PANORAMA 2008

a look at ...

Coalbed methane: current status and outlook

In many parts of the world, there is growing interest in coalbed methane (CBM), which has been exploited for years in the United States. One reason is undoubtedly that some new gas producing countries, including India and China, are seeking to limit the level of their gas dependence. Another is the need to control greenhouse gas emissions, especially using mechanisms set up under the Kyoto Protocol. Finally, the increase in gas prices on international markets also encourages this trend.

Coalbed methane is the methane (i.e. natural gas) recovered from coal. There are three ways to recover CBM. It can be:

- Tapped at existing coal mines, both to avoid the risk of a mine gas explosion and to exploit the gas.
- Extracted at abandoned mines.
- Produced by drilling into virgin coal beds.

CBM could eventually become a significant energy resource for coal producing countries, especially the six that represent about 80% of world production: China (39%), United States (19%), India (7%), Australia (7%), Russia (5%) and Indonesia (4%).

The United States was the first to develop this resource, but now all of these countries are considering this option for reasons of strategy (gas dependence) or relative to the environment (Kyoto effect). The uptrend in gas prices provides another reason to think about developing this new source of supply.

The experience of the United States

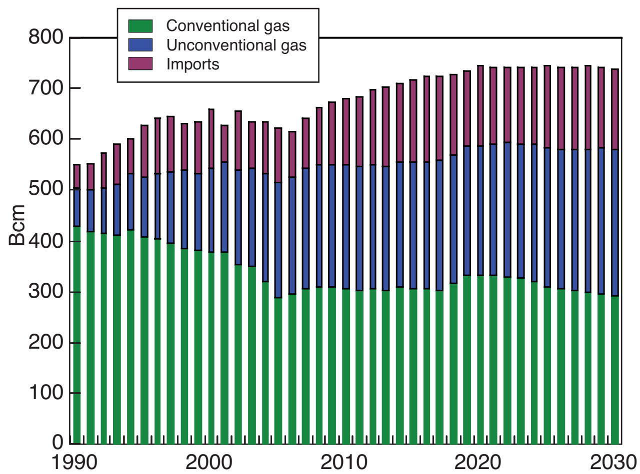
It is difficult to say precisely when gas production peaked in the U.S., because demand varied widely starting in the 1970s. However, it's clear that the production of conventional gas has been declining steadily, probably since the mid-1980s.

Forecasts for 2030 (Figure 1) indicate that unconventional gas resources (coalbed gas, tight sand reservoirs, shale gas) will be important in balancing gas supply and demand. Representing 15% of total production in the 1990s, they now stand at 45% and are expected to reach 50% by 2030.

If consumption reached 740 billion cubic meters (Bcm) by 2030, unconventional gases (including CBM) would account for about 300 Bcm; imports could then be limited to 150 Bcm. This would have an impact at domestic level but also on the international scale, by limiting the need to resort to imports in future.

This is the background for CBM development, which really began in the late 1980s. Tax incentives granted on the production side (1980 to 1992) and/or on the sales side (1980 to 2002) initially boosted development. Output

Fig. 1 - The gas balance in the U.S. (1990 – 2030)



Source: U.S. Department of Energy (DOE)

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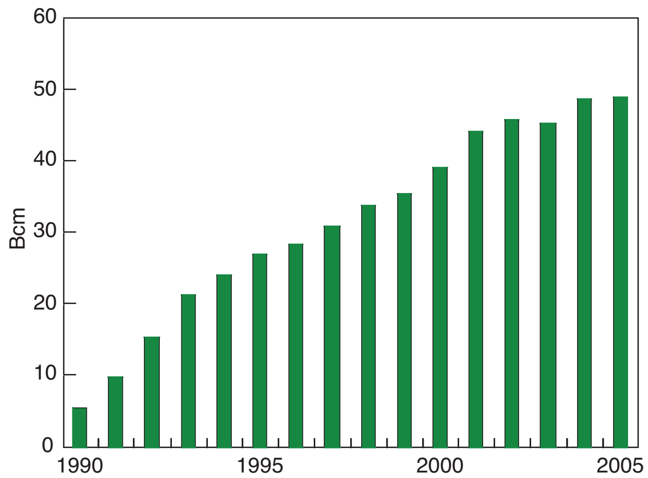
rose steadily from 6 Bcm in 1990 to its present level of about 50 Bcm (Figure 2), accounting for about 10% of current U.S. production and 23% of the production of unconventional gases.

Recent trends seem to indicate a slackening of CBM growth. The rate of increase for proved reserves, which now stand at 560 Bcm (10% of all gas reserves) has slowed significantly. Since 2003, the increase in production has also shown signs of slowing. This being said, given the size of the resources (4.6 trillion cubic meters), one imagines that they will be exploited when conditions become more favorable (tax incentives, gas price, lower costs, etc.).

