Methane to Markets

Reduced Emission Completions / Plunger Lift and Smart Automation

Oil & Gas Subcommittee Technology Transfer Workshop

January 28, 2009
Monterrey, Mexico

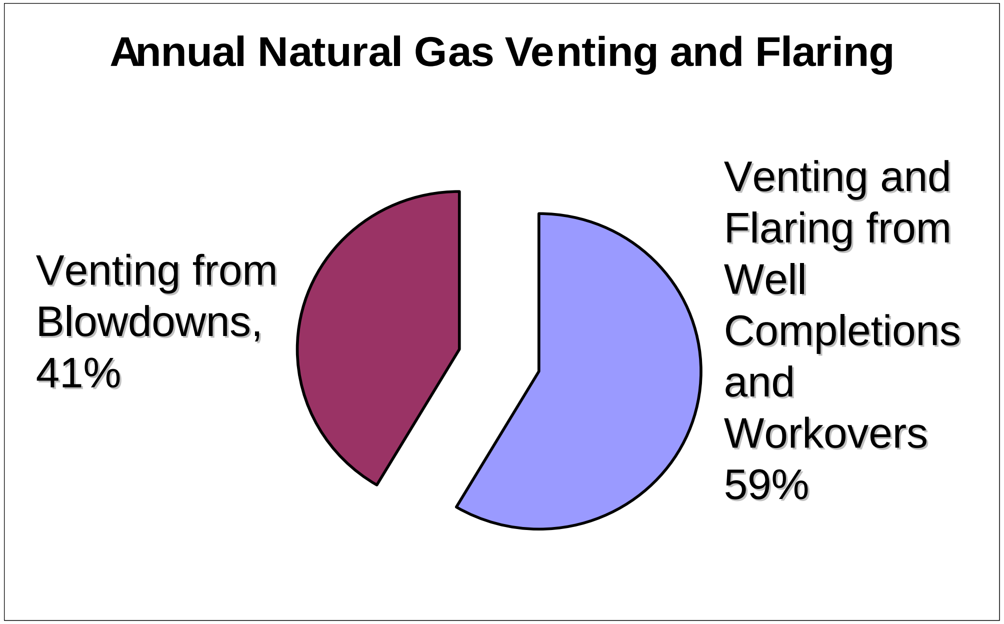
Well Venting Agenda

- Methane Losses
- Methane Recovery
- Is Recovery Profitable?
- Industry Experience
- Discussion

Source: Williams

Methane Losses (U.S.): Gas Well Completions and Workovers

- An estimated 45 Billion cf of natural gas lost annually due to well completions and workovers[1]
- An estimated total of 480,000 Bbl condensate lost annually due to venting and flaring



[1]*Percentage that is flared and vented is not known*

Methane Loss During Gas Well Completions

- It is necessary to clean out the well bore and formation following hydraulic fracturing
  - After new well completion
  - After well workovers
- 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
  - Venting may lead to dangerous gas buildup
  - Flaring is preferred where no fire hazard or nuisance

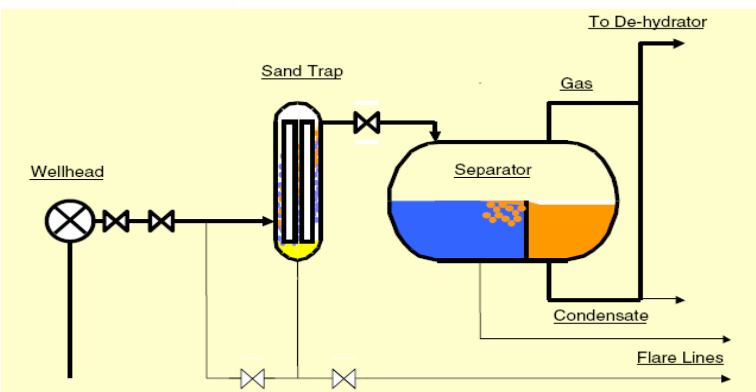
Methane Recovery by Reduced Emission Completions

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

Portable REC Equipment

Reduced Emission 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

Methane to Markets

Reduced Emission Completions: Preconditions

- Permanent equipment required on site before cleanup
  - Piping to well head
  - Dehydrator
  - Lease meter
  - Stock tank
- Sales line gas can be used for energy and/or gas lift in low pressure wells

Reduced Emission Completions: Low Pressure Wells

- Use portable compressors when pressure in well is low
  - Artificial gas lift to clear fluids
  - Boost gas to sales line
  - Higher cost to amortize investment

JERRY McBRIDE / 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
- Improved safety
- Reduced disposal costs

Methane to Markets

Is Recovery Profitable?

