A REVIEW OF RECENT NATURAL GAS DISCOVERIES IN CHINA

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China is thirsty for energy as they modernize and industrialize their economy. As part of their attempts to fill the need, Chinese companies (especially SINOPEC and the Chinese National Petroleum Company [CNPC]) have increased their search for new gas reserves and they have been successful. There have been significant new finds in Sichuan in the southwest, Xinjiang in the west, and other locations as well. The new fields include some of which are very sour such as Luojiazhai and Puguang, both of which have about 10 to 15% hydrogen sulfide.

Major pipelines are being developed to move the gas to markets in the east. Some of the new pipeline developments will also be discussed in this review.

In addition, China is the largest sulfur importing nation in the world. Production of sulfur from their sour gas reserves will lessen China's demand for foreign sulfur and have a significant impact on the global sulfur market. The impact of the potential production of sulfur from sour gas on the sulfur market will also be examined.

1. HISTORY

There is a long history of production of natural gas in China. During the Han Dynasty (ca. 200 BC to 1 AD), the Chinese drilled shallow natural gas wells and transported the gas in bamboo pipes for fuel and lighting. In the modern era China has relied on all fossil fuels to fill their energy needs, but coal remains their dominant fuel.

Figure 1 shows the fossil fuel (coal, oil, and natural gas) consumption for China from 1965 to 2005. The values for coal and natural gas are expressed in terms of oil equivalent in order to make the comparison on a common basis. Furthermore, one must be careful reading this graph because the ordinate is a logarithmic scale. Data for this graph are taken from the *BP Statistical Review*[1].

The first thing that is clear from this plot is that energy consumption is increasing in China. Over the forty years shown on the plot, energy consumption based on fossils fuels has increased tenfold. Also from this graph it can be seen that the consumption of oil is about 10 times that of gas and in turn the consumption of coal is about 10 times that of oil and these ratios remain relatively unchanged for the 40 years shown on the plot.

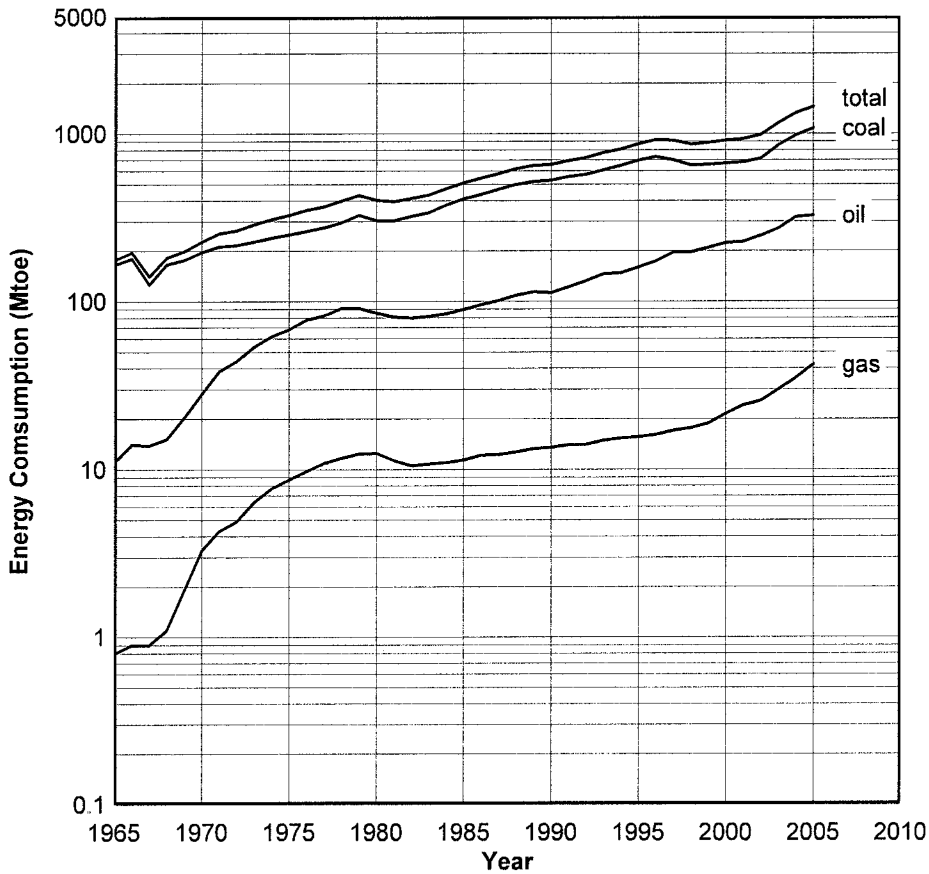

Fig. 1 Historical Data for the Consumption of Fossil Fuels in China

China is the world's largest producer and consumer of coal. Much of the coal is used as fuel in coal-fired electrical plants.

