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# Natural Gas Market in China

## *Current State and Prospects of Development for Trading Activities*

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# Abstract

This research paper comprehensively analyzes the natural gas market in China ("this market"), focusing on this market's current state and prospects for trading activities. For better understanding, the paper also summarizes the historical evolution and reforms of this market and then refers to the US and the UK practices. Main findings include: at present, (1) this market is growing fast driven by policies; (2) the Chinese government plays a pivotal role in this market but is attempting a hands-off approach; (3) physical trading is limited due to state monopolies and the regulated pricing; (4) financial trading is foreseeable but depends on the progress of the ongoing market and pricing reform. Since market liberalization is inevitable, major suggestions for developing this market include: (1) to participate more in the international gas market; (2) to introduce more competition in the upstream market; (3) to accelerate the construction of gas infrastructures and unbundle transportation from sales; (4) to push more trading activities into gas hubs. As marketization deepens, either physical or virtual gas hubs are feasible in China.

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# Table of contents

# List of tables and figures

## Tables



## Figures

# Part I. Introduction

## 1. Research orientation

### 1.1 Background

Natural gas is the kind of primary energy that is clean (**Table 1**), low-carbon (**Table 1**), efficient (**Table 2**), and of high quality. Serving as a bridge (i.e., transitional energy) between fossil fuels and renewable energy, natural gas is a realistic choice for energy conservation and emission reduction, and it is very helpful to cope with urgent ecological problems such as global warming and air pollution.

***Table 1.*** *Air pollutants produced by different kinds of primary energy*

(Pounds per billion British thermal unit (Btu) of energy)

| Pollutant | Natural Gas | Oil | Coal |
|---|---|---|---|
| Carbon Dioxide | 117,000 | 164,000 | 208,000 |
| Carbon Monoxide | 40 | 33 | 208 |
| Nitrogen Oxides | 92 | 448 | 457 |
| Sulfur Dioxide | 0.6 | 1,122 | 2,591 |
| Particulates | 7.0 | 84 | 2,744 |
| Formaldehyde | 0.750 | 0.220 | 0.221 |
| Mercury | 0.000 | 0.007 | 0.016 |

Notes: No post combustion removal of pollutants. Bituminous coal burned in a spreader stoker is compared with No. 6 fuel oil burned in an oil-fired utility boiler and natural gas burned in uncontrolled residential gas burners. Conversion factors are: bituminous coal at 12,027 Btu per pound and 1.64 percent sulfur content; and No. 6 fuel oil at 6.287 million Btu per barrel and 1.03 percent sulfur content—derived from Energy Information Administration, *Cost and Quality of Fuels for Electric Utility Plants* (1996).

Source: Energy Information Administration (EIA), Office of Oil and Gas. **Carbon Monoxide:** derived from EIA, *Emissions of Greenhouse Gases in the United States 1997*, Table B1, p. 106. **Other Pollutants:** derived from Environmental Protection Agency, *Compilation of Air Pollutant Emission Factors*, Vol. 1 (1998).

Source: EIA. (1999). Natural Gas 1998: Issues and trends. Retrieved from http://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/4265704/FID1578/pdf/gas/056098.pdf

***Table 2.*** *Energy efficiency comparison between coal and natural gas*

| Efficiency | Power generation | Industrial boiler – steam generation | Thermal generation for civil use | Consumption for chemicals (kg/tonne of Nitrogen) |
|---|---|---|---|---|
| Coal | Conventional: 35%<br>IGCC:45% | 65% - 80% | 15% - 30% | 1570 - 1800 |
| Natural gas | CCGT:60% | 86% - 90% | 55% - 65% | 990 - 1210 |

Note: IGCC denotes the integrated gasification combined cycle, which is currently the best technology for coal power generation. CCGT denotes the combined cycle gas turbines.

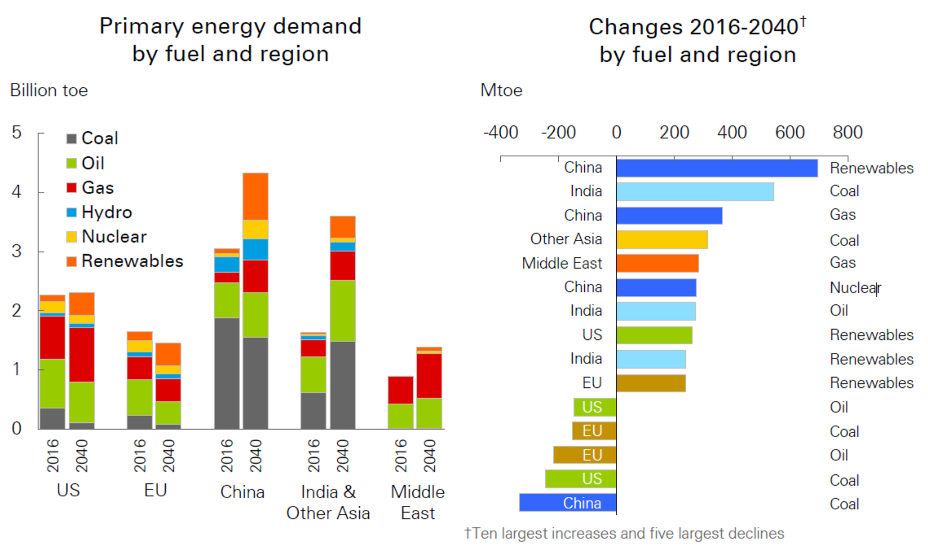
Source: Niu, et al. (2013)

Regarding China's energy situation, according to BP, since 2009, the total energy consumption of China has been ranking first in the world, surpassing that of the United States. In Year 2016, China's energy consumption accounted for 23.0% of the world, in contrast to the US energy consumption ranking second and accounting for 17.1% of the world. Now China is continuing to be the world largest energy consumer — by BP's prediction, in 2040, China's energy consumption will be 24% of the world, in contrast to the US energy consumption to be 13% of the world. However, due to the heaviest weight of coal in its energy mix, for every unit of GDP, China consumes more energy and emits more carbon dioxide than the world average, so it has born pressures from Paris Accord and suffered from poor air quality in major cities.

Realizing such serious problems, China is putting in efforts to cut down its carbon footprint and propel the switch from coal to natural gas. The Chinese government is appealing for the "battle for the blue sky" and the revolution of energy production and consumption. According to the government policy, natural gas shall replace coal to become one of main energy sources in China. Predicted by BP Energy Outlook 2018, China is going to substantially raise the weight of natural gas in its primary energy mix by 2040, thus driving the world energy mix towards a much cleaner one (**Figure 1**).

But the indicators in **Figure 1** will not work out automatically. For China, there are still many obstacles to overcome, one of which is its immature natural gas market and system.

***Figure 1.*** *Changes in the world primary energy demand by fuel from Year 2016 to 2040*




Source: BP (2018, February).

To sum up, because of (1) the superiorities that natural gas has over other primary energy sources and (2) the large impacts that China's energy consumption amount and structure have on the world, it's meaningful to conduct such a research on China's natural gas market as to investigate its current state and to know more about its future trends

– whether this market will help make China cleaner and greener. In the meanwhile, by using various analysis methodologies, the research hopes to raise some valuable suggestions for the development of this market.

## 1.2 Objectives

Considering the impacts of China's energy mix on the world and the strategic position of natural gas in China's energy mix, the research is dedicated to addressing the following questions:

(1) What are the Chinese government policies towards the natural gas market? Are they in line with the world trends and in the right direction? Can natural gas trading activities prosper in such policy environment?

(2) What's the current development stage that China's natural gas market is at, in terms of demand, supply, and infrastructure? Is natural gas effectively used? Is there any weakness in gas supply or threat to energy security? Is demand and supply balanced? Does infrastructure fit demand and supply?

(3) What's the current natural gas market structure and pricing system in China? How can they be improved along the natural gas value chain, compared to the US and the UK natural gas markets? What are China's advantages and disadvantages in the way of improvement?

(4) What are the current states and progresses of natural gas trading hubs in China? How does physical trading work and what are the prospects of financial trading? In comparison with the US and the UK natural gas hubs, how can Chinese gas hubs be properly developed to foster trading and to better serve the Chinese natural gas market reform?

The research aims to comprehensively analyze the current state of the natural gas market and to exhibit the prospects of natural gas trading hubs and trading activities in China. Moreover, by reviewing the historical footsteps of the Chinese natural gas pricing reform and learning the relevant experience of the US and the UK, the research intends to put forward strategic suggestions about the further development of China's gas market and its trading activities.

## 1.3 Methodologies

To answer the questions and achieve the objectives mentioned above, the research basically applies four methodologies as follows:

**(1) Descriptive statistical analysis**

With statistical methods, the research precisely demonstrates the real status quo and the future trends of China's natural gas market. The data used for statistical analysis is collected from multiple sources, which include authoritative databases, academic papers, brokers analysis, media reports, government publications, etc.

**(2) Case study**

The research uses the most related case, the gas shortage in China as of winter 2017-18 (i.e., from early October 2017 to late February 2018), as evidence of the most crucial loopholes in China's natural gas market for now. This case also indicates the directions for future progress of the market.

**(3) Comparative analysis**

After looking through various natural gas markets over the world, the research chooses the US and the UK natural gas markets as the benchmarks, which are the most mature gas markets in the world and believed to provide the most relevant and valuable experience for China to learn from. Hence, with the purpose of making meaningful conclusions and proposals for the development of China's gas market, the research first reviews the reform steps of the US and the UK gas markets, then studies their benchmark gas hubs – the US Henry Hub and the UK National Balancing Point (NBP), and finally makes comparisons with China's gas market and hubs to gain insights.

**(4) SWOT analysis**

To identify the current state and prospects of China's natural gas market in a more organized way, the research uses the SWOT matrix to summarize this market's internal attributes and its external environment. Then by combining SO, ST, WO, or WT in SWOT, strategies for developing this market are logically achieved.

## 1.4 Framework

As shown in **Figure 2**, the research paper is divided into 5 parts (in the largest boxes).

Part 1 is the introduction. First is the orientation of the research, explaining why this research, how the research is carried out, and the research's framework. Then come the reviews of existing studies, pointing out the necessity of deregulating China's gas market and thus setting the tone for the research.

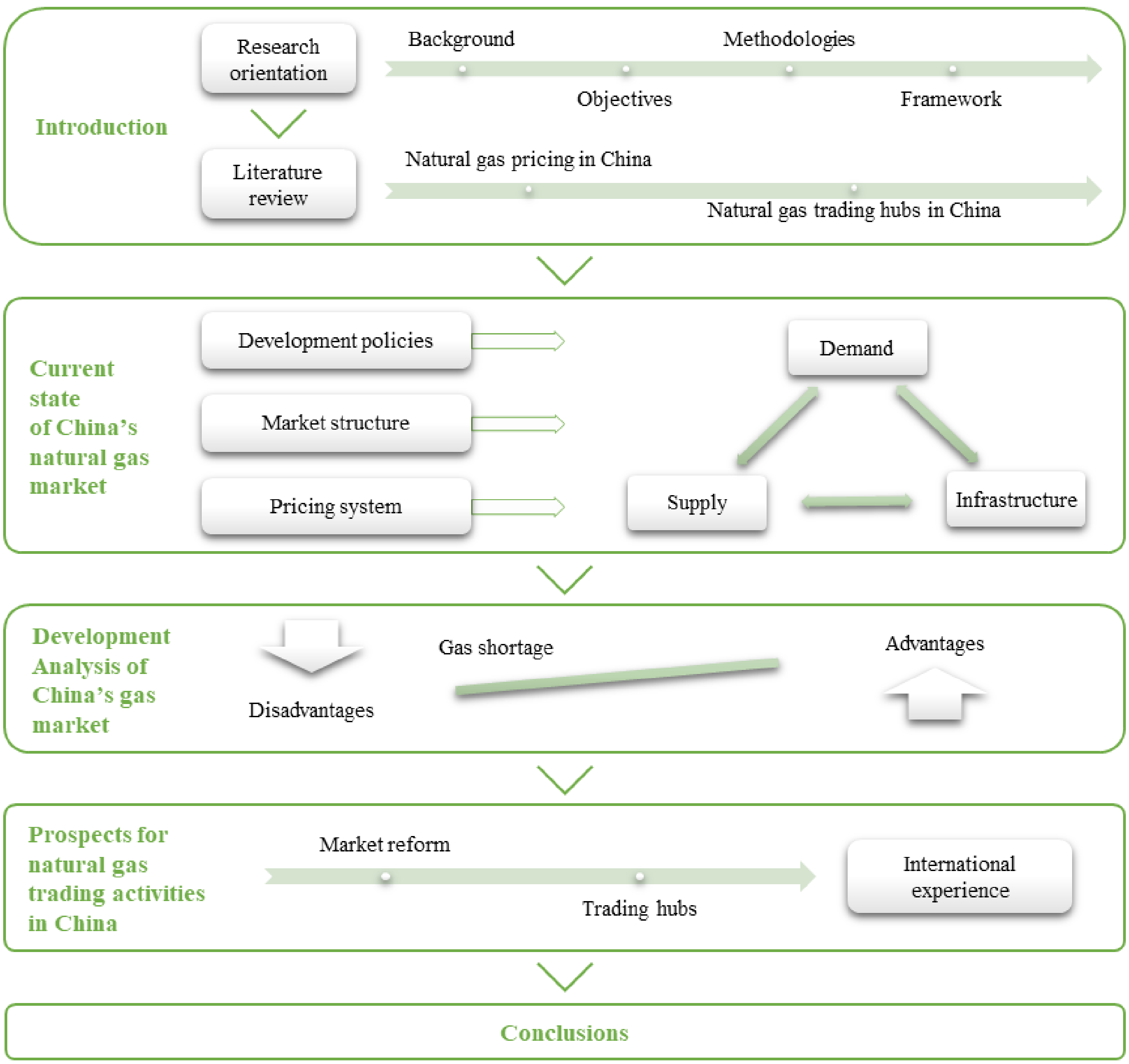
Part 2 presents the current state of China's natural gas market, which is analyzed from six aspects – government policies, demand, supply, infrastructure, the market structure, and the pricing system.

Part 3, as an intermediate conclusion, highlights the advantages and disadvantages in the development process of China's gas market up till the present. This part also shows a real-life case, the gas shortage in China as of winter 2017-18, to further illustrate these development features.

Part 4 starts from looking into the evolution of the US and the UK natural gas markets and their trading activities, draws the successful experience of market reform, and makes comparisons with China's natural gas market. Then this part generalizes the successful reasons of two typical natural gas hubs – the US Henry Hub (physical) and the UK NBP (virtual) – and examines how these reasons can be applied to the establishment of Chinese gas hubs. Next, the part goes into details about the existing natural gas trading hubs in China, reveals their current states and trading activities, and gives outlooks for these hubs through comparison with Henry Hub and the NBP.

In the end, Part 5 concludes the research and brings up strategic recommendations for the upcoming development of the natural gas market in China and its trading activities.

***Figure 2***. *Structure of this research paper*



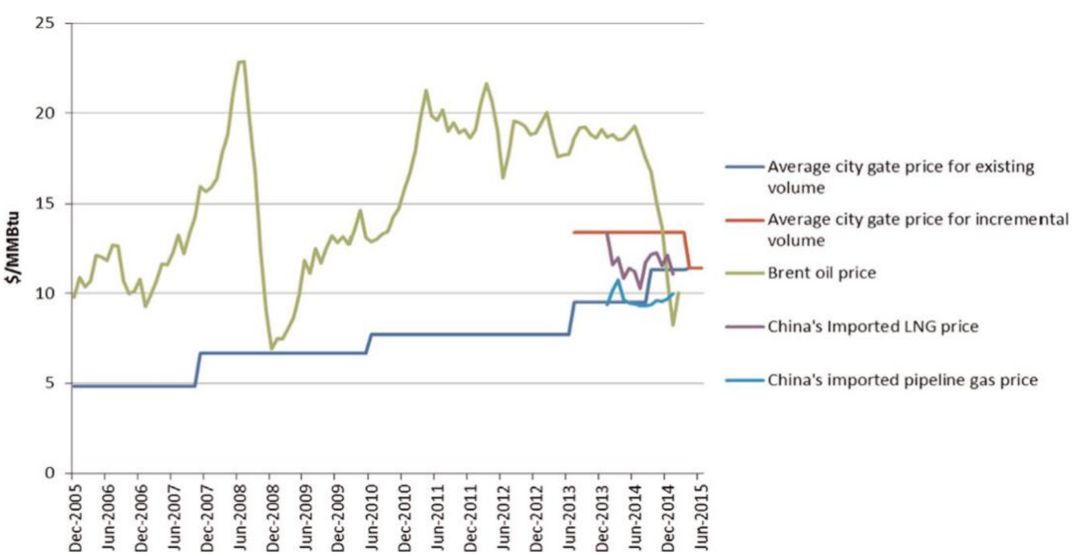
# 2. Literature review

## 2.1 Pricing mechanisms

Both Chinese and international scholars have consensus that China should adopt the gas-on-gas competition (GOG) pricing, allow third-party access (TPA) to gas pipeline networks, and liberalize the natural gas market eventually. It's because among all the pricing mechanisms, GOG or marginal cost pricing maximizes social welfare to the most (Jiang, Q., 2013; Wang, S., 2015). Specially, deregulating the natural gas price can greatly increase the market penetration of natural gas-fired electricity (Tian, R., et al., 2017). And TPA means any operator of natural gas infrastructures shall provide any other party convenient access to the infrastructure. This allows consumers to buy gas directly from sellers, with no need for grants from the infrastructure owner. In this way, TPA endows consumers with stronger bargaining power, thus stimulating the efficiency of the natural gas value chain and increasing the profits of the whole industry (Zhang, Y., 2016).

In fact, since 2005, the Chinese government has carried out a series of reforms of its natural gas pricing methods and raised the gas price several times to make it closer to the market value (**Figure 3**). Hence, a lot of research papers have discussed about the effects of these reforms and whether the liberalization of the natural gas market is a right choice for China.

***Figure 3.*** *Chinese natural prices vs. Brent oil price*




Source: Paltsev, S., & Zhang, D. (2015).

In terms of the Chinese macro economy, in the short term, an increase in the natural gas price will lead to an increase in the Consumer Price Index (CPI) and an increase in the Producer Price Index (PPI), but a decrease in the Gross Domestic Product (GDP) (Wang, S., 2015; Zhang, W., Yang, J., Zhang, Z., & Shackman, J. D., 2017; He, Y., &

Lin, B., 2017). But in the long term, an increase in the gas price won't hurt the GDP too much, and deregulation of the natural gas ex-plant price will decrease the CPI and increase the real GDP (He, Y., & Lin, B., 2017).

In terms of the welfare of gas producers and consumers, the change from the "cost-plus" pricing to the "netback" pricing will increase the producers' profits but decrease the consumer surplus and decrease the total social welfare (Zhu, Y., 2014; Wang, Sh., 2015; He, Y., & Lin, B., 2017). To put it another way, the netback pricing, which links the price of natural gas to the values of its alternatives – imported fuel oil and liquified petroleum gas (LPG), in fact benefits gas producers or large gas suppliers, rather than the consumers who were protected by the cost-plus pricing before the change. Therefore, natural gas supply is incentivized by the netback pricing to satisfy unexpected high demand (Wang, S., 2015; Paltsev, S., & Zhang, D., 2015).

In addition, consumers in China of indigenous gas are more sensitive to the gas price changes than those of imported gas (Jiang, Q., 2013). In this sense, it's reasonable for the Chinese government to hold the prices of indigenous gas in control but deregulate the prices of LNG imports at the current stage, because consumers of indigenous gas will be more hurt than those of imported gas when the market fluctuates. Moreover, industrial users are more sensitive to the gas price changes than residential users (Wang, S., 2015). So, there's still some space to raise the residential gas price, which now in China is just equal to the industrial gas price, whereas in OECD member countries, residential gas prices are generally higher than industrial ones.

Overall, despite some negative effects mentioned above of adjusting the natural gas price to the market, the netback pricing is indeed suitable for China's current situation, because it straightens out the relationship between natural gas and alternative energy sources and makes the gas price more transparent and predictable. Also, in order to avoid any potential negative effect or opposition of a more flexible pricing system, interim arrangements before full liberalization, like the netback pricing, are imperative (Zhang, W., et al, 2017). Specifically, as the gas price increases from the controlled level to the market level, the netback pricing forces consumers to use natural gas more intensively with less waste (Wang, S., 2015).

## 2.2 Trading hubs

Although the Chinese government holds the control of China's natural gas market, this market has its competitive advantages and enjoys late-mover opportunities of establishing a successful natural gas hub (**Table 3**). Firstly, China has diversified natural gas supply, while Singapore and Japan almost 100% rely on imported LNG. Secondly, China has some superior locations equipped with dense transportation facilities and attracting multiple market players, of which Shanghai is the most outstanding. Shanghai is not only the financial center of China, but also a converging point of major pipelines and LNG terminals. If China improves the software conditions such as the market structure, pricing system, and regulations, and adds more gas storage facilities and completes the gas transportation system in

Shanghai, Shanghai has the biggest potential to become a powerful benchmark hub in Asia Pacific (Tong, X., Zheng, J., & Fang, B., 2014).

As a matter of fact, since Shanghai Petroleum and Natural Gas Exchange (SHPGX) was put into formal operation in November 2016, Chinese policymakers has the intention to develop Shanghai into a natural gas pricing center of Asia Pacific. But there're a lot to improve before realizing the goal. The improvements, according to Liu, M. (2017), include: first is to have a market-based natural gas *pricing system*. Reforming the current pricing system, the Chinese government raises an idea which is, "controlling the middle, liberalizing both ends" of the natural gas value chain. Second is to form a competitive natural gas market with numerous diversified *market players*. As state monopolies are dominating China's gas market, this reform has to be pushed by the government efforts. Third is to form a natural gas *futures market*, which shall be done step by step: step 1) to standardize physical natural gas contracts traded in SHPGX; step 2) to widen the range of spot natural gas contracts, particularly to introduce mid-term and long-term spot contracts; step 3) to launch natural gas futures, swaps, and options in some appropriate time.

***Table 3.*** *Competitive analysis of the four countries in Asia Pacific in terms of establishing a natural gas hub*

| | Conditions for establishment | Weight | China | Singapore | Malaysia | Japan |
|---|---|---|---|---|---|---|
| Intrinsic base | Spot and futures trading platforms for natural gas | 20% | + | +++ | −−− | +++ |
| | Abundant natural gas supply | 20% | +++ | −−− | − | −−− |
| Hard conditions | Good ports and excellent international transportation location | 10% | +++ | +++ | + | + |
| | Complete infrastructures | 10% | + | − | −−− | −−− |
| | International energy companies and financial companies | 10% | +++ | +++ | − | + |
| Soft conditions | Free and open market structures | 15% | − | +++ | − | +++ |
| | Complete law and regulation systems | 15% | − | + | − | − |

Note: The basis for score relating to competence is not detailed owing to the limited length of this paper. For further information, please contact the authors directly.

Source: Tong, X., Zheng, J., & Fang, B. (2014).

# Part II. Current state of the natural gas market in China

## 3. Development policies

A main feature of the natural gas market in China is policy-driven. In other words, the Chinese government plays the pivotal role in this market by enacting policies and holding shares in giant oil and gas companies. Therefore, it's essential to understand the Chinese government's development policies relating to the natural gas market, which display a general picture of the current market and indicate where the market is going next.

### 3.1 Thirteenth Five-Year Plan

In December 2016, National Development and Reform Commission (NDRC) of the People's Republic of China (PRC) released "the 13th five-year plan (from 2016 to 2020) for energy development" and particularly "the 13th five-year plan for natural gas development" (hereinafter both two plans referred to as "the Plan"), which demonstrate the top-level design of China's natural gas market by the end of 2020.

The Plan places emphasis on economic efficiency and green development, therefore low-carbon and clean energy like natural gas and renewable energy will be the main increments of energy consumption in China, and the replacement of coal with natural gas will be intensively pushed. Numerically, with the total energy consumption per annum controlled below 5 billion tonnes of standard coal equivalent (TCE) by the end of 2020, the Plan requires that natural gas should account for more than 10% (5.9% in 2015) of the primary energy consumption per annum, non-fossil fuel account for more than 15% (12% in 2015), and coal less than 58% (64% in 2015).

The Plan also stresses that increasing the proportion of natural gas in China's primary energy consumption: (1) is an evitable path towards a clean, low-carbon, safe, and efficient modern energy system; (2) is a realistic choice to effectively control air pollution and to actively deal with ecological environment problems such as climate change; (3) is important content in the promotion of "clean heating" in the Northern area and the revolution of Chinese rural lifestyle; and (4) can push the development of related equipment manufacturing so as to foster a new economic growth point.

Since natural gas is crucial for China to change its energy mix and fulfill its climate pledge in Paris Accord by 2030, in June 2017, NDRC and other 12 relevant government departments jointly released "Opinions on the acceleration of natural gas use" (hereinafter referred to as "the Opinions on the Acceleration"), which additionally sets goals of increasing the consumption proportion of natural gas in primary energy per annum to 15% and increasing the effective working capacity of underground gas storage to over 35 billion cubic meters (bcm) by 2030, in pursuit of making natural gas one of the main energy sources in China's modern energy system.

### 3.1.1 Development goals

The Plan declares 4 development goals of the natural gas industry in China during the 13th Five Years as follows: (1) proven reserves: the proven reserves of conventional gas shall increase by 3 trillion (tn) cubic meters (cu.m), shale gas by 1 tn cu.m, and coalbed gas by 0.42 tn cu.m; (2) guaranteed supply: overall natural gas supply in 2020 shall exceed 0.36 tn cu.m; (3) infrastructure: the length of major pipelines shall increase by 40 thousand (K) kilometers (Km), and the working capacity of underground storage *must* reach 14.8 bcm (compulsory); (4) market system: the natural gas market reform shall be accelerated, along with the improvement of the legal and regulatory system and the policy system. The details are listed in **Table 4**.

***Table 4***. *Political targets of the natural gas industry in China towards Year 2020*

| Natural gas | Year 2015 | Year 2020 | CAGR |
|---|---|---|---|
| **Proportion in primary energy consumption** | 5.9% | 8.3 - 10% | - |
| **Accumulated proven reserves (tn cu.m)** | | | |
| o.w. Conventional gas | 13 | 16 | 4.3% |
| o.w. Shale gas | 0.5 | 1.5 | 24.6% |
| o.w. Coalbed methane (CBM) | 0.58 | 1 | 19.0% |
| **Production (bn cu.m/ year)** | 135 | 207 | 8.9% |
| o.w. Shale gas | 4.6 | 30 | 45.0% |
| o.w. Coalbed gas | 4.4 | 10 | 18.0% |
| **Pipelines** | | | |
| o.w. Length (K Km) | 64 | 104 | 10.2% |
| o.w. One-time transportation capacity (bn cu.m) | 280 | 400 | 7.4% |
| **Working capacity of underground storage (bn cu.m)** | 5.5 | 14.8* | 21.9% |
| **Installed capacity of power generation (GW)** | 66.37 | 110 | 10.6% |
| **No. of LNG filling stations (K)** | 6.5 | 12 | 25.0% |
| **Population covered by gasification (M)** | 330 | 470 | 10.3% |
| Gasification rate of urban population | 42.8% | 57.0% | - |

*: compulsory target.

### 3.1.2 Key tasks

In order to achieve the development goals above, the Plan lists 4 major tasks during the five years as follows.

1. To enhance exploration and exploitation of natural gas to improve domestic production.

In accordance with the policy of "simultaneously developing on shore and off shore, conventional and unconventional", (1) investment in domestic exploration shall be continuously increased, and investigation and assessment shall be strengthened. (2) Production of conventional gas shall mainly come from the proven reserves in 4 production bases – Tarim Basin, Ordos Basin, Sichuan Basin, and the marine area (**Appendix 3**), where exploitation of natural gas shall be accelerated. (3) More efforts shall be put into the research and development (R&D) of low-graded or unconventional gas, especially shale gas and CBM, aiming to make major breakthroughs in technical bottlenecks and realize economic scales.

