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Carbon Asset Management System and Trading Strategies: Empowering Listed Companies in Value Reassessment and Sustainable Development

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Abstract: Carbon asset management and trading are not only important means for enterprises to cope with environmental challenges but also a strategic pathway to promote the sustainable development of enterprises. Upon the definition of core concepts such as carbon assets and carbon asset management, and guided by theories of environmental economics and low carbon economy, this study explores how carbon asset management system and trading influence the development of listed companies from four aspects: providing policy support for carbon trading of listed companies by promoting the carbon asset management system; creating channels for listed companies to improve their value creation capabilities through carbon trading; laying a solid foundation for the sustainable development of listed companies with carbon asset trading and management; and helping enterprises improve the level of positive externalities through carbon asset trading and management. At the end of the study, combined with the development situation of carbon asset management and trading in China, a localized strategy for optimizing the carbon asset management system and trading strategies of listed companies in China is proposed from three levels: improving the top-level system design, optimizing trading portfolio strategies, and perfecting corresponding supporting measures related to talents and finance. It is hoped that this study can provide valuable insights for more listed companies in their development within the field of carbon asset management, and that the study results can accelerate the comprehensive improvement of China's carbon asset management capabilities and contribute to the modernization development characterized by harmonious coexistence between humanity and nature.

KeyWords: Carbon Asset Management System; Carbon Asset Trading; Value Reassessment; Sustainable Development
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1.Preface

After more than 30 years of evolution, global climate governance is now facing challenges such as escalating climate risks, insufficient momentum for emission reduction actions, fragmented governance systems, and threats from unilateral trade measures. At present, global warming has become a serious ecological crisis that humanity is facing. According to the IPCC's Sixth Assessment Report Working Group I report, "Climate Change 2021: The Physical Science Basis", the current global average surface temperature is approximately 1.1°C higher than that in pre-industrial period. Projections for the average temperature change over the next 20 years indicate that global warming is expected to reach or exceed 1.5°C. Climate warming in all regions will intensify, and extreme heat and other extreme weather events will also increase. The realistic

pressures of climate change have promoted the development of global climate governance. By the end of 2024, more than 250 countries or regions, 258 cities, and over 10,000 companies around the world had committed to carbon neutrality in various forms. These countries account for 88% of the global carbon emissions, 92% of the global GDP, and 89% of the global population. Driven by scientific advancements and policy imperatives, factors such as investment, technology, industry, and employment interact with carbon neutrality goals, making carbon asset management a social development objective in more and more countries.

Carbon peak and carbon neutrality, as policy orientations that can significantly mitigate global warming, are gradually becoming a global consensus. As the world's second-largest economy and the largest carbon emitter, China solemnly announced at the global environmental governance meeting in September 2020 that it would strive to achieve carbon peak by 2030 and carbon neutrality by 2060. This marks the first time China has clearly communicated to the world the timeline for completing its carbon neutrality strategy as a major energy-consuming country. China will achieve the world's largest reduction in carbon emission intensity in the shortest time in global history (within only 30 years), and realize the transition from carbon peaking to carbon neutrality. This not only highlights China's active concern for global environmental issues but also demonstrates to the international community its unremitting efforts as the world's largest developing country for global environmental governance and its spirit of responsibility of a major country reflected behind it. The establishment of a carbon asset management system and optimizing carbon asset trading strategies are key steps to achieving the development goals of "carbon peaking and carbon neutrality". As important entities in economic activities, the carbon asset management level and trading strategy selection of listed companies not only concern their own sustainable development capabilities but also have a profound impact on the green transformation of the overall economy and society. An effective carbon asset management system can help listed companies accurately account for and manage their carbon assets, reduce carbon emission costs, and improve resource utilization efficiency. While scientific carbon asset trading strategies can bring new profit growth points for enterprises, maximizing the value of carbon assets through market mechanisms. Therefore, in-depth research on carbon asset management system and trading strategies is of great practical significance for empowering listed companies in value reassessment and promoting their low carbon, green, and sustainable development.

