Ecological Technologies for Green Development and Innovative Mechanisms for Green Finance

Changwei Pang[1], Tai Shan[2,*]

[1]Director Professor of the Russia Central Asia Research Center at China University of Petroleum (Beijing), Beijing, China
[2]Doctoral student at the School of Marxism, China University of Petroleum (Beijing), Beijing, China
*pcw@cup.edu.cn

Abstract. Trump 2.0 announced his withdrawal from the Paris Agreement and the World Health Organization, and increased efforts to develop traditional energy sources, posing challenges to global climate governance. In accelerating green transformation, green industrialization continuously optimizes and innovates its green product design, reducing product carbon footprint through high carbon raw material substitution, reducing consumables, and optimizing process flow. China is firmly committed to achieving its' dual carbon 'goals. Economic greening and green economy are two aspects that constitute the theoretical connotation of green development. The ecological technology system focuses on the development and utilization of renewable resources, which is conducive to the sustainable use of resources and energy. Green technology can effectively save resources and energy, and promote the development of ecological industry and ecological agriculture. Starting from the aspects of energy system, economic system, innovation system, and governance system, in order to promote the smooth realization of green modernization, key challenges and breakthrough paths for systematic reconstruction are proposed.

Keywords: green development, ecological technology, green finance, green technology system

1 Introduction

This paper analyzes from three dimensions: ecological technology, green finance, and green technology innovation system. Ecological technology is the cornerstone of green development. The research and application of advanced energy-saving technologies such as efficient energy management system, intelligent energy control system and new energy-saving materials have significantly improved energy utilization efficiency, reduced energy consumption and reduced carbon emissions. The development of clean energy technology provides a key solution for coping with climate change and realizing energy transformation. Renewable energy technologies such as solar energy, wind energy, hydropower and bioenergy have gradually increased the proportion of clean energy in the energy structure, which has injected a strong impetus into

H. Sun et al. (eds.), *Proceedings of the 2025 10th International Conference on Social Sciences and Economic Development (ICSSED 2025)*, Advances in Economics, Business and Management Research 332,
https://doi.org/10.2991/978-94-6463-734-2_97

the sustainable development of global energy. Ecological protection and restoration technology plays an important role in maintaining ecological balance and restoring damaged ecosystems, ensuring agricultural production and ecological security. Industry-University-Research's deep integration is an important way to promote green technology innovation. Green finance is the booster of green development. Green credit and green insurance reduce the financing cost and risk of enterprises and promote the continuous development of green industries. Green development is inseparable from the innovation drive of eco-technology, the strong support of green finance and the guarantee of green technology innovation system. Eco-technology provides technical support for green development, green finance injects capital power for green development, and green technology innovation system creates a good innovation environment for green development. Only when the three work together can we achieve sustainable economic and social development and promote the global green development process.

2 The Implementation Path of Green Development

2.1 From Economic Greening to Green Economy

Economic greening and green economy are two aspects that constitute the theoretical connotation of green development. The emphasis of the two is different. Economic greening is to transform the economic development mode according to the goal of green ecology, promote the green transformation of the economic system, achieve the decoupling of economic growth and resource and environmental load, and improve the sustainability of resources and environment while achieving economic growth. Green economy aims to make green ecology profitable, which is a higher-level goal of green development.

From the logic of green development, we should first address the issue of economic greening, which is the goal of a higher stage of green development. Economic greening requires efforts from both additive and subtractive aspects to promote the green transformation of the economic system. The so-called addition is to explore new economic growth drivers that are in line with the green development orientation. Developing incentive policies for green development, accelerating innovation in green technologies, promoting the development of green industries, and transforming traditional industries with green technologies can simultaneously achieve economic growth and improve resource and environmental sustainability. The so-called subtraction emphasizes that economic growth should follow natural laws, transform the economic development mode according to green and ecological requirements, and not increase or decrease the burden on resources and environment. When the goals of ecological protection and economic development conflict, on the one hand, it is necessary to emphasize that the load of resources and environment should not exceed the natural carrying capacity, and use the natural carrying capacity as a hard constraint to force industrial transformation. On the other hand, it is necessary to increase efforts in environmental pollution control, win the battle against pollution prevention and control, and effectively solve prominent environmental pollution problems. [1]To promote

