Opportunities for Methane Emissions Reductions in Natural Gas Production

Ministerio de Minas y Energia
Ministerio de Ambiente, Vivienda y Desarrollo Territorial
Occidental Oil & Gas Corporation and
Environmental Protection Agency, USA

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Methane Emissions Reductions: Agenda

- South American Oil and Natural Gas Industry Overview
  - **Roger Fernandez, U.S. EPA**
- Reduced Emission Completions (Green Completions)
  - **Gerald Alberts, Williams**
- Smart-Well Automation
  - **Don Robinson, ICF Consulting**
- Discussion Questions

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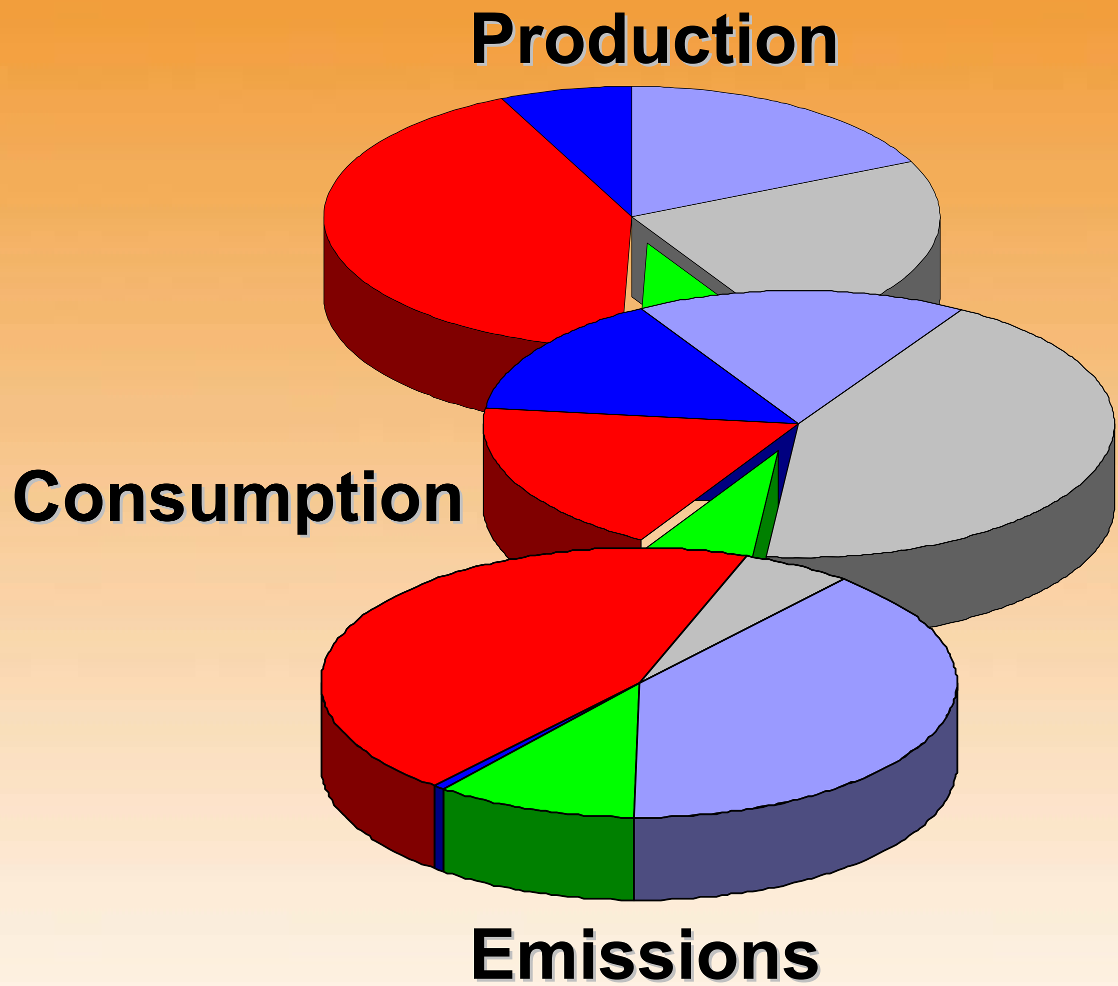
South American Oil and Natural Gas Industry Overview

Agenda

- South American Oil and Gas Statistics
- Columbian Methane Emissions
- Major Emission Sources
- Emission Reduction Opportunities



