

## **Demands and Challenges of UGS Construction in China for the Next Two Decades**

Ding Guosheng

Petrochina Research Institute of Petroleum Exploration and Development-Langfang

**Abstract:** China's natural gas consumption is irreversibly in rapid growth, but as an emerging natural gas market, China's natural gas consumption will rely on international natural gas resources such as Central Asia, Russia and overseas LNG market for a very long time. The demands for peak shaving of gas storage is increased largely due to the needs of peak shaving and strategic reserve, the gradual diversification of natural gas consumption structure, the increase in proportion of urban gas and the need of balancing long-distance backbone pipelines. As the gas storage facilities are inadequate, 4 billion of pipeline deliveries are used for peak shaving each year in China, which reduced the stability and efficiency of some pipelines in different level. Therefore, gas storages are in urgent needs, and which are expected to be 110 billion cubic meters by 2030. At the same time, China is facing the following difficulties in construction of UGS: 1. Peak shaving capacity is not enough for the current gas storage and other major natural gas consumption market; 2. Gas storages are usually buried deeply with poor material conditions and long construction cycle, and there are a series of technical difficulties in constructing low permeability gas reservoirs in deep underground. 3. With the increase of gas storages, it will be harder to manage and coordinate the operation of gas storages and pipelines in different volume and pressure levels; 4. Gas storage operation and management mode does not correspond with the market demand. Under the current gas pricing policy, it is harder and harder to construct gas storage for the increasing requirement of investment, and the cost of pipeline operation will be increased in turn. Therefore, it is also one of the challenges to change the input-output mode of gas storage and reduce the cost of gas storage construction.

**Key words:** Emerging market, resource of gas storage construction, technology, operation mode, challenge

### **1 Current Situation of UGS in China**

UGS has been developed in China since early 90's. After nearly 20 years of development, UGS played an important role in balancing natural gas pipeline network and gas supply in different regions.

The first commercial gas storage in China was put into operation in 2000, and it has played an import role in stabilizing and securing gas supply in Beijing and Tianjin. Its peak gas production each day has reached 1/3 of peak gas consumption in the region. Now a small gas storage base consisting of 6 gas storages has been constructed in Dazhangtuo. A storage base to be completed in Banqiao has ensured the peak shaving and gas supply in winter in Beijing. It has supplied 1.108 billion of peak shaving gas from late 2004 to early 2005, accounting for 33.5% of the gas supply in Shaanxi-Beijing pipeline in the years.

The first salt cavern gas storage in China with designed working gas volume of 1.7 billion cubic meters was started to construct in 2005. The cavity construction is undergoing new, and the whole work will last to 2020. It was the first gas storage converted from salt cavity in China, and played an important role in peak shaving in the region.

Jing 58 gas storage base, the second small gas storage bas in North China with designed working gas volume of 7000 million cubic meters was started to construct in 2009.

Currently, China is actively promoting the construction of gas storages, and 14 gas storages are under construction and evaluation now. The total working gas volume under construction reaches 12 billion cubic meters, starting the large-scale construction of gas storage in China.



## 2 Future demands for UGS in China

1) The market demands for natural gas are growing rapidly, and it is increasingly in short of supply in China. With the continuous improvement of infrastructure and sustainable development of economy in China, it is expected that the demands for natural gas will reach 235 billion cubic meters by 2015, 300-350 billion cubic meters<sup>(1)</sup> by 2020 and 500 billion cubic meters by 2030. Since the domestic natural gas production can not meet consumer demands, we need to import large quantities of natural gas from foreign countries. According to forecasts, the import of natural gas will increase from about 20 billion cubic meters in 2010 to 140 billion cubic meters in 2020 and 210 billion cubic meters in 2030. The import dependency will increase year by year to 38.9% in 2020 and 42% in 2030.

2) Peak shaving and strategic reserve drive the huge demands for natural gas reserve. It is expected that, by 2020, over 50% of natural gas in China will depend on import. According to the practices in foreign countries, once the imported natural gas exceeds 50%, the working gas volume in UGS will account for about 15% of gas consumption. Therefore, if the gas consumption in China reaches to 350 billion cubic meters in 2020, the peak shaving gas volume will reach 52.5 billion cubic meters. And with the increase of dependence on import, the increasing imported natural gas will result in more risks of supply disruption. So we need to consider the needs of strategic reserve. In China, the natural gas is imported mainly from Central Asia, Russia and sea route, so it is recommended to construct gas storages near the three import channels mentioned above or in the domestic long-distance gas pipeline network subs. It is estimated that the strategic reserves in 2020 and 2030 will be 11 billion and 35 billion cubic meters respectively. According to needs of peak shaving and strategic reserve, the working gas volume in UGS in 2020 and 2030 will be 63.5 billion and 110 billion cubic meters respectively.

