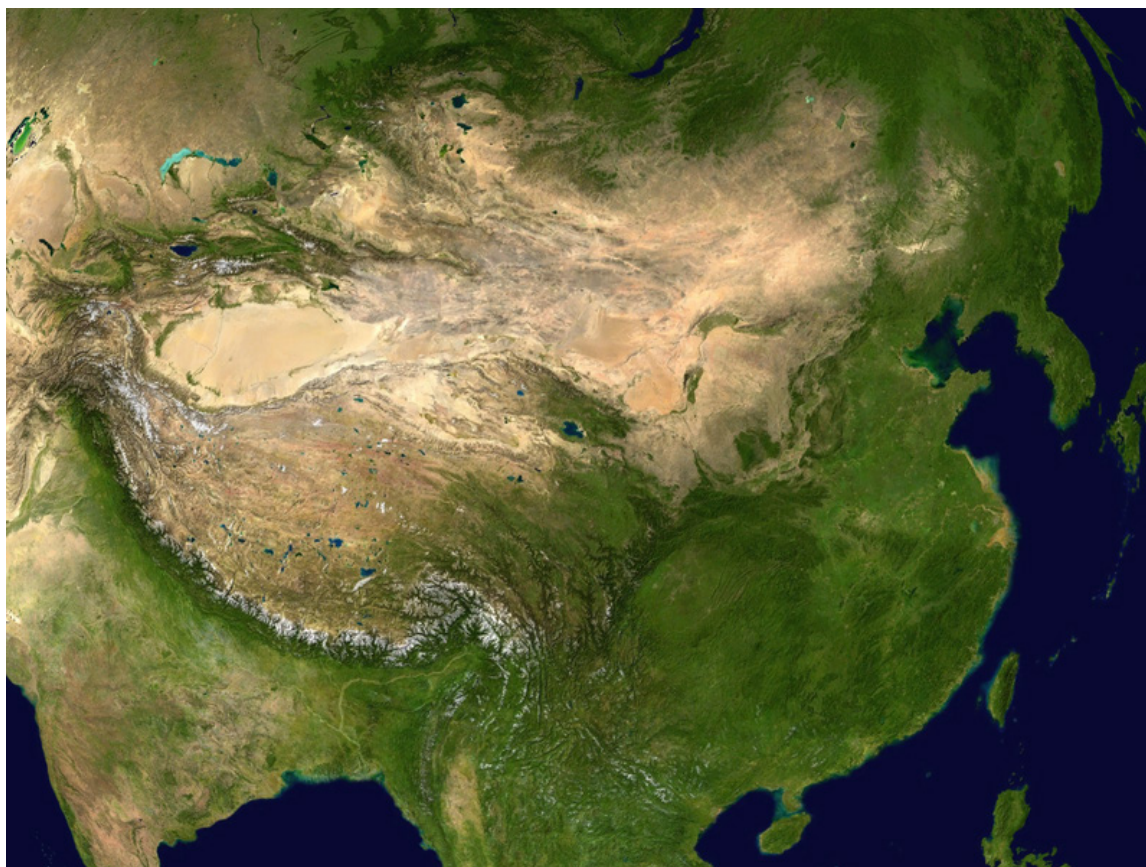


# MEETING CHINA'S SHALE GAS GOALS

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During July 2014, a team led by Columbia University’s Center on Global Energy Policy conducted several dozen interviews on Chinese shale gas policies. Individuals interviewed were from central government ministries, provincial government ministries, state-owned enterprises, independent oil and gas companies, oil and gas service companies, law firms, environmental groups, consultancies and universities. The team also surveyed the Chinese and English-language literature on the Chinese shale gas sector. Based on those interviews and that research, the team provides this report as a resource for discussions in the months and years ahead.

## **EXECUTIVE SUMMARY**

*What will it take to tap China's vast shale gas resource?*

*To help fight air pollution and reduce reliance on imports, the Chinese government has set ambitious goals for shale gas production. Yet the challenges are substantial. Chinese shale is deeper than similar rock in the United States, where a "shale revolution" has transformed energy markets. Much Chinese shale lies under mountainous terrain. Other "above-ground" factors — including high initial production costs, lack of competition, weak incentives for state-owned enterprises, limited data availability and uncertain conditions for foreign businesses — compound these problems. Understaffed regulatory agencies with unclear authorities raise the risk of negative environmental consequences.*

*Shale gas production in China is just starting. Roughly 200 wells have been drilled to date (in comparison to roughly 100,000 in the United States). In the next few years, Chinese shale production will not be substantial. In the medium and long term, low growth and high growth scenarios are both plausible.*

*This report finds that policies hold the key to realizing China's shale gas potential. Government's role in China's economy is central, especially in the energy sector. The progress and details of broader economic reforms and content of shale-specific policies will fundamentally shape the growth of China's shale gas industry. Policies promoting innovation in the shale gas sector will be especially important. Central government and provincial policies will both play a role.*

*The quality of China's source rock will also be key. Currently much about the geology of Chinese shale and its suitability for natural gas production remains unknown (and much of what is known is proprietary). But whether geologic conditions in China prove favorable for shale gas production or more challenging, government policies will play a central role in the future of the sector.*

## **BACKGROUND**

*China has a huge shale gas resource. According to some estimates, it is the world's largest. China's shale is geologically complex, with a composition and fracture history that can make producing natural gas more challenging.*

*Most of the early drilling has been in the western provinces of Sichuan and Chongqing. Two state-owned enterprises — Sinopec and CNPC — dominate the sector. Although Sinopec's Fuling field in Chongqing has shown initial success, costs at early wells have been high. According to one estimate, Sinopec and CNPC's short-term losses from shale gas drilling through the end of 2013 are close \$1 billion.<sup>1</sup>*

*Foreign firms are playing an important role in Chinese shale gas production. In 2012, Shell and CNPC signed the first Production-Sharing Contract (PSC) for shale gas in China, for a block in the Sichuan Basin. Progress at this site has reportedly been slow. Other IOCs including Chevron,*

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<sup>1</sup> Lei Tian et al., *Stimulating Shale Gas Development in China—A Comparison with the US Experience* (RFF 2014), p. 4, <http://www.rff.org/RFF/Documents/RFF-DP-14-18.pdf>.

Conoco Philips, Exxon and Hess are also cooperating with CNPC or Sinopec on shale gas, mostly through Joint Study Agreements.

## **2. THE U.S. EXPERIENCE**

Between 2007 and 2013, U.S. annual shale gas production grew from roughly 3.5 billion cubic feet per day (bcf/day) to 31 bcf/day and now provides more than 46% of U.S. natural gas production. Largely as a result of this boom, the United States is expected to begin exporting natural gas in significant volumes in the decade ahead.

Factors that led to the growth of the U.S. shale gas sector include:

- a large and high-quality shale resource,
- a competitive market system,
- private property rights,
- federal government support for R&D,
- federal tax incentives,
- publicly-available data,
- an extensive pipeline network, and
- an entrepreneurial culture.

## **3. CURRENT CHINESE POLICIES**

Under President Xi Jinping's leadership, China is in the midst of far-reaching reforms. Proposed economic reforms are especially ambitious. The 60-point decision released by the Chinese Communist Party's Third Plenum in November 2013 calls for market forces to play a "decisive" role in the economy (in the context of government policy and excluding natural monopoly situations) and charts an agenda that includes land reform, private investment in state-owned enterprises, fewer investment restrictions, interest rate liberalization and much more.

### **A. Chinese Energy Policies**

In June 2014, President Xi delivered a speech on energy policy announcing the following five-part strategy:

- Promote **revolution in energy consumption**
- Promote **revolution in energy supply**
- Promote **revolution in energy technology**
- Promote **revolution in energy governance**
- Strengthen **international cooperation**

These reforms and broader policies will shape China's shale gas development.

### **B. Central Government Shale Gas Policies**

The Chinese central government strongly supports shale gas production and incentivizes it with a number of policies. The principles guiding China's shale gas policies are set forth in the Shale Gas Five-Year Plan (March 2012), which commits to production incentives, accelerated permitting, improved infrastructure and technology innovation. Central government policies

*to promote shale gas now include:*

- *annual production targets of 6.5 bcm in 2015 and 60-100 bcm in 2020,*
- *a production subsidy of 0.4RMB/cubic meter (roughly \$1.83/thousand cubic feet), which expires in 2015,*
- *waivers of price controls and fees,*
- *listing of shale gas as an independent mineral resource, and*
- *publication of a shale gas industry standard.*

*Two bidding rounds have been held, in which shale gas blocks were made available for exploration, development and production. Progress has been slower than expected. Many of the winners of the second bid round lack oil and gas exploration experience. In addition, the parcels offered are generally considered to be of poor quality. A third bid round is being planned.*

*At least a half-dozen ministries and agencies play a role in Chinese shale gas policy, including the National Development and Reform Commission (NDRC), the National Energy Administration (NEA), the Ministry of Land and Resources (MLR), the Ministry of Finance (MOF), the Ministry of Science and Technology (MOST) and the Ministry of Environmental Protection (MEP).*

### C. Provincial Shale Gas Policies

*Provincial governments will be important players in China's shale gas development. Provincial officials have strong interests in shale development within their borders, which can increase local GDP and provide natural gas for local needs. Officials also have strong interests in preventing environmental damage or social disruption from shale gas production.*

*Three provinces — Sichuan, Chongqing and Guizhou — have released shale gas development plans. Several provinces — including Sichuan, Chongqing, Xinjiang, Hunan and Anhui — have formed shale gas joint ventures with SOEs, including Sinopec, CNPC, CNOOC and China Huadian Corporation.*

### D. Natural Gas Price Reform

*Historically, natural gas prices in China were regulated through the entire value chain. Complex reforms are now underway, with natural gas prices slowly moving toward international parity. As part of these reforms, the wellhead price of shale gas has been deregulated. However a number of factors have limited the practical utility of this reform, including the mixing of shale gas with conventional gas in pipelines and challenges shale gas producers face reaching a broad market for their product.*

### E. Pipeline Reform

*Traditionally, more than 80% of China's oil and gas pipelines have been owned and operated by Petrochina (a subsidiary of CNPC). There was no regulatory authority to govern Petrochina's management of its pipelines or rules to require Petrochina to provide pipeline access to other companies. This created challenges for unconventional gas producers (among others), who found it difficult to reach transportation agreements with pipeline operators due to mismatched bargaining power.*

*Significant reforms are now underway in the management of China's oil and gas pipelines. This includes regulations guaranteeing third-party producers access to oil and gas pipelines when there is excess capacity. How far those reforms will go — or whether they will be enduring — is not yet known.*

#### *F. Chinese Investment in U.S. Shale Plays*

*Chinese companies have invested more than \$8 billion in U.S. shale plays. Many experts believe that Chinese companies are seeking a combination of financial returns, investment diversification and technology. Investing in U.S. shale gas plays may also help familiarize Chinese companies with U.S. regulatory and managerial practices in the shale gas sector. In general, Chinese investors in U.S. shale gas plays have not negotiated for technology license rights or the right to jointly operate gas fields.*

### **4. FINDINGS**

#### *A. Chinese shale gas production in the next few years will not be substantial. After that, low growth and high growth scenarios are both plausible.*

*In our interviews, we found consensus that Chinese shale gas production in the next few years will not be substantial. We agree with that assessment. Building an industrial supply chain, training personnel, negotiating commercial arrangements, developing technologies to address unique Chinese circumstances and implementing reforms that help promote shale gas production will all take time.*

*With respect to the medium and long-term, we found widely divergent views about the prospects for Chinese shale gas development. Some stakeholders were optimistic, others cautiously optimistic and others skeptical about the prospects for significant growth in the decades ahead. These divergent views are reflected in the published literature. As if to highlight these diverging views, on a single day in August 2014 one major Western news organization released a story with the headline “China Drastically Reduces Its Ambitions to Be a Big Shale Gas Producer” and another ran a story with the headline “Chinese Energy Giants Turn Upbeat on Shale Gas.”<sup>2</sup>*

#### *B. Key barriers to growth include high production costs, weak incentives for state-owned enterprises, lack of competition, restrictions on foreign businesses and limited data availability.*

*Initial production costs at Chinese shale gas sites are high. CNPC and Sinopec are hugely well-capitalized companies with the ability to absorb losses on shale gas operations. However, the incentives for these companies and other SOEs to invest in shale gas operations may not be substantial. Meanwhile, potential shale gas entrepreneurs face difficulties gaining access to good acreage and pipelines, among other problems. Lack of data is also a barrier.*

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<sup>2</sup> “China Drastically Reduces Its Ambitions to Be a Big Shale Gas Producer,” *Economist* (August 30, 2014) (accessed online August 29), <http://www.economist.com/news/business/21614187-china-drastically-reduces-its-ambitions-be-big-shale-gas-producer-shale-game>; Charlie Zhu, “Chinese Energy Giants Turn Upbeat” (Reuters August 29, 2014), <http://www.reuters.com/article/2014/08/29/china-shalegas-outlook-idUSL3N0QZ1R420140829>

*The challenges facing foreign companies are even greater. Foreign companies have expertise, technology and capital that could be enormously helpful in developing China's shale resources, but they face significant restrictions on their ability to participate in the Chinese market.*

*C. Government policies will play a central role in determining the growth of the Chinese shale gas sector in the years ahead.*

*Geology and policy will be the most important factors shaping the growth of the Chinese shale gas sector. Much about the geology of Chinese shale and its suitability for natural gas production is unknown (and much of what is known is proprietary). But whether geologic conditions in China prove to be favorable for shale gas production or more challenging, government policies will play a critical role in the growth of the sector.*

*The growth of China's shale gas industry will be shaped by at least three broad factors: the progress and details of economic reforms, the content of shale-specific policies and government's commitment to innovation.*

*D. The environmental impacts of Chinese shale gas production could range from highly positive to highly negative.*

*Shale gas has the potential to displace coal-fired power generation in China, helping fight global warming and urban smog. Shale gas also has the potential to displace gasified coal (sometimes called synthetic natural gas), which could deliver even bigger environmental benefits. With respect to the potential global warming benefits from shale gas however, an important offsetting factor is possible methane leakage.*

*Water pollution is an important concern. Technologies exist to manage shale gas production with little water pollution, however there are questions about the extent to which such technologies will be used in China. Earthquakes are another concern. Hydraulic fracturing does not cause earthquakes, but disposal of produced water in deep underground injection wells has been shown to induce seismicity.*

*At present, there are no specific environmental regulations with respect to shale gas in China.*

*E. Water supply constraints could be a factor in some regions in the medium and long term.*

*Water supply is not likely to be a significant constraint on overall Chinese shale gas production in the short term. Although China faces significant challenges managing its limited water resources, the regions where most initial shale gas production is taking place — Sichuan and Chongqing — have large water endowments. In addition, to the extent that shale gas displaces coal, shale gas may provide substantial water savings.*

*Yet water supply could become a constraint on Chinese shale gas production in the medium or long term. Some shale-rich regions — including the Tarim Basin — have very limited water resources. In addition, droughts could create challenges for shale gas production. Even in provinces with ample water supplies, a sudden surge in shale gas development could overwhelm local water supplies and related infrastructure.*

*F. The U.S. and Chinese governments share common interests with respect to shale gas.*



*The U.S. and Chinese governments work closely together on shale gas. On November 17, 2009, in Beijing, Presidents Barack Obama and Hu Jintao announced a new U.S.-China Shale Gas Resource Initiative. In the years since, many U.S. government agencies and Chinese ministries have worked closely together on shale gas, sharing information and perspectives on topics that include U.S. policies and regulations, characterization and assessment of shale gas resources, geopolitical issues and more. Private companies and SOEs have been core participants in many of these activities.*

*This joint work is fueled by common interests. The Chinese government gives priority to the development of China's shale gas sector in order to help fight air pollution and reduce reliance on natural gas imports. The U.S. government supports the sustainable development of China's shale gas sector for a range of economic, environmental and geostrategic reasons. The two governments share common interests with respect to Chinese investment in the U.S. shale gas sector as well.*

## **5. RECOMMENDATIONS**

*We group our recommendations into five broad categories: (A) accelerate market-based reforms, (B) provide a clear roadmap for foreign companies, (C) build regulatory capacity, (D) invest in innovation, and (E) coordinate among ministries.*

### **A. Accelerate Market-Based Reforms**

*Four market-based reforms — some already underway — can help China meet its shale gas objectives:*

#### *(i) Continue Natural Gas Price Reforms*

*Natural gas price reform has the potential to stimulate technology and lead to a boom in shale gas production, as happened in the United States after natural gas price controls were lifted in the 1980s.*

*In recent years the central government has taken significant steps toward market-based pricing of natural gas. Continuing the natural gas price reforms underway can help shale gas producers realize a return on their investment and stimulate shale gas production.*

#### *(ii) Speed Pipeline Reform*

*China does not need to build a vast national pipeline network to meet its 2015 and 2020 shale gas goals. Most shale gas can be consumed in the same province or even locality where it is produced, at least in the short term. Small LNG facilities can help move shale gas to markets. However, in the medium and long term, pipelines will be important for the growth of the Chinese shale gas sector.*

*In the past year, NEA has taken important steps toward opening China's pipeline network. Next steps could include rules guaranteeing producers access to the pipeline network on non-discriminatory terms and establishment of an independent pipeline regulator. Further steps to open investment in the sector — including to foreign companies — would also be helpful.*

*(iii) Encourage Competition for Mineral Rights*

*Market-based reforms in the management of mineral rights can help China meet its shale gas goals. The second bid round was an important step in this direction, opening shale gas acreage to a wide range of companies. However the lack of progress by the second round winners suggests that adjustments should be made in future rounds, including:*

- *Make better acreage available.*
- *Make better data available.*
- *Provide clear instructions to help foreign companies engage in the auctions.*
- *Allow provincial governments to play a larger role.*

*(iv) Improve Data Availability*

*Data is crucial for the development of shale gas. Many experts cite publicly available data from well logs and other sources as a key factor in the U.S. shale gas revolution. In China, the availability of data for shale gas operations is quite limited. CNPC and Sinopec have no obligation to share data from conventional onshore activities.*

*State-secret laws are also a concern. In some cases oil and gas data have been considered a state secret. It is the right of any government to determine what information is considered a state secret. In the case of Chinese oil and gas data, a review of that policy could have benefits, including more rapid shale gas development.*

*B. Provide a Clear Roadmap for Foreign Companies*

*Foreign companies can play an important role in helping China meet its shale gas objectives. Companies operating in the United States have considerable expertise in hydraulic fracturing, horizontal drilling and other technologies for shale gas production. Many of these companies are willing to work in China if satisfactory returns are available.*

*(i) Develop a Model Production-Sharing Contract (PSC)*

*A production-sharing contract (PSC) is an agreement in which a host country grants an international oil company (IOC) the right to explore for oil and gas and a percentage of the oil and gas produced at a site, in exchange for the IOC's commitment of funds, technology and expertise. A model shale gas PSC could encourage IOCs to pursue opportunities in China's shale gas sector and reduce the time and expense of contract negotiations. However, traditional PSCs — which have been used in the Chinese oil and gas sector since the 1980s — will need to be modified in light of the many differences between conventional and unconventional projects. The types of terms IOCs will be looking for in a model PSC in light of these differences include:*

- *a longer Production Period;*
- *no relinquishment obligation;*
- *a Pilot Stage between the Exploration and Development Stages;*
- *the right to participate in other hydrocarbons discovered in the contract area.*

*In Attachment A, we offer terms for a Model Shale Gas PSC.*

(ii) Use “Rolling ODPs”

*Chinese law requires an Overall Development Program (ODP) for development of an oil and gas field. However NDRC’s current guidance document for ODPs was developed with reference to conventional oil and gas fields, and several of its provisions work poorly for shale gas development. For example, an ODP for conventional gas production generally requires submission of development plans with drilling techniques once at the beginning of a project. This is impractical at a shale gas project, where continual adjustment of drilling plans based on new information is required.*

*Accordingly, a “rolling ODP” is needed. Such an instrument would provide a flexible guide to development, allowing for development of different areas within a shale gas block to be approved at different times.*

C. Build Regulatory Capacity

*Shale gas development requires not only encouragement and promotion, but a robust and stable regulatory regime. Good regulation can encourage companies with advanced technology to participate in the sector, knowing that they can compete on a level playing field and that environmental rules will be enforced fairly and completely.*

*At present, overlapping and unclear authorities are common in China’s shale gas sector. MLR, NEA and MEP have small staff sizes compared to equivalent agencies in other large countries. Local environmental protection bureaus lack clout as compared to large SOEs. Building a robust and stable regulatory capacity for shale gas should be a high priority.*

D. Invest in Innovation

*Growth in the Chinese shale gas sector will require innovation. Technologies used in shale gas development in the United States will need to be adapted to the Chinese context. China will need trucks and rigs with smaller footprints, modular water transport and novel stimulation technologies. New techniques for hydraulic fracturing may be needed, in light of the nature of Chinese source rock.*

*Innovation in Chinese shale gas technologies can be accelerated by ensuring that state-owned enterprises have strong incentives to invest in innovation, by paying attention to the principles of “open innovation” and by launching a shale gas program under the U.S.-China Clean Energy Research Center.*

E. Coordinate among Ministries

*During our interviews, we heard many comments about the lack of coordination among ministries, at both the central government and provincial levels. Improved coordination among ministries could help in policy development and assist stakeholders, including foreign companies, better understand rules and requirements related to shale gas. One useful step would be for ministries to publish a joint guide listing all approvals required to work in the shale gas sector (or commission a respected outside authority to do so).*

## **SUMMARY OF RECOMMENDATIONS**

### **1. Accelerate Market-Based Reforms**

- Accelerate natural gas price reforms.
- Accelerate pipeline reforms.
- Encourage competition for mineral rights.
- Improve data availability.

### **2. Provide a Clear Roadmap for Foreign Companies**

- Develop a model Production Sharing Contract (PSC), recognizing the differences between conventional gas and shale gas production.
- Use a “rolling Overall Development Program (ODP).”

### **3. Build Regulatory Capacity**

- Build a robust and stable regulatory capacity for shale gas, as a high priority.

### **4. Invest in Innovation**

- Ensure national oil companies have strong incentives to invest in innovation.
- Pay attention to the principles of “open innovation.”
- Add a shale gas consortium to the U.S.-China Clean Energy Research Center.

### **5. Coordinate among Ministries**

- Improve inter-ministerial coordination on shale gas, at the central government and provincial levels.
- Publish a guide to all approvals required to work in the shale gas sector.

### **Note on Units**

*In China, natural gas volumes are typically measured in cubic meters. In the United States, natural gas volumes are typically measured in cubic feet.*

*One cubic meter = 35.3 cubic feet.*

*In China, natural gas consumption and production rates are typically measured in billions of cubic meters (bcm) per year. In the United States, natural gas consumption and production rates are typically measured in billions of cubic feet (bcf) per day.*

*One billion cubic meters per year = 0.096 billion cubic feet per day.*

# 1. BACKGROUND

## A. The Resource

China has a huge shale gas resource. According to some estimates, it is the world's largest. U.S. EIA estimates that China possesses 31.6 trillion cubic meters (1,115 trillion cubic feet) of technically recoverable shale gas resources. The Ministry of Land and Resources (MLR) puts the figure at 25.1 trillion cubic meters (886 trillion cubic feet).<sup>3</sup>

The geology of China's shale resource is complex. According to the National Energy Administration, China's shale deposits have been "significantly transformed" by tectonic movements. NEA also reports that "complex geological conditions make collapses and fluid leakages more likely in the process of horizontal drilling" and that roughly a third of China's shale resource is lacustrine or transitional-lacustrine<sup>4</sup> — a type of shale from which natural gas is not currently being produced in the United States.

Many of China's largest shale deposits are located in relatively mountainous regions. Partly as a result, Chinese shale resources are generally much deeper than those in the United States.<sup>5</sup> The mountainous terrain can create siting challenges, since drilling operations require adequate space and road access. Sichuan and Chongqing — home to some of China's richest shale resources — have high population densities compared to U.S. oil and gas regions. All of these factors potentially add expense to Chinese drilling operations.