The U.S. experience demonstrates the technical and economic feasibility of developing this new gas resource in significant proportions.

Fig. 2 - CBM production in the U.S.



Source: U.S. Department of Energy (DOE)

A mature technology

Coalbed methane, a natural gas adsorbed into the seams of coal, contains mostly methane but also nitrogen and carbon dioxide (CO_2) in variable quantities. In Australia, one refers to "coalbed gas" and "coal seam gas", whereas the Canadian term "natural gas in coal" is less commonly used. At any rate, it is important not to get coalbed methane confused with coal gas. Coal gas, containing hydrogen and CO, is obtained by means of the distillation of wood or coal. It was introduced as an illuminating gas for lighting in London in 1812 and Paris in 1815.

During the geological formation of coal, the organic matter contained in plants and trees is transformed under the effects of heat, pressure and geological time. This process gradually yields large quantities of methane, mostly adsorbed (chemically bound to) by the surface of the coal. Smaller quantities form in the network of fractures in the coal (cleats) as free gas. Coal is a very efficient vehicle for the storage of gas. It can hold between six and seven times more gas per unit volume of rock than conventional oil and gas fields.

At present, drilling for methane in virgin coal beds is the most common production technology. The technique consists of reducing pressure inside a seam of coal to release the gas. This is done by drilling a well or extracting (pumping) the water found naturally in coal. In both instances, a process known as fracturing is implemented to enlarge coal seam cleats to allow the gas to escape faster. Fracturing involves pumping a fluid, usually nitrogen, through the cleats at high pressure.

From the environmental standpoint, the fact that water is a by-product of production is problematical. For instance, in the Powder River Basin, Wyoming (U.S.), water was used at the surface, discharged into local watercourses or clarification tanks or sprayed onto farmland. In some cases, minerals in the water reacted with the soil, which had an adverse effect on agricultural activities. In other cases, the quantity of water discharged, or the difference in quality between the water discharged and that of the receiving watercourse was a problem.

To help minimize negative effects, a special permit is needed now to discharge into fresh water, like the one required by the Alberta Ministry of the Environment (Canada). Saline water must be injected into a deep aquifer, a practice that is in line with regulations governing the exploitation of conventional oil and gas resources.

Some formations do not contain water. One example is the Horseshoe Canyon coal field, Canada's largest for the exploitation of coal gas. Horseshoe Canyon accounts for 90% of Alberta's CBM output. It is the only formation of this type under development in the world.

Current research is seeking to improve the recovery rate by increasing the permeability of coal layers to boost the rate of gas flow. Known as "enhanced CBM" or ECBM, this method calls for the injection of nitrogen or carbon dioxide. The CO_2 injection solution offers a real environmental benefit by ensuring the storage of this greenhouse gas. In this respect, it may offer a major advantage when used to supplement the methods now under consideration for storing CO_2 in hydrocarbon formations.

At operating mines, coal mine methane is usually recovered by means of ventilation techniques. Formerly regarded as "waste", this type of methane is seeing increased development, especially in China. The U.S. Environmental Protection Agency, which started its "Methane to Market Partnership" program in 2004, has more than 200 projects worldwide listed. The Kyoto Protocol also encouraged this trend.

Two environmental advantages

The development of CBM represents two advantages from the environmental perspective and more specifically with respect to the greenhouse gas problem, in the sense that it:

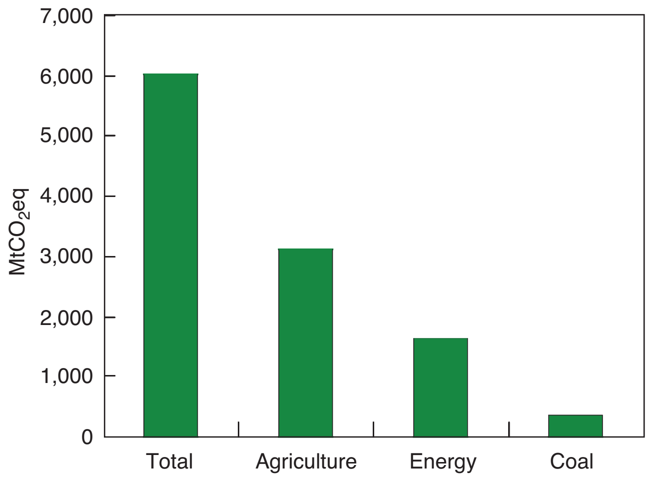
- Has potential as a CO_2 storage solution, as mentioned.
- Avoids methane emissions at operating coal mines, knowing that methane has a high global warming potential and represents a hazard (mine gas explosion).

