Methane to Markets

Transmission Pipeline Opportunities

Advancing Project Development in India
through Public Private Partnerships

22 – 23 February, 2007

Pipeline Maintenance and Repair: Agenda

- **Methane Losses from Pipeline Maintenance**
- Hot Taps
- Composite Wrap
- Pipeline Pumpdowns
- Pipeline Pigging
- Discussion Questions

Methane Losses from Current Pipeline Maintenance Practices

- Natural gas is often vented to the atmosphere when performing pipeline repairs and new connections
  - Up to 56,600 m^3* natural gas vented when making a new connection
  - Up to 170,000 m^3* natural gas vented when replacing pipe that has non-leaking, external damage
- These practices result in methane emissions
  - Loss of sales
  - Service disruption and customer inconvenience
  - Costs of evacuating the existing piping system

*pipelines ranging from 4 to 18 inches (10 – 46 centimeters) diameter operating at 100 to 1,000 pounds per square inch gauge pressure (7.8 – 69 atmospheres)

Methane to Markets

Methane Losses from Major Repairs

- Not always possible to repair a pipeline without taking it out of service
- Major pipeline repairs often involve closing off the repair area and venting gas to the atmosphere
  - Major repairs
  - Internal corrosion
  - Leak repairs
  - Installing large connections
- 850 to 170,000 m^{3*} natural gas vented to the atmosphere with each repair

*pipelines ranging from 4 to 18 inches (10 – 46 cm) diameter operating at 100 to 1,000 pounds per square inch gauge pressure (7.8 – 69 atm)

Pipeline Maintenance and Repair: Agenda

- Methane Losses from Pipeline Maintenance
- **Hot Taps**
- Composite Wrap
- Pipeline Pumpdowns
- Pipeline Pigging
- Discussion Questions

Hot Taps for New Connections

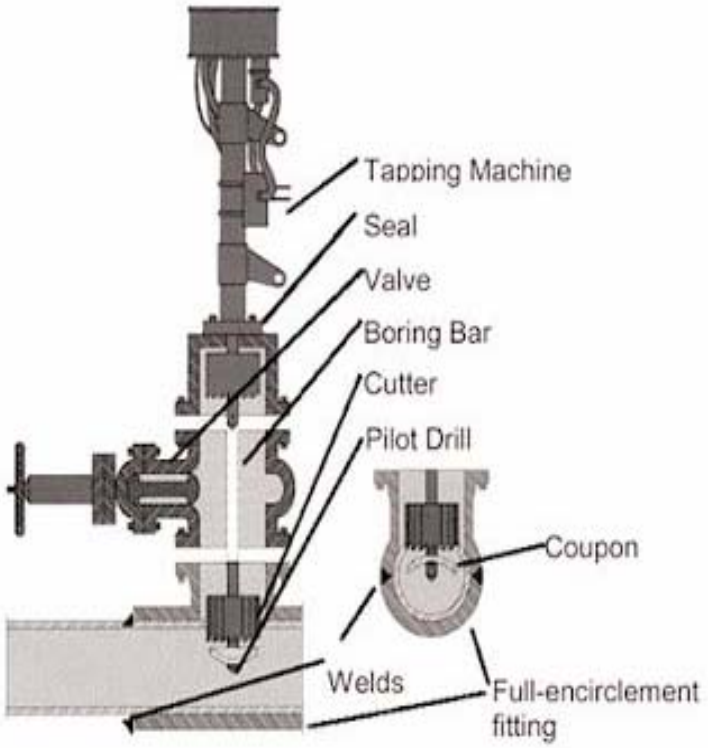
- Connecting pipelines without service disruption or methane emissions

Certified Williamson Industries Technician performing a hot tap with a 760 Tapping Machine as part of a 12" Stopple application.

Source: Williamson Industries Inc.

