PARTNER UPDATE

WINTER 2009

2009 Natural Gas STAR Award Winners

The Natural Gas STAR Program recognized the following companies at this year's annual implementation workshop. Awards were based on reported methane emission reductions achieved, range of different methods to reduce methane emissions, and general involvement in the Program, as well as other innovative company initiatives to address methane emissions.

Production Partner of the Year

Chesapeake Energy

Chesapeake Energy joined Natural Gas STAR in 2007 and quickly integrated the Program throughout its operations. Soon after joining, the company formed a cross-functional implementation team consisting of an engineer from each operating district, as well as representatives from its purchasing and environment, health, and safety departments. These efforts resulted in a number of successful emission reduction projects, including an expansive leak inspection and repair program and development of lean burn gas dehydrators, both of which contributed to impressive methane emission reduction totals for 2008. In addition, Chesapeake Energy has been extremely active in the Natural Gas STAR Program, co-sponsoring and hosting the May 2009 production technology transfer workshop at its headquarters, contributing to the *Partner Update*, as well as providing the keynote address and leading several technical sessions at the 2009 annual implementation workshop.

Chesapeake Energy's Jeff Fisher (center) with EPA Natural Gas STAR Program Representatives

Gathering and Processing Partner of the Year

Western Gas Resources

Western Gas Resources (a subsidiary of Anadarko Petroleum Corporation) joined Natural Gas STAR in 2001. In 2008, the company implemented 12 different technologies and practices, which resulted in significant methane emissions reductions. Such activities include consolidating and optimizing compressors; using hot taps for pipeline tie-ins; and converting gas-driven pumps to solar pumps. The company also has taken advantage of the tools and resources that Natural Gas STAR provides and has worked with EPA to share information with peer companies through technology transfer workshops. In addition to supporting Natural Gas STAR activities, Western Gas Resources also developed an internal environment, health, and safety recognition program.

Anadarko Petroleum Corporation's Edward Schmults (center) with EPA Natural Gas STAR Program Representatives

Transmission Partner of the Year

Spectra Energy

Spectra Energy joined Natural Gas STAR in 2000 as Duke Energy Gas Transmission. Since joining Natural Gas STAR, the company has continuously explored various options for reducing methane emissions from its operations. For 2008, Spectra Energy reported implementing four methane emission reduction technologies and practices and recorded its highest level of methane emissions reductions to date. Activities implemented included using composite wrap repair, using fixed/portable compressors for pipeline pumpdown, using hot taps, and using YALE closures for ESD testing. In addition, Spectra Energy has developed outreach materials, including a YouTube video, promoting the use of natural gas as a clean energy source.

Spectra Energy's Victoria Wagner (center) with EPA Natural Gas STAR Program Representatives

Distribution Partner of the Year

Southwest Gas Corporation

Southwest Gas Corporation joined Natural Gas STAR in 1997. By continuously evaluating technologies and practices, Southwest Gas Corporation is able to implement new processes where applicable. Over the years, the company has implemented nearly 10 different methane emission reduction technologies and practices which include directed inspection and maintenance at gas stations and surface facilities, installation of excess flow valves, testing and repair pressure safety valves, testing of gate station pressure release valves with nitrogen, and use hot taps for in-service pipeline connections.

Southwest Gas Corporation's José Esparza (center) with EPA Natural Gas STAR Program Representatives

International Partner of the Year

Enbridge, Inc.

Enbridge, Inc. joined Natural Gas STAR International in 2006 and has demonstrated its commitment to the Program and continuous environmental improvements. Enbridge's Canadian operations are active in the Program and have implemented complementary internal programs with oversight boards. Enbridge has set an internal goal to reduce absolute direct greenhouse gas emissions to 20 percent below 1990 levels by 2010. To meet this goal, Enbridge is exploring and implementing a variety of projects. The company has implemented directed inspection and maintenance programs, replaced aged heaters with new efficient gas-fired heaters, and replaced compressor rod packing systems.

Enbridge's David McQuade (center) with EPA Natural Gas STAR Program Representatives

Rookie of the Year

Comgas

Comgas joined Natural Gas STAR International in 2008. Aligned with its environmental and sustainability policy, Comgas implements activities to reduce methane emissions from its operations, as well as to enhance network safety and operational integrity. This includes continuous monitoring of the distribution network and focusing on the replacement of its cast-iron pipeline network. Comgas has taken extra steps to understand methane emissions from its cast iron distribution network by collecting more than 900 measurements from leaking pipes prior to insertion of plastic liners. Comgas shared this information with the Program in a Winter 2008 *Partner Update* article. The company also worked with the Natural Gas STAR Program to publish results of its measurement studies in an article in the September 2009 issue of the Pipeline and Gas Journal.