As for enhanced CBM projects, several are already underway. An early project was carried out between 1995 and 2001 in the San Juan Basin in the United States (Colorado). Other projects followed, e.g. in Canada (Alberta), Australia, Japan (the Ishikari coal field) and China (Qinshui Basin). In Europe, the RECOPOL project (Reduction of CO_2 emissions by means of CO_2 storage in the Silesian Coal basin of Poland), financed by the European Commission, got underway in November 2001.

These pilot projects have two objectives: confirm the impact of CO_2 injection on production and look into the possibilities of long-term CO_2 storage at coal mines. Today, this technology is at the stage of applied research; it will be a few more years before the first conclusions can be drawn, about storage in particular.

The second point relates to the problem of greenhouse gas emissions. To understand the implications, one must recall that the global warming potential of methane is 25 times higher than that of CO_2 measured over a 100-year period. At the same time, things must be seen in perspective: the production of coal emits 380 million tons equivalent of CO_2 ($MtCO_2eq$) in the form of methane. This is about 1% of total world CO_2 emissions, estimated in 2000 to be 41 billion tons (Gt). These emissions only represent 6% of the total due to methane alone, estimated to be 6 Gt, including 3.1 Gt

Fig. 3 - Breakdown of CO_2 emissions due to methane



Source: IPCC

generated by agriculture and 1.6 Gt by the energy sector (Figure 3).

However, these emissions are expected to grow substantially as coal production increases. By 2020, they could reach 449 $MtCO_2eq$, with 198 Mt in China, 46 Mt in the United States and 20-30 Mt in India, Russia and Ukraine. In light of global warming, reducing emissions in each sector has become imperative, especially if it is both technically and economically feasible, as in the case of coal mine methane. The Kyoto Protocol provided a framework known as the Clean Development Mechanism that allows signatory industrialized countries to earn emissions credits by investing in emissions-reduction projects in signatory developing countries.

The Annex I parties, i.e. the industrialized countries that have committed to specific emissions abatement targets, may use the reductions achieved by means of these projects to earn credits to cover part of their abatement commitments. The projects must meet certain conditions: the emissions reductions achieved for each activity must be certified by bodies recognized by the Protocol and added to the emissions that would have existed in the absence of the certified activity.

In October 2007, it was estimated that accumulated certified emissions reductions (CERs), measured in tons of CO_2, will amount to 1.09 billion by 2012 for 827 certified projects and to 2.29 billion for a total of 2,647 projects that already exist, are being planned or are under consideration. Table 1 shows that CBM projects rank ninth for emissions reductions expected by 2012, with 106 million accumulated CERs, or nearly 5% of the total.

Tableau 1
CDM projects per type

Type	Number		2012 kCERs	
HFCs	19	0.7%	501,209	21.9%
Hydroelec.	654	24.7%	289,044	12.6%
N_2O	44	1.7%	247,499	10.8%
Biogas	203	7.7%	223,128	9.8%
Efficiency	249	9.4%	220,956	9.7%
Fossil subst.	84	3.2%	161,347	7.1%
Biomass	460	17.4%	158,019	6.9%
Wind power	323	12.2%	143,582	6.3%
CBM	**42**	**1.6%**	**106,682**	**4.7%**
Other	569	21.5%	236,056	10.3%
Total	**2 647**	**100 %**	**2 287,521**	**100 %**

Source: UNEP Risoe CDM/JI Pipeline Analysis and Database. October 2007

Since there are only 42 CBM projects (39 in China, 2 in South Africa and 1 in Mexico), their contribution to the reduction of greenhouse gas emissions is far from negligible.

A relatively favorable business environment

The price of natural gas on major international markets, especially Europe and the United States, has been rising steadily since 2000 (Figure 4). It stood at about USD 3/MBtu (USD 2007) in the 1990s, between USD 4 and 5/MBtu until 2003 and has exceeded USD 6/Mbtu since then. On the European market, where contracts are still largely indexed on petroleum products, the increase is directly tied to the oil price. On the deregulated U.S. market, the increase in price, which depends on the balance between supply and demand, is the result of several factors. For one thing, dependence is rising, which implies purchases at prices close to the international price set by European or Asian contracts. In addition, production costs are up substantially throughout the oil and gas sector. Finally, the price hikes for competing energies also tend to exert pressure on gas prices.

There is every reason to think that, in future, the low reference price will be situated between USD 6/MBtu and USD 7/MBtu.

Obviously, the price of gas is one parameter determining the profitability of a CBM project. But it is not the only one. Whether or not a project is economically viable also depends on royalties and taxation, on drilling costs and on the well productivity rate. A May 2007 report by the National Energy Board (Canada) showed that, based on a well productivity rate of 2.1 million cu.m. per day (77 million cf/d), a price of USD 6/MBtu would yield a rate of return of 13.6%, close to the 15% generally expected in the industry.

