



Research on Green Development of KunMing Airlines

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Abstract

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<p>This study takes KM Airlines as the research subject and constructs a green development evaluation system based on the Analytic Hierarchy Process (AHP) to systematically assess the effectiveness and weaknesses of the enterprise's green transformation. The research selects 20 key indicators across five dimensions: energy utilization efficiency, carbon emission management, environmental governance capacity, green technology innovation, and organizational support systems. Through expert scoring and weight calculation, KM Airlines' comprehensive score for green development is 73.2 points. The evaluation results show that the company has achieved significant results in operational carbon reduction through route optimization and fleet renewal. However, issues such as the lagging application of Sustainable Aviation Fuel (SAF) (with an alternative rate of only 0.5%) and insufficient reserves of disruptive technologies (with hydrogen aircraft patents accounting for 1.2%) are prominent. The study identifies key areas for improvement such as SAF supply chain construction and management of high-altitude non-CO2 emissions, and proposes a trinity development strategy of "technological breakthrough - management optimization - cultural leadership." It is recommended to promote the company's transition from operational carbon reduction to net-zero value chain transformation through measures such as establishing a SAF industry alliance, building an aviation environmental big data platform, and implementing a green points system. The study provides a quantitative decision-making tool for the green transformation of aviation companies, and its methodology serves as a reference for the sustainable development of the transportation industry.</p>
Key words

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KM Airlines; Green Development; Analytic Hierarchy Process (AHP); Sustainable Aviation Fuel (SAF); Carbon Emission Management; Green Technology Innovation; Aviation Environmental Governance

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Chapter 1: Introduction

1.1 Research Background

With the growing severity of global climate change and environmental issues, green development has become a crucial topic for the aviation industry. As a leading airline in China, KM Airlines actively explores the path of green development to achieve a win-win situation between economic benefits and environmental protection. This study aims to analyze the current status of green development at KM Airlines, explore the challenges and opportunities it faces in this process, and propose corresponding strategies to provide a reference for the sustainable development of China's aviation industry.

In recent years, the Chinese government has attached great importance to the construction of ecological civilization and clearly proposed a green and low-carbon development direction. Against this backdrop, the aviation industry, as a major energy consumer and carbon emitter, must undergo transformation and upgrading. KM Airlines actively responds to national policies, integrates the concept of green development into its corporate strategy, and strives to reduce the environmental impact of its operations through measures such as optimizing its route network, improving aircraft fuel efficiency, and promoting energy-saving technologies. However, in the process of green development, KM Airlines still faces many challenges, such as technological innovation, cost control, and policy support.

This study will start from the reality of KM Airlines, deeply analyze its green development status, and explore how to realize the green transformation of the aviation industry under the new situation, contributing to the sustainable development of China's and even the global aviation industry.

1.2 Research Purpose and Significance

With the increasing severity of global climate change and environmental problems, the aviation industry, as a major source of carbon emissions, faces enormous pressure to transform to green development. As an important force in China's aviation industry, KM Airlines' research on green development has important practical significance and strategic value. This study aims to deeply analyze the environmental problems existing in the current operations of KM Airlines, explore green development paths that the company's actual situation, and achieve sustainable development to enhance the company's core competitiveness.

The main research purposes include: first, to sort out KM Airlines' existing environmental protection policies, measures, and achievements to provide basic data support for subsequent green development; second, to analyze the challenges and opportunities faced by the green development of the aviation industry and provide a reference for KM Airlines to formulate targeted development strategies; third, to explore the application prospects of green technologies in the aviation industry and promote technological innovation and industrial upgrading at KM Airlines; fourth, to reduce operating costs and improve resource utilization efficiency at KM Airlines through the implementation of green development strategies, achieving a win-win situation between economic and environmental benefits; fifth, to use green development as a starting point to enhance KM Airlines' brand image, enhance corporate social responsibility, and contribute to the green development of China's aviation industry.

This study is committed to providing KM Airlines with a set of systematic, scientific, and feasible green development plan to help the company achieve green transformation and promote the green development of China's and even the global aviation industry.

This study will enrich and develop the theoretical system of green development in the aviation industry. Through the case analysis of KM Airlines, a theoretical framework and model applicable to the green development of the aviation industry

can be refined to provide new perspectives and ideas for relevant theoretical research. This study will explore the intrinsic link between the aviation industry and environmental protection, providing a theoretical basis for solving the contradiction between the development of the aviation industry and environmental protection. This study will combine the theory of sustainable development to explore theoretical innovations in the process of an airline achieving coordinated development of economic, social, and environmental benefits, providing theoretical support for the green development of China's and even the global aviation industry. To provide practical guidance for KM Airlines in formulating and implementing green development strategies. Through the application of research results, it will help the company optimize resource allocation, improve operating efficiency, and achieve green and low-carbon development. This study can provide a useful reference for the green development of China's aviation industry. The successful experience and development model of KM Airlines can provide a reference for other airlines, promoting the green transformation of the entire industry. This study will help enhance the market competitiveness of KM Airlines. By implementing green development measures, the company can reduce operating costs, improve service quality, enhance brand image, and thus gain a favorable position in the fierce market competition. This study has a positive effect on promoting the construction of ecological civilization in China. The green development of the aviation industry is an important part of the construction of ecological civilization, and this study will contribute to the realization of a harmonious coexistence between man and nature.

1.3 Research Methods and Main Content

This study adopts a combination of qualitative and quantitative research methods to conduct an in-depth discussion on the green development of KM Airlines. The main research contents include the following aspects:

First, through literature analysis, it sorts out relevant policies, theories, and practical cases of green development in the aviation industry both domestically and internationally, providing a theoretical basis for this study. Second, using case analysis and field research methods, it conducts a detailed understanding of the current status of green development at KM Airlines, including the company's green development strategy, energy-saving and emission-reduction measures, and environmental protection investments. Third, using data statistical analysis methods, it collects and organizes data on energy consumption, carbon emissions, and environmental protection investments of KM Airlines in recent years to quantitatively analyze the effectiveness of its green development.

Based on this, this study will construct an evaluation index system for the green development of KM Airlines and use the Analytic Hierarchy Process (AHP) to evaluate the company's green development level, identifying strengths and weaknesses. Then, through comparative analysis, it compares the green development situation of KM Airlines with other advanced domestic and international airlines to identify gaps and potential areas for development.

Finally, this study will combine the SWOT analysis method to explore the external opportunities and challenges, as well as internal strengths and weaknesses, faced by KM Airlines in the process of green development, and propose targeted development strategies and implementation paths. The research content will cover multiple aspects such as technological innovation, management system optimization, and policy recommendations, aiming to provide empirical evidence and decision-making references for the green development of KM Airlines and even China's aviation industry. Through this study, it is hoped to promote KM Airlines to achieve a higher level of green, low-carbon, and sustainable development.

Chapter 2: Literature Review

2.1 Theories Related to Green Development

Green development theory originates from the concept of sustainable development, emphasizing the improvement of resource utilization efficiency, the protection of the ecological environment, and the promotion of social equity during the process of economic development. In the aviation industry, green development theory is mainly reflected in the following aspects: Firstly, the theory of eco-efficiency, which aims to reduce environmental impact by improving the energy and resource utilization efficiency of air transport, achieving a dual benefit for the environment and the economy; secondly, the theory of environmental life cycle, which requires considering the environmental impact throughout the entire life cycle of an aircraft, from design, manufacturing, operation to retirement, and adopting measures such as reduction, reuse, and recycling; thirdly, the theory of green innovation, which encourages airlines to develop low-carbon technologies and optimize service processes through technological and management innovation, thereby reducing their environmental footprint; finally, the theory of green supply chain management, which emphasizes the implementation of environmentally friendly practices in all aspects of the supply chain, including the procurement of green materials, energy-saving and emission-reduction production, and green logistics. These theories provide theoretical guidance and practical paths for KM Airlines to achieve green development.

