SUMMARY REPORT

AN IPIECA WORKSHOP

Washington D.C., USA, 26 September 2006

Natural Gas as a Climate Change Solution:

Breaking Down the Barriers to Methane's Expanding Role

IPIECA

Introduction

Natural gas has the potential to play a significant role in a carbon-constrained energy future as a relatively low-carbon fuel source. While much of the technology necessary to increase the supply of natural gas to the energy market exists, the application of that technology must overcome an array of commercial, political, environmental and social barriers before its full potential can be realized. In addition, continued research and development on the technology necessary to commercialize 'unconventional' gas holds the promise of unlocking new reserves.

Co-sponsored by the Methane-to-Markets Partnership, US EPA and IPIECA, this workshop brought together experts from academia, business, governments, and international and non-governmental organizations to focus on the barriers to bringing methane to market, with attention to both increasing natural gas supply and decreasing fugitive methane emissions, on current strategies for breaching these barriers and on case studies that highlight successful implementation of these strategies in the oil and gas industry. We are grateful to all the participants for their efforts and contributions throughout the workshop.

This booklet summarizes the IPIECA Climate Change Working Group's understanding of the presentations and discussions at the workshop. All workshop presentations are available on the CD at the back of this booklet. They can also be found on the IPIECA website (www.ipieca.org) along with all the publications in the IPIECA climate change workshop series (see back cover).

The workshop and this publication are part of an ongoing effort by IPIECA and its members to raise understanding and provide constructive input on key climate change issues.

Executive Summary

Natural gas is a relatively low-carbon, clean-burning fuel. Displacing the use of coal or oil with natural gas can reduce carbon dioxide (CO_2) emissions, and can play an important role in a greenhouse gas (GHG) mitigation strategy. However, methane (CH_4), the principle component of natural gas, is a potent GHG, with 23[1] times the radiative forcing impact of CO_2 on a weight basis over a 100-year period. Because the lifetime of CH_4 in the atmosphere is only about 12 years, its instantaneous impact on the climate system is much larger. Control of CH_4 emissions can, therefore, also play an important role in the mitigation of GHG emissions.

CH_4 is the second largest contributor to anthropogenic GHG emissions after CO_2, accounting for about 16 per cent of the total on a CO_2-equivalent basis. Most anthropogenic CH_4 emissions are biogenic in nature and are generated by agriculture, waste management and biomass. Of global anthropogenic CH_4 emissions, the natural gas industry accounts for approximately 15 per cent; coal mines for 8 per cent; and the oil industry for 1 per cent. Emissions can occur at all stages of the oil and gas industry. In the USA for example, oil and gas production accounts for 44 per cent of CH_4 emissions; transmission and storage for 26 per cent; and distribution for 19 per cent of oil and gas industry emissions. Opportunities exist for reducing CH_4 emission from all of these activities.

For CO_2 concentrations to stablilize, analyses show that emissions would peak and

[1] As defined in the IPCC *Third Assessment Report* (2001). The *Second Assessment Report* (1996) gave methane a GWP value of 21 which was subsequently adopted by the UNFCCC.

eventually decline to a small fraction of current rates. On a path towards stabilization in such analyses, decreasing coal use while increasing natural gas is expected to be an effective strategy through the emission peak. Following the peak, however, as emission reductions become more severe even these actions become insufficient and natural gas would have to be used in conjunction with carbon capture and storage (CCS) or replaced by non-carbon energy sources. In addition, many approaches to controlling CH_4 emissions can be considerably less expensive mitigation options than other GHG emission reduction approaches, although they are limited in scope to methane's contribution to radiative forcing.

Barriers exist to both increasing the supply of natural gas and reducing CH_4 emissions. A key barrier to increasing supply is the lack of economically-attractive outlets for stranded gas reserves and for the associated gas currently being flared or vented. Other barriers include the lack of an enabling environment in the host countries, and a variety of legal and regulatory hurdles. Key barriers to reducing CH_4 emissions are lack of information on the sources and rates of emissions, the technology available for their control, and the lack of economically attractive outlets for the recovered gas.