- Partners report recovering 2% - 89% (average of 53%) of total gas produced during well completions and workovers

- Estimate 7 – 12,500 Mcf (average of 3,000 Mcf) of natural gas can be recovered from each cleanup

- Estimate 1- 580 Bbl of condensate can be recovered from each cleanup

Note: Values for high pressure wells

Anadarko Experience

- Produces gas from “tight” formations in Wyoming, Colorado, and Utah
- 1998 to 2005 implemented conventional completions
  - 421 wells/year completed average
  - 2,072 MMcf/year lost average
  - 12 days venting/completion average
- Lost US$ 82.9 million[1] of gas in 8 years
  - US$10.4 million/year average

[1] Gas valued at US$5/Mcf

Anadarko Experience

- In 2006 started implementing RECs
- 2006 to 2008 RECs:
  - 613 wells/year completed
  - Net savings: 2,052 MMcf/year
    - Despite 45% increase in well completions
  - Less than 2 *hours* venting/completion on average
- US$10.3 million/year[2] increased revenue

[1] Gas valued at US$5/Mcf

Devon Energy Experience

- Implemented Reduced Emission Completion (REC) in the Fort Worth Basin
- REC performed on 30 wells at an average incremental cost of US$ 8,700
- Average 11,900 Mcf of natural gas sold vs. vented per well
  - Natural gas flow and sales occur 9 days out of 2 to 3 weeks of well completion
  - Low pressure gas sent to gas plant
  - Conservative net value of gas sold is US$ 59,500 per well at Mexico gas price[1]
- Expected emission reductions of 1.5 to 2 Bcf per year moving forward

[1] Gas valued at US$5/Mcf

Williams Experience

- Implemented 1,064 completions with flowback from 2002 through 2006
- Total implementation cost: US$17.41 million
- Recovered a total of 23,700 MMcf (23,700 BBtu[1])
  - Equal to 91,1% recovery
  - Worth US$118.5 million at Mexico gas value[2]

[1] Assumes 1 Mcf = 1 MMBtu
[2] Gas valued at US$5/MMBtu

Discussion Questions

- To what extent are you implementing this opportunity?
- Can you suggest other approaches for reducing well venting?
- How could these opportunities 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?

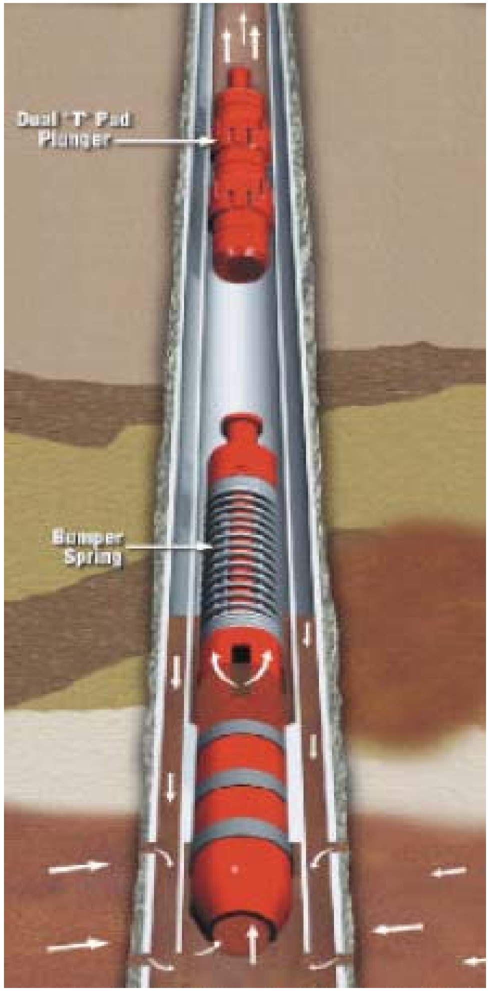
Liquid Unloading

- Accumulation of liquid hydrocarbons or water in the well tubing reduces, and can halt, production
- Operators blow wells to atmosphere to expel liquids

