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ENERGY VISION UPDATE 2011

A New Era for Gas

World Economic Forum
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Message from the Energy Community Leader 2010: The Role of Natural Gas in an Uncertain World

Gérard Mestrallet, Chairman and Chief Executive Officer, GDF Suez, France

The World Energy Outlook 2010, published by the IEA, starts with the following statement. "*The energy world faces unprecedented uncertainty. The global economic crisis of 2008-2009 threw energy markets around the world into turmoil and the pace at which the global economy recovers holds the key to energy prospects for the next several years. But it will be governments, and how they respond to the twin challenges of climate change and energy security, that will shape the future of energy in the longer term.*"

This is not the first time that the energy sector has faced uncertainty – recall the oil shocks of the 1970s and 1980s. Nonetheless, it is at its height now. Uncertainty is particularly dangerous in a sector where investments are long-lived and take a long time to pay off.

Considerable uncertainty clearly extends to global gas markets. Lower demand for gas amid the global recession combined with the increased supply of liquefied natural gas (LNG) and inexpensive unconventional gas are putting pressure on the very structure of markets. Much of Europe's and Asia's gas supply is sold under long-term contracts with prices linked to oil. These contracts were put in place to increase energy security and decrease risk for suppliers and purchasers, but they are strained today by the supply-demand imbalance. Gas is available on a spot basis today in Europe at prices lower than the oil-indexed prices of long-term contracts.

None of the major energy industries – oil, gas or power – developed on the basis of a spot market alone. The search for balance between competition and security is central to an understanding of the role of spot markets and long-term contracts in the global gas trade.

Long-term contracts are crucial in gas markets to guarantee long-term supply security, since European and Asian marketplaces do not offer the liquidity required for a strong spot market. In accordance with the spirit of such contracts, the prices offered must be competitive as regards the conditions and evolution of the market. Although price levels remain a matter of debate and discussion of first importance, we could also adapt price indexes to take into account the development of gas for electricity generation, among other things.

The LNG market represents the beginning of a globalized natural gas market that offers its stakeholders many opportunities. Asia in particular is currently a premium market for LNG, with prices higher than those in Europe or North America. The resolution of today's imbalance between gas supply capacities and demand and the future relationship between spot and oil-indexed prices will depend greatly on the evolution of the Asian LNG market in the coming years.

Despite the rise of LNG, pipelines are still the backbone of the gas industry. Transport by pipeline is not as flexible as by LNG tanker, but is often the cheapest method, depending on the geographical location. The development of a number of new pipeline projects in Europe, starting with Nord Stream, is helping to bolster transmission capacity and security of supply. Recent agreement for new pipelines in emerging markets, particularly between Russia and China, underline the importance of natural gas in the 21st century energy landscape.

Price competitiveness, supply security and environmental quality are societal goals and energy industry challenges around the world. However, these goals are not always consistent. Solutions favourable to the environment, such as photovoltaic solar energy, may have significant effects on price competitiveness. Other solutions favourable to supply security, such as using local coal, may not be favourable to the environment. Energy security and the environment can also come into conflict, such as when the power system relies too heavily on intermittent renewable energy sources.

There is no single ideal solution to achieve these energy policy goals, but at best an optimal mix of solutions. Energy efficiency will have a vital role to play, but even energy efficiency comes at a price. Energy that is not consumed is obviously the cheapest option, but reducing energy consumption often requires investment, and this investment cost is still an obstacle to many energy savings measures.

Coal, oil and gas will continue to play an important role, particularly natural gas. Abundant, affordable and acceptable – gas is a triple A energy source. It is cleaner than coal; gas-fired generation is relatively quick and cheap to build; and the shale revolution in North America has raised hopes that gas is abundant in geological formations the world over. For a few dozen euros per tonne of carbon dioxide (CO_2), replacing coal or fuel by natural gas seems a very "econological" solution.

These are some of the themes that we cover in this year's Energy Vision report that follows. We hope that the analysis of global gas markets and the perspectives of leading figures will help to clarify the uncertainties for this complex and critically important global industry and the markets that it serves.

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A New Age for Gas

EXECUTIVE SUMMARY

What a difference a few years can make in one of the world's major energy markets. Advances in the production of unconventional gas – shale gas, tight gas and coalbed methane (CBM) – coupled with growing LNG capacity have changed longstanding assumptions about natural gas markets around the world. Gas has long been recognized as the preferred fossil fuel from an environmental standpoint, with lower emissions of GHG and other pollutants than coal or oil. Recent advances in gas production technology mean that gas is also likely to be more available, and even potentially less expensive, than was assumed just a few years ago.

Abundant Gas

Natural gas today provides 24% of the world's primary energy. More than half of conventional gas reserves are located in Russia and the Middle East, but the advent of unconventional gas is rapidly expanding the world's recoverable gas resource. Estimates of the world's recoverable gas resource nearly double when unconventional gas resources are included – bringing the total to roughly 250 years of supply at today's rate of production.

The potential of unconventional gas became apparent in 2007-2008 in North America, which continues to be the epicentre of the unconventional gas revolution. Two technologies are crucial to unlocking the potential of shale gas. Horizontal drilling involves drilling vertically into the source rock, and then drilling horizontally to access more of the reservoir. Hydraulic fracturing involves injecting water into the underground formation to fracture the source rock and provide pathways for gas to reach the wellbore. Both techniques are proven and well established. The critical breakthrough comes about through combining them.

In North America, shale is the most prolific source of unconventional natural gas. The "shale gale" has turned the North American gas market on its head. Advances in shale gas production have more than doubled estimates of North American recoverable gas resources. Only a few years ago, North America was widely expected to need substantial LNG imports by now to replace declining domestic production. Instead, shale gas production doubled from 2008 to 2010 and now makes up one-quarter of North American gas production, compared to just 2% in 2000. Most shale gas is also less expensive to produce than conventional gas, at least in North America, owing to efficiencies in the production process.

The "shale gale" is beginning to go global, as companies and governments explore how the North American experience can be brought to other continents. Assessment of unconventional gas resources is underway in Europe and initial results indicate that the resource could rival that in North America. That does not mean, however, that it will reach the same scale.

In Europe, development of unconventional gas, both shale and CBM, faces several challenges, including government ownership of subsurface mineral rights, a population unaccustomed to onshore drilling, higher production costs and the need for new infrastructure. Nonetheless, the prospect of onshore gas production is attractive, especially in terms of replacing declining domestic conventional production in Europe and providing additional supply options.

Potential shale gas and CBM resources are also present in Asia, particularly in China. Credible estimates of the Asian resource are still some years away. CBM is further along the development cycle, with Australia leading the way. In 2010, Australia sanctioned the world's first LNG project based on CBM, and more are set to follow.

Even with the new attention on locally-produced unconventional gas, LNG remains a crucial and growing source of gas supply. Global LNG trade doubled in the 10 years from 2000 to 2010 and is expected to increase another 50% by 2020. Qatar will continue to be the leader in liquefaction capacity – it just celebrated its 77 million tonne milestone. Australia is expected to add the most capacity in the coming years. Japan and South Korea continue to be the largest markets for LNG, but other countries in Asia are rapidly adding regasification capacity.

China has built up a strong portfolio of supply contracts; it has three operating LNG import terminals and five more will be commissioned by 2013 to accommodate these growing supplies. India is likewise expanding its import capabilities. Thailand is scheduled to commence LNG imports in 2011 and Indonesia, Pakistan and Singapore

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will be in a position to import by 2013. Floating regasification is opening up smaller markets to LNG. The Middle East and South America have emerged as new destinations for LNG supply through floating import terminals and onboard regasification.

Meanwhile, intercontinental pipelines will continue to serve as the key arteries of the global gas business. Existing pipelines – in particular, the great trunklines that stretch thousands of miles across Russia into Western Europe – provide the immutable contours around which LNG and unconventional gas must fit. Efforts continue to develop new pipelines as further volumes of gas in Russia and Central Asia seek out markets both westward into Europe and eastward into Asia. Their development is not simply a result of the supply and demand for natural gas as a commodity, but also a manifestation of government-to-government relations, industrial partnerships and the quest for long-term stability and security.

Varying Demand Growth

Gas demand growth is expected to be more evolutionary, unlike the revolutionary changes occurring in supply. The primary uses for gas are expected to remain the same – space and water heating in residential and commercial applications, fuel and feedstock for industrial applications and power generation. In OECD countries with mature gas distribution networks, the most robust growth is expected to come from power generation.

In the United States, low-cost shale gas is a formidable competitor for both renewable electric power and new nuclear energy. In Europe, however, the growth of gas may be limited by environmental policy seeking to develop zero-carbon, rather than low-carbon generation. In the developing world, gas demand is projected to grow across all sectors owing to economic growth and an expanding gas delivery infrastructure.

Transportation is one sector that could develop new uses for natural gas. Natural gas vehicles make up only 1% of today's global vehicle fleet. These vehicles are popular in countries where policy, tax incentives and refuelling infrastructure support their use, including Pakistan, Argentina, Iran and Italy. They also work well in fleet applications where vehicles are refuelled at a central station.

Electric vehicles that run on natural gas-fired power are another way to incorporate more natural gas into the transportation sector. Using gas to produce electricity for transportation is efficient, as the much greater efficiency of an electric motor – as compared to an internal combustion engine – more than makes up for the efficiency of conversion at the power plant and any transmission losses. Gas-to-liquids (GTL) processes and steam reforming of natural gas to produce hydrogen are additional pathways for incorporating gas into the transportation fuel portfolio, but they face substantial challenges in terms of costs.

Challenges to Market Structure

The surge of gas supply in the midst of a global recession has challenged some longstanding tenets of gas markets. In particular, an abundance of spot gas at low prices challenged the structure of long-term contracts with their relatively inflexible delivery provisions, prevalent in Europe and Asia. Spot markets are becoming increasingly active, but long-term contracts will remain a central strategy to provide guaranteed demand to suppliers, guaranteed supply to customers, funding for infrastructure construction and energy security. Over the last two years, however, the market has responded to shifting dynamics with the negotiation of increased flexibility within contracts.

Oil-linked gas prices are a gas market feature that has been under stress. Outside North America, long-term contract gas prices have long been linked to oil prices. However, the price link becomes frayed when the fundamentals in oil and gas markets diverge, as they have in the past three years. Although a link between oil and gas prices is likely here to stay, the nature of that linkage is evolving. Additional flexibility may be needed in future contracts as the new abundance of gas is felt in the marketplace.

CHAPTER 1: A NEW AGE FOR GAS

Introduction

The biggest energy innovation so far in the 21st century involves a fuel that has been part of the energy mix for decades – natural gas. Recent advances in unconventional gas production – including tight gas, CBM and especially shale gas – are revolutionary. A "shale gale" is blowing across North America. The resulting changes in the supply outlook and fundamental economics of natural gas are affecting LNG and pipeline markets in Europe and Asia. They are also having an impact throughout energy spectrum, affecting the prospects for competing technologies from wind to nuclear power. The potential for unconventional gas production in Europe and Asia raises the prospect of gas as a more abundant and relatively inexpensive energy source than was thought possible just a few years ago.

Innovation in unconventional gas production builds on two other technologies that define the modern natural gas industry. Long-distance pipelines now join the world's gas producers to the gas markets across great distances – indeed they made these markets possible. LNG has further broadened and diversified gas transportation and trade, tying what were formally segmented continental markets together in an interconnected global market.

These advances in gas supply and transportation coincide with concern about climate change and other environmental issues. Natural gas produces the lowest greenhouse gas (GHG) emissions of any fossil fuel. Additionally, natural gas results in less local pollution, with lower emissions of sulphur dioxide, nitrogen oxides, particulate matter and metals than coal or oil. When used in modern combined-cycle power plants, gas can produce electricity more efficiently than other fossil fuels, further reducing GHG emissions from electricity production. Altogether, modern gas-fired electricity generation releases less than half the GHG emissions per megawatt-hour of a coal plant. These attributes make natural gas an attractive option for reducing GHG emissions, particularly in the power sector. Alexander Medvedev describes gas as "a cost-comfortable solution to the climate change problem" in his perspective essay, *The Role of Gas in Climate Change and CO_2 Reduction.*

Given the environmental benefits, increasing availability, and cost competitiveness of natural gas, how will it fit into a low carbon future? Much of the low carbon discussion today focuses on zero-emissions technologies, such as wind, solar and nuclear power. Natural gas has often been a fuel without a voice in policy discussions around the world. This Energy Vision Update focuses on the opportunities for gas in a changing world and how recent advances in gas production will change the way it is bought, sold and used around the world.

This report is organized into five chapters:

- The first chapter introduces the basics of gas markets and trade.
- The second chapter describes the revolution of unconventional gas supply playing out today and the role of LNG in a world of changing supply.
- The third chapter provides a view of ongoing trends in gas demand through regional and sector-specific lenses.
- The fourth chapter explores how evolving supply and demand patterns are changing the nature of how gas is bought and sold around the world.
- The final chapter offers conclusions and raises questions for policy-makers and the gas industry.

Connecting Gas Supply and Demand

Natural gas is a mainstay of the global economy, providing 24% of the world's primary energy. But the mix varies widely – from as much as 47% in the Middle East to as little as 11% in the Asia Pacific region. Other markets are between these two extremes, with Europe and Eurasia at 34%, North America at 28% and Latin America at 21%.

Most conventional gas resources are located in the former Soviet Union and in the Middle East. In fact, three countries – Russia, Iran and Qatar – hold 54% of the world's proven conventional gas reserves.[1] Other large

1. IEA, World Energy Outlook 2010, page 187.

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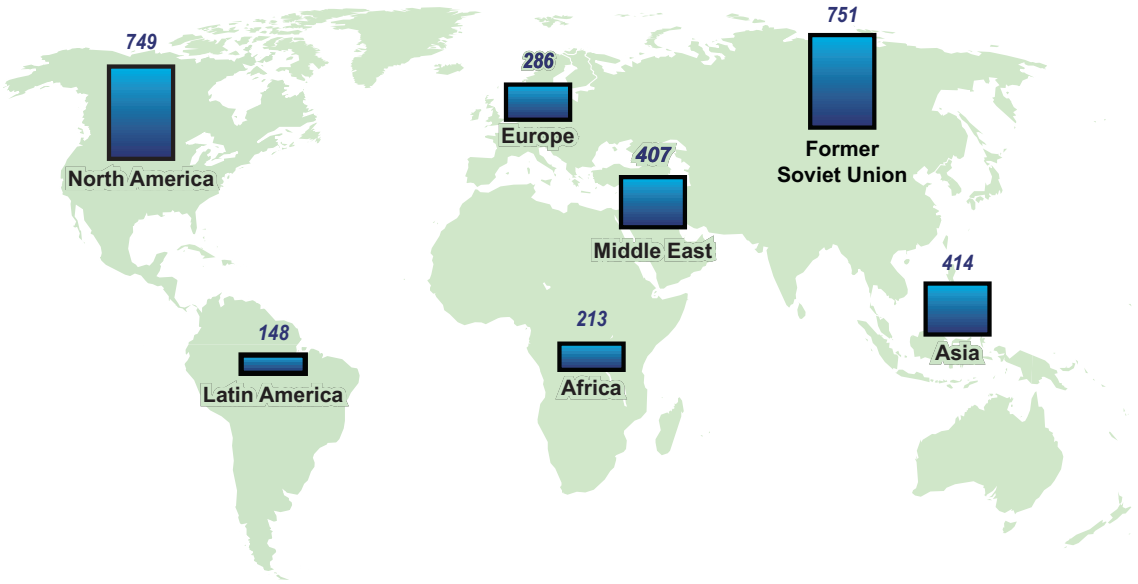
gas producers include the United States and Canada, Norway and the United Kingdom, Indonesia and Algeria. Until recently, the focus has been on these conventional natural gas resources.

Advances in unconventional gas production mean that traditional "proven reserve" estimates require a second look. Until very recently, proven reserves did not include unconventional gas resources. The IEA estimates that adding recoverable unconventional gas resources to the proven reserve estimate could nearly double the world's total, raising the global resource estimate to 250 years of current production.[1] "Peak gas" is a phrase that one never hears in industry discussions these days. Unconventional gas resources are also believed to be more geographically dispersed than conventional resources.