A variety of partnerships have been formed to overcome these barriers. These include:

- *Natural Gas STAR*, a voluntary partnership between the US EPA and 110 partners with the goal of cost-effectively reducing CH_4 emissions from natural gas operations;
- *Natural Gas STAR International*, a new partnership between US EPA and seven oil and gas industry charter members to extend the success of the domestic *Natural Gas STAR* programme to international operations;
- the *Methane to Markets Partnership*, a cooperative agreement between 18 countries designed to reduce CH_4 emissions from all anthropogenic sources, including the oil and gas industries—more than 350 private organizations participate in this partnership through a Project Network; and
- the *Global Gas Flaring Reduction Partnership*, an agreement between 15 countries, 9 international oil companies, the World Bank, OPEC and the EU to support developing country governments and the petroleum industry in their efforts to reduce gas flaring and venting.

Experience drawn from projects and initiatives highlights the importance of information in overcoming the technical barriers to CH_4 emission reduction, and the need for an improved regulatory environment and stakeholder support for projects to increase natural gas supply.

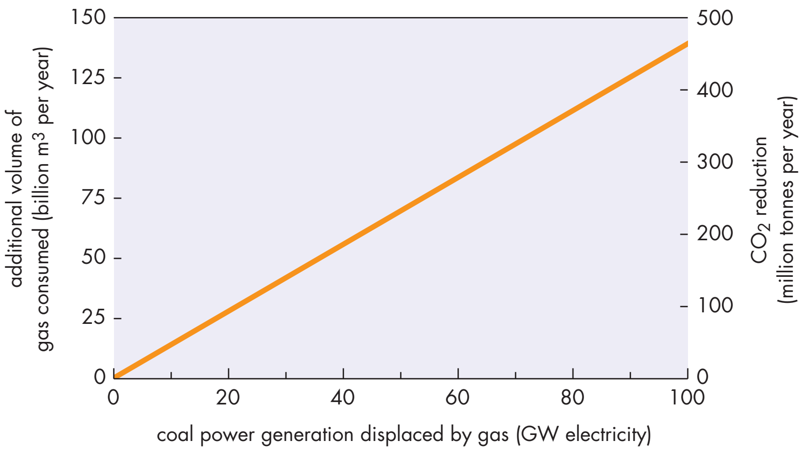
Overview, opportunities and barriers

The role of natural gas in climate change

As an abundant, relatively low-carbon, clean-burning fuel, natural gas has an important role to play in a carbon-constrained world. Displacing, in power generation, the use of coal or oil with natural gas reduces CO_2 emissions (Figure 1), making increased use of natural gas an important component of a portfolio of options to manage the risks of climate change.

Figure 1: CO_2 emission reduction achieved by displacing coal with natural gas use in power generation

Source: Heller, 2006[2]



CH_4, the primary component of natural gas, is a potent GHG. When impact is considered over a 100-year period, a kilogram of CH_4 has 23[3] times the radiative forcing impact on the climate system of a kilogram of CO_2. However, since the lifetime of CH_4 in the atmosphere is only about 12 years, its instantaneous impact on the climate system is much larger. CH_4 is the second largest contributor to anthropogenic GHG emissions after carbon dioxide, accounting for about 16 per cent of the total on a CO_2-equivalent basis (Figure 2a). Most anthropogenic CH_4 emissions are biogenic in nature and are generated by agriculture, waste management and biomass. Consideration of these factors makes the control of CH_4 emissions an important component of GHG emissions mitigation.

