Methane to Markets

Reduced Emission Completions / Plunger Lift and Smart Automation

IAPG & US EPA Technology Transfer Workshop

November 5, 2008
Buenos Aires, Argentina

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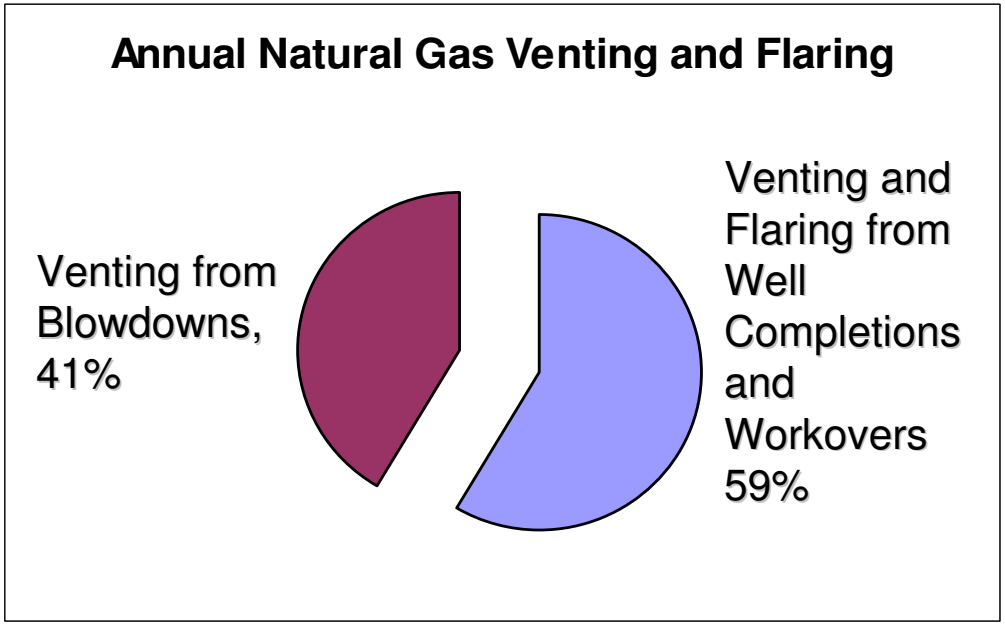
Well Venting Agenda

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

Source: Williams

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

- An estimated 1,27 Bm^3 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*

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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 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 no fire hazard or nuisance

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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

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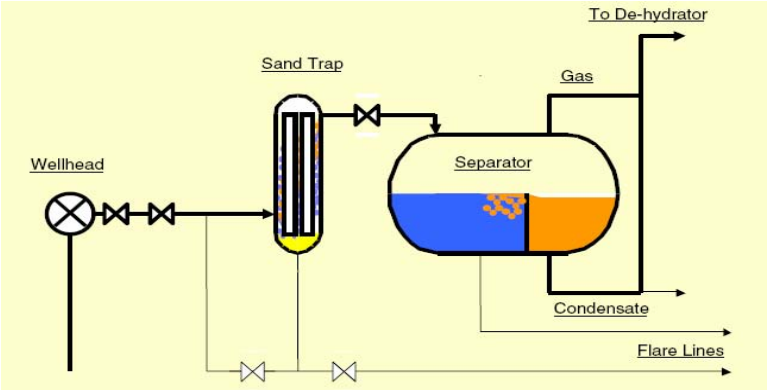
Reduced Emission Completions: Equipment

- 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

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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

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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

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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

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Is Recovery Profitable?

- Partners report recovering 2% - 89% (average of 53%) of total gas produced during well completions and workovers
- Estimate 0,2 – 354 Mm^3 (average of 85 Mm^3) 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

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Anadarko Experience

- Produces gas from “tight” formations in Wyoming, Colorado, and Utah
- 1998 to 2005 implemented conventional completions
  - 421 wells/year completed average
  - 59 MMm^3/year lost average
  - 12 days venting/completion average
- Lost US$33,2 million[1] of gas in 8 years
  - US$4,1 million/year average

[1] Gas valued at US$70,63/Mm^3

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Anadarko Experience

- In 2006 started implementing RECs
- 2006 to 2008 RECs:
  - 613 wells/year completed
  - Net savings: 58 MMm^3/year
    - Despite 45% increase in well completions
  - Less than 2 *hours* venting/completion on average
- $4,1 million/year[1] increased revenue

[1] Gas valued at US$70,63/Mm^3

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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 337 Mm^3 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$23.800 per well at Argentina gas price[1]
- Expected emission reductions of 43 to 57 MMm^3 per year moving forward

[1] Gas valued at US$70,63/$Mm^3$

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Williams Experience

- Implemented 1.064 completions with flowback from 2002 through 2006
- Total implementation cost: US$17,41 million
- Recovered a total of 671 MMm^3
  - Equal to 91,1% recovery
  - Worth US$47,4 million at Argentina gas value[1]

[1] Gas valued at US$70,63/$Mm^3$

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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?