the green transformation of the economic system around the goal of economic greening, it is necessary to fully leverage the role of green development policies, conduct in-depth research on the effectiveness of green development policies, and clarify the positioning of green development policies in the path of economic greening. One is to use the natural carrying capacity to constrain and force industrial transformation. The second is to use environmental regulations to promote environmental pollution control. Thoroughly analyze the cost of environmental pollution control and the behavioral mechanisms of environmental governance entities, and grasp the effectiveness of environmental governance policies. The third is to use green development incentive policies to encourage the development of green industries. Thoroughly analyze the economic feasibility of green technology and the cost of industrial green transformation, grasp the effectiveness of green development incentive policies, and establish an incentive mechanism for the development of green industries.

2.2 Regional Differences in the Implementation Path of Green Development

Due to the different stages of green development in different regions, the implementation path of green development also varies. The dynamic evaluation results of green development show that different types of cities and regions have adopted different green development strategies. We have adopted a strategy of addressing the "shortcomings" of green cities, coordinated development of cities, and low-level development of cities. The main problem faced by cities that adhere to green principles and promote coordinated development in 2020 is low economic performance, resulting in a majority of cities experiencing faster economic performance improvement; The main problem faced by low development cities is environmental sustainability deviation, so sustainability improvement is faster, and the "shortcomings" of sustainability have been significantly addressed. Economic leading cities have adopted more strategies with strong advantages. Due to the good foundation of environmental sustainability, under the inertia of economic growth thinking, the increase in economic performance scores is greater, which further exacerbates the imbalance between economic growth and environmental sustainability. It is worth noting that a few low development cities have not yet shaken off the traditional model of exchanging environment for development, and should strive to achieve a decoupling development between economic growth and resource and environmental loads.

The key to green economy is to make green ecology profitable, and green development can promote economic growth and enhance corporate competitiveness. The main way to achieve green economy is through additive methods, realizing the value of ecological products, transforming ecological advantages into economic advantages, and making green mountains and rivers become invaluable assets. To transform the value of ecological products into economic value, on the one hand, we need to strengthen the construction of ecological infrastructure, increase the supply of local public goods, improve the hard environment for green development, and provide material support for the realization of ecological product value; On the other hand, it is necessary to strengthen the institutional design of green certification, green supervision, green finance, etc., improve the soft environment for green development, pro-

vide institutional guarantees for the realization of ecological product value, and actively explore the practical transformation of ecological product value. At present, the policy system for green economy still lags behind economic greening, and there is an urgent need to improve the institutional and policy design for green economy.

Heidegger pointed out that the essence of modern technology is a "framework", which always forces nature to give up what it needs from the perspective of technology, causing nature to lose its integrity. Air is placed for the production of nitrogen, land is placed for minerals... while atomic energy can be released for the purpose of destruction or peaceful use. On the contrary, traditional techniques always respect and conform to nature, such as "the wings of a windmill do indeed rotate in the wind, they directly let the wind blow, but the windmill did not develop the energy of the airflow to store energy"[2].In the eyes of the British natural theist poet William Wordsworth, nature was brimming with divinity. "In Wordsworth's poetry, one often encounters the celebration and praise of human nature, which is precisely the influence of the humanistic view of natural theism on him."[3]

3 Ecological Technology: The Underlying Support for Promoting Low-carbon Transformation

The most essential characteristic of ecological technology is that it does not cause or causes minimal environmental pollution and ecological damage when used. Ecological technology is based on the latest scientific knowledge developments in environmental science, ecology, sustainable development theory, and information science. Ecological technology innovation involves interdisciplinary fields such as ecology, physics, biology, chemistry, and environmental engineering. Ecological technology is based on the development and utilization technology of energy (mainly renewable energy such as solar energy), centered on high-tech such as biotechnology, information technology, and nanotechnology, supplemented by various renewable or resource utilization technologies, forming a structurally reasonable integrated composite technology network system. The ecological technology system focuses on the development and utilization of renewable resources, which is conducive to the sustainable use of resources and energy. Traditional technology is based on the development and utilization of non renewable resources. For example, metal smelting technology, mineral mining technology, inorganic chemical technology, and so on. The development of traditional technological systems inevitably leads to rapid consumption of resources, ultimately resulting in resource depletion.

