Installing Vapor Recovery Units to Reduce Methane Losses

Lessons Learned

from Natural Gas STAR

Offshore Technology Transfer Workshop

Shell, GCEAG, API, Rice University 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

- ~ 3.88 Bcf methane lost from storage tanks each year in Gulf of Mexico (37% of U.S.)
- Flash losses - occur when crude is transferred from containment at high pressure to containment at lower pressure
- Working losses - occur when crude levels change and when crude in tank is agitated
- Standing losses - occur with daily and seasonal temperature and pressure changes

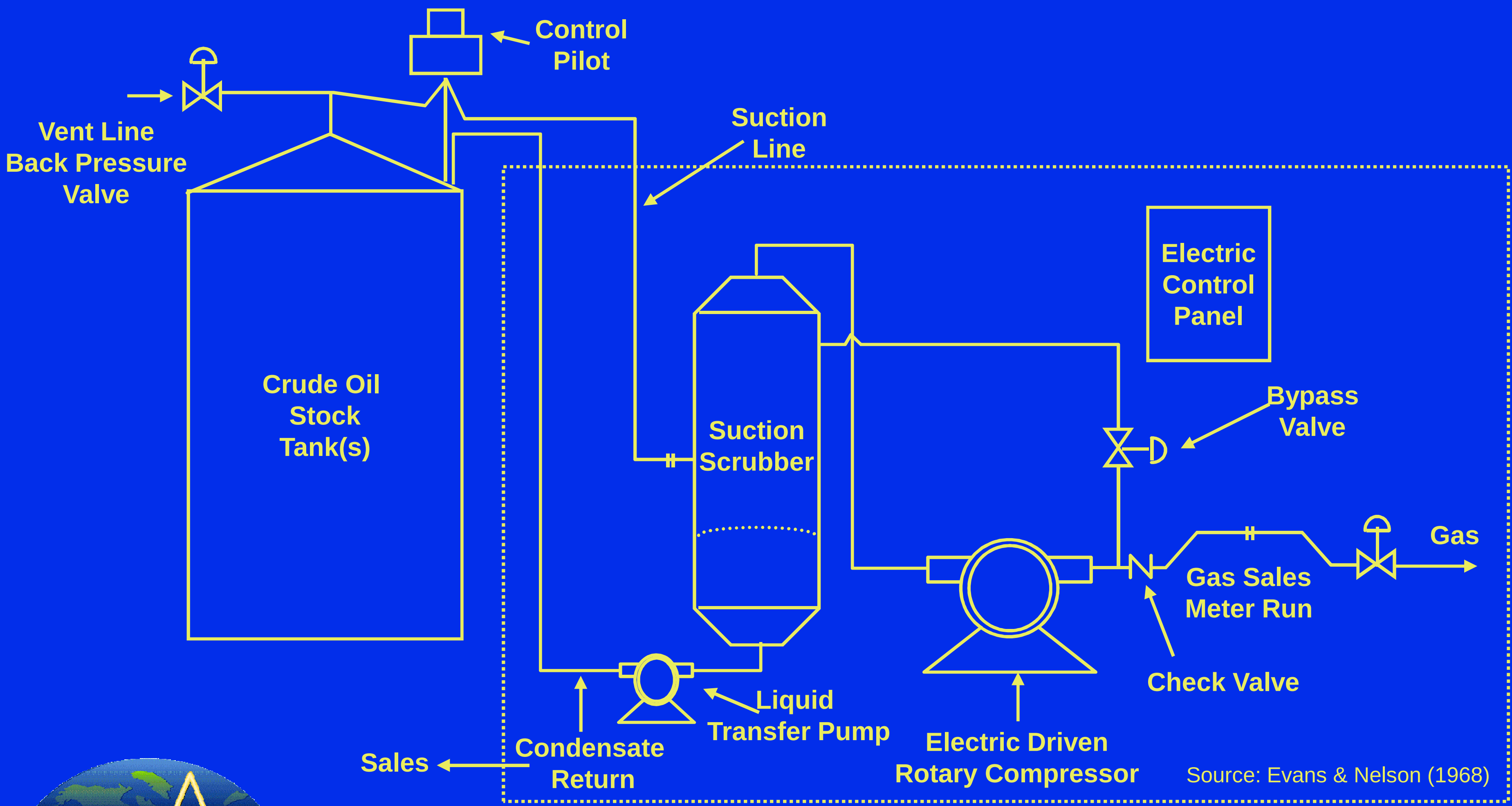
Vapor Recovery Units

- Capture up to 95% of hydrocarbon vapors vented from tanks
- Recovered vapors have higher Btu content than pipeline quality natural gas
- Recovered vapors more valuable than natural gas and have multiple uses
  - **Re-injected into sales pipeline**
  - **Used as on-site fuel**
  - **Sent to processing plants for recovering NGLs**

