ISSN:2790-1661 Volume-5-(2023)

China's oil and gas demand forecast and pipeline network layout optimization analysis

Fengxue Li, Zhongxun Zhao, Baomin Hong, Xintong Miu*

China National Oil and Gas Pipeline Company

smaple2022@126.com*

Topic name:GWHT20220024448, On the implementation of "four revolutions and one cooperation" by the National Pipeline Network Group, and leading the research on deepening the reform of oil and gas system and the reform of pipe network operation mechanism under the leadership of the Party

Abstract. In order to accelerate the speed of pipeline network construction and expand the scale of oil and gas pipeline network, we need to forecast the total oil and gas demand and regional demand structure, so as to better serve the future construction of national oil and gas network. In this paper, the LEAP model is used to forecast the total oil and gas demand consumption and its regional distribution in 2050. The results show that in the low-carbon scenario, China's oil and gas will decrease in 2035, but still maintain a certain proportion. There are great differences in oil and gas demand among provinces. In the future, the layout of oil and gas pipeline network should consider the changes of demand structure and spatial layout, and comprehensively consider the transportation distance, transportation cost, transaction price and other factors of oil and gas pipeline network, so as to scientifically layout oil and gas transportation pipeline and optimize the flow of resources.

Keywords: gas demand; pipeline construction; gasoline scenario;oil demand.

1. Introduction

Oil and natural gas are the lifeblood of the sustained, stable and healthy development of the national economy and people's life, and will remain the main source of energy for a long time to come. By the end of 2021, the total length of oil and gas pipelines in service in mainland China will reach 1.5×105km. It has basically formed an oil and gas backbone pipe network that connects overseas, covers the whole country, spans east and west, runs north and south, and closely follows regional pipe networks. The overall flow direction of "west-east gas transmission, north-south gas transmission, east-Sichuan gas transmission, and sea-landed gas" has remained stable. The four major natural gas import channels have been further improved, and the gas transmission capacity of trunk pipelines in central and eastern regions has been significantly improved. The construction of natural gas storage and peak regulation facilities was accelerated, and five LNG receiving stations were completed: Nanjiang in Tianjin, Beihai in Guangxi, Jieyang in Guangdong, Diai in Shenzhen, and Fangchenggang in Guangxi. Domestic crude oil and refined oil transportation network has realized west to east oil transmission, north oil to south, offshore oil, natural gas has realized west to east gas transmission, Sichuan gas out of Sichuan, north gas to south.

Despite the continuous expansion of oil and gas pipeline network, the scale of oil and gas pipeline is small compared with the national territory and oil and gas consumption. The existing layout structure is unreasonable, and the number of pipe network and transportation volume do not fully match the regional oil and gas supply and demand. China needs to form an oil and gas backbone pipe network that connects overseas, covers the whole country, spans east and west, runs north-south, and closely follows regional pipe networks. In order to speed up the construction of oil and gas network and expand the scale of oil and gas network, we need to forecast the total oil and gas demand and regional demand structure, so as to better serve the future construction of national oil and gas network.

2. Prediction models and assumptions of future oil and gas demand and pipeline construction

In this paper, LEAP model (Long-range Energy Alternatives Planning System) is applied to study and analyze China's oil and gas demand respectively under baseline scenario and low-carbon scenario. This model can be mainly used in national and urban medium - and long-term energy environment planning, and can be used to predict the medium - and long-term energy supply and demand of the whole society under the influence of different driving factors, and calculate the emissions of atmospheric pollutants and greenhouse gases in the process of energy circulation and consumption. This model follows the "bottom-up" principle, and its main research framework is as follows:

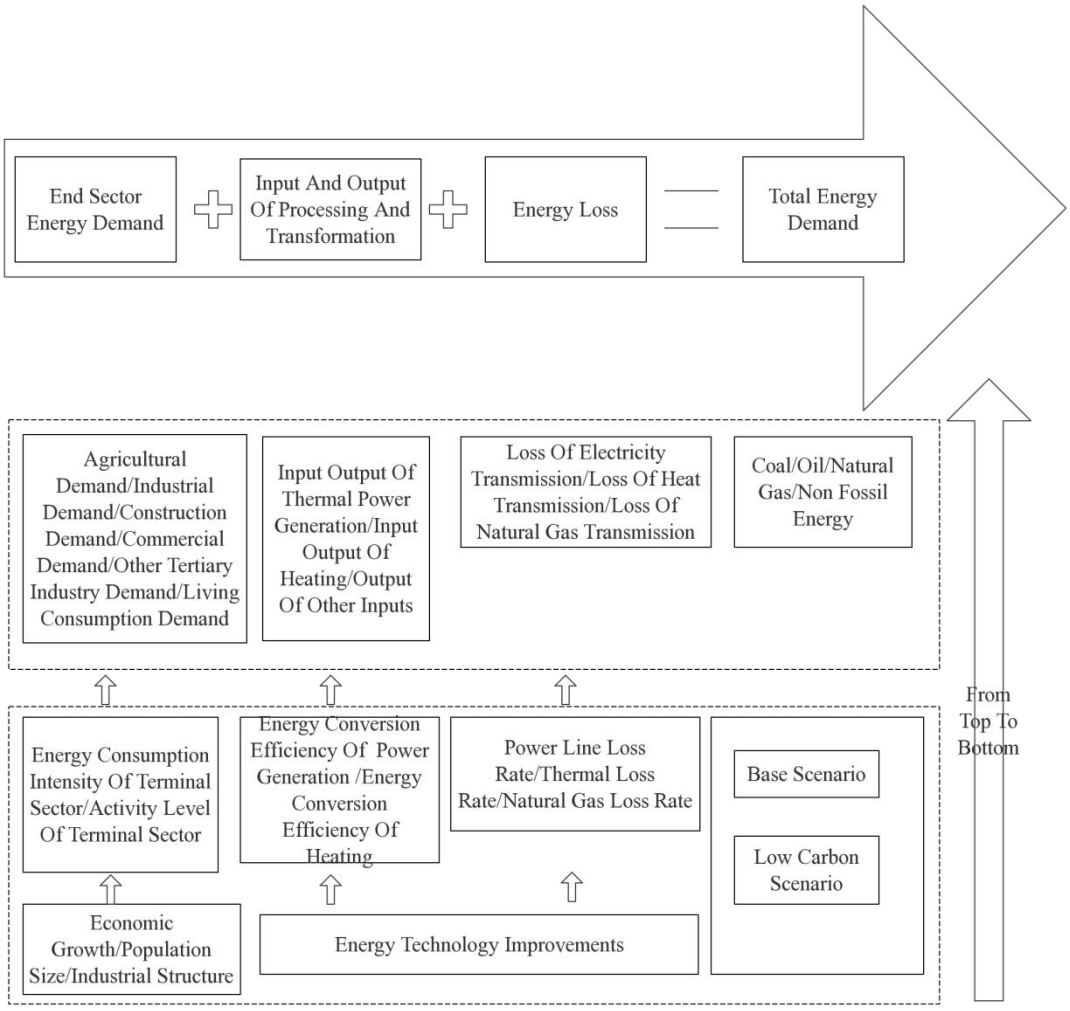

Figure 1 LEAP model computing framework

The Baseline Scenario and Low Carbon Scenario set in this paper correspond to the strong policy intervention scenarios without strong policy intervention and the strong policy intervention scenarios under the two-carbon target respectively. The assumptions are different in terms of future population size, economic growth rate, industrial structure and energy efficiency, etc. The specific parameters are shown in Table 2.