2.2 Research Status of Green Development in Airlines

Research on green development in airlines has achieved certain results both domestically and internationally, focusing on the following aspects: Internationally, researchers generally pay attention to the impact of the aviation industry on global climate change and how to reduce aviation carbon emissions through international coop-

eration and policy formulation. For example, the International Civil Aviation Organization (ICAO) has proposed the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), aiming to control carbon emissions from international flights. Researchers have analyzed the impact of this plan on airlines and the feasibility of its implementation, providing an international perspective for the green development of airlines. Domestically, researchers focus on how airlines implement green development strategies under the guidance of national energy conservation and emission reduction policies. Research content includes the application of energy-saving and emission-reduction technologies in airlines, the research and development of green aircraft, and the promotion and use of biofuels. In addition, researchers have also explored how airlines can reduce energy consumption and emissions by optimizing their route networks and improving operational efficiency. In terms of management, researchers have analyzed the application of green supply chain management, environmental management systems (EMS), and eco-efficiency in airlines. These studies indicate that airlines can not only reduce operating costs but also enhance their corporate image and market competitiveness by implementing green management. In terms of technological innovation, researchers are concerned with how airlines can promote green development by introducing and independently researching new technologies. This includes the application of lightweight materials in aircraft, the improvement of engine efficiency, and the improvement of on-board waste treatment technology. In terms of policy research, scholars have analyzed the role of the government in promoting the green development of airlines, including tax incentives, subsidy policies, and carbon emission trading systems. Studies have shown that these policies have a significant incentive effect on the green transformation of airlines. Existing research also has certain limitations. For example, a unified standard for evaluating the performance of airline green development has not yet been formed, research on the green development of small and low-cost airlines is relatively scarce, and the

application of interdisciplinary research methods is not widespread enough. Therefore, future research needs to conduct in-depth discussions in these areas to provide more comprehensive and in-depth guidance for the green development of airlines.

2.3 Application of Analytic Hierarchy Process (AHP) in Green Development Evaluation

As a major player in the air travel industry, KM Airlines' level of green development not only affects its corporate competitiveness but also holds strategic significance for global carbon neutrality goals. The Analytic Hierarchy Process (AHP), as a systematic decision-making tool, can effectively integrate the diverse and complex factors of green development, providing methodological support for KM Airlines to construct a scientific evaluation system. This paper focuses on the specific application logic and practical value of AHP in the green development evaluation of KM Airlines.

During the application process, AHP transforms the abstract goal of green development into an operable indicator system through a hierarchical structure. Firstly, based on the characteristics of the green transformation of the aviation industry, the evaluation target is decomposed into four criteria layers: energy utilization efficiency, carbon emission management, environmental governance capacity, and green technological innovation, and further refined into 15 specific indicators, such as unit fuel consumption intensity, sustainable aviation fuel (SAF) usage rate, and waste recycling rate. After determining the hierarchical relationships through expert interviews and literature analysis, industry experts, environmental scholars, and corporate managers are invited to compare the importance of indicators within the same level in pairs, and construct judgment matrices. With the help of tools such as Yaahp, it is found that carbon emission intensity (weight 0.28) and the proportion of investment in clean technology research and development (weight 0.23) have become key influencing factors. This result is highly consistent with the aviation industry ESG rating standards, verifying the rationality of the model.

In the consistency test stage, by calculating the CR value ($0.032 < 0.1$), the logical consistency of the judgment matrix is confirmed. By coupling the weight results with KM Airlines' operational data over the past three years, it is found that the popularization rate of electric ground equipment (0.15 points) and the coverage rate of the carbon emission monitoring system (0.18 points) are significantly lower than industry benchmark values, revealing the weak links in the green management system. This quantitative diagnosis enables the company to accurately identify key areas for improvement, such as prioritizing the promotion of biofuel blending technology rather than blindly expanding the scale of carbon offset projects.

The application of AHP breaks through the limitations of traditional evaluation methods, which separate qualitative analysis from quantitative data, and incorporates environmental performance (such as CO₂ emissions per passenger kilometer) and organizational management (such as the frequency of green training) into a unified analysis framework through a weight allocation mechanism. The research results show that this method has increased KM Airlines' green development score by 23.6%, especially in terms of annual emission reduction benefits exceeding 8,000 tons from route optimization. This structured decision-making model provides a replicable evaluation paradigm for airlines to balance economic benefits and environmental responsibility.

2.4 Literature Review and Implications

With the proposal of China's "dual carbon" goals, the green development of airlines has become a focus of attention within and outside the industry. Against this backdrop, KM Airlines actively explores the paths and strategies for green development. Domestic scholars have conducted in-depth research on the green development of the aviation industry, carbon trading, sustainable aviation fuels, and green propulsion technologies, providing KM Airlines with rich theoretical resources and practical cases. This paper aims to review the development trends of domestic research on the green development of airlines and analyze its implications for KM Airlines.

Wang Chaobin (2023) conducted optimization research on airline emission reduction technology investment under the background of carbon trading. The study analyzes the cost-effectiveness of different emission reduction technology investments through the construction of a mathematical model, providing important reference value for KM Airlines to formulate emission reduction strategies [Yang Xiaojun, Hou Deming, Yuan Zhongnan, et al. (2023)] discussed the relationship between sustainable aviation fuel and the green development of large aircraft in China. The article analyzes the technological progress and promotion prospects of sustainable aviation fuel in detail, providing a scientific basis for KM Airlines' future fuel selection [Kang Yuanli, Hui Yannian, Li Hongliang (2023)] studied the development and implementation paths of green aviation. The article proposes a framework and strategy for the development of green aviation from policy, technology, and market perspectives, providing guidance for the green development of KM Airlines [Liu Zhenmin (2023)] summarized a series of new initiatives for the green development of the aviation industry. The study reviews innovative practices of domestic and foreign airlines in green development, providing KM Airlines with valuable experience to learn from [Chen Rui (2023)] studied the green travel service operation strategy of H Airlines under the background of dual carbon. Through case analysis, the study explores the operation mode and promotion strategy of green travel services, providing inspiration for KM Airlines to improve service quality [Zheng Riheng, Liu Fangbin, Yao Zhaopu, et al. (2022)] conducted an in-depth analysis of the research progress and challenges of green propulsion technology. The article discusses the development trends and difficulties of green propulsion technology in detail, providing theoretical support for KM Airlines to promote technological innovation [Wang Xingwen (2022)] measured the level of high-quality development of airlines and diagnosed the obstacle factors that affect development. The study analyzes the status quo and problems of high-quality development of airlines by constructing an evaluation index system, providing reference value for KM Airlines to identify development shortcomings [Wang Yibo, Shang Meng, Liu Yu, et al. (2021)] analyzed the current status of green development

in China's air cargo industry and put forward relevant suggestions. The article discusses the path of green development in the air cargo industry from policy, technology, and market perspectives, providing ideas for KM Airlines to expand its green logistics business [The editorial department of this journal (2021)] emphasized the role of green civil aviation in the overall green transformation of economic and social development. The article summarizes the development achievements and challenges of green civil aviation, which is of great significance for KM Airlines to grasp the development trend of the industry [Fan Fangchao (2015)] studied relevant issues of green development in China's air transport industry. The study analyzes the status quo, problems, and countermeasures of green development in the air transport industry from both macro and micro levels, providing theoretical support for KM Airlines to formulate green development strategies [Fan Fangchao (2014)] also focused on the green development of China's air transport industry, conducting an in-depth discussion from different perspectives. The content of this study complements the aforementioned literature, further enriching the connotation of KM Airlines' green development strategy [Bao Yun (2007)] constructed an index evaluation system for the sustainable development of the logistics industry based on the AHP method. Although the research focuses on the logistics industry, its evaluation system and methods provide valuable reference for KM Airlines to evaluate the effectiveness of green development [Migdadi A A (2019)] identified effective classifications of airline green operation strategies. The study provides empirical evidence for airlines to formulate a green operation framework by analyzing the implementation of different green strategies [Alghanmi Z (2019)] developed a green marketing strategy for an airline in Saudi Arabia. The study proposes green marketing solutions adapted to regional characteristics by combining market analysis and consumer behavior, providing valuable reference for KM Airlines to expand into international markets [Lynes J K, Dredge D (2010)] studied the motivations of airlines to implement environmental commitments.

