



Methane to Markets

Gas Well Reduced Emissions Completions, Devon
& British Petroleum (BP) Case Study Experience

U.S. Environmental Protection Agency

October 31, 2007

Agenda

- Methane Losses
- Methane Recovery
- Reduced Emissions Completions
- Is Recovery Profitable?
- Industry Experience
- Discussion Questions



Methane Losses During 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 well completion
 - After well workovers
- Operators produce the well to an open pit or tank to collect sand, cuttings and reservoir fluids for disposal
- Vent or flare the natural gas produced

Potential Methane Losses: Well Completions and Workovers

- Estimated 4,000 wells drilled per year in China
 - Based on CNPC and Sinopec drilling counts
 - Projected to national level based on production volumes
- An estimated 200 million cubic meters of natural gas and 60,000 barrels condensate may be lost annually if half of these wells require hydraulic fracturing
- This amounts to over \$40 million¹ of lost revenue from well completions in China

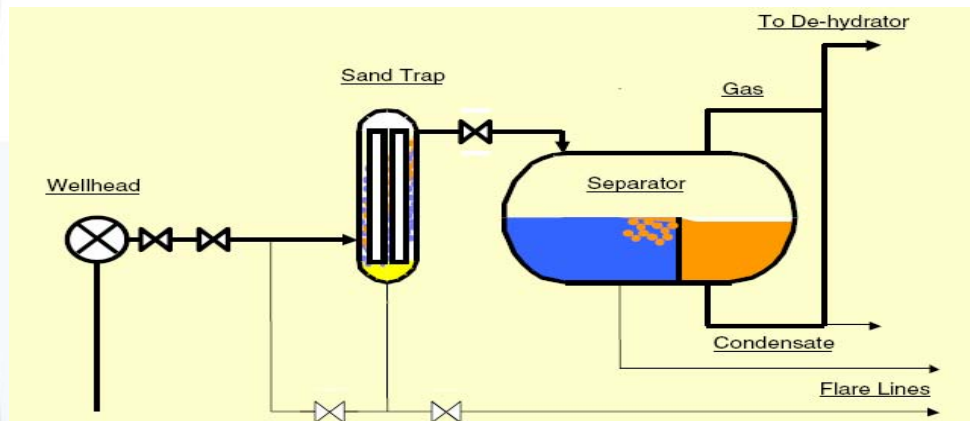
¹ Value of natural gas at \$0.25/cubic meter (m³), Value of condensate at \$22/barrel

Potential Methane Recovery: Reduced Emissions Completions

- Reduced Emissions Completions (REC) or “Green Completions” recover natural gas and condensate produced during well completions or workovers
- Use portable equipment to process well clean-out fluids suitable for gas and condensate sales
- Send recovered gas through permanent dehydrator and meter to sales line, reducing venting and flaring
- More than half, about 100 million cubic meters, or \$20 million of natural gas and condensate may be recovered annually using REC in China

REC: Equipment

- Trailer mounted or portable equipment is used to capture produced gas during cleanup
 - Sand trap
 - Three-phase separator
- Use portable dehydrator for workovers requiring glycol dehydrator maintenance



Temporary, Mobile Surface Facilities

Source: British Petroleum



Source: Williams

REC: 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



Permanent Dehydrators

Source: Williams

REC: 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 with portable compressor



JERRY McBRIDE / Herald

Portable Compressors, Separator and Other Equipment on a trailer

Source: Herald

Is Recovery Profitable?

- Gas STAR partners report recovering an average of 53% of total gas produced during well completions and workovers
- Estimate an average of 85 thousand cubic meters of natural gas can be recovered from each cleanup¹
- Estimate 1 to 580 barrels of condensate can be recovered from each cleanup

¹ Value for high pressure wells

REC: Benefits

- Reduced methane emissions during completions and workovers
- Sales revenue from recovered gas and condensate
- Improved safety
- Reduced disposal costs
- Improved air quality



Source: Weatherford

Industry Experience: Devon

- Reduced 258 million cubic meters of methane emissions by using RECs in the Fort Worth, Texas Basin (Barnet Shale)
- RECs accounted for 78% of Devon's methane emissions reductions in 2005
- REC procedure upon completion of the fracture:
 - Install temporary flowline to sand trap and gas/liquid separator
 - Flow well back to tanks until gas is encountered
 - Connect gas to dehydrator and ***sales line*** while cleaning the well



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



Source: Devon

- Economics of RECs¹
 - Average Additional Sales Per Well: \$65,496
 - Average Incremental Cost: \$6,712
 - Additional Revenue Per Well: \$58,784

¹ Natural gas valued at \$0.23/ cubic meter (\$6.57/Mcf)

British Petroleum Experience Green River Basin

- Capital investment ~ \$500 thousand per skid with portable three-phase separator, sand trap and tanks
- Used Green Completions on 106 wells
- Total natural gas recovered over 1 million cubic meters/year
 - 94 thousand cubic meters per well average
 - Conservative net value of gas saved is \$20,000¹ 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 at \$0.25/cubic meter (\$7/Mcf)

British Petroleum Experience

- Through the end of 2005 BP reports¹
 - 118 million cubic meters of gas, and
 - 53,000 barrels of condensate recovered



Portable Three Phase Separator, Source: BP

¹ This is a combination of activities in the Wamsutter and Jonah/Pinedale fields

Lessons Learned

- **Incremental Costs**
 - Sand traps, separators, portable compressors, dehydrators
- **Process**
 - Sands, liquids, gases separated
 - Natural gas dehydrated to pipeline quality
- **Benefits**
 - Natural gas recovered for sales or fuel
 - Reduce flaring
- **Eligible Wells**
 - New wells that require hydraulic fracture
 - Well workovers with hydraulic fracture

Discussion Questions

- Do you produce from tight gas formations or coal beds that require hydraulic fracturing?
- To what extent are you implementing this opportunity?
- How could this opportunity be improved upon or altered for use in your operation?
- What are the barriers (technological, economic, lack of information, focus, manpower, etc.) that are preventing you from implementing this practice?