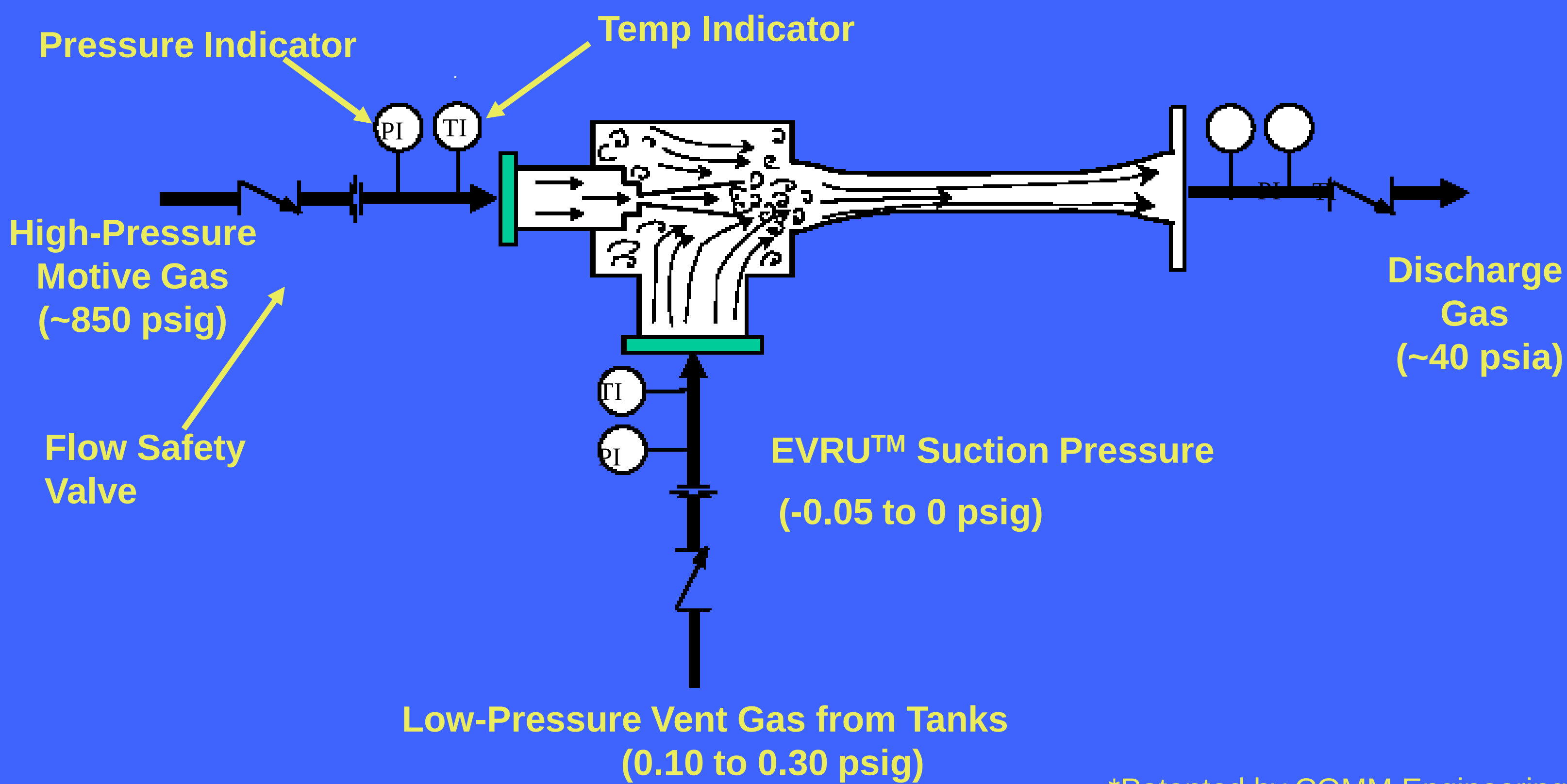
Types of Vapor Recovery Units

- Conventional vapor recovery units (VRUs)
  - **Use rotary compressor to suck vapors out of atmospheric pressure storage tanks**
  - **Require electrical power or engine**
- Venturi Ejector vapor recovery units (EVRUs™)
  - **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**