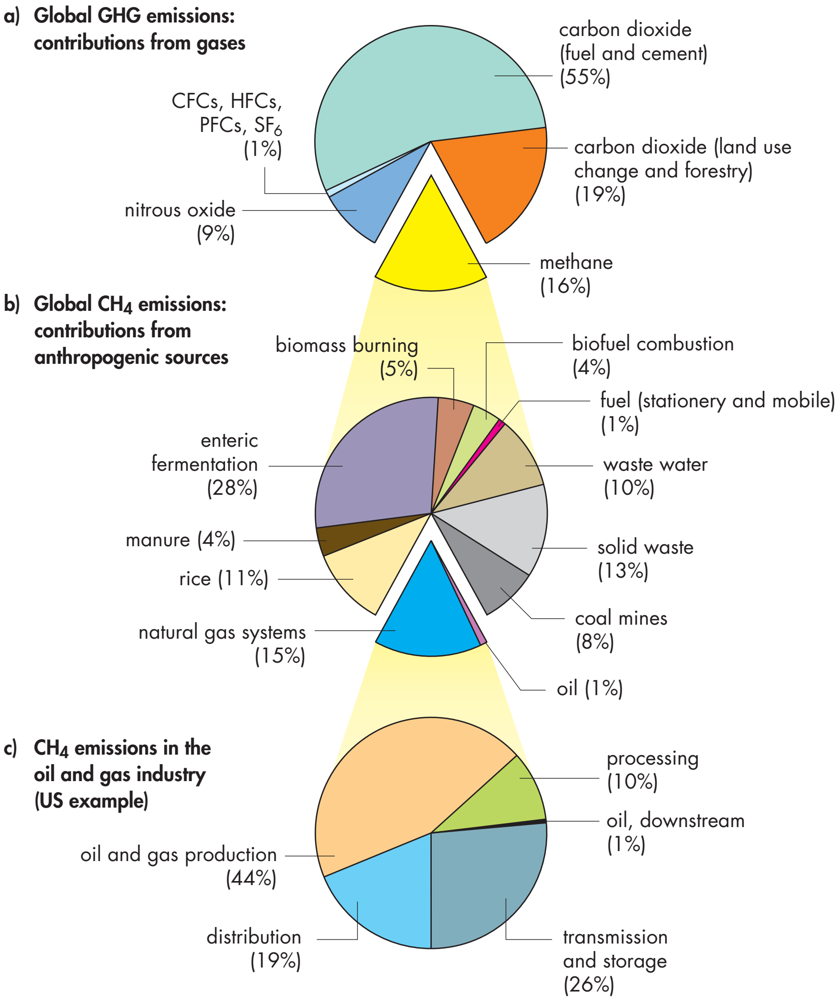
[2] See Thomas C. Heller's presentation on accompanying CD-ROM.

[3] See footnote 1 on page ii.

Of global anthropogenic CH_4 emissions, the natural gas industry accounts for approximately 15 per cent; coal mines for 8 per cent; and the oil industry for 1 per cent (Figure 2b). Emissions can occur at all stages of the oil and gas industry. In the USA for example, oil and gas production accounts for 44 per cent of CH_4 emissions; transmission and storage for 26 per cent; and distribution for 19 per cent of oil and gas industry emissions (Figure 2c). Opportunities exist for reducing CH_4 emission from all of these activities. Recovering CH_4 or preventing losses that would otherwise have been emitted from natural gas exploration, production and use provides safety and environmental benefits, can increase revenues through the sales value of the recovered hydrocarbon, and provides the potential value of the avoided emissions in a carbon market.

Figure 2: Anthropogenic GHG emissions and the role of methane

Source: Kruger/US EPA, 2006[4]



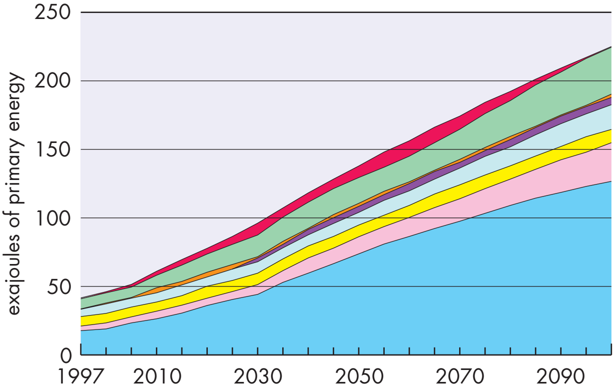
[4] See Dina Kruger's presentation on accompanying CD-ROM.

For CO_2 concentrations to stablilize, analyses show that emissions would peak and eventually decline to a small fraction of current rates. On a path towards stabilization in such analyses, decreasing coal use while increasing natural gas is expected to be an effective strategy through the emission peak. Following the peak, however, as emission reductions become more severe even these actions become insufficient and natural gas would have to be used in conjunction with CCS or replaced by non-carbon energy sources (Figure 3). In addition, many approaches to controlling CH_4 emissions can be considerably less expensive mitigation options than other GHG emission reduction approaches, although they are limited in scope to methane's contribution to radiative forcing.

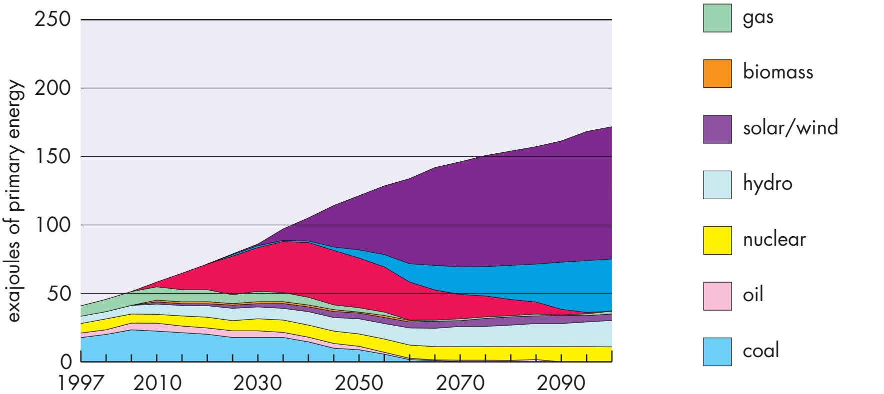
Figure 3: Projections of primary energy use for power generation by fuel type and technology over the 21st century

