Green Bonds and Sustainable Financing Models in Energy Finance

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Abstract: At present, green bonds have demonstrated their crucial role in the low-carbon transformation of the energy system. This article mainly studies how to use green bonds for coordinated development of the energy system, proposes a model framework for sustainable financing, analyzes the existing problems in the connection between current mechanisms and policies, and puts forward improvement suggestions. This study indicates that the key path to enhancing the actual effectiveness and market credibility of green bonds includes: improving the capital flow chain to ensure efficient connection throughout the financing process; Enhance the collaborative cooperation between the government and enterprises, and promote efficient allocation of resources and policies; Establishing a unified rating standard for green projects can help strengthen the coordination between green bonds and energy finance, improve resource allocation efficiency, and enhance the overall effectiveness of policy implementation.

Introduction

Under the guidance of the "dual carbon" strategy, green debt instruments, as an important bridge between financial markets and energy green transformation, can target fundraising, promote green and low-carbon industry projects, and provide corresponding economic support for industries such as clean energy and energy storage equipment. However, the development of green bonds still faces problems such as fragmented financial investment models, unclear project definitions, and vague project ratings. This article takes the application of green debt in energy finance as the starting point to construct a sustainable financing system, thereby providing theoretical support and practical guidance for efficient operation of green investment and low-carbon upgrading of energy systems.

1. Overview of Green Bonds and Energy Finance

Green bonds refer to debt financing instruments specifically designed to support environmentally beneficial projects, which are both financial products and environmentally friendly features. In the era of global climate change and energy structure adjustment, green bonds are increasingly becoming a link between green projects and capital markets. The long-term healthy existence of energy finance is largely driven by diversified, stable, and low-cost fundraising, and green bonds play an indispensable role in this regard, not only expanding the supply of funds, but also enhancing the financing demand and market acceptance of green projects. Under the continuous promotion of the "dual carbon" strategy, green bonds are conducive to the development and utilization of clean

energy such as solar power generation, wind power generation, and battery energy storage. At the same time, by aligning with government guidance and industrial development models, they further strengthen the driving role of financial instruments in energy transformation. The deep integration of "green bonds" and "energy finance" is an important path to accelerate the construction of a modern green finance system and achieve a win-win situation for ecological protection and economic development.

2. Construction of Sustainable Financing Model Framework in Green Bonds and Energy Finance

2.1. Building a financing closed-loop system to ensure effective transmission

The value sustainability of green bonds is reflected in a sound financing cycle chain. At present, some projects are in a state of decoupling in the allocation and use of funds, which cannot truly implement green goals. In order to open up the efficient transmission path of funds, it is necessary to build an integrated closed loop consisting of fundraising, investment, use, management, and evaluation. Each link should be set with clear "small goals" and control points, and generate measurable and auditable capital flow loops. The use of green bond funds should be closely related to the carbon dioxide emission reduction potential, technological progressiveness, and possible environmental impact of funded projects, so as to ensure the environmental benefits and sustainability of capital investment. Form a closed loop of "funding project effectiveness". In practical evaluation, a green performance evaluation function can be introduced:

$$E = \sum_{i=1}^{n} （C_i \cdot R_i) \tag{1}$$

Among them, C_i For the thiWeight of funding investment for a project, R_i The environmental benefit return coefficient for this project, EOverall green performance value. This model can change the weight of fund allocation in real time to obtain a larger proportion of output capital investment. Only with a closed-loop structure can green bond financing activities complete a complete cycle from self funding to green effectiveness, ensuring the sustainability of the energy system transformation through green financial instruments.

2.2. Strengthening policy coordination mechanism to promote efficient operation

The effective operation and development of green bonds not only rely on internal market regulation, but also require coordination and cooperation among government departments. At present, there is a dilemma in green financing where multiple departments are involved in formulating and implementing standards that are inconsistent, and management forms are scattered, resulting in poor liquidity in the capital market and low substantive development rates of projects. Therefore, it is necessary to reach agreements from multiple parties and establish a policy joint system that combines horizontal and vertical aspects to form a coordinated operation in financial subsidies, tax exemptions, supervision and guidance, carbon emission quotas, and other aspects. On this basis, a policy synergy evaluation model can be established:

$$S = \alpha p_f + \beta p_r + \gamma p_s \tag{2}$$

Among them, S For the policy synergy index, P_f, P_r, P_s For financial support, regulatory efficiency, and tax incentives, α, β, γ Weight coefficients for various policies.Equal SReaching a certain threshold, To provide a sound operational foundation for the policy coordination mechanism, which can effectively promote the efficient linkage between green bond issuance and project implementation. The coordination mechanism can bypass barriers in various links through

institutional collaboration, resource collaboration, and information collaboration, thereby accelerating the response and adjustment rate of green bonds to the energy finance landscape.