Hot Tapping Procedure

- Connect branch fitting and permanent valve on the existing pipeline while in service
- Install hot tapping machine on the valve
- Cut through pipeline wall and extract coupon through the valve
- Close valve and remove hot tapping machine
- Connect branch line



Schematic of Hot Tapping Machine

Methane to Markets

Hot Tap Benefits

- Continuous system operation – shutdown and service interruptions are avoided
- No gas released to the atmosphere
- Avoided cutting, realignment and re-welding of pipeline sections
- Avoid inerting / gas freeing pipeline section for hot work
- Reduced planning and coordination costs
- Increased worker safety

Methane to Markets

Project Summary for India

- Using hot taps for in-service pipeline connections

Project Description: Using hot taps for 320 in-service pipeline connections (305 small taps and 15 large taps)

Methane Saved:	691,000 cubic meters per year (24,400 Mcf per year)
Sales Value[1]:	$73,200
Capital and Installation Cost[2]:	($57,800)
Operating and Maintenance Cost[3]:	($1,800) per year
Payback Period:	10 months

1 – Gas price in India $3/Mcf ($106/thousand m^3)

2 – All costs have been converted to an Indian basis using the methodology described in *US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively*, Oil and Gas Journal, July 12, 2004

3 – O&M Cost for purchased small hot tap equipment and contract service cost for larger taps.

Pipeline Maintenance and Repair: Agenda

- Methane Losses from Pipeline Maintenance
- Hot Taps
- **Composite Wrap**
- Pipeline Pumpdowns
- Pipeline Pigging
- Discussion Questions

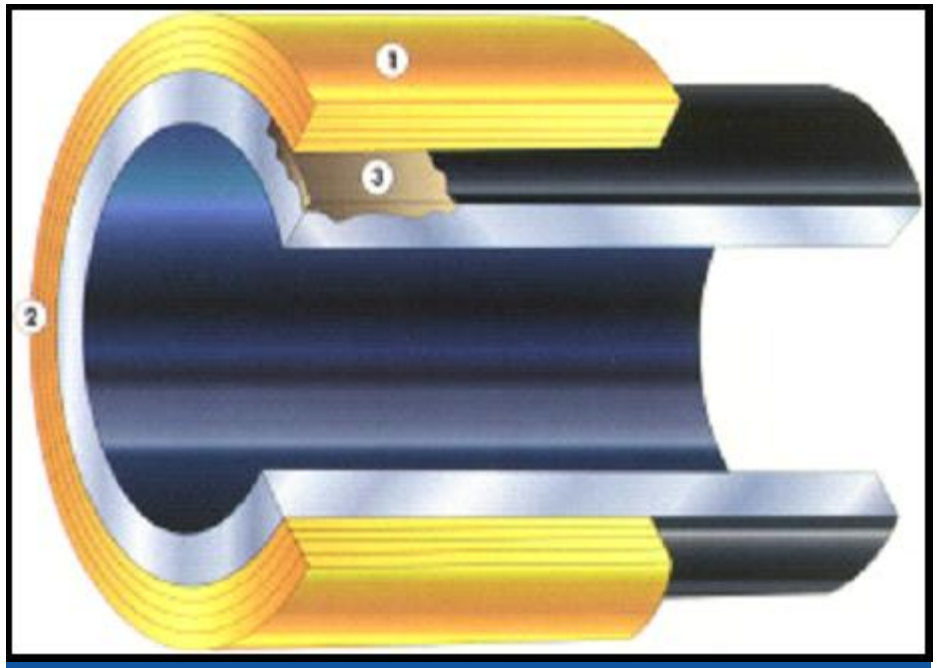
Composite Wrap for External Repair

- Permanent On-Line Pipeline Repair Technology

Source: Duke Energy

Composite Wrap: What Are They?

- 1) A high-strength glass fiber composite or laminate
- 2) An adhesive or resin bonding system
- 3) A high-compressive-strength load transfer filler compound



Source: Clock Spring® Company L. P.

Composite Wrap Installation

- After excavation and pipe preparation
  - External defects filled with filler
  - Composite wrap wound around pipe with adhesive or laminating agents
  - Typically 5 centimeters (2 inches) of wrap must extend beyond damage
  - Excavation site refilled after curing time
- Reducing pressure improves quality of repair

Source: Armor Plate

Methane to Markets

Composite Wrap Lessons Learned

- Trained but not skilled crafts persons required
- Specialized welding and lifting equipment not required
- Minimizes access concerns
- No delays awaiting metal sleeve
- Cathodic protection remains functional
- Proven permanent repair for external defects
- Temporary repair for internal faults
- In-service pipeline repair methodology
- Ideal for urgent and quick repair
- Avoid service disruptions
- Cost-effective