2.Concept Definition and Basic Theories of Carbon Asset Management

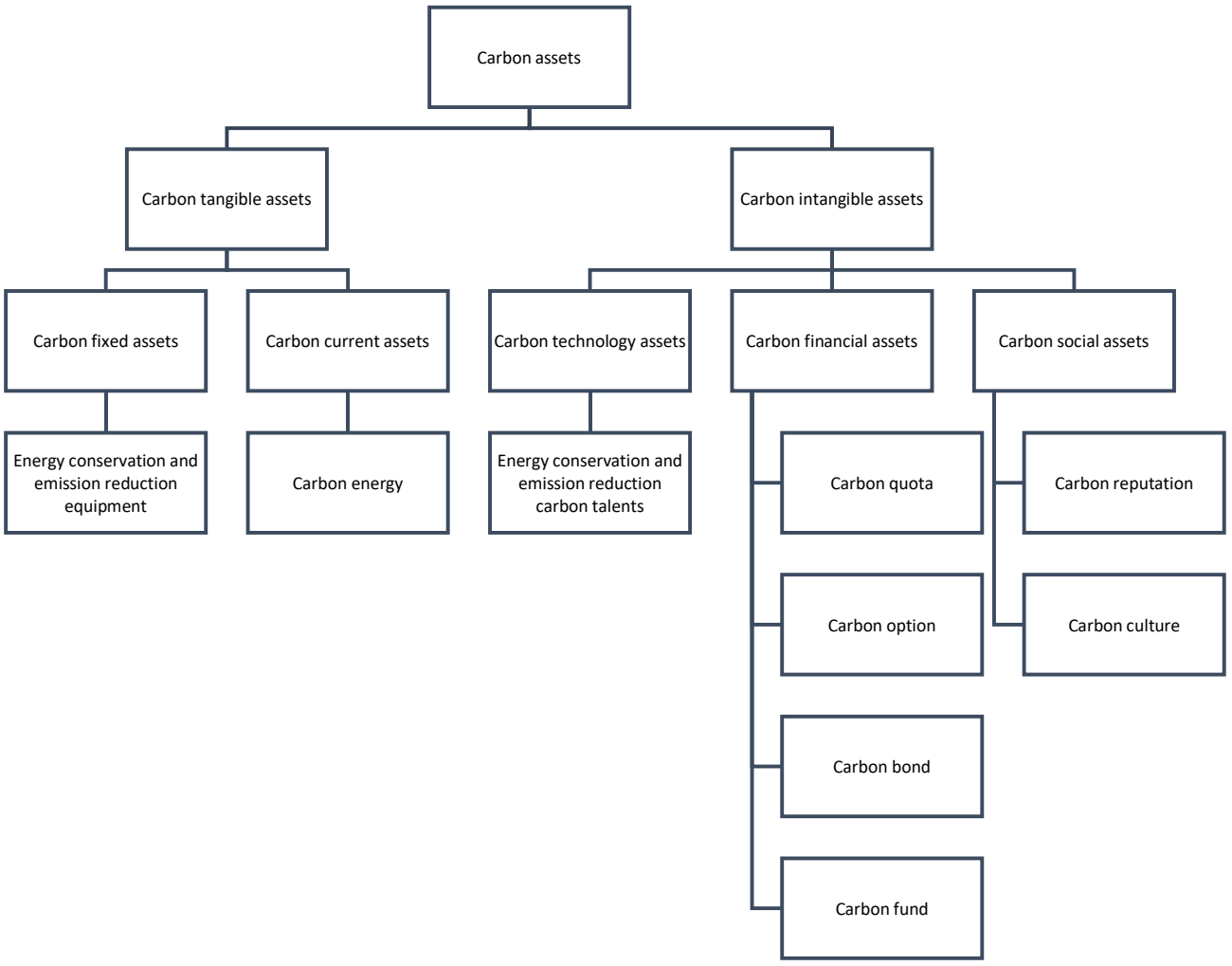
2.1 Concept of Assets and Carbon Asset

From an economic perspective, assets are typically defined as resources formed from past transactions or events of an enterprise, which are owned or controlled by the enterprise and are expected to bring economic benefits to the enterprise. According to this definition, it can be known that carbon emission rights are the most typical carbon assets. Specifically, these can be categorized into two types. One type is the government-allocated carbon assets, and the other type is voluntary emission reduction carbon assets. The former is the carbon emission allowances (CEA) allocated by the government to enterprises. Through internal energy-saving and emission-reduction activities, enterprises can save the surplus carbon emissions and can trade them on the carbon emission trading market, or conversely, enterprises may purchase surplus CEA transferred by other entities. The latter is distinct from the mandatory government-allocated allowances and highlights the "voluntary" principle. Enterprises can apply to relevant authorities for verification and certification of emission reductions achieved through their internal activities. After successful certification, enterprises will obtain Clean Development Mechanism (CDM) projects or China Certified Emission Reduction (CCER) projects, which can also be traded on the carbon emission trading market.

