TLG on China: Gas

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strategy & economic consulting

The Devil Down Below: Developing China's Shale Gas

A seemingly never-ending string of conferences and news articles cover the questions of whether, when, and how China will develop its potentially vast unconventional gas resources. Will China meet its aggressive forecasts?[1] Forecasting is always a bit of a dark art, and forecasting the future of a nascent industry is the darkest of dark arts.

Rather than add yet another forecast of China's gas uptake or shale gas development over the next two decades, we focus on what makes China's situation different and how the fundamental conditions and key policies are evolving. Given the right conditions and incentives, we argue that China can indeed ramp up its future gas production significantly, but it still has a long way to go before it can do that in an efficient way.

In this edition of our **TLG on China**, we examine the status and dynamics of shale gas exploration and development (E&P) in China, assess how close (or far) China is from reaching a meaningful tipping point for growth in shale gas production in an efficient manner, and discuss ways the various current impediments could be overcome.

Slow Progress

The popular energy press speculates endlessly about whether China will replicate the dramatic 'shale gas revolution' in the United States. But realistically, if the end goal is simply to increase production from shale gas over time, there is no one formula for growing an industry, especially for one as new as shale gas. So many differences exist between the gas sectors in the US and China, that comparisons are just not that helpful. China needs to find its own path to developing its resources.

In contrast to the US with highly diverse ownership of gas resources, most of China's first tier (good) shale gas acreages overlap with existing conventional gas blocks owned by just two of China's national oil and gas companies: China National Petroleum Corporation (CNPC) and Sinopec. Although Chinese law does not clearly define the ownership rights of gas resources at different depths, CNPC and Sinopec have treated these overlapping shale gas resources as their assets, effectively placing them beyond the reach of competing developers. So far, the Chinese government has not been clear on what it intends to do about this overlapping resource access issue.

1 The official target by the Chinese government for shale gas production is 6.5 billion cubic metres (bcm) in 2015 and 60-100 bcm in 2020.

Consequently, the shale gas blocks that have been released in the first two rounds of auctions by the Ministry of Land and Resources (MLR) were selected so as not to conflict with CNPC's and Sinopec's conventional gas blocks. These auctioned blocks have been in the mountainous areas in Sichuan and Chongqing as well as in the upper- and mid-Yangtze river region, and they are, at best, second- or third-tiered resources.

If China does not tackle the overlapping resource issue by opening up access to the shale resource players, then China's pace of shale gas development will depend almost entirely on the investment behaviour of CNPC and Sinopec. In such a scenario, policies that strictly mimic US gas market development are unlikely to be effective. A good part of the success in the US has been wide-open access to exceptional shale resources, supported by high quality information, as well as access to gas transportation infrastructure. Also, China's shale resources are almost certainly more expensive to develop than those in the US due to a combination of geo-technical and other factors.

China's best, near-term, alternative, therefore, probably involves finding ways to increase competition between CNPC and Sinopec (assuming China has no intention of breaking these companies up). More competition between CNPC and Sinopec is certainly possible. For example, the two companies have competed more aggressively in other sectors of the oil and gas industry, such as the refining sector and LNG import business, as well as in overseas upstream oil and gas investment.[2]

Notably, when compared to CNPC, Sinopec has significantly fewer conventional gas reserves. Sinopec has more to gain in terms of securing greater financial and other resources from the Chinese government if it can make a China-style shale gas revolution happen. The recent announcement of Sinopec's "big find" in its Fuling shale gas block[3] is potentially the beginning of a new phase. Under such environment, CNPC would then be pressured to show similar progress. But even such a new dynamic is unlikely to lead to similarly rapid development of shale gas as seen in the US.

Table 1 summarises planned shale gas production volumes from a few key blocks controlled by China's national oil and gas companies, though these volumes could accelerate if there is greater competitive pressure across the Chinese majors. As can be seen, much depends on production from Sinopec's Fuling resource.