1.1 Natural Gas

Now focusing on natural gas, Fig. 2 shows the consumption and production of natural gas in more conventional volumetric units. These data are also from the *BP Review*[1]. Again the reader is cautioned be careful interpreting this graph because of the logarithmic scale. From Fig. 2 it can be seen that from 1980 to 2005 production increased by slightly more than 3.5 times.

In 1949 the People's Republic was founded and Chinese gas production was only 1×10^9 m³/yr (97 MMCFD); mostly associated gas production from the oil fields in the north-east. Twenty five years later, in 1974 gas production increased to 7×10^9 m³/yr (677 MMCFD), which represents about 0.6% of the total world gas production at that time. In 1999 the People's Republic of China was 50 years old and gas production reached to 25×10^9 m³/yr (2418 MMCFD) but it was still only 1 % of the total world gas production.

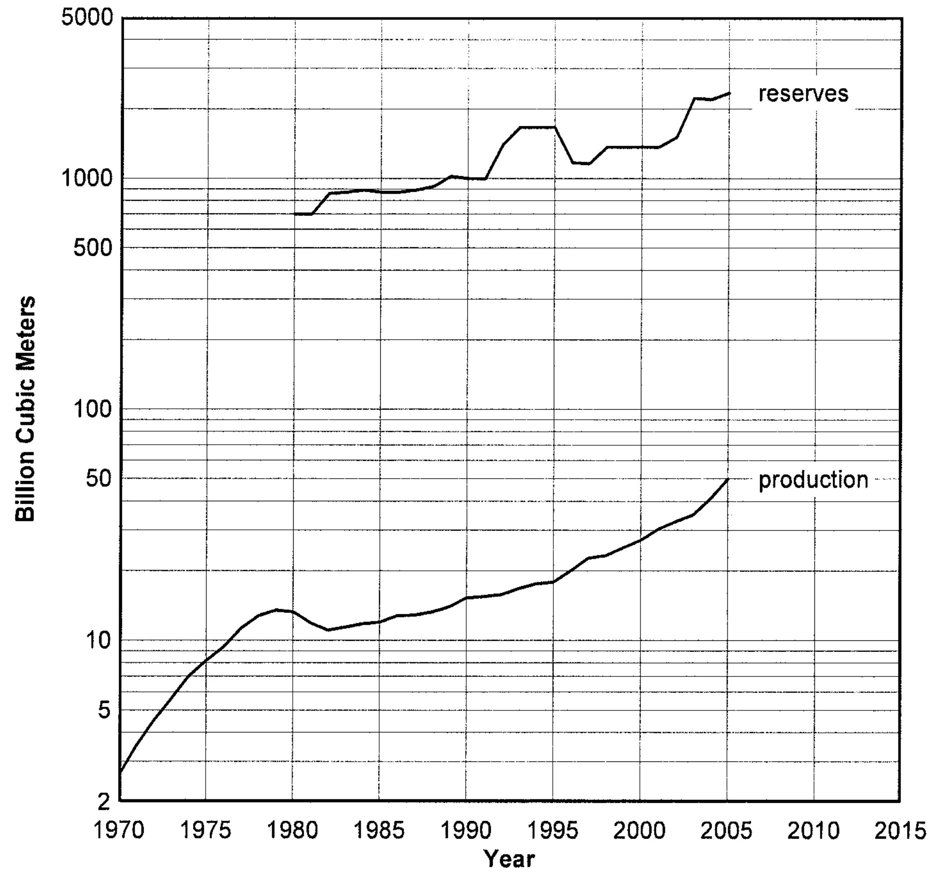

Fig. 2 Production and Proven Reserves of Natural Gas in China

Today the economy of the People's Republic of China is rapidly expanding. China has become one of the largest gas producing countries in the world. Total gas production in 2006 increased to 59×10^9 m³/yr (5700 MMCFD) and they rank as the 11th largest gas producing nation in the world, producing only slightly less natural gas than the oil-giant Saudi Arabia[2]. Chinese production for 2006 is about 2.2% of the total world production.

Not only did production increase but proven reserves also increased significantly as new fields were found. Proven reserves increased by approximately 3.5 times from 1980 to 2005. Based on the data for the year 2005, the Chinese have sufficient reserves for almost 50 years at the current consumption rate.

Most of the gas in China is produced by China National Oil Company (CNPC), China's largest petroleum company and one of the largest companies in the world. However significant amounts are also produced by China's other two large petroleum companies: SINOPEC and China National Offshore Oil Company (CNOOC). These three companies are listed on the world's stock exchanges, but there remains significant state involvement in these companies. Production from these companies is listed in Table 1 since 1995. From this table it can be seen that historically CNPC produces more than 75% of China's natural gas.

