Competitiveness analysis of coal industry in China: A diamond model study

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ABSTRACT

Under the effects of environmental pollution, macro-economical conditions, markets downturn, and squeeze of clean energy, the operation condition of China's whole coal industry attracts more attentions in recent years. This study aims to investigate the comprehensive competitiveness of coal industry in Chinese policy and economy environment. Then, this paper adopts diamond model to analyze internal and external factors that have significant influences on the competitiveness of China's coal industry, namely resource condition, demand condition, industry structure and enterprise strategy, related and support industries, the government, technology and chance. The research indicates that Chinese coal industry suffers from excessive capacity, low coal price and substitute of clean energy, etc. The current performance of Chinese coal industry is not optimistic. Fortunately, Chinese government unceasingly issues policies to support and regulate coal industry, and coal enterprises actively participate in industrial structure adjustments to deal with pressure of downturn. Furthermore, some national strategies, such as Ultra High Voltage transmission and ‘One Belt And One Road’, will greatly promote the recovery of domestic coal industry. In order to survive the downturn and sustain its fundamental position, coal industry should attach importance to these key factors in diamond model for each of them has crucial influences on the comprehensive competitiveness of Chinese coal industry.

1. Introduction

Environment and resource are two key influencing factors for China’s sustainable development. As the worldwide environmental pollution worsens continuously, promotion of energy saving and emission reduction, and development of green economy become urgent and necessary. Determined by resource endowment and technology level, China initially developed economy at the expense of excessive exploitation of fossil resources, which leads to excessive ratio of fossil resources in energy structure. While, unsustainable development patterns and unreasonable energy structures result in China’s growing environmental pollution problems. The using coal enterprises release lots of pollutants, such as PM2.5 and mercury (Ancora et al., 2016), which threatens the health of the mankind. Though the proportion of clean energy in primary energy is increasing, it still has great gap with those in some developed countries and the proportion of coal remains too high. Extensive coal consumption and development pattern of intensive-energy consumption result in China’s worsening air quality to a great extent.

The slow growth of China’s economy, substitute of clean energy and squeeze of imported coal all challenge the resource advantages of domestic coal. The official PMI (Purchasing Managers’ Index) and Caixin PMI both drop below 50%, which means the shrinking manufacturing will reduce the demand for raw materials, and any reduction in coal consumption will negatively affect their industrial added value as well as economic growth (Muhammad et al., 2015). Simultaneously, renewable and clean energy develop rapidly and gradually substitute coal, and the government is eliminating disqualified production capacity, which cause great pressure to industrial chains of coal industry. Besides, domestic coal price and protection policy of fossil energy make imported coal further squeeze domestic coal demand. Under these conditions, the downturn situation of coal industry will continue, for industrial recovery cannot be achieved in short time.

Influenced by the pressure from economy, energy and environment, China’s coal industry is encountering tremendous challenges in recent years. Thus, coal industry reform is an urgent yet essential issue for China to ensure economic development and respond to climate change mitigations. In 2016, merging and reorganization, transformation and exit will be main trends of coal industry. This industry tends to be more intensive, more efficient and greener. However, the coal industry reform needs much exploration for no mature experience to learn from. And a comprehensive analysis from industrial conditions to external environment will benefit the enterprises and the whole industry.

This paper focuses on gaining a comprehensive acknowledgement

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of China’s coal industry. It begins by introducing diamond model that can be used to construct a framework for the competitiveness analysis of China’s coal industry. Previous research lacks comprehensive and systematic analysis, and diamond model is a comprehensive analysis method that focuses on the holistic industrial competitive advantage, while the holistic competitive advantage relies on the integration of basic elements and assistant elements (internal and external factors in this paper). This model is suitable for analyzing the mutual influences between elements and their influences on the whole industry, so it suits the research target of this paper. Then, the paper continues with the analysis of internal and external components in the model. These components include internal basic elements such as resources demand, market demand, industry structure and its enterprises, related and support industries, and external elements such as government policies, support technology, and industrial chance analysis. Based on the analysis above, the mutual influence of each factor on other factors and the whole industry development can be identified, and targeted measures can be taken to recover China’s coal industry.

2. Methodology

Previous researchers in coal industry have carried out a lot of research, such as technology, economy and environment. Take economic evaluation as an example, Table 1 displays the review of main previous works on the evaluation of related subtopics in coal field. However, they seldom focus on the comprehensive competitiveness of this industry, which greatly increases the management difficulty of enterprises managers and policy makers. Thus, this paper introduces diamond model to systematically and comprehensively analyze the competitiveness of coal industry. This model first constructs a framework to determine the external and internal factors that influence the competitiveness of China’s coal industry; then, the influence of each factor on coal industry is analyzed in detail, in order to obtain the mutual influencing relations between each factor, and further obtain targeted schemes to promote industrial competitiveness. Porter’s diamond model is widely used to analyze the competitive advantages of a national industry. For example, Jarungkitkul et al. (2016) developed assessment criteria based on this model and studied logistics targeted schemes to promote industrial competitiveness. Porter’s diamond model is widely used to analyze the competitive advantages of domestic coal industry. Internal factors consist of resource condition, demand condition, industry structure and enterprise strategy, related and support industries, which are positioned at four corners of the tetrahedron, and solid lines represent mutual influences between internal factors. Resource condition is initial advantages, and it is one of the initial driving forces of industrial development. Demand condition is the industry domestic demand, which has key catalytic influences on the international competitiveness of coal industry. Industry structure and enterprise strategy mean that the current industrial structure will adjust towards the corresponding changes of external environment, and the enterprises in this industry have to promptly develop coping strategies. Related and support industries represent the upstream and downstream related industries that stimulate the competitiveness of this industry. By contrast, the government, technology and chance are main external influencing factors of coal industry, which have mutual influences on internal factors, as dotted lines show. The government is the catalyst of industrial development, for it can put forward incentive and regulation policies that will bring opportunity and pressure to domestic coal industry. Technology means current main related technologies that will greatly promote the development advantages of coal industry. And chance means current industrial development advantages and future development trend, which will further influence the industry competitiveness and other main factors in this model. Based on the analysis above, diamond model can form a comprehensive result that includes

