Research on the driving effect of provincial new power system construction on local national economy development -- A case study of Gansu Province

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Abstract. Under the "double carbon" goal, the construction of the new power system is not only a key starting point for the power industry to achieve the "double carbon" goal, but also an important means to ensure energy security and stable economic development. This study deeply analyzed the impact of provincial new power system construction on local economy, society and environment, established the comprehensive benefit evaluation index system and model system of new power system investment construction, took the new power system investment construction of Gansu Province as an example, and evaluated the comprehensive benefits of the construction of new power system in Gansu Province on local economic growth, resident employment, production tax revenue, energy conservation and emission reduction, providing relevant decision support for the rational arrangement of investment in the construction of new power system in Gansu Province.

Keywords: the new power system; driving effect; economic growth; investment.

1. Introduction

In September 2020, the General Secretary Jinping Xi proposed the goal of "carbon peak and carbon neutrality" for the first time at the General debate of the seventy-fifth session of the United Nations General Assembly. Promoting the goal of "double carbon" is a profound change to China's economy and society, and the power system is the largest single source of carbon emissions and the main battlefield for reducing pollution and carbon. The construction of a new type of power system has become the key to achieve the goal of "double carbon" in the power industry. At the same time, the construction of the new power systems is also an important means to ensure energy security and stable economic development. The executive meeting of The State Council on July 21, 2022 proposed to "give full play to the key role of effective investment in strengthening weak boards, adjusting structure, stabilizing employment and consumption, and promoting economic recovery and development." As an important basic industry in China, the power industry provides key upstream inputs for various industries and plays an important role in promoting the security of the industrial chain and the development of the national economy. A number of studies have shown that transportation infrastructure such as railway, highway and high-speed rail, communication infrastructure such as broadband and ICT, and power infrastructure can generally promote economic growth and productivity improvement [1-4]. In the existing researches on electric power construction investment in China, the relationship between electric power construction investment and economic growth and the macroeconomic effect of electric power construction investment are mainly investigated at the national and regional levels [5-6], which is of little guiding significance to local governments.

Gansu Province is rich in new energy resources and has unique advantages in constructing new power system. Since the "double carbon" goal and the concept of new power system construction were proposed, the installed capacity of new energy in Gansu Province has increased significantly, the new energy-related industrial chain has been continuously improved, the production capacity has been continuously expanded, and the investment and construction of the power grid has been

continuously strengthened. The construction of the new power system takes into account the development of the national economy and the improvement of investment efficiency. The "14th Five-Year Plan for Energy Development in Gansu Province" proposes that by 2025, the sustainable development capacity of the Hexi Corridor clean energy base represented by new energy will be comprehensively improved, and a new power system with new energy as the main body will be basically established, forming a large-scale power delivery development pattern. In view of the large-scale investment in the construction of new power system in Gansu Province, it is of great significance to evaluate its impact on economic growth, upstream and downstream industrial chain, resident employment and carbon dioxide emission reduction, etc. It is of great significance for the Gansu provincial government to further explore the industries with high input-output efficiency, prepare industrial policy reserves in advance, and formulate the "dual carbon" target path scientifically and reasonably.

2. The Influence Mechanism of New Power System Construction

The core of the construction of the new power system is to realize the gradual increase of the proportion of new energy, which has the characteristics of clean, low-carbon, safe and abundant, economic and efficient, supply-demand coordination, flexible and intelligent. The substantial increase in the installed scale of new energy requires strengthening the construction of power grids and related supporting projects to ensure the grid-connected consumption of new energy and the stable operation of the power system. As a new economic growth point, the new energy industry has become the consensus of all countries in the world, and the development of the upstream and downstream industry chain of new energy through the construction of new energy installed capacity is of great significance for regional industrial upgrading and energy transformation.

Research shows that the industrial chain of the new power system involves metal mining and selection, metal smelting and rolling products, general equipment manufacturing, special equipment manufacturing, electrical machinery and equipment manufacturing, computer communication and other electronic equipment manufacturing, instrument and meter manufacturing, power and heat production and supply industry, construction, wholesale and retail, transportation and warehousing, postal service and other industries [7]. From the economic point of view, the construction of new power system involves a large number of projects and product production, which can effectively drive the upstream and downstream development of the industrial chain, thus generating large driving effects. From the social level, large-scale investment in the new power system can effectively promote the employment of residents, improve the level of residents' income, and drive the increase of tax revenue. From the environmental level, the construction of new power system can save fossil energy resources, reduce pollutant emissions, and reduce greenhouse gas emissions by increasing the proportion of renewable energy development and utilization. Overall, the construction of new power systems plays an important role in directly or indirectly promoting regional economic development, increasing regional fiscal revenue, driving new jobs, and promoting regional energy conservation and emission reduction.

