Non-Geological Constraints to Coalbed Methane Production in China: Developments from the 1990s to 2014

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PREFACE

This report is part of a research project to identify the non-geological constraints to unconventional gas in East Asia carried out in 2013 and 2014. At that time, unconventional gas was having major consequences for national and international gas markets. Between 2005 and 2013, the production of shale gas in the US grew ten-fold. Coalbed methane had a longer history, but its output was also rising. As a result, countries around the world, including in Asia, began to assess the geological potential for shale gas and coalbed methane within their territories. China has vast resources of coal and preliminary studies suggested that the potential for shale gas was also very large. At the same time, the government was prioritising the domestic production of natural gas in order to address challenges relating to climate change, air pollution and security of supply.

Efforts to extract coalbed methane in China date back to the late 1980s, but had progressed only slowly. Part of the problem lay in the physical characteristics of the coals, which prevented the direct application of techniques applied in the US. The wider regulatory and policy environment also played a significant role of constraining the growth of output. The growing priority assigned to natural gas production led the government to repeatedly adjust the policy incentives to encourage coalbed methane production.

This report presents the results of a study of the policy and regulatory context of coalbed methane exploration and production in China from the 1990s to 2014. Part 1 provides background information on the general institutional environment of governance in China, on the natural gas industry and on the coalbed methane and shale gas industries. Part 2 examines the policy, legal and regulatory context of coalbed methane extraction in terms of a two-level game: the upper level involves the central government and major state-owned enterprises; the lower level game involves a larger range of actors at local level. Although this study was completed in 2014, the key messages remain the same: the main constraints to the sustained growth of coalbed methane in China lie in the political, legal and regulatory environment. Little has changed in the intervening years and thus the report retains its value.

Philip Andrews-Speed
July 2017

1. COALBED METHANE IN CHINA: BACKGROUND AND INTRODUCTION

Philip Andrews-Speed

The aim of this section is to provide general background information on China's gas industry to support the subsequent sections.

General Institutional Environment

The aim of this sub-section is to briefly summarise the key characteristics of the "institutional environment" of the country, in order to provide the context for policymaking and implementation.

Political System

Kenneth Lieberthal and co-researchers have documented the fragmented nature of China's institutions of governance in some detail in a series of publications in the 1980s and 1990s (Lieberthal 1995). Other analyses have concluded that China is a 'dual development state', and the diffuse nature of the state affects both the vertical and horizontal links in the formal organisational structures of government. The Ministries and other major government agencies form important axes of power from the central government level, to as far down as the local county level. However, their influence at the local level is not as great as might be expected. Although China remains a unitary state, the last 30 years have seen the expansion of de facto federalism (Shirk 1992; Zheng 2010a).

Three facets of government have exacerbated the impact of this disaggregated structure on policymaking. First, the framework lacks formal definitions of the powers and scope of authority of the component institutions and explicit guidelines for inter-institutional relationships. Second, and partly as a result of the first, institutions are highly personalised and dependent on the character, power and connections of the leader, as are relationships between institutions. Informal networks are also of great importance. Third, the system is very hierarchical: all institutions and individuals of any importance hold a specific rank, and this rank is a critical determinant of the geometry of policy bargaining. Negotiation takes place between institutions and individuals of equal rank.

In addition to the fragmented nature of government, the power of the state-owned enterprises remains a critical feature of China's economy. In the days of the planned economy, the large state-owned industries were either ministries or reported directly to a ministry. Despite the structural reforms carried out over the last 20 years, the few remaining large state-owned enterprises retain considerable influence at the highest levels of government (Shirk 1993; Zheng 2010a). They can play an important role in policymaking, notably as veto points and rent-seekers, and they are able to use this influence to retain dominant positions in their respective sectors. Nowhere is this more important than in the energy sector (Andrews-Speed 2004; Kong 2010).

Fragmentation could have rapidly led to a breakdown of government were it not for a number of unifying or articulating instruments. The most important of these remains the Communist

Party (Krug and Hendrischke 2008). The Party is the most powerful organisation in China and is intimately intertwined with all government agencies from central to village level, and with all state-owned enterprises. The Party is explicitly dominant over the state, and has been referred to as an 'organisational emperor' (Zheng 2010b). As a result, the Communist Party is pre-eminent in all major political decision-making (Lieberthal 1995).

Policy decisions tend to be made by consensus after wide consultation through meetings and the circulation of documents. Personal links and informal institutional networks reinforce this process of consensus-building (Xia 2000). Research institutes and think tanks have grown in number and diversity of affiliation. Many have no direct connection to the government. Think tanks affiliated to the government not only supply policymakers with information, ideas, policy proposals and critical assessments of policy; they also provide a useful web of links between different strands of government (Naughton 2002; Zhu 2011). Despite this gradual pluralisation, national economic policymaking in China is driven by a technocratic elite, and policy discourse rarely involves the public or the lowest levels of government.

In the case of economic policy, considerable authority has been progressively delegated to the Provinces and to two lower levels of government, namely the cities and prefectures, and the counties. This decentralisation has been essential to the long period of high economic growth experienced by China (Zheng 2010a). The structure of the multi-layered system of governance varies greatly across the country and is constantly evolving (Chung 2010). Despite its complexity, this decentralised structure allows for different areas to pursue development paths, which are more suited to their circumstances. It also allows the central government to carry out reform experiments in selected areas before deciding whether to apply a particular economic policy across the country (Heilmann 2010).

Legal System

Since the introduction of economic reforms in the late 1970s, the Chinese government has made great strides to draft new laws and regulations, to create a new cadre of professional lawyers and judges, and to spread understanding of the importance of the law. In pushing forward these reforms, it has drawn extensively on international examples, especially in the realm of economic law (Chen 1999; Peerenboom 2002; Zhu 2004). Law-making is becoming more transparent and involves seeking suggestions from the public by placing drafts on the Internet. Further, the government has passed a number of administrative laws that seek to enhance the accountability, transparency and effectiveness of government itself, though the results vary greatly across the country (Horsley 2010).

Constraints to the pace and development of legal reform include the close relationship between the courts and both Communist Party and the local government, for the courts are directly responsible to the government and Party at the level at which they operate (Zhu 2004; Zheng 2010b). More fundamentally, the overall approach to the law continues to bear a striking resemblance to that of China's imperial period. For instance, the law is seen as an instrument of government and of the Party—to retain power, to maintain social order and to promote economic development (Peerenboom 2002). The Party also has the option of using its own internal disciplinary process to control or punish members, instead of exposing them to the more transparent legal system. This approach is commonly used for corruption cases (Zheng 2010b).

In terms of the role of law in economic activity, three important features deserve emphasis. First, the law in China has a reputation for failing to provide secure property rights. Rights are poorly defined in law, and government agencies at all levels of government exercise their 'right' to transfer rights with little due process. Within this context, many enterprises have been very successful at enhancing the degree of protection over their property rights through the building of networks and the use of personal relationships (known as *guanxi*) involving both public and private sectors (Wank 1999; Krug and Hendrickse 2008). Second, foreign investors find that sanctity of contract and contract enforceability are not as robust as in many OECD countries, a problem that affects Chinese companies as well. Despite continued weaknesses in the contract law system, the government has made successful and sustained efforts to improve the enforcement of contracts and the quality of dispute resolution, especially in the commercial sphere (Pattison and Herron 2003; Peerenboom and Xie 2009; Tsui 2013). Finally, citizens, enterprises and public agencies continue to prefer to settle civil disputes through out-of-court settlements rather than to go through the court system (Peerenboom 2007).

Economic System

China's economy has grown at an average annual rate of 10–11 per cent since 1978, with peaks of about 14 per cent in 1984 1992 and 2007. Fixed capital investment has contributed to more than 30 per cent of GDP over most of this period, rising sharply after 2002 to 48 per cent in the period 2010–12 (Naughton 2007; China Statistics Press 2013). This capital investment has mainly taken the form of infrastructure and urban construction. As a consequence, this economic growth has been highly energy-intensive.

China overtook Japan in 2010 to become the world's second largest economy. In 2012, China's GOP amounted to US$8.3 trillion, just over half that of the USA and accounting for nearly 12 per cent of the global economy (International Monetary Fund 2013). Despite this success, per capita GDP remains relatively low, lying below that of Iran and Angola.

Before 1978, China's economy was dominated by the state, through central planning and through ownership of most industrial enterprises. Industrial output was dominated by state-owned enterprises (77 per cent in 1978), urban collectives controlled by local governments (14 per cent) and rural collectives (9 per cent) (Naughton 2007). At this time, agriculture accounted for more than 40 per cent of annual GDP and 70 per cent of employment. The succeeding 35 years saw a number of profound changes in the economy (Naughton 2007; Huang 2008; China Statistics Press 2013):

- Land, though still owned by the state, was released from the collectives and was made available for peasants to lease.

- The rural collectives were transformed into township and village enterprises, which then formed the initial engine of entrepreneurial industrial diversification and growth in the 1980s and early 1990s.

- The government privatised companies in many industries, and corporatised many industrial activities previously run by Ministries. This trend picked up pace during the 1990s.

- Private enterprises of different types were at first tolerated and then encouraged. By 2012, Chinese private enterprises, foreign investors, and enterprises with funds from Hong Kong, Macau and Taiwan, together accounted for more than 50 per cent of industrial revenues in China.

- The structure of the economy changed so that by 2012 agriculture accounted for just 10 per cent of GDP, industry for 45 per cent, and the Tertiary sector 45 per cent.

- The government progressively released its control over most commodity prices. Exceptions include energy, transport, fertilisers and certain agricultural products.

- Urbanisation has proceeded rapidly. In 1978, 18 per cent of the population lived in urban areas; in 2012, the official figure was 52 per cent.

- The economy opened up to foreign trade and investment. The share of imports and exports grew from 10 per cent of national GDP in 1978 to a peak of 65 per cent in the period 2005–06 before declining to 47 per cent in 2012. Foreign direct investment rose from a negligible amount in 1978 to a few billion US dollars in 1990, before soaring to US$78 billion in 2012.

These quantifiable economic changes were accompanied and often supported by transformations in the fiscal and financial systems, and in the way that government and businesses operated and interacted. As a consequence, China's economy today has many features of a market economy. Though the Chinese government proclaims that its goal is to have a 'socialist market economy', the hand of the state can be seen in a number of strategic sectors, most notably the energy sector.

This extraordinary economic success has transformed the lives of the population and lifted hundreds of millions out of poverty. However, it has come at a cost, which is now being fully recognised most notably in the form of severe pollution and growing socioeconomic inequality (Brammall 2009).

Gas Industry and Market

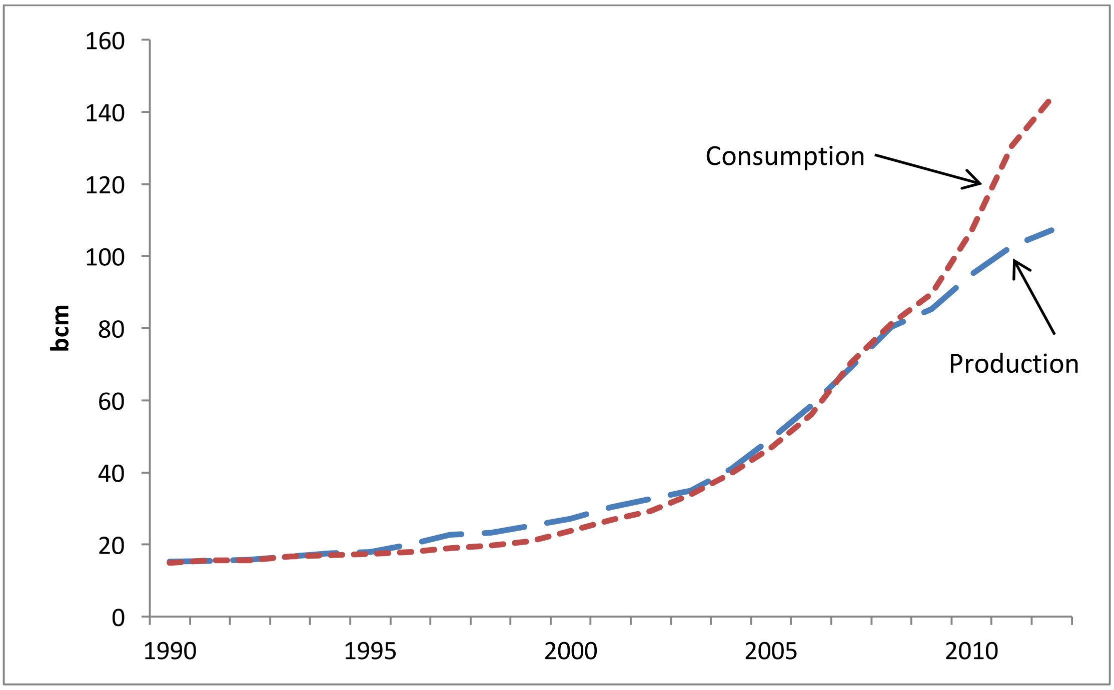
Before the mid-1990s, natural gas played a marginal role in China's energy mix except where it was produced as a by-product of crude oil or in Sichuan Province where natural gas has been used for hundreds of years. Otherwise, the main use for natural gas was to manufacture fertiliser (GK Dragonomics 2012). The period since 1997 has seen a concerted attempt by the government and state companies to raise the level of use of natural gas. Three considerations have underpinned this policy, i.e. the government's desire to: use domestic primary energy sources; to introduce a cleaner fuel to replace coal; and to diversify the energy supply mix (International Energy Agency 2002).