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Liquid Unloading

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

Source: BP

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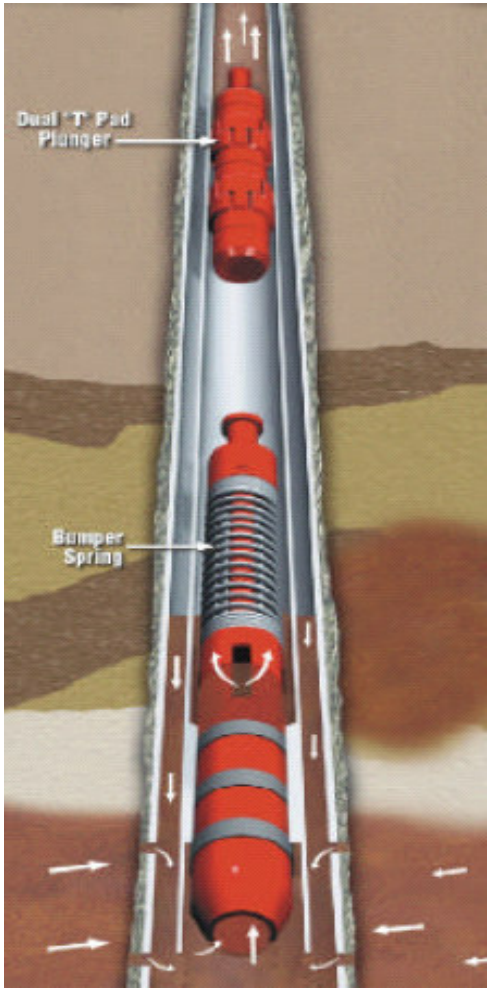
Plunger lift recovers liquids with less gas venting

- 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

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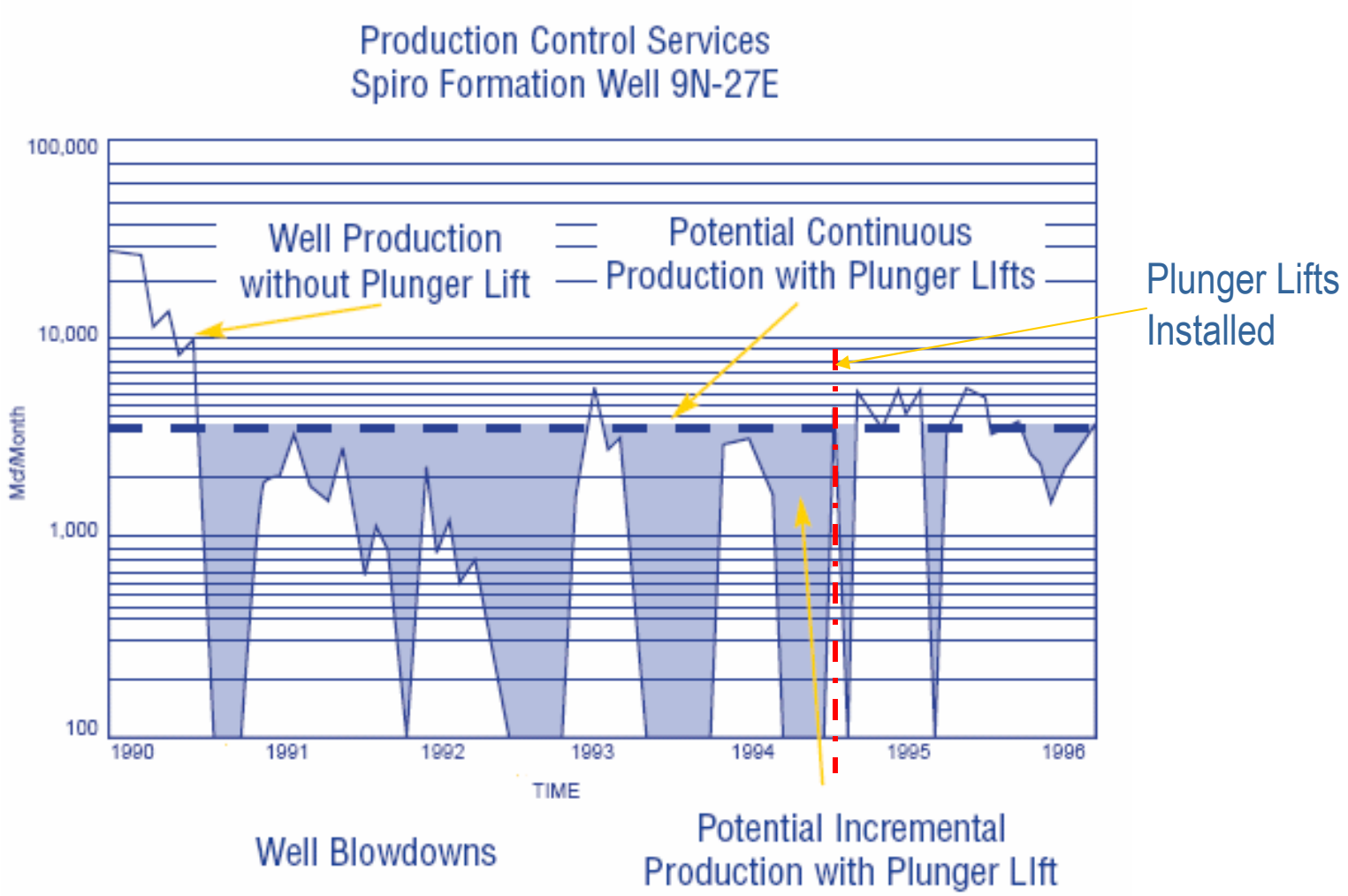
Plunger Lift Cycle



