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A Study on the High-Quality Development Path and Implementation Countermeasures of China's Construction Industry toward the Carbon Peaking and Carbon Neutralization Goals

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Abstract: Proving the quality and efficiency of energy conservation and emission reduction in the construction industry and providing high-quality products and services are important forces in achieving the goal of 'double carbon'. They play a crucial role in the sustainable development of human society and nature and are the typical embodiment of the high-quality development of Chinese modernization. This paper analyzes the proportion and importance of China's construction industry policy system, spatial characteristics, energy consumption, and carbon dioxide emissions in achieving the 'double carbon' goal. The life cycle assessment (LCIA) method identifies that the materialization, operation, and use stages are the key stages of the whole process and the influencing factors of energy consumption and carbon emissions. Using the analytic hierarchy process (AHP) method, this paper explores and creates China's construction industry's '1 + 5 + N' high-quality development index system by proposing four stages: top-level design period, deep development period, consolidation achievement period, and summary planning period. These stages aim to facilitate quality improvement, efficiency enhancement, innovation drive, and whole life cycle sustainability. This system's principles are 'systematic planning, one type of one policy, collaborative efforts, safety, and economy'. The proposed system aims to enhance the policy and standard system, strengthen the implementation of policy tools, increase the investment and application of energy-saving and efficiency-increasing technologies, improve the development of energy consumption and carbon emission monitoring systems and platforms, reinforce green finance, standardize information disclosure, accelerate the renovation of outdated infrastructure, and intensify efforts to promote and guide green consumption, lifestyles, and production methods.

Keywords: double carbon; construction industry; path; countermeasures

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1. Introduction

The IPCC report (2014) states that climate change will bring eight irreversible catastrophic risks. It is no longer an important environmental issue facing human society but a threat, calling for 'rapid, far-reaching and unprecedented changes in all aspects of society' [1]. In the face of major crises, such as the COVID-epidemic and rising temperatures, the solution is fundamentally changing the traditional economic development model, production methods, lifestyle, and consumption patterns; reducing carbon emissions caused by fossil energy consumption; and taking a green, low-carbon, and circular development path. As the world's largest carbon emitter, the Chinese government faces enormous pressure to reduce emissions. Currently, 80% of countries or regions regard architecture as part of their national independent contribution action plans. Pressure, motivation, and potential intersect in developing countries, which is a positive sign. As one of the main greenhouse gas emission and energy consumption sectors [1], the Chinese construction sector accounted for 18.5% of the final energy and 16.2% of the total carbon emissions in 2013 [2,3]. According to the experience of developed countries, the share of building energy consumption in the final energy consumption reached 40% in EU countries in 2010 [4], which is much higher than that in China. On 22 September 2020, at the 75th United Nations General Assembly, China announced to the world that it would increase its national independent contribution, adopt more powerful policies and measures, and put forward that 'carbon dioxide emissions should strive to peak by 2030, and strive to achieve carbon neutrality by 2060'. In 2021, the National Two Sessions incorporated the '3060' goal into the '14th Five-Year Plan' and proposed that various industry departments and governments should formulate corresponding carbon emissions by 2030. According to several studies, the carbon emissions of China's construction industry account for more than half of the country's carbon emissions. Achieving 'carbon neutrality' by 2030 is arduous, and it is significant for China to realize its commitment to the world's 'double carbon' [5]. In 2020, the Ministry of Housing and Urban–Rural Development and seven other departments jointly implemented the 'Green Building Creation Action Plan', which proposes accelerating the green transformation of the construction industry and promoting the use of green buildings. In 2021, the General Office of the State Council proposed in the 'Opinions of the Central Committee of the Communist Party of China and the State Council on Completely and Accurately Implementing the New Development Concept and Doing a Good Job in Carbon Neutralization of Carbon Peaks' that we should vigorously develop energy saving, low-carbon buildings nationwide and comprehensively promote green, low-carbon building materials. In 2022, the National Development and Reform Commission and four other departments jointly issued the 'Implementation Plan for Carbon Peak in Building Materials Industry', which proposed accelerating the production and application of green building materials and comprehensively promoting them in star-rated green buildings by 2030. Experts and scholars in different fields have conducted extensive research on the measurement of carbon emissions throughout the construction process and the strategies for achieving carbon neutrality. This research has played a positive role in guiding project practice and policy decision making.

