

# International Opportunities for Cost-Effective Reductions of Methane Emissions

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“US Natural Gas STAR Program Success Points to Global  
Opportunities to Cut Methane Emissions Cost Effectively”*

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The production, processing, transmission, and distribution of natural gas worldwide releases as much as 88 billion cubic meters (BCM) of methane to the atmosphere annually.<sup>1</sup> Because methane is both the primary constituent of natural gas and a potent greenhouse gas when released to the atmosphere, reducing vented and fugitive emissions along the supply chain from wellhead to burner tip can yield substantial economic and environmental benefits. To the extent that cost effective emission reduction opportunities are available, it is in the best interest of industry leaders everywhere to avoid product losses by instituting technologies and practices that can both reduce methane emissions and increase corporate revenue.

The experiences of U.S. industry working in collaboration with the United States Environmental Protection Agency (EPA) Natural Gas STAR Program have positively affected not only public image, but also greenhouse gas (GHG) emissions levels and corporate profits. The Natural Gas STAR Program is a voluntary partnership between EPA and the oil and gas industry to identify and implement cost-effective technologies and methods to reduce methane emissions. Since 1990, the U.S. oil and gas industry has achieved over 10 BCM of methane emissions reductions.

These reductions have been made primarily as a result of communicating available technologies and efficiency improvements, the integration of which has been facilitated by Natural Gas STAR's efforts to increase understanding of these opportunities among its partners.

Internationally, data shows that significant opportunities exist in the natural gas industry for cost-effective methane leak mitigation projects. This article seeks to encourage development of international methane mitigation projects by using the experience of the U.S. Natural Gas STAR Program to estimate the potential opportunities in several other countries with large and/or growing natural gas industries. In addition, we examine the emerging emission reduction markets that can offer an additional revenue stream beyond increased gas sales and we cite some actual examples of international projects that will achieve methane emission reductions.

## Cost-Effective Mitigation Options

Although natural gas is seen as a relatively clean source of energy, methane emissions from natural gas systems in the United States account for approximately 2 percent of U.S. GHG emissions, or 124 million metric tonnes of carbon dioxide equivalent (MMTCO<sub>2</sub>E) per year (124 MMTCO<sub>2</sub>E is roughly equal to 8.7 BCM of methane).<sup>iii</sup> Because the reduction of system losses (such as those that occur through leaking, venting, or flaring) directly leads to increased profits and environmental benefits, many natural gas companies in the United States have been working voluntarily with Natural Gas STAR to identify and implement practices that have led to significant reductions in methane emissions. In 2000, the experiences of three Natural Gas STAR Partner companies – Enron Gas Pipeline Group, Unocal’s Spirit Energy 76, and BP Amoco – was published in *Oil and Gas Journal* along with their successes in improving leak detection and repair and reducing or eliminating emissions from pneumatic devices.<sup>iv</sup> As of 2004, Natural Gas STAR Partners represent almost 65 percent of the U.S. natural gas industry, and since 1990 have reported emission reductions of more than 140

MMTCO<sub>2</sub>E of methane (approximately 10 BCM), valued at over US\$1 billion.<sup>v</sup>

The successful methane emissions reduction progress of U.S. companies is evident through the declining methane emissions over time as shown in Table 1. The table presents the contributions of the four major stages of the natural gas and oil systems to U.S. methane

**Table 1. U.S. Gas and Petroleum Industry Methane Emissions, Sources and Reduction Options**

Sector	MMTCO <sub>2</sub> E		Main Emission Sources	Mitigation Technologies & Practices
	1995	2000		
Production	54.6	47.4	Well-site equipment, Pneumatic devices, & Dehydrators	Low-bleed pneumatics, Flash tank separators, Desiccant dehydrators, Plunger lifts, Vapor recovery units
Processing & Refining	15.5	15.4	Compressors, Pneumatic devices, & Dehydrators	Low-bleed pneumatics, Flash tank separators, DI&M <sup>1</sup> programs
Transmission & Transportation	46.8	43.4	Compressors, Pneumatic devices, & Pipeline maintenance	Low-bleed pneumatics, Maintaining rod packing, Replacing compressor seals, Composite wrap, DI&M <sup>1</sup> programs
Distribution	33.0	32.0	Subsurface piping & Gate stations	Composite wrap, Pipeline pump down, and DI&M <sup>1</sup> programs

<sup>1</sup> DI&M = Directed Inspection and Maintenance

emissions. In each sector, emissions have dropped since 1995 as a result of continued improvements to management practices and technologies.

