Reducing Methane Emissions from Natural Gas Production: Reduced Emission Completions in Gas Wells and Smart Automation of Gas Well Plunger Lifts

Methane to Markets Partnership Expo

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ICF International

Agenda

- **Reduced Emissions Completions**
  - Methane Losses
  - Methane Recovery
  - Is Recovery Profitable?
  - Partner Experience
- Plunger Lift and Smart Automation
- Contacts

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 workovers
- Operators produce to an open pit or tank to collect sand, cuttings, and fluids for disposal
- Vent or flare the natural gas produced
- Methane emissions from well completions and workovers are estimated to be as high as 800 million cubic meters per year in the U.S.[1]

Williams E&P, Glenwood Springs, CO

1 - Revised Natural Gas STAR Program emissions estimate.

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

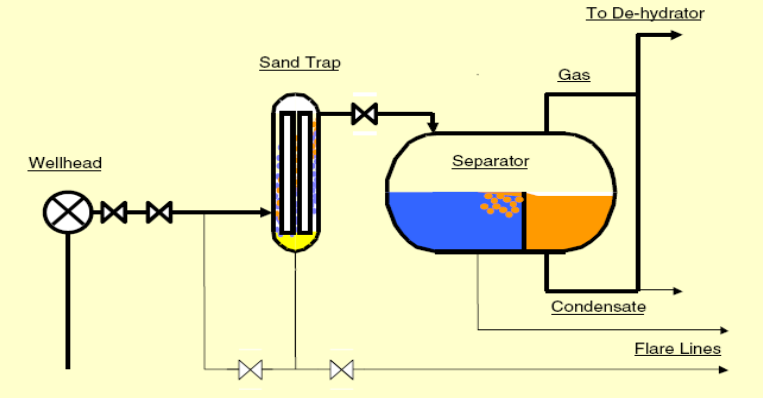
Source: Weatherford

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 low
  - Artificial gas lift to clear fluids
  - Boost gas to sales line
  - Manage slug flow
  - Adds cost to project

Is Recovery Profitable?

- Partners report recovering 2% - 89% (average of 53%) of total gas produced during well completions and workovers
- Estimate 200 – 350 thousand cubic meters (Mcm) of natural gas can be recovered from each cleanup
  - $21,000 to $37,000 savings per completion at $106/Mcm ($3/Mcf)
- Estimate 1 – 580 barrels of condensate can be recovered from each cleanup
  - $50 - $30,000 additional revenue at $50/barrel
- Incremental contracted cost of typical REC is $700 to $6,500/day for 3 to 10 days of well cleanup
- Purchase of REC equipment costs $500,000
  - Payback in 6 to 16 months for 25 well/year drilling program

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- **Plunger Lift and Smart Automation**
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Methane Emissions from Liquid Unloading in Gas Wells

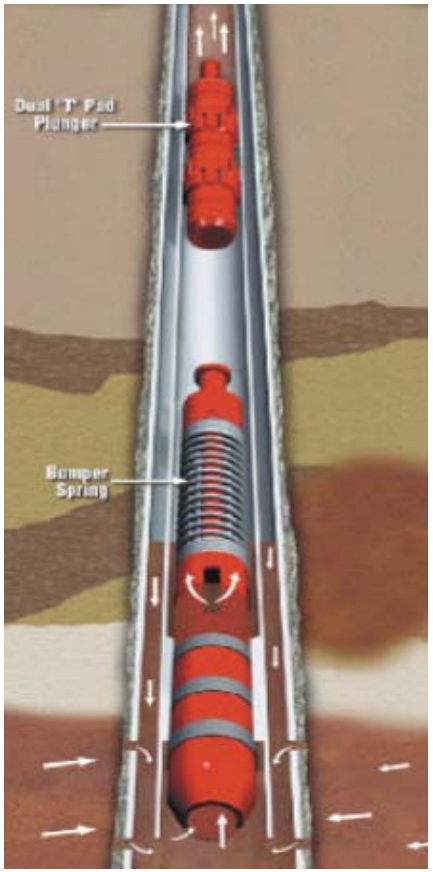
- Completion venting is not the only type of well venting
- Accumulation of liquid hydrocarbons or water in the well tubing reduces, and can halt, production
- Operators traditionally blew wells to atmosphere to expel liquids
- 1.8 billion cubic meters of methane emissions from gas well liquid unloading in the U.S.[1]

Source: BP

1 - Revised Natural Gas STAR Program emissions estimate.