Transportation of gas has always been a challenge. Many important sources of natural gas are not located near major demand centres (see Figure 1). Most natural gas is moved through pipelines that can reach across thousands of kilometres. Cooling the gas to about minus 160 degrees Celsius (minus 260 degrees Fahrenheit), shipping it across oceans and then regasifying it on the other end offers another option. Over the last 10 years, the LNG industry achieved sufficient scale to make LNG globally competitive; it has been able to supply gas to markets that would not otherwise have access to the fuel. This is particularly true in Asia, where several of the largest economies either do not have indigenous gas resources or are in the early stages of developing them. In his perspective essay, *Realising the Natural Gas Opportunity,* Peter Voser describes the growing role

Figure 1

2010 Natural Gas Production by Region
(billion cubic meters)



Source: IHS CERA.
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1. IEA, World Energy Outlook 2010, page 187.

of LNG this way: "The growing global supplies of gas, along with the growth of the LNG industry, should help to bolster the competitiveness of gas." Although the European market is dominated by pipeline gas, either produced locally from the North Sea or transported long distances from Russia, the role of LNG is growing rapidly. The United States was moving towards greater reliance on LNG until the rapid expansion of shale gas production abruptly reversed that trend.

Regional Markets Predominate in the Gas World

The price of oil is a familiar topic of discussion among commodity traders and financial analysts, and indeed in the news. The global gas market, on an energy basis, is 70% the size of the global oil market. Why don't natural gas prices get similar global attention? Prices for oil and gas are not determined in the same way, and differences in the physical characteristics of the two fuels go a long way toward explaining why. Oil can be transported over long distances at reasonable cost because it has a very high energy density under normal pressure and temperature conditions. This ease of transport supported the development of a liquid global market in oil; multiple sources of supply serve multiple markets at transparent prices. Accounting for differences in crude oil quality and transportation cost, oil prices are roughly correlated around the world.

Natural gas markets are near the other end of the spectrum. Although gas is traded across borders, there is no global price for natural gas. The significant infrastructure investment needed to transport natural gas means that the geographic locations of producers and buyers play a major role in determining the value of the gas. Gas suppliers often need long-term contracts to finance the development, processing and transportation infrastructure (pipelines or LNG liquefaction and tankers) and to ensure a market for the produced gas. Long-term contracts can be in the best interest of gas buyers who want guaranteed supplies and face illiquid markets. As a result, buyers and sellers need each other and tend to be linked for long periods of time. For gas suppliers and consumers, long-term contracts explicitly deliver energy security.

Regional gas markets developed from these linkages between buyers and sellers. Three distinct regional gas markets exist today – in North America, Europe and Asia. Differences in resource availability and transport infrastructure have shaped how gas is priced and sold in these three markets. The regulatory philosophy in each region and the number of countries involved also influence the market structure. In North America, the market consists of two generally like-minded countries.[1] In Europe, there are more than 40 countries with different interests, a large number of companies and different endowments of domestic resources.

The North American gas market is the deepest and most liquid of the three. North America has a deep spot market at Henry Hub, a pipeline hub in Louisiana that is the official delivery point for gas contracts on the New York Mercantile Exchange (NYMEX). Henry Hub is connected by an extensive pipeline network to most North American gas markets (see Figure 2). Smaller hubs are located at key locations around the country. The market balances gas supply and demand and provides price discovery. Futures markets allow both buyers and sellers to hedge their positions.

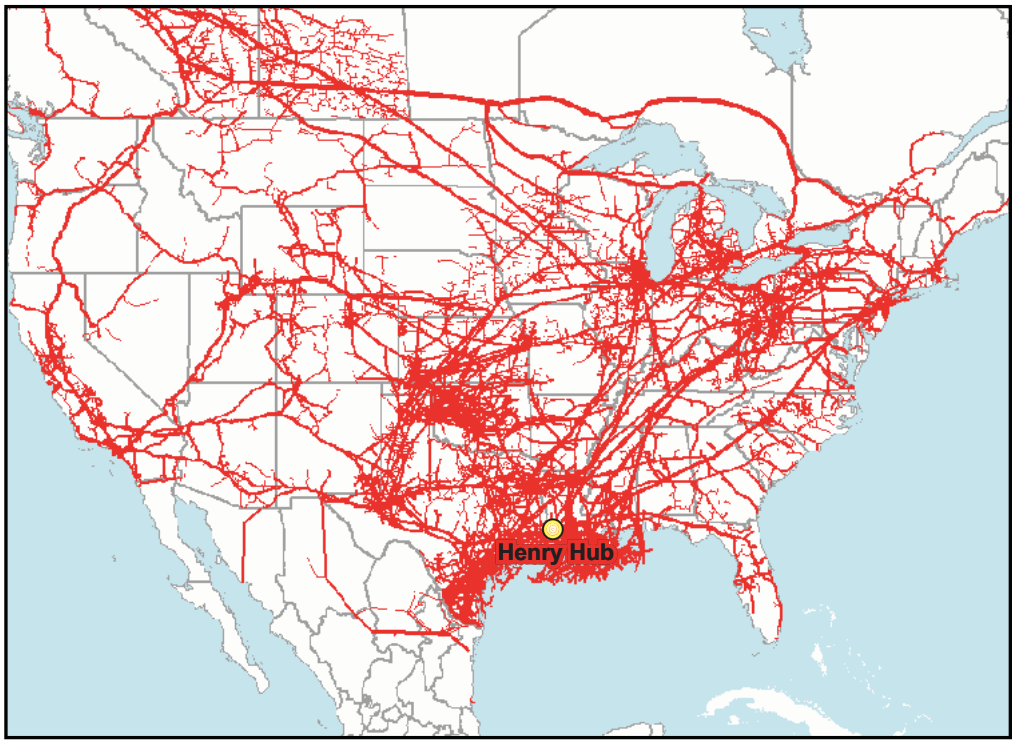
This market structure best fits the economic ideal of setting price according to supply and demand conditions. However, such a market has not been possible everywhere – a lack of infrastructure, not enough buyers and sellers or constraints on gas movement prevented the development of a fully traded market in many areas. However, the UK National Balancing Point (NBP) is a deep and liquid market which acts as the main price setting point for gas traded in Europe. Additional spot markets are developing across Northwest Europe, such as the Title Transfer Facility in the Netherlands, although these remain at an earlier stage of development. Unlike Henry Hub, NBP is not a physical location, but a virtual pricing and delivery point for gas contracts traded over the counter and on the Intercontinental Exchange.

The nature of supply in continental Europe and Asia shapes the way gas is priced and sold there. "Long-term contracts are crucial in gas markets to guarantee long-term security of supply, since European and Asian

1. IHS CERA excludes Mexico from its definition of the North American gas market because Mexico is not integrated into the American and Canadian gas grid.

Figure 2

An Extensive Pipeline Network Serves the North American Gas Market



Source: Platt's POWERMap.
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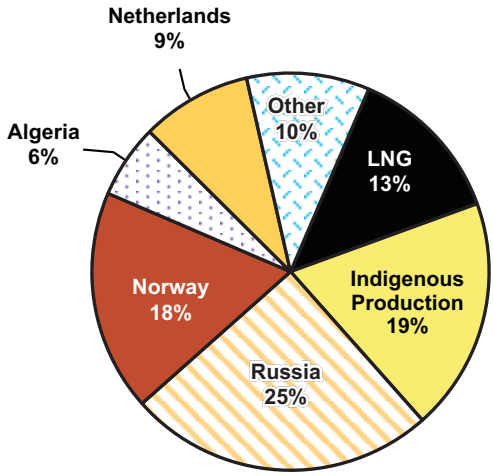
marketplaces do not offer the liquidity required for a strong spot market," remarks Gérard Mestrallet in his perspective essay, *The Role of Gas in an Uncertain World.* When gas markets evolved in the 1950s and 1960s, gas was primarily a substitute for oil products in heating and industrial applications. With no liquid market to provide price discovery, linking the price of gas to its main competitor in the marketplace made sense. Oil-linked gas prices still dominate most supply contracts in Europe and Asia. Additionally, gas prices are less transparent in these markets; prices in long-term contracts are generally kept confidential.

The long transportation routes that supply a large portion of Europe's gas also influence the market structure. About half of OECD Europe's gas is imported, mostly by pipeline from Russia and North Africa (see Figure 3). Long pipelines that cross several national boundaries are particularly challenging to site and build, and guaranteed demand is crucial to obtaining financing to develop the production capacity and the delivery infrastructure. For that reason, long-term supply contracts with "take-or-pay" provisions predominate in Europe. Buyers agree to pay for a minimum annual quantity of gas, usually 85% to 90% of the contract quantity, even if they don't need the gas. Sellers also offer upward volume flexibility, guaranteeing supply of 110% to 115% of the contract quantity if the buyer needs it.

Figure 3

European Gas Supply Mix, 2009



Source: IHS CERA.
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Increased trade on Europe's spot markets and the UK NBP spot market and greater amounts of LNG provide alternatives to imported pipeline gas. These additional sources of supply are influencing price and contract conditions and straining the structure of long-term contracts in Europe, a subject that will be explored in more depth in Chapter 4.

The Asian LNG market has no connection to a liquid spot market for natural gas, and long-term oil-linked contracts predominate. Japan and South Korea are the world's largest LNG consumers, accounting for approximately 60% of global LNG imports in 2009. These countries have few indigenous gas resources and rely almost entirely on LNG from Southeast Asia, Australia and the Middle East. The very large investments needed to build liquefaction and regasification facilities encourage the use of long-term contracts to ensure that these costs are recovered.

LNG: Gas Goes Global

To an even greater degree than for pipeline gas, infrastructure costs are a central concern for LNG development. Christophe de Margerie describes this relationship in *The LNG Market Perspective.* "Long-term partnerships between producing and consuming countries are particularly justified in the LNG business, considering the size of the investments and the integrated make-up of the value chain," he writes. "Producing countries need to secure their outlets and consuming countries need a reliable supply." Historically, projects have needed roughly 30-years worth of gas supplies to justify investments in liquefaction. Long-term contracts with take-or-pay commitments ensure that suppliers can recoup their investment.

Shipping cost and distance are also crucial factors in LNG markets. Shipping is the largest variable cost in the LNG value chain. Greater distance travelled means greater shipping costs per load, but it also means that more ships are needed to keep a route fully supplied owing to the longer travel time. The cost of shipping

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LNG over long distances essentially splits the LNG market into two distinct regions, shown in Figure 4. The Atlantic Basin includes the US East and Gulf Coasts, the Caribbean, Europe and West Africa. The Pacific Basin includes Southeast Asia, eastern Russia, Australia, Japan, continental Asia and the North American Pacific Coast. South America has recently become an LNG importer also, with countries on the east coast, such as Argentina and Brazil, in the Atlantic Basin group and west coast countries such as Chile and Peru in the Pacific Basin. Owing to scale in resources, liquefaction and shipping capacity, the Middle East is uniquely positioned to supply either basin economically, meaning that Middle East LNG producers serve as a link between the two basins.

But there is a new factor that could increase the availability of LNG and bolster its competitiveness. Floating regasification units are beginning to change assumptions about the size and shape of demand necessary to take advantage of LNG. The concept began in Argentina and Brazil and is now in use in the United States, United Kingdom, Kuwait, Dubai and Italy. Floating regas terminals allow LNG suppliers to target markets too small to justify traditional land-based facilities and markets with seasonal or sporadic spikes in gas demand. This system of LNG delivery requires much less capital investment in the receiving market, but the gas has much higher unit costs than gas delivered through a traditional on-shore LNG facility.

Figure 4
Global LNG Trade

Source: IHS CERA.
01211-11

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Perspectives on a New Age for Gas

The chapter includes three perspectives on the growing role of natural gas in global energy markets. The authors are:

- **Christophe de Margerie,** Chairman and Chief Executive Officer, Total, France
- **Alexander Medvedev,** Director General of Gazprom Export, Deputy Chairman of the Management Committee, Gazprom, Russia
- **Peter Voser,** Chief Executive Officer, Royal Dutch Shell, the Netherlands

The LNG Market Perspective

By Christophe de Margerie, Chairman and Chief Executive Officer, Total, France

Natural gas is the fossil fuel with the brightest future. Gas contributes to cleaner energy production. Its flexibility and the fact that it releases far less CO_2 than coal makes it particularly well suited to power generation. In addition, gas reserves are abundant and geographically more diverse than oil reserves.

LNG is the most dynamic segment of the gas market. LNG's share of global gas consumption is only 8% today, but this relatively small portion is expected to increase rapidly, as the demand for LNG is growing more than twice as fast as the demand for gas. This overall trend hides significant regional differences. North American gas demand is expected to grow 1.3% per year from 2010 to 2020. North American supply will come mostly from domestic resources, with a decrease in conventional gas production and a strong increase in unconventional gas production, notably from shale gas. LNG will play a limited role.

LNG is central to the European and Asian gas markets. European gas demand is expected to grow by 1.7% per year in the coming decade. Decreasing North Sea production will be offset by increasing pipeline imports and LNG imports. Asia's gas demand is projected to increase by 5.7% per year. Domestic production and pipeline imports are expected to increase, but the balance will come from nearly doubling LNG imports. Asia and to a lesser extent Europe will thus reinforce their positions as leading LNG markets.

The global gas market is regional and characterized by long-term contracts and varying price formulas in each zone. However, this regional separation is now weakening.

Unlike pipeline gas, cargoes of LNG can be easily diverted to new destinations, thanks to the increase in logistical capacities in the past few years (LNG carriers and regas terminals). Now it is possible to arbitrage among different import markets. LNG thus plays a balancing role across world gas markets. So far, this arbitrage phenomenon involves only limited volumes of gas, but its importance will grow as the share of LNG in world gas consumption increases. This should result in a stronger correlation among regional markets that were previously independent.

Currently the gas market is in a phase of oversupply resulting in lower spot prices. This is a consequence of the global economic crisis and its negative impact on industrial gas demand, combined with the start of production at new large gas facilities. This short-term situation should not be misinterpreted, as it will not last; we believe that in a couple of years the present excess capacities will disappear, leading to a gas shortage and growing competition between Europe and Asia for access to gas resources.

Total brings the perspective of a global gas company to its understanding of LNG markets. With the start of Qatargas II and Yemen LNG in 2009, Total has become the second-largest LNG player worldwide, with liquefaction plants in the Middle East, Africa, Asia and Europe and regasification units in Europe, Asia and the United States. According to Total's current estimates, LNG projects under construction or already firmly decided upon can meet only one-third of the expected LNG demand increase by 2020. New LNG projects are needed. Integrated projects are complex and costly, involving field developments, liquefaction units, shipping facilities and regasification terminals. Their implementation from first design to completion is a lengthy process. Early decisions need to be made to ensure that the required capacity is online by 2015-2020. Securing smooth and efficient gas markets and realizing a more diverse gas supply requires additional gas import facilities in consuming countries, notably LNG receiving terminals in Europe and the main Asian markets.

Long-term partnerships between producing and consuming countries are particularly justified in the LNG business, considering the size of the investments and the integrated make-up of the value chain. Producing countries need to secure their outlets, and consuming countries need a reliable supply. In addition, LNG developments contribute significantly to the local industry's diversification. This convergence of interests between producers and consumers explains the role played by long-term contracts and take-or-pay provisions in LNG marketing.

Developing the LNG business is probably the best way to improve energy efficiency and sustainability and to strengthen relations between consuming and producing countries. Its flexibility contributes significantly to the optimum use of all available energy sources – a contribution that will be increasingly recognized and put to very good use.

The Role of Gas in Climate Change and CO_2 Reduction

By Alexander Medvedev, Director General of Gazprom Export, Deputy Chairman of the Management Committee, Gazprom, Russia

The key role of natural gas in CO_2 reduction strategies must be recognized. Gazprom fully supports the goal of decreasing CO_2 emissions and views it as essential for realizing the ultimate goal of averting crucial climate change.

"No matter what" approaches to the goal of decarbonisation, or of increasing the production and use of carbon-free energy, pose a real danger. Such approaches could frustrate the opportunity to reach CO_2 emission targets in a practical and efficient way by replacing "dirtier" fossil fuels with "cleaner" ones. Prioritizing carbon-free power generation puts all fossil fuels at the same disadvantage, irrespective of their climate friendliness. A sounder and more realistic approach would be based on promoting natural gas as a cleaner alternative to oil and coal.

Natural gas offers a cost-comfortable solution to the climate change problem. Fighting climate change is an expensive exercise that is sure to involve increases in total energy bills well above their current levels.

The EU's forecasted economic benefits depend on fully meeting energy savings targets. Energy efficiency is vitally important, but it is also necessary to be realistic. The experience of the past 20 years shows that energy efficiency cannot be improved in developed economies such as the EU by more than 2% per year (measured as energy consumption per unit of gross domestic product). During the past 10 years energy efficiency has improved at a rate of less than 1% per year.

