

# Causes and Countermeasures of Seasonal Shortages of Natural Gas in China

Xuan Zhou<sup>1,2</sup>, Xiucheng Dong<sup>3,\*</sup>

<sup>1</sup>School of Business Administration, China University of Petroleum (Beijing), Beijing, China

<sup>2</sup>China Petroleum Technology and Development Corporation, Beijing, China

<sup>3</sup>School of International Trade and Economics, University of International Business and Economics, Beijing, China

## Email address

[zxweshall@me.com](mailto:zxweshall@me.com) (Xuan Zhou), [dongxiucheng@cup.edu.cn](mailto:dongxiucheng@cup.edu.cn) (Xiucheng Dong)

\*Corresponding author

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**Abstract:** Along with rapid growth of China's natural gas consumption, frequently happened seasonal shortages affected sustainable development of natural gas industry and also brought serious negative impact on economy and society. This paper analyzed characteristics and immediate causes of seasonal shortages occurred in the winter of 2017, and further explored deep-rooted reasons behind this, including unbalance of natural gas supply and demand, maladjustment to repositioning of natural gas in China's energy structure, distortion caused by cross subsidies and excessive market concentration, etc.. Seasonal shortages reflected the mismatch between formerly centralized management mechanism and current natural gas industry development, so the author regarded market-oriented reform as the core solution to solve seasonal shortages in China, around which following suggestions were proposed: (1) Adjusting the position and development targets of natural gas industry, and fully exploring natural gas's unique value as a clean energy; (2) Developing and optimizing natural gas trading markets through building natural gas trading hubs, adopting basis price to increase standardization level of transactions, and fostering new competitors by removal of barriers to entry; (3) Increasing and diversifying natural gas supply to meet growing demand; (4) Promoting construction and interconnection of natural gas infrastructures.

**Keywords:** China, Natural Gas, Seasonal Shortage, Clean Energy, Cross-Subsidy, Market Concentration, Market-Oriented Reform, Peak-Shaving

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## 1. Introduction

Long-distance transportation and large-scale utilization of natural gas in China started in 2004, while West-East Natural Gas Pipeline Project I completed. Along with China's economic growth, natural gas production and consumption have experienced rapidly increase. By 2018, natural gas production achieved 158.4 billion square meters, accounting for 4.1% of global production, meanwhile consumption reached 280 billion square meters, accounting for 6.5% of global consumption [1]. Besides domestic production, imported natural gas constituted 38% of China's total consumption, including both pipeline gas (44%) and LNG (56%).

Natural gas industry in China adopted cost-based government pricing or government-guided pricing mechanism

over a long period of time. In 2013, with the implementation of *market netback pricing* mechanism, natural gas prices linked to alternative energy prices (imported fuel oil and LPG), meanwhile shale gas, coal-bed gas, coal gas and LNG were deregulated as a pilot of "gas-gas" pricing mechanism. In November 2016, Fujian was empowered as the first province to carry out pilot reform of market-oriented "gas-gas" pricing mechanism.

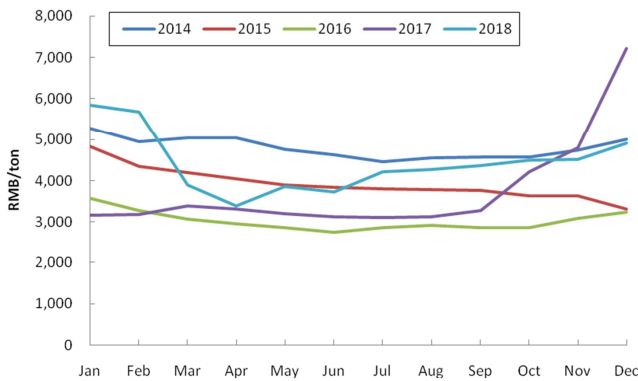
Seasonal shortage in this paper means that supply cannot fully meet peak demand in certain season due to climate reasons. China's natural gas industry has been on a tight balance for years and shortages happened almost every winter, with the most widespread and worst impacted one occurred in the winter of 2017.

The reminder of this paper proceeds as follows. Section 2 analyzes characteristics and immediate causes of natural gas

seasonal shortage in winter of 2017, Section 3 explores underlying reasons of seasonal shortages, Section 4 raised some policy suggestions and Section 5 concludes the paper.