3. The Comprehensive Benefit Evaluation System of New Power System

3.1 Evaluation Index System

According to the principle of scientificity, comprehensiveness and feasibility, this study establishes the evaluation index system of investment benefit of new power system construction. Economic benefit indicators mainly consider driving regional economic growth, driving the development of upstream and downstream industries in the region. Social benefit indicators mainly consider stimulating regional employment, optimizing resource allocation, and improving the business environment. Considering that the emission of conventional pollutants in the power industry has been relatively low, and the current coal power has basically achieved ultra-low

emission transformation, the environmental benefit index mainly considers the amount of energy and resources saved and the emission reduction of greenhouse gases.

Table 1. Evaluation index system of the new power system investment

Primary index	Secondary index	Three-level index
Economic benefit	Boost economic growth	Boost local GDP
		Drive social investment
		Drive social total output
Social benefit	Boost local employment	Job creation
	Optimize resource allocation	Increased cross-regional transmission capacity
	Raise government taxes	Increased production taxes
Environmental benefit	Save energy and resources	Save fossil energy
		Save water resources
	Greenhouse gas reduction	Reduce CO_2 emissions

3.2 Evaluation Model System

3.2.1 Economic and social benefit evaluation model

The economic and social benefit evaluation mainly adopts the input-output model. Based on the annual input-output table of Gansu Province, the correlation effect among different economic sectors is established, and then the driving effect of industrial investment is analyzed.The specific model equation is expressed as follows:

$$X=(I-A)^{-1}Y=(I-A)^{-1}(C+I+EX) \tag{1}$$

A is the direct consumption coefficient matrix, I is the identity matrix, $(I\text{-}A)^{-1}$ is the Leontief inverse matrix, C is the final consumption, I is the gross fixed capital formation, and EX is the net outflow.

According to the input-output model, the expression of the input-output multiplier of industrial investment is as follows:

$$\Delta Y = (I - A)^{-1}\Delta X \tag{2}$$

ΔX represents the exogenous investment vector of power-related sectors, and ΔY represents the change vector of the total output of various industrial sectors. The economic meaning of this formula is that when an additional unit of power investment is added to the total demand for social products, this formula reflects the pulling role and contribution of power investment to the total social output in the form of a matrix.

In the system of national income accounting, *GDP* is equal to the sum of the added value of various industrial sectors. Therefore, when calculating the influence of electric power investment on the *GDP* of various industrial sectors, the calculated influence of electric power investment on the total output of various industrial sectors and the added value coefficient matrix v can be calculated, the diagonal element of which is the added value rate of various sectors. The specific calculation formula is:

$$\Delta GDP = v \times (I - A)^{-1}\Delta X \tag{3}$$

3.2.2 Environmental benefit evaluation model

The calculation formula of fossil energy consumption savings for power generation caused by the construction of new power systems is as follows:

$$G_{coal}\times r_{coal}+G_{gas}\times r_{gas} \tag{4}$$

G_{coal} and G_{gas} respectively represent the generating capacity of coal and gas power replaced by new energy due to the construction of the new power system, r_{coal} represents the average standard coal consumption rate of regional thermal power units, and the average coal consumption of power supply in Gansu during the "14th Five-Year Plan" period is considered as 300g/kWh; r_{gas} refers to

the average standard coal consumption rate of the gas power supply unit, which is generally 220 g/kWh.

The formula for calculating the amount of power generation water resource saving caused by the construction of new power system is as follows:

$$G_{wind}(\mathrm{w}_{coal}-\mathrm{w}_{wind})+G_{PV}(\mathrm{w}_{coal}-\mathrm{w}_{PV}) \tag{5}$$

G_{wind} and G_{PV} respectively represent the newly added wind power and photovoltaic power generation under the construction target of a new power system, while w_{coal}, w_{wind} and w_{PV} respectively represent the water resource utilization coefficient of coal power, wind power and photovoltaic power generation technology[8].

Wind power and photovoltaic power generation do not produce carbon dioxide in the process of power generation, but wind power and photovoltaic equipment will also produce carbon dioxide in the manufacturing process. With the attention paid to carbon footprint at home and abroad, this study uses two methods to estimate the carbon dioxide reduction due to the replacement of coal power by new wind power and photovoltaic power generation in the construction of new power system during the 14th Five-Year Plan period in Gansu Province.

First, only the carbon dioxide reduced in the power generation process is considered, and the whole life cycle process is not considered. The calculation of the amount of carbon dioxide reduced in the power generation process is publicized as follows:

$$F_{\mathrm{elec}} * G_{\mathrm{coal}} \tag{6}$$

F_{elec} represents the carbon dioxide emission factor per unit power generation, this study selects the carbon dioxide emission factor of the national unit power generation in 2022 is selected for calculation, which is about 0.541kg/Kwh.