Implementation Manager of the Year

Andrew McCalmont, Chesapeake Energy

Since Chesapeake Energy joined Natural Gas STAR in 2007, Andrew McCalmont has provided extensive support and leadership in implementing its participation in the Program. Under his leadership, Chesapeake Energy has closely integrated its Natural Gas STAR participation with its core business activities, resulting in significant efficiency improvements and methane emissions reductions. Andrew led the company's Natural Gas STAR implementation team in a massive undertaking to identify methane reduction activities being performed by the company dating back to 2001 by using the STARtracker software. Andrew also has been a champion of Natural Gas STAR's overall technology transfer efforts by facilitating information exchange. Earlier this year, he was influential in coordinating and hosting a technology transfer workshop at Chesapeake Energy's headquarters in Oklahoma City. In addition, he worked with EPA to detail Chesapeake Energy's efforts in implementing a successful Natural Gas STAR Program for the Summer 2009 *Partner Update*.

Chesapeake Energy's Andrew McCalmont (center) with EPA Natural Gas STAR Program Representatives.

Continuing Excellence, 5 years

Enbridge Energy Partners, L.P

Trey Moeller (center left) and David McQuade (center right) with EPA Natural Gas STAR Program Representatives

Enogex LLC

Paul Brewer (center) with EPA Natural Gas STAR Program Representatives

Gulf South Pipeline

David Nickel (center) with EPA Natural Gas STAR Program Representatives

Kinder Morgan

Thomas Bach (center left) and Bradley Stevener (center right) with EPA Natural Gas STAR Program Representatives

Occidental Oil and Gas Corporation

Wesley Scott (center left) and Krish Ravishankar (center right) with EPA Natural Gas STAR Program Representatives

Williams Production RMT Company

Jim Tangeman (center) with EPA Natural Gas STAR Program Representatives

Photos not available for Alliant Energy, Energen Resources

Continuing Excellence, 7 years

DTE Energy- MichCon

Lawrence Dorr (center) with EPA Natural Gas STAR Program Representatives

ExxonMobil Production Company

Neil Ryan (center) with EPA Natural Gas STAR Program Representatives

Northern Natural Gas

Leanne Meyer (center) with EPA Natural Gas STAR Program Representatives

Western Gas Resources

Bill Grygar (center left) and Edward Schmults (center right) with EPA Natural Gas STAR Program Representatives

Continuing Excellence, 10 years

CenterPoint Energy Minnesota Gas

Jeff Bonham (center) with EPA Natural Gas STAR Program Representatives

ConocoPhillips Petroleum Company

Alena Jonas (center left) and Prasad Tamminayana (center right) with EPA Natural Gas STAR Program Representatives

Continuing Excellence, 12 years

Southwest Gas Corporation

José Esparza (center) with EPA Natural Gas STAR Program Representatives

Photo not available for Consumers Energy

Continuing Excellence, 15 years

AGL Resources

Gregory Jones (center) with EPA Natural Gas STAR Program Representatives

Annual implementation workshop proceedings with further information are available online at www.epa.gov/gasstar/workshops/annualimplementation/2009.html.

Partner Profile: Enbridge's Efficiency Approaches to Reducing Methane Emissions

Through its participation in Natural Gas STAR, Enbridge continues to find new ways to reduce methane emissions and increase the efficiency of its distribution system. A Program Partner since 2006, Enbridge's operating arms across North America include Liquids Pipelines, Gas Pipelines, Sponsored Investments, and Gas Distribution and Services. Throughout its operations, Enbridge is identifying and pursuing measures to avoid methane emissions and benefit from the resulting increases in efficiency and gas throughput.

Cast iron main leak measurement

Fugitive emissions from underground pipelines are often one of the largest sources of losses from distribution systems. The frequency and size of leaks vary depending on pipeline use (mains vs. services), material, and age. Cast iron was the material of choice for low pressure distribution mains up until the 1950s and is still in place in Enbridge's Toronto, Ontario network.

The cast iron pipe began to be replaced with steel and polyethylene in Enbridge's system in the 1970s; however the formal cast iron replacement program was not introduced until 1980. At that time the company had 1,850 kilometers (km) of cast iron pipe in service; by 2008 approximately 1,477 km of pipe had been replaced, and the remaining 373 km of pipe is due to be replaced by 2012.

Enbridge's cast iron lines are not welded but are characterized by 12-foot sections connected by bell and spigot joints which are sealed by jute packing plus cement or molten lead. The cast iron system generally operates at about ¼ pounds / square inch gauge (psig). Leaks in these cast iron pipes develop in the packing over time due to heavy overhead traffic, freeze-thaw cycles, or naturally shifting soil. Leaks have also increased due to a shift towards lower moisture content (i.e., dryer) natural gas which reduces the effectiveness of the joint packing.

Apart from enhancing safety and helping to reduce operating costs, the replacement program also eliminates this source of fugitive emissions. Approximately 30 percent of the company's fugitive emissions from pipeline leaks can be attributed to this source, and yet the remaining cast iron is only about 0.001 percent of the total distribution system network.

To help track the fugitive emissions reduction success of the cast iron replacements, Enbridge quantified methane emissions reductions using emission factors. Enbridge recognized that the commonly used emission factors available to industry for cast iron may not be representative of its own system. Consequently, Enbridge designed a company-specific measurement methodology designed to be implemented with the cast iron pipe replacement program. This resulted in one field measurement being successfully concluded to provide additional context for the emission factors currently being used. Enbridge's measurement method was based on the one followed by the 1996 GRI/EPA study, *Methane Emissions from the Natural Gas Industry*. Exhibit 1 summarizes Enbridge's implementation of this methodology.