Resource Base and Production

At about 3.3 trillion cubic meters (tcm) (BP 2014), China's proven reserves of conventional natural gas are relatively modest compared to its growing demand, and most of these reserves lie in the north and west of the country, far from the centres of demand in the east. The new era for natural gas production, which started in the late 1990s, was triggered by the discovery of large accumulations of gas, especially in the Ordos Basin of North China. This persuaded the government to raise the wellhead prices for gas. Further exploration has led to new discoveries, mainly in the northwest of the country and in Sichuan Province, in the Tarim Basin of Northwest China and in Sichuan Province. Exploration also proceeds offshore in the East and South China Seas.

Despite annual increases of 15–20 per cent in the domestic production of natural gas that have allowed China to raise its domestic production of natural gas from 19 billion cubic metres (bcm) in 1997 to 107 bcm in 2012 (Figure 1), gas continues to provide only 4.7 per cent of the country's energy supply as of 2012, up from 2 per cent in the mid-1990s. Delivery of this gas to the energy-consuming regions of eastern China has required the rapid construction of a completely new network of domestic gas pipelines. The most impressive of these are the two West-East pipelines which bring natural gas from the Tarim Basin of Xinjiang and from central Asia to Shanghai and Guangdong Province, and which have an annual capacity of more than 40 bcm. A third West–East gas pipeline is presently under construction and a fourth one is planned.

Figure 1. Natural Gas Production in China: 1990–2013 in billions of cubic metres (bcm)



Source: BP (2014)

Despite the success in discovering new accumulations, it is becoming clear that what is called 'conventional natural gas' is only likely to provide a modest portion of the national energy supply, and that this gas will not be cheap. As a result, the last 10 years have seen significant efforts in China to identify and exploit domestic sources of 'unconventional gas', and these are now starting to bear fruit.

Such is the poor quality of many gas reservoirs in China that the boundary between conventional and unconventional gas is rather blurred. 'Tight gas' is already being exploited in the Ordos Basin of northern China and in the Sichuan Basin. Indeed, these accumulations already provide some 20 per cent of the nation's domestic natural gas production and are expected to provide 30 per cent by 2020 (FACTS Global Energy 2011). Collaboration with foreign companies such as Shell and Total has been crucial for this success.

The country's energy companies have been working jointly with foreign companies since the early 1990s to develop coalbed methane reserves, which are abundant in some of the major coal basins of northern China. Progress has been slow as the companies struggle to overcome technical challenges, as will be described below. Systematic exploration for shale gas started in 2010 and the government has committed to funding the assessment of these reserves. The government is giving significant policy support to the exploitation of shale gas, as will be described below.

Soaring demand for natural gas has stimulated investment in coal gasification to produce synthetic natural gas (SNG). Unlike traditional manufactured gas (also known as town gas or coal gas), SNG comprises pure methane and does not have impurities such as carbon monoxide. At least nine projects have been approved with an aggregate annual capacity of 37 bcm, and another 20 or more projects are planned, bringing the total capacity to 120 bcm. Although these investments could indeed boost national production of methane gas, the technology is not cost-competitive with conventional technologies. Moreover, the carbon emissions are substantially higher for most forms of gas use (Ding et al. 2013; Yang and Jackson 2013).

Consumption

Annual consumption of natural gas picked up slowly from the mid-1990s but then accelerated after 2002. Annual consumption of natural gas grew five-fold between 2002 and 2012, reflecting an annual average increase of 17 per cent (Figure 1). Although a formal policy on natural gas use was not issued until 2007 (National Development and Reform Commission 2007), the top priority quickly became the provision of city gas for residential and commercial use (Table 1). Heavy investment in the upgrading or construction of new city gas distribution infrastructure resulted in a rapid increase in the share of the residential and commercial sector from 14 per cent in 2000 to 33 per cent in 2010. This investment was directed mainly to the northern parts of China where winter heating systems had traditionally relied on coal and coal-gas. The use of gas in the power sector is also growing, and has increasingly become a high priority for the government. Meanwhile, the industry's share of consumption continues to decline.

Table 1. The Changing Structure Natural Gas Consumption: 1990–2010

	Power (%)	**Industry (%)**	**Residentia1/ Commercial (%)**	**Transport (%)**	**Other* (%)**	**Total (bcm)**
1990	6.6	57.9	13.2	0.3	21.9	14.7
2000	12.3	45.1	14.6	0.9	27.0	23.6
2010	15.6	37.9	33.7	0.3	12.4	106.7

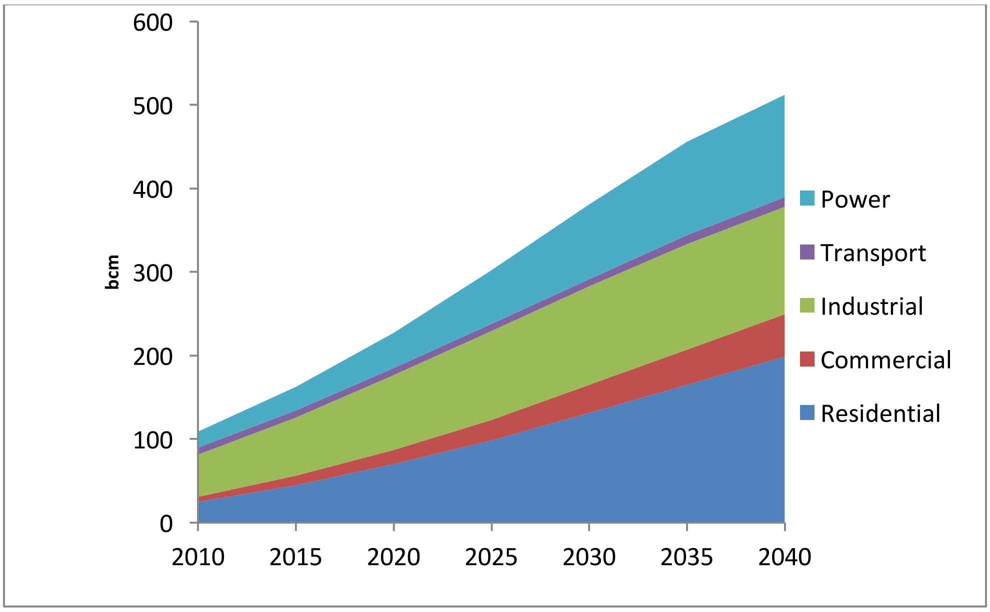
Note: *Other includes agricultural use, oil- and gas-field use, and unspecified others.
Source: FACTS Global Energy (2011)

On 31 October 2012, NDRC issued a new Natural Gas Utilisation Policy, which revised the previous gas utilisation policy promulgated in 2007. Compared with the 2007 policy, the new one reflects a more ambitious natural gas development plan. First, the 2007 policy only put forward natural gas development as a way to improve the environment and people's lives. The new policy clearly states that the share of natural gas should be increased in the mix of primary energy consumption, which indicates strong encouragement of natural gas development. Second, power generation by natural gas is upgraded from the categories of 'permitted' and 'restricted' to the categories of 'priority' and 'permitted ' respectively, suggesting the government's encouragement of using natural gas to generate electricity.

Third, subject to the requirement of emissions control and environmental protection, the new policy permits natural gas to be used in more industrial sectors. Fourth, the new policy pays more attention to the management of operations of the natural gas industry. For example, it lists as a priority the construction of natural gas storage facilities with emergency and peaking functions. It also encourages the building of these facilities through market mechanisms. All these characteristics show the government's ambition to develop natural gas industry in the new economic development period.

The consumption of natural gas is projected to increase in all sectors (Figure 2), though great uncertainty exists regarding the breakdown by sector, especially the penetration of gas in the transportation sector.

Figure 2. Projected Structure of Future Natural Gas Demand in China: 2010–40 in Billions of Cubic Metres (bcm).



Source: Energy Information Administration (2013)

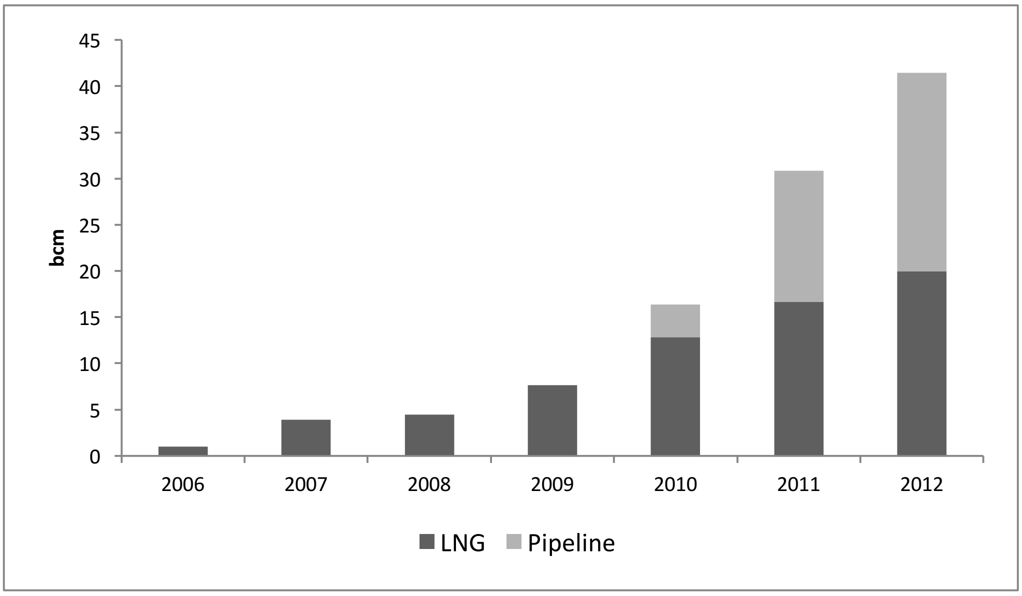
The rapid growth of both supply and demand for natural gas in China continues to pose a challenge of balancing supply with demand. In certain cases in the past, producers were unable to sell their gas as the infrastructure was not in place to transmit the gas to consumers. In other situations, industrial consumers and power companies have the built capacity to use gas, but have been unable to obtain supplies. However, the push by central and local governments to promote gas use on environmental grounds runs the risk of a severe supply shortfall (Li 2013a).

Imports

In order to meet rising demand for natural gas, China has had to import gas both through pipelines and on ships as liquefied natural gas (LNG) (Figure 3). Total imports of natural gas are projected to rise from 1 billion cubic metres in 2006 to 100 billion cubic metres or more in 2020 (Energy Information Administration 2013a; FACTS Global Energy 2011). Pipelines are seen as being more secure because the flow of gas is not open to interruption on the high seas. LNG is more cost-effective over very long distances and, as regional LNG markets develop, LNG can be more flexible because a buyer of gas can have a number of suppliers. By the end of 2013, nine LNG import terminals will be operational in Guangdong, Fujian, Jiangsu, Shanghai and Dalian, with a total capacity of 45 bcm, with more planned for the future.

Central Asia and Russia both contain substantial proven and potential reserves of gas, which could be imported through pipelines and make a major contribution to China's gas supply. In 2006, China and Turkmenistan signed agreements that gave China National Petroleum Corporation (CNPC) the rights to explore for and produce gas in Turkmenistan, and to construct an export pipeline to China. Commissioned at the end of 2009, it is planned for this pipeline to reach a capacity of 30–40 bcm per year by 2020 (FACTS Global Energy 2011). It connects to the new, second West-to-East gas pipeline within China, which brings the gas to southern and eastern parts of the country. In Russia, initiatives to develop gas resources and export them to China have progressed slowly, despite initial planning and discussion dating back to the late 1990s. Progress has been delayed by changes of gas policy priorities within Russia and a continuing failure by both parties to agree on an acceptable price. A gas pipeline from Myanmar was commissioned in 2013, and the annual quantity of gas should reach nearly 10 billion cubic metres by 2020 (FACTS Global Energy 2011).

Figure 3. China's Natural Gas Imports: 2006–14 in Billions of Cubic Metres (bcm)



Note: Figures for 2014 are projections.
Source: BP (2014)

Main Corporate Actors Directly Involved in Gas Production and Consumption

Since the major structural reform carried out in 1998, China's petroleum industry has been dominated by two vertically integrated companies, CNPC (China National Petroleum

Corporation) and Sinopec, and their commercialised and listed subsidiaries, PetroChina Ltd and Sinopec Ltd. These two companies own and operate most of the oil and gas infrastructure onshore, including oil and gas fields, pipelines, oil refineries and gasoline stations. PetroChina is strongest in the North and West of the country where most of the oil and gas fields lie, whilst Sinopec operates mainly in the South and East and has a long history in refining and petrochemicals. CNOOC (China National Offshore Oil Corporation) is the main Chinese operator in offshore exploration and production. On account of the geographical distribution of the assets allocated to it in 1998, PetroChina controls access to the most prospective gas basins in China and is by far the largest producer of natural gas in the country, accounting for about 75 per cent of annual production. Sinopec and CNOOC are the other significant producers.

Foreign companies have been involved in the exploration and production of gas since circa 1983 when Arco discovered the Yacheng gas field in the South China Sea off Hainan Island in 1983. Commercial production began in 1996. Since then, the field has changed hands twice: first to BP and then, in 2013, to the Kuwait Foreign Petroleum Exploration Company. Husky Energy has made three gas discoveries in the South China Sea and is starting. A number of foreign companies have entered into agreements with CNOOC to explore the deeper waters of the South China Sea, including Chevron, ENI, BP and BG.

Shell has been the dominant foreign company onshore since the time it entered into an agreement with PetroChina in 1999 to develop the Changbei tight gas field in the Ordos Basin in northern China which came into production in 2007. Shell also has two gas contracts in the Sichuan Basin, one of which is for shale gas. In 2006, Total joined PetroChina to develop the South Sulige field in the Ordos Basin and started test production in 2012. Chevron is working with PetroChina in the Chuandongbei area of the Sichuan Basin to develop a number of fields of sour gas. A large number of Chinese and foreign companies are involved in coalbed methane and shale gas and these are detailed below. CNPC/PetroChina dominates the long-distance gas pipeline network within China on account of its control of the majority of the production, the distance of this production from the demand centres, and its role in building import pipelines. (FACTS Global Energy 2011). As of 2014, no foreign petroleum company was involved in China's gas pipeline network.

