Installing Vapor Recovery Units to Reduce Methane Losses

Lessons Learned from Natural Gas STAR

Processors Technology Transfer Workshop

**Pioneer Natural Resources, Inc.,
Gas Processors Association and
EPA's Natural Gas STAR Program**

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Vapor Recovery Units: Agenda

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

Sources of Methane Losses

- Estimate 373 MMcf/yr methane lost from atmospheric condensate storage tanks in gathering stations
- EPA/GTI study estimates the methane emissions from storage tanks in the processing sector to be 311 MMcf/yr

EF from Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2002,

AF from EIA financial reporting system (FRS)

Types of Methane Losses

- Flash losses - occur when condensate in pipeline systems enters tanks at atmospheric pressure
- Working losses - occur when condensate levels in tanks change
- Standing losses - occur with daily and seasonal temperature and barometric pressure variations

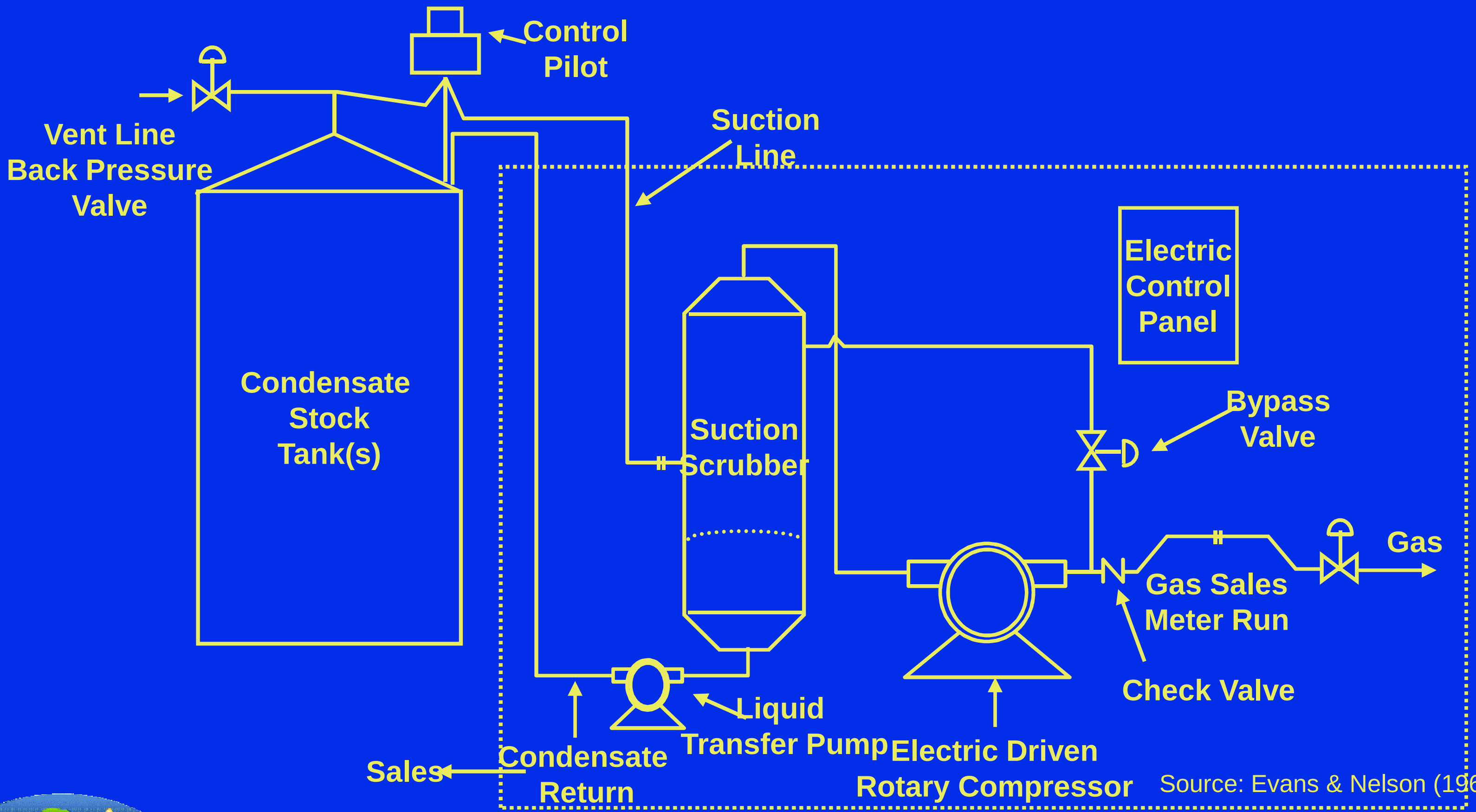
Methane Recovery

- Vapor recovery units capture up to 95% of hydrocarbon vapors vented from tanks
- Recovered vapors have higher Btu content than pipeline quality gas
- Recovered vapors are more valuable than natural gas and have multiple uses
  - **Re-injected into pipeline to recover NGLs**
  - **Used as on-site fuel**

