

New Pipelines Planned to Bring Gas to the European Market

By John Tiratsoo

In the face of declining indigenous gas production, the European Union's need to increase imports and develop the necessary transport infrastructure is clear. And while new LNG receiving terminals are being built, it is also clear that pipeline imports will predominate. But there is considerable debate about the merits of individual projects, both because of where the gas reserves are situated, and the host countries' relationships with the EU and each other.

This article reviews a number of gas pipeline projects that are either under way or planned to bring gas to the EU and provide security of energy supply. Some of them involve technically challeng-

ing deep subsea sections, but in terms of length there are no particular problems in constructing pipelines from any of the areas under discussion to connect to the European gas grid. Modern technology for pipeline design, construction and operation can cope with pipeline lengths of 3,000 kilometres or more almost as easily as with those of a tenth this length. Long-term finance for the projects may be more difficult to raise in the current financial climate but the real issue is political, and outside the scope of this article. Many well-qualified observers are currently commenting on the relative merits of the various schemes described below: it is hoped that this article will provide a useful overview which will allow these comments to be put into a pipeline perspective. The projects described below are ordered alphabetically.

● Blue Stream and Blue Stream 2

The 1,213-km long Blue Stream gas pipeline, which began operations in 2003, transports Russian natural gas to Turkey across the Black Sea, and was constructed by Gazprom to provide a gas export route from Russia that by-passed other countries. The pipeline's Russian section runs for 373 kilometres from the Izobilnoye gas plant at Stavropol Krai to the Beregovaya compressor station on the Black Sea. The 396-km subsea section runs to Durusu in Turkey, from where the final 444-km long section connects to Ankara. Diameters vary along the route from 56in and 48in onshore to 24in for the subsea crossing.

Initial plans were made for the pipeline in the late 1990s, and the main construction took place in 2001-02. Operations began in 2003, but delays due to negotiations on gas price meant that this was on a limited basis. The Durusu compressor station was eventually inaugurated in 2005, heralding an increase in throughput, and in 2006 7.5 bcm of gas passed through the pipeline. This figure increased in 2007 to 9.5 bcm, and by 2010



New pipelines are needed to bring gas to the European market.

the full design capacity of 16 bcm/year is expected to be achieved.

Plans for a second, parallel, pipeline – Blue Stream 2 – have been discussed, but are currently in abeyance following introduction of the South Stream project (see below).

● **Galsi**

Formed in 2003 as a pipeline design company, Galsi is now responsible for the development, construction and operation of a new 837-km pipeline connecting Algeria to Sardinia and Tuscany in Italy, of which around 560 kilometres will be offshore. Reaching depths of 2,824 metres in the Mediterranean Sea crossing between Algeria and Sardinia, the Galsi pipeline will be the deepest underwater pipeline ever laid, representing a huge achievement in technology and engineering for the team engaged in the project's implementation.

The Galsi pipeline is backed by an international consortium that comprises Sonatrach, Edison, Enel, Hera Group and the Region of Sardinia through its financial arm, Sfirs. In November 2007 the partners were joined by Snam Rete Gas, Italy's biggest gas distributor, which signed an agreement with Galsi to build, own and operate the Italian section of the pipeline.

Galsi will start at Koudiet Draouche, near Annaba, on Algeria's Mediterranean coast, where it will connect to a pipeline supplying gas from the Hassi R'Mel field. The first section of the Galsi line will be a 285-km long, 26-in diameter, subsea pipeline, which will make landfall at Porto Botte in Sardinia. The 48-in diameter Sardinian section will be 272 kilometres in length, running northwards to Olbia, followed by a further, 280-km long, 32-in diameter, subsea section in up to 878 metres of water to the Italian landfall at Piombino, from where a connection will be made to the Italian gas grid.

The capacity of the pipeline is being designed as 8 bcm/year, and construction is currently scheduled to start mid-year for a May 2012 completion date.



Blue Stream should reach its full design capacity of 16 bcm/year in 2010. The proposed South Stream pipeline would start at Beregovaya and make landfall at Varna before dividing into two branches.



The Galsi pipeline should be completed by May 2012.

● **Medgaz**

Meanwhile, Algeria's first direct subsea gas link to Spain is expected to come onstream later this year. (The existing MEG/Pedro Durán Farrel pipeline transits Morocco and crosses the Mediterranean by the Straits of Gibraltar.) The €900 million Medgaz



Final welding being carried out on the Medgaz pipeline, which was laid in 2008 and is currently being commissioned.

project is backed by a consortium of Sonatrach (36%), Cepsa (20%), Iberdrola (20%), Endesa (12%) and GDF Suez (12%).

The 210-km long, 24-in diameter pipeline runs from a terminal at Beni Saf on the Algerian coast to the Spanish port of Almeria and has an initial annual capacity of 8 bcm. It will transport gas produced from the Hassi R'Mel field and connect to Enagas's Almeria-Albacete pipeline and thus to the Spanish grid.

The pipeline was laid across the Mediterranean in water depths of up to 2,160 metres during 2008 by the Castoro Sei and Saipem 7000 of Saipem (a subsidiary of ENI). It is now being prepared for commissioning.

● Nabucco

The Nabucco pipeline project, named after a Verdi opera, aims to bring gas from Central Asia to Western Europe via Turkey, Bulgaria, Romania, Hungary and Austria. The project's planners say

that opening up a fourth main supply corridor is the only solution to meet all future gas demands in Europe. The ambitious scheme is therefore being designed to offer a wide range of supply sources, including Azerbaijan, Turkmenistan and Kazakhstan in Central Asia, Egypt, Iran and even Iraq once stability in that country can be established.

The proposed 56-in diameter pipeline's route will run for around 3,300 kilometres from the Turkish border with Georgia (or the Turkish border with Iran) to the Baumgarten gas hub on the Austrian/German border. The route passes through Bulgaria, Romania, Hungary and Austria. Unlike South Stream (and other proposals), Nabucco's route is almost entirely on land, with the exception of a crossing of the Bosphorous; 2,000 kilometres will be in Turkey, followed by 400 kilometres in Bulgaria, 460 kilometres in Romania, 390 kilometres in Hungary, and 46 kilometres in Austria. The pipeline design capacity will be 31 bcm/year, and the current project cost is put at €7.9 billion.