Pricing

Most energy prices in China are controlled by government at central or local levels. The only prices that are largely market-based are those for two primary sources of energy: coal and crude oil. Mid- and downstream forms of energy, such a refinery gate and retail prices for oil products and on-grid (wholesale) and retail prices for electricity, are determined by the Chinese government. Natural gas is an exception in that prices are set by government along the full length of the supply chain. Wellhead prices and the transportation tariff are set by the central government through the NDRC, whilst local price bureaus set end-user tariffs.

The Chinese government faces a fundamental economic challenge as it seeks to promote the use of natural gas across the economy: very few sources of cheap gas in the country, given the combination of the geological conditions of the gas fields and the distance of many of these fields from demand centres. Consequently, natural gas cannot compete with coal on the basis of cost. In order to stimulate the production of gas and the construction of pipelines, the wellhead price and the transmission tariffs have to be set sufficiently high to encourage investment by the commercialised NOCs. At the same time, end-user prices have to be sufficiently low to encourage use in the commercial, industrial and power sectors, and to be acceptable household users.

The prices for natural gas have been set according to two main criteria: cost and the end-user's ability to pay. The resulting system has therefore been extremely complicated with wellhead prices dependent not only on the location and geological conditions, but also on the sectors being supplied. End-user prices also depend on sector, with industrial and commercial users paying the highest prices, and fertiliser plants the lowest (FACTS Global Energy 2011). During the period 2011-2013, China national oil companies (NOCs) suffered from additional financial difficulties arising from the growing differential between the price of most of the gas they import and the domestic prices, and as a result annual financial losses have run into the billions of US dollars (GK Dragonomics 2012).

In order to address the inadequacies of the prevailing approach to pricing, the government ran experiments in Guangdong and Guangxi Provinces, starting in December 2011, in which city gate gas prices were linked to the prices of LPG and imported fuel oil. These experiments formed the basis for a new policy introduced in July 2013 which focused on the city gate price rather than on the wellhead price, as in the past (Houser and Bo 2013). City gate prices for existing consumption volumes were raised by an average of 15 per cent from RMB1.69 per cubic metre (US$7.80 per mmBTU) to RMB1.95 (US$0.32) per cubic metre (US$9.00 per mmBTU). Different categories of end users paid different prices though higher prices than before, whilst residential tariffs remained unchanged. In contrast to that for existing supplies, the price for incremental consumption is linked to a basket of liquefied petroleum gas (LPG) and fuel oil. This two-tiered approach to gas pricing is reminiscent of the 1980s and 1990s when prices for oil and coal were set in multiple tiers reflecting 'in-plan' or 'above-plan' output, with the latter reflecting market prices.

China's NOCs are the obvious winners from the price hike, as their financial losses from importing gas are substantially reduced, though PetroChina may still lose money from its central Asian gas imports. They will also have greater incentive to explore for new domestic reserves of both conventional and unconventional gas.

National Coalbed Methane Industry: Developments and Plans

China has vast reserves of coal, and both national and foreign companies have been testing the potential for coalbed methane for more than 20 years. Nevertheless, progress in raising production has been slow due to a combination of technical and regulatory reasons. This section summarises what is known of the resource base, before examining progress to-date in exploiting this resource and assessing the outlook for future production.

Resource Base

According to the Ministry of Land and Resources, China has a total estimated coalbed methane (CBM) resource of nearly 40 tcm with technical recoverable reserves of about 10 tcm (Table 2). These figures include methane than can be recovered directly from coalmines as what is often called 'coalmine methane'. Actual commercially recoverable reserves are likely to be closer to 10 per cent of the resource in place, which would mean that the national reserve would be less than 4 tcm. The most favourable geological and logistical conditions appear to exist in the Ordos and Qinshui Basins, with substantial, tight gas production in the former basin and a number of major trunk pipelines passing across both basins.

Table 2. Estimates for China's Resource and Reserves of Coalbed Methane

	In place resource (tcm)	**Technically recoverable reserves (tcm)**
NORTH WEST		
Junggar	3.83	0.81
Turfan-Hami	2.12	0.41
Tarim	1.93	0.69
Tianshan	1.63	0.67
NORTH		
Ordos	9.86	1.79
Qinshui	3.95	1.12
NORTH EAST		
Erlian	2.58	2.10
Hailar	1.60	0.45
SOUTH WEST		
Yunnan-Guizhou	3.47	1.29
Sub-total	30.97	9.3
TOTAL	**36.8**	**10.9**

Source: Jia et al. (2012), based on report by the Ministry of Land and Resources published in 2010.

Table 3. Comparison of the Qinshui Basin with US and Australian CBM Basins

Country		**US**		**Australia**	**China**		
Basin		**San Juan**	**Black Warrior**	**Bowen**	**Qinshui**	**Eastern Ordos**	**Southern Ordos**
Net coal thickness	metres	21	5	8	6	<120	9
Gas content	cm/tonne	12	10	15	14 and above	<17	3–6
Permeability	mD	30	50	100	<10	<10	< 25
Plateau production rate	Thousand cm/d	56	3	34	3	-	-
Reserves per well	Million cm	220	14	140	8	-	-
Coal type	Sub-bituminous	Sub-bituminous	Sub-bituminous	Sub-bituminous	Anthra-cite	Bituminous and anthracite	Sub-bituminous and bituminou

Source: Beveridge and Chan (2010); Cai et al. (2011).

Despite the large scale of the resource and of the potentially recoverable reserves, the geological conditions of China's CBM appear to be considerably less favourable than those in the producing basins of the USA and Australia, even in the Qinshui Basin which is seen as the most prospective basin in China (Table 3). Although the overall gas content of the coal is high and the depth of the coal is favourable at 400–1,000 metres over large areas, the permeability is very low and the coals are under-saturated with respect to methane. As a result, plateau production rates and recoverable reserves per well are both low. In the southern parts of the Qinshui Basin, permeability rises to 5 mD at depths of less than 600 metres because of the extensional horizontal stress, which opens the fractures in the coal (Meng et al. 2011). The geological conditions in the eastern part of the Ordos Basin are broadly similar to those in the Qinshui Basin, but some younger coal beds in the southern part of the Ordos Basin have higher permeabilities.

The generally poor geological condition of China's CBM resources poses tough technological challenges and raises costs. These have been important factors in slowing down the exploitation of this gas resource (Gao 2012).

Progress as of 2014

Whilst CBM had been produced from coalmines previously, it was only in the 1990s that the government started to promote CBM exploration by surface drilling. In 1996, the Ministry for Coal Industries and CNPC together established the China United Coal Bed Methane Company (CUCBM) to act as the national champion with a monopoly over cooperation with foreign companies. After the abolition of the Ministry for Coal Industries, its share of CUCBM was taken by the China National Coal Group (ChinaCoal). Likewise, PetroChina took over CNPC's share.

The first foreign companies to explore for CBM in China were major US corporations such as Chevron, Conoco, Philips, Arco and Texaco. A combination of poor flow rates, low demand for gas and low gas prices resulted in these large companies moving out and passing the opportunity to smaller foreign players in the early 2000s. The most active of these have been Green Dragon (owned by Greka Energy), Sino Gas and Energy, and Far East Energy. Other foreign companies include Dart Energy (previously Arrow), Asia American Gas and Pacific Asia Petroleum (Beveridge and Chan 2010).

The slow progress in developing the nation's CBM resources led the Chinese government to introduce a number of policies to accelerate the exploitation of this resource. There were three motives for this. The first was to give an additional boost to the production of natural gas in China, on both energy security and environmental grounds. The second was to encourage coalmine companies to degas the coal beds before mining them to reduce the risk of severe mining accidents. The third was to capture and use methane, rather than to vent it to the atmosphere and add to global warming (International Energy Agency 2009).

In 2007, the Chinese government removed CUCBM's monopoly on foreign cooperation. A year later, PetroChina withdrew from CUCBM and became a CBM player in its own right. Sinopec, the Henan CBM company and other Chinese companies have also started to explore for CBM (FACTS Global Energy 2011). In 2010, CNOOC bought a 50 per cent stake in CUCBM.

In addition to breaking CUCBM's monopoly, the government has progressively introduced a number of favourable fiscal policies. Since 2008, CBM producers have received a direct price subsidy of 0.2 RMB/m^3 (US$0.94/mmBTU). An additional subsidy of 0.05 RMB/m^3 (US$0.23/mmBTU) has also been available in Shanxi Province (Beveridge and Chan 2010; FACTS Global Energy 2011). In 2011, the government eliminated value-added tax (VAT) and import duties on CBM equipment (Yun et al. 2012). A further economic incentive is provided by the decision of the government to allow sale prices for CBM to be free from government control. As a consequence, CBM prices are set by market forces.

Where CBM production sites are not close to existing pipelines, mine producers liquefy the gas in small-scale LNG plants. The liquefied gas can then be sold either for direct use in the transport sector or can be transported to where it is needed, regasified and fed into urban distribution networks or industrial sites. Early in 2013, ex-works LNG prices in Shanxi lay in the range of 10.8–14.1 US$/mmBTU. After the price reform in July, inland LNG prices rose by more than 15 per cent across the country. CBM producers selling compressed natural gas (CNG) or into pipelines also raised their prices by up to 20 per cent, from 1.5 RMB/m^3 (US$7/mmBTU) to 1.8 RMB/$m^3$ (US$8.5/mmBTU) in Shanxi Province.

Despite these incentives and reforms, progress has been slow, especially for CBM produced from wells rather than from mines. Significant production only started in 2007, but most of this was from mines such as coalmine methane (CMM) rather than through drilled wells such as CBM (Table 4).

Table 4. Production and Consumption of coalmine Methane and Coalbed Methane in China: 2005–13 and Targets for 2015 and 2020.

Year	Production bcm				Consumption bcm	
	Total: Target	**Total: Actual**	**coalmine methane**	**Coalbed methane**	**Actual**	**Target**
2005			2.2	0.03		
2006		0.03	3.2	0.13		
2007		4.7	4.4	0.32		
2008		5.3	5.7	0.5		
2009		6.4	6.45	1.0		
2010	10.0*	8.6	7.5	1.5	3.5	8*
2011		11.5	12.5	2.3		
2012	15.5*	14.1	11.4	2.7	5.8	8*
2013		15.6	12.6	3.0	6.6	
2014	18*					8.5*
2015	30*		14*	16*		20*
2020				30*		

Note: * denote targets.

Source*: Interfax China Energy Weekly* (various issues); *Interfax Natural Gas Daily* (various issues); Gao (2012); Xinhua News Agency (2013); FACTS Global Energy (2011); and unpublished government sources.

By the end of 2012, more than 10,000 CBM wells had been drilled, but the annual production of CBM from surface wells amounted to just 2.7 bcm. Although total production of CBM including from mines amounted to 14.1 bcm, consumption reached just 5.8 bcm. Only modest increases were reported for 2013. These data show that the CBM programme suffers from two deficiencies: first, surface wells continue to account for a much smaller share of CBM production than the coalmines; and second, more than 50 per cent of the methane produced is wasted. This waste occurs because the coalmines do not find it profitable to capture the methane and transport it to market.

The National Energy Administration's five-year plan for CBM production published in 2011 set a target of 30 bcm by 2015, of which 16 bcm was to be through drilling from the surface and 14 bcm by draining coalmines. However, in the following year, the State Council in its five-year plan for energy set a target for 2015 of 20 bcm for the commercial production and use of CBM. If these two targets are intended to be complementary, then the utilisation rate of CBM would have to rise from 41 per cent in 2012 to 67 per cent in 2015 (Xinhua News Agency 2013).

National Shale Gas Industry: Developments and Plans

The search for shale gas in China started in 2010 and so the history of shale gas in China is much shorter than that of coalbed methane. Annual production in 2013 had reached just 0.2 bcm, but the level of exploration activity is growing rapidly. This section follows the same structure as the previous section on coalbed methane. It first presents information on the shale gas resource, before examining plans and progress to date, and assessing the outlook for future shale gas production.

Resource Base

Estimates suggest that China may have very large technically recoverable reserves of shale gas, possibly more than the USA and even the largest in the world (Table 5; Energy Information Administration 2013b). In general terms, there are large areas of thick, organic-rich and gas-prone shales. Most of these shales have sufficiently high quartz content and sufficiently low clay content to make them brittle and therefore suitable for hydraulic fracturing (Zou et al. 2010).

According to an assessment carried out for the US Energy Information Administration, the Sichuan Basin probably contains more than 50 per cent of the technically recoverable reserves of shale gas in China (Table 6). The most prospective area in the Sichuan Basin lies in the southwestern part where the geology is less structurally complex and there is a lower content of the poisonous hydrogen sulphide gas. Exploration drilling has proven the potential of this geological play. Flow rates of 30,000–60,000 cubic metres per day have been achieved in a small number of wells. This area also has the advantage of relatively flat surface conditions, existing pipelines, abundant water supplies and access to major urban gas markets. According to the US Energy Information Administration, the other basins have much less potential for a range of different reasons, including the depth of the shale and the structural complexity of the basin.

Despite the large volume of risked technically recoverable reserves, China's shale gas basins have a number of unfavourable characteristics compared to the best productive shale gas basins in the USA, such as the Marcellus and Barnett shales (Energy Information Administration 2013b; Beveridge 2011; Zou et al. 2010). These are highlighted as follows:

- Most of China's prospective shales lie at depths greater than 3,000 metres, whereas those in the US tend to lie above 3,000 metres.