## B. The Industry

China's natural gas industry has grown rapidly in recent years. Between 2003 and 2012, China's natural gas production more than tripled to reach 108 billion cubic meters per year (10.4 billion cubic feet per day). During the same period, consumption more than quadrupled, reaching almost 161 billion cubic meters per year (15.5 billion cubic feet per day).<sup>6</sup>

Yet natural gas is still a small portion of the Chinese energy mix. In 2012, the fuel accounted for roughly 5 percent of China's primary energy consumption.<sup>7</sup> In

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<sup>3</sup> U.S. Energy Information Agency (EIA), Technically Recoverable Shale Oil and Shale Gas Resources (June 2013) at table 6, <http://www.eia.gov/analysis/studies/worldshalegas/pdf/overview.pdf>; Ministry of Land and Resources (MLR), National Survey and Assessment of Shale Gas Resource Potential 2013, [http://www.mlrgov.cn/xwdt/jrxw/201203/t20120302\\_1069466.htm](http://www.mlrgov.cn/xwdt/jrxw/201203/t20120302_1069466.htm). Chinese figure excludes Tibet and Qinghai.

<sup>4</sup> Presentation of Xiaolong Li, NEA at Houston USTDA Conference (July 1, 2014)

<sup>5</sup> See Ella Chou, "Shale Gas in China — Development and Challenges" (July 11, 2013) at p. 8, <http://blogs.law.harvard.edu/ellachou/files/2013/07/Shale-Gas-in-China-Draft.pdf>.

<sup>6</sup> U.S. EIA, "Natural Gas Serves a Small, But Growing, Portion of China's Total Energy Demand," Today in Energy, August 18, 2014, <http://www.eia.gov/todayinenergy/detail.cfm?id=17591&src=email>

<sup>7</sup> Ibid.

Comparison, gas represented 20% of the primary energy consumption in Asian countries excluding China.<sup>8</sup>

The role for natural gas is even smaller as a source of China's power generation. In 2012, gas comprised only 2 percent of China's power generation, far below the global average.<sup>9</sup> To alleviate air pollution caused by heavy coal consumption, the Chinese government hopes to significantly increase the share of natural gas in the power sector.<sup>10</sup>

In addition to power generation, natural gas is used in China for industry, buildings, transportation and other purposes. Leading authorities provide somewhat different breakdowns. In our research, we found estimates for power generation ranging from 17 to 20% of total natural gas use in China, estimates for industrial use ranging from 36 to 43%, estimates for residential/building use ranging from 18 to 25% and estimates for transportation use ranging from 4 to 13%.<sup>11</sup>

China is turning to diverse sources of supply for natural gas. The government's 2015 domestic production target is roughly 5.5 Tcf per year, with substantial production growth planned for the north, west and South China Sea. In addition, China is becoming one of the world's largest importers of LNG (with 10 regasification terminals). Over the past few years, China has also ramped up imports of natural gas through pipelines from Central Asia (Turkmenistan, Uzbekistan and Kazakhstan) and Myanmar. In 2014, China signed a \$400 billion agreement with Russia for natural gas to be transported through a new pipeline starting in 2018.<sup>12</sup>

In China, three vertically-integrated national oil companies (NOCs) — CNPC, Sinopec and CNOOC — control much of the natural gas industry. In 2011, CNPC, Sinopec and CNOOC respectively represented 71 percent, 12 percent and 15 percent of natural gas production in China.<sup>13</sup> PetroChina, a subsidiary of CNPC, controls 80 to 90% of the trunk natural gas pipelines in China. (China has roughly 40,000 kilometers of natural gas pipelines — roughly 10% of that in the United States.) These NOCs dominate not just upstream production and pipelines, but also the oil and gas service sector. As a result of their size and scope, the NOCs have the capacity to cover financial losses in one sector, with profits from another. The relationships between the NOCs and central government can be complex: the companies operate independently yet their senior executives are

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<sup>8</sup>Michael Farina and Adam Wang, *China's Age of Gas* (GE 2013), p.10, <http://www.ge.com/cn/sites/default/files/GE-Gas-China-1015final.pdf>.

<sup>9</sup> Ibid.

<sup>10</sup> NDRC; "12th Five Year Plan on Natural Gas Development," p. 1, [http://www.gov.cn/zwqk/2012-12/03/content\\_2280785.htm](http://www.gov.cn/zwqk/2012-12/03/content_2280785.htm)

<sup>11</sup> Farina and Wang, *China's Age of Gas*, p. 7, at note 8; China Energy Fund Committee, *China Energy Focus Natural Gas 2013*, pp. 23–24, [http://csis.org/files/publication/131212\\_CEFC\\_China\\_Energy\\_Focus\\_Natural\\_Gas.pdf](http://csis.org/files/publication/131212_CEFC_China_Energy_Focus_Natural_Gas.pdf).

<sup>12</sup> U.S. EIA, "Natural gas," at note 6.

<sup>13</sup> Lei Tian et al., *Stimulating Shale Gas Development*, at note 1.

appointed by the central government and often return to the government after serving at the NOCs.<sup>14</sup>

Oil and gas mineral rights in China are owned by the state and managed by the central government. Land use rights and rights to other minerals are sometimes held at the local level. At times, separation of land and mineral rights has led to conflicting interests between government entities. For example, when developing coal-bed methane (CBM), the central government holds the rights to natural gas (CBM in this case) and the local government has rights to the coal mines.<sup>15</sup> As a result, the rights to CBM and coal within a single field can be assigned to two different companies.

Historically, natural gas mineral rights are granted to the major NOCs through a “first come, first served” application process.<sup>16</sup> In recent years, mineral rights for unconventional natural gas have been opened up to the market more broadly. Qualified shale gas developers can participate in auctions for mineral exploration rights.<sup>17</sup> However, nearly 80 percent of China’s shale gas resource overlaps with conventional oil and gas reserves held by the NOCs. In November 2012, the Ministry of Land and Resources published a notice giving NOCs priority in exploring for shale gas in overlapping areas.<sup>18</sup> In the notice, MLR indicates that if an owner of an overlapping block does not put enough effort into exploring shale gas, it could be required to transfer rights to other investors.<sup>19</sup>

### C. Shale Gas Production to Date

Shale gas production in China is just starting. According to NEA, 184 wells have been drilled as of May 2014, resulting in daily production of 134 million cubic feet (1.4 bcm/year).<sup>20</sup> In the United States, in contrast, roughly 100,000 wells have been drilled, resulting in daily production of over 31 bcf (323 bcm/year).<sup>21</sup>

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<sup>14</sup> Ibid., p. 10.

<sup>15</sup> U.S. EIA, China, p. 21, <http://www.eia.gov/countries/analysisbriefs/China/china.pdf> (last updated: February 4, 2014).

<sup>16</sup> Presentation by Huabin Wang, “Governmental Management on Oil and Gas Exploration and Mining in China,” pp. 7–8, Department of Geological Exploration, MLR, July 1, 2014.

<sup>17</sup> Presentation of Xiaolong Li, NEA at Houston USTDA Conference (July 1, 2014)

<sup>18</sup> MLR, “Notice with Regard to Reinforcing Exploration of Shale Gas Resources and Supervising Work Management,” October 2012, [http://www.mlr.gov.cn/zwgk/zytz/201211/t20121122\\_1158928.htm](http://www.mlr.gov.cn/zwgk/zytz/201211/t20121122_1158928.htm).

<sup>19</sup> Ibid.

<sup>20</sup> Presentation of Xiaolong Li, NEA at Houston USTDA Conference (July 1, 2014)

<sup>21</sup> On number of wells drilled, see BakerHughes Well Count at <http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-wellcountus>; American Petroleum Institute, “Investment in U.S. shale well drilling surges in 2011” (April 29, 2013), <http://www.api.org/news-and-media/news/newsitems/2013/april-2013/investment-in-us-shale-well-drilling-surges-in-2011>; Matt Kelso, “Over 1.1 Million Active Oil and Gas Wells in the US,” (March 4, 2014), <http://www.fractracker.org/2014/03/1-million-wells>. On daily production, see Adam Sieminski, [http://www.eia.gov/pressroom/presentations/sieminski\\_01222014.pdf](http://www.eia.gov/pressroom/presentations/sieminski_01222014.pdf), p. 4 (US shale gas production at end of 2013 was roughly 31 billion cubic feet per day)(confirmed in personal communication with author from EIA staff). See also Darren Barbee, “The Great Shale Wall” (December 21, 2013), [http://www.ugcenter.com/International-Shales/The-Great-Shale-Wall-China-Struggles-Emulate-US-Success\\_127423](http://www.ugcenter.com/International-Shales/The-Great-Shale-Wall-China-Struggles-Emulate-US-Success_127423) (quoting Jason Bordoff, Director of Columbia Center on Global Energy Policy, “If it’s the second or third inning in the U.S. shale revolution, it’s like batting practice in China”).

Most shale gas drilling to date has been in Sichuan and Chongqing. The most successful project to date has been Sinopec's Fuling project near Chongqing — the only project to achieve production on a commercial scale. Sinopec reports that it is producing 600 million cubic meters per year of shale gas at Fuling and expects to produce 10 billion cubic meters (bcm) per year at the project by 2017.<sup>22</sup> (In our interviews, we heard rumors that some of the production at Fuling is not from shale rock. Sinopec strongly denies such claims.)<sup>23</sup>

China is making progress in developing a supply chain for shale gas production. According to NEA, 3,000 fracturing vehicles have been put into field operation. Equipment that includes open hole packers, frac plugs and other downhole fracturing tools have been developed, with some now being exported to the North American market. NEA says that China has “gained experiences in horizontal drilling, well completion, and large-volume fracturing technologies.”<sup>24</sup>

However shale gas drilling costs have been high. One expert we spoke with estimated that drilling time at Chinese sites average 250 days, as compared to 10 to 20 days at many U.S. shale plays.<sup>25</sup> According to one estimate, Sinopec and CNPC's short-term losses from shale gas drilling through the end of 2013 are close to \$1 billion.<sup>26</sup>

Foreign firms are playing an important role in Chinese shale gas production. On March 20, 2012, Shell announced that it signed a production-sharing contract (PSC) with CNPC to explore, develop and produce shale gas in the Fushun-Yongchuan block (~3,500 square kilometers) in the Sichuan Basin. This is the first shale gas PSC in China. Progress at this site has reportedly been slow, in part due to “spontaneous village-based blockades.” Shell has reportedly adjusted its investment strategy in China's shale gas sector.<sup>27</sup>

Other IOCs — including Chevron, Conoco Philips, Exxon and Hess — are also cooperating with CNPC or Sinopec on shale gas, mostly through joint study agreements (JSA). (See Attachment B for a list of such agreements based on public announcements, securities filings and media reports.) The extent of progress under those agreements is unclear. In its 2013 SEC 10-K filings, Chevron stated that two exploratory shale gas wells were unsuccessful.

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<sup>22</sup> “Sinopec Makes Breakthrough in Shale Gas (March 25, 2014), [http://www.chinadaily.com.cn/business/2014-03/25/content\\_17377038.htm](http://www.chinadaily.com.cn/business/2014-03/25/content_17377038.htm); “Sinopec's Fuling Shale Gas Project to Hit 10 Bcm/year by end 2017,” Platts, 24 March 2014.

<sup>23</sup> See “Sinopec Shale Gas — Is It True?” *Sina Finance* (June 20, 2014), <http://finance.sina.com.cn/zl/energy/20140620/082619471212.shtml> (Sinopec denies rumors that production at Fuling is not shale gas).

<sup>24</sup> Presentation of Xiaolong Li at note 4.

<sup>25</sup> Author interview.

<sup>26</sup> Lei Tian et al., *Stimulating Shale Gas Development*, p. 4, at note 1.

<sup>27</sup> Shell, “Sinopec and Shell Signed the First Shale Gas PSC in China” (March 20, 2012), -- <http://www.shell.com.cn/zh/aboutshell/media-centre/news-and-media-releases/archive/2012/cnpc-shell-sign-first-shale-gas-production-sharing-contract-20120312.html>; “IOCs are Having Difficulties Developing Shale gas; Shell Shifting to other Assets” (March 31, 2014), NBC, -- <http://www.yicai.com/news/2014/03/3650668.html>; Telegraph, “Shell shuts down 8.3 billion projects in China”, -- <http://www.telegraph.co.uk/finance/newsbysector/energy/oilandgas/10300263/Shell-shuts-down-8.3bn-project-in-China.html>



## **2. U.S. EXPERIENCE**

Between 2007 and 2013, U.S. annual shale gas production grew from roughly 3.5 bcf/day (36.5 bcm/year) to 31 bcf/day (323 bcm/year), reaching more than 46% of U.S. natural gas production.<sup>28</sup> Largely as a result of this boom, the United States is projected to become a natural gas exporter in the decade ahead. Energy historian Dan Yergin has called the U.S. shale gas boom “the biggest energy innovation so far in the 21st century.”<sup>29</sup>

Factors that led to the growth of the U.S. shale gas sector include:

- a large and high-quality shale resource,
- a competitive market system,
- private property rights,
- federal government support for R&D,
- federal tax incentives,
- publicly available data,
- an extensive pipeline network, and
- an entrepreneurial culture.<sup>30</sup>

The United States has one of the world’s largest shale resources. According to U.S. EIA, the United States has 665 trillion cubic feet of technically recoverable shale gas — a figure surpassed only by China, Argentina and Algeria.<sup>31</sup> The shale is located in different regions of the country and more than a dozen states, including Texas, Louisiana, Arkansas, Pennsylvania, Ohio, West Virginia and North Dakota. Much of the resource is relatively near the surface, with thickness, porosity and total organic content conducive to natural gas production. The shale resources are marine shales, with a favorable combination of silt, clay, organic material and fracture density. (There are also substantial tight liquid resources, which produce from siltstone layers.)

Perhaps the most fundamental factor behind the U.S. shale gas boom is the United States’ competitive market system. With respect to natural gas, that system is relatively new. Natural gas prices were regulated in the United States until the 1980s, when those prices

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<sup>28</sup> U.S. EIA, Shale Gas Production, [http://www.eia.gov/dnav/ng/ng\\_prod\\_shalegas\\_s1\\_a.htm](http://www.eia.gov/dnav/ng/ng_prod_shalegas_s1_a.htm) (U.S. shale gas production in 2007 was 1293 bcf); US EIA, Issues and Trends: Natural Gas (Jan 16, 2014) <http://www.eia.gov/naturalgas/issuesandtrends/production/2013/> (U.S. dry natural gas production in 2013 was 66.5 bcf/day); Adam Sieminski, [http://www.eia.gov/pressroom/presentations/sieminski\\_01222014.pdf](http://www.eia.gov/pressroom/presentations/sieminski_01222014.pdf), p. 4 (U.S. shale gas production at end of 2013 was roughly 31 billion cubic feet per day)(confirmed in personal communication with author from EIA staff).

<sup>29</sup> Daniel Yergin, “Shale Gas Development: An Energy Game Changer,” <http://danielyergin.com/shale-gas-development>.

<sup>30</sup> See generally Zhongmin Wang and Alan Krupnick, “US Shale Gas Development: What Led to the Boom?” (RFF 2013), <http://www.rff.org/RFF/Documents/RFF-IB-13-04.pdf>; Michael Shellenberger, Ted Nordhaus, Alex Trembath and Jesse Jenkins, “Where the Shale Gas Revolution Came From” (Breakthrough Institute), <http://thebreakthrough.org/index.php/programs/energy-and-climate/where-the-shale-gas-revolution-came-from>; Duke Suttikulpanich, Ying Wang and Akash Gupta, “China Shale Gas: Potential Unearthed” (Standard Chartered, September 30, 2013); Gregory Zuckerman, The Frackers (2013).

<sup>31</sup> US EIA, “Shale Oil and Shale Gas Resources are Globally Abundant” (January 2, 2014), <http://www.eia.gov/todayinenergy/detail.cfm?id=14431>

were gradually decontrolled. (Restrictions on the use of natural gas in the power sector were lifted at the same time.) The ability to sell natural gas at market prices, along with low barriers to entry in the U.S. natural gas industry, attracted a number of pioneering entrepreneurs who invested considerable risk capital in shale gas development in the 1990s and early 2000s. Foremost among these was George Mitchell of Mitchell Energy, whose relentless efforts during the 1990s played a central role in proving the potential for U.S. shale gas production.

The United States' system of private property rights also played an important role in the shale gas revolution. In the United States mineral rights are privately owned, often by the owner of the surface above where those minerals are located. Mineral rights may be transferred by contract, without approval by government agencies. Developers in the United States are able to gain access to shale resources by purchasing those rights from owners, greatly facilitating production of the resource.

The U.S. federal government played a central role in the shale gas revolution.<sup>32</sup> Federal funding for research and development began in the 1970s, when the U.S. Energy Research and Development Administration and later U.S. Department of Energy supported resource assessments and technology demonstrations in the Appalachian Basin. DOE shared the cost of the first multifracture horizontal drilling play (in West Virginia in 1986) and of Mitchell Energy's first horizontal well (in Texas in 1991). Describing the role of the U.S. Department of Energy in the U.S. shale gas revolution, former Mitchell Energy Vice President Dan Steward said: "DOE started it, and other people took the ball and ran with it. You cannot diminish DOE's involvement."<sup>33</sup>

Federal tax incentives also played a key role. During the 1980s and 1990s, U.S. shale gas producers were entitled to tax credits between \$0.52/Mcf and \$0.94/Mcf. Average wellhead prices for natural gas during those decades were mostly between \$1.5/Mcf and \$2.5/Mcf.<sup>34</sup> For two decades, the federal government therefore supplemented the revenues of many shale gas producers by amounts that ranged from roughly 20% to 60% of market prices.<sup>35</sup> Federal tax credits for shale gas production were phased out in 2002.

Many experts cite publicly available data as a key factor in the U.S. shale gas revolution. State laws throughout the United States require public disclosure of well logs and production data for oil and gas development. Time periods vary, but in general that data

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<sup>32</sup> See Shellenberger et al., "Where the Shale Gas Revolution Came From" at note 30; Zhongmin Wang and Alan Krupnick, "US Shale Gas Development: What Led to the Boom?" (RFF 2013) – <http://www.rff.org/RFF/Documents/RFF-IB-13-04.pdf>; Shellenberger et al., at note 30; Suttikulpanich et al., "China Shale Gas: Potential Unearthed" at note 30.

<sup>33</sup> Michael Shellenberger, "Interview with Dan Steward, Former Mitchell Energy Vice President" (The Breakthrough, December 12, 2011) – [http://thebreakthrough.org/archive/interview\\_with\\_dan\\_steward\\_for](http://thebreakthrough.org/archive/interview_with_dan_steward_for),

<sup>34</sup> Lei Tian et al., *Stimulating Shale Gas Development*, p. 6, at note 1.

<sup>35</sup> A comparison with wind and solar tax credits is instructive. Starting in 1992, the United States adopted a wind production tax credit (PTC), set initially at US\$ 0.015/kWh of wind energy produced, indexed to inflation (now equal to about US\$ 0.022/kWh). Solar photovoltaics benefited from an investment tax credit of 15% of total cost beginning in 1978, falling to 10% from 1988 to 2005, when Congress raised the credit to 30% to the end of 2007. Average retail electricity prices between 1992 and 2000 ranged from 6.64 to 6.93 cents/kWh (nominal prices)(EIA Annual Energy Review, September 2012). <http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0810>).

must be disclosed within 30 to 90 days of the time it is obtained. That data has played an important role in helping shale gas producers target the best opportunities and deploy their limited capital. In addition, the U.S. Geologic Survey maintains maps that can assist with initial decision-making and the Securities and Exchange Commission requires public companies to disclose material information about their business, including information on shale gas reserves and production. In combination, these data sources have provided shale gas producers information critical to their success.

The United States' vast natural gas pipeline network also played an important role in the shale gas revolution. The U.S. has more than 305,000 miles of natural gas pipelines, connecting producers to consumers in almost every region of the country.<sup>36</sup> In addition, federal policies require open access to interstate natural gas pipelines and natural gas storage facilities. These regulations helped provide shale gas producers with confidence that gas produced could reach markets.

Other factors important to the shale gas revolution include the United States' entrepreneurial culture. Small entrepreneurs — not large companies — started the U.S. shale gas revolution. (Some of George Mitchell's early shale gas wells were famously within a few miles of Exxon Mobil's headquarters in Irving, Texas. However the world's largest independent oil company wasn't looking for oil and gas in its own backyard.)<sup>37</sup>

### **3. CURRENT POLICIES**

Under President Xi Jinping's leadership, China is in the midst of far-reaching reforms. Proposed economic reforms are especially ambitious. The 60-point decision released by the Chinese Communist Party's Third Plenum in November 2013 calls for market forces to play a "decisive" role in the economy (within the context of government policy and excluding natural monopoly situations). The decision charts an agenda that includes land reform, private investment in state-owned enterprises, fewer investment restrictions, interest rate liberalization and much more.<sup>38</sup>

This reform agenda will shape China's shale gas sector. China's success in meeting its shale gas goals will be determined not just by shale gas-specific policies (which are described in detail below), but also by the reform agenda more generally. Reducing corruption, reforming the legal system, protecting intellectual property rights, strengthening environmental regulatory regimes and liberalizing investment (such as with a U.S.-China bilateral investment treaty) will all help promote progress in meeting shale gas goals. The leadership's strong commitment to reform can help advance shale gas goals, although

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<sup>36</sup> About U.S. Natural Gas Pipelines," U.S. Department of Energy, Energy Information Administration, 2008. The region of the United States most poorly served by natural gas pipelines is New England. Partly for that reason, natural gas prices in New England spiked to US\$ 50–100/MMBtu during the cold winter of 2014, see Northeast Gas Association, Gas & Power Generation (2014), [http://www.northeastgas.org/gas\\_power\\_generation.php](http://www.northeastgas.org/gas_power_generation.php).

<sup>37</sup> Zuckerman, The Frackers, p. 45, at note 30.

<sup>38</sup> 18th Central Committee of the Communist Party of China, Decision of the Central Committee of the Communist Party of China on Some Major Issues Concerning Comprehensively Deepening the Reform (Nov 15, 2013), Xinhua, -- [http://news.xinhuanet.com/politics/2013-11/15/c\\_118164235.htm](http://news.xinhuanet.com/politics/2013-11/15/c_118164235.htm)

uncertainty over which reforms will receive priority and the pace at which those reforms will proceed could have the opposite impact.<sup>39</sup>

The following sections describe Chinese energy policies broadly, summarize central and provincial government shale gas policies, explain natural gas pricing and pipeline policies (both of which are important for shale gas production) and review Chinese investment in the U.S. shale gas sector.

#### A. Chinese Energy Policies

China's energy policies have undergone major changes over the past decade, as the country copes with the enormous challenge of meeting rapidly growing energy demand while shifting energy production and consumption away from coal. On the production side, the government has focused on promoting wind, solar, nuclear, hydro and natural gas. Among these, natural gas is seen as a key enabling fuel, especially in the power sector, where China needs flexible fuel sources to integrate intermittent renewable sources and meet increasingly variable loads. For gas, policies have included targets, pricing reforms, subsidies and structural reforms within the historically state-dominated sector. China's top leadership has identified reforms in the natural gas sector as a high priority on several occasions.

In November 2012, President Hu Jintao's report to the 18th National Congress of the Communist Party spoke of the need for an "energy revolution," using language uncommon for such communications.<sup>40</sup> In June 2014, the Central Party's Leading Group on Economic and Financial Affairs, chaired by President Xi Jinping, met to discuss energy security. President Xi then made a speech announcing the following five-part strategy:

- Promote **revolution in energy consumption**, to restrict irrational uses of energy. Measures include the determination to control the country's total energy consumption volume, effectively implement energy saving strategy across all sectors and throughout the economic and social development process.
- Promote **revolution in energy supply**, to build a diversified supply system. Measures include progressing on clean and efficient uses of coal, actively developing non-coal energy resources, while strengthening energy transmission and distribution networks and energy reserves.
- Promote **revolution in energy technology**, to foster industrial upgrading. Measures include promoting green and low carbon innovations in technology, industry and business models, and combing technological progress in other areas to form a new powerhouse for economic growth.

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<sup>39</sup> See generally Barry Naughton, "Deepening Reform: The Organization and Emerging Strategy," China Leadership Monitor (Summer 2014); Arthur R. Kroeber, Xi Jinping's Ambitious Agenda for Economic Reform in China (Brookings, November 17, 2013).

<sup>40</sup> President Hu Jintao, report to the Eighteenth National Congress of the Communist Party (November 8, 2012).