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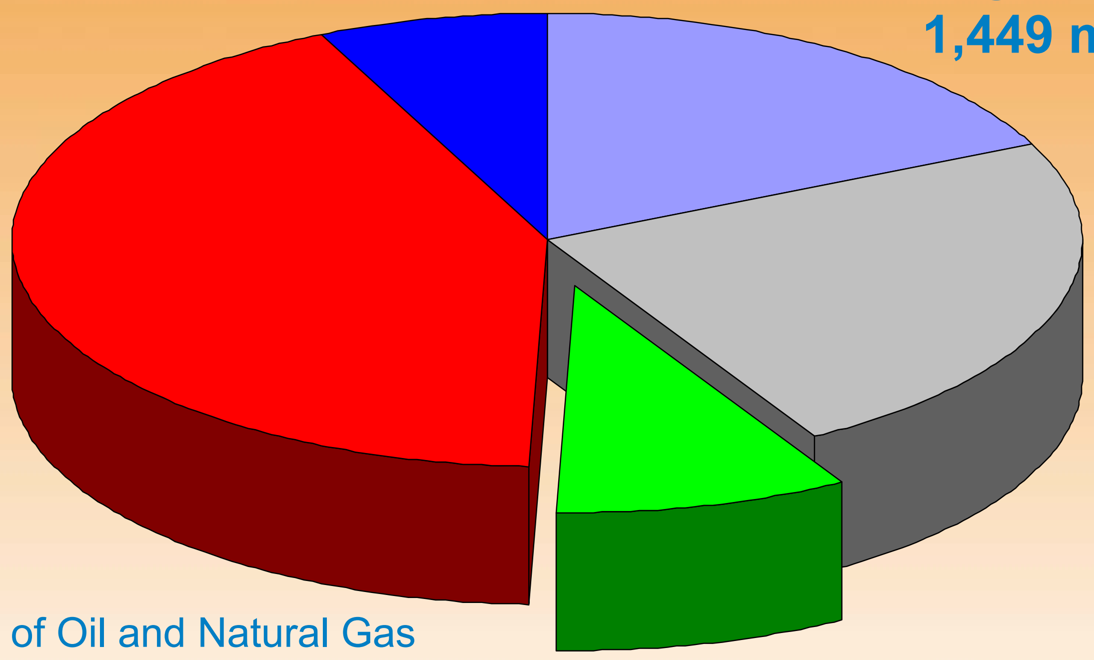
South American Oil and Gas Statistics: Production

- Colombia represents 9% of South American production



Inventory of Oil and Natural Gas provided by Energy Information Administration (EIA)

mboe/d = 1000 barrels of oil equivalent per day

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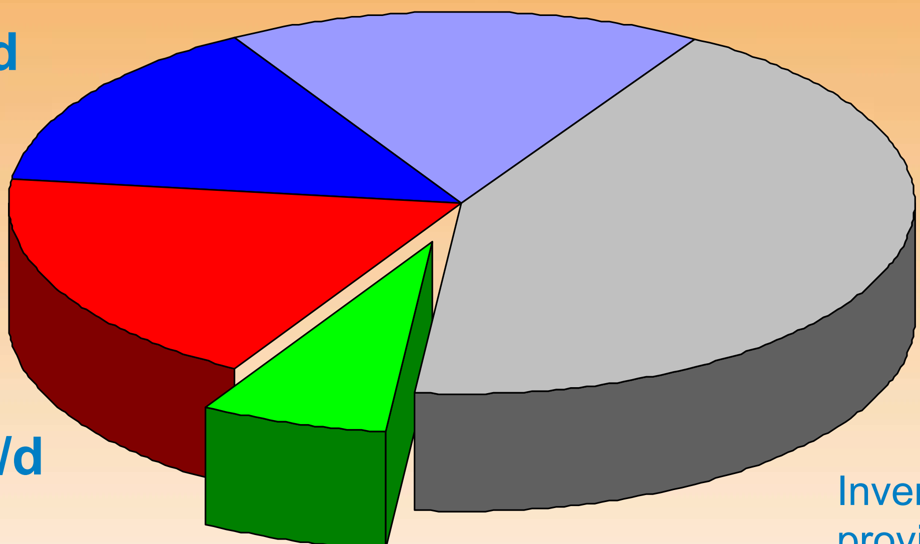
South American Oil and Gas Statistics: Consumption

- Colombia represents 7% of South American consumption



Inventory of Oil and Natural Gas provided by Energy Information Administration (EIA)