The connotation of carbon assets is not limited solely to carbon emission rights. With the continuous deepening of research on carbon assets, elements such as an enterprise's energy-saving and emission-reduction capabilities and technological innovation capacity have gradually been incorporated into the scope of carbon assets, further expanding the concept scope. Generally, the scope of carbon assets in the narrow sense only includes carbon emission rights and a series of related derivative financial products, and only has the core characteristic of economic attributes. In contrast, the scope of carbon assets in the broad sense is broader. In addition to the carbon emission rights, it covers various technological improvement activities undertaken by enterprises to reduce carbon emissions, such as the development of energy-saving and emission-

reduction equipment and the application of clean energy. As can be seen from Figure 1, carbon assets in the broad sense have both social and economic attributes: on the one hand, they can directly bring economic benefits to enterprises through the carbon emission trading market; on the other hand, they can indirectly cultivate new economic growth points for enterprises by fulfilling social responsibilities and enhancing corporate reputation. Given that this paper needs to comprehensively explore the specific pathways of carbon asset management in case companies, the broad definition of carbon assets is adopted in this study, that is, carbon assets include both intangible carbon assets and tangible carbon assets.

Figure 1 Structure of Carbon Assets in the Broad Sense



2.2 Concept of Carbon Asset Management

Based on the aforementioned definition of carbon assets in the broad sense, the carbon assets management pathways are also diverse. From the perspective of management pathways for carbon assets, the management can be classified into three main categories, namely: carbon emission allowance management, which is related to emission reduction technologies; voluntary emission reduction project management, which is closely linked to market trading; and comprehensive carbon asset management.

The first category is carbon emission allowance management, which primarily involves the allocation, use, trading, and monitoring of carbon emission allowances allocated by the government to enterprises. Enterprises should rationally plan their carbon emissions based on their production conditions to ensure they do not exceed their allowances allocated by the government. Meanwhile, they can buy or sell surplus or insufficient carbon emission allowances through market trading mechanisms to maximize their cost efficiency.

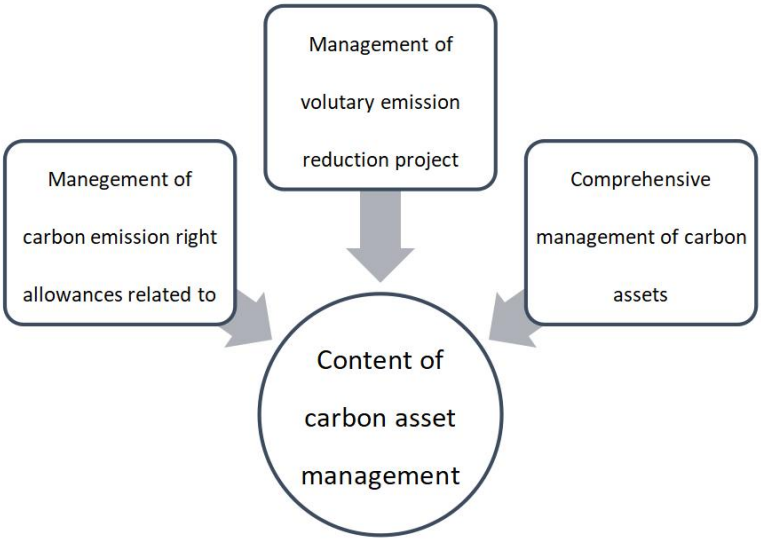
The second category is voluntary emission reduction project management, which focuses on enterprises' reduction of greenhouse gas emissions by independently implementing energy-saving and emission reduction projects, such as using clean

energy, improving energy efficiency, and conducting afforestation for carbon sequestration. Enterprises can convert these emission reductions into tradable carbon credits and trade them in the carbon market through Clean Development Mechanism (CDM) projects or China Certified Emission Reduction (CCER) projects to obtain economic benefits.

