Reducing Venting from Well Completions, Workovers, and Liquids Unloading

Seminar with Russian Independent Oil and Gas Producers on Methane Mitigation Technologies and Strategies
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Don Robinson, Vice President
ICF International
Agenda

- **U.S. Production Sector Methane Emissions**
  - Methane losses

- **Well Completions and Workovers**
  - Reduced Emissions Completions
  - Methane savings/benefits
  - Is recovery profitable?
  - Industry experience

- **Liquids Unloading**
  - Plunger lifts
  - Methane savings/benefits
  - Is recovery profitable?
  - Industry experience

Source: BP
2008 Production Sector Methane Emissions (103 Bcf)

- **Pneumatic Devices**: 37 Bcf
- **Offshore Operations**: 23 Bcf
- **Dehydrators and Pumps**: 11 Bcf
- **Well Venting and Flaring**: 6 Bcf
- **Meters and Pipeline Leaks**: 6 Bcf
- **Compressor Fugitives, Venting, and Engine Exhaust**: 10 Bcf
- **Storage Tank Venting**: 4 Bcf
- **Other Sources**: 6 Bcf
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*Bcf = billion cubic feet*
Methane Losses – U.S. Production

- Over 695,000 producing gas wells\(^1\) in the U.S.

- Wellhead emissions from gas production facilities are estimated to be 4,700 million cubic meters per year\(^2\)
  - Estimated 6.8 thousand cubic meter emissions (Mcm) per well-year
  - Worth RUB 113,600 / well-year\(^3\)

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\(^2\)EPA. *Background Technical Support Document* (docket # EPA-HQ-OAR-2009-0923) for Subpart W.

\(^3\)2008 Russian gas sales price for European Market at $370/Mcm (RUB 11,360/Mcm)
eia.doe.gov/cabs/Russia/NaturalGas.html
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Source: Newfield
Methane Losses During Gas Well Completions

- Gas wells in tight formations and coal beds require hydraulic fracture
- It is necessary to clean out the well bore and formation
  - After new completion
  - After well re-fracturing workovers
- Operators produce to an open pit or tank to collect sand, cuttings, and fluids for disposal
- Vent or flare the natural gas produced
- 1,530 MMcm\(^1\) of methane is vented or flared from completions and workovers in the U.S.; 765 MMcm of methane is emitted\(^1\)

MMcm = million cubic meters

Methane Recovery by Reduced Emission Completions

- Recover natural gas and condensate produced during flow-back following hydraulic fracture
- Portable equipment separates sand and water, processes gas and condensate for sales
- Route recovered gas through dehydrator and meter to sales line, reducing venting and flaring

Portable REC Equipment

Source: Weatherford
Reduced Emission Completions: Preconditions

- Permanent equipment required on site before cleanup
  - Piping from well head to sales line
  - Dehydrator
  - Lease meter
  - Stock tanks for wells producing significant amounts of condensate

- Sales line gas can be used for compressor fuel and/or gas lift in low pressure wells
Reduced Emission Completions: Equipment

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

Temporary, Mobile Surface Facilities,
Source: BP

Source: Williams
Reduced Emission Completions: Low Pressure Wells

- Partners and vendors are perfecting the use of portable compressors when pressure in reservoir is too low to enter sales line
  - Artificial gas lift to clear fluids
  - Boost gas to sales line
  - Manage slug flow
  - Adds cost to project

Source: Herald
Reduced Emission Completions: Benefits

- Reduced methane emissions during completions and workovers
- Sales revenue from recovered gas and condensate
- Improved relations with government agencies and public neighbors
- Reduced environmental impact
- Improved safety
- Reduced disposal costs
Reduced Emission Completions Partner Experience: British Petroleum

- Capital investment of about RUB 15,000,000 per skid on portable three-phase separators, sand traps, and tanks in the Rocky Mountain Region (USA)
- Used REC on 106 wells
- Total natural gas recovered about 9.9 million cubic meters per year (MMcm/year)
  - 93.4 Mcm per well average
    - Conservative net value of gas saved is RUB 700,000 per well
- 6,700 barrels/year condensate recovered
- 1.5 year payback based on BP’s prices for natural gas and condensate

1 Natural gas valued by company to be RUB 7,600/Mcm
Reduced Emission Completions
Partner Experience: BP

Through the end of 2005, BP reported:
- 116 MMcm of gas and
- 53,000 barrels of condensate recovered\(^1\)

\(^1\) Combination of activities in Montana and Wyoming, U.S.
Reduced Emission Completions
Partner Experience: Williams

Two rows of four wells closely spaced.

Source: Williams
Reduced Emission Completions
Partner Experience: Williams

- Williams Fork Formation (Piceance Basin) – low permeability, tight, lenticular sandstone (10% porosity, permeability range of 1 to 10 microdarcies).
- Wells drilled to depths of 2,000 to 2,750 meters
- Flow pressures range from 100 to 170 atm
- Fracture stimulation needed to make wells economical
- Frac about 5 to 6 stages per well
- BRECO flowback skids used to separate sand, water and gas during initial flowback
- BRECO flowback skid resides on typical 4 well pad for 32 days
Piceance Well Completions

- Flow back well, first 12 hours is water, afterwards routed to BRECO skid
- Set plug to isolate frac stage (avg. 5 to 6 stages/well)
- Plugs drilled out by workover rig
- Producing to flowback skid after frac’ing and before plugs drilled out
Reduced Emission Completions Partner Experience: Williams

BRECO Flowback Skids

Sand Vessel

Gas Vessel
Reduced Emission Completions Partner Experience: Williams

How BRECO Works?