Standard Vapor Recovery Unit



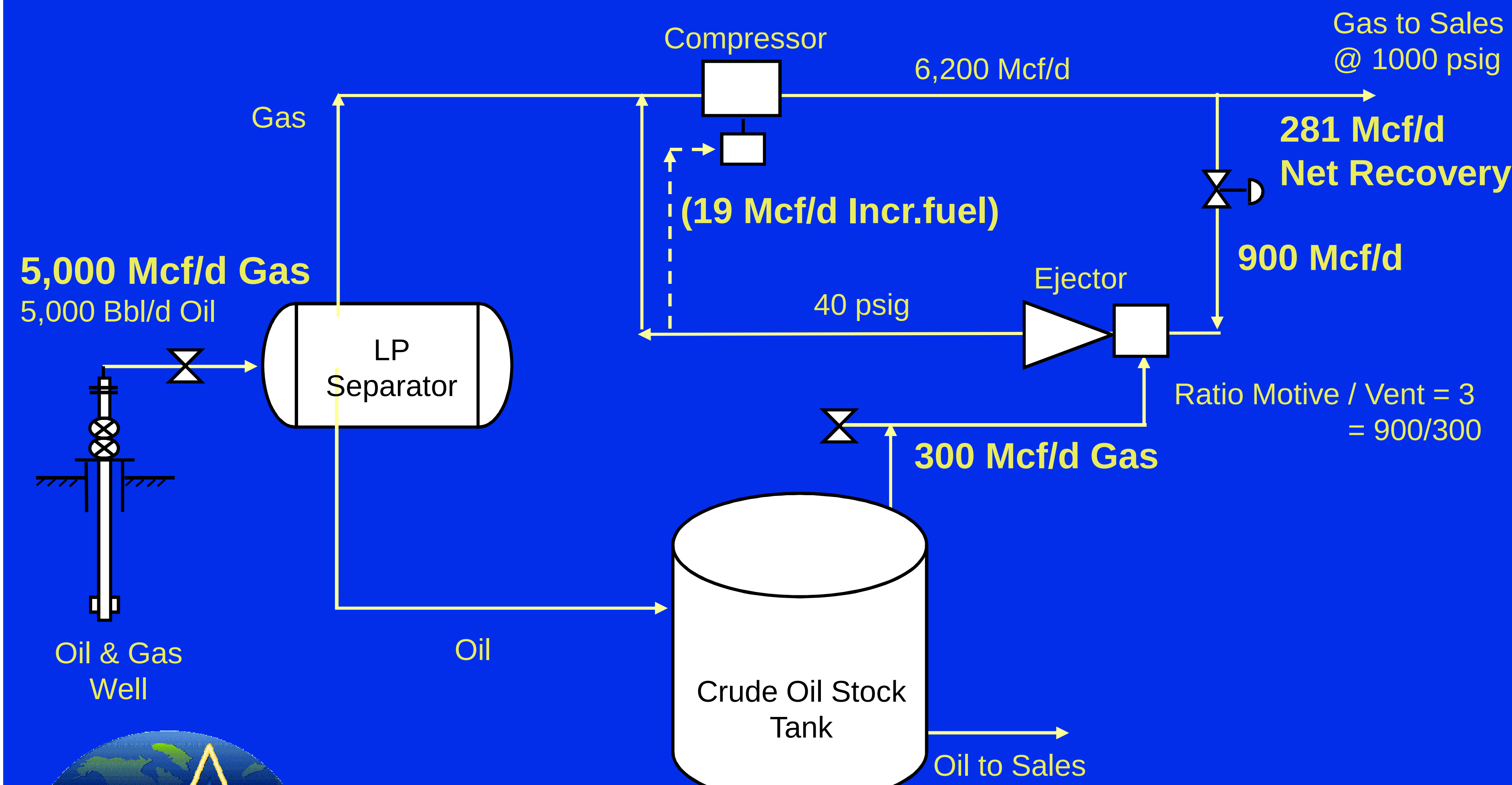
Venturi Jet Ejector*



*Patented by COMM Engineering

Reducing Emissions, Increasing Efficiency, Maximizing Profits

Vapor Recovery with Ejector



Example Facility for EVRU™

- Oil production: 5,000 Bbl/d, 30 Deg API
- Gas production: 5,000 Mcf/d, 1,060 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™
CO2 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™
CO2 Equivalents

Motive gas required:	900 Mcf/d
Engine exhaust:	4,897 Tons/yr @ 980 hp load
