- Set plug to isolate frac stage
- REPEAT for each stage (avg. 5 to 6 stages/well)
- Plugs drilled out by Workover Rig
- Producing to flowback skid during time after fracing and before plugs drilled out
Piceance Well Completions

- Williams Fork formation – low permeability tight lenticular sandstone (10% porosity, permeability range of 0.001 md to 0.0100 md)
- Wells drilled to avg depth 6,500 ft to 9,000 ft
- Flow pressures range from 1,500 to 2,500 psi
- Fracture stimulation needed to make well economical
- Frac about 5 to 6 stages per well
- 32 = Average number of days each well on Breco Flowback Skid for typical 4 well pad
Risks Associated with Green Completions

1 – Wellbore/Reservoir Risk
- Fluids pumped downhole must be recovered as quickly as possible
- Flowing fluids to flowback skid results in decreased flowback rates
- Wellbore damage by fluids can diminish production

2 – Operational Risk
- When plugs drilled out well flows to remove cuttings and reduce head pressure
- Flowing to Breco skid increases backpressure/decreases flow
Risks Associated with Green Completions, con’t

3 – Safety

- Flowing gas, condensate, water, and sand during completion cause pipe and vessel washouts
- Elbows reinforced with high strength metal
- Breco person visits each location every 1 to 1.5 hrs to catch leaks before they become washouts
Flowback Skid – Washout Safety Feature

ABRASION RESISTENT
Flowback Skid - Safety

WASHOUT
### Green Completion Economics

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Number of Well Spuds</th>
<th>No. of Spuds Not Completed or Completed Without Flowback*</th>
<th>Actual Number of Completion Gas Generated (MMscf)</th>
<th>Actual Completion Gas Vented/Flared (MMscf)</th>
<th>Flowback Gas Recovered (MMscf)</th>
<th>Flowback Gas Recovered (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>75</td>
<td>14</td>
<td>61</td>
<td>599</td>
<td>112</td>
<td>487</td>
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<tr>
<td>2003</td>
<td>80</td>
<td>9</td>
<td>71</td>
<td>1348</td>
<td>152</td>
<td>1196</td>
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<tr>
<td>2004</td>
<td>253</td>
<td>34</td>
<td>219</td>
<td>5635</td>
<td>757</td>
<td>4878</td>
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<tr>
<td>2005</td>
<td>134</td>
<td>1</td>
<td>133</td>
<td>2864</td>
<td>21</td>
<td>2843</td>
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<tr>
<td>Total</td>
<td>542</td>
<td>58</td>
<td>484</td>
<td>10445</td>
<td>1042</td>
<td>9403</td>
</tr>
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</table>

### Flowback Revenue/Cost Analysis

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Revenue (MMS)</th>
<th>Recovery Cost (MMS)</th>
<th>Net Savings (MMS)</th>
<th>Actual Methane Generated (MMscf)</th>
<th>Flowback Methane Recovered (MMscf)</th>
<th>Potential Methane Flared (MMscf)</th>
<th>Potential Methane Vented (MMscf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>1.28</td>
<td>.22</td>
<td>1.06</td>
<td>533</td>
<td>434</td>
<td>89</td>
<td>11</td>
</tr>
<tr>
<td>2003</td>
<td>6.32</td>
<td>.89</td>
<td>5.43</td>
<td>1200</td>
<td>1065</td>
<td>1200</td>
<td>15</td>
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<tr>
<td>2004</td>
<td>27.87</td>
<td>2.85</td>
<td>25.02</td>
<td>5017</td>
<td>4343</td>
<td>600</td>
<td>74</td>
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<tr>
<td>2005</td>
<td>10.97</td>
<td>2.84</td>
<td>8.13</td>
<td>2550</td>
<td>2531</td>
<td>17</td>
<td>2</td>
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<tr>
<td>Total</td>
<td>46.45</td>
<td>6.80</td>
<td>39.65</td>
<td>9301</td>
<td>8373</td>
<td>826</td>
<td>102</td>
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</table>