Better integration of the different elements of energy policy, especially in relation to the internal market, supply security and climate change goals, is a highly desirable objective. As a supplier of the cleanest and most efficient fossil fuel, natural gas, Gazprom supports measures that encourage the transition to lower-carbon power generation.

Meanwhile the economic situation imposes constraints on both public and private sector expenditures, limiting the scope for public subsidies for otherwise uncompetitive or experimental alternative and renewable energy sources. At the same time, concerns are growing about the impact on the EU's industrial competiveness if consumers have to bear the full weight of the extra costs involved.

This means that there is a greater need than ever for objective and economically sound analysis and presentation of the costs and benefits of available technologies and fuels in terms of CO_2 reduction. One hopes that the European Commission's ultimate policy proposals will take fuller account of these factors. We believe that an analysis of this kind would point clearly to the advantages of natural gas as a relatively clean, cheap, dependable and flexible fuel for the medium and the long term. Our studies have shown that the EU could achieve half of its 2020 CO_2 reduction targets by replacing every second coal-based power plant with modern gas-turbine units. Moreover, increasing the natural gas share in the EU energy mix by just 1% would reduce CO_2 emissions by more than 3%.

There are also opportunities to utilize natural gas as an engine fuel, both directly (in LNG and compressed natural gas form) and as synthetic diesel fuel produced by GTL technology. These technologies could become a major part of the transportation industry in the foreseeable future; they could also help increase market competition between oil and gas. With significant quantities of GTLs in international trade, the market would have an independent indicator for the value of crude oil. Such competition would narrow the gap between gas contract prices pegged to an oil product basket and spot market prices. Extensive use of gas as an engine fuel in Europe would benefit all gas suppliers and reduce the risks associated with the need to import significant volumes of diesel fuel into the EU.

Realising the Natural Gas Opportunity

By Peter Voser, Chief Executive Officer, Royal Dutch Shell, the Netherlands

We know that global energy demand is likely to double during the first half of this century. We also know that global GHG emissions per unit of energy must drop dramatically over the same time period. Under these circumstances, natural gas has a major role to play as an abundant, affordable and cleaner energy source. However, for natural gas to realize its full potential, industry must work closely and effectively with government to establish policy frameworks that reflect its benefits.

The supply picture for natural gas has improved spectacularly in the past few years, driven by the boom in tight gas, shale gas and CBM in North America. The discovered gas resource base in North America has more than doubled in the past three years and is now large enough to meet current consumption levels for over a century. The unconventional gas boom's echoes are heard far beyond North American shores: it has freed up supplies of LNG (initially destined for the United States) for other parts of the world, and it has inspired other nations to search for new gas resources. The growing global supplies of gas, along with the growth of the LNG industry, should help to bolster the competitiveness of gas, provided that resources are developed in a timely manner.

Natural gas also has strong environmental credentials as a cleaner source of electricity, although water from the production of tight and shale gas must continue to be managed professionally. Modern combined-cycle gas-fired power plants emit 50% less CO_2 than supercritical coal plants and 70% less than older steam turbine coal-fired plants. Displacement of old coal plants by modern gas plants is by far the most cost effective short- to medium-term approach to moderating emissions. If the United States would double the utilization rate of its existing natural gas turbines from around 40% to around 80%, it would displace nearly one-fifth of the CO_2 emissions from coal-fired power plants. Using natural gas rather than coal to meet growing power demand is the cheapest, surest, fastest and most comprehensive way to reduce CO_2 emissions over the crucial next ten years.

These developments together should give governments and investors the confidence to commit to natural gas for the long term. North America, Europe, Asia, Latin America and the Middle East all face different combinations of energy pressures, but enhanced confidence in the future of natural gas could benefit resource consumers and resource suppliers across the world.

In the emerging markets, continued economic growth will result in increasing demand for natural gas across all sectors of the economy. In the OECD markets much hinges on the role natural gas will play in the electricity sector. In the wake of the financial crisis, it is significant that new gas-fired power plants can be installed faster and at much lower capital cost than other sources of electricity – approaching one-third of the cost of coal per megawatt-hour, and less than one-fifth the cost of nuclear or wind. Additionally, unlike coal or nuclear, gas plants are a suitable complement to intermittent wind or solar electricity.

These attributes make natural gas a vital ally in the world's search for cleaner electricity and a more sustainable energy future. To give natural gas the space to grow, governments and regulators possess numerous policy instruments to help forge a clean electricity coalition among natural gas, renewables, nuclear and carbon capture and storage (CCS).

Carbon markets that deliver robust carbon prices are the most effective way to bring this coalition together and stimulate investment in the necessary technologies. Were transparent carbon pricing mechanisms to operate effectively, it would become even more apparent that natural gas, given its small carbon footprint and low capital intensity, is the most attractive fuel for electricity generation. In combination with CCS, gas also would prove to be a very strong low-carbon competitor for the longer term. Besides affordable low-carbon power, gas with CCS can generate hydrogen not only for industrial-scale use but also potentially for distributed use in fuel cell vehicles and combined heat and power units.

However, as CO_2 pricing looks set to remain patchy at best for some considerable time, the non-transparent standards and mandates that are the political compromise should at least aim to replicate the outcomes of CO_2 pricing, with least-cost solutions implemented first. In some regimes, though, the absence of a strong carbon price combined with ambitious obligations for renewable power perversely impose high system costs while extending the life of "old" coal-fired generation. This brings higher electricity bills for the same level of emission reductions.

In today's uncertain environment it is important to remain strongly focused on policies that deliver the least-costly solutions now and encourage the most cost-effective advances in combinations of new technologies in the future. Natural gas offers a way to meet the pressing energy challenges of today and, in combination with CCS, it will provide a cost-effective, low-carbon solution for tomorrow.

CHAPTER 2: REVOLUTION IN NATURAL GAS SUPPLY

What a difference a few years can make. A mere five years ago, North American gas production was expected to decline quickly. Large-scale expansions of liquefaction capacity around the world would pick up the slack in the North American market and supply demand centres in Asia and Europe. Inexpensive and plentiful LNG was expected to compete against conventional gas resources. Little attention was given to unconventional resources, including shale gas, tight gas and CBM.

The "shale gale" has swept away all of those assumptions. Combining known technologies in new ways has led to a breakthrough in the cost-competitiveness of unconventional gas in North America, particularly shale. In most cases, it is now less expensive than conventional gas. Shale was just 2% of US supply in 2002. In 2010 it was 24%.

The potential for unconventional gas is now being explored in other regions. The lessons learned in North America are likely to be applied around the world.

The Unconventional Gas Revolution

Shale gas resources have been known for many decades; in fact, shale is the source rock for many conventional oil and gas resources. Nonetheless, until recently low permeability and porosity made producing natural gas from shales too expensive or technically difficult to be viable. All of that has changed over the past decade, as significant investments in new technology have revolutionized shale gas production in North America and made it cost competitive.

Two technologies are critical to producing natural gas from shale: horizontal drilling and hydraulic fracturing. Both have been in use for decades, but combining the two was the key to igniting the shale gas revolution.

- Horizontal drilling involves drilling a vertical well to the desired depth and then drilling laterally to access a larger portion of the reservoir.
- Hydraulic fracturing – or fraccing – involves injecting fluid under high pressure into a well to create fractures in the reservoir rock. These fractures allow natural gas in the rock to flow towards the wellbore and then to the surface. The fraccing fluid usually consists of water and sand or another solid to hold the fractures open after they are created. Chemicals that make the process more effective make up less than 1% of the fraccing fluid. More recent developments utilize multiple fracs per well to increase production further.

The breakthrough of combining these two technologies occurred in 2002-2003, although it took another half decade for the impact to be recognized. But, combining the technologies is only the starting point for realizing the potential of shale gas. Each geological formation requires a unique approach. Two operators drilling in the same formation a short distance apart often experience different production costs. Reservoir properties such as permeability, porosity and depth vary across shales. When policy and stakeholder issues are included, defining the unconventional gas opportunity in any specific region is even more challenging. Policy is likely to be nearly as important as geology and technology in the unconventional gas revolution.

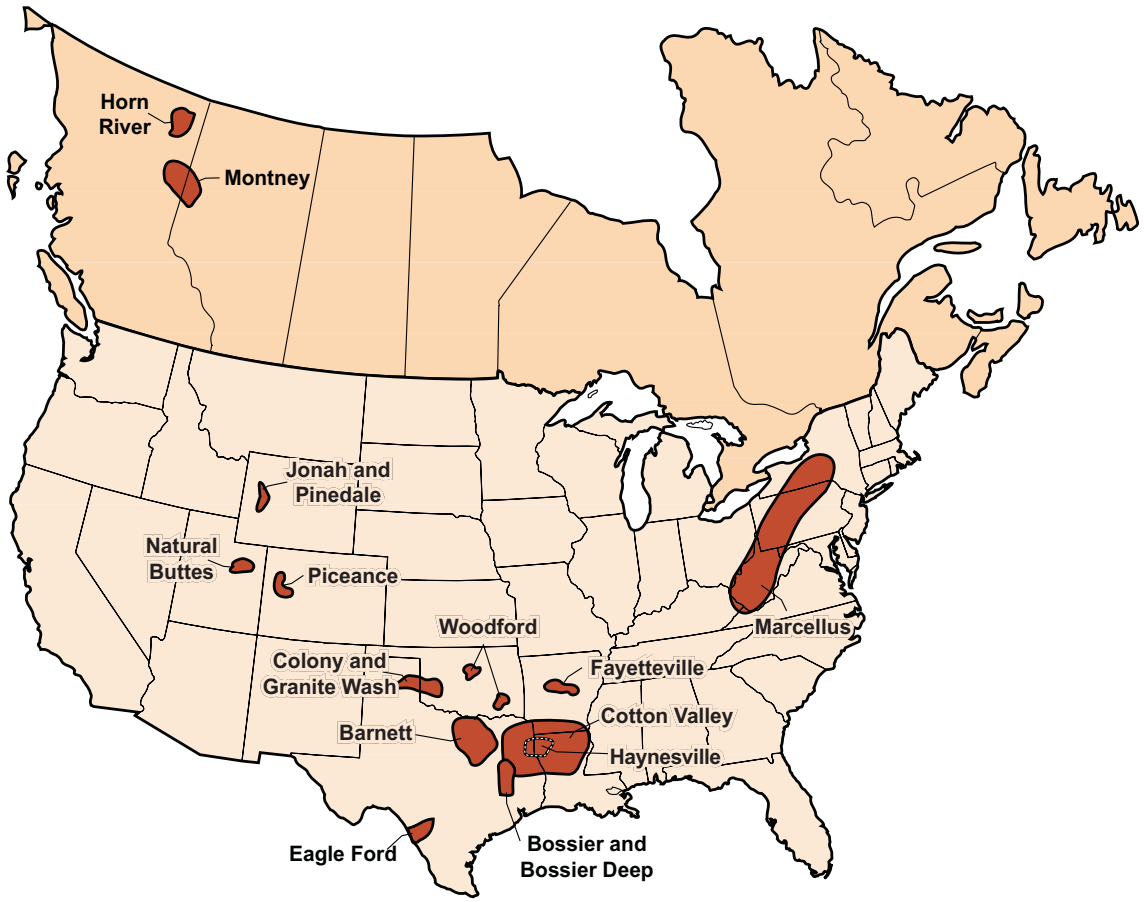
North America: The "Shale Gale"

The shale gale is a game changer in North American gas supply. IHS CERA estimates that unconventional gas plays in North America contain more than 51 trillion cubic meters (Tcm) (1,800 trillion cubic feet [Tcf]) of recoverable gas – more gas than has been produced in North America since 1930. Adding this new resource to previous estimates results in a gas resource base of more than 85 Tcm (3,000 Tcf), a volume that could supply current North American consumption for well over 100 years. Figure 5 shows the location of the most important North American shale resources. The Marcellus Shale resource is particularly prospective because of its size and its location near the demand centres of the US Northeast.

Gas production also reflects the new abundance that shale technology has brought about. The share of shale gas in North American gas production has doubled in just two years, from 12% (0.2 billion cubic meters [Bcm] or 6.6 billion cubic feet [Bcf] per day) in 2008 to 24% (0.4 Bcm or 13.8 Bcf per day) in 2010. By 2020, shale gas is likely to make up 50% of North American gas production.

Figure 5

North American Unconventional Gas Hot Spots



Source: IHS CERA.
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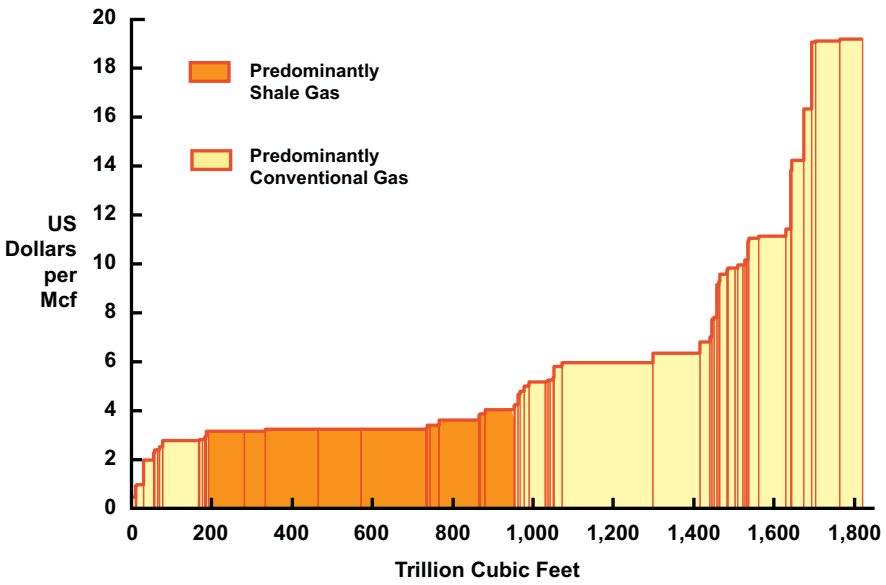
Advances in shale gas production technology have also transformed the North American gas supply curve, as shown in Figure 6. A substantial portion of this new supply can be produced at low cost – less than US$ 145 per thousand cubic meters (Mcm) (US$ 4 per million British thermal units [MMBtu]) in full-cycle cost terms.[1] The availability of so much inexpensive gas is driving the unconventional gas supply surge and changing assumptions about the future direction of North American gas prices. However, the least expensive resources aren't necessarily those that will be produced first. Pipeline capacity must be available to connect areas of production to demand centres. For example, infrastructure constraints may delay the development of the Horn River and Montney Shales in Canada and portions of the Marcellus Shale in the US Mid-Atlantic states. Practical issues such as market size, the acreage

1. Full-cycle unit costs include all of the significant components of the cost equation confronted by producers in a specific play or region, including capital and operating expenditures, royalties and taxes.

Figure 6

Shale Gas Plays Are Changing the Shape of the North American Supply Curve*
(Breakeven Henry Hub Price)



Source: IHS CERA.
*Proved, possible and potential resources.
01211-4

held by individual producers and the capabilities of the service industry will dictate production levels as much as cost.

The low costs associated with many shale plays are a result of greater efficiency in production. Horizontal drilling allows a greater volume of the reservoir to be accessed with a single well. In addition, drilling multiple wells from a single site or "well pad" allows several horizontal wells to be drilled with a single rig without the need to disassemble and reassemble the rig between wells. Locating multiple wells on a pad also reduces land disturbance. Furthermore, "batch" operations – repeating the same operation on multiple wells and drilling a collection of wells in stages – can also increase operating efficiency. Increased efficiency in drilling means that fewer rigs are needed to drill a given number of wells, yielding substantial cost savings. Additionally, shale beds in North America are well understood, meaning that the risk of "dry holes" is low.

Continued strong growth in shale gas production depends upon continued innovations in drilling and well completion, access to land and the removal of delays in obtaining drilling permits. The industry will drive the innovation process. But regulation is a separate matter. John Manzoni describes the regulatory challenge in his perspective essay, *Securing Natural Gas as a Bridge Fuel to a Low-Carbon Future.* "The exploration and production (E&P) sector needs to become more strategic in helping to shape energy policy to secure a great future for gas," he says. Proper management of environmental issues is particularly important to gaining public acceptance of the shale gas industry. Mr. Manzoni adds, "The industry must step up its efforts to ensure

A New Age for Gas

Environmental Challenges of Shale Gas Development

Environmental concerns about shale gas development have become an important issue in some parts of the United States and they are likely to appear in other areas as well as shale gas production expands. In many ways, access to growing reserves of low-carbon natural gas is beneficial, because gas use results in lower emissions of GHGs and many air pollutants than competing fuels. However, the benefits are relatively diffuse and occur when and where the gas is used. In the case of lower GHG emissions, the benefit is global.

