

A Review of Research on Energy-Economy-Environment Systems (3E)

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Abstract: The development of "economic industrialization and social urbanization" worldwide has led to an unprecedented increase in the use of energy, especially oil and gas resources, in order to promote the economic prosperity of each region. However, the problems of environmental degradation and energy depletion have been exposed, and the fossil energy-based consumption structure has led to frequent occurrence of the greenhouse effect, acid rain and other extreme weather conditions. Therefore, how to harmonize the contradictions between energy development, economic development and environmental protection, many scholars have carried out a lot of analysis and research work on this, in-depth investigation of energy-economy-environmental system (3E) of the law of change. Based on this background, this paper comprehends the current research status of the relationship between energy, environment and economy.

Keywords: Energy-Economy-Environment System (3E); Research Status; Sustainable Development

1. History of the development of energy-economy-environment system (3E)

Economic growth is the most basic fact for the progress and development of human society, and for a long time, people have taken the acquisition of "economic benefits" as the primary goal and the gross domestic product (GDP) as the only criterion for development^[1]. 1972, the publication of the landmark report of the Club of Rome "The Limits to Growth" triggered the reflection on the economic development model, and the important role of energy and environment in economic growth was gradually emphasized by economists. development model, the important role of energy and environment in economic growth was gradually emphasized by economists. Scholars in various countries began to adopt economic theory methods to study energy issues and environmental issues, and gradually formed a theoretical system with economy-energy and economy-environment binary system as the object of study^[2]. After the 1980s, with the continuous improvement of the concept of sustainable development, people gradually realized that the energy, environment, and economy are included in a whole to study, in order to understand the role of the three more comprehensively and systematically. The mechanism of the three can be understood more comprehensively and systematically. Since then, many international energy research and environmental protection institutions have joined hands with economists to construct the energy-economy-environment system (3E) research framework system, analyze the development law and internal connection among the three, and carry out research on the integrated balance and coordinated development of the 3E system^[3].

2. Interrelationships between energy, the economy and the environment

2.1 Economy and Energy

Energy is an important material basis for the economic and social development of mankind, and the energy crisis in the 1970s seriously affected the global economic development, which made many foreign scholars start to study the relationship between energy and economic system. Foreign research on the relationship between energy and economic growth mainly uses Granger causality test or cointegration theory to analyze the causal relationship between each other. Kraft, J. & Kraft, A. use the relevant data of the United States from 1947 to 1974, and firstly use the cointegration analysis to carry out the empirical analysis on the existence of unidirectional causality between the United States of America's energy consumption and the gross domestic product^[4]. Subsequently, Bhartend also made a similar argument, due to the selection of sample data observation time period and data processing methods, the study found

that the relationship between energy consumption and economic growth in different countries or regions have different conclusions, the relationship between energy and the economy is confusing^[5].

Domestic scholars pay more attention to analyze the measurement of the relationship between the two, "dual-carbon" goal put forward so that the research between energy and the economy showed an accelerated trend. Alex research shows that economic development is not "zero cost", in the economic development at the same time must lead to an increase in energy consumption [5]. Alex showed that economic development is not "zero cost", and that economic development must lead to an increase in energy consumption^[6]; Huiting argued that with the growth of per capita consumption expenditures and energy consumption per unit of GDP, carbon dioxide emissions will also continue to grow^[7].

2.2 Economy and Environment

Most of the studies on the relationship between the economy and the environment are centered on the Environmental Kuznets Curve (EKC), which was first proposed in the early 1990s^[8]. Scholars have analyzed the drivers of EKC formation from the perspectives of production scale, economic structure, technological level, trade, etc., and all of them confirmed the existence of the inverted U-shaped curve. However, some scholars have also questioned the EKC, for example, Peng Shujun used inter-provincial panel data to empirically test the relationship between China's economic growth and six types of environmental pollution indicators, including water pollution and air pollution, and the results show that the relationship between economic growth and environmental pollution has a variety of forms such as U-type, inverted U-type and N-type^[9].

2.3 Energy, Economy and Environment

Energy and environment are important determinants of economic development^[10]. The emergence of the energy crisis has led many scholars to conduct multi-faceted and multi-angle research on the coordinated development of energy-economic-environmental systems, and pay more attention to the use of models to measure energy consumption, environmental pollution, etc. The 3E system is developing in the direction of complexity and gigantism, and the models mainly include the endogenous economic growth model, the CGE model, the MARKAL model, the input-output model, the DEA model, the multivariate linear programming model, and so on. model, multivariate linear programming model, etc., and the analysis ideas mainly include causality empirical evidence, coupling coordination evaluation, multi-objective planning prediction and so on.

Foreign scholars' research on the 3E system mostly starts from the measurement of the relationship between energy, environment and economy, and the research on the 3E system mainly focuses on analyzing the internal theory of the system and establishing models, but less on measuring the coordination of the 3E system as a whole. Mo Shu analyzed the impact of international oil price fluctuation on China's oil price under the baseline scenario and carbon tax scenario by constructing a computable general equilibrium model with six modules, including production, trade, system, price, environment and equilibrium. Mo Shu analyzed the impacts of international oil price fluctuations on China's energy-economy-environment system under the baseline scenario and the carbon tax scenario^[11].

The research on the coordinated development of China's 3E system started late, mainly from the perspective of sustainable development of energy and environment to evaluate the 3E system, and the research climax was set off between 2010 and 2016, scholars tend to measure the coordination and development of the system by constructing the evaluation index system of the 3E system, and give the corresponding policy recommendations according to the empirical results of the research object. Yang Zhiqing constructs an evaluation index system based on the concept of green development, establishes an evaluation model by combining the principal component analysis method with the entropy value method, measures the green development level of each system of energy, economy and environment (3E) in Henan Province from 2005 to 2017, and introduces a coordination degree model to evaluate and analyze the coordination and development level among the systems^[12]. Lu Jin constructed a coupling model of the three systems of energy, economy and environment, measured the coupling and coordination level among the three systems in the four major regions of China from 1995 to 2014, and made a comprehensive discussion on the changing characteristics of the regional three-system interactions as well as the differences in the temporal and spatial dimensions^[13].

3. Research Review and Future Development Direction

By summarizing the results of previous research, it is found that with the continuous deepening of the research of domestic and

foreign scholars in the field of 3E system, the breadth and depth of the research have been fully expanded, but more attention needs to be paid to the following issues. On the one hand, the study of the interaction of energy, environment and economy can intuitively and accurately see the mechanism of the interaction of energy, environment and economy, but most of the studies on the related modeling involving energy, environment and economy still remain in the study of the binary system, and there is room for further research on the ternary system. On the other hand, domestic scholars mostly adopt the evaluation index system to carry out the research on 3E system, but the construction of the evaluation index system has not jumped out of the framework of the traditional sustainable development index system.

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