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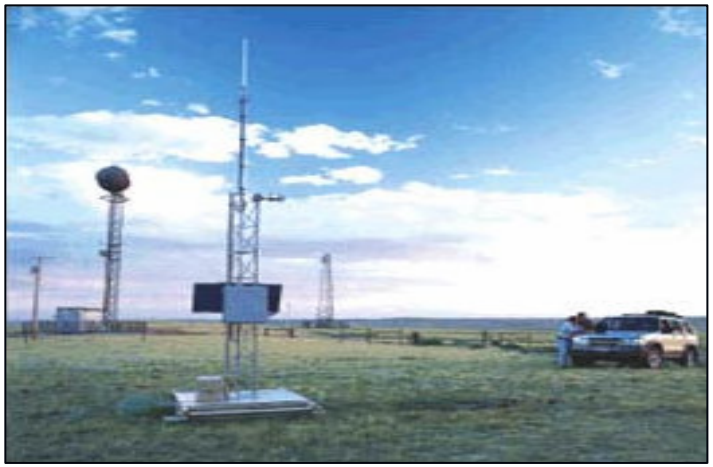
What is the problem?

- 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

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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

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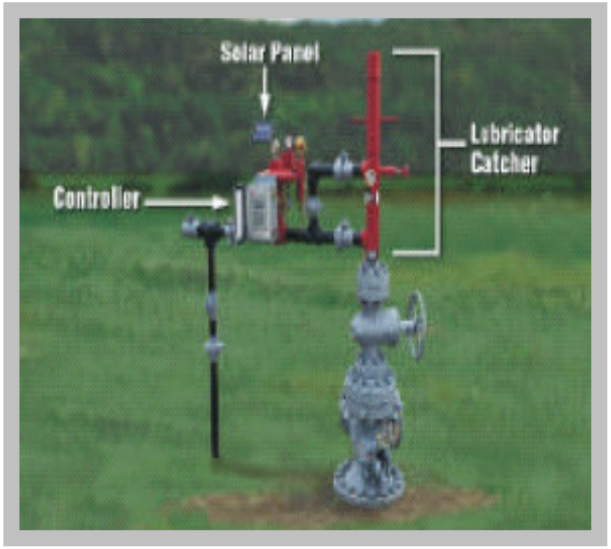
Automated Controllers



- Low-voltage; solar recharged battery power
- Monitor well parameters
- Adjust plunger cycling