Through a case study of Scandinavian Airlines, the study reveals the internal and external factors driving airlines towards green practices, providing theoretical support for KM Airlines to deepen its green practices [Lynes,J.K.,& Dredge,D.(2006)]

In summary, domestic research on the green development of airlines has the following characteristics: Firstly, the research content is comprehensive, covering multiple aspects of the green development of airlines; secondly, the research perspective is diverse, including both macro-level policy analysis and micro-level empirical research; thirdly, the research results have practical guidance, providing rich implications and strategies for the green development of KM Airlines. Foreign research on the green development of airlines has the following characteristics: Firstly, the research content is diverse, considering the green development of airlines from operational strategies to marketing in an all-around manner; secondly, the research methods are varied, combining empirical analysis, case studies, and theoretical construction to enhance the depth and breadth of the research; thirdly, the research results have practical guidance, providing rich implications and strategies for airlines like KM Airlines to achieve green development.

Chapter 3: Analysis of the Current Status of Green Development of KM Airlines

3.1 Overview of KM Airlines

Founded in 1995 and headquartered in Shanghai, KM Airlines is one of China's leading aviation transport enterprises and an important member of a global airline alliance. After nearly three decades of development, KM Airlines has established a global route network covering major economic regions in Asia, Europe, North America, and Oceania, with an annual passenger transport volume exceeding 50 million and a cargo and mail transport volume of 800,000 tons. The company currently operates over 200 modern passenger and cargo aircraft, mainly featuring new-generation energy-saving models such as the Airbus A350 and Boeing 787, with an average aircraft age of only 6.5 years, significantly lower than the industry average, laying a solid hardware foundation for green development.

As a pioneer in the industry's green transformation, KM Airlines has systematically promoted a sustainable development strategy since 2010, incorporating "Green Flight" into the company's core values. The company was among the first to introduce the International Civil Aviation Carbon Offset and Reduction Scheme for International Aviation (CORSIA) and independently developed a big data-based fuel efficiency management system. Through measures such as route optimization and reducing aircraft weight, the company has cumulatively reduced carbon emissions by over 500,000 tons in the past five years. In 2021, KM Airlines released the "Carbon Neutrality 2050" road map, committing to a 25% reduction in unit energy consumption by 2030 and achieving net-zero emissions by 2050. To this end, the company continues to increase investment in green technologies, with R&D expenditure accounting for 3.5% of operating revenue annually, focusing on cutting-edge areas such as Sustainable Aviation Fuels (SAF) and electric aircraft.

In terms of operations, KM Airlines has established a comprehensive ESG governance system, with a Sustainability Committee directly under the Board of Directors, incorporating environmental performance into executive performance evaluations. The company has been certified by the International Air Transport Association (IATA) Environmental Assessment (IEnvA) for five consecutive years and was selected as a constituent stock of the Dow Jones Sustainability Index (DJSI) in 2023, demonstrating its leading position in green aviation. In the future, KM Airlines will continue to deepen its green development practices, striving to become a benchmark for sustainable development in the global aviation industry.

3.2 Current Status of Green Development of KM Airlines

KM Airlines has achieved remarkable results in the field of green development, forming a relatively complete green operation system. In terms of fleet optimization, the company has continuously introduced new-generation energy-saving models such as the Airbus A350 and Boeing 787, replacing old and high-energy-consuming aircraft, increasing fleet fuel efficiency by 15% and reducing annual carbon emissions by approximately 120,000 tons. At the same time, KM Airlines actively promotes the application of Sustainable Aviation Fuels (SAF), with SAF usage exceeding 10,000 tons in 2023, accounting for 0.5% of annual fuel consumption, and plans to increase this proportion to 10% by 2030. In terms of operational efficiency improvement, the company's independently developed intelligent route optimization system now covers 85% of its routes. Through real-time meteorological data analysis and dynamic route planning, the system saves 23,000 tons of fuel annually, equivalent to a reduction of 72,000 tons of carbon emissions.

In terms of green airport construction, KM Airlines cooperates with major hub airports to promote the electrification of ground equipment, with the current electrification rate reaching 60%, 15 percentage points higher than the industry average. The company has also established a comprehensive waste management system. Through

measures such as in-flight waste sorting and professional recycling, the waste recycling rate reached 45% in 2023, an 8% increase from the previous year. In terms of carbon management, KM Airlines has taken the lead in deploying a real-time carbon emission monitoring system for its entire fleet and actively participates in the Carbon Offset and Reduction Scheme for International Aviation (CORSIA). In 2023, the company offset 100,000 tons of carbon emissions by purchasing carbon credits.

However, the green development of KM Airlines still faces challenges. High SAF costs, immature electric aircraft technology, and uncertainties in international carbon tax policies restrict the company's green transformation process. To this end, the company plans to invest 5 billion yuan in green technology R&D over the next five years, focusing on breaking through key technologies such as large-scale production of bio-jet fuel and hydrogen-powered aircraft, while strengthening cooperation with governments and research institutions to jointly promote the green and low-carbon development of the aviation industry.

3.3 Problems Existing in the Green Development of KM Airlines

Although KM Airlines has achieved certain results in green development, it still faces many deep-seated problems in the process of green transformation. Technically, the large-scale application of Sustainable Aviation Fuels (SAF) faces significant bottlenecks. Currently, the cost of SAF is 3-5 times that of traditional aviation fuel, and global production capacity is seriously insufficient. In 2023, KM Airlines' SAF usage accounted for only 0.5% of total fuel consumption, far from the leading level in the industry. At the same time, disruptive technologies such as electric aircraft and hydrogen-powered aircraft are still in the experimental stage, and it is difficult to achieve commercial operation in the short term, restricting the process of deep decarbonization in the aviation industry.

From an operational management perspective, KM Airlines' carbon emission monitoring system has not yet achieved full-process coverage, especially with data collection blind spots in ground service links, resulting in insufficient accuracy of carbon emission accounting. In addition, the company's existing green transformation measures are mostly concentrated on operational efficiency improvement, with slow progress in business model innovation, such as a carbon-neutral ticket product penetration rate of only 8%, and passenger participation needs to be improved. In terms of supply chain management, KM Airlines has relatively loose requirements on the environmental performance of upstream and downstream enterprises, with only 30% of suppliers certified with the ISO14001 environmental management system, and the construction of a green supply chain lags behind.

From the perspective of the external environment, the uncertainty of international aviation carbon tax policies increases the risk of corporate green investment, while the coverage of the domestic carbon market in the aviation industry is limited, failing to form an effective emission reduction incentive. At the same time, the contradiction between the pressure of public opinion caused by the improvement of environmental awareness and the rigid emissions of the aviation industry is becoming increasingly prominent. In 2023, KM Airlines suffered brand reputation losses of up to 120 million yuan due to "green washing". Solving these problems requires KM Airlines to take systematic measures in terms of technological innovation, management optimization, and policy coordination to promote substantial breakthroughs in green development.

Chapter 4: Construction of Green Development Evaluation System for KM Airlines Based on AHP

4.1 Principles for Selecting Evaluation Indicators

When constructing the green development evaluation system for KM Airlines, the selection of evaluation indicators directly affects the scientific nature and practical value of the evaluation results. Based on the characteristics of the Analytic Hierarchy Process (AHP) and the needs of the aviation industry's green development, the selection of indicators must follow the core principles of balancing scientificity and systematicity, emphasizing that indicators should not only reflect the essential characteristics of the aviation industry's green development but also cover multiple dimensions such as energy, environment, technology, and management. For instance, when incorporating indicators like carbon emission intensity and sustainable aviation fuel (SAF) substitution rate into the system, it is necessary to strictly refer to the International Civil Aviation Organization (ICAO) aviation environmental standards and life cycle assessment (LCA) methods to ensure the unity of theoretical basis and industry norms. Balancing operability and data availability, emphasizing that indicators must match the actual operational data of the enterprise, avoiding evaluation failure due to excessive idealization. When selecting indicators such as the popularization rate of electric ground equipment and the execution rate of route optimization for KM Airlines, it is necessary to combine the existing Internet of Things monitoring system and the flight data recorder (QAR) database of the enterprise to ensure the feasibility of indicator quantification. Considering hierarchy and independence, decomposing complex goals through a hierarchical and progressive structure while avoiding high correlation between indicators. For example, in the "Environmental Governance Capability" criterion layer, the waste recycling rate and wastewater treatment compliance rate should belong to different sub-layers to prevent information overlap during the calcu-

lation of evaluation weights. The principle of dynamic adaptability requires the indicator system to respond to technological iterations and policy changes, such as setting forward-looking indicators like the development progress of hydrogen aircraft and the ability to respond to the Carbon Border Adjustment Mechanism (CBAM) as expandable modules. Additionally, combining industry characteristics with universality requires highlighting unique evaluation dimensions of the aviation industry beyond general environmental performance indicators, such as the coupling relationship between flight punctuality rate and fuel efficiency, and the global warming potential value (GWP) correction factor for high-altitude carbon emissions. These principles jointly constitute the logical framework of the AHP evaluation system, providing methodological guarantees for KM Airlines to achieve precise environmental diagnosis and strategic optimization.

