Producer and Processor Partner Reported Opportunities

Lessons Learned from Natural Gas STAR

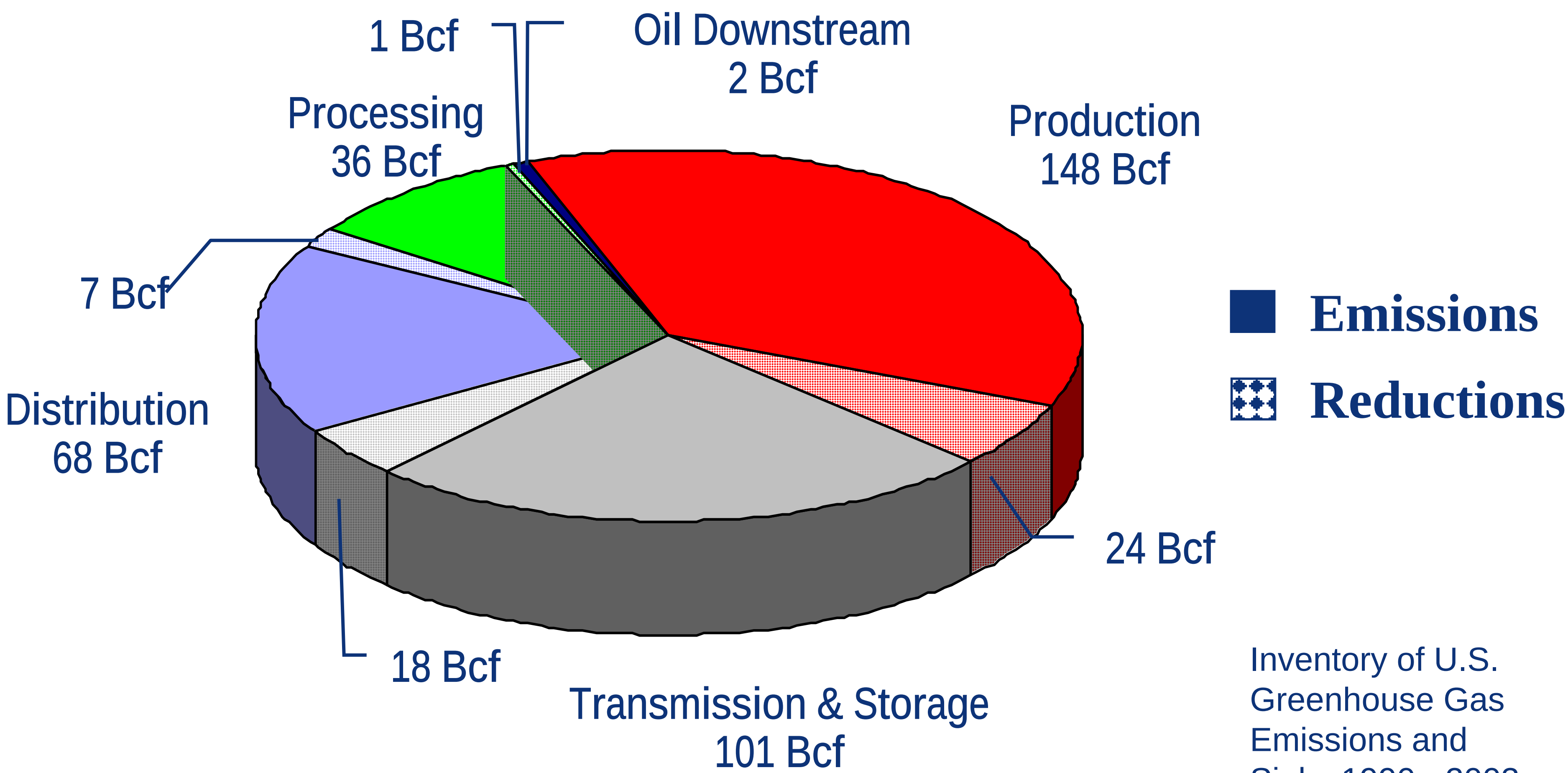
Producers and Processors Technology Transfer Workshop

Western Gas Resources and EPA's Natural Gas STAR Program
Gillette and Rock Springs, WY
May 9 & 11, 2006

Producer and Processor Partner Reported Opportunities : Agenda

- Production Sector Emissions
- Processing Sector Emissions
- Top Partner Reported Opportunities (PROs)
- Gas Prices and Methane Savings
- Other Opportunities
- Discussion Questions

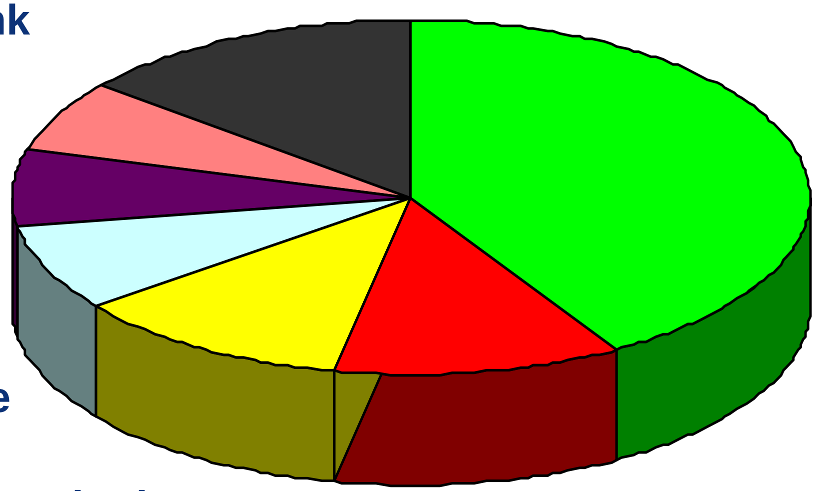
Methane Losses from the Natural Gas Industry



Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2003

Production Sector Emissions

- The production sector has several large methane emission sources that can be targeted for reductions



Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2003

Methane Savings: Vapor Recovery

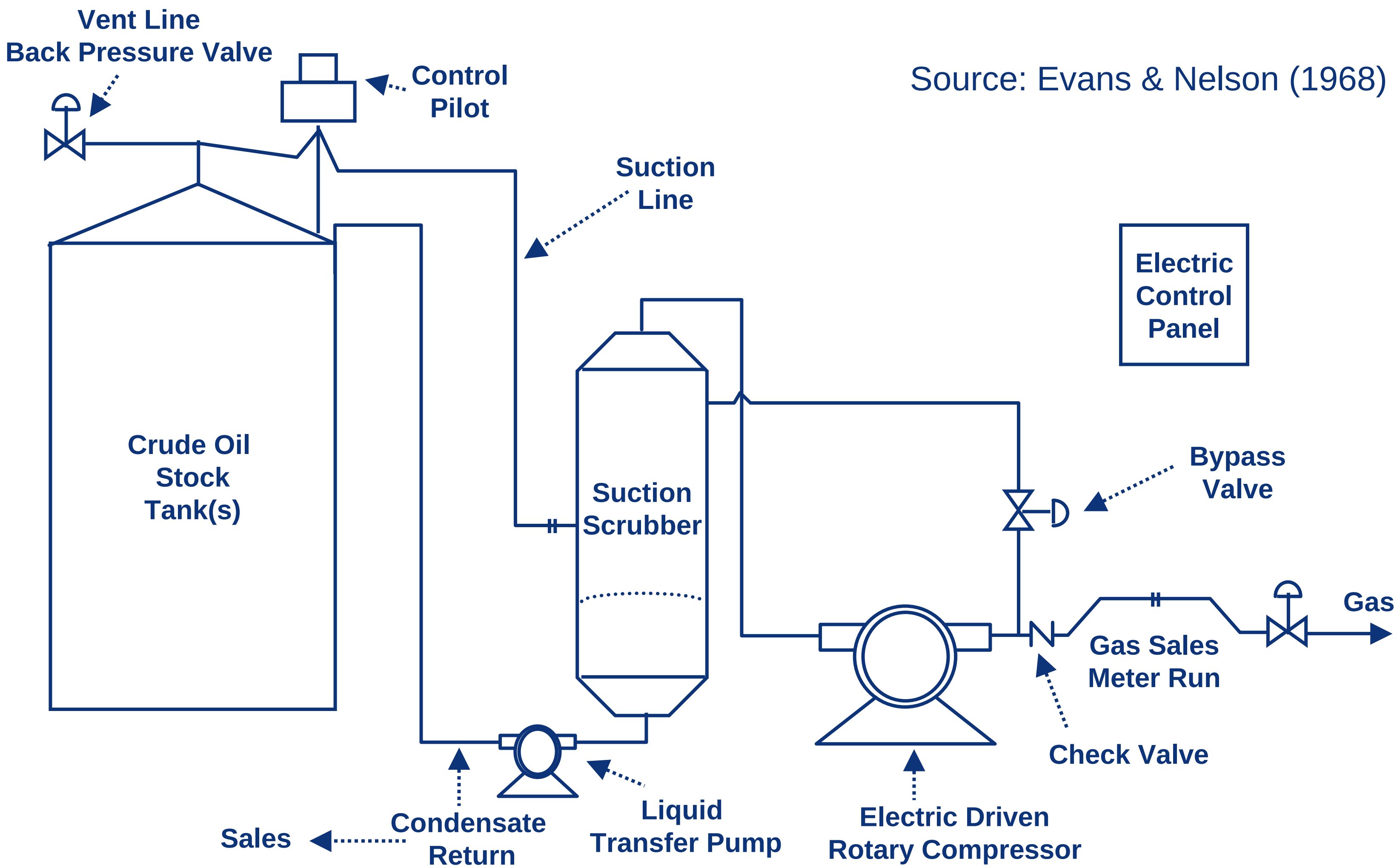
- Vapor recovery can capture up to 95% of hydrocarbon vapors from tanks
- Recovered vapors have higher heat content than pipeline quality natural gas
- Recovered vapors are more valuable than natural gas and have multiple uses
  - Re-inject into sales pipeline
  - Use as on-site fuel
  - Send to processing plants for recovering valuable natural gas liquids

