

Literature Review on Chinese New Energy Investment Research

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Abstract: With the rapid development of China's new energy industry, the new energy investment market has attracted widespread attention from various sectors of society. In response to this, academic research on new energy investment has become increasingly abundant. This paper conducts a comprehensive review and summary of literature related to Chinese new energy investment, focusing on three aspects: "Market and Participants," "Influences and Values," and "Investment Strategies and Risk Management." The main research perspectives from relevant literature are extracted and synthesized. Additionally, the paper analyzes and summarizes the existing shortcomings in research areas, providing directional suggestions for future academic research.

Keywords: New energy investment, Investment value, Investment strategies, Risk management, Green economy

1. Introduction

In 2021, China's electricity generation from coal-fired power plants reached 5,770.27 billion kilowatt-hours¹, accounting for over 71% of the national electricity generation. The excessive exploitation of non-renewable energy sources will lead to serious consequences. On one hand, overexploitation of non-renewable energy sources poses a challenge of resource scarcity for China. On the other hand, a significant amount of emissions, including pollutants, is generated through coal-fired power generation. Currently, air pollution is the foremost environmental issue in China, with nearly 70% of carbon dioxide emitted into the air annually through combustion. In 2011, China's annual emissions of sulfur dioxide reached 18.57 million tons, particulate matter 11.59 million tons, and industrial dust 11.75 million tons², significantly impacting the environment. Therefore, the development of new energy has become one of China's crucial tasks for sustainable development. The advancement of the new energy industry and the optimization of the energy structure are essential pillars for China to achieve its carbon peak and carbon neutrality strategies, ensuring sustainable and healthy economic development. The Chinese government emphasizes the need to actively and prudently advance carbon peak and carbon neutrality, accelerate the planning and construction of a new energy system, strengthen the construction of the energy production-supply-storage-marketing

¹ Data sources: China Electricity Council

² Data sources: State Statistics Bureau

system, and ensure energy security. Unlike some Western countries, China possesses abundant reserves of renewable energy. According to research reports, China receives approximately 3,300 MJ/m² of solar radiation annually, with two-thirds of the country receiving over 6,000 MJ/m² of solar irradiance³. The hydropower reserves are 6,000 TWh, with an average exploitation rate of about 30%. China's potential capacities for tidal and wave energy are 110 GW and 500 GW⁴, respectively, providing a solid foundation for the development of new energy in China.

Regarding new energy, the "Renewable Energy Law" passed in 2005, the "Twelfth Five-Year Plan for Energy Development" issued by the State Council in 2013, and the "Fourteenth Five-Year Plan for Renewable Energy Development" jointly issued by nine departments, including the National Development and Reform Commission and the National Energy Administration, on June 1, 2022, are integral parts of relevant policies. According to these energy policy documents, China will continue to promote the green energy low-carbon transformation. It is projected that by 2025, the proportion of non-fossil energy consumption will reach around 20%. By 2030, this proportion will increase to about 25%, with a total installed capacity of wind and solar power exceeding 1.2 billion kilowatts. The robust support from policies plays a crucial motivating role in the development of new energy, and each introduction of relevant policies serves to encourage and catalyze new developments in the new energy market.

The encouragement policies in China for the development of new energy have ignited enthusiasm among investors towards new energy investments in the country. According to statistics from CINNO Research, the investment in China's new energy projects reached an impressive 5.2 trillion RMB (including Taiwan) in the first half of 2023 alone, positioning the new energy industry as a key investment focus within emerging technological sectors. Fueled by investments in new energy, China surpassed 530 million kilowatts in new energy installed capacity in 2020, claiming the top spot globally in the scale of new energy development and utilization. Additionally, China's photovoltaic (PV) power generation accounted for 52.8% of the total newly installed capacity. In the first half of the year, China's PV product exports reached 28.92 billion USD. According to industry standards and association calculations, the production of polycrystalline silicon, silicon wafers, cells, and modules in the country achieved a new high, with year-on-year growth rates all exceeding 65%. The total export value of PV products reached 28.92 billion USD, reflecting an 11.6% increase year-on-year.

The rapid development of China's new energy investment market has captured the attention of numerous scholars, making new energy investment a current and hot academic topic. The primary objective of this paper is to review and summarize the existing research in this field. The paper conducts a comprehensive review of current research on China's new energy investments using a logical framework of "what - why - how." The value and contribution of this paper lie in organizing existing literature, contemplating new research directions, and laying the groundwork for subsequent studies.

