Methane Reductions from Pipeline Maintenance Activities

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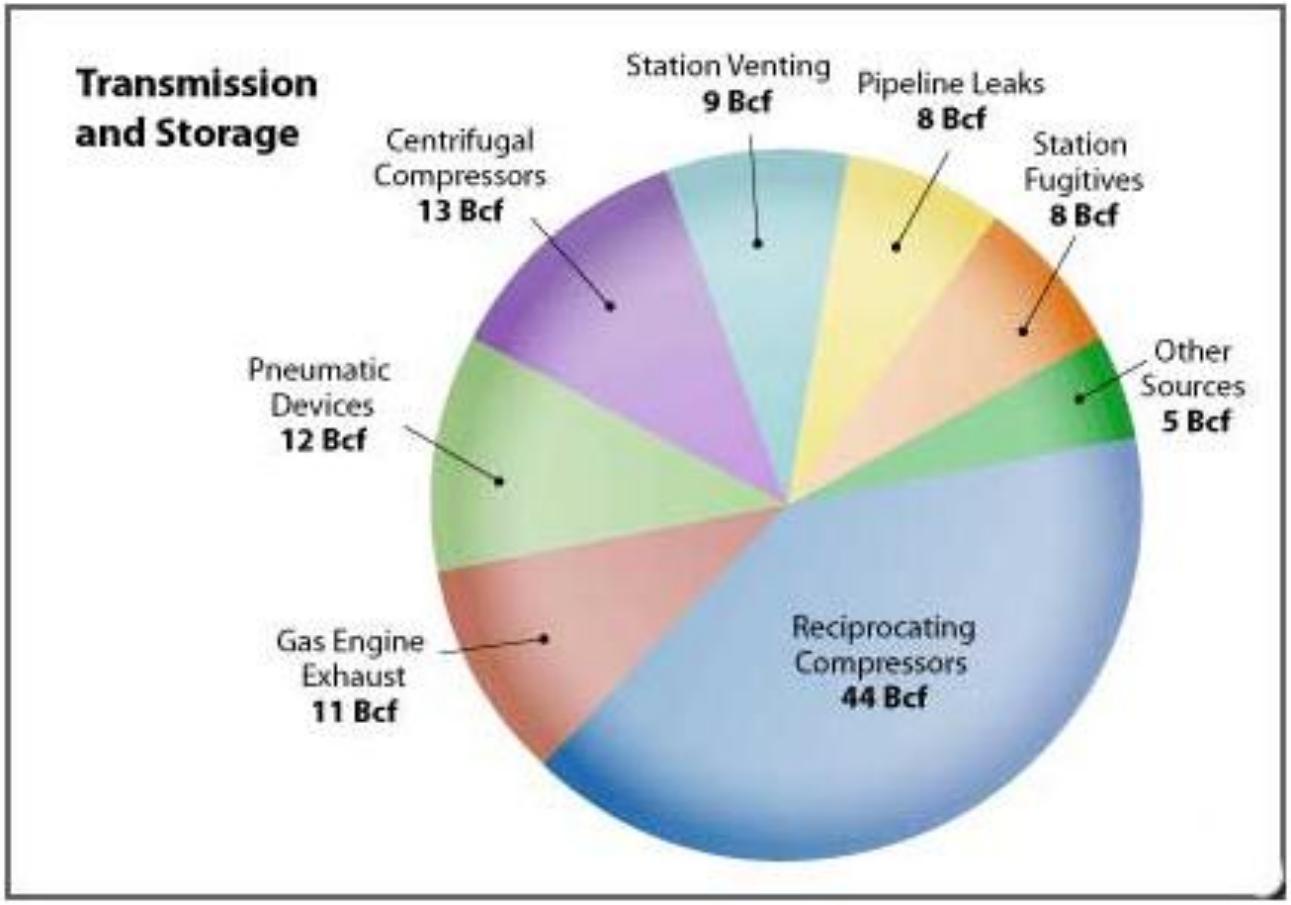
U. S. Natural Gas Transmission Systems

- Transmission and Gathering Systems - approximately 325,000 miles of pipe [1]
- Approximately 1,800 compressor stations [2]
- Over 50,000 reciprocating compressor engines are operated within the U.S. [2]