Clock Spring® Columbia Experience

- Clock Spring® was tested on a 61 centimeter (24 inch) diameter pipeline affected by external damage
- Pipeline had 75% diameter deflection and a defect length of 1.83 meters (6 feet)
- Clock Spring® used 87 ten centimeter (four inch) wide wrap kits and 150 filler kits to repair the damage
- Clocks Spring® wrap passed pressure cycles lasting 15 minutes at pressures up to 1800 pounds per square inch gauge (psig)*

* 1800 psig = 123 atm

Methane to Markets

Project Summary for India

- Composite wrap for repair of non-leaking pipeline defects

Project Description: Using composite wrap to repair a 15 centimeter (6 inch) pipeline defect

Methane Saved:	105,000 cubic meters per year (3,690 Mcf per year)
Sales Value[1]:	$11,100
Capital and Installation Cost[2]:	($5,800)
Operating and Maintenance Cost[2]:	($0) per year
Payback Period:	6 months

1 – Gas price in India $3/Mcf ($106/thousand m^3)

2 – All costs have been converted to an Indian basis using the methodology described in *US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively*, Oil and Gas Journal, July 12, 2004

Pipeline Maintenance and Repair: Agenda

- Methane Losses from Pipeline Maintenance
- Hot Taps
- Composite Wrap
- **Pipeline Pumpdowns**
- Pipeline Pigging
- Discussion Questions