Table 1 Historical Natural Gas Production in China by Company ($\times 10^9$ m^3/yr)[3,4]

Year	CNPC	SINOPEC	CNOOC	Private	Total
1995	15.96	0.00	0.77	1.25	17.98
1996	16.49	0.00	2.82	0.98	20.29
1997	17.27	0.00	3.86	1.46	22.59
1998	15.02	2.45	3.63	1.44	22.53
1999	16.81	1.42	4.41	1.92	24.56
2000	18.35	3.67	3.67	2.15	27.85
2001	20.66	4.15	4.20	1.62	30.63
2002	22.45	5.14	3.82	1.85	33.27
2003	24.75	5.63	3.53	0.31	34.22
2004	29.08	5.10	3.84	1.05	39.06
2005	36.95	6.09	4.10	0.77	47.91
2006	44.21	7.06	6.21	1.07	58.55
2007[5]	54.20	8.02	5.63	1.47	69.31

In the new economy emerging in China more and more private companies are also producing natural gas. Also shown in Table 1 is the production of gas from private companies in China.

1.2 Sulfur

Figure 3 shows the annual production of sulfur in China in all forms. This figure also shows the production of elemental sulfur. Although there are changes from year to year, the average over the 13 years shown is 7.3 million tonnes per year (7.3 Mt/yr) and a maximum of about 9 Mt in 2004[6].

Pyrite is an iron sulfur compound (FeS_2), which is not a primary ore from iron but have been used worldwide as a source of sulfur. However, in China a significant amount of sulfur production comes from pyrites, about half of their total sulfur production comes from pyrite.

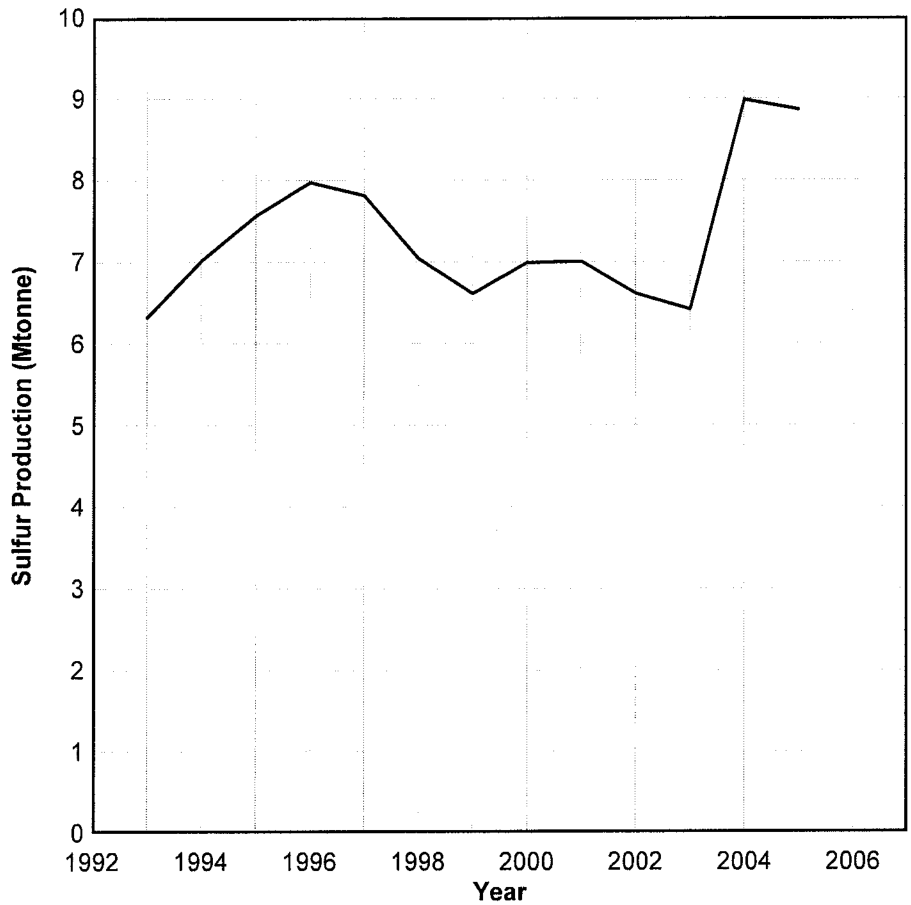

Fig. 3 Annual Production of Sulfur in China in All Forms

2. THE FUTURE

As can be seen from Fig. 2 and Table 1, gas production in China has increased over the last decade (1995 to 2004) by a factor of more than three. On average, production increased by 11.5% per annum over this time period.

