Shale Gas Exploration and Development Progress in China and the Way Forward

Jianghua CHEN¹

¹ College of Geosciences, China University of Petroleum, Beijing 102249, China
fancyboy168@163.com

Abstract. Shale gas exploration in China started late but is progressing very quickly with the strong support from Central Government. China has 21.8 tcm technically recoverable shale gas resources and 764.3 bcm proved shale gas reserve, mainly in marine facies in Sichuan basin. In 2016, overall shale gas production in China is around 7.9 bcm, while it is set to reach 10 bcm in 2017 and 30 bcm in 2020. BP is the only remaining IOC actor in shale gas exploration in China partnering with CNPC in 2 blocks in Sichuan basin. China is encouraging shale gas business both at Central level and at Provincial level through establishing development plan, continuation of subsidies and research funding. Engineering services for shale gas development and infrastructures are developing, while the overall cost and gas marketing conditions will be key factors for the success in shale gas industry.

1. Introduction
Energy security is the main driver for today’s strong push towards shale gas development in China. The country is reluctant to see its natural gas dependency on imports (36.6% in 2016) to follow a similar trend as oil (65.5% dependency in 2016). Environmental constraints (“blue sky” policy and switching from coal to gas for power generation for instance) and GHG (Greenhouse Gas) emissions controls (commitments to COP21 Paris Protocol) are two other factors explaining an increasing demand of this resource in the future.

Shale gas development in China is still in an early stage comparing with North American practice but has been progressing at a fast pace under the pressure of Central Government. It is currently focusing on the evaluation of the resources and the demonstration of the development feasibility in order to achieve large scale of commercial production as early as possible.

2. Shale gas resources potential in China
Based on the results of 2015 MLR (Ministry of Land Resources) resources investigation (the latest one up to now, released in June 2016), China has 21.8 tcm technically recoverable shale gas resources, among which 13 tcm (60%) in marine facies, 5.1 tcm (23%) in transitional facies and 3.7 tcm (17%) in lacustrine facies (Figure 1).

According to MLR Oil & Gas Reserve Booking Review Center, up to July 2017, China has booked 764.3 bcm proved reserve, among which 600.8 bcm (70%) was booked by Sinopec for its Fuling shale gas field and 163.5 bcm (30%) was booked by PetroChina for its Weiyuan (27.3 bcm) and Changning pilot (136.2 bcm) (Figure 2). It is important to notice that those are all located in Sichuan basin, one of the most conventional gas prolific areas in China.
3. Shale Gas Exploration and Development Progress in China

Like in the conventional oil and gas sector, NOCs are also taking the leading roles for the shale gas development in China. From the information available so far, the yearly production climbed up to 7.9 bcm in 2016, achieved almost 76% year on year increase (4.5 bcm in 2015) (Figure 4).
Still nearly all the productions are coming from marine Lower Silurian Longmaxi hot shales produced by both Sinopec and PetroChina in Sichuan basin with a few limited produced by Yanchang Petroleum Company from the lacustrine Upper Triassic Yanchang shale in Ordos basin. According to the current progress, 2017 shale gas production will reach 10 bcm.

In addition, international oil companies (IOCs)’s presence in China shale gas are mainly in the exploration stage in the form of Joint Study Agreements (JSA) or Production Sharing Contract (PSC).

Oil and Gas Research Center of China Geological Survey Bureau which was established in December 2012 under MLR plays a very active role in recent years to conduct geological investigation in the areas where haven’t been registered for oil and gas and to provide such information for public service to stimulate and push forward the oil and gas development in China. In 2016, around 16 wells were drilled which mainly located in West Hubei Provinces. In May 2017, China Geological Bureau announced test result of Eyiye-1 with 60,000 m³/d in Cambrian shale, for the first time to achieve promising result in this “old” shale.

China initiated the first shale gas bidding round in 2011 and a second round in 2012 enlarged to 20 blocks and open to the private sectors for bidding. However, due to the excessive commitments and lack of upstream experiences for some licensees, only several dozens of wells were drilled and a number of seismic were carried out, while in some cases licensees have done almost nothing. Up to now, no major discoveries are made and the actual investments for each single block are all below 50%. Therefore, after internal debate, MLR finally granted the license holders an additional one year to continue the exploration without any penalty. The one year extension was expired in June 2017. The consequences of the non realization of commitments for those domestic non-NOC players are not yet known to the Public.

3.1. Progress made by National Oil Companies (NOCs)

As a major shale gas producer in China, Sinopec is continuing to play the major role for shale gas development in 2017 for the realization of the production target set by Central Government. Continuous efforts were made to enlarge the shale gas production in Fuling shale gas field while exploration is also ongoing in other areas in Sichuan basin.

Fuling, which covers 7,308 km², the first commercial shale gas region in China, is operated by Sinopec Jianghan Oilfield Company. Sinopec completed the 1st phase of 5 bcm production capacity by end 2015 and started the 2nd phase of 5 bcm capacity in 2016. According to the current progress, by end 2017, the production capacity will reach 10 bcm. Currently the daily production of Fuling is stabilized at above 16 mmcm/d, estimated yearly production will achieve 6 bcm by end 2017.