3) Consumption structure of natural gas is gradually diversified, the proportion of urban gas is increased, and the demand for peak shaving of gas storage is increasing. Chemicals and industrial fuels are the main consumers of natural gas before 2000, accounting for 82% of total natural gas consumption in 1996, so it was not in urgent needs of peak shaving. With the growth of urban gas consumption and gas-fired power generation in recent years, the urban gas, industrial fuels, natural gas based chemicals and gas-fired power generation are becoming the equal consumers of natural gas. Since urban gas and gas-fired power generation have higher requirements on peak shaving, we need to construct more peak shaving supporting facilities and underground gas storages.

4) The large-scale development and utilization of coal-bed gas and shale gas made a higher requirement for gas storage. Currently, China is vigorously developing unconventional gas, particularly shale gas, coal-bed gas and tight gas. It is expected that the production of coal-bed gas, shale gas and coal gas will reach 50 billion, 80 billion and 10 billion cubic meters respectively by 2020.<sup>(2)</sup> As the single well production of unconventional gas is low, and itself has weak regulatory function, we have to construct peak shaving supporting facilities to ensure the development of utilization of these natural gas resources.

5) Balancing long-distance pipeline network speeds up the growth in demand for peak shaving gas storage. According to the practices in foreign countries, the demands for gas storages will grow rapidly in 5-10 years after a long-distance pipeline network is constructed, and then grow steadily after the consumption of natural gas reach the peak. Currently, the consumption of natural gas is still in rapid growth in China, so the demands for peak shaving can be satisfied by newly constructed pipelines that are not in full load. But when these long-distance pipeline networks are completed and in full load after 2020, the demand for gas storages will be more urgent.

In short, the demands for UGS will grow rapidly in China due to the growth in consumption of natural gas, the change in consumption structure, the needs of peak shaving and strategic reserve, and the utilization of unconventional natural gas. It is expected that the working gas volume in UGS will reach 65 billion cubic meters by 2020 and 110 cubic meters by 2030.



### **3 Challenges for development of UGS in China**

#### **3.1 Bottlenecks existing in gas peaking field**

1) Gas storage construction lags behind pipeline construction. China has strived to construct long-distance pipeline since the beginning of 21<sup>st</sup> century to meet the need of fast growing gas supply, but gas storage constructions were often officially launched after a pipeline was put into operation, and the construction cycle often lasted for 5-8 years. Therefore, the construction of gas storage could not meet the needs of pipeline construction and peak shaving growth. The contradiction between peaking demand and the lack of facilities has become pronounced.

2) Pipeline and gas peaking measures can not meet the needs of downstream market. China has a vast of lands and uneven distribution of natural gas resources, which are concentrated mainly in the western region while consumer market mainly locating in the eastern and southern regions; all long-distance pipelines are more than 1000km and some even longer than 3000km, so it is hard and expensive for upstream gas field and pipelines to meet the needs of gas shaving in downstream market.

3) The known geological resources for gas storage construction can not meet the future needs of gas storage construction. There are few resources discovered for gas storage construction in China, and the depleted gas reservoirs in major natural gas consuming regions can not meet the need of gas storage construction. In the major consuming regions like the Northeast, the Bohai Rim and Yangtze River Delta, all gas reservoirs has been included in gas storage construction plan, but they are still not enough for the peaking needs in the regions, so we have to look for new water levels for gas storage construction. There is no gas reservoir for gas storage construction in the Southeast and central South regions, so we have to choose aquifers and salt mines for gas storage construction, but it is hard to select site.

4) Design, technology and experience in gas storage construction are incompatible with complex geological conditions. For the gas reservoirs as the targets of gas storage construction, the serious problems like buried deep, low permeability and flooding have plagued the construction of gas storage. The distribution of salt layers in eastern and southern regions are characterized by layered distribution, multi-laminated, small thickness and hard to construct cavity. These are also the technical difficulties in construction of salt cavern gas storage in the world. Construction of gas storage in aquifer and oil reservoir is still a technology to be explored in China.

#### **3.2 The Challenges for development of UGS in China**

##### **1) Resource challenges**

Most of oil and gas reservoirs in eastern China have been included in gas storage construction plan. As the eastern regions have complex geological conditions, it requires a lot of work to find the right targets for gas storage construction. There is no achievement in oil and gas exploration in the southern regions, so it is impossible to construct gas storage based on oil and gas reservoirs, and it is also hard to explore aquifers for gas storage construction. The average working gas volume of individual gas storage in the world is 5000 million cubic meters. Therefore, 100 gas storages are required for each newly increased 50 billion cubic meters of working gas. To construct these gas storages, we have to discover and evaluate about 300 trap formations.