Predictions for 2009 the 60^{th} anniversary of the People's Republic gas production is estimated to more than 80×10^9 m³/yr (7740 MMCFD)[7]. Official government predictions are that production will continue to increase with forecasts of 150×10^9 m³/yr (16,450 MMCFD or 16.45 BCF) by 2020[8], which represents a relatively modest 7% per annum increase in production from the 2006 levels.

It is clear that in order to meet such forecasts China is going to have to rely on the newly found reserves, including sour reserves. These new reserves are the subject of the next section of this paper.

Table 2 Summary of Natural Gas Basins in China[9]

Basin	Proven Reserves ($\times 10^9$ m³)	Number of Fields with Reserves Greater than 100×10^9 m³	Number of Fields with Reserves Between 10×10^9 and 100×10^9 m³
Tuha	40	0	2
Zhujiangkou†	50	0	2
Junggar	70	0	3
East China Sea†	120	0	5
Songliao	200	1	1
Yingqionghai†	280	0	3
Qaidam	290	0	4
Bohai Bay	320	0	8
Tarima	740	1	12
Sichuan	1240	1	24
Ordos	1610	6	1
Total	4960	9	65

† – offshore basin

3. NEW DISCOVERIES

There are eleven major basins in China where natural gas has been found, eight onshore and three offshore. Table 2 lists these basins and the map shown in Fig. 4 shows the location of these basins. The significant new discoveries have been in the Sichuan and Ordos basins, which are already the largest basins. The Sichuan and Ordos basins currently account for almost 60% of the reserves in China.

Much of China's sour natural gas is in the Sichuan basin. Table 3 summarizes the gas fields in that area. Not only do these fields contain H_2S they also contain significant amounts of CO_2.

Sour gas production from the northeast Sichuan region (including Puguang, Luojiazhai, Tieshanpo, and Dukouhe) will be 20×10^9 m³/yr (1930 MMCFD) by the end of 2011. Three of these will be examined in more detail in the following sections. The Chinese classify fields based on the H_2S concentration. The classification system is given in Appendix B and will be used here to describe the various fields.

Another significant new find is the Sulige field in the Ordos basin in Inner Mongolia, which is currently the largest gas field in China. This is a sweet gas field, which will also be discussed later.

Fig. 4 Map of China Showing the Eleven Natural Gas Basins

A further noteworthy change in China is the invitation of foreign companies to help produce these sour resources. For example, in June 2007 it was announced that Chevron would help CNPC develop the Chuandongbei gas area in Sichuan[10]. The Chuandongbei area includes Tieshanpo, Dukouhe, and Luojiazhai gas fields. In this arrangement, Chevron would have a 49% interest and CNPC 51%.

At the time of writing this paper there is news of another large gas discovery in the Sichuan basin by CNPC at Longgang. It is unconfirmed, but reserves at the Longgang field may be as high as 700×10^9 m^3 (25 TCF)[11], which would make it larger than Sulige. Because this field is the Sichuan basin, it is assumed that this is also a high-sulfur field, but this too is unconfirmed at this time.

3.1 Puguang Field

Of the new discoveries in Sichuan province the Puguang field is the largest with proven reserves of 356×10^9 m^3 (12.5 TCF)[12,13]. Puguang was discovered by SINOPEC in 2002 and originally it was estimated that the reserves were only 240×10^9 m^3 (8.5 TCF), but this was revised upwards after further exploration. This is currently the second largest gas field in China and the largest sour field.

Puguang is a high sulfur field with hydrogen sulfide concentrations of about 15% and in addition it contains about 9% carbon dioxide.

Table 3 Summary of Some of the High Sulfur Fields in the Sichuan Basin[14,15,16]

Field	Proven Reserves ($\times 10^9$ m³)	H_2S Concentration (%)	CO_2 Concentration (%)
Jinzhuping	2.45	5.00	2.5~3.8
Zhongba	8.63	4.90	5.00
Guanzhiping	13.90	13.74	8.93
Moxi	35.00	1.66-2.35	0.36-0.89
Dukouhe	35.90	15.27	3.29
Tieshanpo	37.40	14.19	6.36
Molonghe	37.90	10.00	8.00
Weiyuan	40.81	0.8-1.4	4.5~6.0
Luojiazhai	58.11	7.13-10.49	10.41
Puguang[17]	356.07	15.50	9.10
Total	626.16	–	–

According to the SINOPEC Puguang gas field development plan, construction has begun on the facilities at Puguang and SINOPEC expects an initial production of 4×10^9 m³/yr (387 MMCFD) by 2008 and 8×10^9 m³/yr (775 MMCFD) by 2010

3.1.1 Potential Sulfur Production

Given that the hydrogen sulfide concentration in this gas is 15%, the production rates given above are equivalent to 2225 tonnes per day of elemental sulfur (8.10×10^5 t/yr or 0.81 Mt/yr) for 2008 and increasing to 4450 t/day (1.62 Mt/yr) by 2010. At current consumption rates, this represents 11% of China's sulfur consumption in 2008 and 22% in 2010.