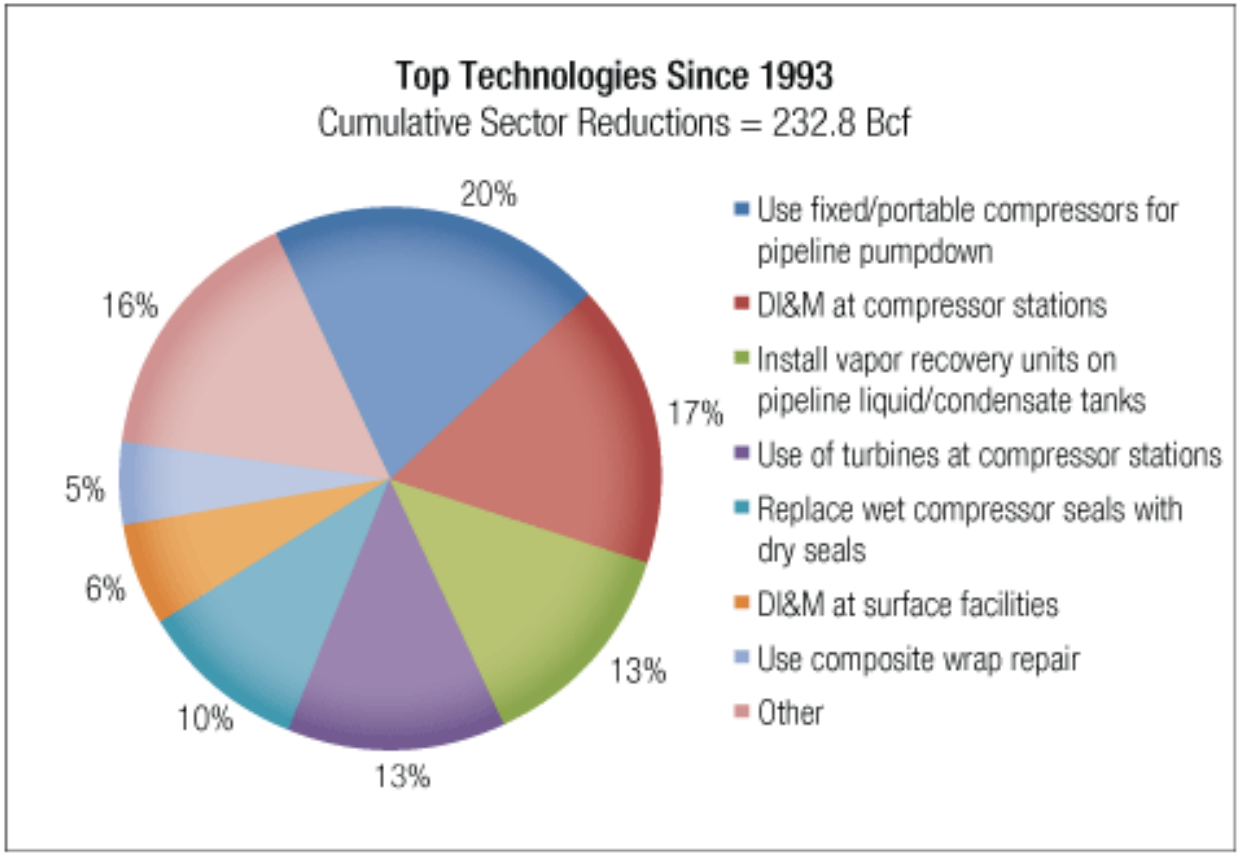
1 U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration
2 U.S. Environmental Protection Agency estimate

Methane Emissions - Natural Gas Sector



Reference: Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 - 2009, USEPA, April, 2011

Gas Transmission Sector Reduction Technologies Since 1993



Reference: EPA Natural Gas STAR Program Web Page

Methane Emission Reduction Methodologies

- Under the Natural Gas STAR Program, EPA identifies 10 available reduction methodologies
  - Pipeline Pump-Down: lower pipeline pressure prior to maintenance activities
    - Use fixed or portable compressors
  - Install Composite Wrap for Pipeline Repairs