Table 1 Main parameters and characteristics of baseline scenario and low-carbon scenario

	Benchmark scenario	Low carbon scenario
population	In 2022, the total population	Same benchmark scenario

size	reached its peak, about 1.405 billion people, and in 2050 it was about 1.26 billion people.	
economic growth	Maintain an average annual rate from 2020 to 2025.Maintain an average annual rate from 2026 to 2035.Maintain in 2036-2050	Same benchmark scenario
Urbanization rate	In 2030, it was 72%，79% in 2025	Same benchmark scenario
industrial structure	Optimization of economic structure: In 2030, the primary industry will increase by 4.3% in the national gdp.The secondary industry increased its proportion.45.5% ， The added value of tertiary industry accounts for 50.2%，In 2050, the proportion of the added value of the first, second and third industries in the national gdp is respectively 2.5%，36.4% and 61.2%	Optimization of economic structure: In 2030, the primary industry will increase by 3.2% in the national gdp.The secondary industry increased its proportion.41.1%， The added value of tertiary industry accounts for 55.7%， In 2050, the proportion of the added value of the first, second and third industries in the national gdp is respectively 2.2%，26.4% and 71.4%
Transportation	Rapid development, convenient public transportation and perfect rail transit in big cities.	The public transport network will be further improved, and environmental protection travel will be carried out. Rail transit will be basically available in all cities, and the rate of private electric vehicles will reach 80% in 2050.
Energy intensity	Set according to the scenario objectives of the 14th Five-Year Plan.	In 2050, the energy intensity of various industries is 70%
Machining conversion efficiency	The energy conversion rate of power generation and heating is expected to reach 56% in 2030.It will reach 72% in 2050.	The energy conversion efficiency of power generation and heating is expected to reach 60% by 2030.It will reach 80% in 2050.

Energy transmission efficiency	In 2050, the national power transmission loss rate was 3.8%	In 2050, the national power transmission loss rate was 3%.
Energy utilization structure of terminal department	Based on the existing policy development, in 2015, the ratio of coal, oil, natural gas, electricity, heat and other energy sources in the energy structure of China's terminal departments was 29.62: 32.88: 7.38: 22.77: 6.12: 1.23.In 2050, the ratio of coal, oil, natural gas, electricity, heat and other energy sources in the energy structure of China terminal sector was 21.59: 35.52: 9.26: 25.22: 6.22: 2.18.	In the scene of accelerating electrification, In 2035, the ratio of coal, oil, natural gas, electricity, heat and other energy in China's terminal sector was 18.93: 21.49: 7.29: 20.72: 4.94: 2.84.In 2050, the ratio of coal, oil, natural gas, electricity, heat and other energy sources in China in 2035 was 14.24: 19.87: 8.79: 21.93：5.20：5.37

3. Forecast results of national oil and gas demand

3.1 National oil and gas demand benchmark scenario

From 2020 to 2030, energy consumption will peak, and the proportion of oil and gas demand will steadily increase. During this period, the consumption of high-carbon energy such as coal and oil peaked and began to decline slowly. Natural gas played its role of low-carbon, clean and flexible, maintaining rapid growth, and renewable energy grew rapidly. It is predicted that the total energy consumption will peak at about 5.8×10^{9} tce in 2030, with oil demand accounting for 20.9% and natural gas demand for 11.6%.

From 2030 to 2035, the total energy consumption platform will oscillate, oil demand will decline slowly, and the proportion of natural gas will be basically stable. In this stage, the consumption of coal and oil accelerated to decline, natural gas and renewable energy fully integrated development, consumption demand increased slightly and tended to peak, non-fossil energy development further accelerated, becoming one of the main energy. Oil demand is projected to decline from 1.21×10^{9} tce in 2030 to 1.05×10^{9} tce in 2035, while natural gas demand is basically stable at 6.5×10^{8} tce during this period.