2.3. Establish dual evaluation criteria to measure comprehensive benefits

For the effectiveness of using green bonds in energy finance, it is not only necessary to consider the amount of capital invested or the completion of projects, but also to establish a comprehensive evaluation model with environmental performance and economic benefits, laying the foundation for scientifically evaluating the comprehensive benefits. Single indicator evaluation can deviate resources from the essence of environmental protection, and even create a "green veil". From the perspective of environmental effects analysis, carbon reduction, resource conservation, pollution control, etc. are mainly considered, while from the perspective of economic benefits, cost, profit, and risk management level need to be considered. To achieve quantitative measurement, a comprehensive rating function for green projects can be constructed:

$$T = \lambda E_S + (1 - \lambda)F_s \qquad (3)$$

Among them, TOverall score for the project, E_sTo evaluate environmental performance, F_sTo evaluate financial performance, λ ,$\in [0,1]$Weight coefficients for environment and economy.Equal λ approach to1, The model focuses more on environmental contributions;When approaching0, Emphasis on economic benefits. The model can be used in the early stages of selection, execution, and post evaluation, making management more refined and efficient. By establishing a unified and open binary judgment standard, improving the efficiency of using green debt financing tools, and thereby enhancing their credibility and social responsibility in the market, this will greatly promote the development of green finance to a higher level.

3. The Problems of Sustainable Financing Models in Green Bonds and Energy Finance

3.1. The breakdown of the financing chain affects the transmission of effectiveness

In the process of carrying out energy finance, green bonds often lead to interruptions in financing channels, affecting the effective transmission of funds from fundraising to achieving results. Although the debt instruments have been successfully sold, there are still issues of time delays in project selection, applicability, and execution, with funds stranded and unable to start construction as soon as possible. Due to the issuer's lack of a comprehensive investment linkage system, its green project portfolio is scarce, which reduces the utilization rate of funds. At the same time, the application standards are complex and require approval from multiple departments, the procedures are cumbersome and the process takes a long time, and the decision-making process of inconsistent standards increases the complexity of the financing chain. In addition, there are also problems such as lagging information release and inadequate supervision, which may affect the achievement of green finance goals and increase the risk of misallocation of resources.

3.2. Insufficient policy linkage weakens execution efficiency

Due to the failure of various relevant departments to cooperate in the coordinated release and implementation of policies such as fiscal, environmental, energy, and financial policies, the effectiveness of implementation has been greatly reduced. Additionally, different departments have different requirements regarding project and fund review and use, as well as green bonds, which may result in overlapping responsibilities and procedural conflicts. Some local governments have relatively lagging implementation, and there are areas where green bonds have not been uniformly

managed, which increases the difficulty of enterprise declaration and implementation; The lack of information sharing and the separation of project approval and financial review have reduced the efficiency of fund utilization and project implementation speed, ultimately leading to a decline in the operational efficiency of the entire green finance system.