![Fig. 1. Diamond model.](image)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Objects</th>
<th>Method/indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoffmann et al. (2012)</td>
<td>co-firing coal in thermal power plants in the south of Brazil</td>
<td>availability of biomass; technical feasibility of co-combustion; viability in terms of CO2 emissions; economic viability</td>
</tr>
<tr>
<td>Li et al. (2015)</td>
<td>correlation between coal development and economic growth in China</td>
<td>multiple linear regression models, the measurement model of environmental damage cost/GDP, gross value of industrial output, output of raw coal, gross value of coal industrial output, new investment in fixed assets of coal system-wide sensitivity analysis/cost, efficiency, fuel prices, emission limits, performance characteristics</td>
</tr>
<tr>
<td>Aitken and Loughlin (2016)</td>
<td>coal-and-biomass-to-liquids-and-electricity plants</td>
<td>Aspen Plus software/Internal Rate of Return, the payback period and the net present value capital costs and specific capital investments, operational &amp; maintenance costs, cost of electricity, CO2 capture costs</td>
</tr>
<tr>
<td>Bassano et al. (2014)</td>
<td>coal to Liquid plants</td>
<td>costs of initial investment, annual operating and raw coal purchase, revenues from the sale of major products</td>
</tr>
<tr>
<td>Cormos (2014)</td>
<td>coal-based power plants</td>
<td>ASU cost, CPU cost, ASU share of total EPC, CPU share of total EPC, total EPC, owner cost, total capital investment, specific investment, BESP mass-analysis model/ investment and operating costs, cost of CO2 avoided, syngas manufacturing cost</td>
</tr>
<tr>
<td>Bae et al. (2012)</td>
<td>direct coal liquefaction, indirect coal liquefaction and hybrid coal liquefaction processes</td>
<td>Capex, Opex, Coal and biomass, CO2 penalties/credits, REC revenues</td>
</tr>
<tr>
<td>Huang et al. (2012)</td>
<td>pulverized coal-fired power plants</td>
<td>capital expenditures, operating expenditures</td>
</tr>
<tr>
<td>Chiu and Blom (2012)</td>
<td>nuclear-assisted coal-to-liquid</td>
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<td>Khilvero et al. (2014)</td>
<td>coal-fired power plants</td>
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<td>Jilvero et al. (2014)</td>
<td>coal-fired power plants</td>
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longitudinal and transverse perspectives. The longitudinal analysis covers the factors along the industrial chain, and transverse analysis covers the external influencing factors of coal industries. Therefore, the diamond model is suitable for competitiveness analysis of coal industry because it can take full consideration of the related influencing factors.

3. Comprehensive analysis

3.1. Resource condition

3.1.1. Energy structure

Though the proportion of coal in primary energy descends continuously, it is still too high, and the proportion of clean energy needs further improving, according to data from BP Statistical Review of World Energy 2015 in Table 2. Influenced by factors like supply and demand, price and environmental protection, surplus production capacity is serious in China, and then the government put forward policies to control the production and weed out backward capacity. In this case, coal enterprises should reduce the use cost and improve the production efficiency, in order to ensure the competitiveness of coal resource.

Currently renewable and clean energy develop rapidly and substitute part of coal consumption, which greatly affect the coal demand. Developing renewable and clean energy is not only the need of environmental protection, but also a vital measure for sustainable development. The clean energy has attracted great attention owing to its advantages in reducing pollutant emissions, but cost and technology are the bottleneck of its generalization. With the development of technology, the proportion of clean energy in energy structure will improve constantly. Simultaneously, the present condition of coal industry also promotes the generalization of clean energy.

The development of clean energy, is not only beneficial to protect the environment and optimize energy structure, but also helpful to ensure energy security. In recent years, imported coal is favored by the littoral for lower price, and its import is gradually increasing yearly. While excessive dependence on imported coal will threaten domestic coal enterprises and national energy security. Thus, the government should guide coal industry to optimize industrial structure and achieve the goal of clean and efficient use of coal, which can enhance competitiveness advantages of domestic coal over imported coal. The production capacity of coal should be controlled in a reasonable range, in case of resources waste, disordered competition, excessive dependence on imported coal, and decreased resistance to global market. Simultaneously, the government should promote the application of clean energy, in order to reduce environmental pollutions and form green and sustainable development pattern.

3.1.2. Resource potential

The distribution area of China’s coal resource reaches 600 thousand square kilometers. The geological condition of China determines its distribution pattern of more in the east and less in the west, more in the north and less in the south, which determines development trend of coal transported from north to south, and from east to west. Period of 2002–2012 is the Golden Decade for coal industry, when the CAGR (Compound Annual Growth Rate) is 8.1% and annual average production growth is 200 million tons. But after 2012, the coal market suffers downturn and this industry has been under Entrepreneurs Confidence Threshold. The raw coal output is 3.87 billion tons in 2014, year-on-year growth decreasing by 2.5%, which is the first decrease since 2000. During the first 11 months in 2015, the coal output is 3.37 billion tons, year-on-year growth decreasing by 4.1% (Hexun Futures, 2016).

Influenced by the negative industrial factors, the investment on the geological survey declines gradually, and the exploration of coal resource reserves slows down simultaneously. In 2014, coal resource proven reserves is 1530 billion tons, and newly-added reserves is 53.62 billion tons (Ministry of Land and Resources, 2014), while the newly-added reserves are respectively 74.9, 61.6 and 67.3 billion tons from 2011 to 2013 according to China Mineral Resources (2014). Simultaneously, nationwide coal consumption has been negatively increasing. According to the statistical data from China National Coal Association in 2014, coal consumption of key power generation enterprises is 1.24 billion tons, year-on-year growth decreasing by 7.5%, and the raw coal consumption is about 3.51 billion tons, year-on-year decreasing by 2.9%. Owing to excessive investment on fixed investment in earlier stage, capacity of coal industry has increased rapidly, as Fig. 2 shows. It is estimated that actual capacity has reached 4.3 billion tons, but the efficiency of capacity is only 86%, which means that surplus production capacity is rather serious.

The influencing factors like price decreasing, surplus production capacity and environmental pressure impel coal industry to eliminate backward production capacity and control production, coal enterprises to reduce exploitation cost and expand production chain, and downstream enterprises to reduce use cost and promote energy saving and emission reduction. These countermeasures have influences on demand and price of coal. In the future, coal enterprises should transform or expand business to product with higher added value. Once the goal of clean and efficient use is achieved, coal resource may reach another peak demand, which will maintain its pillar position for a long time. Simultaneously, coal industry should focus on integration with renewable and clean energy, which will optimize the energy structure and ensure energy security.

3.2. Demand condition

3.2.1. Economy operation condition

Influenced by severe inner and outer environments, coal price has continuously dropped since 2012, and the price fluctuation of steam coal with 5000 kcal in Qinhuangdao port is shown in Fig. 3. Unceasing
decrease of coal price, results in the increase of debt and financing cost of coal enterprises, of which 90 large-scale enterprises are in deficit and the total debt reaches 3200 billion CNY. This impels coal enterprises to decrease cost and increase efficiency. The low coal price has its disadvantage and advantage, for it can create conditions for cancellation of two-track price system, promotion of complete marketization and electricity price reform. Also, it can alleviate the pressure of rising prices, which help form sustainable and healthy development of national economy.

The economy operation condition of China’s coal is very poor, as shown in Table 3. Except coal storage and yield, the absolute and relative quantities of other indicators have dropped a lot. Most enterprises cannot turn loss into gain in a short time, and then the pressure on coal industry will be heavier. Though the lower price will benefit the downstream enterprises in a short time, beneficial enterprises should be prepared for coal market changes.