- The total organic content of Chinese shales tend to be less than the best US shales, as are the gas content, permeability and resource abundance per cubic kilometre.

- Many of the prospective basins in China are structurally complex compared to the best US basins.

- Some of the prospective areas suffer from different combinations of hill topography, a shortage of water and remoteness from pipelines.

Together, these factors are likely to result in high costs for China's shale gas production compared to the USA, as well as longer periods to assess and develop the resource.

Table 5. Estimates of China's Shale Gas Resource Base

Date	Agency	Total shale gas resource (tern)	Source
2013	Energy Information Administration (EIA)	31 *	Energy Information Administration
2012	China's Ministry of Land and Resources	25	FACTS Global Energy (2011)
2009	PetroChina Research Institute of Exploration & Development	10-20	FACTS Global Energy (2011)
2008	PetroChina Research Institute (Langfang Branch)	11	FACTS Global Energy (2011)
2008	China University of Geosciences	26	FACTS Global Energy (2011)

Note: *Risked, technically recoverable reserves

Table 6. Estimates of Risked Technically Recoverable Reserves of Shale Gas by Basin

Basin	Formation	Reserves (tcm)	Average depth {m)	Average organic content (wt%)	Clay content	Gas phase	Geology
Sichuan Basin	Qiongzhusi	3.50	4,000	3.0	Low	Dry gas	Brittle shale
	Longmaxi	8.04	3,500	3.2	Low	Dry gas	
	Permian	6.02	2,950	4.0	low	Dry gas	
	Sub-total	17.56					
Yangtze Platform	Lower Cambrian	1.26	4,000	3.0	Low	Dry gas	Structurally complex
	Lower Silurian	2.91	3,500	3.2	Low	Dry gas	
	Sub-total	4.17					
Jianghan Basin	Niutitang/Shuijintu	0.31	4,000	6.6	Low	Dry gas	Structurally very complex
	Longmaxi	0.20	3,000-3,800	2.0	Low	Dry & wet gas	
	Qixia/Maokou	0.28	1,700-3,500	2.0	Low	Dry & wet gas	
	Sub-total	0.79					
Greater Subei	Mufushan	0.20	4,500	2.1	Low	Dry gas	Structurally complex
	Wufeng/ Gaobiajian	1.00	3,800-4,400	1.1	Low	Dry & wet gas	
	Upper Permian	0.06	1,800-2,750	2.0	Low	Dry & wet gas	
	Sub-total	1.26					
Tarim Basin	Lower Cambrian	1.23	4,500	2.0	Low	Dry gas	Simple structure, but mainly very deep. Nitrogen risk
	Lower Ordovician	2.63	4,200	2.4	Low	Dry gas	
	M-U Ordovician	1.71	3,300-3,700	2.1-2.5	Low	Dry/ Assoc. gas	
	Ketuer	0.45	3,950	3.0	Low	Assoc. gas	
	Sub-total	6.02					
Junggar Basin	Pingdiquan/Lucaog	0.48	3,500	5.0	Medium	Assoc. gas	Thick shales, simple structure
	Triassic	0.53	3,050	4.0	Medium	Assoc. gas	
	Sub-total	1.01					
Songliao Basin	Qinhshankou	0.45	1,500	4.0	Medium	Assoc. gas	
	Sub-total	0.45					
	TOTAL	**31.26**					

Source: Energy Information Administration (2013b)

Progress as of 2014
Interest in shale gas in China started to grow from 2008 when, inspired by the growth of shale gas production in the USA, the PetroChina Research Institute for Petroleum Exploration and Research drilled a shale gas well in the Sichuan Basin. In the following year, PetroChina started a systematic drilling programme in the southern part of the basin and papers started appearing in Chinese research literature on the potential for shale gas in China (Zou et al. 2010). That same year, China and the USA launched an initiative to promote collaboration between the two countries on shale gas, with the objectives of assessing and conducting technical studies on China's potential shale gas resources and promoting international investment. By 2010, companies such as Shell, BP and ConocoPhillips were discussing possible collaborations with PetroChina and Sinopec in exploring for shale gas in the provinces of Sichuan and Guizhou. PetroChina and Sinopec announced targets for the year 2015 of 0.5 bcm and 2.5 bcm, respectively (Bai and Chen 2010).

The first licensing round was held in June 2011, and opened four blocks to participation by just six companies, all Chinese, namely: PetroChina, Sinopec, CNOOC, Shaanxi Yanchang Petroleum, CUCBM, and the Henan Provincial Coal Seam Gas Company. The blocks on offer all lay outside the areas held by the two large NOCs: PetroChina and Sinopec. Only two blocks were awarded, both in the Sichuan Basin: to Sinopec and the Henan Provincial Coal Seam Gas Company. The companies committed to invest RMB591 million (US$92 million) and RMB247 million (US$43 million) respectively over the three-year period of the licenses (Interfax China Energy Weekly 2011). The year 2011 also saw PetroChina drill China's first horizontal shale gas well which flowed at about 12,000 cubic metres per day (Interfax China Energy Weekly 2012a).

In January 2011, the government announced that a second round of licensing would be held at the end of the year, and that both state-owned enterprises and privately owned Chinese companies would be eligible to bid. This broadening of scope of eligibility arose from the decision of the Ministry of Land and Resources to reclassify shale gas as an 'independent mineral resource', thus removing the monopoly of the three large NOCs (PetroChina, Sinopec and CNOOC) and the Shaanxi Yanchang Petroleum Group (Interfax China Energy Weekly 2012b). Foreign companies were still barred from participating in the licensing round directly, but were allowed to form joint ventures with Chinese companies.

In March 2012, the government issued the Five-Year Shale Gas Development Plan which set a target of 6.5 bcm for annual production in 2015, to rise to 60–100 bcm by 2020. In the same month, Shell signed a production-sharing contract (PSC) with PetroChina for the development of shale gas in the Fushun-Yongchuan Block on the Sichuan Basin, but this PSC only received formal approval from the Ministry of Commerce one year later. This block lay within an area in which PetroChina held rights, and therefore the PSC was issued independently of the licensing rounds.

By May 2012, China's NOCs had drilled 58 shale gas wells in the Sichuan, Ordos and Bohai Basins, of which 15 were horizontal. The average costs at this time lay in the range RMB20,000–30,000 (US$3,170–4,750) per metre, resulting in total costs in excess of US$15 million for wells deeper than 3,000 metres. These costs would certainly decline over time (Interfax China Energy Weekly 2012c).

The much delayed second licensing round eventually took place in October 2012, and drew 152 bids from 83 companies for 20 blocks located in several different basins across the country. At the same time, the government announced a price subsidy for shale gas of RMB 0.40 (US$0.06) per cubic metre (Interfax China Energy Weekly 2012d). The Ministry of Finance, which provides the subsidy, defined shale gas as gas that is trapped in a source rock with a total organic content of at least 1 per cent and an absorbed gas content of more than 20 per cent (Interfax China Energy Weekly 2012e).

Table 7. Summary of First and Second Licensing Round Awards

Company	**Basin**	**Block name**
First Round		
Sinopec	Sichuan	Nanchuan
Henan Provincial Coal Seam Gas Development and	Sichuan	Xiushan
Second Round		
Huadian Coal Ind Grp	Sichuan	Suiyang (Guizhou)
China Coal Geology Engineering	Sichuan	Fenggang 1(Guizhou)
Huaying Shanxi Energy Investment	Sichuan	Fenggang 2 (Guizhou)
Beijing Taitantongyuan Natural-gas Technology	Sichuan	Fenggang 3 (Guizhou)
Tongren Energy Investment	Sichuan	Cengong (Guizhou)
Chongqing Energy Investment Group	Sichuan	Qianjiang (Chongqing)
Chongqing Mineral Resources Development	Sichuan	Youyang East (Chongqing)
State Development & Investment Corp.	Sichuan	Chengkou (Chongqing)
Hunan Huasheng Energy Investment &	Hunan	Longshan (Hunan)
Shenhua Geological Exploration	Hunan	Baojing (Hunan)
China Huadian	Hunan	Huayuan (Hunan)
China Coal Geology Engineering	Hunan	Sangzhi (Hunan)
Hunan Shale Gas Development	Hunan	Yongshun (Hunan)
Hubei Huadian	Hunan	Laifeng Xianfeng (Hubei)
Hubei Huadian	Hunan	Hefeng (Hubei)
Jiangxi Provincial Natural Gas Holdings	Jiangxi	Xiuwu Basin (Jiangxi)
Anhui Energy Group	Zhejiang	Lin'an (Zhejiang)
Henan Yukuang Geological Investment	Henan	Wenxian (Henan)
Henan Yukuang Geological Investment	Henan	Zhongmou (Henan)

Source: Compiled by author from various news publications.

The results of the second round were announced on 6 December 2012. 16 companies were awarded licenses over 19 blocks, leaving one block unallocated; none of the NOCs won a block. The winners included a range of energy companies mainly owned at the provincial level and involved variously in gas, coal and electricity. Many of the provincial companies were allocated blocks in their own province. Just two of the companies were privately owned: Huaying Shanxi Energy and Taitantongyuan Natural Gas (Table 7). The total financial commitment of the winning bids is believed to be in excess of RMB 12.8 billion (US$ 2 billion), to be spent on exploration and development over just three years (Nakano and Kushkina 2013). By September 2013, foreign oil companies had signed at least eight joint study agreements for shale gas with China's NOCs (Table 8). In addition to its PSC with PetroChina where drilling has started, Shell has signed a letter of intent with Hunan Huasheng Energy (one of the winners in the second licensing round) to explore for shale gas in Hunan (Li and Shek 2013). Furthermore, Total plans to drill its first well in the Xuancheng block in Anhui Province before the end of 2013 (Li 2013b). Foreign oilfield service companies such as Halliburton, Schlumberger and Weatherford are also developing partnerships or buying shares in Chinese oilfield service companies to position themselves to support the shale gas industry.

Table 8. Summary of Foreign Companies' Joint Study Agreements for Shale Gas

Partnership	Location	Date signed
ENIICNPC	Rongchang, Sichuan	May 2013
Total/Sinopec	Xuancheng, Anhui	March 2013
ConocoPhilips/PetroChina	Neijiang-Dazu, Sichuan	February 2012
ConocoPhilips/Sinopec	Qijiang, Sichuan	December 2012
ExxonMobil/Sinopec	Wuzhishan-Meigu, Sichuan	July2011
Chevron/Sinopec	Qiannan Basin, Guizhou	April2011
Hess/Sinopec	Shengli oilfield, Shandong	July 2010
Newfield Exploration/PetroChina	Weiyuan, Sichuan	October 2007

Source: Compiled by author from various news publications.

PetroChina and Sinopec are active in a number of areas, particularly in the Sichuan Basin (Table 9). In its Pengshui block, a single well was producing gas at a daily rate of about 83,000 cubic metres, and this gas was being sold to local households and vehicle filling stations (Dong and Shek 2013). PetroChina is also building a pipeline to connect its daily production of 4.5 million cubic meters from the Changning block to a trunk line (Tang and Shek 2013). Despite all this apparent activity, progress has been slower than the government had hoped a few years ago when it set its ambitious targets. By September 2013, only 129 shale gas wells had been drilled, of which 38 wells had produced more than 10,000 cubic metres per day and eight wells more than 100,000 cubic metres per day. Almost all this drilling has occurred in areas outside the blocks awarded in the two licensing rounds where progress has been very slow, not least due to the inexperience of the many of the license holders (World Gas Intelligence 2013). In their first round, blocks Sinopec and the Henan Provincial Coal Seam Gas Company had between them shot about 800 km of seismic and drilled three wells by October 2013 (Li 2013c).

The rate of drilling accelerated in the second half of 2013. By the end of April 2014, 322 wells had been drilled, including 96 horizontal wells, and a total of RMB 15 billion (US$2.42 billion) had been invested (Zhang 2014a). A third round of licensing had been planned for 2013, but as of August 2014 no announcement was made and the government is reported to be rethinking its licensing strategy (Zhang 2014b). In addition, there is evidence that the National Energy Administration may be about to lower the target for shale gas production for 2020 from 60–100 bcm to as low as 30 bcm (Chen and Hua 2014).

Table 9. Summary of Chinese Companies' Licenses for Shale Gas
(Excluding the Two Licensing Rounds)

NOCs	Basin/Location	PSC/License/Block	Partner
Sinopec	Sichuan	-	Sichuan Energy Industry Investment Group
Sinopec	Sichuan	Pengshui block	-
Sinopec	Sichuan	Fuling block	-
Sinopec	Sichuan	Qijiang block	-
Sinopec	Bohai	Shengli	-
Sinopec	Longli, Hunan	Xiangye-1well	-
Sinopec	Guizhou	Kaili	-
Sinopec	Guizhou	Fangshen-1well	-
Sinopec	Chongqing-Guizhou	Nanchuan block	-
CNPC	Sichuan	Changning	-
CNPC	Yunnan	Zhaotong	-
CNPC	Sichuan	Rongcheng block	-
CNPC	Sichuan	Fushun-Yongchuan	Shell
PetroChina	Sichuan	Neijiang-Dazu	-
PetroChina	Sichuan	Weiyuan,	-
Henan Provincial Coal Seam Gas	Sichuan-Hubei-Hunan	Xiushan block,Yuqian	-
Wuhan Kaidi Electric Power	Hubei	Exi block	-
Shaanxi Yanchang Petroleum Group	Ordos	Yan'an block	-

Source: Compiled by author from various news publications.

Overseas, all three major NOCs have been investing in shale gas and shale oil assets in North America, most notably:

- Sinopec formed a joint venture with Chesapeake to develop the Mississippi Lime shale gas in Oklahoma and Kansas.
- PetroChina bought a 50 per cent stake in the Cutbank Ridge shale gas project in western Canada.
- Sinopec formed a joint venture with Devon Energy to develop unconventional oil and gas in a number of US basins.