From 2035 to 2050, total energy consumption will decline slowly, oil demand will decline rapidly, and natural gas will decline slightly after peaking. During this stage, the consumption of coal and oil dropped rapidly, leaving the stage of the main energy, natural gas and renewable energy were fully integrated, and the focus was shifted from terminal fuel to power generation, and the consumption decreased slightly at the peak level. Non-fossil energy grew exponentially, and established a core position under the support of gas, electricity, energy storage and other technologies, becoming the absolute main energy. In 2050, the demand for coal, oil, natural gas and non-fossil energy is expected to be 4.3×10^{8} tce, 3.2×10^{8} tce, 7.4×10^{8} tce and 37.1×10^{8} tce, respectively.

3.2 National low-carbon oil and gas demand scenario

Under the low-carbon scenario, China's total energy demand in major years will be reduced by 8% (2035) and 15% (2050), respectively, compared with the baseline scenario, under the combined effect of economic transformation and improvement of energy utilization efficiency and transmission efficiency. It is expected that the total energy demand will peak at 5.51×10^{9} tce around 2030 and decrease to 4.42×10^{9} tce in 2050 under the low-carbon scenario.

In terms of natural gas demand, the proportion of natural gas demand in 2020-2035 will continue to increase, and the total volume will show an increasing trend, specifically from 4.2×10^{8} tce in 2020 to 5.6×10^{8} tce in 2035. After reaching the peak, natural gas demand will decline rapidly due to the strengthening of non-fossil energy substitution. By 2050 it will account for only about 4%.

In terms of oil, the proportion of oil demand will decline slowly during 2020-2030, but due to the rapid increase of total energy demand, oil demand will still increase slowly and reach a peak around 2030, with a peak level of about 109tce. From 2030 to 2035, oil demand fluctuated slightly, accounting for 18% on average. After 2035, oil demand began to decline rapidly, falling to 3.4×10^{8} tce in 2050.

4. Oil and gas demand forecast structure at provincial level

4.1 Changes in total energy demand of each province

In terms of total energy demand, Shandong Province is the country's highest energy consumption province, accounting for the highest proportion of energy demand in every year during the forecast period, and is expected to reach 9% of the VIVnational energy demand in 2035. Hainan Province is the province with the lowest energy demand ratio, which is basically maintained in the range of 5‰ to 6‰. By 2035, the top 10 provinces in terms of energy demand are Shandong, Guangdong, Jiangsu, Hebei, Zhejiang, Xinjiang, Henan, Shanxi, Inner Mongolia and Liaoning.

From the changing trend of energy demand share, 30 provincial administrative regions can be roughly divided into three groups: rising proportion, stable proportion and decreasing proportion.

The proportion of energy demand in 15 provinces, Gansu, Guangdong, Guangxi, Hebei, Heilongjiang, Inner Mongolia, Ningxia, Qinghai, Shandong, Shaanxi, Tianjin, Xinjiang, Zhejiang, Hainan and Yunnan, will increase. Among them, the proportion of energy demand increased the most in Xinjiang Autonomous Region, from 4.34 percent in 2020 to 5.42 percent in 2035.

Five provinces with "stable ratios" -- Anhui, Henan, Jiangsu, Jiangxi and Shanxi -- will see their energy demand ratios remain stable. Among the five provinces, Jiangsu has the highest energy demand, accounting for about 8% of the national total. Jiangxi has the lowest energy demand, accounting for only 2 percent.

The "declining" provinces -- Beijing, Fujian, Guizhou, Hubei, Hunan, Jilin, Liaoning, Shanghai, Sichuan and Chongqing -- will see their share of energy demand decline. Among them. The share of energy demand decreased most in Hubei province, from 3.42 percent in 2020 to 2.61 percent in 2035.

