Opportunities for Methane Emissions Reductions from Natural Gas Production

Lessons Learned from Natural Gas STAR

Producers Technology Transfer Workshop

Occidental Oil and Gas and
EPA's Natural Gas STAR Program
Midland, TX
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EPA

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

Methane Losses During Well Completions

- It is necessary to clean out the well bore and formation surrounding perforations
  - After new well completion
  - After well workovers
- 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

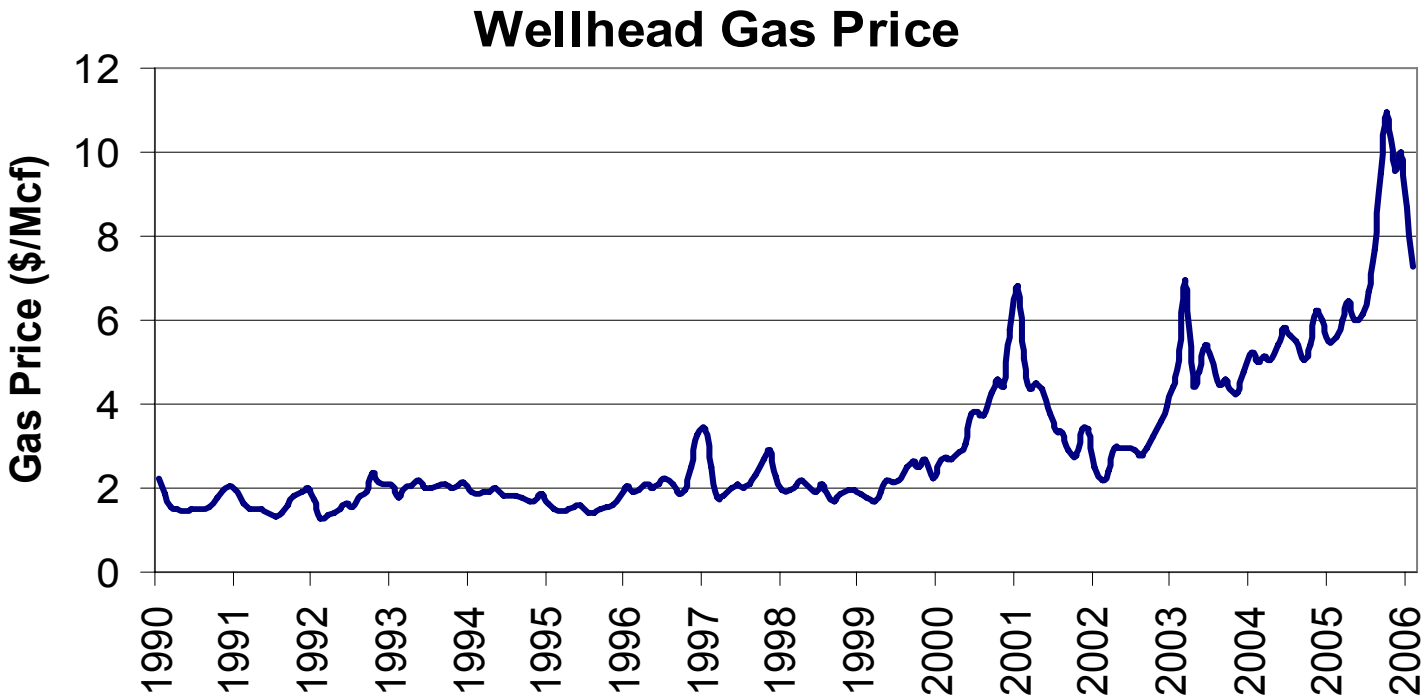
Methane Losses: Well Completions and Workovers

- An estimated 44.5 Bcf of natural gas lost annually due to well completions and workovers[1]
  - 44,000 MMcf in losses from high pressure wells
  - 319 MMcf in losses from low pressure wells
  - 48 MMcf in losses from workovers
- An estimated total of 480,000 Bbl condensate lost annually due to venting and flaring
- This amounts to over $322 million[2] lost due to well completions and workovers