Types of Vapor Recovery Units

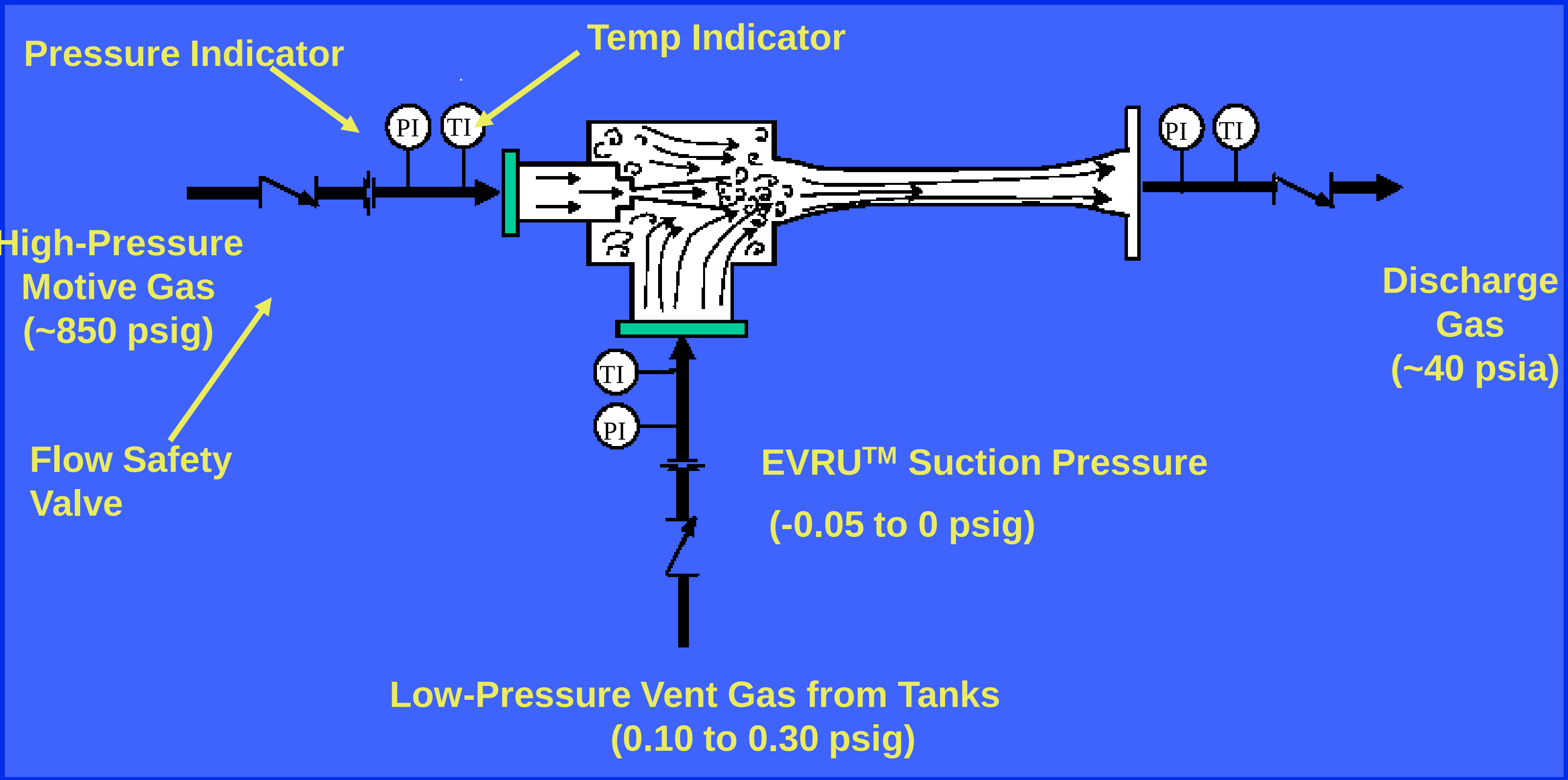
- Conventional vapor recovery units (VRU)
  - **Use rotary compressor to extract vapors out of atmospheric pressure storage tanks**
  - **Require electrical power or engine**
- Venturi ejector vapor recovery units (EVRU™)
  - **Use Venturi jet ejector in place of rotary compressor**
  - **Do not contain any moving parts**
  - **Require source of high pressure gas and intermediate pressure system**