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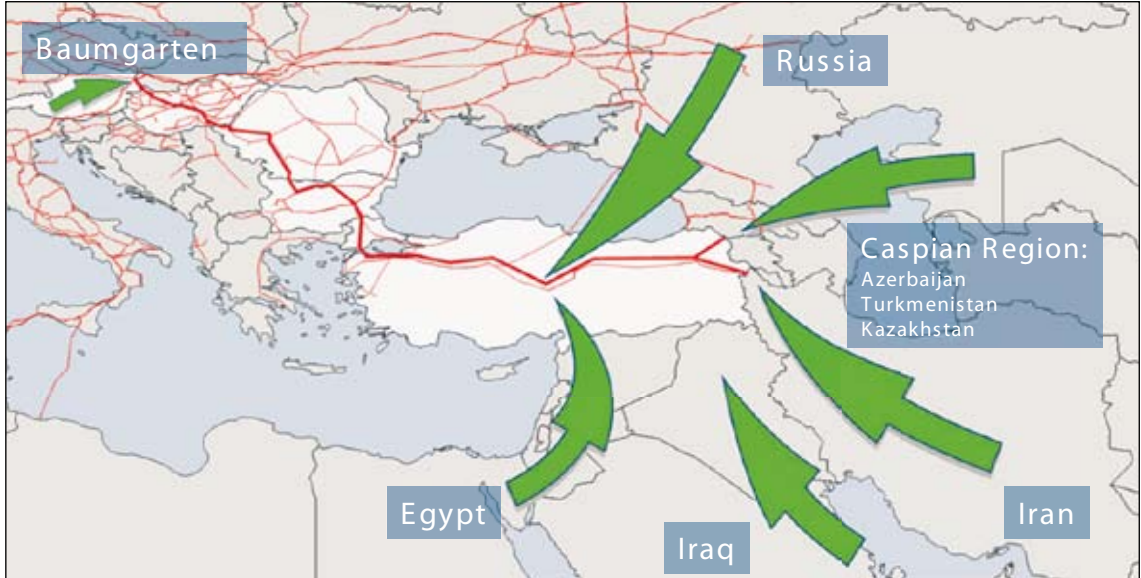
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The first construction phase, planned to start in 2011, will cover the 2,000-km section between Ankara and Baumgarten. Existing pipelines between the Turkish/Georgian or Turkish/Iranian borders and Ankara will be used for an interim period of two years, and this will enable the project to start operation and marketing in 2014 with an initial pipeline

capacity of around 8 bcm/year. The second phase of construction will be between 2014 and the end of 2015, and will see construction of the remaining section between the Turkish border and Ankara, following which installation of further compression stations at key points along the route will increase the pipeline's capacity up to its planned total.



TOP Sources of gas for the Nabucco pipeline project which will end at the Baumgarten gas hub (ABOVE)

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First talks about this complex project took place in February 2002 between OMV Gas of Austria and Turkey's Botas, followed by further discussions involving MOL of Hungary, Transgaz of Romania and Bulgargaz of Bulgaria. Later that year a protocol was signed by all five parties in Istanbul, which marked the real starting point of the project.

By the end of 2004 various feasibility studies had been finalised, the results of which showed that the project was both technically feasible and financially viable. In the first half of 2005, the Nabucco partners decided to commit to the project and to enter into the development phase, during which the technical, legal, commercial and financial issues will be resolved. This phase is planned to last until the end of 2010, with the financial arrangements in place by the end of this year.

A further important step for the project is to establish intergovernmental agreements between the governments of the states across whose territory the pipeline is to be constructed and operated, and which will also establish a legal framework for gas transit between Turkey and the EU Member States. A similar important stage will be the establishment of the various national Nabucco companies. In February 2008 RWE joined the project, as a result of which there are now six shareholders with holding equal 16.67% shares.

Despite the controversy that has surrounded the project, and the length of time that has elapsed since its first inception, it seems likely that the pipeline will now be built. Speaking recently to the BBC, Reinhard Mitschek, Managing Director of Nabucco Gas Pipeline International GmbH, said: "Now the group of the shareholders are united and fully committed to Nabucco. It is clear that in a liberalised and diversified European gas market, companies work on several projects in several markets, but that does not affect negatively the commitment for Nabucco. All the countries involved are committed, and we are far advanced with the wording of the intergovernmental agreement which is now under discussion between the European

Commission and the governments involved. And we expect a signing ceremony for the intergovernmental agreement in the first quarter of 2009."

● Nord Stream

This project was reviewed in the last issue of the IGU Magazine (October 2008, pages 142-144) so will only be briefly summarised here for the sake of completeness. Nord Stream comprises two 48-in diameter lines, each totalling 1,210 kilometres in length and with a combined capacity of 55 bcm/year, running from Vyborg in Russia to Greifswald in Germany. Its route under the Baltic Sea has been the subject of controversy, but careful planning and extensive environmental investigations have allowed an agreement to be reached with the countries across whose seabeds the pipeline route passes.

The pipeline's owner, Switzerland-based Nord Stream AG, plans to have the first of the two parallel pipelines operational in the spring of 2011, followed by the second in 2012. The company, an international joint venture, has four shareholders: Gazprom holds 51%, BASF/Wintershall and E.ON Ruhrgas each hold 20% and Nederlandse Gasunie holds the balance of 9%.

● South Stream

The South Stream pipeline project, to transport gas from Russia across the Black Sea to Bulgaria, and then on to Greece and Italy via one branch, and to Austria and North-western Europe via a second, was established in 2007 when Gazprom and Eni signed an agreement setting up a joint project company to undertake marketing and technical feasibility studies. On January 18, 2008, Gazprom and Eni then registered the joint-venture South Stream AG in Switzerland, in which the two companies own equal shares.

This project is seen by some as a direct competitor to the Nabucco pipeline – indeed it has the same design capacity of 31 bcm/year – but its supporters feel there is room for both. South Stream's 900-km offshore section is planned to



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Nord Stream carried out extensive survey work during 2008 for the subsea section.

start at the Russian Black Sea Beregovaya compressor station, and would run to Varna in Bulgaria, crossing the Continental Shelves of both Ukraine and Romania. This routing will require consent of both these governments, however. The subsea section would be constructed and operated by South Stream AG, while Russia has so far signed agreements with Bulgaria, Greece, Serbia and Hungary to set up jointly-owned companies to construct and operate their respective national sections.

From Varna, one branch would run to Greece and onwards to cross the Ionian Sea and link into the Italian gas network in southern Italy. Connecting this leg of the South Stream pipeline to the planned Turkey-Greece-Italy pipeline is also seen as a possibility. The initial plan for the second branch of the pipeline is to cross Serbia, Hungary and Austria to terminate at Baumgarten. Other suggestions are that the pipeline route could cross

Slovenia to northern Italy, and for lines to be constructed through Bosnia and Herzegovina to Ploce, and through Croatia to Rijeka and onwards to Trieste in Italy. Also under discussion is a connection to the Haidach gas storage facility in Austria.

At present, a feasibility study is being prepared by Saipem, which is expected to be completed by the end of this year. It is thought that construction could thereafter be completed in less than three years, following approval from the EU's planning, competition and regulatory authorities. If all goes to plan, the pipeline's full capacity for transporting gas to Europe could come onstream in 2013.

● **White Stream**

UK-based GUEU-White Stream Pipeline Co. Ltd, which has for some time been working on the implementation of a major new gas pipeline across the Black Sea from Georgia to Ukraine and Romania,

is carrying out engineering and marketing studies which clearly indicate the strategic importance and commercial viability of the project. Roberto Pirani, Chairman of PSE-UK, a partner in GUEU, says that currently the preferred option is an ultra-deep 24-in diameter pipeline across the Black Sea.

The pipeline will make it possible to deliver more gas, initially from Azerbaijan and later potentially from other abundant Caspian Sea resources, via Georgia directly to Ukraine, and then onwards to Romania and markets in Eastern and Central Europe. Its planners say that the White Stream project will provide strong synergy and mutual reinforcement to the Nabucco project by boosting upstream investment in the Caspian region.