According to the latest 'China Building Energy Consumption Research Report', in 2020, China's construction process contributed 5.08 billion tCO_2, accounting for approximately 51% of the country's carbon emissions. Specifically, the building stage accounted for around 29% of these emissions, and the operation stage accounted for approximately 22% [6,7]. The potential for carbon emission reduction and the space available in the construction industry are both substantial. Qi, S.J. et al. [8] used input–output analysis to analyze the carbon footprint model of the construction industry and utilized a modified Kaya identity to decompose the influencing factors of carbon emissions in the construction industry. The analysis concluded that the energy structure and industrial scale of the construction industry are the key areas for energy conservation and emission reduction. The building stage includes building materials production, transportation, construction, etc., and its cost accounts for about 90% of the entire single building cost, of which building materials account for about 60%. Steel and cement are the main sources of energy consumption in building materials and the main sources that produce carbon dioxide emissions in the industrial sector. With China's large population base and backward traditional industrial technology, the national urbanization process has accelerated in recent years. Accelerating the transformation and upgrading of China's construction industry is crucial to promoting the high-quality development of Chinese style.

This paper identifies the development status of China's construction industry and the international and domestic problems, challenges, and risks faced by low-carbon transformation; analyzes the connotation and evaluation index system of Chinese-style high-quality development; and proposes high-quality development goals, directions, and implementable paths for China's construction industry. This paper analyzes the core problems that need to be overcome in the current development status of the construction industry and puts forward targeted measures and suggestions from the perspectives of governments, enterprises, and consumers to help the high-quality development of China's construction industry.

2. Connotation, Characteristics, Influencing Factors, and Measurement Index System of High-Quality Development

The National Congress of the Communist Party of China report proposed that 'China's economy has shifted from a high-speed growth stage to a high-quality development stage'. From the perspective of the wheel of historical development, the high-quality development of Chinese modernization is a development strategy put forward to solve the changes in the main social contradictions in the new stage of development, adapting to the national conditions and keeping in line with the times [6].

2.1. Connotation

From the perspective of item attributes, quality refers to the use value characteristics of the product that can meet the actual needs. It has certain material attributes and utility of use value, including macro and micro quality. From an economic perspective, under certain conditions, the level of quality reflects the benefits or costs in market transactions [6]. High quality is the unity of quality and quantity, a new driving mechanism with true value rationality that is more focused on demand. From the perspective of the development of human society, high-quality development refers to a bottom-up, top-down, high-efficiency, fair, and green sustainable development model set to meet the growing needs of the people for a better life.

2.2. Characteristics

According to the definition, satisfying people is the preposition, the good life is fundamental, the need is the behavioral motivation, and it exhibits conformity, applicability, and satisfaction [9]. To a certain extent, adhering to high-quality development is a kind of conscious initiative, reflecting fairness, efficiency, and inclusiveness.

From a systematic standpoint, this approach focuses on people of all ethnic groups as the central point and the good life as the direction. It is characterized by a multi-dimensional perspective, multiple objectives, and a multi-linear dynamic mechanism. High-quality development is indicative of a sustainable model for complex system reduction.

2.3. Influencing Factors

Based on the consideration of connotation and characteristics, high-quality development can be realized through three levels: macro, industry, and enterprise, and there is a subordinate and inclusive relationship among the three. From a macro perspective, high-quality development highlights strong economic strength, balanced development benefits, and a sense of public inclusion and requires a positive development environment encompassing economic, social, and political factors [9,10]. From an industry perspective, high-quality development reflects a smooth industrial system, excellent industrial structure, and virtuous cycle of industrial competitiveness, which requires a good policy mechanism and standard system. From the perspective of enterprises, high-quality development is manifested in good product quality, brand image, management, and competitive advantages, which require a good business environment, sufficient input of production factors, innovation motivation, and new technologies.

2.4. Measurement Index System

The measurement of development quality directly reflects the implementation of institutional mechanisms, standard systems, and development goals. The selection of a measurement index system should focus on the unity of overall and local, long-term and short-term, structure and technology, quantitative and qualitative, and the ability to reflect as many quality and results indicators as possible.

The measurement index system started earlier for developed countries and achieved remarkable results. Some of them have been widely promoted to contribute to realizing the national 'double carbon' goal. For example, in 2007, the EU developed a sustainable development index system (Sustainable Development Index, SDIs); in 2010, Germany constructed a national welfare measurement index system (National Welfare Index, NWI).