The reasons for current operation condition of coal industry include not only macro economy market, but also new industrial structure changes: (1) Unbalanced supply and demand. The coal demand gradually decreases since negative growth occurred in 2012, while fixed asset investment of mining and dressing as well as production capacity (existing capacity 4 billion tons, and 1.1 billion tons under construction) exceeds much more than practical demand. (2) Unreasonable industrial and technical structure. Industrial and technical structures are unreasonable because of low industry concentration, single product structure, weak innovation ability and low average working efficiency. (3) Constraints of system mechanism. Problems like relaxing enterprises management, heavy tax burden, and imperfect exit mechanism, restrict the sustainable and industrial healthy development. Based on the above analyses, coal industry should actively take measures to start from ‘restrict total volume, stabilize market price, and ensure mining safety’; enhance sustainable ability and production efficiency, explore new ways and patterns of structure adjustment and transformation; encourage coal enterprises to develop towards production serving enterprises.

3.2.2. Coal demand

The 1978 reform-and-open-up policy enabled the miracle of China’s economic growth at a two-digit growth rate. China’s early development is based on fossil resources such as coal, natural gas and petroleum, and coal occupies the largest proportion in primary energy. According to main applications, coal is divided into two categories: steam coal and coking coal. The related information about specific applications and proportions are listed in Table 4.

The China’s coal industry in 2014 has witnessed downturn of the consumption for the first time, and the condition continues to worsen further. Recently, the supply of imported coal increases continuously. Imported coal has the advantage of lower price over domestic coal, and it is preferred by southeastern coastal areas, which promotes the import of steam coal and shakes domestic coal market. But the imported coal bring not only challenge, but also chance. Imported coal can lighten the transportation pressure and save transport capacity, which promote China’s coal industrial structure adjustment to some extent. Simultaneously, clean energy power generation impairs the coal demand of thermal power, and coal demand of cement and steel is much less in construction industry. These make domestic coal industry on a status of demand recession, and soaring coal demand is difficult to appear again.

The reducing demands in coal-intensive enterprises, and substitutions of clean energy and imported coal, will have key influence on domestic coal demand. Take example for electricity industry, the coal demand of coal-fired power accounts for large proportion of domestic coal demand. In recent years, coal consumption in electricity industry is decreasing, whose trend is basically in concordance with that of domestic coal consumption, as Fig. 4 shows. This phenomenon is mainly attributed to the environmental pollution caused by coal combustion and vigorous promotion of clean energy. The output change curves of coal-fired power and main clean energy power generation are shown in Fig. 5. Since 2015, nuclear power has developed rapidly, and the commercial installed capacity in East China and South China reach 10.0 and 10.2 million kilowatt. What’s more, hydropower plays key role in supplying power to coastal areas.
during these two summers, as shown in Table 5. It’s expected that installed capacity of hydropower and nuclear power will reach 320 and 120 million kilowatt until 2020, which greatly promotes the decrease of coal demand and then bring pressure to coal market.

Though China’s coal industry is encountering downturn, challenge and opportunity both exist. China is vigorously developing low-carbon economy, but implementation of related policy has time-lag and construction period of industrial chains of alternative energy is long, so the position of coal in social and economical development will be unshakable. Coal price now is under national average cost, and its change range will not be large in the future, so coal will still be a most economical raw material and energy. Simultaneously, One Belt And One Road strategy will further drive the demand of energy-intensive industry like steel and non-ferrous metal, which then drives coal demand and relieves the pressure of coal industry. And domestic coal enterprises should actively explore international coal market, deal with industrial structure adjustment, develop clean coal techniques, and transform towards production serving enterprises. In the long run, safe, green, efficient development is inevitable for coal industry. The proportion of coal consumption should be gradually decreased, and coal should be transformed from pillar energy to foundational energy.

3.3. Industry structure and enterprise strategy

As the external environment changes rapidly, all the stakeholders in coal industry take measures to respond to these changes, which will have great influences on the whole industrial chain. For example, if coal transported by railway is substituted by power transported by UHV grid, coal using cost and on-grid price of thermal power will increase, which in turn promotes domestic coal demand. As the focus of new power system reform is releasing the limit on electricity selling sides, high-quality power generation enterprises will strive for more generation shares with its technology and capital advantages, which will also promotes domestic coal demand.

3.3.1. Industry structure adjustment

Influenced by macro economy operation and environmental protection policies, coal market changes drive the industrial chains to change greatly (Analysis on the coal industry technical characteristics in 2014, 2014). (1) Longitudinal structure changes. Coal industry is closely related to macro economy, while traditional economic development pattern of government leading has changed. The growth of GDP has slowed down, and then development environment of coal industry is experiencing great changes. (2) Administrative driving force changes. Traditional economic development relies on the government investment to drive the massive demand of industrial raw materials, which exposes lots of defects, so the government put forward policies to reduce the chase passion of local government for infrastructure construction projects, which worsens coal terminal demand market. (3) Transverse industrial chain changes. The coal industrial chain is shown in Fig. 6, where full lines express upstream and downstream relationships, and dotted lines express resource destination and corresponding proportions. The terminal demand of coal focuses on industries such as infrastructure construction and real estate, which are the driving forces of China’s macro economy during the past decades. While the driving effect has weakened yearly, so coal industrial chain would make great changes with directivity changes of terminal demand.

Related government departments take measures to coordinate the relationship among eliminating capacity, guaranteeing supply and stabilizing price, in order to impel the balanced and healthy development of coal industrial chain: firstly, eliminate capacity and optimize...
industrial structure unswervingly. China should deeply promote the merging and restructuring of coal industry and eliminate “zombie enterprises”, which will promote industrial structure adjustment, transformation and upgrading, optimization layout. Secondly, take multiple measures to guarantee supply and stabilize price. Coal industry should release orderly advanced capacity and strengthen the coordination of produce-transportation-supply in some areas with tight thermal coal supply. The medium and long term cooperation between coal supply side and demand side are encouraged to guarantee coal steady supply (National Development and Reform Commission, 2016).

To deal with the changes of industrial environment and demand, coal industrial structure should make corresponding adjustments. In 2016, merging and reorganization, transformation, and exit are main development trends. For example, shutting down the small-scale coal mines and encouraging mergers will increase the environmental benefit of coal industry (Liu et al., 2016). Coal industry will be more intense, efficient and clean in the future. Though coal industrial transformation cannot be completed in a short time, reform direction should be right. Hold the direction of clean and low-carbon pattern, and reduce resource waste, are the basic principles for enterprises transformation. Coal enterprises should make clear transformation orientation, consider fully market demand, technical reserve, talent training, and sales network, and avoid suffering heavier loss for blind transformation (TIME, 2016).

Facing severe situation at home and abroad, coal industry has actively explored new thoughts and measures. Study shows that R & D can not only improve production efficiency of coal enterprises, but also improve competitive position of China’s mining enterprises in the international market (Sun and Anwar, 2015; Dzonzi-Undi et al., 2016). The achievements of coal industry are mainly listed below (Reform and development conditions of China’s coal industry in 2015, 2016).

(1) Unceasing optimization of industrial structure. Until the end of 2015, the number of national coal mine reaches 10.8 thousand. Among these coal mines, 1050 are large coal mines with annual output of over 1.2 million tons, 400 mines more than that of 2010, and output proportion increased from 58% to 68%. In contrast, over 7000 mines are small with annual output of below 0.3 million tons, 4000 mines less than that of 2010, and output proportion decreased from 21.6% to 10%.