In addition, as another major shale gas actor within Sinopec, Sinopec Huadong Oilfield Company started to develop the Pingqiao south area in 2016 which is located in the north of Nanchuan block and close to Fuling shale gas development zone.

Though PetroChina is the country’s largest gas producer, it comes second in terms of shale gas production. PetroChina started the shale gas exploration much earlier than Sinopec in 2006 while the
development and production coming late due to its own strategy focus. Unlike Sinopec whom mainly developing shale gas by itself through the affiliates, PetroChina is more active to introduce external partners in this domain including provincial energy companies and foreign oil companies.

In 2016, PetroChina produced 2.5 bcm shale gas from three pilot projects in Southwestern Sichuan (Changning-Weiyuan) and Northern Yunnan Province (Zhaotong), more than doubled its 2015 production (1 bcm). 2.3 bcm of its annual shale gas production in 2016 was from Changning-Weiyuan block in South Sichuan basin, operated by PetroChina Southwest Oilfield Company. Currently daily production is above 7 mcm/d and estimated annual production in 2017 will reach 2.5 bcm.

The other main contributing block to PetroChina’s 2016 production tally was Zhaotong in Northwest Yunnan Province, operated by PetroChina Zhejiang Oilfield Company. In 2016, the annual production achieved 0.5 bcm from its 22 producing wells.

3.2. IOC’s presence in China Shale Gas

Along with the end of several JSAs in 2015 (Shell Xiang’exi with Sinopec and Hess Rongchangbei with PetroChina, etc.), international investment in China domestic shale gas domain became more limited in 2016 owing to a combination of complex geology and a lack of openness in the industry, as well as the fact that IOCs have reined in spending because of the oil industry downturn.

After four years of involvement in China’s shale gas exploration efforts since 2013, Shell decided to stop further investment in 2015 in its Fushun-Yongchuan PSC with PetroChina where Shell acted as an operator. Fushun-Yongchuan block, which covers around 3500 km², is the first shale gas PSC in China. Due to structural complexity and challenging drilling conditions, Shell decided to divest party of its share to 3rd party in end 2015 but failed. It is learned that Shell officially terminated Fushun-Yongchuan PSC in May 2017.

When others are back off, on the other side, BP signed 2 shale gas PSCs with CNPC, namely Neijiang-Dazhu (2000 km²) signed in March 2016 and Rongchangbei (1000 km²) signed in September 2016. Unlike Shell Fushun-Yongchuan PSC, PetroChina is taking the role of operator while BP is acting as technical advisor and investing in 100%. The exact commitments for both PSCs were unknown. The latest news released that 100 km² 3D seismic was acquired in January 2017. 3 horizontal wells and 1 vertical well are planned to be drilled in the block in 2017. 1 of them already was spudded in late August 2017 and currently under drilling in horizontal section.

4. Challenges and Way forward

4.1. Major challenges

Based on the E&P practice on China shale gas in recent years, the following challenges have been identified for the consideration of further actions.

- Intensive investment for building of production capacity. Unit cost for a single well is still high due to geological complexity and unfavourable surface conditions. Due to the fast decline of shale gas production, more drillings are needed to maintain the production level which result in massive investment in a certain period.

- Lacking of experience for the shale gas development deeper than 3,500m. Through the practice in 12th 5-Year plan (2011-2015), China has accumulated the relevant technology for the shale gas development shallower than 3,500m. However, according to the study, more than half of shale gas resources in Sichuan basin are trapped deeper than 3,500m, the development of which requires more advanced technology in horizontal drilling, completion and stimulation. Whether it can be developed efficiently or not has a big impact on the realization of China 13th 5-Year Plan for shale gas.

- Competition is still not sufficient. The majority of the shale gas resources are in conventional blocks already registered by NOCs where the relinquish system is not working well. Engineering service is at an early stage and not sufficient enough to bring the cost down through competitive CFT (Call For Tender).
Difficulties for gas marketing. Certain pipelines have been built to connect the shale gas blocks in 12th 5-Year Plan and some are planned in 13th 5-Year plan, which will definitely help to supply gas to end users. However, the increased conventional gas production, long term contract of gas import from Central Asia, Russia and Myanmar as well as LNG, largely increase the gas supply capacity, while comparing with gas consumption increasing rate and shale gas development cost, it will be difficult to expand the market for shale gas.

4.2. Policies and Way forward

4.2.1. Policies in place supporting the further development of shale gas in China

China issued several instruction policies regarding the development in energy section. According to “Shale Gas Development Plan 2016-2020” issued by NEA on September 2016, “13th 5-Year Plan for Energy Development” and “13th 5-Year Plan for Natural Gas Development” issued by NDRC on December 2016, the key points for shale gas development are extracted and summarized as below.