Ecological technology is a technological system. Ecological technology does not refer to a single technology, but rather a group of interrelated technologies, including not only industrial clean production and ecological agriculture, but also ecological destruction and prevention technologies for sewage, waste gas, and solid waste, as well as pollution control biotechnology and environmental monitoring high-tech. Such as alternative technologies, reduction technologies, resource utilization technologies, reuse technologies, etc.

From the perspective of architecture, ecological technology should be based on renewable energy such as solar energy and bioenergy as the main energy foundation, with high-tech such as biotechnology and information technology as the center, supplemented by various renewable or low consumption conventional technologies, forming a structurally reasonable integrated composite technology network system. Green technology supports the formation of green production methods. Integrating green technology comprehensively into workers, labor materials, and labor objects can improve the efficiency of material transformation between humans and nature, and promote the development of new quality productivity. To further leverage the positive role of green ecological technology in empowering harmonious coexistence between humans and nature in modernization, we must first completely abandon the influence of industrialized technological views and comprehensively establish an ecological technological view; Secondly, we need to promote green technology innovation and improve the green technology system.

3.1 Energy Technology Revolution

Green technology can effectively save resources and energy, search for new energy, improve waste utilization efficiency, reduce production waste emissions, and promote the development of ecological industry and ecological agriculture. The use of enzymatic desulfurization technology can achieve a sulfur elimination rate of 80% in coal. "[4]

The technological direction of China's energy technology revolution is to innovate key technologies in the ten major fields of nuclear energy, wind energy, solar energy, energy storage, oil and gas resources, clean coal, hydropower, biomass energy, integration of smart grid and energy grid, and energy conservation. It aims to develop various biomass energy industries, plan and develop technologies such as energy plant breeding and planting, agricultural and forestry waste energy chemical industry, characteristic agricultural and forestry waste resource utilization, livestock and poultry manure energy chemical industry, collaborative disposal and utilization of various wastes, and comprehensive utilization of solid waste in daily life.

(1). Industrial decarbonization technology

-Carbon Capture and Storage (CCUS): The Northern Lights project in Norway stores 1.5 million tons of CO_2 annually, while the Qilu Petrochemical Shengli Oilfield project in China achieves integrated capture, displacement, and storage.

-Electric arc furnace steelmaking: Sweden's HYBRIT project replaces coke with green hydrogen, reducing carbon emissions by 90%. The estimated cost of global steel industry transformation is $1.3 trillion.

-Biobased materials: Bolt Threads in the United States has developed mycelial leather, which emits only 1/10 of the carbon emissions of animal leather.

(2). Smart ecosystem management

-AI+ecological monitoring: Microsoft AI for Earth platform analyzes 12 million satellite images to accurately identify hotspots of Amazon rainforest degradation.

-Vertical Agriculture System: Sky Greens hydroponic farm in Singapore has a yield per unit area that is 10 times higher than traditional agriculture and reduces water consumption by 95%.

-Blue Carbon Economy: Mangrove restoration projects (such as Blue Carbon in the United Arab Emirates) can sequester 10 times the annual carbon per hectare of tropical rainforests.

Ecological technology innovation urgently requires institutional collaborative innovation, such as the government formulating fiscal and tax subsidy policies from both supply and demand sides to support the development of new energy vehicles. At the same time, a green ecological technology innovation system led by the government, with enterprises as the main body, market-oriented, industry university research collaborative innovation, and extensive public participation. Stimulating the driving force for the development of green technology, such as reshaping the market competition mechanism through the design of resource and environmental paid use system, carbon emission trading system, and green finance and taxation system, forcing enterprises to adopt green technology to seek their own development. Improve the mechanism for the transformation and promotion of green technology achievements, increase the conversion rate of green technology achievements and the speed of their promotion throughout society, such as establishing a green technology innovation and promotion service center for enterprises, providing one-stop services such as consulting and intermediaries; Improve green technology promotion demonstration bases and innovation and entrepreneurship parks; Digitize and disseminate new knowledge and technologies through digital technology and its platforms; Promote public acceptance of knowledge and skills training related to green technology through education.