Many cost-effective emission-reduction practices have been shown to return initial investment costs within one year, further supporting the case that such investments are worth making. In fact, the options identified in this article represent only a subset of those options that are technically feasible and cost-effective within each industry sector. These

**Table 2. Emission Reduction Technologies and Practices<sup>ii</sup>**

Action	Volume of Gas Saved (Mcm/yr)	Value of Gas Saved (US\$/yr)	Cost of Implementation (US\$)	Payback (months)
High-bleed pneumatics - replacement	1 - 6	150 - 600	150 - 250	5 - 12
High-bleed pneumatics - retrofit	6	690	500	9
High-bleed pneumatics - improved maintenance	1 - 7	135 - 780	0 - 350	0 - 5
Replace pneumatics with instrument air system	566	60,000	50,000/yr	<1
Reduce TEG circulation rates	4 - 372	390 - 39,400	0	0
Flash tank separator	7 - 201	710 - 21,295	5,000 - 14,000	5 - 17
Desiccant dehydrator	30	3,189	12,750	35
Plunger lift system	133 - 517	14,100 - 54,750	2,000 - 8,000	<12
Vapor recovery units	139 - 2,719	14,000 - 273,500	22,685 - 88,000+ 5,250 - 12,220/yr	3 - 41
Compressor rod packing replacement	24	2,595	400	0
Replace compressor wet seals with dry seals	1,278	135,360	240,000	14
Composite wrap pipeline repairs	112	11,880	3,963	0
Pipeline pump down	5,664	600,000	75,000	2
DI&M at compressor stations	833	88,239	26,248	4
DI&M at gas processing plants	956 - 2,719	101,250 - 288,000	53,000 - 128,000	6 - 12
DI&M at gate stations	0 - 17	0 - 1,800	20 - 1,200	0 - 12

options have been chosen for presentation here because of their comparatively high emission reduction efficiencies and low costs.

Table 2 presents several technologies and practices that natural gas companies in the United States have implemented to reduce methane emissions and save money. Many of these reductions have been achieved through the Natural Gas STAR Program – working with industry to identify technologies and practices, developing technical documents, and conducting workshops to increase understanding of the opportunities available.

#### Successful Cost-Effective Mitigation Methods

Unocal installed an air compression system in its Fresh Water Bayou facility in southern Vermillion Parish, Louisiana, in place of gas-powered pneumatic controls. The cost of this system was \$60,000, but it reduced annual methane emissions by over 69,000 Mcf, worth over \$200,000 per year.

As shown, many of these practices result in significant benefits relatively quickly. Most noticeably, early rod packing replacement in the transmission sector, and composite wrap pipeline repairs—applicable to all sectors—incurred minimal costs and provide for net savings almost immediately. A complete description of all of these technologies and practices can be found on the Natural Gas STAR website ([www.epa.gov/gasstar](http://www.epa.gov/gasstar)).

### Global Opportunities

The success of U.S. companies suggests that there are significant opportunities globally to reduce methane emissions cost-effectively. A recent EPA study examined many of the most economic means of reducing emissions of methane associated with the natural gas industry in several countries.<sup>vi</sup> The study identified best practices and technologies for fugitive methane leak reduction in order to help achieve international greenhouse gas emissions reductions at the lowest possible cost. The countries selected have either large methane emissions or rapidly growing natural gas industries, and are listed in Table 3.<sup>ii, vii</sup>