*Newly drilled wells may not have been completed at the time of this report. These will be reconciled during the 1st quarter each year. It is estimated that greater than 99% of all well spuds are completed using the flowback recovery unit.
Green Completion Economics continued

<table>
<thead>
<tr>
<th>AVERAGE PER WELL FLOWBACK STATISTICS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Number of Days of Flowback =</td>
<td>32</td>
</tr>
<tr>
<td>Average MMscf Gas Recovered During Flowback =</td>
<td>22.3</td>
</tr>
<tr>
<td>Average MMscf Gas Flowback Recovered/Day =</td>
<td>0.69</td>
</tr>
<tr>
<td>Average Revenue Per Flowback ($) =</td>
<td>$109,967</td>
</tr>
<tr>
<td>Average Cost Per Flowback ($) =</td>
<td>$16,015</td>
</tr>
<tr>
<td>Average Net Saving Per Flowback ($) =</td>
<td>$94,474</td>
</tr>
<tr>
<td>CH$_4$ recovered in 2004 =</td>
<td>4,343 MMscf</td>
</tr>
</tbody>
</table>

Estimated Mean Methane Concentration Gas: 89.043 vol. %
Conclusion

• Reduce methane emissions, a potent GHG
• Well completion type determines viability of green completion technologies
• Produced water and stimulation fluids from green completions are recycled
• Eliminate citizen complaints associated with flaring
• Increase Economic Value Added
Smart-Well Automation

Agenda

• Methane Losses
• Methane Recovery
• Methane Savings
• Is Recovery Profitable?

Source: Weatherford
Methane Losses from Plunger Lifts

• 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 can’t lift fluid to top
    • Gas slippage around plunger and fluid (waste of motive energy)

Source: Weatherford
Conventional Plunger Lift Operations

• Manual, on-site adjustments tuned plunger cycle time to well’s parameters
  – Not performed regularly
  – Do not account for gathering line pressure fluctuations, declining wells, plunger wear

• Manual vent to atmosphere when plunger lift is overloaded
Methane Recovery from Smart-Well Automation

- Smart automation continuously varies plunger cycling 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 and battery powered
- Monitor well parameters
- Adjust plunger cycling

Remote well management
- Continuous data logging
- Remote data transmission
- Receive remote instructions
Plunger Lift Cycle

Production Control Services
Spiro Formation Well 9N-27E

Well Production without Plunger Lift
Potential Continuous Production with Plunger Lifts

Well Blowdowns
TIME
Potential Incremental Production with Plunger Lift

Mcf/Month
100,000
10,000
1,000
100

Methane to Markets
Methane Savings

- Methane emissions savings 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/yr emissions savings for average well

\(^1\)Weatherford
Other Benefits

• Reduced manpower cost per well
• Continuously optimized production conditions
• Remotely identify potential unsafe operating conditions
• Monitor and log other well site equipment
  – Glycol dehydrator
  – Compressor
  – Stock Tank
  – VRU
Is Recovery Profitable?

- Smart automation controller installed cost: ~$15,500
  - Conventional plunger lift timer: ~$7,000
- Personnel savings: double productivity
- Production increases: 10% to 20% increased production
- $ Savings per year =
  \[(\text{Mcf/yr}) \times (10\% \text{ increased production}) \times (\text{gas price})\]
  \[+ (\text{Mcf/yr}) \times (1\% \text{ emissions savings}) \times (\text{gas price})\]
  \[+ (\text{personnel hours/yr}) \times (0.5) \times (\text{labor rate})\]
Contacts

• Roger Fernandez, U.S. EPA
  (202) 343-9386
  fernandez.roger@epa.gov

• Gerard G. Alberts, Williams
  (303) 572-3900
  Jerry.albersts@williams.com

• Don Robinson, ICF Consulting
  (703) 218-2512
  drobinson@icfconsulting.com

• Program website: www.methanetomarkets.org
Discussion Questions

• To what extent are you implementing these options?
• How could these options be improved upon or altered for use in your operation(s)?
• What are the barriers (technological, economic, lack of information, regulatory, focus, manpower, etc.) that are preventing you from implementing these options?