3.2 Vigorously Promote the Transformation of the Energy System

Reducing emissions is not about reducing productivity or not emitting, but about taking the path of ecological priority, green and low-carbon development, promoting green transformation in economic development, and achieving greater development in green transformation. We must adhere to overall planning, ensure energy security, industrial chain supply chain security, food security while reducing carbon emissions, and ensure the normal life of the people. "

The primary task that needs to be addressed in green modernization is to promote energy transformation and establish a clean, low-carbon, and efficient modern energy system

Firstly, we must base ourselves on the national energy and resource endowment, adhere to the principle of first establishing and then breaking, and overall planning and layout. We must vigorously develop new and clean energy to form safe and reliable new energy. On this basis, we will gradually withdraw from traditional fossil fuels, strengthen risk control, and ensure the safe and stable supply and transition of energy.

Secondly, it is necessary to make reasonable use of the national energy production foundation, vigorously promote the clean, low-carbon, safe and efficient utilization of

energy, and take the lead in deepening the green and low-carbon transformation in industries such as construction and transportation.

Thirdly, we will continue to implement the energy development strategy that prioritizes energy conservation, comprehensively improve energy utilization efficiency, improve the energy management system, accelerate the implementation of energy-saving and carbon reduction upgrades, vigorously promote the deep integration of modern energy technology with modern information, new materials, and advanced manufacturing technology, take the lead in deepening the reform of the energy system and mechanism, and provide a foundation for improving the unified energy market.

A new round of technological revolution and industrial transformation is emerging, and emerging energy technologies are accelerating their replacement of traditional energy technologies at an unprecedented speed, which will continue to change the world energy landscape. China closely follows the pace of energy industry transformation and upgrading, concentrating its efforts to accelerate

Breaking through major key technological bottlenecks, promoting the energy technology revolution to lead significant changes in energy production and consumption patterns, and facilitating the coordinated advancement of energy technologies across multiple fields.

-Scale up of renewable energy: The cost of photovoltaic power generation has decreased by 90% in ten years, the single unit capacity of offshore wind power has exceeded 20MW, and solar thermal power generation and molten salt energy storage technology have achieved 24-hour stable power supply.

-Breakthrough in the hydrogen energy industry chain: Green hydrogen production (alkaline electrolysis cell efficiency reaches 80%), liquid hydrogen storage and transportation (Kawasaki Heavy Industries -196 ℃ transportation technology), and fuel cell (Toyota Mirai range of 850 kilometers) form a closed loop.

-The fourth generation technology of nuclear energy: China's Shidao Bay high-temperature gas cooled reactor realizes direct power generation from helium turbines, increasing the efficiency of nuclear hydrogen production to 50%.

4 Green Finance Mechanism: Paradigm Reconstruction of Capital Allocation

The development of green finance has strong environmental positive externalities. From the perspective of green premium, green premium refers to the difference between the cost of clean zero carbon production and the cost of carbon containing production. The lower the green premium, the smaller the cost gap between clean production and traditional production methods.

We should guide market resources and social funds to enter the climate field, and stimulate green finance to move towards a new stage of development. After fully mobilizing social funds into the green industry, the green premium gradually decreases or even turns negative, and its attractiveness to market funds will become increasingly high. Therefore, the resource allocation role of green finance also helps to promote social capital to enter industries with low green premiums.

Green finance guides the flow of funds to weak links. The rational guidance role of green finance in resource allocation also needs to be played in directing more funds to weak links, expanding the coverage of green finance, and strengthening the comprehensive support of finance for the real economy. At the same time, the coverage of green finance should be improved from the perspective of proactive transformation. Many small and medium-sized enterprises and other "climate sensitive groups" that are greatly affected by climate have a low level of participation in green investment and financing, making it difficult to effectively obtain the support and convenience brought by green funds. Therefore, for the development of green finance targeting small and medium-sized enterprises, the primary task is to overcome the information asymmetry problem in environmental detection and assessment. Only by developing large-scale and low-cost environmental assessment products for small and medium-sized enterprises can we reduce the information barriers for green funds to flow into them, and improve and upgrade traditional credit evaluations through green credit transformation and climate financing

Estimation mode and credit rules.