For developing countries, the measurement index system is still in its infancy. At the macro level, developing countries 'high-quality development' index system is based on efficient, fair, and sustainable development principles. It primarily includes factors such as disposable income, malignant events, labor productivity, additional output value per unit of GDP, urban–rural gap, employment, medical care, air, and climate (see Table 1) [9,11]. Some provinces and cities take the lead in formulating a city-level index system of high-quality development. For example, in 2020, Beijing issued the 'Implementation Plan for Promoting the Construction of High-quality Development Standard System in the Capital'; in 2021, Shanghai innovated and built a 'comprehensive performance evaluation method and index system for high-quality development'.

Table 1. The proposed framework entails establishing an indicator system to assess the progress of developing countries in achieving high-quality development.

Median	Disposable income of efficient residents.
	Labor productivity per hour worked.
	The number of malignant events caused by product quality problems.
	Product quality satisfaction.
	Domestic value-added rate per unit of export.
	Life expectancy at fair birth.
Average	Life expectancy at fair birth.
	Years of education (years).
	Regional development gap.
	Gini coefficient of per capita GDP.
	Urban–rural income gap.
	Income gap between people.
	People's livelihood satisfaction (education, medical care).
	(Survey) Long-term unemployment rate.
Sustainable	Air quality (proportion of days with excellent air quality in prefecture-level and above cities).
	Water environment quality (the proportion of surface water reaching or better than Class III water body).
	Local environmental quality satisfaction.

Self-made, according to the requirements of the article.

From an industrial perspective, the index system for 'high-quality development' primarily focuses on comprehensive quality and efficiency, innovative, coordinated, green, open, and shared development, characteristic indicators, etc. It includes specific indicators, such as total amount, growth rate, profit level, factor efficiency, and factor input refinement. These indicators are representative and crucial in the industry. For example, in 2020, Guangzhou took the lead in exploring 'Guangzhou's implementation plan for promoting the construction of a comprehensive evaluation index system for high-quality development of manufacturing industry'.

From an enterprise perspective, according to the principle of maximizing corporate interests, the index system for achieving 'high-quality development' mainly encompasses the dimensions of 'innovation, coordination, green, openness, sharing and efficiency'. The process refines the indicators to conform with international standards and increases the intensity and efficiency of innovation and reform as the core indicators. It is suggested that the proportion of innovation and efficiency should be significant to stimulate the technological reform of enterprises. For example, in 2021, Shenzhen took the lead in releasing the 'White Paper on the Evaluation Index System of High-quality Development of Shenzhen Enterprises' for enterprises in the Guangdong–Hong Kong–Macao Greater Bay Area.

3. Development Status, Objectives, and Key Issues of China's Construction Industry

The construction industry is the main source of energy resource consumption and carbon dioxide emissions worldwide. The construction industry's environmental cost refers to increasing or reducing the environmental burden caused by energy consumption, pollutant emissions, and non-renewable natural resources. Most appear as hidden costs, such as haze and dust storms. Mostly, energy savings are reflected in water and material savings. Because water and building materials can be quantified in the form of currency, the environmental cost can be calculated. By examining the management of the whole life cycle process of both traditional and green buildings, as well as the implementation of construction technology routes, it becomes apparent that traditional buildings increase environmental costs due to factors such as excessive energy consumption, increased pollution, extensive management mode, and technical guidelines. On the contrary, green buildings reduce environmental costs due to low energy consumption, low pollution, fine management, and advanced technical routes, which can promote the analysis and research of environmental costs [12–14].

To facilitate statistics, accounting, and critical path identification, the whole building process can be divided into the building stage (building material production, transportation, and construction), building operation and maintenance, and demolition stage (recycling), considering time and space dimensions. According to the accounting boundary of building carbon emissions, these include building direct carbon emissions (direct energy consumption), indirect carbon emissions (building operation stage), and embodied carbon emissions (building material production and construction stage).