These investments have been aimed at gaining access to skills and technology as well as financial returns.

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REFERENCES

Andrews-Speed, P. (2004) *Energy Policy and Regulation in the People's Republic of China*. London: Kluwer Law International.

Bai, J. and A. Chen (2010) "China's Fledgling Shale Gas Exploration". *Reuters*, 24 August. Beijing. http://www.reuters.com/article/2010/08/24/china-gas-shale-idUSTOE67NOOR20100824 [accessed 24November 2010].

Beveridge, N. (2011) *Great Expectations—China Kicks Off Its First Shale Gas Exploration Round*. Hong Kong: Bernstein Energy-Pac Energy, Bernstein Research.

Beveridge, N. and A. Chan (2010) *Coal Bed Methane: Is It Time for China's Unconventional Gas Revolution?* Hong Kong: Bernstein Energy-Pac Energy, Bernstein Research.

BP (2014) *BP Statistical Review of World Energy 2014*. London: BP.

Brammall, C. (2009) *Chinese Economic Development*. Abingdon: Routledge.

Cai, Y., D. Liu, Y. Yao et al. (2011) "Geological Controls on Prediction of Coalbed Methane of No. 3 Coal Seam in Southern Qinshui Basin, North China". *International Journal of Coal Geology* 88: 101–12.

Chen, J. (1999) *Chinese Law: Towards an Understanding of Chinese Law, Its Nature and Development*. The Hague: Kluwer Law International.

Chen, A. and J. Hua (2014) "China Finds Shale Gas Challenging, Halves 2020 Output Target". *Reuters*, 7 August. http://www.reuters.com/article/2014/08/07/us-china-shale-target-idUSKBNOG70GS20140807 [accessed 8 August 2014].

China Statistics Press (2013) *China Statistical Yearbook 2013*. Beijing: China Statistics Press.

Chung, J.H. (2010) "The Evolving Hierarchy of China's Local Administration: Tradition and Change". In *China's Local Administration. Traditions and Changes in the Sub-national Hierarchy*, ed. J.H. Chung and T.C. Lam. London: Routledge, pp. 1–13.

Ding, Y., W. Han, Q. Chai et al. (2013), "Coal-based Synthetic Natural Gas (SNG): A Solution to China's Energy Security and CO2 Reduction?". *Energy Policy* 55: 445–53.

Dong, H. and C. Shek (2013) "Sinopec Makes Progress at Pengshui Block". *Interfax Natural Gas Daily*, 29 August, p. 8.

Energy Information Administration (2013a) *International Energy Outlook 2013*. Washington DC: Energy Information Administration.

________ (2013b). *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries outside the United States*. Washington DC: Energy Information Administration.

FACTS Global Energy (2011) *A New Era for Natural Gas in China toward 2030—From Self Sufficiency to Import Dependency*. Honolulu, HI: FACTS Global Energy.

Gao, F. (2012) *Will There be a Shale Gas Revolution in China by 2020?* Oxford: Oxford Institute for Energy Studies.

GK Dragonomics (2012) *In Profile, Natural Gas. Dreams of Plenty*. Beijing: GK Dragonomics.

Heilmann, S. (2010) "Economic Governance: Authoritarian Upgrading and Innovative Potential". In *China Today, China Tomorrow. Domestic Politics, Economy, and Society*, ed. J. Fewsmith (Lanham: Rowman & Littlefield), pp. 109–26.

Horsley, J. (2010) "The Rule of Law: Pushing the Limits of Party Rule". In *China Today, China Tomorrow: Domestic Politics, Economy, and Society* (Lanham, MD: Rowman & Littlefield), 52–68.

Houser, T. and B. Bo (2013) *The Geopolitics of Natural Gas: Charting China's Natural Gas Future*. Houston, TX: Harvard University's Belfer Center and Rice University's Baker Institute Center for Energy Studies.

Howell, J. (2004). "Governance Matters: Key Challenges and Emerging Tendencies". In *Governance in China*, ed. J. Howell. Lanham, MD: Rowman & Littlefield, pp. 1–18.

Huang, Y. (2008) *Capitalism with Chinese Characteristics: Entrepreneurship and the State*. Cambridge: Cambridge University Press.

International Energy Agency (2002) *Developing China's Natural Gas Market. The Energy Policy Challenges*. Paris: OECD/IEA.

________ (2009) *Coalmine Methane in China: A Budding Asset with a Potential to Bloom*. IEA Information Paper. Paris: OECD/IEA.

International Monetary Fund (2013) *World Economic Outlook 2013*. Washington, DC: International Monetary Fund.

Interfax China Energy Weekly (2011) "NEA Completes 2011–2015 Shale Gas Development Plan". *Interfax China Energy Weekly*, 18–24 August, p. 4.

________ (2012a) "CNPC Outputs 2.6 MMcm of Shale Gas to Date". *Interfax China Energy Weekly*, 16–20 January, p. 13.

________ (2012b) "China to Hold Second Round of Shale Gas Rights Auction this Month". *Interfax China Energy Weekly*, 3–6 January, p. 13.

________ (2012c) "Sinopec to Build Shale Gas Production Site in Fuling Region". *Interfax China Energy Weekly*, 5–11 May, p. 17.

________ (2012d) "China Eyes More Incentives to Support Shale Gas Development". *Interfax China Energy Weekly*, 17–23 November, p. 4.

________ (2012e). "Onerous Shale Gas Subsidy Faulted". *Interfax China Energy Weekly*, 1–7 December, p. 5.

Jia, C., M. Zheng and Y. Zhang (2012) "Unconventional Hydrocarbon Resources in China and the Prospect of Exploration and Development". *Petroleum Exploration and Development* 39, 2: 139–46.

Kong, B. (2010) *China's International Petroleum Policy*. Santa Barbara, CA: Praeger.

Krug, B. and H. Hendrischke (2008) "China's Institutional Architecture: A New Institutional Economics and Organisation Theory Perspective on the Links between Local Governance and Local Enterprises". ERIM Report Series, Research in Management. http://papers.ssrn.com/sol3/papers.cfm?abstract id=1131026 [accessed 19 August 2011].

Li, X. (2013a) "China Risks Severe Shortfalls with Gas Expansion". *Interfax Natural Gas Daily*, 17 October, pp. 6–7.

________ (2013b) "Total to Drill First Shale Gas Well at Xuancheng by Year-End". *Interfax Natural Gas Daily*, 27 June 2013, p.7.

________ (2013c) "Shale Gas Blocks Maligned ahead of China's Third Tender". *Interfax Natural Gas Daily*, 14 October, p. 1.

Li, X. and C. Shek (2013) "Shell Deepens Chinese Shale Reach with Hunan Tie-Up". *Interfax Natural Gas Daily*, 12 July, pp. 1–2.

Lieberthal, K.G. (1995) *Governing China: From Revolution through Reform*. New York: W.W. Norton.

Meng, Z., J. Zhang and R. Wang (2011) "In-Situ Stress, Pore Pressure and Stress-Dependent Permeability in the Southern Qinshui Basin". *International Journal of Rock Mechanics and Mining Sciences* 48: 122–31.

Nakano, J. and K. Kushkina (2013) "China Awards More Shale Gas Blocks though Much Remain to be Seen". Center for Strategic and International Studies, 29 January. http://csis.org/publication/china-awards-more-shale-gas-blocks-although-much-remains-be-seen [accessed 10 May 2013].

National Development and Reform Commission (2007) *China Gas Utilisation Policy*. Beijing: National Development and Reform Commission.

Naughton, B. (2002) “China’s Economic Think Tanks: Their Changing Role in the 1990s”. *The China Quarterly* 171: 625–35.

________ (2007) The Chinese Economy. Transitions and Growth. Cambridge, MA: MIT Press.

Pattison, P. and D. Herron (2003) “The Mountains are High and the Emperor is Far Away: Sanctity of Contract in China”. *American Business Law Journal* 40: 459–510.

Peerenboom, R. (2002) *China’s Long March toward the Rule of Law*. Cambridge: Cambridge University Press.

________ (2007) *China Modernizes: Threat to the West, or Model for the Rest?* New York: Oxford University Press.

Peerenboom, R. and X. He (2009) “Dispute Resolution in China: Patterns, Causes and Prognosis”. *East Asia Law Review* 4, 1: 1–61.

Shirk, S.L. (1992) “The Chinese Political System and the Political Strategy of Economic Reform”. In *Bureaucracy, Politics, and Decision Making in Post-Mao China*, ed. K.G. Lieberthal and D.M. Lampton. Berkeley, CA: University of California Press, pp. 59–91.

________ (1993) *The Political Logic of Economic Reform in China*. Berkeley, CA: University of California Press.

Sun, H., L. Shan and X. Wang (2013) “China Natural Gas Development in 2013 and Outlook in 2013”. *International Petroleum Economics* 6: 21–5.

Tang, T. and C. Shek (2013) “PetroChina Building Country’s First Shale Gas Pipeline”. *Interfax Natural Gas Daily*, 20 June, p. 7.

Tsui, T.C. (2013) “Rule of Law in China-Legislation Reasoning and Enforcement of Anti-Monopoly Law in China and the West”. *Frontiers of Law in China* 8, 4: 689–767.

Wank, D.L. (1999) “Producing Property Rights: Strategies, Networks, and Efficiency in Urban China’s Nonstate Firms”. In *Property Rights and Economic Reform in China*, ed. J.C. Oi and A.G. Walder. Stanford, CA: Stanford University Press, pp. 248–72.

World Gas Intelligence (2013) “China Shale—Bust not Boom”. *World Gas Intelligence* 24, 29 (25 September): 1–2.

Xia, M. (2000) *The Dual Developmental State. Development Strategy and Institutional Arrangements for China’s Transition*. Aldershot: Ashgate.

Xinhua News Agency (2013) "Coal-Bed Gas Target: Mission Impossible?" *People's Daily Online*, 14 March. http://english.people.com.cn/90778/8167878.html [accessed 15 March 2013].

Yang, C.J. and R.B. Jackson (2013) "China's Synthetic Natural Gas Revolution". *Nature Climate Change* 3: 852–4.

Yun, J., F. Xu, L. Liu et al. (2012) "New Progress and Future Prospects of CBM Exploration and Development in China". *International Journal of Mining Science and Technology* 22: 363–9.

Zhang, Y. (2014a) "Hurdles for China Unconventionals Debated". *Interfax Natural Gas Daily*, 31 July, p. 9.

_________ (2014b) "China Mulls Shake-Up of Shale Tenders". *Interfax Natural Gas Daily*, 17 July, p. 6.

Zheng, Y. (2010a) "Central-Local Relations: The Power to Dominate". In *China Today, China Tomorrow: Domestic Politics, Economy, and Society*, ed. J. Fewsmith. Lanham, MD: Rowman & Littlefield, pp. 193–222.

_________ (2010b) *The Chinese Communist Party as Organisational Emperor: Culture, Reproduction and Transformation*. London: Routledge.

Zhu, S. (2004) "Reforming State Institutions: Privatising The Lawyers' System". In *Governance in China*, ed. J. Howell. Lanham, MD: Rowman & Littlefield, pp. 58–76.

Zhu, X. (2011) "Government Advisors or Public Advocates? Roles of Think Tanks in China from the Perspective of Regional Variations". *The China Quarterly* 207: 668–86.

Zou, C., D. Dong, S. Wang et al. (2010) "Geological Characteristics and Resource Potential of Shale Gas in China". *Petroleum Exploration and Development* 37, 6: 641–53.

2. COALBED METHANE IN CHINA: ANALYSIS OF THE UPPER AND LOWER LEVEL GAMES

Xu Xiangyang

Explaining the Upper and Lower Level Games

In this account, we have simplified China's complex governance system into an Upper and a Lower Level game. The Upper Level game is the arena of national-level governance where national policies, laws and strategies are made. The principal actors are the agencies of national government and the state-owned enterprises reporting directly to central government. The Lower Level game involves the implementation of policies involving local government agencies and various types of enterprise, state-owned and private, domestic and foreign. It is in this Lower Level that central government policies are played out and the interactions between the actors determine the degree of success of the policies.

The Upper Level Game

The Actors

The main actors in the Upper Level game include a number of agencies in the Chinese central government who influence or set policy and make regulations, and state-owned companies controlled by the central government.

The key government bodies for CBM are:

- The State Council
- The National Development and Reform Commission
- The National Energy Administration
- The Ministry of Land and Resources
- The Ministry of Finance
- The Ministry of the Environment
- The State Administration of Work Safety

The main centrally controlled state-owned companies are:

- China United Coal Bed Methane Corporation
- China National Petroleum Corporation (CNPC) and its listed subsidiary PetroChina Ltd
- China Petroleum Corporation (Sinopec) and its listed subsidiary Sinopec Ltd
- China National Offshore Oil Company (CNOOC) and its listed subsidiary CNOOC Ltd

Policies for CBM Extraction and Resource Rights

In January 2013, the State Council issued the notice relating to the Twelfth Five-Year Plan of National Energy [国务院《能源”十二五”规划》] in which it urged that priority be given to develop unconventional gas resources, specifically CBM and shale gas. In China, the ownership of mineral resources lies with the state, and the State Council exercises the ownership rights of mineral resources on behalf of the state. The Ministry of Land and Resources (MLR) under the authority of the State Council conducts the unified management of the country's mineral resources. Therefore, coalbed methane (CBM) resources belong to the state, and MLR exercises the management rights both directly and through its bureaus at lower levels of government.