Types of Vapor Recovery Units

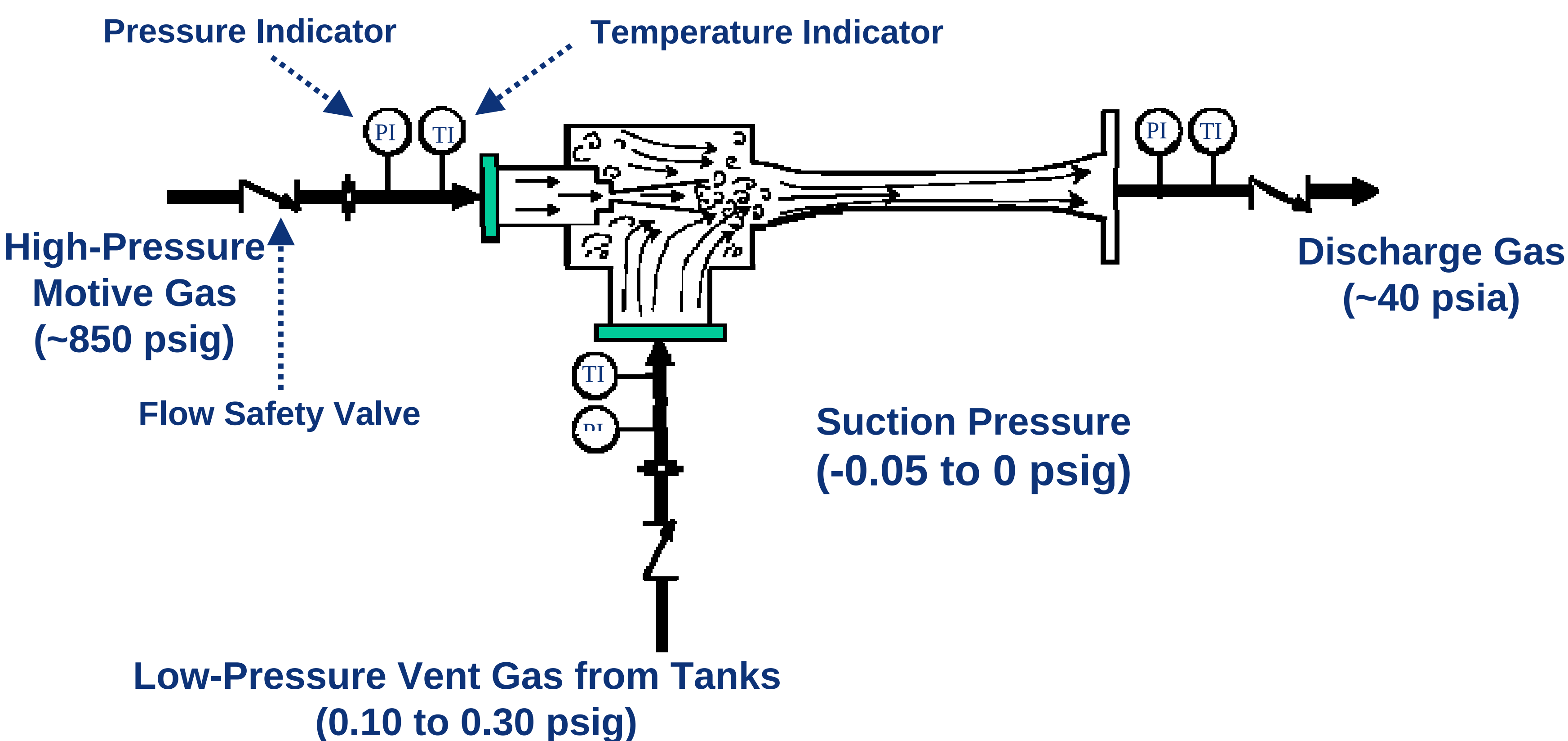
- Conventional vapor recovery units (VRUs)
  - Use rotary compressor to suck vapors out of atmospheric pressure storage tanks
  - Require electrical power or engine driver
- Venturi ejector vapor recovery units (EVRU^{TM}) or Vapor Jet
  - Use Venturi jet ejectors in place of rotary compressors
  - Contain no moving parts
  - EVRU^{TM} requires source of high pressure gas and intermediate pressure system
  - Vapor Jet requires high pressure water motive

Conventional Vapor Recovery Unit

Source: Evans & Nelson (1968)