The third category is comprehensive carbon asset management, which is a more holistic and systematic approach. It not only covers the carbon emission allowance management and voluntary emission reduction project management but also involves multiple aspects such as risk management of carbon assets, investment strategies, information disclosure, and communication with stakeholders. Through comprehensive carbon asset management, enterprises can more effectively integrate internal resources, optimize the allocation of carbon assets, and enhance the value of their carbon assets. At the same time, they can actively respond to national carbon neutrality policies, promote green and low carbon transition, and achieve sustainable development.

Based on the conceptual connotation of carbon asset management, the carbon asset management system refers to the top-level design of carbon asset management for enterprises, that is, ensuring the completeness and reliability of carbon information disclosure through the establishment of systems, and also including the control of possible carbon risks of the enterprise.

Figure 2 Content Structure of Carbon Asset Management



2.3 Theoretical Foundations of Carbon Asset Management

2.3.1 Theory of Low Carbon Economy

The theory of low carbon economy is an important fundamental theoretical basis for promoting carbon asset management. The theory originates from the UK Energy White Paper Our Energy Future: Creating a Low Carbon Economy in 2003, which refers to reducing high-carbon energy consumption and greenhouse gas emissions through technological innovation, institutional optimization, industrial transformation and other means under the premise of ensuring sustained economic growth, and achieving the “decoupling” of economic development and carbon emissions. The theory breaks the traditional view that economic growth is inevitably accompanied by high emissions, clarifying the development path with low energy consumption, low pollution, and low emissions. Carbon asset management precisely enables enterprises to control the total amount of emissions through allowance management and explore the potential for emission reduction through voluntary emission reduction projects. These measures are essentially concrete responses to the carbon reduction goals of a low carbon economy. With the continuous enrichment of the theory of low carbon economy, international organizations and academia have further expanded its connotation. For instance, the United Nations Development Programme (UNDP) proposed in its Human Development Report that “a low carbon economy must balance ecological benefits with social equity”, emphasizing the need for enterprises to consider issues such as employment security and equitable technology access during the process of carbon reduction. This extension also directly affects the category of carbon asset management, driving its transformation from mere emission control toward integrated value management.

Guided by the theory of low carbon economy, carbon asset management not only focuses on the control of carbon emissions

and the improvement of resource utilization efficiency within enterprises, but also emphasizes the interaction and coordination between enterprises and the external environment. Enterprises need to establish a comprehensive carbon asset management system, clearly define the objectives, principles, procedures, and responsibilities of carbon asset management, and ensure the effective accounting, monitoring, and trading of carbon assets. Building a carbon trading market and optimizing trading strategies, it not only provides a positive external environment for the operation and development of enterprises, but also promotes the value creation and sustainable development of carbon trading companies.

2.3.2 Environmental Economics Theory

The theory of environmental economics originated from the explorations of synergistic development of the economy and the environment in the early 20th century. In 1920, Arthur Cecil Pigou first proposed the “externality theory” in his The Economics of Welfare, clarifying the concept that the public product attribute of environmental resources would lead to market failure. And the core logic of environmental economics lies in “internalizing” environmental externality through institutional design, making market entities bear all the costs and benefits of their environmental behaviors, thereby steering resources toward low carbon and efficient allocations.

The core connotation of environmental economics can be summarized into three dimensions: First, the internalization of externalities. Through measures such as carbon taxes and carbon markets, the negative externalities of carbon emissions are transformed into explicit corporate costs, compelling enterprises to strengthen their carbon asset management. Second, the definition of environmental property rights. Based on the Coase Theorem, it clarifies the ownership of environmental resources, providing a theoretical basis for the allocation and trading of carbon allowances. Third, the environmental value pluralism, which challenges the traditional perception that the environment is valueless, categorizes the value of environmental resources into economic, ecological, and social values, providing theoretical support for the concept that carbon assets in the broad sense possess both economic and social attributes. The theory of environmental economics provides critical guidance for carbon asset management. By defining carbon asset property rights and establishing carbon trading markets, it enables enterprises to buy and sell emission rights based on their specific carbon emission levels and abatement costs, thereby achieving optimal allocation of carbon assets. This market mechanism not only can incentivize enterprises to proactively reduce emissions but also can promote the development and application of low carbon technologies, driving the low carbon transition of the entire society.