Conventional Vapor Recovery Unit



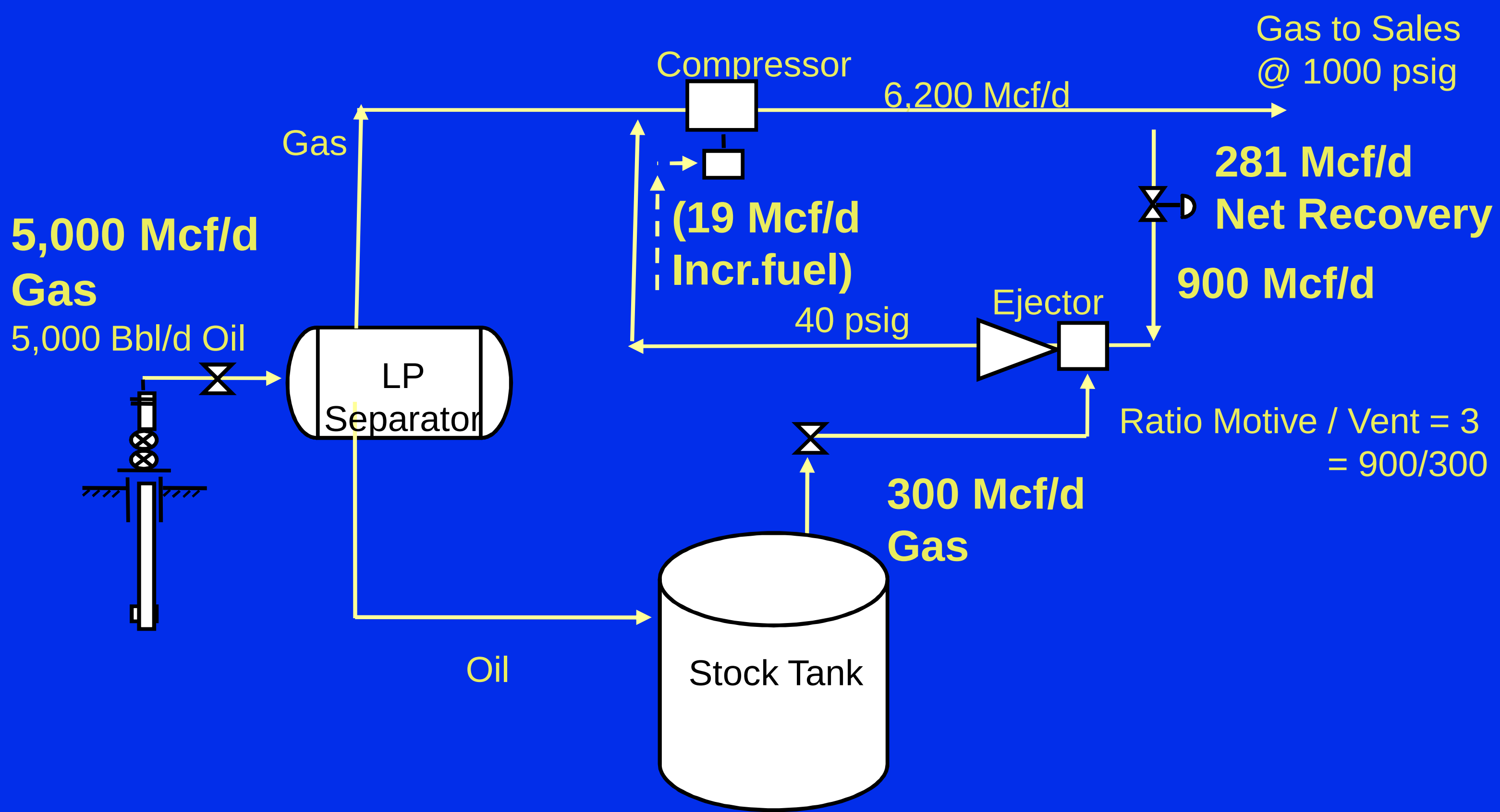
Source: Evans & Nelson (1968)

Venturi Jet Ejector*



*Patented by COMM Engineering

Vapor Recovery with Ejector



Note: Production application example.

