FINANCIAL SUPPORT FOR GREEN TECHNOLOGY DEVELOPMENT: CHINA’S PRACTICES AND EXPERIENCES

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With the contributions from:
Global Institute of China International Capital Corporation (CGI)
Planning and Research Institute at China Development Bank
Institute of Finance & Banking at Chinese Academy of Social Sciences
National School of Development at Peking University

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The development and deployment of green technologies play a pivotal role in accelerating the transition towards a sustainable future, fostering high-quality economic growth, and advancing progress in societies. Green technologies will also be critical in helping countries around the world move towards carbon neutrality. From an economic standpoint, decarbonization poses new constraints on future economic development. As many developing countries prioritize economic growth, achieving net-zero targets necessitates a green transformation of the growth model, underpinned by a comprehensive range of strategies. These approaches include internalizing external costs through carbon pricing, driving technological innovation to transform the energy production paradigm, and fostering behavioral changes that promote low-carbon lifestyles. Among these factors, technological innovation stands out as the most significant contributor. Not only does it help reduce the carbon intensity of energy consumption and the energy intensity of GDP, but it also fosters long-term economic growth.

Green innovation encounters similar challenges as innovation in other technological domains. It involves cutting-edge and nascent fields with high upfront investment costs and long lead times from the stage of research and development to when economic benefits can be generated. These factors contribute to elevated investment risks and uncertainties. Many companies struggle to anticipate the potential future benefits derived from green innovation, which diminishes their intrinsic motivation to engage in the development and deployment of green technology. Furthermore, only a small fraction of green innovations successfully reaches the commercialization stage, limiting the potential for generating returns.

Nevertheless, green innovation possesses unique characteristics. From a theoretical perspective, green innovation exhibits the "double externality" feature emphasized by Nobel laureate economist Dr. William Nordhaus. Actions taken to combat climate change benefit humanity as a whole, and innovation itself generates strong positive spillover effects. Both aspects indicate that the social benefits outweigh private gains, resulting in an underprovision of green innovation. In practical terms, the green technology industry faces specific industrial and political risks, including those stemming from climate policies, natural factors (such as sunlight duration and wind power availability), and fluctuations in energy and carbon prices. Without appropriate risk management tools, investors may hesitate to take actions.

To achieve a satisfactory level of investment in green and low-carbon technologies, it is imperative to internalize green externalities through both price and non-price mechanisms. These include establishing carbon markets and setting emission standards. Meanwhile, policy incentives and financial support for technological innovation are crucial. They provide the necessary risk-sharing mechanisms and facilitate the development of an effective financial service system to
support green and low-carbon technology companies and projects. This paper is structured as follows: the first section examines the challenges of financing green technology; the second and third sections delve into the innovative practices in the financial sector and policy support respectively; the final section concludes with policy recommendations.

1. Challenges in Financing Green and Low-carbon Technologies

While it is widely acknowledged that substantial investments are needed to finance green and low-carbon technologies, there exist various institutional and technical barriers.

Green and low-carbon technologies face challenges due to the lack of consistent and comprehensive standards. Varying taxonomies are adopted by different countries. Although efforts have been made under the International Platform on Sustainable Finance (IPSF) to establish a Common Ground Taxonomy to align the taxonomies between the EU and China, there is still a considerable amount of work that needs to be done to harmonize the definition and classification of green and low-carbon technologies around the world.

It is difficult to quantify the environmental benefits of green technology, and its monetization is challenging due to the lack of consistent and widely accepted valuation methodologies. Financial institutions and markets find it difficult to translate environmental benefits into predictable economic gains and future cash flows. In practice, investors, including private equity (PE) and venture capital (VC) firms, lack a standardized vetting process for identifying sustainable investments, which is further hindered by inadequate disclosure of environmental and carbon-emission performance by companies. Additionally, the lack of definition or certification standards for green technologies may lead to "greenwashing", making it difficult for investors to determine whether projects genuinely deliver environmental and climate benefits.