It can be seen from this that the theoretical foundation of carbon asset management covers multiple aspects, including the theory of low carbon economy and the theory of environmental economics. These theories provide a solid conceptual basis and directional guidance for carbon asset management, promoting the continuous evolution of carbon asset management from concept to practice.

3.Analysis of The Path of Carbon Asset Management System and Trading Affecting the Development of Listed Companies

3.1 Carbon Asset Management System Provide a Policy Basis for Carbon Trading by Listed Companies

The carbon asset management system establish a solid policy foundation for the compliant execution of carbon trading by listed companies through clarifying rules, standardizing procedures, and controlling risks. From the operational perspective, the system will unify carbon asset accounting standards, helping enterprises accurately measure the scale of carbon assets such as emission allowances and voluntary emission reductions, thereby avoiding transaction disputes caused by inconsistent accounting standards. Furthermore, the system will specify detailed operational procedures for carbon trading, including timelines and operation requirements for allowance applications, compliance surrenders, and carbon credit transactions, ensuring that enterprises have clear rules to follow when conducting transactions. The EU Emissions Trading System (EU ETS), as the longest-operating and most mature transnational carbon market in the world, has developed a systematic institutional system through nearly twenty years of development. Regarding accounting standards, it uniformly requires the included enterprises to adhere to the EU Carbon Emission Monitoring, Reporting and Verification Regulation, which clearly defines the measurement methods and verification procedures for emission data in sectors such as power, steel, and shipping, ensuring consistent carbon asset accounting standards across all participants. Électricité de France (EDF), a key enterprise

in the EU power sector, relies on this system within its carbon asset management department to collect and calculate carbon emission data from its power facilities across Europe. After verification by a third-party verification agency every year, it generates standardized reports, laying the foundation for subsequent allowance trading and compliance.

From the perspective of risk management, carbon asset management system will also establish mechanisms for controlling carbon trading risks, such as setting upper limits on allowance holdings and monitoring abnormal price fluctuations, helping enterprises mitigate compliance and market risks. EDF Trading, the independent carbon trading department established by Électricité de France, relies on the risk hedging instruments permitted under the system to manage price risks through combined operations involving allowances and carbon derivatives. During the fluctuation period when the EU carbon price exceeded 80 euros per ton in 2023, the department employed the intertemporal trading strategies permitted under the system to lock in costs for some compliance allowances in advance, thus avoiding operational impacts from short-term price surges. Similarly, when CNOOC Gas and Power Group expanded into the Australian carbon market, it also opened two carbon credit accounts simultaneously in accordance with the risk control requirements of the local new emission reduction act to diversify trading risks, ensuring the compliance and fulfillment of its investment projects in Australia. This system design that integrates accounting, process and risk control eliminates the uncertainty of carbon trading for listed companies, ensures their legal and compliant operations in the carbon market, and provides a fundamental guarantee for the stable development of trading activities.

3.2 Carbon Trading Provides More Channels for Listed Companies to Optimize Their Value Creation Capacities

Carbon asset trading enhances the value of listed companies significantly from both financial and market value perspectives. At the financial value level, enterprises can obtain direct revenue through carbon trading. Enterprises with surplus allowances can sell their allowances when carbon prices are high, while those enterprises with voluntary emission reduction projects can gain additional cash flow through carbon credit transactions—these proceeds are directly recorded in the income statement, enhancing the profitability of the enterprises. Additionally, enterprises can also optimize costs through trading, for instance, by using lower-cost CCERs to offset part of their allowance surrender obligations, thereby reducing carbon compliance costs. According to the observation report on the long-term operation data of EU ETS by the non-profit Carbon Market Watch and Dutch consultancy CE Delft, between 2008 and 2019, European energy-intensive industries obtained speculative profits of up to 50 billion euros through the carbon trading mechanism. The core approach involved surpluses in emission allowances freely allocated by the government, which enterprises sold at market highs to increase their revenue. Specifically, the cement sector made a profit of 3.1 billion euros solely by selling surplus free allowances, and the petrochemical industry made a profit of 600 million euros through the approach. On the other hand, the steel and oil refining enterprises adopted a combined strategy of “purchasing international carbon offsets at low prices and selling free allowances at high prices”, achieving additional revenues of 850 million euros and 630 million euros respectively. Such revenues are not isolated cases; During the same period, enterprises in Portugal also made revenues of nearly 1 billion euros in supplementary profits from the carbon market during the same period, fully demonstrating the direct driving effect of carbon trading on the financial profits of enterprises.