Exhibit 1: Diaphragm meter deployed to measure leak rate of an isolated length of Enbridge's cast iron pipe.

Leak Measurement Method for Distribution Pipe
Enbridge based its cast iron leak rate measurements on a method used by the 1996 GRI/EPA study and in co-operation with the planned pipe replacement program. First, the cast iron segment to be measured was selected based on the pipe replacement program and the proximity to a pressure regulator to ensure a steady pressure required for the leak measurement as shown. At least 10 feet downstream and upstream of the leak is excavated and this is the segment that is isolated. The isolated segment is then connected to receive sufficient gas passing through a meter to sustain its normal operating pressure. The measured gas flow rate needed to maintain the normal operating pressure in the isolated segment is the leak rate.

The measurement was performed over a 5,872.7 meter segment, of which 5,071.3 meters was cast iron with 1,387 cast iron joints. The other pipe material type along this segment was plastic and steel and based on the above-ground leak detection was assumed to have zero leaks. From this sample Enbridge has calculated a cast iron leak emission factor is 546,959 cubic feet (cf) methane/mile/year before accounting for soil oxidation. The results are shown below in Exhibit 2 and compared with widely used factors. Although not statistically valid, this result shows that the fugitive emissions from cast iron may be under-reported.

Study	Methane leak factor for cast iron distribution pipe (cubic feet methane / mile / year)
Enbridge Measured Value	536,020
Handbook for Estimating Methane Emissions from Canadian Natural Gas Systems. GRI Canada May 25, 1998.	430,151
Methane Emissions from the Natural Gas Industry. GRI/EPA. 1996.	399,867

Exhibit 2: Enbridge's measurement and common cast iron leak emission factors.

The value of the gas lost in the segment measured by Enbridge was determined to be about $12,000 annually. The experiences gained in performing the measurement led Enbridge to contribute to ongoing fugitive emission factor development for other sources, as well as the development of a fugitive emissions best management practices manual for the Canadian natural gas industry, being conducted in association with the Canadian Energy Partnership for Environmental Innovation. Given that this was just one site, the result did not provide sufficient statistical rationale to change the emissions factors being used. However, consideration is being given to accelerate the replacement program in part due to this measurement outcome.

Reciprocating compressor rod packing replacement
Enbridge also recognized compressor rod packing emissions as an efficiency opportunity at its Enbridge Gas Storage business unit. All rod packing leaks under normal conditions, the amount depending on cylinder pressure, fitting and alignment of the packing parts, and wear. For Enbridge, the focus on rod packing began as a result of a leak detection and quantification study at its Tecumseh gas storage facility, in Sarnia, Ontario. The leak survey allowed Enbridge

to determine that valves and compressor rod packing were key methane emissions sources. Leaking valves were either repaired or replaced within a short time period after the survey was completed, and Enbridge then targeted rod packing for a sustained emissions reductions project. The survey was conducted in 2007 and found that on one of the compressors tested, where high performance seals had been installed, that there was a 60% reduction in fugitive emissions, representing a volume reduction from 168 10^3 m^3/yr to about 68 10^3 m^3/yr. At a value of $7.00 /GJ this represented a saving of about $26,000/yr.

Enbridge's gas storage compressors are driven by natural gas reciprocating engines and range in age from 14 to 45 years, with an average age of 36 years. Compressors range from 2,500 to 4,200 horsepower, have four cylinders each, and operate between 1000 and 1440 psig.

Enbridge investigated the options for reducing rod packing emissions from its compression fleet through discussions with vendors and decided to standardize their replacement on new low emission packing for all compressors. As the original packing becomes worn and the compressor is due for an overhaul, the packing is replaced with a new copper – lead combination material which is softer, provides and improved sealing over its lifetime, but that has the potential to wear quicker.

For rod packing retrofits, Enbridge targeted all eight of its Dresser Rand KVR compressor units, with other units of a different model in consideration for rod packing material upgrades in the future. The first two units were retrofitted in the summer of 2007, and since then two units have been retrofitted each year. By 2010 all 8 KVR units will have had this retrofit completed on them. Enbridge does not expect significant additional costs from using the new packing type as part of its normal maintenance and is tracking wear over time. Initial indications are that the new packing is performing well and emitting significantly less methane to the atmosphere.

Hybrid fuel cell and turbine power generation

Enbridge is also pursuing projects that increase energy efficiency. Direct reduction of fugitive emissions will reduce greenhouse gases; however, a related opportunity to reduce greenhouse gases, and other air pollutants, is to harvest a waste energy stream and generate useful work from this otherwise wasted resource.

Enbridge partnered with FuelCell Energy, of Danbury, Connecticut, to develop a hybrid fuel cell specifically for natural gas utilities. For all gas utilities, natural gas pressure reduction is a normal part of business in the day to day delivery of gas from high pressure systems to lower pressure gas pipelines. Normally this is done using a pressure reduction valve. The utility obtains controlled expansion of the gas; but no other useful work occurs. Ironically, gas expansion during pressure reduction causes the gas to cool, and the utilities typically add more energy at these pressure reduction stations through line-heaters or gas-fired boilers.