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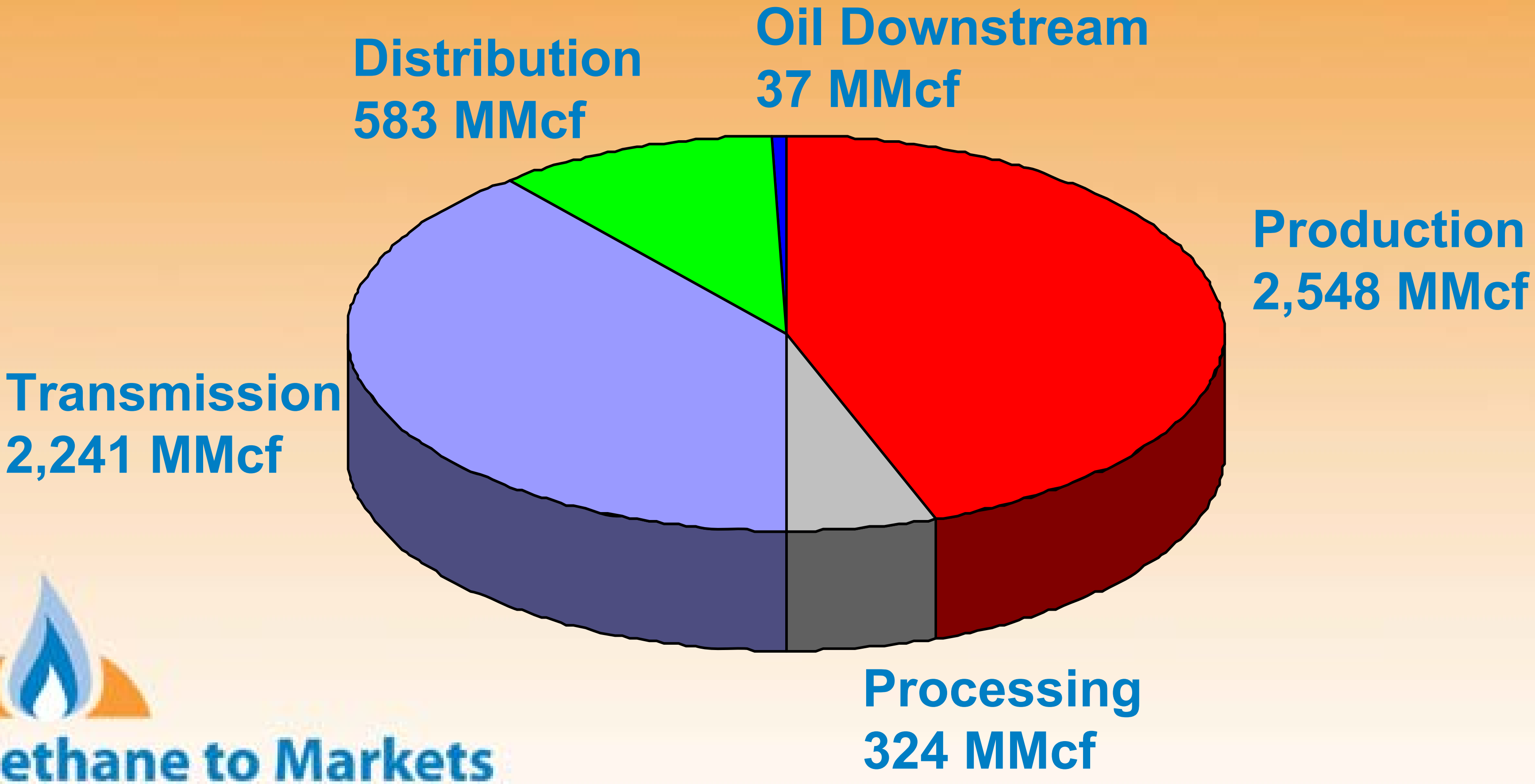
Colombian Methane Emissions Estimates

- Oil and gas production contribute 44% of methane emissions



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Major Emissions Sources

Production	% of Total Sector Emissions	Transmission	% of Total Sector Emissions
Pneumatic Devices	41%	Reciprocating Compressors	42%
Well Venting and Flaring	12%	Pneumatic Devices	11%
Dehydrators and Pumps	9%	Engines	11%
Gas Engine Exhaust	8%	Centrifugal Compressors	8%

Processing	% of Total Sector Emissions	Distribution	% of Total Sector Emissions
Reciprocating Compressors	48%	M&R Stations	25%
Engines	20%	Unprotected Steel Mains/Services	18%
Centrifugal Compressors	16%	Regulators	16%
Blowdowns	6%	Cast Iron Mains	12%