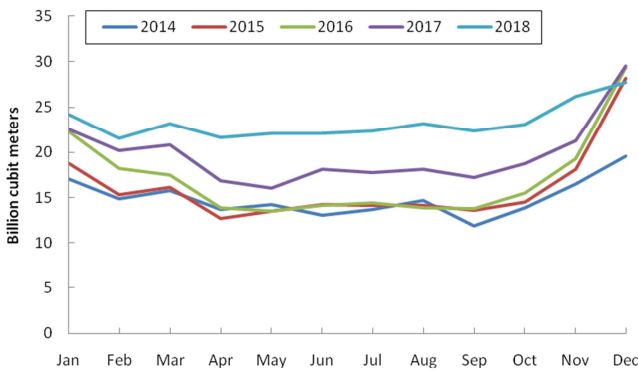
## 2. Characteristics and Immediate Causes of Natural Gas Shortage in the Winter of 2017

With the stagnation of global economic growth and drops of international natural gas prices in 2015, China's natural gas market experienced decelerated growth. Consumption declined in the summer (figure 1) and LNG prices showed no significant increase even in winters (figure 2). However in the summer of 2017, consumption started to spike, then LNG price soared in mid-September, finally shortage emerged in many places after entering heating season.



Source: National Development and Reform Commission

Figure 1. Monthly natural gas apparent consumption.



Source: National Bureau of Statistics

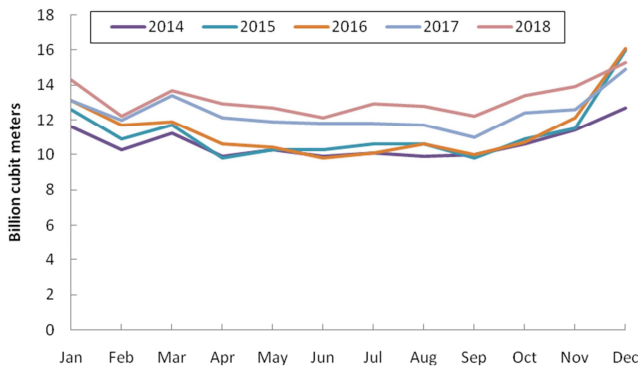
Figure 2. Monthly LNG prices.

Compared with previous years, natural gas shortage in the winter of 2017 has the following characteristics: 1. The shortage is more widespread. Formerly natural gas shortage mainly concentrated in north China, but this time expanded to central, southwest and northwest China [2]. 2. The shortage lasts longer. Natural gas prices started to rise as early as late September and reached peak till mid-February of 2018. 3. Demand-supply gap is wider. China's daily gas consumption in December increased 20%, while

demand-supply gap in the whole winter exceeded 16 billion square meters. Demand-supply gap even outnumbered 20% in Shaanxi, Hubei, Shandong, Sichuan, Chongqing and other provinces. 4. The shortage burst fast and pushes price up too far. According to data issued by National Bureau of Statistics (Figure 2), average nationwide LNG price stabilized at around RMB 3,100/ton before mid-September but rose to RMB 7,400/ton in mid-December, with 130% growth in three months.