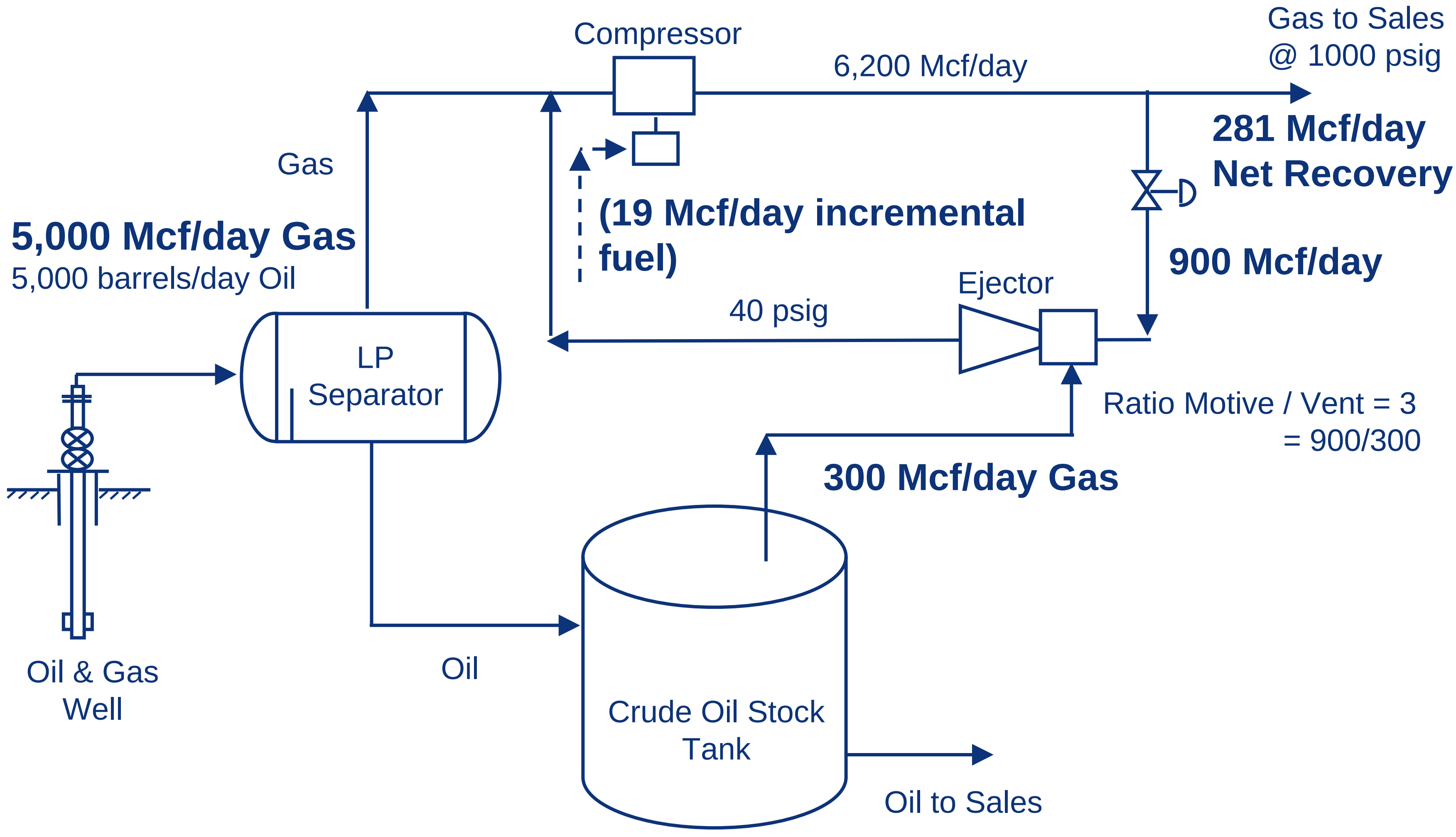
Venturi Jet Ejector*



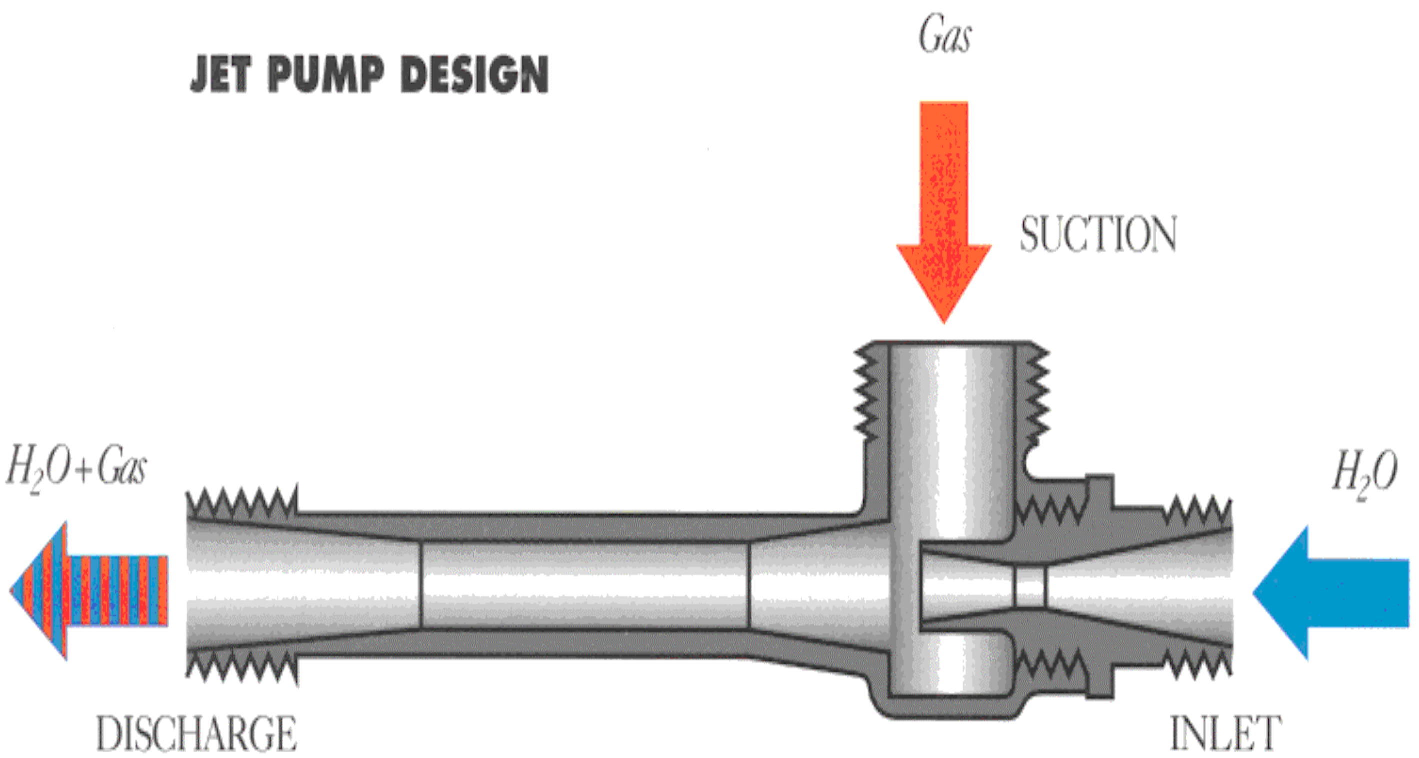
*EVRU™ Patented by COMM Engineering

Adapted from SRI/USEPA-GHG-VR-19
psig = pound per square inch, gauge
psia = pounds per square inch, atmospheric