The second is to consider the carbon emissions reduced in the whole life cycle of different power generation technologies, and use carbon footprint emission factors to calculate. The life cycle emission reduction formula is as follows:

$$G'_{wind}(\mathrm{F}_{coal}-\mathrm{F}_{wind})+G'_{PV}(\mathrm{F}_{coal}-\mathrm{F}_{PV}) \tag{7}$$

G'_{wind} and G'_{PV} respectively represent the new wind and photovoltaic power generation in the whole life cycle, and the life cycle of photovoltaic and wind power is calculated according to 20 years; F_{coal}, F_{wind} and F_{PV} represent the carbon footprint emission factors of coal power, wind power and photovoltaic power generation respectively.

4. Comprehensive Benefit Evaluation of New Power System Construction in Gansu Province

4.1 Correlation parameter definition

Research data show that the average investment cost of wind installation is about 3000-4000 yuan/kW. It is known that during the "14th Five-Year Plan" period, Gansu Province's new energy planning new installed capacity of about 56.83 million kilowatts, of which PV 32.03 million kilowatts, wind power 24.8 million kilowatts, according to estimates of new energy installed investment of about 200 billion. According to the survey, during the "14th Five-Year Plan" period, the total investment of Gansu power grid can reach 58 billion.

Regarding the distribution of investment in different departments, according to the capital distribution of power construction investment in major departments during the "13th Five-Year Plan" period, it can be estimated that: The distribution proportion of power construction investment in the construction sector is about 41%~46%, the distribution proportion in the electrical machinery and equipment manufacturing industry is about 23%~27%, the distribution proportion in the power and heat production and supply industry is about 18%~22%, and the distribution proportion in the instrumentation manufacturing industry is about 7.2%~8.5%. The distribution ratio in the special equipment manufacturing industry is about 1.4%~1.6%, the distribution ratio in the communication

equipment, computer and other electronic equipment manufacturing industry is about 0.8%~1.0%, the distribution ratio in the integrated technical service sector is about 0.32%~0.39%, and the distribution ratio in the metal products industry is about 0.14%~0.17%. The distribution ratio in the general equipment industry is about 0.09%~0.11%. In this study, average values were selected.

4.2 Result analysis

In terms of economic benefits, the power grid and new energy construction investment during the "14th Five-Year Plan" period can drive an increase of 533 billion yuan in total social investment, drive a total output of 9114 trillion yuan, drive GDP of about 306.5 billion yuan, and drive an average annual GDP of about 61.3 billion yuan, equivalent to 5.5% of Gansu Province's GDP in 2022. In terms of social benefits, about 530,000 new jobs will be created, and the net production tax will increase by about 21.3 billion yuan. In terms of environmental benefits, the newly installed wind power and photovoltaic power generation in Gansu Province during the 14th Five-Year Plan period will save about 27 million tons of standard coal in 2025, which is equivalent to about 0.9% of the national coal consumption in 2022. In 2025, the amount of water resources saved is about 0.3 to 320 million cubic meters, which is equivalent to about 0.03% to 0.3% of the total industrial water use in 2022. In 2025, the carbon dioxide emission reduction is about 48.69 million tons, which is equivalent to about 1.0% of the carbon dioxide emissions of the national power industry in 2022. The life-cycle carbon dioxide emission reduction is about 1.28 billion to 2.40 billion tons, which is equivalent to about 11.1% to 20.9% of the national carbon dioxide emissions in 2022.

5. Conclusions and recommendation

The industrial sectors with a strong driving role mainly include the transportation equipment industry, electrical machinery and equipment industry, instrumentation industry, metal smelting and rolling processing products industry, metal products industry, communication equipment, computers and other electronic equipment industry, wood processing products and furniture industry, construction industry, general equipment industry, etc., which can consider the priority layout.Industrial sectors with a strong basic role include: finance, chemical products, production and supply of electricity and heat, wholesale and retail, metal smelting and rolling processing products, transportation warehousing and postal services, leasing and business services, paper printing and cultural, educational and sporting goods, oil and gas exploitation products, etc.,which need to develop in advance.

Research suggestions are as follows. First, strengthen the tracking and analysis of industrial development status and correlation effects, and timely adjust and improve industrial policies. In the context of the construction of new power systems, the related driving role of the power industry may be enhanced, and it is necessary to strengthen the tracking of the latest statistical data and do relevant analysis in a timely manner. The second is to rely on the construction of a new power system, strengthen policy guidance and industrial supporting construction, and promote the industrial chain of Gansu's new power system to achieve "strong chain, complementary chain, and extended chain". Make full use of the opportunity of the construction of Shage Desert base, strengthen the top-level design of the coordination of Shage desert base planning and industrial transfer, and attract high-end new energy industries to land in Gansu. Strengthen the forward-looking planning and guidance for the industrial chain layout of new power systems. Accelerate the establishment of industry-university-research collaborative innovation system and related supporting systems for the development of new power system industry in Gansu.

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