Country-specific marginal abatement cost (MAC) curves, developed to analyze the

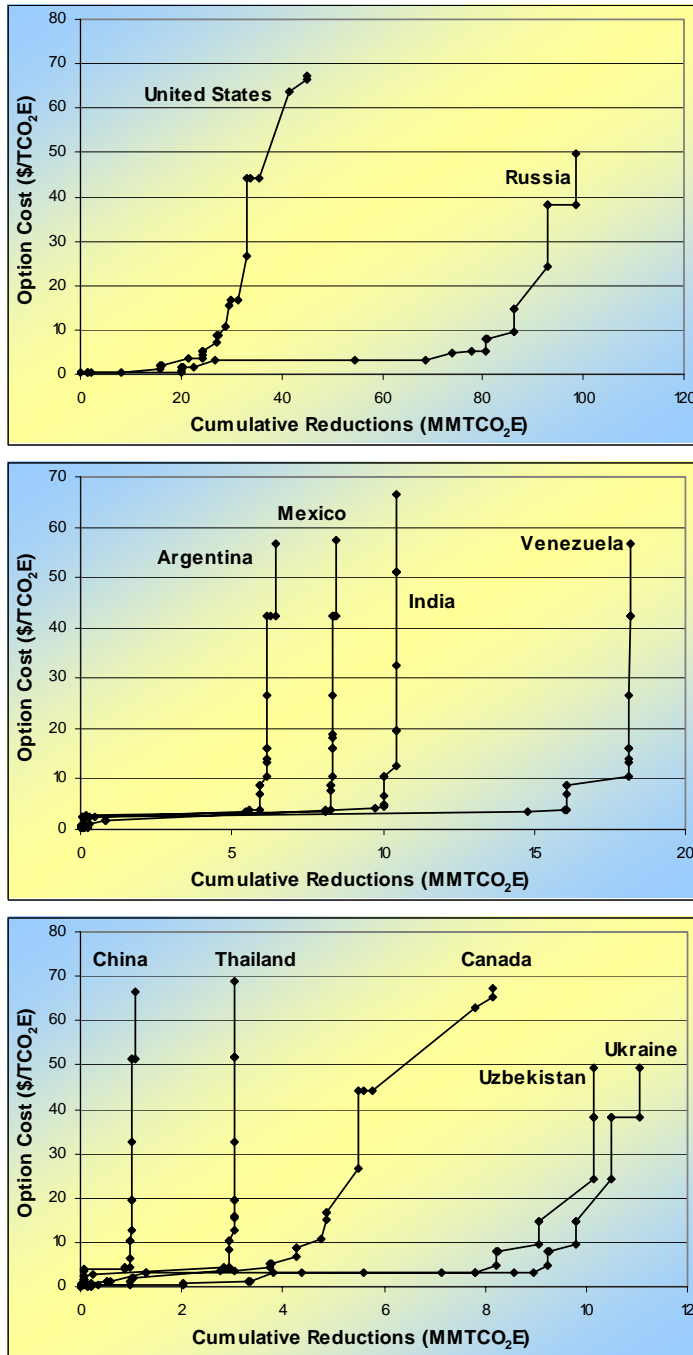
quantity of emissions reductions that can be obtained through implementation of specific abatement options, show that a significant fraction of emission reductions are achievable at values under US\$10 per tonne CO<sub>2</sub>E for all countries analyzed.

These cost-effective methane reduction opportunities are illustrated by Figure 1, Figure 2, and Figure 3, which show MAC curves for the countries listed in Table 3 implementing various mitigation technologies. The curves are based on a five-year discounted cash flow analysis using a 10 percent discount rate, excluding tax considerations. The estimated size, sectors and characteristics of each country’s gas industry were derived from the data shown in Table 3 together with applicable mitigation options and specific emission reduction potentials. Examples of actual mitigation projects in Russia are presented in the final section of this article.