Vapor Recovery with Ejector

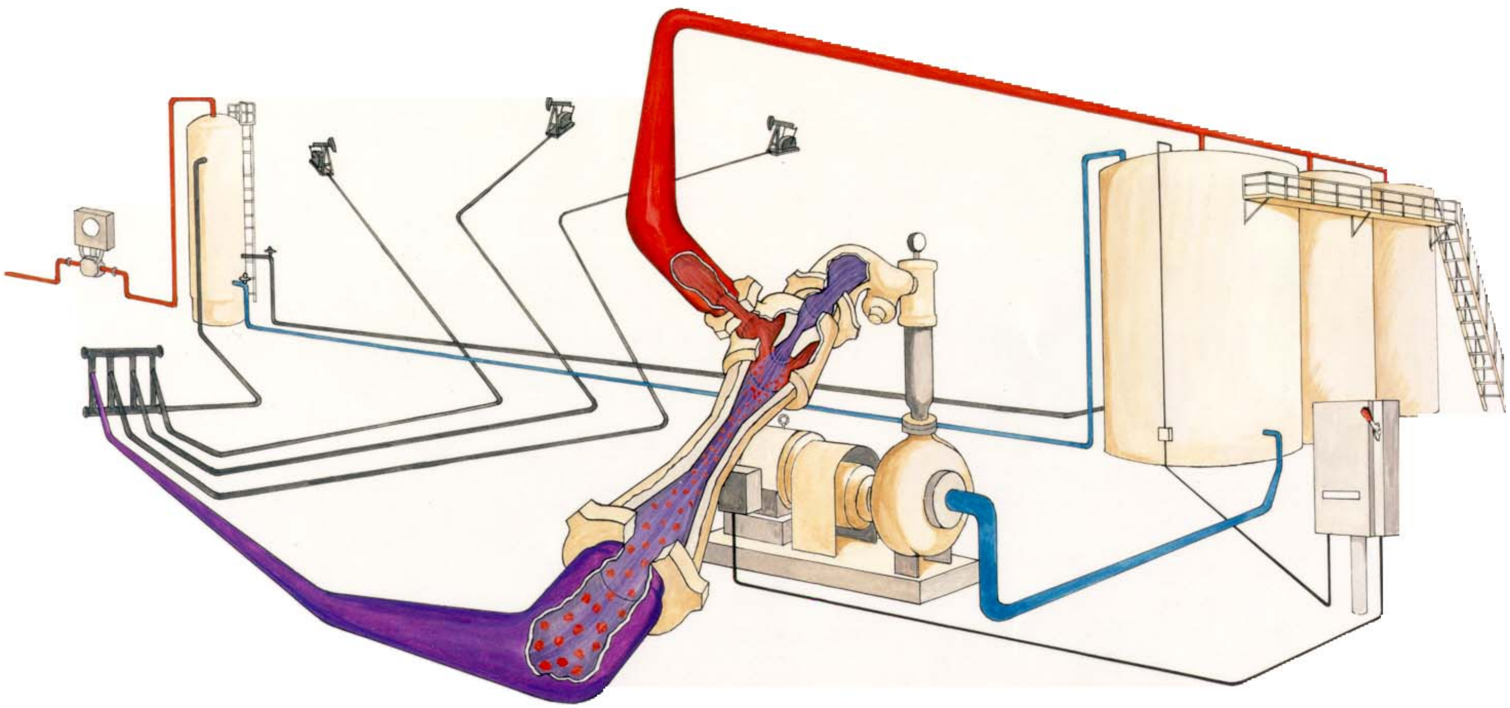


Vapor Jet System*



*Patented by Hy-Bon Engineering

Vapor Jet System*



- Utilizes produced water in closed loop system to effect gas gathering from tanks
- Small centrifugal pump forces water into Venturi jet, creating vacuum effect
- Limited to gas volumes of 77 Mcf / day and discharge pressure of 40 psig

*Patented by Hy-Bon Engineering

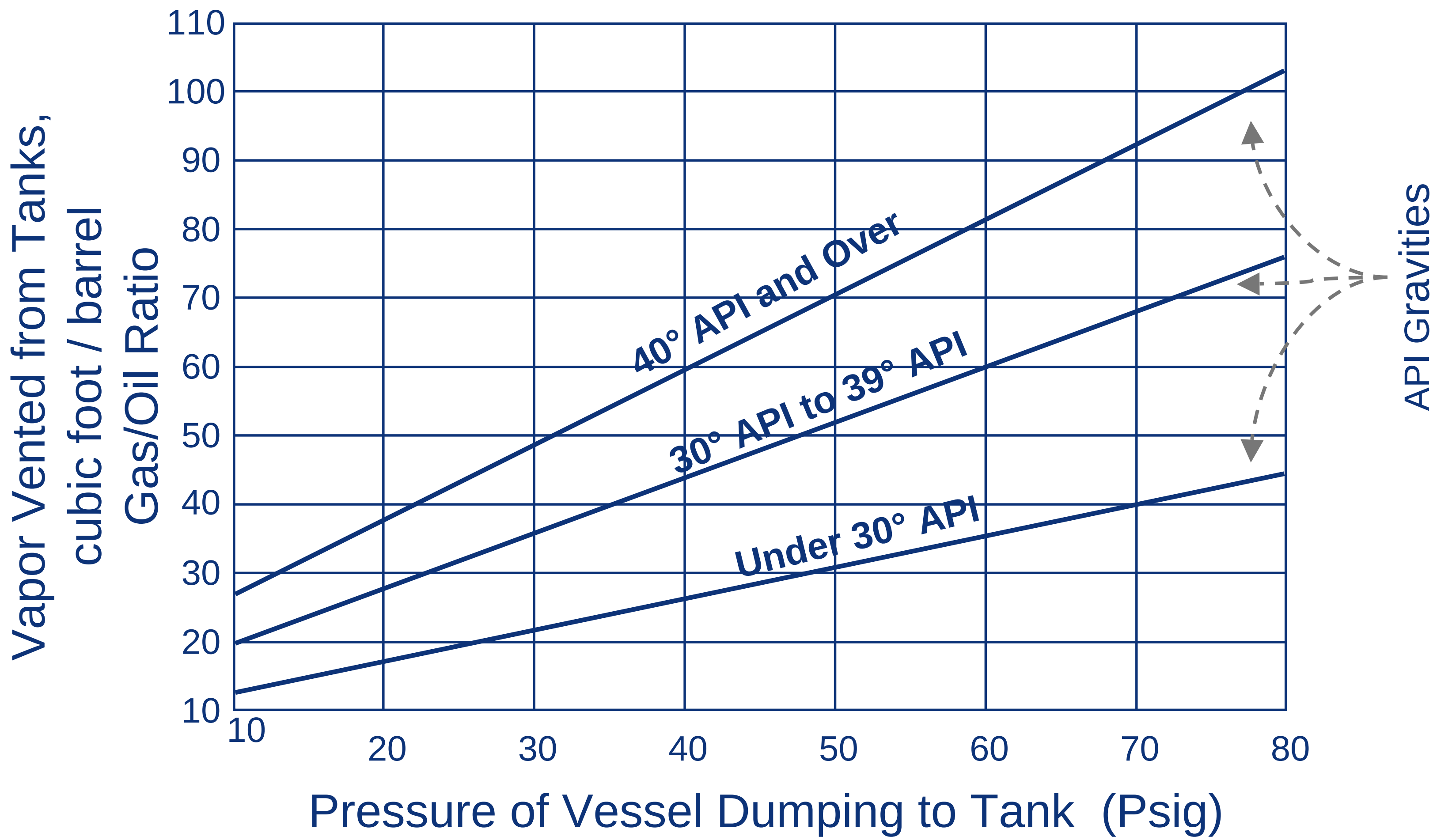
Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
  - Crude oil stock tank
  - Flash tank, heater/treater, water skimmer vents
  - Gas pneumatic controllers and pumps
- Outlet for recovered gas
  - Access to low pressure gas pipeline, compressor suction, or on-site fuel system
- Tank batteries not subject to air regulations