- Promote **revolution in energy governance**, to pave a fast track for energy development. Measures include firmly progressing reform to give energy back its commodity nature, building a competitive market, forming a mechanism where market determines energy prices, changing the way government regulates energy industry and building a system of rules by the law.
- Strengthen **international cooperation in an all-around manner**, to ensure energy security under open market conditions. Measures include promoting international cooperation in every aspect of the energy production and consumption to effectively use international resources.<sup>41</sup>

While state-owned enterprises (SOEs) continue to dominate the energy sector, mixed ownership and investment diversification is being pursued in a number of areas. On July 15, 2014, the State-owned Assets Supervision and Administration Commission (SASAC) selected eight national SOEs to implement mixed-ownership and management reforms.<sup>42</sup> Meanwhile, CNPC and Sinopec have started their own mixed-ownership reform initiative. Sinopec announced it will open its retail business for private investors, and CNPC has announced it will strip off its core pipeline assets. Allowing private investors, including foreign investors, to take a minority stake in SOEs could promote transparency, improve governance and speed technology transfer. At the same time, skeptics have noted the potential for strong resistance to such changes. If private minority stakes are just treated as a capital injection, it could paradoxically represent a setback for market reforms.<sup>43</sup>

Energy sector reform is a centerpiece of China's current economic restructuring. Within the context of energy sector reform, shale gas has the potential to be especially important for at least two reasons. First, China's vast shale gas resources could help the country meet a number of its energy policy goals, including cutting coal's share in the power sector and reducing reliance on imports. Second, many of the policies needed to realize China's shale gas potential could have applicability in other contexts. Market-based reforms will be especially important to shale gas development, for example. Technological innovation and new forms of international cooperation will also be key. If China succeeds in developing its shale gas potential by accelerating market-based reforms, promoting technological innovation and fashioning new forms of international cooperation, the experiences and lessons learned could have ripple effects in reforms in the energy sector and economy as a whole.

#### B. Central Government Shale Gas Policies

The Chinese central government strongly supports shale gas production and incentivizes it with a number of policies. The principles guiding Chinese shale gas policies are set forth in the Shale Gas Five-Year Plan (March 2012), which declares the government's strong support for shale gas production and commits to production incentives, accelerated permitting,

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<sup>41</sup> Xinhua Daily Telegraph, "Xi Jinping: Promote Energy Production and Consumption Revolution" (June 14, 2014), -- [http://news.xinhuanet.com/politics/2014-06/13/c\\_1111139161.htm](http://news.xinhuanet.com/politics/2014-06/13/c_1111139161.htm); Translation from Beijing Energy Club, China's Call for Energy Revolution (July 2014).

<sup>42</sup> State-owned Assets Supervision and Administration Commission, Press Conference on Four Reform Pilot (July 15, 2014).

<sup>43</sup> Dexter Roberts, "Is China Rethinking the Dominance of Its State Sector?" *Bloomberg Businessweek*, March 14, 2014; Jing Song, "China's SOE Revamp May Lead to Problems," *FinanceAsia*, April 12, 2014.

improved infrastructure and technology innovation. More detailed policies are set forth in the Shale Gas Industry Policy (October 2013), which designates shale gas development a “national strategic new industry,” and other official documents.<sup>44</sup>

At least a half-dozen ministries and agencies play a role in Chinese shale gas policy. The National Development and Reform Commission (NDRC) shapes overall policy and regulates natural gas prices. The National Energy Administration (NEA) establishes shale gas production targets. The Ministry of Land and Resources (MLR) controls mineral rights and runs the bid rounds for shale gas. The Ministry of Finance (MOF) administers a shale gas production subsidy. The Ministry of Science and Technology (MOST) funds research and development in shale gas technologies. The Ministry of Environmental Protection (MEP) establishes rules to protect air and water quality.

Central government policies to promote shale gas include:

- production targets,
- a production subsidy,
- waivers of price controls and fees,
- listing of shale gas as an independent mineral resource, and
- publication of a shale gas industry standard.

The government’s shale gas production targets are 6.5 bcm per year by 2015 and 60–100 bcm by 2020. CNPC and Sinopec have each been directed to do their part to ensure these targets are met. On August 7, 2014, Reuters reported that NEA had cut China’s 2020 production target for shale gas to 30 bcm.<sup>45</sup> As of this writing, NEA has not issued any official announcement changing its production target.

The Ministry of Finance provides a production subsidy of 0.4RMB/cubic meter of shale gas. (This is equivalent to roughly \$1.83/Mcf.) This subsidy expires in 2015. No decisions have been announced with respect to the amount of production subsidy — if any — past 2015.

There are other fiscal benefits for producing shale gas. Perhaps most important, shale gas may be sold at market prices, except when being sold into the residential market. (Natural gas in China is subject to a complex system of price controls, with prices varying from city to city and depending on whether production sources are “old” or “new.”) In addition, several fees generally charged in connection with natural gas production — including the exploration right fee and mineral resource compensation fee — are waived for shale gas.

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<sup>44</sup> NDRC, MOF, MLR and NEA, Shale Gas 12th Five Year Plan, March 2012, <http://www.cbichina.org.cn/cbichina/upload/fckeditor/Full%20Translation%20of%20the%2012th%20Five-Year%20Plan.pdf>; and Shale Gas Industrial Policy, NEA, October 2103, <http://www.sidley.com/Chinas-First-Shale-Gas-Policy-11-12-2013/>. For other official documents, see in particular Notice on Strengthening the Exploration and Exploitation of Shale Gas, MLR, October 2012, [http://www.morganlewis.com/pubs/greaterchina\\_lf\\_chinashalegasdevelopment\\_29nov12.pdf](http://www.morganlewis.com/pubs/greaterchina_lf_chinashalegasdevelopment_29nov12.pdf); see also <http://www.nortonrosefulbright.com/knowledge/publications/64620/chinas-12th-five-year-plan-for-shale-gas>.

<sup>45</sup> Chen Aizhu et al., “China Finds Shale Gas Challenging, Halves 2020 Output Target,” Reuters, (August 7, 2014), <http://www.reuters.com/article/2014/08/07/us-china-shale-target-idUSKBN0G71FX20140807>.

By decision of the State Council, shale gas is listed as an independent mineral resource. That decision has far-reaching consequences. For example, it provides private companies the opportunity to invest in shale gas production. (Only the major NOCs are allowed to engage in exploration and production of conventional natural gas.) Listing shale gas as an independent natural resource also provides MLR more discretion in establishing policies to promote shale gas.

The Ministry of Land and Resources has held two rounds of bidding for shale gas blocks and is planning a third. The first round was held in 2011. Six state-owned enterprises — CNPC, Sinopec, CNOOC, Yanchang Petroleum, CUCBM and Henan CBM — were invited to compete for four blocks. Sinopec and Henan CBM each won one block. (The other two blocks were not awarded.)<sup>46</sup> The second bid round opened in September 2012, with MLR offering 20 blocks to any Chinese company with at least 300 million RMB registered capital. (Foreign companies were permitted to participate only as minority partners in joint ventures.)<sup>47</sup>

Nineteen blocks were awarded in the second bid round, to 17 SOEs and two private companies. Though SOEs won almost all of the parcels, private companies represented a third of bids.<sup>48</sup> China Huadian and Shenhua both won parcels, with China Huadian capturing five parcels — over a fourth of the blocks awarded. Companies that dominated the first bidding round — CNPC, Sinopec, CNOOC and Yanchang Petroleum — didn't win any parcels.<sup>49</sup> This is possibly because these firms had been given priority in overlapping parcels according to a notice from MLR, and most of the shale parcels were in this overlapping area.<sup>50</sup>

Progress since the bidding results were released has been slower than expected. The parcels offered were generally considered to be of poor quality, and many of the firms that won parcels lacked oil and gas exploration experience.<sup>51</sup> Some bid winners have reportedly tried to transfer their exploration rights on the parcel. According to Southern Weekly, the transfer negotiation between Chongqing Energy Investment Corporation and CUCBM on the Qianjiang parcel is in the final stages of discussion.<sup>52</sup>

In April 2014, MLR published technical standards for shale gas reserve and production calculations. MLR sets forth specific methodologies and criteria that developers must use, with the aim of standardizing data presentations and promoting transparency. MLR also sets forth a specific definition for shale gas:

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<sup>46</sup> See Yuping He, *China: A Brief Analysis Of Shale Gas Industry Policies*, May 23, 2014, <http://www.mondaq.com/x/316130/Oil+Gas+Electricity/A+Brief+Analysis+Of+Shale+Gas+Industry+Policies>.

<sup>47</sup> MLR, Shale Gas Exploration Right Bidding Announcement, September 10, 2012, [http://www.mlrgov.cn/zwgk/zytz/201209/t20120910\\_1139187.htm](http://www.mlrgov.cn/zwgk/zytz/201209/t20120910_1139187.htm).

<sup>48</sup> MLR, The Second Round Of Shale Gas Exploration Right Bidding Result, January 21, 2013-- [http://www.gov.cn/gzdt/2013-01/21/content\\_2316805.htm](http://www.gov.cn/gzdt/2013-01/21/content_2316805.htm).

<sup>49</sup> Ibid.

<sup>50</sup> "Four Oil Companies Enjoy Shale Gas Exploration Rights in the Overlapping Area," *China Securities Journal*, November 24, 2012, [http://www.cs.com.cn/ssgs/hyzz/201211/t20121124\\_3746705.html](http://www.cs.com.cn/ssgs/hyzz/201211/t20121124_3746705.html) [tz]

<sup>51</sup> "Progress For the Second Bid Parcels Was Slow," *China 5e*, October 18, 2013, <http://www.china5e.com/news/news-849286-1.html>.

<sup>52</sup> "The Bid-Winning Companies in the Second Round Made Slow Progress," *Southern Weekly*, July 19, 2013, <http://www.infzm.com/content/92489>.

“Shale gas often occurs in mud shale and is interlayered with rich organic matter. Shale gas is a kind of unconventional natural gas in a form of adsorption or free-state. Shale gas is a type of clean energy resource, and is mainly composed of methane.”<sup>53</sup>

Although foreign companies are not allowed to participate directly in oil and gas exploration, their involvement in JVs has been actively encouraged, and there are a number of international JVs established, indicating both an eagerness of foreign firms to participate and the desire of Chinese firms to gain from foreign expertise and experience. Foreign firms in JVs include Shell, BP, Total, Newfield, Chevron, ExxonMobil, ENI, and ConocoPhillips. SOEs and private firms have also reached out to international oil services firms, including Schlumberger, Halliburton and BakerHughes. Most recently, Sinopec announced the formation of an oil services JV with Weatherford International to develop products related to shale production in regions with high pressure and temperatures.

In several respects, China’s shale gas policies resemble those from the early stages of U.S. shale development. Like the United States in the 1970s and 1980s, China has introduced government subsidies, provided government funding for research and development and taken steps to both deregulate natural gas prices and provide open access to pipeline networks.<sup>54</sup> In other ways, however, the policy approaches differ. China has taken few if any steps toward private ownership of mineral rights or requiring public disclosure of geologic or shale gas production data.

### C. Provincial Shale Gas Policies

Chinese provincial governments have strong interests in shale development within their borders. For many provincial officials, the highest priority may be the GDP increase likely to accompany shale gas development. Provincial officials may hope to use the shale gas produced for local needs. Provincial officials also have strong interests in preventing any environmental damage or social disruption from shale gas production.

To date, provincial governments have used at least three tools for shale gas development: shale gas development plans, standards and joint ventures.

- Three provinces — Sichuan, Chongqing and Guizhou — have released shale gas development plans. (Other provinces, including Xinjiang, refer to shale gas in comprehensive plans for oil and gas development.)
- At least one province — Hunan — has released local technical standards on shale gas drilling.<sup>55</sup>
- Several provinces — including Sichuan, Chongqing, Xinjiang, Hunan and Anhui — have formed joint ventures with SOEs active in shale such as Sinopec, CNPC, CNOOC

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<sup>53</sup> China Economic Net, Plan for Shale Gas Sector 2011–2015, February 1, 2013, [http://www.ce.cn/cyssc/ny/zcid/201302/01/t20130201\\_21331779.shtml](http://www.ce.cn/cyssc/ny/zcid/201302/01/t20130201_21331779.shtml).

<sup>54</sup> Suttikulpanich et al., “China Shale Gas: Potential Unearthed,” p. 25, at note 30.

<sup>55</sup> Lingli Yan and Liqing Zou, “A Golden Path to the New Energy Strategic Landscape,” July 24, 2014, [http://www.zgkyb.com/observation/20140724\\_5945.htm](http://www.zgkyb.com/observation/20140724_5945.htm).



or China Huadian Corporation. Such joint ventures may help provincial governments capture some of the economic benefits from shale gas production, although they may also lead to regional monopolies and discrimination against other developers.

Current policies in several leading provinces are summarized below.

(i) Sichuan

In July 2013, the Sichuan Development and Reform Commission and Energy Administration published the Sichuan Shale Gas E&P 2013 Work Plan.<sup>56</sup> The plan sets production and investment targets, lists Yibin (Changning block) as a pilot within the province and sets a target of 1 bcm of production from Changning.

In December 2013, Sichuan Changning Gas Development Company was founded with 1 billion RMB of registered capital. The company has four shareholders — CNPC (55%), Sichuan Energy Investment Group, a provincial SOE (30%), Yibin State-Owned Assets Operation Co Ltd., a local SOE (10%) and Beijing Guolian Energy Industry Investment Fund (5%).<sup>57</sup> The new company will focus on the shale gas project development in the Changning block. CNPC will sell its four existing wells in the block to the new company. However, it is unclear if CNPC will transfer/lease overall mining rights in the block to the new company.

Sichuan Changning Gas Company was the first joint venture between a provincial government and upstream producer to co-develop shale gas. The joint venture is endorsed by NEA and will receive policy support at the national, provincial and local levels.

(ii) Chongqing

In February 2014, the Chongqing Fuling government published the Fuling Shale Gas Development and Usage Implementation Plan.<sup>58</sup> The Plan set a production target of 3.2 bcm by 2015 and other targets including 7.4 billion RMB of investment in shale gas industrial parks and infrastructure. The Plan includes details on environmental management as well.

In May 2014, Sinopec, Chongqing Gas Company (a provincial SOE) and the Fuling Government formed three joint ventures to develop shale gas in the Fuling District. The three joint ventures include Sinopec, Chongqing Fuling Shale Gas E&P Company, Sinopec Chongqing Gas Pipeline Company and Sinopec Chongqing Fuling Shale Gas Retail Company.<sup>59</sup>

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<sup>56</sup> Yibin Municipal Development and Reform Commission, "Sichuan Shale Gas E&P 2013 Work Plan released," July 24, 2013, <http://fg.yb.gov.cn/content.jsp?classId=650702&newsId=351827>.

<sup>57</sup> Jianqiao Li, "CNPC Team Up with Sichuan; First Central SOEs and Local Government Shale Gas JV Incorporated," *21cbh.com*, December 12, 2013, <http://biz.21cbh.com/2013/12-12/0MNDE3Xzk4MjI0MA.html>.

<sup>58</sup> Chongqing Fuling Government, "Fuling Shale Gas Development and Usage Implementation Plan," Feb. 10, 2014, <http://www.flagri.gov.cn/jiaoshi/Details.aspx?topicId=544965&ci=3192&psi=3408>

<sup>59</sup> Qi Yue, "Chongqing Formed JV to Develop Shale Gas with Sinopec," May 5, 2014, *NBD*, <http://www.nbd.com.cn/articles/2014-05-05/830769.html>

In June 2014, Chongqing Finance Bureau has allocated 240 million RMB to support the Chongqing Shale Gas Resource Survey project, which aims to better understand the shale gas resources allocation in Chongqing.<sup>60</sup>

(iii) Guizhou

In January 2013, the Guizhou provincial government signed a Joint Development Framework with MLR to develop shale gas in Guizhou. The Framework sets forth a two-phase shale gas development plan in Guizhou. Between 2013 and 2015, surveys will be conducted and the first pilot wells drilled. Between 2016 and 2020, pilot projects will be constructed and commercial wells will be drilled.<sup>61</sup>

In May 2013, the Guizhou Fenggang county government published the Fenggang Shale Gas Exploration and Production Service Work Plan. The plan focuses on exploration work and helping the survey team.<sup>62</sup> In July 2013, the Guizhou Department of Land and Resources completed the Guizhou Shale Gas Resource Survey project after 16 months of work. The project identified 17 high shale gas potential blocks in Guizhou.<sup>63</sup>

(iv) Other Provinces

Other shale-rich provinces have not yet published shale gas production plans. Xinjiang, which has considerable shale resources, has focused on its enormous coal and conventional gas resources instead. However, in April 2014, Xinjiang State-owned Assets Supervision and Administration Commission (SASAC) published the Xinjiang Uygur Autonomous Region SASAC Development Plan 2014–2020 (draft),<sup>64</sup> which emphasized that the government will gradually open the oil and gas resource development market. In May 2014, the Second National Xinjiang Work Forum indicated more Xinjiang local companies should be involved in the oil and gas resource survey work.<sup>65</sup> NDRC has confirmed Xinjiang as the first pilot province in oil and gas, and the National Energy Administration is issuing qualification licenses on oil exploration and development to five private companies.<sup>66</sup> If this process proceeds, it could break the monopoly of state-owned enterprises in the upstream oil and gas industry, accelerating development of all oil and gas, including shale gas.

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<sup>60</sup> Chongqing Finance Bureau, “240 million RMB allocation for Chongqing Shale Gas Resource Survey Project,” June 2014, <http://www.cq.gov.cn/publicinfo/web/views/Show!detail.action?sid=3906008>.

<sup>61</sup> MLR, “MLR signed Shale Gas Joint Development Framework with Guizhou Provincial Government,” January, 2013, [http://www.mlr.gov.cn/xwdt/jrxw/201301/t20130129\\_1179140.htm](http://www.mlr.gov.cn/xwdt/jrxw/201301/t20130129_1179140.htm).

<sup>62</sup> Fenggang Government, “Fenggang Shale Gas Exploration and Production Service Work Plan,” May 02, 2013, <http://www.gzfenggang.gov.cn/xxgk/gsgg/zxwj/12531.shtml>.

<sup>63</sup> Guizhou Department of Land and Resources, “Guizhou Shale Gas Resource Survey Project Passed Initial Assessment,” July 2, 2013, [http://www.gzgtzy.gov.cn/Html/2013/07/02/20130702\\_103756\\_25035.html](http://www.gzgtzy.gov.cn/Html/2013/07/02/20130702_103756_25035.html).

<sup>64</sup> Zheling Zhou, “Positive Policy Changes Boosting Xinjiang’s Economy,” *China Securities Journal*, April 2014, [http://www.cs.com.cn/ssgs/gstt/201404/t20140415\\_4362990.html](http://www.cs.com.cn/ssgs/gstt/201404/t20140415_4362990.html).

<sup>65</sup> “Xi Jinping’s Speech at the Second National Xinjiang Work Forum,” May 29, 2014, <http://q.stock.sohu.com/news/cn/251/600251/3354260.shtml>.

<sup>66</sup> Guangkai Zhang, “Xinjiang Became the First Pilot Province on Oil and Gas Reform, Local Companies Are Welcomed to Join Oil and Gas Exploration,” *Guancha.com*, May 30, 2014, [http://www.guancha.cn/economy/2014\\_05\\_30\\_234013.shtml](http://www.guancha.cn/economy/2014_05_30_234013.shtml).

In Shaanxi province, Yanchang Petroleum has conducted a shale gas pilot project and drilled 39 wells by the end of 2013.<sup>67</sup>

#### D. Natural Gas Price Reform

Historically, natural gas prices in China were regulated through the entire value chain. Complex reforms are now underway, with natural gas prices slowly moving toward international parity. As part of these reforms, the wellhead price of shale gas has been deregulated. However, the remaining price controls on conventional gas negatively impact shale gas producers, as explained below.

Until recently, natural gas wellhead prices, pipeline tariffs and end-user prices were all regulated by the central government:

- Wellhead prices were set by NDRC, based on production costs with a profit margin added. These approved prices served as a baseline, with suppliers and buyers free to negotiate increases of no more than 10%.<sup>68</sup>
- Pipeline tariffs were also determined by NDRC, based on three factors: cost, distance from gas field to city gate and a profit margin set at a guaranteed internal rate of return of 12%.<sup>69</sup>
- End-user prices added another layer of complexity, with variations depending on gas source and usage (e.g., residential, commercial, industry or fertilizer).

In July 2013, a nation-wide natural gas price reform was implemented by NDRC. These reforms were a move toward market pricing (but not simplicity). Prices for “old gas” — up to 2012 consumption levels — are now capped at 2012 prices plus increases of no more than 0.4 RMB/cubic meter per year. Prices for “new gas” — above 2012 consumption levels — are linked to prices for fuel oil and liquefied petroleum gas (LPG) based on heating values, with natural gas receiving a 15% discount.

Consistent with these reforms, in August 2014 NDRC announced that prices for non-residential “old gas” would be increased by 0.4 RMB/cubic meter — an average increase of roughly 20% from 2013 levels. Average city gate price for nonresidential “old gas” are now roughly 2.35 RMB/cubic meter (\$10.65/Mcf).<sup>70</sup> (Attachment C sets forth the city gate price cap for each province after the August 2014 adjustment.)

In addition, wellhead prices for shale gas (and other unconventional) have now been deregulated. Producers are free to negotiate market prices with non-residential buyers. However a number of factors have limited the practical utility of this reform:

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<sup>67</sup> “Overview and Outlook of China Shale Gas Exploration and Production in 2013,” *sina finance*, July 29, 2014, <http://finance.sina.com.cn/energy/industrydynamics/20140729/102819849264.shtml>.

<sup>68</sup> China Energy Fund Committee, at note 11.

<sup>69</sup> *Ibid.*, p.46.

<sup>70</sup> NDRC, “Notice to Adjust Non-residential Natural Gas Price,” [http://www.sdpc.gov.cn/gzdt/201408/t20140812\\_622009.html](http://www.sdpc.gov.cn/gzdt/201408/t20140812_622009.html); Xuequan Mu, “China to Raise Natural Gas Prices,” *Xinhua*, August 12, 2014, [http://news.xinhuanet.com/english/china/2014-08/12/c\\_126863237.htm](http://news.xinhuanet.com/english/china/2014-08/12/c_126863237.htm).

- First, shale gas producers in some regions may have no access to pipelines in the short term, due to China's limited pipeline network and the ability of pipeline owners to restrict third party access. Although shale gas can be transported as LNG in trucks, truck transport over long distances is expensive. That means that in practice shale gas producers may often be limited to industrial or commercial customers near the production site. These customers will drive a harder bargain on price, knowing the producer has few options for offtake.
- In addition, when shale gas succeeds in entering the pipeline system it will often mix with conventional natural gas, making price discrimination at the point of withdrawal difficult. Until very recently, shale gas in the pipeline system was still subjected to the city gate price regulations. In the August 2014 price reform, NDRC announced a new measure to address this problem, allowing buyers and sellers to negotiate a separate price for the exact volume of shale gas delivered into the pipeline system. This price is now allowed to be higher than the city gate price caps.<sup>71</sup>

Jianfeng Chemical, a local-government owned company in Chongqing, is reported to be the first industrial user of shale gas, partly because of its proximity to the shale gas wells in Fuling. Between September 15 and December 31, 2013, Sinopec supplied Jianfeng Chemical with 119 million cubic meters of shale gas through a pipeline from Fuling Jiaoshi. In return, Jianfeng Chemical prepaid 214 million RMB (1.88 RMB/m<sup>3</sup>). However, Jianfeng Chemical and Sinopec have reportedly been unable to reach a final agreement on price.<sup>72</sup>

#### E. Pipeline Reform

Significant reforms are underway in the management of China's oil and gas pipelines. How far those reforms will go — or whether they will be enduring — is not yet known.

Traditionally more than 80% of China's oil and gas pipelines have been owned and operated by a single state-owned company — Petrochina (a subsidiary of CNPC). There was no regulatory authority to govern Petrochina's management of its pipeline assets or rules to require Petrochina to provide pipeline access to other companies. This created challenges for unconventional gas producers (among others), who found it difficult to reach transportation agreements with pipeline operators due to mismatched bargaining power.<sup>73</sup>

The coal-bed methane industry, for example, found it difficult to reach transportation agreements with pipeline operators. As a result, the industry turned to alternative methods of transportation, including liquefying coal bed methane and building new pipelines, which increased costs and slowed development.

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<sup>71</sup> Xuequan Mu, "China to Raise Natural Gas Prices," Xinhua, August 12, 2014, [http://news.xinhuanet.com/english/china/2014-08/12/c\\_126863237.htm](http://news.xinhuanet.com/english/china/2014-08/12/c_126863237.htm).