2. To foster natural gas consumption and promote efficient usage.

Gasification and gas usage shall be promoted in three fields: (1) fuels in regions with heavy air pollution – the Beijing-Tianjin-Hebei (BTH) region, the Yangtze River Delta (YRD), the Pearl River Delta (PRD), and the Northeast; (2) electricity generation (By 2020, natural gas-fired generation shall account for over 5% of the total installed capacity of power generation.); (3) vehicles including city buses, taxis, sanitation cars, and cargo trucks, and LNG fueled vessels in inland rivers, lakes, and coastal areas (By 2020, about 10 million vehicles will be gasified, with over 12,000 gas stations and over 200 marine gas stations built.). In the meanwhile, the efficient and economical usage of natural gas by advanced technologies and equipment is encouraged to avoid any waste.

3. To accelerate construction of pipeline networks.

Major importing channels and domestic arteries shall be further improved, including pipelines linking to LNG import terminals. Gas transportation capabilities in the BTH region and the urban agglomerations in the middle of Yangtze River need to be greatly enhanced. The Opinions on the Acceleration also asks to complete "the last one mile" of pipelines connecting to rural and remote areas. Moreover, interconnections between pipelines run by different transmission operators and TPA will be allowed.

4. Accelerate construction of storage facilities and enhance peak load regulation.

The working capacity of underground gas storage and the capacity of LNG storage tanks shall be increased. With regards to this issue, in April 2018, NDRC and National Energy Administration (NEA) of the PRC released "Opinions on accelerating construction of gas storage facilities and improving the market mechanism of gas storage and peak regulation services", in which 3 targets by 2020 are clarified: (1) A gas supplier shall set up storage facilities which have a capacity of no less than 10% of its annual contractual sales, enough to meet seasonal (monthly) peak-shaving requirement or cope with emergent disruptions. (2) A prefecture-level city shall have a storage capacity which could satisfy 3-day gas demand of the city every day. Cities in the North, especially those in The BTH region suffering severe air pollution, should further raise the storage standards. (3) A local distribution company shall set up storage facilities and have a capacity of no less than 5% of its annual use. In addition, large end users are encouraged to build self-owned storage facilities and other emergency measures. Also, when in shortage, gas for residential use shall be guaranteed first and unconditionally – whether written in contracts or not.

Prices of storage facilities and services and gas used for peak shaving shall be market-determined, that is, dependent on demand and supply with no government intervention. What's more, (1) storage facilities shall be financially independent; (2) independent companies specialized in storage services are encouraged to be set up; (3) gas for storage is encouraged to be listed for trading in Shanghai and Chongqing natural gas exchanges.

### 3.1.3 Supporting measures

The Plan states eight supporting measures to guarantee its key tasks to be perfectly executed, of which the most notable ones are further reforming the natural gas value chain, further restructuring state-owned oil & gas companies, and deepening the marketization of the natural gas industry. Following the Plan, in May 2017, the Central Committee of the Communist Party and the State Council of the PRC co-issued "Several opinions on deepening the reform of the oil and gas system", which lists 8 tasks as detailed expansions of the supporting measures stated in the Plan. **Table 5** summarizes main contents of the 8 tasks and identifies possible obstacles during the execution of these tasks.

***Table 5***. *Tasks and obstacles of the Chinese natural gas system reform*

| Task | Main contents | Obstacles |
|---|---|---|
| 1. Open access to exploration and exploitation | 1) Participation of diverse economic entities besides state-owned companies;<br>2) Mineral rights bidding system;<br>3) Stricter exit mechanism. | 1) Specific requirements on exploration or exploitation qualifications;<br>2) Quality of blocks released by state-owned companies. |
| 2. Improve gas import and export management system | Enhancement of the capabilities of utilizing international and domestic resources and preventing market risk. | China's natural gas pricing power is relatively weak, for it doesn't have an enough mature gas trading hub yet, nor a convincing pricing system. |
| 3. Unbundle pipeline networks | 1) Unbundling of pipeline transportation and gas sales step by step;<br>2) TPA to pipelines. | Possible contradictions between restructuring of state-owned companies and the unbundling process. |
| 4. Deepen competition in the downstream | 1) Expansion of gas consumption;<br>2) Fair competition in gas distribution. | Gas distribution companies may face more fierce competition or even be forced to change business models. |

| | | |
|---|---|---|
| 5. Advance pricing reform | 1) More market-based prices of gas for non-residential use;<br>2) Accelerated development of natural gas trading platforms;<br>3) Strengthened regulation on the costs and prices of pipeline transportation. | Differentiation and positioning of multitude trading platforms. |
| 6. Restructure state-owned oil & gas companies | 1) Private or foreign capital investment;<br>2) Demerger of departments like engineering technology, construction, and equipment manufacturing. | 1) Timeline of restructuring;<br>2) Complicated ownership structures. |
| 7. Improve gas storage and peak load regulation | Gas suppliers, pipeline companies, gas distribution companies, and large end users shall all have responsibilities of storing and peak shaving of natural gas. | Related companies may have pressures (because of lacking money) of building these facilities. |
| 8. Improve safety and environmental protection in the system | 1) A complete system of safe production, especially risk management;<br>2) Safe and clean operation in the whole natural gas value chain. | Contradictions between economic profits and safety or environment protection. |

Overall, this system reform, if strictly carried out, will change China's natural gas market in two major parts. First, it will break down the state monopolies and introduce competition into the upstream and the downstream of the gas value chain. Second, gas wellhead prices and storage prices will be determined by the market, while transportation prices are controlled by the government – so called "controlling the middle, liberalizing both ends".

The Opinions on Accelerating also suggests reducing the hierarchies in the midstream of the gas value chain and letting end users freely choose gas supply sources and transport paths, by which way gas flows along the value chain will be more efficient and cost-saving.

## 3.2 Coal-to-gas switching

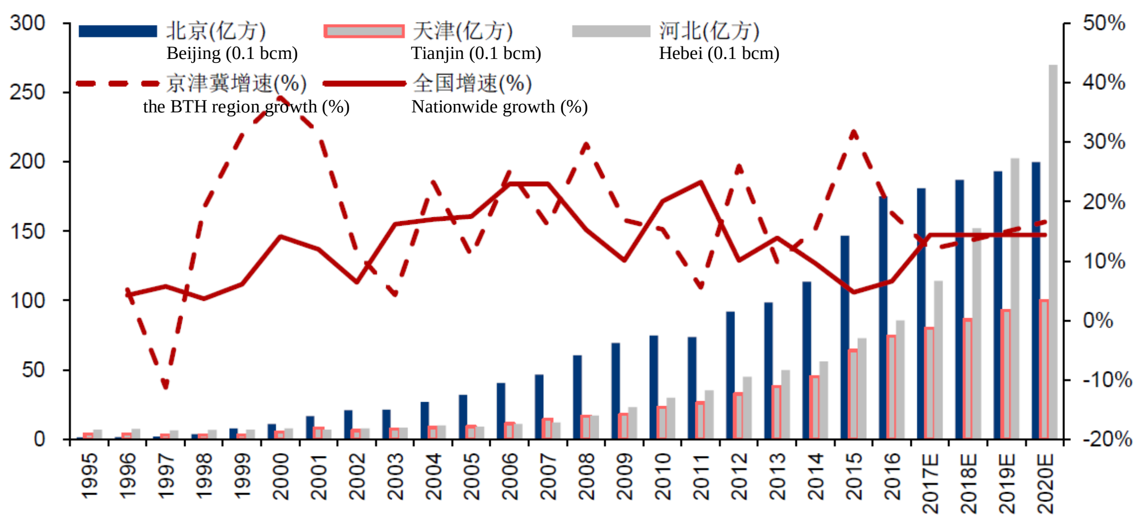
In September 2013, the State Council of the PRC issued the "Air pollution prevention and control action plan" which states 10 measures to prevent and control the air pollution (hereinafter referred to as "the Ten Articles") as the starting point of the coal-to-gas switching policy. The Ten Articles requires adjusting the energy mix more quickly where clean energy should be more heavily weighted, and the BTH region, the YRD, and the PRD – the three key megalopolises – are targeted with a priority.

In specific indicators, compared with 2012, by 2017, nationwide urban concentrations of PM10 should decreased by more than 10%; regional PM2.5 concentrations should respectively drop by about 25% in the BTH, 20% in the YRD, and 15% in the PRD, among which the annual average concentration of PM2.5 in Beijing should be specially controlled below 60 micrograms per cu.m.

Policies relating to the coal-to-gas switching in the Ten Articles are mainly: (1) to implement ceilings of coal consumption (The 3 key megalopolises should have negative growth of coal consumption by way of replacing coal with electricity, natural gas, and non-fossil fuels, and restricting coal-fired power plants.); (2) to push the utilization of clean energy (The incremental supply of natural gas should be used preferentially in the residential sector or as a substitute to coal; by 2017, the increase of the gas pipeline capacity should be more than 150 bcm and cover the 3 key megalopolises, and the switching from coal-fired to gas-fired facilities in industries of the 3 key megalopolises should be substantially finished.); (3) to reform natural gas pricing mechanisms, making gas prices in line with prices of alternative energy sources.

Following the Ten Articles, a series of government policies, either national or local, are issued to urge the replacement of coal with natural gas as soon as possible. The Plan vigorously promotes coal-to-gas projects in key cities in the BTH region, the YRD, the PRD, and the Northeast, such as phasing out of coal boilers, industrial kilns, and coal-fired facilities, and expanding the scope of zones prohibited from burning high-pollution fuels. The Opinions on the Acceleration appeals that by 2017, the "2+26" key cities of the BTH air pollution transmission channel should basically realize the conversion from coal-fired heating to clean heating, such as natural gas-fired heating, electric power, geothermal, and industrial waste heat. Pushed by the government's stricter rules, the consumption growth rates in the BTH region since the Ten Articles was enacted are much higher than the growth of the national consumption (**Figure 4**). The result is optimistic: by the end of 2017, when the Ten Articles has finished its first 5 years, all numerical targets were achieved.

***Figure 4****. Natural gas consumption in the BTH region and China*




Source: Huatai Securities (2017, November 6).

But the "battle for the blue sky" won't come to the end with the deadline of the Ten Articles until the air pollution is completely controlled. In December 2017, NDRC, NEA and other 8 government agencies issued the "2017–2021 winter clean heating plan for northern regions", one of the new targets set by which is to make clean heating cover over 70% of the heated floor space in the North and 100% in the "2+26" key cities by the end of 2021.

# 4. Demand, supply, and infrastructure

## 4.1 Demand

### 4.1.1 Vertical comparison

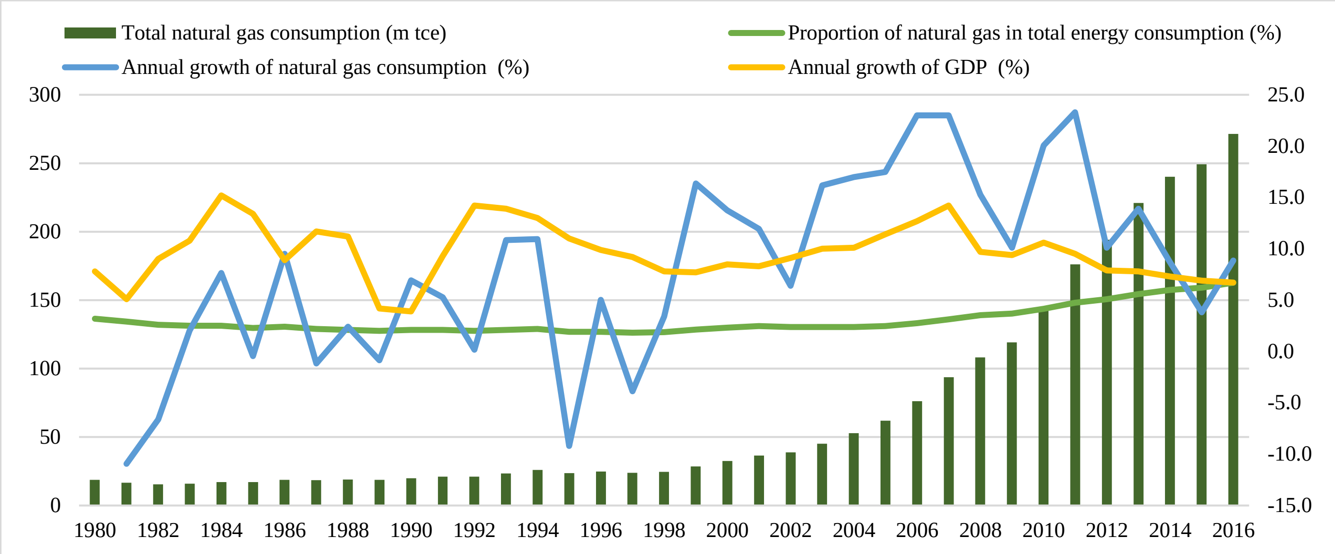
China's consumption of natural gas is highly related to the GDP growth, urbanization, and price relations between natural gas and alternative energy sources. With the rapid growth of China's GDP (**Figure 5**) and continuing urbanization (**Figure 6**), the natural gas consumption (**Figure 5**) keeps rising since 1998. Specifically, before 1990, the consumption of natural gas was little and volatile. In 1991 - 1995, the Compound Average Growth Rate (CAGR) of natural gas consumption is 3.1%; in 1996 - 2000, the CAGR increased to 6.7%.

When entering the 21th century, the consumption was greatly boosted by the discovery of gas fields in Ordos basin and Tarim basin and the construction of West-East gas pipelines. The operation of West-East Gas Pipeline I from the beginning of 2005 opened a new era of the natural gas industry in China, with the CAGR of gas consumption going up to 13.7% in 2001 - 2005 and 18.3% in 2006 - 2010.

However, the gas consumption slowed down afterwards, because of two major factors. One factor is slower GDP growth, which decreases year by year, from 10.6% per annum in 2010 to 6.7% in 2016. The other factor is natural gas pricing reform, which majorly changed the former cost-plus pricing method to the current net-back method (linked to prices of Liquefied Petroleum Gas, i.e., LPG, and fuel oil), whose trial in Guangdong Province and Guangxi Province started in 2011, followed by a formal launch across the country in 2013. The reform increased gas prices, thus holding back gas demand. In addition, as crude oil prices dropped in 2015, gas further lost its competitive advantage to coal and refined petroleum products. As a result, the growth rate of natural gas consumption decreased from 23.3% in 2011 to 3.8% in 2015.

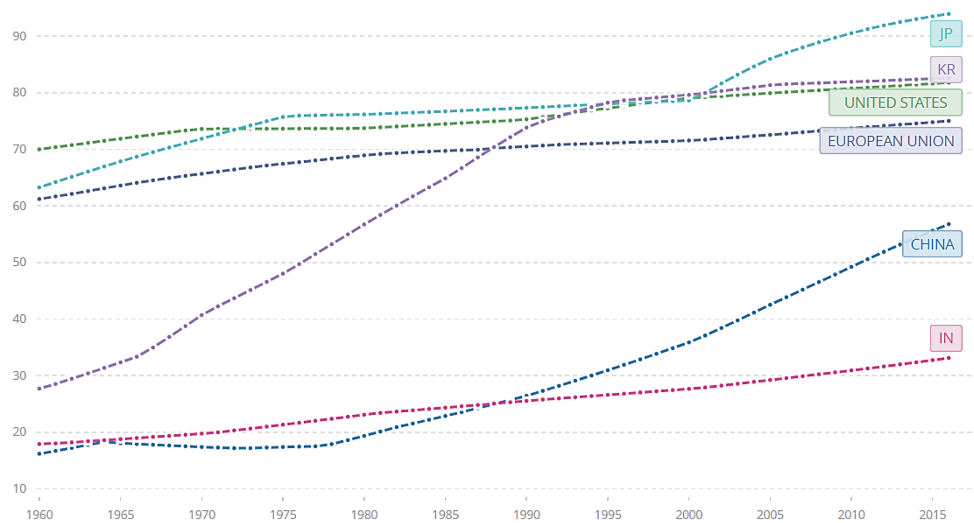
In order to promote the coal-to-gas switching policy, NDRC lowered the benchmark city gate price of gas for non-residential use by 0.7 yuan/cu.m in November 2015 and lowered the price again by 0.1 yuan/cu.m in August 2017. As the deadline of realizing the specific indicators set by the Ten Articles fell at the end of 2017 and the coal-to-gas switching is being executed more and more fiercely, the growth of gas consumption bounced back to 6.7% in 2016 and even to 15.3% in 2017. The apparent consumption of natural gas in 2017 reaches 237.3 bcm.

*Figure 5. China's natural gas consumption and GDP growth*




Data source: Department of Energy Statistics, National Bureau of Statistics, the PRC. (2017). *China energy statistical yearbook 2017*. Beijing: China Statistical Press.

*Figure 6. Urban population by regions (% of total)*




Note: "JP" indicates Japan. "KR" indicates South Korea. "European Union" includes the United Kingdom.

Source: The World Bank Group. (2018). Retrieved from https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS

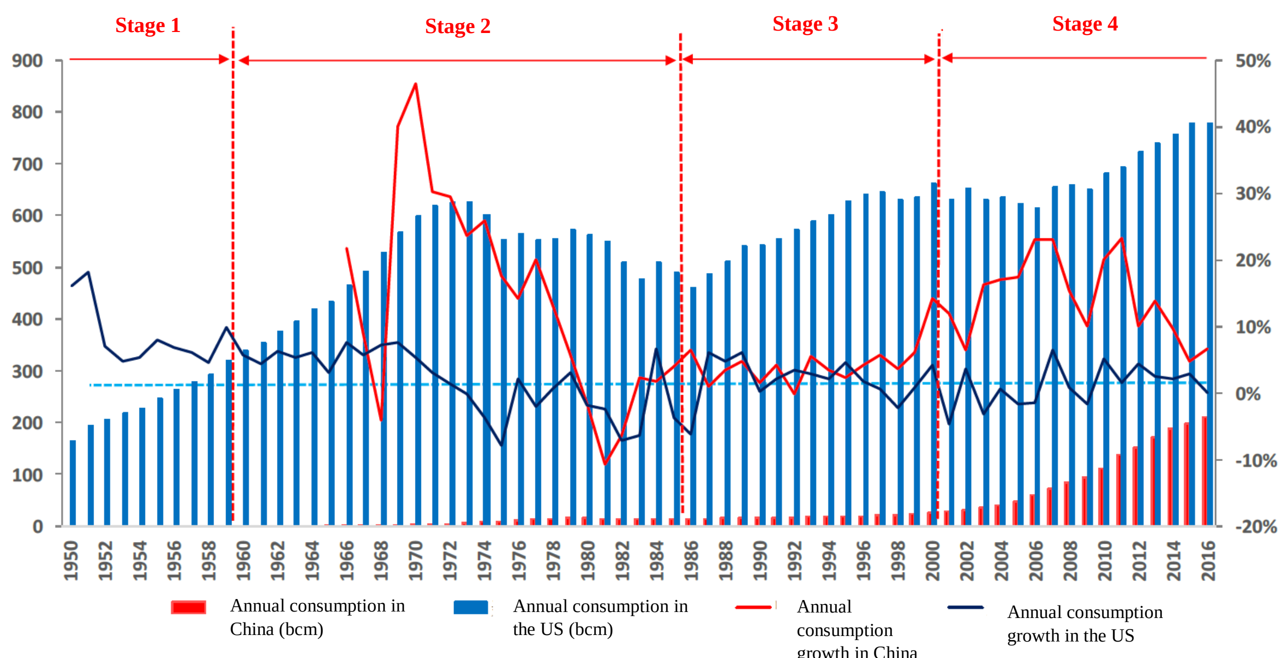
Following the recent trend, three favorable factors would boost the gas consumption in China: (1) an obvious competitive advantage of gas prices relative to coal and oil; (2) a market-oriented reform which diversifies gas sources, leading to renegotiates of current long-term contracts; and (3) environmental policies which forces the usage of gas instead of coal. Besides, if the goals set in the Plan are fundamentally realized by 2020, the CAGR of gas consumption in 2017 – 2020 by estimate should be around **18.7%**, much more than the CAGRs of other energy sources such as non-fossil fuels (around 6%), coal (around 3.2%) and oil (0.7%).

On top of that, within a certain year, the seasonality of natural gas consumption is quite significant. The ratio of the average peak-valley difference in summer vs. the average difference in winter reaches 1.7: 1 as of 2016. Along with the promotion of clean heating projects in winter, the peak-valley difference in winter will be much wider, as well as the gap between winter and summer. The peak-valley and winter-summer spreads clearly require more gas storage facilities and stronger peak-shaving capabilities.

### 4.1.2 Horizontal comparison

According to the industry life cycle theorem, the development of a natural gas market can be divided into four stages, where the natural gas consumption displays different growth patterns.

***Figure 7****. Growth rates and volumes of natural gas consumption in the US vs. China*




Note: Red fronts are the developing stages of the US gas market.

Source: Huatai Securities (2017, November 28).

**Stage 1: Introduction.** This is a stage when the natural gas market starts from scratch and all participants fight fiercely to get a firm position in the value chain. The market is characterized by fierce competition, rapid expansion, and low supervision.

**Stage 2: Non-Competition.** Because gas infrastructures like pipelines need vast capital investment, owners or operators of the infrastructures could naturally take over the market, resulting in a monopolistic or oligopolistic market structure. In order to break down the uneven market power, governments intervene and set standards to lead the market. The consumption growth becomes volatile and may even decline.

**Stage 3: Liberalization.** Due to excessive governance, the market development is abnormal. The supply is especially weak. Therefore, the government gradually relaxes its control and lets prices be competitively formed by the demand and supply. Supply is stimulated again by increased economic surplus and participants all benefit from the revival of the market. The consumption rebounds.

**Stage 4: Maturity.** The market structure is relatively stable. The consumption stays at a high level and doesn't change too much.

As shown in **Figure 7**, China's natural gas market is shifting to Stage 3, with consumption only equal to that of the United States in the 1950s. Since China's natural gas consumption didn't enter rapid growth until late 1990s, there's still broad space for development. Regarding China's large economic volume, undergoing structural reforms, and stricter environmental policies, the future will see appreciable gas consumption in China.

### 4.1.3 Regional comparison

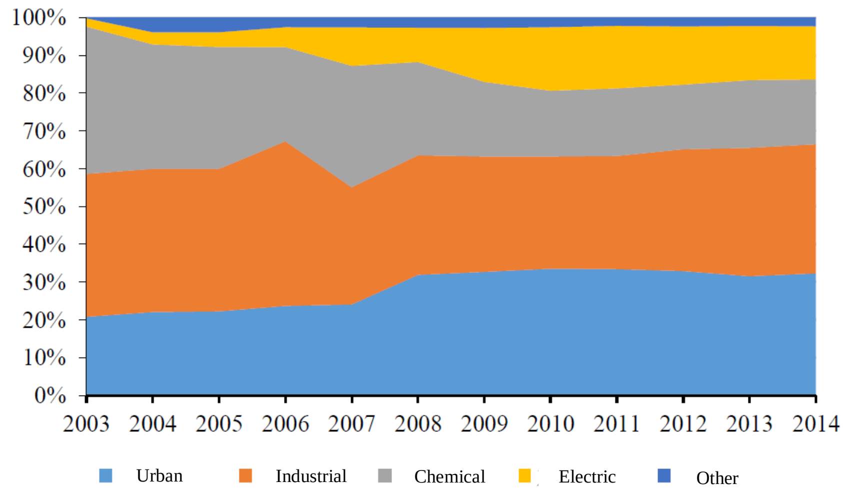
Natural gas consumption in China is concentrated in four regions (**Appendix 1**) – the West (Xinjiang, Chongqing, Sichuan), the Bohai Economic Rim (Beijing, Tianjin, Heibei, Shandong, Liaoning), the YRD (Shanghai, Zhejiang, Jiangsu), and Southeast coastal areas (Fujian, Guangdong). These four regions are either in the cluster of gas fields (the West), or relatively more developed (the other three regions) thus in greater need of natural gas. Since West-East Gas Pipeline and Sichuan-Shanghai Gas Pipeline were completed around 2010, natural gas consumption in the latter three regions has been greatly boosted, which reaches 101.9 bcm in 2016, accounting for above 50% of the national total. In 2016, provinces consuming 10 bcm and above of natural gas are: Xinjiang, Sichuan, Beijing, Shandong, Jiangsu, Guangdong.

### 4.1.4 Market segments

In China, natural gas is used in 4 major segments: urban fuel, industrial fuel, power generation, and chemical production. The proportions of these fields in the national total consumption (from 2003 to 2014 shown in **Figure 8**) respectively are 32.5%/ 38.2%/ 14.7%/ 14.6% in *Year 2015*; 35.4% /34.6% /17.8%/ 12.2% in *Year 2016*, and **37.6%** / 30.9%/ **19.9%**/ 11.6% in *Year 2017*. As the total gas consumption is continuingly growing in recent years, uses in **urban fuel** and **power generation** are expanding much faster than other fields. This has much to do with the government guidance, including the coal-to-gas switching policy more rigid in urban fuel, the guarantee for residential demand by suppressing commercial and industrial demand when in gas shortages, as well as much lower prices of gas for residential use than for non-residential.

Both the Plan and The Opinions on the Acceleration promote the utilization of gas in urban fuel, industrial fuel, power generation, and transport fuel. The historical growth in these four fields are shown in **Appendix 2**.

***Figure 8***. *Proportions of China's gas consumption in different segments from 2003 to 2014*




Source: Minsheng Securities (2017).

**Urban fuel.** Not only the coal-to-gas switching process is accelerated, but the upgrade of public service systems concerning natural gas supply and use is required, such as the coverage of pipelines in "the last one mile", rightly in combination with the new-type urbanization. Natural gas heating projects are also encouraged in southern China, with the purpose of bettering public services.

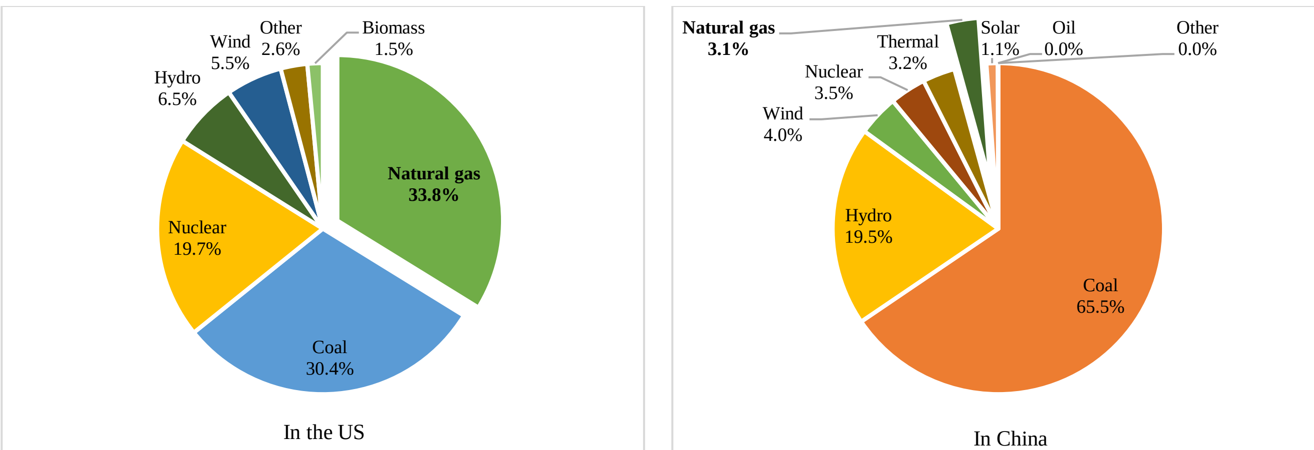
**Industrial fuel.** The proportion of natural gas vs. coal in the industrial fuel mix of China currently is around 10%: 70%, making it urgent to convert industrial boilers and kilns into natural gas fired. However, facing high costs of conversion and high prices of natural gas, this field needs more government subsidies.