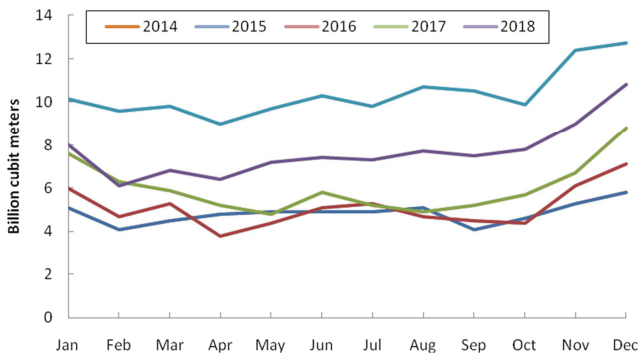
Immediate causes for the shortage include: 1. Demand increased too fast [3]. To deal with serious air pollution problems, *Air Pollution Prevention and Control Action Plan*, issued by the State Council of China in September 2013, clarified specific measures and phased targets for air pollution prevention and control. In the action plan, 2017 is arranged as the final year for the first phase of implementation, under evaluation pressure, *coal-to-gas switch* projects were pushed too fast, lacking of advanced planning and coordination. 2. Supply capacity grew slowly and encountered contingencies [4]. Following natural gas price collapses in 2015, domestic natural gas producers lacked the enthusiasm to increase production, so in 2015 and 2016, domestic natural gas production increased by only 5.6% and 1.6% respectively (Figure 3), so increased consumption in winter is mainly met by imports (Figure 4). Demand improvement was noticed by domestic producers in the summer of 2017, but supply capacity cannot catch up accordingly, since it takes much longer time to increase domestic production and import. In addition, original supply capacity suffered a significant reduction due to Turkmenistan's cut-down of gas-input into CNPC's Central Asian Pipeline and delayed commissioning of Sinopec's Tianjin LNG terminal. 3. Ineffective implementation of peak-shaving policy. Central government requires local governments and related companies to implement *reducing non-resident and guaranteeing resident* policy, which means non-resident natural gas usage should be reduced to guarantee resident usage in winter. However, many local governments failed to formulate strict, detailed and executable measures to implement the policy. More seriously, many urban gas companies misappropriated low-cost resident quota to non-residents for seeking huge difference. 4. Spot market ran into liquidity dried up. Due to natural gas shortage, Shanghai Petroleum and Natural Gas Exchange experienced liquidity dried up from September 2017 to June 2018, with almost no LNG transaction and plunged pipeline gas transactions. Consequently users turned to LNG plants which occupy a tiny market share and were already enforced to trim capacity. Demand far exceeded tradable supply and triggered soaring LNG prices, which further aggravated the panic. 5. Natural gas storages and peak-shaving capacity are seriously inadequate to cope with short-term supply and demand fluctuations. There are less than 20 underground natural gas storages in China, with effective volume only accounting for 2% of domestic consumption, far below international average of 16%.

After implementing following emergency measures, natural gas shortage was finally alleviated: 1. Increased production volume of underground natural gas storages [3]; 2. Persuaded Central Asia countries to increase gas-input into Central Asian Pipeline; 3. Suspended some industrial and thermal electric usage to guarantee resident usage; 4. Broke market segmentation and reallocated southern natural gas to the northern areas; 5. Released urgently an order to suspend the “coal-to-gas switch”.



Source: National Development and Reform Commission

Figure 3. Monthly domestic natural gas production.



Source: National Development and Reform Commission

Source: National Development and Reform Commission

Figure 4. Monthly natural gas importation.

### 3. Deep-Rooted Reasons for Seasonal Shortages of Natural Gas in China

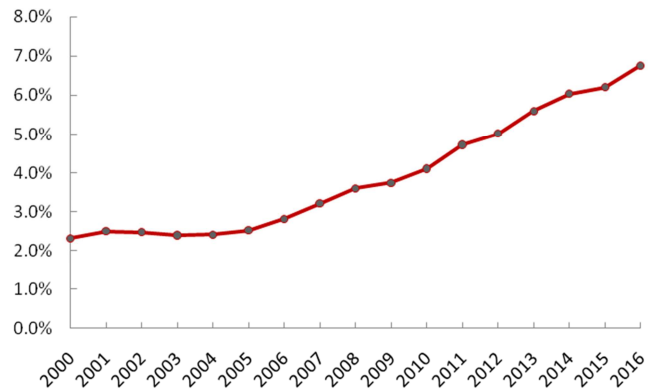
#### 3.1. Unbalance of Natural Gas Supply and Demand

Unbalance of natural gas supply and demand is reflected in both aggregative and structural problems.

##### 3.1.1. Overview of Natural Gas Supply and Demand

Proved reserves of natural gas in China reached 5.5 trillion square meters in 2017, accounting for 2.8% of world's total, with reserves-to-production ratio of 36.7. Shale gas and coal-bed gas have good potential, but accounted for only 6% and 5% of China's total production in 2007 respectively. Subjecting to technology and cost constrains, detailed

exploration and large-scale development are still on the way. Share of natural gas in primary energy was stabled between 2.3% and 2.5% before 2004, however started to rise since 2005 and reached 6.8% in 2016 (Figure 5).



Source: National Bureau of Statistics, Electrothermal equivalent method

Figure 5. Yearly natural gas's proportion in primary energy.