3.3. Lack of evaluation system restricts the measurement of benefits

In the application of green bonds in the field of energy finance, there are problems with insufficient evaluation methods and an incomplete system, which makes it difficult to accurately measure the comprehensive benefits. Most green projects lack environmental effectiveness certification, often using fuzzy qualitative indicators instead of quantitative evaluation, and lack follow-up tracking mechanisms, making it difficult to transmit environmental benefits to the end of fund utilization. From an economic perspective, financing is often initiated before financial feasibility assessment, lacking a systematic analysis of returns, risks, and efficiency. Incomplete information disclosure, lack of unified standards and third-party evaluation, further increase the difficulty of performance recognition, weaken regulatory judgment and market trust, and affect the effectiveness of green bonds.
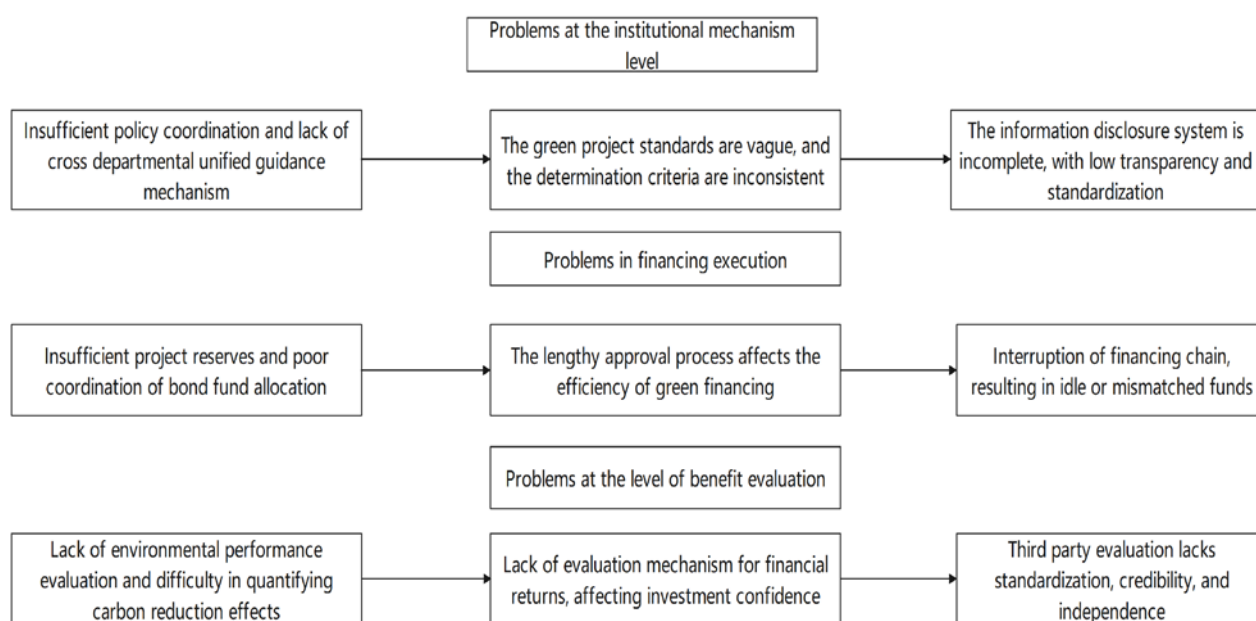

Figure 1: Problems with Sustainable Financing Models in Green Bonds and Energy Finance

4. Optimization strategies for sustainable financing models in green bonds and energy finance

4.1. Improve the construction of financing system and strengthen the transmission of effectiveness

It is necessary to establish a circular model that covers the project selection stage, bond issuance stage, fund investment stage, implementation supervision stage, and environmental performance feedback stage in the early stage of the project, with the goal of "visualizing the entire project process and controlling the entire funding chain". Establish a green project database and complete project screening and registration before issuance to ensure that fund users have clear environmental attributes and that their investment projects have relevant implementation experience and professional foundations. Strengthen the design of the information disclosure system, clarify the

requirement for regular disclosure of its actual use, investment situation, implementation progress, and green performance, in order to improve the transparency of lending. Use intelligent control tools to check the investment situation of green funds in real time, prevent the misappropriation and non compliant use of green funds. At the same time, introduce third-party institutions for green certification to certify green bond funds at multiple stages, ensure the verifiability of green elements in green bonds, and improve the efficiency and green implementation effect of green bond funds through institutional closure and technological parallel implementation, making it more effective in promoting energy transformation.

On a large-scale distributed solar power plant in Taicang City, Jiangsu Province, the local government, in conjunction with financial institutions and environmental certification agencies, has designed a rolling investment model of "application approval financing evaluation". Prior to bond issuance, the green attribute review and confirmation of expected benefits have been completed, and the project's initiation, implementation, capital investment, and benefit monitoring are synchronized. By adopting the tagging technology of blockchain ledger, the synchronous identification of capital flow and construction process can be achieved, and this information cannot be eliminated to avoid the phenomenon of traditional investment disappearing without a trace. This not only shortens the time to use green bonds, but also enhances investors' confidence in green benefits. It is a typical case of local application of green finance assistance.