The development of green and low-carbon technologies faces numerous uncertainties. First, green technology startups tend to be highly technology-intensive and require significant upfront costs. Second, the transition from the proof-of-concept phase to commercialization for green technologies requires a significant amount of time. To mitigate risks, financial institutions often rely on making short-term liquidity loans, resulting in relatively limited room for offering medium and long-term financial support. Third, green and low-carbon technologies are vulnerable to unstable industrial policy expectations. Many countries, especially developing ones, lack clearly defined environmental and climate policies, which can potentially impact risk-adjusted returns on investments. Furthermore, many countries lack systematic policy incentives for the development of green and low-carbon technology, with support being scattered across various documents.
Financial institutions often lend based on criteria that cannot be easily met by green technology innovation companies. On the one hand, traditional lending processes in commercial banks rely heavily on collateral, which poses challenges for green technology startups that often lack substantial assets. Existing green financial products primarily cater to large environmental protection enterprises and clean energy projects, with limited consideration for the diverse financing needs of small and medium-sized green projects. On the other hand, the investment period of PE/VC institutions in many developing countries is relatively short, typically 5-7 years, which fails to align with the longer payback periods of green technology projects, often exceeding 10 years.

Financial institutions face a shortage of professionals with expertise in green finance and experience in assessing the risk and return of green technology projects. Gathering information on how projects are performing in terms of environmental impacts is time-consuming, and evaluating these projects is complex. As a result, financial institutions often struggle to effectively apply their past experiences in current projects. Moreover, financial institutions generally lack specialized teams with an understanding of green technology, as well as proficiency in green project business models and hands-on experience. The scarcity of professionals with knowledge in both finance and green technology has impeded the innovation of green financial products and services, thus limiting the development of financial support for green technology.
2. Innovative Practices of Financial Institutions and Market Infrastructure

In terms of financing channels, financial institutions have implemented three types of innovative practices, namely: (1) expanding indirect financing channels by developing credit products such as "green revolving loans" and "Frontier Pass"; (2) broadening direct financing channels by promoting participation in multi-level capital markets; and (3) devising innovative approaches to fostering synergies between indirect and direct financing.

2.1 Development of Innovative Credit Products

First, financial institutions can leverage funding from policy banks and multilateral financial institutions to reduce the cost of capital. For instance, "impact investment" funds and overseas loan transfers can be utilized. An example of this is when a financial institution makes use of low-cost overseas loans from the World Bank or KfW Bank Group. These funds provide a low-interest loan product with an annual interest rate of only 2.8% for a 3-year term. The KfW Bank Group, a prominent German state-owned investment and development bank, raises funds in the international capital market and bundles them to create green financial products. These products are then sold to banks at minimal profit, thus enabling them to offer their customers green financial products and services for environmentally friendly initiatives, energy-saving measures, and greenhouse gas emission reduction projects at preferential interest rates and loan terms.

Second, financial institutions are exploring innovative lending approaches that go beyond relying solely on cash flow or income for credit assessment. Companies can optimize financing terms by using equity warrants as a credit enhancement. For example, a Chinese bank was able to evaluate the growth potential of a hydrogen cell engine company based on factors such as technology, management, development prospects, and policy subsidies. By innovating its rating model with a risk-based approach, the bank used the innovative product "Frontier Pass" to provide CNY 50 million to address the company's equity financing gap during a loss period, significantly alleviating the pressure on R&D financing. Financial institutions can also transform carbon reduction activities, such as China Certified Emission Reductions (CCERs), into economic benefits for small- to micro-sized green technology companies, thus reducing credit barriers. For instance, with the support of the China Beijing Green Exchange, a company obtained a CNY 3 million loan using its CCERs as collateral. This loan, based on the historical average CCER transaction price on the Beijing Electronic Trading Platform for Carbon Emission Rights, supported the company's forestry carbon sequestration project and marked the first ever CCER pledge loan in Beijing.
Third, financial institutions provide longer-term loans to companies at the R&D stage, considering factors such as technology levels and market prospects. To address the mismatch between loan terms and R&D cycles in corporate financing, one financial institution has developed the "R&D loan" to effectively resolve the funding shortage for companies at the R&D and trial production stages. So far, it has provided CNY 200 million in low-cost, 5-year dedicated R&D loans to companies. Financial institutions are optimizing product design to meet the diverse needs of companies. Loan terms typically range from 5 to a maximum of 10 years, depending on the nature of the research and development, considering technology iteration cycles, industrialization timelines, and the borrower's ability to repay. Different levels of interest rate concessions are also granted to technology companies of different types and development stages.