Example Facility for EVRU^{TM}

Oil production:	5,000 Bbl/d, 30 Deg API
Gas production:	5,000 Mcf/d, 1060 Btu/cf
Separator:	50 psig, 100ºF
Storage tanks:	4 - 1500 Bbls @1.5oz relief
Gas compressor:	Wauk7042GSI/3stgAriel
Suction pressure:	40 psig
Discharge pressure:	1000 psig
Measured tank vent:	300 Mcf/d @ 1,850 Btu/cf

Emissions Before EVRU™
CO_2 Equivalents

- Engine exhaust: 3,950 Tons/yr @ 790 Hp load
- Tank vents: 14,543 Tons/yr
- Total CO2 equivalents: 18,493 Tons/yr
- Fuel consumption @ 9000 Btu/Hp-hr = 171 MMBtu/d
- Gas sales: 5,129 MMBtu/d
- Gas value: $25,645/d @ $5/MMBtu

Emissions After EVRU™ CO_2 Equivalents

Motive gas required:	900 Mcf/d
Engine exhaust:	4,897 Tons/yr @ 980 Hp load
Tank vents:	0 Tons/yr
Fuel consumption @ 9000 Btu/Hp-hr:	190 MMBtu/d
Total CO_2 equivalents:	4,897 Tons/yr
Reduction:	13,596 Tons/yr (73.5%)
Total CO_2 equivalents:	4,897 Tons/yr
Reduction:	13,596 Tons/yr (73.5%)
Gas sales:	5,643 MMBtu/d
Gas value:	$28,215/d @ $5/MMBtu
Income increase:	$2,570/d = $77,100/mo
EVRU cost installed:	$75,000
Installed cost per recovered unit of gas:	$0.68/Mcf/yr
Payout:	<1 month

Vapor Recovery Unit Decision Process

IDENTIFY possible locations for VRUs

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QUANTIFY the volume of losses

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DETERMINE the value of recoverable losses

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DETERMINE the cost of a VRU project

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EVALUATE VRU project economics