**Power generation.** In fact, the use of natural gas in this field is just starting out in China. More than half of the electricity in China is generated from coal (**Figure 9**). In 2016, Gas-fired electricity only takes up 3.1% of the total production, compared to 33.8% in the US. By the end of 2017, the installed capacity of power generation using natural gas is 76.29 GW, only accounting for 4.3% of the total installed electricity capacity, far from the world average, 20%. NDRC has seen the gap, so the Plan lays out the targets that by 2020, the installed capacity of natural gas-fired electric generation shall be above 110 GW, accounting for more than 5% of the total. Three major gas-fired generation projects are promoted, which are: distributed generation, peak power stations, and combined heat and power generation (CHP). However, to shift the energy mix of electricity generation sources into a much cleaner one, many obstacles need to be overcome, among which is the domestic high prices of natural gas making it uneconomical to be extensively used.

**Transport fuel**. Natural gas vehicles, i.e., cars and ships powered by compressed natural gas (CNG) or liquefied natural gas (LNG), have been greatly supported by the government with substantial subsidies. Policies are also pushing the construction of CNG/ LNG filling stations. The Plan stipulates that by 2020, there should be about 10 million natural gas vehicles, more than 12,000 gas stations, and more than 200 marine refueling stations.

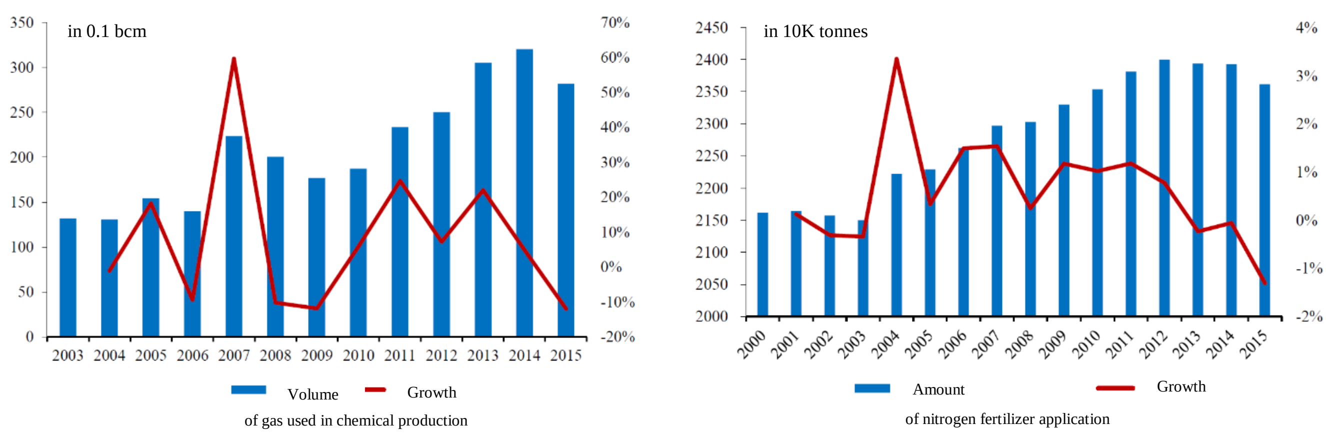
**Chemical production**. Here natural gas is used as raw material of menthol and nitrogen fertilizer. Because natural gas is not economical in China for its high prices, the final chemical products are low-value added. Therefore, the use of gas in chemicals is neither encouraged nor restricted. However, natural gas is indispensable in the production of nitrogen fertilizer – as shown in **Figure 10**, in the past few years, the trend of natural gas consumptions in chemical production is very similar to that of nitrogen fertilizer application. Considering there's rigid and high demand for nitrogen fertilizer in China as an agricultural producing country, the total consumption of natural gas used in chemical production will still maintain in a certain scale, though the proportion is shrinking.

***Figure 9.*** *Electric power generation by energy sources in the US vs. China in 2016*




Data source: (left) EIA. Retrieved from https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_1_01. (right) China Energy Portal. Retrieved from https://chinaenergyportal.org/en/2016-detailed-electricity-statistics-updated/

***Figure 10.*** *Gas consumption in chemical production and Nitrogen fertilizer application*

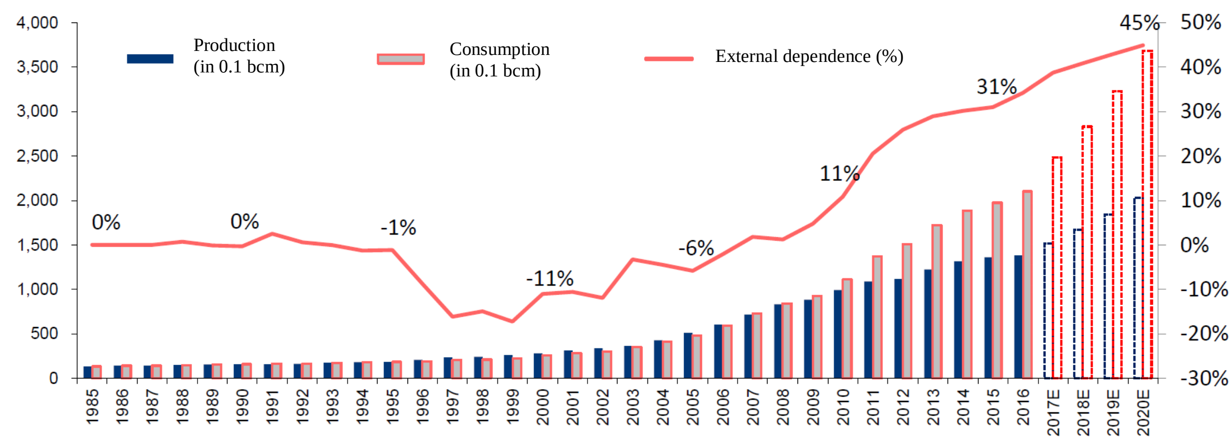



Source: Mingsheng Securities (2017).

## 4.2 Supply

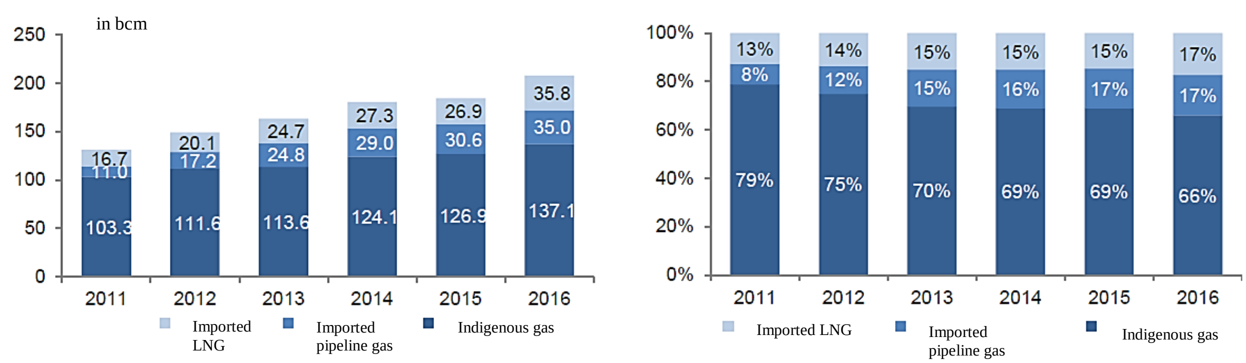
China's natural gas supply capacity is continuously enhanced by the demand side, and its external dependence (imports as a proportion of total consumption) is increasing notably – from a low of 2% in 2008 to **38%** in 2017 (**Figure 11**). At present, China has formed a supply pattern of "West gas to the East, North gas to the South, off shore gas landing, suppling nearby", with diversified sources from indigenous conventional or unconventional gas to imported pipeline or liquified gas (**Figure 12**).

***Figure 11.*** *China's natural gas production, consumption, and external dependence*




Source: Huatai Securities (2017, November 28).

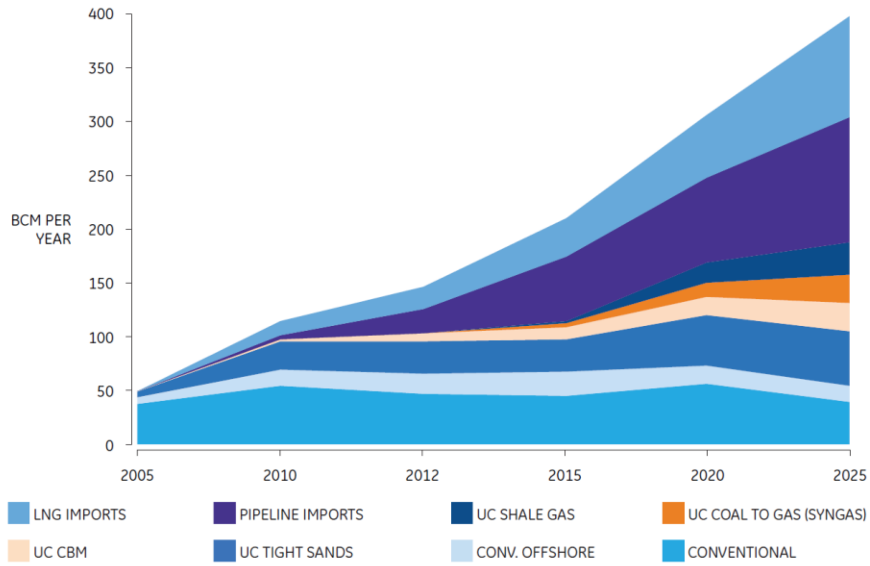
***Figure 12.*** *Supply volumes and proportions of different gas sources in China*




Source: Haitong Securities (2017, May 21).

GE Strategy and Analytics 2013 (Farina M. F.  & Wang, A., 2013) projected that by 2025 (**Figure 13**), China's indigenous gas production would grow by 75%, among which unconventional gas would represent 1/3 of the total supply, and shale gas would represent production of 30 bcm (lower than the government's target) or 7% of the total supply as of Year 2025. Imported gas was estimated to account for 45% of China's gas supply in 2020 and 50% in 2025. China's gas supply pattern would be more balanced between domestic and international gas sources in following years. This forecast is very close to most of existing Chinese brokers' analysis.

***Figure 13.*** *Trend of China's natural gas supply by sources*




Note: UC: Unconventional gas resources.

Source: Farina M. F. & Wang, A. (2013).

### 4.2.1 Indigenous gas

China is rich in natural gas resources, which are mainly in the North and marine areas (**Appendix 3**). In particular, according to the US EIA estimate, China owns 31.6 trillion cu.m of technically recoverable shale gas resources, ranking the world's second only to the US. At the end of 2016, the proven rate of conventional gas reserves was 13% and the rate of unconventional gas was less than 3% (**Table 6**), indicating that China is just in the early stage of exploration and has big potentials.

***Table 6.*** *Proven rates and recovery rates of gas reserves in China by the end of 2016*

| Natural gas (in bcm) | Proven reserves | Proven rate of total reserves | Accumulated production | Recovery rate of proven reserves | Remaining recoverable reserves |
|---|---|---|---|---|---|
| Conventional gas (incl. Tight gas) | 11,700 | 13.0% | 1,400 | 12.0% | 5,200 |
| CBM | 692.83 | 2.3% | 24.11 | 3.5% | 334.40 |
| Shale gas | 544.13 | 0.4% | 13.62 | 2.5% | 122.41 |

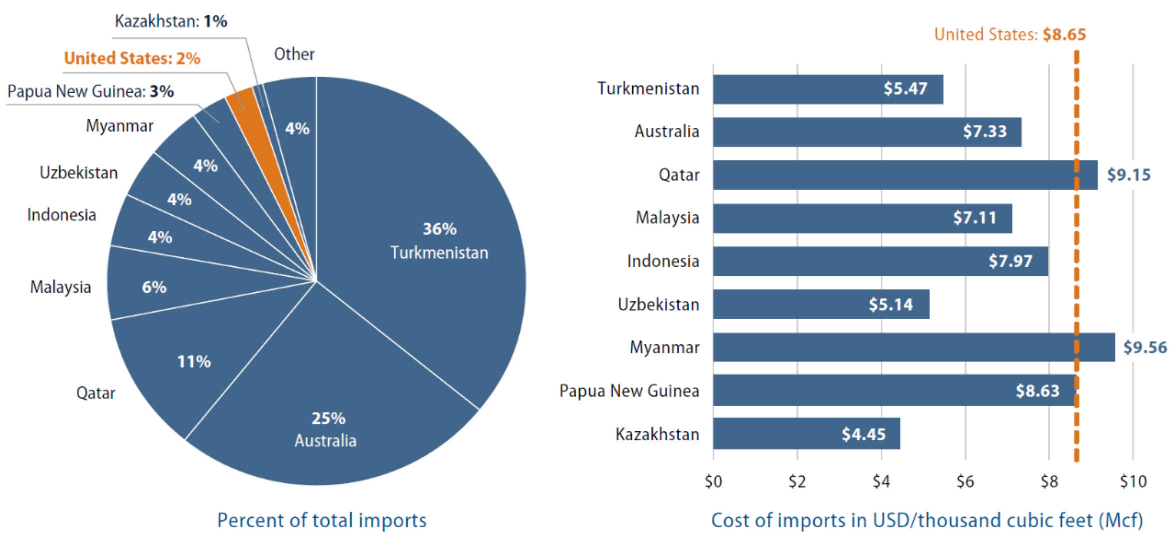
Data source: NEA, Development Research Center of the State Council, and Ministry of Land and Resources of PRC (2017).

However, the difficulty of gas exploration and exploitation in China is increasing. With intensive exploitation and consumption of high-quality resources in the past few decades, about 80% of remaining conventional gas resources are low-quality and high-risk types: 35% in low-permeability reservoirs, 25% in tight gas reservoirs, and 20% in the deep sea. As for the unconventional gas, the exploitation is not feasible for most reserves under current technological conditions, let alone create positive economic values. The geological conditions of China's shale gas are much more complicated than that of the US. The locations of shale gas resources in China are mostly mountainous, lacking in water, and densely populated, all making it challenging to exploit on a large scale.

Overall, although China possesses abundant natural gas resources, the complexity of these resources requires advanced technology and continuous capital investment. Protecting ecological civilization is also a serious issue. However, with shrinking production of conventional gas and for energy security, the Chinese government currently is supporting the production of shale gas: 0.3 yuan is subsidized for every cubic meter of shale gas produced in 2016-2018, and 0.2 yuan in 2019-2020, with the aim of hitting the Plan's target of 30 bcm in 2020.

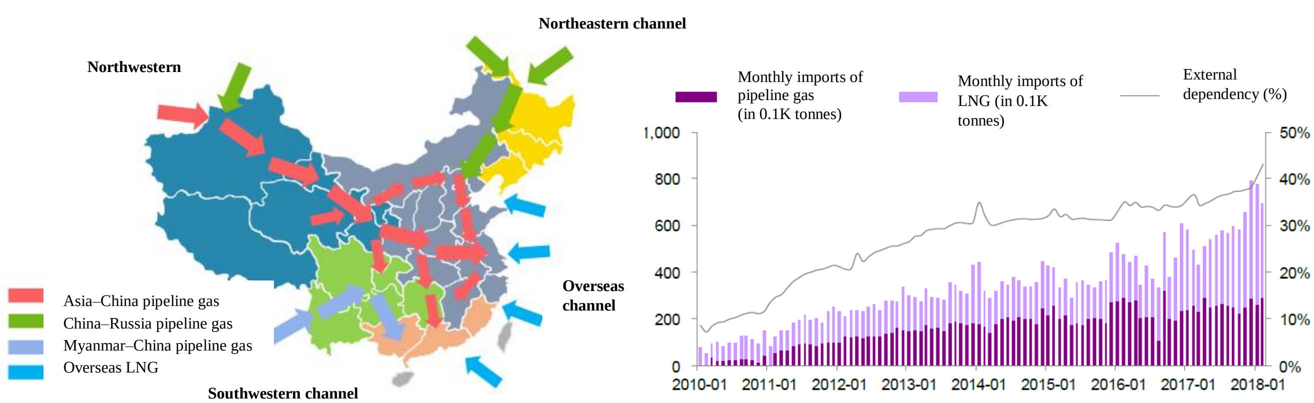
### 4.2.2 Imported gas

***Figure 14.*** *China's top 10 natural gas suppliers by volume in 2017*




Source: Hart, M., Bassett, L., and Johnson, B., 2018.

***Figure 15****. Strategic channels of importing gas to China and Import volumes of pipeline gas vs. LNG*




Source: (left) Haitong Securities (2017, May 24); (right) Guangda Securities (2018).

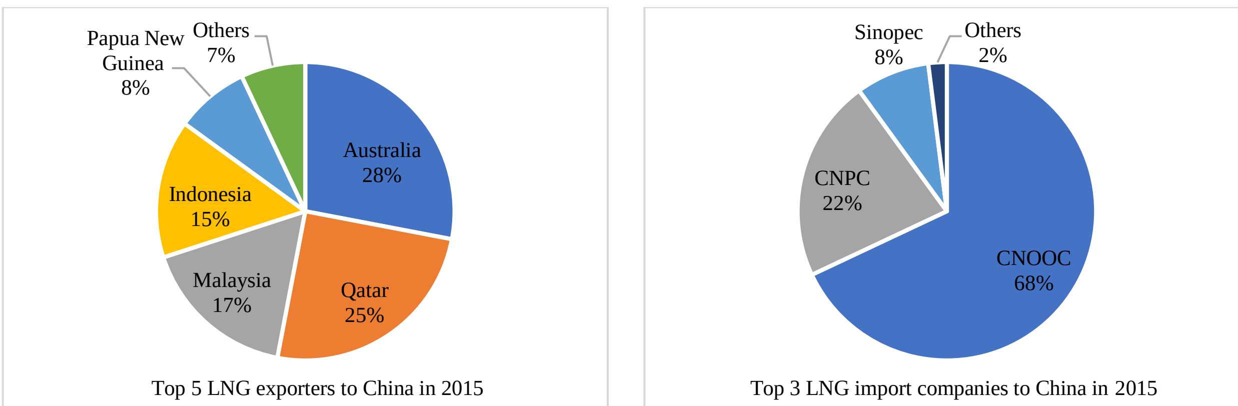
Because exploiting indigenous gas resources in China is not as easy as in the US, China pays attention to importing gas from several countries (**Figure 14**). Strategic importing channels from four corners have formed (**Figure 15**, left).

The amount of LNG imports and that of pipeline gas imports are very close, with the amount of LNG slightly larger in recent years (**Figure 15**, right).

#### 4.2.2.1 LNG imports

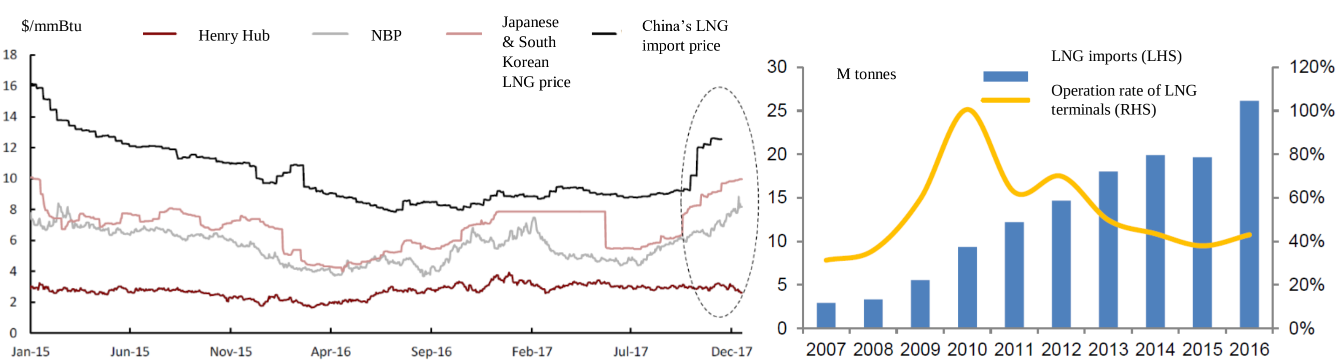
Starting from the first LNG tank fleet from Australia landing in Guangdong Province in 2006, LNG imports to China have expanded fast. According to statistics in 2015 (**Figure 16**), China's five largest LNG exporters are Australia, Qatar, Malaysia, Indonesia, and Papua New Guinea; China's three largest LNG importers are China National Petroleum Corporation (CNPC), China Petrochemical Corporation (Sinopec), China National Offshore Oil Corporation (CNOOC) – hereinafter referred to as "the Big Three". (Just to clarify, PetroChina Co., Ltd is a subsidiary of CNPC, and CNPC holds approximately 82.71% of PetroChina shares on December 31, 2017.)

***Figure 16****. China's top 5 LNG exporters and top 3 importers by volume in 2015*




Data source: Haitong Securities (2017, May 21).

***Figure 17****. Comparison of China's LNG import prices with other indicators and Operation rates of LNG terminals in China*




Source: China International Capital Co., Ltd (2017).

However, the average operation rate of current LNG terminals in China is quite low (**Figure 17**, right). It's because LNG purchasing prices predetermined in the long-term "take-or-pay" contracts are too high, higher than international prices (**Figure 17**, left) and even higher than domestic gas selling prices at city gates. To put it another way, the city gate gas price is controlled at a very low level by the government, whereas the LNG import price is totally determined by the market and thus often soars when in strong demand, so it's often the case where LNG purchasing costs are much higher than its selling prices and LNG sellers lose money for every unit of LNG sold.

In the future, favorable factors which can bring more LNG imports to China include: a global downward trend of LNG prices, new LNG terminals built in China making renegotiation of existing long-term contracts possible, new LNG contracts with flexible terms, and Chinese gas pricing reform.

#### 4.2.2.2 Pipeline gas imports

At present, China has three international pipelines in operation (**Table 7**). Since the pipelines were completed, China's top suppliers of pipeline gas have been Turkmenistan, Uzbekistan, Kazakhstan, and Myanmar. In 2016, China imported about 29.4 bcm of pipeline gas from Turkmenistan, taking up **77%** of the nation's total pipeline gas imports. The percentage indicates a high dependency on a single country and thus a high concentration risk. What's worse, Turkmenistan is politically unstable. According to Sun, L., Wu X., Li, J. S, Y. (2016), in Year 2014, the regulatory safety index of Turkmenistan was 17.92, Uzbekistan 14.74, and Myanmar 8.43, in stark contrast to the regulatory safety indices of China's top two LNG suppliers, Australia and Qatar, which respectively were 92.75 and 82.71. Therefore, to ensure energy security, it's necessary for China to have both LNG imports and pipeline gas imports in the long run.

***Table 7.*** *Cross-border gas pipelines in China*

| Cross-border pipelines | Location of Gas sources | Status | Length (Km) | Capacity (bcm/year) | Year of completion | International connecting point |
|---|---|---|---|---|---|---|
| Central Asia - China Gas Pipeline A | Turkmenistan, Uzbekistan, and Kazakhstan | In operation | 1833 | 15 | 2009 | Khorgos in Xinjiang |
| Central Asia - China Gas Pipeline B | | In operation | 1833 | 15 | 2010 | Khorgos in Xinjiang |
| Central Asia - China Gas Pipeline C | | In operation | 1840 | 25 | 2014 | Khorgos in Xinjiang |
| Central Asia - China Gas Pipeline D | | In research | 970 | 30 | 2020E | Wuqia in Xinjiang |
| Myanmar - China Pipeline | Myanmar | In operation | 2520 | 12 | 2013 | Guigang in Guangxi |
| China - Russia East Pipeline | Russia | Under construction | 4000 | 38 | 2019E | Heihe in Heilongjiang |
| China - Russia West Pipeline | Russia | Delayed | N/A | 30 | N/A | N/A |

Note: The owner and operator of these pipelines above is PetroChina Co., Ltd.

Data source: Haitong Securities (2017, May 21).

## 4.3 Infrastructure

Natural gas infrastructures constitute the midstream of the gas value chain, which are comprised of transportation and storage facilities such as gas pipelines, gas storage, LNG receiving terminals, LNG tankers trunks, etc.

**Gas pipelines.** By the end of 2016, the length of pipelines in operation was 68 thousand Km and the transmission capacity of major pipelines exceeded 280 bcm of gas per year, which are targeted respectively at 104 thousand Km and a transmission capacity of 400 bcm/year by 2020. Besides cross-border pipelines (**Table 7**), domestic pipelines are also expanding quickly, expected to cover 90% of prefecture-level cities by 2020 and 95% by 2030. **Table 8** shows some information as of the end of Year 2015 about the top 5 domestic pipelines.

***Table 8.*** *Top 5 domestic pipelines in China at the end of 2015*

| Domestic pipelines | Capacity (bcm/year) | Length (Km) | Year of completion | No. of provinces covered | Main gas sources | Transmission operator |
|---|---|---|---|---|---|---|
| West - East Gas Pipeline III | 30 | 7,378 | 2014 | 10 | Central Asia | PetroChina |
| West - East Gas Pipeline II | 30 | 4,859 | 2012 | 15 | Central Asia | PetroChina |
| West - East Gas Pipeline I | 12 | 4,200 | 2004 | 9 | Kela2 Gas Field in Tarim Basin | PetroChina |
| Sichuan - East Gas Pipeline | 12 | 2,203 | 2010 | 7 | Sichuan Basin | Sinopec |
| Zhong - Gui Pipeline | 15 | 1,636 | 2012 | 6 | Tarim Basin, Central Asia, Myanmar | PetroChina |

Data source: Haitong Securities (2017, May 21).

**Underground gas storage.** At the end of 2016, 18 underground gas storage reservoirs were in operation, whose total volume of working gas was 6.4 bcm, making up only **3.1%** of natural gas consumption in 2016 – this was far from the basic need. The world average ratio of working gas capacity to annual gas consumption is 12% - 15%, or the ratio should be at least 10% to ensure the needs of peak shaving and supply guarantee. Hence, a few relevant policies have been launched, of which the most specific one is "Opinions on accelerating construction of gas storage facilities and improving the market mechanism of gas storage and peak regulation services" issued by NDRC and NEA in April 2018, as a tough position against the severe gas shortage in 2017. In this document, three indicators are set: (1) by 2020, a gas supplier shall have a storage capacity as above 10% of its contractual sales; (2) a prefecture-level city shall have a daily storage capacity as above average 3 days demand of the city; (3) a gas distribution company shall have a storage capacity as above 5% of its annual gas consumption.

**LNG facilities.** According to International Gas Union (IGU) 2017 World LNG Report, China owned 11 LNG **carriers** by April 2017.

By the end of 2015, China had 12 LNG **import terminals** in operation, whose reception capacity was 43.8 billion tonnes per year; by 2020, there will be more than 21 LNG import terminals in operation. Tank capacities of these LNG terminals at present only accounts for 2.2% of the national gas consumption, in contrast with about 15% in Japan and South Korea. This is another indication that China lacks gas storage capacity. While seeing the great profits in the future, private companies have begun to actively participate in China's LNG market. For now, more than 40 LNG terminals are in construction or in plan, half of which are owned by private companies.

The number of LNG **tanker trucks** in China reached 9,106 by 2017 (from around 5,000 in 2013), increasing by 14.45% compared to 2016. The coal-to-gas switching policy clearly pulled the increase, for the new LNG tanker trucks notably concentrated in the BTH region, especially in the Hebei province, where the number of LNG tanker trucks was increased by 22.76%, far above the national average.

The development of LNG **railway tankers** is also underway, as the prototype design of China's first LNG railway tanker was approved in April 2015. The transportation cost of LNG railway is expected to be 0.37-0.42 yuan/tonne per Km, which is much lower than that of road or pipeline transportation.