Country	Methane Emissions (MMT CO <sub>2</sub> E)		
	1990	2000	2010
Russia	335.3	252.9	273.5
United States	147.6	138.2	144.8
Ukraine	71.6	60.2	39.4
Venezuela	40.2	52.2	68.0
Uzbekistan	27.2	33.7	42.9
India	12.9	24.4	54.9
Canada	17.1	23.3	23.8
Mexico	11.1	15.4	22.1
Argentina	8.0	13.7	30.5
Thailand	2.9	8.6	15.9
China	0.9	1.5	4.9

In order to put forth the most conservative break-even price estimate, revenues from the sale of gas prevented from release to the atmosphere was not included in the calculations. This assumption was made because no reliable wholesale natural gas sales price data was available for many of the countries analyzed. It should be noted, then, that the methane emission reduction value, expressed in US\$ per tonne of CO<sub>2</sub>E, at which options are presented does not include additional earnings that may be realized through recovered gas sales.

**Figure 3, 3, & 3. 2010 Marginal Abatement Cost Curves for International Methane Emissions (10 % discount rate)**



In countries with developing natural gas markets – where infrastructure such as transmission pipelines and distribution networks are limited – a larger proportion of gas produced in association with crude oil production is vented. Consequently, retrofitting or installing high-efficiency flares offers such countries the greatest potential for cost effective methane

emissions reductions (i.e., less than US\$10/TCO<sub>2</sub>E). In the cases of India and Argentina, for example, flare-related reductions are estimated to account for over 85 and 77 percent, respectively, of total achievable carbon-equivalent emission reductions. Certain cost-effective abatement options, such as directed inspection and maintenance (DI&M), are applicable in several industry sectors; however, their potential impact is dependent on the relative size of the developing country's infrastructure. This situation is illustrated in the case of India, which has a relatively limited natural gas transmission system (i.e., less than 1,700 kilometers), but larger gas processing capacity. DI&M may provide a greater benefit within the processing sector than the transmission sector in India. Although the potential reduction associated with DI&M within the processing, transmission, and distribution sectors of emerging gas industries can be small, this option generally provides a very cost effective opportunity because it is labor-driven.<sup>vi</sup>

### An Emerging Market

Across Europe, in the United States, and in Asia, emission reduction markets are emerging. In many cases, these markets represent opportunities to increase profits. By taking advantage of them, positive revenue streams achieved through increased gas sales can be further enhanced by monetizing (selling) GHG emission reductions. For those projects that can successfully achieve and document emission reductions that meet certain criteria, a host of potential project development finance sources exist.<sup>i</sup>

Of particular interest are what are termed project-based “flexibility mechanisms,” under which project developers in one country are able to generate carbon emission reductions that are recognized as valid and that have monetary value in another country. These reductions can be sold (monetized) to generate an additional revenue stream to complement a project's cash flow, or held (banked) under the expectation that the emission reduction unit price will be greater in the future.

## Market Framework

The emerging carbon emission reduction market represents a source of revenue in addition to the sale of saved or recovered natural gas. Its framework consists of market drivers, market buyers, and market enhancers or facilitators. Together, these three market supporters constitute an institutional framework that can offer project developers opportunities for enhancing project investments or revenues.

Market drivers are entities or organizations that have helped establish the framework for acceptable carbon emission reduction projects and in the process have created a financial market within which emission reductions can be bought and sold. Also, initiatives derived from the United Nations Framework Convention on Climate Change have evolved into what are termed project based “flexibility mechanisms,” such as domestic and international emissions trading markets and the international schemes *Joint Implementation (JI)* and *Clean Development Mechanism (CDM)*. These market drivers and mechanisms provide platforms upon which companies producing saleable GHG emissions reductions (such as the oil and gas industry) can sell and—if necessary to meet corporate or regulatory requirements—buy generated emissions reduction credits.