Clause 4 of China's *Mineral Resources Law* stipulates that state-owned mining enterprises should be the main actors to exploit mineral resources, but the law also supports collective and private enterprises to conduct mining activities as well as foreign companies. Exploration licenses require the approval of the relevant departments of land and resources at national level and provincial levels, but mineral extraction licenses require the approval of departments at municipal and county levels as well. The level of government which formally issues the exploration or mining license depends on the scale of the project and the degree of national importance: MLR for the larger and more important projects; and provincial departments for other projects.

The MLR and the National Energy Administration (NEA) are responsible for making policy on resources rights. On 23 March 2013, NEA issued a national Coalbed Methane Industrial Policy [国家能源局公告 2013 第 2 号，煤层气产业政策] intended to promote the development of the CBM industry in China.[1] It requires the entity which holds the exploration right to conduct comprehensive exploration for CBM and coal resources within the area of exploration licence, to evaluate these mineral reserves, and to submit a report on the CBM and coal resources.

As in many countries, a key regulatory challenge relating to coalbed methane production in China arises from the tension between coal-mining companies and CBM companies. This situation arises because methane lies within the coal seams, and it can be drained by the coal-mining enterprises as coalmine methane (CMM) or drained from the surface as CBM. In an area where a company already holds coal-mining exploration rights but where no CBM exploration rights have been issued, if the area is prospective for CBM, the enterprise holding the coal exploration rights should manage both the CBM and coal exploration licenses. The enterprise may undertake the CBM exploration independently or cooperate with others. Where a CBM exploration right has already been issued, the entity holding this right should carefully integrate CBM extraction with coal mining. In particular, CBM exploration should serve the needs of safe coal mining. In other words, the enterprise should first explore for and start extracting the CBM and only then move on to mining the coal.

On 22 September 2013, the State Council re-emphasised this prioritisation in its document, *Opinion to Further Accelerate the Coalbed Methane and coalmine Methane Drainage and Utilisation*, which stipulated that enterprises should first extract coalbed methane and later mine coal.[2] This document from the State Council clarified an earlier one issued in 2006 entitled *Opinions on Accelerating Coalbed Methane and coalmine Methane Drainage and Utilisation*.[3] This document stressed the principle that CBM exploration should serve coal

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1 *China Coalbed Methane Industrial Policy*, No. 2, 2013 [In Chinese: 国家能源局公告 2013 第 2 号，煤层气产业政策].

2 *Opinion to Further Accelerate the Coalbed Methane and coalmine Methane Drainage and Utilisation*, No. 93, 2013 [In Chinese:国务院办公厅《关于进一步加快 煤层气（煤矿瓦斯）抽采利用的意见》国办发〔2013〕93号].

3 *Opinions on Accelerating Coalbed Methane and coalmine Methane Drainage and Utilisation*, No. 47, 2006 [In Chinese: 国务院办公厅 《关于加快煤层气(煤矿瓦斯)抽采利用的若干意见》(国办发［2006］47 号].

development, and that CBM enterprises should cooperate with coal-mining enterprises. If necessary, the scope of CBM mineral rights should be adjusted to optimise the development of the coal resource.

Finally, the 2013 State Council Opinion proposed that the relevant authorities should impose much more stringent progress reporting requirements on the holders of CBM licenses, and that enterprises failing to undertake an appropriate level of work activity should be obliged to relinquish part of their licence area.

Investment Approvals

General

The National Energy Administration has the authority to make initial investment approval. In March 2013, NEA published "Coal Bed Methane Industrial Policy" which stipulated that enterprises which engage in the coalbed methane exploration and development should have the necessary investment capacity, be in a good financial condition, and possess a rigorous modern accounting system. The CBM enterprise should employ suitably qualified professionals and be fully informed on national regulations and standards relating to industry practices, technology and safety.

Qualified enterprises from each type of ownership system are encouraged to participate in CBM exploration and development: the large-scale coal-mining enterprises and the oil and gas enterprises are encouraged to establish professional coalbed methane companies. In addition, the responsible departments of local government are permitted to introduce measures that support the CBM industry in their region.

The approval authority for CBM pipelines depends on the capacity of the pipeline. Proposals for pipelines with an annual capacity greater than 500 MMcm and those that cross provincial borders require the approval of the investment department of the State Council. If its annual capacity is below this threshold, the pipeline can be approved by the investment department of the provincial government. In cases where coal-mining enterprises are draining methane for their own use, no formal government approval is needed, but the enterprises must inform the local government.

Foreign Investment

Since the 1990s, the Chinese government has established a comprehensive legal system to stimulate foreign investment. In the energy sector, the government promotes foreign companies to conduct exploration and development of petroleum, natural gas and unconventional gas in the form of cooperation with Chinese companies. In the oil and gas sector, such cooperation usually takes the form of a production-sharing contract (PSC). The activities to be encouraged are specified in official *Foreign Investment Guidance Catalogues*[4], which are updated and re-issued, periodically by the National Development and Reform Commission and the Ministry of Commerce. The *Catalogue* issued in 1997 was the first to explicitly identify the exploration and development of coalbed methane as an investment to be encouraged.

[4] *Foreign Investment Guidance Catalogues* [In Chinese:《外商投资产业指导目录》].

In the past, any Chinese company wanting to undertake the exploration or exploitation of a mineral resource in China needed the approval of both the Ministry of Commerce and the Ministry of Land and Resources. These requirements were removed for CBM as a result of two decisions. First, in July 2013 through State Council Decree No. 638, *Decision on the Cancellation and Amendment of Certain Administrative Regulations*[5]; second in February 2014, with the State Council's *Decision to Further Eliminate Certain Administrative Approval Items and Delegate Administrative Power to Lower Government Authorities*.[6] These two decisions left the authority for approval with lower levels of government. These steps also dramatically simplify the approval procedure for foreign investment in CBM and other mineral resources.

In 1996, the Ministry for Coal Industries and China National Petroleum Corporation (CNPC) together established the China United Coal Bed Methane Company (CUCBM) to act as the national champion with a monopoly over cooperation with foreign companies. After the abolition of the Ministry for Coal Industries, its share of CUCBM was taken first by the Ministry of Land and Natural Resources and later by the China National Coal Group (ChinaCoal). Likewise, PetroChina took over CNPC's share.

In 2007, the government removed CUCBM's monopoly on foreign cooperation. A year later, PetroChina withdrew from CUCBM and became a CBM player in its own right. In 2010, the Ministry of Commerce issued a notice that permitted PetroChina, Sinopec and the Henan CBM Company to cooperate with foreign investors. That year, CNOOC bought a 50 per cent stake in CUCBM.

Environment, Land and Water

CBM exploitation can cause damage to water, land and air. Hence, the Chinese government has placed the following main government departments in charge of regulating the environment and water: the Ministry of Environmental Protection; the General Administration of Quality Supervision, Inspection and Quarantine; the Ministry of Land and Resources; and the National Energy Administration.

CBM production in China requires the injection of water to drain the reservoir. During this process, a group of wells are used to produce CBM—among these group wells, only one is used for water injection; the others are used for pumping water out and decreasing the formation pressure in order to promote the flow of methane. The purpose of injecting water is to control the decline of formation pressure in the coal seam.

The production process disrupts sub-surface aquifers and requires the disposal of large quantities of water that hold natural but often toxic ingredients. Investigations in Shanxi Province have revealed that CBM production affects local water resources and the environment

[5] *Decision on the Cancellation and Amendment of Certain Administrative Regulations*, No. 638, 2013 [In Chinese:《国务院关于废止和修改部分行政法规的决定》 (国务院令第 638 号, 2013)].

[6] *Decision to Further Eliminate Certain Administrative Approval Items and Delegate Administrative Power to Lower Government Authorities*, No. 5, 2015 [In Chinese:《国务院关于取消和下放一批行政审批项目等事项的决定》 (国发(2014)5 号)].

in a number of ways: declines in flows from shallow and medium-depth water wells; drying up of spring water flows; the pollution of surface and sub-surface water; the destruction of vegetation; and soil erosion.[7]

The *Coal Bed Methane Industrial Policy* issued in 2013 by NEA laid out the energy conservation and environmental protection requirements for China's CBM industry.[8] CBM projects should implement comprehensive energy conservation strategies; promote the use of energy-efficient equipment; and make use of the CBM produced during the exploration and trial production periods. All CBM projects should carry out the legally required "Environmental Impact Assessment" (EIA). Project sites should be selected so that they avoid ecologically sensitive regions such as nature protection regions and drinking water sources. Enterprises should also strictly adhere to the CBM emission standards and prevent the direct discharge of methane. All waste gas, waste water and other materials discharged during CBM production should meet national emission standards. Solid waste should be properly treated to avoid the pollution of underground water. Article 25 of the *Coal Bed Methane Industrial Policy* stipulates that a risk assessment for social stability should be carried out for those projects that might bring significant social impact.

The *Regulation on Land Reclamation* approved on 22 February 2011 places the obligation for the rehabilitation of land damaged by production and construction on enterprises or individuals responsible for the damage.[9] However, local government agencies above the county level are responsible for organising reclamation of land for which the responsible enterprises or individuals cannot be identified.

A further environmental concern arises from the venting of methane into the atmosphere by CBM and CMM operations. In April 2008, the Ministry of Environment Protection and the General Administration of Quality Supervision, Inspection and Quarantine jointly issued the *Emission Standard for Coalbed Methane (Coalmine Gas) Discharge Standard (Tentative)*.[10] Under the subject of coalmine safety ventilation, it set emission limits for coalmine CMM and CBM, prohibiting the discharge of gas if the methane concentration of the gas is equal to or greater than 30 per cent. The content density of gas is equal to or above 30 per cent.

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[7] Provincial research group conducted fieldwork of coalbed methane mining and water resources protection in our city [In Chinese: 省调研组在我市调研煤层气开采与水资源保护情况], JCOnline, 19 June 2013. Available in Chinese at http://www.jconline.cn/Contents/Channel_6916/2013/0619/963504/content_963504.htm (accessed 15 June 2017).

[8] *Coal Bed Methane Industrial Policy*, No. 2, 2013 [In Chinese: 国家能源局公告 2013 第 2 号，煤层气产业政策].

[9] Regulation of Land Reclamation, 22 February 2011 [In Chinese: 土地复垦条例, 2011 年 2 月 22 日 国务院第 145 次常务会议通过]. Available in Chinese: http://www.gov.cn/zwgk/2011-03/11/content_1822591.htm (accessed 15 June 2017).

[10] *Emission Standard for Coalbed Methane (Coalmine Gas) Discharge Standard (Tentative)* , April 2015 [In Chinese: 环保部和国家质监总局联合发布《煤层气（煤矿瓦斯）排放标准暂行》（2008 年 4 月）].

In its *Notice on Strengthening the Supervision of Coal and CBM Exploration and Exploitation of CBM and Supervision of the Work*,[11] the Ministry of Land and Resources consolidated many of these legal requirements relating to water, land and the environment. However, since CBM development and production is a new industry in China, the relevant monitoring and management mechanisms are weak and not integrated.

Pipeline Access

The State Council and National Energy Administration are responsible for regulating pipeline access. Almost all long-distance pipelines between centres of production and consumption were built by and are owned and used by China's national oil companies (NOCs), notably PetroChina. Until 2013, there was no policy or regulation requiring pipeline owners to provide access to their pipelines to third parties. The companies that built and owned the pipelines were able to deny access to third parties or to set the transmission tariff at unreasonably high levels. In the past, this had been a problem as the NOCs owned nearly all the gas production facilities and the limited pipeline network had little or no spare capacity to take additional gas. This situation changed with the discovery of CBM reserves by companies other than the NOCs.

To address these deficiencies, the Chinese government has identified two policy priorities relating to gas pipelines, and aimed at supporting the development of natural gas in general and unconventional gas (CBM and shale gas) in particular. Both the *Twelfth Five-Year Plan for Energy* and the *Coal Bed Methane Industrial Policy* identified the need to accelerate the construction of a nation-wide integrated pipeline network. The aims are to import increasing quantities of gas from Russia, central Asia and Southeast Asia, as well as to ensure that all forms of gas, including synthetic natural gas, produced in China can reach the centres of consumption.

In a second initiative, the NDRC published the *Management Measures for Natural Gas Infrastructure Construction and Operation* in February 2014 by the National Energy Bureau.[12] This document addresses a number of issues relating to gas infrastructure, including construction approvals, gas pricing, and the need for separate accounting and support for interconnection. In addition, it places on NEA the responsibility of ensuring that gas infrastructure is managed in a way that promotes fairness and openness, and of constraining the monopoly power of the infrastructure owners. Despite the favourable nature of these provisions, NEA will need to provide detailed rules in order to bring these policies into effect.

Safety and Technical Standards

The State Administration of Coalmine Safety and the National Energy Administration are responsible for safety standards in CBM production. In February 2012, the State Administration of Coalmine Safety published *Coalbed Methane Ground Mining Safety Regulation (Tentative)*,

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[11] *Notice on Strengthening The Supervision Of Coal And CBM Exploration And Exploitation Of CBM And Supervision Of The Work* [In Chinese:关于加强煤炭和煤层气资源综合勘查开采管理的通知]. Available in Chinese: http://www.mlr.gov.cn/tdzt/zxgz/zdhgfkczykfzx/xgwj/200806/t20080627_676997.htm (accessed 15 June 2017).

[12] *Management Measures for Natural Gas Infrastructure Construction and Operation*, No. 8, 2014 [In Chinese: 《天然气基础设施建设与运营管理办法》 2014 年第 8 号令].

which made specific regulations about CBM extraction and issues relating to project design, well drilling, well logging, fracturing, gas production, collection and transportation.[13]

In its *Coal Bed Methane Industrial Policy*, NEA charged CBM enterprises with establishing safe production responsibility systems and structures, and specified the need to employ qualified safety personnel, and to establish safety control systems and practical operation rules. Besides the above, the CBM enterprises should establish a system for assessing the social stability risk relating to coalbed methane construction projects which might cause substantial and long-term impacts on local people's livelihoods.