Fourth, financial support is extended to upstream and downstream industrial companies through supply chain finance. A city introduced an innovative local green finance product called the "Green Circulation Loan" to expand credit support for companies along the industrial supply chain. It provides financing guarantees or interest rate concessions through centralized and batch lending, following two development models: "Bank + Cooperative + Members + Guarantee Fund" and "Bank + Enterprise + Farmer + Farm". So far, a total of 475 agricultural entities have received Green Circulation Loans amounting to CNY 591 million. Additionally, a bank in Beijing has established an online financing platform to promote the construction of a green and low-carbon transportation network. Their "e-New Energy Loan" financing program incentivizes logistics companies to replace existing trucks with new energy light-duty vehicles.

2.2 Encouragement of Participation in Multi-level Capital Markets

Financial institutions and market infrastructure aim to expand direct financing channels by helping eligible companies raise funds through bond issuance, equity investment, and initial public offerings (IPOs), thus fully utilizing the resources available in multi-level capital markets.

First, the Sci-Tech Innovation Board, also known as the STAR Market, plays a crucial role in enabling direct financing for green technology innovation companies while supporting the virtuous cycle of technology, capital, and industry. As of December 28, 2022, there were 500 listed companies on the STAR Market, and together they have raised nearly CNY 760 billion through IPOs and have a total market capitalization of CNY 6.12 trillion. Many of these listed companies operate within the green and low-carbon technology sector. The STAR Market has implemented a series of institutional innovations in areas such as issuance, listing, trading, refinancing, mergers and acquisitions, and delisting, thus gradually establishing itself as the preferred listing destination for "hard & core tech" companies in China. Notably, it has shown
inclusiveness towards unprofitable companies at the time of listing, companies with special equity structures, red-chip companies, and those meeting specific listing standards, thus enabling their successful listing in China. The launch of the STAR Market has fostered pro-innovation capital investment in early-stage, small-scale, and technology-driven companies, effectively facilitating the entire process of fundraising, investing, and managing funds, as well as the exiting of investments. By effectively integrating capital and innovation elements, the STAR Market has played an active role in promoting the deep integration of the innovation chain, industry chain, funding chain, and talent chain.

Second, financial institutions such as PE and VC firms are encouraged to increase financial support for green technology innovation. Green technology investments involve high risk, but they also offer high rewards, which align with the investment models of PE and VC firms. This trend is particularly noticeable in developed countries with well-established multi-level capital markets. In Silicon Valley, for instance, approximately 80% of VC funds have shifted their focus from IT to renewable energy and energy-saving technologies. This shift ensures a certain level of funding for renewable energy development in the United States. As a result, the renewable energy industry has become the third-largest sector for VC investment in the United States, following the IT and biotechnology industries. In China, the city of Huzhou has attracted 132 renowned domestic and international investment institutions, which have facilitated direct financing in 139 green projects at a combined CNY 12.3 billion.

Furthermore, corporate venture capital (CVC) serves as an additional source of funding for the development and deployment of green and low-carbon technologies. CVC refers to the venture capital divisions of large companies that directly invest in external companies using corporate funds. Fossil fuel companies have begun increasing investments in areas such as hydrogen energy, fuel cells, and electric vehicles as they transition towards sustainability. For example, British Petroleum invested $50 million in FreeWire\(^1\), a company specializing in rapid charging technology for electric vehicles. Additionally, Heart Aerospace, a Swedish startup developing short-range electric aircraft powered by lithium batteries, secured a $35 million investment from investors, including United Airlines and Mesa Air Group. Not only does this facilitate the low-carbon transformation of traditional high-emissions companies, but it also helps bridge the financing gap for the development and deployment of green technologies.