4.2. Establish a sound mechanism for government enterprise collaboration to enhance operational efficiency

Construct a political and economic cooperation network composed of different levels and types of entities, establish a management platform for environmental bonds, maintain regular interaction between government and enterprise agencies in policy formulation, project docking, and implementation feedback, and form institutionalized cooperation. The government sets up a dedicated environmental bond management team or cross departmental working group to standardize and integrate various departments, provide centralized guidance, and save the time and cost of enterprise borrowing and financing. We can compile a list of environmental projects in important areas, clarify various support methods such as finance, taxes, and construction land, and stimulate the motivation of enterprises to make green investments in important areas. Financial regulatory authorities should strengthen information communication with relevant departments to ensure that financial product development complies with energy policy requirements. Early intervention in the policy-making process of enterprises can provide a more accurate understanding of financing constraints and legal requirements, and improve the adaptability and performance of their bond products.

The tripartite collaborative model of "Financial Bureau Environmental Protection Bureau Issuing Company". The Guangzhou Green Bond Demonstration Zone adopts a three in one model of "Financial Bureau Project Environmental Impact Assessment Financial Subsidy", mainly led by the Financial Bureau to design financial preferential policies, the Environmental Protection Bureau is mainly responsible for the environmental evaluation of projects, and enterprises complete the specific operational and financial planning requirements required by the government; On the other hand, the Guangzhou Municipal Government has also established a one-on-one project liaison for green bonds, in order to track the adaptability and progress of projects and policies, which can greatly shorten the review time. For example, the Guangzhou Metro Green Bond project only took 45 days, nearly 50% faster than before, demonstrating to some extent the ability and determination of the government and enterprises to jointly carry out green financing.

4.3. Establishing a unified evaluation system to ensure the measurement of benefits

For green bonds, a comprehensive and integrated work system must be established with specific data, evaluation indicators, and evaluation systems as the core. One is to establish appropriate green evaluation indicators; Secondly, establish a unified data standard; The third is to improve and determine the green evaluation steps and evaluation methods; The fourth is to ensure that the evaluation results can be applied. The evaluation of green bonds should set specific evaluation criteria based on different types of bonds, including specific environmental benefit indicators (such as carbon emission reduction, renewable energy usage, and pollution reduction rate); Including specific economic performance indicators (such as investment utilization efficiency, return situation, and project risk management); Secondly, we will promote the construction of a national green project evaluation index database (including various standards and specifications related to project evaluation) and data interface standards, to achieve comparability and fairness of evaluation results across different regions and types; The third is to promote the "dual review system" for green bond evaluation, which means that the green adaptability evaluation of bonds before issuance and the environmental performance evaluation of products after issuance are undertaken by independent third-party institutions; The fourth is to further utilize the evaluation results of green bonds, open up the linkage channels with fiscal incentives, carbon trading quota allocation, green credit, etc., and enhance the policy guidance ability and credibility of green evaluation.

The Shenzhen Clean Energy Microgrid Project is located in Nanshan District. The Nanshan District Government, in conjunction with the city level unified green project evaluation index system, has introduced a multi index comprehensive evaluation system for feasibility assessment from the beginning of the project. The method used is consistent with the city level green project evaluation system and serves as an important basis for feasibility study to improve the scientific and forward-looking nature of project evaluation. The indicators include the carbon emission reduction intensity of unit investment, the contribution of regional energy structure adjustment to carbon emission reduction, and the investment cycle. For project construction, sensor devices are introduced to obtain real-time data on production energy consumption, emission reduction, and other work, and the energy consumption level and financial benefits of the project are evaluated in the form of third-party annual reports. After the completion of the practical project, the Shenzhen Green Finance Platform used its published green bond evaluation report as a demonstration project and promoted its application to similar projects, thereby ensuring the closed-loop implementation of green investment and financing on the platform.

Conclusion

Green bonds, as an effective tool for promoting the energy revolution and the development of green finance, have important concerns at the policy level and market entities regarding their fundraising efficiency, environmental impact, and change effects. This article focuses on the discussion of green bonds as a path for the development of energy finance, designing a mechanism for circulating capital flow, policy coordination, and two evaluation criteria and four aspects of sustainable financing models. It also explores the problems in financing models that hinder the use of green bonds, the correlation between policies, and the lack of consistent evaluation criteria. It proposes practical and feasible financing optimization models, government enterprise collaborative promotion mechanisms, and consistent evaluation system reform suggestions to improve the efficiency of fund utilization. In the future, we should strengthen the innovative development of green bond products under a complete, open, and effective management system, and closely cooperate with various links in the energy system to leverage green bonds as an important link to

promote green and high-quality economic development, and accelerate the achievement of the "dual carbon" goal.

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