Quantify Volume of Losses

- Estimate losses from chart based on oil characteristics, pressure, and temperature at each location (± 50%)
- Estimate emissions using the E&P Tank Model (± 20%)
- Measure losses using recording manometer and well tester or ultrasonic meter over several cycles (± 5%)
  - This is the best approach for facility design

Estimated Volume of Tank Vapors



° API = API gravity

What is the Recovered Gas Worth?

- Value depends on heat content of gas
- Value depends on how gas is used
  - On-site fuel
    - Valued in terms of fuel that is replaced
  - Natural gas pipeline
    - Measured by the higher price for rich (higher heat content) gas
  - Gas processing plant
    - Measured by value of natural gas liquids and methane, which can be separated

Value of Natural Gas Liquids

	1 Btu/gallon	2 MMBtu/ gallon	3 $/gallon	4 $/MMBtu[1,2] (=3/2)
Methane	59,755	0.06	0.43	7.15
Ethane	74,010	0.07	0.64	9.14
Propane	91,740	0.09	0.98	10.89
n Butane	103,787	0.10	1.32	13.20
iso Butane	100,176	0.10	1.42	14.20
Pentanes+	105,000	0.11	1.50	13.63

	5 Btu/cf	6 MMBtu/Mcf	7 $/Mcf (=4*6)	8 $/MMBtu	9 Vapor Composition	10 Mixture (MMBtu/Mcf)	11 Value ($/Mcf) (=8*10)
Methane	1,012	1.01	$ 7.22	7.15	82%	0.83	$ 5.93
Ethane	1,773	1.77	$ 16.18	9.14	8%	0.14	$ 1.28
Propane	2,524	2.52	$ 27.44	10.89	4%	0.10	$ 1.09
n Butane	3,271	3.27	$ 43.16	13.20	3%	0.10	$ 1.32
iso Butane	3,261	3.26	$ 46.29	14.20	1%	0.03	$ 0.43
Pentanes+	4,380	4.38	$ 59.70	13.63	2%	0.09	$ 1.23
Total						1.289	$ 11.28

1 Natural Gas Price assumed at $7.15/MMBtu as on Mar 16, 2006 at Henry Hub

2 Prices of Individual NGL components are from Platts Oilgram for Mont Belvieu, TX, January 11,2006

3 Other natural gas liquids information obtained from Oil and Gas Journal, Refining Report, March 19, 2001, p-83

Btu = British Thermal Units, MMBtu = Million British Thermal Units

Is Recovery Profitable?

Financial Analysis for a conventional VRU Project						
Peak Capacity (Mcf / day)	Installation & Capital Costs[1]	O & M Costs ($ / year)	Value of Gas[2] ($ / year)	Annual Savings	Simple Payback (months)	Return on Investment
25	26,470	5,250	$ 51,465	$ 46,215	7	175%
50	34,125	6,000	$ 102,930	$ 96,930	5	284%
100	41,125	7,200	$ 205,860	$ 198,660	3	483%
200	55,125	8,400	$ 411,720	$ 403,320	2	732%
500	77,000	12,000	$ 1,029,300	$ 1,017,300	1	1321%

