Research on Provincial Energy and Electricity Planning Method under the Situation of High-quality Economic Development

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Abstract. In the context of high-quality economic development, more factors should be taken into account in energy and power planning methods to make the planning more scientific and rational. This paper constructs a provincial energy planning model based on carbon emission reduction and comprehensive comparison of multi-regional electricity input. Considering the economic structure optimization and energy structure cleaner, and the constraints of carbon emission reduction, environmental pollution reduction, water resources, coal productivity and transportation capacity, the model expands and optimizes the provincial energy planning methodology, providing methodological reference for provincial energy planning.

Introduction

The report of the Nineteenth National Congress points out that China's economy has changed from a stage of high-speed growth to a stage of high-quality development. Promoting high-quality development is the basic requirement of current and future development ideas, formulation of economic policies and implementation of macro-control. At present, the allocation of resource elements has not been fully realized from extensive to intensive and economical, and the pressure of ecological environment is relatively high. High-quality economic development is not confined to the economic sphere, but also should consider various factors. Energy is the fundamental driving force to support economic development and the basis of economic development. In the field of energy and power development, with the development of society, economic growth and the improvement of people's living standards, the demand for energy and electricity power is further enhanced, and the external dependence of energy is still high. Therefore, energy development planning is very important. At present, energy and power planning methods tend to be more scientific and reasonable. For example, document [1] establishes an evaluation index system of transmission network planning scheme considering three multi-stakeholders: power grid enterprises, government and end users. Literature [2] establishes a two-stage stochastic chance-constrained power planning model. Literature [3] establishes a low-carbon power grid planning method considering demand side management. Literature [4] establishes capacity selection and location models for distribution networks with low carbon constraints. Document [5] proposes the global energy Internet backbone framework planning. At present, there are few theoretical studies on provincial energy and power planning under the scenario of carbon emission reduction and high-quality economic development. Especially, scientific planning considering carbon emission reduction, environmental pollution reduction, water resources constraints, coal production capacity and capacity, economic structural improvement and upgrading is not found in relevant public researches.

Demand Analysis

Based on the key laboratory of State Grid Corporation (Power Supply and Demand Research Laboratory), this paper establishes a Mid-and-long Term Economy, Energy, and Electricity Demand Forecasting Model System, as shown in Fig. 1. Based on Computable General Equilibrium Model and the Mid-and-long Term Macroeconomic Econometric Model, national economic growth can be
analyzed. Based on LEAP model, national Mid-and-long Term energy and Electricity power demand can be analyzed.

**Mid-and-long Term Macroeconomic Econometric Model**

Based on the judgment of the changing trend of labor supply, fixed assets investment, technological progress and world economic growth in the future, this paper uses the Mid-and-long Term macroeconomic model to make scenario analysis of Mid-and-long Term economic growth. Under the background of high-quality economic development, the economic growth rate is changed from high-speed to medium-high-speed, and the driving force of economic growth is shifted from factor quantity input to the factor productivity promotion. The exogenous variables mainly include tax rate, population and employment ratio of various industries, interest rate, exchange rate, world gross national product, foreign investment, government budget, factor efficiency and so on. The simulation results mainly include GDP, three industries added value, investment in fixed assets of the whole society, resident income and consumption, fiscal revenue and expenditure, import and export, etc.

**Computable General Equilibrium Model**

Based on total quantity forecasting results of Mid-and-long Term Macroeconomic Econometric Model, Computable General Equilibrium Model can subdivide the development and change of industries. The model is based on the input-output relationship among industries, uses a group of mathematical equations, and describes the equilibrium relationship between supply and demand on various markets. In this group of equations, there are exogenous variables (generally showing shocks received by the economic system), and endogenous variables (generally showing quantities and prices of goods within the economic system). Changes of the exogenous variables that influence any part of the economy can spread to the entire system. This leads to universal changes in the quantity and prices of key goods and factors. These large-scale changes can cause the entire economic system to shift from one equilibrium state to another. By solving the CGE model, you will get a set of figures and prices when the demand and supply from different market all become equilibrium during the transition period.

**National Final Energy Demand Forecasting Model**

The model can forecast the energy consumption intensity of various energy services demand in the future and the final energy demand, including agriculture, industry (summarized by industry subdivisions), construction, transportation, commerce, other tertiary industries and household energy demand, based on the historical changes of energy consumption per unit output value (coal/oil/natural gas).
gas/electricity/heat), per unit product energy consumption, per capita energy consumption in urban areas and rural areas. This model reflects the cleaner final energy consumption structure and energy efficiency improvement. As the continuous substitution of electric energy for fossil energy such as coal, oil and gas, the electrification level on the consumption side increase continuously.

**National primary energy demand Forecasting Model**

The model can calculate respectively the annual coal, petroleum, natural gas and non-fossil energy demand in the forecasting period, from which the primary energy demand is summarized, and the carbon dioxide emissions are calculated according to the carbon emission factors of various energy sources, based on the final energy demand forecasting results, considering power generation, heating and oil refining Technology and efficiency etc. In calculating the demand for coal, oil and natural gas, the constraints of major pollutants emission, CO₂ emission, water resources and the bottleneck constraints of fossil energy resource endowment and supply capacity are taken into account. In calculating the demand for non-fossil energy, the long-term planning for the development of nuclear energy and renewable energy is also considered.

**Provincial Primary Energy Demand Forecasting**

Using the method of energy consumption per added value, the annual energy demand in the future can be calculated, and the unified energy demand forecast results of each province can be obtained by comparing and checking the national energy demand forecasting results.