1 - Percentage that is flared and vented unknown
2 - Value of natural gas at $7/Mcf, Value of condensate at $22/bbl

Wellhead Gas Prices

- Gas prices have increased sharply in recent years to over $7/Mcf



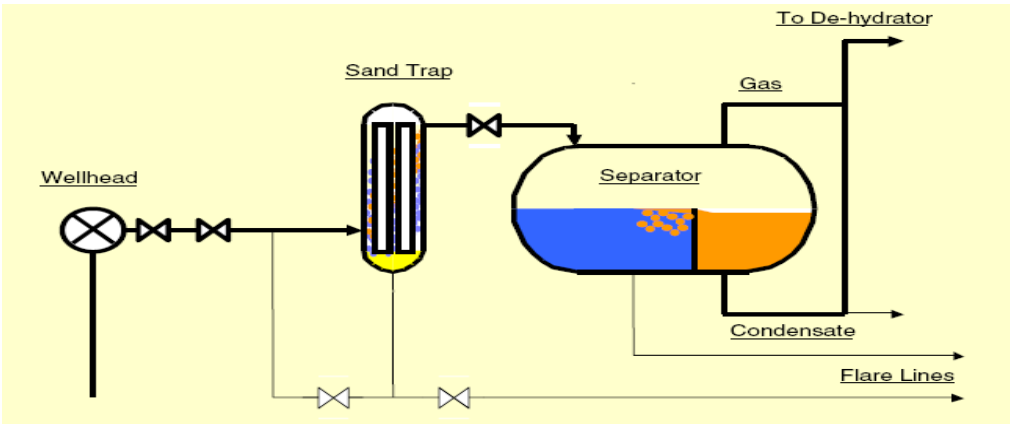
Source: EIA "US Natural Gas Wellhead Price" 1990 – 2006 available at http://tonto.eia.doe.gov/dnav/ng/hist/n9190us3m.htm

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
  - 25,000 MMcf from high pressure wells
  - 181 MMcf from low pressure wells
  - 27 MMcf from workovers

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



Temporary, Mobile Surface Facilities
Source: BP

Green Completions: Preconditions

- Must have permanent equipment on site before cleanup
  - Piping from wellhead to sales line
  - Dehydrator
  - Lease meter
  - Stock tank
- Sales line gas can be used for fuel and/ or gas lift in low pressure wells

Green Completions: Low Pressure Wells

- Can use portable compressors to start-up the 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

Portable Compressors, Separator and Other Equipment on a trailer

Source: Herald

Is Recovery Profitable?

- Partners report recovering an average of 53% of total gas produced during well completions and workovers
- Estimate an average of 3,000 Mcf[1] of natural gas can be recovered from each cleanup
- Estimate 1 to 580 Bbl of condensate can be recovered from each cleanup

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 state agencies and public neighbors
- Improved safety
- Reduced disposal costs

Industry Experience: Devon

- Reduced 9.11 Bcf of methane emissions by using reduced emissions completions (RECs) in the Fort Worth Basin
- RECs account for 78% of Devon's reductions in 2005
- REC procedure upon completion of the frac job:
  - Install temporary flowline and meter run on location during completion process
  - Flow well back to frac tanks until gas is encountered
  - Turn well down line and ***sell gas*** while cleaning up the well
  - Snub tubing in the hole while ***selling gas*** back to reduce the pressure on the well
  - Run required tests ***through sales*** to calculate the absolute open flow potential

Source: Devon

Devon Experience

- Benefits of RECs
  - Reduces the volume of methane emissions
  - Allows wells to be cleaned up longer with better results
  - Additional gas sales
  - Safer work environment
- Economics of RECs[1]
  - Average Additional Sales Per Well: $65,496
  - Average Incremental Cost: $6,712
  - Additional Revenue Per Well: $58,784

Source: Devon

1 - Gas Price at $6.57/Mcf

Weatherford Durango Experience

- Successfully completed pilot project in the Fruitland coal formations in Durango, Colorado
  - 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 MMcf of gas and sold by client

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 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?