Inventory of US Greenhouse Gas Emissions and Sinks, 1990 - 2003

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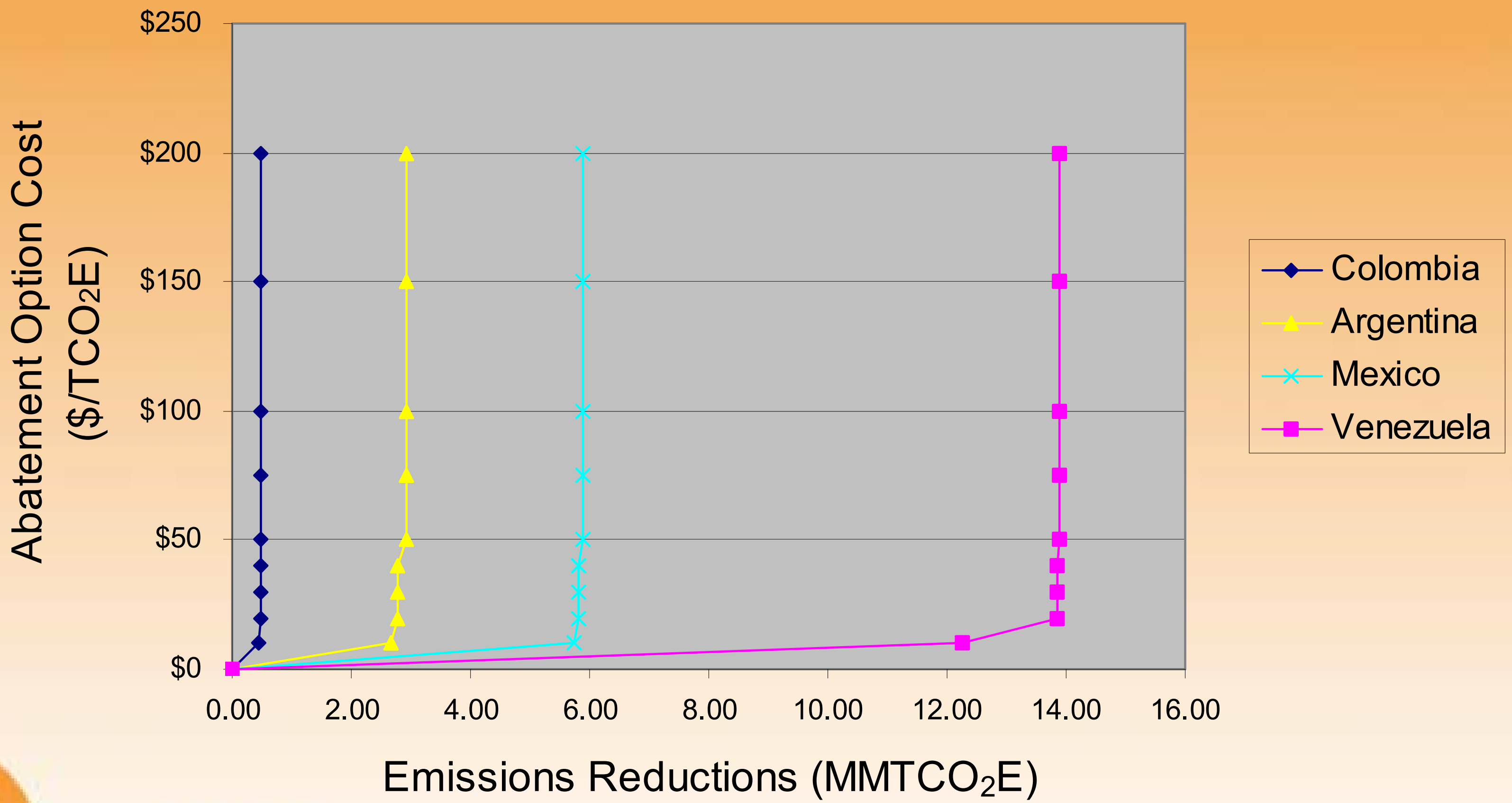
South American Emission Reduction Opportunities

- Significant emissions reductions can be achieved at low cost



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Reduced Emission Completions (Green Completions)

Agenda

- Green Completions
- Flowback Skids
- Piceance Well Completions
- Green Completion Economics
- Conclusion

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Green Completions

- Technology used to recover gas that is otherwise vented or flared during the completion phase of natural gas well
- At Williams, Green Completion technology is a flowback separator skid leased from Breco
- Flowback skids used to separate sand, water and gas

