Methane Savings from Transmission Pipelines: Agenda

- Transmission Pipeline Opportunities for Methane Recovery:
  - Pipeline pumpdowns
  - Composite wrap
  - Hot taps
  - Pipeline pigging
  - Aerial leak detection

- Discussion
Reducing Methane Emissions from Pipelines: Economics

- All technologies and practices promoted by Methane to Markets and Natural Gas STAR are proven based on successful field implementation by Partner companies.
- Examples represented in the following presentation are based on company specific data collected from actual projects in the U.S. and other countries; economic information is presented according to U.S. costs and gas prices.
- One example estimates the economics for Russia using a range of natural gas prices and a factor to adjust for Russian capital and labor costs (slides 16 to 18) using data from the Oil and Gas Journal.
Overview: Pipeline Pumpdown

- Most applicable to large pipelines operating at high pressures
- 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
Pipeline Pumpdown Sequence of Depressurization Events

1. Identify Pipeline Segment Needing Repair
   - Pipeline  Compressor Block Valve Open  Compressor Block Valve Open  Pipeline

2. Depressurize Segment by 50% Using In-line Pipeline Compressor
   - Pipeline  Compressor Block Valve Closed  Compressor Block Valve Open  Pipeline

3. Depressurize Segment Further by 90% Using Portable Compressor In Sequence With an In-line Compressor
   - Pipeline  Compressor Block Valve Closed  Compressor Block Valve Closed  Pipeline

Legend:
- Normal pipeline pressure
- Pipeline with pressure reduced by 50%
- Pipeline with pressure reduced by 90%
Economics of Pipeline Pumpdowns

- Calculate total gas that would be vented by depressurizing pipeline to atmosphere
- Calculate gas savings from pumpdown with in-line compressors
- Calculate costs and savings from pumpdown with portable compressor
- Calculate annual savings
Pipeline Pumpdown: Calculate Gas Savings

- Estimate the quantity and value of gas that in-line and portable compressors can recover:

  - Total gas in pipeline segment:
    \[ M = L \times (1,000 \text{ m/km}) \times (\pi \times l^2/4) \times (P/101.3 \text{ kPa}) \times (1 \text{ Mcm}/1,000 \text{ m}^3) \]

  - Gas saved by in-line compressor:
    \[ N_i = M - (M/R_i) \]

  - Gas saved by portable compressor:
    \[ N_p = N_i - (N_i / R_p) \]
Pipeline Pumpdown: Calculate Gas Savings

- Example Calculation
  - Given:
    - Pipeline isolated length (L) = 16.1 kilometer (km)
    - Pipeline interior diameter (I) = 0.724 meter (m)
    - Pipeline operating pressure (P) = 4,134 kilopascals (kPa)
    - In-line compressor compression ratio (Ri) = 2
    - Portable compression ratio (Rp) = 8

<table>
<thead>
<tr>
<th></th>
<th>Volume of Gas (Mcm)</th>
<th>Value of Gas Saved ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Gas in Pipeline Segment</td>
<td>270</td>
<td></td>
</tr>
<tr>
<td>Gas Saved by In-Line Compressor</td>
<td>135</td>
<td>$34,000</td>
</tr>
<tr>
<td>Gas Saved by Portable Compressor</td>
<td>118</td>
<td>$30,000</td>
</tr>
<tr>
<td>Total Gas Saved by Pumpdown</td>
<td>253</td>
<td>$64,000</td>
</tr>
</tbody>
</table>

Source: EPA Natural Gas STAR Lessons Learned Document “Using Pipeline Pumpdown Techniques to Lower Gas Line Pressure Before Maintenance”
Pipeline Pumpdown: Calculate Portable Compressor Costs

- Estimate the costs associated with using a portable compressor
  - Capital or compressor leasing costs
  - Fuel costs (mostly natural gas) ~ 7.38 – 8.86 MJ per brake horse power per hour
  - Maintenance costs ~ $5 – $12 per horsepower per month
  - Labor costs
  - Taxes and administrative costs
  - Installation costs
  - Freight costs
## Calculate Portable Compressor Capital Costs

### Example: Total cost of using the portable compressor during a 12 month period

- fuel costs + lease and maintenance costs + freight costs
- \( 12 \times (\$500 + \$31,000) + \$19,000 \)
- \( \$397,000 \)