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

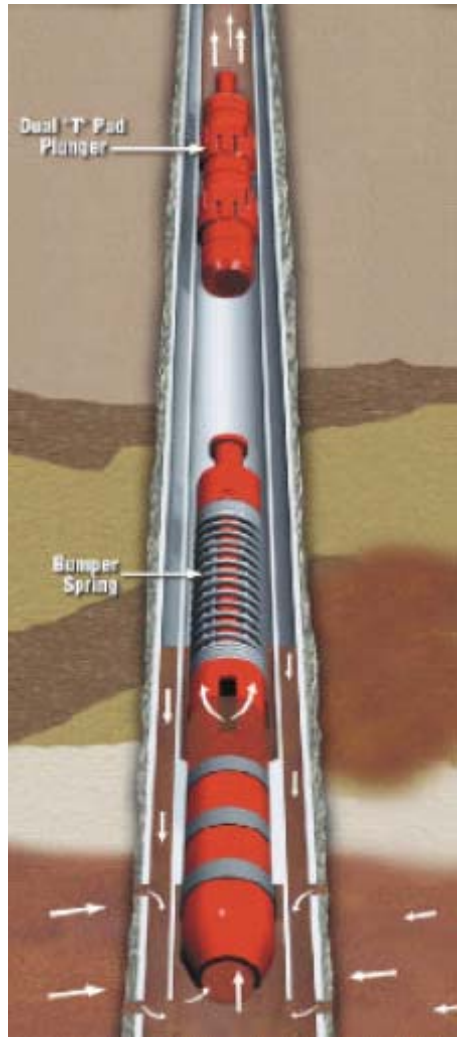
Methane Losses

- There are 390,000 natural gas and condensate wells (on and offshore) in the U.S.[1]
- 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 1600 Mcf/year[2] to the atmosphere per well
- Estimate 9 Bcf/year methane emissions from U.S. onshore well venting[1]

1 - Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2004
2 - 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 can't lift fluid to top
    - May have to vent to atmosphere to lift plunger



Source: Weatherford

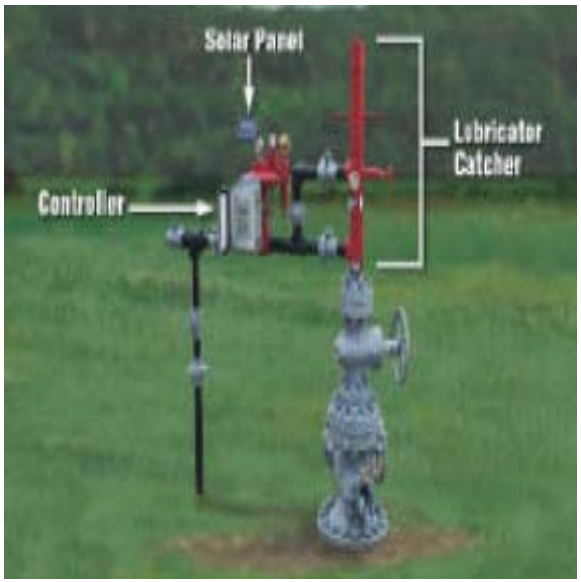
Conventional Plunger Lift Operations

- 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
- Results in manual venting to atmosphere when plunger lift is overloaded