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2 In the Chinese refining sector, internal competition among the Chinese National Oil Companies (Sinopec, CNPC and CNOOC) have incentivised them to build more refining capacity than economically justified in the country.

In the LNG import business, it is generally believed that PetroChina entered into expensive long-term LNG contract agreements in 2010 and 2011, partly driven by the desire to enter the LNG business to compete with CNOOC. More "competition" does not necessarily mean cheaper gas, as it may also simply mean more aggressive (but not more economic) commitments.

3 In 2012, Sinopec discovered high yield gas flow of 203,000 cubic metres per day (cu m/d) from Jiaoye-1H well in the Fuling shale block in Chongqing. Currently, this well has maintained a steady 60,000 cu m/d rate of output for more than 500 days. Following the 2012 breakthrough, Sinopec has pushed forward and as of March 2014, has built 600 million cubic metres of annual production capacity. The Fuling demonstration area has 21 experimental wells with maximum testing production volume of 555,000 cu m/d and average production volume of 337,000 cu m /d. It operates 11 ground gas stations generating sales of 2 million cu m/d.

To ensure steady gas yield rate, Sinopec has invested in optimizing drilling technologies and staged horizontal well fracturing. The longest horizontal well testing section is 2,100 metres with fracturing occurring in 26 stages.

Table 1: China shale gas production targets, billion cubic metres (bcm)

Companies	2014 capacity (bcm)	2014 production target (bcm)	2015 capacity (bcm)	2015 production target (bcm)	2020 production target (bcm)
CNPC (Changning, Weiyuan Zhaotong JV)	-	0.8	-	2.6	11
Sinopec (Sichuan) Fuling	1.8	1.0	5.0	3.2	15
Yanchang Petroleum				0.5	4
Total				**6.3**	**30**

Source: Various news releases

If China can stimulate competition between Sinopec and CNPC, then the scope for private companies and investors to partner with CNPC or Sinopec to provide more capital, and foreign oil and gas companies can partner to provide technological and technical expertise would also increase. To date, PetroChina has formed a joint venture with several private companies/funds (Yibin City Holding and Beijing Guolian Energy Investment Fund) in Sichuan to explore a ChangNing shale gas block.
More than anything, the overlapping gas resource issue, which effectively concentrates control of China's best shale gas resources in just two large companies, places China on a completely different pathway for shale gas development as compared to the US experience.

Three Other Obstacles

The challenges above are just part of the overall problem. If any meaningful private sector interest is to emerge, China also needs[4]:

- Clearer laws and regulation for shale gas resource extraction;
- Infrastructure networks with open access; and
- A market-based pricing structure.

China has made some progress in each area, but much remains to be done.

Clear Laws and Regulations

In 2011, China changed the legal status of shale gas by declaring it to be China's "172nd independent mining resource", distinguishing it from conventional natural gas and making clear that China is working to encourage broader exploration of its shale gas reserves. Independent Mining Resource status exempts shale gas E&P from restrictions imposed on other hydrocarbon exploration and production activities in China.

In addition, before the second round was announced, the government officially placed foreign direct investment in China's shale gas industry in the "encouraged" category of its Foreign Investment Industry Guidance Catalogue. Foreign investors can invest in the

4 There are other challenges to China shale gas development, such as lack of water and challenging geology and environmental regulation. However, these should be available through technology, learning and market-based pricing. They are unlikely to be the key obstacles for China shale gas development in the long term.

sector without being subjected to customs duty for imported capital. Foreign investors can also enter joint-ventures with Chinese enterprises (although 51% Chinese stake is still encouraged, as observed in the requirements for the second round of shale gas block tendering). These developments are a positive sign, as it shows China's interest in attracting private and foreign capital and expertise to the sector.