Notable examples that may be relevant to natural gas emission reduction projects include: the European Union, where a market is set to begin trading carbon emission reductions in 2005 and is expected to become the world’s largest GHG emissions trading market; the United Kingdom, where a project-based emissions reduction pilot has been implemented under the voluntary UK Emissions Trading Scheme launched in April, 2002; Denmark, where a CO<sub>2</sub> trading program covering electricity generators was initiated in 2001; the United States, where the Chicago Climate Exchange (CCX) was established as a pilot cap-and-trade program; and in other countries, most notably Norway, Japan, Switzerland, and Canada, that have either indicated interest or begun planning to introduce emissions trading in the future.<sup>1</sup> Two recent projects, one between Ruhrgas (Germany) and Gazprom (Russia), and another between Nippon

Steel (Japan), Sumitomo (Japan) and Gazprom, illustrate the potential for cooperation under the mechanisms discussed above.

Market buyers are organizations established specifically to purchase GHG emission reductions. These organizations include: the Prototype Carbon Fund (PCF), which provides financial support for projects that produce high quality GHG emission reductions that meet specific criteria in exchange for the title to those reductions; the Certified Emission Reduction Unit Procurement Tender (CERUPT) and the IFC-Netherlands Carbon Facility (INCaF), both in the Netherlands, which purchase GHG emission reductions created by projects in developing countries; and the Natsource GHG Credit Buyers Pool, which is intended to allow its members to obtain carbon credits from a diverse portfolio of project-based emissions reductions including those originating internationally.

Market enhancers and facilitators are sources of finance for emissions reduction projects that seek reductions that are consistent with their goals and that again meet certain criteria. Market enhancers include the Asian Development Bank, a multilateral development finance institution dedicated to reducing poverty in Asia and the Pacific and committed to promoting environmentally sound development; the European Bank for Reconstruction and Development, which offers an investment vehicle to fund projects in Central and Eastern Europe that will utilize clean, renewable energy and/or energy efficient technologies to improve industrial processes and mitigate climate change; and the Global Environment Facility, which provides cost-sharing grants and concessional funding to help developing countries fund projects and programs that protect the environment.

In addition to the institutions listed above, there has been an emergence of a number of commercial entities that serve as brokers of emission reductions. Functioning essentially in the same manner as stockbrokers, these brokers bring carbon emission reduction sellers and buyers together globally in a structured environment to facilitate and ensure

transparency in the transactions necessary to monetize carbon emission reductions.

Methane mitigation projects in the natural gas sector have significant potential for cost-effective, verifiable emission reductions that qualify for most sources of financing. Natural gas emission reduction project developers will have to develop credible emissions estimates and document that project-related emission reductions are actually achieved. In light of the increasing price of natural gas and unit prices reflected in recent carbon emission reduction transactions, projects that reduce methane emissions from natural gas systems often may yield sufficiently high returns to be attractive to sources of necessary finance.

### **Current International Efforts**

The emerging markets described above can – and do – offer short-term investment opportunities for the natural gas industry to capitalize on low-cost emission reductions. In fact, several international firms have already taken the initial step of partnering to pursue projects that will reduce emissions.

Nippon Steel Corporation and Sumitomo Corporation announced in early 2004 that they would partner with Gazprom to repair an aging Siberian gas pipeline. This partnership is expected to result in five million tonnes of CO<sub>2</sub>E reductions among the partnering entities. The *Nihon Keizai Shimbun* reported that potential credits gained under the agreement are expected to result in a 12.5 billion yen (US\$116 million) profit over five years (assuming a market value of 500 yen per tonne CO<sub>2</sub>E reduction).<sup>viii</sup>

A second international project, in which Gazprom is also a partner, established a partnership with Ruhrgas. Gazprom and Ruhrgas have signed a memorandum of understanding aimed at optimizing a section of the Russian natural gas system. The project is expected to abate 447,000 metric tonnes CO<sub>2</sub>E annually.<sup>ix</sup> According to Dr. Klaus-Robert Kabelitz, head of the Economic Research, Energy Industry and Environment Department at Ruhrgas AG, the installation of state-of-the-art energy infrastructure will provide significant benefits for Russia and Gazprom, including

lower energy costs and reductions in greenhouse gas emissions, as well as improvements in energy efficiency that consequently will have a positive employment and economic growth effect. The expected benefits for Ruhrgas and Germany will be the achievement of EU emission reduction commitments more cost-effectively. Additionally, from a business perspective, the increased presence in Russia may present opportunities for market access.<sup>x</sup>