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- Remote well management
  - Continuous data logging
  - Remote data transmission
  - Receive remote instructions
  - Monitor other equipment

Source: Weatherford

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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
- 14 Mm^3/year methane emissions savings for average U.S. well

Source: BP

1 - Reported by Weatherford

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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

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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 =
  (Mm^3/year) x (10% increased prod.) x (gas price)
  + (Mm^3/year) x (1% emissions savings) x (gas price)
  + (personnel hours/year) x (0.5) x (labor rate)

$ savings per year

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Economic Analysis

- Non-discounted savings for average well =

(1.416 Mm^3/year) x (10% incr. prod.) x (US$70,63/$Mm^3$)

+ (1.416 Mm^3/year) x (1% emissions savings) x (US$70,63/$Mm^3$)

US$11.000 savings / year

- 16.5 months simple payback at Argentina gas price

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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

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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
  - 40 Mm^3 reported annual savings per well
  - Total of 88 MMm^3/year savings
  - Worth US$6,2 million/year

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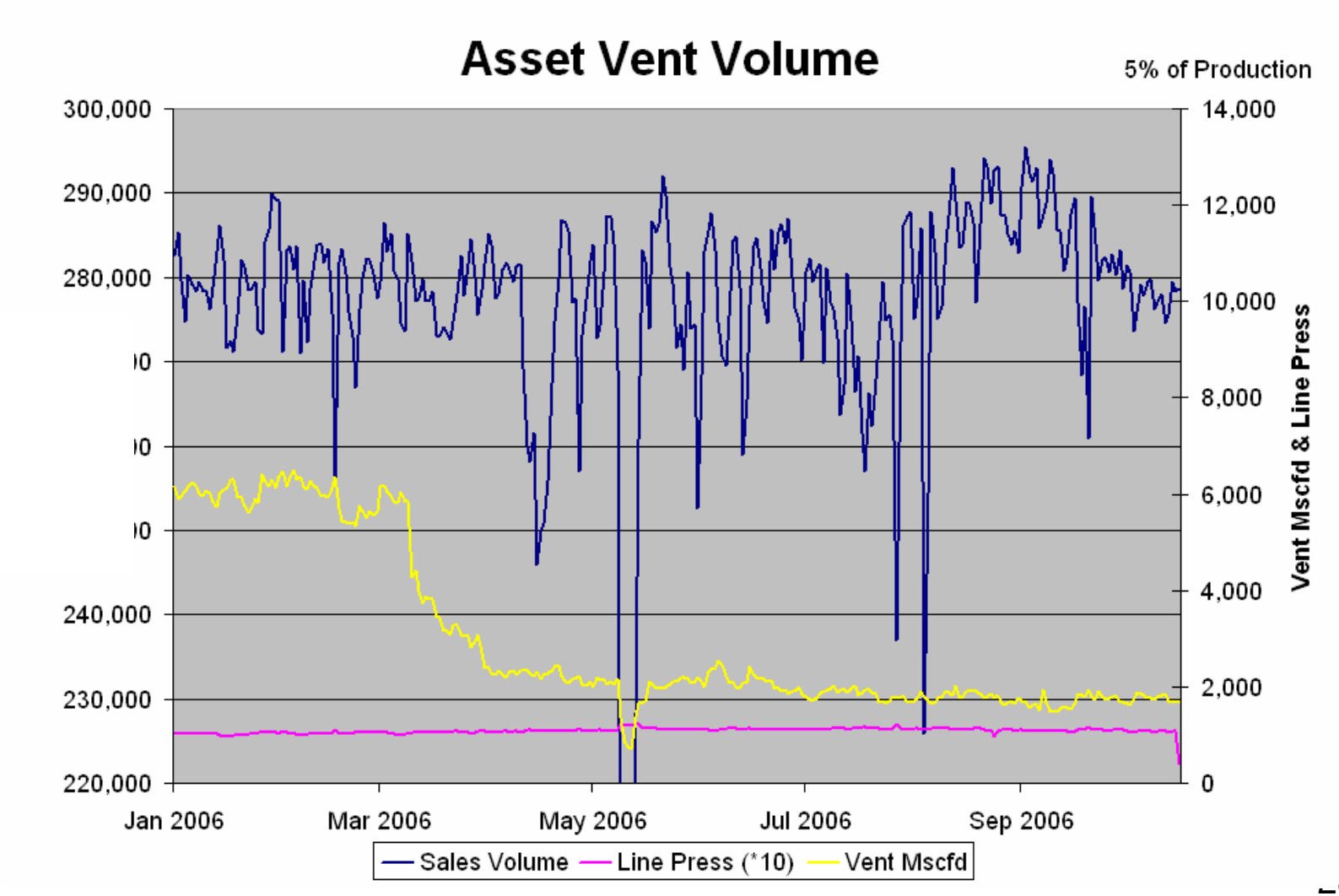