The National Energy Administration and China United Coal Bed Methane Cooperation (CUCBM) are responsible for setting the technical standards for CBM exploration and exploitation.

On 8 November 2013, NEA approved the establishment of the *Professional Technology Committee of Coal Bed Methane standardisation in the Energy Industry*.[14] The National Engineering Research Centre for Coal Gas Control provides the secretariat for this committee. This centre is responsible for the standardisation work for CBM exploration, development and utilisation, and supports the routine work of the professional technology committee.

Gas Pricing and Subsidies

The State Council and the NDRC are both responsible for setting policies for gas prices and have introduced a number of measures to support the production of CBM. The NDRC in its *Notice on CBM Price Management* [关于煤层气价格管理的通知], issued in 2007, clearly states that the CBM price should be negotiated between buyers and sellers, and that local governments should actively create conditions for price liberalisation as soon as possible. This policy, combined with a shortage of pipeline infrastructure, has encouraged CBM producers to liquefy or compress their gas to supply the transport or industrial sectors. This can generate reasonable profits, depending on market conditions. In contrast, gas injected into pipelines is likely to be sold at the city gate for prices set by the local government on a cost-plus basis which will yield unattractive returns.

On 6 March 2007, the State Council proposed for CBM production to receive a price subsidy at the *Meeting on the Comprehensive Utilisation of Coalmine* Gas.[15] That same year on 20 April, the Ministry of Finance formally agreed to provide a subsidy to the CBM-mining enterprises of 0.2 RMB/m^3 on top of the relevant prevailing price.[16] Local finance departments are also permitted

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13 *Coalbed Methane Ground Mining Safety Regulation (Tentative)*, February 2012 [In Chinese: 国家安全生产管理监督总局《煤层气地面开采安全规程（试行）》（2012 年 2 月）].

14 *Professional Technology Committee of Coal Bed Methane standardisation in the Energy Industry*, 8 November 2013 [In Chinese: 能源局 "能源行业煤矿瓦斯治理与利用标准化技术委员会," (NEA/TC27), 8 November 2013].

15 *Meeting on the Comprehensive Utilisation of Coalmine* Gas, 6 March 2007 [In Chinese: 国务院《研究煤矿瓦斯综合治理利用专题会议纪要》(国[2007]19 号)（2007 年 3 月 6 日）].

16 *About Coal-Bed Methane Development and Utilization Of The Implementation Opinions Subsidies*, No. 114, 2007 [In Chinese: 财政部《关于煤层气(瓦斯) 开发利用补贴的实施意见》(财建〔2007〕114 号)]. Available in Chinese:

to provide some subsidies to local CBM exploration and utilisation enterprises depending on the local situation. The specific levels and methods for the subsidy can be decided by the local finance departments. In September 2013, the State Council expressed its opinion State Council through document No. 93, *Coalbed Methane Industry will Gain the Policy Dividend*, that the level of subsidy being offered was too low and should be increased from 0.2 RMB/m^3 to 0.6–0.8 RMB/m^3 given the high costs of extracting CBM.[17]

In 2006, the State Council suggested that coal-mining enterprises should be able to use the CBM to generate electricity for their own purposes. If there is surplus electricity available to be sold to the grid, the grid company should arrange the grid connection. The price paid for this electricity was to be either that approved by the responsible price department of the state or the benchmark electricity price for the local coal-fired generating plant using flue-gas desulphurisation equipment.[18]

In April 2007, the NDRC turned this proposal into formal policy when it issued the *Notice on the Utilisation of Coalbed Methane (Coal Gas) for Implementation Power Generation*.[19] This provides for coalbed methane power plants to receive the same price for electricity supply as biomass plants, provided that they do not participate in market competition and do not undertake peak shaving. The tariff for biomass plants had been set the previous year at 0.25 RMB per kWh as part of measures to promote renewable energy.[20]

Taxes and Fees

The State Administration of Taxation, the Ministry of Land and Resources, and the Ministry of Finance are responsible for setting policies pertaining to enterprise and resource taxation. A number of taxes are applicable to CBM extraction, though the Chinese government has had to clarify certain points and has introduced a number of allowances.

Business Taxes and Fees

Value Added Tax (VAT)

According to the regulation of *The Interim Regulations of the People's Republic of China on Value Added Tax* [中华人民共和国增值税暂行条例] released by the State Council in November

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http://jjs.mof.gov.cn/zhengwuxinxi/zhengcefagui/201110/t20111026_602044.html (accessed 15 June 2017).

17 *Coalbed Methane Industry will Gain the Policy Dividend*, No. 93, 2013 [In Chinese: 国务院出台 93 号文煤层气产业获政策红利, 2013].

18 *Several Opinions about Speeding Up Drainage and Utilization of Coal Bed Methane (Coalmine Gas)*," State Council, No. 47, 2006 [In Chinese: 国务院办公厅《关于加快煤层气（煤矿瓦斯）抽采利用的若干意见》(国办发［2006］47 号)].

19 *Notice on the Utilisation of Coalbed Methane (Coal Gas) for Implementation Power Generation* [In Chinese: 国家发展改革委印发 关于利用煤层气(煤矿瓦斯)发电工作实施意见的通知].

20 *The Trial Measures for Renewable Energy Power Generation Prices and the Cost Sharing Management* [可再生能源发电价格和费用分摊管理试行办法], 25 July 2009. Available in Chinese at: http://www.fenglifadian.com/news/zhengce/4754D1584.html (accessed 15 June 2017).

2008,[21] the VAT rate is 17 per cent. On 7 February 2007, the Ministry of Finance and the State Administration of Taxation jointly issued the *Notice on Accelerating the Coal Seam Gas Drainage on Tax Policy Issues*.[22] This provided for CBM enterprises to receive refunds on their VAT payments, provided that these refunds be devoted specifically to research and the increase of production. In addition, CBM enterprises would be exempt from corporate income tax. In order to bring CBM in line with conventional oil and gas extraction, on 7 June 2013, the State Administration of Taxation issued the *Notice about Related Issues of VAT in Coalbed Methane and Shale Gas Exploitation by Oil and Gas Enterprises*. This clarified that oil and gas field enterprises that provide productive services for the development of CBM should be subject to VAT of 17 per cent, according to the *Management Method for VAT in Oil and Gas Enterprises* issued in 2009.[23] However, it was pointed out that this Notice failed to clarify what VAT rate should apply to CBM production and sale activities.[24]

Corporate Income Tax

Corporate income is taxed at the rate of 25 per cent, having been reduced from 33 per cent in 2008. A number of provisions have been introduced that are favourable for CBP development. On 7 February 2007, the Ministry of Finance and the State Administration of Taxation jointly issued the *Notice on Related Issues of Tax Policy for Accelerating the Coal Bed Methane Extraction*.[25] This provided for CBM enterprises to recover their equipment costs more rapidly by providing a choice for depreciation between the double declining balance method or accelerated depreciation.

Sino-foreign cooperative ventures also receive some favourable treatment. The State Council's 2007 *Notice on the Implementation of Transitional Favourable Policies for Business Income Tax* [国务院《关于实施企业所得税过渡优惠政策的通知》] states that Sino-foreign cooperation enterprises which conduct CBM exploitation will be eligible for the favourable levy tax policy of "two exemptions and three half reductions". This term refers to an exemption from income tax for the first and second years of profitability, and a 50 per cent reduction in income tax in

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21 *The Interim Regulations of the People's Republic of China on Value Added Tax*, No. 538, 2008 [In Chinese: 中华人民共和国增值税暂行条例,中华人民共和国国务院令第 538 号,2008]. Available in Chinese: http://www.chinaacc.com/new/63_67_/2008_11_17_wa8088515201711180021980.shtml (acccessed 15 June 2017).

22 *Notice on Accelerating the Coal Seam Gas Drainage on Tax Policy Issues*, No. 16, 2007 [In Chinese: 财政部、国家税务总局联合下发的《关于加快煤层气抽采有关税收政策问题的通知》(财税[2007] 16 号)]. Available in Chinese: http://www.chinatax.gov.cn/n8136506/n8136563/n8193451/n8193481/n8193977/8241138.html (acccessed 15 June 2017).

23 *Management Method for VAT in Oil and Gas Enterprises*, No. 8, 2009 [In Chinese: 油气田企业增值税管理办法)（财税[2009]8 号）].

24 KPMG, *Clarifications Issued on the Value Added Tax (VAT) Treatments Related to Coalbed Methane and Shale Gas Development,* China Alert: Energy and Natural Resources Focus, Issue 2, June 2013. Available at https://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Newsletters/China-alert-Energy-Natural-Resources-Focus/Documents/china-alert-ENR-1306-02.pdf (accessed 10 July 2014).

25 *Notice on Related Issues of Tax Policy for Accelerating the Coal Bed Methane Extraction*, No. 16, 2007 [In Chinese: 财政部、国家税务总局联合下发的《关于加快煤层气抽采有关税收政策问题的通知》(财税[2007] 16 号)].

the third, fourth and fifth years. These exemptions apply to foreign invested enterprises that have been in operations for over 10 years. In addition, for those newly established joint venture enterprises that purchase domestic equipment, 40 per cent of the cost of this equipment can be credited to any increase in corporate income tax payable in the following year.[26]

Import Duty and VAT

On 25 October 2006, the Ministry of Finance and the General Administration of Customs and State Administration of Taxation jointly issued the *Notice on Tax Exemption of Goods and Materials Import for CBM Exploration and Development Projects*.[27] This provides for exemptions on import duty and VAT for the China United Coal Bed Methane Company and its partners when importing equipment for CBM exploration and development that cannot be manufactured in China. Other enterprises that engaged in the CBM exploration and development should apply for exemptions to the Ministry of Finance before import takes place. Approval is required from the Ministry of Finance, the General Administration of Customs, the State Administration of Taxation and other departments.

Resource-related Taxes and Fees

Resource Tax

China's resource tax is equivalent to a mineral royalty of the specific or unit of production type, and is payable by Chinese companies. According to the *Temporary Regulations for Resource Tax in the People's Republic of China* issued in 1993, the resource tax applicable to CBM is RMB2–15 per thousand cubic metres.[28] However, in February 2007, the Ministry of Finance and State Administration of Taxation jointly issued *The Notice on Related Tax Policy for Accelerating CBM Extraction*, which temporarily removed the need for enterprises to pay the resource tax on the CBM production.[29]

Royalties

Royalties are payable by foreign-invested enterprises. The coalbed methane mining royalties should be paid as a percentage of gross production according to "Provisional Regulations on Royalties concerning Foreign Cooperative Exploitation of Onshore Petroleum Resources" (The Ministry of Finance [1995] No.63), according to a sliding scale (Table 1).[30]

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[26] *Notice about Relevant Issues on the Compensation for Corporate Income Tax of the Foreign Investment Enterprises and Foreign Companies that Purchase Domestic Equipment*, No. 49, 2000 [In Chinese: 《关于外商投资企业和外国企业购买国产设备投资抵免企业所得税有关问题的通知》（财税字[2000]49 号）].

[27] *Notice on Tax Exemption of Goods and Materials Import for CBM Exploration and Development Projects*, No. 13, 2006 [In Chinese: 国家税务总局《关于煤层气勘探开发项目进口物资免征进口税收的规定》（财关税[2006]13 号）].

[28] *Temporary Regulations for Resource Tax in the People's Republic of China, 1993* [In Chinese: 《中华人民共和国资源税暂行条例》(1993)].

[29] *The Notice on Related Tax Policy for Accelerating CBM Extraction*, No. 16, 2007 [In Chinese: 《关于加快煤层气抽采有关税收政策问题的通知》（财税[2007]16 号）].

[30] "Provisional Regulations on Royalties concerning Foreign Cooperative Exploitation of Onshore Petroleum Resources" (The Ministry of Finance [1995] No. 63). [In Chinese: 中外合作开采陆上石油资源缴纳矿区使用费暂行规定.(a 财税[1995] 63 号). Available in Chinese at: http://www.csj.sh.gov.cn/pub/xxgk/zcfg/ykgf/200403/t20040301_290664.html (accessed 15 June

Table 1. Royalty Rates for Onshore Gas Production

Annual production	Royalty rate
Less than 1.0 bcm	0%
1.0–2.5 bcm	1%
2.5–5.0 bcm	2%
Greater than 5.0 bcm	3%

Mineral Resource Rights Users' Fees

According to clause 12 of the *Measures for the Area Registration Administration of Mineral Resources* from 1998,[31] mining enterprises should pay an annual resource right users' fee. During the exploration phase, the fee is RMB100 per square kilometre. Thereafter, the fee rises by RMB100 per year to a maximum of RMB500 per square kilometre. During mineral extraction, the annual fee is RMB1,000 per square kilometre.

The *Measures on the Waiver of Prospecting and Mining Royalties*, issued by the Ministry of Land and Resources and the Ministry of Finance in June 2000, provided some dispensation.[32] During the exploration phase, investors are exempted from paying this fee in the first year of exploration. In the second and third year, the exemption is 50 per cent, and this is reduced to 25 per cent from the fourth to seventh years of exploration. During the production phase, investors are exempted in the first year of production. In the second, the exemption is 50 per cent, and this is reduced to 25 per cent from the third to seventh years of exploration.

Supporting and Constraining Factors in the Upper Level Game

Technology

Technology is the single most important factor in the development of CBM. Though the total CBM resource is very large, the geological conditions of many of China's coal deposits are structurally complex. The distribution of estimated CBM by coal rank is estimated at 21 per cent in high-rank coals, 39 per cent in middle-rank coals and 40 per cent in low-rank coals. Great progress has been made in the development of CBM from high-rank coals, with commercial production in the Qinshui Basin in the southern part of Shanxi Province. The development of middle-rank coals has made some progress in the Ordos region area, but the technology to extract CBM from low-rank coals in China has yet to be developed. Even after

2017).