However, the risk of detrimental environmental effects related to shale gas development would occur locally where gas is produced. These problems are most prevalent during site preparation, drilling and fraccing. Land disturbance, nuisance dust, noise and diesel exhaust emissions occur during development, but impacts are minimal once the well is in the production phase.

The most prominent concerns about shale gas development relate to water. Fifteen million to 19 million litres (four million to five million gallons) of water are required to drill and fracture each shale gas well. For comparison, this volume of water could serve 35 to 45 American households for a year. However, shale gas is less water intensive than some competing fuels. Coal, for instance, requires about four times as much water from production through electricity generation as shale gas, assuming that the power plant uses closed-loop cooling. However, the availability of water resources varies by location and water availability may be a challenge in dry areas.

Contamination of drinking water sources is also a key concern, focused on the hydraulic fracturing process and its potential to contaminate aquifers. However, geology and proper well installation make such an event improbable. A properly installed well includes steel casing surrounded by concrete to separate the well from aquifers that it passes through. The surface casing extends at least 50 to 100 feet below the deepest potential source of drinking water. Shale gas deposits are generally located several thousand feet below the deepest potential drinking water aquifer. The low permeability of shale rock and other intervening formations restricts the flow of fraccing fluids from the shale upward into drinking water sources, even under the pressure applied by the fraccing process.

Although water contamination from hydraulic fracturing is unlikely, the storage and disposal of produced water and the water and chemicals used during well development are potential sources of water contamination. Similarly the release of drilling mud, stored in pits adjacent to the well, is also possible. These risks are common to all oil and gas development but have received less public attention than fraccing-related issues. Proper management of water and other materials at the surface is critical to avoid runoff and surface water contamination.

maintenance of the highest standards and collaboration with communities to reduce surface disturbances, minimize impacts on wildlife and protect groundwater."

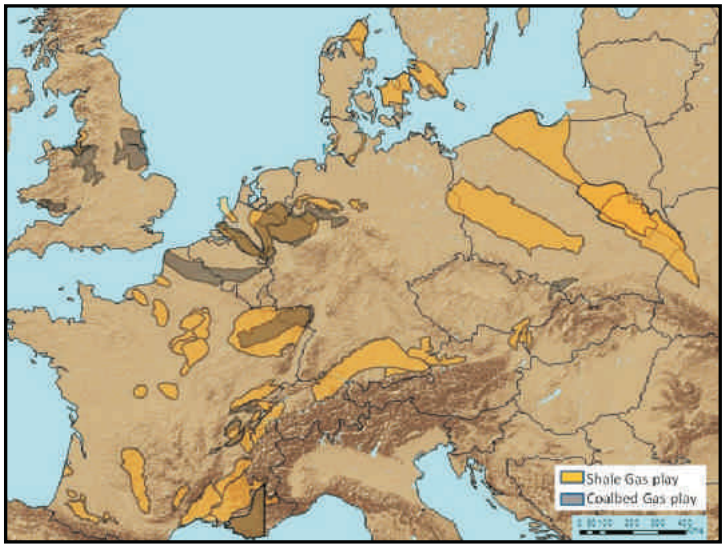
Europe: Understanding the Potential

Estimates of the shale gas resources in Europe rival those in North America. In his perspective *Breaking with Convention: Prospects for European Unconventional Gas,* IHS CERA Senior Director Peter Jackson assesses European prospects and describes "world class" shale resources in Poland, the Baltics, Germany and Austria, as shown in Figure 7. However, the European unconventional gas opportunity is likely to play out differently than the revolution in North America for several reasons.

First, the ownership of mineral rights in Europe presents different challenges for European developers than E&P companies have faced in North America. Typically mineral rights for US properties are privately owned and are conveyed along with the surface rights. Property owners can also sell or otherwise transfer the rights to resources beneath their property. On the other hand, in Europe mineral resources generally belong to the state. Thus E&P companies in Europe negotiate with the government instead of individual property owners. This introduces potential obstacles to development. Negotiating with the government could be a more

Figure 7

Unconventional Gas Resources in Europe



Source: IHS CERA.
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time- and resource-intensive process. And the resulting concession could bring the producer into conflict with the surface owner, who may not share in the income produced.

Second, aboveground activities are inevitable during drilling and production. Such activity would include the construction of roads and infrastructure to transport heavy equipment to drilling sites, disposal of wastewater and cosmetic changes to the landscape in areas that have not seen onshore drilling in the past. Because of Europe's greater population density and limited experience with onshore drilling, it will be particularly important to minimize such disturbances. Additionally, since landowners will have less of a financial stake in the outcome of gas development than those in North America, they will have less incentive to accept the disruption that it will cause.

Third, Europe does not have an established fleet of the specialized onshore rigs needed to drill in unconventional gas plays. This raises technical and logistical hurdles that must be overcome before development of resources can commence on a large scale. Logistical systems have to be created to support an onshore gas exploration and production industry.

Despite these potential challenges, the case for developing the onshore gas resource base in Europe is compelling. Diversification of supply could bring greater stability to the gas market. It could also create greater confidence in a broader use of natural gas, especially in power generation.

Poland has the largest potential for unconventional gas production in Europe. In its high production case, IHS CERA projects that unconventional gas production in Poland could increase from around 5 Bcm per year (0.5 Bcf per day) today to more than 100 Bcm per year (9.7 Bcf per day) by 2025. Poland's domestic

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Modern Natural Gas Drilling Rig

gas consumption is projected to grow to slightly more than 20 Bcm per year (1.9 Bcf per day) in the same timeframe, meaning that Poland could become a significant gas exporter and transform gas supply throughout Central Europe. Even lower production scenarios for Poland would turn the country from a gas importer into a gas exporter.

Peter Jackson describes the policy challenge for unconventional gas in Europe this way: "Energy policy will be at least as important as geology in shaping the future of unconventional gas in Europe. Without rationalization of the regulatory environment, the take-off of unconventional gas production will be geographically restricted or delayed. Over time policy-makers could face a strategic choice between support for unconventional gas – as a relatively clean indigenous resource – and more costly zero-emission clean technologies." At the same time, the possibility of significant unconventional gas resource in Europe is further complicating the debate about potential new supply from the Caspian and Central Asia.

Asia: Just Getting Started

The evaluation of shale gas resources in Asia is in its infancy. China has shown the most interest in shale gas, and several basins in China meet screening criteria for shale gas potential. An active technical program is underway to investigate Chinese shale gas resources,

generally run by Chinese oil and gas companies with Western partners. Nevertheless, a realistic estimate of the resource potential is several years away.

CBM in Australia currently leads the race for Asian unconventional gas development. LNG facilities that will use CBM as the source gas are now under construction, and additional projects are likely to be sanctioned. Investment in Australia has been strong for the past decade, as industry players seek to take advantage of Australia's proximity to fast-growing Asian markets.

Outside Australia, CBM development is moving more slowly. Modest production of CBM is underway in China, mostly to serve local markets rather than interprovincial ones. India and Indonesia have also shown interest, but definitive numbers on the resource in place are not yet available. Even if the largest estimates prove correct, the rate at which this gas becomes available will be the crucial variable.

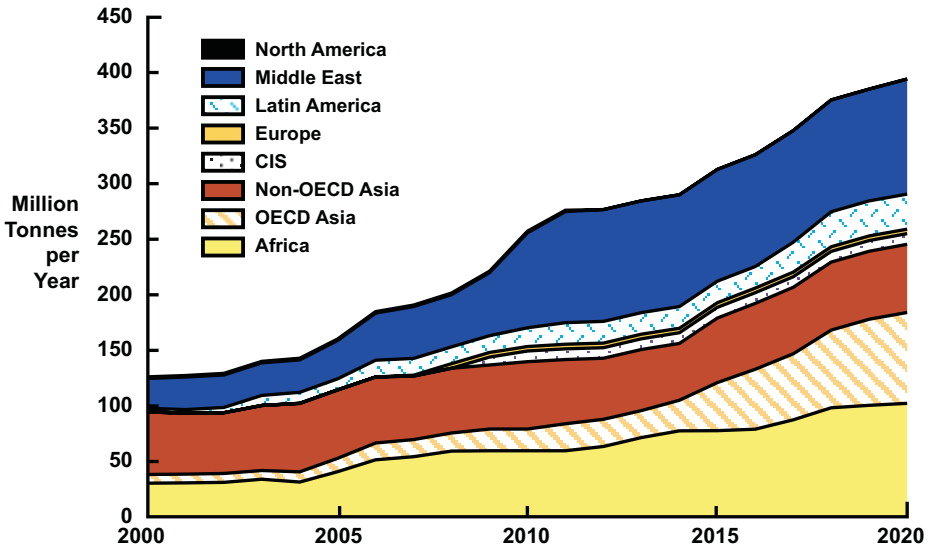
Liquefied Natural Gas: Still a Pivotal Source of Supply

Even though unconventional gas is getting more attention, LNG remains a crucial supply source in much of the world. Global LNG trade doubled in the decade from 2000 to 2010 and is expected to increase another 50% or more in the next 10 years (see Figure 8). Development of unconventional gas resources in Europe and Asia is still at an early stage, so both areas remain strong markets for LNG. North America is the only region where the projected demand for LNG has decreased substantially. Nonetheless, the LNG industry has faced a daunting challenge in recent years.

From 2000 to 2007 the LNG industry invested heavily across the value chain to make up for the expected decline in North American gas production and to meet rapid demand growth in Asia. The global leader is Qatar, where capacity recently reached 77 million tons. However, when new liquefaction terminals were finished

Figure 8

Global Liquefaction Capacity Is Expanding Rapidly



Source: IHS CERA.
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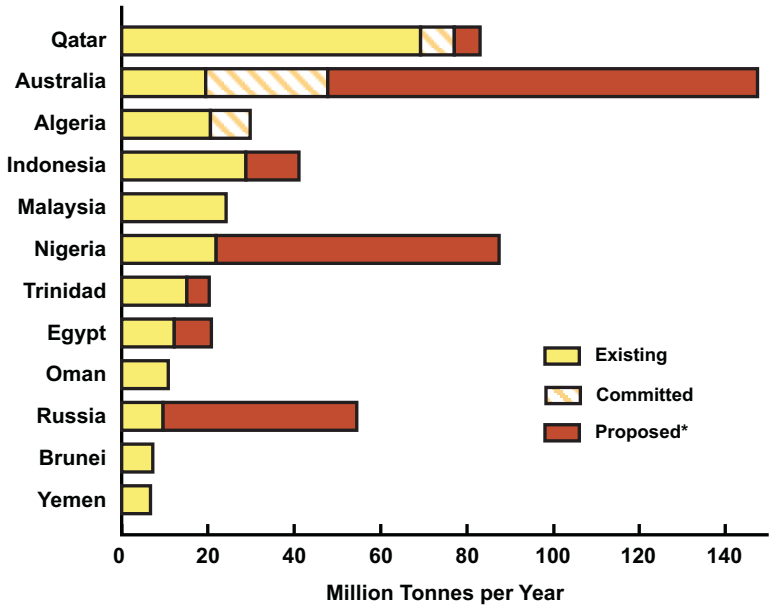
A New Age for Gas

in 2008 and 2009, the market was very different than expected earlier. Projects that reached final investment decision during a high price environment came online when North American gas production was expanding rapidly and the world was in the midst of a deep recession. Paolo Scaroni describes the situation in his perspective essay, *The Fuel of the Future.* "Many LNG projects have recently come online amid declining US LNG demand (owing to the 'discovery' of shale) and declining global demand (owing to the economic downturn). LNG tankers previously destined for the shores of North America are now being redirected to Europe and Asia." Shipping also experienced a glut, as newly designed Q-Max supertankers were commissioned in a slack market.

The global recession may have temporarily put a damper on LNG. But as shown in Figure 9, the world's largest LNG producers could bring as much as 150 million tonnes per year of new liquefaction capacity online by 2020. Australia is the largest contributor, with 40 million tonnes per year of proposed or committed new liquefaction capacity. Don Voelte describes the potential for Australian LNG in his perspective essay, *Answering the Call: Australia and Global Natural Gas.* "Australia currently has about 210 Tcf of proven and probable natural gas resource, including 12 Tcf of proven and probable resource from coal seam methane. Exploration is adding new reserves. Australia has the potential to emerge as the world's second largest LNG supplier after Qatar." Qatar will continue to be the largest global

Figure 9

Countries with the Largest Liquefaction Capacity by 2020



Source: IHS CERA.
*Proposed projects vary in their likelihood of completion.
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supplier of LNG, but its most dramatic growth in capacity has already occurred and it is, at least for the time being, postponing new development.

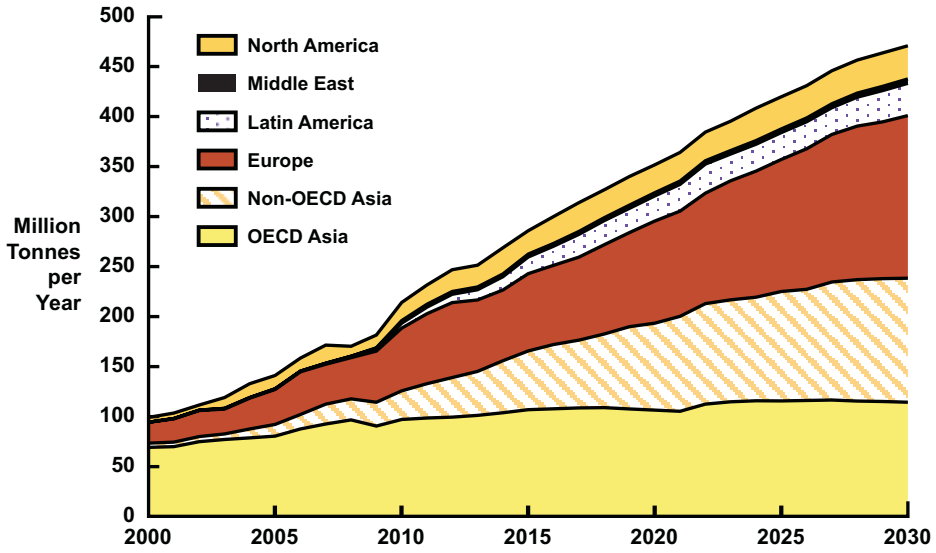
Asia will remain the largest market for LNG (see Figure 10). Japan and Korea have negligible domestic gas resources and meet nearly all of their demand with LNG. Much of Asia, with the exception of Japan, emerged from economic recession faster than North America and Europe – a boon for the LNG trade.

Non-OECD Asia has tremendous potential for LNG demand growth. Indeed somewhat counterbalancing the "lost" US market, Asian demand is growing more rapidly than anticipated even a year or two ago. Until 2006, China was self-sufficient in natural gas and did not have the infrastructure necessary to accommodate imports. Today China has three operating LNG import terminals and five more will be commissioned by 2013. Thailand is scheduled to commission an LNG terminal in 2011 and Indonesia, Pakistan and Singapore are expected to do so by 2013.

In Europe LNG imports are growing faster than imports of pipeline gas. LNG's share of the European supply mix is projected to grow from 13% in 2009 to nearly 20% in 2020. LNG in expected to replace much of the decline in production from the North Sea.

Figure 10

LNG Imports by Region



Source: IHS CERA, US Energy Information Administration and IEA.
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A New Age for Gas

Perspectives on the Gas Supply Revolution

The chapter includes four perspectives that describe the revolution currently occurring in natural gas supply. The authors are:

- **Peter Jackson,** Senior Director, Oil Industry Activity, IHS CERA, United Kingdom
- **John Manzoni,** President and Chief Executive Officer, Talisman Energy, Canada
- **Paolo Scaroni,** Chief Executive Officer, Eni, Italy
- **Don Voelte,** Managing Director and Chief Executive Officer, Woodside Energy Ltd., Australia

Breaking with Convention: Prospects for European Unconventional Gas

By Peter Jackson, Senior Director, Oil Industry Activity, IHS CERA, United Kingdom

The explosion of unconventional gas production in North America begs the question: do other regions have similar potential? IHS CERA has endeavoured to answer this question for Europe.[1] We have systematically mapped and screened all of the key unconventional gas plays – both shale gas and CBM – in seven regions across Europe, including northwestern Turkey. Our assessment included a total of 36 shale gas plays and 19 coal bed gas plays.

We found that the European shale gas resource is comparable to that of North America at 157 Tcm (5,568 Tcf), of which 3.5 Tcm (125 Tcf) could be commercially recovered in the base case. The results show a concentration of world-class shale gas potential in the Baltic region, including southern Sweden and Poland, as well as in Germany and Austria.