At the market value level, enterprises that actively participate in carbon trading often obtain higher ESG ratings, attracting increased investment from green investors such as ESG funds, thereby elevating their stock prices and valuation benchmarks. Moreover, the “low carbon” label associated with carbon trading can enhance consumer recognition of corporate products, increase market share, and further amplify market value of enterprises. Ørsted, a Danish renewable energy company that has transformed from traditional fossil fuels, optimized its carbon asset configuration through long-term engagement in the EU carbon trading: on one hand, it converted emission reductions from wind power projects into tradable carbon credits; one the other hand, it offset its emission costs from traditional operations through allowance trading. This series of measures has pushed its ESG risk rating to reach the “low risk” level of Sustainalytics, making it an ESG benchmark among global energy enterprises. As of 2024, Ørsted’s stock price had risen by over 120% in the past five years, far exceeding the average level of traditional energy companies in EuropeMoreover, it has been included in the core holdings of more than 200 global

ESG-themed funds, with its valuation benchmark nearly 80% higher than that before transition. Fortescue Metals Group, an Australian mining giant, also enhanced its corporate value through carbon asset trading. In 2024 alone, Fortescue generated over 230 million US dollars in cash flow from decarbonized assets like green power and green hydrogen, and directly offset 10% of its decarbonization investment costs by locking in revenues through carbon trading mechanisms. This virtuous cycle of decarbonization investment and carbon trading profits enabled Fortescue's MSCI ESG rating leap from BBB to A. It is evident that the low carbon operational capabilities formed by carbon trading can translate into a "value safety cushion" recognized by investors through ESG ratings, thereby promoting the increase of enterprise market value.

3.3 Carbon Asset Management and Trading Solidify the Foundation for Sustainable Development of Listed Companies

Carbon asset management and trading provide long-term support for the sustainable development of listed companies by compelling low carbon transition, incentivizing technological innovation, and optimizing the industrial chain ecosystem. In terms of low carbon transition, carbon asset management system drives companies to proactively phase out high-energy-consumption equipment and optimize production processes. W.A.Parish gas-fired power plant in the U.S., in its carbon capture, utilization, and storage (CCUS) project, channels part of the captured CO_2 for methanol production and a port for storage in saline aquifer. In 2023 alone, the plant generated 120 million US dollars revenue from regional carbon price transactions in the U.S., and realized 360 million US dollars from revenue methanol sales. The plant allocated 40% of these profits for technological upgrades, improving the CO_2 enrichment efficiency of membrane separation units and developing new low-cost absorbents, which further reduced the capture costs by 18% and created a positive cycle of technological advancement and revenue growth. Similarly, Japan's JERA invested its carbon credit revenues from its wind power projects into R&D for "24/7 carbon-free electricity" technology and partnered with Shizen Connect to build a virtual power plant system for real-time matching of renewable energy supply and demand. The technology has also been piloted commercially in 2025 and is expected to reduce the cost of green electricity use by 30% for manufacturing customers It can be seen from this that the profits brought by carbon trading can be fed back to the research and development of low-carbon technologies. Enterprises can invest the profits from carbon trading in technological breakthroughs such as carbon capture and clean energy utilization, forming a virtuous cycle of "emission reduction - profits - further research and development", and enhancing their core technological competitiveness.

In terms of industrial chain ecosystem, advanced carbon asset management capabilities can also drive collaborative emission reductions across upstream and downstream enterprises. For instance, Microsoft is not only building its own data centers with cross-laminated wood (65% lower carbon footprint than traditional concrete buildings), but also has a contract that requires core suppliers to use 100% carbon-free electricity by 2030, and has set up a carbon footprint tracking platform to provide suppliers with free carbon accounting tools. For those who meet the standards first, Microsoft will offer an order preference of 10% to 15%. For those lagging in emission reductions, Microsoft provides subsidies for them with its carbon trading revenues. By 2024, 78% of Microsoft's top 500 global suppliers had accessed the carbon management platform, the overall carbon emission intensity of the supply chain has decreased by 19%, and the brand premium brought by the green supply chain has increased the renewal rate of enterprise customers of Microsoft cloud services to 92%. It is evident that by requiring suppliers to provide carbon footprint data, core enterprises can not only promote the low-carbonization of the entire supply chain and form a green industrial chain advantage, but also further enhance the long-term development resilience of enterprises through this industrial chain synergy capability.