<sup>72</sup> Qi Yue, "Jianfeng Petrochemical's Price Dilemma Reflect the High Cost of Shale Gas," *NBD*, April 29, 2014, <http://www.nbd.com.cn/articles/2014-04-29/829757.html>.

<sup>73</sup> Fan Gao, *Will There be a Shale Gas Revolution in China by 2020?* (Oxford Institute for Energy Studies, April 2012), pp. 11–12, <http://www.oxfordenergy.org/wpcms/wp-content/uploads/2012/04/NG-61.pdf>.

However, the rules governing these pipelines are changing. In late 2013, NEA published draft opinions indicating that third parties should have access to natural gas pipelines and other related infrastructure with excess capacity on a non-discriminatory basis.<sup>74</sup> Then, in February 2014, NEA released two policies on natural gas pipelines:

- On February 13, NEA published regulations guaranteeing third-party producers access to oil and gas pipelines when there is excess capacity.<sup>75</sup> This policy has been described as a signal with respect to breaking the pipeline monopoly.<sup>76</sup> (However, in the short term, unconventional gas developers will still have challenges gaining access to pipelines, due to the limited spare capacity of the gas pipeline system.)
- On February 28, 2014, NDRC published guidance indicating that the government welcomes capital from different sources for investment in natural gas infrastructure. The guidance requires local governments to supervise and facilitate the establishment and operation of natural gas infrastructure.<sup>77</sup>

In early May 2014, CNPC announced its intention to transfer its First and Second West-East Gas Pipelines assets to PetroChina Eastern Pipelines Co., a newly established and wholly-owned subsidiary. According to CNPC, these assets — valued at 82 billion RMB — will be sold through public tenders.<sup>78</sup> CNPC also responded to NEA's regulations on third-party access by announcing that the company will open its oil and gas pipelines to third-party use.<sup>79</sup> On August 7, 2014, Xinhua reported that CNPC has set the basic principles for opening up its pipeline infrastructure to the market and pipeline capacity will be contracted on a "first-come, first-served" basis.<sup>80</sup>

On June 19, 2013, CNPC announced construction of China's first shale gas pipeline, in Sichuan. The pipeline will be 93 kilometers (58 miles) long, with daily delivery capacity of 4.5 million cubic meters, connecting Sichuan Changning parcel to an existing natural gas pipeline to Yunan.<sup>81</sup> In May 2014, Sinopec announced plans to promote private investment in shale gas transportation.<sup>82</sup>

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<sup>74</sup> NEA, "Oil and Gas Pipeline Could Soon Open to Third Parties," December 09, 2013, [http://www.nea.gov.cn/2013-12/09/c\\_132952957.htm](http://www.nea.gov.cn/2013-12/09/c_132952957.htm).

<sup>75</sup> NEA, "Measures for the Supervision of the Fair Access to the Oil and Gas Pipeline Facilities (for Trial Implementation)," Feb 13, 2014, [http://zfxgk.nea.gov.cn/auto92/201402/t20140224\\_1768.htm](http://zfxgk.nea.gov.cn/auto92/201402/t20140224_1768.htm).

<sup>76</sup> Xuan Jiang, "Market-oriented Operation Will Be Key to the Mix Ownership Reform of CNPC's Pipeline Assets," *CBM*, June 30, 2014, <http://www.yicai.com/news/2014/06/3985467.html/>.

<sup>77</sup> NDRC, "The Management Measures of Natural Gas Infrastructure Construction and Operation," February 28, 2014, [http://www.sdpc.gov.cn/zcfb/zcfbl/201403/t20140320\\_603521.html](http://www.sdpc.gov.cn/zcfb/zcfbl/201403/t20140320_603521.html).

<sup>78</sup> Juan Du, "CNPC Moves to Open Pipeline Facilities," *China Daily*, June 30, 2014, [http://usa.chinadaily.com.cn/epaper/2014-06/30/content\\_17626883.htm](http://usa.chinadaily.com.cn/epaper/2014-06/30/content_17626883.htm).

<sup>79</sup> *Ibid.*

<sup>80</sup> Xin Xu, "CNPC Sets Principles for Opening Up Pipelines," *Xinhua*, August 7, 2014, [http://news.xinhuanet.com/english/china/2014-08/07/c\\_133540009.htm](http://news.xinhuanet.com/english/china/2014-08/07/c_133540009.htm).

<sup>81</sup> Yang Wang, "CNPC Started the First Shale Gas Pipeline Construction in China," *Reuters*, June 19, 2013, <http://cn.reuters.com/article/cnMoneyNews/idCNL3S0EV1E520130619>.

<sup>82</sup> Chunlian Li, "CNPC Focuses on Pipeline Reforms While Sinopec Pushes for Shale Gas Development," *China Economic Net*, May 28, 2014, [http://finance.ce.cn/rolling/201405/28/t20140528\\_2883573.shtml](http://finance.ce.cn/rolling/201405/28/t20140528_2883573.shtml).

## F. Chinese Investment in U.S. Shale Gas Plays

Chinese companies have invested more than \$8 billion in U.S. shale plays. CNOOC made the first major investment, buying a \$1.1 billion stake in Chesapeake's Eagle Ford acreage in 2010 and then a \$1.3 billion stake in Chesapeake's Colorado and Wyoming acreage in 2011.<sup>83</sup> Sinopec followed with two investments totaling roughly \$3.2 billion starting in 2012, in deals with Chesapeake and Devon. Sinopec's investments are spread across Ohio, Michigan, Louisiana, Oklahoma and other states.<sup>84</sup> In May 2013, Sinochem and Pioneer Natural Resources reached a \$1.7 billion deal for Texas acreage.<sup>85</sup> In late 2012, Lanzhou Haimo Technologies Co. announced a joint venture with Carrizo Oil & Gas in the Niobrara Basin, becoming the first private Chinese company to enter U.S. shale gas exploration.<sup>86</sup>

The motives for these investments are mostly unstated. However many experts believe that Chinese companies are seeking a combination of financial returns, investment diversification and technology.<sup>87</sup> Investing in U.S. shale gas plays may also help familiarize Chinese companies with U.S. regulatory and managerial practices in the shale gas sector.<sup>88</sup> In announcing CNOOC's first deal with Chesapeake, CNOOC Limited CEO Yang Hua said, "The execution of this project will benefit CNOOC Limited's long term production and reserves growth and should produce considerable returns for our shareholders."<sup>89</sup>

In general, Chinese investors in U.S. shale gas plays have not negotiated for technology license rights or the right to jointly operate gas fields. Chesapeake's former CEO Aubrey

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<sup>83</sup> Chesapeake Energy Corporation, "Chesapeake Energy Corporation and CNOOC Limited Announce Eagle Ford Shale Project Cooperation Agreement" (October 10, 2010),

<http://www.chk.com/news/articles/pages/1480846.aspx>; Paritosh Bansal and Farah Master, "Chesapeake, CNOOC Strike Second Shale Deal for \$1.3 bln" (January 30, 2011),

<http://www.reuters.com/article/2011/01/31/cnooc-chesapeake-idUKN3017000120110131>.

<sup>84</sup> Devon Energy Corporation, "Devon Energy Announces \$2.2 Billion Transaction on Five New Venture Plays" (January 3, 2012),

<http://www.devonenergy.com/newsroom/Pages/NewsRelease.aspx?id=1644020#terms?disclaimer>

[=yes](http://www.chk.com/news/articles/Pages/1834132.aspx); Chesapeake Energy Corporation, "Chesapeake Energy Corporation Announces Closing of Mississippi Lime Joint Venture with Sinopec" (July 1, 2013),

<http://www.chk.com/news/articles/Pages/1834132.aspx>.

<sup>85</sup> Pioneer Natural Resources Company, "Pioneer Natural Resources Announces Closing of \$1.7 Billion Horizontal Wolfcamp Shale Transaction with Sinochem" (May 31, 2013),

<http://investors.pxd.com/phoenix.zhtml?c=90959&p=irol-newsArticle&ID=1825928&highlight=>

<sup>86</sup> "China's Haimo Seals US Shale Gas Stake" (October 26, 2012), *Chinadaily*,

[http://usa.chinadaily.com.cn/business/2012-10/26/content\\_15849981.htm](http://usa.chinadaily.com.cn/business/2012-10/26/content_15849981.htm); Haimo, *Company*

*Overview*, <http://www.haimo.com.cn/about.aspx?treeid=287&fatherid=260>.

<sup>87</sup> Interviews by authors; see also Angel Gonzalez and Ryan Dezember, "Sinopec Enters U.S. Shale" (January 4, 2012), *WSJ*,

<http://online.wsj.com/news/articles/SB10001424052970203550304577138493192325500>.

<sup>88</sup> Author interviews. See also comments of Steven Lewis in

<http://www.monitorglobaloutlook.com/Briefings/2014/07/US-sanctions-complicate-CNPC-entry-into-US-shale-market>.

<sup>89</sup> Chesapeake Energy Corporation, "Chesapeake Energy Corporation and CNOOC Limited," in note 87.

McLendon, speaking about CNOOC's role in projects where Chesapeake and CNOOC would have joint interests, was quoted as saying, "They'll have to watch from afar."<sup>90</sup>

The United States government has a strong commitment to open investment. The Committee on Foreign Investment in the United States (CFIUS) — a U.S. government interagency committee chaired by the Treasury Department — has authority to deny approval for foreign investments in U.S. companies in certain limited situations involving threats to national security. There is no record of CFIUS objecting to any Chinese investment in the U.S. shale gas sector.

#### **4. FINDINGS**

*A. Chinese shale gas production in the next few years will not be substantial. After that, low growth and high growth scenarios are both plausible.*

In our interviews, we found consensus on one point: that Chinese shale gas production in the next few years will not be substantial. We agree with that assessment. Building an industrial supply chain, training personnel, negotiating commercial arrangements and developing technologies to address unique Chinese circumstances will all take time. Implementing reforms that help promote shale gas production, including market-based natural gas pricing, will take time as well. Some observers we spoke with noted that the United States' success with shale gas production did not happen overnight and that China will require several years to put the pieces in place for significant shale gas production.

With respect to the medium and long-term, we found widely divergent views about the prospects for Chinese shale gas development. Some stakeholders were enthusiastic, describing shale gas as an important growth sector with strong prospects for contributing to economic growth, energy security and air quality in China. Others were cautiously optimistic. Many predicted the government's 2015 production target of 6.5 bcm will be met, and some said the 2020 production target of 60–100 bcm will likely be met as well.<sup>91</sup> This is a marked change from one year ago, when most stakeholders in a similar round of interviews expressed considerable skepticism about the prospects for meeting either target.

Nevertheless, we found a significant current of deep skepticism about the medium and long term prospects for shale gas production. Several stakeholders emphasized that, in their view, production of shale gas in China will be far more difficult than in the United States, citing the nature of Chinese source rock, terrain and other factors. Several of these stakeholders highlighted the need for significant technological innovation before shale gas can be produced at a profit in China. Several also noted the lack of data available to shale gas

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<sup>90</sup> Angel Gonzalez, "China Turns to Texas for Drilling Know-How," *Wall Street Journal* (December 12, 2010), *WSJ* <http://online.wsj.com/news/articles/SB10001424052748703358504575545183782651388>.

<sup>91</sup> <http://www.reuters.com/article/2014/06/13/us-breakingviews-energy-shale-idUSKBN0EO16F20140613> (Sinopec and PetroChina recently announced new shale growth forecasts that would exceed a government target of 6.5 bcm of shale production by 2015). But see Suttikulpanich et al., "China Shale Gas: Potential Unearthed," predicting that the 2015 target will not be met but the 2020 target will be.

producers in China, contrasting that with publicly available geologic and production in the United States.<sup>92</sup>

These divergent views are reflected in the published literature. Some sources project significant growth in Chinese shale gas production in the years ahead. A Standard Chartered report released in 2013, for example, projects that China will reach its target of 60 bcm (2.118 Tcf) of shale gas production by 2020 and that, by 2030, shale gas will be the largest component of China's domestic gas supply.<sup>93</sup> A paper released by several MIT authors in 2013 is also generally optimistic about long-term prospects for the industry, discussing a model that, under different scenarios, shows shale gas production reaching 140–200 bcm/year (13–19 bcf/day) in 2030 and roughly 700–900bcm/year (68–87 bcf/day) in 2050.<sup>94</sup>

Other reports are more skeptical or project slower growth. A 2014 report by the International Energy Agency — while predicting that China will likely reach its 6.5 bcm (229 bcf) target by 2015 — predicts that China will reach only half its 60 bcm (2.12 trillion cubic feet) target by 2020.<sup>95</sup> A Harvard and Rice University joint report from 2013 predicts that the 6.5 bcm-by-2015 production goal will not be met and says “meeting Beijing’s 2020 target of 60–100 bcm will be extremely difficult.”<sup>96</sup> A 2012 report released by the Oxford Institute for Energy Studies predicts that shale gas development in China is likely to grow quite slowly, reaching 10 bcm/year in 2020.<sup>97</sup> In a 2012 paper, a Peking University study agreed with this projection and predicts 10 bcm/year of China’s shale gas production level in 2020 and 60 bcm/year in 2030.<sup>98</sup> BP’s Energy Outlook 2030 also projects shale gas production to be around 60 bcm/year by 2030.<sup>99</sup>

As if to highlight these diverging views, on a single day in August 2014 one major Western news organization released a story with the headline “China Drastically Reduces Its Ambitions to Be a Big Shale Gas Producer” and another ran a story with the headline “Chinese Energy Giants Turn Upbeat on Shale Gas.”<sup>100</sup>

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<sup>92</sup> Underscoring this skeptical strain, on August 7, 2014, Reuters reported that NEA had cut China’s 2020 production target for shale gas to 30 bcm. Aizhu et al., “China Finds Shale Gas Challenging,” at note 45. As of this writing, NEA has not issued any official announcement changing its production target.

<sup>93</sup> Suttikulpanich et al., “China Shale Gas: Potential Unearthed,” pp. 53–54, at note 30.

<sup>94</sup> Sergey Paltsev et al., Shale Gas in China: Can We Expect a Revolution? (April 2013), p. 12, Massachusetts Institute of Technology, <https://www.gtap.agecon.purdue.edu/resources/download/6387.pdf>.

<sup>95</sup> IEA, Medium-Term Gas Market Report 2014 (June 10, 2014), <http://www.iea.org/w/bookshop/add.aspx?id=473> [needs confirmation]

<sup>96</sup> Trevor Houser and Beibei Bao, The Geopolitics of Natural Gas — Charting China’s Natural Gas Future (October 2013), p. 27, Harvard University’s Belfer Center and Rice University’s Baker Institute Center for Energy Studies, <http://bakerinstitute.org/media/files/Research/07a18d60/CES-pub-GeoGasChina2-103113.pdf>.

<sup>97</sup> Gao, Will There be a Shale Gas Revolution, p. 40, in note 77.

<sup>98</sup> Dazhong Dong et al., Experience from Global Shale Gas Development and the Long Term Overview of Developments in China (2012), p. 74, Peking University, [http://www.enginisci.cn/chinaes/ch/reader/create\\_pdf.aspx?file\\_no=20120419003&year\\_id=2012&quarter\\_id=6&falg=1](http://www.enginisci.cn/chinaes/ch/reader/create_pdf.aspx?file_no=20120419003&year_id=2012&quarter_id=6&falg=1).

<sup>99</sup> BP Energy Outlook 2030, p. 47, January 2013, [http://www.bp.com/content/dam/bp/pdf/Energy-economics/Energy-Outlook/BP\\_Energy\\_Outlook\\_Booklet\\_2013.pdf](http://www.bp.com/content/dam/bp/pdf/Energy-economics/Energy-Outlook/BP_Energy_Outlook_Booklet_2013.pdf).

<sup>100</sup> “China Drastically Reduces Its Ambitions to Be a Big Shale Gas Producer,” Economist (August 30,



*B. Key barriers to growth include high initial production costs, weak incentives for state-owned enterprises, lack of competition, restrictions on foreign businesses and limited data availability.*

Initial production costs at Chinese shale gas sites are high. Those costs are the product of challenging geology (including composition, depth and fracture history), difficult surface conditions, limited technical expertise, a young industrial supply chain and other factors. Current shale gas developers are losing money on each well drilled.<sup>101</sup>

High costs are not unusual for new technologies or technologies introduced in new situations. Production costs at Chinese shale gas sites can be expected to decline as expertise improves, the supply chain matures and the industry scales. However, some of the drivers of high costs — including the challenging geology and difficult surface conditions — may require technological innovations unique to the Chinese context. Whether those innovations emerge rapidly enough to spur growth in the industry is an important open question. The pace at which high production costs can be reduced will be a central factor determining the pace of Chinese shale gas development.

In one respect, the dominant role of state-owned enterprises in the Chinese shale gas sector helps to manage the problem of high initial costs.<sup>102</sup> CNPC and Sinopec, in particular, are hugely well-capitalized companies with the ability to absorb substantial losses. Their objectives are broader and more complex than those of public U.S. companies focused primarily on maximizing shareholder return. However, the incentives for SOEs to invest in shale gas operations may be limited. SOEs may do the amount needed to satisfy government mandates, but be reluctant to divert resources from their core business with low likelihood of short- or medium-term profit. The upside for investing risk capital in speculative operations may not seem compelling.

In the United States, the shale gas industry was developed by risk-taking entrepreneurs seeking large returns. In China, potential shale gas entrepreneurs face difficulties gaining access to good acreage and pipelines, among other problems. China's oil and gas resources are mostly controlled by large SOEs, leaving smaller companies with a much narrower range of opportunities in upstream development. Pipelines are held by the large SOEs, with only limited obligations to make them available to others. The extra expense of truck shipment may be required to bring gas to market.

The challenges facing foreign companies are even greater. Foreign companies have expertise, technology and capital that could be enormously helpful in developing China's shale resources, but they face significant restrictions on their ability to participate in the Chinese market. Foreign companies have in practice not been allowed to participate in shale gas bid rounds, for example. To gain access to Chinese acreage, foreign companies must help

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2014) (accessed online August 29), <http://www.economist.com/news/business/21614187-china-dramatically-reduces-its-ambitions-be-big-shale-gas-producer-shale-game>; Zhu, "Chinese Energy Giants Turn Upbeat" in note 2.

<sup>101</sup> According to one estimate, Sinopec and CNPC's short-term losses from shale gas drilling through the end of 2013 are close to \$1 billion. See Lei Tian et al., *Stimulating Shale Gas Development*, p. 4, at note 1.

<sup>102</sup> See discussion in *ibid.*

their NOC partner obtain access to acreage for oil and gas production outside of China, delaying projects and preventing some IOCs from participating in the Chinese shale gas sector.

At present there is a limited global supply of know-how available for shale gas production. Companies with shale gas expertise and technology are able to choose among countries with the most promising returns. In our interviews, we heard little to suggest that the Chinese government or industry sees itself in a competition for the know-how and technology required to develop shale gas. Instead, there tends to be an expectation that foreign businesses that possess such know-how and technology will work to adapt themselves to the Chinese context. This orientation may be a barrier to rapid development of shale gas in China, in light of the considerable returns available elsewhere to those who already possess shale gas know-how. One successful U.S. shale gas entrepreneur told us bluntly: “I have no interest in working in China. The business environment there is too uncertain. Why should I deploy capital there instead of the United States?”

Lack of data is also a barrier. In the United States, the public availability of well logs and production data has been important to the shale gas industry’s success. In China, there is no obligation to share or disclose such data, most of which is in the hands of state-owned enterprises. Indeed, some oil and gas data have been considered state secrets, creating risks for those working in this area. The lack of data slows the movement of capital and personnel to the best locations, increasing costs and lengthening the time needed for shale gas production.

*C. Government policies will play a central role in determining the growth of the Chinese shale gas sector in the years ahead.*

Geology and policy will be the most important factors shaping the growth of the Chinese shale gas sector. Much about the geology of Chinese shale and its suitability for natural gas production is unknown (and much of what is known is proprietary). An analysis of that issue is beyond the scope of this paper. But whether geologic conditions in China prove to be favorable for shale gas production or more challenging, government policies will play a critical role in the growth of the sector.

As a starting point, the Chinese government of course plays a central role in the country’s economy.<sup>103</sup> Although China’s transition from a planned to market economy has been dramatic, the government’s role in China’s economy is still substantial. That is especially so for the energy sector. China’s Five-Year Plans establish directions and set targets that shape China’s energy industries. State-owned enterprises dominate the energy sector, including in oil and gas. Government ministries set rules concerning land use, foreign partnerships and other matters with far-reaching impacts on the energy sector.

The growth of China’s shale gas industry will be shaped by at least three broad factors.

A first factor is the extent of explicit policy support for shale gas. As detailed in Section 3(C) above, the central government currently supports shale gas with production targets, a

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<sup>103</sup> See generally World Bank, *China 2030* (2013), [http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/03/27/000350881\\_20130327163105/Rendered/PDF/762990PUB0china0Box374372B00PUBLIC0.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/03/27/000350881_20130327163105/Rendered/PDF/762990PUB0china0Box374372B00PUBLIC0.pdf).

production subsidy and other policies. The target is rumored to be under revision,<sup>104</sup> and the subsidy expires in 2015. The target has been an important driver of shale gas production in the past year, and the subsidy assists the NOCs with the considerable costs of early-stage shale gas development. How these policies and others are continued during the period of China's 13th Five-Year Plan (2016–2020) will have a material impact on the industry.

A second factor will be the progress and details of economic reforms. President Xi Jinping's ambitious and far-reaching reform agenda includes many elements important to the development of shale gas, including market-based allocation of resources, reform of the state-owned enterprises, land reform and strengthening environmental regulations. The pace of progress and specific details of these reforms will shape development of the shale gas industry in important ways.

A final factor is the commitment to innovation. Growth in China's shale gas sector will require innovation, as technologies and approaches developed in the U.S. context are applied in China. Some of these innovations may be relatively straightforward, such as transport equipment redesigned for mountainous conditions. Others may be more challenging, such as new hydraulic fracturing techniques to respond to China's unique geology. Foreign partners can help contribute to innovation, if given incentives and allowed to do so. The extent to which China creates conditions in which innovations and innovators can thrive will be central to the growth of the Chinese shale gas sector.<sup>105</sup>

*D. The environmental impacts of Chinese shale gas production could range from highly positive to highly negative.*

Shale gas has the potential to displace coal-fired power generation in China, helping fight global warming and urban smog. Burning shale gas for power reduces carbon emissions (the major cause of global warming) by roughly 50% and particulate emissions (the major cause of China's smog) by more than 99%, as compared to burning coal.<sup>106</sup>

Shale gas also has the potential to displace gasified coal (sometimes called synthetic natural gas or SNG), which could deliver even bigger environmental benefits. Burning SNG for power generates *more* greenhouse gas emissions than a coal plant, on a lifecycle basis. Using SNG as a chemical feedstock or for other purposes also generates high greenhouse gas emissions. China is investing heavily in SNG, with at least nine large-scale SNG plants approved.<sup>107</sup> To the extent that shale gas slows the pace at which SNG plants are built or used in China, the environmental benefits could be significant.

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<sup>104</sup> Aizhu et al., "China Finds Shale Gas Challenging," at note 45.

<sup>105</sup> On innovation, see Section 5D below. On the role of policy in shale gas development generally, see IHS CERA, Unconventional Frontier — China (2012), p. E-3 ("Government policy is crucial. Energy policy will be at least as important as geology in shaping the future of unconventional gas. Rationalization of the regulatory environment is necessary to expedite the takeoff of unconventional gas production."); Beijing Energy Club, Enabling Policy and Regulatory Conditions for Successful Shale Gas Development in China (November 16, 2012) (Reform of policy and regulatory conditions is the key to success for China's shale gas development)

<sup>106</sup> US EIA, Natural Gas 1998 (April 1999) at p.53, [http://www.eia.gov/pub/oil\\_gas/natural\\_gas/analysis\\_publications/natural\\_gas\\_1998\\_issues\\_trends/pdf/it98.pdf](http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/it98.pdf). See also <http://naturalgas.org/environment/naturalgas/>.

<sup>107</sup> See Chi-Jen Yang and Robert B. Jackson, "China's Synthetic Natural Gas Revolution,"

How much carbon reduction could Chinese shale gas deliver? If 100bcm of shale gas (the upper end of the central government's 2020 production target) were all used to displaced coal-fired power generation, carbon emissions would be reduced by approximately 310 million metric tons — roughly 2.5% of China's projected greenhouse gas emissions for that year.<sup>108</sup> These amounts would grow with additional shale gas production.