Pipeline Pumpdown

- Minimizing emissions when you must cut out a section of pipeline

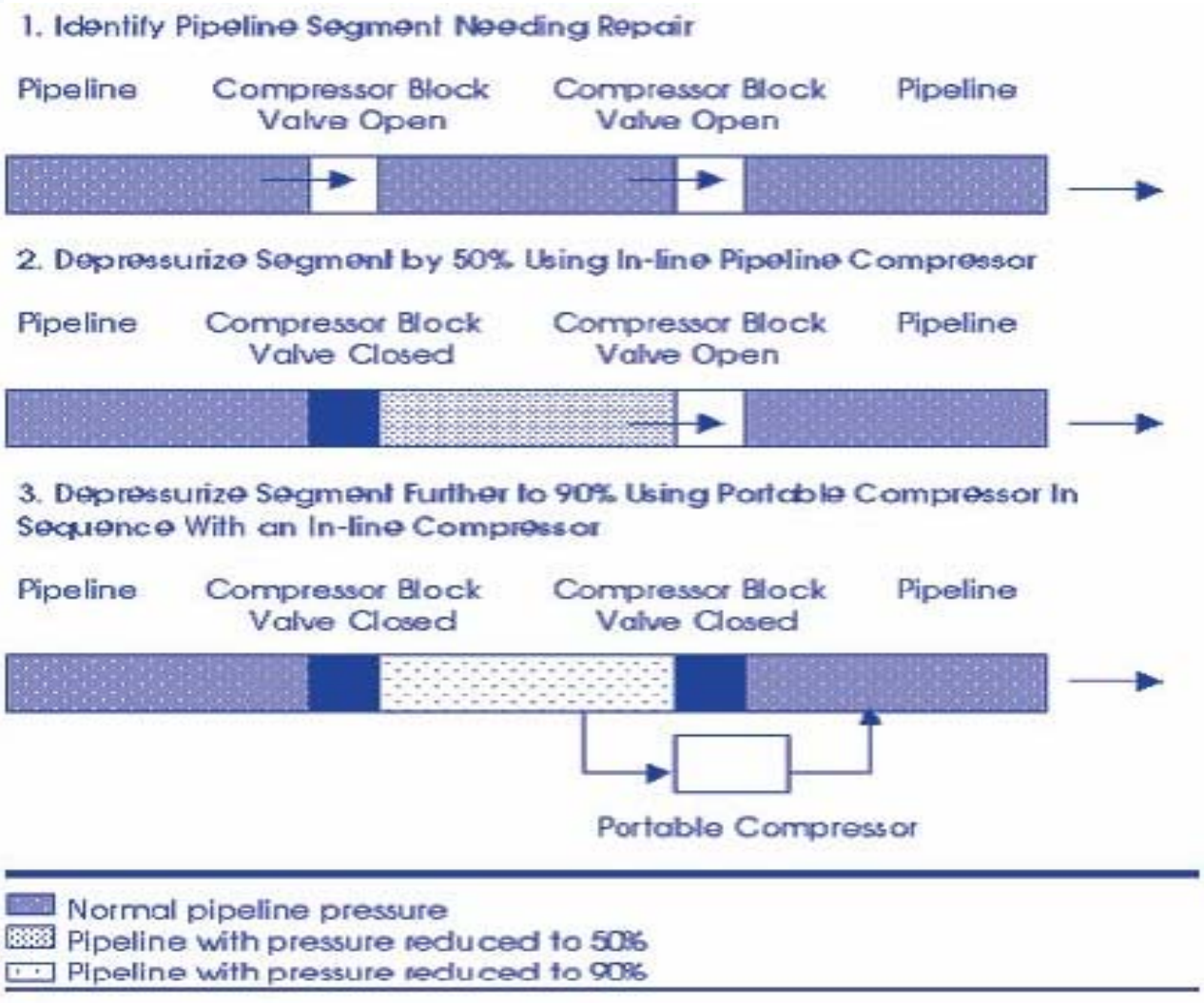
Source: Duke Energy

Methane Recovery by Pipeline Pumpdown

- Use in-line compressors to “pull down” the pressure to minimum suction pressure
- Use portable compressor to “pull down” pressure even further
- Cost is justified by immediate payback in gas savings
- About 90% of gas usually vented is recoverable

Methane to Markets

Sequence of Depressurization Events



Pipeline Pumpdown Equipment

- In-line pipeline compressor
  - Typically has compression ratio of 2 to 1
  - Blocking upstream valve reduces pipeline pressure to safe limits for maintenance
- Portable compressor
  - Typically has compression ratio of 5 to 1
  - Can be used in conjunction with in-line compressor to further reduce pressure in the pipeline section
  - Justifiable only when multiple sections of pipeline are to be serviced (i.e. long sections of maintenance or pipeline valve station maintenance where stopples are not feasible)

Methane to Markets

Economics of Pipeline Pumpdown

- Calculate gas vented to atmosphere by depressuring pipeline
- Calculate gas saved with in-line compressors
- Calculate gas saved with portable compressor
  - Consider cost of a portable compressor
  - O&M costs of a portable compressor
  - Consider fuel costs for operating portable compressor
- Calculate the difference in gas savings

Methane to Markets

Project Summary for India

- Using pipeline pump-down techniques to lower gas line pressure before maintenance

Project Description: Performing a pump-down four times per month on a 76 cm (30 inch) pipeline at 600 psig with a portable compressor

Methane Saved:	7,500,000 cubic meters per year (265,000 Mcf per year)
Sales Value[1]:	$795,000
Fuel Cost[2]:	($9,900) per year
Lease and Maintenance Cost[3]:	($454,000) per year
Payback Period:	7 months

1 – Gas price in India $3/Mcf ($106/thousand m^3)

2 – Fuel cost is based on consuming 1,950 m^3 (69 Mcf) of gas per application at $3/Mcf ($106/thousand m^3)

3 – All costs have been converted to an Indian basis using the methodology described in *US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively*, Oil and Gas Journal, July 12, 2004

Pipeline Maintenance and Repair: Agenda

- Methane Losses from Pipeline Maintenance
- Hot Taps
- Composite Wrap
- Pipeline Pumpdowns
- **Pipeline Pigging**
- Discussion Questions

Methane Losses from Pipeline Pigging

- Gas lost when launching and receiving a pig
- Fugitive emissions from pig launcher/receiver valves
- Gas lost from storage tanks receiving condensate removed by pigging
- Gas vented from pipeline blowdowns

Pigging Pipelines

- Hydrocarbons and water condense inside pipelines, causing pressure drop and reducing gas flow
- Periodic line pigging removes liquids and debris to improve gas flow
  - Also inspect pipeline integrity
- Efficient pigging:
  - Keeps pipeline running continuously
  - Keeps pipeline near maximum throughput by removing debris
  - Minimizes product losses during launch/capture