The subsequent sections are as follows: Section Two reviews research related to the new energy investment market and its participants; Section Three provides a survey of existing literature analyzing the impact and value of new energy investments; Section Four summarizes research papers on new energy investment strategies and risk management; and Section Five, building upon the preceding sections, offers critical reviews of the existing literature.

³ Data sources: China Meteorological Data Network

⁴ Data sources: Renewable Energy

2. Research on the New Energy Investment Market and Participants

As the Chinese new energy industry continues to evolve, the new energy investment market has gradually taken shape. Consequently, some scholars have conducted research on the development of the new energy investment market. An Yan analyzed the current status and existing issues of new energy project investments in China after the introduction of the “Fourteenth Five-Year Plan.” An Yan also provided corresponding recommendations for new energy enterprise project investments under the context of the “Dual Carbon” initiative.[1] In addition to research on the domestic market, some scholars are also paying attention to the development of overseas new energy investment markets. For example, Dai Xiao outlined three modes of new energy investment by Chinese enterprises abroad. Taking state-owned power groups focusing on Engineering, Procurement, and Construction (EPC) as a primary example, Dai Xiao analyzed the influencing factors during the project approval process. [2] Furthermore, the construction of the policy system is also an important aspect of new energy investment market development. Zhao Baoqing, taking the United States as an example, analyzed and evaluated various specific measures from a legal and policy perspective to address the risks faced by new energy investments in the U.S., providing insights for the improvement of China’s legal and policy framework in the new energy investment market.[3]

Moreover, to deepen the understanding of new energy investment, some scholars have analyzed the influencing factors of new energy investment. Taking a global perspective, Wu Yelu and Shao Wanqin analyzed the global development of new energy from 2004 to 2019. They found that a country’s economic strength, international pressure on carbon reduction, resource endowment, and energy consumption structure all influence a country’s participation in new energy. [4] From the perspective of investment influencing factors, Deng Nan analyzed the current status of the new energy industry’s development and the influencing factors and opportunities under the carbon neutrality target. The investment in the energy industry is significantly affected by factors such as the expected development status of the industry, energy investment methods, industry costs, international oil prices, energy industry transformation, and industry risks. [5] Additionally, carbon trading factors also impact new energy investments. Ma Zhaoxia, using a dual split model, found that carbon trading significantly promotes investments in new energy enterprises, with a stronger effect on state-owned new energy enterprises compared to non-state-owned enterprises. [6] Financial and tax support is also an influencing factor. Li Zhixue et al. used the Richardson Inefficiency Investment Model to explore the impact of financial and tax support on the efficiency of investment in the new energy industry. The study found that the overall investment in the new energy industry is excessive, and fiscal subsidies increase overinvestment, while tax incentives can alleviate insufficient investment.[7]

In addition to studying the market itself, another group of scholars focuses on various participants in the new energy investment market. Among them, the government, as a policy maker and implementer, is one of the crucial participants in the energy investment market. Zhang Weiguo et al. analyzed the government’s role in the new energy investment system using the evolutionary game theory. The study found that government incentive strategies play a crucial guiding role in investor behavior. However, this influence gradually weakens as the new energy investment environment improves, suggesting the need for timely policy adjustments and transitions between the roles of government and the market. [8] Some scholars have conducted research on investment entities. Wang Xuehua focused on the construction of the financial management system of new energy investment enterprises, concluding that it is imperative for these enterprises to build a high-quality financial management system. [9] In addition to investment enterprises, some new energy companies themselves are engaged in corresponding investments. In theoretical research, Tan Yingshuang et al. primarily analyzed cross-border new energy enterprises in the investment environment. They balanced factors such as uncertainty and competitiveness using a physical option game model.