Tank vents:	0 Tons/yr
Fuel consumption @ 9000Btu/hp-h r:	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:	$150,000
Installed cost per recovered unit of gas:	$1.37/Mcf/yr
Payout:	<2 months

Vapor Recovery Unit Decision Process

IDENTIFY possible locations for VRUs

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QUANTIFY the volume of losses

↓

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

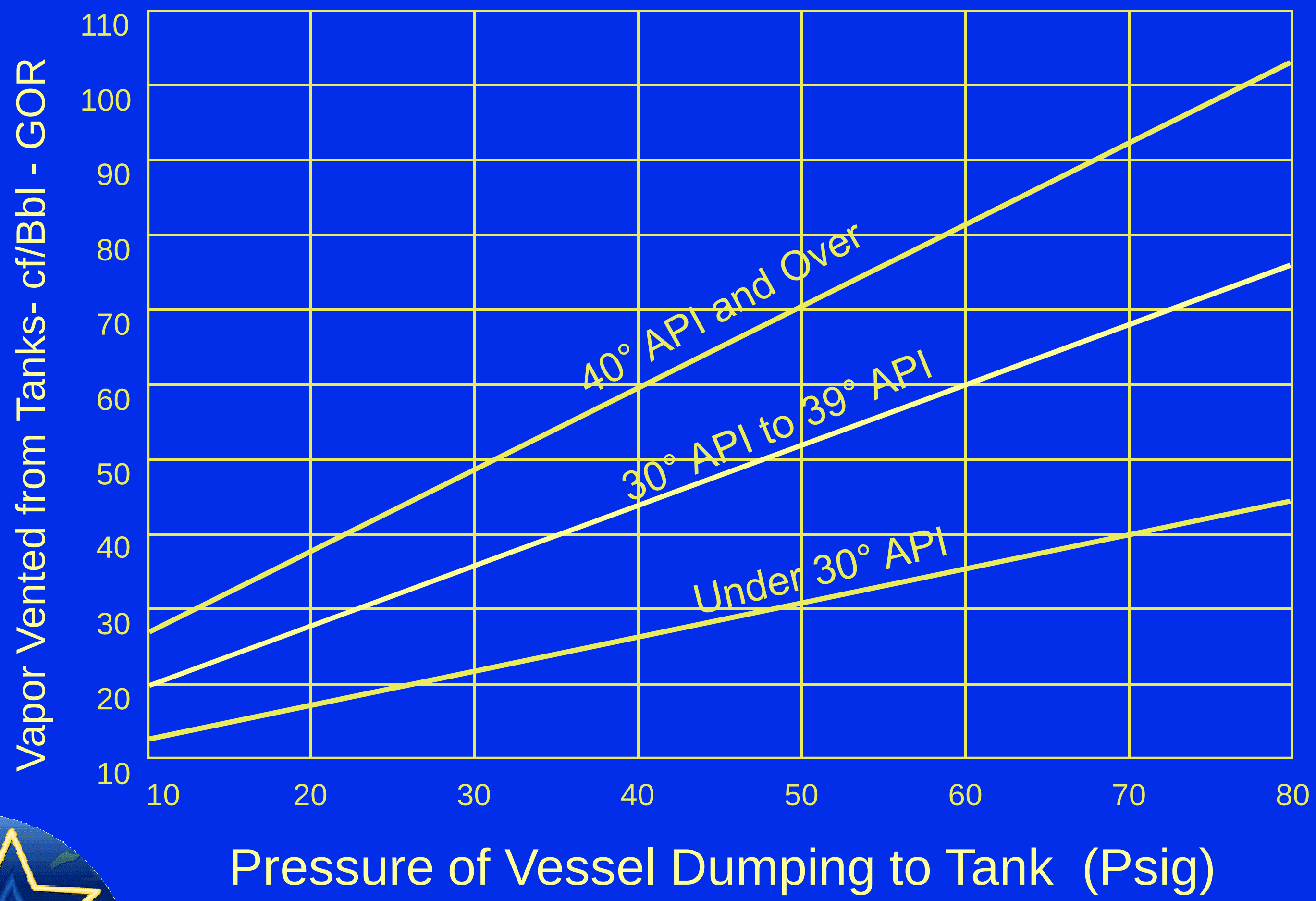
Criteria for Vapor Recovery Unit Locations