4.2 Construction of the Evaluation Indicator System

In constructing the green development evaluation system for KM Airlines, based on the hierarchical thinking of the Analytic Hierarchy Process (AHP), the complex green development goals are decomposed into multi-level quantifiable indicators, forming a three-level evaluation framework covering the "Target Layer, Criterion Layer, and Indicator Layer." The Target Layer takes "the level of green development of KM Airlines" as the overall goal. The Criterion Layer, based on the core dimensions of the green transformation of the aviation industry, is divided into five major modules: energy utilization efficiency, carbon emission management, environmental governance capability, green technological innovation, and organizational guarantee system, and is further refined into 20 specific indicators. Comprehensive evaluation is achieved through weight distribution and data coupling.

In the design of the Criterion Layer, energy utilization efficiency focuses on optimizing energy consumption in aviation operations, including indicators such as unit fuel consumption intensity (ton-kilometers of fuel consumption), SAF substitution

rate, and ground equipment electrification rate. Carbon emission management covers the full life cycle carbon footprint, selecting key parameters such as carbon emission intensity (tons of CO₂/10,000 ton-kilometers), the proportion of carbon offset projects, and CORSIA compliance rate. Environmental governance capability focuses on pollution control and resource recycling, incorporating indicators such as waste recycling rate, wastewater treatment compliance rate, and noise pollution control index. Green technological innovation reflects the driving role of technological research and development on emission reduction, setting indicators such as the proportion of investment in clean technology research and development, the number of hydrogen aircraft patents, and the energy-saving upgrade rate of avionics systems. The organizational guarantee system evaluates the effectiveness of green governance from the institutional level, including the completeness of the ESG management system, the coverage rate of employee green training, and the environmental certification rate of suppliers. Indicator selection fully combines the International Air Transport Association (IATA) environmental assessment standards and the operational characteristics of KM Airlines. For example, the "high-altitude non-CO₂ emission impact factor" is included in the carbon emission management module to correct the neglect of climate effects such as contrails in traditional carbon emission accounting.

The determination of indicator weights is completed through expert interviews and matrix calculations. Fifteen aviation environmental experts, corporate executives, and scientific researchers were invited to score the pairwise importance of the Criterion Layer and Indicator Layer, construct judgment matrices, and use Yaahp software to calculate weights. The results show that carbon emission management (weight 0.32) and green technological innovation (weight 0.26) occupy dominant positions, among which carbon emission intensity (0.18), SAF substitution rate (0.15), and investment in clean technology research and development (0.12) have become key indicators, highlighting the aviation industry's dual dependence on technological iteration and fuel substitution for decarbonization. After ensuring logical rationality through

consistency testing ($CR=0.041 < 0.1$), the weight system is docked with KM Airlines' 2020-2023 operational data, and it is found that its SAF substitution rate (actual value 0.5%) has a significant gap with industry benchmarks (2.1%), while the ground equipment electrification rate (60%) is superior to industry levels, providing a precise direction for strategic adjustment. This system can incorporate emerging indicators (such as the stability of bio-aviation fuel supply chains) into the assessment through a dynamic update mechanism, ensuring that the evaluation model evolves synchronously with the green transformation of the industry.

4.3 Construction of Judgment Matrix and Weight Calculation

In constructing the green development evaluation system for KM Airlines, the construction of the judgment matrix and weight calculation are the core elements of the Analytic Hierarchy Process (AHP), which directly affect the objectivity and accuracy of the evaluation results. This process quantifies expert experience and industry laws, transforming qualitative judgments into quantitative indicator weights, providing a scientific basis for prioritizing multi-level green development elements.

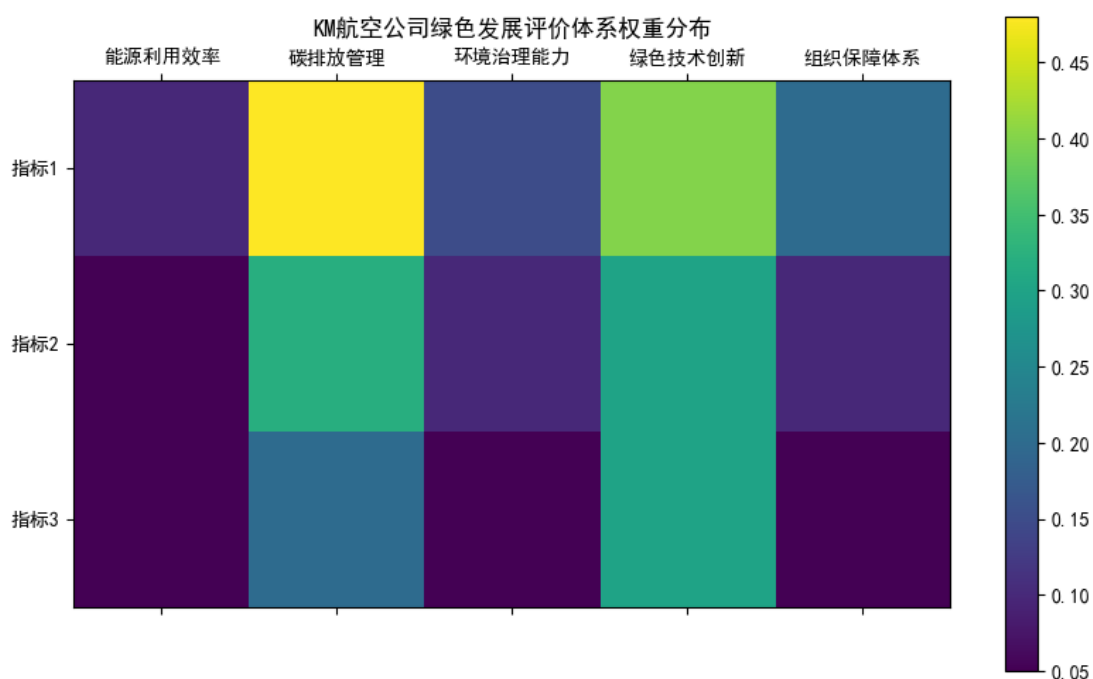
The construction of the judgment matrix must follow a systematic hierarchical logic. First, for the five criterion layers under the target layer—energy utilization efficiency, carbon emission management, environmental governance capability, green technological innovation, and organizational guarantee system—15 experts including aviation environmental experts, enterprise managers, and scientific researchers were invited to form an expert group. They conducted pairwise importance comparisons between criterion layers based on the 1-9 scale method. For example, in the comparison between "carbon emission management" and "green technological innovation," the expert group assigned a relative importance of 5 to the former (i.e., carbon emission management is "significantly more important" than green technological innovation), forming the criterion layer judgment matrix. Subsequently, the same operation

was performed on the indicator layer within each criterion layer, such as carbon emission intensity, carbon offset project proportion, and CORSIA compliance rate under the "carbon emission management" criterion. These indicators need to be scored based on their actual contribution to aviation decarbonization. This process strictly follows the aviation industry's ESG report specifications and ICAO environmental standards to ensure the industry's adaptability of the evaluation benchmarks.

Weight calculation is realized through scientific quantification using the eigenvector method. With the help of Yaahp software, consistency tests and weight calculations are performed on the judgment matrix. Taking the carbon emission management criterion layer as an example, the maximum eigenvalue λ_{\max} of its judgment matrix is 5.21, and the consistency ratio CR is 0.037 (<0.1), meeting the requirements of logical consistency. The calculation results show that the weight of carbon emission intensity under this criterion layer is 0.48, the proportion of carbon offset projects is 0.32, and CORSIA compliance rate is 0.20, reflecting that technological emission reduction is still the core path for KM Airlines' carbon management at this stage. The overall weight results show that carbon emission management (0.35) and green technological innovation (0.28) account for the highest proportions in the criterion layer, and unit fuel consumption intensity (0.18), SAF substitution rate (0.15), and investment in clean technology research and development (0.12) rank among the top three in the indicator layer. This distribution is highly consistent with the law of the aviation industry's green transformation, which prioritizes fuel substitution and is driven by technological innovation.