www.girardind.com/

Pigging Applications

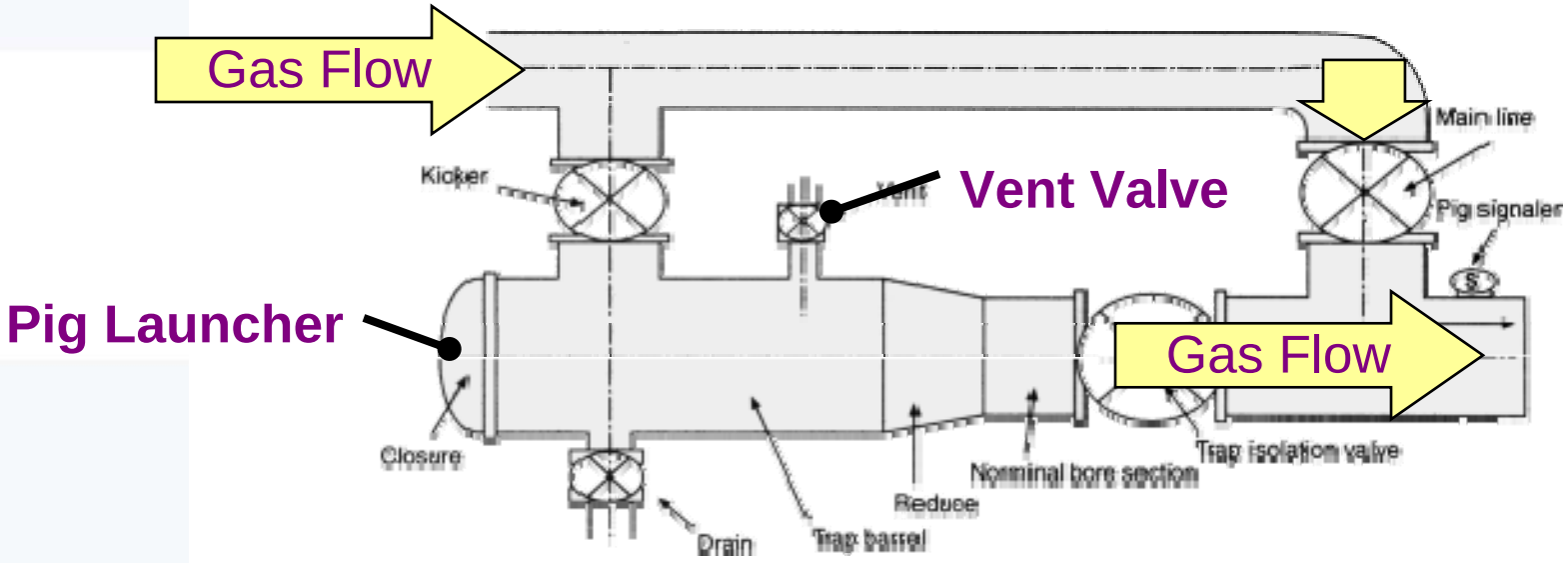
- Pipeline pigs come in a variety of shapes and sizes for different applications
  - Cleaning pigs
    - Have brushes or blades to help remove debris
  - Sealing pigs
    - Make tight seal for removing liquids from the pipe
  - Inspection pigs
    - Specialized pigs outfitted with instruments to monitor the pipeline integrity

www.westernfilterco.com

Methane to Markets

How Does Pigging Vent Methane?

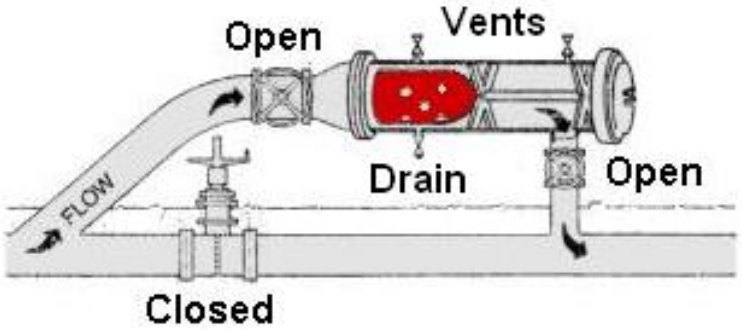
- Pig launchers have isolation valves for loading pigs, pressurizing pigs, and launching pigs with gas bypassed from the pipeline
- Launcher pressuring/depressuring loses methane out the vent valve



www.girardind.com/

Pigging Vents Methane Twice!