3.2 Luojiazhai Field

Another recently discovered gas field in Sichuan province is Luojiazhai, which was discovered by CNPC in 1999[18]. This is also designated a high sulfur field with an H_2S concentration between 7 and 11%. The estimated reserves are 58×10^9 m³ (2.05 TCF).

Unfortunately the Luojiazhai field already has a poor history. In December 2003 a blowout from a well drilled in this field released large quantities of hydrogen sulfide that killed approximately 250 people, about 4000 others were hospitalized, and more than 50,000 were evacuated.[19,20] A second blowout from a well in this field in March 2006 was less deadly but still resulted in the evacuation of thousands of people[20]. These tragic accidents almost certainly contributed to the decision to invite foreign companies to cooperate on projects in the Chuandongbei area.

All produced gas from CNPC`s Sichuan gas field will be sent to four gas plants in Chongqing, with the treatment capacity of 16.8×10^6 m³/day (590 MMCFD), and to one plant in Zhongqian county with the treatment capacity of 6×10^6 m³/day (210 MMCFD), which is currently under construction.

3.2.1 Potential Sulfur Production

Consider the potential for sulfur production from the treatment plants in Chongqing assuming the feed gas contains approximately 10% hydrogen sulfide. For the plants processing 590 MMCFD of raw gas, approximately 2260 t/day (0.83 Mt/yr) of elemental sulfur will be produced – about 11% of China's current sulfur consumption.

3.3 Tieshanpo

In 1996, CNPC discovered the Tieshanpo gas field which is in Sichuan province in the region between Xuanhan county and Wanyuan City[21]. This gas field has reserves of 37.4×10^9 m^3 (1.3 TCF). This is a high sulfur field with an H_2S concentration of about 14% and it also contains about 6% CO_2.

CNPC plan to produce 4×10^6 m^3/day (140 MMCFD) from Tieshanpo in 2007. Initially production will be sent to the treatment facilities in Chongqing (see previous section). In addition, CNPC plan to build a special gas plant to treat the gas produced from Tieshanpo gas field. This gas plant will be finished before December 2008 and have a total capacity of 6×10^6 m^3/day (210 MMCFD).

3.4 Sulige Field

Of the new natural gas discoveries in China, Sulige may be the most significant[22,23]. Discovered in August 2000, it has been established as the largest gas field in China with proven reserves of 534×10^9 m^3 (18.9 TCF) and covers an area of 5500 km^2 (0.55 million hectares or 1.35 million acres). The gas in this field is sweet with little or no CO_2.

Sulige is in the Ordos basin, which is at higher altitude than any of the other natural gas basins in China. The geology is complex and has four significant features:

1. Low reservoir pressure
2. Low permeability
3. Very heterogeneous, with poor communication within the formations
4. Low production rates per well

These four features make Sulige a very difficult field to develop – amongst the most difficult in the world. Thus, during the six years from 2000 to 2006, CNPC invested a significant amount of money and manpower to study the Sulige gas field and a development plan was established with work to begin in 2007.

By October 2007 a total 690 production wells had been drilled with an average production rate of 13×10^3 m^3/day (0.46 MMCFD) per well. According to CNPC, Sulige will produce 10×10^9 m^3/yr (960 MMCFD) in 2009 increasing to 20×10^9 m^3/yr (1930 MMCFD) by 2012. This will be the main source of gas for the West-East pipeline.

Since Sulige is a sweet field there is no potential for sulphur production. Processing of this gas will largely consist of dehydration and compression.

4. PIPELINES

At approximately 9.6 million km², China is a large country only slightly smaller than Canada and approximately the same area as the USA. In addition China is the most populous country in the world with a population of about 1,300,000,000 – almost one-fifth of the world's population. Thus it is important to be able to move the gas from the production basins to the markets.

China's oil and gas pipeline industry has a 50-year history. However, in the last ten years this industry has grown rapidly. Currently the total natural gas pipelines in China measure about 30 000 km (18,500 miles)[24]. China has an ambitious schedule for pipeline development. They have plans for an additional 15 000 km (9300 miles) of pipeline to be complete by 2010[25].

In this section some of the new pipeline developments in China are discussed. Table 4 summarizes several significant gas pipelines in China, both planned and completed and Fig. 5 shows a map of China with the routing for some of the lines. A few of these lines will be discussed in detail in the sections that follow.

4.1 First West-East Gas Pipeline

The first West-East Gas Pipeline[26] is 4,000 km (2,485 mile) in length and runs from the Tarim basin in the northwest region of Xinjiang to booming eastern regions of China including Shanghai. Construction began in February 2002 and was completed in October 2004. The line came into operation in December 2004. The total cost was approximately ¥46 billion ($6.6 billion US).