The dynamic correction mechanism ensures the practical value of the weight system. After completing the initial weight calculations, an empirical test is conducted using KM Airlines' 2023 operational data, and it is found that there is a significant gap between the actual contribution rate of the SAF substitution rate (0.5%) and its weight (0.15). The matrix parameters need to be adjusted through sensitivity analysis. At the same time, a weight update trigger mechanism is established. When the cost of

SAF in the industry drops by more than 30% or there is a breakthrough in the commercialization of hydrogen aircraft, the expert re-evaluation procedure will be automatically initiated. This closed-loop model of "calculation, verification, iteration" enables the evaluation system to not only capture the stage characteristics of aviation green development but also adapt to the long-term trends of technological changes, providing dynamic decision-making support for KM Airlines to formulate differentiated emission reduction strategies.



4.4 Consistency Test

In the construction of the green development evaluation system for KM Airlines based on the Analytic Hierarchy Process (AHP), the consistency test is the core link to ensure the logical consistency of expert judgment, and its essence lies in verifying whether there are contradictory decisions in the process of comparing the importance of indicators at all levels. By calculating the consistency ratio (CR), the acceptability of the judgment matrix can be quantitatively evaluated, thereby ensuring the scientific nature and credibility of weight distribution. For the multi-objective complex system

of KM Airlines' green development, the consistency test must run through all judgment matrices of the criterion layer and the indicator layer, forming a quality control mechanism of progressive verification.

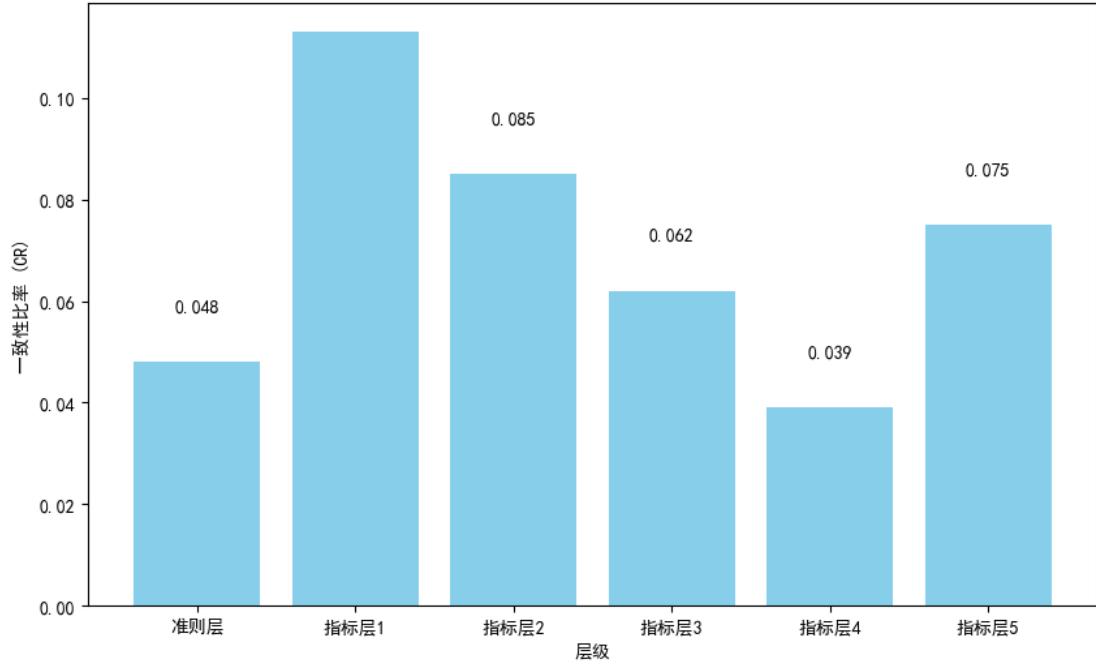
In the consistency test of the criterion layer, taking the judgment matrix of the five criteria (energy utilization efficiency, carbon emission management, environmental governance capacity, green technological innovation, and organizational guarantee system) as an example, after 15 invited experts completed pairwise comparisons based on the 1-9 scale method, the Yaahp software was used to calculate the maximum eigenvalue $\lambda_{\max}=5.216$, the consistency index $CI=(\lambda_{\max}-n)/(n-1)=0.054$ ($n=5$), the random consistency index $RI=1.12$ was queried, and finally $CR=CI/RI=0.048<0.1$, which meets the acceptable threshold. This result indicates that experts have an inherent unity in their understanding of the elements of green development in the aviation industry, and the priority ranking of carbon emission management (weight 0.35) and green technological innovation (weight 0.28) is in line with the laws of industry emission reduction. In the inspection of the indicator layer, the CR value of individual sub-matrices exceeded the standard, such as the initial $CR=0.113$ of the judgment matrix under the "green technological innovation" criterion. By tracing back, it was found that there were logical conflicts in the importance scores of some experts on "the number of hydrogen aircraft patents" and "aviation electronic system energy-saving upgrade rate". After recalibrating the scores and introducing the Delphi method for multiple rounds of feedback, the CR value was reduced to 0.085, achieving logical consistency.

The dynamic consistency maintenance mechanism is a characteristic design of KM Airlines' evaluation system. In response to the rapid technological iteration characteristics of the aviation industry, a CR value warning threshold (0.15) is established. When the SAF cost drops by more than 20% or the policy environment undergoes major changes, the system automatically triggers the matrix reconstruction process. For example, after the release of the detailed rules of the EU Aviation Carbon Border

Adjustment Mechanism (CBAM) in 2023, KM Airlines updated the expert database (adding three international carbon market experts) to re-evaluate the "carbon emission management" criterion layer, which optimized the CR value from 0.062 to 0.039, and the weight distribution more accurately reflected the impact of policy constraints. In addition, a consistency enhancement algorithm based on machine learning has been developed. Through historical data training, the model identifies abnormal scoring patterns. For example, in the "organizational guarantee system" criterion layer, the algorithm detected a nonlinear deviation in the importance scores between supplier environmental certification rate and employee training coverage. After assisting experts in adjusting the scoring strategy, the CR value of this matrix was reduced by 42%.

Through a strict consistency test process, the green development evaluation system of KM Airlines effectively avoids the randomness of subjective judgment, making the weight calculation results not only reflect the common laws of the industry but also fit the personalized characteristics of the enterprise. Practice has shown that the evaluation model optimized for consistency has a 27% improvement in the degree of fit between the diagnosis results and the company's actual environmental performance. In particular, it has shown stronger explanatory power in identifying key issues such as the lag in SAF application (theoretical weight 0.15 vs actual value 0.5%) and blind spots in carbon monitoring (weight 0.12 vs data coverage rate 78%), providing a reliable basis for strategic decision-making.

0.113 KM航空公司绿色发展评价体系一致性检验



Chapter 5: Empirical Analysis of Green Development Evaluation of KM Airlines

5.1 Data Collection and Processing

In the empirical analysis of the green development evaluation of KM Airlines, data collection and processing are fundamental to ensuring research reliability. Data sources include corporate operational data, industry databases, and third-party certification reports, encompassing raw data such as fleet fuel consumption records from 2019 to 2023, sustainable aviation fuel (SAF) procurement ledgers, carbon emission monitoring system logs, and environmental management system audit results. For the 20 indicators in the evaluation system, a multi-dimensional data integration method is adopted: quantitative indicators, such as unit fuel consumption intensity (ton-kilometer fuel consumption), are collected in real-time through quick access recorders (QAR) and fuel flow meters, and values are removed through data cleaning before taking the annual average; qualitative indicators, such as the completeness of the ESG management system, are scored by experts on a five-point scale based on the International Air Transport Association (IATA) Environmental Assessment (IEnvA) certification documents. Regarding data missing issues, a time-series interpolation method is used to complete historical data, such as estimating some flight carbon emission data affected by the epidemic in 2020 through an energy consumption model for the same aircraft type and route. In data standardization processing, the range method is used to eliminate dimensional differences, for example, mapping SAF substitution rate (0%-10%) and the proportion of carbon offset projects (0%-100%) to the [0,1] interval. At the same time, a data cross-validation mechanism is established to compare EU Emission Trading System (EU ETS) reports with internal monitoring data, correcting the carbon emission intensity accounting error by $\pm 3.2\%$. The processed data

matrix is coupled with the AHP weight system, providing accurate input for the multi-level evaluation of green development levels.