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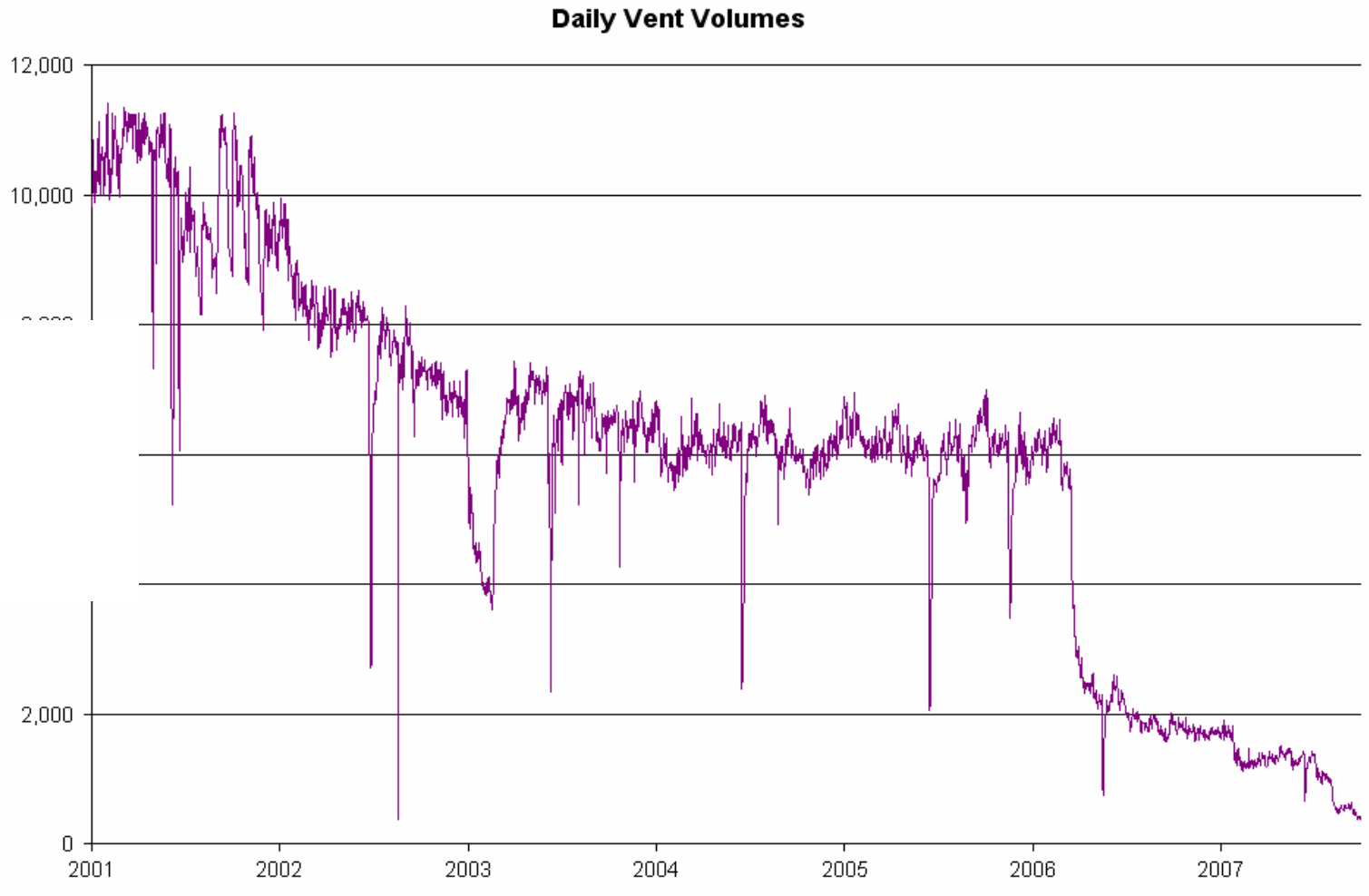

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Discussion

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