Despite these measures, progress of shale gas exploration and development after the first two rounds of auctions has been slow.[5] A third round has since been delayed.[6] Government encouragement and support has neither proven to be fast nor large enough. Partly the problem is that the shale gas blocks for the first two rounds of auctions were not very high quality, and consequently their development may not even be profitable. China does not have the same level or quality of information about shale gas resources as has been developed in the US over decades. Second and third tier resources are inherently less certain and also more challenging. As winning firms encountered unexpected difficulties during the exploration phase, most reduced their focus on further exploration, deciding, instead, to redirect their resources to other more profitable endeavours. Despite various prequalification requirements, the winning firms have lacked the specialized technology, expertise, and funds required to navigate and gather data from the complex geological terrain.

Looking forward, we see three challenges for the MLR:

- Encourage greater cooperation and sharing of data and experience among winning enterprises;
- Increase supervision of shale gas block progress and coordination between enterprises and local governments; and
- Strengthen research and assessment of shale gas resources to provide better quality information and reduce risk to investors.

Allied to these three areas, China should develop a new licensing arrangement for shale gas exploration and production. Currently, licenses for conventional gas exploration are separate from licenses for production. For shale gas development, the regulations around these licensing arrangements have not been clear. Consequently, the expectation in the mind of investors is that the licensing arrangements follow the two-stage conventional gas tradition. But a two-stage process is much more risky for an investor, especially for shale gas resources as exploration and production could occur simultaneously. Moreover, why would anyone want to incur the considerable investment needed to explore a region, without knowing if it can actually sell the gas it finds?

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5 The first round in June 2011 was invitation-only and featured the four large state-owned oil and gas companies and two coal bed methane (CBM) producers (CNPC, Sinopec, CNOOC, Yanchang Petroleum, CUCBM, and Henan CBM), who bid for four gas blocks. The enterprises proposing greatest capital investment and plans for development were ultimately selected. In the second round held in October 2012, the MLR opened the auctioning of 20 shale gas blocks to both private firms and foreign joint ventures. To participate, firms had to have at least 300 million Yuan in registered capital and meet oil and gas exploration standards (or otherwise partner with firms that do); thus, encouraging more cooperation and interchange of technological knowledge and experience. One-third of the 83 bidding companies were privately owned; of the 16 winners, two were private firms. The two winning private firms were Huaying Shanxi Energy Investment and Beijing Taitan Tongyuan Natural Gas Resource Technology. We have provided two detailed tables on the progress of shale gas blocks in round 1 and 2 in the appendix.

6 The third round has been delayed several times. It may be because the Chinese government is in the process of working out clearer regulation and policy for shale gas exploration and development. It might also potentially be due to the anti-corruption campaign in China since last year.

The MLR has mentioned that it would shift its focus to areas that have traditionally shown more favourable fracking conditions such as Sichuan and Chongqing in the third round of shale gas bidding. The existence of completed infrastructure and facilities in those regions may also help to conserve resources and reduce development costs.

In March 2014, the Hunan Provincial Department also revealed five new shale gas blocks that will be included in MLR's third round of auctions - Changde, Shimen, Lianyuan, Zhangjiajie, and Cili.

For example, for coal bed methane (CBM) exploration and development, private companies are required to obtain a separate overall development plan (ODP) license to progress from the exploration stage to commercial production of gas. And ODP requires approvals from many government agencies from local to national level, covering all aspects of environmental impact, social issues and financial responsibility. There are frequently lengthy delays in obtaining the ODP license for commercial production. Private sector companies see this process as imposing a major risk and have correspondingly limited their interest in the CBM sector. Clarifying and streamlining the licensing process is critical to accelerating development.

The lack of service companies and skilled workforce in China is another key challenge for private shale gas developers. With only a few oil and gas service companies in China (almost all of which are closely linked to the national oil and gas companies), there is much less support available to the private companies. Similarly, most of China's skilled workforce is currently working for the national oil and gas companies. Therefore, private companies have more difficulty accessing technologies and experienced human resources to assist with exploring and producing shale gas, particularly given the lower quality of tier 2 and tier 3 resources that are available. This problem is a bit like the problem of the chicken and the egg. Without support, the industry cannot take off. Without taking off, the prospect of investing in and expanding support is less attractive.