Source: BP

Plunger lift recovers liquids with less gas venting

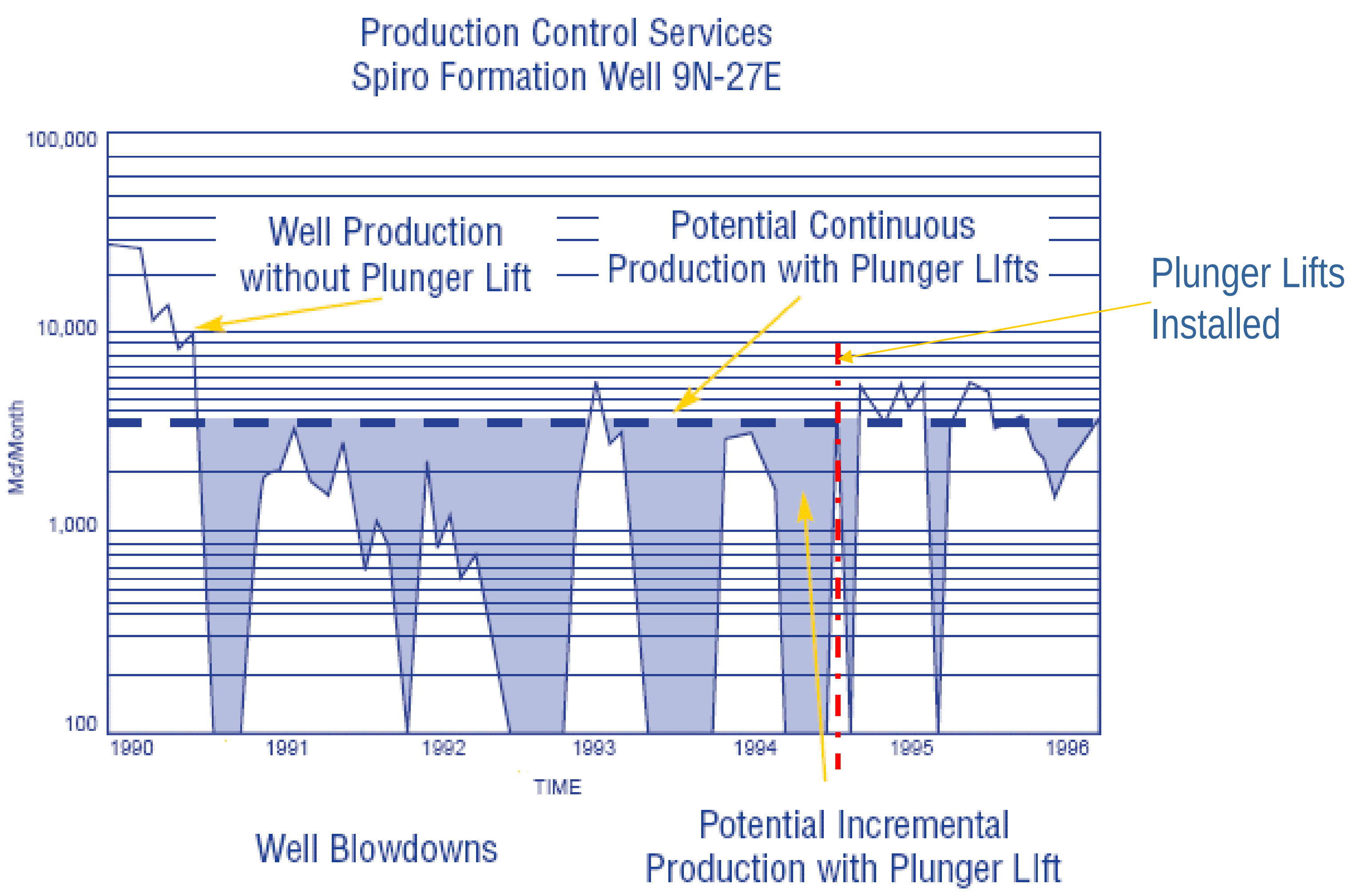
- Conventional plunger lift systems use gas pressure buildups to repeatedly lift columns of fluid out of well
- Fixed timer cycles may not match reservoir performance
  - Cycle too frequently (high plunger velocity)
    - Plunger not fully loaded
  - Cycle too late (low plunger velocity)
    - Shut-in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