Source: Reilly, 2006[5]

a) Reference case: no climate policy



b) 550 ppm case: idealized climate policy (global carbon tax) to limit atmospheric CO_2 level to 550 ppm



[5] See John Reilly's presentation on accompanying CD-ROM. [6] Carbon Capture and Storage. [7] Natural Gas Combined Cycle.

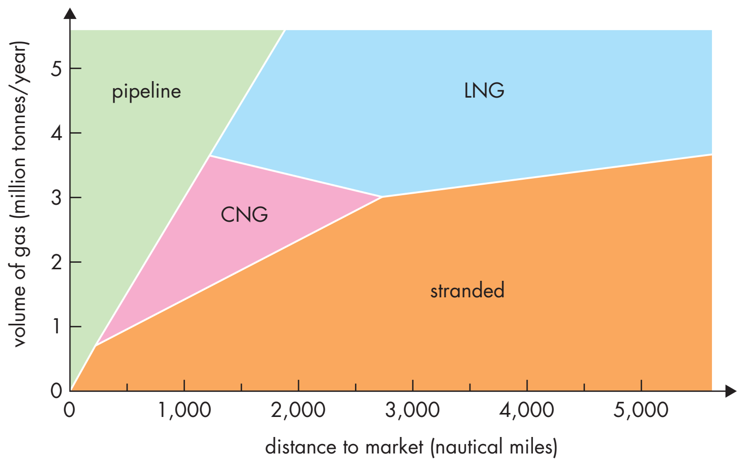
Opportunities to reduce CH_4 emissions and increase natural gas supply

A wide variety of technologies are available to reduce CH_4 emissions from natural gas production and use. The *Natural Gas STAR* programme, a voluntary partnership between the US oil and gas industry and the US Environmental Agency (EPA) has identified almost 100 emission reduction techniques. Many of these technologies are relatively simple, such as vapour recovery for storage tanks, and the use of electric motors rather than gas-fired engines to power wellhead equipment. As a result of the application of these and other techniques, CH_4 emissions from the US gas industry are now 6 per cent lower than in 1990 and have avoided cumulative emissions of 460 billion cubic feet (Bcf) of natural gas. Further decreases in emissions are projected through 2020. Avoided CH_4 emissions have co-benefits and are used to increase natural gas volumes supplied to markets, provide on-site power generation so reducing purchased power and improve oil recovery through reinjection.

Approximately 150 billion cubic metres[8] of associated gas (natural gas produced in conjunction with oil) are flared or vented each year, mostly in Russia, West Africa and the Middle East. The amount of gas flared has been constant for about 20 years, and results in GHG emissions of about 400 million metric tonnes CO_2 equivalent/year. The gas is flared because there are no economically attractive outlets for its use, or because business conditions in the host country are not conducive to developing the resource. Other gas is 'stranded', i.e. left in the ground because, at present, there are no economically attractive ways to produce and transport the gas to market (Figure 4).

Figure 4: The influence of a natural gas resource's distance to market and potential rate of production on whether that resource will be stranded (not produced) or produced and transported via pipeline, or as CNG or LNG

Source: Heller, 2006[9]



[8] 1 cubic metre = 35.3 cubic feet. 1 metric tonne CO_2 equivalent = 43.5 kilograms = 60.9 cubic metres of CH_4.

[9] See Thomas C. Heller's presentation on accompanying CD-ROM.

Barriers to decreasing emissions and increasing supply

CH_4 emission reduction projects may not be developed for a variety of reasons. In some instances there is a lack of information about emission levels and the value of the fuel being lost. Traditional industry practice, i.e. using high pressure natural gas in pneumatic devices, can also be a barrier to considering lower emission alternatives. Regulatory and legal obstacles prevent implementation of some projects, and limited markets and infrastructure for the fuel and an uncertain investment climate can create economic hurdles. Furthermore, emission mitigation measures, even cost-effective projects, have to compete with other capital investment activities.