##### **2) Technical challenges**

(1) The targets for gas storage construction in China are more complex than those in foreign countries. It is a considerable challenge for constructing gas storages in low permeability and ultra deep geological conditions with complex gas-water system. In the targets for gas storage construction, underground gas and oil reservoirs are generally buried deep to over 2000m and even 5000m in deepest, with poor reservoir properties, some even only several Mds; and some targets are flooded, and it is hard to expend for gas storage construction. Moreover, a lot of these gas reservoirs were developed in 60s and 70s with complex well conditions, and it is difficult to repair them to reduce impact on the safety of gas storages. At the same time, a lot of the gas reservoirs are highly exhausted with low pressure

coefficients, and it is hard to drill, cement and complete wells.

(2) There is no aquifer gas storage and cavern gas storage constructed due to technical difficulty, but they are very important for southern China. For gas storage construction in salt layer, although the Jintan salt layer gas storage provided some experiences, there are still a lot of difficulties in cavity control and real-time monitoring during constructing gas storages in multi-laminated salt layers.

(3) In engineering technologies, especially for drilling and completion, there are still a lot of difficulties in ensuring safety of well bore. Presently, all gas storages are in key construction phase, but there are still a lot of difficulties in ensuring the safety of drilling and the quality of well cementing. Once these gas storages are put into operation, all injection well bores will face periodic changes in temperature and pressure during injection operation. It is essential to establish a scientific and effective system of safety evaluation to ensure safe operation of gas storage.

### 3) Management challenges

(1) Optimization of gas storage management and operation and improvement of gas storage operating performance is a very complex subject. It includes raising operating pressure, reducing the effects of water intrusion, safety management practices; emergency injection program, gas storage monitoring, and well bore and system integrity management and monitoring.

(2) Gas storages continue to increase with different types, and distribute along and on the upstream and downstream of different pipelines. It is essential to optimize the management of pipelines and gas storages as a whole based on different diameter, pressure system and injection peaking methods. It is necessary to research a best deployment and operation program taking into account the pipeline transportation efficiency and gas storage capacity under normal peak shaving condition; the most optimized gas storage injection operation program for different pipelines, gas supply phases, pipeline maintenance and accident conditions; and the reasonable pipeline and gas storage allocation program under extreme weather conditions in different regions, so that to provide a systematic emergency response plan.

## 4 Solutions for challenges

To overcome the difficulties in constructing gas storages in China's complex geological conditions, the government strives to provide security measures to ensure safe and stable operation of natural gas.

1 China is striving to construct strategic reserves of natural gas taking the advantages of large gas fields and closing to main import channel in central and western China, to face the increasingly complex situation of gas import and gas supply security, so as to reduce the risk of gas supply interruption due to unexpected events.

2 Step up and accelerate the construction of scheduled gas storages to meet the needs of gas storage peaking and emergency gas supply. It is expected that the total working gas volume for these purpose will reach 15 billion cubic meters by 2015.

3 Actively carry out international cooperation, with emphasis on improving operating performance of low permeability gas reservoirs, management of gas well integrity in deep gas reservoirs, and construction of gas storages in multi-laminated, salt and aquifer layers.

4 Strengthen reservoir site evolution and exploration to look for new gas storage construction resources. To solve the problems of inefficient resources for gas storage construction in the downstream of pipelines and the high pressure on peak shaving, gas operators are exploring and evaluating gas reservoirs along pipelines and near target markets. At the same time, they are actively studying LNG and other emergency response measures for peak shaving to meet the growing demand for gas storage in these regions.

5 The government is studying and driving the change of natural gas pricing mechanism and the peaking gas pricing system, so that to drive a more commercial construction of peak shaving facilities and encourage the construction of UGS.

## 5 Conclusion



In short, China's UGS is still in the initial stage of development, and there are a lot of challenges for construction of gas storages, but as long as we pay attention to the significance of gas storage in the upstream and downstream, make effort to introduce foreign experiences and technologies to innovate our technologies and management, and continuously strengthen construction of gas storage, our gas storage industry will undoubtedly develop rapidly with the development of natural gas industry. It will also play an important role in stable and safe supply of natural gas in China.

#### **About the author**

Ding Guosheng, male, born in 1966, Senior Engineer and post doctorate, is now the Deputy Director of UGS Center, Langfang Branch, RIPED. He has long been engaged in underground gas storage planning, research and design.

Add: UGS Center, P.O. Box No.44, Wanzhuang, Langfang City 065007, Hebei Province  
email: [dgs69@petrochina.com.cn](mailto:dgs69@petrochina.com.cn)

#### **【 References 】**

- [1] Qiu Jian, Fang Hui, Surging of Natural Gas in China: A New Journey of China's Petroleum Industry [J]. Natural Gas Industry, 2009, 29 (10): 1~4
- [2] Pan Jiping, Hu Jianwu, An Haizhong, Policies for Promoting the Development of Unconventional Natural Gas Resources in China [J]. Natural Gas Industry, 2011, 31 (9) :1-6.