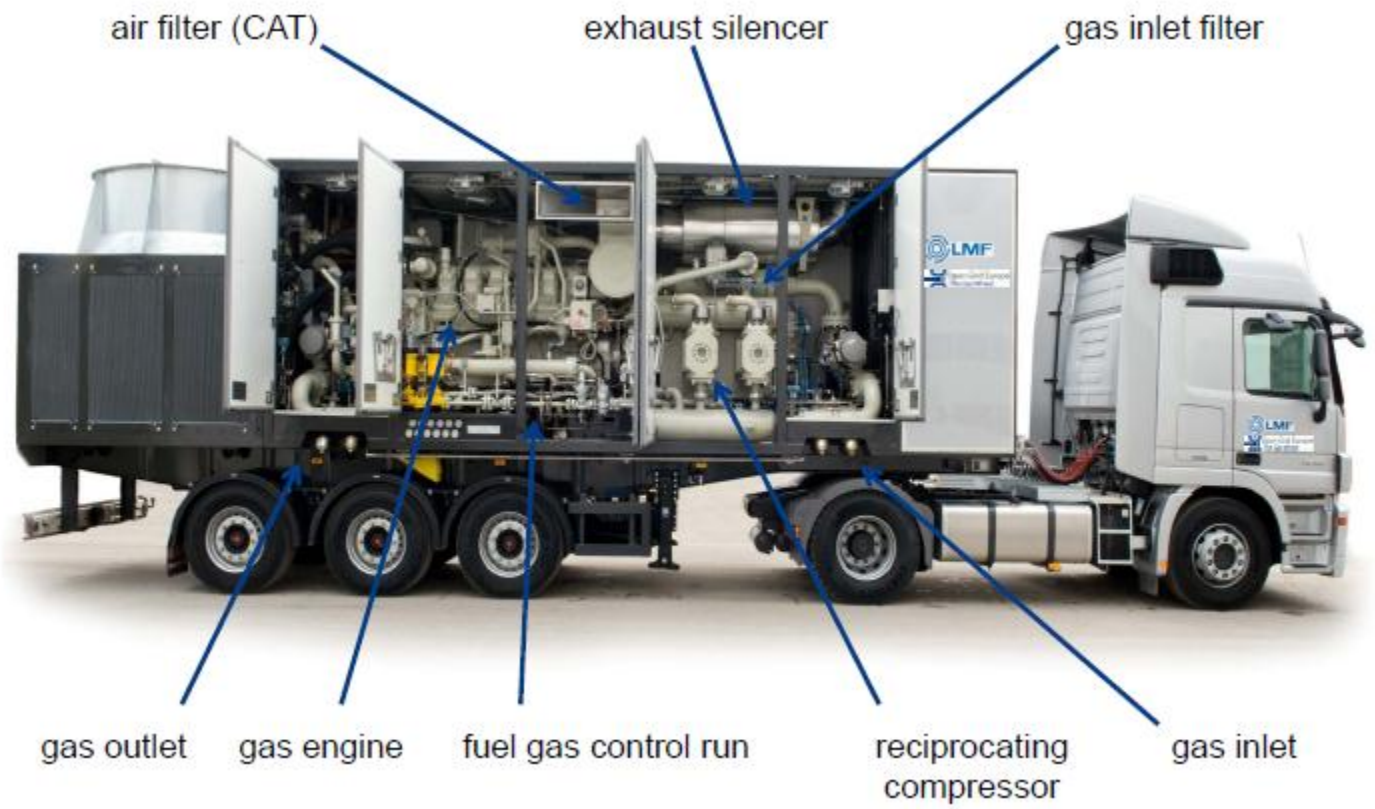
Pipeline Pump-Down

- Goal: Minimize natural gas blow downs associated with pipeline maintenance activities
- Pipeline Pressure Reduction Methodologies include:
  - Reduce pipeline pressure using downstream take-away capacity
    - Applicable for non-urgent, scheduled maintenance activities
  - Use fixed compression, typically existing compressor stations
  - Use portable compression, incremental cost for temporary compression