The hybrid fuel cell is designed specifically for utility pressure reduction stations. Instead of expanding gas across a valve, Enbridge has installed a turbo expander at a Toronto gate station which harvests energy during the pressure reduction. As depicted in Exhibit 3, gas at 375 psig enters the turbine at an average rate of 2 million cf / hour and exits at 175 psig, using the pressure drop for electric power generation which is provided to the local electricity utility like a wind turbine would. The turboexpander provides 1 megawatt of electricity, and the project incorporates a 1.2 megawatt Direct FuelCell® that operates off low-pressure natural gas that is part of the turboexpander's seal leakage. Additional natural gas, as required, is supplied from the pipeline, and the fuel cell electrochemically converts the hydrogen in natural gas to electricity. This electrochemical process, similar to a battery, starts with what is known as

internal reforming of the fuel to obtain the hydrogen. No external hydrogen supply is required. Fuel is combined with oxygen from air to produce Ultra-Clean electrical power, in the form of direct current (DC), and heat. The DC electricity is then converted to AC power to match the electrical grid requirements.

The fuel cell does two things. First, it more than doubles the amount of electricity delivered to the grid compared to a stand-alone turboexpander. This provides a number of economic benefits. Secondly, the high-quality heat from the fuel cell is used to preheat the natural gas eliminating the air contaminants that would otherwise be produced by the boilers or line heaters used in the pressure reduction process. The fuel cell operates without burning the natural gas so its clean air benefits are unmatched. Compared to Ontario's typical electricity mix of coal, natural gas, nuclear and hydroelectric the hybrid fuel cell offers significant reductions in GHG, NOx, SOx, particulate, and unburned hydrocarbons. The utility is now generating a second revenue stream from its day to day pressure reduction process. The hybrid fuel cell project has been operating since November, 2008, and has produced a cumulative 3 gigawatt hours of electricity from January through May of 2009.

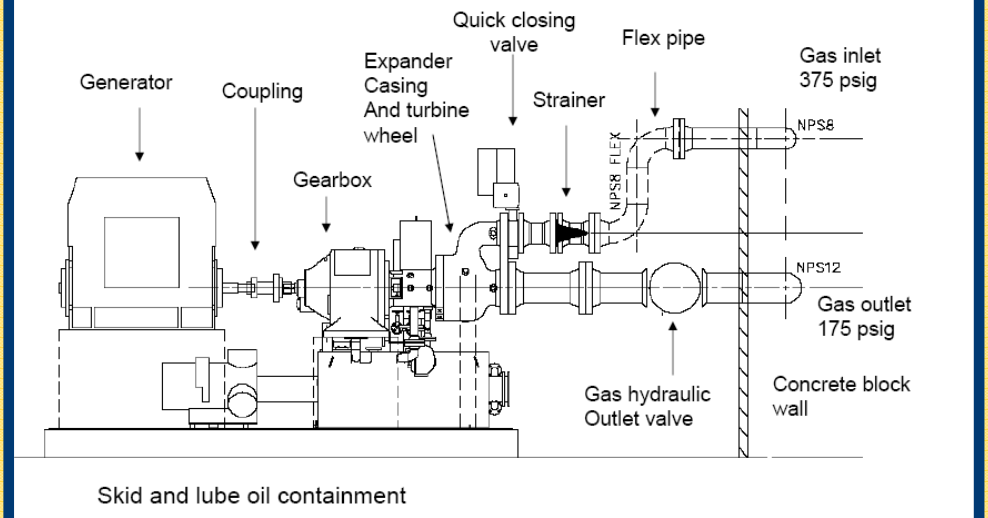


Exhibit 3: Turboexpander schematic

The project costs about $10 million including first-time engineering costs. Enbridge has identified a number of cost reduction opportunities, and it is planning future projects if the technology is awarded electricity price premiums similar to biomass and biogas electricity rates which are 12 to 14.5 cents Cdn. / kilowatt hour in Ontario, Canada. Besides electricity generation and elimination of the gas-fired boiler, advantages include a small footprint suitable for urban facilities, low noise, proximity to electric power consumers, and power generation with reduced air emissions.

Environmental legislation pertaining to the regulation of air emissions, including greenhouse gases should take a holistic view rather than the current sectoral approach. This technology admirably demonstrates that implementation in one sector (in this case gas distribution) can have cumulative benefits in another sector in this case electric generation. Often, cross-

sectoral, or co-industrial benefits are not so recognized making it difficult to link any financial benefit for reduced emissions to the investment in these emerging technologies.

Conclusion
Throughout its infrastructure, Enbridge is pinpointing areas of methane loss and energy loss. With new technology and processes, the Company is finding new ways to quantify methane emissions reduction opportunities and new project ideas to increase pipeline delivery efficiency. Enbridge plans to continue its cast iron pipeline replacement program through 2012. It also plans to have eight reciprocating compressors, in its gas storage operations, retrofitted to the new rod packing type by 2010. As supportive energy policies embrace technologies like fuel cells the Company will promote the expanded use of the hybrid fuel cell technology as a proven solution to Ultra-Clean power generation.