3.1. Development Status of the Construction Industry

According to China's annual total number of monitored buildings statistics, the carbon emission coefficient method and the input–output method are used to preliminarily measure the energy consumption and carbon emissions of the construction industry, which exceeds the industrial and transportation sectors and ranks among the most carbon-emitting areas in China (see Tables 2 and 3). Due to the influence of climate zoning, economic development level, and population distribution differences, the development of the construction industry in different regions of China presents certain spatial characteristics. There is a significant linear relationship between carbon emissions and heating demand, economic development level, population structure and distribution, project management informatization level, energy-saving technology application level, green building materials procurement demand, and other factors. Using the life cycle assessment (LCIA) method [9,15], carbon emissions are calculated using the global warming potential characteristic factors recommended by the IPCC agency. The energy consumption evaluation model and emission evaluation model in the life cycle of the construction industry are formulated according to Equations (1) and (2) [16–19]:

$$\text{Etotal} = \text{Eoil} + \text{Ecoal} + \text{Egas} \tag{1}$$

$$\text{Gtotal} = \sum \text{Gi} \cdot \text{Fi} \tag{2}$$

Etotal is the total primary energy consumption (MJ); Eoil is the total consumption of crude oil (MJ); Ecoal is the total consumption of raw coal (MJ); Egas is the total original natural gas consumption (MJ); Gtotal is the total amount of global warming potential in the life cycle;

and Gi and Fi are the second types of greenhouse gas emissions and the corresponding characterization factors.

Table 2. The total energy consumption of the building process in China in 2020.

Whole Life Cycle Stage	Total Energy Consumption/100 Million TCE	The Total Energy Consumption of the Whole Process Accounts for/%
Building materials production stage	11.1	22.3
Construction phase	0.9	1.9
Building operation stage	10.6	21.3
Subtotal	22.7	45.5

Self-estimation according to the statistical yearbook.

Table 3. China's construction industry's carbon emissions in 2020.

Whole Life Cycle Stage	The Proportion of Carbon Emissions/100 Million tCO_2	National Carbon Emissions/%
Building materials production stage	28.2	28.2
Construction stage	1.0	1.0
Building operation stage	21.6	21.7
Subtotal	50.8	50.9

Self-estimation according to the statistical yearbook.

The pollution caused by standard coal combustion mainly consists of the emission of atmospheric pollutants such as CO_2, SO_2, NO_X, and soot. As a result, the formula for calculating the external coefficient of standard coal use is as follows [11,20]:

$$\text{Standard coal} = K_{CO_2} \cdot P_{CO_2} + k_{SO_2} \cdot P_{SO_2} + K_{NOX} \cdot P_{NOX} + K_{soot} \cdot P_{soot} \quad (3)$$

K is the emission coefficient (the emission coefficient per unit of pollutant X produced by the combustion of standard coal); P is the emission reduction value of pollutant X (the environmental externality coefficient of pollutant X, which has a relationship between global emission pollutants and energy consumption).

The interpretation of the results includes identification, evaluation, and reporting. The role of influencing factors is identified, and a sensitivity model is constructed, as shown in Equation (4) [9,20].

$$\text{Smn} = (\Delta\text{Rm}/\text{Rm})/(\Delta\text{Ln}/\text{Ln}) \quad (4)$$

Rm is the LCA result of the mth environmental impact; ΔRm is the mth environmental impact LCA result change value; Ln is the nrh link in the list data value; ΔLn is the change value of the nth link list data; and Smnis the sensitivity of Ln to Rm.

According to the energy-saving emission reduction control indicators and national economic conditions, combined with local emission charging standards and research results, the value of CO_2 emission reduction is CNY 160/t, the value of SO_2 emission reduction is CNY 20,000/t, the value of NOx emission reduction is CNY 631.16/t, and the value of soot emission reduction is CNY 275.2/t. Based on the above externality coefficient and emission reduction values, standard coal combustion's externality coefficient can be calculated as 733.5. Different building grades in the same region have different technical standards, construction standards, and technical personnel requirements. The main aspects encompassed are preliminary research, design fees, sound insulation, maintenance structure, intelligent settings, water-saving systems, community garbage disposal, product certification, and other aspects. There is little difference in other parts, which leads to differences in economic cost input and environmental benefits [11,15,21].

It can be seen from the above Tables 2 and 3 that the proportion of carbon emissions in the building stage is significantly higher than that of energy consumption, indicating that building materials are the key factors affecting carbon emissions. Steel and cement are the most consumed building materials, accounting for approximately 95% of total consumption. With the increase in the total number of buildings and the improvement of people's living standards, the proportion of building terminal energy demand, total carbon dioxide emissions to national terminal energy consumption, and total greenhouse gas emissions show an increasing trend [16]. The construction stage is an important part of emission reduction actions. Therefore, it plays a key role in promoting the reform and transformation of the construction industry, realizing the industry's carbon peak as soon as possible, and ensuring the low-carbon transformation of the construction industry in a safe and orderly manner [22,23].