Introducing a Poisson jump process based on the basic and expanded models, they discovered that there are optimal investment critical values and optimal investment times corresponding to different degrees of demand shocks for new energy enterprises. [10] In empirical research, Tang Jian et al. focused on the investment status of new energy enterprises in China. They selected financial report data from 2013 to 2018 for new energy enterprises listed on the A-share market and examined the impact of equity financing and different-term debt financing on the inefficiency investment of new energy enterprises. The results showed that although equity financing provides significant support for the development of new energy enterprises, its effect is not significant. Short-term liabilities constrain overinvestment, while long-term liabilities promote effective investment expenditure for enterprises.[11]

3. Research on the Impact and Value of New Energy Investments

Currently, the Chinese government places significant emphasis on the role of capital markets in serving the real economy. In particular, the new energy investment market plays a crucial role in attracting sustained funds for China's new energy industry, making the impact of new energy investments an important research focus. On one hand, driving relevant investments in new energy is a vital channel for China to achieve carbon reduction and promote the development of a green economy. Therefore, scholars have conducted research around such impacts. For instance, He Lingyun et al. , based on relevant data on China's renewable energy investments from 2004 to 2013, found that there is no direct correlation between renewable energy investment and carbon emissions. Instead, it exerts a regulatory effect on carbon emissions through pathways such as quantity, structure, and efficiency. The ultimate impact depends on the game between carbon-driving and carbon-restraining effects in the system. [12] Chen Jie and Deng Xueping utilized Henson's threshold regression method, constructing a panel threshold model to examine the non-linear relationship between green credit and green development under different levels of renewable energy investments. They identified three thresholds for green credit affecting the green development index. [13] Additionally, new energy investments have propelled the transformation of China's energy structure. To analyze the impact of green investments on the regional energy consumption structure, Liu Xudong and Yan Haokun conducted an empirical analysis using panel data from 30 provinces and cities in China from 2007 to 2016. They found significant regional variations in the influence of green investments on the energy consumption structure, primarily attributed to differences in economic development levels, industrial structure characteristics, population size, and technological levels among the eastern, central, and western regions.[14]

Furthermore, in general, the analysis of investment value is a common entry point for studying industrial investments. Therefore, another group of scholars has conducted a value analysis of new energy investments. To perform a value analysis of new energy investments in the context of the "Dual Carbon" initiative, Lin Ruiying analyzed the development environment of companies listed in the energy concept sector. Using the PEST model as the analytical perspective, the study separately analyzed four macro factors in the new energy industry: political, economic, social, and technological. By quantitatively evaluating the investment value of individual stocks in the new energy sector, the study aimed to guide investors toward rational investment in the new energy sector. [15] Since the assessment of investment value is inseparable from the assessment of investment risks, some scholars have also studied and analyzed the relevant risks of new energy investments. Li Tao et al., under the COSO-ERM (Enterprise Risk Management) framework, based on an analysis of the characteristics of new energy projects and their investment risk orientation, introduced a four-dimensional investment evaluation indicator system involving Benefits (B), Opportunities (O), Costs (C), and Risks (R). This system harmonized the contradiction between risk and return. With the help of a multi-attribute fuzzy evaluation model and improved operators, the study further enhanced the

scientific validity and effectiveness of the investment evaluation model.[16] With the development of China's new energy industry, many new energy enterprises have become listed and have become significant investment targets. The investment value of these enterprises has garnered attention from some scholars. Xiao Yanchun, employing relevant theories and methods related to the investment value of listed companies, systematically studied the investment value of listed companies in the new energy sector. The study constructed a comprehensive evaluation model and, through data analysis, obtained the comprehensive evaluation results of listed companies in the new energy industry. [17] In addition to constructing a comprehensive evaluation model, some scholars have chosen to build a factor analysis model to analyze the investment value of listed companies in the new energy sector. For example, Fang Weiguo et al., focusing on 27 A-share listed new energy companies, utilized the TOPSIS method to obtain the closest factor scheme of listed companies, thereby analyzing the investment value of the sample companies. The research results indicate that only 17.65% of the listed companies in the sample have a factor scheme closeness greater than 0.7, suggesting that the investment value of listed new energy companies in China needs improvement. [18]