(2) Steady advancement of big base construction. The output of 14 big bases accounts for 92.3% of national output, 4.3 percentages
higher than that of 2010. And the output of 8 coal provinces with output of over 100 million tons accounts for 84.1% of total output.

(3) Higher industrial concentration. The output of first 4 coal enterprises is 0.87 billion tons, which accounts for 23.6% of national output and is 1.6% higher than that of 2010. The output of first 8 coal enterprises is 1.31 billion tons, accounting for 35.5% of national output and is 5.4% higher than that of 2010.

(4) Rapid development of large-scale coal enterprises. The number of coal enterprises with output of over 100 thousand tons increases to 9 (Shenhua group, Datong coal mine group, Shandong energy group, and so on), 4 more than that in 2010, and their total output is 1.41 billion tons, accounting for 38.2% of national output and 13% higher.

(5) Remarkable performance of coal electricity joint management and coal electricity integration. The total installed capacity of power stations whose stock is controlled by coal enterprises is 14 billion kilowatt, accounting for 16% of thermal power and 11% of national installed capacity. And coal production capacity operated by power enterprises is 0.32 billion tons, whose output is 0.26 billion tons, accounting for 13% of national coal consumed by power plants.

Besides, the technology of clean and efficient use has greatly improved. Comprehensive utilization of coal gangue reaches to 64.2%, 2.8% higher; utilization of mine gas extraction is 46.4%, 15.7% higher; the comprehensive energy consumption and power consumption of large and medium mines are respectively 14.6% and 14.8% less than those in 2010. Many evidences show that China’s coal industry still has promising future.

### 3.3.2. Coal enterprises reform

According to the Action Plan for the Control of Air Pollution (The State Council, 2013), small coal-fired boilers of central heating are required to be eliminated and replaced by electricity or clean energy; new cogenerations, thermal-power generation projects are banned and required to be replaced by clean and renewable energy power generation; “coal to gas” and “coal to electricity” projects are encouraged by the government. These policies will decrease the ratio of thermal power installed capacity, and increase the coal enterprises’ strategic and operational risk. The falls of demand and price have hindered capital flow of coal enterprises and reduce their profitability. For the first 10 months of 2015, profit of coal enterprises decreases by 62% year-on-year, and scale of loss reaches over 80%, of which state-owned coal enterprises transform from profit of 30 billion CNY last year to loss of 22.3 billion CNY (Business community, 2015). Great operational pressures make inferior enterprises with high cost exit coal market gradually, which is beneficial to the clearing of coal overcapacity. And, the State Council decides to stop, reorganize, and eliminate enterprises of long-term loss. Till the end of Thirteen Five-year Plans, the number of coal enterprises will be reduced from 6390 in 2015 to below 3000, in order to promote industrial structure adjustment and upgrade. Coal industry will be one of key rectification industries in Supply Side Reform.

Under the current situation, two issues of coal enterprise reformation should be paid great attention (A new round of reform is launched among the largest state-owned coal enterprises in Henan, 2016): (1) Reassign laid-off workers during eliminating overcapacity. The enterprises should reassign the workers involved in the enterprises whose capacity is reduced, which will greatly improve enterprises’ profit capacity. (2) Guarantee security of enterprise fund chain. Coal enterprises should not only increases the dynamics of inner fund turnover, but also expand financing channels, in order to strive for sufficient financial support.

There are several main reform trends for coal enterprises (21st Century Business Herald (Gangzhou), 2015; Contracting management mode is gradually promoted in coking coal enterprises (2016)).

(1) Extend industrial chain to clean energy and high value-added products. Shenhua Group, as well as Shaanxi Coal and Chemical Industry has set foot into new fields, in order to complement between different businesses. (2) Promote scientific and technological innovation. Coal enterprises should positively promote technology progress, and the impelling function of technology innovation in coal industry sustainable development. (3) Utilize Internet to reduce cost of procurement and sales, and increase transaction probability. Since 2013, Shenhua and China National Coal Group have successively constructed online transaction platform. What’s more, Shaxi province, Inner Mongolia, and Qinhuangdao have gradually developed e-commerce transactions. (4) Lock in price, profit and loss by futures of bulk goods, in order to alleviate current enterprises crisis. (5) Apply contracting management mode to improve enterprises mechanism. Coal enterprises should operate and manage independently, which can motivate management vitality and improve independent management level. While these reforms cannot directly change supply and demand of national coal market, and cannot ensure industrial competitiveness for long. Thus, the focus of coal enterprises reform is transformation and improvement of its own competitiveness. Meanwhile, coal enterprises should carefully select new technical route and product orientation, for the success probability of investment in non-coal industry is small without basing on their main industry. The enterprises involved in non-coal industry should base on its own advantages and avoid suffering further loss caused by blind transformation. In the future, the size and scale of coal enterprises will still increasing, and four orientations (Wang, 2008) will further increase concentrations of industrial capacities.

### 3.4. Related and support industries

#### 3.4.1. Overall condition

The direct downstream industries mainly include thermal power, steel, building materials and chemical industry, whose coal consumption reaches 80%. The industrial structure and corresponding propor-
tions of coal consumption are shown in Fig. 7.

As Fig. 7 shows, terminal consumptions of coal are infrastructure and real estate, which consume over 20% of coal. These two industries are closely influenced by macro policies, and investment changes in these two industries drive the changes in electricity industry, which will ultimately influence the coal industry. For these two industries are not direct downstream industries of coal industry, the relations between these two industries and coal industry are too complex to quantify.

However, the relations between upstream and downstream industries of coal industry are complex, and developments between different industries have some time-lag. For example, the growth of infrastructure construction is almost synchronous with coal economy operation. When economic status is poor, the government promotes economic development based on investment in infrastructure construction (in 2006 and 2009). When the economic status is better, growth of infrastructure construction will be reduced (in 2007 and 2009). What’s more, period of real estate is almost synchronous with that of coal industry. The infrastructure construction is about 1 year ahead of real estate. And infrastructure construction is conversion period, while real estate is pro-cyclicality. Therefore, it is the best opportunity to invest infrastructure construction when its growth is speeding up. Thus, coal industrial structure adjustment should focus on the change trends of upstream and downstream industries, and grasp industrial development opportunity.

3.4.2. Industrial chain subdivisions

In order to comprehensively understand branch industries of coal industry, this paper details the coal industrial chain based on resource classification (Deeply refine the industrial chain of China’s coal industry, 2015), as shown in Fig. 8. Steam coal is mainly used for electricity industry, and coking coal as well as anthracite is mainly used for steel industry and chemical industry.

(1) Steel-coke-coking coal industrial chain

Coking coal is used to produce coke, which is divided into meager lean coal, lean coal, coking coal, fat coal, 1/3 coking coal, gas-fat coal, gas coal and 1/2 caking coal based on their coalification degree. The production and supply of coking coal is in central and western China, while its consumption is mainly in the eastern areas, which decides the development trend of coal transported from north to south, and from east to west. Coke lies in the middle of branch industrial chain, whose profit room is narrow and loss is great due to surplus production capacity, low concentration, weak competitiveness, as well as pressure from upstream and downstream enterprises. Steel lies behind coke and its downstream industries include infrastructure construction, real estate and machinery. Overall, the changes of steel price conduct through industrial chain to raw materials upstream. Seen from the change sequence of price and production, steel precedes coke and coke precedes coking coal.