The White Stream pipeline route is currently being planned to branch off from the Baku-Tbilisi-Erzurum (BTE) pipeline (also known as the South Caucasus pipeline) west of Borjomi and run approximately 100 kilometres to Georgia's Black Sea coast nearby Supsa. From there, two alternatives are being considered, both involving pipelaying in upwards of 2,100 metres of water. One alternative would run 650 kilometres to Ukraine's Crimean shore near Feodosiya, and connect to Ukraine's main network after a 250-km-long land route across the Crimea. This route would then go subsea again for 300 kilometres in shallow water to Constanta on the coast of Romania, and onwards via the existing pipeline network to Trieste in Italy and elsewhere. The second alternative – technically even more ambitious – again starts nearby Supsa and goes subsea for 1,100 kilometres to Constanta. An intermediate compressor station could be required, which could well be floating.

Both the alternative routes for the White Stream pipeline would cross the existing Blue Stream pipeline on the seabed, and would require the White Stream line to be laid across it on a complex overbridge. Another technically challenging aspect of the project involves the actual laying of the pipe in the very deep waters of the Black Sea. The ground-breaking experience gained from the Blue

Stream 'J-lay' pipelaying – the world's deepest pipeline project at that time – by Italy's ENI and Saipem could be employed, and some of the engineers who worked on Blue Stream are understood already to be involved in White Stream.

The onshore sections of the pipeline are expected to be 42in diameter, with the subsea sections 24in.

GUEU is continuing to gain increasing international support from the interested countries and from the European Union for this prestigious project. Ukraine's Prime Minister Yulia Tymoshenko publicly and strongly supported the pipeline project at a joint press conference last year with European Commissioner for External Relations and European Neighbourhood Policy, Benita Ferrero-Waldner in Brussels: "We suggest [to] the Commission joint implementation of the White Stream project ... via the territory of Ukraine to Europe," Ms Tymoshenko said. "We would like the European Union and Ukraine to be partners in implementation of the project." The EU Coordinator for the Caspian Sea – Middle East – European Union gas route, Joazias Van Aartsen, is now in charge of coordinating the White Stream development, an appointment which the GUEU project team has welcomed. This follows the announcement by the EU's DG10 Directorate in 2007 that it is to provide funding for a major study for the White Stream pipeline.

In a further, very recent, gesture of support for the project from Serbia, Transnafta's CEO Bratislav Čeperković said in late January this year that Serbia could be receiving an alternative source of gas supplies via the White Stream pipeline. Mr Čeperković said that the advantage of White Stream was that it could become operational two years before the South Stream and Nabucco pipelines, and that it was "compatible with both, and did not jeopardise the construction of either, because it did not depend on the same sources as the other two".

John Tiratsoo is the Editor of Global Pipeline Monthly (www.gasandoil.com/gpm).

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Coal-bed Methane Moves Up the Agenda

By Iain Esau

Coal-bed methane (CBM), once an invisible killer of coal miners, has undergone an image transformation in recent decades due to its inherent value as a commercial energy source.

Since the early 20th century, methane vented for safety reasons from working or soon-to-be-worked coal mines has been gathered for use as fuel, as has methane from abandoned mines. This resource tends to be known as coal-mine methane (CMM) and among the key producers are Russia, the US, Australia, China, Germany, Ukraine and Poland.

In the US, coal mining is believed to account for about 10% of the country's total methane emissions so, at a time when global warming is high on the agenda, using this highly potent greenhouse gas

as an energy source can make a lot of environmental and commercial sense.

However, most of the world's coal-associated methane potential lies in virgin coalfields that have never been mined and it is this methane resource that, in the strictest sense, is classified as CBM. In some parts of the world, CBM goes by a slightly different name such as coal-seam gas or coal-seam methane.

Three characteristics that producers look for when assessing a coal's CBM potential are a thick seam, a high gas content and good permeability. Estimates of global CBM resources are hazy but range somewhere between 6,000 and 24,000 tcf (170 to 670 tcm).

Russia and the CIS countries are estimated to hold two-thirds of the lower resource estimate with China reckoned to house more than 1,000 tcf and the US believed to host some 740 tcf.

Reserve estimates tend to be ill-defined because there are areas of the world with huge coal reserves – such as southern Africa – whose potential to hold commercial methane is not well understood, if at all. This is because the CBM industry is very young, just a few decades old, so little serious effort has been made outside the US, Canada, Australia, China, India and Europe to better assess resources.

This situation will change in the coming decades when CBM will no longer be classified as an unconventional gas and, like natural gas now, will soon be considered a form of conventional energy.

In recent years, due to a boom in global energy demand, environmental concerns that make gas a favoured fuel and the cost of oil and gas imports putting huge dents in foreign exchange coffers, a number of countries outside North America have begun to seriously address the potential for domestic CBM exploitation.

CBM was first exploited in the US in the 1970s with Canada soon catching on and these two countries remain the world's biggest producers (see *Figure 1*). Other parts of the world lag far behind, although Australia is a hot new frontier with major



19th century mine workers called "penitents" (because the clothing they wore resembled that of religious orders) had the dangerous task of setting fire to pockets of methane before they got large enough to explode.

oil companies and state-owned players snapping up acreage in order to secure feedstock for LNG export plants targeting the Asia-Pacific market.

For a variety of reasons, countries such as China, India, the UK, Romania and Ukraine have been slow on the uptake but are now seriously looking at CBM – as opposed to CMM – as a potentially vital element in meeting their energy demand.

South Africa and Botswana are also in the early stages of understanding the CBM potential in their enormous coal fields.

Russia, despite its abundant resources, has little focus on CBM because it also holds the world's largest reserves of conventional natural gas.

● United States

CBM was first exploited from virgin seams in the US in the 1970s since when production has grown significantly. The first commercial production is believed to have taken place in 1979 from Amoco's Cedar Hill field in the San Juan Basin. However, US Steel, working with the US government began a project in 1976 in the Appalachian Basin that some say laid the foundation for today's business.

According to the latest available figures from the country's Energy Information Agency (EIA), CBM accounted for about 9.9% of US gas production in 2004, and the country remains the world's largest producer.

The nation's in-place potential resources stand at some 740 tcf with more than 160 tcf currently recoverable, reckons the Gas Technology Institute.

In 2005, America's proven remaining reserves stood at about 19.6 tcf, equivalent to some 10% of the nation's total dry gas resources.

High energy prices in the 1970s and advances in drilling technology increased interest in CBM, but the key event that truly stimulated investment was Section 29 of the 1980 Crude Oil Windfall Profits Tax Act. This allowed companies to benefit from a tax credit amounting to about \$1.05 per 1,000 cubic feet of gas produced from unconventional reservoirs, giving a major boost to project

economics. Although the tax credit was stopped in 1993, gas produced from wells drilled before that time benefited from the arrangement until the end of 2002.

It was not until the mid-1980s that technology moved on sufficiently to improve economics at the same time that new CBM basins were being discovered, particularly in the Rocky Mountains. The two key technology drivers were horizontal wells that could exploit thin seams and techniques to create artificial cleats, or fractures in the coal through which methane could flow to the surface.

The San Juan Basin, which straddles the New Mexico-Colorado border, was not only the first major CBM play developed in the US in the 1980s, but it has been the most prolific with the key players being ConocoPhillips and BP. According to the EIA, this basin had produced 66% of all the country's CBM by the end of 2006, equivalent to just over 13 tcf. But output started to edge down





slightly in 2000 as the major fields matured.