Give full play to the inclusiveness of green financial resource allocation. The inclusiveness of green finance is an important element of the resource allocation function of green finance, and the targets of inclusive green finance, such as natural persons, small and medium-sized enterprises, farmers, low-income groups, etc., are precisely the groups that need the support of green finance the most in climate change. Green digital technology can gradually compensate for the information asymmetry between inclusive groups and banks in green credit activities. The credit system in the digital age has been improved through data, and it will not be entirely based on fixed assets. The credit evaluation of the subject also depends on its future repayment ability. Digital technology can not only empower low-carbon and energy management in the production process, but also provide standardized and scaled green models for the financing process. The most fundamental aspect is the unified management of individual and enterprise carbon accounts through financial big data, which connects multiple aspects such as carbon account accounting, carbon emission statistical accounting, environmental impact assessment, and green financing emission reduction benefit evaluation. By using green technology to master carbon assets, green economy can be integrated into the development of digital economy, and green finance can achieve inclusiveness in rational and optimized resource allocation.

(1). Market driven tools

-Carbon pricing system: The EU carbon price has exceeded 100 euros/ton, China's national carbon market covers 4.5 billion tons of emissions (accounting for one-third of the world), and the California Quebec carbon market linkage forms a cross regional pricing model.

-Green Bond Standards: The International Capital Markets Association (ICMA) Green Bond Principles require transparency in the use of funds, with a global issuance of $600 billion by 2023 and China's "carbon neutral bonds" accounting for over 30%.

-ESG investment rating: MSCI ESG rating covers 8500 companies, reducing financing costs for high rated enterprises by 0.5-1 percentage point.

(2). Policy innovation mechanism

-Central bank climate intervention: The European Central Bank will include carbon footprint in the collateral framework, and the Federal Reserve's stress tests will be included in climate scenario analysis.

-Transition Financial Framework: Japan has introduced the "Climate Transition Classification System" to clarify the financing standards for technology roadmaps in high carbon industries such as steel and chemicals.

-Sovereign Green Fund: Norway's sovereign fund withdraws investment in 54 coal companies, UAE sets up $30 billion ALT É RRA climate fund focused on global southern projects.

(3). Risk hedging tools

-Climate derivatives: Chicago Mercantile Exchange (CME) launches regional drought index futures to hedge agricultural climate risks.

-Green Insurance Securitization: The Caribbean Catastrophic Risk Insurance Fund (CCRIF) issues $150 million in bonds to cover hurricane losses.

-Natural Related Financial Disclosures (TNFD): Companies are required to assess their biodiversity dependence, and HSBC has included it in its loan risk assessment.

5 Improve the Green Technology Innovation System

To deeply understand the major task of green modernization, we need to start from the aspects of energy system, economic system, innovation system, and governance system to promote the smooth realization of green modernization. Continuously implementing the innovation driven development strategy, accelerating the green and low-carbon technological revolution, accelerating the improvement of green technology innovation, industrial innovation, and institutional mechanism innovation, forming a safe and shared green technology innovation system, and enhancing China's overall innovation capability are the scientific and technological foundation tasks for achieving green modernization in China. [5]

Firstly, all innovation entities should actively strengthen their efforts in tackling green and low-carbon technologies, increase the research and development of advanced technologies, and vigorously promote their application. They should continue to improve the evaluation and trading system of green and low-carbon technologies, promote the effective transformation of scientific and technological innovation achievements, and lead the exclusive low-carbon industrial structure and energy structure of urban agglomerations based on scientific and technological innovation.

Secondly, the country will continue to increase investment in science, technology, and education, enrich talent training models, encourage higher education institutions and research institutes to expand the scale of talent training, and strengthen the construction of science and technology related disciplines. Through comprehensive measures, we will promote the further improvement of the green technology innovation system and provide technological support for China's green modernization.

Key challenges and breakthrough paths

(1). Technological financial synergy bottleneck

-The IRR of the hydrogen energy project is less than 8%, and market risk needs to be reduced through the German H2Global contract for difference mechanism.

-In the early stage of the carbon capture project, CAPEX accounts for 70%, and a gradual subsidy in the form of Dutch SDE++needs to be designed.