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



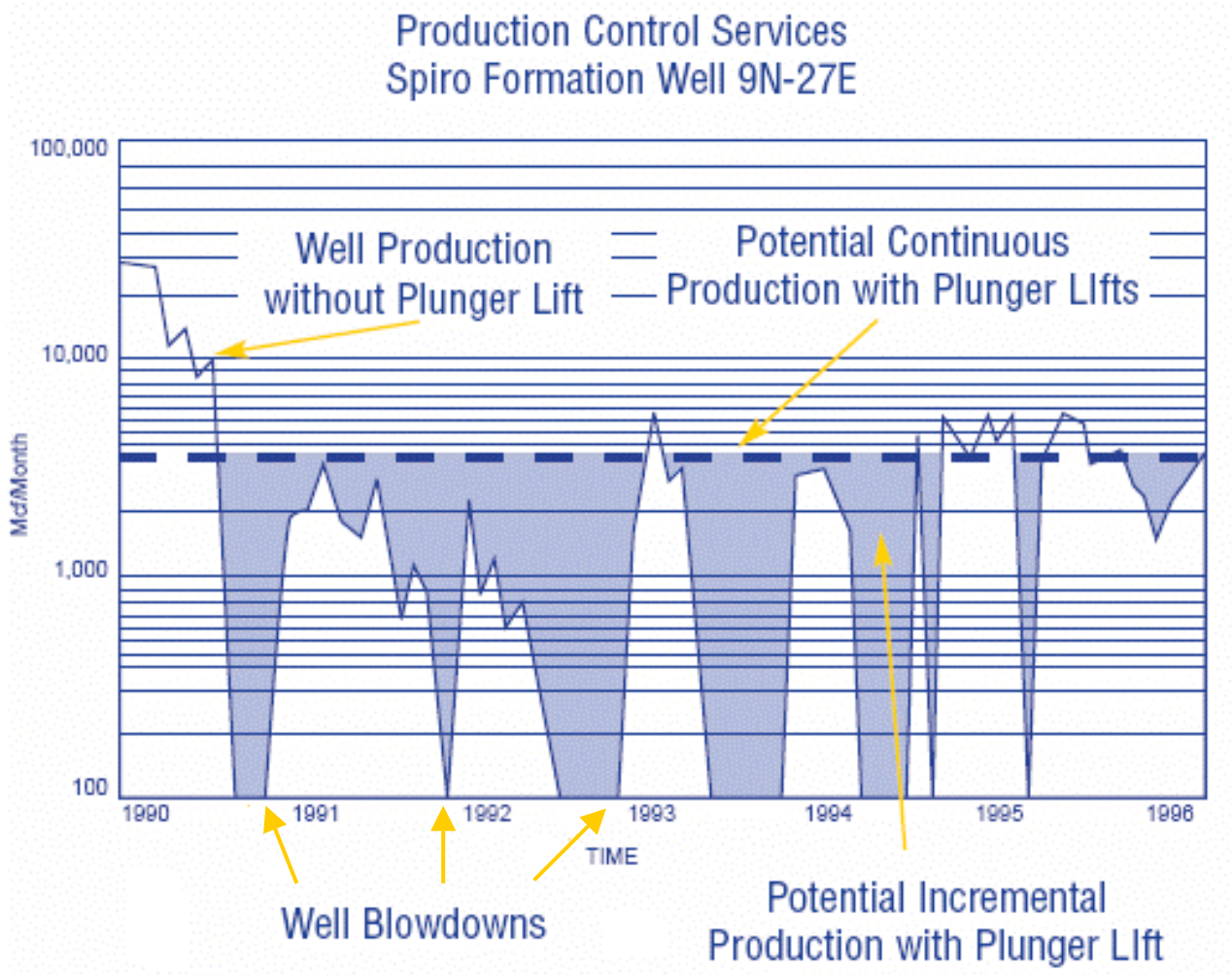
Source: Weatherford

- 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

Plunger Lift Cycle



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/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 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: ~$11,000
  - Conventional plunger lift timer: ~$5,000
- Personnel savings: double productivity
- Production increases: 10% to 20% increased production

- Savings =

$$\frac{\begin{array}{l}(\text{Mcf/year}) \times (10\%\ \text{increased production}) \times (\text{gas price}) \\ + (\text{Mcf/year}) \times (1\%\ \text{emissions savings}) \times (\text{gas price}) \\ + (\text{personnel hours/year}) \times (0.5) \times (\text{labor rate})\end{array}}{\$\ \text{savings per year}}$$

Economic Analysis

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

(50,000 Mcf/year) x (10% increased production) x ($7/Mcf)
+ (50,000 Mcf/year) x (1% emissions savings) x ($7/Mcf)
+ (500 personnel hours/year) x (0.5) x ($30/hr)
- ($11,000) cost

$35,000 savings in first year

3 month simple payback

Industry Experience

- BP reported installing plunger lifts with automated control systems on ~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[1]

1 - Morrow, Stan and Stan Lusk, Ferguson Beauregard, Inc. Plunger-Lift: Automated Control Via Telemetry. 2000.

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