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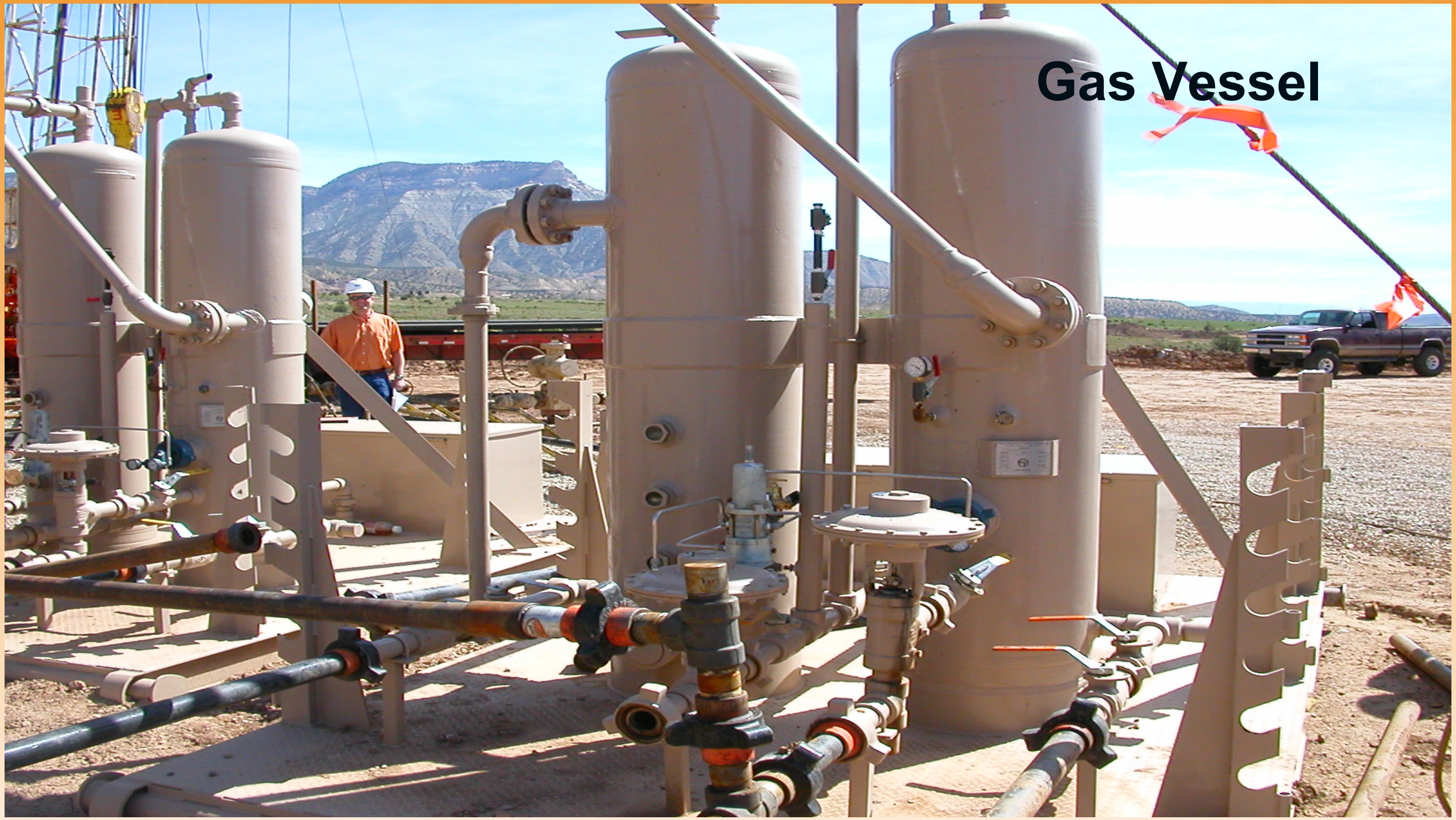
Breco Flowback Skid