- Privilege opportunity for gas development. Natural gas will play a bigger role in the energy structure optimization following the strongly promote of clean and low carbon development strategy as well as China’s commitments for the Paris Agreement. According to the abovementioned plans, with the overall energy consumption, the share of natural gas consumption will be increased to 10% from the current 5.9%, which requires the acceleration of shale gas development.
- Ambitious objectives are set for efforts. In the 13th 5-Year Plan, it is targeted to add 1 more tcm proved shale gas reserve, produce 30 bcm shale gas in 2020 and 80-100 bcm in 2030.
- Subsidy for shale gas development will continue to be put in place. Though lower than the 0.4 RMB/m³ in 2012-2015, the subsidy is adjusted to 0.3 RMB/m³ for 2016-2018 and 0.2 RMB/m³ for 2019-2020.
- Foreign cooperation will continue to be implemented. Based on the lessons learned from two existing shale gas bidding round and current cooperation practices undertaking by PetroChina, access to the shale gas domain for foreign cooperation will be further encouraged and promoted for continuous improvement of applicable technology and investment diversification to ensure the ultimate target set by central government can be realized.

4.2.2. Way forward

According to the current E&P status and study results of shale gas in China, phased E&P arrangement is set according to the different types of the areas as defined like key production area, appraisal breakthrough area and potential study area (Table 1). For the key production area, continue to expand the production capacity and play the major role for the production increase contribution. For the appraisal breakthrough area, accelerate the pilot test and start the development ASAP. For the potential study area, continue the G&G study and select favorable areas for future replacements.

All in all, marine hot shales in Sichuan basin and its adjacent areas are still the key strategic focus during the implementation of the 13th 5-Year Plan.

In addition, Having been postponed several times since 2013, it is understood that China has decided against its long-awaited national shale licensing round, choosing instead to allow individual provinces to tender acreage themselves based on the results of previous two bid rounds.

Sinopec is ready to increase the output capacity of the flagship Fuling gas field in the Sichuan Basin to 7-8 bcm in 2017 and plan to develop a new shale block Yongchuan-Rongchang in Southeastern Sichuan Basin, which has the potential to produce 2 bcm/y.

PetroChina plans to drill a total of 600 wells from 2016 to 2020 and to reach 10 bcm of shale gas output by 2020 in the Sichuan Basin.

Provinces like Chongqing, Sichuan, Guizhou and Hubei are actively setting up their own dedicated plans and associated policies to boost shale gas development inside the regions.
Table 1 Phased E&P arrangement for shale gas by Central Government

| No. | Name              | Location                  | Target                | Depth (m) | Area (km²) | GIP (tcm) |
|-----|-------------------|---------------------------|-----------------------|-----------|------------|-----------|
| 1   | Fuling            | East Chongqing            | L.Silurian Longmaxi   | <4,000    | 600        | 0.48      |
| 2   | Changning         | Southern Sichuan basin    | Shuilu-Xuyong, Muxian-Yin   | <4,000    | 4,450      | 1.9       |
| 3   | Weiyan            | Southern Sichuan basin    | Neijiang-Jianwei, Anyua-Tongnan, Dazu-Zigong, Bishan-Hejing and Luolan-Changning | <4,000    | 8,500      | 3.9       |
| 4   | Zhaolong          | North Yunnan              | L.Silurian Longmaxi    | <4,000    | 1,430      | 0.5       |
| 5   | Fushun-Yongchuan  | Southern Sichuan basin    | L.Silurian Longmaxi    | <4,000    | 1,000      | 0.5       |

5. Conclusions
Shale gas exploration and development in China started late but is progressing rapidly with 7.9 bcm production in 2016. The shale gas resources potential in China is huge with 21.8 tcm technically recoverable and 764.3 bcm proved reserve, which are mainly in marine facies in Sichuan basin. NOCs are still taking the leading roles for the shale gas development in China and will continue to contribute more based on their rich experience and strategic plans. IOC’s presence in shale gas sector is limited at current stage with only BP involving with PetroChina.

The shale gas business in China will continue to be encouraged both at Central level and at Provincial level through establishing phased development plan, continuation of subsidies and research funding in order to lower China’s dependency on gas imports. Engineering technology is becoming mature on development shallower than 3500m and the cost has been reduced down while the next focus will be technology breakthrough for shale gas development deeper than 3500m and in “older” Cambrian shale. The overall cost reduction and gas marketing conditions improvement will be key factors for the future success of shale gas development in China.

Acknowledgement
The author thanks the experts for reviewing the article and appreciates their useful comments.

References
[1] Chen S B, Zhu Y M, Qin Y, Wang H Y, Liu H L, Fang J H, 2014. Reservoir evaluation of the lower silurian longmaxi formation shale gas in the southern Sichuan Basin of China. Marine and Petroleum Geology 57, 619-630.
[2] EIA, 2013. Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States. U.S. Department of Energy Washington. DC.
[3] Hu W R, Bao J W, 2013. To explore the way of Chinese-style shale gas development. Natural Gas Industry 32, 93-97 (in Chinese with English abstract).
[4] Jia C Z, Zhang M, Zhang Y F, 2012. Unconventional hydrocarbon resources in China and the prospect of exploration and development. Petrol. Explor. Develop. 39, 139-146.
[5] Zou C N, Dong D Z, Wang S J, Li J Z, Li X J, Li Y M, Wang D H, Cheng K M, 2010. Geological characteristics and resource potential of shale gas in China. Petrol. Explor.
Develop. 37, 641-653.