Source: Weatherford

Methane to Markets

Plunger Lift Cycle



What is the problem?

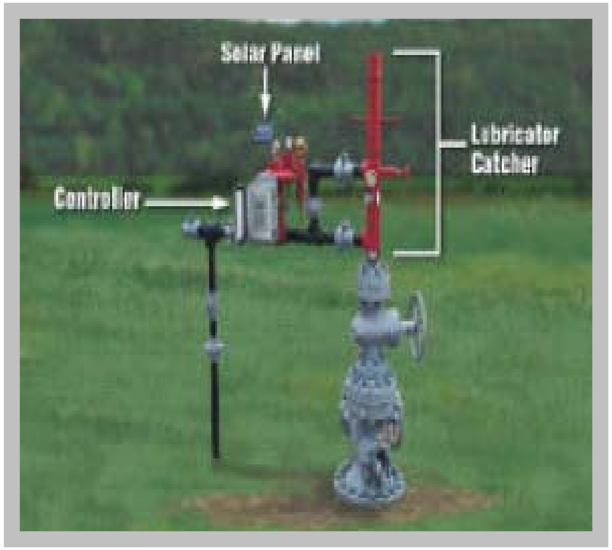
- Fixed timer requires manual adjustments of the plunger cycle time
  - Not performed regularly
  - Do not account for gathering line pressure fluctuations, declining well performance, plunger wear
- Results in manual venting to atmosphere when plunger lift is overloaded

Source: BP

Smart Automation Well Venting

- Automation can enhance the performance of plunger lifts by monitoring wellhead parameters
  - Tubing and casing pressure
  - Sales line 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

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

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 1%[1] production increase from avoided venting
- 500 Mcf/year methane emissions savings for average U.S. well

Source: BP

[1] Reported by Weatherford

Methane to Markets

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

Source: BP

Is Recovery Profitable?

- Smart automation controller installed cost: ~US$15,000
  - Conventional plunger lift timer: ~US$7,000
- Personnel savings: double productivity
- Production increases: 10% to 20% increased production
- Production increase from avoided venting: 1%

- Savings =
  (MMBtu/year) x (10% increased prod.) x (gas price)
  \+ (MMBtu/year) x (1% emissions savings) x (gas price)
  \+ (personnel hours/year) x (0.5) x (labor rate)

$ savings per year

Economic Analysis

- Non-discounted savings for average well =

(50,000 MMBtu/year) x (10% incr. prod.) x (US$5/MMBtu)

+ (50,000 MMBtu/year) x (1% emissions savings) x (US$5/MMBtu)

US$27,500 savings / year

- 6.6 months simple payback at US$ 5/MMBtu

Gas Price (US$/MMBtu)	3	5	7
Payback (months)	12.3	8.1	6.1
NPV (US$)	50,077	86,955	123,833

Methane to Markets

BP Experience

- BP's first automation project designed and funded in 2000
- Pilot installations and testing in 2000
  - Installed plunger lifts with automated control systems on ~2,200 wells
  - ~US$15,000 per well Remote Terminal Unit (RTU) installment cost
  - US$50,000 - US$750,000 host system installment cost
- Achieved roughly 50% reduction in venting from 2000 to 2004