- Sand vessel separates sand from backflow fluids
- Gas vessel separates gas from water used for hydraulic fracturing
  - Gas routed to sales line
- Sand is dumped to reserve pit manually
- Water dumps to holding tanks automatically
  - Water is filtered and reused for future frac jobs
- Flowback skid operates at 2 to 4 atm higher pressure than gas gathering line, which is about 19 to 23 atm in Piceance Basin
Flowback Skid – When Is It Used?

- Used after each zone is fracture 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)
- Production well must have flow lines to gathering system
- Wildcat and step-out wells are not completed with REC Technology
- One Month = time wells at typical 4-well pad are routed to flowback skid
Reduced Emission Completions Economics

<table>
<thead>
<tr>
<th>AVERAGE PER WELL FLOWBACK STATISTICS</th>
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<tbody>
<tr>
<td>Average Number of Days of Flowback =</td>
</tr>
<tr>
<td>Average Mcm Gas Recovered During Flowback =</td>
</tr>
<tr>
<td>Average Mcm Gas Flowback Recovered/Day =</td>
</tr>
<tr>
<td>Average Revenue Per Flowback ($) =</td>
</tr>
<tr>
<td>Average Cost Drill/Complete Well ($) =</td>
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<tr>
<td>Average Cost Per Flowback ($) =</td>
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<tr>
<td>Average Net Saving Per Flowback ($) =</td>
</tr>
<tr>
<td>CH$_4$ recovered in 2005 =</td>
</tr>
<tr>
<td>Estimated Mean Methane Concentration Gas:</td>
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Natural Gas STAR Partner-reported data (Williams)
Conclusions: Reduced Emission Completions

- Reduces methane emissions, a potent greenhouse gas (GHG)
- Well completion type determines viability of reduced emission completion technologies
- Produced water and stimulation fluids from reduced emission completions are recycled
- Eliminates emissions, noise and citizen complaints associated with flaring
- Increases economic value added
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Source: BP
Methane Losses – Natural Gas Well Liquid Unloading

- Blowdowns to unload fluids can vent 2 to 45 thousand cubic meters per year to the atmosphere per well\(^1\)
- Accumulation of liquid hydrocarbons or water in the well tubing reduces, and can halt, production
- Operators vent (i.e., blowdown) wells to atmosphere to expel liquids


Source: BP
Plunger Lift Liquid Unloading

- Conventional plunger lift systems use well shut-in pressure buildups to efficiently lift plunger and columns of fluid out of well without venting.
- U.S. gas wells have 175,000 plunger lifts\(^1\).
- Emission reductions using plunger lifts are 4,600 MMcm/year\(^2\).
- Gas production is estimated to be as much as 10 percent higher using plunger lifts.

\(^1\)Estimate from plunger lift vendors

\(^2\)Assumes 40% of plunger lift systems equipped with “smart” automation, 50% reduction from plunger lift and 75% reduction from plunger lift with “smart” automation.

Source: Weatherford
Conventional Plunger Lifts Have Significant Drawbacks

- Fixed timer cycles may not match reservoir performance
  - Cycle too frequently (high plunger velocity)
    - Plunger not fully loaded
  - Cycle too late (low plunger velocity)
    - Plunger over-loaded, stalls
    - Shut-in pressure can’t lift plunger and fluid to top
    - May have to vent to atmosphere to lift plunger

- Results in 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 cycle time
  - To minimize well venting to atmosphere
  - Recover more gas
  - Further reduce methane emissions
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

Source: Weatherford
Methane Savings

- Methane emissions savings a secondary benefit
  - Optimized plunger cycling to remove liquids increases well production by 10 to 20%\(^1\)
  - Additional 1%\(^1\) production increase from avoided venting

- 12 thousand cubic meters per year of methane emissions savings for average U.S. well requiring unloading

\(^1\) Reported by Weatherford, Natural Gas STAR Producers Technology Transfer Workshop, April 2008. epa.gov/gasstar/workshops/techtransfer/index.html

Source: BP
Increased Production is the Main Benefit of Plunger Lifts
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
  - Vapor recovery unit
Is Recovery Profitable?

- Smart automation controller installed cost: ~RUB 323,000
  - Conventional plunger lift timer: ~RUB 162,000
- Personnel savings: double productivity
- Production increases: 10% to 20% increased production

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

= RUB savings per year
Economic Analysis

- Non-discounted savings for an average well =

\[
(1,400 \text{ Mcm/year}) \times (10\% \text{ increased production}) \times (\text{RUB 11,360/Mcm}^1) \\
+ (1,400 \text{ Mcm/year}) \times (1\% \text{ emissions savings}) \times (\text{RUB 11,360/Mcm}) \\
+ (500 \text{ personnel hours/year}) \times (0.5) \times (\text{RUB 490/hr}) \\
- (\text{RUB 323,000}) \text{ cost}
\]

RUB 1,550,000 savings in first year

3 month simple payback
Industry Experience: British Petroleum (BP)

- BP’s first plunger lift project designed and funded in 2000
- Pilot installations and testing in 2000
  - Installed plunger lifts with automated control systems on ~2,200 wells
  - ~RUB 460,800 per well remote terminal unit (RTU) installment cost
  - RUB 1,536,000 – RUB 23,040,500 host system installment cost
- Achieved 50% reduction in venting between 2000 and 2004
- Installed Programmable Logic Controllers in 2006
- Achieved 90% reduction from 2000 venting by 2007
BP Well Venting Reduction Using Plunger Lifts and Smart Automation

Daily Vent Volumes

Vent Rate (Mscf/d)

2001 2002 2003 2004 2005 2006 2007
Contact Information and Further Information

- More detail is available on these practices and over 80 others online at: [epa.gov/gasstar/tools/recommended.html](http://epa.gov/gasstar/tools/recommended.html)

- For further assistance, direct questions to:

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