CBM has a much smaller potential footprint, with an estimated 15.6 Tcm (550 Tcf) in place, with the highest potential in France and the United Kingdom. CBM plays have far less commercial potential than shale. The CBM resource has been known in Europe for many years and given the limited progress with investments made to date, it seems unlikely to play a major role in future European gas supply.

Although unconventional gas exploration and exploitation in Europe is at a very early stage, a recent flurry of licensing activity focused on shale gas has captured most of the prospective acreage across the region. The majors, large independents and national energy companies have played a major role in the license acquisition in Europe. This stands in contrast to the early US experience, in which smaller independents led the way.

Investment is gearing up to drill and test a limited number of wells that will be the key to unlocking the commercial potential of selected plays. Lessons learned in the United States about well design, hydraulic fracturing and identifying the most prospective segments of individual plays (sweet spots) will benefit European operators.

Very little is currently known about the long-term production potential of shale and coal gas reservoirs in Europe. The results of these early drilling operations will have a major influence on the pace of development in the medium term. Some early encouragement is essential. For the North American Shale Gale to approach European shores, investors will need to see successful application of state-of-the-art hydraulic fracturing technology, contained costs and evidence of strong production performance.

In addition to estimating the resource in place, we used our extensive knowledge of the performance of US unconventional gas plays to project European productive capacity through 2070. We combined an analysis and understanding of subsurface risk, the likely cost framework, complex regulatory structures and the broad spectrum of above-ground risks including permitting, water usage, access issues and pipeline infrastructure. We project a plateau productive capacity for Europe in the range six to 20 Bcf per day, reached between 2025 and 2030.

At present, not enough drilling rigs and hydraulic fracturing units are available in Europe to support our projected production profiles, but we believe that the service sector could gear up very quickly in the success case. We anticipate that the surface footprint of unconventional activity in Europe will be smaller than that in the United States owing to technology improvements and because Europe's complex permitting process will limit the selection of drilling sites. Successful management of regulatory issues and a complex spectrum of local issues will be major factors in the future progress of individual unconventional gas developments.

The bottom line is that even in the best case, Europe will remain a net gas importer. Unconventional gas supply will broadly balance the decline of conventional gas production over time. Nonetheless, we anticipate some notable unconventional gas successes in certain geographic areas, such as Poland. Even for the unconventional plays that succeed, gas production could get off the ground rather slowly – with regulatory and tie-back factors a common source of delay – but then increase with surprising speed, as was the case in the United States. These take-off moments for individual plays will begin after 2015, with most coming on stream after 2020.

Unconventional gas is likely to be competitive with a long-run average European contract price range of US$ 290 to US$ 326 per Mcm (US$ 8 to US$ 9 per MMBtu), even though most unconventional plays could not compete with existing supply on a delivered-cost basis. Incumbent suppliers could try to marginalize unconventional gas through aggressive pricing policies, but only if they were willing to upend existing pricing mechanisms.

Energy policy will be at least as important as geology in shaping the future of unconventional gas in Europe. Without rationalization of the regulatory environment, the take-off of unconventional gas production will be geographically restricted or delayed. Over time policy-makers could face a strategic choice between support for unconventional gas – as a relatively clean indigenous resource – and more costly zero-emission clean technologies.

1. *Breaking with Convention: Prospects for European Unconventional Gas.* November 2010. IHS CERA.

Securing Natural Gas as a Bridge Fuel to a Low-Carbon Future

By John Manzoni, President and Chief Executive Officer, Talisman Energy, Canada

The evidence seems irrefutable today that shale gas in the Barnett Shale and many other plays has transformed the supply situation in North America. This is a great change from the future predicted in 2003, when natural gas prices rose amid fears of tight supply. The emerging application of horizontal drilling within the Barnett Shale in Texas enabled a revolution. Natural gas resource estimates have nearly doubled in the past three years – and tripled in the past seven years – leaving little doubt that the future promises decades of supply at affordable prices. However, the path to that outcome is not yet clear, and steps by both industry and government should be taken to promote a future of secure, economic and low-carbon energy supply to North America.

The natural gas industry in North America has fundamentally changed in the years since 2003. Only a few years ago, industry players saw significant rewards as they developed new technologies and honed techniques in drilling and hydraulic fracturing (or fraccing) horizontal wells. But those techniques have turned a supply deficit into a surplus. Natural gas prices have fallen and appear unlikely to return to their previous high levels. NYMEX gas futures no longer exceed US$ 254 per Mcm (US$ 7 per MMBtu) at any time before 2020. Consequently, industry returns also are tightening as the need for greater efficiency and productivity increases with gas market competition.

To maintain a competitive advantage, E&P firms will increasingly need to be positioned in only the best rocks and have excellent operations and access to premium markets. Beyond the scope of individual company operations, the E&P sector needs to become more strategic in helping to shape energy policy to secure a great future for gas.

Aboveground issues that are within the industry's control represent the most important challenge to securing the growth of shale gas. Key priorities are to resolve issues concerning fraccing and the use of water. Fraccing has been employed for well stimulation in the United States since 1947, but is being applied now in many regions that are new to large-scale energy development. The E&P sector unequivocally supports strong well integrity standards, a key to ground water protection. The industry's concern, however, is that regulation could be co-opted by special interests and that growth could be slowed in what might otherwise be the best means to provide an economic, abundant and low-emission energy source. The industry must step up its efforts to ensure maintenance of the highest standards and collaboration with communities to reduce surface disturbances, minimize impacts on wildlife and protect groundwater.

In partnership with government, industry also bears a responsibility to engage actively in the climate policy debate. The industry has the opportunity to reduce CO_2 emissions economically, but needs a level playing field within a context of a sensible carbon policy. This begins with good measurement, efficient price signals and proper incentives to retire 40- to 60-year-old coal-fired generation plants in North America and elsewhere. With no additional infrastructure costs, gas-fired generation can substitute for existing coal-fired capacity with roughly half the CO_2 emissions of coal. Moreover, the flexibility of natural gas-fired generation to ramp up or down in accordance with power loads also makes it a complement for the increased use of intermittent renewable power sources, such as wind or solar energy. Given these beneficial characteristics, natural gas should play an important role in the future energy mix, but current policies do not reflect the potential prize.

For gas demand to grow materially, it needs to make more substantive inroads into the power generation sector and possibly into transportation (via electrification of light-duty vehicles or natural gas fleet applications, for example). These inroads require a substantive turnover in capital and, at least among the developed economies, government policies that clear the way – if not provide an impetus – for the market to utilize gas as a bridge fuel. Industry has a responsibility to educate and persuade government and energy users that shale gas is more reliable and will be available for longer than previous conventional supplies and thus deserves promotion on its merits. And government has an obligation to promulgate regulations that allow the best solutions to come to the fore.

Shale gas in North America is the proving ground for global shale gas sources, and the stakes are high. From Europe and Russia to developing Asia and South America, the successful and environmentally secure development of shale and other forms of unconventional gas has the potential to dramatically shift global energy and unlock a precious solution to meeting long-run climate objectives. But such a future is not yet secured, and industry and governments must collaborate more urgently to realize the possibilities.

The Fuel of the Future

By Paolo Scaroni, Chief Executive Officer, Eni, Italy

It seems as though we cannot make it through any year without a new, different and pressing topic with regards to energy. Over the past few years, the world has been confronted by climate change, gas supply cuts in Eastern Europe, extremely volatile oil prices, peak oil concerns and increasing demand in Asia. And these challenges continue.

This year's hot topic is the current "gas glut" and the future of gas. The gas market has changed as the result of three important factors: shale, LNG and the economic downturn.

First, we must recognize how shale gas has stormed into the US gas market. Technical advances in hydraulic fracturing and horizontal drilling have made vast amounts of previously unattainable natural gas accessible, securing energy supplies in North America for years to come. As a result, predictions of an increasingly import-dependent United States have turned out to be wrong, with a profound impact on the investments conceived by gas-producing countries to meet that demand.

Second, the world is experiencing an idyllic period in which LNG supply is high and prices are low. Many LNG projects have recently come online amid declining US LNG demand (owing to the "discovery" of shale) and declining global demand (owing to the economic downturn). LNG tankers previously destined for the shores of North America are now being redirected to Europe and Asia. For the first time, natural gas is becoming a true global product; the United States itself is re-exporting gas to Europe that it has contracted but does not need.

The third and perhaps most important factor changing today's gas market is the economic downturn, which reduced demand for natural gas imports and delayed the demand growth necessary for future investment. The current stagnation represents an opportunity for the gas industry in the struggle for a more sustainable future.

The recent financial crisis and the resulting economic slowdown delayed predicted increases in GHG emissions in the world economy. In terms of fighting climate change and increasing energy supply security, we have been given a few precious years to act before the trends pick up again. This is why Eni fully supports EU policies to tackle these issues and believes that gas has a crucial role to play if we are to achieve sustainable economic growth. Renewable energy is still years from reaching the point where it does not need financial support. Natural gas is the only energy source that is truly capable of both fuelling economic development and addressing climate change.

Natural gas produces 50% less CO_2 per kilowatt-hour than coal, and 30% less than oil. Gas-fired power generation is now cheaper than coal (thanks mainly to oversupply). The gains from switching from coal to gas for power generation have never been greater – both economically and in terms of GHG reductions. Moreover, natural gas generation adapts easily to the intermittency of renewable sources, making natural gas the fuel of the future.

Despite today's "gas glut", demand for gas will pick up and the rise of LNG will only comfort those with doubts about supply security. However, with consumption in Asia and Europe increasing (and Europe's domestic supply decreasing), up to 300 Bcm per year (29 Bcf per day) in extra imports will be needed by 2020, necessitating further investments in supply.

In the European context, a further 180 Bcm per year (17 Bcf per day) in imports will be required by the end of this decade, and policy-makers unsurprisingly are concerned about the origin of these imports. Headlines about the European Union's dependence on Russian gas are quite common these days, but the fear they create is somewhat unjustified.

Russia has been a reliable supplier for decades, including during the Cold War. However, the fact that 80% of Russia's gas exports to Europe pass through Ukraine and the rest through Belarus has been an ongoing challenge. A consortium of gas companies is addressing this challenge by building the Nord Stream pipeline. Additionally, Eni is working in cooperation with Gazprom to build the South Stream pipeline, with a capacity of 63 Bcm per year (six Bcf per day), through southern Europe.

Perhaps most importantly, Russia supplies around one-quarter of total EU gas consumption (a share that has decreased from about 75% in the early 1990s) but nearly 100% in the new member states. For this reason, a single interconnected European energy market is a practical solution that can be achieved at a fraction of the cost and risk of some alternatives that look outside Europe's borders. To achieve an integrated energy market, the European Union needs a stable and coherent regulatory framework that supports the entrance of new competitors into the new member states, addresses bottlenecks by supporting infrastructure investments and provides true diversification.

No governing body has made greater efforts on the climate change front than the European Union, which has established an emissions trading system and invested heavily in renewables. These actions point towards natural gas as the fossil fuel of choice to sustain Europe's economic growth and support its carbon reduction targets. The economic downturn provides breathing space to support the investments in natural gas that Europe requires to reduce its reliance on coal, oil and nuclear and to meet its growing energy needs.

Answering the Call: Australia and Global Natural Gas

By Don Voelte, Managing Director and Chief Executive Officer, Woodside Energy Ltd., Australia

The world is calling for more Australian natural gas. Global markets are looking to Australia to make a greater contribution to sustainable energy, the development of new supply competition in the global gas market and energy security.

Australia is blessed with abundant resources of natural gas available for export as LNG, including traditional offshore gas fields and onshore coal seam methane. The greatest practical contribution Australia can make to sustainable energy is to export as much natural gas as possible, particularly to developing markets in Asia. For every tonne of GHG emitted in the production of Australian LNG, at least four tonnes of GHG emissions in customer countries are avoided when LNG displaces coal in electric generation.

The world needs Australia to play a bigger role in meeting growing demand for gas. According to IHS CERA, global LNG demand will reach more than 350 million tonnes per year by 2020. Of that, demand in Asia will be about 190 million tonnes, which will be predominantly met through long-term supply contracts. Traditional markets in Japan, South Korea and Taiwan will remain the core, with both re-contracting and some growth. In emerging markets, China and India capture most of the headlines. According to IHS CERA, combined they will account for about one-third of uncontracted LNG demand in emerging Asia by 2015, and nearly half in 2020. But China and India are only half of the story. The other 50% of uncontracted LNG demand in emerging Asia by 2020 will come from new importers, including growing economies like Thailand and Singapore and new markets in traditional LNG exporting countries such as Malaysia and Indonesia. In Asia alone, new LNG supply of about 50 million tonnes per year will be required by 2020 to meet this growing demand. Sources of potential large new LNG supply capacity include Russia, Qatar, Iran, Nigeria – and Australia. But Australia alone has the potential to meet the entire incremental Asian LNG requirement.

Natural gas consumers also need Australia in their supply portfolio to maximize commercial efficiency and ensure competitive commercial terms. Customers with strategic purchasing vision know that supply from Australia will balance their portfolios and enhance negotiating leverage. Finally, LNG consumers want Australian gas to help ensure diversity of supply and energy security, which are vital to underpin continued economic growth. In geostrategic terms, Australia's proximity to core Asian markets is an advantage, and its reputation for stability and reliability is outstanding in a world often marked by uncertainty.

Markets are thus calling for more Australian gas, but Australian gas projects face challenges in getting to market on time. Construction and labour costs in Australia are relatively high. Woodside has built and operates five of the six operating LNG trains in Australia, with a sixth nearing completion, so we understand how to manage these challenges effectively. New modular construction technologies and fair but competitive industrial relations management are essential. Tying gas resources to centralised LNG infrastructure hubs will also help reduce overall cost and environmental impact.

Many people point to the difficulties of securing land and environmental approvals. For the Pluto LNG project alone, Woodside was granted 300 individual approvals. It takes operating experience to navigate such challenging regulatory processes. In Australia the gas industry has an obligation to expedite resource developments for shareholders and customers and for the benefit of the Australian people. The Australian government recently emphasised its requirement for timely resource development in a retention lease decision for the Browse LNG Development. This precedent-setting decision was unanimously accepted by Woodside and our joint venturers. It sets schedule, work plan and budget targets leading to a 2012 Final Investment Decision. Leadership like this will help put the Australian LNG industry on a faster development path.

Australia still has a lot of work to meet its potential as a global LNG supplier. According to IHS CERA, Australia currently has about 210 Tcf of proven and probable natural gas resource, including 12 Tcf of proven and probable resource from coal seam methane. Exploration is adding new reserves. Australia has the potential to emerge as the world's second largest LNG supplier after Qatar. Proposed Australian LNG projects would add almost 100 million tonnes per year of liquefaction capacity. However, it is unlikely that all of these projects to go forward as planned. If we are to reach anything like the impressive developments in Qatar – if Australia is to take up the greater role that natural gas consumers demand of us – we must craft even stronger partnerships for growth.

Beyond partnerships with other energy companies, local communities and Australian government at all levels, Australian suppliers also look to LNG customers to join us in answering the market's call for more Australian LNG by ensuring the new projects come on line to meet demand. Savvy customers will move early, take advantage of partnership with suppliers in Australia and commit to move LNG projects forward. By doing so, customers will not only become our partners, they will help themselves avoid supply and price volatility, while accessing all of Australia's advantages.

CHAPTER 3: EVOLUTION IN NATURAL GAS DEMAND

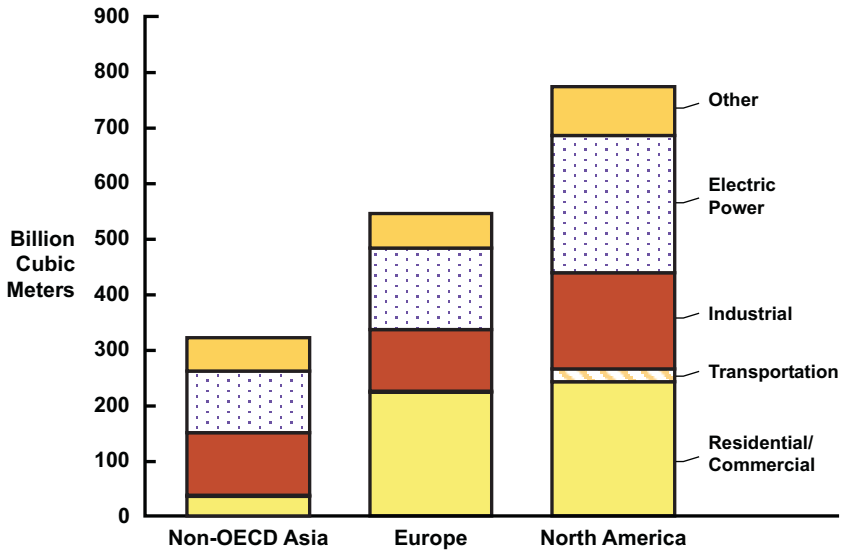
Unlike in production, no revolutionary change appears to be brewing in natural gas demand. Gas is primarily used for space and water heating in the residential and commercial sectors, for power generation, and for industrial purposes as both fuel and feedstock. The only significant potential new use on the horizon is in the transportation sector. Changes afoot in gas demand are largely evolutionary, not revolutionary. However, the type of demand evolution we expect is different between OECD and non-OECD countries.