Climate Policy Update: Clean Development Mechanism (CDM) Executive Board approves revision of methodology

At the fiftieth meeting of the Executive Board on October 13 to 16, 2009, a proposed revision to Approved Methodology (AM) 0023 was accepted. The revision allows for two additional methane emissions measurement methods, calibrated bagging and ultrasonic flow metering, in addition to the previously specified methods.

AM0023 is a CDM methodology to reduce methane leaks from surface facilities along natural gas pipelines, such as compressor stations and gate stations. The methodology is applicable to pipeline operations where measures are not in place to systematically identify and repair leaks, where the leaks can be identified and accurately measured, and where continual monitoring takes place after leak repair.

The previous version of AM0023 allows for several methods to quantify methane leaks:

- Bagging technique (constructing an enclosure around a leak and directing an inert gas at a known flow rate through the bag to allow for sampling and determination of the methane leak rate).
- Hi volume sampler.
- Rotameter.

This most recent version of AM0023 adds calibrated bagging (using anti-static bags of known volume to completely capture the leak source and recording time to full bag inflation) and ultrasonic metering as permitted measurement options.

The Executive Board meeting archives are available at cdm.unfccc.int/EB/archives/index.html. The list of approved methodologies is available at cdm.unfccc.int/methodologies/PAmethodologies/approved.html.

New Partners Natural Gas STAR welcomes two new companies

Naftogaz

The Unites States Environmental Protection Agency (EPA) is very pleased to welcome Naftogaz as an official partner in the Natural Gas STAR International Program. Naftogaz joins 12 other oil and natural gas companies in this Program, which aims to identify and implement cost-effective methane emission reduction projects in the oil and natural gas sector. By working through the Natural Gas STAR Program, EPA and the oil and gas industry are preventing methane losses and delivering more natural gas to markets around the world. For more information on the Natural Gas STAR International Program, visit http://www.epa.gov/gasstar/international/index.html.

Naftogaz of Ukraine engages in the full range of upstream, midstream and downstream operations in the oil and gas sectors. This includes oil and gas exploration, gas and condensate processing, operation of pipelines and other shipping installations, and retail sales of oil and gas products to Ukrainian customers. Naftogaz and its subsidiaries provide 91 percent of all domestically produced natural gas in Ukraine. Naftogaz is the largest company in Ukraine.

SC Ukrtransgaz, a subsidiary, operates Ukraine's natural gas transmission system, which transits over 80% of the gas traveling from Russia to Western Europe. It consists of 38,200 kilometers of pipelines, 73 compressor stations, and 13 underground gas storage facilities.

Naftogaz has five plants that process gas and gas condensate as well as a network of natural gas vehicle refueling stations. The network consists of 91 stations capable of filling 75,000 vehicles with compressed natural gas daily. Naftogaz develops and maintains gas distribution systems within Ukraine. Throughout its infrastructure, Naftogaz plans to implement energy-saving measures such as replacing old compressors, installing co-generation units at compressor stations, and building power plants at oil and gas production sites.

Plains Exploration & Production Company

The Unites States Environmental Protection Agency (EPA) is very pleased to welcome Plains Exploration & Production Company (PXP) as an official partner in the Natural Gas STAR Program. PXP is an independent oil and gas company primarily engaged in acquiring, developing, exploring, and producing oil and gas properties. PXP's principal focus areas include mature properties as well as newer properties. PXP produced 33.5 million barrels of oil equivalent (BOE) in 2008 and reported year-end proved reserves of 292 million BOE. PXP was founded in December 2002 as a result of a spin-off from Plains Resources Inc. and is headquartered in Houston, Texas with core operations located in Los Angeles and San Joaquin Basins onshore California; offshore California; Gulf of Mexico; Gulf Coast region; and Texas.

Technology Spotlight Update on Membrane Dehydration

The previous *Partner Update* examined U.S. Department of Energy work to compare membrane dehydration with the more conventional glycol dehydration, where membrane dehydration has the potential for reduced methane emissions. This article provides additional examples.

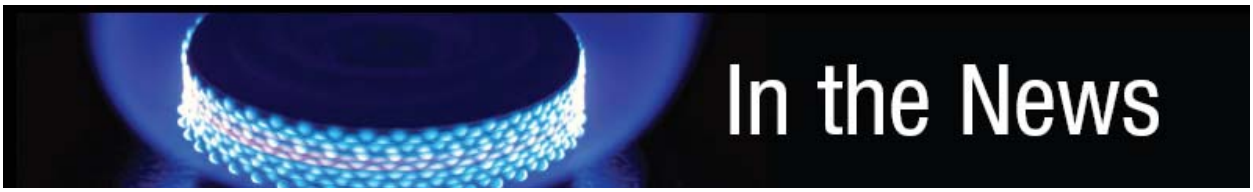
About 15 years ago, a technical article[1] was published detailing the use of a membrane process in the United States as a substitute for an amine/glycol sweetening and dehydration system. Twelve years later, a follow up article[2] presented an analysis of the successful operation of a three-train membrane system processing 45 million standard cubic feet per day (MMcfd) of natural gas at 1000 pounds per square inch to a specification of less than 2 moles carbon dioxide and less than 7 pounds/MMcfd water.