From the Table 4, it can be seen that during the 'Eleventh Five-Year' period, the state increased real estate investment and policy support, resulting in a significant increase in the proportion of energy consumption during the 'Twelfth Five-Year' period, higher than the average growth rate in 15 years [16,19]. At the same time, with energy-saving innovation technology and information project management, the growth rate of energy consumption and carbon emissions has declined, as has the total growth rate. However, the total energy consumption and carbon emissions still rank first in all departments.

Table 4. Energy consumption and carbon emissions in China's construction process from 2005 to 2020.

Temporal Interval	Growth Rate of Energy Consumption in Time Interval/%	Average Growth Rate of National Carbon Emissions/%
'Eleventh Five-Year'	5.9	7.8
'Twelfth Five-Year'	8.3	6.8
'Thirteenth Five-Year'	3.7	2.3
2005–2020	6.0	5.6

China building energy consumption and carbon emissions research report, 2022.

3.2. Development Goals

The high-quality development of the construction industry directly affects the degree of urbanization in China, the realization of the 'double carbon' goal, the implementation effect of the policy system, and the efficiency and satisfaction of meeting people's needs for a better life. Based on the principle of systematic planning, one type of policy, coordinated efforts, safety, and economy, we should vigorously develop green, low-carbon, and zero-energy buildings. Additionally, we should promote the adoption of energy-saving technologies, green building materials, and diverse energy services in rural areas, ensuring a safe and organized approach. Using human needs as the first starting point, we should renovate old residential areas, enrich the applicability and conformity of urban public buildings, strengthen dynamic monitoring of energy consumption and carbon reduction, explore the quantitative method of dynamic life cycle assessment of green and low-carbon buildings, and propose development goals for the four stages that follow [12,24,25].

The first stage, which will take place from 2024 to 2030, is the top-level design period. The total number of new buildings continues to rise as the real estate investment and financing system is optimized, the housing sales policy is stimulated, stock construction land is listed, and the formulation of policies and systems, such as improved housing demand, old community renovation, and urban renewal, is accelerated. This stage aims to strengthen top-level design, improve the dynamic evaluation index system of high-quality development, establish standards for zero-carbon building technology, implement green certification for building materials, certify building product services, establish a carbon emission dynamic monitoring system, disclose carbon information, implement a market trading mechanism, and strive to achieve the construction industry's carbon peak ahead of schedule.

The second stage is the deep development period from 2030 to 2050. The utilization of electrification in buildings has been widely adopted, along with the utilization of alternative energy sources, energy-saving technology, and green building materials. During this phase, the renovation of existing buildings will be completed, the green finance and carbon trading market will be stable and well-developed, and the promotion of zero-carbon buildings will lead to self-sufficiency in new constructions.

The third stage, which will take place from 2050 to 2055, aims to consolidate the outcomes achieved during the previous periods. Zero emissions in urban residential and public buildings can be achieved through implementing policies, energy-saving technologies, market mechanisms, and the active participation of various stakeholders. Additionally, the full implementation of green buildings in rural areas and the adoption of low-carbon building practices are essential steps towards achieving the goal of zero emissions.

The fourth stage, which will take place from 2055 to 2060, will be the summary planning period. The government, market, and stakeholders can work together to independently adjust, explore the potential space for emission reduction, and realize the high-quality development of the construction industry.

3.3. Key Issues

The system of policies and standards is insufficient, and the implementation of policy tools needs to be strengthened. The construction industry's 'double carbon' goal involves multiple units, diverse interests, and complex influencing factors. Although a series of rules and regulations have been formulated, there is still a gap in implementation. Some of them only clarify the macro direction and do not have specific standards and assessments, resulting in poor implementation. Human factors in China include some law enforcement not being strict enough, information on law enforcement equipment and facilities being insufficient, and the low illegal cost, which leads to the addition of or inability to dismantle illegal buildings. The early stage of achieving the carbon goal is mainly based on the enterprise or individual's own input, such as tax, financing, and other preferential margins and landing effects, which are unsatisfactory [20,22]. Therefore, industry authorities and associations should accelerate the improvement of the policies and standards, implement detailed incentive measures, mobilize the initiative of stakeholders, and guide the transformation and upgrading of the construction industry in different ways.