Figure 11 shows the current pattern of gas use by region and sector. In the mature gas markets of the OECD, competing forces will be at work in determining the shape of future demand. On the one hand, increasing energy efficiency is likely to put downward pressure on industrial, residential and commercial gas demand over the coming years. On the other hand, demand from the power sector is likely to increase as generators turn to natural gas as they strive to meet increasing power demand while reducing their emissions of GHGs and other air pollutants. Older coal plants may be retired if competitive gas prices and increasingly stringent environmental regulations make gas the more economical choice. In his perspective essay, *Shale Gas: An Energy Security Game Changer,* David Goldwyn describes the appeal of gas. "Natural gas has become a fuel of choice for consumers in many countries, mainly because of its abundance, clean-burning nature and increasing cost-competitiveness with other options, such as coal."

Southeast Europe is one region with more growth potential. Turkey alone is expected to account for nearly one-third of gas demand growth in Europe over the next 25 years. Turkey has the potential to become one of the largest gas markets in Europe owing to industrial growth and increasing residential gas connections – which is unusual among OECD countries.

Figure 11

Natural Gas Demand by Region and Sector



Source: IHS CERA.
Note: Other includes gas used within the energy sector and distribution losses.
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A New Age for Gas

Power Generation Is a Key Source of Natural Gas Demand Growth

In non-OECD countries the demand picture is more straightforward. Gas demand is expected to increase across the board as economic growth continues. Industrial, residential and commercial demand will grow as more customers become linked to gas infrastructure, especially in India and China. Gas demand for power production will also grow, although not as much as the power sector overall. Coal will still be king in many areas. Import and distribution infrastructure is expanding rapidly in the non-OECD world to meet expected demand growth.

Demand Drivers: Power Generation

Power generation will be the key driver of global natural gas demand growth over the next two decades. Unlike for gas, the number of uses for electric power just keeps growing, bringing about demand growth even in mature markets. In addition to overall growth in electricity demand, many aging power generation facilities are likely to be replaced with more efficient gas turbine generation plants. Gas-fired generation is particularly attractive in the OECD because of its relatively low emissions of GHGs and other pollutants. Peter Voser describes the potential for gas in power generation in this way: "Modern combined cycle gas-fired power plants emit 50% less CO_2 than supercritical coal plants and 70% less than

Home Insulation Brings About Greater Efficiency in Residential Gas Use

older steam turbine coal-fired plants. Displacement of old coal plants by modern gas plants is by far the most cost-effective short- to medium-term approach to moderating emissions." In his perspective essay *The Prince of Hydrocarbons,* Simon Blakey points out the speed with which natural gas can be deployed in the power sector. "We cannot wait until a perfect carbon-free energy system is in place…. Gas-fired power plants can be up and running within 18 months in most parts of the world."

In North America, natural gas–fired power plants currently run at lower utilization rates on average than coal-fired plants. In the United States, on average, gas-fired generating capacity runs 25% of the time compared to 73% for coal-fired generation. The question often arises: Why can't the power sector reduce its GHG emissions by increasing the utilization rate of existing gas-fired plants and decreasing the utilization of coal-fired plants?

The answer to this question requires an understanding of the nature of power demand and the characteristics of gas- and coal-fired power plants. Few technologies exist to store utility-scale quantities of electricity, so power is generated as it is demanded to keep the power grid in balance. Power demand varies during the day, from peak periods during the day to troughs at night, and seasonally as power demand for heating or cooling changes with the weather. Coal plants are generally not able to start up fast enough or ramp production up and

A New Age for Gas

Efficiency Drives Decline in OECD Residential Gas Demand

Two uses of natural gas dominate residential demand. Sixty percent of US residential gas is used for space heating and another 30% is used for water heating. Therefore, efficiency improvements in these two technologies can have marked effects on demand. The average residential furnace in 1980 had an efficiency of 65%, measured as the amount of usable heat produced by the furnace compared to the energy contained in the fuel. More than one-third of furnaces sold today have efficiency of 90% or greater. Efficiency improvements in water heaters have been slightly less dramatic, but have still improved by about 25% since the 1980s. Since space heaters are typically used for 15 to 20 years and water heaters for 10 to 15 years, these efficiency improvements will continue to work their way into homes for years to come.

In addition to developments in gas furnaces, improvements in the thermal envelope characteristics of the buildings they serve are also pushing down residential gas demand. The US federal government passed regulation in 2009 that requires nationwide development and implementation of residential building codes for energy efficiency. The US government also allocates funding for low-income families to retrofit their homes for energy efficiency. Similar programs are in place in Canada and Europe.

down easily to follow power demand. Thus, coal plants (along with hydroelectric and nuclear plants) are generally used for base-load capacity. Natural gas generation, on the other hand, is able to react much more quickly to changes in demand. For this reason gas-fired units can be used as peaking and cycling plants that run only when needed.

Building additional gas plants to replace coal-fired plants for base-load generation is a viable option to reduce GHG emissions from the power sector, but running existing gas plants more and existing coal plants less is often not feasible because a portion of the gas-fired generation capacity is reserved to follow power demand fluctuations. In addition to the difficulty coal plants have in following load, the overall utilization rates for coal and gas plants do not take into account that coal and gas plants are concentrated in different regions and often not directly substitutable. Even for coal and gas plants that are reasonably close together, their relative positions on the grid may make substitution difficult. Cost is always important as well, and a wide range of efficiencies and costs are associated with the two types of generation. Simple generalizations are difficult to draw.

The ability of natural gas–fired generation to provide power quickly on demand makes it a useful complement to renewable power sources as well. This establishes a new role for natural gas as an essential partner for renewable energy. The typical annual utilization rate of wind turbines in the United States and Europe is 25% to 35% and solar is even lower at about 20%.[1] These rates are similar to those for gas in North America, but there is an important difference. Gas-fired generation is available whenever it is needed and is used to balance the system, but wind and solar are available only when the wind blows or the sun shines. This back-up or complimentary function for natural gas will likely result in a need to develop additional gas-fired generating capacity. However, the additional capacity might run at low utilization rates. The role of natural gas in backing up renewables is recognized; however, although this role could result in growing demand for natural gas generating capacity, the additional demand for natural gas itself will not be as great.

In China gas demand in the power sector is uncertain. Today gas-fired power plants make up only 3% of China's generation capacity. As gas demand in the residential sector soared, government policy restricted gas use in the power sector. The few gas-fired plants in place today have run at very low utilization rates because of a lack of gas supply, with most used only as peaking units. Natural gas is expected to be part of the "emerging energy" emphasis of the Twelfth Five Year Plan (2011-2015). This policy direction points to significant gas-fired power capacity additions, particularly in coastal China, and a loosening of policy restrictions on gas use in the power sector. China is also increasing

1. *Fueling North America's Energy Future.* November 2009. IHS CERA, page VI-9; Pure Power. November 2009. European Wind Energy Association, page 45.

its focus on domestic natural gas resources including unconventional gas, and diversified imports. In addition, gas will be bundled with wind generation. Thus, natural gas is likely to play a more important role in the country's power supply mix in the future as these policy changes take effect and China's gas supply expands.

Demand Drivers: Industry

The industrial sector accounts for nearly 40% of today's global natural gas demand.[1] The chemical, pulp and paper, metals, refining, petrochemical and plastics industries are important consumers of natural gas.

In the OECD, efficiency gains are likely to outrun growth in industrial output, resulting in little growth in industrial gas demand. Additionally, many OECD economies are experiencing a structural shift towards less energy-intensive sectors, pushing demand down further.

Nonetheless, there are exceptions to the general lack of industrial gas demand growth in the OECD. In Europe industrial gas demand is shifting to the faster-developing and lower-cost regions – the Balkans, Turkey and Central Europe. The oil sands of Canada are a notable exception to the downward trend in North American industrial gas demand. Oil sands production in Canada is expected to increase substantially and could nearly triple by 2035. Even when improvements in the efficiency of oil sands extraction and processing are taken into account, gas use in the oil sands is expected to increase from 9% of North American industrial gas demand (18 Bcm per year or 1.8 Bcf per day) in 2009 to 18% (40 Bcm per year or 3.9 Bcf per day) by 2035.

In non-OECD countries, access to gas distribution infrastructure is the critical determining factor for industrial gas demand. Gas has the opportunity to displace oil or coal for economic, environmental and policy reasons. Oil-based fuels are widely used in parts of China that do not have indigenous gas supply or substantial coal reserves, such as northeast China and Guangdong Province. Feedstocks such as naphtha and fuel oil are often used for fertilizer production in India, where gas supply is limited. As gas distribution infrastructure is extended in these countries, substantial industrial demand growth is likely to result.

1. *IEA World Energy Outlook 2010,* page 184.

Demand Drivers: Residential and Commercial

Demand in the residential and commercial sectors has a similar pattern to that of the industrial sector. Where demand increases are occurring, they are driven primarily by new customers for gas, not from new uses; gas is used mostly for space and water heating. Therefore, demand growth is occurring mainly in areas where the number of households and businesses with access to gas service is increasing. Such growth is most prevalent in the developing world, although Turkey and the Balkans are experiencing similar growth in Europe.

In OECD countries, residential and commercial gas demand per household is generally decreasing. Improvements in appliance and heating system efficiency and better insulation in new buildings add up to real savings. In the United States, houses constructed between 1990 and 2005 consumed 25% less gas for space heating than houses constructed before 1990.[2] Efficiency improvements will likely continue in newer buildings. However, the 2008-2009 recession dealt a significant blow to the construction industry in many countries, potentially delaying the march towards efficiency.

In Europe the average number of people per household has been declining and is expected to continue to do so. The population is expected to grow quite slowly, but the number of households is projected to rise at twice the rate of population growth. This increase in the number of households will drive some demand increase in the residential sector, particularly for space heating. Whether the increasing number of households will outrun increasing energy efficiency remains to be seen.

Expanding access to gas service is driving residential and commercial demand growth in non-OECD countries. Residential use is the fastest growing sector of Chinese gas demand, as city gas networks expand rapidly to serve a growing proportion of the population. The urban population with access to gas grew from 71 million in 2005 to 122 million in 2008, and the outlook is for further growth to nearly 300 million by 2015. Similarly, residential and commercial gas demand in India has been limited by a lack of distribution infrastructure; city gas service

2. US Energy Information Administration, Residential Energy Consumption Survey 2005.

today is limited to the larger cities. Residential gas use today makes up less than 1% of demand, but India is catching up as incomes rise and a greater portion of the population moves to urban areas.

Demand Drivers: Transportation

Little natural gas is used in the transportation sector today, apart from in a few countries that have invested in infrastructure for natural gas vehicles (NGVs). As a result the transportation sector is often mentioned as a potential growth market for gas. How might this happen and what barriers stand in the way?

Natural gas can be used in the transportation sector in four ways. It can be burned directly in internal combustion engines, used to generate electricity that can power electric vehicles (EVs), run through a GTL process to produce a high-quality diesel-like fuel, or used to produce hydrogen for fuel cell vehicles.

NGVs are the first technology that comes to mind when considering gas in the transportation sector. Vehicles that run directly on natural gas make up about 1% of the world's light duty vehicle fleet, primarily in Asia and Latin America. Pakistan leads the world in NGVs with a fleet of 2.3 million, followed by Argentina, Iran and Brazil, each with more than 1.5 million vehicles.[1] These countries, which had abundant domestic gas supply but had to import liquid transportation fuels, all encouraged NGVs. In Iran the shortage of liquid fuels is due to a lack of refining capacity rather than a lack of oil. India also has a large natural gas vehicle fleet. Such vehicles are encouraged in Italy to improve local air quality and in India for to improve air quality and reduce the cost to the government of oil subsidies.

Natural gas prices today compete favourably with gasoline in many markets, but NGVs still have not taken off in much of the world. One important hurdle has been the lack of refuelling infrastructure. In countries where NGVs are prevalent, significant investment into refuelling has been made, often encouraged by the government. The energy density of natural gas is 70% less than that of gasoline or diesel fuel. This raises an additional hurdle, since the driving range of an NGV with the same size fuel tank as a gasoline or diesel vehicle would be 70% shorter.[2] The shorter range combined with the lack of refuelling infrastructure in many markets deals a severe blow to the utility of NGVs, except in fleet applications, such as taxicabs, municipal buses or delivery vans, where vehicles are driven limited distances and can refuel at a central depot. Finally, any NGV would require a heavy steel tank onboard to hold the gas. The expense, weight and needed space of the fuel tanks are unavoidable challenges. Natural gas vehicles initiatives also face competition from biofuels and electric vehicles.

Counterintuitively, converting gas to electricity may well be the most efficient way to use natural gas in the vehicle fleet. The much greater efficiency of an electric motor compared to an internal combustion engine, along with the high conversion efficiency of a modern combined cycle gas power plant, overcomes the energy loss during electricity transmission and distribution. Additionally, emissions of all pollutants are likely to be lower from a fleet running on electricity produced from natural gas rather than on natural gas directly. In addition to pollution reductions resulting from the greater net efficiency, pollutant control is much easier from one large point source than from many mobile sources. Refuelling infrastructure investment is less crucial to jump-start the transition, since most owners could charge their vehicles at home. However, range is a hurdle for EVs and their up-front cost is prohibitive. A breakthrough in battery technology could help overcome both of these hurdles and make EVs more practical and affordable for the masses.

Production of liquid fuels, primarily diesel, from coal began in the 1920s with the development of the Fischer-Tropsch process. This process has been adapted to convert natural gas to liquid fuels. This process has some advantages. Liquid fuels are easy to transport and can be sold in markets around the world without the need for gas-specific infrastructure. Demand for diesel fuel in many parts of the world is growing rapidly. Additionally, diesel produced from GTL processes is a premium product, with a high cetane number, low aromatic content and low emissions of particulate matter and sulphur. However, the cost of producing GTL fuels is high and is very sensitive to the price of natural gas. GTL

1. "Natural Gas Vehicle Statistics Section". International Association for Natural Gas Vehicles, http://www.iangv.org/tools-resources/statistics.html, 2010.

2. *Natural Gas for Transportation: Niche Market or More?* October 2010, IHS CERA.

facilities could be used to monetize gas resources in areas where building a pipeline or an LNG terminal is not practical, but cost will be a continuing concern.

The final possibility for integrating natural gas into the vehicle fleet is less proven than the others. Natural gas can be used to produce hydrogen through the process of steam reforming, and the resulting hydrogen could then be used in fuel cell–powered vehicles. However, fuel cell vehicles are unlikely to demonstrate significant advantages over EVs in efficiency or in life-cycle GHG emissions when using hydrogen produced from natural gas. Producing and compressing hydrogen gas for storage on board the vehicle requires energy equal to 20% to 40% of the energy content of the fuel. Additionally, fuel cell vehicles require all of the mechanical and electrical systems of an EV, but the cost of the fuel cell and hydrogen storage system is likely to be higher than that of a chemical battery. Without low-cost sources of hydrogen or a breakthrough in on-board hydrogen production, fuel cell vehicles are likely to remain more expensive than EVs.

Perspectives on Evolving Natural Gas Demand

The chapter includes two perspectives on the potential for growth in natural gas demand. The authors are:

- **Simon Blakey,** Special Envoy, Eurogas, Belgium
- **David Goldwyn,** Special Envoy and Coordinator for International Energy Affairs, US Department of State

The Prince of Hydrocarbons

By Simon Blakey, Special Envoy, Eurogas, Belgium

Natural gas, proudly labelled "the Prince of Hydrocarbons", may be about to inherit its kingdom. Gas is likely to be the main means of reducing the carbon footprint of mankind's energy use in the coming years.

This confident assertion is based on the recent reductions in Europe's GHG emissions brought about by the use of natural gas, and on what can – and likely will – be achieved in the near future. Natural gas offers much more, in terms of scale, cost, and speed, than other strategies available to us to reduce carbon emissions.

