Discussion and Consideration on Key Issues of Coal Power Development in China

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Abstract. Coal power generation capacity has exceeded 1 billion kilowatts in China currently. As the ballast stone and stabilizer in the field of energy and power, coal power attracted more and more considerations today. A reasonable and scientific planning is important to power system security and efficiency, especially the coal power development path. The full-cycle coal power cost model used in the power expanding planning is proposed in this paper, in order to optimize the power capacity in the future. Based on this method, the peak capacity of coal power is evaluated firstly. Then the peak awareness and bottom line thinking principle are put forward based on the analysis above. Finally, the external cost internalization and flexibility transformation of coal power are discussed, which are the main issues in the coal power industry nowadays.

1. Introduction
The Central Economic Work Conference at the end of 2018 pointed out that the main contradiction in China economic operation is still structural problem on the supply side, based on the policy called "consolidating, enhancing, promoting, and smoothing". Energy is a critical area of economic society. The national energy planning confirmed the development structure [1-2]. In recent years, the supply-side structural reform in the power sector has achieved outstanding results, especially the coal power capacity has been effectively controlled. From 2015 to 2018, the annual installed capacity has been significantly reduced from 54 million kilowatts to 29 million kilowatts, reaching the lowest level since 2003, and the average hours of utilization of thermal power units rose from 4,165 hours to 4,361 hours. At the same time, the supporting role of coal power in promoting new energy consumption is further demonstrated. In 2018, China's wind curtailment rate was 7.2%, downing 4.9 percentage points year-on-year. And the solar curtailment rate was 3.0%, downing 2.8 percentage points year-on-year [3].

As the "main force" in the power field, coal power generation currently has exceeded 1 billion kilowatts in China. How to lead to the high-quality development of the power industry and gradually form an effective support for the modern energy economic system is an important issue for the development of the coal power industry, especially the power system expansion planning. The power expansion planning theory is widely researched in these years. China electricity demand growth under the new economic norm is analyzed, which is a basic precondition in power system expansion planning [4]. The main challenges and countermeasures in China power system development and operation are also discussed [5-6]. A two-stage robust generation expansion planning is proposed in
reference [7]. Transmission expansion planning model facilitating low-carbon power sources development is researched in reference [8-9]. An optimum investment strategy in the power industry is also discussed [10]. In this paper, based on the power expansion planning model with a consideration of full-cycle coal power cost model, as well as the power policies, the coal power development scene in China is analyzed. Meanwhile, coal and coal power policies are discussed for sustainable development for energy and power industry in China.

2. Power expansion planning theory with full-cycle coal power cost model
The reasonable and scientific development path is important to power system security and efficiency. Especially considering the background of the coal power needs to be included in the optimization process of power system planning with detailed description of the comprehensive cost of coal power units, as shown in figure 1.

![Full-life cycle cost model of coal generation](image)

Figure 1. Full-cycle cost model of coal power.

Based on the effects of these costs on the coal power industry, the cost can be further divided into internal and external costs. The internal cost refers to the part of the cost that can be directly internalized into the coal power industry. Meanwhile, the internal cost can be economized, such as construction cost, transportation cost, resource cost, environmental investment cost, operating cost, management cost, sewage taxes, waste disposal costs, carbon taxes and so on. External costs refer to the additional costs that may have been incurred by the coal power production to the external society. This part has not yet been included in the cost of production and operation, such as the impact of major environmental pollution incidents and their influences on the ecological environment and human health.

2.1. Coal exploit and transportation stage
The pre-period cost of coal power generation is modeled as equation $1. C_{pre}^{pre}$ is the utilization of coal of type $j$ based on the current power generation technology. $S_j$ is the transportation distance for the coal. $c_j$ is the unit transportation costs. The total cost of coal transportation is proportional to distance, unit cost, supply scale and so on. $F(Q_j)$ is the cost of resource utilization. It is the purchase cost of different types of coal, as well as a function of the amount of coal procurement. $C_{env}^{env}$ is the pre-environmental costs, including pre-purchase of environmental protection equipment investment, environmental technology costs, pre-environmental disposal costs and so on.

$$C_{pre}^{pre} = \sum_{j=1}^{Q_j} S_j \cdot c_j + \sum_{j=1}^{Q_j} F(Q_j) + C_{env}^{env}$$ (1)
2.2. Coal power generation stage

\[ C_{ij}^{\text{Gene}} = F(Q_{j}^{elc}) + G(l) + \sum_{i=1}^{j} \sum_{i=1}^{P_i} c_i \]

\[ P_i = \lambda_{ij} \xi_{ij} (1 - \varphi_i) Q_{j}^{elc} \]

2.3. Subsequent stage

\[ C_{j}^{\text{post}} = F(P_i) + f(P_z) + R_{\text{carb}}(P_{\text{carb}}) + W(P_w) + C_{\text{accid}} \]

2.4. Comprehensive optimization processes

Based on the models mentioned above, the full-cycle cost model of coal power is introduced into the comprehensive optimization process of power planning.

\[ \min C_T = \sum_{i=1}^{N} \sum_{t=1}^{T} \left[ \sum_{i} \left( I_{i,t,z} - S_{i,t,z} + F_{i,t,z} + V_{i,t,z} \right) \cdot (1 + \gamma)^{t} + \sum_{k} \left( I_{k,t,z} - S_{k,t,z} \right. \right. \\
\left. \left. + F_{k,t,z} + V_{k,t,z} \right) \cdot (1 + \gamma)^{t} + E_{z,t} \cdot (1 + \gamma)^{t} + \Phi_{z,t} \cdot (1 + \gamma)^{t} \right] \]

Type is the different generation. Z is the research areas. R is the total planning period. I, S, F, V, E, \Phi means the investment costs, added remaining value of fixed assets at the end of the period, fixed operating costs, variable operating costs, loss of power costs and environmental costs respectively. The energy and electricity power balance, environmental limitation, distributed generation acceptance limitation, unit maintenance arrangement, peak regulation and other constraints are included in the power planning model.