Barriers to reducing flaring in developing nations include the lack of: a market for the associated gas; capacity or an enabling environment in the host country; and cooperation between the host country and the oil companies that have to implement flare reduction projects. Furthermore there may be resistance from local communities to the building of the infrastructure (e.g. liquefied natural gas (LNG) terminals and pipelines) needed to transport recovered gas to market, and this can can lead to the delay or blocking of projects. Government regulations, some of which hinder the recovery and marketing of flared or vented gas, can also be a barrier.

Global natural gas reserves have increased steadily over the past 25 years. However, consumption is forecast to grow substantially over the medium term and the supply of natural gas is likely to be restricted. Furthermore, with many of the new reserves being supplied from the Middle East, and with the cost of finding and developing natural gas resources increasing dramatically in many regions, the supply of natural gas may face additional future constraints.

Technical barriers hinder attempts to utilize 'unconventional' gas resources. However, advances in science, technology research and development, and investment have led to unrelenting technological progress and the commercialization of gas production from more challenging resources, including deeper and more severe environments, and tight gas reservoirs.

Addressing the barriers

Economic and institutional barriers

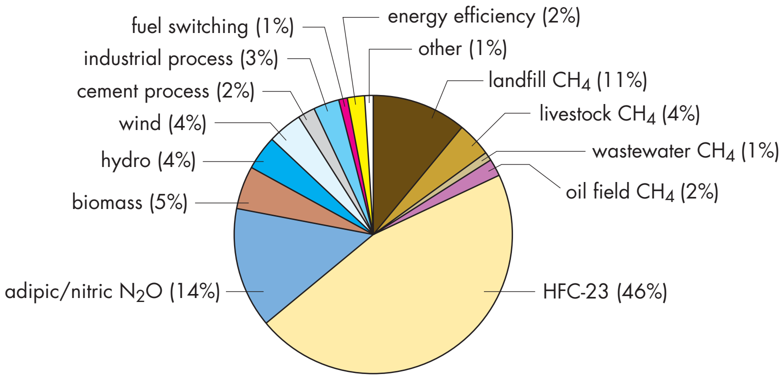
Electric power generation represents the largest potential market for fuel switching from coal to natural gas. The IEA estimates that use of high efficiency natural gas-fired combined cycle turbines for electric power generation instead of conventional coal technology could avoid emissions of 1.6 billion tonnes CO_2/year by 2050. China is a rapidly growing market for electricity, currently adding more than 50 gigawatts (GW) of capacity, or 10 per cent of installed capacity, each year. If China installed 50 GW of natural gas-fired capacity instead of coal-fired capacity, the emission savings would be more than 200 million tonnes of CO_2 per year.

China currently plans to install 60 GW of gas-fired electricity generating capacity by 2020, but further expansion faces several challenges. Chinese energy policy is controlled by provincial governments limiting the ability for federal government to impose climate change policies. Natural gas technologies are imported whereas coal turbines are produced domestically providing employment and growth. In addition, Chinese gas supply is limited with much of the supply dedicated to residential heating. Any expansion of natural gas for power would require additional gas to be imported as LNG. Despite these challenges, two LNG terminals are scheduled to open, potentially providing the capacity for an expansion of natural gas-fired electricity generation in China.

The Kyoto Protocol's flexible mechanisms, the *Clean Development Mechanism* (CDM) and *Joint Implementation* (JI), can provide carbon credits for fuel switching or CH_4 emission reduction projects. However, as of the end of 2005, only 2 per cent of the

Figure 5: Percentage of CDM market in various sectors[10]

Source: Heller, 2006[11]



[10] As of 23 December 2005: includes 509 projects. [11] See Thomas C. Heller's presentation on accompanying CD-ROM.

credits from approved or proposed CDM projects were for reduction of CH_4 emissions from oil and gas operations (Figure 5). Credits from the flexible mechanisms can be used in the EU's Emission Trading Scheme (EU ETS) or sold in the carbon market. Under the EU ETS fuel switching from coal fired electricity production to natural gas-fired electricity production may be promoted where the incremental rise in costs is met or exceeded by the value of carbon credits.

Technical barriers

Technical barriers to CH_4 emission reduction from oil and gas operations can arise from a lack of measurement techniques to characterize emissions and of familiarity with technical options and their benefits. The capital costs of emission recovery techniques may have to compete with oil and gas production projects that could offer higher rates of return. These problems can be compounded by limited outlets for the recovered gas and a lack of resources to recover the gas. Successful programmes to address technical barriers have focused on the cost-effective 'low-hanging fruit' which can provide relatively short pay-back times.

