Analysis of Gas Supply & Demand in China and Suggestions for China’s Gas Industry Development

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Abstract. The global natural gas markets are undergoing profound changes, with the supply and demand patterns in a historical transformation; the market supply and demand keep loose – both the gas traders and trade volume are increasing, the links between regional gas markets are enhanced, the gas pricing and trading mechanisms are diversified, the LNG trade share keeps growing, and the links between regional LNG markets are also strengthened. Influenced by the supply side reform and the accelerated urbanization, among other factors, gas consumption in China is increasing rapidly. However, the consumption of natural gas changes significantly from region to region, affected by the mismatch in gas production and consumption locations, as well as the gas import patterns. With the continuous energy restructuring in China, the gas consumption in different sectors is growing at very different paces. Analysis of the current situation, future trend and characteristics of China’s gas industry indicates that it is in the third stage of fast growth. Natural gas will play an even more important role in the future energy structure. With the continuous growth of gas consumption at home, the existing and expected gas deliverability is still faced with the risk of enlarging shortage in the mid-long term. In consideration of such circumstance, it is suggested that top-level design be strengthened on the national strategic level to seek rational, robust and scale development of the China’s gas industry. Internationally, diversified import channels should be sought to dilute supply risks, cooperation with the Asia-Pacific markets should be enhanced, and establishment of an international gas trading centre should be accelerated. Domestically, construction of a national gas interconnection system and a number of gas hubs should be speeded up, to make the gas industry an important component of the national energy network; the gas pricing mechanism should be established and completed as soon as possible to facilitate scientific allocation of profits and costs for gas production, storage and distribution, and to ultimately promote the sustainable and scale development of the whole chain of China’s gas industry.

1. Introduction
In nearly 6 decades of development, China's natural gas industry has shifted from the period with regional markets in the vicinity of gas fields to a period with fast-growing national markets. Consumption is growing rapidly and supply continues to be diversified. The share of natural gas in China's energy structure continues to rise, and it is of great significance in the future energy restructuring. Although the gas industry is being developed rapidly, a series of new challenges have also emerged. Under such circumstance, it is necessary to analyse the current international gas markets to figure out the possible sources of China's incremental gas import volume in the new era; it is of great importance to forecast China's future gas consumption, the gap between demand and supply with the policy adjustment targets taken into consideration, and to identify the key issues to be
addressed for maintaining the balance between demand and supply; last but not least, it is also vital to put forward a strategic plan for the development of the gas industry in mid-long term.

2. **Analysis of international gas supply and demand**

There are huge natural gas resources around the world. The remaining gas reserves reached $197 \times 10^{12} \text{m}^3$ in 2018, and the reserves-production ratio stayed at about 50, much higher than that required for maintaining plateau production (reserves-production ratio of 10), which provides resource basis for long term production increase. Actually, the global gas production keeps increasing and amounted to $2.87 \times 10^{12} \text{m}^3$ in 2018 (Fig.1).

![Figure 1. Remaining reserves, production and reserves-production ratio of natural gas in the world](image)

The gas trade volume increases as the gas production increases. Under the background where the total volume keeps growing, the natural gas markets are undergoing profound changes: the LNG trade has increased by 5.4% annually over the last decade, while the pipeline gas trade has only increased by 0.2% annually. Clearly, the global incremental gas trade volume is mainly attributed to the growth in the LNG exports. The market share of pipeline gas reduced from 73.4% in 2000 to 54.3% in 2018. In contrast, the market share of LNG rose from 26.6% in 2000 to 45.7% in 2018 (Fig.2). As the LNG exports from America, Australia, Russia and other countries increase furthermore, the market share of LNG will soon exceed that of pipeline gas [1].

![Figure 2. Trade volume and growth rate of pipeline and LNG](image)
Generally, the global gas supply and demand keep loose, with the average supply surplus added up to $300 \times 10^8$ m$^3$ over the last decade (Fig.3).