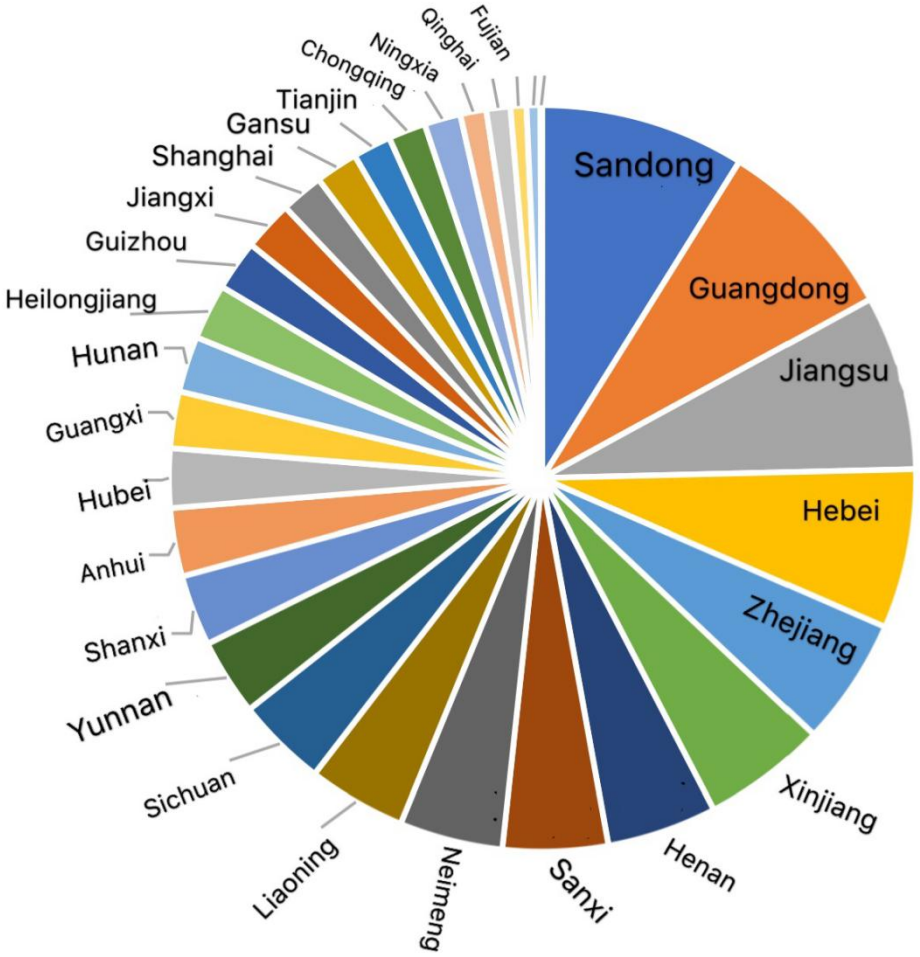

Figure 2 The proportion of energy demand by provinces in the national calendar year in 2035

4.2 Oil demand forecast of each province

From the ranking of provinces, Shandong Province has the highest average demand, which reaches 9.5×10^7 tce in baseline scenario and 8.4×10^7 tce in low-carbon scenario. Hainan Province has the smallest average demand, with 6.19×10^6 tce in the baseline scenario and 5.46×10^6 tce in the low-carbon scenario. Overall, the total oil demand in the low-carbon scenario is 88.4 per cent of the base scenario. The 30 provinces can be roughly divided into three tiers based on total oil demand. Among them, Shandong, Guangdong, Jiangsu and Hebei are the first tier, whose oil demand under the baseline scenario is more than 7×10^7 tce ; Zhejiang, Xinjiang, Henan, Shanxi, Inner Mongolia, Liaoning, Sichuan, Yunnan, Shaanxi, Anhui and Hubei are the second tier, whose oil demand under the baseline scenario is 3×10^7 tce $\sim 6\times10^7$ tce ; Hunan, Guangxi, Heilongjiang, Guizhou, Shanghai, Jiangxi, Gansu, Chongqing, Tianjin, Ningxia, Fujian, Beijing, Qinghai, Jilin and Hainan are the third tier, whose oil demand under the baseline scenario is less than 3×10^7 tce .