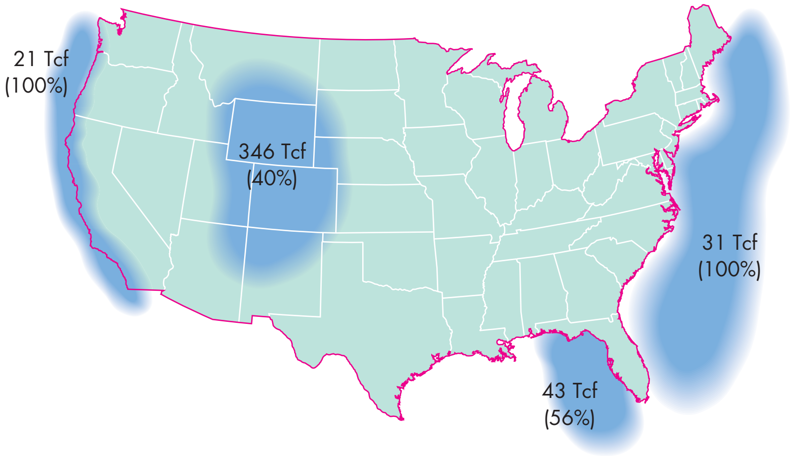
Addressing technical barriers requires implementation of a phased approach to emission reduction. Initial steps require that all existing and potential sources of emissions are identified and inventorized. Following characterization of emission sources the alternate technological options for reducing emissions can be evaluated, and project feasibility studies developed. Reviewing and evaluating experiences, as well as information sharing through partnerships, enables these barriers to be addressed. Management support for this process is critical, as is education at the operator/technician level.

Regulatory and commercial barriers

Regulatory barriers can block production of otherwise economically recoverable natural gas resources. Much of the potential natural gas production capacity in the USA is currently inaccessible because of regulatory restrictions. This includes the Atlantic and Pacific coasts, the Eastern Gulf of Mexico and much of the Rocky Mountains (Figure 6). Removing these restrictions requires public, political and industry support. Some governments have regulations restricting access to gas markets, forcing associated gas flaring or through subsidy systems that provide free electricity to many consumers making it difficult for investors to recover the cost of installing natural gas facilities.

Figure 6: Location and size of US gas resources in trillion cubic feet (Tcf), and the percentages of those resources restricted due to regulatory barriers

Source: Wilkinson, 2006[12]



Recent increases in natural gas prices should make it economically attractive to implement some previously uneconomic projects to either reduce CH_4 emissions or recover stranded gas. Traditionally, the price of gas has been linked to the price of oil because at the margin the two were competitive for chemicals manufacture. However, with large quantities of gas being used for electricity generation, much of the competition is with coal. Freeing gas price from oil price could improve the attractiveness of many projects.

Social barriers

Building natural gas production and transportation (pipelines, LNG terminals) facilities requires stakeholder support. Obtaining stakeholder support is needed at the early stages of project planning, long before the permitting process begins. Environmental studies for the proposed Alaska North Slope Gas Pipeline project, designed to bring gas from the Alaskan North Slope to the US Midwest, began in 2001, at least eight years before the start of construction. Consultations with stakeholders began at least six years before the start of construction. The scope of consultations has to be broad,

[12] See Paul Wilkinson's presentation on accompanying CD-ROM.

including indigenous groups, governments at all levels, private landowners, environmental and other NGO groups, and individuals. While many stakeholders are supportive of projects, all need information about its scope and impacts.

Consideration of the climate change benefits of natural gas infrastructure development is low on the agenda for local communities. Local groups are primarily interested in the real and perceived near-term impacts of projects such as economic, health and local environmental affects. Meanwhile governments, particularly in developing countries, have to balance short-term economic pressure against the long-term climate change challenge.

Addressing the barriers—initiatives

A number of government-industry partnerships and international cooperative efforts have been formed to overcome barriers to reducing CH_4 emissions and increasing natural gas supply.

Natural Gas STAR is a voluntary partnership between the US EPA and oil and gas industry partners with the goal of implementing cost-effective technologies and practices to reduce CH_4 emissions from oil and gas operations. The *Natural Gas STAR* partners have identified approximately 100 emission reduction techniques, which have led to cumulative emissions reductions of 460 Bcf.