The Black Warrior Basin in Alabama has also passed its peak. First brought online in the early 1990s, this play had pumped out about 1.9 tcf by the end of 2006, equating to around 9% of cumulative US output.

It took until the mid-1990s for the CBM business to expand beyond these basins, and some of the nation's most promising new plays lie in Wyoming. The Powder River Basin was producing 1 bcf per day in 2004, mainly from shallow coal seams. Recent years have witnessed increased exploitation of deeper coal seams. Such has been the scale of activity in this basin since the late 1990s that, as of two years ago, it had accounted for 12% of all CBM produced in the US, equivalent to about 2.3 tcf.

The Central Appalachian Basin is another significant producer with a large part of its output emanating from Virginia's Pocohontas sub-basin. By 2006, it had produced more than 770 bcf, some 4% of the country's total.

The Uinta Basin in Utah matches the Central Appalachian Basin for size and is estimated to have been responsible for sending out some 760 bcf by late 2006. However, it now appears to be in decline.

The Raton Basin, straddling the New Mexico/Colorado state line, was initially a challenging and costly play due to its geology and remote location. But investment in new technology and gas gathering infrastructure has borne fruit and by late 2006 Raton had produced some 625 bcf of CBM, 3% of the US total.

In Colorado's Piceance Basin, ambitious companies have proved that very deep seams – down to 2,300 metres below surface – can be commercial. Other minor producing basins include Arkoma, Cherokee, Northern Appalachian, Greater Green River and Wind River. Between them, about a dozen of these smaller plays had supplied about 2% of the country's CBM through to the end of 2006.

In terms of remaining resources, the San Juan Basin again dominates the scene with about 43% of proven reserves, equating to some 8.5 tcf. Four

other basins each account for more than 10% of remaining reserves: Raton (14% or 2.8 tcf), Powder River (12%; 2.4 tcf), Black Warrior (10.5%; 2.1 tcf) and Central Appalachian (10.1%; 2 tcf).

In terms of future resources, the situation changes dramatically. According to the non-profit US Potential Gas Committee, made up of people from academia, industry and government, the nation could hold a further 158 tcf of extractable CBM.

The mature San Juan Basin represents only 5% of this resource and Raton just 3% while Alaska dominates with 35% – equating to about 57 tcf – spread across multiple basins.

Powder River has the second highest potential (11% or 18.5 tcf) followed by the Michigan Basin with 17.3 tcf. Other smaller basins include Hannah-Carbon, Southwestern and Forest City, which each host about 4% of future resources.

● Canada

Canada is estimated to contain between 187 and 460 tcf of in-place CBM, according to the Canadian Gas Potential Committee (CGPC).

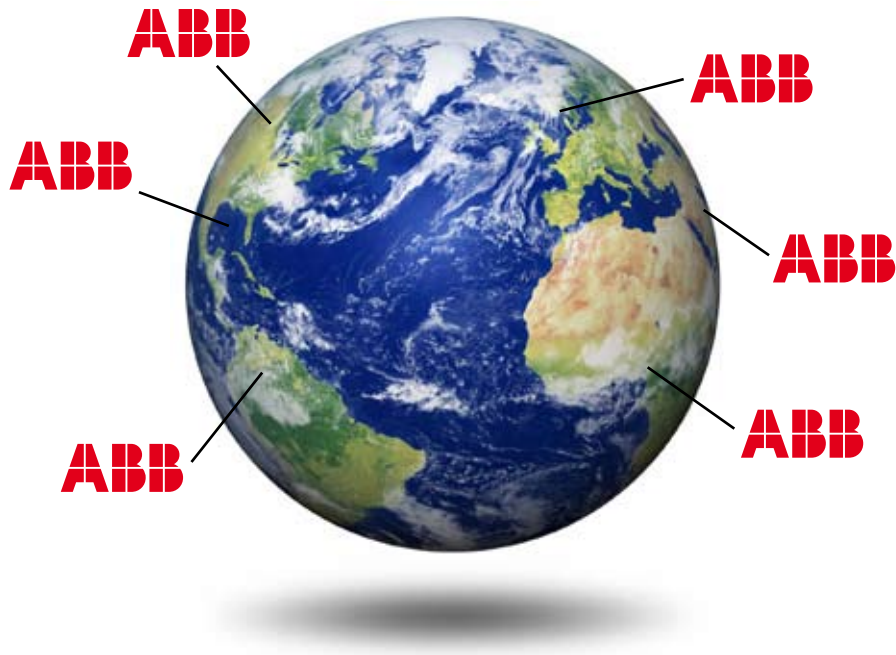
Alberta, which has six producing and potential CBM plays, dominates production which began in 2002. The remaining output comes from British Columbia while there is also potential in Nova Scotia.

Potentially the most prolific play, according to the CPGC, are Alberta's Manneville coals which hold about 123 tcf of in-place reserves although only about 8 tcf is currently recoverable.

Horseshoe Canyon – where CBM was first produced – has far less gas-in place, some 54 tcf, but recoverable reserves stand at about 9 tcf. Accordingly, this is Canada's prime CBM zone because its dry gas does not need to be dewatered. In 2007, it accounted for about 85% of the country's output.

The third major play in Alberta is called Ardley and its in-place resource stands at some 54 tcf of which 5 tcf may be extracted. Kootenay, Belly River and Luscar are the other, much smaller CBM producing areas.

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At the end of 2006, Albertan production had reached about 450 million cubic feet per day (Mmcf) while output in 2007 was estimated to have shot up to 750 Mmcf, accounting for about 5% of Canadian gas output.

Canada's National Energy Board forecasts that production could reach 860 Mmcf in 2010.

● **Other commercial players**

Outside North America, Australia, India and China are currently the only other commercial CBM producers of note although pilot production is underway in countries such as the UK, France, Germany, Colombia, South Africa and Botswana.

Commercial CBM production began in the Australian state of Queensland in 1996, providing pipeline-quality gas to three coastal cities, and by 2005 was estimated to be meeting just under half of eastern Queensland's gas demand. CBM is also produced in New South Wales.

Queensland's in-place reserves stand at about 141 tcf while New South Wales' figure is 130 tcf and the states between them house the majority of Australia's total reserves of 282 tcf.

Queensland's resources in particular are proving attractive to major companies such as Petronas, BG and ConocoPhillips, who have been acquiring local players with plans to use the CBM as feedstock for a number of LNG export projects.

India's CBM potential resources are thought to be about 92 tcf, with more than a quarter in Jharkhand and a further 25% or so spread equally between Rajasthan and Gujarat. The country has been trying to develop its resources for a decade or so, partly aided by UN funds.

A CBM strategy was formulated in 1997 and licensing rounds took place in 2001, 2003 and 2006. These resulted in the award of 26 blocks thought to contain 50 tcf of CBM and upwards of 230 wells have so far been drilled on this acreage.



The first stage of the Spring Gully CBM development in Queensland, Australia, was completed in June 2005. Up to 400 wells are expected to be drilled in the area over the next 20 years.

The first commercial production began in July 2007 and the government reckons that Indian CBM output could reach 260 Mmcf by 2012-2013.

China has large CBM resources; some 1,236 tcf, according to China University of Petroleum, with almost 85% lying in the country's north and northwest provinces.