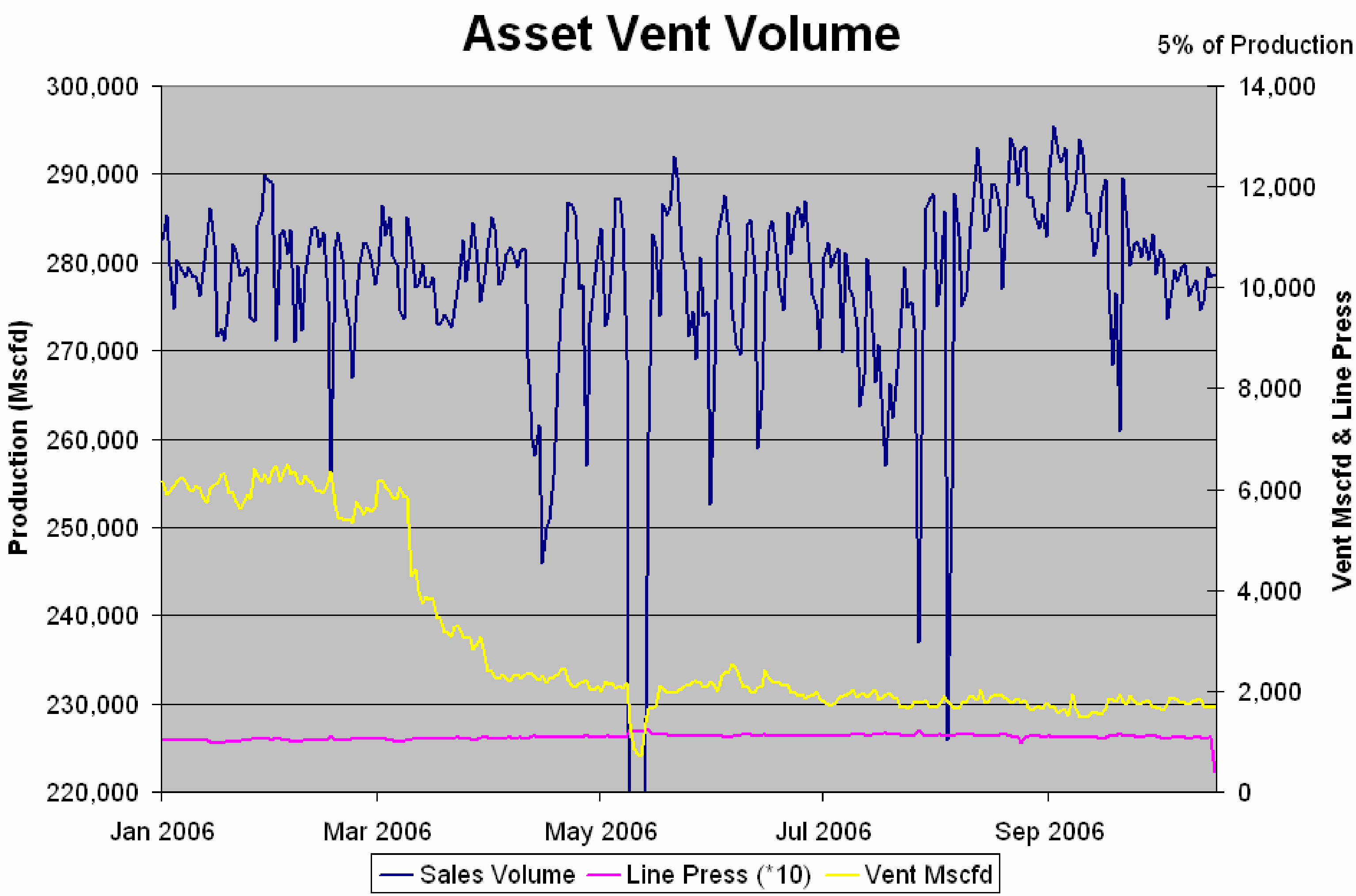
Methane to Markets

BP Experience

- BP designed two pilot studies in 2006 to further improve well scientific control
  - Interviewed control room staff and worked closely with the field automation team leader
  - Established a new procedure based on plunger lift expertise and pilot well analysis
- In mid 2006, "smarter" automation was applied to wells
  - 1,424 Mcf reported annual savings per well
  - Total of 3.1 Bcf/year savings (3,100 Bbtu/year)
  - Worth US$15.5 million/year[1]