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The Chinese oil majors continue to expand China's gas transmission and distribution pipeline network. Furthermore, China appears to be commencing a slow process of de-regulating the mid-stream sector. On 13 February 2014, China's National Energy Administration (NEA) issued a provisional administrative measure for a fair mechanism to open up the oil & gas pipeline networks (including both main trunk and sub pipelines and related facilities) for third party access if spare capacity is available. This policy is unlikely to have much impact in the near term, however, as the existing key gas pipelines have a high utilization rate. However, it is still a positive move as it set the tone for further de-regulation.

The government is also keen to promote the development of a centralized trading platform for pipeline transmission gas and related derivative products over the long term. Currently, Shanghai Petroleum Exchange Limited (SPEX) offers LNG and LPG products in its exchange. Last winter, under the National Development and Reform Commission (NDRC) and NEA guidance, PetroChina and Shenergy conducted transactions with city gas companies like ENN, China gas and Towngas China through SPEX for buying LNG and delivering pipeline gas for winter season gas supply.[7]

Finally, an interesting trend occurring in the mid-stream infrastructure is the rapid expansion of small scale LNG (SSLNG) in China.[8] SSLNG provides an independent and alternative pathway to monetise unconventional gas production in inland provinces. Shale gas producers can utilise SSLNG technology to get new sources of gas to high value segments, such as gas for bunkering, transportation, off-grid residential and industrial users, whose alternative fuels are usually liquid petroleum products.

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7 The transaction was recorded at 112 thousand tonne of LNG. PetroChina also allowed third-party access to its pipeline for free.

8 The small scale LNG processing capacity is expanded from less than 1 million tonnes per annum (mtpa) in 2008 to nearly 9 mtpa in end 2013. At least another 8-10 mtpa new capacity is either near completion or under construction.

In our view, SSLNG will play an increasingly important role as a back-up/alternative gas source for pipeline gas users in the industrial and transportation sector. Given modularisation of SSLNG equipment and the rapidly growing number of companies offering newer SSLNG technologies[9], costs are likely to fall.

An evolving mid-stream sector is crucial to support faster shale gas development. That said, it seems unlikely that these mid-stream developments will be fast enough to drive a dramatic increase in shale gas production in the short- and medium-term. China's shale gas development appears set to follow more of a slow and steady pathway, than a big bang, at least for now.

Market-based Pricing Structure

The Chinese government provides a subsidy of 0.4 yuan/cubic metre subsidy for shale gas and the price of shale gas is not regulated. Nonetheless, the price at which it is sold to customers is heavily affected by the regulated price of conventional gas because conventional gas is the direct alternative to shale gas for most end consumers. In July 2013, the National Development and Reform Commission (NDRC) announced a new gas pricing mechanism based on two tranches:

- Existing gas (as determined by 2012 consumption volumes) prices were increased with an increasing amount capping at 0.4 yuan/m3 in July 2013 when the new pricing mechanism was announced. Prices will be gradually increase to be the same as incremental gas over the next few years; and
- Incremental gas prices are linked to a new net-back pricing mechanism based on the cost of fuel oil and liquefied petroleum gas (LPG).

The new mechanism, which needs more time to be fully implemented and understood, is more likely to be supportive of shale gas development – particularly first tier resources. Recent reports on Sinopec's shale gas production in its Fuling Block in Chongqing imply production costs of around 2 yuan per cubic metre[10], which is commercially viable given the current subsidy level of 0.4 yuan per cubic metre and current city gas tariff for incremental gas set at 2.8 yuan per cubic metres in Sichuan and Chongqing. The margin is even bigger when compared to the sales prices of imported LNG, or the imported pipeline gas from Central Asian countries and Russia.