In 1994, an organisation was established to boost understanding and awareness of China's potential and this appears to have done the trick with production kicking off in 2005. It reached 49.5 bcf in 2006 and Beijing is targeting an output of 353 bcf by 2010. Two of the key players are state-owned Sinopec and PetroChina.

● Countries with CBM potential

Russia has huge potential CBM resources – between 2,650 and 2,825 tcf – some 350 tcf of which lies in the Kuzbass Basin, about 120 tcf in the Pechora Basin and more in the remote Tungusk Basin. While little effort has been put into developing CBM so far, the country has established Uglemetan, an autonomous, not-for-profit organisation dedicated to promoting CBM recovery and use in Russia and its near neighbours.

In Ukraine, a plethora of legal, technical and infrastructure issues and a lack of governmental support have hampered CBM development to date. However, initiatives are underway to change this situation. Ukraine's reserves are estimated at 60 tcf.

Kazakhstan has significant resources, possibly as high as 31 tcf and mainly held in the Karaganda Basin.

Europe is expected to be the next region to see a rapid increase in CBM output.

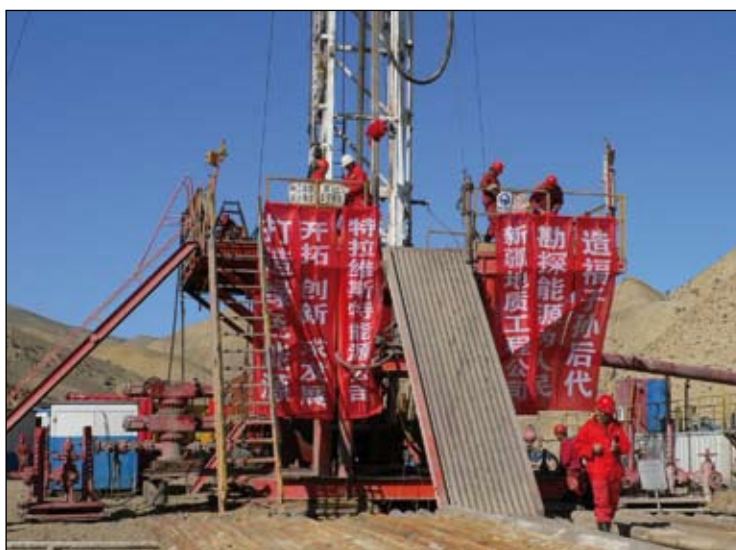
In the UK the key coalfields with CBM potential lie in central Scotland, South Wales and northern England and most of the good acreage has been licensed. Initially the sector was dominated by smaller companies, but in the last few licensing rounds the UK's potential has been recognised by bigger companies. The country's resource is estimated at some 102 tcf.



A CBM well in Jincheng, Shanxi Province, China. Utilising multi-lateral drilling techniques has made the well 40 times more productive than vertical drilled wells in the region.

There is no CBM recovery from virgin coal seams in Germany at present although the country has potential in-place resources of 100 tcf.

Poland has about 56 tcf of in-place CBM but no production as yet. Bulgarian CBM resources lie in the Dobroudja Basin and are estimated to be about 7 tcf, while the Czech Republic's potential is limited despite initial efforts. Hungary, however, could hold about 5.6 tcf of CBM in the Mecsek Basin where pilot tests are planned in 2009.



Also in China is this CBM well in the Lihuanggou area of Xinjiang province, part of a project involving the first CBM production sharing contract signed between PetroChina and a foreign company – Petromin Resources of Canada.



Further east, Turkey could hold substantial resources – some 105 tcf – in the Zonguldak Basin.

Southern Africa also holds great CBM potential and its exploitation could help reduce wood burning and also improve the balance of payments. Moreover, some observers suggest the region's CBM resources could match North Africa's conventional gas resources.

South Africa's CBM resource is estimated to be almost 10 tcf. There is currently no commercial production but pilot wells have been drilled. The most promising areas are the Waterberg basin and the Highveld coalfield.

Botswana has a significant CBM resource, thought to be around 200 tcf, held in Central Kalahari/Karoo Basin where small companies are starting to test the potential with pilot wells.

In Asia, Indonesia's CBM resources range from 337 to 453 tcf with the most promising areas believed to be in Kalimantan, Sumatra and Java.

CBM exploration is also underway in Argentina, Chile, Mexico, Mongolia, Pakistan, Vietnam, Thailand, New Zealand, Spain, France and Italy.

● Exploiting CBM

There are two distinct types of CBM which, while mainly consisting of methane, can also contain CO₂ and nitrogen.

Biogenic methane is generated from bacteria in organic matter and is typically a dry gas usually found at depths of less than 300 metres in coals with a lower carbon content.

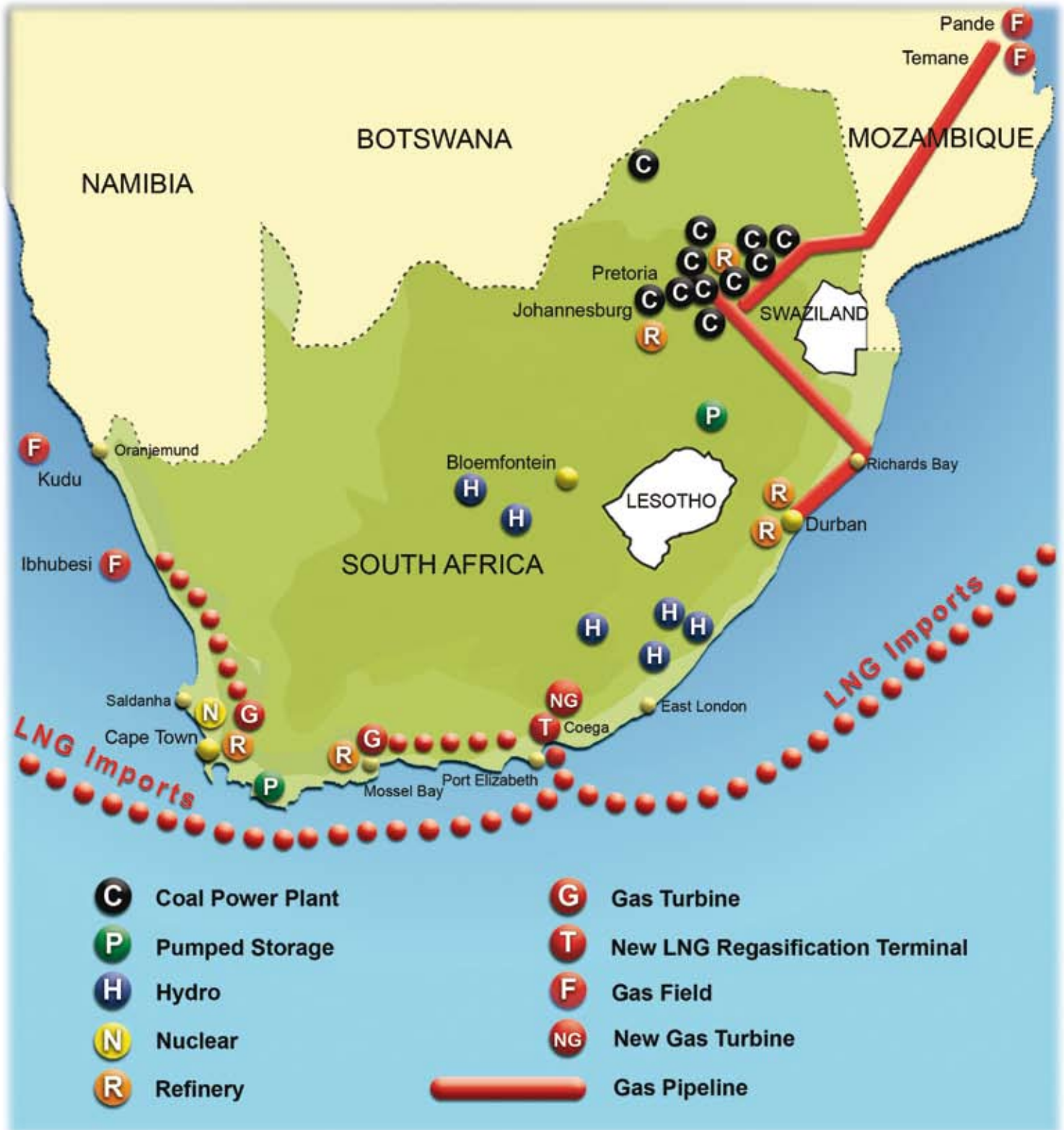
Thermogenic methane, on the other hand, forms when heat and pressure transform organic matter found in coal into methane. This is typically a wet gas and is likely to contain small amounts of water, CO₂, nitrogen and hydrogen sulphide. It is generally found at greater depths than biogenic methane in coals with a higher carbon content.