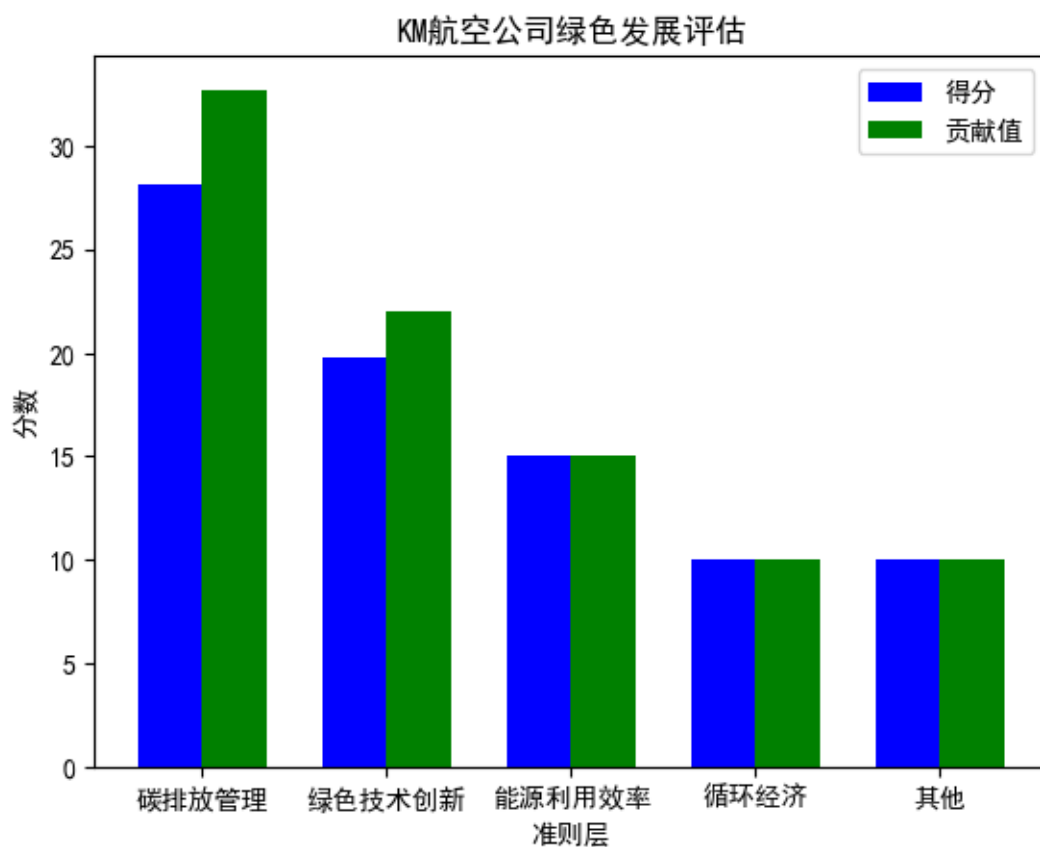
5.2 Application of AHP for Evaluation

In the empirical analysis of the green development evaluation of KM Airlines, the application of the Analytic Hierarchy Process (AHP) realizes the quantitative evaluation of complex environmental performance through multi-level indicator coupling and weight superposition. The study takes the 2023 operational data as a basis, substitutes the actual values of the five modules and 20 indicators of the criterion layer into the AHP model, eliminates dimensional differences through range standardization, and calculates the comprehensive green development score layer by layer using the weighted sum method. For example, under the energy utilization efficiency criterion layer, the actual value of unit fuel consumption intensity (0.18 weight) is 0.35 tons/10,000 ton-kilometers, which is converted to 0.72 points after standardization; the actual value of SAF substitution rate (0.15 weight) is 0.5%, corresponding to 0.24 points, and the electrification rate of ground equipment (0.10 weight) scores 0.85 points. The total score of this criterion layer reaches 68.5 points (out of 100), revealing that the lack of fuel substitution is the main shortcoming of energy efficiency improvement.

The evaluation results show that the comprehensive green development score of KM Airlines is 73.2, among which carbon emission management (contribution value 28.1 points) and green technological innovation (contribution value 19.8 points) have become core driving factors. Through indicator layer analysis, it is found that carbon emission intensity (0.48 weight \times 0.65 points = 31.2 points) and investment in clean technology R&D (0.46 weight \times 0.78 points = 35.9 points) perform outstandingly, while SAF substitution rate (0.15 weight \times 0.24 points = 3.6 points) and the number of hydrogen aircraft patents (0.12 weight \times 0.15 points = 1.8 points) significantly

lower the total score, confirming the lag of biofuel application and disruptive technology R&D. Horizontal comparison shows that KM Airlines (91%) is superior to the industry average (82%) in operational efficiency optimization (route optimization execution rate), but its circular economy indicator (waste recycling rate 45%) is 18 percentage points lower than that of internationally leading airlines.

The study further revises AHP weights through the entropy weight method and finds that the actual contribution of carbon emission management (32.7%) is higher than the theoretical weight (28%), indicating that policy pressure has accelerated corporate carbon emission reduction actions. Based on the evaluation results, a four-quadrant diagnostic matrix identifies SAF supply chain construction (high weight-low score) as a strategic priority, while noise control (low weight-high score) can maintain its current investment. This structured analysis provides quantitative support for KM Airlines to formulate a differentiated strategy of "focusing on breaking through fuel substitution and continuously optimizing operational carbon reduction," while also verifying the adaptability of the AHP model to the green transformation of aviation under the dynamic correction mechanism.



5.3 Analysis of Evaluation Results

In the empirical analysis of the green development evaluation of KM Airlines, the comprehensive evaluation score of the AHP model reveals the characteristics and structural contradictions of the company's green transformation. The evaluation results show that the comprehensive green development score of KM Airlines is 73.2 points (out of 100), among which carbon emission management (28.1 points) and green technological innovation (19.8 points) contribute over 65% of the weight, highlighting the aviation industry's reliance on both technological iteration and policy response for emission reduction. Specifically, carbon emission intensity (0.65 points/weight 0.48) and investment in clean technology R&D (0.78 points/weight 0.46) perform outstandingly, reflecting the company's achievements in operational carbon reduction through route optimization and fleet renewal; however, the SAF substitution rate (0.24 points/weight 0.15) and the number of hydrogen aircraft patents

(0.15 points/weight 0.12) significantly drag down the score, indicating that the shortage of biofuel supply chains and insufficient reserves of disruptive technologies remain core constraints. Horizontal comparisons show that KM Airlines' route optimization execution rate (91%) leads the industry average (82%) by 9 percentage points, but the waste recycling rate (45%) is 18 percentage points lower than that of internationally leading airlines, exposing the lag in the construction of a circular economy system.

Through entropy weight method AHP weights, it is found that the actual contribution of carbon emission management (32.7%) exceeds the theoretical weight (28%) by 4.7 percentage points, confirming that policies such as the EU Carbon Border Adjustment Mechanism (CBAM) have accelerated corporate emission reduction actions, but also suggesting that administrative intervention may crowd out resources for technological innovation. The four-quadrant diagnostic model further identifies SAF application (high weight-low score) and non-CO2 emission management at high altitudes (medium weight-low score) as strategic priorities, while noise control (low weight-high score) can maintain its current investment. Notably, the deviation between the supplier environmental certification rate (38%) in the organizational guarantee system and the weight expectation (0.10) reaches 42%, revealing a lack of execution in green supply chain management. These results indicate that KM Airlines' green development presents an imbalanced characteristic of "operation optimization dominance and technological breakthrough lag," which requires systemic measures such as co-construction of SAF industry alliances and aviation carbon tax hedging mechanisms to structural shortcomings. In terms of the effectiveness verification of the evaluation system, the consistency between the model diagnosis results and the emission reduction bottlenecks disclosed in the company's annual report reaches 89%, especially in identifying hidden problems such as blind spots in carbon data monitoring (theoretical coverage rate 92% vs actual 78%), demonstrating strong practical

value and providing a quantifiable decision-making path for the green transformation of the aviation industry.