**In conclusion**, gas infrastructures in China are quite limited, restraining the expansion of both ends of the natural gas value chain. Long-distance gas pipelines are not so many that they have residual capacities which can be given out to third parties, even though favorable policies have been issued by NEA that gas transmission operators should fairly give third-parties fair access to their gas infrastructures ("Supervision measures to fairly open oil and gas pipeline network facilities (trial)" issued in February 2014), and publicize all the information of their pipeline networks and LNG terminals ("Notification of the completion of information disclosure related to oil and gas pipeline network facilities" issued in September 2016).

Furthermore, as the gas shortage in winter 2017-18 evidenced, the most crucial problem in China's natural gas market for now is the lack of the gas storage and peak regulation capacity, that is, far from enough underground gas reservoirs and LNG storage tanks. Therefore, China needs to make great efforts to construct more gas infrastructures. Only in this way, its boosted gas demand can be satisfied, and its extended supply can be used in place.

# 5. Market structure

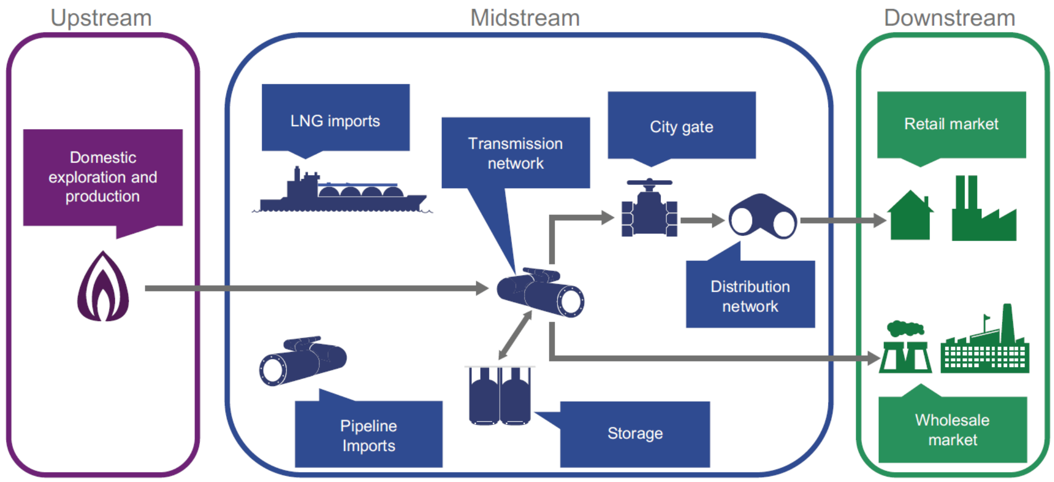
The natural gas value chain is shown in **Figure 18**. Because of different product characters, the natural gas market can be divided into two segments: the pipeline natural gas market and the liquified natural gas (LNG) market.

In the Chines pipeline gas market, three national oil and gas companies, China National Petroleum Corp. (CNPC), China Petrochemical Corp. (Sinopec), China National Offshore Oil Corp. (CNOOC), i.e., "the Big Three" dominate the upstream and midstream of the value chain. The Big Three make a vertical integrated market structure, for they explore, produce, transport, and store gas, and can bundle these services into one sales product. It's significant that the Big Three own the most of exploration and exploitation rights and trunk pipelines. The downstream market, however, is more competitive, which is comprised of different kinds of gas distribution companies and wholesale end users that are state-owned, private, or foreign invested.

Except the importation side which depends on the ownership of receiving terminals, the LNG market is already full of various players from the upstream to the downstream. Now with more and more LNG terminals run by non-big-three companies, the entire LNG market in China is going to be highly competitive.

Further details of the market structures along the natural gas value chain in China are summarized in **Table 9**.

***Figure 18.*** *Natural gas value chain*




Source: The Development Research Center of the State Council of PRC and Shell International (2015).

***Table 9.*** *Pipeline gas and LNG market structures and players in China*

| **Pipeline gas** | | | | |
|---|---|---|---|---|
| **Position in the gas value chain** | **Upstream** | **Midstream** | | **Downstream** |
| **Function** | Domestic production | Pipeline gas imports | Transmission and storage | Distribution and end uses |
| **Competitiveness** | State-owned oligopoly | State-owned oligopoly | State-owned oligopoly | Highly competitive |
| **Players** | The Big Three, Yanchang Petroleum, and smaller players mainly producing unconventional gas | The Big Three, and several smaller players | The Big Three, and several smaller players having pipelines within small geographic scopes | More than 1,450 city gas companies, and numerous end users of different kinds |
| **LNG** | | | | |
| **Position in the gas value chain** | **Upstream** | **Midstream** | | **Downstream** |
| **Function** | Liquification plants | LNG imports & terminals | LNG tank trucks | LNG fueling stations |
| **Competitiveness** | Highly competitive | State-owned oligopoly | Highly competitive | Highly competitive |
| **Players** | 50% private companies, and 50% state-owned companies | The Big Three, and several smaller players | PetroChina, and many more private companies | Numerous companies |

## 5.1 Upstream

China's natural gas upstream market is oligopolistic, with the Big Three holding **96.50%** of exploitation rights (by area) and providing **83.01%** of the national gas production in 2016 (**Table 10**). Apart from the Big Three, Shaanxi Yanchang Petroleum (Group) Co., Ltd, a local state-owned oil company (owned by the government of Shaanxi Province), is the only one with the state-approved qualification to explore or exploit natural gas in the country, meaning that it can directly get the rights from the government for a specific gas field. But in reality, Yangchang Petroleum is only capable of exploring or exploiting gas within a very limited geographical range.

***Table 10.*** *Companies with the state-approved qualifications to explore or exploit natural gas in China*

| Company | Area covered by exploration rights of oil & gas (K square Km) | Area covered by exploitation rights (K square Km) | Proven reserves of natural gas (bcm) | Production of natural gas (bcm) |
|---|---|---|---|---|
| CNPC | 1,259.8 | 117.0 | 2,228.85 | 851.85 |
| *Percentage* | *35.59%* | *75.88%* | *48.00%* | *62.26%* |
| Sinopec | 742.6 | 28.4 | 202.78 | 216.97 |
| *Percentage* | *20.98%* | *18.42%* | *4.37%* | *15.86%* |
| CNOOC | 257.3 | 3.4 | 165.50 | 67.06 |
| *Percentage* | *7.27%* | *2.20%* | *3.56%* | *4.90%* |
| **The Big Three** | **2,259.7** | **148.8** | **2,597.13** | **1,135.88** |
| ***Percentage*** | ***63.83%*** | ***96.50%*** | ***55.93%*** | ***83.01%*** |
| Yanchang | 4.02 | 0.4 | Unknown | Unknown |
| *Percentage* | *1.14%* | *0.26%* | *N/A* | *N/A* |
| **The Nation** | **3,540.0** | **154.2** | **4,643.42** | **1,368.30** |

Data source: Haitong Securities (2017, May 21).

Transferring the rights is restricted and rare. If existing rights were not transferred, companies with no state-approved qualifications could either participate in exploration or exploitation of conventional gas by cooperation with the Big Three and Yangchang Petroleum or apply to explore or exploit unconventional gas. Because producing unconventional gas is much harder and requires more technological expertise, making its economic margins quite thin, companies without qualification are less motivated to engage in significant production activities. And cooperation with the Big Three and Yangchang Petroleum is often hindered by the state-owned structure.

However, reform is underway. In July 2015, the Ministry of Natural Resources of China first time called for tenders for the exploration rights of 6 oil and gas blocks in Xinjiang Uighur Autonomous Region, and domestic entities were invited. At that time, more private companies participated in this tendering than state-owned companies except CNPC, whereas after the government's evaluation of all the tenders, 1 state-owned company, Beijing Energy Investment Holding Co., Ltd, won 3 out of 4 rights tendered, and one private company got 1 right. In December 2017, the exploration rights of 5 oil and gas blocks in Xinjiang were listed for bidding (i.e., like an auction without the government evaluation), which was the second time when natural gas exploration rights were open to others except the 4 companies with qualification. Again, 2 state-owned companies won 2 out of 3 rights bid and 1 private company got 1 right.

As seen from these two processes of open tendering, competition in the upstream market from smaller players and new entrants is still limited, due to their current weakness in capital and technology. The road from exploration to production is also long. However, the public bidding of exploration rights indeed provided other companies with an "open, fair and just" platform and more opportunities to participate in the utilization of natural gas resources, which can be regarded an important measure of reforming the natural gas market.

In the future, with the deepening of the systematic reform in the oil and gas industry, more social entities are expected to be introduced into the gas upstream market.

## 5.2 Midstream

The Big Three also dominate the natural gas midstream market, owning the most of gas pipelines, LNG terminals, and underground gas storage reservoirs.

**Pipeline gas imports.** Currently, pipeline gas imports are mainly from CNPC's and Sinopec's long-term contracts signed with Myanmar and countries in central Asia. After China - Russia East Pipeline is completed (expectedly in 2019), CNPC will import pipeline gas from Russia.

The grand cross-border natural gas pipelines shown in **Table 7** are all owned and built or going to be built by CNPC. In addition, one small cross-border pipeline first invested and built by a private company, Guanghui Energy Co., Ltd, has been put into operation in 2013, carrying the gas produced in Kazakhstan to Guanghui's LNG plant in Xinjiang. Its annual transporting capacity is 0.5 bcm of gas.

**Gas pipelines.** The Big Three possess the most of long-distance gas pipelines (i.e., main lines) in the country. By the end of 2016, the length of major pipelines completed and ready for operation over the country was about 68.25 thousand Km. CNPC had 51.734 thousand Km gas pipelines completed and ready for operation, accounting for about 75.8% of the total; Sinopec had 5.418 thousand Km, accounting for 7.9%; CNOOC had 3.465 thousand Km, accounting for 5.1%; in all, the Big Three accounted for 88.8%.

CNPC's gas pipeline transportation services have been separated from its gas sales since November 25, 2016. This was completed with two steps: (1) On November 23, 2015, PetroChina Pipeline Co., Ltd was incorporated as CNPC's subsidiary, and on December 24, 2015, PetroChina Pipeline Co., Ltd acquired all the other CNPC's pipeline companies. (2) On November 25, 2016, CNPC set up 5 regional natural gas sales branches, completely isolating its gas sales business from PetroChina Pipeline.

Sinopec and CNOOC also have separate subsidiaries respectively performing gas transportation and sales businesses. According to analysts, PetroChina Pipeline Co., Ltd is going to merge all the remaining pipeline assets in the country and become a national gas pipeline company like National Grid UK. Then gas transportation services will be totally unbundled from gas sales.

**Underground gas storage.** At present, there're 25 underground gas reservoirs in operation, 23 owned by CNPC, accounting for 98% of the peak regulation capacity of underground gas storage in China, and 2 owned by Sinopec. This is because underground gas storage is the auxiliary facility of long-distance pipelines, and long-distance pipelines in majority are owned by CNPC.

**LNG imports.** Although there's no more restriction on gas importation rights since 2006. LNG importers and owners of LNG terminals majorly are the Big Three. This oligopolistic situation won't change too much in the foreseen future, due to the sizes and terms in long-term "take-or-pay" LNG contracts and the long construction period of LNG terminals. On one hand, if no new contract added, the "take" volume of existing LNG import contracts will reach 45 million tonnes in 2020, of which the Big Three takes up 96%, despite slightly smaller than the percentage in 2017. On the other hand, the LNG receiving capacities of the Big Three are keeping growing, whose CAGR from 2006 to 2017 was 35% and will continue to be double-digit in next 5 years. It's estimated that the Big Three will contribute more than 60% of the increase of LNG receiving capacities by 2023.

Nevertheless, other companies have already seen the potential prosperity of LNG markets in China and want to take a bite of the big cake. Moreover, the Chinese government is encouraging competition in the LNG market.

Firstly, in February 2014, NEA announced "Supervision measures to fairly open oil and gas pipeline network facilities (trial)". This document gives other companies the opportunity to import LNG by using the Big Three's LNG terminals. The first privately-owned company as LNG importer is ENN Energy Holdings Ltd, who borrowed CNPC's Rudong LNG terminal to receive its cargo in December 2014. Afterwards, in March 2015, a foreign-invested company, Pacific Oil && Gas Ltd, also borrowed Rudong LNG terminal to receive its LNG imports to China. As acknowledge widely, TPA is gradually breaking the state-owned oligopolistic structure in LNG importers.

Secondly, considering that borrowing is not the best solution because of the limited window period of occupying and uncontrollable queueing time, a lot of companies besides the Big Three are constructing or planning to construct new LNG terminals. At present, there're 17 LNG receiving terminals, of which 7 belong to CNOOC, 4 belong to CNPC, 2 belong to Sinopec, and 4 belong to private companies – 2 belong to Shenengergy (local state-owned), 1 belong to JOVO Group (private), and 1 belong to Guanghui (private). If everything goes well as planned, there will be more than two-thirds owned by non-big-three companies of all LNG terminals completed, including ENN Energy, Pacific Oil && Gas Ltd, Shenenergy, Guanghui Energy, Beijing Energy, etc. By then, various companies will be able to import LNG with good terms, for they have their own LNG terminals.

## 5.3 Downstream

In December 2002, "Opinions on accelerating the marketization process of the municipal public utilities industry" issued by the Ministry of Housing and Urban-Rural Development of PRC guided all kinds of capital to actively participate in the investment, construction, and management of urban gas infrastructures. Since then, numerous city gas companies have been set up as distribution network operators, who own provincial branch lines and home connections and transmit gas from long-distance pipelines to the city gates or end users. By the end of 2016, China had 1,426 city gas companies, which are state-owned, foreign-invested, or private.

Apart from gas distributors, natural gas power plants, LNG fueling stations which support LNG cars and vessels, and industrial or chemical end users are numerous and mainly privately owned.

To conclude, the downstream market is highly competitive, just opposite to the one of major pipelines monopolized by the Big Three.

# 6. Pricing system

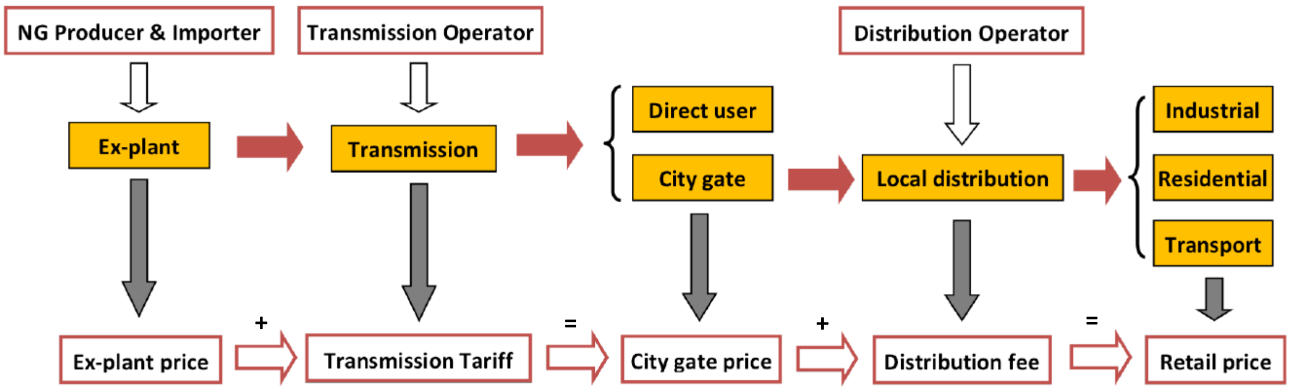
## 6.1 System overview

International Gas Union (IGU) categorizes formation mechanisms of the natural gas wholesale price into 9 types (the explanations are listed in **Appendix 4**): oil price escalation (OPE), gas-on-gas competition (GOG), bilateral monopoly (BIM), netback from final product (NET), regulation: cost of service (RCS), regulation: social and political (RSP), regulation: below cost (RBC), no price (NP), and not known (NK). Leaving out NK, natural gas price formation types can be further generalized into two kinds: market-based and regulation-based. The market-based types are OPE, GOG, BIM, and NET; the regulation-based types are RCS, RSP, RBC, and NP.

In the guidance of NDRC's "Notice of adjustment on the natural gas price" issued on June 28, 2013, a major Chinese natural gas price reform took effect over the country on July 10, 2013 (hereinafter referred to as "Price Reform 2013"). In this reform, natural gas pricing has essentially changed from regulation-based to market-based. In other words, the ex-plant price mechanism is changed from the cost-plus approach (RCS) to the netback approach (NET), though the Chinese netback approach is not exactly the same as the one defined by IGU, for the price doesn't constantly change with the market movement. Moreover, Price Reform 2013 has moved the government instruction point from the ex-plant price to the city gate price.

The formation of a Chinese natural gas retail price (**Figure 19**) is comprised of 3 parts – ex-plant price, transmission tariff, and distribution fee.

*Figure 19. Diagram of natural gas price formulation*




Note: Direct users are the large end users comprised of industrial users and fertilizer manufacturers.

Source: Paltsev, S. and Zhang, D. (2015).

The following is an overview of Chinese natural gas price system **before Price Reform 2013**.

**Ex-plant price.** Before Price Reform 2013, ex-plant prices were set by the government based on the costs-plus-appropriate-margin approach. The formula was: Ex-plant price = Wellhead price + Purification fee + Taxes + Appropriate margin. The benchmark ex-plant prices varied according to end users, who were categorized simply into 3 classes since December 26, 2005: fertilizer manufacture, industrial use, and unban fuel.

Beginning from December 26, 2005, when NDRC's "Notice of reforming the formation mechanism of the natural gas ex-plant price and raising the natural gas ex-plant price appropriately in the near future" took effect, the actual ex-plant price could be negotiated between producers and buyers within a 10% increase or decrease of the benchmark price, except for the gas out of plan (the second level of gas), whose price had no lower bound.

Also, after this notice, the benchmark ex-plant price would be adjusted by NDRC once a year (within 3 - 5 years, only the second-level gas prices were adjusted). The adjustment coefficient was based on a weighted moving average movement of alternative energy sources' prices, that is, to weight 5-year moving averages of crude oil, LPG (liquefied petroleum gas), and coal prices respectively by 40%, 20%, and 40%, but the coefficient should be not more than 8%.

**Transmission tariff.** The transmission tariff comprises the pipeline transportation tariff and the gas storage fee. Before 1984, the transmission tariff including the storage fee was just a specific price set by the central government. Then until January 1, 2017, the tariff was determined by the government based on proposals from transmission operators, who from 1984, should calculated their transmission prices with the project evaluation (i.e., Internal Rate of Return, IRR) method, or more generally, the costs-plus-appropriate-margin approach.

**City gate price.** The city gate price is the sum of the ex-plant price and transmission tariff. It is the wholesale price that gas distributors and direct users pay to pipeline operators.

**Distribution fee.** This distribution fee is determined by local governments based on proposals from local distributors, who should price their distribution service with the costs-plus-appropriate-margin approach.

**End user prices.** The end user price is the sum of the city gate price and the distribution fee. It is the retail price that end users pay to local distributors.

In conclusion, before Price Reform 2013, ex-plant prices, transmission tariffs, and distribution fees were all set by the government based on the cost-plus approach, which protected the producers but didn't well reflect the true demand. As a result, gas suppliers couldn't enjoy extra economic profits and so were not sufficiently incentivized to produce more gas. Among them, gas importers were hurt the most, who were squeezed by increasing market-based contract prices but much lower regulation-based city gate prices.

## 6.2 Pricing reform

### 6.2.1 Ex-plant price & city gate price

Generally, before the reform experimentation in Guangdong and Guangxi provinces on December 26, 2011, NDRC controlled the ex-plant price by setting a benchmark, which was calculated on the cost-plus basis and adjusted once a year according to a weighted average price index of alternative energy sources. The benchmark prices were different for end users classified into 3 categories. The actual price could be negotiated within a 10% increase or decrease of the benchmark price.

Starting the reform experimentation in 2011 and the nationwide implementation in 2013, NDRC controlled the city gate price by setting a cap, which was calculated on the market-netback basis linking to specific prices of alternative energy sources (as shown in the formula below) and adjusted at least once a year. This cap was no more different for any end user. Supplies and buyers could negotiate their transaction prices under the maximum. However, local pricing authorities should monitor these transaction prices, who might establish a price linkage mechanism between city gates and end users.

The formula of the market-netback basis set the ceiling of the city gate price at Shanghai as the central market, which is (hereinafter referred to as "Formula 1"):

$$P_{SHCG} = K \times (\alpha \times P_{FO} \times \frac{H_{NG}}{H_{FO}} + \beta \times P_{LPG} \times \frac{H_{NG}}{H_{LPG}}) \times (1 + R)$$

$P_{SHCG}$: the ceiling price of natural gas at Shanghai's city gate;

K: a constant discount coefficient (90% in Guangdong and Guangxi's trial, and 85% nationwide);

$P_{FO}$ and $P_{LPG}$: average prices of imported fuel oil and liquefied petroleum gas (LPG) in the pricing period;

$\alpha$ and $\beta$: weights of fuel oil and LPG;

$H_{NG}$, $H_{FO}$, and $H_{LPG}$: heat values of natural gas, fuel oil and LPG;

R: the value added tax (VAT) rate of natural gas.

Based on this benchmark price $P_{SHCG}$, the city gate price in every province is determined by considering the flow of main resources in the natural gas market and the cost of pipeline transportation.

Notably, this regulation is only applied to domestic onshore natural gas and imported pipeline gas. Prices of unconventional gas and LNG are entirely determined by supply and demand, expect for the gas entering long-distance pipelines, which will have city gate prices regulated the same as domestic onshore natural gas and imported pipeline gas. In addition, prices of gas used for residents (including schools and nursing institutions for the aged) were not changed according to the formula until June 10, 2018.

For transition, the annual consumption of domestic onshore natural gas and imported pipeline gas was divided into two parts. One part was the "existing volume", equal to the gas consumption amount in 2012, and the remaining part was the "incremental volume". Until April 1, 2015, only the price for the incremental volume was calculated by the volume above, whereas the price for the existing volume was increased to the same level as the incremental volume step by step. From April 1, 2015 and on, there's no more difference between the two parts and the division is removed. In addition, city gate prices of gas for direct users except fertilizer manufacturers are liberalized, i.e., entirely dependent on the market.

More measures of liberalizing natural gas prices are taken ever since.

From November 20, 2015, NDRC begins to control the city gate benchmark price in each province instead of the ceiling price. The city gate price of non-residential gas previously set as the highest price was reduced by 0.7 yuan/cu.m as the benchmark. Gas suppliers and buyers can negotiate their deal prices up to a 20% increase of the benchmark price.

In November 2016, NDRC further removed the regulation on the city gate price for fertilizer manufacturers. Also, as a reform experiment, NDRC let the Fujian Province's city gate price of natural gas from the West - East Gas Pipeline be totally determined by the market supply and demand.

From June 10, 2018, the benchmark city gate price of residential gas becomes the same with that of non-residential gas. The actual deal prices also can be negotiated up to a 20% increase of the benchmark, though in the first year, they're not allowed to float upward. And market players are encouraged to transact in Shanghai Petroleum and Gas Exchange (SHPGX) or Chongqing Petroleum and Gas Exchange (CQPGX), though the prices formed shall still be based on the benchmark – within the regulated range.

**Table 11** sums up in more details the evolution of Chinese natural gas pricing mechanisms.

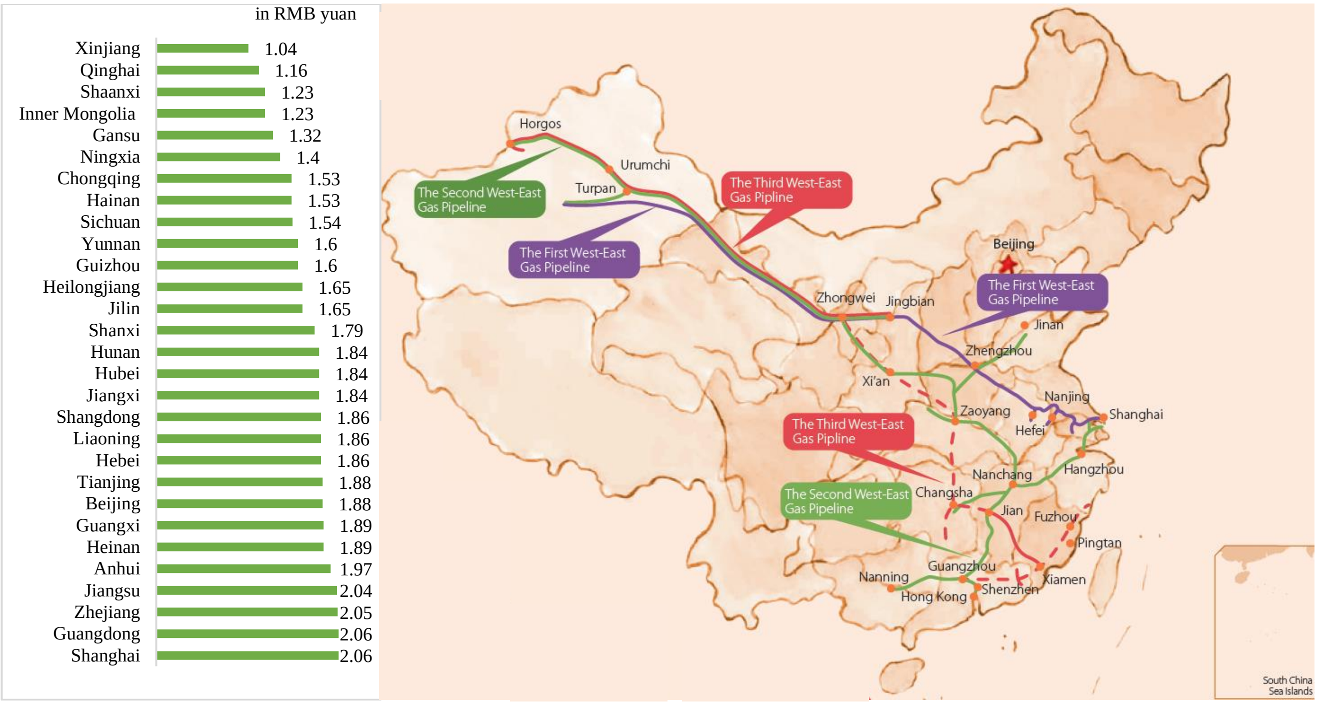
***Table 11.*** *Evolution of natural gas pricing in China*

Note: Policy effective date is the starting point of a typical period.

| Policy effective time | Description of the typical period | IGU type |
|---|---|---|
| May 1958 | The production and consumption of natural gas are majorly planned by the government, so is the wellhead price. The purification fee is introduced in Dec 1987 and regulated by the government as well. | RSP |
| **Dec 2005** | NDRC sets the benchmark ex-plant prices, which would be adjusted every year with the movement of alternative energy sources' prices. The actual price should be within a 10% increase or decrease of the benchmark price. | RCS |
| Dec 2011 | In Guangdong and Guangxi provinces, a market-based natural gas price system is implemented:<br>1. NDRC sets the cap of the city gate price based on "Formula 1" linked to alternative energy sources' prices;<br>2. Ex-plant prices of unconventional gas except that entering long-distance pipelines are liberalized. | Regulated NET |
| **Jul 2013** | 1. Ceiling city gate prices all over the country of "incremental" gas for non-residential use are set by NDRC with the same method as the one in Guangdong and Guangxi;<br>2. Ex-plant prices of LNG and unconventional gas except that entering long-distance pipelines are liberalized. | |
| Mar 2014 | Tiered pricing of residential gas at end users: 80% of consumption is priced at 1x; 15% at 1.2x; 5% at 1.5x. | |
| Aug 2014 | 1. The ceiling city gate price of "existing" gas is increased by 0.4 yuan/cu.m.<br>2. Ex-plant prices of LNG and unconventional gas entering long-distance pipelines are liberalized. | |
| **Apr 2015** | 1. The difference between city gate prices of "existing" gas and "incremental" gas is removed;<br>2. City gate gas prices for direct users except fertilizer manufacturers are liberalized. | |
| **Nov 2015** | NDRC sets the benchmark city gate prices of non-residential gas instead of the ceiling, and the actual price shouldn't exceed 120% of the benchmark price. | |
| Nov 2016 | 1. Gas prices for fertilizers are fully liberalized. Gas for fertilizer is encouraged to be traded in oil and gas trading platforms, so as to form market prices which are public and transparent.<br>2. Fujian Province's city gate price of natural gas coming from the West - East Gas Pipeline is liberalized. This gas is encouraged to be traded in oil and gas trading platforms, so as to form market prices which are public and transparent. | Trial GOG |
| Jun 2018 | The difference between city gate prices of residential gas and non-residential gas is removed. That is, NDRC sets the benchmark rather than the ceiling city gate price of residential gas, which is the same as that of non-residential. | |

At present, differences among the benchmark gas price at each province's city gate generally reflect the main resources' flow and the transmission cost (**Figure 20**).