Sand Vessel



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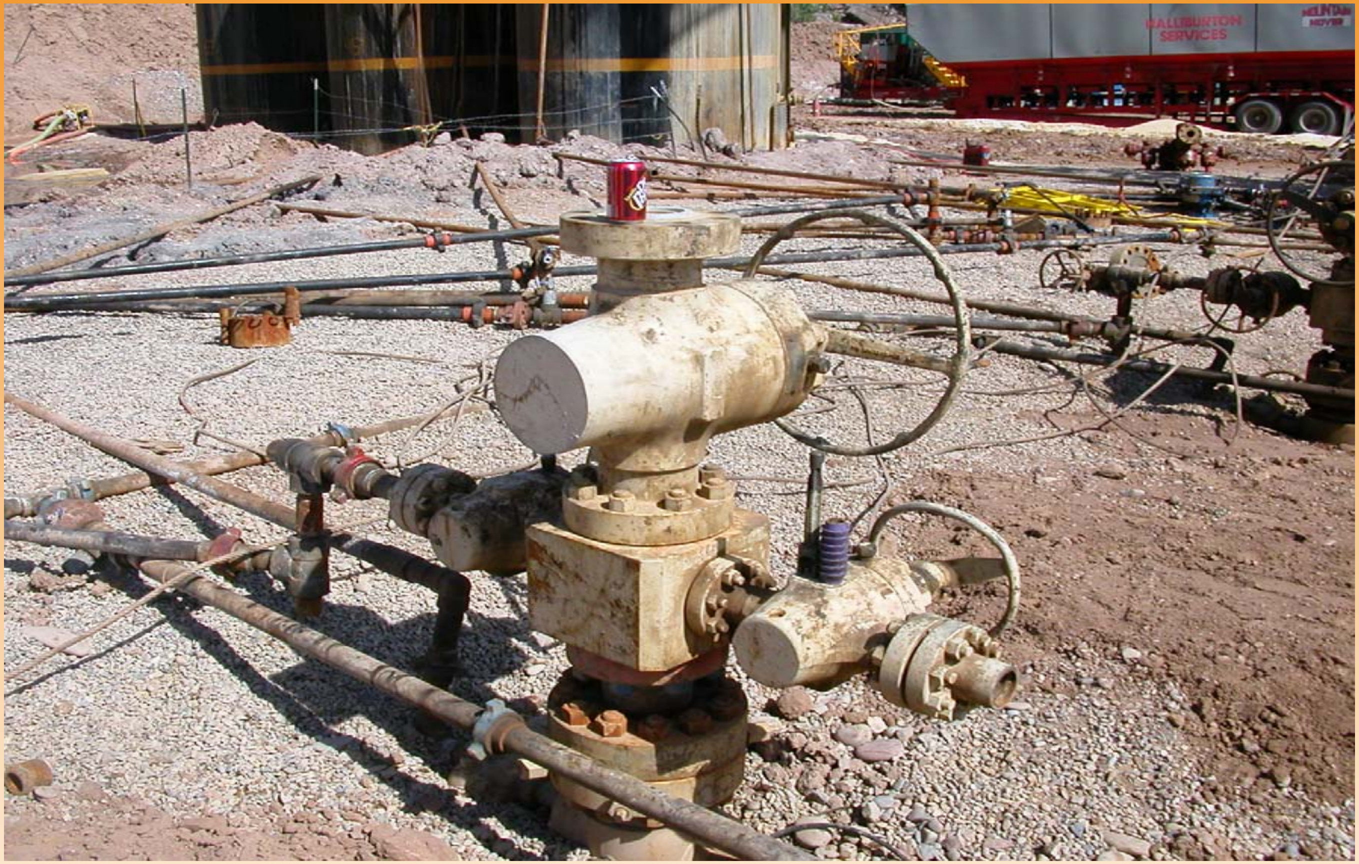
Flowback Skid – When Is It Used?

- Used after each zone is facture stimulated (frac'd)
- Used when all zones are fractured and waiting for workover rig to drill out plugs for final completion (Up to 10 days)
- When production well is located near gathering system
- Wildcat and step-out wells are not completed with green completion technology
- One Month = time wells at typical 4-well pad are routed to flowback skid

Flowback Skid - Operation

- Sand Vessel separates sand from field gas
- Gas Vessel separates gas from water used for hydrologic frac'ing
  - **Gas routed to sales line**
- Sand dumps to drill pit manually
- Water dumps to media tanks automatically
  - **Water is filtered and reused for future frac jobs**
- Flowback skid operates at 20 to 40 psi greater than gas gathering line pressure which is about 260 to 320 psi in Piceance Basin

Flowback Skid – Wellhead Equipment



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Flowback Skid – Drilling Pit and Water Tanks

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Piceance Well Completions

Well Completion Type = Mechanical Isolation

- Perforate casing prior to Stage 1 – makes fracture stimulation possible
- Frac Stage 1
- Flowback well, first 12 hrs water, afterwards routed to Breco skid
- Set plug to isolate frac stage
- REPEAT for each stage (avg. 5 to 6 stages/well)
- Plugs drilled out by Workover Rig
- Producing to flowback skid during time after fracing and before plugs drilled out

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Piceance Well Completions

- Williams Fork formation – low permeability tight lenticular sandstone (10% porosity, permeability range of 0.001 md to 0.0100 md)
- Wells drilled to avg depth 6,500 ft to 9,000 ft
- Flow pressures range from 1,500 to 2,500 psi
- Fracture stimulation needed to make well economical
- Frac about 5 to 6 stages per well
- 32 = Average number of days each well on Breco Flowback Skid for typical 4 well pad

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Piceance Well Completions

Risks Associated with Green Completions

1 – Wellbore/Reservoir Risk

- Fluids pumped downhole must be recovered as quickly as possible
- Flowing fluids to flowback skid results in decreased flowback rates
- Wellbore damage by fluids can diminish production

2 – Operational Risk

- When plugs drilled out well flows to remove cuttings and reduce head pressure
- Flowing to Breco skid increases backpressure/decreases flow

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Piceance Well Completions

Risks Associated with Green Completions, con't

3 – Safety

- Flowing gas, condensate, water, and sand during completion cause pipe and vessel washouts
- Elbows reinforced with high strength metal
- Breco person visits each location every 1 to 1.5 hrs to catch leaks before they become washouts