The major regional gas markets across the world have experienced material changes. In North America, the US has seen dramatic reduction in gas import volume due to quick increase in shale gas production, and turned into a net gas exporter in 2018; in contrast, the gas export volume of Canada has kept reducing as its domestic gas consumption keeps growing. The CIS countries have witnessed steady increase in gas export [2]. In the Middle East, as the giant gas exporter Qatar has undergone slowing down growth in export, the overall gas export of the region has increased gently. In Africa, the total gas export remains stable. In Asia, variations in different countries have being enlarged – from the gas export end, Australia has seen rapid growth, Malaysia seen roughly unchanged gas export, and Indonesia has gone through reduction; from the gas import end, Japan has lived through negative growth, South Korea and India are still in the rapid increase stage, and China has entered a very fast growth stage. In Europe, the overall gas import has roughly remained stable (Fig.4). To sum up, a new global market pattern where the gas supply is “moving west” while the gas demand is “moving east” is further emerging [3] (Fig.5).
3. Analysis of domestic gas supply and demand

3.1. Development stages of gas supply and demand in China

The total energy consumption is continually increasing in China, stimulated by its stable economic growth. The natural gas consumption is growing rapidly, driven by the dual wheels, including the continuous total demand growth and the reform in the energy supply side, as well as the policies encouraging the energy consumption structure to shift to environment-friendly and low-carbon energies. The apparent natural gas consumption was approximate to 2800×10^8 m^3 in China in 2018, jumped to the third place in the world, and up by 18% over the previous year (Fig. 6). Restricted by the gas resource endowment, China’s gas production is hard to increase significantly, and the production growth rate is much slower than the consumption growth rate [4]. As a result, China’s gas consumption is more and more depending on gas import – as much as 45.3% of China’s gas consumption is satisfied by gas import in 2018 (Fig. 7).

Compared with the mature gas markets in other countries, the development of China’s gas industry starts rather late [4-6]. Generally, it can be divided into three stages: from 1950 to 1997, China’s gas industry was initiated, when the gas consumption scale was under 200×10^8 m^3. In terms of gas production, free gas and solution gas respectively contributed half, and the petroleum industry attached greater importance to oil than to gas. Gas was consumed mainly in areas near the gas production regions such as Sichuan, Chongqing, Shanxi, Gansu, Ningxia, and Xinjiang, via local pipeline transportation. In 1997-2006, China’s gas industry was developed steadily, when more gas discoveries were made by exploration, the gas consumption area was enlarged, and the gas pipelines are increased across different regions. Consequently, natural gas was started to be transported and consumed across regions through the extended regional pipelines and the long-distance national pipelines. Gas consumption was still based on the domestic resources in this period, and the market consumption was determined by the gas production. Since 2006, China’s gas industry has been developed rapidly, when a large number of gas fields were put into production, and the gas resources were further verified. As the west-to-east gas pipelines were gradually completed and new LNG terminals were put into operation, gas supply from multiple sources was increased quickly. In the 3rd stage, interconnection of gas pipelines was started and natural gas was consumed across regions [7-8].
In addition, as the gas consumption sectors were extended, the demand for gas grew rapidly. With the continuous extension and expansion of long-distance pipelines, both the gas sources and supply are increasing [9]. Meanwhile, the gas pricing reform mechanism was piloted, and a market controlled gas consumption pattern was gradually emerging (Fig.8). By and large, since China’s gas industry was initiated rather late on a weak basis, it is still in the rapid development period. There is a long way to go to attain stable gas supply, fully built pipelines, sufficient pipeline interconnection, and the industry still has huge development potential.

Figure 6. China’s GDP and gas consumption growth trends

Figure 7. China’s gas consumption and import dependence growth trends
3.2. Current gas consumption in China

Constrained by resource endowment, coal has long taken an absolute dominant role in China’s energy consumption structure. Even at present, China’s energy consumption structure is still dominated by coal, which is similar to that of Europe and North America in 1960s-1970s. The share of coal in China’s energy consumption was beyond 65% for long time before 2014. Fortunately, coal consumption has gradually been reduced by raising the conditions for access to the coal market, reducing the coal mining capacity, strengthening the environment protection, promoting the energy conservation and emission reduction and replacing coal with other energy since 2014, following the deepening of China’s energy restructuring. As a result, a historic turning point has appeared in China’s energy consumption – natural gas is replacing coal and refined oil in a series of consumption sectors, indicated by the rising gas consumption and its share in the energy structure (Fig.9).
boosted by the “coal-to-gas” project among other factors. Accordingly, the percentage consumption shares of these regions have reduced.