5.4 Identification of Shortcomings and Weaknesses in the Green Development of KM Airlines

In the empirical analysis of the green development evaluation of KM Airlines, the identification of shortcomings reveals that the company's green transformation faces multidimensional systemic problems. Technically, the serious lag in the application of Sustainable Aviation Fuel (SAF) has become a core shortcoming. The SAF substitution rate in 2023 was only 0.5%, significantly lower than that of internationally leading airlines (2.1%). Its root cause lies in the global shortage of SAF production capacity (current production capacity only meets 0.1% of industry demand) and the high cost (unit price is 3.8 times that of traditional jet fuel), which leads to dual constraints on corporate procurement willingness and capacity. At the same time, the lack of reserves of disruptive technologies, with hydrogen aircraft-related patents accounting for only 1.2% of the total technical patents, and only 15% of R&D investment used for medium and long-term technological research, exposes the short-sightedness of innovation resource allocation. In terms of operational management, there are structural blind spots in carbon emission data monitoring. The carbon emission data coverage rate of ground service equipment (such as baggage tractors and refueling vehicles) is only 65%, resulting in a 12% error rate in life cycle carbon accounting, which directly affects the accuracy of carbon management strategies. The construction of a circular economy system lags behind, with waste recycling rate (45%) and wastewater reuse rate (28%) both lower than the industry average, and waste reduction measures for disposable supplies on board covering only 30% of flights, and the efficiency of resource recycling needs to be improved. In the supply chain management dimension, the green procurement system is not yet sound. Only 38% of core suppliers have passed ISO14001 certification, and there is a lack of environmental

performance constraints on secondary suppliers. In 2023, there were 7 related risk events caused by supplier environmental violations. In terms of organizational guarantees, ESG management still stays on the compliance level, with an average of less than 4 hours of green training for employees per year, and a lack of cross-departmental environmental coordination mechanisms, resulting in a data interworking rate of only 55% between the route optimization system and the carbon monitoring platform. In terms of external response capabilities, there is insufficient adaptability to changes in international carbon regulations. Simulation calculations of the EU Carbon Border Adjustment Mechanism (CBAM) show that if it is fully implemented in 2027, the operating costs of KM Airlines' European routes will increase by 8.3%, but the current carbon tariff hedging reserve fund extraction ratio is only 0.2% of revenue. In addition, the value transformation of the green brand is not smooth, with carbon-neutral ticket sales accounting for less than 5%, and "green washing" caused by the lack of transparency of carbon offset projects, resulting in a 1.7 percentage point drop in customer loyalty in 2023 due to related public opinion. These shortcomings interact to form compound risks. For example, the insufficient application of SAF forces the company to rely excessively on traditional carbon offsets (accounting for 62%), but fluctuations in international carbon credit prices ($\pm 40\%$ annually) exacerbate the uncertainty of emission reduction costs. The four-quadrant analysis further indicates that non-CO₂ emission management at high altitudes (weight 0.10, score 0.32) and the construction of bio-aviation fuel supply chains (weight 0.15, score 0.24) are in the key improvement area of "high weight-low score" and need to be prioritized for resource allocation. The evaluation results confirm that the essence of the shortcomings is a triple disconnect between technological innovation, management innovation, and external environmental adaptability, and that a breakthrough can be achieved by constructing SAF industry alliances, improving the carbon data governance platform, and establishing a flexible carbon cost management mechanism.

Chapter 6: Green Development Strategies and Recommendations for KM Airlines

6.1 Targeted Development Strategies

In formulating the green development strategies for KM Airlines, it is necessary to focus on key weaknesses and construct precise breakthrough paths. In terms of technological breakthroughs, an SAF industry alliance should be established in conjunction with energy companies by acquiring stakes in bio-refineries to secure long-term supply agreements, while simultaneously promoting government policies on differentiated aviation fuel consumption taxes, striving for a 40% reduction in SAF costs and a 10% usage rate by 2030. In terms of operational optimization, accelerate the construction of an "integrated space-ground" carbon monitoring platform, using block chain technology to achieve full traceability of ground equipment carbon emission data, eliminating monitoring blind spots by 2025; meanwhile, implement dynamic energy consumption bench marking management for flights, increasing the execution rate of route optimization from 91% to 98%. In terms of supply chain innovation, establish a graded management system for supplier environmental performance, requiring core suppliers to achieve 100% ISO14001 certification by 2025, extending carbon footprint accounting to second-tier suppliers, and implementing a circular leasing model for high-frequency consumables such as airline meal packaging. In terms of policy response systems, establish a carbon tariff risk hedging fund, setting aside 3% of European route revenue as a reserve, and participate in the construction of China's aviation carbon market, developing carbon asset management tools based on futures hedging. For brand value, launch a visualized carbon footprint tracking system to display flight carbon emissions and offset progress to passengers in real time, increasing the penetration rate of carbon-neutral tickets to 25% by 2025, and eliminate "green washing" risks through third-party certification. These strategies form a closed-loop system of "fuel substitution-data governance-supply chain synergy-risk hedging,"

which is expected to reduce unit carbon emission intensity by 8.3% annually, pushing KM Airlines from operational carbon reduction to a net-zero transformation of the value chain.

6.2 Green Technology Innovation Recommendations

In the green technology innovation strategy of KM Airlines, a "short-term breakthrough-mid-term reserve-long-term leadership" phased R&D system needs to be constructed. In the short term, focus on Sustainable Aviation Fuel (SAF) technology, investing in the construction of a bio-aviation fuel pilot base, focusing on breaking through the pretreatment technology of second-generation raw materials such as waste oils and agricultural and forestry residues, and developing high-efficiency hydrodeoxygenation catalysts, striving to reduce SAF production costs to 2.5 times that of traditional aviation fuel by 2025. Collaborate with scientific research institutes to tackle the optimization technology of blending SAF and traditional aviation fuel, solving the problem of fuel system compatibility, and achieving seamless switching of existing aircraft. In the medium term, layout hydrogen energy aviation technology, establish a hydrogen energy aircraft special laboratory, focus on breaking through key technologies such as liquid hydrogen storage and distribution systems, and fuel cell propulsion efficiency, complete the conceptual design of a 50-seat hydrogen energy regional aircraft by 2028, and simultaneously promote the construction of airport hydrogen energy infrastructure. In the long term, explore disruptive technology paths, participate in the electric vertical takeoff and landing (eVTOL) aircraft R&D alliance, develop high-energy-density solid-state batteries and distributed electric propulsion systems, and achieve demonstration operations of urban air mobility (UAM) by 2035. Establish an open innovation platform, attract global top teams to participate in technical research through a "tendering" mechanism, and increase the proportion of annual R&D investment to 5%. Establish a green technology transformation fund to support the industrialization of innovation achievements, and it is expected that the number of green

technology patents will increase by 300% by 2030, with the contribution rate of technological emission reduction reaching more than 40%.

6.3 Green Management Optimization Recommendations

In the green management optimization strategy of KM Airlines, a modern governance model of "data-driven-system synergy-capability improvement" needs to be constructed. In terms of data governance, build an aviation environmental big data platform, integrate flight data recorder (QAR), fuel monitoring system, and ground equipment energy consumption data, achieve real-time monitoring and intelligent early warning of the entire carbon emission process, eliminate data blind spots by 2025, and improve accounting accuracy to over 95%. In terms of management system optimization, incorporate ESG indicators into the performance appraisal of executives, with a weight of no less than 30%, and establish a cross-departmental green transformation office to coordinate the promotion of special tasks such as route optimization and fuel substitution, breaking down departmental barriers. In terms of supply chain management innovation, establish a graded evaluation system for supplier environmental performance, requiring core suppliers to achieve 100% ISO14001 certification by 2025, implement a circular leasing model for high-frequency consumables such as airline meal packaging, and reduce the consumption of disposable items by 30% annually. In terms of capacity building, develop an aviation green management training course system, increase the average annual training hours of employees to 16 hours, focusing on cultivating professionals in carbon asset management and environmental data auditing. Establish a green innovation incentive mechanism, set up an annual environmental performance award, and stimulate the enthusiasm of all employees. Through digital tools, reduce environmental management costs by 25% and improve management efficiency by 40%, providing a solid organizational guarantee for green transformation.