Yet the actual situation will be more complicated. Not all shale gas produced in China will be used to replace coal-fired power generation. Indeed, the provinces with the strongest initial prospects for shale gas production — Sichuan and Chongqing — use less coal in power generation than the national average.<sup>109</sup> Shale gas there and elsewhere might be used as a chemical feedstock, for transportation or for other purposes. This could result in larger or smaller carbon reductions than displacing coal-fired power generation, depending on a number of factors, including whether the shale gas is displacing SNG. Further analysis is needed.

With respect to the potential global warming benefits of shale, an important offsetting factor is methane leakage. Methane — the principal component of natural gas — is 34 to 86 times more potent than carbon as a greenhouse gas.<sup>110</sup> Methane emissions from natural gas systems can be significant. Substantial research is currently underway to better understand the nature and extent of methane leakage from U.S. natural gas systems, including from upstream shale gas production. While one recent U.S. study found that “system-wide leakage is unlikely to be large enough to negate the climate benefits of coal-to-natural gas substitution,” another found methane emissions from a few well pads to be hundreds to thousands of times greater than U.S. EPA estimates.<sup>111</sup> In order for Chinese shale gas

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Nature Climate Change (October 2013), <http://people.duke.edu/~cy42/SNG.pdf>.

<sup>108</sup> See Explanatory Note in Attachment D.

<sup>109</sup> In Sichuan, roughly 60% of power production typically comes from coal. In Chongqing, the figure is roughly 45%. See Adam Worthington, “Chinese Power and Energy,” (Macquarie, July 17, 2012), pp. 33–42. (Figures based on adding adjusted capacity figures for each fuel, averaged between winter and summer months, and dividing by the total. These percentages will vary, month to month and year to year, depending mainly on hydro resources.)

<sup>110</sup> For time horizons between 20 and 100 years. See IPCC Fifth Assessment Report Working Group 1, Chapter 8: “Anthropogenic and Natural Radiative Forcing” (table 8.7, p. 714) [http://www.climatechange2013.org/images/report/WG1AR5\\_Chapter08\\_FINAL.pdf](http://www.climatechange2013.org/images/report/WG1AR5_Chapter08_FINAL.pdf).

<sup>111</sup> See A. R. Brandt et al., “Methane Leaks from North American Natural Gas Systems,” Science (February 14, 2014) (Official inventories in North America consistently underestimate methane emissions from the overall natural gas system, yet “system-wide leakage is unlikely to be large enough to negate climate benefits of coal-to-NG substitution”); Dana Caulton et al., “Toward a Better Understanding and Quantification of Methane Emissions from Shale Gas Development,” PNAS Early Edition (March 2014) (emissions from several shale gas well pads observed from aircraft found to be two to three orders of magnitude greater than U.S. EPA estimates); David Allen et al., “Measurements of Methane Emissions at Natural Gas Production Sites in the United States,” PNAS Early Edition (August 2013) (Direct measurement at 190 onshore natural gas production sites in the United States finds total emissions similar to most recent EPA inventory of methane emissions); F. O'Sullivan and S. Paltsev, “Shale gas production: potential versus actual greenhouse gas emissions,” Environmental Research Letters (2012) (Fugitive emissions from fracking are likely less than previously thought); Robert Howarth et al., “Methane and the Greenhouse-Gas Footprint of Natural Gas from Shale Formations,” Climatic Change (2011) (methane emissions from hydraulic fracturing of shale formations at least 30% greater than from conventional natural gas production).

production to deliver global warming benefits, fugitive methane emissions must be minimized.

Water pollution is also a concern. Hydraulic fracturing fluids contain proppants (including sand), thickeners, friction reducers, biocides and corrosion inhibitors. Wells also contain water from within the subsurface rock formation, often high in salts, heavy metals and volatile organic compounds such as benzene. Both hydraulic fracturing fluids and water from within the formation flows back to the surface through the well and must be disposed of. Studies of the Marcellus shale have shown high levels of barium, bromide, radium-228, strontium and salts in flowback and produced waters.<sup>112</sup>

Some of this polluted water can be reinjected into shale wells, with estimates ranging from 10 to 80%.<sup>113</sup> Increased recycling can reduce the volume of polluted effluent requiring treatment and/or disposal (as well as overall water use). However, water recycling also increases the concentration of some pollutants in the water later discharged.

Technologies exist to manage shale gas production with little water pollution. However, there are questions about the extent to which such technologies will be used in China. The United States has a robust system for protection of surface water quality, with standards, permitting requirements and enforcement officials. China's infrastructure for protecting water quality is much more limited. Several recent reports contain recommendations for protecting U.S. water quality in shale gas development, including institutionalizing water risk management within companies, brackish water use and recycling, limiting deep disposal wells and increasing water treatment and developing comprehensive water protection plans and increasing stakeholder engagement.<sup>114</sup> These recommendations are worth examining for potential application in the Chinese context.

Earthquakes are another concern. Hydraulic fracturing does not cause earthquakes, but disposal of produced water (from conventional or unconventional production) in deep underground injection wells has been shown to induce seismicity.<sup>115</sup> Although these earthquakes have been minor, any human-induced seismicity could become extremely controversial in some of the shale-abundant regions in China. Sichuan, the province that is ranked first in terms of shale gas reserve, lies at the edge of the largest continent-continent collision in the world and has suffered two major earthquakes during the past five years.<sup>116</sup> In 2008, Wenchuan city in Sichuan suffered one of the most serious earthquakes in China's history, during which nearly 70,000 people were killed. A study conducted by the Earthquake Administration Bureau of Sichuan, Hebei and Zigong Municipality from 2007 to 2010, found that more than 2,700 seismic events were recorded near an underground

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<sup>112</sup> Yusuke Kuwayama et al., "Water Resources and Unconventional Fossil Fuel Development," (Resources for the Future, 2013), pp. 4–5.

<sup>113</sup> Ibid, p. 4.

<sup>114</sup> Monika Freeman, "Hydraulic Fracturing & Water Stress: Water Demand by the Numbers," CERES, February 2014, pp. 38–45.

<sup>115</sup> Nicholas J. van der Elst et al., "Enhanced Remote Earthquake Triggering at Fluid-Injection Sites in the Midwestern United States," *Science*, July 12, 2013: vol. 341, no. 6142, pp. 164–67, <http://www.sciencemag.org/content/341/6142/164.abstract>.

<sup>116</sup> Benjamin Haas, "China Fracking Quake-Prone Province Shows Zeal for Gas," August 1, 2013, <http://www.bloomberg.com/news/2013-07-31/china-fracking-quake-prone-province-shows-zeal-for-gas.html>.

injection well in Zigong, Sichuan.<sup>117</sup> At present, seismic vulnerability is not required as part of the standard environment assessment for oil and gas projects.<sup>118</sup> As shale gas production grows in Sichuan, clearer regulation will be needed before the subject becomes increasingly controversial.

At present, there are no specific environmental regulations with respect shale gas in China. An NEA official recently said, “Up to now, China has yet to experience any incident of environmental pollution associated with shale gas exploration and development. We will be actively involved in the development of standards and legislation on shale gas development.”<sup>119</sup>

*E. Water supply constraints could be a factor in some regions in the medium and long term.*

Shale gas production uses large amounts of water. In the United States, shale gas wells use roughly 3 to 4 million gallons of water per well and up to 6 million gallons in deep formations.<sup>120</sup> Water use varies considerably by type of formation: pure gas plays generally involve less water per well than associated gas plays.<sup>121</sup> Horizontal wells use more water than vertical wells on average, partly because such wells may have horizontal sections thousands of feet long.

Shale gas production in China will likely require more water per unit of gas produced than in the United States, because of the depth of China’s shale. However China faces substantial challenges in managing its water supplies. On a per capita basis, China’s water resources are roughly one-fourth of those in the U.S. and one-third the global average.<sup>122</sup> The recent drought in South China underscores the country’s vulnerability to water stress. These factors suggest that water supply could become a constraint on Chinese shale gas development.

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<sup>117</sup> Zhi-Wei Zhang et al., “Study on Earthquakes Induced by Water Injection in Zigong-Longchang Area, Sichuan.” *Chinese Journal Geophysics*, 2012 (5), pp. 1635–45, <http://manu16.magtech.com.cn/geophy/CN/abstract/abstract8667.shtml>.

<sup>118</sup> Law of the People’s Republic of China on Evaluation of Environmental Effects (Order of the President No.77), October 28, 2002, [http://english.gov.cn/laws/2005-10/09/content\\_75327.htm](http://english.gov.cn/laws/2005-10/09/content_75327.htm).

<sup>119</sup> Presentation by Xiaolong Li, NEA, July 1, 2014

<sup>120</sup> Suttikulpanich et al., “China Shale Gas: Potential Unearthed,” p. 19, at note 30. See also “Draft Plan to Study the Potential Impacts of Hydraulic Fracturing in Drinking Water Resource,” U.S. Environmental Protection Agency, Feb. 7, 2011, (table 3, p. 19); Matthew E. Mantel, “Produced Water Reuse and Recycling Challenges and Opportunities Across Major Shale Plays,” Chesapeake Energy Corporation, presentation delivered at the EPA Hydraulic Fracturing Study Technical Workshop #4, Mar. 29, 2011, p. 5. According to FracFocus.org, the average U.S. well between January 2011 and May 2013 consumed 2.5 million gallons of water. See Freeman, “Hydraulic Fracturing & Water Stress, in note 120. See generally *Water and Shale Gas Development* (Accenture 2012), <http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Water-And-Shale-Gas-Development.pdf>

<sup>121</sup> Matthew E. Mantel, “Produced Water Reuse and Recycling Challenges and Opportunities,” p. 5, in note 126.

<sup>122</sup> Scott Moore, “Water Resource Issues, Policy and Politics in China” (Brookings, February 12, 2013), [http://www.brookings.edu/research/papers/2013/02/water-politics-china-moore#\\_edn2](http://www.brookings.edu/research/papers/2013/02/water-politics-china-moore#_edn2); World Bank, “Renewable internal fresh water resources per capita” 2012, <http://data.worldbank.org/indicator/ER.H2O.INTR.PC>.

Yet water supply is not likely to be a significant constraint on overall Chinese shale gas production in the short term. The regions where most initial shale gas production is taking place — Sichuan and Chongqing — have large water endowments. Water use there is small compared to water availability. One recent study found that current residential, commercial and industrial activities use roughly 10% of Sichuan’s available water resources.<sup>123</sup> The same study found that less than 0.1% of water resources in most regions would be needed to meet the demand for water to produce shale gas.<sup>124</sup> Another study found that to produce 40 bcm of shale gas in 2020, China would need 40 billion gallons (150 million cubic meters) of water annually — roughly 0.5% of national water consumption.<sup>125</sup>

In addition, shale gas production uses *less* water per unit of energy than coal mining.<sup>126</sup> Combined-cycle natural gas turbines use less water than coal-fired power plants. (According to one source, one hydraulic fracturing operation uses about the same amount of water as a 1000 MW coal plant uses in 10 hours.)<sup>127</sup> To the extent that shale gas displaces coal production, there may be net savings in water use. Furthermore, China is rapidly developing coal-to-gas plants, which are estimated to consume roughly 60 times as much water as shale gas per unit of natural gas produced.<sup>128</sup> To the extent that shale gas displaces coal — and in particular coal-to-gas plants — shale gas may provide a significant water savings.

However water supply could become a constraint on Chinese shale gas production in the medium or long term. First, water supply in China is unevenly distributed. Some shale-rich regions — including in particular the Tarim Basin — have very limited water supplies. As shale gas production scales up in those regions, water supply will be an important factor. Second, water supply varies from year to year. Droughts could create challenges for shale gas production. Shale gas development plans should reflect large potential inter-annual variation in water supplies.<sup>129</sup>

In addition, water is a highly localized resource. Even in provinces with ample water supplies, a sudden surge in shale gas development in rural areas could overwhelm local

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<sup>123</sup> Suttikulpanich et al., “China Shale Gas: Potential Unearthed,” p. 41, at note 32.

<sup>124</sup> *Ibid.*, pp. 38, 41.

<sup>125</sup> Gao, *Will There Be a Shale Gas Revolution*, in note 77.

<sup>126</sup> E. Mielke, L. D. Anadon and V. Narayanamurti. “Water Consumption of Energy Resource Extraction, Processing, and Conversion,” 2010. See <http://www.wri.org/blog/2013/10/china%E2%80%99s-response-air-pollution-poses-threat-water> for graph.

<sup>127</sup> Lisa Genasci, “Is Fracking the Answer for Water Scarce China” (China Water Risk, October 10, 2012), <http://chinawaterrisk.org/resources/analysis-reviews/is-fracking-the-answer-for-water-scarce-china/>.

<sup>128</sup> Chi-Jen Yang, “China’s Synthetic Natural Gas Revolution,” *Nature Climate Change*, vol. 3, October 2013.

<sup>129</sup> See Paul Reig et al., *Global Shale Gas Development: Water Availability & Business Risks* (World Resources Institute, September 2014),

[http://www.wri.org/sites/default/files/wri14\\_report\\_shalegas.pdf](http://www.wri.org/sites/default/files/wri14_report_shalegas.pdf). See also

[http://www.wri.org/sites/default/files/uploads/china\\_sng\\_updated.png](http://www.wri.org/sites/default/files/uploads/china_sng_updated.png) and

<http://www.ogj.com/articles/print/vol-110/issue-3/exploration-development/china-vigorously-promoting.html>; <http://www.circleofblue.org/waternews/2012/world/chinas-water-reserves-and-worlds-warming-atmosphere-wait-for-natural-gas-breakthrough/>.

water supplies and related infrastructure. Sichuan and Chongqing are highly populous, even in rural areas, and shale production may compete directly with agricultural and residential uses in some locations. Furthermore, water consumption in shale gas production is episodic, not continuous. Some localities may be unprepared for a sudden surge in water consumption at a well.

In both the United States and China, interesting work is underway to minimize water use in shale gas production, as well as to find fluids or gases (such as propane or CO<sub>2</sub>) to replace water in hydraulic fracturing. This could be a valuable topic for work by the U.S.-China Clean Energy Research Center.<sup>130</sup>

*F. The U.S. and Chinese governments share common interests with respect to shale gas.*

The U.S. and Chinese governments work closely together on shale gas. This cooperation has support at the highest levels. On November 17, 2009, in Beijing, Presidents Barack Obama and Hu Jintao announced a new U.S.-China Shale Gas Resource Initiative. The White House fact sheet reported that:

The two Presidents announced the launch of a new U.S.-China Shale Gas Resource Initiative. Under the Initiative, the U.S. and China will use experience gained in the United States to assess China's shale gas potential, promote environmentally-sustainable development of shale gas resources, conduct joint technical studies to accelerate development of shale gas resources in China, and promote shale gas investment in China through the U.S.-China Oil and Gas Industry Forum, study tours, and workshops.<sup>131</sup>

In the years since, bilateral work has been extensive and wide ranging. The U.S. Department of Energy, U.S. State Department, U.S. Trade and Development Agency and other federal agencies have worked with the National Energy Administration, Ministry of Land and Resources, provincial governments and others on meetings, workshops and delegation visits covering a range of shale gas topics. Topics discussed have included U.S. federal policies and regulations, U.S. state policies and regulations, characterization and assessment of shale gas resources, drilling and completion, cost saving in shale gas development, Production Sharing Contracts, geopolitical issues and more. Private companies and SOEs have been core participants in many of these events.

This joint work is fueled by common interests. The Chinese government gives priority to the development of China's shale gas sector in order to help fight air pollution and reduce reliance on natural gas imports. The U.S. government supports the sustainable development of China's shale gas sector for a range of economic, environmental and geostrategic reasons. First, Chinese shale gas development offers export opportunities for U.S. companies. Second, Chinese shale gas development could deliver global environmental benefits — in particular, lower carbon emissions. (U.S. technical expertise could help reduce fugitive methane

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<sup>130</sup> Peter Marsters, "A Revolution on the Horizon: The Potential of Shale Gas Development in China and Its Impact on Water Resources," in Jennifer Turner et al. (eds.), *China Environment Series: Special Water and Energy Issue*, Wilson Center, 2012/2013, pp. 40–42. With respect to the US-China Clean Energy Research Center, see <http://www.us-china-cerc.org/> and Section 5D below.

<sup>131</sup> "U.S. China Clean Energy Announcements," Office of the Press Secretary, The White House (November 17, 2009), <http://www.whitehouse.gov/the-press-office/us-china-clean-energy-announcements>



emissions at production sites, improving the likelihood of global warming benefits from Chinese shale gas development.) Third, Chinese shale gas could reduce pressure on global gas markets and in the long term reduce China's dependence on both Iran and Russia as energy suppliers.

The two governments share common interests with respect to the U.S. shale gas sector as well. The United States welcomes foreign investment, including in the shale gas sector. Chinese companies seek opportunities for profitable investments abroad, as part of China's "going out" strategy, as well as technology acquisition. The result has been over \$8 billion of Chinese investment in the U.S. shale gas sector.

Not all parts of the U.S.-China energy relationship enjoy such a range of joint activities and common interests. The two governments have sparred over solar trade policies, with disputes adjudicated by the World Trade Organization. Disagreements concerning cyber espionage and intellectual property theft in the energy sector have contributed to broader tensions in the bilateral relationship.

Nor are relationships in the shale gas sector entirely free of discord. The U.S. government has urged the Chinese government to remove restrictions on U.S. companies operating in the Chinese shale gas sector, for example. But in general the U.S.-China shale gas relationship is characterized by productive activities and common interests. In this regard, shale gas is similar to other energy topics on which the U.S. and Chinese governments have often if not always worked productively together in recent years, including civil nuclear programs, strategic petroleum stocks and the U.S.-China Clean Energy Research Center.

## **5. RECOMMENDATIONS**

We group our recommendations into five broad categories:

### **A. Accelerate Market-Based Reforms**

*"Realizing the Chinese dream of the great national rejuvenation would mean China's becoming a prosperous country, a revitalized nation, and a happy people." — President Xi Jinping, March 13, 2013<sup>132</sup>*

In this section we discuss four market-based reforms — some already underway — that can help China meet its shale gas objectives.

#### **(i) Continue Natural Gas Price Reform**

Natural gas price reform has the potential to stimulate technology and lead to a boom in shale gas production, as happened in the United States after natural gas price controls were lifted in the 1980s.

In recent years the central government has taken significant steps toward market-based pricing of natural gas. Wellhead prices of unconventional gas, including shale gas, are

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<sup>132</sup> "Xi Jinping's Speech on the 1st Session of the 12th National People's Congress," *people.com*, March 17, 2013, [file://localhost/2013.http://theory.people.com.cn:n:2013:0318:c40531-20819774.html](http://localhost/2013.http://theory.people.com.cn:n:2013:0318:c40531-20819774.html).

completely deregulated. However a number of factors have limited the practical utility of this reform, including the mixing of shale gas with conventional gas in pipelines and challenges shale gas producers face reaching a broad market for their product.<sup>133</sup>

Continuing the natural gas price reforms underway will help shale gas producers realize a return on their investment and stimulate shale gas production. This will likely be part of larger reform packages. Among the constraints on rapid movement toward full market-based pricing are higher fuel costs for households. NDRC's "ladder pricing" guideline, under which prices are cheapest for households with the lowest consumption, is an important response to this problem.<sup>134</sup> (The guidelines — which currently apply only to urban households — could be extended to rural households, especially those in the vicinity of shale gas production sites.) Another constraint is uneven market power between NOC producers and consumers. Movement toward full market-based pricing is naturally related to reforms opening upstream oil and gas production to companies in addition to the large NOCs.

#### (ii) Speed Pipeline Reform

China does not need to build a vast national pipeline network to meet its 2015 and 2020 shale gas goals. Most shale gas can be consumed in the same province or even locality where it is produced, at least in the short term. Provincial governments have begun building small LNG facilities to help move shale gas to markets. Although more expensive than pipelines, LNG trucks offer a reasonable short-term solution for shale gas transport.

In the medium and long term, however, pipelines will be important for the growth of the Chinese shale gas sector. Yet as the coal bed methane experience demonstrates, independent natural gas producers face challenges gaining access to pipeline infrastructure and ancillary services in China, because the major NOCs fully control the existing gas pipelines.<sup>135</sup> Open access to the pipeline system, with clear standards for tariffs and an independent regulator, will be key.

In the past year, NEA has taken important steps toward opening China's pipeline network, announcing policies to guarantee third-party access when pipelines have excess capacity. Next steps could include rules guaranteeing producers access to the pipeline network on non-discriminatory terms and establishment of an independent pipeline regulator. Further steps to open investment in the sector — including to foreign companies — would also be helpful. Over the longer-term, separating ownership of pipeline assets from upstream oil and gas production would enhance competition and help promote shale gas production.

#### (iii) Encourage Competition for Mineral Rights

Market-based reforms in the management of mineral rights can help China meet its shale gas goals. The second bid round was an important step in this direction, opening shale gas acreage to a wide range of companies. However, the lack of progress by the second round

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<sup>133</sup> See fuller discussion in Section 3D above.

<sup>134</sup> Nan Zhong, "NDRC Issues Ladder Pricing Guideline for Gas," *China Daily*, March 21, 2013, [http://www.chinadaily.com.cn/bizchina/greenchina/2014-03/21/content\\_17369412.htm](http://www.chinadaily.com.cn/bizchina/greenchina/2014-03/21/content_17369412.htm).

<sup>135</sup> See discussion at Section 3E above. See also *Oil, Energy and Power*, p. 308, 2013 White Paper, AmCham, China.

winners suggests that adjustments should be made in the third and subsequent bid rounds. Among the most important measures:

- Make better acreage available. There is a widespread perception that acreage offered as part of the second bid round was of poor quality. The better the acreage that is made available, the more the next bid round will advance China's shale gas goals.
- Make better data available. Data packages for the second round reportedly offered little useful information for evaluating the potential of blocks. The most capable bidders — who have many other opportunities in light of their capabilities — are unlikely to bid without adequate information. (See discussion of data availability below.)
- Provide clear instructions to help foreign companies engage in the auctions. Allowing foreign companies to get involved early would significantly increase the pace at which China develops its shale gas sector. Chinese companies are allowed to invest directly in U.S. shale acreage. Recognizing the different systems of land ownership in each country, both China and the U.S. would benefit if U.S. companies had more rights with respect to exploration and development in China.
- Allow provincial governments to play a larger role in the next bid round. Provincial governments have a substantial stake in the success of the auctions, including local economic growth and greater tax revenues. With a larger role in the auctions, the provincial governments can help move the process forward and facilitate development. However, an expanded provincial role in the auctions creates risks of local favoritism and deal-making that could be counterproductive in meeting shale gas development goals. The results of local auctions could be evaluated after the next bid round to determine whether such auctions should be continued.

Another helpful step would be to establish a cure process for first- or second-round bid winners who have not met minimum work requirements. These bid winners could be allowed additional time to develop their acreage and an opportunity to engage in cooperative activities with other companies. A similar process could be established for NOCs that own parcels with overlapping mineral rights. These NOCs are currently required to transfer shale gas exploration rights if they do not explore for shale gas.<sup>136</sup> They could be given additional time to develop the shale gas, with a hard deadline after which the rights would be transferred.

#### (iv) Improve Data Availability

Data is crucial for the development of shale gas. Information on geological setting, 2D and 3D seismic data, well logs and core samples are important to assess a site and find the sweet spots. Indeed many experts cite publicly available data as a key factor in the U.S. shale gas

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<sup>136</sup> MLR, "Notice with Regard to Reinforcing Exploration of Shale Gas Resources and Supervising Work Management," October 2012, [http://www.mlr.gov.cn/zwgk/zytz/201211/t20121122\\_1158928.htm](http://www.mlr.gov.cn/zwgk/zytz/201211/t20121122_1158928.htm).

revolution. State laws require public disclosure of well logs and shale gas production data. This data plays an important role in helping U.S. shale gas producers target the best opportunities and deploy their limited capital.

In China, the availability of data for shale gas operations is quite limited. CNPC and Sinopec have accumulated abundant data from their onshore conventional oil and gas operations but have no obligation to share that data. Other companies — domestic and foreign — struggle to obtain information needed to evaluate potential shale gas opportunities. Data packages for the first- and second-bid rounds, for example, were very basic and widely considered to be insufficient to assess shale gas prospects at the sites offered. Even when information can be obtained, its quality can vary and cost can be prohibitive.