3.4 Carbon Asset Management and Trading Help Enhance the Level of Positive Externality for Enterprises

From the aforementioned theoretical content of environmental economics, externality is a key mechanism through which carbon asset management and trading achieve positive externality. Specifically, through system design and market trading, carbon asset management transforms the negative externality of carbon emissions into internal costs, and at the same time transforms the positive externality of emission reduction into market benefits, so as to promote enterprises to change from passive compliance to active emission reduction and form a positive feedback to the social environment. Taking the EU ETS

as an example, by setting sectoral benchmarks and allowance allocation rules, it compels high-emission enterprises to pay for excess emissions, while low carbon companies can earn revenues by selling allowances. This mechanism of "penalizing high emitters and rewarding low emitters" directly internalizes environmental costs, prompting enterprises to proactively adjust their production structures. In addition, the German chemical company BASF has also optimized its carbon asset management and transferred some of its production processes to regions rich in renewable energy. This not only reduced its own carbon emissions but also promoted the development of the local clean energy industry, creating a two-way positive interaction between the enterprise and the region.

Beyond the positive externalities brought about by the active promotion of carbon trading by the aforementioned enterprises, at the government-enterprise relationship level, enterprises that actively implement carbon asset management are more likely to align with China's "carbon peaking and carbon neutrality" policy direction and enjoy policy preferences such as prioritized access to green credit, tax incentives, and inclusion in low carbon demonstration enterprise lists. These supports can further reduce the operational costs of enterprises. At the industry collaboration level, the carbon management practices of leading enterprises set industry benchmarks, driving peers to engage in carbon asset management and trading and promoting the entire industry toward low carbon development. In this process, enterprises will establish leading positions within their industries, strengthening their influence in external collaborations and fostering a positive external development environment.

4.Localized Plan for Carbon Asset Management System and Trading Strategies of Listed Companies in China

4.1 Top-Level Design: Improving the framework of the carbon asset management system for listed companies in the carbon market

The key distinction of carbon asset management from other assets lies in that it is a policy-driven product, with policy implications and a background of its era. Various policies and systems, including those for controlling carbon emissions, regulating carbon trading and carbon information disclosure, provide institutional guarantees and legal foundations for carbon asset management, which represent the most direct and effective means to promote the transformation of enterprises and society towards low-carbonization.

To refine the framework of the carbon asset management system for listed companies in the carbon market, it is essential to first establish a unified legal and regulatory system for carbon asset management at national level, clearly defining the ownership of carbon assets, trading rules, accounting standards and regulatory mechanisms, providing clear institutional guidance for listed companies. In terms of property right definition, the Coase Theorem in environmental economics theory should be relied upon, combined with the actual situation of carbon asset management in China, the legal status of carbon emission rights should be established through legislation, and their tradable and collateralizable attributes should be clarified, so as to stimulate the enthusiasm of enterprises to participate in the carbon market. Simultaneously, detailed carbon asset accounting guidelines should be formulated to unify accounting methods across different industries and regions, so as to ensure the accuracy and comparability of carbon asset data and provide a solid foundation for carbon trading.

In terms of trading rules, flexible and diverse trading mechanisms should be designed, including spot trading, futures trading, and options trading, so as to meet the diverse risk management needs of listed companies. At the same time, entry and exit mechanisms for the carbon trading market should be established for strict reviews of participant qualifications and creditworthiness, so as to prevent market manipulation and excessive speculation, thereby maintaining the fairness, impartiality, and transparency of market. Furthermore, a risk early-warning and emergency response system for the carbon trading market should be built to monitor price fluctuations and trading anomalies in real time and take timely measures to prevent systemic risks.

In terms of regulatory mechanisms, a cross-departmental, cross-regional collaborative regulatory system can be established to enhance the communication and coordination among ecological and environmental authorities, financial regulators, and market supervision departments to form a synergistic regulatory force. Additionally, third-party verification agencies should be introduced to independently audit the carbon asset data of listed companies, ensuring its authenticity and reliability. Violators should be severely punished in accordance with the law, increasing the cost of non-compliance and forming an

effective deterrent.