According to the trend of change, in both the low-carbon scenario and the base scenario, the provinces will basically reach the peak of oil demand around 2030, which is consistent with the national trend. For example, the peak value of Shandong, Guangdong, Hebei and other provinces is more obvious, while the peak value of Qinghai, Hainan and other provinces also appears, but the overall trend is relatively stable. The exception is Fujian Province, where oil demand has declined over the past 15 years.

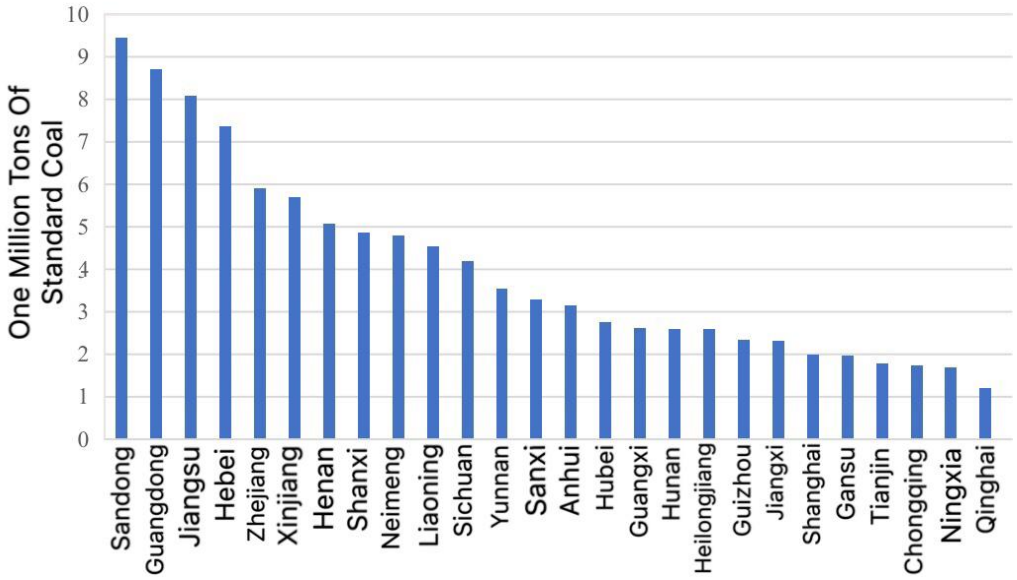

Figure 3 Oil demand forecast by provinces in 2035 under the baseline scenario

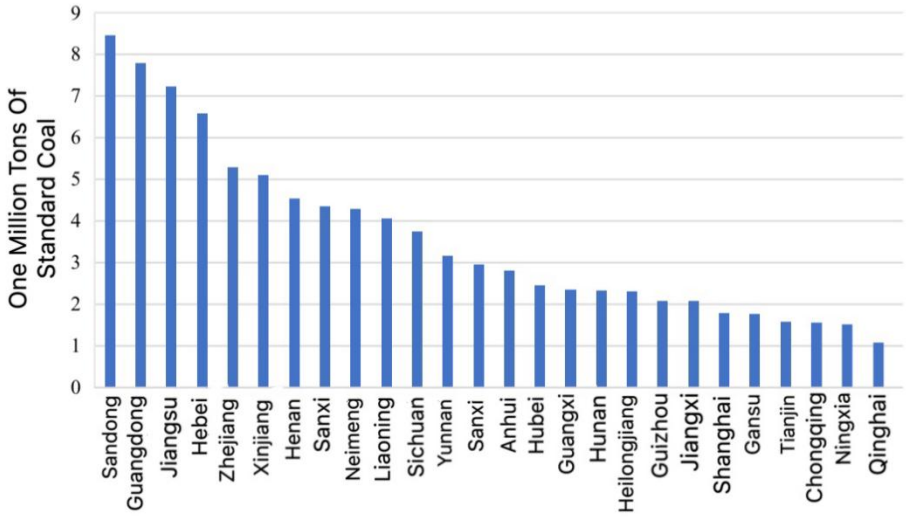

Figure 4 Oil demand forecast by provinces in 2035 under the low-carbon scenario

4.3 Forecast of natural gas demand in each province

From the ranking of provinces, Shandong Province has the highest average demand, which reaches 5×10^7 tce in baseline scenario and 4.4×10^7 tce in low-carbon scenario. Hainan Province has the smallest average demand, reaching 3.28×10^6 tce standard coal in the baseline scenario and 2.86×10^6 tce in the low-carbon scenario. Overall, the total gas demand in the low-carbon scenario is 87.5% of the base scenario.