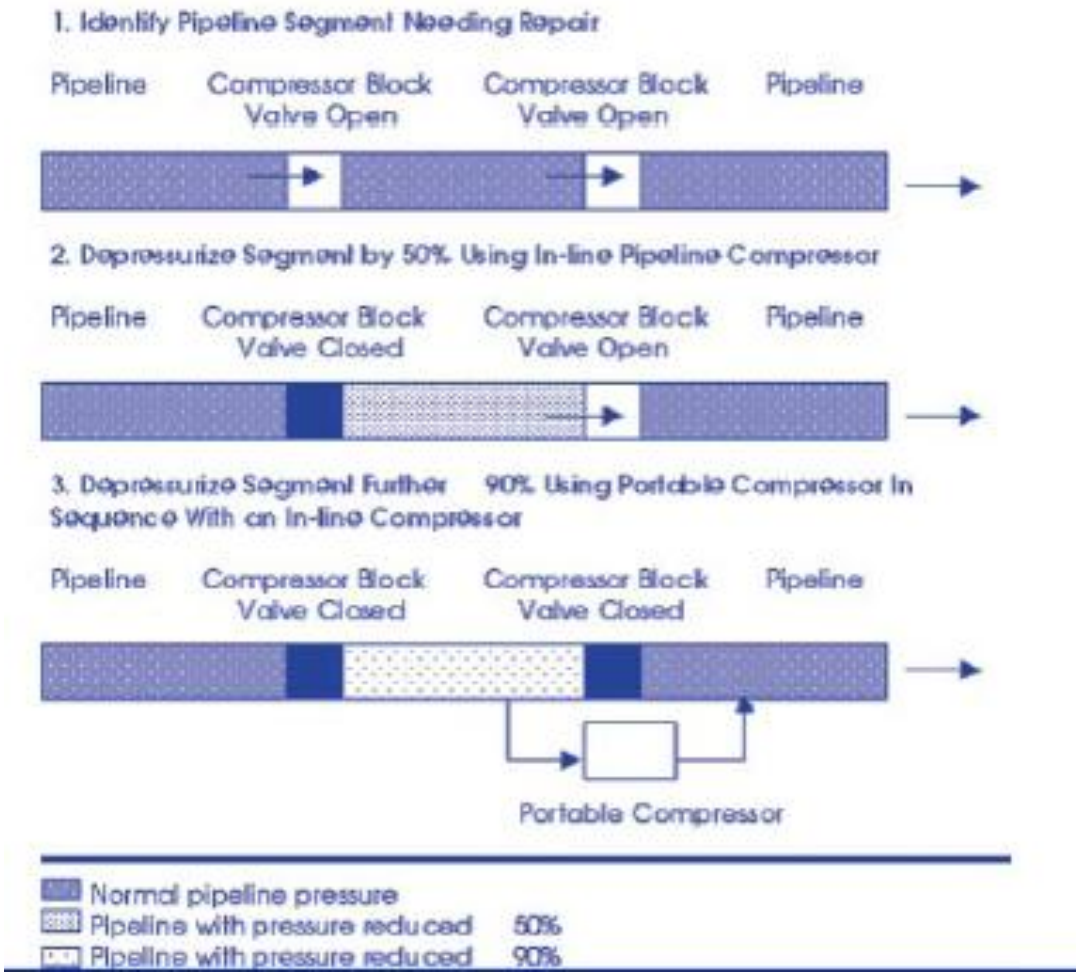
Pipeline Pump-Down Use

- Applicable Maintenance Activities
  - Pipeline Anomaly Repairs, if time allows
  - Hydrostatic Testing
  - Pipeline segment abandonment

Portable Compression



Pipeline Depressurization



Install Composite Wrap for Pipeline Repairs

- Goal: Minimize natural gas blow downs associated with pipeline maintenance activities
- Mechanical sleeves or composite wrap repair methods
- Benefits:
  - Repairs made without taking pipeline out of service
  - Operating pressure reduction may be required, but no gas blow down required

Composite Wrap

- Types:
  - Clock Spring® - composed of glass fibers and polyester resin
  - Strong Back system – water activated, can be used on wet surfaces
  - Armor Plate® - variety of wrap systems for high/low pressure or temperature applications and underwater applications
  - PermaWrapTM – allows detection of previous wrap by inline inspection tools (e.g., smart pigs)