A pilot test well in Airth, Scotland, the appraisal of the coals in this area is the most extensive so far in the UK.

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Both types of CBM, especially biogenic, need little if any processing to meet pipeline specifications.

Many coal beds hold methane but whether this can be extracted depends a lot on the coal's permeability. As a rule of thumb, one cubic foot of coal can contain between six and seven times the volume of natural gas found in a cubic foot of a conventional sandstone reservoir.

Hydrostatic pressure causes methane to bond to coal surfaces via a phenomenon known as adsorption. If reservoir pressure is reduced by slowly extracting all water from the coal – a technique called dewatering – this breaks the chemical and physical bonds that bind methane to the coal – a process called desorption. The methane can then flow through a network of natural fractures in the coal seam called cleats. If vertical, horizontal or multi-lateral wells are drilled into these cleats, then methane can flow to the surface, be gathered, processed and piped to markets.

Initially pumps will be installed downhole to help extract the water which in most cases is ancient seawater that, once iron has been extracted, can be pumped into the sea or reinjected.

If needed, dewatering of a coal seam must take place before methane can be extracted but this can take some time – in some cases as long as three years – before the process is advanced enough to indicate whether a particular seam is able to produce commercial quantities of CBM.

Drilling and completing a CBM well usually takes between two days and one week because, compared to conventional gas wells, the gas reservoir (that is, the coal seam) is usually at a much shallower depth sub-surface. Accordingly, CBM wells are also cheaper to drill and gas methane production can begin shortly after completion.

The type of cleat system will determine the type of well that can be used and whether the flow of methane needs to be enhanced artificially.

The life of a CBM well can be very long – as much as 50 years – but production rates and pressures remain low throughout that time, as a result of which compression is required to increase the pressure to pipeline specifications.

To boost recovery, injecting high pressure water into coal creates man-made cleats, while a technique called cavitating enlarges an original well-bore and links it with a cleat system in one or more coal seams.

The injection of CO₂ into unmineable coal beds is also being researched as a possible method of accessing CBM because coal seams have an enormous capacity to store CO₂ which would then displace the methane. This could be linked to carbon capture and storage projects.

According to the US Department of Energy (DoE), the net result would be less CO₂ in the atmosphere, and additional recovery of sorely needed gas. "Although technical and economic hurdles remain, successful research can provide a new solution to our energy and environmental concerns," says the DoE.

An entirely different process of exploiting CBM can take place after a mine has collapsed. The mine debris, known as "gob", also holds methane which can be recovered via wells. Gob gas initially consists of 30-80% methane, although over time, as it mixes with air, its quality declines. Nevertheless, it can be used by power stations and heating providers, two end-users that can handle CBM of variable quality.

As with extraction of any natural resource, commercialising CBM can have its drawbacks. One of the biggest issues is how best to dispose of produced water which can be contaminated with mine waste. In addition, accessing CBM resources can mean drilling wells in environmentally sensitive areas, so licensing, environmental approvals, planning and legal issues all need to be addressed carefully.

Iain Esau is the London correspondent of the international oil and gas newspaper Upstream.

About the National Hydrocarbons Corporation

The National Hydrocarbons Corporation of Cameroon (known by its French acronym as SNH) is a State-funded industrial and commercial company which has financial autonomy and its head office in Yaoundé.

Created on 12 March 1980, its mission is to promote the development of liquid hydrocarbons and natural gas in Cameroon, as well as export projects when the need arises; and to manage State interests in this domain.

As such, it is empowered to:

- ▶ carry out all studies related to liquid hydrocarbons and natural gas;
- ▶ collect and store all information related thereto;
- ▶ negotiate oil and gas contracts, in relation to ministries in charge of Mines, Economy, Environment and Trade;
- ▶ ensure professional training and further training of Cameroonian staff;
- ▶ carry out all commercial, movable and property directly or indirectly related to the corporate;

- ▶ effect all financial operations jointly with the Ministry of Finance;
- ▶ promote the realisation of natural gas transportation and treatment on the national territory;
- ▶ collect natural gas from producing companies and its transportation to industries, power producers, other eligible customers, gas distribution companies and treatment sites intended for gas exportation;
- ▶ monitor the execution of oil and gas contracts signed between the State and companies operating in the liquid hydrocarbons and natural gas sectors;
- ▶ sign, when the need arises, all contracts with companies operating in the production, transportation, distribution, processing or storage of liquid hydrocarbons and natural gas, based in Cameroon and with technical and financial capacity.

SNH markets, on the basis of contracts signed with international partners, the share of national crude oil production accruing to the State. Income derived from such sales is transferred to the Public Treasury after deducting all costs.



The National Hydrocarbons Corporation of Cameroon

Promoting the development of national gas resources

Major projects

● Power generation from gas

Gas resources from Sanaga Sud field will supply the thermal power station due to be constructed at Kribi. This station will have an original installed capacity of 216 MW, which could be increased to 330 MW. Also, studies have been completed with a view to supply the Logbaba gas resources to a thermal power station which will be constructed near Douala.

● LNG export project

The alternatives of this project include an LNG plant offshore or onshore in the Kribi or Limbé area. Studies on the way include, notably, extraction of liquefied petroleum gas (LPG) for domestic needs; the production of condensates necessary to increase supply of local crude oil to Cameroon's refinery, and the creation of additional

capacity for power generation.

● Supply of gas to industries

Part of the estimated 53 billion cubic feet Logbaba gas reserves will be supplied as fuel to industries in the industrial zone of Douala.

● Construction of liquefied petroleum gas (LPG) storage tanks

Three storage tanks with a total capacity of 8000 m³ will be constructed at Kribi in 2009. The second phase of the project will cover the following towns: Douala, Yaoundé, Ngaoundéré and Maroua.