According to the change trend of natural gas demand under the baseline scenario, all provinces will achieve the peak of natural gas demand around 2030. Compared with oil demand, the difference between the change speed of natural gas demand before and after the peak is larger, and the rise speed before the peak is obviously faster than the decline speed after the peak. Different

from other provinces, the demand for natural gas in Fujian Province has always shown a downward trend.

From the change trend of natural gas demand under the low-carbon scenario, except Fujian Province, the demand for natural gas in all provinces has always shown an upward trend. Although the rate of increase slows down around 2030, the upward trend remains unchanged. In the low-carbon scenario, the proportion of energy consumption, such as oil and coal, will be briefly replaced by cleaner energy sources, such as natural gas. Therefore, natural gas consumption will continue to rise until 2035, which is consistent with the country's overall energy forecast.

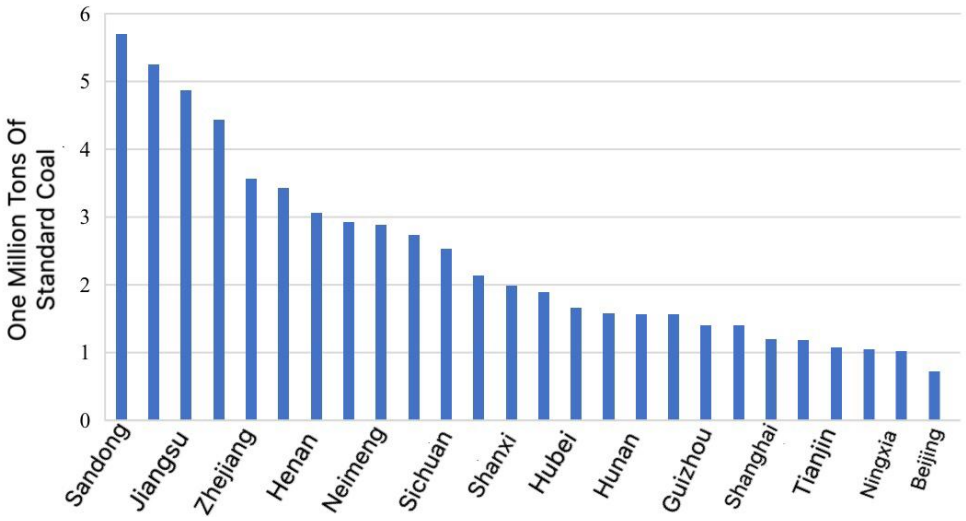

Figure 5 Natural gas demand forecast by provinces in 2035 under the baseline scenario