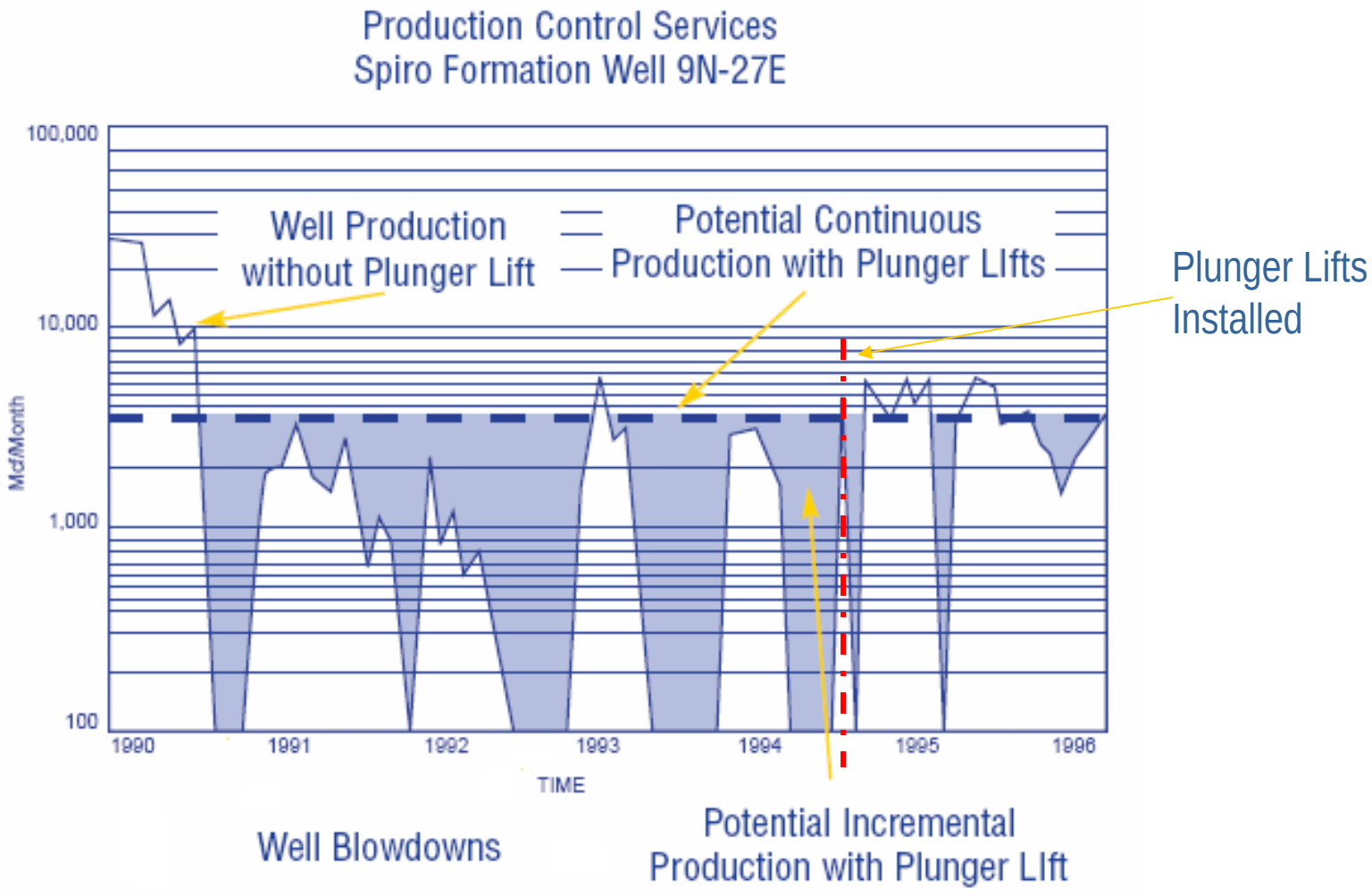
Methane Reductions from Plunger Lifts

- Plunger lifts automatically produce liquids without blowing the well to the atmosphere
- Shut-in gas pressure stored in the casing annulus periodically pushes the plunger and liquid load from the well bottom to surface separator
- Wells with the right combination of shut-in pressure, depth and liquid accumulation are kept productive with less operator attention



Source: Weatherford

The Real Benefit is Increased Production



Is Recovery Profitable?

- Partners report annual gas savings of $90,000 to $130,000[1] per well by the installation of plunger lifts
- Estimate 130 – 520 Mcm per well of natural gas can be recovered by the installation of plunger lifts
  - $14,000 to $56,000 savings at $106/Mcm ($3/Mcf)
- Benefits from both increased gas production and emissions savings are well and reservoir specific and vary considerably
- Cost of implementation ranges from $2,600 to $10,000 per well
- Purchase of plunger lifts costs about $8,000[1]
  - Payback in 2 to 14 months for incremental gas production ranging from 850 m^3/day to 85 m^3/day

Gas Price (U.S.$/Mcm)	$106	$177	$247
Payback (months)	2.8	1.9	1.5
NPV (U.S.$)	120,630	176,157	231,684

1 - EPA Lessons Learned 2006, “Installing plunger lift systems in gas wells.”