Composite Wrap

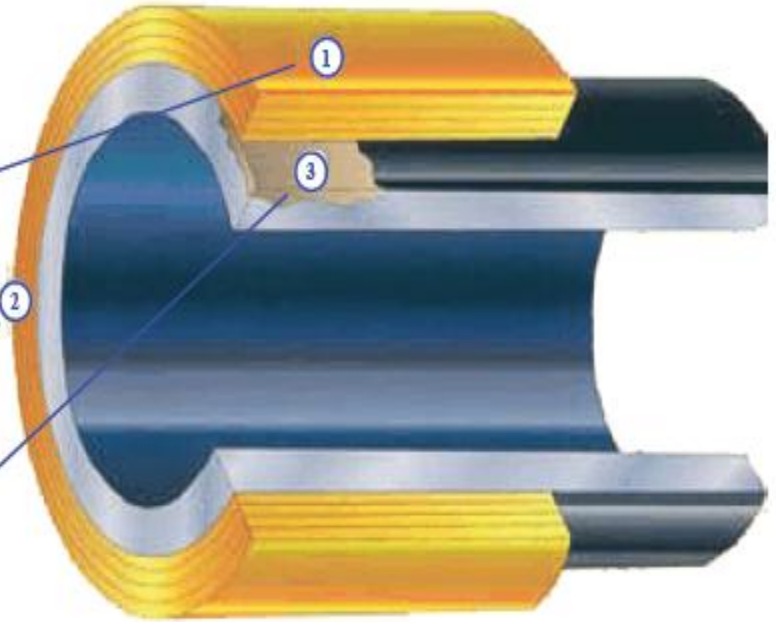
Clock Spring®

A Clock Spring® composite wrap consists of three parts:

1. A high-strength, unidirectional composite structure of glass fibers and a polymer base;

2. A fast curing, high-performance, two-part adhesive system; and

3. A high compressive-strength, load-transferring filler compound.



Clock Spring® Company L.P.

Repair Factors

- Determine whether suitable application
  - Defect type
    - Dent, gouge or corrosion
  - Defect Depth – % metal loss
  - Pipeline depth
  - Pipeline diameter and wall thickness
  - Pipe yield strength
  - Length of pipe wall loss or deformation
  - Defect axial length

Mechanical Sleeve or Composite Wrap Repair Evaluation

- Sleeve or Wrap Application is suitable
- Determine repair cost
- Compare to pipeline section replacement cost
- Estimate natural gas savings (volume and cost)
- Repair method based on engineering and economic evaluation

Factors for Determining Project/Repair Costs

- Labor cost
- Material costs
  - Sleeve or composite wrap
  - Replacement pipe
- Equipment cost
  - Backhoe, other equipment
  - Contractor
  - Inspection
  - Temporary/Rental compression
- Indirect Costs
  - Right-of-way damages
  - Permits

Estimating Natural Gas Savings

$$V\ natural\ gas = \frac{\pi \left(\frac{D}{2}\right)^2 L\ (P)}{1{,}000}$$

Where:

- $V_{\text{Natural Gas}}$ = Volume of Natural Gas, mcf
- D = Inside diameter of pipe, feet
- L = Length of pipe, feet
- P = Pipeline Pressure, psia

Example: 10 mile section of 30 inch pipe

$$V = \frac{3.1416\,(\frac{30\ in/2}{12\ in/ft})^2\ \left(10\ mi\ x\ 5{,}280\,\frac{ft}{mi}\right)\frac{(700\ psi + 14.73\ psi)}{14.73\ psi}}{1{,}000\ cf/mcf}$$