Third, green bonds play a significant role in innovative financing for green and low-carbon projects. Green bonds raise funds to support eligible green industries, projects, or

\(^1\) https://www.iea.org/reports/world-energy-investment-2022
financial activities and encompass various types, such as green financial bonds, green corporate bonds, and green asset-backed securities. With the comprehensive development of net-zero strategies, the top-level design of the green bond market has become increasingly refined. Its market size continues to expand, and various innovative types of green bonds have been introduced to channel funds into environmentally friendly projects. For instance, in February 2023, China Power International Holding Ltd successfully issued CNY 800 million of green Panda Bonds for technology innovation on the Shanghai Stock Exchange. These funds will be fully utilized for clean energy projects, such as wind power and solar energy, in Kazakhstan.

Finally, green indices play a pivotal role in directing funds towards the green and low-carbon technology sector. These indices serve as investment indicators and facilitate the allocation of funds. For instance, the CSI Hydrogen Energy Index (released in April 2023 by China Securities Index Co., Ltd.) selects securities of companies listed on the Shanghai and Shenzhen stock exchanges that are involved in hydrogen production, hydrogen storage and transportation, and hydrogen fuel cells. By tracking these stocks, the index not only represents the development of the hydrogen energy industry but also guides funds towards related companies, thus facilitating investments in, and the development of, hydrogen energy technology.

2.3 Innovations in Linking Multiple Financing Methods

First, financial institutions are employing a range of financing methods to support green and low-carbon technologies, with particular prominence given to the venture loan model. In the Hefei National High-tech Industry Development Zone, the venture loan model plays a significant role by providing loans to research-oriented technology startups aligned with national green development objectives (refer to Column 1 for details). Through the venture loan approach, VC funds make equity or option investments in technology startups that have received bank loans. This in turn gives commercial banks confidence in providing additional loans to these startups or similar companies. During the pilot phase, the finance department of this high-tech zone allocated an additional risk reserve of CNY 20 million to cover potential losses stemming from the pilot bank loans. In cases where risk losses surpass 1% of the non-performing loan ratio, the excess risk reserve, along with the pilot bank, jointly compensates up to 85% of the loan principal.

Second, there is continuous improvement in multi-level risk-sharing mechanisms. One notable example is the "4321" model, which serves as a novel government-backed risk-sharing approach. Under this model, (1) national and provincial government-backed financing guarantee institutions at the city and county levels, (2) provincial-level re-guarantee institutions, (3) financial institutions, and (4) local special fiscal funds collaborate to share credit risks in a
proportion of 4:3:2:1. This model supports various sectors with universal benefits, including green and low-carbon technologies, and establishes and enhances multi-level risk-sharing mechanisms through the cooperative efforts of guarantee companies, insurance institutions, and financial institutions.

Third, the utilization of risk-sharing tools such as insurance is vital in providing comprehensive protection for green projects. For instance, to mitigate the risk of "greenwashing" resulting from inadequate implementation of green technologies in the construction of green buildings, the local government in Huzhou, China, has undertaken innovative collaborations with policy banks and insurance companies to develop green building performance insurance. Incentives, in the form of subsidies amounting to a maximum of 20% of the premium with a cap of CNY 500,000 per project, are offered by the government to encourage project participation in this insurance scheme. Currently, Huzhou has implemented 11 green building performance insurance policies, covering 35% of all green building projects. The total premium has reached nearly CNY 8 million, providing risk coverage of up to CNY 119 million.

### Column 1: The Innovative "Venture Loan" Model in the Hefei National High-tech Industry Development Zone Effectively Addresses the Mismatch between Return and Risks Associated with Investment in the R&D of Green Low-Carbon Technology

Green low-carbon technology companies are characterized by their "light assets, high growth, and high uncertainty", which poses challenges for financial institutions due to the mismatch in risk-return. In response, the Hefei National High-tech Industry Development Zone in Anhui province has developed an enhanced “venture loan” model tailored to R&D-intensive technology companies. This model integrates equity returns and guarantee compensation to assist banks in addressing the risk-return imbalance. By the end of 2022, the four pilot banks had provided loans totaling CNY 390 million to a total of 138 companies under this model, with approximately 25% of these companies operating in the green low-carbon sector. The specific measures are outlined as follows:

The first measure aims to improve financing efficiency through batch processing. This involves a government-led batch recommendation, banks' graded evaluation, and collaboration between banks and the government in credit disbursement. The government establishes a white list of technology-oriented companies and periodically recommends promising and technology-intensive enterprises to banks in batches. Banks assess these companies based on the government's white list and collaborate with government entities during the credit approval process. This approach shifts from the traditional individual-based lending model to a batch-oriented approach,
streamlining credit approval efficiency and reducing risks associated with individual loans.