4. Research on New Energy Investment Strategies and Risk Management

For investors, formulating appropriate investment strategies is crucial. Consequently, scholars have conducted relevant research on investment strategies in the field of new energy. The "Dual Carbon" initiative has recently become a hot topic. Under the strategic goals of "Dual Carbon," Xu Jin and Dong Dapeng proposed investment strategies focusing on clean energy base projects, strategic resource reserves, and overseas project development and construction. This proposal stems from an analysis of the prospects for new energy development and the major issues facing its advancement. [19] As the current pandemic gradually stabilizes and external economic conditions undergo corresponding changes, Zhou An et al. conducted an in-depth analysis of the distribution of new energy resources and policy status. They put forward three major investment strategies for new energy in the post-pandemic era: "Reducing marginal costs through regional-scale development," "Focusing on high-quality resources to ensure electricity generation hours," and "Expanding financing channels to reduce financial costs." These strategies aim to contribute to the scaling and improvement of the quality of new energy generation. [20] Zhao Xikang, based on economic analysis of energy substitution, emphasized the importance of price mechanisms in the substitution of old and new energy. This insight guides future investment strategies in the new energy industry. For example, Zhao highlighted the need for caution in investing in new energy vehicles. This caution arises from the current relatively low marginal social utilization cost of fossil fuels and the considerable uncertainties in the future development of this industry. [21]

Risk management is a crucial aspect of assessing the investment capabilities of investment institutions. Against this backdrop, some scholars have conducted research on risk management in new energy investments. Tian Shuai introduced theories of risk investment and risk management into the practice of new energy development and construction. By integrating relevant theories of strategic management, risk investment, and new energy development and construction, the study constructed a comprehensive risk management indicator system for the full life cycle of new energy risk investments. [22] Regarding risk assessment, Yao Yuan believes that as a new direction in resource development and utilization, new energy will be influenced by policy, industry, technology, and market risks during its development. With the support of relevant national policies, appropriate risk response measures can be formulated through comprehensive market analysis, thereby enhancing the risk resistance of industries related to new energy. [23] Addressing the political risks encountered in the process of new energy investment, Wang Zhifu and Liang Enmiao used photovoltaic power stations as an example. They systematically outlined and analyzed political risks in the international engineering new energy investment process. Building on this analysis and combining it with the

actual situation of a photovoltaic power station in a certain African country, the study investigated political risks and found that these risks vary based on the company, country, and project, and they change over time. [24]

5. Conclusion

By reviewing existing literature, it is evident that Chinese scholars have conducted numerous analyses and studies in the field of new energy investments, accumulating a substantial amount of research outcomes. Particularly, literature in the areas of various participants in the new energy investment market and the value of new energy investments is notably rich. The abundance of the former may be attributed to the diverse participants in the new energy investment market, providing a wealth of research subjects and consequently resulting in a higher volume of academic papers. As for the latter, the richness in literature may be because analyzing and demonstrating the value of new energy investments is one of the most fundamental and intuitive research topics. It serves as a prerequisite and foundation for in-depth research into other subjects, and both the government and academia place a high emphasis on this argument. Consequently, scholars have provided more comprehensive analyses in this area. However, on the other hand, certain specific aspects within the realm of new energy investments still lack more in-depth academic research. For instance, there is a relatively limited amount of literature on the development status of the new energy investment market, the analysis of the impacts of new energy investments, specific investment strategies for new energy, and research on risk management in new energy investments. Specifically, existing literature on the development status of the new energy investment market mainly consists of qualitative discussions, lacking analyses based on mathematical models. The insufficiencies in research on the impacts of new energy investments, specific investment strategies for new energy, and risk management in new energy investments may stem from the fact that such studies require micro-level cases or investment data. However, much of the new energy investment market operates in non-public markets, and the development cycle of new energy investments in China is relatively short compared to other traditional industries. Consequently, relevant data and cases are limited and less accessible, making research in these areas more challenging and resulting in relatively fewer academic research outcomes.

Based on the above analysis, it is recommended that scholars pay more attention to areas with limited literature. Specifically, deepening the theoretical model research related to new energy investments from a macroeconomic perspective is suggested. New energy investments have become increasingly important in driving infrastructure investment in China and further promoting economic development. Thus, exploring the relationship between new energy investments and macroeconomic growth through the construction of mathematical models has become a potential important topic. In terms of micro-level research, scholars should strengthen the sorting and accumulation of relevant cases and data, establish professional databases, and provide materials for corresponding research. Additionally, there are still potential topics that require more in-depth exploration. For example, in recent years, China has introduced numerous policies encouraging the development of new energy. It is worth investigating whether such supportive policies have also driven the development of the new energy investment market. Furthermore, in the new energy investment market, financial intermediaries such as banks play a crucial role, but there is currently limited literature focusing on them as research subjects. This area also needs to be supplemented by future scholars.

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