The line is 1016 mm (40 in) in diameter, constructed from API grade X70 steel with a design pressure of 10 MPa (1451 psia). It has a design capacity of 12×10^9 m³/yr (1160 MMCFD), although this can be increased to 18×10^9 m³/yr (1740 MMCFD) if necessary.

The ownership of this pipeline has changed over the years, but the current ownership is a consortium led by CNPC, who control 50%, with partners that include Shell, Gazprom, Exxon-Mobil and SINOPEC.

4.2 Second West-East Gas Pipeline

On February 22, 2008, a commencement ceremony for the Second West-East Gas Pipeline project was held at the Great Hall of the People in Beijing, a rare honor for a natural gas project indicating its national importance. The Second West-East Gas Pipeline project, undertaken by CNPC, began construction in Xinjiang, Gansu, Ningxia and Shaanxi on the same day.

The Second West-East Gas Pipeline[27] will comprise a trunk line and eight branches, with a total length (trunk and branches) of 9000 km (5592 miles) and a total investment of ¥142 billion ($20 billion US). The main line goes from Xinjian with a south branch to Hong Kong and an east branch to Shanghai and traverses 14 Chinese provinces.

Table 4 Summary of Some Significant Recent Chinese Natural Gas Pipelines

Pipeline	Project Dates	Length (km)	Diam. (mm)	Press (MPa)	Volume (10^9 m³/yr)	Cost (10^9 yuan)
West-East #1	2002-2004	4200	1016	10	12	46
West-East #2	2008-2011	9000	1219	12	30	142
Shaanxi-Beijing #1	1991-1997	1256	660	6.4	3.6	6
Shaanxi-Beijing #2	2004-2005	932	1016	10	12	13
Sichuan-Shanghai[28]	2007-2010	1700	1016	10	12	63
Zhongxian-Wuhan	2001-2004	738	711	6.4	3.0	5
Lianzhou-Yinchuan[29]	2006-2007	469	610	10	3.5	1.9
Guangzhou Zhuhai-Zhongshan†	2005-2007	66	660	7.8	1.1	7.2

Pipeline	Project Dates	Length (miles)	Diam. (in)	Press (psia)	Volume (MMCFD)	Cost (10^9 US$)
West-East #1	2002-2004	2610	40	1451	1160	6.6
West-East #2	2008-2011	5592	48	1741	2900	20.3
Shaanxi-Beijing #1	1991-1997	780	26	928	350	0.9
Shaanxi-Beijing #2	2004-2005	579	40	1451	1160	1.8
Sichuan-Shanghai	2007-2010	1056	40	1451	1160	9.0
Zhongxian-Wuhan	2001-2004	459	28	928	290	0.7
Lianzhou-Yinchuan	2006-2007	291	24	1451	340	0.27
Guangzhou Zhuhai-Zhongshan†	2005-2007	41	26	1132	105	0.10

† – includes a subsea section of 2.6 km – one of the world's longest subsea pipelines

The 4843-km (3009-mile) long trunk line will be constructed with API Grade X-80 pipeline steel, and has a diameter of 1219 mm (48 in), designed maximum pressure of 12 MPa (1741 psia), and annual deliverability of 30×10^9 m³/yr (2900 MMCFD). Once completed in 2011; the pipeline is expected to ensure stable gas delivery for over 30 years.