*Figure 20. The benchmark city gate price set by NDRC for every province since June 10, 2018 and the sketch map of the West-East Gas Pipelines*




Source: (left) NDRC. (right) CNPC's 2016 Sustainability Report.

## 6.2.2 Transmission tariff

The transmission tariff is comprised of the pipeline transportation tariff and the gas storage fee.

### 6.2.2.1 Pipeline transportation tariff

Pipeline transportation tariffs have been always set by the government, but the calculation method changes from time to time. **Table 12** demonstrates the historical evolution of natural gas transmission tariffs in China.

***Table 12.*** *Evolution of gas transmission pricing in China*

| Effective year | Pricing mechanism | Description |
| --- | --- | --- |
| 1964 | Uniform pricing | The national-uniform transmission tariff is 0.023 yuan/cu.m. |
| 1976 | Tiered pricing | The transmission rate increases with the distance. Every 50 Km is one tier. |
| 1984 | Economic evaluation of one pipeline | Transmission in old pipelines is priced at national-uniform rates (tiered). However, a new pipeline's transmission rate should be set with the method of economic evaluation of construction projects. The benchmark after-tax IRR of capital invested in a new natural gas pipeline project is set at 10% in 2006. |
| 2017 | Economic evaluation of one pipeline company | Pipeline transportation tariff set by a pipeline company should be calculated with the permitted-cost-plus-reasonable-profit approach. The permitted costs are checked and ratified by the government and the reasonable profits is a product of a permitted rate and the amount of the pipeline company' effective assets. |

At present, effective from January 1, 2017 to December 31, 2022, both “Management measures of natural gas pipeline transportation prices” and “Supervision and auditing measures of natural gas pipeline transportation pricing costs” issued by NDRC, stipulate that any pipeline company should separate its natural gas transportation business as an independent business division from other businesses such as gas storage, or at least implement independent financial accounting of its natural gas transportation business, if the former separation is difficult at this moment.

Then based on the financial independence, the pipeline company shall price its gas transportation service with the *permitted-cost-plus-reasonable-profit* approach. That is: (1) the permitted costs including depreciation & amortization expenses and operations & maintenance expenses, shall be verified by the price department of the State Council through supervision and audit. (2) The permitted profits shall be determined by multiplying the amount of effective assets by the permitted rate of return. The permitted rate of return should be determined under the condition that the after-tax return on investment (ROI) is equal to 8% when the pipeline load rate (i.e., actual transmission volume/ designed capacity) is not lower than 75% (if lower than 75%, the pipeline load rate is assumed to be equal to 75%). Notably, effective assets exclude gas storage reservoirs and LNG terminals.

To put the approach in another way, annual allowable pipeline transportation revenues determine the pipeline transportation tariff, while:

- Allowable pipeline transportation revenues = Permitted costs + Permitted profits + Taxes;
- Permitted profits = Amount of effective assets × Permitted rate of return.

#### 6.2.2.2 Gas storage fee

Starting from October 2016, after NDRC issued “Notification of Pricing Policies on Gas Storage Facilities”, the gas storage fee is no more stipulated by the government but determined entirely by the interaction of market supply and demand. This notification also encourages the volume of gas which is to be sold externally, to be trade in SHPGX or other trading markets, in which way public and transparent prices can be formed.

In addition to marketization of the gas storage fee, as mentioned above, since effective assets exclude gas storage reservoirs and LNG terminals from January 1, 2017, the gas storage fee is completely separated from the transmission tariff.

### 6.2.3 Distribution price

Previously, the gas distribution fee was included in the retail price paid by end users to gas distributors, i.e., city gas companies. And local authorities only supervised the gas retail price. In another word, the distribution fee was not separately regulated.

However, NDRC commands in “Guidance on Strengthening Regulation of Gas Distribution Prices” released in June 2017 that the distribution fee should be separated from the retail price and calculated independently. The calculation is also with the *permitted-cost-plus-reasonable-profit* method. That is, a city gas company should set its distribution price based on it permitted annual revenues, which are calculated as following:

- Permitted annual revenues = Permitted costs + Amount of effective assets × Permitted rate of return + Taxes – Net income of other businesses.

Specifically, “Other businesses” refer to businesses using the assets and workforce related to gas distribution, such as marketing, installation, etc.; the permitted return rate is after-tax ROC, which should be determined equal to or below 7%.

## 6.3 Current pricing mechanisms

The overall idea of the natural gas pricing reform is to “control the middle, liberalize both ends”. Because the midstream where infrastructures need large capital investment is of natural monopoly nature, the government should control gas pipeline transport prices and distribution prices, which China has achieved for now. However, prices of gas sources (the upstream) and final selling prices (the downstream) are not well liberalized (**Table 13**).

In need of supporting the nation’s natural gas consumption, lower gas prices shall be generated through the price liberalization at both ends, which however, needs deeper natural gas market reforms, including to introduce private capital, to add competition in the gas production, to unbundle gas transportation and sales, to implement TPA to infrastructures, etc.

Meanwhile, natural gas trading platforms or market centers must be founded and developed along with the whole natural gas market. Financial derivatives based on natural gas can also be introduced at some time, with the purpose of forming more fair prices. To this extent, China still has much to improve before realizing a highly effective and efficient market.

***Table 13.*** *Pricing mechanisms by different gas sources*

<table>
<tr><th>Category</th><th>IGU type</th><th>Ex-plant price</th><th>City gate price</th><th>End user price</th></tr>
<tr><td>Domestic pipeline gas</td><td>Regulated NET and Trial GOG</td><td>= City gate price – Transmission tariff</td><td rowspan="2">Regulated NET calculated from Formula 1, except gas for direct users or in Fujian which is priced on GOG basis.</td><td rowspan="2">= City gate price + Distribution fee</td></tr>
<tr><td>Imported pipeline gas</td><td>BIM</td><td>Bilaterally negotiated</td></tr>
<tr><td>Domestic offshore gas</td><td>GOG</td><td>Market price</td><td>N/A, except such gas entering long-distance pipelines, to which city gate prices above apply.</td><td rowspan="2">Market price</td></tr>
<tr><td>Imported LNG</td><td>OPE</td><td>Linked to the Japan Customs-cleared Crude (JCC)</td><td>N/A, except such gas entering long-distance pipelines, to which city gate prices above apply.</td></tr>
</table>

# Part III. Development analysis of the natural gas market in China

The development of the natural gas market in China is mainly propelled by the government. In other words, advantages and opportunities of the development have come from internal political supports and abundant external supply. However, it's challenging for this market to go further. To precisely analyze and deal with disadvantages and contradictions at the current stage is important for a healthy progress of this market.

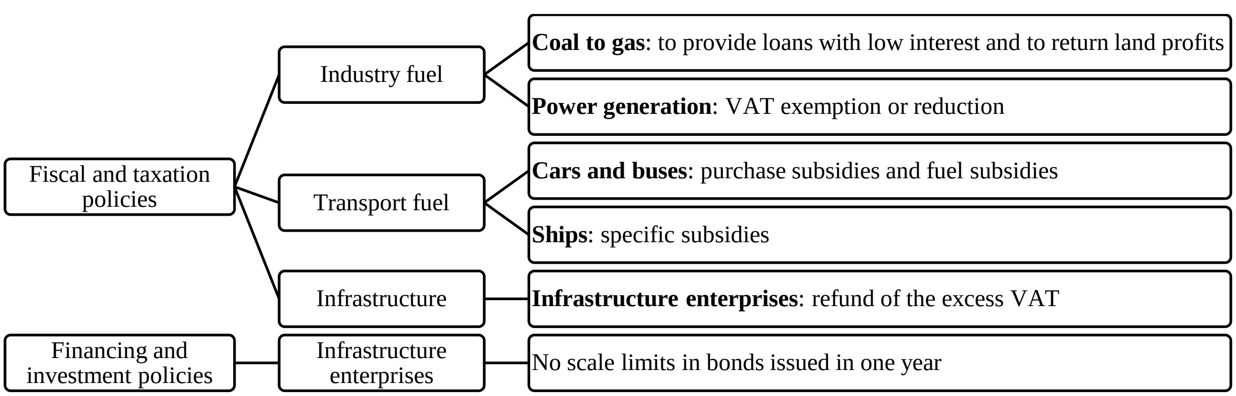
## 7. Main features of the development

### 7.1 Advantages

**1. Natural gas demand is boosted by the transition of China's energy mix.**

As environmental problems become increasingly serious, including air pollution and global warming, China determines to change its energy mix in a much quicker way. Not only China has promised in Paris Accord to reduce its carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level by 2030 and to peak its carbon dioxide emissions by around 2030 or earlier, but also China has set goals for air quality and reduction in coal consumption.

***Figure 21.*** *Current financial policies supporting the utilization of natural gas in China*




Source: Guangfa Securities. (2017, March 30). Special topic of the natural gas value chain: the economic advantage expands, and the industry has development opportunities. Available from hibor.com.cn.

As an important “bridge” transitioning the primary energy mix from more fossil fuels weighted to more non-fossil fuels weighted, natural gas is planned by the Chinese government to be utilized more widely and efficiently. This promotion of natural gas is also combined with Chinese new-type urbanization, which is characterized by ecological civilization and green low-carbon development. **Figure 21** shows a part of supportive policies.

**2. Natural gas supply is guaranteed with domestic production and imports from neighboring countries.**

Domestically, China is at an early stage of exploration: the proven rate of conventional gas reserves was 13% and the one of unconventional gas was less than 3% by 2016. A few large and medium-sized gas fields are now in the preliminary evaluation or the construction period, which will become the main components of future natural gas production. Commercialized exploitation of unconventional gas such as shale gas has been gradually realized. If more capital and competition are introduced in this field, technology may see great breakthroughs, and gas production in economic scales can be expected.

Internationally, China is actively sinking cooperation and involved in the development of gas fields overseas. Except traditional exporters such as Australia, Turkmenistan, and Qatar, Russia and the US have newly signed long-term LNG Sale and Purchase Agreements (SPAs) with China.

In May 2014, China and Russia reached a SPA of $400 billion under which Gazprom, the biggest Russian natural gas company, is contracted to supply CNPC with natural gas of 38 bcm/year for 30 years. This initiated the construction of the East-route of China-Russia Gas Pipeline in June 2015, including two cross-border underwater tunnels across the Heilongjiang River connecting to Russia’s Power of Siberia gas pipeline. The Power of Siberia is reported to have been 83% completed by now and start pumping gas to China in December 2019.

In February 2018, CNPC and Houston-based Cheniere Energy entered two 25-year SPAs terminating in 2043, under which CNPC will purchase about 1.2 million tonnes of LNG every year from Cheniere. A portion of the contracted delivery will start in 2018 and the balance will start in 2023. The contract price will be indexed to the Henry Hub price plus a fixed component, thanks to Cheniere’s toll gate business model where Cheniere itself doesn’t produce but buys gas all over the US.

**3. The reform of the natural gas industry is accelerated.**

As evidenced by the timeline of the revolution of natural gas pricing system and the establishment of SHPGX and CQPGX, the steps of reforming the natural gas market are apparently speeding up in recent years. Especially in “Several Opinions on Deepening the Reform of Oil and Gas System”, several problems in the current natural gas market are tackled, indicating the directions of change. In the next 5 to 10 years, at least 4 transformations are expected: (1) TPA to gas infrastructures; (2) unbundled gas transportation; (3) more competition in the upstream and the downstream coming from private and foreign capitals; (4) gas pricing more dependent on the market.

The reform will stir up the development potential of China's natural gas market, which will in turn expedite stable and healthy operation of this market.

## 7.2 Disadvantages

**1. The expansion of natural gas consumption couldn't be achieved singly.**

Ahead there're still a lot of obstacles against the utilization of natural gas, such as insufficient infrastructures and gas-fueled facilities, distorted gas prices, absence of administrative supervision, etc. The construction of natural gas pipelines and storage facilities is arduous and needs lots of coordination. For instance, along with the urbanization, third-party damages of the pipelines increase noticeably, and contradictions between urban planning and pipeline construction become increasingly serious.

Due to China's immature natural gas industry, it's impossible to pull up gas consumption largely in a short term. To Break the old development model calls for effective implementation of the reform policies and strong cooperation among all related parties.

**2. The security of natural gas supply is severe.**

Domestically, although China is rich in natural gas reserves, domestic supply is not as easy as before, for about 80% of remaining conventional gas resources are low-quality and high-risk types, of which the exploitation requires high and new technologies and costs more money, let alone unconventional gas in which field China is a novice. Besides, there's not enough players in the upstream market due to political restrictions on production qualification.

Internationally, geopolitical risks are big issues, such as the instability of Turkmenistan and Myanmar and the uncertainty of US diplomatic policies.

**3. The lack of transparency and supervision hinders the reform.**

Except for SHPGX listing the transaction prices of natural gas, in China there's neither electronic bulletin board which shows all the gas prices and pipeline capacity, nor specialized organization like US Energy Information Administration (EIA) who collects and analyzes all the relevant natural gas information. This limits the correction of price distortions and non-discriminatory TPA, for prices or access couldn't be compared in a very wide range.

There's also a lack of transparency in price setting. Even though NDRC has given out its pricing methods, it doesn't publicize in detail what data it uses for the inputs, nor adjust the benchmark prices in a regular basis.

In the supervision system, duties of government departments like NDRC, NEA, and Ministry of Ecology and Environment overlap. China doesn't have an independent regulation authority like the Office of Gas and Electricity

Markets (Ofgem) in the UK overseeing the whole natural gas industry. As a result, sustainable development sometimes is not guaranteed when local governments chase to hit the targets set by the central government.

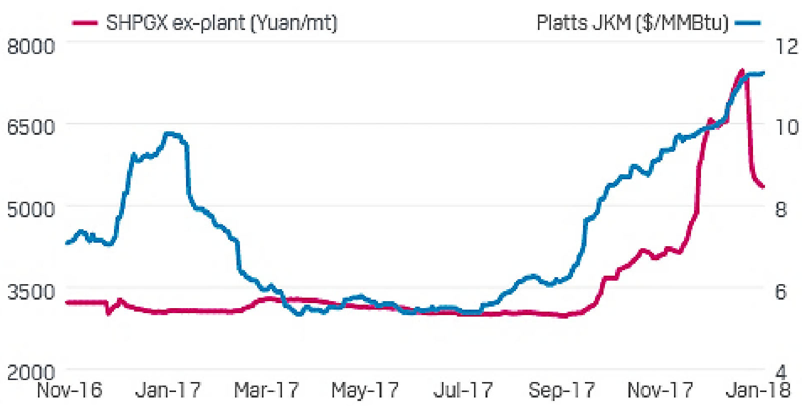
Furthermore, relevant laws and administrative rules need to be improved and to fill up current regulatory loopholes as soon as possible.

## 7.3 Case study: gas shortage in winter 2017-18

2017 is the last year for local governments to achieve the numerical indictors of air quality set in the Ten Articles. Therefore, stringent restrictions of burning coal were implemented, especially in the BTH region, where air pollution was the most severe in the county whereas the targets were the most rigorous. For example, Hebei government has forbidden 18 counties to use coal and forced them to complete the switch from coal to gas or electricity before October 2017.

This coal-to-gas switching pressure plus a colder winter in 2017 triggered an acute gas shortage in North China. In the most serious situation, gas supply to industrial users was stopped and to residential users was limited. Domestic LNG prices rose to the highest since 2011, 7,472 yuan/tonne of the ex-plant price reported by SHPGX on December 22, 2017, which was more than the double of the price in early October (**Figure 22**). Also, in 2017, China imported an unprecedently large volume of LNG, surpassing South Korea and becoming the second-largest LNG importer in the world, just behind Japan. China's urgent demand for LNG pushed LNG imported prices in Japan and South Korea, indexed in the Platts JKM, to a highest point since 2014.

***Figure 22.*** *China's national LNG ex-plant price index (in SHPGX) and the Platts JKM from Nov 2016 to Jan 2018*




Source: Platts. Retrieved from https://www.platts.com/latest-news/metals/singapore/analysis-chinas-met-coke-makers-riding-on-lng-26868304

However, the coal-to-gas switching policy is not the only reason that caused gas shortage in from early October 2017 to late February 2018 (hereinafter referred to as "winter 2017-18"). Suddenly reduced supply of pipeline gas from Turkmenistan once in early December 2017 and 3 times in January 2018 also worsen the problem. This instability is not infrequent however, urging China to diversify its gas sources and manage geopolitical risks.

The most critical issue, as Chinese politicians and scholars have realized, is insufficient capacity of gas storage and peak regulation. If gas supply had been well balanced, demand for LNG as a flexible gas source wouldn't have surged sharply.

In addition, gas suppliers were required by the government to provide gas first to residential users in the shortage, whereas the regulated city gate prices of gas for residential use were the lowest, way below LNG purchase prices. Suppliers had to bear the losses from government intervention.

Overall, the gas shortage in winter 2017-18 is a typical reflection of the most crucial problems in the current natural gas market in China, including the distorted gas pricing system and lack of trading systems for market players to hedge against the volatilities. This overregulated market needs to be liberalized.

# Part IV. Prospects for natural gas trading activities in China

## 8. International experience of market reform

### 8.1 Natural gas market in the United States

#### 8.1.1 Market evolution

The development of the US natural gas market can be divided into 4 phases: initial development (before 1938), comprehensive regulation (1938 - 1978), relaxing regulation (1978 - 1992), and full liberalization (after 1992).

The natural gas industry in the US emerged near 1900. At the initial development stage, the US natural gas market was vertically separated into production, transmission, and distribution, which segments were operated by different companies. However, pipeline companies in the midstream who owned the heavily invested transmission infrastructures naturally monopolized the whole market, as monopolistic buyers from the upstream and monopolistic sellers to the downstream. Pipeline companies purchased gas from producers at a wellhead price, and then sold and transported the gas to distributors at the wellhead price plus a transmission fee.

To prevent pipeline companies from abusing their market power, from 1938, the federal government involved in the interstate gas markets by controlling gas transportation and wellhead prices, resulting in abnormal differences between interstate and intrastate markets and large imbalances between supply and demand. The gas industry was discouraged by over regulation.

Having seen this depression, the federal government gradually removed its regulation from 1978. Wellhead prices were unleashed and TPA was introduced. Gas consumption rebounded accordingly.

The unbundling of interstate pipeline transportation in 1992 indicates that a fully liberalized natural gas market in US has formed ever after.

Further details of the US natural gas market reform are shown in **Table 14**.

#### 8.1.2 Current market structure

Nowadays, the US has established a highly competitive gas market with more than numerous gas producers, end users, marketers, distributors, and unbundled pipeline companies. Pipeline networks are open to third parties, so producers can directly sell their natural gas to large users or distributors instead of pipeline companies. Wholesale gas prices are formed on GOG basis, benchmarked against Henry Hub spot prices.

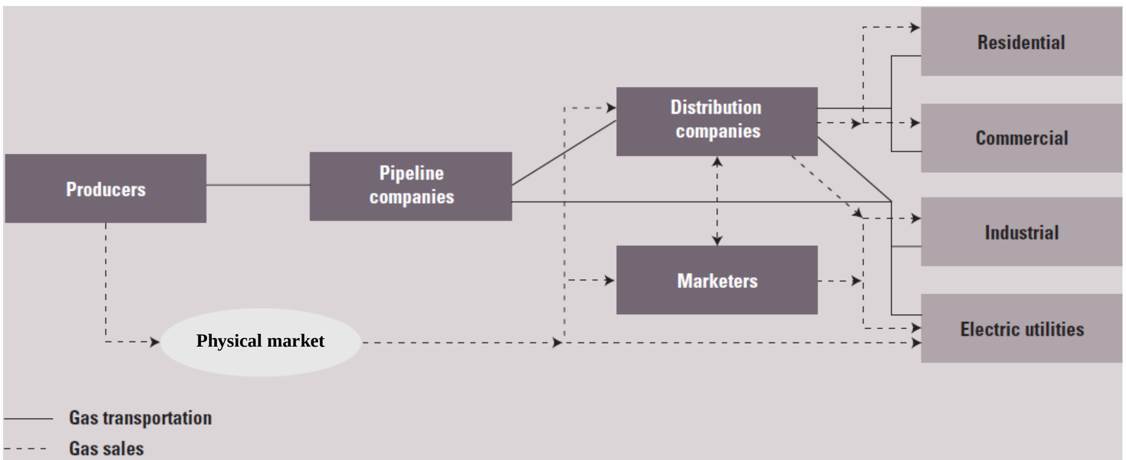
***Table 14.*** *Reforms of the US natural gas market*

| Stage | Time | Target | Policy | Contents |
|---|---|---|---|---|
| 1. Initial development | Before 1938 | - | - | Pipeline companies naturally monopolized the market and set monopolistic prices without authorities' supervision.<br>As gas pipelines spread beyond municipal boundaries, state governments such as New York and Wisconsin began to intervene the newly-developing intrastate natural gas market in 1907. |
| 2. Comprehensive regulation | 1938 | Pipeline | Natural Gas Act | The federal government intervened the interstate gas market by appointing the Federal Power Commission (FPC) to regulate interstate transportation and commerce of natural gas, including transmission tariffs and construction certifications. |
| | 1954 | Wellhead price | The Phillips Decision | FPC set the wellhead price of gas sold out of the state, by applying the "cost-of-service" method. Because the price was too low, supply couldn't cover demand, leading to natural gas shortages in early 1970s. |
| 3. Relaxing regulation | 1978 | Wellhead price | Natural Gas Policy Act | Federal Energy Regulatory Commission (FERC) took place of FPC. FERC: (1) raised wellhead price ceilings step by step till complete decontrol on wellhead prices by 1985; and (2) removed the barriers between interstate and intrastate pipelines. |
| | 1985 | Pipeline | FERC Order No. 436 | Pipeline companies were *encouraged* to provide transportation services to all customers non-discriminatorily, i.e., TPA. Thus, end users could buy natural gas and transportation service separately from producers and pipelines.<br>Transportation rates were competitively set within regulatory boundaries; wellhead price was determined by the netback method. |
| | 1989 | Wellhead price | Natural Gas Wellhead Decontrol Act | All the regulations on wellhead price were removed, leaving the market to discover the fair rate at the wellhead. |
| | 1992 | Pipeline | FERC Order No. 636 | Pipeline companies were *forced* to:<br>(1) open access to third-parties and separate transportation and sales services, so that all pipeline customers could freely select gas sales, transportation, and storage services.<br>(2) show transmission capacities whether available for purchase or lease on electronic bulletin boards. |
| 4. Fully liberalization | After 1992 | - | - | The market is well-organized. Fluidity and orderly competition have been strengthened. |

Pipeline companies have no right to buy or sell gas, but only provide gas transmission services to producers, direct users, or local distributors. Since pipeline companies can't trade, the transmission (including storage) price is controlled by the government. It is FERC who set the price of transmission and distribution services based on the "cost-of-service" ratemaking methodology.

Producers, distributors, direct users, and marketers trade natural gas and transmission capacities in the physical market (**Figure 23**). Marketers here play an important role in balancing and stabilizing the whole market. They are intermediaries and physical traders who gather different needs from sellers and buyers, match the needs, and then buy and sell gas and arrange deliveries. By pooling demand and supply, marketers can build diversified portfolios, thus minimizing price and volume risks and transaction costs.

***Figure 23.*** *Structural model of the US natural gas spot market*




Source: Juris, A. (1998a).

### 8.1.3 Trading activities

**Physical trading** takes place in more than 30 market centers or hubs in North America (**Figure 24**), many of which are intersections of several pipelines. Market participants may trade 24/7 on the telephone or the internet on daily spot basis. Monthly spot trades often happen in the last 5 business days of a month, namely, "bid week", allowing producers to sell and consumers to buy their core volumes to be delivered in the upcoming month.

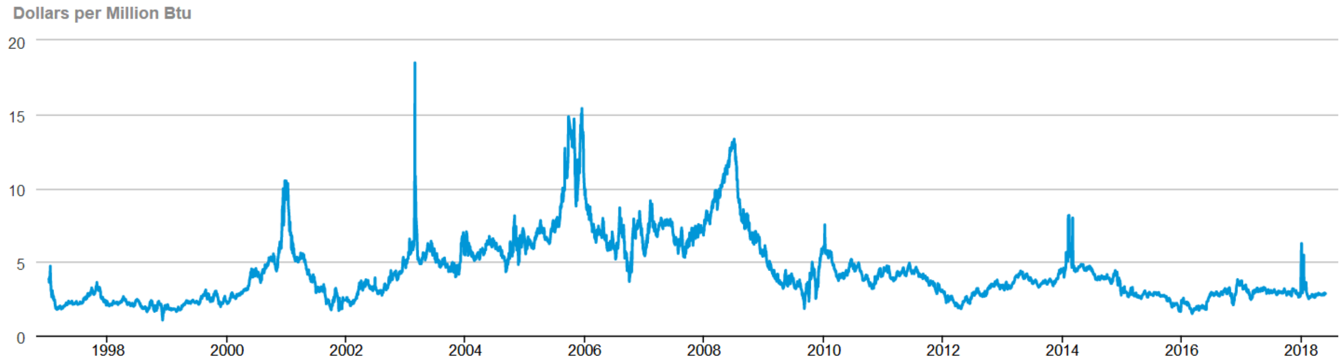
Spot prices are formed at different market centers. A market center can have its own price index reported by a publisher, who'd calculate the price index based on data collected from daily or monthly spot transactions at this center. The most famous one is Henry Hub Index (**Figure 25**), serving as the benchmark price for North America.

Market participants also trade for delivery in a longer period. However, these longer-term contracts often don't nail a specific price but rather link the delivery price to a daily or monthly spot price index.

***Figure 24.*** *Top 25 North American gas trading locations by transaction volumes*


Source: Understanding natural gas markets (2014).

***Figure 25.*** *Henry Hub daily gas spot price index*




Source: EIA. Retrieved from https://www.eia.gov/dnav/ng/hist/rngwhhdD.htm

**Financial trading** emerged in the US in the late 1980s, when several financial institutions offered customized natural gas derivatives. Natural gas futures began trading from April 3, 1990 and options from trading November 2, 1992, both on New York Mercantile Exchange (NYMEX) and delivered at Henry Hub. Since then, Henry Hub Natural Gas Futures and Options prices are based on Henry Hub, which thus become a natural gas benchmark in North America.

A Henry Hub Natural Gas Futures unit is 10,000 mmBtu and its minimum price fluctuation is $0.001 per mmBtu. One Henry Hub Natural Gas Option's underlying asset is one Henry Hub Natural Gas Futures contract. Non-standardized contracts like natural gas forwards and swaps are traded in over-the-counter (OTC) markets.