Under government-regulated pricing, natural gas prices stay low and there is no flexible price mechanism to reflect changes in supply and demand. Therefore, with poor profitability, domestic producers lack enthusiasm for investment and production, meanwhile as the only pipeline gas importer, CNPC suffered big loss for years while domestic and abroad prices hang upside down. Low prices also stimulated the excessive growth and sub-optimal structure of demand-side.

#### 3.1.2. Balancing Supply and Demand Depends on Long-Distance Pipelines

Natural gas reserves and production are concentrated in the central and western provinces, like Xinjiang, Shaanxi, Inner Mongolia, and Sichuan, etc., meanwhile imported pipeline gas gets into China from northwest, northeast and southwest borders via China-Central Asia, China-Russia and China-Myanmar natural gas pipelines respectively. However natural gas markets are centralized in southeast coastal and central areas, so gas sources and markets are far away from each other. Therefore, investment and construction of long-distance pipelines seriously restrict total capacity, cost and response speed of natural gas supply. China's existing long-distance pipelines are mainly invested, constructed, and operated by upstream producers such as CNPC and Sinopec, etc., with transportation costs bundled into citygate prices. According to top-level design of natural gas reform, pipeline networks will achieve independent operation, cost-based pricing, interconnection and third-party access in the future.

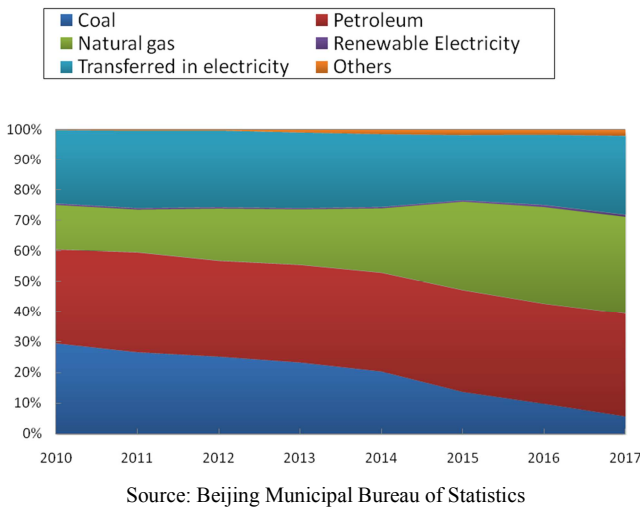
#### 3.1.3. Seasonal Characteristics of Natural Gas Demand

With the promotion of *coal-to-gas switch*, residents in China gradually turned to natural gas for heating in winter, meanwhile, interruptible and trough-load users are very few, so peak-shaving and load shifting are unable to be achieved, and peak-to-valley difference of China's natural gas monthly

consumption reached 2.2:1 in 2017 [5].

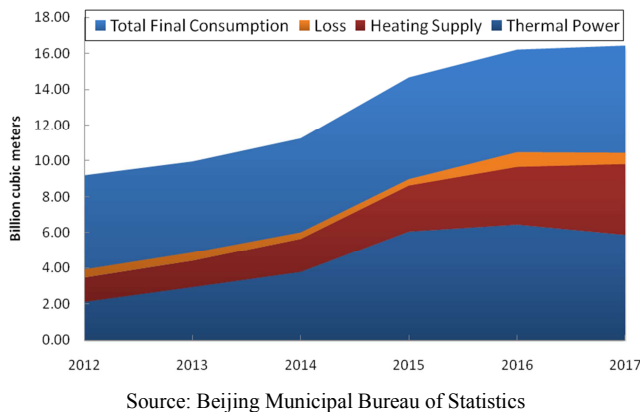
### 3.2. Repositioning of Natural Gas in China's Energy Structure

Natural gas was once undervalued and identified only as a transitional energy between past fossil fuels like coal and crude oil, and future renewable energies [6]. Following issuing of *Air Pollution Prevention and Control Action Plan* and reaching of *Paris Agreement* in December 2015, natural gas was recognized as the most important alternative energy for coal owing to its obtainability, affordability and environmental friendliness. Released in December 2016, *Energy Production and Consumption Transition Strategy (2016-2030)* and *13th Natural Gas Development Five-year Plan (2016-2020)* further proposed the scheme of controlling air pollution by adjusting energy consumption structure. In the plan, natural gas is expected to account for 10 percent of primary energy by 2020 and 15 percent by 2030.