Conclusion

It would not take that much change for China to develop more of its shale resources. But the changes are hard, and the prices of those resources are unlikely to be anywhere near as low as what has been experienced in the US. China's experience with the Fuling development in Chongqing is promising, but remains just a "one-off" – hardly enough to base robust forecasts of a looming Chinese shale gas revolution. China's pace of development seems unlikely to take off dramatically as it has in the US. Furthermore, China's political and market set-up makes it impractical to analyse China's progress strictly through a template of the conditions that incubated US shale growth.

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9 The size of SSLNG market is also growing fast in the US because of the shale gas revolution, which could drive more technological innovation and spill the benefit over to China.

10 We assume that the initial daily production rate of 70,000 cubic metres in the first year and the production decreases to 80% in the second year, 20% in the fifth year and then slowly down to 5% in the 15th year. The production cost is about RMB 1.8 per cubic metre under assumptions of the well cost at RMB 75 million and supporting infrastructure at RMB 10 million and annual fixed cost of RMB 2 million, along with others.

Therefore, China is unlikely to experience the rapid development of shale gas in the manner that the US has experienced, driven by numerous competing firms. Instead, China appears set to depend more on Sinopec and CNPC. Political and economic incentives may foster increased competition between these companies, which could see positive developments. Other steps are needed, however, to support private sector entry. China is making some progress in each area, though it has been decidedly slow. Continued failure to reach targeted production levels and increase gas tariff due to higher imports will keep the pressure on for further reforms. Of these, pricing reforms offer some of the more promising long-term support for accelerated shale gas development. But we are still talking about a long-term outcome and a continuing evolution within China's energy sector, not a near-term shale gas 'revolution'.

Appendix: Progress of Shale Gas Blocks in Bidding Round 1 and 2

Table 2 summarizes the results of two rounds of shale gas bidding. Shale gas production reached 200 million cubic metres in 2013, up from 25 million cubic metres in 2012 and zero in 2011.[11] Its overall investment in shale gas exploration and development totals 15 billion yuan according to Chinese media reports. The Chinese players are also gaining experience in the sector. The time from start of drilling to completion has been reduced from around 100 days in 2012 to an average of 70-75 days in 2014 and the cost decreased from around 100 million yuan per well in 2012 to 80 million in 2014. The Chinese government is also very keen to push forward more shale gas exploration and development. It has announced a shale gas subsidy of 0.4 yuan/cubic metre in November 2012.

A meeting organized by the China Geological Survey Bureau with 18 (including the joint bidders) of the second round auction winners in September 2013 revealed that most enterprises are in the midst of geological surveying, performing 2D seismic studies, and other exploratory work.[12] Table 3 provides more details.

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11 According to China Geological Survey, China has drilled 129 wells for shale gas exploration/evaluation, 28 of which are horizontal water-fracking wells, by the end of 2012. By the end of 2013, China's Ministry of Land and Resources reported that China had drilled a total of 285 wells, of which there are 105 vertical surveying wells, 94 vertical exploratory wells, and 86 horizontal appraisal wells. After hydraulic fracturing and testing, 38 wells had daily output exceeding 10,000 cubic metres, of which 18 were vertical and 20 were horizontal wells. Only 23 wells (3 vertical and 20 horizontal) produced more than 100,000 cu m of daily output.

12 http://www.mlr.gov.cn/xwdt/jrxw/201309/t20130918_1272537.htm. According to a 2013 MLR report, most firms have abided by their contractual responsibilities and successfully begun construction of surveying projects within six months of obtaining exploratory rights. The second round winning firms have completed 78 km of geological surveying of the total 4,586 km and measured 80 out of 118 km of total geological sections. 2D seismic work has been done on 16 of the blocks, of which nine blocks have been bid on and five have collected 2D seismic data on 627 km.