The introduction of financial derivatives greatly helps market players manage the natural gas price risks resulting from uncertain weather, policies, microeconomies, etc., and promote price discovery. In the US, the trading value occurring in the financial natural gas market is estimated 10 - 12 times[1] larger than the value in the physical natural gas market.

## 8.2 Natural gas market in the United Kingdom

### 8.2.1 Market evolution

Three landmark policies – Gas Act of 1948, Gas Act of 1986, and Gas Act of 1995, and the ownership unbundling of the midstream sector in 2002, in turn transformed the UK natural gas market into a different development stage.

The UK used gas to fuel street lighting as early as 1816, followed by numerous small private or municipal gas companies coming out to produce town gas. It was not until 1948 that a government monopoly era started. Gas Act of 1948 nationalized the UK gas industry by merging all these small gas companies into 12 area gas boards, each a separate state-owned company and collectively referred to “British Gas”. The gas market was then vertically integrated and monopolized by British Gas, who took charge of gas production, sale, and distribution.

As natural gas was discovered in the United Kingdom Continental Shelf (UKCS) in 1965, the UK gas supply was changed by policy in 1966 from town gas to natural gas. Other companies like Shell, BP, Exxon, and Amoco, were also allowed to engage in upstream exploration and production of North Sea gas, but they had no access to midstream onshore transportation and had to sell their gas at landfall to British Gas. In other words, despite competition in the upstream, the gas market from the midstream to the downstream was still vertically integrated and monopolized by British Gas. In 1972, the 12 gas boards were abolished and replaced by British Gas Corporation with the passage of Gas Act of 1972.

But the Thatcher government believed that public ownership could suppress efficiency of resource allocation and pricing, so it conducted a mass-privatization program. Gas Act of 1986 was then brought out, according to which British Gas Corporation was privatized and became British Gas plc, and the Office Gas of Supply (Ofgas) was founded by the government as the gas industry regulator. Moreover, third-party access to the gas transmission system was launched. The market was opened to large consumers whose gas consumption was over 25,000 therms per annum (the threshold was lowered to 2,500 therms per annum from 1992), meaning that they could buy gas directly from producers and then buy gas transportation services from transmission operators. Nevertheless, small

[1] Data source: NaturalGas.org. (2013, September 20). Retrieved from http://naturalgas.org/naturalgas/marketing/

consumers had no choice but to buy gas plus transportation from British Gas plc. This situation didn't change until 1996, when competition in natural gas supply was also introduced to the retail market.

Starting from 1986, the government made efforts to break the monopoly power of British Gas and let more competition in, including setting a 90:10 rule and lowering the threshold for large consumers. The market share of British Gas was greatly reduced (**Table 15**).

***Table 15.*** *British Gas's market share in 1990 - 1996*

| Market | Oct '90 | Oct '91 | Oct '92 | Oct '93 | Dec '94 | Apr '95 | Jun '96 |
|---|---|---|---|---|---|---|---|
| Small firm supply (<2,500 therms p.a.) | **100** | 100 | 100 | 77 | 52 | 45 | **43** |
| Large firm supply (>2,500 therms p.a.) | **93** | 80 | 57 | 32 | 9 | 10 | **19** |
| Interruptible (exc power) | **100** | 100 | 100 | 100 | 93 | 57 | **34** |
| Power stations | **No mkt** | 9 | 26 | 12 | 17 | 32 | **24** |
| TOTAL (exc power) | **97** | 91 | 81 | 77 | 47 | 35 | **29** |

Source: Heather, P. (2010).

Gas Act of 1995 was profound, for it set a licensing system for public gas transporters, gas suppliers, and gas shippers, thus promoting orderly competition. Afterwards, the National Balancing Point (NBP) and the On-the-Day Commodity Market (OCM) trading system was established under the Network Code in 1996. British Gas plc further went through several rounds of restructuring (**Figure 26**), and finally completed the ownership unbundling of its transportation and storage business with the merger of Lattice Group and National Grid in 2002. Perfect competition in the upstream and downstream markets has formed ever since.

***Figure 26.*** *History of demerger of British Gas plc*


Source: Centrica. Retrieved from https://www.centrica.com/investors/investor-information/demerger-history

Further details of the UK natural gas market reform are shown in **Table 16**.

***Table 16.*** *Reforms of the UK natural gas market*

| Stage | Time | Policy | Contents |
|---|---|---|---|
| 1. Initial development | Before 1949 | - | County councils and small private firms manufactured synthetic gas from coal (i.e., town gas) and ran the market. |
| 2. Government monopoly | 1948 | Gas Act of 1948 | Over 1,000 privately owned or municipal gas companies were merged into 12 state-owned area gas boards, collectively known as British Gas. The market became vertically integrated. |
| 3. Introduction of competition | 1986 | Gas Act of 1986 | (1) British Gas Corp was changed to a private company, British Gas plc, whose shares were floated on the London Stock Exchange on December 8, 1986 along with the "Tell Sid" campaign.<br>(2) The government created the Office Gas of Supply (Ofgas) to regulate the gas industry. (In 1999, Ofgas was merged with OFFER, the electricity regulator, to form Ofgem – the Office of Gas and Electricity Markets.)<br>(3) End users consuming more than 25,000 therms a year (i.e., large consumers) could directly buy gas from producers, bypassing British Gas plc and without the government's pricing control. In addition, obligatory TPA to transportation infrastructures was introduced. |
| | 1989 | 90:10 rule | British Gas plc was limited to a contract volume with any new gas field on the UKCS of no more than 90% of this field's production. |
| | 1992 | - | The threshold for large consumers was reduced from 25,000 therms to 2,500 therms, meaning more consumers could freely contract with gas producers. |
| | 1994 | - | British Gas plc reorganized its businesses into 5 divisions, and the transportation and storage division became a subsidiary named as "Transco", owing and operating national pipeline networks (i.e., National Transmission System, NTS). Thus, gas transmission business was *legally unbundled* (defined in **Appendix 5**). |
| 4. Enforcement of competition | 1995 | Gas Act of 1995 | The Act established a regulation system of licensing of activities relating to gas, which were classified by pipeline operators (gas transporters), wholesalers (gas shippers), and retailers (gas suppliers). This led to orderly and full competition in the downstream. |
| | 1996 | Network Code | The Code set rules and procedures of TPA to NTS and introduced a system of daily balancing, giving rise to short-term gas trading activities.<br>The Code created the Flexibility Mechanism, which later became the On-the-Day Commodity Market (OCM), and the National Balancing Point (NBP), whose own trading terms and conditions were NBP 1997 and NBP 2015.<br>In 2005, the Code was revised and replaced by the Uniform Network Code. |
| | 2000 | - | After British Gas plc transferred its retail business to Centrica plc and renamed itself as BG Group plc in 1997, Transco was demerged from BG Group plc and became an independent corporation, Lattice Group. Thus, gas transmission business was *structural unbundled.* |
| | 2002 | - | A "merger of equals" between Lattice and National Grid was executed, forming National Grid Transco plc (renamed as National Grid plc in 2005), since when Gas transmission business was *ownership unbundled.* |
| 5. Full liberalization | After 2002 | - | A mature and highly competitive natural gas market has come into being. Subsequent policies were issued to improve security of gas supply and to promote a better-functioning system. |

### 8.2.2 Current market structure

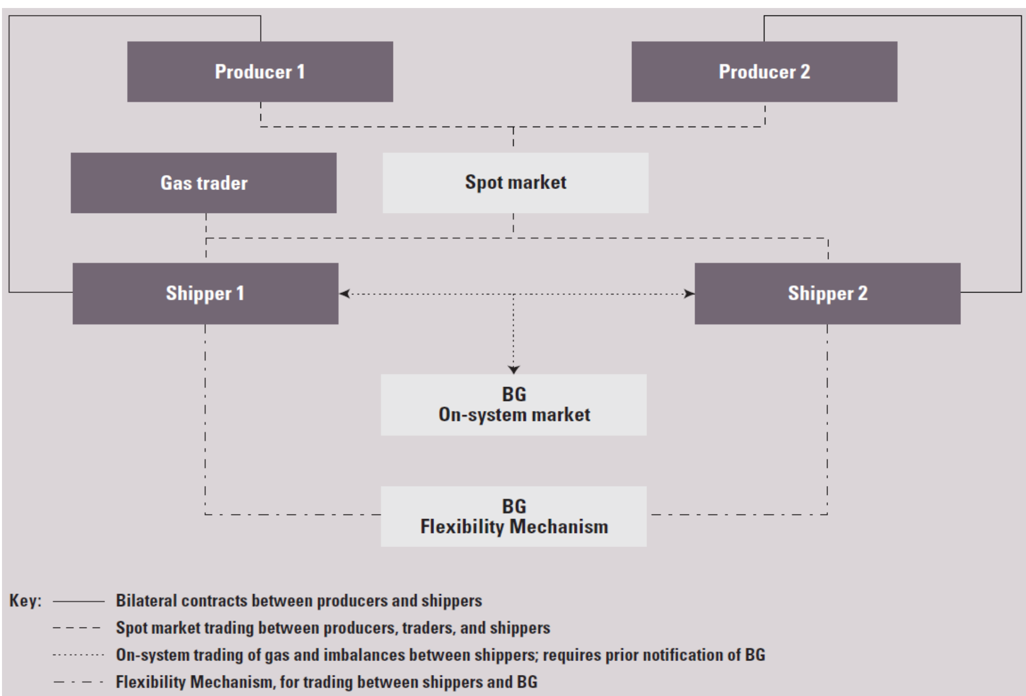
Because the natural gas upstream and downstream markets are highly competitive with numerous suppliers and buyers, wholesale gas prices are determined on GOG basis.

But the midstream market is characterized by natural monopolies and therefore regulated by Ofgem. The current midstream sector is comprised of (1) the National Transmission System (NTS), spreading over the country; (2) eight local gas distribution networks, each covering a separate geographical region; and (3) a number of smaller networks within the eight regional networks. National Grid plc is the only owner and operator of the NTS. Eight gas distribution networks are owned and operated by 4 companies, Cadent Gas, Northern Gas Networks, SGN, and Wales & West Utilities. Smaller networks are owned and operated by numerous independent gas transporters. Ofgem uses the "RIIO" model to control the network prices, that is, *Revenue = Incentives + Innovation + Outputs*.

### 8.2.3 Trading activities

In the **physical market**, Juris, A. (1998b) concluded that there're four mechanisms for trading natural gas in the UK (**Figure 27**): (1) bilateral contracts, (2) spot markets, (3) the on-system market, and (4) the Flexibility Mechanism.

***Figure 27.*** *Natural gas trading mechanisms in the UK*




Note: BG has become National Grid plc, and the Flexibility Mechanism has become the OCM today.
Source: Juris, A. (1998b).

(1) **Bilateral contracts** are signed between producers and shippers or large consumers, typically under long-term and "take-or-pay" terms.

(2) The **spot market** involves all market participants. The most traded are day-ahead and monthly contracts with delivery respectively on the next day and in the next month. Other contracts with delivery within the day, within the month, in a longer period, or in an exchanged period are also allowed.

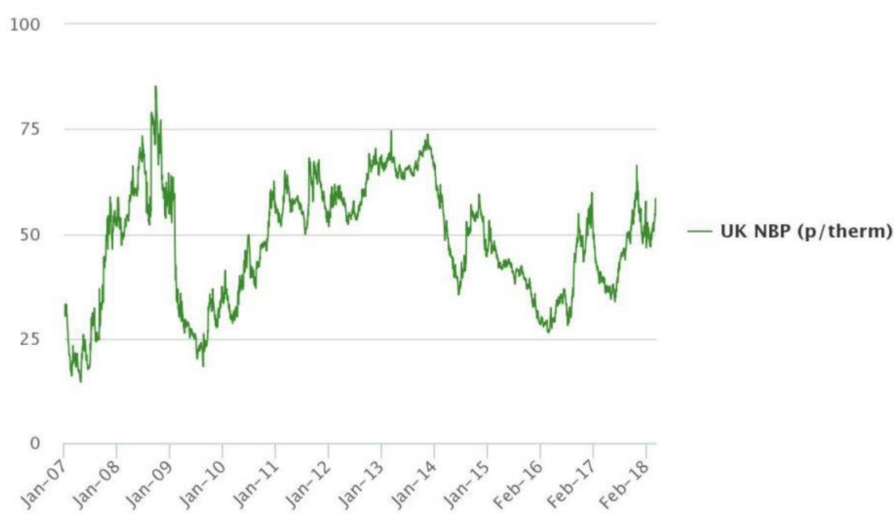
(3) The **on-system market** is spot traded between shippers with delivery at the NBP, a notional trading point on the National Transmission System (NTS) operated by National Grid plc.

(4) The **Flexibility Mechanism** has now evolved into the On-the-Day Commodity Market (OCM), where National Grid plc trades on the spot with shippers for the imbalanced volumes at the NBP. The OCM is operated by ICE Endex, who's appointed by National Grid, and traded on WebICE trading platform and cleared by ICE Clear Europe (ICEU) clearing house. The ICE Endex OCM Index (i.e., the average of prices traded for a certain delivery day) is used by National Grid to charge shippers for their imbalances.

The OCM offers 3 types of trades: title trade (i.e., transfer of title of gas), physical trade (i.e., physical transfer of gas at the location(s) specified), and locational trade (i.e., transfer of a single entry/exit point). Delivery for title trades and physical trades shall be made within the day, whereas locational trades have multiple delivery periods ranging from 1 day to 7 days. Trading hours for a "gas day" start from 08:00 (D–1) to 02:35 (D+1), thus the OCM is open 24/7 except the daily maintenance time from 03:40 to 04:00. The minimum trading size for any type is 1 lot = 1,000 thm/day, and the minimum order quantity 4 lots = 4,000 thm/day.

In natural gas spot markets, like Henry Hub, the NBP as a virtual trading point also has its spot indices reported by a few publications. One example is shown in **Figure 28**.

***Figure 28.*** *The UK NBP natural gas spot price*




Source: ERC Equipoise Limited. Retrieved from http://www.ercequipoise.com/graph/uk-natural-gas-nbp-spot-price/

In the **financial market**, International Petroleum Exchange (IPE) in London, now ICE Futures, introduced the first natural gas futures contract in the UK in January 1997, whose delivery point was the NBP. Now UK natural gas futures and options are both traded in ICE Futures and delivered at the NBP, for UK natural gas options use UK natural gas futures as underlying. UK natural gas options are European options, which will be automatically exercised unless abandoned if in the money at expiry and otherwise will be unexercised.

## 8.3 Experience learnt

The trends towards liberalization in the US and the UK markets prove that full retail competition is the best structure for the natural gas market, which facilitates efficient allocation and flows of resources, as well as just and appropriate pricing. It is consumers who are the ultimate beneficiaries. But the trends need to be pushed by the government and fit into the industry's development status.

Summarized from the current US and UK natural gas markets, both of which have achieved full retail competition, characteristics of a fully liberalized gas market are: (1) perfect competition in gas supply; (2) direct gas sales to consumers without price control; (3) unbundled gas transmission services with non-discriminatory TPA but controlled services prices; (4) sufficient physical and financial trading activities for gas delivered at a hub, thus forming hub-based gas prices fair enough as a benchmark. The financial market supports the physical market with hedging, arbitrage, and speculation, protects participants from price risks, and can be a barometer of the physical market if the financial market is mature enough.

To liberalize the US natural gas market is mainly by way of removing the government control of wellhead prices, whereas to liberalize the UK natural gas market is mainly by way of breaking down the government monopoly through privatizing and restructuring the state-owned company, British Gas, for the UK gas industry was once nationalized but the US wasn't. However, third-party access (TPA) to infrastructures and unbundling of transportation and sales are vital in both ways of liberalization. Only if the midstream sector, which is characterized by natural monopolization, is separated from gas supply and demand, the vertical integration of the natural gas value chain can be dismantled. Hence, to liberalize the natural gas market, several preconditions need to be satisfied:

(1) a large number of diversified gas suppliers and end users;

(2) sufficient pipeline networks and other gas transportation and storage facilities;

(3) open and transparent information regarding the market and the industry;

(4) complete laws and regulations;

(5) TPA to infrastructures and unbundling of transmission and sales;

(6) an independent regulatory authority controlling TPA and transmission prices, ensuring security of supply, supervising the market, promoting competitiveness, etc.

In fact, in the past 5 years, China has been making a lot of efforts to realize these preconditions above, in the direction of "controlling the middle, liberalizing both ends", which is consistent with the UK and US experience.

For (1), as mentioned before, China has given out a few rights of conventional gas exploration to companies other than the Big Three and Yanchang Petroleum. The importation of LNG and the exploration and exploitation of unconventional gas are open to all kinds of companies. What's more, gas utilization in various areas such as power generation and traffic are being boosted.

For (2), not only specifying targets in the Plan, in retrospect of the gas shortage in winter 2017-18, the Chinese government calls for urgent efforts to build more storage facilities and to complete pipeline networks.

(3) and (4) will be improved with the development of natural gas exchanges, which are existing SHPGX and CQPGX, and expected Xinjiang Oil and Gas Exchange.

For (5), besides required by the Plan, TPA is specified in NEA's administrative orders (**Table 17**). Following the order in September 2016, the Big Three first time publicized detailed information of their own pipelines. Afterwards, on December 7, 2016, CNPC and Guanghui Energy signed a framework contract, under which CNPC's West - East Gas Pipeline would be opened to Guanghui, and Guanghui would transfer gas from its LNG station to this pipeline. Access to transportation facilities is gradually opened to other parties.

***Table 17.*** *Chinese policies about TPA*

| Issue date | Policy | Main contents |
|---|---|---|
| Feb 13, 2014 | Trial Supervision Measures for the Fair and Open Access to Oil and Gas Pipeline facilities | Oil & gas pipeline operators with surplus capacity must provide pipeline access and services, including transport, storage, gasification, liquefaction, and compression, to third parties in a fair and nondiscriminatory manner according to the order in which contracts are signed. |
| Sep 2, 2016 | Information Disclosure of Access to Oil and Gas Pipeline Facilities | Oil & gas pipeline operators are required to complete the information disclosure of their oil & gas networks before October 31, 2016. |

China also moved an important step towards unbundling transmission services. In December 2015, CNPC restructured its pipeline transportation services into one subsidiary, PetroChina Pipeline Co., Ltd. In November 2016, CNPC set up 5 gas marketing branches, independent from its gas transmission business managed by PetroChina Pipeline. It's very likely that PetroChina Pipeline will become a national transmission system operator just like National Grid in the UK.

For (6), there is no independent gas regulator in China yet. The gas market is majorly directed and overseen by NDRC and NEA, while NEA itself is managed by NDRC. But regulatory powers are often decentralized or overlapped among different departments of the State Council, so cross-functional cooperation is needed. NDRC and NEA must coordinate with other relevant departments such as Ministry of Commerce, Ministry of Natural

Resources, and Ministry of Ecology and Environment, to guarantee the implement of one policy.

Concerning the limited scale of China's natural gas industry, the Chinese government doesn't feel such an urge to set up an independent supervision institute immediately, especially when the biggest three state monopolies can exert great influence on the industry's development. After all, FPC founded in 1938 and Ofgas founded in 1986 were both required by a privatized industry, when state power was weak in the market.

Nevertheless, like the progress of the UK natural gas market, the development of China's natural gas market will be accompanied by the restructuring and demerger of the Big Three. And an independent natural gas regulatory authority shall be founded with the growth of the industry.

# 9. Trading hubs

The first natural gas hubs (also known as "market centers") emerged in the United States near 1990, providing extra meeting places for gas sellers and buyers besides production areas. Since different production areas were attached to different pipelines, these inter-pipeline hubs made gas buyers unconfined to original areas. Hubs greatly prospered after FERC Order No. 636 was issued in April 1992, which stipulated TPA and unbundling of transmission system, and supported the development of market centers.

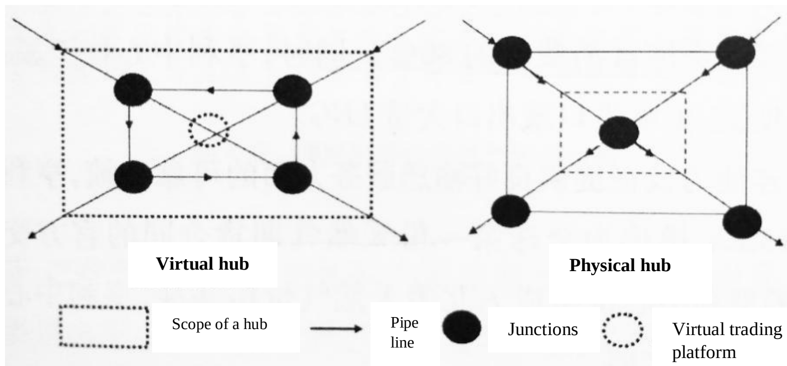
Natural gas market reform followed up in Europe. In 1996, the UK NBP was established by the government as part of gas market liberalization. Then Belgium's Zeebrugge (ZEE) came into operation in 2000, the Netherlands' Title Transfer Facility (TTF) and Italian Punto di Scambio Virtuale (PSV) in 2003, French Points d'Exchange (PEG Nord and Sud) in 2004, and so on.

A natural gas hub shall be both a geographical point where shippers deliver/receive gas to/from another point of the same or an interconnected pipeline, and a contractual point where traders buy/sell gas and exchange the ownership. The key services that a hub provides are transportation and trading, plus related supports to facilitate gas physical and/or title transfers.

A hub can be either physical, a point at which several pipelines intersect like Henry Hub; or virtual/notional, a (balancing) point covering a whole pipeline system like the NBP and the TTF. The differences between physical and virtual hubs are shown in **Figure 29**.

A well-developed natural gas hub has two major effects: one is to bring market players together to trade aggregately thus improving transaction efficiency, the other is to generate a competitive price which balances demand and supply. A reliable hub-based price can be a benchmark for the relevant trading area. For instance, Henry Hub price is the benchmark price for North America. The NBP provides the only wholesale price for the UK regardless of geographic differentials due to transport costs. The TTF sets the reference for continental Europe. What's more, these hubs are futures and options contracts' delivery points, so they form forward prices.

***Figure 29.*** *Diagrams of a physical and a virtual hub*




Source: Niu, Y.B., et al. (2013).

## 9.1 Successful experience of establishing a hub

The Development Research Center of the State Council of PRC and Shell International (2015) concluded that a successful natural gas hub needs to satisfy three main conditions: (1) complete transportation networks with non-discriminatory TPA; (2) large numbers of independent buyers and sellers involved in arbitrage without domination; (3) government supports for a liberalized market with stable and reliable regulations.

EIA (2017) pointed out that it's prerequisite for a hub to be equipped with adequate physical facilities, which include sufficient pipeline capacities and interconnections, nearby gas storage, market operators, and even LNG receiving and regasification terminals.

EIA (2017) then fit detailed market conditions into 10 stages of hub development: (1) deregulation of gas prices and unbundling of transmission; (2) TPA to transportation; (3) bilateral trading between producers and distributors or large end users (i.e., physical traders); (4) transparency in trading prices and volumes; (5) standardization of trading rules and contracts; (6) over-the-counter (OTC) brokered trading; (7) price indexation; (8) financial traders; (9) futures exchange; (10) liquid forward price curve. This is quite similar to the liberalization process of a natural gas market. In a strict point of view, up till today, only Henry Hub and the NBP are fully functional market hubs that have arrived at Stage 10.

In general, to be a successful gas trading hub, it should meet both institutional and structural requirements.

*Institutionally*, the government should take its hands off the pricing and trading activities at the hub. Separation of transport and sales is necessary, as well as TPA to pipelines.

*Structurally*, the hub first should be a convenient transit place, at the heart of abundant transportation infrastructures including interconnected pipelines, LNG terminals, and storage facilities, with the ability of moving supplies immediately. It's then qualified to be a widely accepted delivery point for physical commodities.

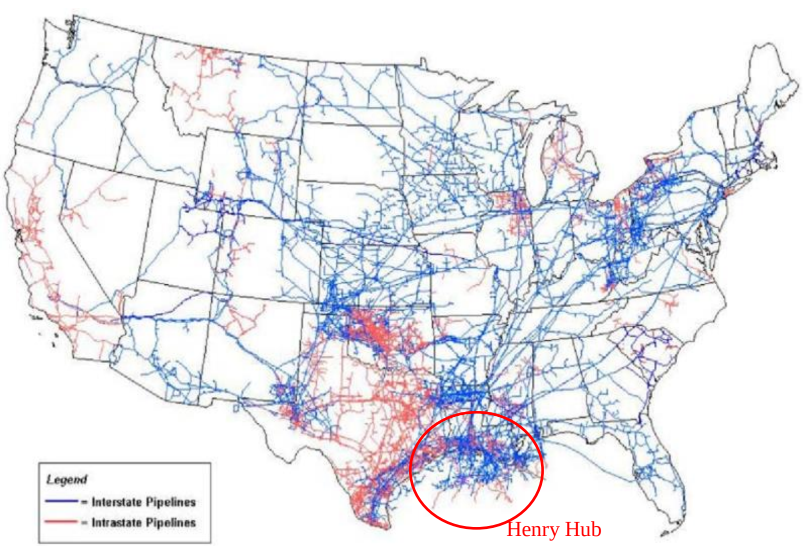
Second, the hub should have diverse sources of gas supplies, from domestic productions and pipeline imports to flexible LNG shipments. It's because only a variety of gas supplies can grow and serve a large customer base with vast consumption needs and abilities. Often, an oversupply of gas is needed in the early stage of the hub's development, in order to attract potential buyers and to ensure the market fluidity.

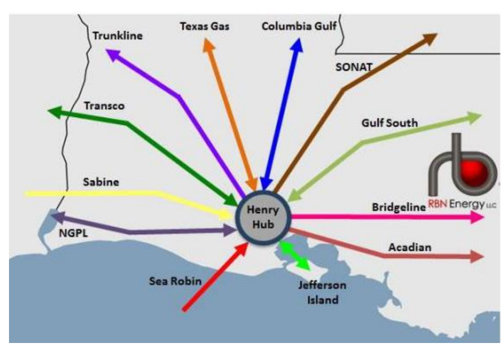
Third, a trading hub should be highly competitive without dominants, allowing arbitragers and speculators to come in. Thus, a fair price can be formed, reflecting the true relationship between supply and demand. Gas derivatives markets grow and make the hub their price reference point.

### 9.1.1 Henry Hub

Henry Hub is a physical gas hub established in March 1988. It is in Erath, on the Louisiana-Texas border and just by the Gulf of Mexico. It was one of the first market centers emerging in this top producing area in the US, with dense pipeline networks developed. As NYMEX needed to find a delivery point for its futures contracts of natural gas, preferably an industry-accepted benchmark, Sabine Pipe Line LLC, the owner and operator of Henry Hub, swooped in and made Henry Hub the one. In April 1990, the first natural gas futures contract in the world was traded in NYMEX and Henry Hub was the delivery point. Thereafter, Henry Hub has been the pricing reference point for gas traded both in spot and futures market in North America, as well as LNG exports.

***Figure 30.*** *The US natural gas pipeline network in 2009 and Schematic diagram of Henry Hub*




Source: (left) EIA. (right) The evolution of the Henry Hub natural gas benchmark in the US. (2015, July 24). Retrieved from http://www.shaledispatch.com/the-evolution-of-the-henry-hub-natural-gas-benchmark-in-the-us/

NYMEX's choice didn't come from nowhere. Henry Hub was qualified as the benchmark by its diversity of supply, high level of interconnectedness, and spot price liquidity. Not only Texas, Louisiana, and the Gulf of Mexico have ample onshore and offshore gas productions and possess extensive pipelines (**Figure 30**), but also most LNG import/export terminals – either currently in operation or in the plan- are situated in the Gulf Coast. Henry Hub is interconnected to 8 interstate pipelines and 3 intrastate pipelines and directly linked to storage facilities, including Jefferson Island, Acadian and Sorrento which allow for several withdrawal and injection cycles per year. These hardware conditions facilitate a lot of trading at Henry Hub, thus guaranteeing market liquidity.