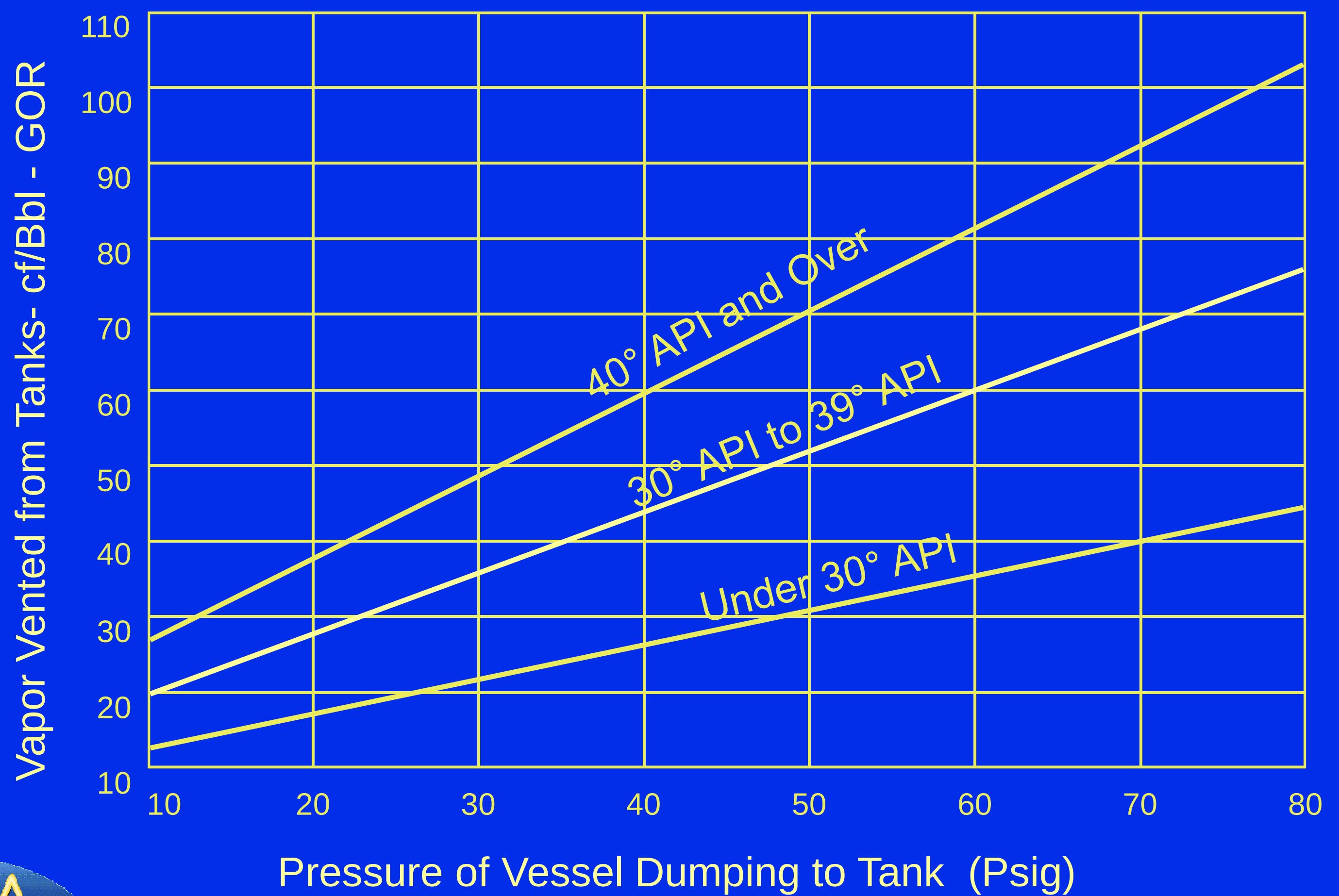
Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
  - **Condensate tanks at gathering/ boosting stations**
  - **Pig trap liquids tanks**
- Outlet for recovered gas
  - **Access to pipeline or on-site fuel**
- 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 ultrasonic meter (± 5%)
- Measure losses using recording manometer and orifice well tester (± 100%)

Estimated Volume of Tank Vapors



Source: Natural Gas Star, Lessons Learned – Installing Vapor Recovery Units on Crude Oil Storage Tanks

Quantify Volume of Losses

- E&P Tank Model
  - **Computer software developed by API and GRI**
  - **Estimates flash, working and standing losses**
  - **Calculates losses using specific operating conditions for each tank**
  - **Provides composition of hydrocarbon losses**

What is the Recovered Gas Worth?

- Value depends on Btu 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 Btu) gas**
  - **Gas processing plant - measured by value of NGLs and methane, which can be separated**

Value of Recovered Gas

Gross revenue per year = (Q x P x 365) + NGL

Q = Rate of vapor recovery (Mcfd)

P = Price of recovered natural gas

NGL = Value of natural gas liquids

Cost of a VRU

- Major cost items:
  - **Capital equipment costs**
  - **Installation costs**
  - **Operating costs**

Cost of a Conventional VRU

Vapor Recovery Unit Sizes and Costs				
Capacity (Mcfd)	**Compressor Horsepower**	**Captial Costs ($)**	**Installation Costs ($)**	**O&M Costs ($/year)**
25	5-10	15,125	7,560 - 15,125	5,250
50	10-15	19,500	9,750 - 19,500	6,000
100	15 - 25	23,500	11,750 - 23,500	7,200
200	30 - 50	31,500	15,750 - 31,500	8,400
500	60 - 80	44,000	22,000 - 44,000	12,000

Note: Cost information provided by Partners and VRU manufacturers.

Value of Recovered NGLs

	1 Btu/gal	2 MMBtu/gal	3 $/gal	4 $/MMBtu[1,2] (=3/2)
Methane	**59,755**	0.06	**0.32**	5.32
Ethane	**74,010**	0.07	**0.42**	5.64
Propane	**91,740**	0.09	**0.59**	6.43
n Butane	**103,787**	0.10	**0.73**	7.06
iso Butane	**100,176**	0.10	**0.78**	7.81
Pentanes+	**105,000**	0.11	**0.85**	8.05
Total				