3. Coal power development scene in China

Based on the theory and method proposed before, the coal power development and the coal consumption are analyzed in this section. It can be concluded that the coal production capacity control remains strict, there is still room for coal power construction. The peak value of coal power will exceed 1.3 billion kilowatts in the period between 2025-2030. It is necessary to establish "peak awareness" and "bottom line thinking" in coal power development.

Table 1. Optimized power capacity development scene in 2025 and 2030.(unit:million kW)

| Type       | 2025 | 2030 |
|------------|------|------|
| Coal power | 1250 | 1300 |
| Gas power  | 140  | 190  |
Hydro power & 400 & 450  
Pump storage power & 85 & 110  
Nuclear power & 85 & 115  
Wind power & 370 & 520  
Solar power & 380 & 520  
Biomass energy power & 65 & 80  
others & 10 & 37  

At present, the international political trend has turned to the right and the economic situation has become more uncertain. For the development of coal power, the author suggests taking care from two aspects. First, China's coal power development should establish a "peak awareness". It is necessary to scientifically judge and calmly deal with the large fluctuations in the growth rate of power demand, and avoid a new round of coal-fired power capacity surplus. During the "14th Five-Year Plan" and "15th Five-Year Plan" period, if the annual average power demand growth rate is considered at 4.5% and 2.9%, the peak value of coal power will exceed 1.3 billion kilowatts, as shown in table 1.

Second, whether it is from China energy resource endowment or the current status of the power industry, coal power will not change in the basic position of the power system for a certain period of time. Coal power of a certain scale is indispensable. Especially, it is necessary to establish a "bottom line thinking" in the construction of safety support units in some areas. According to statistics, since 2003, China's coal-fired power installations have entered a period of rapid development, with an average annual growth rate of 50 million kilowatts, of which more than 65% are concentrated in the eastern and central regions. According to the original design of 20 to 30 years of economic life, if the coal-fired power unit is not extended, the eastern and central regions will be retired after 2025. However, the newly added coal-fired power projects are mainly concentrated in the western and northern regions. In the future, the power security in some areas needs to be planned and arranged in advance.

4. Coal and coal power policy analysis
From the perspective of energy consumption structure, the total coal consumption in China in 2013 reached a peak of 4.24 billion tons in recent years. Since then, due to economic growth, clean energy and low carbon transformation requirements, and ecological and environmental constraints, the total coal consumption in 2016 has dropped to 3.85 billion tons. In the past two years, the policy of stable investment has increased the demand for coal in industries such as steel and building materials. Coal consumption reached 3.93 billion tons in 2018. According to the National "Energy Development 13th Five-Year Plan": Total coal consumption in 2020 should be reduced to 58% of primary energy. At the end of 2018, the proportion of China's coal consumption fell to 59%. At the same time, the "eight-character policy" proposed by the Central Economic Work Conference at the end of 2018 confirmed that the control of coal production capacity will not relax. It is expected that China's total coal consumption is expected to reach the peak range around 2020. There are two important issues should be emphasized here.

4.1. External cost internalization
According to the latest data released by the Atmospheric Observation and Research Institute of the United States, the carbon dioxide content in the atmosphere has exceeded 415 ppm, which is the highest historical value since the birth of mankind. The current global concentration of carbon dioxide has exceeded the expectations of the Paris Agreement. Climate change is not only an important issue in the energy field, but also an important part of China's participation in global governance. The internalization of coal-fired carbon emission costs will be an important challenge for future development.
By the end of 2018, China's carbon emissions trading volume has reached nearly 800 million tons, and the cumulative carbon emissions trading volume is more than 11 billion yuan. From the past few years, Hubei's carbon emissions trading volume accounted for more than 40%, and the Beijing Carbon Emissions Exchange had the highest price, reaching 52.72 yuan / ton. In the future, although the carbon emission cost of coal and electricity can be neutralized in the form of profitability of power auxiliary services. The increase in external costs will still bring greater pressure, which needs to be planned in advance.

4.2. Coal power flexibility transformation
The National “13th Five-Year Plan for Power Development” clearly requires that the "Three North" region thermal power flexibility transformation of 215 million kilowatts during the period. According to the investigation and collection of funds in various provinces, as of the end of November 2018, the “Three North” area has completed a transformation scale of only 40.09 million kilowatts, of which about 60% (total 23.8 million kilowatts) is in the northeast region. The reason is mainly that the price mechanism of the power auxiliary service market has played an important role. Relevant data show that in 2018, Northeast Electric Power's paid peaking auxiliary service costs totaled 2.78 billion yuan, and the average price was 0.525 yuan, which is higher than the local coal power benchmark electricity price, and 96% of the auxiliary service compensation fees in the Northeast are used for peak shaving. In addition, the market for power-assisted services such as Northwest China and North China has been gradually improved.

5. Conclusion
In summary, coal power will play an important and fundamental role in building a clean, low-carbon, safe and efficient modern energy system. In the future, on the basis of maintaining “peak awareness” and “bottom line thinking”, the coal power industry should lead the high-quality development of the energy and power industry to contribute more to the construction of the national modern energy economic system, which by taking clean and flexible transformation as the starting point, actively adjusting the development orientation.

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