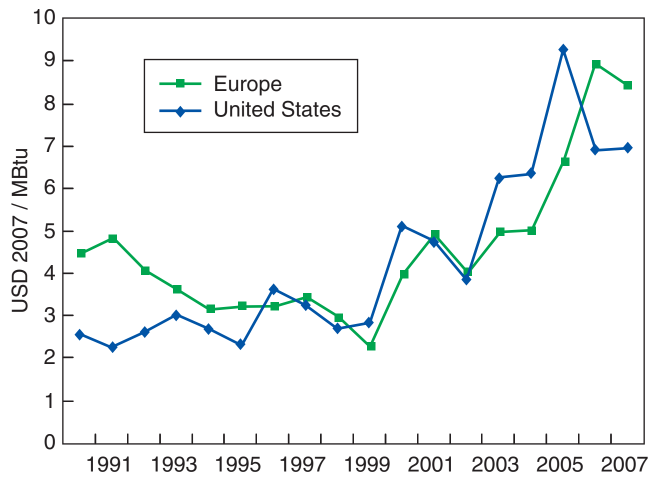
However, this report emphasized that a cost increase of 15% would lower the rate of return to only 10.7%. Similarly, a decline of about 15% in the productivity rate would bring profitability below 10%. This would explain why CBM projects have slowed somewhat on the North American market even though prices are rising. Fears of further cost increases would account for this.

Obviously, this example is not representative of the situation in other countries, such as China or India, but it does illustrate that CBM projects currently find themselves in an economically tight situation in the industrialized countries, in the absence of tax incentives.

Outlook

World CBM resources, not known with any great precision, were estimated in 1994 by the U.S. Geological Survey to be 210 Tm^3 (7,500 Tcf). In 2004, the American Association of Petroleum Geologists (AAPG) published a range of 164 - 685 Tm^3. Without specific analyses, it is difficult to know which of these resources can actually be developed. Based on the U.S. ratio of proved reserves to resources of 15%, total world recoverable resources would be situated between 25-100 Tm^3. These are very large volumes comparable to those of proved gas reserves (180 Tm^3).

Fig. 4 - The price of gas in Europe and the United States (USD 2007)



Source: BP

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Table 2
Estimated world CBM resources

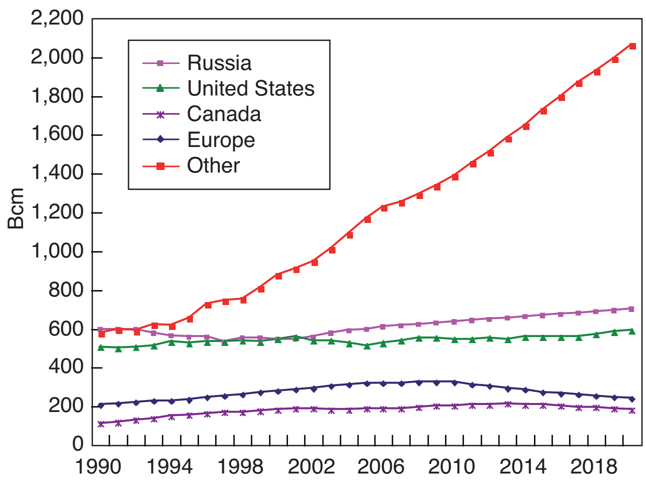
Tm³	Low end	High end
Asia	18.3	95.1
North America	26.9	124.1
South America	0.4	0.9
CIS	113.3	456.3
Europe	4.6	7.6
Africa	0.8	1.6
World	**164.2**	**685.7**

Source: The American Association of Petroleum Geologists

There are other producing countries besides the United States (50 Gm^3), such as Australia, China and India, but their output is much lower, on the order of 2 to 5 Bcm per year. The next echelon of producing countries includes Russia, Ukraine, Poland, Canada, Germany and the United Kingdom. World production is probably lower than 100 Bcm, which still represents only a small percentage of conventional gas production (2.8 trillion cubic meters).

World demand is expected to see annual growth of 2%, at a time when the output of major production zones (Russia, United States, Canada, Europe) should increase slightly or remain flat. As a result, it will become increasingly necessary to rely on the other gas producing countries (Figure 5), whose market share is expected to reach 54% by 2020, compared to 43% in 2006 and about 30% in 1990.

Fig. 5 - Outlook for world natural gas production



Source: BP (1990 -2006) – IFP (Forecasts)

This represents a real challenge, not only in terms of investment, but also in terms of the risk associated with the rising level of dependence in certain geographic areas, especially Europe. Given this situation, the development of unconventional gases like CBM could eventually become a priority. Without being decisive, this development appears necessary to limit regional dependence and potential pressures on supply. That's what the United States set out to do in the 1980s.

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