Table 2: Summary of Bidding Results

	Firm	Gas Block	Min. Investment (Mill. RMB)
Round 1 2010	China National Petroleum Corporation (CNPC	Nanchuan block in Chongqing and Guizhou	132
	Henan Provincial Coal Seam Gas Development and Utilization Co.	Xiushan block in Chongqing, Guizhou &Hunan	122
Round 2 2012	Huadian Coal Industry Group	Guizhou Suiyang Shale Gas Block	108
	China Huadian Engineering (Group)	Hunan Huayuan Shale Gas Block	36
	Huadian Hubei Power [China Huadian Corp.]	Hubei Laifeng Xianfeng Shale Gas Block, Hubei Hefeng Shale Gas Block	33 208
	Huaying Shanxi Energy Investment	No.2 of Guizhou Fenggang Shale Gas Block	93
	Beijing Taitan Tongyuan Natural Gas Resource Technology	No.3 of Guizhou Fenggang Shale Gas Block	105
	Tongren Energy Investment Co., Ltd	Guizhou Cengong Shale Gas Block	82
	Chongqing Energy Investment Group	Chongqing Qianjiang Shale Gas Block	115
	Chong Qing Mineral Resources Development	Chongqing East Youyang Shale Gas Block	90
	The State Development & Investment Corporation (SDIC)	Chongqing Chengkou Shale Gas Block	92
	Hunan Huasheng Energy Investment Development	Hunan Longshan Shale Gas Block	79
	Shenhua Geological Exploration	Hunan Baojing Shale Gas Block	107
	China Corporation of Coal Geology Engineering	No.1 of Guizhou Fenggang Shale Gas Block, Hunan Sangzhi Shale Gas Block	95 68
	Hunan Shale Gas Development	Hunan Yongshun Shalge Gas Block	88
	Jiangxi Natural Gas (Gan Tou Qi Tong) Holding	Jiangxi Xiuwu Basin Shale Block	54
	Anhui Energy Group	Zhejiang Lin'an Shale Gas Block	52
	Henan Yukang Geological Exploration Investment	Henan Wen County Shale Gas, Henan Zhongmu Shale Gas Block	124 126

Source: TLG Research based on various government publications and media reports

Table 3: Updates on Second Round Tenders by Province

Province/ Region	Shale gas resources (1000 bcm)	Main players	First Activities	First Activities
Sichuan	27.5	CNPC/ PetroChina	2012: Ning201-H1 became first horizontal well commercially producing gas 150,000 cm/d	2014: 16 wells, 12 fracturing gas test wells; vertical wells of 2,000-33,000 cm/d; horizontal wells of 10,000-160,000 cm/d. At of the end of 2013, output of Changning shale gas totaled 20m cu m, which is planned to reach 3bcm in 2020
Chongqing	12.75	Sinopec, CNPC, CQEIG, Shenhua Group	2009: first well drilled, Yuye Well 1 2012: Sinopec discovered gas flow of 203,000 cm/d at Fuling's Jiaoye 1H well 2012: CQEIG and Shell signed strategic cooperation memo to explore and develop shale gas	2014: Sinopec's Jiaoye-1H well achieved stable output of 60,000 cm/d for >500 days May 2014: Sinopec's Fuling block: 47 wells - 21 experiment wells with maximum testing production volume of 555,000 cu m/d and average production volume of 337,000 cu m /d; 82 wells being drilled, with 11 ground gas stations generating sales of 2m cu m/ day.total daily shale gas output is 550,000 cm. May 2014: CNPC teams up with Chongqing Administration of Land, Resources and Housing, State Development & Investment Corp., and Sinochem Corp. to explore shale gas resources in Chongqing with plans to build first well in June 2014: Chongqing has allocated $39 million to shale gas investigation and exploration
Guizhou	10.48	Sinopec, Shenhua Group, Tongren Energy Investment Co.	2010: Sinopec signed with BP to explore shale gas 2013: Shenhua signs with Guizhou government to invest >50 billion yuan up till 2020 December 2013: Tongren opened first exploratory wells Star-1 well (1800m deep, 50m thick, 1bcmpa expected)	February 2014: Sinopec discovers 4,147 m deep shale gas well (Dingye-2HF) with max output of 105,000 cm/d and average of 43,000 cm/d
Yunnan	2.14	CNPC	Zhaotong block: 2011 spent RMB 100 million on drilling and fracturing, RMB 126 million on seismic surveys	2014: 7 wells drilled; 2 fracturing gas test wells completed; vertical wells of 2,500 cm/d; horizontal wells of 15,000-36,000 cm/d
Shaanxi	7.17	Yanchang Oil & Gas	2011: first continental shale gas well Liuping 177 in Ordos Basin with 2,350 cm/d	2014: 39 shale gas wells drilled,32 are vertical wells, 3 cluster vertical wells, 4 horizontal wells; 34 completed fracturing with shale gas; initial proven shale gas area of 130 sq km and reserves of 29bn cu m.
Hubei	9.48	Sinopec, CNPC	2011: CNPC drilled first well and Sinopec drilled a horizontal well 2012: Sinopec and Shell signed joint study agreement (JSA) of the region and in 2003 drilled 2 exploratory wells (Liye-1, Engye-1) with first sealed due to unsatisfactory results	August 2013: Huadian Group has signed with Hubei province a strategic cooperation agreement to develop shale gas in the region April 2014: 5 shale gas blocks have been put up for bidding with 3 passing evaluation, granted RMB 200 million each and expected to be completed by end of 2014.