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Natural Gas for Decentralised Power Generation – A Global Opportunity

By David M. Sweet and Sridhar Samudrala

The global economy is facing massive challenges in the coming years – how to recover from the financial meltdown of 2008 while, at the same time, combating the growing threat of climate change. With the closing of a year that saw fossil fuel prices climb to dizzying heights only to crash back down to earth, energy management and efficiency will continue to be a major global issue. Decentralised energy (DE) technology, which is on the shelf today, is one of the best investments that can be made in terms of financial and environmental payback.

Research carried out by the World Alliance for Decentralised Energy (WADE), the world's leading non-profit organisation focused on decentralised generation technology, policy and investment issues, has consistently demonstrated that as more DE is deployed, not only does the environment improve through reduction of CO₂ emissions as well as other pollutants, but that delivered electricity costs are also reduced because of the efficiency gains through local power generation. Take the US, for example, where a recent report issued by the Oak Ridge National Laboratory discussed the benefit of combined heat and power (CHP) as an effective solution for a sustainable future. There were a number of striking findings in the report. The US currently gets about 12% of its power generation from CHP, and this alone is responsible for avoiding 248 million tonnes of CO₂ emissions (the equivalent of removing 45 million cars from the road). With the right mix of policies the US could get 20% of its power from CHP, allowing it to save over 800 million tonnes of CO₂ per year, generate \$234 billion in new investments and create nearly 1 million new jobs.

As natural gas supplies become available in new markets through pipeline projects and the expansion of LNG deliveries, the potential to expand the local production of electricity fuelled by clean natural gas and the ability to realise significant environmental and economic benefits, has never been greater.

The wider use of DE is a key solution for bringing about the cost-effective modernisation and development of the world's electricity systems. The role of decentralised generation in driving sustainable energy solutions is complementary to, rather than a substitute for, centralised generation. This is achieved through CHP or cogeneration, which is an efficient, clean and reliable approach to generating electricity and heat energy from a single fuel source. Installing a CHP system designed to meet the thermal and electrical base loads of a facility can greatly increase the facility's operational efficiency and decrease energy costs. At the same time, CHP reduces the emission of greenhouse gases which contribute to global climate change. When electricity is produced on-site with a CHP plant, excess heat is recycled to produce both processed heat and additional power. To sum up, the advantages of CHP are:

- Cost savings for the energy consumer;
- Greater efficiency of energy use;
- Lower CO₂ emissions;
- Increased diversity of fuel mix through the use of waste, biomass and new natural gas supplies;
- Ability to produce energy where it is needed, avoiding transmission and distribution network losses;
- Ability to recapture and use the heat normally wasted in power production, greatly increasing the efficiency of overall fuel use;
- Can be applied to a wide variety of applications including district heating, industrial facilities and commercial complexes, using a broad array of technologies and fuels;
- Reduced investments in energy system infrastructure; and

- Enhanced energy network reliability and resilience.

Beyond the environmental, economic and efficiency drivers behind the move to DE, benefits include the ability to provide improved energy security and reliability of service. In politically unstable areas of the world where a diverse portfolio of generating assets offers enhanced protection against physical attack, a decentralised approach offers greater security that electricity will continue to flow. However, even in areas of the world where a relatively sophisticated and stable grid is in place, the increased presence of intermittent renewable resources, such as solar or wind power, means that strategically located decentralised power generation is required to assure system reliability and balance out interruptions that would otherwise occur when the wind stops blowing or the sun does not shine.

● CHP in China

According to the International Energy Agency (IEA), China's CHP market has developed significantly in recent decades, as shown in *Figure 1*. At present, China is second in the world in installed CHP

capacity, which by 2005 reached almost 70 GW of capacity, with an increasing annual growth rate of 18.5% from 2001-05. During this time, the share of CHP capacity in thermal generation increased from 11.3% in 1990 to 17.8% in 2005.

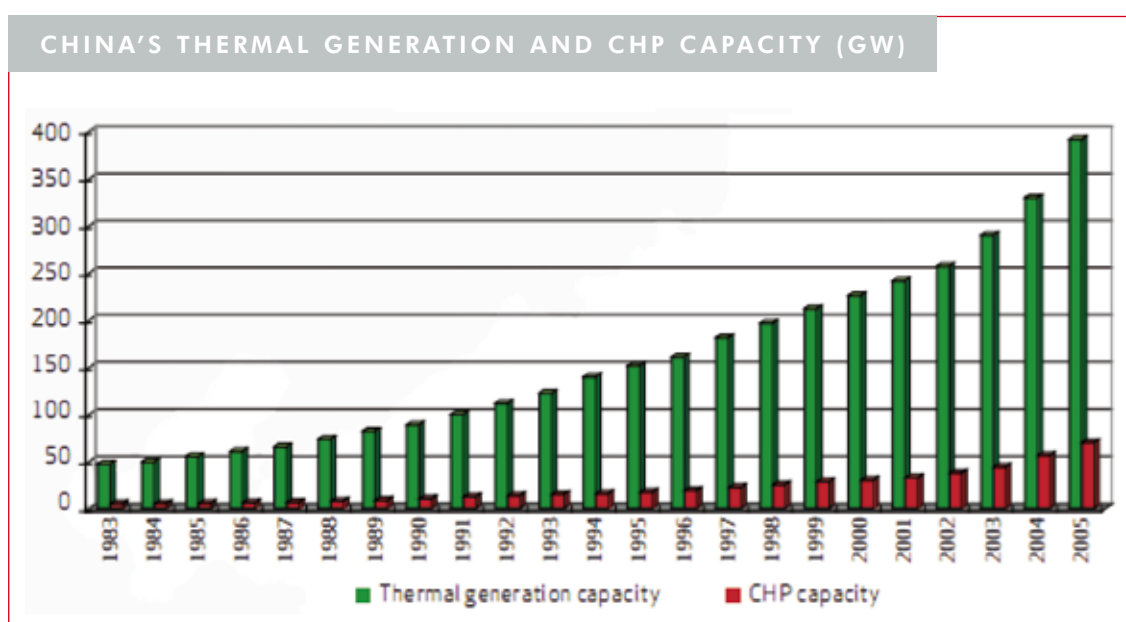
Over the past several decades, China has issued a series of policies to promote CHP. However, there is still tremendous potential for the expansion of CHP in the country.

WADE, with support from the US Department of State and the Asia-Pacific Partnership programme*, has brought together a team to analyse the potential for CHP in China and build support for greater deployment of the technology in regions with access to natural gas supplies. China has significant opportunities to improve its energy efficiency and reduce CO₂ emissions from its use of coal in the industrial, building and energy transformation sectors. Expanding the use of CHP at the industrial level can help reduce this energy consumption, especially since typical heat-only boilers in China tend to be quite inefficient by international comparison.

The best applications for CHP are those that can meet high coincidental thermal and electric loads

*For more information on the Asia-Pacific Partnership on Clean Development and Climate see www.asiapacificpartnership.org.

LEFT
Figure 1.



that persist most of the year. The high thermal loads of district heating plants make them an excellent fit for expanded CHP deployment if the electricity can be sold to the grid or used by industry. If trigeneration is used to produce heat, electricity and cooling, the efficiency rate can reach 90%. Achieving this level of overall efficiency and diversifying the types of fuel used for supplying power and thermal energy could have an enormous impact on China's future energy consumption and resulting CO₂ emissions.