**Maximum Load Forecasting**

Maximum load is closely related to maximum load utilization hours. Maximum load utilization hours are affected by economic structure and industrial electricity consumption, electricity consumption habits, electricity price policy, demand side management, temperature and climate, etc.

**Supply Analysis**

**Layout of Clean Energy Development**

According to the resource endowment and technological feasibility potential of the province, combined with the development plan of clean energy such as hydropower, wind power, solar energy and nuclear power at the national level, the development layout of clean energy in the province is formulated.

**Coal and Electricity Development Layout**

Mid-and-long term coal-fired power construction is mainly constrained by two factors: power coal transport capacity and environmental protection emissions. According to the coal output and production capacity in the province, the coal output is forecasted. In some provinces, the total coal resources are insufficient, and the resources suitable for generating electricity are less. It is difficult to increase the annual output of coal in the medium and long term. The problem can be solved by purchasing coal from other provinces. Therefore, the calculation of coal-electricity scale based on transportation capacity includes the calculation of the amount of electricity-coal transferred by railway and the amount of electricity-coal transferred by water. As China is one of the world's coal importers, many provinces need to import coal. There are certain uncertainties in importing coal, such as international relations, policy regulation and other factors. Therefore, the reliability of imported coal should be analyzed to determine the supply of imported coal. Based on the above situation, the layout of coal-fired power development is designed.

Through the prediction of the total environmental protection control index, it is concluded that the environmental protection space can support the installed scale. Among them, the documents on which the calculation is based include the national environmental protection plan, the national energy conservation and emission reduction plan, etc. The total amount of sulfur dioxide and nitrogen oxides
is calculated. While estimating the development space of coal and electricity by using the total amount of environmental protection emissions, the main parameters such as standard coal consumption, desulfurization efficiency, comprehensive sulfur content of coal and average emission coefficient of nitrogen oxides have great influence on the calculation results. Therefore, it is particularly important to select parameters scientifically.

**Analysis of Power Supply and Demand Situation**

Power supply and demand need to consider power supply, power grid, cross-regional and inter-provincial transmission, renewable energy consumption and other factors. According to the calculation results of electricity balance, it is necessary to consider the addition of external electricity if it is always in a state of power shortage.

**Energy and Electricity Planning Method**

According to the traditional energy and power planning method, considering the current external environment, a set of general provincial energy and power planning method has been formed, which provides a scientific basis for the overall energy planning, improves the overall investment efficiency of the society, and indirectly reduces the emission of environmental pollutants.

The specific steps are as follows:

1. **The first step is economic analysis and prediction:** according to the trend of national macroeconomic situation, the economic situation and industrial status and development pattern of energy development in the province are analyzed and forecasted, and the index data of national and provincial economic growth in the near and medium term are determined respectively.

2. **The second step is energy supply and demand forecasting:** according to the national energy production and consumption form, as well as the province's resource endowment, emission reduction situation, transport channel construction and other constraints, the province's energy status and development situation are analyzed and predicted.

3. **The third step is power demand side forecasting:** according to the results of economic forecasting and the current situation of power demand, using Mid-and-long Term Economy, Energy, and Electricity Demand Forecasting Model System to calculate mid-and-long term load, after comprehensive analysis to determine the final load data. Predict the maximum load and determine the overall and regional load situation in the future. Through the first, second and third steps to determine the overall demand side demand.

4. **The fourth step is the layout of clean energy development:** according to the principle of clean priority absorption and the specific resource endowment and technology development potential, combined with the scale structure of power supply, this paper puts forward planning proposals for the development of clean energy such as hydropower, wind power, solar energy and nuclear energy, and determines the supply of clean energy on the supply side.

5. **The fifth step is the layout of coal and electricity development.** According to the coal production, water transportation and railway external coal transfer, the coal resources based on transport capacity can be calculated to support installation. According to the total emission index and emission parameters of electric power environmental protection, the calculation of environmental protection space can support the installation of the machine. By analyzing the situation of coal supply and demand at home and abroad, the situation of coal output and supply is determined. Comparing the three calculation results, the maximum supporting coal and electricity development layout is determined. Through the fourth and fifth steps to determine the overall supply side supply.

6. **The sixth step is power supply and demand balance.** According to the current situation of power supply and demand, the data of power supply and demand balance are determined by considering local installation, cross-regional transmission, renewable energy consumption and other factors. If the supply and demand are balanced, we should go to the next step directly. If the supply and demand are unbalanced, we should turn to the supply side and continue to optimize the calculation of coal and electricity layout until the supply and demand reach a balance.
The seventh step is the analysis of external electricity: According to various constraints faced by specific energy sources, the necessity and urgency of the construction of external electricity channels are analyzed. The economy of coal transportation and power transmission is determined and compared by calculating the constraints of freight and electricity price. If the transmission is uneconomical, it will end directly. If the transmission economy is good, it will be analyzed to determine the safety and so on. According to the constraints of construction sequence, electricity price, regulation and substitution of foreign electricity, the input analysis is carried out and the optimization strategy is determined.

The eighth step is output analysis results: According to the analysis of economic analysis and forecasting, energy and electricity demand and supply, output various analysis results, including various economic indicators, mid-and-long term load forecasting, clean energy development layout, coal-fired power installation layout, power balance, external power timing, mode and so on.

Figure 2. Schematic Map of Provincial Energy and Electricity Planning Method.

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