(2) Steam coal industrial chain

Destination of steam coal focuses on industries such as electricity, building materials, chemical and steel, whose specific consumption situations are shown in Table 6. The electric power industry is the biggest contributor to the coal resources consumption. Now China is rapidly developing clean energy and renewable energy, which unceasingly compress the installed capacity of thermal power. And the coal demand of coal-intense industries such as steel and building materials also decreases. The coal consumption of building materials is composed with those of cement, glass and lime, of which cement consumes about 70%. Cement is widely used in infrastructure construction and real estate, and it is closely related to macro economy and social situation. The coal consumed in steel is cleaned coking coal and fuel coal. The growths of pig iron production slow down in 2011 and 2012, which are 0.63 and 0.66 billion tons. New coal chemicals like coal liquefaction and coal gasification are good substitutes for fossil energy, but the driving influence of coal chemical on steam coal is weakening with the decrease of oil price and chemical terminal products. The steam coal is mainly produced by large-scale enterprises, whose technology is relatively mature and changes in exploration cost are small, and then their profit is determined by coal price. For recent years, with excessive investment on fixed assets, production capacity of steam coal is seriously surplus.

(3) Anthracite-chemical and building materials industrial chain

Anthracite is of the highest coalification degree, and it is divided into lump coal, powdered coal and slack coal, of which lump coal is used in industries like chemical fertilizer (nitrogenous fertilizer, synthesis ammonia) and ceramics, and powdered coal is mainly used in metallurgical industry. The industrial concentration rate of anthracite is higher, so is its price. Anthracite is the main
material of chemical fertilizer, especially nitrogenous fertilizer. In current nitrogenous fertilizer enterprises, 70% material is coal, of which 64% is anthracite. Now, chemical fertilizer industry is also encountering serious surplus production capacity.

In summary, several factors determine the decrease of coal demand. With the macro environment more severe, the branch industries of coal industry are faced with production adjustment, which will influence the coal demand through the industrial chain. Then, coal industry should first improve its own competitiveness advantage, and then closely focus on the development of related industries. Once discovering chances, coal industry should take measures in time. Besides, coal industry should also be ready at any time for any negative influence from branch industries.

3.5. Government

The government acts as a catalyst and challenger, which encourages this industry to move to higher levels of competitive performance. It must encourage enterprises in this industry to raise higher performance, stimulate demand for products, and stimulate local rivalry by limiting direct cooperation and enforcing regulations or deregulations (Jarungkitkul and Sukcharoensin, 2016). In this study, the role of government is separated into two sets: industry regulator and motivator. The government plays a key role to regulate the industrial market, especially when the current industrial environment is not sound; the government plays a role as coordinator and motivator, it can motivate the driving force for the improvement of competitiveness (Zhao et al., 2011).

3.5.1. Industry regulations

China’s past development policies and economy operation condition have led to excessive investment in coal industry and low operational efficiency of the whole industry. Surplus production capacity exists in coal industry, and environmental pollution is caused by coal combustion. Therefore, policies for coal industry have focused on elimination of production capacity, energy saving and emission reduction, and improvement of industrial efficiency. And government sectors unceasingly issue new policies, as Table 7 shows.

As shown in Table 7, recent policies mainly include these factors (Yuan et al, 2014; Guo et al., 2014b): (1) Intensify air-pollution control management by speeding up the desulfuration and denitration renovation. (2) Stop imports of inferior foreign coal and restrict sales of bulk coal with high ash and sulfur, for high-quality coal used during power generation can improve plant efficiency and lower the fuel and water requirements (Ou et al., 2016). (3) Raise the proportion of washed coal to reduce air pollutant emissions in the process of coal combustion. (4) Optimize the industrial layout. (5) Replace small coal-fired boilers in central heating by the use of electricity or natural gas, and increase the ratio of clean low-carbon fossil energy and non-fossil energy. Meanwhile, constructing a proper supervision system is essential to coal industry. For example, a safety supervision system can enhance coal mine safety management and avoid further development of illegal rent-seeking (Chen et al., 2014). These measures will greatly increase operational risk, cash flow risk, and cost risk for power generation enterprises and coal enterprises, but the measures such as eliminating backward production capacity, strengthening energy conservation, and implementing clean energy replacement will contribute to the sustain-

![Branch industrial chains of coal industry.](image)

### Table 6

Consumption situation of steam coal from 2007 to 2012.

<table>
<thead>
<tr>
<th>Year</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total consumption (billion tons)</td>
<td>20,386</td>
<td>20,986</td>
<td>22,825</td>
<td>25,430</td>
<td>27,516</td>
<td>29,817</td>
</tr>
<tr>
<td>electricity consumption</td>
<td>13,433</td>
<td>13,575</td>
<td>14,382</td>
<td>16,287</td>
<td>17,504</td>
<td>18,555</td>
</tr>
<tr>
<td>ratio(%)</td>
<td>65.89</td>
<td>64.69</td>
<td>63.01</td>
<td>64.05</td>
<td>63.61</td>
<td>62.23</td>
</tr>
<tr>
<td>building materials consumption</td>
<td>4150</td>
<td>4259</td>
<td>4928</td>
<td>5534</td>
<td>5932</td>
<td>6278</td>
</tr>
<tr>
<td>ratio(%)</td>
<td>20.36</td>
<td>20.29</td>
<td>21.59</td>
<td>21.76</td>
<td>21.56</td>
<td>21.05</td>
</tr>
<tr>
<td>chemical consumption</td>
<td>999</td>
<td>1181</td>
<td>1207</td>
<td>1169</td>
<td>1029</td>
<td>1106</td>
</tr>
<tr>
<td>ratio(%)</td>
<td>4.90</td>
<td>5.63</td>
<td>5.29</td>
<td>4.60</td>
<td>3.74</td>
<td>3.71</td>
</tr>
<tr>
<td>metallurgy consumption</td>
<td>729</td>
<td>750</td>
<td>831</td>
<td>896</td>
<td>963</td>
<td>1004</td>
</tr>
<tr>
<td>ratio(%)</td>
<td>3.57</td>
<td>3.57</td>
<td>3.64</td>
<td>3.52</td>
<td>3.50</td>
<td>3.37</td>
</tr>
<tr>
<td>others consumption</td>
<td>1875</td>
<td>2121</td>
<td>2401</td>
<td>2437</td>
<td>3000</td>
<td>3857</td>
</tr>
<tr>
<td>ratio(%)</td>
<td>5.27</td>
<td>5.82</td>
<td>6.47</td>
<td>6.07</td>
<td>7.59</td>
<td>9.64</td>
</tr>
</tbody>
</table>
able development of natural environment in the long run.