From these implementations, a list of advantages and disadvantages of membranes for dehydration can be explored.

- Advantages
  - Simple design
  - Simple one step process: ideal for unmanned operations
  - Energy efficient
  - Zero emissions are possible when permeate is utilized
  - Lower construction and operating costs
- Disadvantages
  - Dependent on membrane separation quality
  - Dependent on feed gas composition
    - Fouling
    - Water saturation negates permeability process
  - Requires a use or sink for permeate gas

Membranes may play an increasing role in gas processing with evolution of efficient and durable membranes. Natural Gas STAR will continue to follow the evolution of this technology.

[1]Hydrocarbon Processing , April 1995
[2]Hydrocarbon Engineering, May 2007



Below is a summary of several recent Natural Gas STAR and Methane to Markets pieces featured in publications and conferences.

New York Times Article Highlights Methane Emissions Reduction

A recent article published in the "New York Times" emphasizes methane emissions reductions as being a profitable and effective way of curbing greenhouse gas emissions. Key topics covered by the article were:

- Natural Gas STAR Partner EnCana is using infrared cameras for leak detection and repair
- Natural Gas STAR Partner BP is reducing wellhead methane emissions.
- Methane has a much shorter atmospheric lifetime than carbon dioxide, and therefore methane emissions reductions can have a more immediate impact and benefit on climate change.

Methane Leaks from Storage Tanks

The full article can be found here.

Methane to Markets Submission Awarded "Best Paper" at World Gas Conference

A Methane to Markets report highlighting the efforts of participants in the Partnership was awarded "Best Paper" at the 24th World Gas Conference (WGC), which took place in Buenos Aires, Argentina on October 5 to 9, 2009. The paper, Methane's Role in Promoting Sustainable Development in the Oil and Natural Gas Industry, discusses projects undertaken by PEMEX, Pluspetrol, Gazprom, and EnCana to reduce methane emissions cost-effectively. The "Best Paper" award is a longstanding tradition of the IGU, with a two-step selection process involving the IGU Technical Committees and a jury established especially for the final selection stage. The paper was selected from 240 papers accepted to the conference.

The projects examined by the paper were implemented in Mexico, Argentina, Russia, and the United States. These case studies illustrate how the methane emissions source, geography, energy market, and costs can vary, but a common result is reduced emissions and positive net cash flow.

Pipeline & Gas Journal Article Shares Efforts to Quantify Cast Iron Main Emissions

A recent article published in the "Pipeline & Gas Journal" on Comgas, the distribution company of Sao Paulo, Brazil and Natural Gas STAR International Partner, provides data on methane leaks from cast iron distribution mains.

Since 2005, Comgas, the largest natural gas distribution company in Brazil by distribution volume, has measured leak rates from 912 segments of cast iron pipelines. The article outlines Comgas's measurement methods and results, and it compares them to the EPA/GRI study *Methane Emissions from the Natural Gas Industry*, which is used as the basis for the U.S. Inventory and Natural Gas STAR presentations. The analysis shows that the average volume of natural gas lost from cast iron distribution networks can vary and points to the need for further study of loss rates globally. For example, the Comgas study yielded average leak rates of almost double that in the U.S. Inventory.

In 1993 Comgas converted from town gas to natural gas, with the dryer natural gas causing cast iron joints to dry and gas leakage to increase. This in part motivated Comgas to undertake the measurement study and emissions reduction measures. During the first five years of this effort, Comgas spent $82 million to rehabilitate 250 kilometers (155 miles) by inserting polyethylene pipes into the existing cast iron network—eliminating the equivalent of 125 MMcf per year of gas losses.

A copy of the article will be posted on the Natural Gas STAR website.

Prospective Projects Spotlight Ideal Distribution Facility: Gate Stations and Surface Facilities