Henry Hub now is providing full-fledged services including wheeling, parking, loaning, balancing, compression, gas trading, title transfer, information, administrative, etc. It has become a globally important reference point for the gas industry.

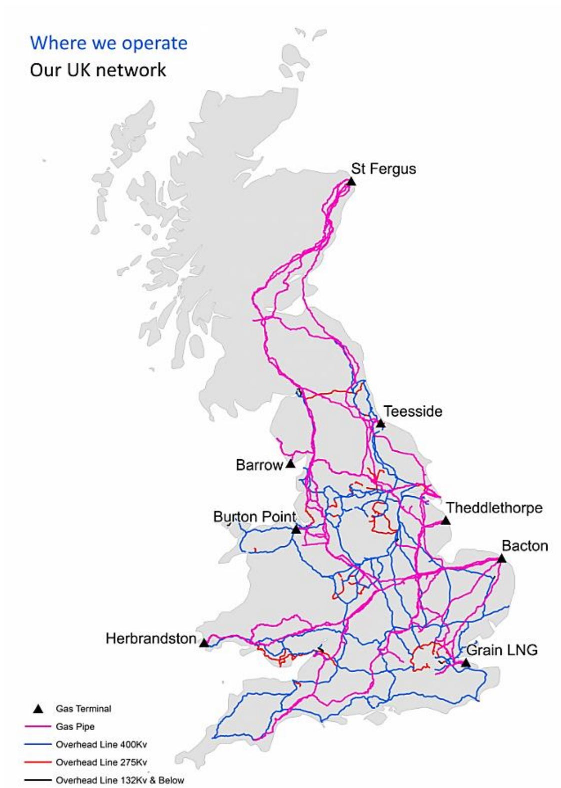
### 9.1.2 National Balancing Point

The National Balancing Point (NBP) was created by the Network Code in 1996 (now changed to the Uniform Network Code since 2005) with the purpose of balancing daily gas injection/withdrawal of the NTS. Then it has evolved into a notional pricing and deliver point for shippers to buy/sell physical gas, and for non-shippers to trade natural gas derivatives in ICE futures or OTC. The NBP offers trading for multiple delivery periods, ranging from within-day to day-ahead to years. Whether in exchange or OTC, as long as gas traded flows into/out of the NBP, participants need to abide by NBP terms (NBP 1997 or NBP 2015).

Unlike the US, where numbers of private companies transport natural gas via numbers of different pipelines, the UK has a limited territorial area such that only National Grid plc owns and operate the national pipeline networks, i.e., the NTS (**Figure 31**). The NTS has high pressure pipes of about 7,600 Km and 8 gas terminals covering the whole country. Therefore, instead of picking a specific intersection of pipelines as a physical hub, the UK government sets every point of the NTS as the NBP for gas shippers to trade. National Grid balances the NBP on any gas day by trading in the OCM. As a result, a gas price at any point on the NTS is the same, with neither geographical differentials nor transportation costs. Gas shippers must pay to National Grid (1) capacity fees for any entry/exit of the NTS and (2) commodity fees for every volume of gas transported in the NTS.

The prosperity of the NBP is mainly because the UK enjoys abundant gas supply both from indigenous production and abroad, as well as well-developed infrastructures covering the nation and connecting to Continental Europe (**Appendix 6**). In 2017, the UK produced 43% of its domestic consumptions from the North Sea and the East Irish Sea, imported 44% via pipelines from Norway, the Netherlands, and Belgium, and imported 13% via LNG tankers from various countries such as Qatar and Algeria. Moreover, since the UK-Belgium natural gas pipeline was completed in 1998, the interconnection between the UK gas market and continental European gas markets has increased tremendously, which has also made the NBP an important reference point for European gas markets.

*Figure 31.* *Network route map of National Transmission System*




Source: National Grid. (2018, May). Retrieved from https://www.nationalgrid.com/uk/about-grid/our-networks-and-assets/gas-and-electricity-network-routes

## 9.2 Rationales for China to develop hubs

With the continuous growth of natural gas consumption in China, contradictions between gas demand and supply become more and more serious; with the increasing need for natural gas imports, China's natural gas market gets more connections with the global gas market. In order to reflect China's real situation of gas demand and supply and to strengthen China's pricing power in the international trade, it is of great strategic significance for China to establish regional or national natural gas trading hubs, which have functions and meanings as following.

**(1) To optimize the allocation of natural gas resources**

A natural gas hub forms an open and transparent market where transaction information is public and easily accessible, thus reducing transaction costs and increasing market liquidity. Through the hub, natural gas can be fairly and effectively distributed to different customers at different time, places, volumes, prices, etc. For instance, customers with rigid demand, such as gas distribution companies with obligations to guarantee the supply to households during the winter, take higher gas prices; customers with elastic demand, such as industrial users with other-energy-fired facilities, take lower gas prices. Overall, a gas hub can quickly match supply and demand and eliminate imbalances, which contributes to the diversification of gas sources and the formation of gas-on-gas competitions.

**(2) To help participants adjust their natural gas portfolios**

By centralizing trading, a hub provides liquidity for market players to adjust their gas portfolios overtime. Financial derivatives based on the hub also make it easier for player to hedge their exposures to gas price and volume risks. Generally, hubs can promote both physical and financial trading of natural gas, so that market participants can arrange production or consumption in advance and on spot, as well as minimize risks.

**(3) To guarantee energy security**

Long-term bilateral contracts can be mingled with short-term multilateral trading at a hub, thus reducing the dependency on a certain supplier or a certain gas source. A hub is also essential for GOG pricing, which guarantees the fairness of gas prices.

**(4) To promote the domestic production and the construction of infrastructures**

It's a chicken-or-egg situation, because a hub can't prosper without sufficient gas supply and well-developed infrastructures. But the hub helps discover the demand-supply gap and specific defects of infrastructures, which give guidance to the following investment, production, and construction.

**(5) To improve the natural gas pricing system**

It's widely acknowledged that the "Asian premium" in natural gas is mainly because there's no gas trading hub in Asia yet. The establishment of a gas trading hub in China will facilitate natural gas price discovery and help eliminate the "Asian premium". In the meantime, by developing a reliable hub-based pricing system, China can improve its own pricing power in the international market.

## 9.3 Current states of trading hubs in China

At present, China has two natural gas trading hubs, both of which are national: Shanghai Petroleum and Natural Gas Exchange (SHPGX), which was incorporated on March 4, 2015 and officially put into operation on November 26, 2016, and Chongqing Petroleum and Natural Gas Exchange (CQPGX), which was incorporated on July 25, 2017, and listed its first natural gas order on May 11, 2018. In addition, the establishment of another national gas trading hub in Karamay, Xinjiang has entered a substantive stage. In "Reply to the issues relating to preparatory work for the establishment of Xinjiang Oil and Gas Exchange" released on December 14, 2017, NDRC approved the work and asked to research on the establishment of Xinjiang International (Central Asia) Energy Trading Center.

It is also reported that Shenzhen is planning to establish a natural gas trading hub of Guangdong-Hong Kong-Macau Greater Bay Area.

The 4 hubs mentioned above are located respectively in east (Shanghai), southwest (Chongqing), northwest (Xinjiang), and south (Shenzhen) China. These locations have several characteristics in common: dense pipeline networks, ample and diverse gas sources, large consumption abilities, and developed commodity or stock exchanges. Hence, all these 4 hubs are quite potential to become the most liquid and important natural gas hubs in China. Take Xinjiang Oil and Gas Exchange for example, it is going to help create financial centers and complete the energy channels in the Northwest, and to improve Xinjiang's strategic position and functions as the core zone of the Silk Road Economic Belt.

Additionally, since SHPGX was founded, NDRC has encouraged sellers and buyers of natural gas that is either (1) for non-residential use or (2) transported in West-East Gas Pipeline to Fujian Province to trade in gas hubs, to make transactions and prices open and transparent.

### 9.3.1 Trading rules

Current rules in Shanghai and Chongqing natural gas hubs are shown in **Table 18**.

***Table 18.*** *Trading rules in SHPGX and CQPGX*

| Spot trading | SHPGX | CQPGX |
|---|---|---|
| Trading hours | Monday to Friday (except national statutory holidays): 9:00 - 11:30 and 13:30 - 15:00 | Monday to Friday (except national statutory holidays): 9:30 - 11:30 and 13:30 - 15:00 |
| Trading model | Listing, or bidding | Listing, bidding, or trading by agreement |
| Delivery | Autonomous, or organized by the exchange | Autonomous |
| Settlement | Margin system, and special settlement account | |

#### 9.3.1.1 Trading models

**Listing:** There're two types of listing: buyer listing and seller listing. Namely, a buyer or a seller lists on his/her price quotation and other relevant information of a certain commodity on the electronic trading platform of the natural gas exchange, according to the exchange rules. Afterwards, other sellers or buyers shall close the deal only at that quoted price.

**Bidding**: There're two types of bidding: buyer bidding and seller bidding, that is, to bid for either a purchase or a sale. On the exchange's electronic trading platform, a buyer or a seller publicly posts the highest price to buy or the lowest price to sell and other relevant information of a certain commodity. Then, other sellers or buyers can bid to sell below the highest buying price or to buy above the lowest selling price. After a required period, the exchange will match all the bids to the post on a *price-time priority* basis.

**Trading by agreement**: Approved by the exchange, a buyer or a seller announces in a private placement manner, through on the exchange's electronic trading platform, the quantity of a certain commodity that he/she is to buy or sell. Within a required period, the buyer or the seller must negotiate with other market participants in order to achieve an agreement, according to which the deal can be closed.

In conclusion, there's no bilateral trading yet. Trading activities of natural gas in China is highly regulated and directed by the government.

#### 9.3.1.2 Delivery

**Autonomous**: The buyer and the seller, i.e., the contracting parities, shall offline specify every detail of the delivery on their contract, according to which the seller delivers the commodity to the seller out of the exchange. That is, the commodity, payments, bills, etc. do not go through the exchange. The exchange will supervise the delivery, but it's the contracting parties who bear all the risks.

**Organized by the exchange**: The buyer and the seller jointly agree in the contract that they entrust the exchange to deliver the commodity via the pipelines designated by the exchange and to provide relevant delivery services according to the contract. On basis of confirmation certificates of goods delivery and receipt issued by both parties, the exchange then transfers the payments and settles the deal.

In conclusion, with limited gas transmission facilities, there's no trading of transportation capacities yet, and offline negotiation of the delivery is often time-consuming and inefficient.

### 9.3.2 Shanghai Petroleum and Natural Gas Exchange

#### 9.3.2.1 Overview of the exchange

On March 4, 2015, Shanghai Petroleum and Natural Gas Exchange Co., ltd. (SHPGX) was incorporated in China (Shanghai) Pilot Free Trade Zone. On July 1, 2015, SHPGX started trial operation. On the same day, PetroChina's West-East Gas Pipeline Branch Company sold 245 million cu.m of pipeline gas to Shanghai Natural Gas Pipeline Networks Co., Ltd through the exchange, which was delivered at two stations of Shanghai Natural Gas Pipeline Networks Co., Ltd within a week.

On November 26, 2016, SHPGX started official operation. On July 20, 2017, SHPGX held the first special session of bidding for LNG online, where 64 sell orders totaling 11,420 tonnes of LNG were posted and fulfilled by 8 buyers within the day. By the end of 2017, the trading volume in SHPGX has reached 51.2 bcm, accounting for about 11% of China's natural gas consumption in 2017. SHPGX now has over 1,600 members registered.

SHPGX's registered capital is 1 billion yuan, invested by 10 shareholders. The top 5 shareholders are China Economic Information Service Co., Ltd (holding 33% of total shares), PetroChina (10%), Sinopec (10%), CNOOC (10%), and Shenenergy (7%). China Economic Information Service (CEIS) is a wholly-owned subsidiary of Xinhua

News Agency. With the aim that SHPGX can obtain timely, authoritative, and comprehensive trading information and render professional information services, CEIS has jurisdiction over SHPGX and actively participates in its development. SHPGX is also directed and supervised by NDRC, NRA, and the Ministry of Commerce.

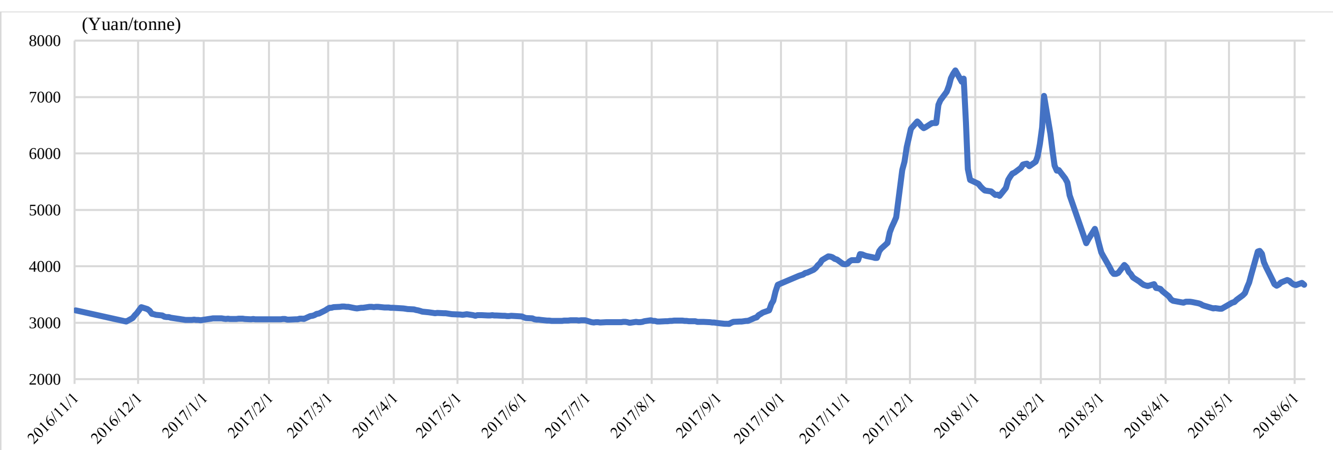
It's quite natural for Shanghai to be the first gas trading hub in China. Shanghai is the end point of a few trunk pipelines, such as West-East Gas Pipeline and Sichuan-East Gas Pipeline, and a major entrance of LNG imports with 8 LNG terminals in operation, construction, or planning nearby (including the ones in Zhejiang and Jiangsu). And as the core city of the Yangtze River delta economic zone, Shanghai enjoys unique geographical advantages and is developing rapidly, indicating a strong ability of consuming natural gas. Moreover, Shanghai owns the most mature and influential financial system in China, with several exchanges such as Shanghai Futures Exchange, Shanghai Stock Exchange, Shanghai International Energy Exchange (INE), etc.

Spot trading of pipeline gas was launched first in SHPGX and now has a number of city gates as its delivery points, covering all the parts of China. However, as the city gate price is controlled by the government within a 20% increase from the benchmark, trading of pipeline gas is not marketized enough. In contrast, as LNG prices are fully liberalized, trading of LNG in SHPGX is quite marketized. SHPGX has been publishing 3 types of LNG price indices: national LNG ex-plant price index, Provincial LNG ex-plant price index, and Southeastern LNG transaction price index.

#### 9.3.2.2 LNG price indices

**National LNG ex-plant price index** (**Figure 32**): The index is published exclusively by SHPGX to reflect the trend of domestic LNG prices. SHPGX calculates the index by monitoring in priority about 50 LNG plants or receiving terminals in 14 regions, based on the transaction data in SHPGX and assisted with quotations from SHPGX's shareholders and cooperative information agencies.

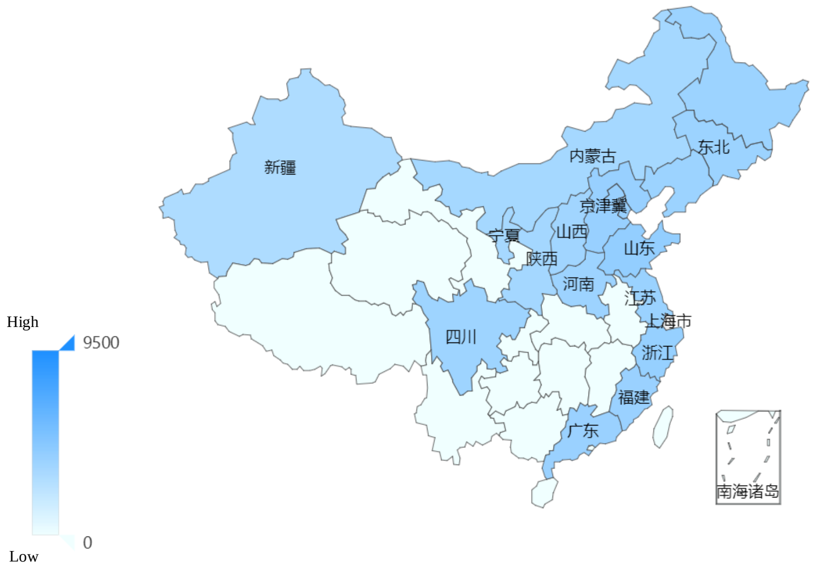
***Figure 32.*** *Historical trend of the national LNG ex-plant price index*




Data source: SHPGX.

**Provincial LNG ex-plant price index** (**Figure 33**): The calculation method of this index is the same as the national LNG ex-plant price index. The only difference between the national index and the provincial index is the geographical coverage.

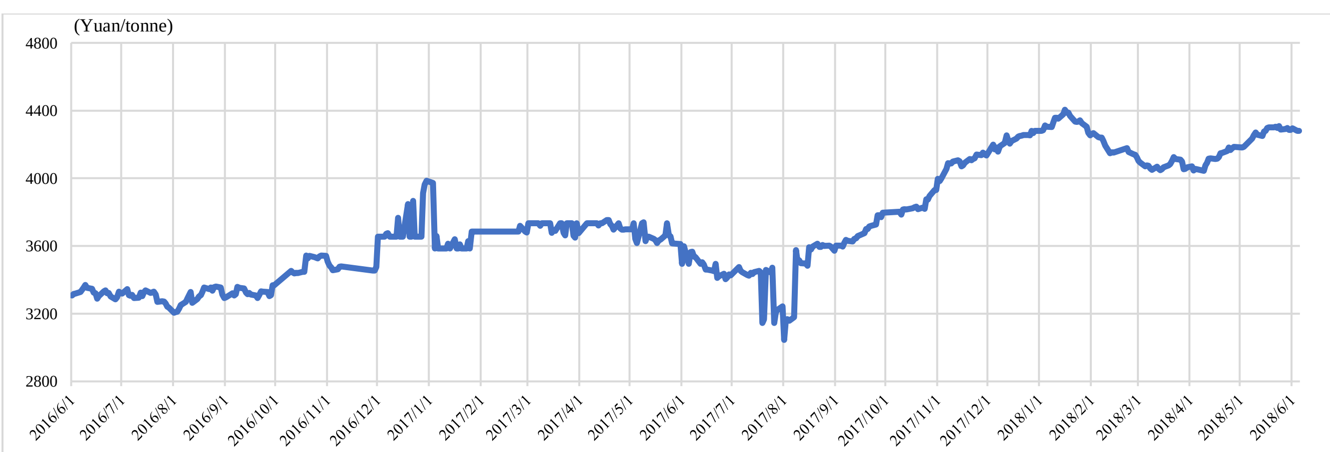
*Figure 33. Provincial LNG ex-plant price indices on June 6, 2018*




Source: SHPGX. Retrieved from https://www.shpgx.com/marketzhishu/mapprovincelng/37

**Southeastern LNG transaction price index** (**Figure 34**): The index is published exclusively by SHPGX to reflect the market valuation of LNG in southeast China assuming that there's no transaction. SHPGX calculates the index comprehensively by linking to the prices of domestic pipeline gas, imported LNG, and imported crude oil, as well as considering at the same time the prices of several alternative energy sources like fuel oil, liquefied petroleum gas (LPG), diesel oil, and electricity power.

*Figure 34. Historical trend of the Southeastern LNG transaction price index*




Data source: SHPGX.

#### 9.3.2.3 Preselling

On April 18, 2018, SHPGX held a special session for CNOOC to presell LNG, which was to be delivered in July and November 2018 at CNOOC's Ningbo LNG terminal. In support of online trading, CNOOC offered a 100 yuan/tonne discount.

SHPGX preannounced this bidding session and its trading rules on April 13. According to the rules, the LNG to be delivered July in should be traded in the "buyer bidding" model. The LNG to be delivered in November should be traded in the "seller listing" model, which was also privately listed for the buyers of the LNG to be delivered in July, each with a listed quantity of 50% of the one bought for July. The minimum trading amount was 500 tonnes, and the maximum was unlimited. The price fluctuation was set at 10 yuan/tonne. And the LNG traded in shouldn't change hands after the session.

In the morning on April 18, CNOOC posted on SHPGX's electronic trading platform 60 thousand tonnes of LNG for delivery in July. Within 15 minutes, all the quantities listed were sold, at prices ranging from 3,380 to 3,390 yuan/tonne. The largest order fulfilled was 12 thousand tonnes and the smallest was 500 tonnes. 12 companies participated in the bidding and 11 companies won the bids. In the afternoon session, CNOOC listed in SHPGX 30 thousand tonnes of LNG for delivery in November. All the quantities listed were sold out again, of which 27.95 thousand tonnes was sold at 4,200 yuan/tonne and the rest at 4,210 yuan/tonne.

This preselling benefits the gas market in two respects: (1) consumers predetermine a part of gas for winter; (2) the transaction prices serve as a signal for spot prices in winter. Overall, this pre-allocation of natural gas lays foundation for forward trading of natural gas in China.

#### 9.3.3.4 Potential for natural gas futures

On November 6, 2013, Shanghai International Energy Exchange Co., Ltd (INE) was incorporated in China (Shanghai) Pilot Free Trade Zone and intended for trading activities of energy derivatives including crude oil, natural gas, petrochemicals, etc. Now it has crude oil traded on its platform. With the development of physical natural gas trading in SHPGX, introduction of natural gas futures in the INE is foreseeable in the coming years.

### 9.3.3 Chongqing Petroleum and Natural Gas Exchange

Chongqing Petroleum and Natural Gas Exchange Co., ltd (CQPGX) is the second natural gas trading hub in China, which was incorporated on July 25, 2017, and got its business license on November 22, 2017. Its registered capital is 10 billion yuan invested by 13 shareholders, among whom the top 5 are PetroChina (holding 13% of the total shares), Sinopec (13%), Chongqing Energy Investment Group Co., Ltd (13%), Chongqing Hongrongxin Enterprise Management Co., Ltd (9%), and Chongqing Chemical Medicine Holding (Group) Company (8%).

Chongqing is of strategic importance for China’s natural gas industry. First, Chongqing is one of the leading producing areas of both conventional and unconventional gas in China. Particularly, it contributes 70% of the national shale gas production. Second, resulting from the abundant natural gas resources, many large consumers of natural gas concentrate in Chongqing, including industrial users and fertilizer manufacturers. Third, gas infrastructures in Chongqing are ample and developed, with several national trunk pipelines going though, such as Sichuan-East Gas Pipeline and Zhongwei-Guiyang Pipeline, and China’s largest underground gas storage – Xiangguo Temple Gas Storage. Last but not the least, Chongqing is endeavoring to become the financial center in the upstream of the Yangtze River, with supports from “One Belt and One Road”, the Yangtze river economic belt, and the Chongqing free trade zone. By now, besides CQPGX, there’re Chongqing Financial Assets Exchange and Chongqing Share Transfer Center as well.

The first online trading in CQPGX was launched on May 11, 2018. PetroChina listed 28.16 million cu.m of pipeline gas on CQPGX’s electronic trading platform in terms of “seller listing” and all the gas was sold out within the day. 56 deals coming from 56 city gas companies located in southwest China were made, and the transaction prices ranged from 1,695 to 2,065 yuan/cu.m.

LNG was first traded in CQPGX on May 17, 2018. The trading model was “buyer bidding”. PetroChina posted 400 tonnes of LNG from 2 p.m. to 2:30 p.m. on CQPGX’s electronic trading platform and 400 tonnes was sold out within 30 minutes. 6 deals were made at a price of 3,750 yuan/tonne, and the delivery point was Jiangsu Rudong LNG terminal.

Because CQPGX is in a primary stage of development, price index can’t be formed due to small trading volumes.

## 9.4 Prospects of trading activities in China

To a large extent, market liquidity and competitiveness in SHPGX and CQPGX are restricted by the infrastructure and the marketization degree of China’s natural gas industry.

Firstly, in the strict definition, SHPGX and CQPGX are not gas trading hubs but are just electronic trading platforms, because they are not the delivery points – pipeline gas is delivered at a certain city gate, and LNG is delivered at an LNG terminal. Most of the LNG traded in SHPGX is delivered at CNOOC’s Zhoushan LNG terminal. This is mainly because natural gas prices are controlled at city gates, and the benchmark city gate price in every province is not the same. Besides, pipelines connecting to LNG terminals are not complete, and transportation facilities are too limited with few extra capacities released out for companies other than the Big Three. Due to the lack of gas transportation capacities, market participants have to determine the transportation means themselves, rather than being efficiently arranged by the exchange.

Secondly, the Chinese natural gas pricing system is highly regulated, and the Big Three are the major gas suppliers who monopolize the market. These facts confine the diversity of trading models and the formation of competitive prices. Natural gas to be posted on the platform for bids shall be examined and verified by the exchange. There's no bilateral physical trading yet, let alone financial trading of natural gas derivatives.

Thirdly, in China, gas is not priced on basis of per unit of its heating value, such as "dollars/mmBtu", which is the international practice. Pipeline gas is priced in terms of unit of volume, i.e., "yuan/cu.m", and LNG is priced in terms of unit of weight, i.e., "yuan/tonne". This restricts different gas sources to compete in the same market, thus restricting China to have stronger pricing power in the international market. Therefore, it's quite necessary and will be profound to change current natural gas meters from the ones metering the volume or weight of gas to the ones metering the heating value, although it will take a lot of time and money to change all the meters over the country.

Both the US and the UK can offer valuable experience for the development of China's natural gas market and hubs.

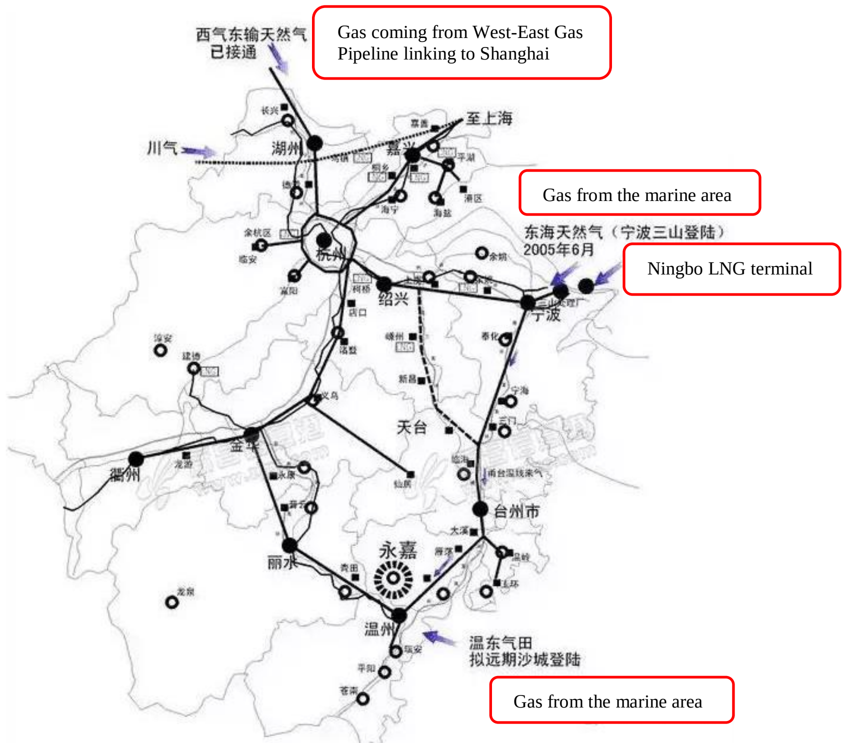
Considering the large land area and substantial regional disparities, China faces similar situations with the US. There must be a few regional gas trading hubs, each of which shall rightly fit in the regional conditions and needs, balance demand and supply in this specific region, and form regional fair prices. A national gas hub is also needed, like Henry Hub, serving as the benchmark and the delivery point for natural gas futures and options. It's agreed that SHPGX is most likely to be a "Chinese Henry Hub".