### Portable Compressor Purchase and Lease Cost Range*

<table>
<thead>
<tr>
<th>Purchase</th>
<th>Lease</th>
<th>Purchase</th>
<th>Lease</th>
<th>Purchase</th>
<th>Lease</th>
</tr>
</thead>
<tbody>
<tr>
<td>68 atm – High Flow</td>
<td>$3 - $6 million</td>
<td>$77,000 - $194,000 per month</td>
<td>$1.0 - $1.6 million</td>
<td>$31,000 - $46,000 per month</td>
<td>$518,131 - $777,197</td>
</tr>
<tr>
<td>41 atm – Medium Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 atm – Low Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$15,000 - $23,000 per month</td>
</tr>
</tbody>
</table>

*Based on assumptions that purchase cost does not include cost of freight or installation and that lease cost is 3 percent of purchase cost

Source: EPA Natural Gas STAR Lessons Learned Document “Using Pipeline Pumpdown Techniques to Lower Gas Line Pressure Before Maintenance”
Pipeline Pumpdown: Calculate Annual Savings

Based on this example:

- Gross value of gas recoverable during a 12-month period, **In-line Compressor**
  
  \[ \text{Gross} = 34,000 \times 4 \times 12 = 1,632,000 \]

- Gross value of gas recoverable during a 12-month period, **Portable Compressor**
  
  \[ \text{Gross} = 30,000 \times 4 \times 12 = 1,440,000 \]

- **Net Savings** associated with using both In-line and Portable Compressor
  
  \[ \text{Savings} = 1,632,000 + (1,440,000 - 397,000) = 2,675,000 \]

---

\(^1\)Gross value of the recoverable gas during a 12-month period, assuming an average of 4 pump-downs per month
Methane Savings from Transmission Pipelines: Agenda

- Transmission Pipeline Opportunities for Methane Recovery:
  - Pipeline pumpdowns
  - **Composite wrap**
  - Hot taps
  - Pipeline pigging
  - Aerial leak detection

- Discussion

Source: Armor Plate
What is Composite Wrap?

- Non-leaking pipeline defects can only be fixed in one of three ways:
  - Cut out damaged segment and replace with new pipes
  - Install a full-encirclement steel split sleeve over the damaged area
  - Install a composite sleeve over the damaged area

- Composite wrap advantages:
  - Can be performed without taking pipeline out of service
  - Repair is quick and less costly than replacement or sleeve options
  - Eliminates venting associated with replacement
Composite Wrap Overview

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
4) Replaces lost hoop strength

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 cm of wrap must extend beyond damage
  - Excavation site refilled after mandated curing time

- Reducing pressure improves quality of repair

Source: Armor Plate
Economics of Composite Wrap

- Calculate associated costs
  - State assumptions (pipeline diameter, distance between shut-off valves, value of gas, etc.)
  - Calculate labor cost
  - Calculate capital and equipment costs
  - Calculate indirect costs

- Calculate natural gas savings

- Compare options
Example Economic Analysis: Adjusted Russian Cost Scenario

- The chart on the next slide shows a comparison of economics for pipeline replacement vs. composite wrap

- Economics are estimated for Russia using a range of natural gas prices and factors from the Oil and Gas Journal\(^1\) to adjust for Russian capital and labor costs

Comparison of Options: Pipeline Replacement vs. Composite Wrap

<table>
<thead>
<tr>
<th>Cost Factors</th>
<th>Natural Gas Lost (Mcm)</th>
<th>Purge Gas (Mcm)</th>
<th>Number of Wrap Kits</th>
<th>Cost of Natural Gas Lost</th>
<th>Cost of Purge Gas</th>
<th>Labor</th>
<th>Equipment and Materials</th>
<th>Indirect Costs</th>
<th>Total Cost of Repair</th>
<th>Most Economical Option</th>
</tr>
</thead>
</table>
|                              | 15 cm Defect           | 595 cm Defect   | 15 cm Defect        | 595 cm Defect            | 15 cm Defect     | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defect | 15 cm Defect | 595 cm Defe
Composite Wrap versus Pipeline Replacement

- Based on this example and Natural Gas Star Partner company experiences, composite wrap is the most cost-effective repair option for small defects.

- Larger defects may be repaired using composite wrap or pipeline replacement depending on value of gas, labor costs, and equipment costs.
  - Note: using higher Russian cost estimates, our economic analysis showed pipeline replacement may be more economic for larger defects.
  - Companies should calculate break even point for defect size based on your specific capital and labor costs.
Summary: Composite Wrap Lessons Learned

- Reduced gas venting as opposed to pipeline replacement
- 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
- Trained but not skilled crafts persons required
- Specialized welding and lifting equipment not required
- No delays awaiting metal sleeve
- Cathodic protection remains functional
Methane Savings from Transmission Pipelines: Agenda

- Transmission Pipeline Opportunities for Methane Recovery:
  - Pipeline pumpdowns
  - Composite wrap
  - Hot taps
  - Pipeline pigging
  - Aerial leak detection

- Discussion

Source: Williamson Industries Inc.
What are Hot Taps?