Scale. Politicians, the public and industry are struggling with the sheer scale of transformation in energy use that is needed to achieve measurable impact on carbon emissions. The process is less daunting when natural gas is brought into the equation. For example, replacing just five conventional coal-fired power stations with combined-cycle gas plants saves the same amount of carbon each year as 9,000 megawatts of wind power – about two thousand windmills.

Cost. Private companies are prepared to take the financial risks of building such power stations without subsidies, a reliable sign that the costs are sustainable for an economy as a whole. Governments today face difficulties with the cost of subsidies for renewable electricity in countries such as Germany and Spain. Entrepreneurs are beginning to wonder whether they can rely on subsidy-based investment.

Speed. The carbon-reduction agenda is urgent. Strategies based only on renewable electricity and electrification of transport do not address this urgency. The atmosphere already contains over 390 parts per million (ppm) CO_2, and the concentration rises by about 3 ppm per year. We cannot wait until a perfect carbon-free energy system is in place – we need to act now to have any chance of staying below 450 or even 500 ppm. Gas-fired power plants can be up and running within 18 months in most parts of the world.

So what has been achieved across Europe in terms of energy-led carbon reductions? Eurogas calculates that without the penetration of natural gas that has occurred in the European electricity portfolio since 1990, Europe's annual CO_2 emissions would be 200 million tonnes higher today.[1] That is nearly 5% of energy-related European CO_2 emissions. Natural gas has made a significant contribution against Europe's Kyoto target of an 8% reduction from 1990 levels by 2010.

The GHG emission reductions from greater use of natural gas in Europe's electricity sector are only slightly smaller than those that resulted from the conversion of inefficient, Soviet-style economies into today's modernizing central European economies. The collapse in industrial output that followed the October 2008 financial crisis knocked 6% off of emissions, according to the first estimates for the European Environment Agency.[2] But the demise of central planning was a one-off event that cannot be repeated. And, although recession may return, European politicians and public do not want to repeat soon the experience of 2008–2009!

Improved energy efficiency and a growing share of renewables have made a modest contribution. But the big win in Europe has come largely from the increasing share of gas in the energy mix. Identifying the big wins of tomorrow is the challenge for European energy investors and policy-makers.

Energy 2020 Strategy, published by the European Commission in November 2010, notes that "... natural gas will continue to play a key role in the European energy mix." The attention of policy-makers is turning now to the question of what lies beyond 2020, and the debate will focus on a roadmap to 2050.

Europe's natural gas industry enters this debate with a mixture of prudence and ambition. So far, national roadmaps such as Germany's Energy Concept or the UK's Pathways to 2050 almost ignore the role of gas. This is difficult to square with the reality of what gas has achieved and can achieve in terms of CO_2 reduction – without subsidy and without cost to the public purse.

The industry has allies in Europe's Green movement. Green politicians and non-governmental organizations (NGOs) increasingly recognize that the urgency of the carbon problem means that natural gas needs to be part of the solution. We cannot wait for a fully decarbonized electricity system if there are to be further quick, scalable reductions in Europe's CO_2 output. Moreover, for renewables to play a larger role, natural gas is needed to help balance their intermittent output.

Europe expects much from increasing energy efficiency and from smarter grids that enable changes in behaviour. Together with renewables, these will be an essential part of Europe's energy future. But if Europe wants scale and speed in carbon reduction, and if the public and governments want this at an acceptable economic cost, then natural gas will have a place at centre stage.

1. Eurogas analysis of data from Annual EU greenhouse gas inventory 1990-2008 and inventory report 2010 Submission to the UNFCCC Secretariat. 2010. Copenhagen: European Environment Agency.
2. Approximated EU GHG Inventory for 2009, Technical Paper 2010. 4 September 2010. Bilthoven: European Topic Centre on Air and Climate Change.

Shale Gas: An Energy Security Game Changer

By David Goldwyn, Special Envoy and Coordinator for International Energy Affairs, US Department of State, USA

Energy security for any country usually means access to sufficient, affordable and secure supplies of energy to support a range of economic sectors and activities. Natural gas has become a fuel of choice for consumers in many countries, mainly because of its abundance, clean-burning nature and increasing cost-competitiveness with other options, such as coal. Unconventional gas resources – shale gas, tight gas and CBM – are more difficult to develop but represent the next wave in supply. As is true for conventional gas, shale gas has half the carbon footprint of coal and potentially is available at economy-scale levels in many countries that are expected to undergo large increases in energy demand during the coming decades.

Achieving the benefits of the unconventional gas revolution around the world will require international collaboration and indeed a global gas agenda. That will help accelerate the spread of knowledge, technology and know-how as well as the establishment of the regulatory systems that will promote timely and responsible development.

The positive impact would be considerable. Shale gas could be a game changer in the global energy market just as it has been in the United States. Already increased shale gas production has made natural gas more cost competitive with coal in the United States. It also has helped to make LNG more affordable and available worldwide. The IEA projects that by 2030 shale gas will represent 7% of total global gas supplies. Future climate change policies could boost demand for shale gas as a lower carbon "bridge fuel" in the efforts to reduce CO_2 emissions growth.

Based in part on the known presence of shale worldwide, specific regions and countries can be identified as prospective for shale gas resources. But the extent of these resources is not well understood. Although the presence of certain types of shale provide baseline indicators about potential, any global resource estimates carry high uncertainty simply because limited drilling activity has occurred outside of North America. Certain parameters – gas content within a shale, thermal maturity, type and amount of organic matter and specific rock properties – need to be understood to make scientifically accurate volumetric estimates.

To help develop this global gas agenda, the US Department of State is working to leverage US success in shale gas to clarify the global picture, with the specific aim of enhancing global energy and climate security. In April 2010 the US Department of State launched the Global Shale Gas Initiative (GSGI) to help other governments improve the understanding of their countries' shale gas resource potential as well as to identify the technologies, environmental risk mitigation measures and investment requirements needed to spur its development. To assist in this goal, the GSGI uses government-to-government diplomacy and policy engagement to connect the technical expertise and regulatory experience at the US federal and state government levels. Although the US shale gas experience cannot be precisely duplicated, GSGI can help governments understand broader issues such as how to develop nascent gas markets, improve the pricing of competing fuel sources and develop shale gas as an economically feasible alternative to coal, oil and even wood.

Through a program tailored to each country's specific needs (and depending on funding availability), GSGI activities can include conducting shale gas resource assessments, holding technical workshops to outline data needs and scientific assessment methodology, undertaking studies to ascertain the production capability, economics and investment potential of shale gas resources in a given country and promoting sustainable investment in shale gas development through the exchange of experience and best practices, study tours and public-private events in the United States.

Experience to date demonstrates the intensity of interest in global collaboration and learning. Twenty countries from four continents have expressed interest in the GSGI program. The US Department of State has signed separate memoranda of understanding (MOU) with China and India. Under these MOU frameworks and with US Department of State funding, the US Geological Survey (USGS) is conducting shale gas resource assessments of pre-specified basins or areas in both countries. The USGS also is holding its first technical workshops in China in late 2010 and in India in early 2011. These will cover data requirements, screening processes for unconventional accumulations and geologic modelling. Limited field work also will be undertaken jointly with both governments. In addition to its work with China and India, we anticipate that the US Department of State will fund additional shale gas resource assessments in a dozen countries during 2011. The GSGI also offers member countries the opportunity to visit the United States to learn first-hand from the US experience with shale gas.

Shale gas development on a global basis faces challenges. But with international collaboration through programs such as GSGI, responsible shale gas development could bolster global energy security and support the attainment of climate change goals.

CHAPTER 4: NATURAL GAS MARKETS IN AN ERA OF CHANGE

Growing natural gas supplies and shifting patterns of demand are challenging the structure of gas markets around the world. Many long-term tenets of regional gas markets bent, but did not break during the recent years of global recession and market oversupply. As natural gas supply and demand continue to evolve, are the current pricing and contract mechanisms resilient enough to survive?

The Great Recession Stress Test

Recent events can be thought of as a "stress test" for gas markets and pricing structures around the world. The 2008-2009 recession reduced gas demand in most OECD countries and slowed demand growth in other parts of the world. At the same time, global LNG liquefaction capacity increased by roughly one-quarter and the unconventional gas revolution in North America brought about a sea change in supply. This market stress played out differently in the three major gas markets.

In Europe the result was an oversupplied market. Spot gas was available at prices much lower than oil-indexed long-term contract prices, and buyers with flexibility moved into the spot market to the extent that they could. However, some gas buyers had insufficient demand to meet the minimum volumes in their take-or-pay contracts, requiring them to make upfront payments amounting to billions of US dollars for future deliveries. Rather than make these upfront payments, some companies continued to purchase higher cost contract gas. They then re-sold this gas on the spot market, exacerbating the oversupply problem. This was a boon for buyers who could take advantage of low spot prices but a challenge to buyers with long-term contracts and the sellers who were under pressure to renegotiate those contracts.

In North America, prices are based largely on supply and demand, so the oversupply came through in the form of much lower prices. The price of gas at Henry Hub dropped by more than two-thirds, from its high point of more than US$ 435 per Mcm (US$ 12 per MMBtu) in June 2008 to less than US$ 145 per Mcm (US$ 4 per MMBtu) throughout 2009. However, supply did not decline as much in response as might have been expected. Drilling activity has continued despite low prices because leaseholders need to drill to hold onto lease options, rather than let them expire as worthless. This trend is likely to continue into 2011, regardless of gas price.

In Asia the recession drove a demand decline in the largest LNG markets of Japan, South Korea and Taiwan. As in Europe, buyers struggled to meet the minimum volumes under their contracts. However, demand in the region suffered less than in Europe and North America since China's and India's imports continued to grow strongly. Rapid emergence of new markets such as Dubai and Kuwait further supported demand.

The market stress test also put pressure on the oil-indexed take-or-pay contract structure. Several gas suppliers made concessions in their minimum volume obligations, reducing the minimum volume by as much as 10% to 20%. A number of suppliers also changed their pricing formulas to make contracted gas more competitive with spot gas.

Allowing more leeway in take-or-pay contracts is making the European gas market more closely resemble the oil market with respect to how risk is managed. In the oil market, the economic risk associated with decreasing demand falls on oil producers, and buyers take on the risk of rising prices. Oversupply appears in the form of excess oil production capacity and is reflected in expanding inventories and low prices for crude oil and refined products. The North American gas market also functions this way.

In Europe the sharing of risk embedded in long-term contracts is somewhat different – buyers traditionally carried volume risk and sellers carried price risk. This risk sharing arrangement assumed that gas was competing with oil and that demand would continue to grow. The events of the past two years brought about a mismatch in risk – with buyers now carrying significant price risk in addition to volume risk. The increased risk carried by buyers has forced renegotiation of some long-term contracts, with sellers reducing minimum volumes and taking some of the downside demand risk. How this risk sharing détente will change when demand and supply are more evenly balanced is an open question.

Will Gas Prices Converge Around the World?

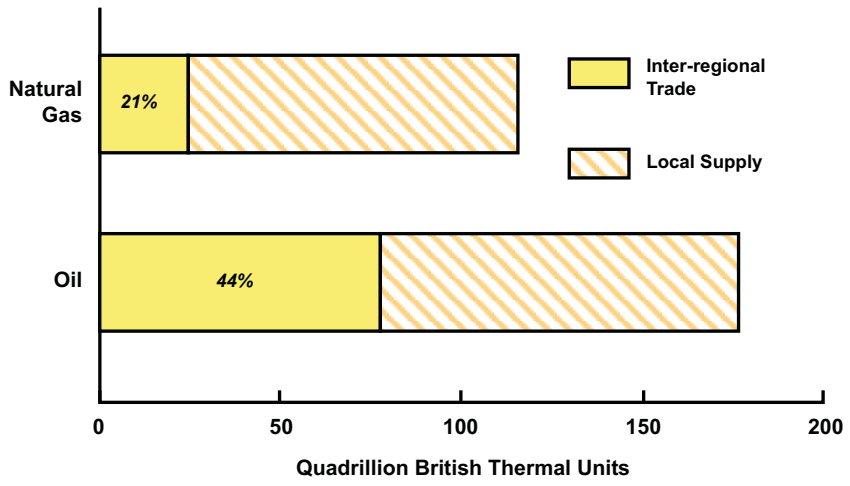
As shown in Figure 12, much less gas is shipped between regions than oil, limiting the ability of regional gas markets to interact. Increasing gas trade across regions has the potential to change this dynamic. The ability to ship LNG cargoes to the market that provides the greatest value means that producers can arbitrage differences in price. As Wojciech Jasinski points out in his perspective essay, *The Role of Natural Gas in Poland's Future,* "LNG brings stronger linkages and correlations among regional gas markets." If enough gas flows between regions, such trade could even bring about price convergence. The question that often arises is, will gas become a true global commodity? Could there be a global gas market as there is a global oil market? With the advent of much wider LNG trade, this prospect seemed increasingly possible.

The advent of the "shale gale" in North America has slowed or reversed the move toward price convergence. Growing gas production means that North America will be much less dependent on LNG than was projected just three years ago. So long as North America does not become a significant LNG exporter, prices in North American gas markets will be based on supply and demand conditions within the region, not on LNG prices. LNG producers may need North America as a liquid market in which to sell spot cargoes in times of surplus, but North America is unlikely to need much LNG, disconnecting the market from gas prices elsewhere. North America is therefore set to play the role of a marginal balancing system but is unlikely to feature significantly in the volume of trade.

A second important hurdle is that 52% of Atlantic Basin and 85% of Asian LNG is delivered under long-term contracts. If an LNG producer wants to take advantage of price differences among markets, it might need to procure additional gas to cover its contract delivery obligation. This is a manageable problem in today's oversupplied markets, but in areas that do not have a liquid spot market, lining up additional gas under more balanced supply and demand conditions could be

Figure 12

Oil Moves Between Regions Much More than Natural Gas



Source: IEA and IHS CERA.
01211-7

A New Age for Gas

LNG Supplies Gas to Markets that Would Not Otherwise Have Access

challenging. In areas that do have liquid spot markets, buying additional gas on the market could drive up prices and destroy the arbitrage opportunity.

Logistics provide another hurdle to price convergence. Diverting cargoes to an alternate market requires that sufficient infrastructure be available to handle the shipment. If the alternate market is farther from the source, additional tankers would also be needed to keep regular customers supplied. Another key challenge is the role of very large cargo ships, with capacity greater than 200,000 cubic meters (seven million cubic feet). Such ships provide economies of scale in shipping, but cannot be unloaded at all terminals because of their size. Finally, scheduling berthing times at regasification facilities can also be a challenge. Slack in LNG facilities and cargo capacity around the world could ease these logistical barriers, but owners and operators of this capacity will not intentionally create such conditions for fear of harming their profitability.

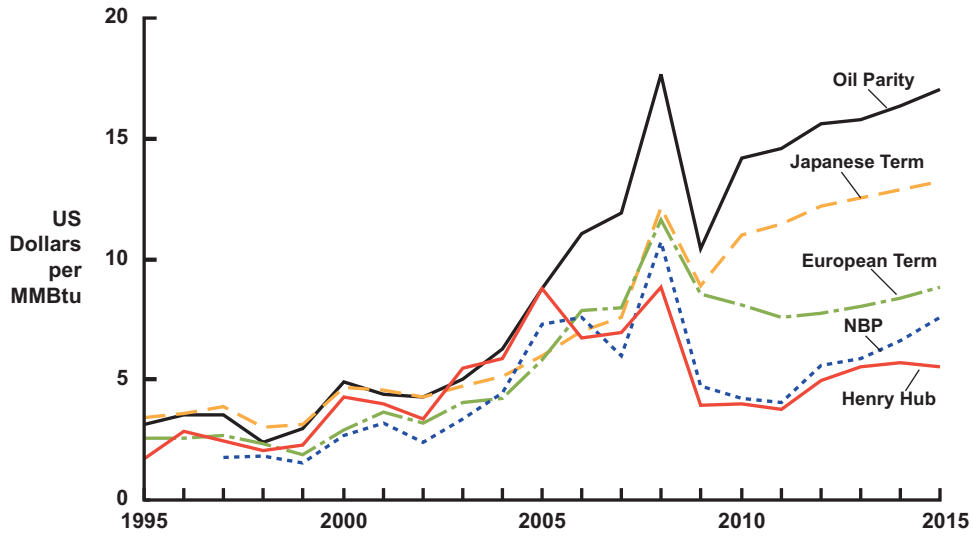
Due to the growing share of LNG in global gas consumption, the relationship between gas markets is expected to change. Increased interconnection is expected between Asia and Europe leading to an inter-regional, though not global, market. The North American gas market is mostly self-sufficient and thus disconnected from the rest of the world.