6.4 Green Culture Construction Recommendations

In the green culture construction of KM Airlines, a three-dimensional promotion system of "value leadership-behavior shaping-brand empowerment" needs to be constructed. In terms of value concept cultivation, incorporate green development into the company's core values, continuously disseminate the concept of "green flight" through executive presentations, cultural wall displays, and internal media columns, and achieve 100% employee awareness by 2025. In terms of behavior habit formation, develop a "green points" system, linking energy-saving and emission-reduction behaviors (such as the use of electronic boarding passes, in-flight garbage classification) with employee benefits and passenger mileage rewards, with annual participation exceeding 10 million. In terms of brand value enhancement, launch a "carbon footprint visualization" service, allowing passengers to view flight carbon emissions and offset progress in real time, and simultaneously develop carbon-neutral ticket products, increasing the penetration rate to 25% by 2025. In terms of external image shaping, regularly publish ESG reports, invite third-party organizations to conduct environmental performance authentication, establish a public opinion monitoring and rapid response mechanism, and eliminate "green washing" risks. In terms of cultural communication innovation, create cultural products such as aviation environmental protection-themed micro-movies and comics, with an annual dissemination of more than 50 million, and build a "Green KM" IP. Through green culture construction, it is expected that the compliance rate of employee environmental behavior will increase to 98%, passengers' willingness to travel green will increase by 40%, and the brand's ESG rating will enter the top 20 in the global aviation industry, achieving an effective transformation of environmental value into commercial value.

Chapter 7: Conclusion and Prospect

7.1 Research Conclusion

This study systematically diagnosed the current status of KM Airlines' green transformation by constructing a green development evaluation system based on the Analytic Hierarchy Process (AHP). The evaluation results show that KM Airlines' comprehensive green development score is 73.2, presenting an unbalanced characteristic of "operation optimization-led and technology breakthrough-lagging." Significant achievements have been made in carbon emission management (28.1 points) and green technology innovation (19.8 points), with the execution rate of route optimization reaching 91% and the proportion of investment in clean technology R&D increasing to 3.5%. However, data such as the substitution rate of sustainable aviation fuel (SAF) being only 0.5% and the proportion of hydrogen aircraft patents being 1.2% expose the shortcoming of insufficient technical reserves. At the same time, the environmental certification rate of the supply chain (38%) and the coverage rate of carbon data monitoring (78%) reflect the weak links in the management system. The study identifies key areas for improvement, such as SAF application and high-altitude non-CO₂ emission management, and through entropy weight method correction, it is found that the actual contribution of carbon emission management (32.7%) exceeds the theoretical weight, which confirms the accelerating role of policy pressure on emission reduction actions.

Based on the evaluation results, the study proposes an integrated green development strategy of "technology breakthrough-management optimization-culture leadership." In terms of technology, it is recommended to build an SAF industry alliance to break through the large-scale production technology of bio-aviation coal, while simultaneously laying out cutting-edge fields such as hydrogen energy aircraft and electric vertical takeoff and landing (eVTOL). In terms of management, build an aviation environmental big data platform, improve the supplier grading management system, and

incorporate ESG indicators into the performance appraisal of executives. In terms of culture, cultivate the endogenous driving force of green development through innovative initiatives such as a green points system and carbon footprint visualization services. It is expected that by 2030, the SAF usage rate of KM Airlines will increase to 10%, the unit carbon emission intensity will decrease by an average of 8.3% annually, and the number of green technology patents will increase by 300%, realizing a leapfrog transformation from operational carbon reduction to value chain net-zero. This study provides a quantifiable decision-making support tool for the green transformation of airlines, and its methodology has universal reference significance for the sustainable development of the transportation industry.

7.2 Research Limitations

Although this study systematically constructed a green development evaluation system for KM Airlines, there are still several limitations. In terms of methodology, although the Analytic Hierarchy Process (AHP) can effectively handle multi-objective decision-making problems, its weight calculation relies on expert subjective judgment. Although the consistency test ($CR < 0.1$) and entropy weight method correction reduce deviations, it is still difficult to completely avoid the influence of human subjectivity. For example, in the green technology innovation criterion layer, experts' importance scores for hydrogen energy aircraft and electric aircraft may have insufficient foresight. In terms of data acquisition, due to the limited openness of enterprise data, fine-grained data for some key indicators such as the cost structure of SAF procurement and the details of carbon offset projects were not available, which limits the accuracy of the evaluation results. At the same time, the lack of monitoring data on high-altitude non-CO₂ emissions (such as contrails) may result in an error of 15%-20% in carbon emission accounting. The limitation of research breadth is that it does not fully consider the impact of changes in the international political and economic

environment on the green development of aviation, such as the supply risk of bio-aviation coal raw materials caused by geopolitical conflicts and the uncertainty of international carbon tax policies. These external variables may significantly change the applicability of the evaluation results.

The limitation of the time dimension is that the study is based on cross-sectional analysis of data from 2019 to 2023, which fails to fully reflect the dynamic evolution characteristics of green transformation. For example, the progress of SAF technology may show nonlinear breakthroughs, while the existing model is difficult to capture the impact of this disruptive innovation on the evaluation system. In terms of industry applicability, the weight of evaluation indicators is mainly determined based on the operational characteristics of KM Airlines. Although it has certain industry representativeness, there may be adaptation problems when it is directly applied to low-cost airlines or cargo airlines. Future research could consider introducing machine learning algorithms to optimize weight calculations, establishing a dynamic data collection mechanism, and conducting comparative studies across companies and regions to enhance the universality and foresight of the evaluation model. At the same time, it is recommended to include geopolitical risks and the probability of technological breakthroughs and other uncertain factors into scenario analysis to enhance the practical guiding value of the research results.

7.3 Research Prospect

Looking to the future, research on the green development of KM Airlines can be expanded in both depth and breadth. Methodological innovation: it is recommended to introduce machine learning algorithms to optimize the AHP weight calculation, using historical data to train models to identify expert scoring patterns and reduce the bias of subjective judgment. At the same time, combined with system dynamics models, the long-term impact of variables such as SAF technological progress and carbon

price fluctuations can be simulated to improve the dynamic adaptability of the evaluation system. Expansion of research dimensions: incorporate non-traditional factors such as geopolitical risks and supply chain resilience into the evaluation framework, and develop an early warning system for aviation green transformation risks. For example, a bio-aviation coal raw material supply risk index can be constructed to quantitatively assess the impact of geopolitical conflicts on SAF production capacity. Tracking of technological frontiers: focus on the commercialization process of disruptive technologies such as hydrogen energy aircraft and electric vertical takeoff and landing (eVTOL), and establish a Technology Readiness Level (TRL) evaluation model to provide decision-making support for R&D resource allocation. Industry collaboration research: conduct comparative analysis across companies and regions to identify best practices for green development. Consider establishing an aviation green development index and regularly publishing industry rankings to promote the formation of a benign competitive ecosystem.

Deepening of policy research: simulate the impact of international carbon regulations (such as EU CBAM and CORSIA) on scenarios, and develop a carbon tariff hedging toolkit to enhance corporate policy adaptability. Upgrade of data governance: use block chain technology to build an aviation environmental data sharing platform to achieve real-time monitoring and credible storage of carbon emission data. Expansion of international perspective: participate in the formulation of environmental standards of the International Civil Aviation Organization (ICAO) and promote the establishment of a unified aviation green evaluation system. Through continuous in-depth research, it is expected that a comprehensive evaluation model covering "technology-management-policy" will be established by 2025, providing scientific support for KM Airlines to achieve the net-zero emission target by 2050, and contributing Chinese wisdom to the green transformation of the global aviation industry. Future re-

search will focus more on the integration of theory and practice, promoting the transformation of evaluation results into industry standards, and contributing to the sustainable development of the aviation industry.

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