Figure 10. Gas consumption by region in China

The gas consumption in different sectors is influenced by such factors as gas price affordability, degree of energy replacement and policies. The consumption growth varies greatly from sector to sector. The manufacturing, living consumption, power generation, traffic and transportation industries are the four sectors seeing the fastest gas consumption growth (Fig.11).

Figure 11. Gas consumption by sector in China

The interconnected national gas supply and demand pattern has not come into being yet, and the separation of regional gas markets is still very prominent [10-11]. Analysis of the natural gas by supply sources, regional consumption, sector consumption, and flow directions indicates that most of the gas is consumed near the supply sources. The natural gas produced at home mainly flows to the gas production areas such as Sichuan, Chongqing, Xinjiang and their neighboring areas. The imported pipeline gas flows to the areas along the pipelines and preferentially meets the demands in the Beijing-Tianjin, Yangtze River delta, and Pearl River delta areas by quota allocation. The consumption growth in the coastal areas far away from the gas production areas is mainly secured by increasing LNG import volume. Even so, the high gas supply costs caused by the mismatch in gas production and consumption regions, the long-distance pipeline transportation, and the market fluctuation resulted from rapid growth in the import dependence of LNG, are getting more and more challenging. The national gas production, supply, storage and distribution system is still weak in terms of obtaining stable and sufficient gas sources. The gas consumption pattern differs greatly from region to region –
there are significant seasonal fluctuations in the north, while there are great peak-shaving demands in the south. Furthermore, the accelerated urbanization in the south pushes the fuel gas in urbans to increase rapidly. In a word, the supply and demand unbalance caused by regional disequilibrium and seasonal fluctuations is continually enlarging (Fig.12).

3.3. Outlook of gas demand in China

The prospect of an industry is determined by the demand for it. The key indicator for judging the natural gas industry is the growth trend of the gas consumption [12-13]. A large number of model-based researches were conducted by predecessors for predicting the gas consumption in China. In the approaches such as Leap, Medees, and the grey models, predictions were done from the aspects of GDP and GDP growth rate, population growth and urbanization, consumption sectors and gas utilization rates. In contrast, the elastic coefficient methods take into account the energy structure, policy adjustment, gas price and economic growth rate etc. However, the actual gas consumption in China surpasses the predicted results in the high cases presented by most forecast methods. Only the elastic coefficient method (II) comprehensively considering the energy structure and policy scenarios indicates rather small errors (Fig.13).

As China’s development has entered a new normal state, quality development becomes the core development philosophy. The implementation of the macro restructuring such as the supply side reform in energy and the environment protection policies will definitely be further reinforced. Among a series of indexes for comprehensive adjustments, natural gas, wind, photoelectric and nuclear energies are important targets. The authors of this paper did a research and forecast in 2018, based on the adjustment commitment made by the Chinese government in the Paris Agreement and the elastic coefficients. The results indicate that China’s minimum natural gas consumption should reach $6.3\times10^8\text{m}^3$ in 2030, under the base scenario (the scenario fulfilling the commitment made in the Paris Agreement), pursuant to the state energy restructuring targets. However, according to the strategic targets set in the Energy Production and Consumption Revolution Strategy (2016-2030) issued by NDRC (National Development and Reform Commission) and NEA (National Energy Administration) in 2016, China’s total energy consumption will be controlled under $6\times10^8\text{t}$ of standard coal by 2030, among which, natural gas will reach 15% or over $7\times10^8\text{m}^3$. It is thought, by combining the investigations done by various institutions, that the natural gas consumption will reach $6.5\times10^8\text{m}^3$ in 2030 and $7\times10^8\text{m}^3$ in 2035 under the base scenario, while the natural gas consumption will reach $7\times10^8\text{m}^3$ in 2030 and $8\times10^8\text{m}^3$ in 2035 under the state policy scenario (the scenario achieving the strategic targets).
4. Suggestions for gas industry development
4.1. Seek new gas sources to supplement the insufficient current gas sources