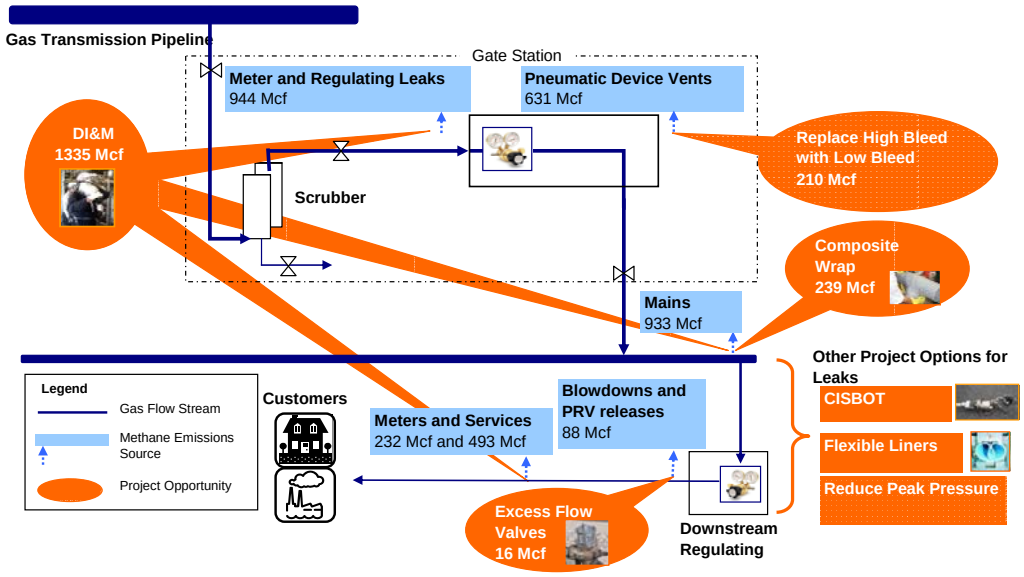
Since the inception of Natural Gas STAR, distribution Partners have reported many cost-effective technologies and techniques to reduce methane emissions, with projects applicable to virtually every part of the distribution process. Considering these projects together provides a new approach to reducing emissions, creating an ideal low methane emissions facility.

Natural Gas STAR Partners around the globe face a diverse set of conditions and markets in which to operate, and the ideal facility concept can help structure a strategy for finding and implementing the most cost-effective projects for a specific setting. For Partners expanding into new construction, the ideal facility approach can provide an up-front focus on the value of reduced methane emissions and incorporate it into facility design. For Partners scheduling significant facility or system overhauls, the ideal facility approach can identify efficiency improvements at the most convenient time for their implementation. The ideal facility approach also treats methane capture and use projects as a system-wide investment which can viably compete for funding with other project types on a financial basis. The approach is implemented below using a sample distribution system. The system's process flow is defined, paths to the atmosphere are identified, mitigation projects for each source are considered, and financial performance of the projects is considered.

Background: Gas Distribution Methane Emissions

Below is process flow diagram for natural gas distribution. Natural gas from a high pressure transmission line is routed to a distribution gate station where the pressure is stepped down and the gas is metered and odorized. Gas leaves the gate station and enters the distribution network which includes high and low pressure mains, meter and regulating vaults, low pressure service lines, and customer meters. Major methane emissions sources along this route are also identified in the diagram and include equipment leaks, line leaks, and pressure regulator vents.

Exhibit 1:
Distribution process flow, typical annual methane emissions, and potential savings



This process flow depiction of methane emissions identifies key paths to the atmosphere and the affected parts of the system. Diagramming distribution systems allows all identified emissions sources to be paired with cost-effective project options. Below is a list of projects that can be considered in a system-wide review of methane emissions.

Emission Reduction Opportunities: Achieving the Ideal Natural Gas STAR Facility

Below is a list of key Partner-reported projects that can form the basis of an ideal Natural Gas STAR distribution facility.

Directed Inspection and Maintenance (DI&M) has proven to be a cost-effective way to detect, measure, prioritize, and repair equipment leaks to reduce methane emissions. A DI&M program begins with a baseline survey to identify and quantify leaks. Repairs that are cost-effective are then made to the leaking components. Subsequent surveys are based on data from previous surveys, allowing operators to concentrate on the components that are most likely to leak and are profitable to repair.

Cast Iron Joint Sealing Robot (CISBOT) is a miniature robotic system developed with funding from Con Ed and Enbridge Consumers Gas that seals leaking joints with an anaerobic sealant, without service disruption and with minimal excavation. In addition to sealing leaks, the anaerobic sealant injections act as a packing within the joint and help reduce future leaks.

Insert Gas Main Flexible Liners has been reported by Partners where replacement of lines with plastic piping is not feasible or permitted (e.g., bridge crossings). Thin-walled plastic liners can be pulled through long lengths of buried piping and bonded at joints to minimize gas leaks.

Composite Wrap is a permanent, cost-effective pipeline repair technology, suitable for non-leaking defects such as pits, dents, gouges, and external corrosion that restores the pressure-containing capability of the pipe without service disruption. Use of composite wrap as an alternative to pipeline replacement can reduce safety risks, decrease pipeline downtime, and avoid methane emissions from pipe blowdowns.

Excess Flow Valves automatically shut off ruptured gas service lines, preventing catastrophic accidents and methane emissions to the atmosphere. Excess flow valves used by Partners respond to the high-pressure differential created when a line is severed by snapping shut to stop the flow of gas.

Lower Distribution System Pressure minimizes leak rates. Peak demand pressures are set for extended periods of time to meet customer demand but are necessary only for fraction of the time. Higher than necessary pressure intensifies leak rates and increases maintenance costs. Natural Gas STAR Partners have reported adjusting distribution system pressures for shorter intervals to better match current demand, reducing methane emissions and maintenance costs while increasing gas savings.

Converting high-bleed pneumatic devices to low-bleed has resulted in significant methane emissions reductions for Natural Gas STAR Partners. The retrofit or complete replacement of worn units can provide better system-wide performance and reliability and improve monitoring of parameters such as gas flow and pressure.