The second measure introduces the “venture loan” concept, which aims to address the risk-return mismatch by linking lending with investment vehicles. The Hefei National High-tech Industry Development Zone, in partnership with pilot banks, has established a "loan + equity (option)" investment model. Under this model, eligible companies can obtain credit loans of up to CNY 10 million for a 3-year term at an interest rate not exceeding the 1-year Loan Prime Rate (LPR) plus 50 bp. Additionally, the venture capital funds of Hefei Gaoxin Development & Investment Group Co., Ltd make equity investments in technology-oriented companies that have received bank loans. This in turn gives commercial banks confidence in providing loans to these types of companies.

The third measure addresses the challenge of commercial sustainability through the establishment of excess risk reserves. In the initial phase of the pilot program, the High-Tech Zone allocated a CNY 20 million excess risk reserve fund from its fiscal budget. This fund will be utilized to compensate for loan losses incurred by the pilot banks. In cases where the nonperforming loan rate exceeds 1%, the excess risk reserves and the pilot banks will proportionally cover the risk losses, amounting to 85% of the loan principal. As the pilot program evolves, the reserve fund will no longer rely on fiscal injections but will primarily be replenished through the premium returns generated from equity (option) investments in technology-oriented companies made by its VC/PE funds.
3. Experiences on Policy Support

Policy guidance and support at the government level provide critical support and assurance for financing green technology. They mainly include the following categories: (1) setting clear development goals for green industries and creating a stable policy environment that encourages more companies to engage in green innovation as well as enhances investors’ confidence in future returns; (2) optimizing fiscal and financial policies to provide financing support and reduce financing costs; and (3) providing green investment and financing services through various mechanisms and platforms.

3.1 Establishment of Clear Development Goals for Green Industries

Develop comprehensive action plans and corresponding policies aimed at achieving carbon neutrality and promoting green technology, thus integrating them as vital components of regional development strategies to facilitate the advancement and implementation of sustainable innovations. Clearly defined policy objectives contribute to establishing a stable policy environment and enhancing investor confidence. As an illustrative example, Zhejiang province of China has pioneered the implementation of policies that emphasize the importance of augmenting financial and technological investments in green technology. These policies leverage the guiding role of technological innovation funds and foster support from various social entities for research and development in green technology. Furthermore, Zhejiang province aims to enhance the effectiveness of technology investment and financing by fostering a diverse, multi-level, and multi-channel ecosystem. Financial institutions are encouraged to compile a list of green and low-carbon technology commercialization projects while bolstering the assessment, connection, and nurturing of these initiatives. In a similar vein, the Administrative Committee of the Anqing Economic and Technological Development Zone has issued explicit policies to support the growth of the green technology service industry, promote the adoption of environmentally friendly and low-carbon production technologies by industrial enterprises, and facilitate the establishment of public platforms dedicated to the advancement of green and low-carbon industries.

3.2 Optimization of Fiscal and Financial Policies to Reduce Financing Costs

First, provide support for key sectors and strategic companies through fiscal incentives, loan interest subsidies, and government loan guarantees. Fiscal incentives can involve proactive measures, such as offering financial assistance and cash rewards to leading companies in the green and low-carbon industry. These incentives directly enhance project returns. For instance, the Guangzhou Economic and Technological Development Zone in China has introduced industrial
policies that provide increased support for investments in key areas of hydrogen energy. Major projects initiated by hydrogen energy companies or research institutions may receive incentives of up to CNY 100 million. Furthermore, the government has established a CNY 5 billion hydrogen energy industrial fund to financially support hydrogen energy projects.

Regarding loan interest subsidies, eligible green technology research and development companies (or projects) in Huzhou, China, can receive an annual subsidy of up to CNY 500,000. Companies with patent-backed loans can receive a subsidy of up to 50% of the annual benchmark interest rate, with a maximum subsidy of CNY 250,000.