Though lots of regulations are put forward, little attention is paid to sustainable use of coal. Thus, except increasing the efficiency of coal use, CCS (carbon capture and storage) is also necessary to optimize coal consumption (Yuan et al., 2014). And the regulations relating to investment in appropriate abatement technologies (Huang et al., 2014), as well as safety and environmental investment (Dzonzi-Undi and Li, 2015), prove essential to coal industry. What's more, rare policies focus on the supervision of coal transportation vehicles. Though UHV will be important energy conveying path in the future, coal transportation vehicles are still important mobile pollution sources in short time. Therefore, governments at all levels should first restrict vehicles under environmental protection standard and overloaded vehicles on the road, and then forbid sales and use of environmental substandard vehicles. These measures will influence the profit of using coal enterprises, but will benefit the environment in the long run.

3.5.2. Economic incentives

Except the regulations, the governments also issue incentive measures to reduce pressure of coal enterprises and help them get through the difficult time of economic and industrial environment deterioration, as Table 8 shows. The measures mainly include these factors: (1) Perfect the electricity price policy considering the cost of desulfuration and denitrification. (2) Unceasingly put forward steady growth policy to assist coal enterprises to go through the difficult time (Comments on data of coal industry in December, 2015, 2016). (3) Perfect added-value tax of mining enterprises to reduce exploitation cost (State Administration of Taxation, 2015). (4) Perfect the policy of port construction dues to reduce coal transportation cost and further reduce industrial operation cost (Ministry of Finance of the People's Republic of China, 2015). (5) Lower added-value tax rate to deal with decline of coal price.

China is taking a sustainable environmental and economic development pattern by controlling coal consumption, increasing the ratio of clean coal and washed coal, decreasing the proportion of fossil energy, and raising the effectiveness of power companies and coal enterprises. With more pressure on coal enterprises, the governments at all levels have intensified support force and frequency, in order to build a better operation environment. In the long run, the supply and demand pattern is expected to be optimized with implementation of more regulation and incentive policies. These policies not only provide the marketization reform and innovation, but also contribute to optimization of energy structure and improvement of use efficiency.

3.6. Technology

For using coal enterprises, reducing harmful gas and soot emissions are basic requirements under the influences of atmospheric pollutant emissions policies. The fact, that thermal power consumes the most coal and causes lots of pollution, urges this industry to reduce production capacity and installed capacity. But owing to early excessive investment on fixed assets, blind reduce of installed capacity in a short time will make equipment idle and fund wasted. Therefore, new technologies and modes are in need to enhance industrial competitiveness, such as peak load shifting utilization mode of electricity-generating coal gas resources (He et al., 2015), CO2 geological storage combining with deep saline water/brine recovery (Li et al., 2014). And other technologies like UHV (Dong et al., 2015) and power storage (Lin et al., 2016) will also cause great influences on coal industry.

3.6.1. Energy transportation

About 76% of coal resource is distributed in the north and northwest of China, but over 70% of energy demand is in the east and middle. The distance of energy base and load center is from 1000 km to 3000 km. Coal transportation by railway can cause environmental pollution, and long-distance transportation will increase its use cost. The higher cost of domestic coal results in excessive dependence on imported coal, which might threaten China's energy security. While reducing the losses during power transmission and distribution will reduce emissions by 7% and improve efficiency of power plants by 9% (Muhammad et al., 2015), so the State Grid Corporation has established long-distance, high-capacity and low-loss UHV transmission lines, which reduces the pressure of energy trans-regional transportation, balances coal supply and demand, and expand widely use of clean energy.

Though many obstacles need overcoming, such as high construction cost (He et al., 2016), high geomagnetic risk (Guo et al., 2014a) and difficult live-line work (Liao et al., 2015), in general the advantages of UHV outweigh its disadvantages, as shown below (State Grid Corporation of China, 2015): (1) It contributes to the conversion of coal areas from resource advantages to economic advantages, and promotes rational areas division. With UHV, the energy transportation

---

**Table 7**

<table>
<thead>
<tr>
<th>Time</th>
<th>Name</th>
<th>Key words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.1</td>
<td>Temporary regulation on commercial coal quality management</td>
<td>coal import, sales and transportation</td>
</tr>
<tr>
<td>Jan.12</td>
<td>Comprehensive use of coal gangue management method</td>
<td>storage yard of coal gangue</td>
</tr>
<tr>
<td>Feb.23</td>
<td>Advices on promotion of safe green exploitation and clean efficient use</td>
<td>processing and transforming, transformation to both raw materials and fuels</td>
</tr>
<tr>
<td>Feb.26</td>
<td>Action plan of CBM exploration and development</td>
<td>CBM extraction</td>
</tr>
<tr>
<td>Mar.1</td>
<td>Action plan of clean and efficient use in industrial circle</td>
<td>reduce coal consumption</td>
</tr>
<tr>
<td>Mar.25</td>
<td>Advice on promoting scientific development of coal industry</td>
<td>New Normal, optimize overall arrangement, adjust industrial structure, enhance planning management</td>
</tr>
<tr>
<td>June.4</td>
<td>Notifications on implementing the measures for governing the enterprises of violating laws and rules</td>
<td>coal enterprises of violating laws and rules</td>
</tr>
<tr>
<td>July.7</td>
<td>Advices on regulating the demonstrations of coal to fuel</td>
<td>demonstration projects of coal to fuel, perfect innovative technology</td>
</tr>
<tr>
<td>Sept.25</td>
<td>Implementation schemes for safe production check and specific rectification of coal mines</td>
<td>safe production check, punish construction of violating laws and rules</td>
</tr>
<tr>
<td>Dec.15</td>
<td>Action plan on implementing transformation towards ultra-low emissions and energy conservation</td>
<td>ultra-low emissions</td>
</tr>
</tbody>
</table>

**Table 8**

<table>
<thead>
<tr>
<th>Time</th>
<th>Main contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.6</td>
<td>tax-fee adjustment in Henan, Hebei, Liaoning, Hunan, Guangxi, Guangzhou, Guizhou, Shaanxi provinces</td>
</tr>
<tr>
<td>Apr.21</td>
<td>standardize charges of coal enterprises, reduce proportion of resource tax of iron ore</td>
</tr>
<tr>
<td>Apr.29</td>
<td>perfect charges policy on waste water and garbage disposal, support raising investment by corporate bond and project revenue bond, encourage social capital to flow into the fields of wastewater and garbage treatment</td>
</tr>
<tr>
<td>Nov.14</td>
<td>clear stipulations in VAT input tax deduction of mining enterprises</td>
</tr>
</tbody>
</table>
way is extended, which brings opportunities for economy development of coal production areas. Constructing power station near the pithead, will promote the output of high added-value products, enhance the return of investment, increase the employment, promote local economic development, and narrow the gap between urban and rural areas. It is estimated that the ratio of contribution to the GDP of Shanxi province by coal transmission and power transmission is 1.6, and ratio of driving employment effect is 1:2. (2) It ensures national energy security. By UHV, the ratio of coal transportation and power transportation can be balanced, which everts safeguards between two energy transportation ways and reduces the pressure on rail transport. (3) It is beneficial to optimizing resources allocation. As most of China’s coal-fired power plants are distributed in areas of coal resource scarcity, then the UHV can bring energy base closer to consumption center, optimizing the resource allocation and reducing transportation pressure. The UHV of 1000 kV, for example, can transport 2–5 million kilowatts of electricity, equivalent of 25–60 thousand tons of raw coal. The ‘three vertical, three horizontal, and one ring network’ UHV grid has been constructed in China, as shown in Fig. 9. And interconnection between the east and the west will be finished by 2020. In the future, the UHV will gradually widen its overseas market and contribute to the Global Energy Network plan.