State-secret laws are also a concern. The definition of a state secret is vague. In some cases oil and gas data have been considered a state secret.<sup>137</sup> The lack of clarity concerning state-secrets laws makes attempts to develop useful oil and gas data more challenging.

The Chinese government is working to help small- and medium-size companies overcome the data barrier for shale gas. MLR reportedly plans to conduct basic seismic surveys and drill exploratory wells, making the data obtained available in connection with the next bid round.<sup>138</sup> MLR collects geologic data from all companies conducting oil and gas operations<sup>139</sup> and could make that data available if it chose to do so.

Requiring public disclosure of well logs and shale gas production data, as in the United States, would help in assessing the best opportunities for shale gas production. Reviewing and clarifying the state secrets law would remove concerns that inhibit work in this area. It is the right of any government to determine what information is considered a state secret. In the case of Chinese oil and gas data, a review of that policy could have benefits, including more rapid shale gas development.

**RECOMMENDATIONS:**

- (i) Continue natural gas price reforms
- (ii) Speed pipeline reforms
- (iii) Encourage competition for mineral rights
- (iv) Improve data availability

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<sup>137</sup> Keith B. Richburg, “China Sentences American Geologist to 8 Years for Stealing State Secrets,” *Washington Post*, July 5, 2010, <http://www.washingtonpost.com/wp-dyn/content/article/2010/07/05/AR2010070500859.html>.

<sup>138</sup> “3rd Bidding Round for Shale Gas Exploration Right May Start at Earliest at the Year-End,” June 07, 2013, <http://finance.sina.com.cn/stock/t/20130607/083215732283.shtml>.

<sup>139</sup> State Council, Regulations on Administration of Geological Data, March 19, 2002, [http://www.mlrgov.cn/zwgk/flfg/kczyflfg/200406/t20040625\\_4601.htm](http://www.mlrgov.cn/zwgk/flfg/kczyflfg/200406/t20040625_4601.htm).

## B. Provide a Clear Roadmap for Foreign Companies

Foreign companies can play an important role in helping China meet its shale gas objectives. Companies operating in the United States have considerable expertise in hydraulic fracturing, horizontal drilling and other technologies for shale gas production. Many of these companies are willing to work in China if satisfactory returns are available. Their expertise and technologies could help dramatically to quicken the pace at which the Chinese shale sector develops in the years ahead.

The Chinese government and state-owned enterprises have worked closely with foreign oil and gas companies for many years. In 1979, China entered into eight agreements for offshore oil exploration with foreign companies, including BP, Arco, Mobil, Texaco and Exxon. In 1998, China formally opened coal bed methane (CBM) to foreign investment.

These experiences provide a framework for foreign companies to participate in China's shale gas sector. Many well-established practices from previous projects with foreign oil and gas companies can be applied, including the use of production-sharing contracts (PSCs) and Overall Development Plans (ODPs). However, several provisions used in previous PSCs and ODPs will need to be revised to adapt to the special characteristics of shale gas projects, as explained below

### (i) Develop a Model Production-Sharing Contract (PSC)

A production-sharing contract is an agreement in which a host country grants an international oil company (IOC) the right to explore for oil and gas and a percentage of the oil and gas produced at a site, in exchange for the IOC's commitment of funds, technology and expertise. China has used PSCs in the upstream oil and gas sector since the 1980s.

These traditional PSCs will need to be modified to work effectively in the shale gas sector. Conventional oil and gas production has distinct phases, with exploration, development and production easily separated and distinguishable. Traditional PSCs have been structured accordingly, with the rights and obligations of each party shifting in each phase. In shale gas development, however, the differences between phases are far less distinct — exploration, development and production can all go on simultaneously. A PSC for shale gas development must reflect this difference and others. PSC's used in coal bed methane development in China contain provisions that parties can draw on in developing PSCs in the shale gas sector.

One important tool for realizing the potential of the shale gas sector in China would be development of a model PSC. A model shale gas PSC could help China meet its shale gas goals for several reasons. First, a model PSC could encourage IOCs to explore opportunities in China's shale gas sector, by clarifying the likely structure of any commercial deal. Second, a model PSC would reduce the time and expense associated with contract negotiations.

Many provisions from previous PSCs in China can be used in a model shale gas PSC. However other provisions will need to be adapted to the unique circumstances of shale gas production. Following are some key features of a model shale gas PSC, reflecting the types of terms IOCs will be looking for to invest in Chinese shale gas development:

### Production Period

Shale gas wells generally deplete more quickly than conventional wells. After an initial period of decline, shale gas wells typically approach a long-term production rate that remains stable for many years. As compared to conventional wells, shale gas wells generally take longer to reach payout and provide less economic benefit after payout is achieved. Furthermore, it could take many years for the cost of well drilling to drop sufficiently for all areas in a block to be economically attractive.

Taking exploration, drilling and completion costs into account, the production cycle for shale gas fields are likely to be longer than for conventional fields. As a result, to provide IOCs sufficient incentives to invest in Chinese shale blocks, neither the 15-year Production Period used in offshore oil projects nor the 20-year Production Period used in CBM projects are likely to be adequate. The Production Period under a model shale gas PSC will likely need to be longer, such as 30 years.

### Relinquishment

PSCs for conventional oil and gas typically require the IOC to commit to explore a block and, after exploration work is completed, relinquish areas that have not shown commercial viability. The purpose of the relinquishment requirement is to provide the IOC with a mandate to invest in acreage efficiently and make some acreage available for newcomers.

Such forced relinquishments work poorly in shale gas projects. Shale gas development is typically dispersed over large areas. It involves locating “sweet spots” in shale layers, applying the right mix of technologies and developing commercially attractive flow-rates at different locations within a block, sometimes over extended periods of time. The timeframe in which the commercial viability of a shale gas project can be determined is not necessarily predictable. Early relinquishments will not help generate the optimum results for the overall development.

The Onshore CBM PSC does not contain a relinquishment obligation for the IOC. This approach should also apply to a shale gas PSC.

### Pilot Project Stage between Exploration and Development

The CBM PSC includes a Pilot Project Stage, including the drilling of exploratory wells, trial production and the completion of long-term gas sales. A similar concept is important for the shale gas model PSC. In the Pilot Project Stage, the IOC would have the opportunity to evaluate the potential returns from a shale gas block, before committing to the significant cost of full-scale development.

The CBM PSC does not address the ownership of gas during the Pilot Project Stage. It is reasonable to treat the gas produced in this stage the same as the equity gas during the Production Period, with each party having the right to market gas for the best commercial value.

### Other Petroleum Discoveries

The objective of a shale gas PSC is to produce shale gas in the contract area. However, other hydrocarbons — such as conventional oil, conventional gas or liquids within the shale formation — may coexist in the same contract area and be discovered during exploration for shale gas. Shale gas PSCs should give the IOC a right to participate in development of any other hydrocarbons discovered. (The CBM PSC contains such a provision.) This will help avoid the building of redundant infrastructure in the same area by different operators with rights to different mineral types and improve the efficiency of resource development.

### Rolling Overall Development Programs (ODPs)

At a conventional gas site, commerciality is determined once, at the end of the Exploration Period. The approval of an ODP then marks the beginning of the Development Period. At a shale gas project, commerciality is determined gradually in course of exploitation, as drilling progresses often over many years. ODPs should be prepared for sub-areas of the block, not the block as a whole. In a shale gas PSC, the entire nature of an ODP should be different than at a conventional site. (See discussion below.)

Attachment A sets forth terms for a model shale gas PSC.

In addition, the Chinese government should consider authorizing companies other than the national oil companies to enter into PSCs for shale gas.<sup>140</sup> Such a step could enhance competition and help promote innovation in the sector.

#### (ii) Use “Rolling Overall Development Programs (ODPs)”

The Overall Development Program (ODP) is the guidance document for development of an oil and gas field. Both Chinese law and Chinese PSCs require the operator (domestic or foreign) to compile an ODP before a field is developed. NDRC is in charge of ODP approvals.<sup>141</sup>

The ODP plays a critical role in an oil and gas project. The ODP provides detailed information on the project, with items including drilling techniques and health and safety practices.<sup>142</sup> However the guidance document for ODPs was developed with reference to conventional oil and gas fields. Several of its provisions work poorly for shale gas development, due to the differences between conventional and shale gas production. For example:

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<sup>140</sup> Whether such PSCs are currently authorized under Chinese law is ambiguous. The Regulations of the People's Republic of China on Exploitation of On-shore Petroleum Resources under Foreign Cooperation, which limits PSCs to the three national oil companies, applies only to conventional oil and gas and coal bed methane projects, [http://www.mof.gov.cn/zhengwuxinxi/zhengcefabu/201110/t20111011\\_598575.htm](http://www.mof.gov.cn/zhengwuxinxi/zhengcefabu/201110/t20111011_598575.htm).

<sup>141</sup> State Council of the People's Republic of China, “Decision to Amend Regulations on Exploitation of On-shore Petroleum Resources under Foreign Cooperation,” November 2011, [http://www.mof.gov.cn/zhengwuxinxi/zhengcefabu/201110/t20111011\\_598575.htm](http://www.mof.gov.cn/zhengwuxinxi/zhengcefabu/201110/t20111011_598575.htm).

<sup>142</sup> NDRC, Guide to Programing Overall Development Program for Oil Fields (SY/T 10011—2006).

Approval of technical plans. In an ODP for conventional gas production, development plans with drilling techniques are generally submitted for approval once at the beginning of a project. This is impractical at a shale gas project, where continual adjustment of drilling plans based on new information is required.

Investment appraisal. At a shale gas project, the rate of return will likely be lower than with a conventional gas project. If a standard rate of return is applied as the threshold for granting approval of an ODP, the ODP will likely be rejected. Therefore, the government should allow a lower rate of return chosen by the operator.

Furthermore, even if an operator uses all available data collected during Exploration, Appraisal and Pilot Development to compile an accurate ODP, significant new information will be gained as drilling in the shale formation takes place during the Development Period. In order to realize the maximum potential of shale formations in the block, there must be flexibility to quickly adjust the way the shale formation is developed, taking into account the learning during development. This flexibility is essential to the success of a shale gas development.

Accordingly, “rolling ODPs” is needed. Such an instrument would allow for development of different areas within a shale gas block to be approved at different times. The objective would be greater flexibility in operations and quicker approvals than with a standard ODP.

In conventional oil and gas projects, ODPs are used by government authorities as fixed governing documents, requiring the operator’s strict adherence. However, in shale gas projects, ODPs should instead be flexible guides to development.<sup>143</sup> This is a “rolling ODP.”

(iii) Consider Other Legal Forms

As Chinese and foreign companies explore ways to work together in China’s shale gas sector, the flexibility to use legal structures other than PSCs and ODPs could be helpful. One possibility is an equity joint venture (EJV). An EJV is a limited liability entity established under Chinese law with equity contributions from both parties. It is one of the most traditional vehicles to attract foreign direct investment in China. An EJV could be an attractive alternative to a PSC in a shale gas project, because EJVs are eligible to bid on shale gas mining licenses, forming an EJV is quicker than obtaining approval for a PSC and the legal structure is familiar.

According to NEA officials, there is no prohibition under Chinese law on the use of joint ventures between Chinese and foreign companies in the shale gas sector. Indeed, NDRC and MOFCOM guidance expressly authorizes such joint ventures.<sup>144</sup> Sinopec and Total are reportedly exploring the establishment of an equity joint venture for work in the Chinese shale gas sector.<sup>145</sup> There are also examples of EJVs between two Chinese companies to

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<sup>143</sup> Oil, Energy and Power, p. 308, in note 143.

<sup>144</sup> China's NDRC and the Ministry of Commerce, Catalogue of Industries for Guiding Foreign Investment (Item 9 under Section 2), December 24, 2011, [http://www.china.com.cn/policy/txt/2011-12/29/content\\_24283092.htm](http://www.china.com.cn/policy/txt/2011-12/29/content_24283092.htm).

<sup>145</sup> Pei An, “Total and Sinopec are Exploring the Establishment of JV Company for Shale Gas,” March 25, 2014, <http://www.ineng.org/news/56742.html>.



conduct shale gas exploration and production, including the EJV formed between Xinjiang Tianfu Energy Co., Ltd. (600509, Shanghai Stock Exchange) and Hubei Shale Gas Co., Ltd., a subsidiary of China Huadian Corporation, which was a winner in the second bidding round, and the EJV formed among Sinopec and Chongqing local state-owned enterprises.<sup>146</sup>

Based upon our interviews, the use of service contracts in the Chinese shale gas sector is under consideration by some parties. (A service contract is a long-term contractual framework in which an IOC explores and develops an oil or gas field in return for fees from a host government.) However, service contracts are new to Chinese NOCs and the relevant Chinese government agencies. Legal and regulatory reforms may be required before they are used. Furthermore, service contracts are unlikely to be attractive to IOCs, whose ability to book reserves with this type of legal instrument is limited. Other legal structures seem more promising for expanded work between NOCs and IOCs in the shale gas sector.

#### RECOMMENDATIONS:

- Develop a model Production Sharing Contract (PSC) for shale gas, with terms designed to reflect the unique nature of shale gas production.
- Use a “rolling Overall Development Program (ODP)” at shale gas projects.
- Give companies working in shale gas production flexibility to enter into agreements with other legal forms, including equity joint ventures.

#### C. Build Regulatory Capacity

Development of shale gas resources requires not only encouragement and promotion, but a robust and stable regulatory regime. Good regulation can encourage companies with advanced technology to participate in the sector, knowing that they can compete on a level playing field and that relevant environmental rules will be enforced fairly and completely.

Currently, the lack of an effective regulatory system represents a potential barrier to shale gas development and increases environmental risk. MLR, NEA and MEP have small staff sizes compared to equivalent agencies in other large countries. In light of small staff levels, inspections are infrequent, monitoring capabilities are low and agencies often rely extensively on citizen complaint hotlines and media coverage. This results in enforcement that bears little relationship to public health or environmental risks.<sup>147</sup> China’s challenge in monitoring and enforcement of shale gas development will be immense.

Overlapping and unclear authorities are common in the shale sector. Groundwater protection, for example, is overseen by at least three agencies.<sup>148</sup> Overlapping

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<sup>146</sup> “Tianfu Thermo Power Provides RMB165MM to Set Up Shale Gas JV,” May 30, 2014, <http://finance.china.com.cn/industry/energy/fcgy/20140530/2436758.shtml>; Qi Yue, “Chongqing and Sinopec Establish JV Company Which May Set Model for Central and Local Government’s Cooperation,” *NBD*, May 6, 2014, <http://www.mrijxw.com/shtml/mrijxw/20140505/48844.shtml>.

<sup>147</sup> Li Wanxin, “Environmental Monitoring and Public Reporting,” EU-China Environmental Governance Program, December 2012.

<sup>148</sup> Feng Hu, “MEP Reform: From Mountaintop to Ocean?” (China Water Risk, March 12, 2014), <http://chinawaterrisk.org/resources/analysis-reviews/mep-reform-from-mountaintop-to-ocean>.

responsibilities mean that when one agency issues regulations, the details or implementation may be left vague to account for lack of clear authority. Furthermore the central government issues a large number of directives, some of which matter more than others. Determining which are the most important often comes down to studying how frequently they are mentioned by officials at various levels. Companies, potential investors and the public are left guessing whether and when regulations will be enforced and whether some targets are optional or mandatory.

Local and provincial officials, and SOEs, wield considerable power in determining regulatory outcomes, especially on environmental issues. For years, observers have noted that most environmental enforcement is delegated to local environmental protection bureaus, which in turn answer to local officials concerned about meeting economic objectives. Local environmental protection bureaus also lack clout as compared to SOEs such as Sinopec and PetroChina. Fines are often tiny in comparison to the cost of compliance or profits at stake. (China's new environmental law, which increased fines and changes how frequently they can be applied, may help change this.) In some cases, local environmental protection bureaus have reportedly been reduced to sending anonymous complaints about polluters to the central government.<sup>149</sup>

Though the central government has recently strengthened key performance indicators related to the environment, it is too early to say whether these measures will be effective.<sup>150</sup> Proposals to create an environmental super-ministry or make local environmental protection bureaus more accountable to the central government have so far not been adopted. Private players and investors remain uncertain whether regulations, if enforced, will be applied evenly.

RECOMMENDATIONS:

- Build a robust and stable regulatory capacity for shale gas, as a high priority.

D. Invest in Innovation

Growth in the Chinese shale gas sector will require innovation. Technologies used in shale gas development in the United States will need to be adapted to the Chinese context. China will need trucks and rigs with smaller footprints, modular water transport and novel stimulation technologies. Several experts we spoke with questioned whether horizontal drilling and multi-stage fracturing — the technologies at the core of the U.S. shale gas boom — can work in some shale-rich regions in China in light of the nature of Chinese source rock.

How can innovation in Chinese shale gas technologies be accelerated?

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<sup>149</sup> Xin Qiu and Honglin Li, "China's Environmental Super Ministry Reform: Background, Challenges, and the Future," (Environmental Law Institute, 2009).

<sup>150</sup> In the past, greater spending on the environment have reportedly hurt local officials' promotion chances. See Malcolm Moore, "Green Politicians Less Likely to Be Promoted in China," [The Telegraph](#) (February 26, 2013).

First, by ensuring that CNPC, Sinopec and other national oil companies have strong incentives to invest in innovation. By virtue of their experience, capital and exploration rights, these NOCs will likely dominate Chinese shale gas development for at least the next decade. They are enormously well-capitalized and have the financial resources to invest in shale gas innovation, should they choose to do so. The key will be ensuring they have adequate and appropriate incentives.<sup>151</sup>

At present, the incentives for NOCs to invest in shale gas innovation are relatively modest. They earn enormous revenues from conventional oil and gas production. Their managers and engineers have deep expertise in conventional oil and gas but little experience with shale gas. Any returns from investment in shale gas technologies are speculative.

The central government's strong messages concerning the priority of shale gas development provides the most important incentive. CNPC, Sinopec and the other NOCs are not just businesses but instruments of national policy, with senior party officials in top leadership positions. To the extent the NOCs believe they will continue to face aggressive production targets for shale gas, they will be motivated to invest in innovative technologies to help cut costs and increase revenues. Market pricing of natural gas and shale gas production subsidies (if available over the long term) also provide important incentives.

Yet large companies — especially large state-owned companies — are often challenged when it comes to innovation. Small companies were central to the U.S. shale gas revolution. To promote innovation in shale gas technologies, the NOCs should pay attention to the principles of “open innovation.”<sup>152</sup>

Chinese energy SOEs and other large Chinese companies with existing shale gas R&D capability could benefit from pursuing strategies reflecting attention to the principles of open innovation. These strategies recognize that innovation often happens best when companies reach beyond in-house expertise. Many of today's large multinationals have consciously adopted R&D activities characterized as open innovation, including a variety of collaborations with universities, suppliers and customers. In many cases, Western firms have opened R&D centers in China, connected with universities and local supplier networks—and the results of such collaborations have been positive for the firms involved.<sup>153</sup> Chinese firms as well have benefited from open innovation strategies, but large SOEs with in-house R&D capability have sometimes been reluctant to pursue open-ended,

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<sup>151</sup> For a thoughtful analysis of this issue, see Lei Tan et al., [Stimulating Shale Gas Development in China](#) (Resources for the Future, July 2014) (arguing that NOCs are central to shale gas innovation in China).

<sup>152</sup> See Henry Chesbrough, [Open Innovation: The New Imperative for Creating and Profiting from Technology](#), (Harvard Business Press, 2003).

<sup>153</sup> B. Jaruzelski and K. Dehoff, “Beyond borders: The Global Innovation 1000,” [Strategy+business](#) (November 25, 2008), vol. 53, pp. 54–67, <http://www.strategy-business.com/article/08405?pg=all>; Lee Branstetter, Guangwei Li and Francisco Veloso, “The Rise of International Co-invention,” [National Bureau of Economic Research](#) (October 2013), p. 3, <http://www.nber.org/chapters/c13028.pdf>; see also Gwynn Guilford, “China’s engineers Are Innovating Like Crazy—To the Benefit of Foreign Companies,” [Quartz](#) (November 13, 2013), <http://qz.com/146945/chinas-engineers-are-innovating-like-crazy-to-the-benefit-of-foreign-companies/>.

long-term collaborations.<sup>154</sup> These types of collaborations—both within and outside of China—could help enormously with development of China’s shale gas sector. Joint ventures with major international service providers such as Schlumberger, Halliburton, BakerHughes and Weatherford are a first step. The shale gas R&D center established by Honghua Group and BakerHughes in Sichuan is an interesting model.<sup>155</sup> Indeed the partnership, announced in 2012, has already led to deployment of new hydraulic fracturing equipment in Texas.<sup>156</sup>

Finally, the U.S.-China Clean Energy Research Center (CERC) should launch a shale gas program. Established in 2009 by the U.S. Department of Energy, the Ministry of Science and Technology and the National Energy Administration, the CERC’s goal is

to accelerate the development and deployment of clean energy technologies for the benefit of both countries. This is done by providing a supportive platform for collaborative research, protecting intellectual property, and encouraging top scientists and engineers in both countries to join forces, learn from each other, and capitalize on unique assets and complementary strengths.<sup>157</sup>

The CERC currently supports 1,100 researchers working in three areas: clean coal, electric vehicles and efficient buildings. A shale gas program would be an excellent complement to this work.

RECOMMENDATIONS:

- Ensure NOCs have strong incentives to invest in innovation.
- Pay attention to the principles of “open innovation.”
- Add a shale gas consortium to the U.S.-China Clean Energy Research Center.

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<sup>154</sup> Yuandi Wang et al., “How Chinese Firms Employ Open Innovation to Accelerate the Development of Their Technological Capability,” *Social Science Research Network*, SSRN 1925149 (June 9, 2011), [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=1925149](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1925149) (accessed July 30, 2014); Xiaolan Fu and Hongru Xiong, “Open Innovation in China: Policies and Practices,” University of Oxford Department of International Development, TMD Working Paper Series No. 44, ISSN 2045-5119, - <http://www.tmd-oxford.org/sites/www.tmd-oxford.org/files/SLPTMD-WP-044.pdf> (accessed July 30, 2014).

<sup>155</sup> Honghua Group and Baker Hughes Collaborate to Explore and Develop China’s Unconventional Hydrocarbons Market,” *PR Newswire* (December 12, 2012), <http://www.prnewswire.com/news-releases/honghua-group-and-baker-hughes-collaborate-to-explore-and-develop-chinas-unconventional-hydrocarbons-market-183144911.html>.

<sup>156</sup> Honghua Developing New-Generation Shale-Drilling Rig, Plans Testing of Frac Pump,” *Drilling Contractor* (May 23, 2013), <http://www.drillingcontractor.org/honghua-developing-new-generation-shale-drilling-rig-plans-testing-of-frac-pump-23278>.

<sup>157</sup> U.S.-China Clean Energy Research Center: Recent Achievements (July 2014), [http://www.us-china-cerc.org/pdfs/June\\_2014\\_Steering\\_Committee\\_Meeting/CERC\\_booklet\\_FINAL.pdf](http://www.us-china-cerc.org/pdfs/June_2014_Steering_Committee_Meeting/CERC_booklet_FINAL.pdf). See generally <http://www.us-china-cerc.org/>.

## E. Coordinate among Ministries

At least a half-dozen ministries and agencies play an important role in Chinese shale gas policy. The National Development and Reform Commission (NDRC) shapes overall policy and regulates natural gas prices. The National Energy Administration (NEA) establishes shale gas production targets. The Ministry of Land and Resources (MLR) controls mineral rights and runs the bid rounds for shale gas. The Ministry of Finance (MOF) administers a shale gas production subsidy. The Ministry of Science and Technology (MOST) funds research and development in shale gas technologies. The Ministry of Environmental Protection (MEP) establishes rules to protect air and water quality.

During our interviews, we heard many comments about the lack of coordination among ministries. This is perceived to be a problem for at least two reasons. First, policy development on shale gas suffers. The development of clear policies with respect to groundwater protection, for example, is complicated by the overlapping jurisdictions of the Ministry of Environmental Protection, Ministry of Water and Ministry of Land and Resources.<sup>158</sup> Second, investment in the sector proceeds more slowly, because companies that receive an approval from one ministry remain unsure whether approvals from other ministries will also be needed. This is particularly a challenge for foreign companies, some of which report a lack of clarity concerning the roles of MLR, NEA and NDRC.