	5 Btu/cf	6 MMBtu/Mcf	7 $/Mcf (=4*6)	8 $/MMBtu	9 Vapor Compostion	10 Mixture (MMbtu/Mcf)	11 Value ($/Mcf) (=(8*10)/1 000)
Methane	1,012	1.01	**$ 5.37**	5.32	**82%**	0.83	$ 4.41
Ethane	1,773	1.77	$ 9.98	5.64	**8%**	0.14	$ 0.80
Propane	2,524	2.52	$ 16.21	6.43	**4%**	0.10	$ 0.65
n Butane	3,271	3.27	$ 23.08	7.06	**3%**	0.10	$ 0.69
iso Butane	3,261	3.26	$ 25.46	7.81	**1%**	0.03	$ 0.25
Pentanes+	4,380	4.38	$ 35.25	8.05	**2%**	0.09	$ 0.70
Total						**1.289**	**$ 7.51**

1 Nautral Gas Price assumed at $5.32/MMBtu as on mar 5 at Henry Hub

2 Prices of Indvidual NGL components are from Platts Oilgram for Mont Belvieu, TX, March 05,2004

3 Other NGl information obtained from Oil and Gas Journal, refining Report, March 19, 2001, p-83

Is Recovery Profitable?

- Economics for various sized conventional VRUs

Financial Analysis for a conventional VRU Project						
Peak Capacity (Mcfd)	Installation & Capital Costs[1]	O & M Costs ($/year)	Value of Gas[2] ($/year)	Annual Savings	Payback period[3] (months)	Return on Investment[4]
25	26,470	5,250	$ 34,242	$ 28,992	11	107%
50	34,125	6,000	$ 68,484	$ 62,484	7	182%
100	41,125	7,200	$ 136,967	$ 129,767	4	315%
200	55,125	8,400	$ 273,935	$ 265,535	2	482%
500	77,000	12,000	$ 684,836	$ 672,836	1	874%

[1] Unit Cost plus esimated installation at 75% of unit cost

[2] $7.51 x 1/2 capacity x 365, Assumed price includes Btu enriched gas (1.289 MMBtu/Mcf)

[3] Based on 10% Discount rate for future savings. Excludes value of recovered NGLs

[4] Calculated for 5 years

Trade Offs

	Conventional VRU	Ejector
Fuel for electricity (Mcf/yr)	2,281	_
Fuel (Mcf/yr)	_	6,935
Operating factor	70%	100%
Maintenance	High	Low
Installed cost per recovered unit of gas ($/Mcf/yr)	$1.00	$0.68
Payback (excl. maintenance)	3 to 27 months	<1 month

Technology Comparison

- Mechanical VRU advantages
  - **Gas recovery**
  - **Readily available**
- Mechanical VRU disadvantages
  - **Maintenance costs**
  - **Operation costs**
  - **Lube oil contamination**
  - **~ 70% runtime**
  - **Sizing/turndown**
- EVRU advantages
  - **Gas recovery**
  - **Readily available**
  - **Simple technology**
  - **100% runtime**
  - **Low maintenance/ operation /install costs**
  - **Sizing/turndown (100%)**
  - **Minimal space required (mount in pipe rack)**
- EVRU disadvantages
  - **Need HP Motive Gas**
  - **Recompression of motive gas**

Lessons Learned

- Vapor recovery can yield generous returns when there are market outlets for recovered gas
  - **Recovered high Btu gas or liquids have extra value**
  - **VRU technology can be highly cost-effective**
  - **EVRU™ technology has extra O&M savings, higher operating factor**
- Potential for reduced compliance costs can be considered when evaluating economics of VRU/EVRU™

Lessons Learned (cont'd)

- VRU should be sized for maximum volume expected from storage tanks (rule-of-thumb is to double daily average volume)
- Rotary vane or screw type compressors recommended for VRUs where there is no source of high-pressure gas and/or no intermediate pressure system
- EVRUs™ recommended where there is gas compressor with excess capacity

Case Study – Pioneer

- Pioneer Natural Resources USA, Inc. recycled vapors from 3 phase separators to the plant inlet
  - **Methane emissions reduction = 3796 Mcf**
  - **Estimated cost incurred = $5,000**
  - **Total value of gas saved = $11,388**

Vapor Recovery Units

- Profitable technology to reduce gas losses
- Can help reduce regulatory requirements and costs
- Additional value of NGLs further improves cost-effectiveness
- Exemplifies profitable conservation

Discussion Questions

- To what extent are you implementing this BMP?
- How can this BMP be improved upon or altered for use in your operation(s)?
- What is stopping you from implementing this technology (technological, economic, lack of information, focus, manpower, etc.)?