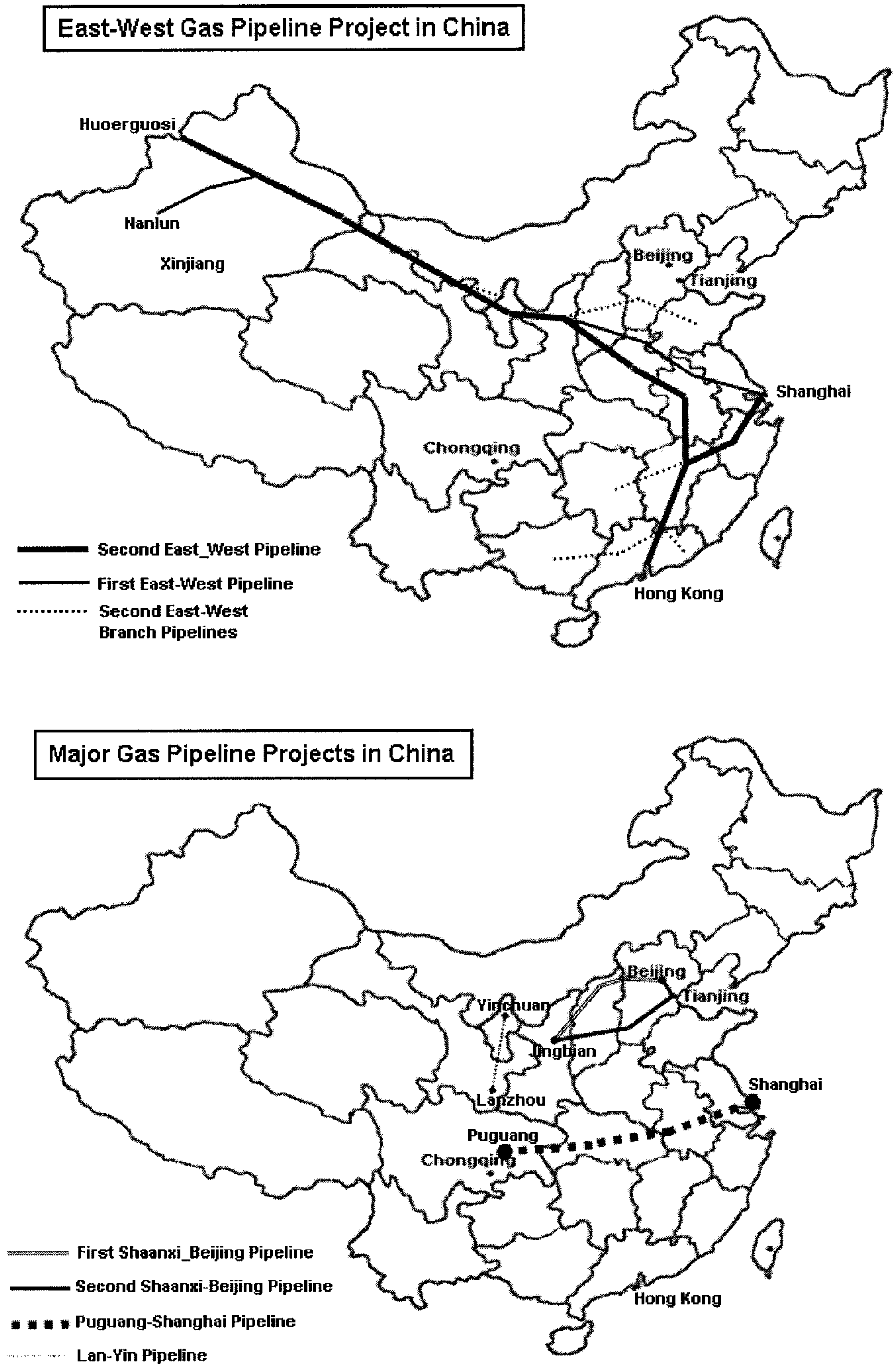

Fig. 5 Pipelines Routes for Several Major Gas Pipelines in China

Initially gas for this line will be supplied from the neighboring countries of Turkmenistan and Kazakhstan. However as the line reaches Inner Mongolia additional gas will be added from the Sulige gas field.

4.3 Second Shaanxi-Beijing Natural Gas Pipeline

The first Shaanxi-Beijing pipeline[30] was the first major gas pipeline built in China and was completed in 1997. The second Shaanxi-Beijing gas pipeline starts at Yulin City in Shaanxi Province, and terminates at Beijing. This pipeline has total length as 932 km (579 mile) with diameter 1016 mm (40 in) and a design pressure 10 MPa (1451 psia) and 12×10^9 m^3/yr (1160 MMCFD) of designed delivery capacity. The total cost is estimated to be ¥13 billion ($1.8 billion US).

Project construction was started in March 2004 and was completed in July 2005. The second Shaanxi-Beijing gas pipeline supplies gas to Beijing and also supplies gas for injection to the gas storage facility in Tianjin-Dagang District.

After the completion of the second Shaanxi-Beijing gas pipeline, the total gas delivery capacity for the two lines will be to 15.6×10^9 m^3/yr (1510 MMCFD). In 2008, the Shaanxi-Beijing gas pipeline will ensure a gas supply to Beijing during Olympic Games.

4.4 Sichuan Puguang-Shanghai Gas Pipeline

Another current major gas pipeline project in China is the pipeline project from Sichuan Puguang gas field to Shanghai of SINOPEC[31]. This project started in 2007 and will be completed in 2010 and will have an estimated total cost of ¥63 billion ($9 billion US).

The gas pipeline from the Puguang gas field in Sichuan to Shanghai will pass through eight Chinese provinces and cross the Yangzi River five times. The river crossings are significant construction projects in themselves. A recently completed tunnel in Hubei province had a diameter of slightly more than 3 m (almost 10 ft), a length of 1.4 km (4600 ft) and was approximately 20 m (65 ft) below the river bed[32].