Improved coordination among ministries would help address these concerns. Two years ago, the State Council's Development Research Center recommended a dedicated coordination mechanism for shale gas at the State Council level.<sup>159</sup> The existing inter-ministerial working group could also be strengthened. Of course inter-ministerial coordination can present challenges in any country, and each country will find its own ways to address these issues.<sup>160</sup>

One useful step would be for ministries to publish a joint guide listing all approvals required to work in the shale gas sector (or commission a respected outside authority to do so). Similar guides have been helpful in the United States.<sup>161</sup> A guide endorsed by ministries with responsibilities for shale gas development would help improve transparency and promote investment in the sector.

A related issue is coordination among ministries and other stakeholders at the local level. The Beijing Energy Club, with a membership of leaders from the Chinese energy community, has recommended focusing in particular on local-level coordination in shale gas development. In a November 2012 report, the Beijing Energy Club notes the challenges of regulatory coordination and recommends considering "an appropriate mechanism at the

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<sup>158</sup> See Hu, "MEP Reform: From Mountaintop to Ocean?," in note 156.

<sup>159</sup> See Beijing Energy Club, Enabling Policy and Regulatory Conditions for Successful Shale Gas Development in China (November 16, 2012).

<sup>160</sup> For background on interministerial coordination mechanisms, see Naughton, "Deepening Reform, at note 41; China's National Leading Group to Address Climate Change, Zhu Xufeng, EAI Background Brief No. 572, <http://www.eai.nus.edu.sg/BB572.pdf>; "China sets up national energy leading group," China Daily (June 4, 2005), [http://english.peopledaily.com.cn/200506/04/eng20050604\\_188432.html](http://english.peopledaily.com.cn/200506/04/eng20050604_188432.html).

<sup>161</sup> See for example John Pertgen, Federal Regulatory Actions Impacting Offshore Drilling (International Association of Drilling Contractors, June 30, 2014), <http://www.iadc.org/wp-content/uploads/2014/02/July14FederalSummary.pdf>.

local level, to allow local government, NGOs and local communities to participate in environmental regulatory work.”<sup>162</sup>

RECOMMENDATIONS:

- Improve inter-ministerial coordination on shale gas.
- Publish a guide to all approvals required to work in the shale gas sector.

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<sup>162</sup> Beijing Energy Club, Enabling Policy and Regulatory Conditions for Successful Shale Gas Development in China (November 16, 2012)

## **SUMMARY OF RECOMMENDATIONS**

### **1. Accelerate Market-Based Reforms**

- Accelerate natural gas price reforms.
- Accelerate pipeline reforms.
- Encourage competition for mineral rights.
- Improve data availability.

### **2. Provide a Clear Roadmap for Foreign Companies**

- Develop a model Production Sharing Contract (PSC) for shale gas, with terms designed to reflect the unique nature of shale gas production.
- Use a “rolling Overall Development Program” (ODP) at shale gas projects.
- Give companies working in shale gas production flexibility to enter into agreements with other legal forms, including equity joint ventures.

### **3. Build Regulatory Capacity**

- Build a robust and stable regulatory capacity for shale gas, as a high priority.

### **4. Invest in Innovation**

- Ensure NOCs have strong incentives to invest in innovation.
- Pay attention to the principles of “open innovation.”
- Add a shale gas consortium to the U.S.-China Clean Energy Research Center.

### **5. Coordinate among Ministries**

- Improve inter-ministerial coordination on shale gas.
- Publish a guide to all approvals required to work in the shale gas sector.

## ATTACHMENT A – Model Shale Gas Production Sharing Contract

Following are suggested terms for a model shale gas PSC, with notes and analysis.<sup>163</sup>

PSC Article (in Order of Layout)	Sub-section (by Topic)	Suggested Model Shale Gas PSC (PSC)	Notes
<b>Definitions</b>	Shale Gas, Other Hydrocarbons	<p><i>“Shale Gas means an accumulation of natural gas in the form of absorbed gas, free gas and dissolved gas, which is stored in organic substance rich shale layer(s); Shale Gas belongs to unconventional nature gas, and can become commercial gas stream through hydraulic fracturing.”</i></p> <p><i>Separate definition for Other Hydrocarbons including conventional oil and gas, and liquid hydrocarbons extracted from shale layers.</i></p>	<p><i>Definition of Shale Gas follows the definition in Shale Gas Resource/Reserve Calculation and Evaluation Technical Standard (DZ/T 0254-2014).</i></p> <p><i>Hydrocarbons beyond Shale Gas, including conventional oil, gas, and liquid hydrocarbons from shale layers are defined as Other Hydrocarbons.</i></p>
	Gas Field	<p><i>An accumulation of Shale Gas in the Contract Area which has commercial value and development plans.</i></p>	<p><i>This provision is similar to the onshore CBM PSC.</i></p> <p><i>Based on the definition of Shale Gas, the accumulation of shale gas is limited to the layer(s) of certain depths.</i></p>

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<sup>163</sup> This model PSC draws on the material in *Model Production Sharing Contract for Foreign Cooperation in Shale Gas Exploration, Appraisal, Development and Production in China* (ConocoPhillips China Inc., January 16 2012) and *2014 Model Unconventional Resources Operating Agreement* (June 2014 AIPN Model Contracts Workshop).



	<p>Petroleum Operations, Exploration Operations, Appraisal Operations, Development Operations, Pilot Project</p>	<p><i>Petroleum Operations include Exploration (incl. appraisal), Development and Production Operations.</i></p> <p><i>Defined by time – Development starts when ODP is approved, Production starts from Commencement of Commercial Production.</i></p> <p><i>Additionally, Exploration Operations includes Pilot Project (incl. production therefrom) and execution of long term gas sales and transportation contracts.</i></p> <p><i>“Pilot Project means the set of operations, activities, wells and facilities needed to evaluate the shale gas exploitation methodologies to be used to exploit specified Sub-Area(s) in a Shale Gas resource in order to determine the commercial viability of a large scale exploitation of Shale Gas.”</i></p>	<p><i>This provision is similar to the onshore CBM PSC.</i></p> <p><i>In addition, Pilot Project is added under Exploration Operations to determine the commercial viability of the exploitation of Shale Gas in a large scale.</i></p>
	<p>Exploratory Well, Appraisal Well, Development Well</p>	<p><i>Development Well is any well drilled in Development or Production Area after ODP approval for the purpose of producing or increasing/ accelerating the production of Petroleum.</i></p>	<p><i>This provision is similar to the onshore CBM PSC.</i></p> <p><i>There is not concept of Exploratory Well or Appraisal Well (Pilot Project includes wells drilling).</i></p>
	<p>Development Area, Production Area, Sub-Area</p>	<p><i>Sub-Area, as determined by the JMC, is a portion of the Contract Area with Shale Gas prospects for the Pilot Project.</i></p>	<p><i>This provision is similar to the onshore CBM PSC.</i></p> <p><i>There is concept of Exploration Area.</i></p>

		<p><i>Development Area is a portion of the Contract Area designated for development plus potential contiguous extension areas, which is identified in the ODP and approved.</i></p> <p><i>Production Area is within the Development Area and designated for Production Operations – need NOC approval.</i></p>	<p><i>The concept of Sub-Area is added.</i></p>
	Date of Commencement of Commercial Production	<p><i>Date proposed and announced by the JMC.</i></p>	<p><i>This provision follows that onshore CBM PSC. The provision does not mention completion of Development Operations or government approval.</i></p>
	Overall Development Plan (ODP)	<p><i>The ODP must be reviewed and adopted by the JMC, confirmed by the NOC and approved by the government; it must include recoverable reserves, designs, production profile, economic analysis and time schedule of Development Operations.</i></p> <p><i>Development plan can be compiled for the Sub-Area in case of phased development.</i></p>	<p><i>This provision follows the onshore CBM PSC.</i></p> <p><i>The onshore CBM PSC includes the concept of a development plan for “part of a CBM field” in case of phased development.</i></p> <p><i>Similarly, the provision clarifies that an ODP can be submitted for a Sub-Area, and the Contract Area contains different Sub-Areas covered by different ODPs.</i></p>
	Deemed Interest	<p><i>Interest on development costs when such costs are recovered by the Parties (i% per annum).</i></p>	<p><i>This provision is similar to the onshore CBM PSC.</i></p>
	Delivery Point	<p><i>Shale Gas’s Delivery Point shall be the most economically viable nearby pipeline having available capacity.</i></p>	<p><i>This provision follows the onshore CBM PSC.</i></p>

<b>Objective of the Contract</b>		<p><i>Explore, develop and produce Shale Gas in the Contract Area.</i></p> <p><i>Contractor to apply advanced technology, and transfer technology to Chinese personnel and train them.</i></p>	<p><i>This provision follows the onshore CBM PSC.</i></p>
<b>Other Discoveries</b>		<p><i>In case that the IOC has discoveries of Other Hydrocarbons other than Shale gas during its implementation of the PSC, NOC shall negotiate with IOC, at IOC's request, regarding IOC's participation in the exploitation of Other Hydrocarbons.</i></p>	<p><i>This provision is newly added.</i></p> <p><i>The IOC may discover other petroleum resources, such as conventional oil, gas or other liquid hydrocarbons, during its implementation of the PSC. Since the IOC made such discovery, it is reasonable that a Shale gas PSC gives the IOC an opportunity to participate in the exploitation of other petroleum resources, maybe with lower participation interests.</i></p>
<b>Contract Area</b>		<p><i>Surface area defined by geographic coordinates.</i></p>	<p><i>This provision follows the onshore CBM PSC.</i></p>
<b>Contract Term</b>	<p>Exploration Period, Development Period and Production Period</p>	<p><i>"Exploration Period" begins when the PSC is implemented and ends when the ODP is approved, and shall be 20 to 24 months unless otherwise agreed.</i></p> <p><i>Development Period begins when the ODP is approved and ends when Development Operations is completed in accordance with the ODP, but may continue while the production period begins.</i></p> <p><i>Production Period begins on Declaration of Commencement of Commercial Production and ends on the date specified in the ODP, but</i></p>	<p><i>Each Sub-Area may be in its own development and production period, and two periods may co-exist within the Contract Area.</i></p> <p><i>The Development Period of one Sub-Area begins, while, Exploration of another Sub-Area may continue.</i></p>

		<p><i>shall not exceed 30 yrs.by the parties.</i></p> <p><i>Each Sub-Area may be in its own development and production period. The Development Period of one Sub-Area begins, while, Exploration of another Sub-Area may continue.</i></p>	
	Extensions of Production Period	<i>Possible with approval of Chinese govt. in certain circumstances.</i>	<i>This provision follows the offshore PSC and the onshore CBM PSC.</i>
	Abandonment of Field	<p><i>Either Party may propose to abandon production from any Field.</i></p> <p><i>If the Parties mutually agree to abandon a Field, the abandonment cost is shared.</i></p> <p><i>If only the Contractor elects to abandon a Field, all of its rights and obligations related to that field are terminated.</i></p> <p><i>Mechanism laid out under Relinquishment section (since there is no relinquishment obligation by Contractor).</i></p>	<i>This provision follows the offshore PSC and onshore CBM PSC.</i>
	Term	<i>30 years with extension at Contractor's request.</i>	<i>This provision follows the offshore PSC and onshore CBM PSC.</i>
<b>Relinquishment</b>	Relinquishment Commitment	<i>Contractor has no relinquishment obligation, only the right to abandon a portion of the Contract Area.</i>	<i>This provision follows the onshore CBM PSC.</i>

	Fee for Exploration or Mining Rights	<p><i>In the Exploration Period, Contractor shall bear the fee for Shale Gas's exploration right required by law.</i></p> <p><i>In the development or production periods, the fee for mining rights shall be shared by the parties.</i></p> <p><i>But the above is not linked to relinquishment.</i></p>	<i>This provision follows the onshore CBM PSC.</i>
<b>Minimum Exploration Commitment and Expenditures</b>		<p><i>Contractor to fulfill work commitment in Exploration Period, incl. Pilot Project, gas in place, EIA, ODP, gas sales contracts, project financing.</i></p> <p><i>No minimum spend specified and no penalty if Contractor does not fulfill commitment.</i></p>	<i>This provision follows the onshore CBM PSC.</i>
<b>Management Organization and its Function</b>	Joint Management Committee (JMC) Members	<p><i>NOC and Contractor to each appoint equal number of members (1-3) on JMC.</i></p> <p><i>Chairman shall be from NOC and Vice Chairman shall be from Contractor.</i></p>	<i>This provision follows the offshore PSC and onshore CBM PSC.</i>
	JMC's Role	<i>Lists items to be determined and/or reviewed and/or approved by JMC.</i>	<i>This provision follows the onshore CBM PSC.</i>
<b>Operator</b>	Designates Operator	<i>Contractor is Operator unless transferred according with PSC provisions.</i>	<i>This provision follows the offshore PSC and the onshore CBM PSC.</i>
	Operator's Role	<i>Lists Operator's obligations.</i>	<i>This provision follows the onshore CBM PSC.</i>
	Transfer of Production Operations	<i>From Cost Recovery Date, NOC and Contractor shall conduct Shale Gas Operations within the Contract Area under a Joint Operating Agreement.</i>	<i>This provision follows the onshore CBM PSC.</i>

	Land Use	<i>Operator shall have the right to use or occupy land incl. right of way inside and outside Contract Area, in order to conduct the Work Programs.</i>	<i>This provision follows the onshore CBM PSC.</i>
<b>Assistance from NOC</b>		<i>NOC to provide assistance for matters related to government approvals, permits, local office, staff hire, onshore facilities and gas marketing and transportation plan.</i>	<i>This provision follows the onshore CBM PSC.</i>
<b>Work Program and Budget</b>	Timeframe	<i>Operator shall submit an annual Work Program and budget to the JMC for review, then NOC for approval in a fixed timeframe.</i>	<i>This provision follows the offshore PSC and the onshore CBM PSC.</i>
	Expenditures Outside Budget	<i>Sets the limits to the extent of excess spend beyond the Work Program and budget.  If JMC does not consider annual spend in excess of 5% of the budget to be reasonable, an expert group should be formed to determine whether the spend should be charged to the joint account.</i>	<i>This provision follows the offshore PSC and the onshore CBM PSC.</i>
<b>Determination of Commerciality</b>	Timeframe	<i>Sets timeframe for process:</i> <ul style="list-style-type: none"> <li>- <i>Operator’s determination of “sweet spot”</i></li> <li>- <i>Appraisal Work Program operation and report</i></li> <li>- <i>JMC’s Determination of “Sub-Area” which is with Shale Gas prospect after exploration;</i></li> <li>- <i>Pilot Project preparation and JMC approval;</i></li> <li>- <i>Pilot Project Work Program (which includes the conclusion of gas sales and transportation contracts) should be completed instead of an appraisal Work</i></li> </ul>	<i>This provision is adapted from the offshore PSC. Two major changes are i) this provision is made to be reoccurring for different “Sub-Areas”; and ii) the ODP is linked to a Sub-area.</i>

		<p><i>Program;</i></p> <ul style="list-style-type: none"> <li>- <i>JMC review and determination of commerciality of this Sub-Area;</i></li> <li>- <i>Submission and approval of the ODP for the Sub-Area;</i></li> <li>- <i>Start of Development Operations and production consequently;</i></li> </ul> <p>- <i>The same sequence repeats from another "sweet spot".</i></p> <p>...</p>	
	Sole Development	<p><i>1. If Contractor does not consider the certain Sub-Area to have commercial value, the NOC may develop the field, and Contractor can later decide to participate before the DCCP if it pays its share of the development costs plus a 300% additional fee. If Contractor does not participate before the DCCP, the field will be excluded from the Contract Area – but Development and Production Operations should still be carried out by Operator.</i></p> <p><i>If the NOC does not consider a Sub-Area to have commercial value, Contractor may solely develop the field at its own costs and risks, and without NOC working interest.</i></p> <p><i>2. Subject to any necessary approval under the Contract and the Laws, and provided that safety and Joint Operations are not impaired, any Party may propose to expand the capacity of the existing multi-pad production</i></p>	<p><i>The first part under this provision is similar to the offshore PSC, but different from the onshore CBM PSC. The offshore PSC allows sole risk development, but the onshore CBM PSC does not include such concept.</i></p> <p><i>In addition, expanding a multi-pad production facility at one party's sole risk is added to promote development of shale gas. However, the sole risk activities shall be approved by the JMC to avoid any disturbance to the existing operations.</i></p>

		<i>facility at its sole risk and expense. In this event, the Party shall present a proposal to the JMC for its consideration and such expansion may not take place until the JMC has granted its approval.</i>	
	Trial Production	<i>Trial Production is Included in the Pilot Project.</i>	<i>This provision follows the onshore CBM PSC.</i>
	Other Operations in the Region	<i>Parties shall reach agreement on development of the Contract Area in a manner that does not interfere unreasonably with the potential development of conventional petroleum resources in the Contract Area.</i>	<i>This provision is similar to the onshore CBM PSC.  In case that conventional resources are discovered during the exploration or development of shale gas, and the IOC and the NOC cannot reach an agreement to exploit such conventional resources together, the parties shall not interfere with each other when exploiting the Shale Gas and conventional petroleum resources in parallel.</i>
<b>Financing and Cost Recovery</b>	Financing of Exploration, Development and Production Costs	<i>Exploration costs borne by Contractor; development and production costs shared by PSC parties.</i>	<i>This provision follows the offshore PSC and the onshore CBM PSC.</i>
	Cost Recovery	<i>All operating, exploration and development costs incurred in Petroleum Operations can be recovered from Shale Gas produced and the agreed Other Hydrocarbons produced.  Cost recovery starts after the Declaration of Commencement of Commercial Production.  No interest is applied to exploration costs; a Deemed Interest is applied to development</i>	<i>This provision is similar to the onshore CBM PSC.  Costs can be recovered from Shale Gas produced. In addition, if there are other hydrocarbon discoveries in the Contract Area and the IOC's participation is agreed by the contracting parties, such Hydrocarbons produced can be used for cost recovery.</i>



		<p><i>costs.</i></p> <p><i>Costs can be recovered from the Shale Gas produced and the agreed Other Hydrocarbons produced.</i></p>	
<b>Production and Allocation</b>	Gross Annual Production, Cost Recovery Shale Gas, Investment Recovery Shale Gas, Remainder Shale Gas, Allocable Remainder Shale Gas	<p><i>Lays out the allocation of production in a fixed sequence:</i></p> <ul style="list-style-type: none"> <li>- <i>VAT</i></li> <li>- <i>Royalty</i></li> <li>- <i>Cost recovery (by cost type and limited to 62.5% of Annual Gross Production)</i></li> <li>- <i>Factor (X)</i></li> </ul> <p><i>Parties share</i></p> <p><i>70% of Annual Gross Production is deemed as Cost Recovery Shale Gas and Other Hydrocarbons.</i></p>	<i>This provision follows the onshore CBM PSC.</i>
<b>Quality, Quantity, Price and Destination</b>	Quality	<i>Quality analysis shall take place at the Delivery Point (local pipeline).</i>	<i>This provision follows the onshore CBM PSC.</i>
	Quantity	<i>Quantity lifted shall be made at a delivery point and with measuring device as agreed by the parties.</i>	<i>This provision follows the offshore PSC and onshore CBM PSC.</i>
	Price	<i>Based on the actual free market price, the price will be volumetric weighted average of i) price of Contractor's and NOC's determination; and ii) the fair market price, accounting for prevailing market condition.</i>	<i>This provision follows the onshore CBM PSC.</i>

		<p><i>The transportation costs included in the price at Delivery Point shall be agreed to in the long-term sales agreement during the Exploration Period.</i></p> <p><i>Payment in USD per cubic meter.</i></p>	
	Destination	<p><i>Contractor may sell a part or all of its gas and/or Other Hydrocarbons to:</i></p> <ul style="list-style-type: none"> <li>- <i>jointly with the NOC to the buyers;</i></li> <li>- <i>to Chinese buyers;</i></li> <li>- <i>to the NOC or its affiliate (who have obligation to buy all or part of Contractor's Shale Gas/ Other Hydrocarbons if requested by Contractor);</i></li> <li>- <i>any other lawful buyers.</i></li> </ul>	<i>This provision follows the onshore CBM PSC.</i>
	Pipeline Access	<p><i>Contractor shall be guaranteed the access and priority use of a pipeline owned by the NOC contracting party or its affiliate (provided a transportation contract is signed).</i></p> <p><i>"The NOC shall use its reasonable endeavors to negotiate, or facilitate the Contractor to negotiate, with the other pipeline owners to secure pipeline access and priority use of a pipeline which is not owned by the NOC."</i></p>	<p><i>This provision follows the onshore CBM PSC.</i></p> <p><i>In addition, obligations are added to NOC to facilitate the IOC to secure pipeline access.</i></p>
<b>Chinese Personnel, Goods and Services</b>		<p><i>Preference shall be given to employment of Chinese personnel and procuring goods and services from Chinese subcontractors (provided their conditions are competitive).</i></p> <p><i>Contractor's hire of Chinese personnel shall</i></p>	<i>This provision follows the onshore CBM PSC.</i>

		<i>be consistent with conducting Shale Gas operations in an efficient manner and in accordance with international practices. Also all Chinese employees shall sign contracts with the Operator who has the right to dismiss them if they breach the terms.</i>	
<b>Training and Technology Transfer</b>	Contractor's Commitment	<p><i>Contractor shall use advanced technology during operations, train Chinese personnel (according to a training plan), and conduct scientific exchange.</i></p> <p><i>The advanced technology and managerial experience transferred to the NOC remains the property of the Contractor and subject to confidentiality restrictions.</i></p>	<p><i>This provision follows the onshore CBM PSC.</i></p> <p><i>There is no minimum percentage threshold of Chinese personnel that should be maintained by the IOC.</i></p>
	Costs	<p><i>The costs of such training or technology transfer may be charged to development costs or operating costs, depending on when they are incurred.</i></p> <p><i>The costs of training or technology transfer may also be charged to exploration costs if incurred before first ODP approval.</i></p>	<i>Because there may be more than one ODP needed for Shale Gas project, "first" ODP is added to avoid the confusion if multiple ODPs will be compiled and approved.</i>
<b>Ownership of Asset and Data</b>		<i>NOC shall own all assets developed under the Work Program from the earlier occurring date of either the Contractor fully recovering its development costs or the end of the production period.</i>	<i>This provision follows the onshore CBM PSC.</i>

		<p><i>NOC owns any data and records obtained the course of the Petroleum Operations.</i></p> <p><i>“Common Facilities” (facilities constructed for the Shale Gas Operations, whether located within or outside the Contract Area) may be used by NOC or Contractor free of charge.</i></p>	
<b>Accounting, Auditing and Personnel Costs</b>		<p><i>Operator responsible to keep accounts of costs and applicable deemed interest, and the quantity and price of crude oil and gas produced.</i></p> <p><i>Non-operator parties may audit the accounts kept by the Operator in accordance with the PSC provisions.</i></p> <p><i>Salaries and staffing plan should be determined by the Operator and reviewed by JMC.</i></p>	<i>This provision follows the offshore PSC and onshore CBM PSC.</i>
<b>Taxation</b>		<p><i>Contractor shall pay own taxes according to Chinese law.</i></p> <p><i>Operator shall advise subcontractors (and their employees) to pay their taxes according to Chinese law.</i></p>	<i>This provision follows the offshore PSC and onshore CBM PSC.</i>
<b>Insurance</b>		<p><i>Operator shall prepare insurance program and, after JMC approval, obtain the insurance from a Chinese insurance company.</i></p> <p><i>Specified the types of insurance which must be obtained e.g. pollution, vessels. All motor vehicles used during Shale Gas operations</i></p>	<i>This provision follows the onshore CBM PSC.</i>

		<p><i>should be insured.</i></p> <p><i>Premiums may be charged to exploration, development or operating costs, as applicable.</i></p>	
<b>Confidentiality</b>		<p><i>No party may disclose information designated by JMC as confidential to any third parties.</i></p> <p><i>NOC may disclose such information (but not data, patents etc. owned by Contractor) to relevant third parties after a set timeframe.</i></p> <p><i>List exceptions i.e. third parties who may receive information such as banks, subcontractors, assignees.</i></p>	<i>This provision follows the offshore PSC and onshore CBM PSC.</i>
<b>Assignment</b>		<p><i>Contractor can assign its rights/obligations to its affiliate with NOC's prior consent, and Contractor's performance guarantee; or to a third party if NOC does not exercise its right of first refusal..</i></p> <p><i>NOC's consent for Contractor's assignment to its affiliate, or NOC's exercise of its ROFR must be given within 60 days of Contractor's notice.</i></p> <p><i>NOC may authorize its subsidiary to implement the PSC; or, NOC may transfer its rights/obligations to any third party subject to govt. approval.</i></p>	<i>This provision follows the onshore CBM PSC.</i>