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Flowback Skid – Washout Safety Feature

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Flowback Skid - Safety

Green Completion Economics

Year	Total Number of Well Spuds	No. of Spuds Not Completed or Completed Without Flowback*	Actual Number of Flowback Completions	Actual Completion Gas Generated (MMscf)	Actual Completion Gas Vented/Flared (MMscf)	Flowback Gas Recovered (MMscf)	Flowback Gas Recovered (%)
2002	75	14	61	599	112	487	81.3
2003	80	9	71	1348	152	1196	88.8
2004	253	34	219	5635	757	4878	86.6
2005	134	1	133	2864	21	2843	99.3
Total	**542**	**58**	**484**	**10445**	**1042**	**9403**	**90.0**

Flowback Revenue/Cost Analysis							
Year	Total Revenue (MM$)	Recovery Cost (MM$)	Net Savings (MM$)	Actual Methane Generated (MMscf)	Flowback Methane Recovered (MMscf)	Potential Methane Flared (MMscf)	Potential Methane Vented (MMscf)
2002	1.28	.22	1.06	533	434	89	11
2003	6.32	.89	5.43	1200	1065	1200	15
2004	27.87	2.85	25.02	5017	4343	600	74
2005	10.97	2.84	8.13	2550	2531	17	2
Total	**46.45**	**6.80**	**39.65**	**9301**	**8373**	**826**	**102**

*Newly drilled wells may not have been completed at the time of this report. These will be reconciled during the 1st quarter each year. It is estimated that greater than 99% of all well spuds are completed using the flowback recovery unit.

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Green Completion Economics continued

AVERAGE PER WELL FLOWBACK STATISTICS	
Average Number of Days of Flowback =	32
Average MMscf Gas Recovered During Flowback =	22.3
Average MMscf Gas Flowback Recovered/Day =	0.69
Average Revenue Per Flowback ($) =	$109,967
Average Cost Per Flowback ($) =	$ 16.015
Average Net Saving Per Flowback ($) =	$ 94, 474
CH_4 recovered in 2004 =	4,343 MMscf

Estimated Mean Methane Concentration Gas: 89.043 vol. %

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Conclusion

- Reduce methane emissions, a potent GHG
- Well completion type determines viability of green completion technologies
- Produced water and stimulation fluids from green completions are recycled
- Eliminate citizen complaints associated with flaring
- Increase Economic Value Added

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Smart-Well Automation

Agenda

- Methane Losses
- Methane Recovery
- Methane Savings
- Is Recovery Profitable?

Source: Weatherford

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Methane Losses from Plunger Lifts

- 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**
    - **Gas slippage around plunger and fluid (waste of motive energy)**

Source: Weatherford

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Conventional Plunger Lift Operations

- Manual, on-site adjustments tuned plunger cycle time to well's parameters
  - **Not performed regularly**
  - **Do not account for gathering line pressure fluctuations, declining wells, plunger wear**
- Manual vent to atmosphere when plunger lift is overloaded

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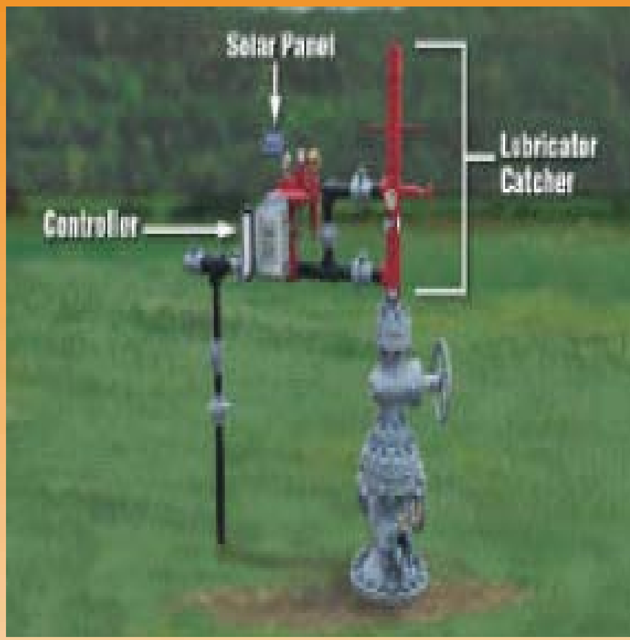
Methane Recovery from Smart-Well Automation

- Smart automation continuously varies plunger cycling 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 and battery powered
- Monitor well parameters
- Adjust plunger cycling

- Remote well management
  - **Continuous data logging**
  - **Remote data transmission**
  - **Receive remote instructions**