Roughly half of China's population lives in northern regions where temperatures fall below 4°C for more than 90 days every year. China's urban residential stock is expected to more than double over the next 20 years, which will result in greater demand for space heating and other home energy uses. Increasing the use of CHP in large buildings and in district heating could significantly help manage energy demand and mitigate the associated environmental impact.



China has significant opportunities to improve its energy efficiency and reduce CO₂ emissions from its use of coal.

Natural gas is a clean fuel that is very commonly used in CHP applications around the world. Today, China is highly reliant on coal, but it has plans to increase natural gas supply. Natural gas made up 3.2% of total primary energy consumption in 2007, a far lower rate than the world average of 24% and the average level in Asia, which was 10.6% in 2007.

Natural gas demand will grow at a greater rate than that of coal and oil in the decade to come, due to the gradual improvement of natural gas infrastructure and market developments in China. Some 5,000 MW (or 1.7%) of thermal-fired power was generated with natural gas in China in 2003. It is estimated that natural gas demand will be 100 bcm in 2010, 150 bcm in 2015, and 200 bcm in 2020. The share of natural gas in primary energy consumption will reach 6% in 2010 and approximately 9% in 2020.

Currently, China gets natural gas from three main sources:

- Imported LNG, through a limited but growing number of LNG terminals;
- Domestic offshore gas production; and
- Domestic onshore production via the West-East gas pipeline, which is the largest of the sources.

However, there are a number of barriers to CHP in China which must be overcome, including:

- Uncertainty during reforms;
- Shortage of domestic equipment suppliers and CHP professionals;
- Lack of experienced energy management companies (EMCOs);
- Interconnection policy;
- Electricity pricing;
- Lack of access to financing for small and medium-sized CHP projects;
- Lending controls; and
- Implementation of the Clean Development Mechanism (CDM).

The WADE team will work to address these barriers and arrive at a number of national and



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provincial level policy recommendations that will allow CHP technology to flourish.

● CHP in India

Industrial CHP has been of interest in India for over a decade on account of the government's need to supplement unreliable grid supplies and the desire to use scarce energy resources more efficiently. Due to its low cost and domestic availability, coal is the dominant fuel source for electricity generation in India, and its use is forecast to grow between now and 2030 (see Figure 2). For this reason, India is investing in a number of coal-fired power plant efficiency measures. However, these strategies are only part of the solution. There are important options for CHP in the industrial sector that can contribute to cleaner power generation.

Using the best available data, the IEA estimates that in 2005, CHP capacity in India was over 10 GW from over 700 units, with a heat-generating capacity of 170 MW. This is about 5% of the total electricity generated. There is currently no district heating in India for climatic reasons and district cooling is as yet not in use, but holds promise.

The prospect for CHP growth appears promising as increased competition and higher energy costs



CNG use is slowly gaining ground in India.

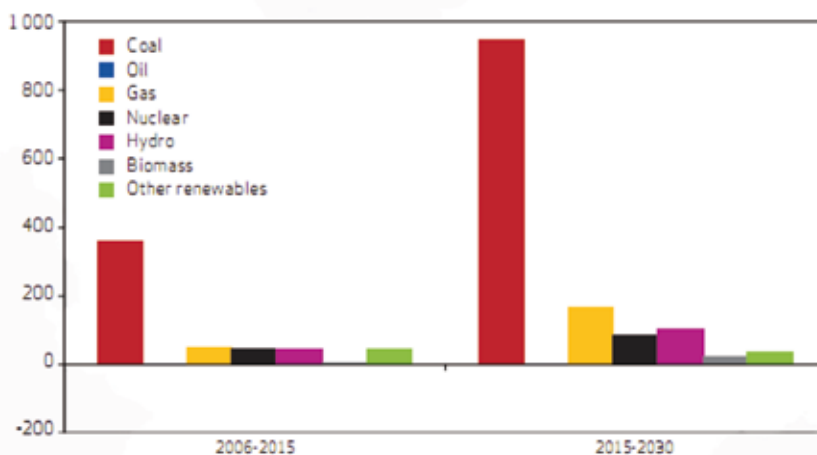
drive industries and commercial establishments to attain greater energy efficiency and “total” solutions to meeting their energy needs. Further, the Electricity Act 2003 provides for liberalised generation

policies, and for greater use of distributed generation. As a result, malls, offices and residential complexes in Mumbai have begun to use CNG to fuel small generation sets. This presents an opportunity to use waste heat to provide space cooling.

In India most industrial facilities are connected to the main grid for their power needs. High energy costs and lack of reliable power have led some industrial plants to invest in on-site generation via CHP. While this is a start, there

BELOW
Figure 2.

PROJECTED CHANGES IN INDIA'S ELECTRICITY GENERATION MIX



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appears to be substantial additional potential for CHP and district cooling uptake if key barriers can be addressed. Some barriers include the following:

Legislative and policy

While some policies have been enacted (e.g., the 1993 Cogeneration Policy and approval for feed-in tariffs for CHP), there is insufficient government expertise on CHP. This has led to the lack of a clear definition of cogeneration or CHP. (Cogeneration is often assumed to be limited to CHP fired by bagasse, the fibrous residue remaining after sugarcane or sorghum stalks are crushed to extract their juice.) Furthermore, no detailed study of India's CHP and district cooling potential (and associated benefits) has been completed. Such a study could provide a foundation for future expansion.

Technological constraints

City gas is currently restricted to LPG for cooking and CNG for vehicles, with very limited use for space heating. While CNG use is slowly gaining ground, city gas investments cannot be sustained by LPG use in households. Thus, only certain areas

in the proximity of gas sources have distribution pipelines for local household or commercial use.

WADE has been working with the IEA to study the market for CHP in India and communicate the potential for the country. The Indian government and industry are beginning to take important steps, however, there is still much more to be accomplished.

● CHP in other developing markets

While China and India have been the major developing economies that are driving global energy demand, there are interesting developments elsewhere. For example, in Peru, where the Camisea pipeline is allowing access to natural gas supplies that were previously unavailable, a modern 56 MW cogeneration plant was recently brought on-line. In countries with ample developed energy supplies, such as Australia, Canada, the UAE and the US, growing concern about climate change and energy efficiency is producing new and interesting opportunities for investment in CHP. In the US, President Obama has announced that clean energy growth will be one of the major objectives of his Administration. Furthermore, in Japan and the EU there is growing interest in micro CHP applications for residential consumers. Natural gas will be the fuel of choice to provide these homes with heat and power through this emerging technology.

To sum up, the political, economic and environmental climate has never been better for dramatic change in our energy infrastructure. The market for natural gas based decentralised energy solutions is bright, as is the future of the companies with the technology and know-how to meet this growing opportunity.

David M. Sweet is the Executive Director of the World Alliance for Decentralised Energy and Sridhar Samudrala is WADE's Director in Asia. For more information on WADE please see www.localpower.org.



Sudamericana de Fibras (SdF) became the first company in Peru to use natural gas from the Camisea field for cogeneration in July 2006 and recently developed a second and much larger cogeneration plant. On site in the picture are Enrique Gubbins, General Manager of SdF, and Katharine Fierro, Country Manager – WADE Peru.



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