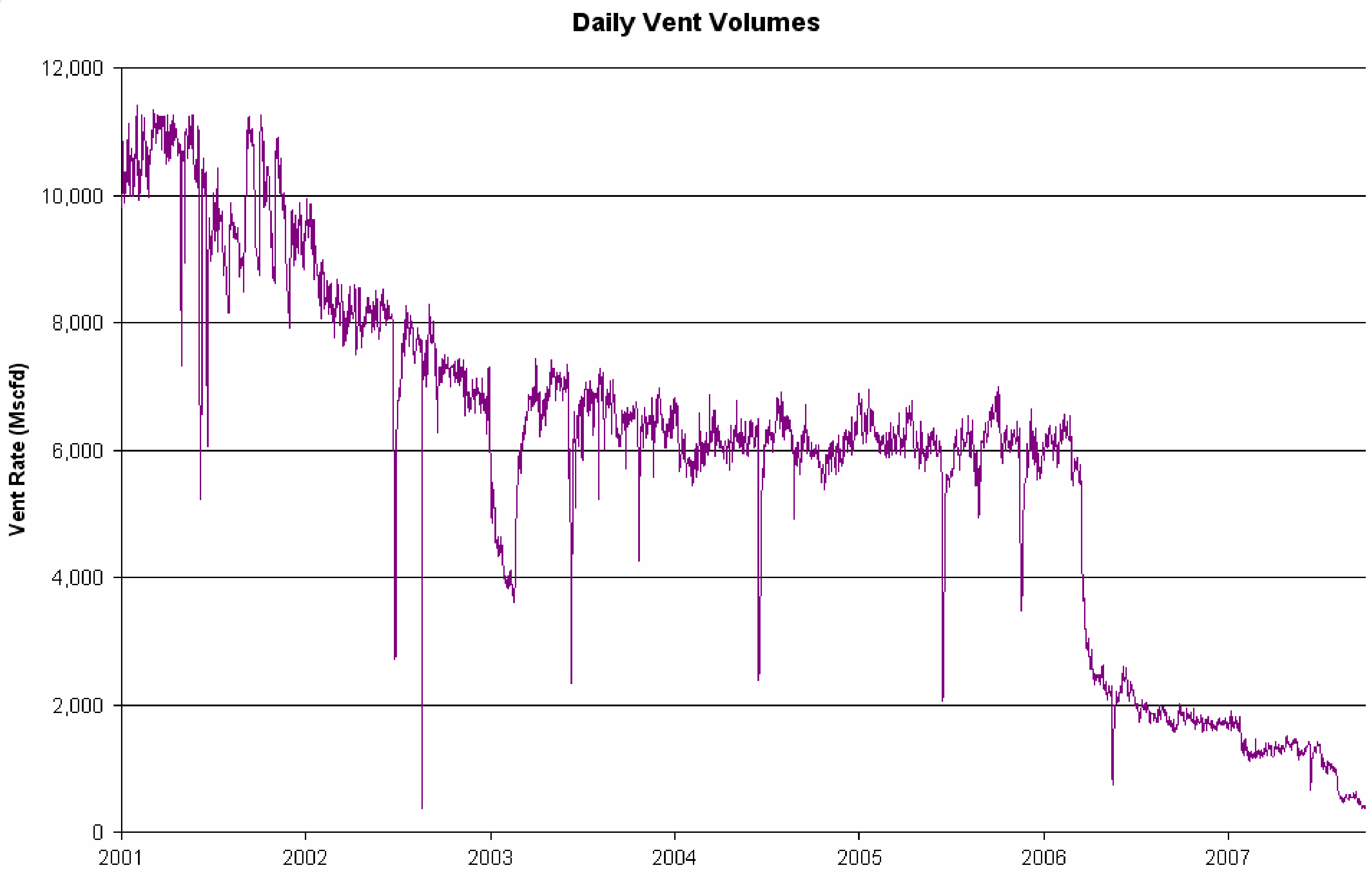
[1] Gas valued at US$5/MMBtu

BP Experience



Methane to Markets

BP Experience



Methane to Markets

Discussion

- Industry experience applying these technologies and practices
- Limitations on application of these technologies and practices
- Actual costs and benefits