[31] "*Measures for the Area Registration Administration of Mineral Resources,*" (State Council Decree. No. 240)(1998) [In Chinese: 矿产资源勘查区块登记管理办法. 国务院令第 240 号(1998)]. Available in Chinese at: http://www.chinaacc.com/new/63_73_/2009_11_25_wa5706485149521190020.shtml (accessed 15 June 2017).

[32] The Measures on the Waiver of Prospecting and Mining Royalties (MLR issue [2000] No. 174) [In Chinese: 探矿权采矿权使用费减免办法.(国土资发 (2000) 174 号]. Available in Chinese at: http://www.gov.cn/gongbao/content/2001/content_60754.htm (accessed 15 June 2017).

more than 20 years of CBM exploration and development, China's CBM industry needs further technological advancement in order to continue boosting commercial production, especially for low-rank coals and for coals that are buried to great depths.

Lack of Exploration Investment

The second most important factor that is constraining the development of CBM is the limited scale of investment in exploration. Although the three big companies—CUCBM, PetroChina and Sinopec—have undertaken CBM exploration, the scale of their activity remains relatively small, and so more investment is needed from private enterprises, both Chinese and foreign.

The main reason for the low level of investment has been the commercial attractiveness of CBM production in China and this in turn relates to the way that gas prices are set and the level of subsidies for CBM. As discussed earlier, gas sold close to the production site as LNG or CNG can generate reasonable financial returns, but these are subject to market conditions. Gas sold into pipelines yields lower returns, as the obligation for pipeline owners and operators to provide third-party access at an acceptable cost is still poorly defined, even with the new regulation. Moreover, it can take many years for a production capacity of a region to be sufficient in order to justify a dedicated pipeline network.

Although the Chinese government in 2013 provided a subsidy of 0.2 RMB/m^3, both the State Council and CBM enterprises claim that this is too low to encourage a much larger scale of investment in CBM. Comparison can be made to the tax credits that the US federal government provided to the producers of unconventional gas for wells drilled between 1979 and 1993, and for production from these wells until 2002.

<u>The Lower Level Game</u>

The Actors

Below the level of the central government, the main actors involved in the exploration and extraction of CBM fall into the following categories:

- Government departments at provincial and lower levels of government.
- Chinese state-owned companies owned at the central government level, such as the national oil companies and CUCBM.
- Chinese state-owned companies owned at provincial or lower levels of government, such as the Shaanxi Yanchang Petroleum Group, the Jingcheng Antracite Mining Group (Shanxi Province), the Henan Provincial Coal bed Methane Company, the Guizhou Panjiang Coal Bed Methane Company, and the Sichuan Coal Bed Methane Development and Investment Company.
- Privately owned Chinese companies, such as the Shatuhe Coal Bed Methane Company, the Jiazuo Coal Bed Methane Company, and the Jingyuan Coal Bed Methane Company.

- Foreign participation in CBM exploration and production as of 2013 was dominated by small, independent companies, such as Green Dragon, Fortune Oil, Sino-American Energy, Asia American Gas, Far East Energy, Sino Gas Holdings, and Orion Energy. But there are frequent changes in their participation with some companies leaving and others coming in. As of 2013, Shell was the only major international oil company with active operations in China's CBM sector.

Local Policies and Regulations

The provincial governments in each of the main coal-producing areas have issued policy papers on local support for the development of the local coalbed methane industry and to provide incentives (see Table 2). These documents make a number of provisions, for example, on financial support, tax policies and pricing mechanisms, In addition to measures targeted specifically at CBM, local governments may also use policies aimed at supporting strategic emerging industries and new technologies to support CBM development.

Table 2. Provincial Policy on CBM

Province	Promulgated time	Document
Shanxi	13 August 2013	Several Opinions of the People's Government of Shanxi Province on Accelerating the Development of Coal-bed Methane Industry
Anhui	10 December 2007	Implementation Opinions on Accelerating the CBM (coal gas) Extraction Use
Guizhou	3 November 2007	Advice on the Implementation of Relevant National Policies to Support and Gangue Comprehensive Utilisation of Coal-bed Methane Project
Hebei	December 2013	Opinions on Further Accelerating the Utilisation of Coal-Bed Methane Extraction of Hebei Province
Hunan	31 December 2008	Hunan Provincial People's Government Office Implementation Opinions on Accelerating the CBM (coal gas) Extraction Use
Jiangxi	30 September 2006	Jiangxi Provincial People's Government Council on Accelerating the CBM (coal gas) Extraction Comments Utilisation
Yunnnan	4 June 2009	The CBM (coal gas) Development and Utilisation of the Opinions of Yunnan Province
Chongqing	25 June 2012	Opinions of Chongqing Municipal People's Government on Further Strengthening the Work of Coalmine Gas Prevention and Control

Source: Compiled by the author

In addition to these supporting measures, provincial, and some city governments such as Jincheng have issued their own policies and regulations relating to environmental protection, land reclamation, water use, waste disposal, energy use and emissions reduction.

Conflicting and Coincident Interests

The two main types of conflict that constrain CBM development relate to overlapping rights and illegal extraction. In the past, significant areas of overlap existed between CBM and coal-mining licences. As a result, serious conflicts arose in some areas. In Shanxi Province, for example, in the first half of 2010, there were 37 registered CBM licences covering 24,300 km^2. However, only four licences were without conflict, whilst the other 33 are all overlapping coal-mining licence areas. In total, there were 197 areas of overlap, totalling 3,400 km^2. Such overlaps make coordination between CBM and coal-mining enterprises very difficult and prevents the exploitation of valuable energy resources. In addition, the uncontrolled mining of coal can waste valuable CBM resources.

Although the actual overlap of resource rights is relatively small, significant conflicts of interest remain, for historical reasons and due to local protectionism. As CBM activities increased, the violation of the rights of CBM enterprises by coal-mining enterprises has become more serious. To solve this problem, the State Council has issued a number of regulations and principles that require the operator of a newly established coalmine to extract the methane first and only then start to mine the coal, as mentioned earlier in this piece (refer to the earlier section on *Policies for CBM Extraction and Resource Rights*).

Local protectionism can also hinder the development of the coalbed methane industry because, as mentioned above, many CBM companies are owned by local governments. In September 2013, Shell pulled out from its North Shi Lou Bei CBM project where it held a PSC with PetroChina. There were a number of reasons behind Shell's withdrawal, but one reported factor was the illegal extraction of CBM by the Shanxi Lan Yan CBM Group. This company had no legal rights in the licence area, but was protected by the local government. Such behaviour undermines the proper governance of the CBM sector and risks damaging the CBM reservoirs.

Although there is conflict between the coal industry and petroleum and the natural gas industry in some regions of China, cooperation exists between other actors. In Guizhou Province, for example, when coal-mining enterprises plan to extract CBM resources, they apply to the local petroleum and natural gas bureaus. These bureaus willingly grant CBM licences to such coal-mining companies rather than to specialist gas or CBM companies.

Environmental Damage

Reports suggest that environmental management at sites of CBM production have not yet met the required standards. The Qingshui Basin in Shanxi Province has been the major target for CBM exploration and development for several years. Here CBM extraction has affected groundwater quality and destroyed the underground water resources. During the drilling and completion phases, drilling fluid leakage has polluted groundwater pollution, and ground water levels have dropped during dewatering and CBM recovery.[33] Waste water drained from CBM

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[33] 周娉[Zhou Ping]. 中国煤层气产业发展评价及途径研究 [China's CBM Industry Development: Evaluation and Approaches],博士学位论文[Doctoral Dissertation], 北京:中国地质大学 [China University of Geosciences], 2012; 郝宁[Hao ning], 康静文 [Kang Jingwen],张凌云 [Zhang lingyun].

wells tends to have a high content of salts and heavy minerals. These can accumulate in the soil, as well as cause compaction of the soil. This chemical and physical damage directly affects the soil organisms and plant growth. Crop yields are reduced and native plants are replaced by salt-resistant species.[34]

Interactions between the Upper and Lower Levels

In this account, we have described the governance of China's CBM industry in terms of two games: an Upper Level game in which actors engage with each other to set policies and supporting laws and regulations; and a Lower Level game where a largely different set of actors seek to address their own, often diverging, interests. This conflict between central and local interests and even between local interests results in local governments frequently not fully implementing the central government's policies. This leads to a gap between the central government's requirements and local government's objectives in the development of the CBM industry. Local protectionism is one example, as earlier discussed.

Another source of problems can be found in the poor coordination between central and local governments. For example, in Shanxi Province, the Qinshui Coalfield has abundant coal-bed methane resources. Since the 1990s, the central government has issued CBM rights to many companies, including CNPC, CUCBM, and the Shanxi Jincheng CBM Group, as well as other centrally and provincially controlled enterprises and a number of foreign companies. This relatively small area is also the key zone where the Jincheng city government plans to develop the coal, electric power and chemical industries. Communication and coordination between the central government, local government and enterprises has been poor. This has led to a failure to bring about the development of the CBM industry according to the local economic and social development plans. It has additionally caused damage to local water resources, land and the environment.

The fundamental problem underlying these issues is that most of the CBM enterprises in China are owned by the central or local government. The governments at different levels allocate resource rights, set the CBM price and provide funding to CBM enterprises. As a result of this direct involvement of the governments in the CBM industry, the economic and technical performance of the industry depends on the administrative actions of the government rather than on the competence of the enterprises themselves. Instead, the role of the government should be regulatory rather than administrative.

Addressing these challenges has become a major priority for the central government. The Third Plenary Session of the Eighteenth Meeting of the Communist Party of China proposed to build up a unified, open, competitive and orderly market system. This proposal reference raised

沁水盆地郑庄区块煤层气开发对地下水环境的影响分析[Analysis of Influence of CBM Development of Zhengzhuang Block, Qinshui Basin on Groundwater Environment]. 太原理工大学学报[Taiyuan University of Technology], 2013, 44(4): 427-430.

[34] 张强 [Zhang Qiang], 王紫襄 [Wang Zixiang],李明亮[Li Mingliang], 周晓婷[Zhou Xiaoting], 夏拓 [Xia Tuo], 晋城区煤层气井产气阶段排出水对环境的影响研究 [Study of the Influence of Drain Water from CBM Production on Environment in Jincheng District]. 绿色科技 [Green Technology], 2012, 9(9): 154-156.

expectations in the gas industry which has suffered extensively from local protectionism. Article 9 of the "The Communist Party of China Central Committee on Deepening Reform of the Overall Number of Major Issues" [《中共中央关于全面深化改革若干重大问题的定》] states that a key priority is to reform the market supervision system, to unify market regulation, and to clean up and abolish a variety of rules and practices that hinder a unified national market and fair competition. Further objectives are to prohibit and punish all kinds of illegal acts and behaviour that implement preferential policies, to oppose local protectionism, and especially to address the problems faced in establishing a unified oil and gas market. On 10 December 2013, the Ministry of Commerce and 12 other departments jointly issued the document *Work Scheme of Eliminating the Regional Blockade and Breaking Up Monopolies*, which expressed that local protection has become a strategic task cannot be further delayed.[35]

Conclusions and Policy Recommendations

The overriding constraint on CBM production in China is the slow development of the technology and techniques required to produce the methane. This difficulty arises from the geological complexity of some of the basins in China and from the fact that many of the coals are medium and low rank and are therefore more difficult to exploit than high rank coal. CBM enterprises are also constrained by the relative lack of commercial attractiveness of CBM in China, which has its origins in the pricing system and the way in which access to pipelines is governed. These factors are exacerbated by overlaps between CBM and coal-mining licence areas, local protectionism and poor coordination between different levels of government.

This analysis has presented the governance regime for CBM as a two-level game. In the Upper Level game, the central government agencies and, to a lesser extent, the centrally-owned state-owned enterprises engage in the formulating of the policy and regulatory framework for CBM development. However, these frameworks lack the incentives necessary to compensate for the risk and costs involved in CBM development in China and encourage large and sustained investment programmes. The actors in the Lower Level game, notably local governments and their state-owned enterprises, further undermine the already inadequate national framework as they pursue their own interests. This conflict of interests between actors in the Upper and Lower Level games, is exacerbated by poor coordination between the levels.

There are several actions needed to improve the outlook. In the short term, the legal and regulation system needs to be improved, to guarantee that policy is effectively implemented. The coalbed methane industry should have its own set of laws and regulations covering exploration, extraction and utilisation—one that clearly defines each participant's rights and obligations, and promotes coordination between CBM and coal development. It should provide a stable investment and business operational environment for enterprises, in order to reduce uncertainty and investment risk. On account of the close relationship between the CBM and natural gas industries, the government should set up a special law for CBM and natural gas, which can cover the whole production chain, to guide and promote CBM development. Next, it needs to improve the management of CBM exploration and extraction in order to avoid low-

[35] *Work Scheme of Eliminating the Regional Blockade and Breaking Up Monopolies* [In Chinese: 12 部门部署开展消除地区封锁打破行业垄断工作]. Available in Chinese at: http://www.gov.cn/gzdt/2013-12/10/content_2545710.htm (accessed 12 June 2017).

efficiency investment and to reduce costs. In addition, it needs to increase the transparency in the process involving investment and licensing, to attract more investors.

In the long term, there are three areas to look into. First, strengthen technological innovation to stimulate key breakthroughs in CBM drainage and commercial utilisation, especially for technology to drain CBM from low-rank coal resources. There is a need to establish a Chinese geological theory for CBM exploration and mining. Second, further expand the pipeline network, and putting in place a transparent system of third-party access. Third, pay attention to personnel training, to lay the foundation for future CBM development.

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