Source: Beijing Municipal Bureau of Statistics

Figure 6. Yearly Beijing's energy consumption structure.



Source: Beijing Municipal Bureau of Statistics

Figure 7. Yearly Beijing's natural gas consumption.

Beijing firstly implemented air pollution control policies in September 2013 and achieved remarkable results. Through *coal-to-gas switch* and *coal-to-electricity switch*, coal's share in Beijing's energy consumption structure fell from 25.2% in 2012 to 5.7% in 2017 (Figure 6). Due to climatic conditions and cost

constraints, clean energies such as solar and wind grown rapidly, but still account for a very low share. Coal consumption was mainly replaced by natural gas consumption, which increased from 9.2 billion square meters (17.1%) in 2012 to 16.5 billion square meters (31.8%) in 2017 (Figure 7). Beijing's peak-to-valley difference in consumption surpassed five times due to the high proportion of heating usage in winters. To cope with it, CNPC newly built the Fourth Shaanxi-Beijing Pipeline, expanded Dalian and Tangshan LNG terminals, and significantly increased working gas capacity of gas storages around Beijing to safeguard stable supply in winter.

Based on government planning and Beijing's experience, China's natural gas consumption is expected to reach 360 billion cubic meters in 2020 and 540 billion cubic meters in 2025. During fast growth phase, mismatch or non-synchronization between supply-side and demand-side happen frequently and easily lead to undersupply or oversupply, as well as price shoot up or down. Therefore, comprehensive, moderate and forward-looking expectation, top-level design and detailed planning by central government, ordered and efficient execution by local governments and effective coordination between governmental departments will be of great importance. Adjustment in management system and pricing mechanism is also necessary to adapt to the new supply and demand structure, and to further promote development of natural gas industry.

### 3.3. Distortion Caused by Cross-Subsidies

Cross-subsidy in this paper means that some users subsidize other users due to unreasonable pricing mechanism, in which price fails to reflect true cost and value of nature gas [7]. There are mainly two reasons for government related cross-subsidies: 1. China's natural gas industry has long been regarded as a public utility by government, as a result, economic objectives were weakened by social objectives like public welfare and universal service, etc. 2. Natural gas prices cannot truly and timely reflect changes in costs, value, and supply-demand relationship, since government-dominated pricing mechanism lacks reasonability and flexibility.

Cross-subsidies of China's natural gas industry can be classified into the following categories.

#### 3.3.1. Cross-Subsidy Between Resident and Non-resident Users

Natural gas consumption of residents has significant features of small volume, high distribution cost, peak-period usage and inelastic demand, etc., therefore resident's price should be higher than that of non-resident. However residents in China enjoyed much lower prices and were subsidized by non-residents for a long time. On the one hand, this cross-subsidy undermined fairness of society, dampened producers' enthusiasm to increase production, and limited long-term development of natural gas industry; on the other hand, this cross-subsidy induced policy arbitrage and disrupted market order, for instance, some local governments and urban gas companies privately sell subsidized resident quota to non-residents to exploit the difference.

### 3.3.2. Cross-Subsidy Among Regional Markets

Citygate price is the central price of a province determined by National Development and Reform Commission, applying *market netback pricing* method. Real transaction prices are restricted to float within 20% of its citygate price. Chosen to be the central market and pricing benchmark, Shanghai's citygate price is calculated based on substitute energy prices with fixed conversion coefficient, while other provinces' citygate prices are adjusted considering flow direction of trunk lines and transmission cost, as well as regional development, resources compensation and other factors. Citygate prices have attracted various disputes and contradictions: 1. Scientific rationality of substitute energy selection and feasibility of citygate price calculation are widely debated, considering the complexity of natural gas market, pipeline networks and flow directions in China. 2. Many provinces try to break constraints of citygate prices through inter-provincial networking. 3. In leading producing provinces, such as Shaanxi and Inner Mongolia, low-cost natural gas was liquefied, transported by tank trucks and sold to other provinces at higher price to avoid citygate price restriction, with the sacrifice of circulation efficiency. 4. Natural gas consumption in low-price provinces is too extensive, failing to achieve optimal environmental and economic benefits.