Analysis of the gas supply and demand in the previous section indicates that natural gas will still be in a rapid development period for quite a long time influenced by the energy restructuring, although the growth rate of energy demand will slow down as China’s economic growth rate slows down. If the current gas source conditions remains unchanged, the gap between the gas demand and supply will widen furthermore, which can be demonstrated by the following figures and facts: the growth rate of gas production in China is weak – the annual gas output was $1580 \times 10^8 m^3$ in 2018, up by 7.2% over the previous year, while the annual gas import volume was $1254 \times 10^8 m^3$ in the same year, increased by 31.7% over 2017, with the import dependence rising to 45.3%. Clearly, the growth rate of demand is much higher than that of supply, making the supply shortage more and more significant. It is estimated that the gas consumption growth rate will keep the present pace before 2030 and will slow down during 2031-2035, based on the gas availability and consumption. The gap between the gas demand and supply will reach $1400-1500 \times 10^8 m^3$ in 2030 and further increase to $1800-2000 \times 10^8 m^3$ during 2031-2035, based on the estimated gas consumption, the existing and to-be-launched LNG import capacities, together with the existing, being built and being negotiated pipeline gas import capacities (Fig.14). Constrained by the resource endowment of natural gas, the conventional gas production doesn’t have much growth potential in China. New gas discoveries are mainly to make up the production decline from discovered gas fields, and gas production is approaching the peak. As for the unconventional gas such as coal bed methane and shale gas, their production scales could not be very large either, restricted by technologies and costs. It is expected that the total gas production in China will transit from high growth rate period to mid-low growth rate period, and the peak production from all discovered gas resources will not exceed $3000 \times 10^8 m^3$. Therefore, the gap between demand and supply continues to enlarge, the development of the gas industry is faced with various challenges [14-15]. After viewing the gas production at home, let’s look at the gas import: the deliverability of pipeline gas is hard to increase, restricted by resource host countries and pipeline routes, and the existing LNG capacity is unable to satisfy the demand in the future. Gas import channels need to be extended furthermore in the future. Analysis of the global gas supply and resource potential indicates that more pipeline gas should be imported from Russia and Turkmenistan. In addition, a pipeline system from Iran to China through Pakistan can be built in the future if the ban on export from Iran is completely lifted and the geopolitics is improved. When it comes to LNG import, the existing exporters including Qatar, Malaysia, Nigeria, Indonesia, and Trinidad and Tobago show weak growth, even decrease in export. Hence, it can be considered to increase LNG import from the US, LNG import from the US also has two more benefits – the gas prices are relatively low in North America, and it helps to reduce China’s trade surplus against the US to relieve the trade war between the two countries. Last but not least, cooperation with Russia in the Arctic LNG projects should be enhanced to increase China’s LNG import from Russia.
4.2. Enhance interconnection of gas pipelines across the country and build an international gas trading center in China

At present, the gas utilization rate is not very high in China, because of low networking degree of gas pipelines and insufficient interconnection [16]. As of 2018, the gas consumption per capita is only $200 \times 10^8 \text{m}^3$ in China, much lower than the average gas consumption level of $480 \times 10^8 \text{m}^3$ in the world. Except increasing gas import channels and making more new gas discoveries at home, setting up gas trading hubs and controlling centers should be strengthened. In addition, construction of gas transmission pipeline network should also be reinforced to realize interconnection, and establishment of gas storage infrastructures should be accelerated to safeguard energy supply safety. Particularly, it is suggested to speed up building an international gas trading center to relieve the “Asian Premium”. Out of the three largest regional gas markets including North America, Europe and Asia-Pacific, North America has built a demand-supply based free market, thus the gas prices are totally independent of the oil prices and fully determined by demand-supply relations; Europe has formed a complete gas trading hub and network system, and has rather strong market bargaining ability; Asia-Pacific does not have any international gas trading center with market bargaining ability yet, and the premium phenomenon still exists. A natural gas trading hub is an important platform to fulfill international transactions, a key instrument to facilitate balance between supply and demand, and an indicator showing a natural gas market enters the mature development stage. As the global gas supply and demand will keep to be loose in the future, and the major countries with growing LNG export take an optimistic view of the Chinese gas market, China is the most qualified country for building an international gas trading hub dominated by buyers, and will have a bigger say in the future gas transactions. Therefore, efforts should be made from two aspects to push the development of China’s gas industry: a) A number of regional market trading centers should be developed within China to make the gas production, supply and storage system transit from being controlled by the government to being allocated by the trading centers [17]. The trading centers should be fair, open and informational trading platforms. In addition, the reform of market pricing system should be pushed forward to resolve the supply-demand unbalance by markets. b) Cooperation with international regional markets should be enhanced. Specially, dedicated cooperation on LNG trade should be strengthened with the giant Asia-Pacific LNG consumers such as Japan, South Korea and India to build a unified buyer’s market bargaining system.