Except optimizing energy structure and reducing environmental pollutions, UHV can also attract investment and drive economic development. The UHV promotes the intense development of resources in the west and north, drives local energy to transport outward, releases unbalance between supply and demand, and accelerates the environmental governance in the east and middle of China. As the State Grid plans, with the completion of ‘Ximeng-Taizhou’ and ‘Shanghaimiao-Shandong’ lines, 110 billion kilowatts power can be transported to central and eastern China every year, which reduces transportation of coal by 5.04 million tons, and reduces emission of soot by 40 thousand tons, sulfur dioxide by 248 thousand tons, nitrous oxides by 262 thousand tons and carbon dioxide by 99 million tons. Besides, the UHV can stimulate demand of equipment manufacturing industry and further drive economic development. For example, the total investment of two direct-current lines reaches 47.4 billion CNY, which increases the output of equipment manufacturing of power-transmission by 21.3 billion CNY, stimulates investment of power supply by 118.5 billion CNY, creates jobs by 33 thousand, and finally drives GDP growth by 15.2 billion CNY. According to plans from the State Grid, another 26 UHV lines will be finished by 2020, and investment will reach over 500 billion CNY. With the increase of investment, demand of related UHV equipments will reach a peak during the 13th Five Year Plan, and equipment field will attract lots of investors in the future.

3.6.2. Electricity storage
The development of energy storage equipment has key impact on coal industry: (1) generation capacity. Generation capacity can save the construction investment of conventional power generation projects. The operation of energy storage equipment can enhance the ability of power system to deal with peak load. (2) Increase generation efficiency. The popularization of energy storage system can help thermal power plants operate in their best working condition. It can improve efficiency of thermal power plants and further increase coal competitive advantage, which can lead to higher coal demand (Sun et al., 2013.). Therefore, the development of energy storage equipment can increase demand pressure of coal industry in short term, but in the long run it not only improves coal industrial competitiveness, but also play a significant role in national energy safety, economic sustainable development and environmental protection.

Energy storage technology has played key technical supporting role in smart grid operation, distributed generation, micro-grid construction, etc. From the perspective of electricity transportation (generation, transmission, distribution and end user), the functions of energy storage equipment can be divided into short term, medium term and long term according to duration (Johannes and Mariko, 2016), as Fig. 10 shows. Appropriate scale of energy storage equipment can coordinate and optimize operations of energy storage equipments, renewable energy generation and power grid. Installed capacity of energy storage system has experienced rapid development. According to data from CNESA, until to the end of June 2015, the number and installed capacity of new-added energy storage programs is 45 and 307.5 MW (operation projects 14, 63.7 MW; under construction projects 4, 47.5 MW; planning projects 27, 196.3 MW).

The application of electricity storage technology is of great prospect.
in the future, which is divided into physical storage (pumped storage power station and compressed-air energy storage), electrochemical storage (lead-acid battery, NaS battery), and electromagnetic storage (superconducting electromagnets, supercapacitors). EPRI list the cost of several main energy storage technologies (EPRI, 2010), as Table 9 shows. And according to analysis result from Ye et al. (2016), the annual average cost of pumped storage power station and compressed-air energy storage are separately 377 dollars/kW and 321 dollars/kW, which is mainly composed of investment cost and cost of electrical consumption; the annual average cost of lead-acid battery is 1347 dollars/kW, which is obviously higher and composed of investment cost, replacement cost and cost of electrical consumption. Lack of policy, subsidy, investment and financing supports, the current cost of electricity storage technology is too high. And its return on investment is too low to attract the market investment, which seriously restrict the development of energy storage technology.

Cost reduction of energy storage technology will greatly promote its popularization and marketization, and main measures to reduce cost mainly focus on the following respects: (1) Reduce the material cost, which means reduce its use cost and improves its performance. (2) Implement scale production of energy storage equipment, which will reduce the purchase cost of raw materials, raise production efficiency of supply chain, and improve productivity, quality and process precision of supply chain (Hong and Jin, 2012). (3) Improve mechanism of policy incentives, and introduce more preferential policies. (4) Build up more demonstrative projects, and increase input in R & D, which help

Table 9
Cost comparisons on different energy storage technologies by EPRI.

<table>
<thead>
<tr>
<th>Storage option</th>
<th>Application</th>
<th>Level of maturity</th>
<th>Energy duration (cycle)/h</th>
<th>Efficiency (ac/ac)%</th>
<th>Total installed capital cost/ $kW</th>
<th>Total installed cost/$kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>pumped hydro</td>
<td>ISO services wind integration</td>
<td>mature</td>
<td>10–20( &gt; 13,000)</td>
<td>80–82</td>
<td>1500–4300</td>
<td>250–430</td>
</tr>
<tr>
<td>compressed air</td>
<td>ISO services wind integration</td>
<td>demo</td>
<td>10–20( &gt; 13,000)</td>
<td>4000 Btu(kW h)</td>
<td>960–1250</td>
<td>60–125</td>
</tr>
<tr>
<td>NaS</td>
<td>grid support wind integration</td>
<td>mature</td>
<td>6(4500)</td>
<td>80</td>
<td>3200–4200</td>
<td>445–555</td>
</tr>
<tr>
<td>lead acid battery</td>
<td>grid support ISO services wind/PV</td>
<td>mature demo</td>
<td>4(2200–4500)</td>
<td>85–90</td>
<td>2020–3040</td>
<td>505–760</td>
</tr>
<tr>
<td>flow battery (various types)</td>
<td>grid support wind/PV integration</td>
<td>demo</td>
<td>4( &gt; 10,000)</td>
<td>66–70</td>
<td>2350–4500</td>
<td>470–1125</td>
</tr>
<tr>
<td>Li-ion battery</td>
<td>ISO services grid support C &amp; l energy Mgt PV integration</td>
<td>demo</td>
<td>0.25( &gt; 10,000)</td>
<td>90</td>
<td>1200–1500</td>
<td>4800–6000</td>
</tr>
<tr>
<td>fly wheels</td>
<td>ISO services</td>
<td>demo</td>
<td>0.25( &gt; &gt; 20,000)</td>
<td>90</td>
<td>1900–2250</td>
<td>7800–7900</td>
</tr>
</tbody>
</table>

Fig. 10. Operational use of energy storage in the power value chain.
get latest information and data, and acquire breakthroughs of key technologies. (5) Promote innovations of financing and investment patterns, and encourage participation of private capital and international cooperation, which will promote the investor diversification. The prospect of energy storage market in China is promising. With the help of Energy Internet and One Belt And One Road, energy storage industry in China will influence domestic electricity industry, and it will further influence coal demand in the world (Market research analysis report of energy storage industry in, 2015, 2015).