- New branch connection while the pipeline remains in service
  - Attach a branch connection and valve to the main pipeline
  - Cut-out a section of the main pipeline wall through the valve to connect the branch to the main pipeline
- Current technology has improved reliability and reduced complications
- Hot tapping can be used to add connections to a wide range of pipelines
  - Transmission pipelines
  - Distribution mains

Schematic of Hot Tapping Machine
Hot Tapping Procedure

- Connect fitting and permanent valve on the existing pipeline
- Install hot tapping machine on the valve
- Perform hot tap and extract coupon through the valve
- Close valve and remove hot tapping machine
- Connect branch line
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
- Reduced planning and coordination costs
- Increased worker safety
- No gas outages for customers
Hot Tap Economics

- Determine physical conditions of existing line
- Calculate the cost of a shutdown interconnect
- Calculate the cost of a hot tap procedure
- Estimate annual hot tap program costs
- Estimate annual hot tap program savings
- Economic analysis of hot tap vs. shutdown
Hot Taps: Determine physical conditions of existing line

- Maximum operating pressure (during hot tap)
- Type of pipe material
- Condition of parent pipeline (internal/external corrosion and wall thickness)
- Emergency valve location for isolation in case of accidents
- Working space evaluation (desired tap diameter, location of other welds, obstructions, etc.)
- Check if the line is looped
## Estimated Annual Hot Tap Savings

### Estimated Annual Gas Savings for the Example Scenario

<table>
<thead>
<tr>
<th>Tap Scenario</th>
<th>Annual Tap Number</th>
<th>Natural Gas Savings</th>
<th>Nitrogen Purge Gas Savings</th>
<th>Total Gas Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.2 cm pipeline, 24.8 atm, 3.2 km</td>
<td>250</td>
<td>0.6</td>
<td>155.7</td>
<td>0.05 14.1 42,500</td>
</tr>
<tr>
<td>20.3 cm pipeline, 7.8 atm, 1.6 km</td>
<td>30</td>
<td>0.4</td>
<td>11</td>
<td>0.1 3.4 3,690</td>
</tr>
<tr>
<td>25.4 cm pipeline, 69.0 atm, 4.8 km</td>
<td>25</td>
<td>16.7</td>
<td>417</td>
<td>0.5 13.4 106,875</td>
</tr>
<tr>
<td>45.7 cm pipeline, 14.6 atm, 3.2 km</td>
<td>15</td>
<td>7.2</td>
<td>108.3</td>
<td>1.2 17.4 31,695</td>
</tr>
<tr>
<td><strong>Total Annual</strong></td>
<td><strong>320</strong></td>
<td><strong>692.1</strong></td>
<td><strong>48.4</strong></td>
<td><strong>184,760</strong></td>
</tr>
</tbody>
</table>

1 Source: EPA Natural Gas STAR Lessons Learned Document "Using Hot Taps for In Service Pipeline Connections"
## Economic Analysis of Hot Tap vs. Shutdown

### Economic Analysis for Five Year Hot Tap Program (320 taps/yr)\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost, $</td>
<td>$(47,409)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Contract Service Cost, $</td>
<td>0</td>
<td>$(54,263)</td>
<td>$(54,263)</td>
<td>$(54,263)</td>
<td>$(54,263)</td>
<td>$(54,263)</td>
</tr>
<tr>
<td>O&amp;M Cost, $</td>
<td>0</td>
<td>$(7,959)</td>
<td>$(7,959)</td>
<td>$(7,959)</td>
<td>$(7,959)</td>
<td>$(7,959)</td>
</tr>
<tr>
<td>Natural Gas Savings, $</td>
<td>171,080</td>
<td>171,080</td>
<td>171,080</td>
<td>171,080</td>
<td>171,080</td>
<td>171,080</td>
</tr>
<tr>
<td>Inert Gas Savings, $</td>
<td>13,680</td>
<td>13,680</td>
<td>13,680</td>
<td>13,680</td>
<td>13,680</td>
<td>13,680</td>
</tr>
<tr>
<td>Net Benefit, $</td>
<td>$(47,409)</td>
<td>122,538</td>
<td>122,538</td>
<td>122,538</td>
<td>122,538</td>
<td>122,538</td>
</tr>
<tr>
<td>Payback (months)</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>258 %</td>
</tr>
<tr>
<td>NPV(^2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$417,107</td>
</tr>
</tbody>
</table>