Will Oil-linked Gas Prices Survive?

Linking natural gas prices to oil prices was a neat solution to the challenge of pricing gas. It evolved when there was no market to allow gas price discovery and oil

Figure 13

Selected Natural Gas Prices Around the World



Source: IHS CERA.
00602-1B

was the primary competitor for gas. Indexation ensured that natural gas was competitively priced against its main alternative and thus ensured market growth. Over time gas has replaced oil in OECD markets in most of the applications where it is economic to do so, but the link between oil and gas remains in Europe and Asia.

Indeed, linking natural gas prices to oil prices is not ideal. An important problem with oil-linked gas prices is that they reflect supply and demand conditions in the global oil market, rather than in the regional gas market. This relationship can get out of kilter when the fundamentals in the two markets diverge. Figure 13 shows gas prices in selected world markets during the past 10 years. The 2007-2008 oil price spike affected oil-linked gas prices in Asia and Europe a bit more severely than market gas prices in North America or the United Kingdom. The real difference came in 2008 through 2010. The global recession and abundance of natural gas resulted in lower prices at Henry Hub and the UK NBP, while oil-linked prices in Asia and Europe barely budged.

Oil-linked prices have little ability to respond to regional gas market fundamentals in the short term, but more ability to respond over the long run. Adjusting the degree of oil parity in the pricing formula or changing the take-or-pay language can provide flexibility. These options require negotiating new contracts or reopening existing ones, meaning that they are less responsive to short-term market hiccups.

Long-term contracts are an integral part of markets with a high degree of import dependence. Such arrangements are required to ensure security of supply. The contracts provide buyers with a guarantee that gas will be delivered. Gas developers also need long-term contracts to underwrite large, capital-intensive investments in gas production and infrastructure.

Nonetheless, over the last year the established link between oil prices and gas prices in Europe has weakened somewhat, as relatively high oil prices and an oversupplied gas market struggled to coexist. Continental Europe's link to the UK NBP spot market

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makes it difficult to maintain a large difference between spot and oil-linked prices. How this mechanism will change as gas markets tighten remains to be seen, but continuation of a hybrid market with increased spot trading and substantial long-term contracts seems the most likely outcome. In his perspective essay Paolo Scaroni advocates for a more unified European energy market and remarks on the conditions needed for such a market. "To achieve an integrated energy market, the EU needs a stable and coherent regulatory framework that supports the entrance of new competitors into the new member states, addresses bottlenecks by supporting infrastructure investments and provides true diversification," he notes.

Oil-indexed pricing remains more firmly established in Asia. Spot cargoes provide some linkage to markets in Europe, but not enough spot gas is sold to provide robust price discovery. Asian markets generally perceive their supply as constrained since they rely on LNG.

The fraying link between oil and gas prices raises a second question: will low spot prices in competitive gas markets create an opportunity to replace more expensive oil with cheaper gas? In 2010 the price ratio between West Texas Intermediate crude oil and Henry Hub gas reached an all-time high of more than 20-to-1, creating an arbitrage opportunity for those that can switch between the two fuels.

In spite of the large price difference, this arbitrage opportunity is somewhat limited today. The best opportunities for switching from oil to gas have been exhausted in the power generation, residential and industrial sectors. Oil currently has a tight grip on the transportation market. As described in the previous section, substituting gas into transportation would require investments in NGVs or EVs that could run on gas-generated power. A breakthrough in GTL technology could allow switching from oil to gas in the transportation market with less change in infrastructure or consumer behaviour. Any of these breakthroughs would require time and a sustained large price difference between oil and gas prices.

Storage: A Key Factor in Market Structure

Natural gas requires more specialized infrastructure for storage than do coal or oil. Thus, the availability of storage can plays a larger, and often underappreciated, role in gas markets than it does in the markets for other fuels. A lack of storage capacity makes it more difficult to balance supply with fluctuations in demand. The result is often more volatile prices in areas short on storage. Storage capacity can also affect the way in which operating companies, legislators and financial traders think about various markets.

Just as some regions are endowed with larger gas resources, some regions have more favourable geology for gas storage. The most economical gas storage facilities are underground in salt dome caverns, depleted reservoirs and aquifers. Aboveground storage of gas, in tanks at LNG facilities for example, is more expensive than underground storage. To complicate matters further, some nations have the right geology for gas storage, but in less than optimal locations. For example, the US Northeast has major demand centres, but the nearest large complex of storage facilities is several hundred miles away.

Relative to other regions, North America is blessed with an abundance of underground storage capacity. This abundance was a factor in the strong build-out of LNG regasification capacity that occurred in North America in the early 2000s. The status of North America as the world's largest gas market and the market with the largest gas storage infrastructure led to the concept of North America as the market of last resort for LNG exports.

Although Europe has somewhat less storage capacity than North America, it is well supplied with storage. Europe's dependence on relatively flat pipeline imports requires large volumes of storage to meet winter peaks in demand. Looking forward, increased interconnections among markets and enhanced access provisions should allow for more efficient use of exiting storage. More storage will be required, but it is needed on the borders of Europe. Additional capacity is required in the United Kingdom to compensate for declining North Sea production and in Turkey and the Balkans to manage rapidly growing demand.

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Development of more storage infrastructure is a requirement for increasing gas use in China. Until the mid 1990s much of China's gas consumption was localized relative to sources of supply and a lack of interprovincial pipelines was the bottleneck to greater gas usage. Recent rapid development of gas pipelines has brought new customers, primarily city residents, into the system. However, residential gas consumption is much more seasonal than industrial or power generation consumption. Such seasonality creates a need for gas storage capacity, but thus far, storage development has not kept pace. Appropriate storage sites will have to be identified in eastern China, the area of largest population and greatest need.

Perspectives on Natural Gas Markets in an Era of Change

The chapter includes a perspective that describes the changes occurring in natural gas markets. The author is:

- **Wojciech Jasinski,** Chair of the Economic Committee, Parliament of Poland

The Role of Natural Gas in Poland's Future

By Wojciech Jasinski, Chair of the Economic Committee, Parliament of Poland

The Polish energy sector is an excellent case study for discussing the role fossil fuels will play in the 21st century energy outlook. Poland is the 20th largest economy in the world, located geographically in the middle of Europe. Yet it seems that some of the main issues and challenges in the fossil fuels sector are focused here in our country.

The Polish economy is historically based on coal, with some of the largest coal and lignite resources in Europe. The Polish energy mix currently consists of coal and lignite (60%), oil (23%), natural gas (13%) and renewable sources (4%). Coal and lignite mainly come from indigenous production, but oil and natural gas are mostly imported. Discussions are ongoing in the European Union and particularly in Poland about the impact of carbon emissions reduction on the coal industry and on economic competitiveness.

Additionally, the Central European gas market has only one source of supply – Siberian gas fields. Therefore there is no opportunity to benefit from price arbitrage, and the bargaining position of gas consumers is very weak when negotiating with suppliers.

Finally, Poland is at the beginning of long path of shale gas exploration. For this reason we should be prepared for different gas market scenarios in the near future, based on the gas price revolution we have observed in North America and its impact on gas prices in the Atlantic Basin and worldwide.

Poland is watching carefully the world's discussions on carbon reduction. We see advantages in protecting the environment and great threats to our economy if carbon reduction goals are too strict. Plans for increasing Europe's carbon reduction target to 30% are against Polish interests. Moreover, some European countries may have problems achieving the 20% target. As a responsible country, we have to keep coal as a main source of primary energy, applying new clean coal technologies and improving energy efficiency. We are convinced that all coal-based economies understand their long-term energy strategy in a very similar way.

We see natural gas in power generation as a way to meet seasonal and daily peaks and as a complement to nuclear, renewable and coal-fired (new technologies) energy production. Moreover, we think that such a scenario is the best solution for most of the world's coal-based economies.

Most gas markets are regional, but LNG technology and trading are making natural gas a global commodity. This is likely to strengthen the integration of the regional gas markets into a global gas market. Central Europe has an opportunity to enter the global gas market using the LNG "window". Polish authorities are working to diversify gas supplies by building a regasification terminal on the Baltic coast and a new gas grid to enable distribution of natural gas coming in from the sea. Moreover, the Polish LNG terminal is the only one in Europe that continues to be built despite the global decrease in gas demand and world economic crisis.

LNG brings stronger linkages and correlations among regional gas markets. This benefits Poland and Central Europe at large. Our goal is to have diversified supplies and become as integrated with the global gas market as Western Europe.

A big discussion is beginning about unconventional gas in Europe, especially in the light of potential reserves in Poland. We invited global players to take exploration concessions and start to work in the most prospective areas in northwest and southeast Poland. We hope the geological surveys will be finished soon and that exploratory drilling will begin. Nonetheless, achieving full knowledge about the possibility of commercial production will take a few years. We are glad to have North American companies in Poland with experience in developing shale gas. Based on the North American example, we hope to be able to talk about Polish "shale success" in eight to 10 years time.

Despite the potential for increasing production of unconventional natural gas in Poland, we do not see any prospect of large-scale switching from coal to gas in the Polish energy mix. Total replacement of coal with gas in our economy would be against Polish long-term energy and economic security for two reasons. First, our best interest lies in keeping a balance among different energy sources and not making the economy over-dependant on natural gas. Second, natural gas can be sold on international markets much more easily than coal. Therefore coal will remain our true indigenous resource for internal use, while natural gas might become an export product, allowing us to monetize its higher economic value.

Overall, advancement and development of shale gas in Poland will not only diversify our energy supplies, but also further integrate our energy sector and economy into global gas markets. LNG will play a role as an important link and "price-transmitter". New gas supplies will not replace coal as Poland's main energy source. Rather, they will help to build Poland's role as a potential gas supplier in the future.

CHAPTER 5: NEW PROMISE, NEW CHALLENGES

Only recently, the global natural gas industry faced a daunting challenge: how to supply enough gas to satisfy growing world demand, especially in China, India and other emerging markets and, at the same time, replace declining production in North America and the North Sea. The industry did more than find a solution – it created a revolution.

Vast supplies of gas have found new markets through expansion of LNG trade. Global liquefaction capacity roughly doubled in the last 10 years and regasification and shipping capacity underwent corresponding growth. At the same time, technology innovation brought about a flood of new supply from shale gas in North America, setting off a race to explore and commercialize shale resources in other parts of the world.

For all these reasons, natural gas is a fuel on the upswing. And yet the gas industry still faces challenges in realizing this new potential.

Gas Abundance: A Whole New Ball Game

The surge of new gas supply in the last three years is unprecedented. Such a surge developing in the midst of a global economic downturn compounded the challenge for industry and consumers. The new abundance of gas raises new opportunities for gas markets, but may also require the development of new methods for doing business.

In particular, the new abundance of gas has challenged the structure of many long-term contracts around the world. Long-term contracts will remain a central strategy, especially in the gas markets of Europe and Asia, to provide security of supply and demand and to fund infrastructure construction. However, recent events have shifted the balance in the marketplace. Suppliers have adjusted the oil-linked prices and take-or-pay volumes in many gas contracts to reflect this new balance.

Demand in much of the world is already recovering after the recession, particularly in the non-OECD world. As the surplus in gas production unwinds and new supplies of LNG and unconventional gas reach the marketplace, gas markets will continue to evolve. Spot markets in Europe are here to stay and greater flexibility in long-term contracts is already appearing in Europe and to a lesser degree in Asia.

The Challenge of Demand

The gas industry does not expect a revolution in demand to match the revolution that is occurring in supply. The primary uses for gas remain the same – space and water heating in residential and commercial applications, fuel and feedstock for industrial applications and power generation. Only the transportation sector provides the opportunity for substantial new uses for gas, in NGVs or in EVs that use electricity generated from natural gas. The opportunity for sizeable contribution to gas demand from the transportation sector is at least 10 to 15 years away, however. In OECD countries with mature gas distribution infrastructure, the most robust growth is expected to come from power generation. In the developing world, gas demand is projected to grow across all sectors, owing to economic growth and an expanding gas delivery infrastructure.

The imperative to reduce GHG emissions provides immediate opportunities for gas in the power sector. Natural gas is the cleanest fossil fuel, with the lowest emissions of GHGs and other pollutants. For this reason, gas-fired power plants have the potential to help the power sector reduce its GHG emissions by replacing ageing coal-fired plants and by becoming the partner to renewables like wind and solar. Natural gas power generation is cost competitive today. The revolution in unconventional gas production means that gas is likely to be a secure and reliable energy source in the future, although power companies and industrial consumers who have lived through previous gas price cycles may still need some additional persuading that they can rely on stable supply and stable prices.

However, the natural gas industry is curiously underrepresented in many policy debates around the world. It is, in some ways, a “fuel without a voice”. Europe’s 20-20-20 policy and US stimulus funding and portfolio standards focus on technologies that produce zero GHG emissions, including nuclear, wind, solar and coal with CCS. These technologies will be crucial as the world moves towards a lower emissions future. Nonetheless, gas has an important role to play in reducing emissions in the near term. Natural gas is

a critical and important part of an economically and environmentally sound energy mix to meet future needs. But to have that impact, the "voice of gas" needs to be articulated and heard.

The lack of a strong voice for the gas industry in policy circles extends beyond discussions of GHG emissions reduction. The ability to develop unconventional gas resources in North America and around the world depends on a policy environment willing to support such development. Industry and policy-makers must work together to understand and resolve concerns about drilling and pipeline safety and water. Such cooperation will allow the world to gain the GHG and economic advantages that gas offers while protecting other environmental resources.

The Gas Supply Shuffle

The nature of the infrastructure needed to transport gas makes geography much more important in gas markets than in those for other fuels. The ongoing revolution in unconventional gas production is changing some long-held assumptions about how gas will move from producing to consuming areas. LNG producers ramped up production to supply North America and replace declining domestic production there. But shale gas obviated the need for LNG imports into North America, changing the strategy of large LNG exporters worldwide and the direction of their exports.

The first scene for this supply shuffle is Europe. Pipelines from Russia provide a great deal of Europe's gas, but face greater competition than anticipated from LNG, particularly the LNG originally slated for North America that is now looking for new markets.

The potential for unconventional gas in Europe also plays into this competition. Only time will tell how unconventional gas supply will fit into Europe's supply picture. One consequence of unconventional gas development in Europe could be to increase confidence in the stability of gas and expand the overall gas market, especially in power generation.

The supply shuffle is also spreading to Asia. Growing Asian markets are soaking up much of the world's incremental LNG supply. LNG supplies from the Middle East to both Europe and Asia provide a link in market dynamics. Will increasing demand in the developing markets of Asia begin to pull up LNG prices in Europe?

On the other hand, with Australian LNG and the potential for unconventional gas in China and elsewhere, could the Asian gas market become less connected to the rest of the world rather than more? At the same time, new connections could develop as new pipeline projects carry gas from Russia and Central Asia to the growing Asian markets. Any far-reaching change in the structure of Asia's gas market is many years off, but considering such questions makes it clear that the geography of gas is not static. The general interest in expanding natural gas markets is clear, as will be reflected in China's 12th Five-Year Plan.

Questions for the Future

The answers to the following key questions will shape the future of the gas industry.

Policy

- How should policy-makers think about gas as part of the future energy mix, particularly in the power sector? Encouraging gas use can bring about quick reductions in GHG emissions, but how will GHG emissions from gas fit into overall long-term budgets for emissions?
- How will increasing unconventional gas production change the relations among countries and regions?
- Will natural gas gain a "voice" commensurate with its role as the provider of one-quarter of the world's energy?

Environmental

- How can industry and government work together to develop unconventional gas resources while protecting water resources and the local environment?
- Gas development necessarily involves balancing the local impacts in the area of drilling with the global benefit of reduced GHG emissions. How will communities, industry and governments manage these trade-offs?

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Markets

- Will technologies developed in North American shale plays carry over into unconventional gas resources in other parts of the world? How relevant are the "lessons learned"?
- Will growing LNG and unconventional gas supplies bring about a more unified global market, or a more fragmented one?
- Will floating LNG regasification change the way that LNG is marketed around the world?
- How will natural gas figure in the transportation sector – directly in vehicle engines or through the route of gas-fired power plants providing power for electric vehicles?
- Will natural gas – because of its cost attributes, availability, environmental qualities and ability to be deployed relatively quickly – play a bigger role in future power generation than would have been thought a few years ago?

The World Economic Forum and IHS CERA will be exploring these critical questions in the months ahead.

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