- D = 30 inch, nominal
- L = 10 miles
- P = 700 psi

- Natural Gas Savings = 12,576 mcf

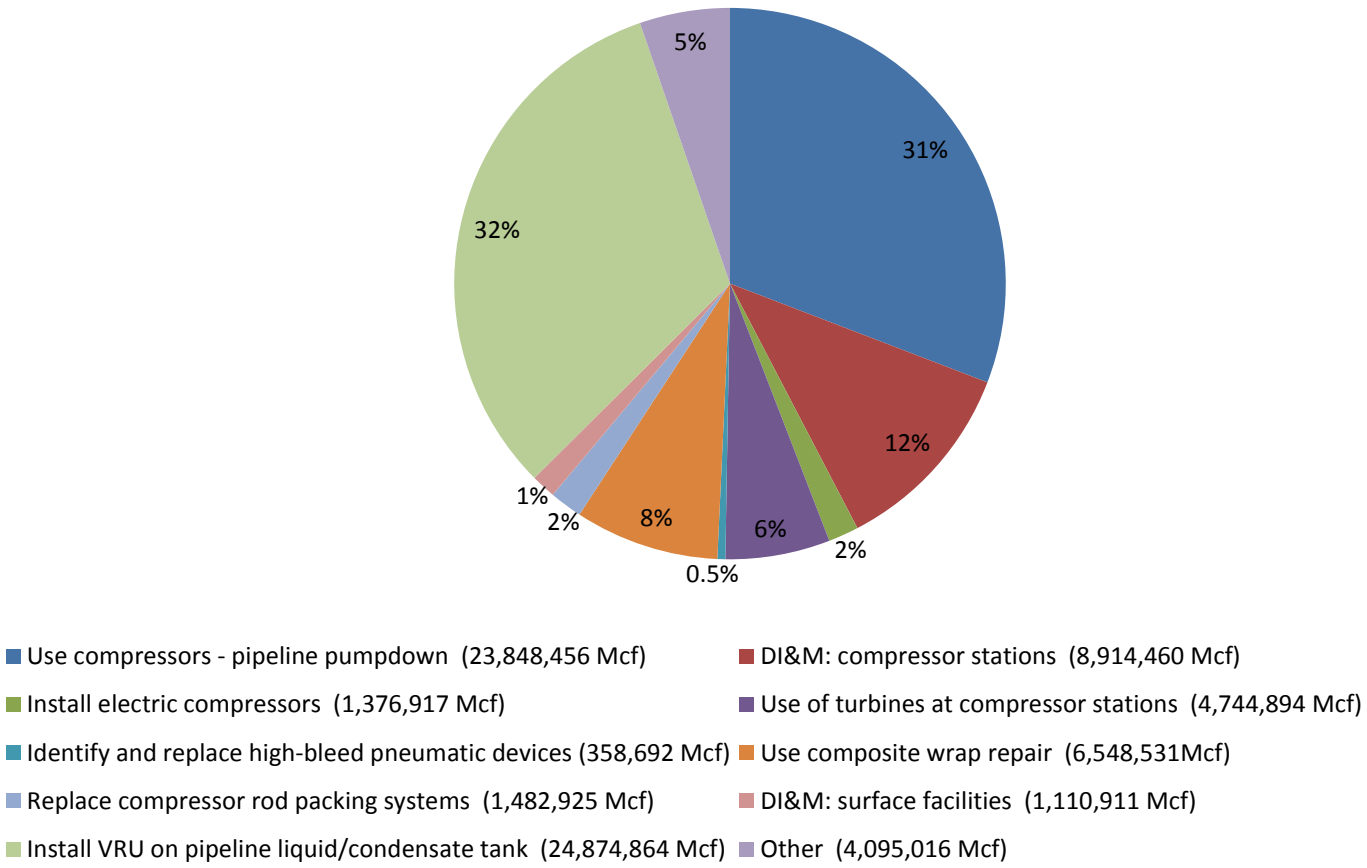
Kinder Morgan's Natural Gas Pipeline Operations

- Largest natural gas transporter and storage operator in US
  - Operates approximately 62,000 miles of natural gas pipelines
- Key Assets
  - Texas Intrastate Pipeline Group serving producers and customers in Texas
  - Tennessee Gas Pipeline serving markets from Texas to northeastern US markets (e.g., New York City and Boston)
  - Southern Natural Gas serving southeastern US markets (e.g., Atlanta)
  - Natural Gas Pipeline Company of America serving central and mid-western US markets (e.g., Chicago)
  - El Paso Natural Gas serving southwestern US markets (e.g., Phoenix, Tucson and California)
  - Colorado Interstate Gas, Wyoming Interstate Company and TransColorado Gas Transmission Company serving Rocky Mountain markets
  - Mohave Pipeline Company and the Ruby Pipeline serving California markets

Kinder Morgan's Natural Gas STAR Program Experience

- Kinder Morgan's natural gas pipeline companies have participated in EPA Natural Gas STAR program since 1993
- Since 1993, Kinder Morgan companies have achieved cumulative methane reductions of over 77.3 Bcf
  - Pipeline Pump-down and temporary compression: 23.8 Bcf
  - Mechanical sleeve or Composite wrap: 6.5 Bcf

Kinder Morgan Cumulative Methane Reductions (1993-2010): 77.3 Bcf



More Information

- Additional information regarding methane emission reduction technologies is available from EPA's Natural Gas STAR Program Web Page:
- http://www.epa.gov/gasstar/
- Technical Documents are available in Arabic, Chinese, Russian and Spanish