Concerning credit guarantees, the Tongling Economic and Technological Development Zone offers pure credit guarantees for small and medium-sized green and low-carbon companies, reducing premium rates through policy-oriented guarantee companies.

Second, reduce the financing costs for companies through tools such as refinancing and preferential interest rates. In April 2022, the People's Bank of China established CNY 200 billion of refinancing loans for science and technology innovation to provide low-cost funds (1.75%, 1 year, can be extended twice) to financial institutions. Under the premise of independent decision-making and self-assurance of risk, the refinancing loans aim to guide financial institutions to lend to science and technology enterprises. The specific science and technology enterprises to be supported are identified according to the current standards of the Ministry of Science and Technology and the Ministry of Industry and Information Technology. Information on the enterprises is provided to financial institutions through the National Science and Technology Innovation and Entrepreneurship Data Platform and the National Industry Integration Cooperation Platform, among others.

Third, establish green industry funds to cultivate high-quality market entities and to channel funds directly into the green technology sector. Green funds have the opportunity to invest in a large number of high-quality companies by focusing on forward-looking and cutting-edge green fields such as hydrogen energy, solar energy, power batteries, and new energy vehicles. For example, a green industry fund in China led the B-round financing of a technology company, marking the largest single-round equity financing in China's hydrogen energy industry to date. In addition, through collaboration with local governments, top asset management companies, and industry leaders, green industry funds can leverage fiscal resources to guide and stimulate social investment in the green and low-carbon sectors. For instance, the National Green Development Fund contributed CNY 1 billion and jointly established a green carbon private equity fund together with a conglomerate, and a number of insurance companies and investment institutions. This fund represents the largest carbon neutrality-themed fund in the domestic market to date. Moreover, the
market-oriented operating model of green funds investing in the green technology sector ensures sustainability. The National Green Development Fund, for example, adopts a flexible investment and professional management approach. The separation of ownership, management, and trusteeship ensures that the fund's investment management and exit operations follow market rules. Decisions regarding projects under CNY 500 million are made by the management company, while projects above CNY 500 million are evaluated by the fund's experts and approved by the fund's board. This guarantees the efficiency, security, and sustainability of the fund's operations.

3.3 Provision of Green Investment and Financing Infrastructure

First, it is important to establish green technology trading centers. In Zhejiang province, the National Green Technology Trading Center has been established, leveraging the innovation and entrepreneurship center of State Grid Zhejiang Electric Power Company as its foundation. The trading center has established cooperative mechanisms with over 10 financial institutions, providing financial services such as green fund investments and financing through green technology intellectual property pledges. Since its establishment, the center has facilitated CNY 110 million of grants to green technology companies.

Second, the development of full-industrial-chain green platforms is crucial. The Hefei National High-tech Industry Development Zone has implemented a strategy of collaboration between prestigious universities, research institutes, and companies, creating a complete innovation system that spans from original innovation and technology development to commercializing outcomes. Similarly, the Bengbu National High-tech Industry Development Zone supports green technology innovation and promotion in fields such as silicon-based new materials, electronic information, and high-end equipment, by providing support to universities, research institutes, and local companies. The Zone has successfully hosted two international conferences on the new materials industry and has facilitated collaboration activities.

Developed countries have extensive experience in green technology incubators. For instance, in 2010, the European Institute of Innovation & Technology (EIT), a subsidiary of the EU, launched the Climate Knowledge and Innovation Community (Climate-KIC). This initiative represents the largest public-private innovation partnership in Europe, enabling member countries and institutions to share research findings and investment opportunities. Another example comes from the United States, where the Infrastructure Investment and Jobs Act was passed in November 2021. The Act created the Clean Energy Demonstration Initiative, which aims to select, fund, and manage demonstration projects while promoting their adoption in the market through government initiatives. The initiative has currently secured $21.5 billion for the development and deployment
of low-carbon technologies from 2022 to 2025. Of this funding, 37% is allocated to hydrogen hubs, 22% to the grid and energy storage, 16% to CCUS (carbon capture, utilization, and storage), and 2% to industrial emissions reduction. Furthermore, Temasek launched the 6-month “Sustaintech Xcelerator Accelerator Program”. This program aims to enhance the confidence of investors and carbon credit buyers in nature-based solutions.