The success of the domestic *Natural Gas STAR* programme has led to its expansion into an international programme. *Natural Gas STAR International* works to promote technology transfer and provide assistance to international oil and gas companies to develop and implement cost-effective CH_4 emission reduction plans, and report on successes in controlling CH_4 emissions from their international natural gas operations.

The *Methane to Markets Partnership* is a cooperative agreement between countries designed to reduce CH_4 emissions from all anthropogenic sources, including the oil and gas industry. Private companies participate through a project network, which now includes more than 350 organizations. In 2005, the partner countries accounted for 56 per cent of global methane emissions from the oil and gas industry.

The *Global Gas Flaring Reduction Partnership* is an agreement between countries, international oil companies, The World Bank, OPEC and the EU to support developing nation governments and the petroleum industry in their efforts to reduce gas flaring and venting. It has developed global standards for flaring and venting, regulatory best practices and a gas flaring data tool, and promoted carbon credit financing for flare reduction projects. In its first phase, which is nearing completion, it established 17 flare reduction demonstration projects. The *Partnership's* second phase, scheduled to begin in 2007, will focus on in-country deliverables and sustainable flare reduction.

The *Asia-Pacific Partnership on Clean Development and Climate* involves six countries (Australia, China, India, Japan, Korea and the USA) and has the goal of promoting the development and deployment of clean energy technologies. One of its eight task forces is focused on cleaner fossil fuel technology, including greater use of LNG.

Experience drawn from projects and initiatives highlights the importance of information in overcoming the technical barriers to CH_4 emission reduction, and the need for an improved regulatory environment and stakeholder support for projects to increase natural gas supply.

Workshop programme

Welcome presentation

- Arthur Lee (Chevron, IPIECA CCWG Chairman)

Introduction to the workshops

- Haroon Kheshgi (ExxonMobil)

Workshop scene-set

- Natural Gas as a Climate Change Solution Roger Fernandez (US EPA)

Session 1: Overview, opportunities and barriers

- Introduction, Roger Fernandez (US EPA)
- Methane and Climate Policy John Reilly (Massachusetts Institute of Technology)
- Natural Gas and Climate Change—Will the Potential be Realized? Paul Wilkinson (American Gas Association)

Session 2: Addressing the barriers, initiatives

- Introduction, Bruce Wilcoxon (ConocoPhillips)
- Advancing Methane Recovery and Use in the Oil and Gas Industry: Domestic and International Partnership Opportunities Dina Kruger (US EPA)
- Recovery of Associated Gas for Independent Power Generation (IPP) Giorgio Vicini (ENI)
- Global Gas Flaring Reduction (GGFR) Partnership Yuriy Myroshnychenko (World Bank)

Session 3: Addressing the barriers: select case studies

- Introduction, Russell Jones (API)
- LNG and Climate: Prices and Pacing Thomas C. Heller (Stanford University)
- Technical Barriers to Emissions Reductions: Gas STAR Case Studies Krish Ravishankar (Occidental)
- Commercial Barriers to Natural Gas Capture, Supply and Delivery Don Robinson (ICF Consulting)
- Consultation on Anticipated Social Issue: Alaska Gas Pipeline Project Mike Wofford (ConocoPhillips)
- Panel Discussion: Panel Moderator, Haroon Kheshgi (ExxonMobil)