<b>Environmental Protection and Safety</b>		<p><i>Operator shall comply with all environmental protection laws of China, and cooperate with any government inspectors.</i></p> <p><i>Includes additional provision that Operator shall restore the operating sites to the condition at the start of the PSC.</i></p>	<i>This provision follows the onshore CBM PSC.</i>
<b>Force Majeure(FM)</b>	Definition	<i>“(a)ny event or combination of events which could not be foreseen and/or which is beyond the control of such party including government actions.”</i>	<i>This provision follows the offshore PSC and onshore CBM PSC.</i>
	Application	<p><i>When such an event prevents a party’s performance of its PSC obligations, and the party has taken all reasonable actions to overcome the obstacle and notified the other party of FM, the party shall not be considered in default of the PSC, and the parties shall consult to find an equitable solution.</i></p> <p><i>If the operation is suspended for over 30 days due to FM, the period of operations may be extended.</i></p> <p><i>Includes additional provision that Contractor may terminate the PSC if the FM condition continues for 24 months.</i></p>	<i>This provision follows the onshore CBM PSC.</i>
<b>Consultation and Arbitration</b>	Dispute Resolution Procedure	<i>Friendly consultation first; then arbitration, which will be final and binding.</i>	<i>This provision follows the offshore PSC and CBM PSC.</i>
	Location and Rules	<i>Any dispute arising out of or in connection with this contract, including any question regarding its existence, validity or</i>	<i>The Offshore PSC and CBM PSC adopt two-step arbitration approach, i.e. if agreed by the parties, arbitration will be referred to</i>

		<p><i>termination, shall be referred to and finally resolved by arbitration in Singapore administered by the Singapore International Arbitration Centre (SIAC) in accordance with the Arbitration Rules of the Singapore International Arbitration Centre ("SIAC Rules") for the time being in force, which rules are deemed to be incorporated by reference in this clause.</i></p> <p><i>The seat of the arbitration shall be Singapore.</i></p> <p><i>The Tribunal shall consist of 3 arbitrators.</i></p> <p><i>The language of the arbitration shall be Chinese and English.</i></p>	<p><i>CIETAC; and, if parties cannot agree on arbitration arrangement, ad hoc arbitration shall take place; the location will be agreed by the selected arbitrators; the Parties should set up ad hoc tribunal if the place of arbitration is not agreed within 45 days of one party's first request for arbitration.</i></p> <p><i>Validity of the two-step arbitration approach and ad hoc arbitration is uncertain under Chinese law, and such clauses presents a risk to the parties as they may be forced into a Chinese court for resolution, therefore the clauses should be replaced with arbitration in a 3<sup>rd</sup> country other than those of the Parties. Arbitration in Singapore is provided as an example.</i></p>
<b>Effectiveness, Termination and Cancellation</b>	Effective Date	<p><i>The Contract shall take effect as of its execution by both Parties.</i></p>	<p><i>Offshore PSC and onshore CBM PSC take effect from the date of the approval of Ministry of Commerce.</i></p> <p><i>The effectiveness of a PSC is no longer subject to the approval of MOFCOM, so it takes effect as of its execution to mitigate uncertainty.</i></p>
	Termination, Cancellation	<p><i>List circumstances under which the PSC terminates, generally due to lack of discovery during exploration period, or PSC reaches the end of production period, or the Maximum Period has passed.</i></p> <p><i>One party may terminate the agreement if the other commits a material breach of the</i></p>	<p><i>This provision follows the offshore PSC and onshore CBM PSC.</i></p>

		<i>PSC, as determined by the arbitration award.</i>	
<b>Applicable Law</b>		<i>The PSC is governed by Chinese Law. Economic stabilization provision.</i>	<i>This provision follows the offshore PSC and the onshore CBM PSC.</i>
<b>Language</b>		<i>Chinese and English are with equal effect.</i>	<i>This provision follows the offshore PSC and onshore CBM PSC.</i>
<b>Miscellaneous</b>		<p><i>Notices; "Contractor" composition; PSC interpretation;</i></p> <p><i>No signature fee.</i></p> <p><i>In addition, add in a "Waiver of Sovereign Immunity":</i></p> <p><i>Any Party that now or later has a right to claim sovereign immunity for itself or any of its assets hereby waives any such immunity to the fullest extent permitted by the laws of any applicable jurisdiction. This waiver includes immunity from:</i></p> <p><i>a. any expert determination, mediation, or arbitration proceeding commenced under this Agreement;</i></p> <p><i>b. any judicial, administrative or other proceedings to aid the expert determination, mediation, or arbitration commenced under this Agreement; and</i></p> <p><i>c. any effort to confirm, enforce, or execute any decision, settlement, award, judgment, service of process, execution order or</i></p>	<p><i>In general, the provision follows the onshore CBM PSC.</i></p> <p><i>In addition, because the Chinese NOC enters into the PSC as a commercial entity, the Waiver of Sovereign Immunity is included.</i></p>



		<p><i>attachment (including pre - judgment attachment) that results from an expert determination, mediation, arbitration or any judicial or administrative proceedings commenced under this Agreement.</i></p> <p><i>For the purposes of this waiver only, each Party acknowledges that its rights and obligations under this Agreement are of a commercial and not a governmental nature.”</i></p>	
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## ATTACHMENT B – IOC Shale Gas Projects to Date

(Compiled from public announcements, media and securities filings)

<b>Entrance Time</b>	<b>IOCs</b>	<b>NOCs</b>	<b>Location</b>	<b>Work Commitment and Status</b>
Oct 2007 <sup>164</sup>	Newfield Exploration	PetroChina	Weiyuan field in the Sichuan Basin	No details
July 2010 <sup>165</sup>	Hess Corp.	Sinopec	Shengli Oil Field, in east China	No details
April 2011 <sup>166</sup>	Chevron	Sinopec	Qiannan Basin	Seismic; two exploratory wells, both were unsuccessful. <sup>167</sup>
Mar 2012 <sup>168</sup>	Total	Sinopec	Anhui Province	No details
Mar 2012 <sup>169</sup>	Shell	CNPC	Fushun-Yongchuan block	Work Program under the PSC
Jun 2012 <sup>170</sup>	Shell	Sinopec	Hunan, Hubei and Jiangxi	Seismic and 2-3 wells

<sup>164</sup> “CNPC and US Company Newfield Signed Agreement to Explore Gas Field Domestically (中石油与美国新田公司签订协议勘探国内气田),” January 18, 2008, [http://www.china.com.cn/economic/txt/2008-01/18/content\\_9550629.htm](http://www.china.com.cn/economic/txt/2008-01/18/content_9550629.htm).

<sup>165</sup> Chen Aizhu, “FACTBOX—Foreign Firms in China’s Shale Sector,” Reuters, November 14, 2013, [http://articles.chicagotribune.com/2013-11-14/news/sns-rt-china-shaleforeign--factbox-20131114\\_1\\_shale-resources-anton-oilfield-services-group-factbox-foreign-firms](http://articles.chicagotribune.com/2013-11-14/news/sns-rt-china-shaleforeign--factbox-20131114_1_shale-resources-anton-oilfield-services-group-factbox-foreign-firms) [Edited by qy]

<sup>166</sup> “Form 10-K Chevron Corporation,” Chevron, 23rd day of February, 2012, <http://www.sec.gov/Archives/edgar/data/93410/000095012312002976/f60351e10vk.htm> [Edited by qy]

<sup>167</sup> “Form 10-K Chevron Corporation,” Chevron, February 23, 2014, <http://www.sec.gov/Archives/edgar/data/93410/000009341014000011/cvx-123113x10kdoc.htm>.

<sup>168</sup> Aizhu, “FACTBOX—Foreign Firms in China’s Shale Sector,” in note 172.

<sup>176</sup> “CNPC and Shell Sign First Shale Gas Production Sharing Contract in China,” Shell, 2012, <http://www.shell.com/global/aboutshell/media/news-and-media-releases/2012/cnpc-shell-shale-gas-psc-china-20032012.html>.

<sup>177</sup> “Shell and Sinopec Jointly Explore Shale Gas in the Middle Region in China, November 15, 2013, <http://cn.reuters.com/article/chinaNews/idCNCNE9AE04220131115>.

Dec 2012 <sup>171</sup>	ConocoPhillips	Sinopec	Qijiang, Sichuan Basin	Seismic and two wells
Feb 2013 <sup>172</sup>	ConocoPhillips	CNPC	Neijiang-Dazu, Sichuan Basin	No details
Mar 2013 <sup>173</sup>	Eni	CNPC	Rongchang block, Sichuan Basin	No details
July 2013 <sup>174</sup>	Hess Corp.	CNPC	Xinjiang	No details

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<sup>171</sup> “ConocoPhillips China Inc. Enters a Joint Study Agreement with Sinopec Southern Exploration Company for the Qijiang Shale Gas Block,” ConocoPhillips China, December 28, 2012, <http://www.conocophillips.com.cn/EN/newsroom/news-releases/Pages/Articles/conocophillips-china-inc-enters-a-joint-study-agreement-with-sinopec-southern-exploration-company-for-the-qijiang-shale-gas.aspx> [Edited by qy]

<sup>172</sup> “ConocoPhillips Announces Three Agreements with PetroChina,” ConocoPhillips China, February 21, 2013, <http://www.conocophillips.com.cn/EN/newsroom/news-releases/Pages/Articles/conocophillips-announces-three-agreements-with-petrochina.aspx>.

<sup>173</sup> Aizhu, “FACTBOX—Foreign Firms in China’s Shale Sector,” in note 172.

<sup>180</sup> Chen Aizhu, “UPDATE 1-Hess, PetroChina Sign China's 1st Shale Oil Deal,” July 2013, <http://www.reuters.com/article/2013/07/24/cnpc-hess-shale-idUSL4N0FU2LR20130724?feedType=RSS&feedName=rbssEnergyNews>.

## ATTACHMENT C – City Gate Prices

<b>The city gate price cap in each province after August 2014 adjustment</b>				
Unit: 1 RMB/cubic meter = \$4.53/Mcf				
	RMB/cubic meter	RMB/cubic meter	\$/Mcf	\$/Mcf
Provinces	"Old" gas	"New" gas	"Old" gas	"New" gas
Beijing	2.66	3.14	12.05	14.22
Tianjin	2.66	3.14	12.05	14.22
Hebei	2.64	3.12	11.96	14.13
Shanxi	2.57	3.05	11.64	13.82
Inner Mongolia	2.00	2.48	9.06	11.23
Liaoning	2.64	3.12	11.96	14.13
Jilin	2.42	2.90	10.96	13.14
Heilongjiang	2.42	2.90	10.96	13.14
Shanghai	2.84	3.32	12.87	15.04
Jiangsu	2.82	3.30	12.77	14.95
Zhejiang	2.83	3.31	12.82	14.99
Anhui	2.75	3.23	12.46	14.63
Shanxi	2.62	3.10	11.87	14.04
Shandong	2.64	3.12	11.96	14.13
Henan	2.67	3.15	12.10	14.27
Hubei	2.62	3.10	11.87	14.04
Hunan	2.62	3.10	11.87	14.04
Guangdong	2.86	3.32	12.96	15.04
Guangxi	2.69	3.15	12.19	14.27
Hainan	2.32	2.78	10.51	12.59
Chongqing	2.32	2.78	10.51	12.59
Sichuang	2.33	2.79	10.55	12.64
Guizhou	2.37	2.85	10.74	12.91
Yunnan	2.37	2.85	10.74	12.91
Shaanxi	2.00	2.48	9.06	11.23
Gansu	2.09	2.57	9.47	11.64
Ningxia	2.17	2.65	9.83	12.00
Qinghai	1.93	2.41	8.74	10.92
Xinjiang	1.81	2.29	8.20	10.37

Source: NDRC

## ATTACHMENT D – Explanatory Note

### CO<sub>2</sub> REDUCTIONS FROM 100 BCM OF SHALE GAS USED TO DISPLACE COAL-FIRED POWER GENERATION

See discussion in text at Section 4D.

Note: All conversion and emissions factors from U.S. EPA, Unit Conversions, Emissions Factors and Other Reference Data (November 2004),  
<http://www.epa.gov/appdstar/pdf/brochure.pdf>

1. Convert 100 bcm to cubic feet:

$$1.0 \times 10^{11} \text{ m}^3 \text{ nat gas} \times \frac{35.315 \text{ ft}^3}{1 \text{ m}^3} = 3.5315 \times 10^{12} \text{ ft}^3 \text{ nat gas} \quad (= 3.5315 \text{ Tcf nat gas})$$

2. Calculate energy content of that gas:

$$3.5315 \times 10^{12} \text{ ft}^3 \text{ nat gas} \times \frac{1.027 \times 10^3 \text{ btu}}{1 \text{ ft}^3 \text{ nat gas}} = 3.626851 \times 10^{15} \text{ btu}$$

3. Assume 60% efficient combined cycle gas turbine:

$$3.626851 \times 10^{15} \text{ btu} \times 60\% = 2.176111 \times 10^{15} \text{ btu}$$

4. Calculate amount of coal required to generate that much energy, assuming a 40% efficient supercritical coal plant:

$$\frac{2.176111 \times 10^{15} \text{ btu}}{2.493 \times 10^7 \text{ btu/ton coal} \times 40\%} = 2.1822 \times 10^8 \text{ tons of coal}$$

5. Calculate CO<sub>2</sub> emissions from that amount of coal:

$$2.1822 \times 10^8 \text{ tons of coal} \times \frac{5.086 \times 10^3 \text{ lb CO}_2}{\text{ton coal}} = 11.0988 \times 10^{11} \text{ lb CO}_2$$

6. Convert to metric tons

$$11.0988 \times 10^{11} \text{ lb CO}_2 \times \frac{4.5359 \times 10^{-4} \text{ metric tons}}{1 \text{ lb}} = 50.34 \times 10^7 \text{ metric tons} = 503.4 \text{ MMT}$$

7. Calculate CO<sub>2</sub> emissions from 100 bcm of natural gas

$$100 \text{ bcm nat gas} = 3.5315 \times 10^{12} \text{ ft}^3 \text{ nat gas} \times \frac{0.12 \text{ lb CO}_2}{1 \text{ ft}^3 \text{ nat gas}} = 4.2378 \times 10^{11} \text{ lb CO}_2$$

8. Convert to metric tons

$$0.42378 \times 10^{12} \text{ lb } CO_2 \times \frac{4.5359 \times 10^{-4} \text{ metric tons}}{1 \text{ lb}} = 1.922 \times 10^8 \text{ metric tons} = 192.2 \text{ MMT}$$

9. Subtract natural gas emissions from coal emissions

$$503.4 \text{ MMT} - 192.2 \text{ MMT} = \mathbf{311.2 \text{ MMT avoided emissions}}$$

## ATTACHMENT E – Shale Gas Players and Progress by July 2014

Bidding Round / Pilot Project	Company	Type	Area (km <sup>2</sup> )	Block Location	Partnership	Wells drilled	Progress	Source/News
1	Sinopec	NOC	N/A	Fuling Block, Chongqing	FTS International	62	2015 expected production of 5 BCM/Y	<a href="http://www.reuters.com/article/2014/06/10/us-fts-jv-idUSKBN0EL1KY20140610">http://www.reuters.com/article/2014/06/10/us-fts-jv-idUSKBN0EL1KY20140610</a>
					Chong Qing Government			<a href="http://news.xinhuanet.com/zyd/energy/20140709/c_1111536373.htm">http://news.xinhuanet.com/zyd/energy/20140709/c_1111536373.htm</a>
1	Henan Coalbed Gas Company	Local SOE	2038.87	Xiushan, Chongqing	林州重机 (Linzhou Heavy Machinery)	6	8-9 wells completed by 2014	<a href="http://ggid.cnstock.com/company/scp_ggid/tjd_ggkx/201407/3087348.htm">http://ggid.cnstock.com/company/scp_ggid/tjd_ggkx/201407/3087348.htm</a>
2	Huadian Coal Industry Group Co.	SOE	1204.53	Suiyang Block, Guizhou	山东省煤田地质规划勘察研究院 (Shandong Provincial Research Institute of Coal Geology Planning and Exploration)	N/A	Complete shale gas field geological investigation report and overall project design	<a href="http://paper.people.com.cn/zgnyb/html/2013-09/09/content_1296049.htm">http://paper.people.com.cn/zgnyb/html/2013-09/09/content_1296049.htm</a> <a href="http://www.sicgee.com/contents/5/1063.html">http://www.sicgee.com/contents/5/1063.html</a>
2	China Coal Geological Engineering Co.	SOE	1053.37	Fenggang #1 Block, Guizhou	成城股份 (Jilin Cheng Cheng Group Co)	N/A	N/A	<a href="http://q.stock.sohu.com/cn,gg,600247,1631854637.shtml">http://q.stock.sohu.com/cn,gg,600247,1631854637.shtml</a>
				Sangzhi Block, Hunan		N/A	465 investment to be made in 2013-2015	
2	Huaying Shanxi Energy Investment Co.	Private	1030.4	Fenggang #2 Block, Guizhou	江苏长江地质勘查院 (Jiangsu Yangtze River Geological Exploration Institute)	1	Parameter well drilled in Dec, 2013	<a href="http://stock.sohu.com/20130108/n362830500.shtml">http://stock.sohu.com/20130108/n362830500.shtml</a>
2	Titangas Co.	Private	1167.49	Fenggang #3 Block, Guizhou	中石油集团东方地球物理公司 (BGP Inc, CNPC)	N/A	2D dimensional seismic survey completed	<a href="http://finance.sina.com.cn/chanjing/cyxw/20140317/025518523131.shtml">http://finance.sina.com.cn/chanjing/cyxw/20140317/025518523131.shtml</a>
2	Tongren Energy Investment Co.	Local SOE	914.63	Cengong Block, Guizhou	中国国储能源化工集团 (China Energy Reserve and Chemicals Group)	1	First well drilled in Dec, 2013	<a href="http://finance.gog.com.cn/system/2012/04/27/011429892.shtml">http://finance.gog.com.cn/system/2012/04/27/011429892.shtml</a>

2	Chongqing Energy Investment Co.	Local SOE	1272.4	Qianjiang Block, Chongqing	US Natural Resources Group (PSC)	2	1.7 billion RMB investment deal made in Jan, 2014	<a href="http://shalegas.cleantechpoland.com/?page=edition&amp;id=10&amp;id_article=46">http://shalegas.cleantechpoland.com/?page=edition&amp;id=10&amp;id_article=46</a>
2	Chongqing Mineral Resources Development Co.	Local SOE (JV)	1002.09	Youyang East Block, Chongqing	(Co-founded by Chongqing Energy, Chongqing Institute Geology and Mineral Resources) - Partnered with China Huaneng Group	N/A	3-5 wells expected to be drilled in 2014	<a href="http://changceinstitute.org/first-domestic-equity-transaction-on-shale-gas-signed/">http://changceinstitute.org/first-domestic-equity-transaction-on-shale-gas-signed/</a>
2	State Development and Investment Corporation	SOE	1020.95	Chengkou Block, Chongqing	The Chongqing Administration of Land, Resources and Housing (CALRH), CNPC, State Development & Investment Corporation (SDIC) and Sinochem Co signed a letter of intent on May 8, 2014	1	First well drilled in Nov, 2013	<a href="http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20140515000089&amp;cid=1206">http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20140515000089&amp;cid=1206</a>
2	Hunan Huasheng energy investment and Development Co.	Local SOE (JV)	878	Longshan Block, Hunan	Joint Venture formed by Valin Group, Xiangmei Group, and Hunan Development Group	N/A	First well drilled in Jun, 2014	<a href="http://xnyqt.cnpc.com.cn/News/xnyqt/sylm/tydt/201407/20140703_C604.shtml?COLLCC=3063107176&amp;">http://xnyqt.cnpc.com.cn/News/xnyqt/sylm/tydt/201407/20140703_C604.shtml?COLLCC=3063107176&amp;</a>
2	Shenhua geological exploration Co.	SOE	1189.72	Baojing Block, Hunan	Strategic Partnership agreement signed with Honghua in February 2013	1	First well drilled in Jun, 2014	<a href="http://www.gmw.cn/ny/2013-02/18/content_6721631.htm">http://www.gmw.cn/ny/2013-02/18/content_6721631.htm</a>
2	Chinese Huadian Engineering (Group) Co.	SOE	400.43	Huayuan Block, Hunan	N/A	N/A	159 million RMB investment approved in Mar, 2013	
2	Hunan Province Shale Gas Development Co.	Local SOE (JV)	982.23	Yongshun Block, Hunan	(Co-founded by Huadian & Coal Geology Bureau in Hunan Province)	3	Huadian planed to invest RMB 1.13 billion on Yongshun and Huayuan from 2013 to 2016 Started survey in March, 2013	<a href="http://www.chechne.com/cn/news/110">http://www.chechne.com/cn/news/110</a> <a href="http://www.bchyxw.com/Info/View.Asp?id=11181">http://www.bchyxw.com/Info/View.Asp?id=11181</a> <a href="http://safety.gasshow.com/News_20130320/333737.html">http://safety.gasshow.com/News_20130320/333737.html</a>
2	Huadian Hubei Power Co.	SOE	369.23	Laifeng Xianfeng Block, Hubei	Hubei Provincial Government	N/A	Started survey in July, 2013; and Huadian planned to invest RMB 482 million on the survey work from 2013 to 2016	<a href="http://www.cuog.cn/html/8486.html">http://www.cuog.cn/html/8486.html</a> <a href="http://www.enshi.cn/20130203/ca276477.htm">http://www.enshi.cn/20130203/ca276477.htm</a>



2	Huadian Hubei Power Co.	SOE	2306.71	Hefeng Block, Hubei	Hubei Provincial Government	N/A	Started survey in July, 2013; and Huadian planned to invest RMB 700 million on the survey work from 2013 to 2016	<a href="http://www.cuog.cn/html/8486.html">http://www.cuog.cn/html/8486.html</a>
2	Jiangxi Natural Gas Holdings.	Local SOE	598.28	Xiuwu Block, Jiangxi	Open tender to look for contractor	N/A	Open tender initiated in Jun, 2014	<a href="http://www.csgcn.com.cn/news/show-41690.html">http://www.csgcn.com.cn/news/show-41690.html</a>
2	Anhui Energy Group Co.	Local SOE	580.09	Lin-an Block, Zhejiang	(Co-founded Anhui provincial shale gas development Co.)	N/A	N/A	<a href="http://info.glinfo.com/13/0624/07/27AFA46806F5AFB5.html">http://info.glinfo.com/13/0624/07/27AFA46806F5AFB5.html</a>
2	Henan Yukuang Geological Engineering and Investment Co.	Local SOE	1377.91	Wenxian Block, Henan	(Co-founded by Henan Provincial Bureau of Geo-Exploration & Mineral Development)	N/A	N/A	
			1395.99	Zhongmou Block, Henan		N/A	N/A	
First National Level Pilot Project	Shannxi Yanchang Petroleum Co.	Local SOE			UT Austin	39 (by 2013)	39 wells completed by the end of 2013	<a href="http://www.sxycpc.com/ycinfo.jsp?urltype=news.NewsContentUrl&amp;wbtreeid=1062&amp;wbnewsid=37322">http://www.sxycpc.com/ycinfo.jsp?urltype=news.NewsContentUrl&amp;wbtreeid=1062&amp;wbnewsid=37322</a>
Two National Pilot Projects	CNPC	NOC		Weijin-Changning, and Shao Tong. Both national level pilot areas	Shell (PSC), Conoco Phillips	50 (by 2013)	50 wells completed by the end of 2013	<a href="http://wap.cnpc.com.cn/system/2014/07/14/001497185.shtml">http://wap.cnpc.com.cn/system/2014/07/14/001497185.shtml</a>
Through Application to MOLAR	CNOOC	NOC		Chaohu, Anhui 安徽巢湖	Shell (JV)		First well drilled in March 2013	<a href="http://wap.cnpc.com.cn/system/2014/07/14/001497185.shtml">http://wap.cnpc.com.cn/system/2014/07/14/001497185.shtml</a> <a href="http://www.bloomberg.com/news/2012-01-11/cnooc-starts-its-first-shale-gas-project-in-eastern-china.html">http://www.bloomberg.com/news/2012-01-11/cnooc-starts-its-first-shale-gas-project-in-eastern-china.html</a>

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