Smart Automation Well Venting

- Automation can enhance the performance of plunger lifts by monitoring wellhead parameters
  - Tubing and casing pressure
  - Reservoir pressure recovery time
  - 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

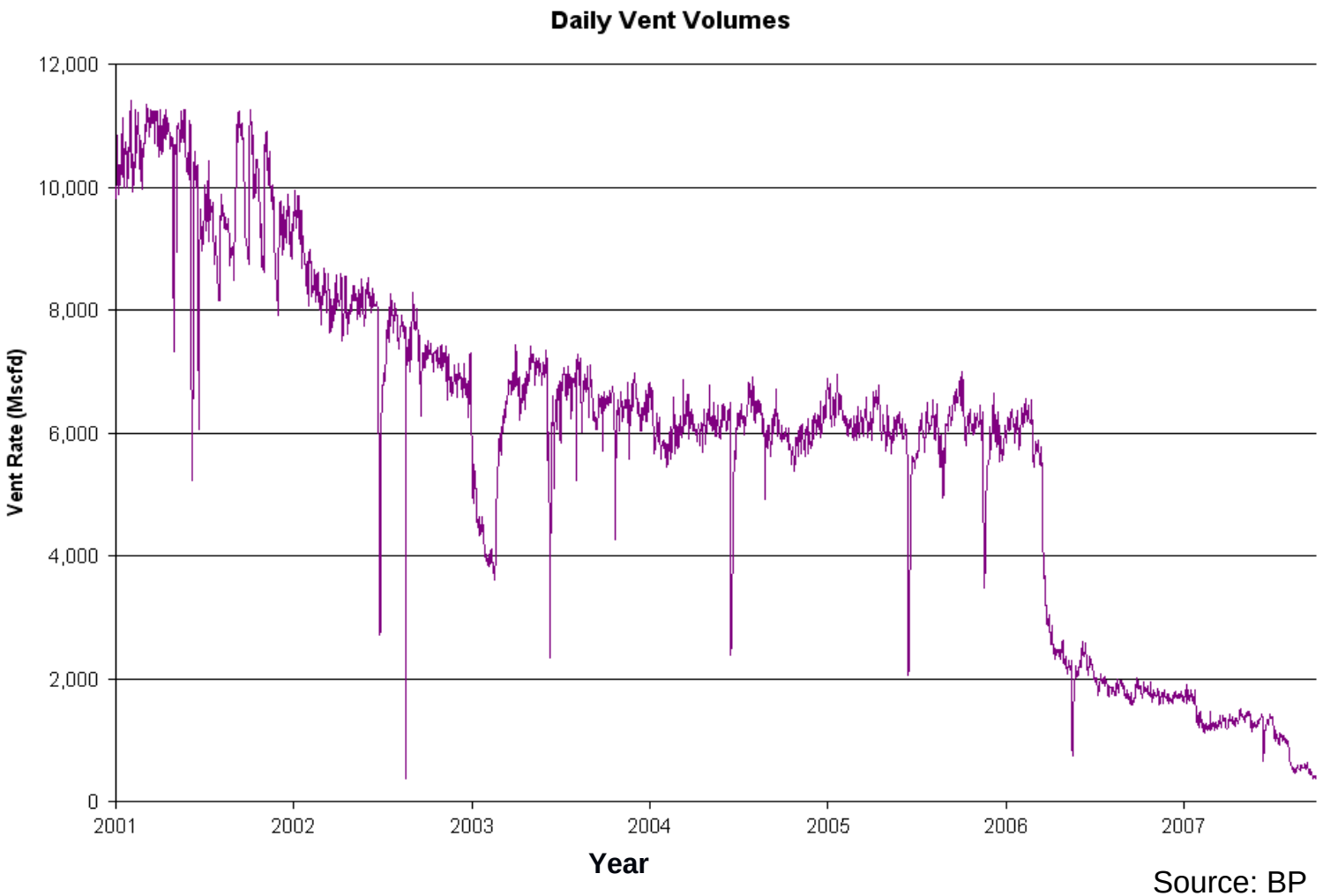
Methane to Markets

Smart Automation Partner Experience: BP

- 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
  - ~$15,000 per well Remote Terminal Unit (RTU) installment cost
  - $50,000 - $750,000 host system installment cost
- Achieved roughly 50% reduction in venting from 2000 to 2004

Methane to Markets

Smart Automation Partner Experience: BP



Source: BP

Is Recovery Profitable?

- Estimate 180 – 700 Mcm per well of natural gas can be recovered by the installation of smart automation
  - $19,000 to $74,000 savings at $106/Mcm ($3/Mcf)
- Benefits from significant reductions in gas venting volumes along with production improvements
- Automation System can be installed at a cost of less than $12,000 per well
  - Payback in 1 to 3 years

Gas Price (U.S.$/Mcm)	$106	$177	$247
Payback (months)	16	10	7
NPV (U.S.$)	40,548	82,247	123,945

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