Considering the state monopoly and the provincial divisions, the UK natural gas market has a lot to learn from as well. On one hand, the natural gas market in China is monopolized by the Big Three, just like the gas market monopolized by British Gas in the UK over 30 years ago. With the goal of achieving a healthy and well-functioned natural gas market, it's inevitable to restructure or demerge the Big Three, by introducing private capital, unbundling transportation businesses, streamlining operations, etc.

On the other hand, some provinces such as Zhejiang and Guangdong have realized the "One Province, One Gas Network", namely, the natural gas transmission system (except minor distribution networks) covering the whole province is owned and operated by one pipeline company, just like the UK NTS owned and operated by National Grid. For example, Zhejiang Natural Gas Development Co., Ltd owns and operates all the provincial pipeline networks in Zhejiang Province (**Figure 35**). Therefore, it's possible to establish regional virtual trading hubs in such provinces, like the UK NBP. Then such a province will have only one hub-based wholesale price of natural gas without geographical differences.

Given that physical natural gas trading in China just emerged 2 years ago and is at a primary stage, and the natural gas pricing system reform and the restructuring of state-owned oil & gas companies haven't completed, the outlook of a financial natural gas market developed in a large scale in China is quite dim. However, since SHPGX has formed three LNG indices, it's possible to introduce LNG futures to guide spot trading and to facilitate risk management. For instance, an LNG futures contract delivered at Guangdong Zhuahai or Yuedong LNG terminal can be created, because LNG delivered at Guangdong Zhuahai and Yuedong LNG terminals are frequently traded in SHPGX. What's more, SHPGX has published daily Guangdong Province's LNG ex-plant price index and the daily Southeastern LNG transaction price index, both of which can be the benchmark price for the futures contract.

***Figure 35.*** *Pipeline networks in Zhejiang Province*




Source: Xinchang Information Port (2016, October 10). Retrieved from http://diyitui.com/content-1476058190.58070146.html

# Part V. Conclusion

## 10. Conclusions and suggestions

### 10.1 Conclusions

This paper presents an overview of the natural gas market in China and focuses on this market's current state and prospects for trading activities. For better understanding, the paper also summarizes the historical evolution and reforms of China's natural gas market and then refers to the US and the UK practice. The current state of the natural gas market in China are demonstrated in the SWOT matrix (**Table 19**).

***Table 19.*** *SWOT analysis of the natural gas market in China*

| | **Helpful** | **Harmful** |
|---|---|---|
| **Internal origin** | Strengths (S) | Weaknesses (W) |
| | 1. Diversified natural gas supply;<br>2. Fast growth of the natural gas industry supported by the government policies;<br>3. Accelerated market reform, including information disclosure of gas transportation facilities and TPA, gradual demerger of the big three state monopolies, gradual removal of the government control on pricing;<br>4. Establishment of natural gas trading hubs. | 1. Decrease of domestic high-quality natural gas proven reserves while lack of sophisticated technology;<br>2. Insufficient infrastructures;<br>3. High degree of state monopolization;<br>4. Lack of transparency and rules;<br>5. Distorted natural gas pricing system, resulting in limited trading activities in hubs. |
| **External origin** | Opportunities (O) | Threats (T) |
| | 1. Sufficient natural gas supply overseas;<br>2. International advanced technologies;<br>3. Strengthened international cooperation;<br>4. Consistent with the world trend towards a cleaner energy mix. | 1. Competition with alternative energy sources;<br>2. Increase of reliance on gas imports thus exposing to higher geopolitical risks;<br>3. Likely establishment of LNG trading hubs and futures exchanges in Japan and Singapore in competing for the LNG pricing power in Asia Pacific. |

Main findings are as follows.

(1) The Chinese government plays a decisive role in its natural gas market, both by making policies and by holding stake in the three largest national oil and gas companies and local gas distribution companies.

(2) Driven by the Chinese government's coal-to-gas switch policy and endeavor to change China's energy mix, the natural gas market in China is growing fast, but with increasing foreign dependency.

(3) The natural gas market in China is highly monopolized by the three giant state-owned oil and gas companies, CNPC, Sinopec, and CNOOC, among whom CNPC is the largest. They dominate every layer of the natural gas value chain. But now the Chinese government has been attempting to liberalize the market. Attempts include introducing private companies into the upstream market, permitting third-party access (TPA) to natural gas infrastructure, restructuring state-owned oil and gas companies, marketizing natural gas prices, etc.

(4) The Chinese natural gas pricing system is moving towards a market-based one, less opaque, more predictable, and more effective.

(5) To facilitate the Chinese natural gas pricing reform, two natural gas trading hubs respectively in Shanghai and Chongqing have been established and more hubs in China are expected. Also, with the advance of this reform, trading activities in these hubs are increasing and more types of gas contracts are to be introduced.

(6) Natural gas derivatives are foreseeable, for an exchange specially intended for energy derivatives trading (i.e., Shanghai International Energy Exchange, INE) has been set up, and spot contracts with longer-term delivery (i.e., preselling) have been launched in Shanghai gas hub recently.

Crucial issues along the natural gas value chain and corresponding suggested solutions are as follows.

(1) **Upstream**: Energy security should be attached more importance than ever before. On one hand, domestic production slows down due to the depletion of high-quality conventional gas reserves. On the other hand, China's major external suppliers are countries in Central Asia, who are highly unstable and insecure. In order to minimize the risks, various producers and importers in the upstream market shall be more welcomed to compete with the Big Three.

(2) **Midstream**: Natural gas infrastructures especially storage facilities are seriously inadequate, which is the main reason of the gas shortage in winter 2017-18. Hence, more investment and efforts shall be made into the construction of infrastructures. In addition, it's necessary to speed up the unbundling of gas transportation and sales (i.e., direct sales of natural gas without transportation services and independent transportation services), so as to streamline the operations of infrastructure companies and enhance the companies' efficiency.

(3) **Downstream**: Preselling natural gas in SHPGX in April 2018 is a good sign that more kinds of trading activities are encouraged in the gas hubs. Moreover, financial gas trading is advocated by Chinese policymakers and thus is expected in the near future. But the natural gas market structure and pricing system impede the further development of the hubs, while the prosperity of hubs can facilitate the liberalization of market. Therefore, to develop the trading hubs and to reform the market shall walk hand in hand, ensuring that they benefit each other.

## 10.2 Suggestions

Based on the SWOT analysis, strategic suggestions for China's natural gas market can be derived by combining S or W with O or T (**Table 20**). The prospects of trading activities in this market to a large extent depend on how its SWOT is handled.

***Table 20.*** *Recommended strategies for China's natural gas market based on SWOT analysis*

| | **Enhance strengths** | **Reduce weaknesses** |
|---|---|---|
| **Utilize opportunities** | Strength-Opportunity (SO) strategies | Weakness-Opportunity (WO) strategies |
| | 1. Participate in the development of overseas natural gas resources/fields, by means of equity investment or business cooperation;<br>2. Learn successful experience of market reform and trading hubs from developed countries;<br>3. Increase communication and cooperation with foreign gas markets and trading hubs. | 1. Learn advanced technologies overseas of developing unconventional gas and constructing infrastructures;<br>2. Introduce private capital and foreign capital into natural gas production and importation, so as to diversify upstream market player and to increase their numbers;<br>3. Take a more active part in the international gas market. |
| **Avoid threats** | Strength-Threat (ST) strategies | Weakness-Threat (WT) strategies |
| | 1. Further promote the coal-to-gas switch in urban heating and industrial fuel;<br>2. Promote more efficient utilization of natural gas in various areas especially electricity power generation and public transportation;<br>3. Accelerate to reform the natural gas pricing system to make it a more flexible and market-based one;<br>4. Urge market players to carry out trading activities in hubs. | 1. Diversify and upgrade sources of natural gas imports, from politically unstable countries to stable countries;<br>2. Increase investment and accelerate the construction of infrastructures, especially gas storage facilities;<br>3. Upgrade and reinforce the safety system around the natural gas value chain, especially in gas production and transportation;<br>4. Improve the competitiveness (management, operation efficiency, R&D abilities etc.) of domestic natural gas companies by way of M&A, restructuring, streamlining, etc.;<br>5. Complete laws and regulations relating to natural gas. |

Furthermore, to develop the natural gas market in China, a lot of experience can be learnt from the US and the UK. Main learnings are as follows.

(1) In terms of the **market structure**, a high degree of competition in the upstream and the downstream of the natural gas value chain is necessary, while the midstream sector shall be in the government's control. Also, TPA to the midstream and unbundling of gas transportation and sales are required.

(2) In terms of the **pricing system**, the government shall completely take hands off the gas wellhead prices but keep control of gas transmission tariffs and distribution fees.

(3) In terms of **trading hubs**, both physical hubs like Henry Hub and virtual hubs like the NBP are reasonable in China, for some provinces have realized favorable circumstances where one major pipeline network covers the whole province.

In view of the international experience, the trend of breaking down the state monopolies and liberalizing the natural gas market is inevitable, which as widely acknowledged, promotes both physical and financial trading activities, lets the pricing reflect the true relationship between demand and supply, makes resource allocation more effective and efficient, improves risk management, etc.

Therefore, given the strategic position of natural gas in China's energy mix, it's essential to liberalize the natural gas market and promote more trading activities in China. Only in this way:

(1) *market price signals* can be formed to guide the gas production, importation, transportation, and usage, as well as the construction of natural gas infrastructures;

(2) *more gas suppliers* other than the Big Three are willing to participate in this market, for gas prices become less distorted and they can flexibly hedge against risks with various trading tools;

(3) *energy security* can thus be guaranteed with different kinds of gas supply sources; last but not the least,

(4) *more energy consumers* are willing to buy natural gas instead of other energy sources, with the increasing gas supply and a more liquid trading market making it possible to adjust gas portfolios and hedge against different kinds of risks in time.

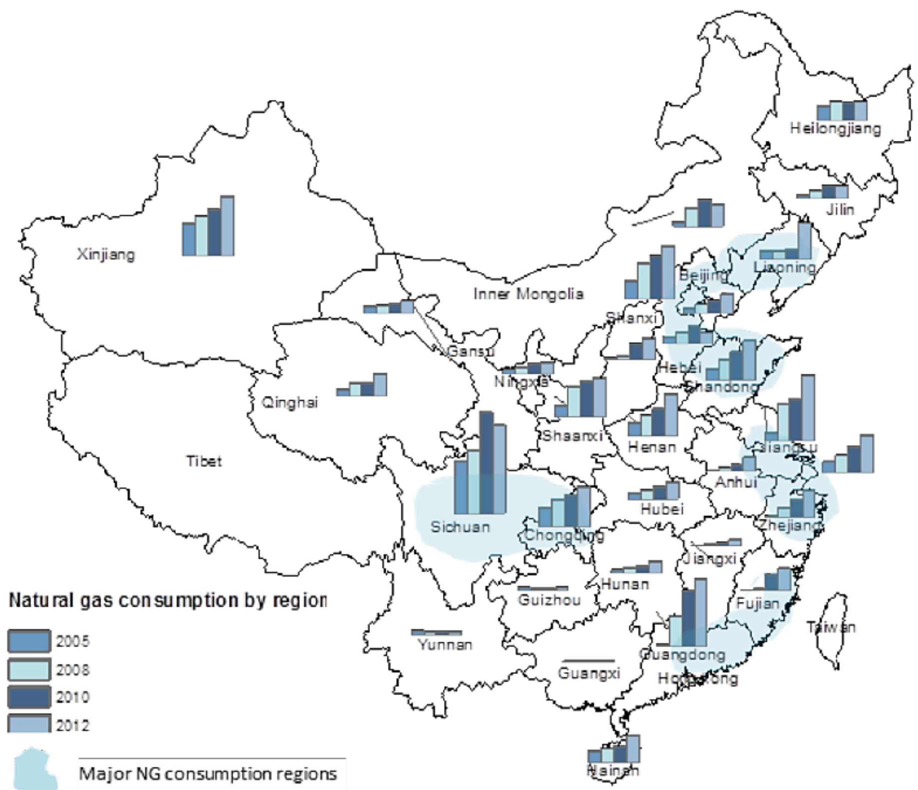
In short, because of the clean, low-carbon, and efficient characteristics of natural gas, developing a natural gas trading market in China is a vital tool to facilitate the use of natural gas and thus to prevent air pollution and reduce the carbon footprint in China's energy mix, even though the development has to be achieved step by step and will generally take a long time.

# Appendices

## Table of Appendices



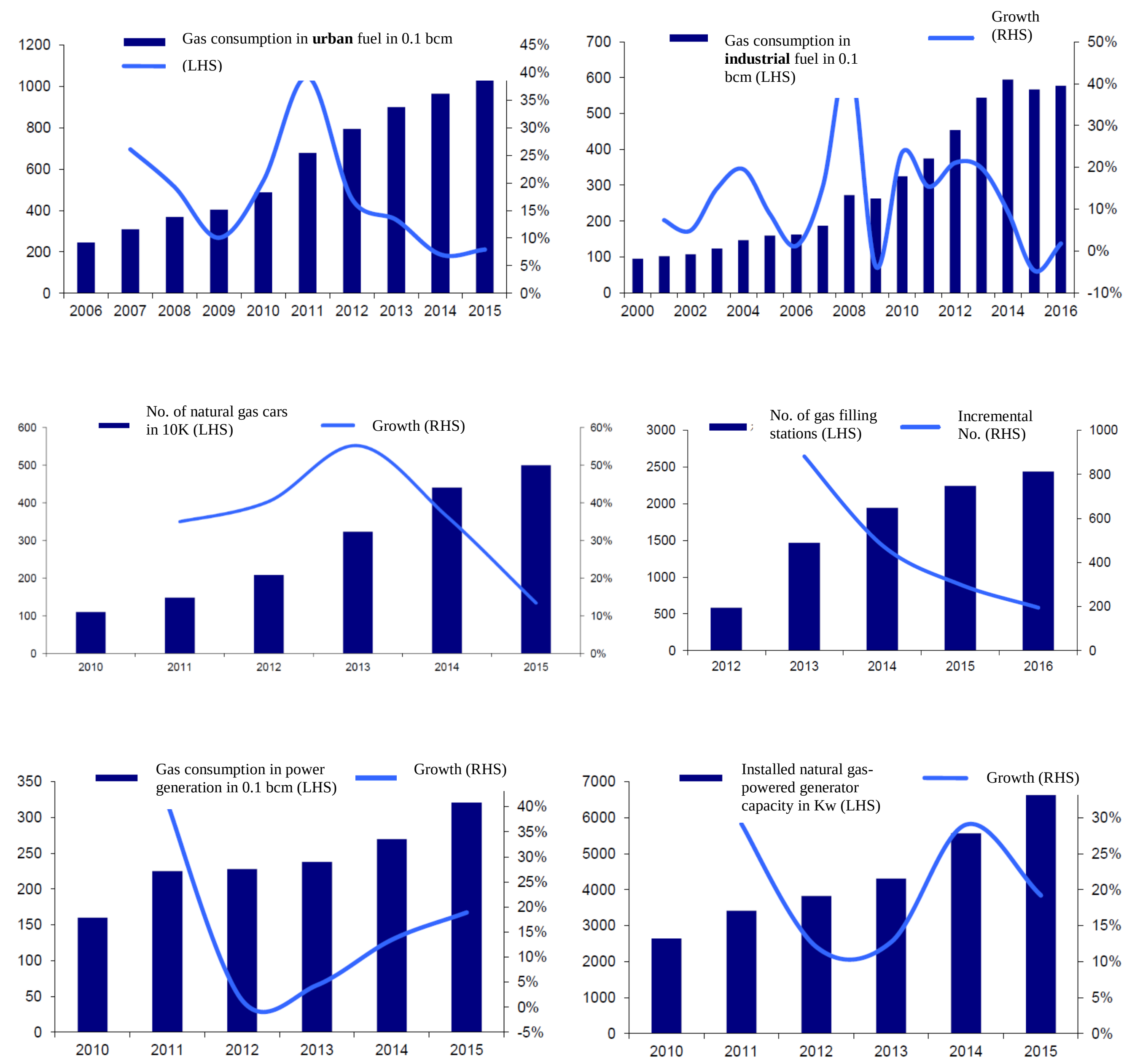
***Appendix 1: Figure 36.*** *Gas consumption by region during 2005 - 2012*




Note: The vertical bars for each province represent relative consumption over time. In 2012, the consumption was 15 bcm in Sichuan and 10 bcm in Xinjiang.

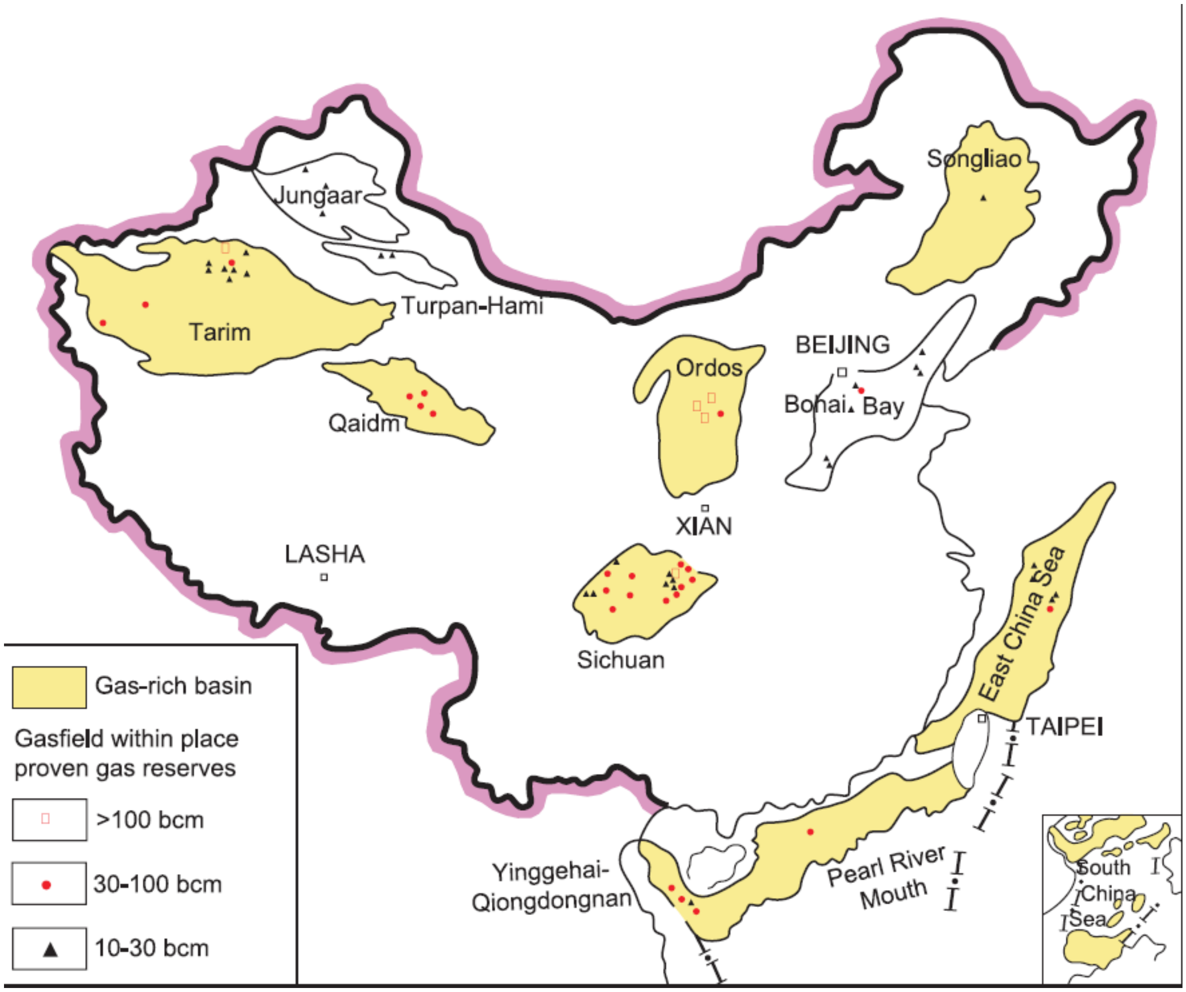
Source: Paltsev, S. and Zhang, D. (2015, July).

***Appendix 2: Figure 37.*** *Gas consumption in urban and industrial fuel, numbers of natural gas cars and filling stations, and gas consumption in power generation and installed gas-powered generators*




Source: Haitong Securities (2017, May 21).

*__Appendix 3: Figure 38.__ Distribution of major gas-bearing basins and gas fields in China*




Note: The proven in place gas reserves for individual fields are labeled using different symbols.

Source: Zhao, W., Wang, Z., Li, J., Li, J., Xie, Z., & Wang, Z. (2008). Natural gas resources of the sedimentary basins in China. *Marine and Petroleum Geology*, *25*(4-5), 309-319.

***Appendix 4: Table 21.*** *IGU types of price formation mechanisms*

| | |
|---|---|
| **OIL PRICE ESCALATION (OPE)** | The price is linked, usually through a base price and an escalation clause, to competing fuels, typically crude oil, gas oil and/or fuel oil. In some cases coal prices can be used as can electricity prices. |
| **GAS-ON-GAS COMPETITION (GOG)** | The price is determined by the interplay of supply and demand – gas-on-gas competition – and is traded over a variety of different periods (daily, monthly, annually or other periods). Trading takes place at physical hubs (e.g. Henry Hub) or notional hubs (e.g. NBP in the UK). There are likely to be developed futures markets (NYMEX or ICE). Not all gas is bought and sold on a short term fixed price basis and there will be longer term contracts but these will use gas price indices to determine the monthly price, for example, rather than competing fuel indices. Also included in this category is spot LNG, any pricing which is linked to hub or spot prices and also bilateral agreements in markets where there are multiple buyers and sellers. |
| **BILATERAL MONOPOLY (BIM)** | The price is determined by bilateral discussions and agreements between a large seller and a large buyer, with the price being fixed for a period of time – typically one year. There may be a written contract in place but often the arrangement is at the Government or state-owned company level. Typically there would be a single dominant buyer or seller on at least one side of the transaction, to distinguish this category from GOG, where there would be multiple buyers and sellers trading bilaterally. |
| **NETBACK FROM FINAL PRODUCT (NET)** | The price received by the gas supplier is a function of the price received by the buyer for the final product the buyer produces. This may occur where the gas is used as a feedstock in chemical plants, such as ammonia or methanol, and is the major variable cost in producing the product. |
| **REGULATION: COST OF SERVICE (RCS)** | The price is determined, or approved, formally by a regulatory authority, or possibly a Ministry, but the level is set to cover the "cost of service", including the recovery of investment and a reasonable rate of return. |
| **REGULATION: SOCIAL AND POLITICAL (RSP)** | The price is set, on an irregular basis, probably by a Ministry, on a political/social basis, in response to the need to cover increasing costs, or possibly as a revenue raising exercise – a hybrid between RCS and RBC. |
| **REGULATION: BELOW COST (RBC)** | The price is ***knowingly*** set below the average cost of producing and transporting the gas often as a form of state subsidy to the population. |
| **NO PRICE (NP)** | The gas produced is either provided free to the population and industry, possibly as a feedstock for chemical and fertilizer plants, or in refinery processes and enhanced oil recovery. The gas produced maybe associated with oil and/or liquids and treated as a by-product. |
| **NOT KNOWN (NK)** | No data or evidence. |

Source: IGU (2017).

***Appendix 5: Table 22.*** *Key unbundling models*

| Extent of unbundling | Model | Changes | Aims | Relationship to previous changes |
|---|---|---|---|---|
| I | Service unbundling | Midstream services (in particular pipeline services) must be unbundled from gas wholesale businesses, with service then being provided independently | From the point of view of the gas wholesale business, if transport services are not provided independently, this will have a negative impact on market competition, as the supplier is unlikely to sell gas to users other than the pipeline company | |
| II | Financial unbundling | The profits and losses of midstream operations will be borne by the company itself, having been isolated from the upstream and downstream concerns | This prevents reliance on midstream assets to cover losses or support upstream or downstream operations | If midstream operations do not become an independent service subject to individual taxation, then the midstream services are unlikely to possess a separate account for their own finances |
| III | Legal unbundling | The midstream business becomes an independent legal entity, while remaining within the vertically integrated structure, for instance existing as a wholly-owned subsidiary | The subsidiary must be in the form of a legal representative with its own legal standing. By introducing independent legal entities, it is possible to achieve more effective separation of managerial duties | An independent legal entity must have separate accounts for its finances and provide a separate service |
| IV | Structural unbundling | In order to isolate themselves from upstream and downstream motivations, many midstream services formulate their business policies in advance | This roots out any anti-competitive motivation; by removing such motivation from the midstream business of the entities concerned, it is possible to achieve more effective market liberalisation | A midstream company needs to be a legal entity; only then will it be able to respond appropriately to circumstances and fulfil its duties |
| V | Ownership unbundling | The midstream service must be split off from the vertically integrated structure and ownership must have been transferred to an independent entity | Comprehensive ownership unbundling completely separates the interests of midstream businesses from upstream and downstream businesses | If a company is under independent ownership, then it is intrinsically an independent legal entity, with independent accounts for finances and providing an independent service |

Source: The Development Research Center of the State Council of PRC & Shell International (2015)

***Appendix 6: Figure 39.*** *The UK gas transmission system*


Original source: IEA and the Department for Business, Energy & Industrial Strategy (BEIS) of the UK.

# Acronyms, abbreviations, and units of measure

## Acronyms and abbreviations

| | |
|---|---|
| BTH | The Beijing-Tianjin-Hebei Region in China |
| CBM | Coalbed Methane |
| CNOOC | China National Offshore Oil Corporation |
| CNG | Compressed Natural Gas |
| CNPC | China National Petroleum Corporation |
| CQPGX | Chongqing Petroleum and Natural Gas Exchange |
| EIA | The Us Energy Information Administration |
| FERC | Federal Energy Regulatory Commission of the US |
| ICE | Intercontinental Exchange |
| IEA | International Energy Agency |
| IGU | International Gas Union |
| LNG | Liquefied Natural Gas |
| NBP | The UK National Balancing Point |
| NDRC | National Development and Reform Commission of the PRC |
| NEA | National Energy Administration of the PRC |
| NYMEX | New York Mercantile Exchange |
| Ofgem | Office of Gas and Electricity Markets in the UK |
| OTC | Over the Counter |
| PetroChina | Petrochina Co., Ltd *(Petrochina Co., Ltd is a subsidiary of CNPC, who holds approximately 82.71% of Petrochina shares on December 31, 2017.)* |
| PRC | The People's Republic of China |
| PRD | The Pearl River Delta in China |
| SHPGX | Shanghai Petroleum and Natural Gas Exchange |
| Sinopec | China Petrochemical Corporation |
| SPA | Sale and Purchase Agreement |
| TPA | Third-Party Access |
| YRD | The Yangtze River Delta in China |

## Units of measure

| | |
|---|---|
| bcm | Billion cubic meters |
| bn | Billion |
| cu.m | Cubic meter(s) |
| K | Thousand |
| Km | Kilometers |
| M | Million |
| mmBtu | Million British thermal units |
| TCE | Tonne of standard coal equivalent |
| tn | Trillion |

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