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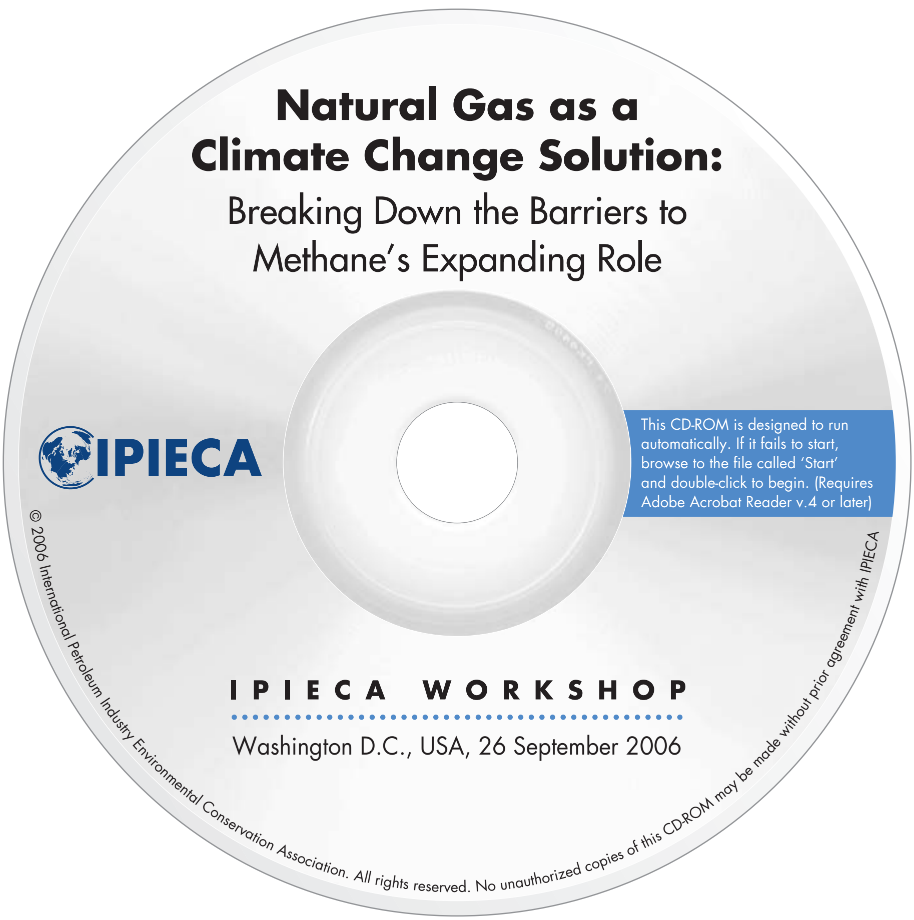
The IPIECA Workshop on CD-ROM

The CD-ROM included with this report contains the Workshop speakers' presentation slides in PDF format (requires Acrobat Reader™). The disc is designed to start automatically when you insert it into your PC. If it fails to run, browse to the file called 'Start' and double-click to begin. This file provides an introduction to the CD-ROM, a list of contents and instructions on how to navigate the disc. Acrobat Reader™ is available for free download from the Adobe website at:
www.adobe.co.uk/products/acrobat/readstep2.html



IPIECA

The International Petroleum Industry Environmental Conservation Association (IPIECA) was founded in 1974 following the establishment of the United Nations Environment Programme (UNEP). IPIECA provides one of the industry's principal channels of communication with the United Nations.

IPIECA is the single global association representing both the upstream and downstream oil and gas industry on key global environmental and social issues. IPIECA's programme takes full account of international developments in these issues, serving as a forum for discussion and cooperation involving industry and international organizations.

IPIECA's aims are to develop and promote scientifically-sound, cost-effective, practical, socially and economically acceptable solutions to global environmental and social issues pertaining to the oil and gas industry. IPIECA is not a lobbying organization, but provides a forum for encouraging continuous improvement of industry performance.

Climate Change Working Group

Formed in 1988, the IPIECA Climate Change Working Group (CCWG) monitors, analyses and informs the membership of key developments in the issue, especially those taking place at the UNFCCC and IPCC. The CCWG encourages the development of policy options that strike a balance between the projected consequences of potential climate change and the estimated costs of response options to mitigate or adapt to climate change. The CCWG sponsors dialogues and workshops addressing key aspects of the ongoing negotiations, and provides a technical publication series as a means of constructive input to the process.

Publications in the IPIECA Climate Change series include:

- *Long-Term Energy and Carbon Management: Issues and Approaches*
- *A Guide to the Intergovernmental Panel on Climate Change*
- *Buenos Aires and Beyond—a Guide to the Climate Change Negotiations*
- *Technology Assessment in Climate Change Mitigation—an IPIECA Workshop*
- *Opportunities, Issues and Barriers to the Practical Application of the Kyoto Mechanisms*
- *Long–Range Scenarios for Climate Change Policy Analysis*
- *Critical Issues in the Economics of Climate Change*
- *Climate Change: a Glossary of Terms*
- *Development and Climate Change: Issues and Approaches in Asia*
- *Energy, Development and Climate Change: Considerations in Asia and Latin America*
- *Petroleum Industry Guidelines for Reporting GHG Emissions*
- *Carbon Dioxide Capture and Geological Storage: Contributing to Climate Change Solutions*
- *Transportation and Climate Change: Opportunities, Challenges and Long-term Strategies*
- *International Policy Approaches to Address the Climate Change Challenge*

Workshop Task Force

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