- Steady source and sufficient quantity of losses
  - **Crude oil stock tank**
  - **Flash tank, heater/treater, water skimmer vents**
  - **Leaking valve in blanket gas system**
- Outlet for recovered gas
  - **Access to pipeline or on-site utilities**
- Tank batteries not subject to air regulations
- Adequate platform space for VRU footprint
  - **EVRU™ does not require deck space**

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



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 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 VRU (cont'd)

Vapor Recovery Unit Sizes and Costs for Offshore Operations				
Capacity (Mcfd)	Compressor Horsepower	Captial Costs ($)	Installation Costs ($)	O&M Costs ($/year)
25	5-10	30,250	15,120 - 30,250	10,500
50	10-15	39,000	19,500 - 39,000	12,000
100	15 - 25	47,000	23,500 - 47,000	14,400
200	30 - 50	63,000	31,500 -63,000	16,800
500	60 - 80	88,000	44,000 - 88,000	24,000
Note: Cost information provided by Partners and VRU manufacturers. Offshore factors estimated at twice the onshore costs given by manufacturers.				

Value of 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)/1000)
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

What Is the Payback?

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	52,940	10,500	$ 34,242	$ 23,742	27	35%
50	68,250	12,000	$ 68,484	$ 56,484	14	78%
100	82,250	14,400	$ 136,967	$ 122,567	8	147%
200	110,250	16,800	$ 273,935	$ 257,135	5	233%
500	154,000	24,000	$ 684,836	$ 660,836	3	429%

[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]	$2.01	$1.37
Payback (excl. maintenance)	3 to 27 months	<2 months

1. Capital costs are double the onshore capital costs

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

Top Gas STAR Partners for VRUs

Top five companies for Emissions Reduction using VRUs in 2003

Company	Reduction (Mcf)
Marathon Oil Company	1,333,484
Kerr-McGee Corporation	633,919
Chevron	532,134
Union Pacific Resources Group, Inc.	403,454
Burlington Resources, Inc.	299,609

Source: Natural GasSTAR Program

Case Study – Chevron

- Chevron installed eight VRUs at crude oil stock tanks in 1996

Project Economics – Chevron				
Methane Loss Reduction (Mcf/unit/yr)	**Approximate Savings per Unit[1]**	**Total Savings**	**Total Capital and Installation Costs**	**Payback**
21,900	**$43,800**	**$525,600**	**$240,000**	**<1 yr**

[1] Assumes a $3 per Mcf gas price; excludes value of recovered NGLs. Refer to the *Lessons Learned* for more information.

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.)?