### 3.3.3. Cross-Subsidy Among Different Usage Times

Seasonal and diurnal fluctuation of natural gas demand requires seasonal and diurnal peaking-shaving [8]. On the supply side, China mainly rely on increasing of gasfield production and pipeline capacity, underground gas storage, LNG terminals and tanks for peak-shaving; on the demand side, implement *reducing non-resident and guaranteeing resident* policy. Lacking market-oriented balancing mechanism and peak-to-valley prices, gas storage costs cannot be recovered, hence only state-own oil and gas companies have their own storages, other bodies of supply chain such as local governments, urban gas companies and non-resident users, etc. reluctant to construct gas storage facilities and shift off their responsibility to others. In addition, cross-subsidy among different usage times cut down industrial and interruptible users which could have displayed peaking-shaving advantage.

### 3.3.4. Cross-Subsidy Among Different Gas Qualities

China's natural gas industry still uses *volume* for measuring and pricing, which cannot reflect true economic value of natural gas from source to source with wildly different heating value [9]. Long-distance pipeline operators reject coal-bed gas and coal gas with lower heating value compared with domestic and imported natural gas, this behavior affects interconnection and third-party access of pipeline networks, and hinders free trade and integration of China's natural gas market. There are also sellers who make a profit illegally by blending nitrogen into natural gas with higher heating value.

## 3.4. Excessive Market Concentration

### 3.4.1. Upstream Concentration

According to *Mineral Resources Law of the People's Republic of China*, natural gas resources are owned by government, and only four companies were approved by the State Council to do the exploration and production, namely CNPC, Sinopec, CNOOC and Yanchang Petroleum. Among domestic production in 2017, CNPC accounted for 69% and Sinopec accounted for 17%. Imported pipeline gas is exclusively operated by CNPC under government approval. Among imported LNG, CNOOC (including joint ventures) accounted for 54%, CNPC (including joint ventures) accounted for 28%, and Sinopec accounted for 15%. In conclusion, number of upstream competitors is too small and the market is too concentrated.

### 3.4.2. Midstream Concentration

China's natural gas pipeline includes trans-provincial pipelines and provincial pipeline networks. Trans-provincial pipelines are under approval and supervision of National Development and Reform Commission. In 2017, China has 13 inter-provincial pipeline operation companies, with a total of 52,000 kilometers of long-distance pipelines and CNPC accounts for 93% of total mileage. Provincial pipeline networks are approved and supervised by provincial governments, and mainly constructed by joint ventures of central state-owned companies, local state-owned companies, and private companies. LNG terminals are mostly invested by central state-owned companies such as CNOOC (43%), CNPC (30%) and Sinopec (18%), while local state-owned companies and private companies start to participate. 92% of underground gas storages are built by CNPC, and others belong to Sinopec. This shows that most of natural gas facilities are concentrated in central state-owned oil and gas companies' hands, which generally implement vertical integration operations and are unwilling to promote interconnection and third-party access.

### 3.4.3. Downstream Concentration

Downstream competitors exceed 200 and are more diversified, including central state-owned companies, local state-owned companies, private companies and foreign companies. Franchise rights of urban gas are usually exclusive, covering a long period, and with distribution and sales bundled together, so local governments are easily caught in a dilemma: if franchise is authorized to one company, regional monopoly is a high likelihood; if authorized to more than one company, disorderly competition and repeated construction are inevitable.

## 4. Policy Recommendations to Address Seasonal Shortages of Natural Gas in China

Market-oriented reform is the fundamental way to solve seasonal shortages of natural gas [10]. Focused on price

mechanism reform, existing problems will be dissolved gradually, once open up upstream and downstream to let market play a decisive role in resources allocation, while government manage only midstream.

#### **4.1. Adjusting the Position and Development Targets of Natural Gas Industry**

Natural gas has three major attributes: mineral resources, public utility and clean energy, corresponding to different concepts and policy objectives. In the very critical period of environmental pollution control, reducing supply chain costs and increasing natural gas utilization should be the primary policy objective. As a public utility, natural gas's responsibility of public welfare and universal service should be undertaken by local governments and realized through direct subsidies. As a mineral resource, domestic production's proportion in total consumption has dropped to 72%, so government should cut down mineral rights fee accordingly.