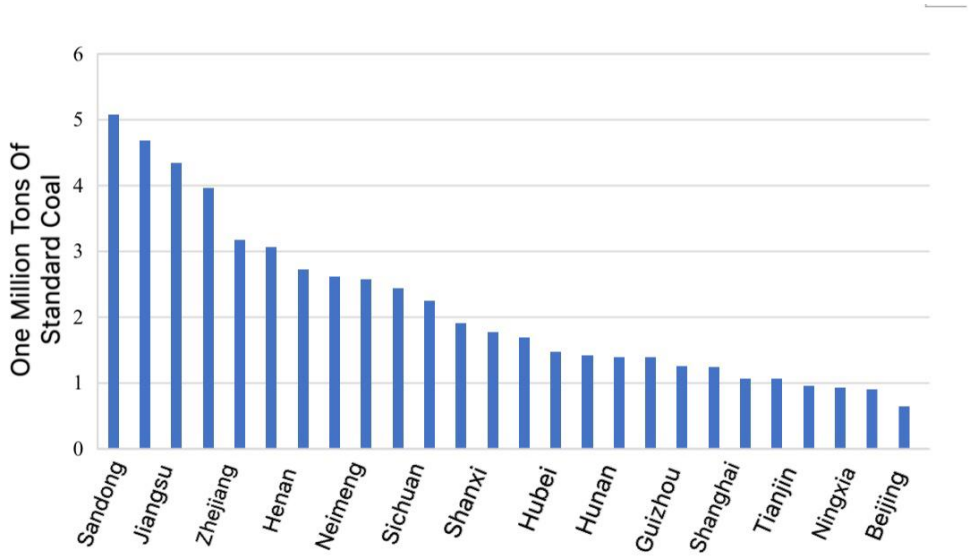

Figure 6 Forecast of natural gas demand by provinces in 2035 under the low-carbon scenario

5. Conclusions and Suggestions

The oil and gas industry as a whole is in the stage of rapid growth. The industry development foundation is good and the future prospects are broad. Chinese oil and gas pipeline construction has a big development space, and has made certain achievements, but facing the increasingly complex domestic and international development environment and many problems in the growth of the

industry, there is still room to optimize the overall scale, structure layout and system mechanism. Many domestic trunk pipelines that make up resource channels are already running at full capacity, and the pressure may increase further as the demand increases in the future. Therefore, in order to realize the further optimization of oil and gas pipelines, it is necessary to actively connect branch pipelines on the basis of the construction of Shinkansen pipelines, improve the overall coverage rate, and constantly improve the structural layout of oil and gas pipelines in combination with the balance of oil and gas supply and demand. With the expansion of the scale of oil and gas pipelines in the future, the management of pipe network risks and the improvement of safety will become the key optimization direction of the industry.

In the future, the operation of pipe network should be further optimized to reduce consumption and increase efficiency. Based on the characteristics of natural gas resources and the changes in market demand along the route, the flow direction of pipeline resources should be adjusted in time, the pipeline transport load should be arranged scientifically, and the gas transmission process should be adjusted flexibly, so as to achieve the optimal transmission mode of the main pipeline. Strengthen the organic integration of primary and secondary oil pipeline control business, actively promote the transformation of on-site process technology, reasonable arrangement of transport batch plan, overall maintenance and repair and major hot operation stop window, to ensure that high-load pipeline transport capacity to achieve benefits, low-load pipeline digging efficiency to reduce costs. Specifically, there are differences in economic development level, economic structure, resource endowment and other aspects in different regions, so there will be differences in the demand and supply of oil and gas resources. When optimizing the overall layout of oil and gas pipeline construction in our country, the actual supply and demand of oil and gas resources in various provinces should be taken into consideration, such as the transmission distance of oil and gas, transmission cost, transaction price and other factors, so as to coordinate the pipeline network of oil and gas scientifically and optimize the flow of resources.

The 14th Five-Year Plan period will be a new stage of "national one net" development of oil and gas network, which has fully entered physical interconnection and fair and open service. The 14th Five-Year Plan will completely realize the overall planning and construction of pipe network facilities, independent accounting of operating cost of pipe network, steady improvement of safety management of pipe network, is the key period of the rapid development of oil and gas pipe network, featuring the gradual improvement of the planning and layout of pipe network, rapid expansion of pipe network scale, and rapid improvement of service level of pipe network. The National Pipeline Network Group was established and is responsible for the construction and operation of the national main pipeline network, which can more effectively coordinate the oil and gas resources and market demand. On the basis of giving full play to the capacity of the existing pipeline network facilities, the national oil and gas pipeline network is planned and distributed according to the pipeline transportation bottleneck and future growth demand.