4.3. Strengthen top-level design and make development plan for the whole gas industry chain

Compared with other types of energy such as coal and oil, almost each link of the whole natural gas industry chain including supply, distribution, utilization and consumption is not so developed. According to the future energy restructuring targets, gas and oil will take equivalent roles in the energy structure. Since both the oil and gas production at home faces bottleneck, it is highly probable that both of them will be import dependent. Under such circumstance, it is one of the key energy safety issues to ensure the robust development of the gas industry. Currently, China’s gas industry is in the early stage of rapid development when the key elements in the industry chain like production, import, consumption, pipeline transmission and storage systems are growing quickly; the gas consumption sectors and scenarios are extending; the corresponding gas pricing mechanism, laws and regulations are being framed and piloted. It can be expected that the future development scenarios are with strong momentum.

It is suggested to raise the development of the gas industry to the strategic level of national energy safety, enhance top-level design and make a development plan for the gas industry as early as possible. Specifically, systematic planning should be done from various aspects such as gas production, import, supply, storage, pricing mechanism, sector consumption so on and so forth. In terms of gas production, technical innovation should be strengthened to develop unconventional gas business represented by shale gas, to investigate the economic development of gas hydrate, and to explore, discover and
produce deep and ultra-deep conventional gas. Gas reserves and production at home can be increased by the above actions, and the gas import dependence can be controlled under 50%, which is very important to guarantee the energy safety. In terms of gas import, it is suggested to attach great importance to make a strategic plan for utilizing the overseas gas resources: new gas import sources should be sought, while maintaining the existing sources, to diversify the import channels and patterns; more efforts should be put in directly producing overseas natural gas by various ways such as joint venture cooperation, mutual shareholding, joint venture cross-operation, purchasing reserves and gas fields etc. State oil companies, local enterprises and private businesses should be encouraged to participate in importing LNG so as to further diversify gas import channels. In terms of gas consumption, it is suggested to strengthen analyse the potential of alternatives of the gas markets, instruct rational use of natural gas by various sectors and facilitate effective operation of the market supply, demand and the pricing mechanism.

5. Conclusion
There are abundant natural gas resources across the world. As a result, both the gas reserves and production are increasing, the gas supply and demand keep loose, the interconnection between regional gas markets are enhanced significantly; both the number of LNG exporting countries and volume of LNG export are growing, and so is the LNG share. A new global market pattern where the gas supply is “moving west” while the gas demand is “moving east” is further emerging. China’s gas industry has entered early period of the third fast growth stage when gas consumption increases rapidly; under the background of loose supply and demand in the global gas markets, China will be in an advantageous position in extending gas sources and obtaining buyer’s market rights. The existing gas production base, import capacity and expected availability are not enough to meet the rapidly rising gas demand. More gas import channels should be sought to prevent the gap between demand and supply from widening. China’s gas industry is of strong momentum. The elements in the gas industry chain are in the rapid growth period, the gas consumption sectors and utilizing scenarios are extending, the gas pricing mechanism, laws and regulations are being framed and piloted. It is suggested to highlight the policies supporting the gas industry, guide the gas consumption, strengthen the construction of infrastructures and interconnection facilities, plan to build a gas trading centre with international bargaining ability, and enhance top-level design to direct the scientific and rational development of the gas industry.

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