#### **4.2. Building and Optimizing Natural Gas Trading Market**

China has established two national-level oil and gas trading centers in Shanghai and Chongqing, which are responsible for centrally organizing natural gas physical trading. At present, transaction volume increases steadily, however, price discovery cannot be achieved due to scattered transactions, low level of standardization and insufficient liquidity [11]. So following aspects should be strengthened: 1. Building natural gas trading hubs. Trading hub is a pipe network facility dedicated to centralized trading and settlement of natural gas. It can be a physical trading hub covering a section of pipeline or a pipeline junction, or a virtual balancing point within pipeline networks of certain area. Natural gas in a trading hub has the same quality and flows freely without additional cost, so hub price can be discovered through gas-gas competition. Prices among different hubs are interrelated and balanced through no-arbitrage pricing. Trading hub with more participants, larger trading volume, and better liquidity and transparency will gradually mature and develop into a benchmark hub through competition. 2. Adopting basis price trading to increase standardization level of transactions. Basis price is the difference between price of natural gas in one market and price of natural gas in a different market, including calendar basis, locational basis and product/quality basis. Calendar basis is between natural gas settling on different date and reflects storage expenses; locational basis is between natural gas in different delivery point and reflects transportation expenses; product basis is between natural gas with different quality and reflects processing expenses. By increasing standardization level of transactions, basis price simplified transactions and integrated entire natural gas market. 3. Protecting new competitors by removal of barriers to entry. Chinese government should make further effort to remove barriers to entry and protect new competitors through reform of mineral rights and import rights, meanwhile encourage economic entities under all forms of ownership to

participate and freely compete in natural gas production, transportation, distribution, wholesale and retail, etc..

#### **4.3. Increasing and Diversifying Natural Gas Supply to Meet Growing Demand**

With rapid growth of China's total natural gas consumption, the following measures are recommended to increase and diversify natural gas supply: 1. Stimulate exploration and development of domestic natural gas, shale gas and coal-bed gas through reform of mineral rights and pricing mechanism. 2. Stabilize existing pipeline gas import volume and diversify import channels through intergovernmental negotiations. 3. Increase volume of spot LNG import by implementing third-party access to LNG terminals and removing trade barriers; 4. Further open up domestic natural gas price to enhance connectivity and linkage with international market.

#### **4.4. Promoting Construction and Interconnection of Natural Gas Infrastructures**

Vertically-integrated state-owned oil and gas companies construct and expand long-distance pipelines, LNG terminals and gas storages on the premise of fixed upstream natural gas resources and downstream sales. So far most existing infrastructures (with future demand considered) have not reached full capacity, but there will still be large-scale construction in recent years to accommodate additional demand. Seasonal shortages mainly exposed problems of insufficient gas storages and poor interconnection of pipeline networks [12]. So it's important to design and establish a completed natural gas storage system, including both strategic reserves invested by the central and local governments, and commercial reserves of producers and urban gas companies. Volume of working gas in underground storages is only 11.7 billion cubic meters by 2017, however according to planning of National Development and Reform Commission, working gas will reach 14.8 billion cubic meters in 2020, 30 billion cubic meters in 2025 and 35 billion cubic meters in 2030. Interconnecting existing pipelines to form a pipeline network system is also urgent and will greatly improve efficiency of resources allocation. National Development and Reform Commission regards interconnection as the key work of the natural gas industry in 2018 and coordinates relevant companies to connect pipelines, LNG terminal and storages. Simultaneously central state-owned oil and gas companies actively promote connection and two-way transmission of internal facilities.

### **5. Conclusion**

Centralized management and pricing mechanism dominated by Chinese government could no longer fit for natural gas industry's current scale, differentiation and variability, so multiple problems are emerged, like imbalance between supply and demand, uneven distribution of interests, and high market concentration, all of these lead to seasonal

shortages as a concentrated reflection. In addition, with rapid growth and great potential of demand created by environmental protection, status of natural gas in China's energy structure increased significantly. Only through relaxing government regulation and giving pricing power to market, can we stimulate vitality of the whole supply chain to increase supply of natural gas, infrastructures and services, as well as improve efficiency of resources allocation. China's natural gas market-oriented reform has been actively promoted, and the future work will focus on integration and regulatory pricing of midstream infrastructures, building of spot and forward trading markets, and adding new suppliers to bring down market concentration.

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