Management practices to reduce methane emissions such as developing greenhouse gas inventories to track methane emissions, encouraging all levels of personnel to develop new project ideas, monitoring ongoing projects, and viewing such projects as business opportunities can help create a corporate culture to further optimize operations and emissions reductions.

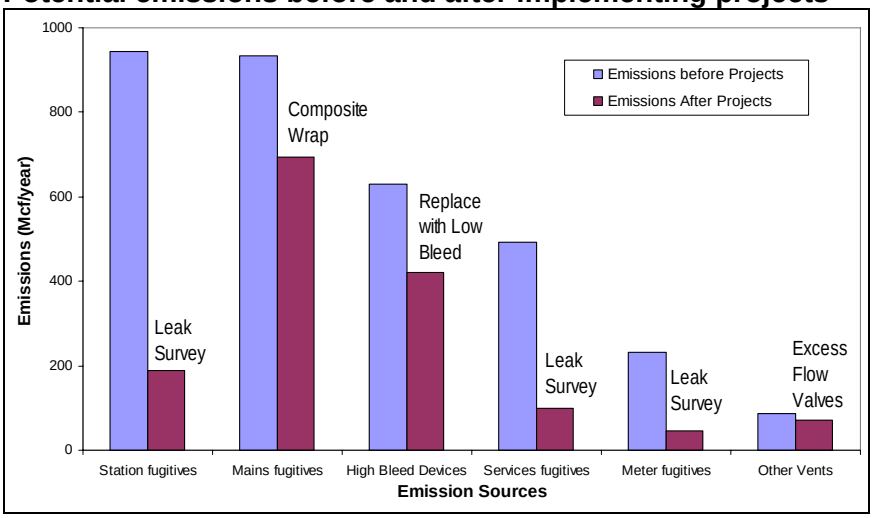
Partners have implemented these as standalone methane emissions reduction projects and found them to be cost-effective. Considering these project types together allows for further economic advantages, such as finding capital and operating cost savings when implementing leak identification and repair both at surface facilities and along distribution lines.

Other Partner reported emission reduction technologies include testing gate station pressure relief valves with nitrogen gas, using hot taps for in service pipeline connections, and pipeline damage prevention.

Implementation and Economics: Ideal Distribution Facility Example

Exhibit 2 illustrates potential emissions reductions that can be obtained by targeting methane emissions within the system with the most cost-effective reduction projects. The total methane emission from the sample system is estimated to be 3,321 Mcf per year. The potential emissions savings from projects with low investment and positive cash flow is 1,801 Mcf per year, resulting in gas savings of $12,600 at a gas value $7 per Mcf.

Exhibit 2:
Potential emissions before and after implementing projects



The investment to cover the implementation of the methane emissions reduction technologies and practices illustrated by Exhibit 2 includes the capital cost of the leak detection and measurement equipment, composite wrap, and excess flow valves. Using data provided by manufacturers and operators and assuming that multiple facilities share capital equipment, the capital cost required is $6,400 or $3.57 per Mcf gas saved in the first year. Operating and maintenance costs include labor costs for conducting surveys and repairs, which is estimated to

be $10,700 per year or $5.96 per Mcf gas saved per year. Savings are in the form of reduced emissions and increased throughput and depend on gas price. Example project economics are shown in Exhibit 3.

Exhibit 3:
Project summary for ideal distribution facility example

CAPITAL & INSTALLATION COSTS	$6,400		
ANNUAL LABOR & MAINTENANCE COSTS	$10,700		
Gas Price per Mcf	**$3**	**$7**	**$10**
Annual Value of Gas Saved	$5,400	$16,600	$18,000
Payback Period in Years	none	3.4	0.9

Conclusion

The ideal distribution facility concept can offer companies a positive cash flow business opportunity with additional climate change benefits. As highlighted in this example, addressing methane emissions at the facility level has the advantages of considering multiple emissions sources to capture, considering multiple methods to capture them, and moving forward with the most profitable methods. This type of coordinated effort to reduce methane emissions facility wide can result in additional efficiencies such as carrying implementation successes to other locations or identifying additional methane emissions reduction projects. The ideal distribution facility concept may vary from location to location, but viewing methane emissions as an unrealized revenue stream is the first step towards achieving it.

Upcoming Event Methane to Markets Partnership Expo

New Delhi, India
March 2 to 5, 2010

The Methane to Markets Partnership Expo is the premier international forum for promoting methane recovery and use project opportunities and technologies. The second Partnership Expo will be held in India and will cover methane capture-and-use projects in agriculture, coal mines, landfills, and oil and gas. The Expo's program will feature:

- **Four sector-specific conference tracks.** Key methane capture and use technologies and policy issues as well as barriers to project development and how to overcome them.
- **Methane Marketplace.** Methane recovery and use projects for immediate financing or implementation and technology providers showcasing the latest products and services.
- **Partnership working meetings.** Government and industry discussions on how Methane to Markets can effectively promote methane capture and use projects and activities around the world.

For more information, see www.methanetomarkets.org/expo/index.htm.

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