The pipeline length will total 1700 km (1056 mile) and be 1016 mm (40 in) in diameter. The design pressure is 10 MPa (1451 psia) and will have a capacity to deliver 12×10^9 m^3/yr (1160 MMCFD) of purified natural gas.

5. IN CLOSING

China is an energy thirsty country. The Chinese have ambitious exploration plans that have been successful in finding new natural gas reserves. In addition they have plans to produce and process significant volumes of both sour and sweet gas, process the gas, and transport it across the country.

As outlined in this paper, Chinese companies have spent hundreds of billions of yuan to develop their new gas fields (including production, processing, and transportation). In addition they have sought outside expertise to help in these developments.

As a byproduct of the sour gas production, China will produce significant amounts of elemental sulfur, which will greatly reduce their reliance on imported sulfur. As noted above, just two of the sour gas developments have the potential to produce 2.45 Mt/yr. There are some rumors that China is becoming concerned with the potential sulfur production and are considering alternatives.

APPENDIX A
Some Useful Conversions and Additional Information

The purpose of his appendix is to supply some numerical values and conversion factors that are useful for the natural gas business. Table A1 has some useful data for interpreting the values presented in the main portion of this paper.

Table A1 Some Useful Conversion Factors and Other Useful Data

1 million	10^6 = 1,000,000
1 billion	10^9 = 1,000,000,000
1 trillion	10^{12} = 1,000,000,000,000
1×10^6 m³	35.3147 MMCF
1×10^9 m³	35.3147 BCF
1×10^{12} m³	35.3147 TCF
1 MMCF	28.3168×10^3 m³
1 BCF	28.3168×10^6 m³
1 TCF	28.3168×10^9 m³
1×10^9 Sm³	6.29 million BOE
1×10^9 Sm³	1.00×10^6 Sm³ BOE
1×10^9 Sm³	0.90 MtOE
1 BSCF	0.18 million BOE
1 BSCF	28 600 Sm³ BOE
1 BSCF	0.026 MtOE
1 Sm³	0.985 Nm³
1 Nm³	1.015 Sm³

BOE = barrels of oil equivalent
MtOE = million tonnes of oil equivalent (1 tonne = 1000 kg = 2206 lb)

To begin, large numbers can be a little confusion (as one author of this paper can attest) and translating from Chinese can add to the confusion. In the western world large numbers are based on powers of one thousand (thousand, million, billion, trillion, etc.)

whereas in China they are based on ten thousand (for example wan is ten thousand, shi wan [ten times ten thousand] is 100,000 and băi wan [one hundred times ten thousand] is 1,000,000, and finally yì is 100,000,000, which is 10,000 × 10,000).

To add to the confusion is the use of the prefix M. In American engineering units the prefix M means 1,000 and thus MM means 1,000,000, whereas in SI the prefix M is mega or 1,000,000.

In the petroleum business the standard condition is 60°F and 14.696 psia ($15\frac{5}{9}$°C and 101.325 kPa). In Europe and other parts of the world it is common to use normal conditions (20°C and 1 atm). Furthermore, chemists refer to "standard temperature and pressure" STP as 0°C and 1 atm. To further add to the confusion, some refer to 0°C and 1 atm as normal conditions.

A.1 Currency

The basic unit of currency in China is the yuan (¥). Until July 2005 the yuan was pegged to the US dollar and the conversion was $1 = ¥8.28. In 2005 the Chinese currency was allowed to float, to some extent, and thus the exchange rate varied. In 2006 the average conversion was $1 = ¥8.0 and in 2007 it was $1 = ¥7.6. The current exchange rate is about $1 = ¥7.0. In this paper, for converting values from yuan to dollars a conversion factor of 7 to 1 was employed.

APPENDIX B
Classification of Sour Gas Fields in China

In China natural gas is classified based on the hydrogen sulfide content. The classification scheme was modified slightly in 2005. Table B1 summarizes the classification system used. These definitions were used in this paper.

Table B1 Field Standard for H_2S Concentration in Natural Gas[33]

1995			2005	
Field Definition	H_2S Concentration		Field Definition	H_2S Conc.
Ultra Low	< 0.0013%	< 0.2 g/m³	Ultra Low	< 0.02 g/m³
Low Sulfur	0.0013-0.3	0.02-5	Low Sulfur	0.02-5
Medium Sulfur	0.3-2	5-30	Medium Sulfur	5-30
High Sulfur	2-10	30-150	High Sulfur	> 30
Ultra-high Sulfur	10-50	150-770		
H_2S	> 50	> 770		

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Statistics presented in this paper come from several sources and the data do not necessarily match. No attempt has been made to reconcile the difference and values from the original sources are presented in each case.
In addition, large numbers and the various units presented in this paper lead to some confusion. Appendix A provides some useful information to help alleviate the confusion.

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