(2). Strengthen international cooperation and bridge the North South divide

-Drawing on the Just Energy Transition Partnership (JETP), South Africa has received $8.5 billion in support for the retirement of coal-fired power.

-The International Monetary Fund (IMF) has increased the Resilience and Sustainability Trust (RST) quota to $100 billion.

(3). The Data Governance Revolution

-Blockchain carbon traceability: IBM Food Trust tracks coffee carbon footprint with an error rate of less than 5%.

-Satellite remote sensing financial applications: The World Bank uses NASA data to develop a global methane monitoring financing platform.

Economic activities require the organic connection of various production factors in production, distribution, circulation, and consumption, in order to achieve circular circulation. "[6] Vigorously promote the efficient and smooth flow of production factors in various links, and comprehensively achieve green modernization. In the exchange link of the economic system, accelerate the planning and construction of a "channel+hub+network" circulation pattern, improve transportation, warehousing, and logistics infrastructure, increase the application of high-tech in the transportation and logistics field, promote green, low-carbon, circular and efficient resource exchange, and comprehensively achieve green exchange. In the consumption sector of the economic system, we advocate for green consumption and low-carbon travel, and increase efforts to promote the concept of green and low-carbon consumption. Realize green consumption. Enrich economic means to stimulate green consumption, promote the formation of green lifestyles and consumption patterns.

Future vision: Systematic restructuring

-On a technical level: By 2030, the levelized cost of photovoltaic energy storage (LCOE) may fall below 0.01 US dollars per kilowatt hour, and CCUS costs will decrease to 30 US dollars per ton.

-Financial aspect: ISSB global disclosure standards are enforced, and carbon tariffs (CBAM) trigger global supply chain restructuring.

-At the governance level, based on the principle of "common but differentiated responsibilities+respective capabilities", a triangular framework of technology transfer, capital flow, and data sharing is formed.

6 Conclusion

Global climate governance is undergoing a deep transformation from "emission reduction commitments" to a "technology finance system" trinity, and its success or failure will determine whether humanity can achieve sustainable development under

the "2 ℃ hard constraint" by the end of this century. In accordance with the Paris Agreement and the requirements of the first global inventory, the 2035 Nationally Determined Contributions (NDCs) target will be timely communicated to the Secretariat of the United Nations Framework Convention on Climate Change this year. China's carbon emission intensity continues to decline, the proportion of non fossil energy consumption is steadily increasing, and the forest storage volume and total installed capacity of wind and solar power have reached the international commitment targets ahead of schedule. The "2024 Emissions Gap Report" released by the United Nations Environment Programme points out that countries must update their Nationally Determined Contributions (NDCs) with greater ambition and action, otherwise the 1.5 ℃ target of the Paris Agreement will disappear within a few years. China balances economic growth and ecological protection through sustainable development of ecological technologies and green finance mechanisms, and continuously promotes the "dual carbon" strategy through the dual drive of technological innovation and financial mechanisms. By 2050, China will further increase environmental governance, improve the quality of the ecological environment, actively promote carbon emission control and energy transformation, deeply participate in global environmental governance, and enhance China's voice and influence in the global environmental governance system. The long-term goal for carbon emission control by 2060 is mainly to achieve a basic stability in total energy consumption, with non fossil energy accounting for more than half of primary energy consumption, significantly reducing carbon emissions, and striving to achieve carbon neutrality before 2060.

References

1. Shi Minjun: China's Economic Green Development: Concept, Path and Policy, China Renmin University Press, 2021
2. Heidelberg (2016). Heidegger: Selected Works of Heidegger, translated by Sun Zhouxing, Shanghai Sanlian Bookstore 1996.
3. Nie Meng: Research on Wordsworth's View of Nature, Wuhan University Press 2021.
4. Zhang Yunfei:" Research on the Systematic Approach to Ecological Civilization Construction ", People's Publishing House, 2023.
5. Jiang Xiaojuan, Yang Weimin, Cai Fang, Liu Wei, Hu Angang, Xue Lan, Zhou Shaojie: Evolution and Prospect of China's Economic Development Model, People's Publishing House, 2024.
6. Selected Readings of Xi Jinping's Works, Volume 2, People's Publishing House, 2023.