Source: Weatherford

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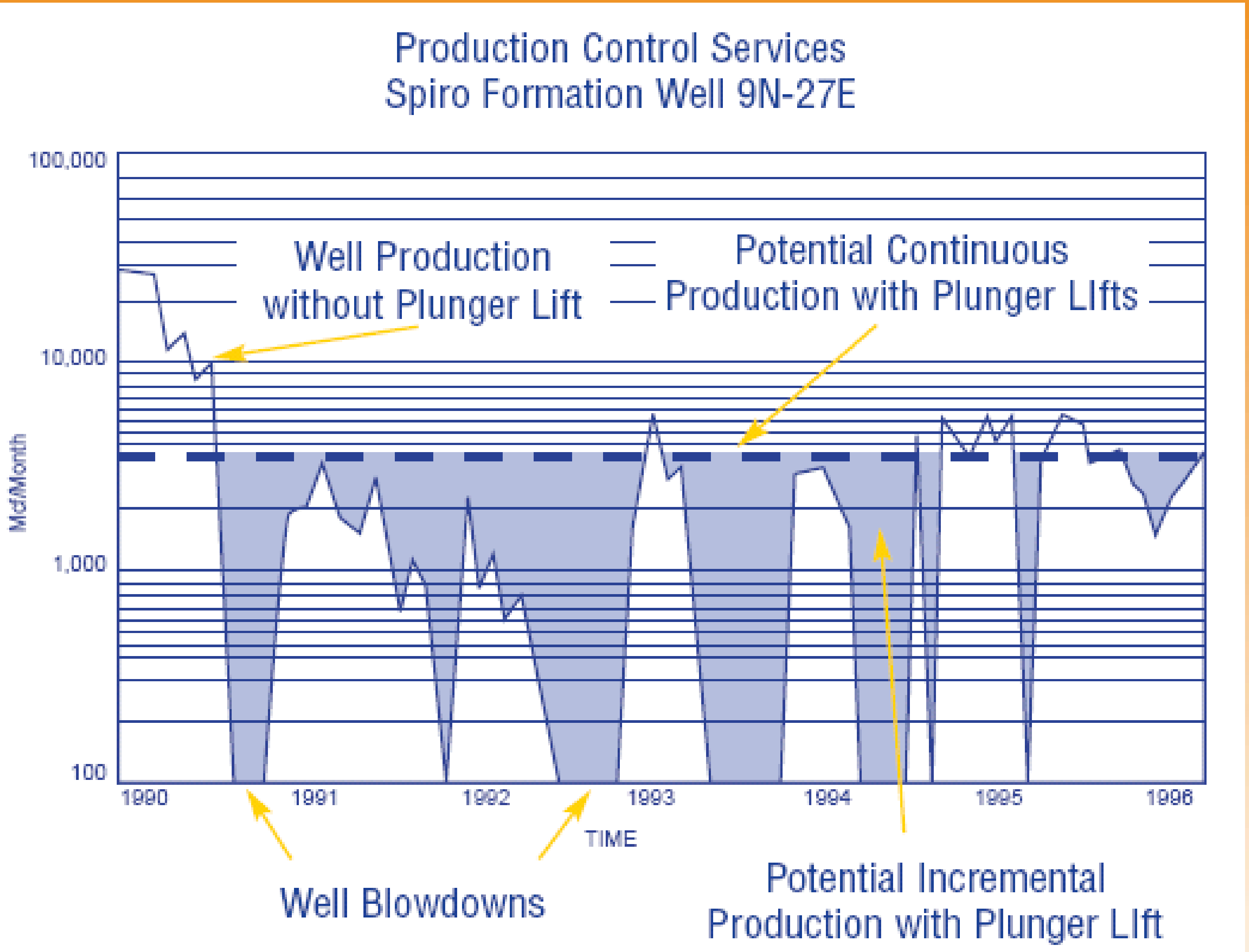
Plunger Lift Cycle



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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 10%[1] production increase from avoided venting**
- 500 Mcf/yr emissions savings for average well

[1]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**
  - **VRU**

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Is Recovery Profitable?

- Smart automation controller installed cost: ~$15,500
  - Conventional plunger lift timer: ~$7,000
- Personnel savings: double productivity
- Production increases: 10% to 20% increased production
- $ Savings per year =

(Mcf/yr) x (10% increased production) x (gas price)
+ (Mcf/yr) x (1% emissions savings) x (gas price)
+ (personnel hours/yr) x (0.5) x (labor rate)

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Discussion Questions

- To what extent are you implementing these options?
- How could these options be improved upon or altered for use in your operation(s)?
- What are the barriers (technological, economic, lack of information, regulatory, focus, manpower, etc.) that are preventing you from implementing these options?

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