Continued overleaf

Table 3: Updates on Second Round Tenders by Province (cont)

Province/ Region	Shale gas resources (1000 bcm)	Main players	First Activities	First Activities
Hunan	9.19	Hunan Huasheng Energy Investment Development Co., Shenhua Group, Sinopec	2011: Sinopec completed drilling at Xiangye - no. 1 well with >1,000cm/d, expects commercial production of 20,0000-100,000 2012: Shenhua Group won bid for land and completed field extraction in 2013	2014: Shenhua Group puts into use Hunan's first shale gas well of 3,208 m deep and expected 100,000 cm/d. March 2014: China Geological Survey Bureau of Hunan province has invested 14.7 million RMB and conducted two shale gas project investigation and assessment projects. June 2014: Shenhua Group in Baojing block - total investment of 200 million RMB, fastest progress, earliest development, and most work completed of all the 5 Hunan blocks. 2 exploratory wells, electromagnetic detection of area, geological survey, first batch of 2D seismic surveys, BaoCan-1 well completion, and research and analysis regarding drilling. Carried out 6 well feasibility studies and developed new methods and models for shale gas exploration
Jiangxi	1.18	Jiangxi Natural Gas	2011: Jiangxi Bureau of Geology and Mineral Resources surveyed resources and built 2 pilot wells to determine location for first ignited >1000m 1500m well (Fengye-1) drilled in 2013. 2012: Jiangxi province released expected output of 100mcm/a by 2020.	2014: Jiangxi Bureau and Jiangxi Natural Gas's data from Ganye-1 and Fengye-1 wells revealed shale resource potential of 588 bcm. Status: still in exploratory phase
Anhui	2.12	CNOOC, Sinopec	2012: CNOOC completed Chaohu-1 well and core drilling with completion of first 3 drill holes 2013: Sinopec signs with Total to jointly explore shale gas reserves	2014: CNOOC successfully drilled first exploratory well, Huiye-1 well, 3,001m deep with 91-day cycle, 12 times coring operations, coring footage of 54.65m, 53.36 harvest core, core harvest rate of 98% 2014: Total and Sinopec will explore 4,000 sq km Xuancheng permit near Nanjing after conducting 2-d seismic surveys
Jiangsu	5.33	Sinopec	2009: Sinopec and BP in talks over potential cooperation block - 1000km area in Huangqiao, Jiangsu 2010 drill investigation wells	2014: Sinopec East Branch implemented JinYePing-1, 2378.23m deep horizontal well

Source: TLG Research based on various government publications and media reports

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