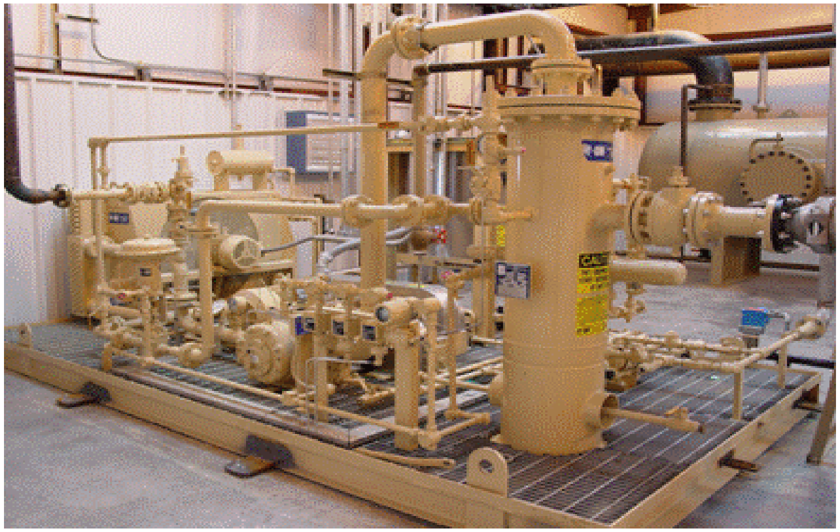
1 Unit Cost plus estimated installation at 75% of unit cost

2 $11.28 x 1/2 capacity x 365, Assumed price includes Btu enriched gas (1.289 MMBtu/Mcf)

Vapor Recovery Installations

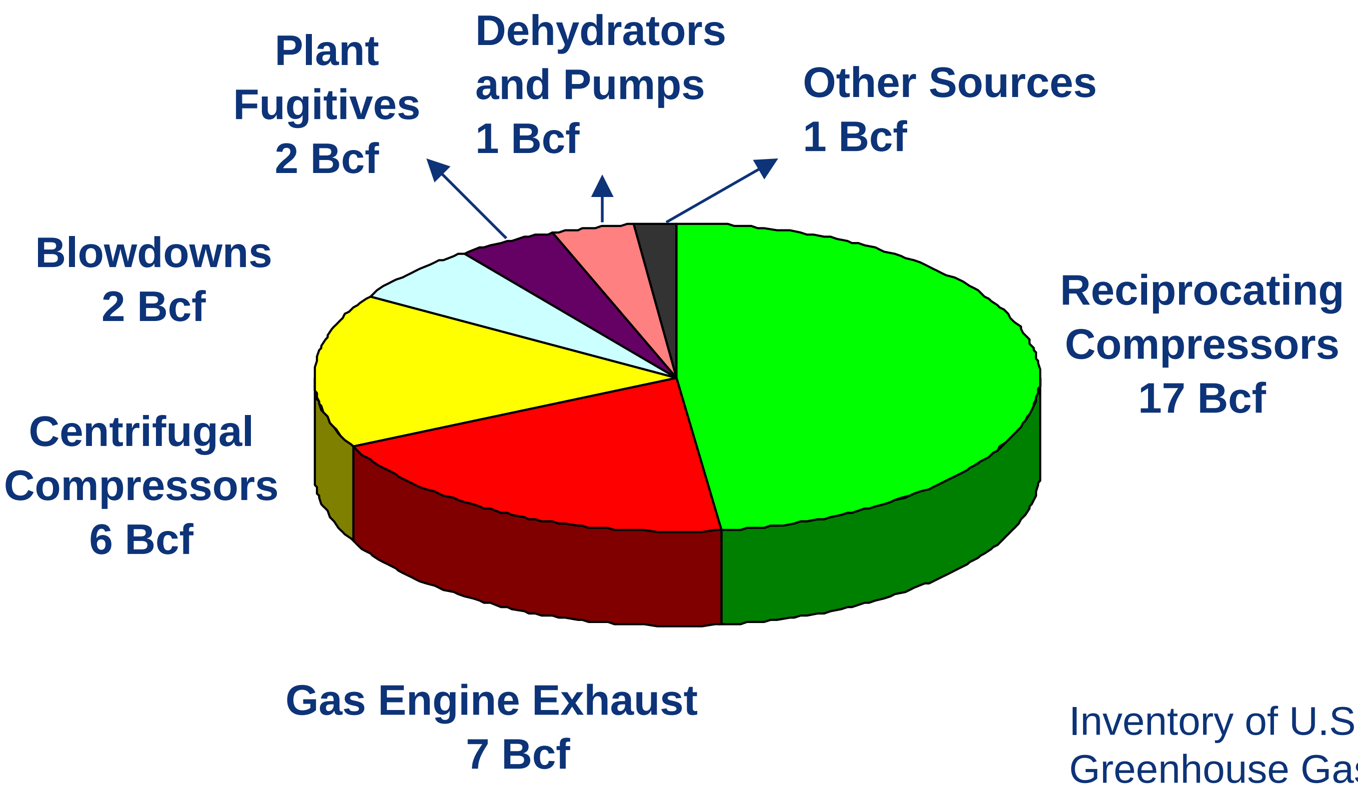
8 Units capturing ~ 2MMSCFD

Vapor Recovery Installations



Processing Sector Emissions

- The processing sector emits less methane, but still has several large emission sources



Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2003

Highly Implemented PROs

- The Gas STAR program has identified
  - 42 production sector PROs
  - 29 processing sector PROs
- Ten “top” PROs from each sector:
  - PROs most reported by Gas STAR partners in production and processing sectors
  - All target major emissions sources
  - Responsible for over 65% of all emission reductions in the production and processing sectors