4.2 Trading Optimization: Design Carbon Asset Portfolio Trading Strategies Align with Domestic Market

Trading is a key link in promoting the maximization of enterprise carbon assets. The design of carbon asset portfolio trading strategies for the domestic market must fully consider the unique characteristics of China's carbon market. At present, taking the power industry as a breakthrough point, China's carbon market gradually incorporates high-emission industries like steel and building materials, and operates the regional pilot markets in parallel with the national market, providing enterprises with room for arbitrage by taking advantage of the price differences and varying trading rules across markets. Listed companies can, based on their industry attributes and carbon asset structure, construct portfolio strategies encompassing basic allowances, derivatives, and cross-market trading.

At the basic allowance trading level, enterprises can dynamically adjust their allowance holdings by analyzing the gap between their carbon emission intensity and the industrial benchmark. For enterprises with emission intensity below the benchmark, the government may allow them to sell their surplus allowances when carbon prices are high to obtain direct benefits. In contrast, enterprises with emission intensity near or above the benchmark need to purchase allowances or use CCERs to offset compliance obligations in advance, so as to avoid increased compliance costs due to allowance shortages. In terms of derivatives trading, enterprises can lock in future compliance costs by purchasing carbon futures contracts or earn premium income by selling call options, thereby reducing their financial costs of carbon asset management and hedging against price volatility risks.

At the cross-market trading level, enterprises can arbitrage price differences between regional pilot markets and the national market. When the carbon price in a regional pilot market is significantly lower than in the national market, enterprises can purchase allowances in the regional market and resell them in the national market to obtain profits from the price difference. By establishing portfolio strategies based on basic allowances, derivatives, and cross-market trading, listed companies can not only maximize the value of their carbon assets but also effectively diversify trading risks, enhancing the flexibility and efficiency of carbon asset management.

4.3 Supporting Facilities: Improve the Supporting System for Carbon Asset Management and Trading of Listed Companies

In terms of technological innovation in carbon asset management, the introduction of big data technologies enables enterprises to collect, integrate, and deeply analyze large volumes of carbon emission data in real time. The data cover a wide range of information such as enterprises' own emissions, market dynamics, and policy changes. Therefore, to optimize carbon asset trading for listed companies, it is necessary to actively promote the application of digital technologies in carbon asset transaction management. By establishing a digital platform for carbon asset management, enterprises can integrate carbon emission data from internal departments and across the supply chain, enabling real-time data updates and sharing. The platform can deeply analyze historical carbon trading data and policy change information based on machine learning algorithms, forecasting future carbon price trends and providing transaction decision support for listed companies.

Secondly, enterprises need to strengthen talent cultivation and technical support for carbon asset management. By establishing professional training institutions, carrying out international cooperation and exchanges, the professional competence and practical skills of carbon asset managers in listed companies can be enhanced. At the same time, research institutions and enterprises should be encouraged to increase R&D investment in areas such as carbon capture, utilization, and storage (CCUS) and low carbon technologies, so as to promote technological innovation and the commercialization of results, thereby advancing the sustainable development of listed companies.

Finally, efforts should be made to accelerate the construction of a mechanism that links the carbon assets with green finance. By developing financial products such as carbon asset pledge financing, carbon insurance, and carbon funds, diversified financing channels and risk protection should be provided for listed companies to participate in carbon trading. The government can introduce relevant policies to encourage financial institutions to engage in carbon asset financial services, offering tax incentives and fiscal subsidies to institutions involved in such businesses, promote the deep integration of carbon

assets and green finance, and provide solid financial support for carbon asset management and trading of listed companies.

5.Conclusions

In the era of green and low carbon development, carbon asset management is no longer an option for listed companies but a must-answer question concerning their future survival and development. It requires enterprises to start from a strategic height, establish scientific institutional systems, formulate flexible trading strategies, and actively embrace open cooperation. This study provides a localization solution for the carbon asset management system and trading strategies of listed companies in China from the top-level design of the carbon asset management system, the carbon asset trading portfolio strategy, as well as the corresponding financial support, talent support and other supporting measures.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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