\(^1\) Source: EPA Natural Gas STAR Lessons Learned Document "Using Hot Taps for In Service Pipeline Connections

\(^2\) Net Present Value (NPV) based on 10% discount rate for 5 years.
Methane Savings from Transmission Pipelines: Agenda

- Transmission Pipeline Opportunities for Methane Recovery
  - Pipeline pumpdowns
  - Composite wrap
  - Hot taps
  - Pipeline pigging
  - Aerial leak detection

- Discussion

Source: www.girardind.com/
Overview: 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
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.

Source: 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
- *More than twice*: isolation valve leaks may cause excessive venting to depressure

Source: www.girardind.com/
Pipeline Pigging: Methane Recovery

- Pipeline maintenance requires pipe section blowdown before work can begin
- Gas in pipeline is usually vented to the atmosphere
- Route vent to vapor recovery system or fuel gas
  - One processing company reported connecting pig receiver vent to fuel gas to recover gas while working a tight isolation
Pipeline Pigging: Is Recovery Profitable?

- One U.S. processing company pigged gathering lines 30 to 40 times per year, collecting several thousand barrels of condensate per application.
- Reported saving 606 Mcm/year from recovering flash gases.
- Dedicated vapor recovery unit (VRU) was installed with an electric compressor at an installation cost of $24,000 and an annual operating cost of $40,000 mostly for electricity. Large gas savings and increasing gas prices will offset costs.

<table>
<thead>
<tr>
<th>Gas Price ($/Mcm)</th>
<th>$250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Saved (Mcm/year)</td>
<td>606</td>
</tr>
<tr>
<td>Annual Savings ($/year)</td>
<td>$149,800</td>
</tr>
<tr>
<td>Installed Cost</td>
<td>$24,000</td>
</tr>
<tr>
<td>Operating Cost</td>
<td>$40,000</td>
</tr>
<tr>
<td>Payback Period (years)</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Source: EPA Natural Gas STAR Partner Reported Opportunity “Recover Gas from Pipeline Pigging Operations” Fact Sheet
Methane Savings from Pipelines: Agenda

- Pipeline Opportunities
  - Pipeline pumpdowns
  - Composite wrap
  - Hot taps
  - Pipeline pigging
  - Aerial leak detection
- Discussion
Aerial Leak Detection

- Aerial surveys can quickly detect leaks over long distance transmission pipelines
- U.S. pipeline companies report performing aerial surveys from different platforms using infrared leak detection technologies
  - Fixed wing aircraft or helicopter
  - Passive IR imaging or Light Detection and Ranging (LIDAR) sensors

Source: LaSen, Inc.
DCP Midstream (U.S. Gathering and Processing Company) Aerial Leak Detection

- DCP operates nearly 100,000 km of gathering pipelines
  - No straight sections longer than 8 km
- Decided on helicopter surveys using the Airborne LIDAR Pipeline Inspection System (ALPIS)
- DCP prioritizes survey activities by using system balance measurements to determine which pipeline segments may be leaking
Using the ALPIS system, DCP was able to locate 70 – 80% of pipeline leaks.

DCP has combined aerial surveys with on the ground screening using the RMLD to help pinpoint leaks.

- DCP is able to locate 97% of leaks by combining ALPIS aerial surveys with ground-based RMLD follow-up surveys.

Since beginning these surveys, DCP has reduced lost and unaccounted for gas up to 50%.
Northern Natural Gas (U.S. Transmission Company): Pipelines Inspected with ANGEL Service

- Airborne Natural Gas Emission LIDAR (ANGEL) Service
  - ANGEL system can detect, image and map emissions of natural gas
  - Miles of Pipeline Surveyed: 1,183 Miles
  - Total Collection Time (DIAL): 13.5 Hours
  -Leaks Found and Verified: 27 Locations
Northern Natural Gas: Underground Pipeline Leak - Texas - 2006

DIAL Gas Detection and Measurement

DIAL Scan Pattern
80 foot wide swath

Ground Confirmation

Source: Northern Natural Gas
Northern Natural Gas: Facility Emissions - Texas - 2006

Controlled release of 8 scfm

Location D ANGEL Service Detection, 25 Jan 06 @ 10:16 AM

Source: Northern Natural Gas
Discussion

- Industry experience applying these technologies and practices
- Limitations on application of these technologies and practices
- Actual costs and benefits