### **Overview**

Methane leaks and other fugitive emissions along the natural gas industry's supply chain represent product losses that can be avoided using readily available, cost-effective practices and technologies. With payback periods that are often less than one year, significant savings can result. The success of the U.S. oil and gas industry, working in partnership with the US EPA's Natural Gas STAR Program demonstrates that the implementation of emissions mitigation options can yield significant methane emissions reductions, cost savings and increased profits. Internationally, the U.S. experience suggests that there are significant cost-effective methane emission reduction opportunities in the oil and natural gas sectors. Companies can take advantage of flexible emissions trading mechanisms to develop projects internationally, giving occasion for firms in developed countries to partner with industry in other developed or in developing countries to reap mutual financial, social and GHG emissions reduction benefits.

In addition to the financial benefits discussed in this article, pursuing natural gas emission reductions also makes good environmental sense, supporting corporate citizenship efforts and effectively contributing to both natural resource and environmental stewardship. With a global warming potential (GWP) 23 times that of carbon dioxide, methane releases from natural gas systems contribute substantially to global GHG loadings to the atmosphere, and have the potential to account for significant improvements in GHG emissions levels.<sup>xi</sup>



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Mitigation Conference in Novosibirsk, Russia, and at the Third International Methane and Nitrous Oxide Mitigation Conference in Beijing, China. In the private sector, Mr. Robinson worked with BP on their GHG emissions auditing program, and development of ICF’s proprietary Greenhouse Gas Emissions Management System (GEMS™). He also contributed to studies of crude oil disruption scenarios for the U.S. Strategic Petroleum Reserve and numerous other fuels and environmental issues. Mr. Robinson received BS and MS degrees, Tau Beta Pi, in Chemical Engineering from the University of Southern California.

<sup>i</sup> Fernandez, Roger L., Matthew Mendis, and Lee Schultz, 2003. *Project Finance Opportunities for Natural Gas Emission Mitigation*. Proceedings of the 3<sup>rd</sup> International Methane and Nitrous Oxide Mitigation Conference, 17 – 21 November, 2003.

<sup>ii</sup> Tingley, Kevin A. and Roger Fernandez, 2003. *Methods for Reducing Methane Emissions from Natural Gas Systems*. Proceedings of the 3<sup>rd</sup> International Methane and Nitrous Oxide Mitigation Conference, 17 – 21 November, 2003.

<sup>iii</sup> EPA, 2004. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2002*. EPA 430-R-04-003. April 15, 2004.

<sup>iv</sup> James Frederick et. al. *Oil and Gas Journal*, August 28, 2000. *Reducing Methane Emissions Through Cost-Effective Management Practices*

<sup>v</sup> <http://www.epa.gov/gasstar/>

<sup>vi</sup> Robinson, D.R., Roger Fernandez, and Ravi Kantamaneni, 2003. *Methane Emissions Mitigation Options in the Global Oil and Natural Gas Industries*. Proceedings of the 3<sup>rd</sup> International Methane and Nitrous Oxide Mitigation Conference, 17 – 21 November, 2003.

<sup>vii</sup> EIA (2002), “International Energy Outlook 2002,” Energy Information Administration, Washington, DC.

(<http://www.eia.doe.gov/oiaf/archive/ieo02/index.html>)

<sup>viii</sup> AFX.com, 29 January 2004. *Nippon Steel, Sumitomo to fix Russia’s Gazprom Pipeline for CO<sub>2</sub> rights*.

<sup>ix</sup> <http://ruhrgas.de/englisch/index2.htm>

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[http://www.europarl.eu.int/workshop/kyoto/kabelitz\\_en.doc](http://www.europarl.eu.int/workshop/kyoto/kabelitz_en.doc)

<sup>xi</sup> IPCC (2001): *Climate Change 2001: The Scientific Basis*, Intergovernmental Panel on Climate Change, Cambridge University Press, 2001.