- Methane lost through vent valve on the launcher and again through vent valve on the receiver
  - Once receiver is isolated from the line, it must be depressured to remove the pig
  - Liquids ahead of the pig drain to a vessel or tank
- Isolation valve leaks may cause excessive venting to depressure



www.girardind.com/

Estimating Pigging Vents

- E = P * V / 14.7 * n * f

  where:

  E = methane emissions (m^3)

  P = Gathering line pressure (psia)

  V = Launcher and receiver volume (m^3)

  n = % methane

  f = number of piggings

- Pig trap isolation valve leakage greatly increases this minimum amount of gas venting

psia = pounds per square inch absolute

Estimating Emissions from Pigging

- Estimating V

Line Diameter		Methane Emissions Volume	
(inches)	(cm)	(cf)	(m^3)
6	15	0.9	0.025
12	30	4.6	0.130
18	46	11.5	0.326
26	66	27.7	0.784
34	86	65.2	1.846
48	122	170.7	4.834

Adapted from www.pigsunlimited.com

- Estimating P
  - **Default: 315 psia***

  * 315 psia = 21.4 atm

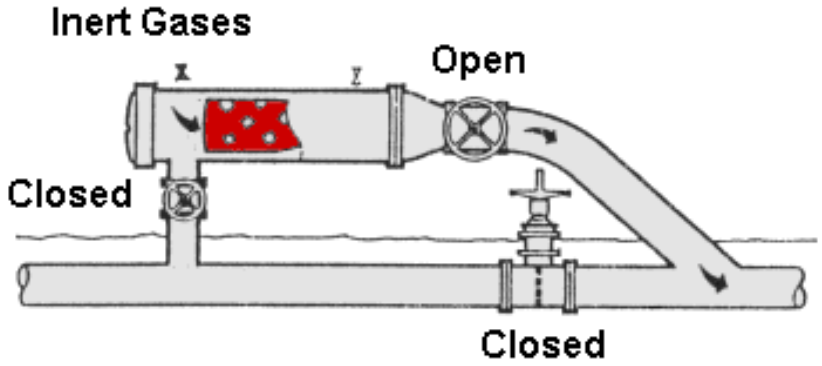
- Estimating n
  - **Default: 78.8 % methane**

Methane Recovery: Use Inert Gases

- Pipeline maintenance requires pipe section blowdown before work can begin
- Gas in pipeline is usually vented to the atmosphere
- Inert gas can be used to drive a pig down the section of pipe to be serviced, displacing the natural gas to a product line rather than venting
- Inert gas is then blown down to the atmosphere, avoiding methane loss

Inert Gas Setup

- Existing pig launcher can be used, set up to work with inert gases
- Portable nitrogen supply connected to the pig launcher vent
- Close valve on the main pipeline, pressurize launcher with inert gas, open launcher to main pipeline
- Supply nitrogen until pig reaches receiver



www.girardind.com/

Industry Experience

- One partner reported using inert gas to purge six pipelines for maintenance
- Gas savings from these applications was 15,200 m^3 (538 Mcf)
- These savings correspond to a typical application of:
  - 3.2 kilometers (2 miles) of 25 centimeters (10 inch) diameter pipeline

Methane to Markets

Is Recovery Profitable?

- No capital costs with existing pigging facilities
- Labor costs are estimated at eight hours for two operators
- Increased safety is the primary benefit of this project
- Gas savings are a secondary benefit, as the labor and nitrogen costs outweigh the gas value

Methane to Markets

Project Summary for India

- Using inert gases and pigs to perform pipeline purges

Project Description: Purging 3.2 kilometers (2 miles) of 25 centimeters (10 inch) diameter pipeline using nitrogen from a nitrogen rejection unit (NRU)	
Methane Saved:	2,500 cubic meters per year (90 Mcf per year)
Sales Value[1]:	$270
Capital and Installation Cost[2]:	($0)
Operating and Maintenance Cost[2]:	($16) per year
Payback Period:	1 month

1 – Gas price in India $3/Mcf ($106/thousand m^3)

2 – All costs have been converted to an Indian basis using the methodology described in *US Natural Gas STAR program success points to global opportunities to cut methane emissions cost-effectively*, Oil and Gas Journal, July 12, 2004

Methane to Markets

Discussion Questions

- To what extent are you implementing these practices?
- How could these practices 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 practices?