Production and Processing Top PROs

Top PROs	Sector		Payback[1]	Methane Savings
	Production	Processing		
Install flares	x	x	None	2,000 Mcf/yr
Install vapor recovery units	x	x	1-3 yr	4,900 Mcf/yr
Install plunger lifts	x		<1 yr	4,700 Mcf/yr
Install instrument air systems	x		<1 yr	20,000 Mcf/yr
Eliminate unnecessary equipment and/or systems	x	x	<1 yr	2,000 Mcf/yr
Perform green completions	x		1-3 yr	7,000 Mcf/yr
Conduct leak surveys	x		1-3 yr	4,000 Mcf/yr
Install electric compressors	x	x	>10 yr	6,440 Mcf/yr
Consolidate crude oil production and water storage tanks	x		1-3 yr	4,200 Mcf/yr
Alter blowdown piping	x		1-3 yr	1,000 Mcf/yr
Use hot taps for in-service pipeline connections		x	1-3 yr	24,400 Mcf/yr
Redesign blowdown systems and alter ESD practices		x	1-3 yr	2,000 Mcf/yr
Rerouting of glycol skimmer gas		x	<1 yr	7,600 Mcf/yr
Shut down compressors		x	<1 yr	5,000 Mcf/yr
Replace gas starters with air		x	<1 yr	1,300 Mcf/yr
Replace glycol dehydration units with methanol injection		x	<1 yr	800 Mcf/yr

1 – based on $3/Mcf gas price

Implementation of Top PROs

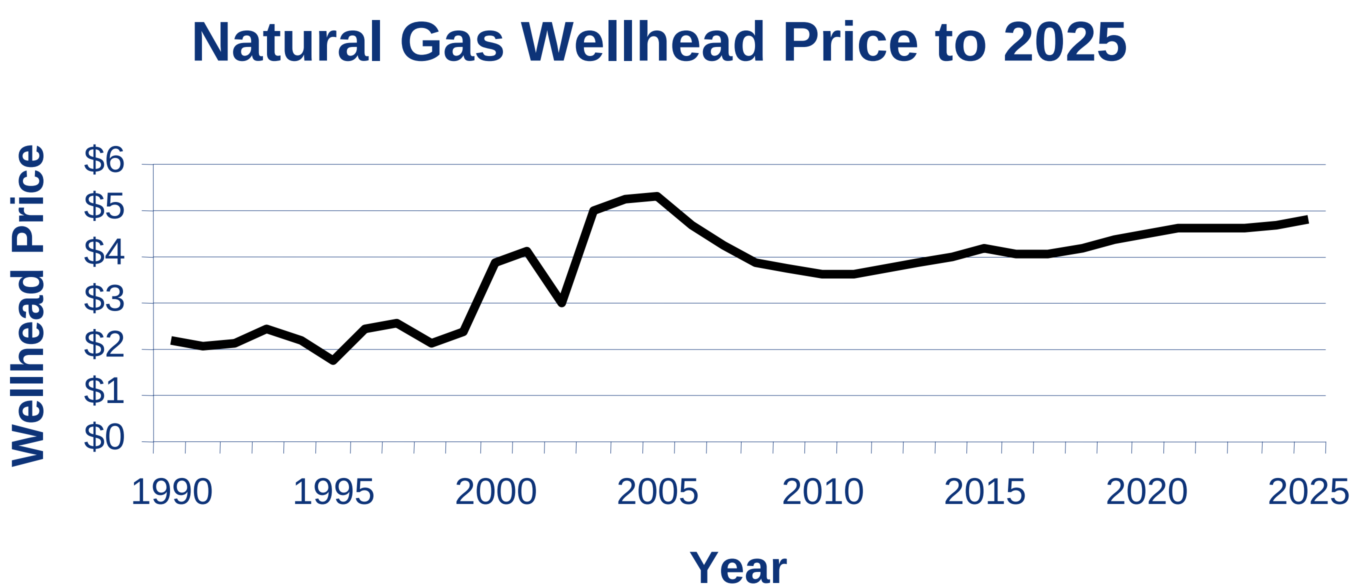
- These PROs have been proven to reduce emissions economically
- Top PROs target the largest sources of methane emissions in the production sector
- Room for a great deal of further emissions reductions

Emissions Targeted by Top PROs

- BMPs and top PROs target over 75% of production and processing sector emissions
- This means:
  - Partners that report PROs recognize major sources of methane losses and are taking steps to mitigate emissions
  - Partners not practicing all BMPs and top PROs may have further opportunities for methane savings

Gas Prices and Methane Savings

- Economics of implementing new PROs change with gas price
- PRO fact sheets use nominal gas price of $3/Mcf
- Many PROs were reported when gas price <$2



EIA *Annual Energy Outlook with Projections to 2025. http://www.eia.doe.gov/oiaf/aeo/gas.html*

Other Opportunities

The Gas STAR Program has the following PRO Fact Sheets available

Production

- 8 Compressor
- 6 Dehydrator
- 2 Pneumatics/Controls
- 3 Pipelines
- 5 Tanks
- 6 Valves
- 9 Wells
- 3 Other

Processing

- 9 Compressor
- 5 Dehydrator
- 2 Pneumatics/Controls
- 2 Pipelines
- 3 Tanks
- 6 Valves
- 2 Other

Other PROs with High Potential Savings

PRO	Sector: Production	Sector: Processing	Payback[1]	Methane Savings
Nitrogen Rejection Unit Optimization		x	<1 yr	200,000
Install Compressor to Capture Casinghead Gas	x		<1 yr	32,850
Zero Emissions Dehydrators	x	x	<1 yr	31,400
Connect Casing to Vapor Recovery Unit	x		<1 yr	7,300
Inspect & Repair Compressor Station Blowdown Valves	x	x	<1 yr	2,000
Use Ultrasound to Identify Leaks	x	x	<1 yr	2,000

1 – based on $3/Mcf gas price

- Partners implementing all top PROs have further opportunities for emissions reductions
- These PROs reduce emissions and with higher gas prices pay back more quickly

Discussion Questions

- Do you find any of the top PROs to be economically unattractive?
- How do you take into account the price of gas when examining which PROs to implement?
- What are some of the other issues that are preventing you from implementing these practices?