3.7. Chance

3.7.1. Industry advantages

Coal serves as pillar industry of China’s national economy, which has played irreplaceable role in improving economic development, ensuring energy security and maintaining social stability. However, influenced by lower economy growth, surplus production capacity, pressure from clean energy and imported coal, the unbalance between supply and demand has been more serious and economy operation environment of coal industry has changed greatly since 2012. Faced with enormous pressure, coal industry will make new industrial adjustments, and this industry still has a bright future. The position of coal will not be substituted in a short time, for the proportion of coal will maintain over 50% in primary energy before 2050, according to the China’s medium and long term energy strategy, as shown in Fig. 11.

With the supporting role of coal in economic and social development, China has gradually formed the ‘Coal-based Pluralism Development’ strategic principle. Owing to its reliability and low cost, coal has become key base resource for multiple industries, as shown in Table 10. In detail, coal industry has these advantages (Report on development situation of China’s coal industry, 2015): (1) Coal is abundant and its support capacity is strong. By the end of 2014, proven reserves of China’s coal is 1.53 billion tons, accounting for 94% that of total fossil energy and rising by 15% than that in 2010. (2) Coal is the most economic energy. By the end of 2015, the prices of gasoline and diesel, steam coal with 5500 kcal in Qinhuangdao port, and natural gas for power generation are respectively 7400 CNY/ton, 365 CNY/ton and 3.10 CNY/m3, and then their cost ratio is 1:11.15:5.02 after converted for equivalent heat release, which means the price of coal is 1/11 that of gasoline and diesel and 1/5 that of natural gas. (3) Coal will be gradually utilized cleanly. With technical reform of ultra low emission, coal-fired power plants will reduce the pollutant emissions such as dust, SO2 and NOx, and the generation cost after technical reform increases by 0.18–0.26 CNY/kw·h, still lower than that of natural gas. At the same time, the innovative technology of independent intellectual property like efficient coal powder boiler and coal water slurry, will be generalized, which further promotes clean use of coal resource. (4) The development of clean energy needs further improving. It is estimated that from 2015 to 2020, annual average growths of hydropower, wind power, solar power and nuclear power installed capacity are 10, 20, 14.6, 6 million kilowatts, but many difficulties still exist in technology, economy, and investment. Besides, the achievements of coal industry in resource exploitation and use, market mechanism, safe production mechanism will ensure the position of coal in primary energy.

With the constant improvement of marketization reform, coal industry will face more severe challenges, but the basic position of coal will be irreplaceable. The rising external dependencies of petroleum and natural gas hinder their rapid development. Besides, the constraints including technology, economy and environment make clean energy hard to substitute coal in a short time. Therefore, for a long time, ‘Coal-based Pluralism Development’ strategic principle will not be changed, and the position and influence of coal serving as pillar energy will also not be changed.

3.7.2. Future development trend

Coal industry is in the key period when slow growth of coal demand, surplus production capacity, more environment constraints, and imperfect development pattern exist, so coal industry should eliminate the backward production capacity and optimize industrial structure, in order to form a ‘energy saving and emission reduction, scientific and technological innovation’ development pattern. Though the economy operation of coal industry will not be thoroughly improved soon, coal is still the most reliable and economical energy, and its position in economic and social development will not be changed.

The ‘Coal-based Pluralism Development’ strategic principle will not be changed, and the government constantly takes measures to help coal industry through difficulties, which focus on the perspectives below: (1) Create a stable macro policy environment, for moderate fiscal and monetary policy will influence coal demand and enterprises financing cost. (2) Increase the coal demand. The government will stimulate the coal demands in electric power, steel and cement fields by macro strategies such as One Belt And One Road, and Energy Internet. (3) Regulate coal industry more strictly. The relevant departments require coal enterprises to produce according to the approved production capacity, and supervising mechanism towards illegal production capacity is established, which will optimize the whole industrial chain. Under the current situation, coal industry is facing polarization trend, and the gaps between enterprises are widening. Though this will influence the economic benefits of coal enterprises, it will optimize the resource allocation and industrial structure, and promote operation level of the whole industry in the long run.

With the influences of macro policy and interaction between business environment and industrial structure, coal industry takes on new development trend: green and intelligent exploitation, clean and efficient use, sustainable development, intensive growth as well as transformation towards production serving pattern. Therefore, coal enterprises must follow the principles in Table 11 if they want to maintain their advantages and market competitiveness (Report on development situation of China’s coal industry, 2015).

Table 10

<table>
<thead>
<tr>
<th>Items</th>
<th>1978</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw coal output (million tons)</td>
<td>618</td>
<td>3874</td>
</tr>
<tr>
<td>Coal consumption (billion tons)</td>
<td>570</td>
<td>4120</td>
</tr>
<tr>
<td>GDP (billion CNY)</td>
<td>360</td>
<td>6300</td>
</tr>
<tr>
<td>Installed capacity of thermal power (million kilowatt-hour)</td>
<td>40</td>
<td>916</td>
</tr>
<tr>
<td>Crude steel output (million tons)</td>
<td>32</td>
<td>823</td>
</tr>
<tr>
<td>Cement output (million tons)</td>
<td>65</td>
<td>2480</td>
</tr>
<tr>
<td>Chemical fertilizer output (million tons)</td>
<td>8.84</td>
<td>68.87</td>
</tr>
</tbody>
</table>

Fig. 11. Proportion trend of coal resource.

4. Conclusions

This paper analyzes the competitiveness of China’s coal industry based on a Porter’s diamond model. The analysis result can be concluded that: China has witnessed a rapid recession of coal industry during past few years. The slow growth of domestic economy,
substitute of clean energy and squeeze of imported coal all have negative influence on coal demand and increase the operation pressure of coal industry. Besides, inside problems such as low profit and oversupply weaken the industrial competitiveness. These problems seriously affect the sustainable development of China’s coal industry. Fortunately, though the coal industry is encountering downtown, coal has great potential in the future and its pillar position in primary energies will not change. In the future, the coal will be used in more clean and sustainable ways, which will stimulate the demand of coal and further contribute to the new round of coal industry prosperity.

A competitive coal industry can not only help mitigate the impact of environmental pressure, but also can ensure social stability and energy security. In order to maintain and enhance the competitiveness of China’s coal industry, it is necessary to comprehensively analyze the factors and strengthen the elements in the above model, so that a positive interaction can be achieved. Facing fierce chance and competition in the coal market, the government as well as related enterprises should always focus on the industry’s constantly changing environment, in order to formulate strategies for industry recovery. The Chinese government should continuously encourage the development of coal industry and take measures to optimize investment environment to promote the development of the coal industry in China by means of supporting policies, legislations and financial incentives. The enterprises in coal industry have also taken measures to deal with the industrial structure adjustment, such as enhancing the technological innovation, eliminating backward capacity, improving production efficiency, and reducing pollution in coal combustion. What’s more, great chances in external environment should be grasped, such as Energy Internet and One Belt And One Road.

Conflicts of interest

The authors declare no conflict of interest.

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