Energy-saving efficiency technology is insufficient; the pilot application is not timely. Advanced and efficient building materials and construction technology are key to achieving the 'double carbon' goal. Currently, there is a lack of consistency among project site management personnel, resulting in varying energy-saving awareness and knowledge reserve levels. The utilization of energy-saving and environmental protection technology and materials is weak, and there is insufficient investment in some intelligent technology, new energy, and new technology. Additionally, some advanced technology research is still in the exploratory stage. Further investment in technical research and personnel training is necessary in the future.

The energy consumption structure is relatively simple, and the dynamic monitoring system is imperfect. The construction of a carbon emission factor database is the basis of accurate carbon emission accounting. There are phenomena, such as the incomplete scope of dynamic monitoring projects, ncompl, and non-sharing of management information among multiple departments, such as hydropower and heating, and insufficient use of big data. It is necessary to optimize the energy structure, strengthen information sharing and data exchange, fully use new technologies, and improve management efficiency.

The green financial system needs improvement, and the carbon information disclosure mechanism has not yet been fully developed. The funds mainly come from government subsidies and special fund support, and the input cost is high. Green finance and other investment and financing support for the construction market are insufficient, and some cannot be implemented. Some small and medium-sized enterprises have insufficient financial instruments and a single structure.

There are deficiencies in construction industrialization, and project management is not advanced enough. Prefabricated buildings are an important way to develop green buildings. There are some phenomena in the industrial production of buildings, such as low utilization rate, substandard product quality, and irregular modularization. In some small projects, the utilization rate is very low. China has the best infrastructure construction in the world. However, the lack of professional project management talents and the simple and crude management mode has led to the phenomenon of 'bean curd residue' in many high-quality projects. There are flaws in project schedule control, process management, and key node quality control [26,27].

The quality of products and services needs to be improved, and the awareness of carbon emission reduction needs to be strengthened. Building products and services to meet people's demand for good quality is the ultimate goal of developing 'double carbon' and achieving the effective exploration of social welfare maximization. The goal of building 'double carbon' is reflected in the whole building process. There is a gap between building quality and service and expectations from planning, design, selection of building materials and accessories, on-site construction, daily use, etc., due to incomplete standards and specifications, irresponsible implementers, and weak awareness of emission reduction and carbon reduction [28,29].

4. The High-Quality Development Path of China's Construction Industry

4.1. Establish a High-Quality Development Measurement Index System for the Construction Industry

From the construction industry's perspective, high-quality buildings represent the need to enhance quality control capabilities and move towards high-quality products and services. Now, the supply and demand sides have undergone great changes. The leading market has changed from a seller to a buyer. The empirical practice of constructing a high-quality development measurement index system is how to win in the second half.

For the construction industry, due to the adoption of new energy-saving technologies and the continuous increase in electrification rate, energy consumption, and carbon emissions in the building stage will be reduced. However, due to the changes in population structure and significant aging in the future, there will be greater demand for energy-saving technology investment and efficiency research to meet the increased demand for heating, lighting, and other systems.

Focusing on the goals of high efficiency, inclusiveness, and sustainable development, a new model of sustainable development in the whole life cycle of the construction field is innovated, and development advantages are systematically created based on the construction of green and low-carbon 'products' that can be promoted. The comprehensive scoring method is used to explore the construction of the '1 + 5 + N' construction industry high-quality development index system. The index system is divided into three levels: 7 first-level indicators, second-level indicators, and 37 specific indicators, as shown in Appendix A Table A1.

1. First-level indicators. Seven primary indicators have been established: comprehensive quality and efficiency, innovative development, coordinated development, green development, open development, shared development, and characteristic indicators. Each first-level indicator includes several second-level indicators, reflecting different aspects of high-quality development.
2. Secondary indicators. Secondary indicators are set for each indicator level to achieve fairness and justice. Core indicators are then selected based on their exceptional representativeness and importance.
3. Weight and score. The evaluation system has a total weight of 100, and the weight of each index is dynamically adjusted. The expert scoring method and analytic hierarchy process are used to calculate the weight, and the weight of 10 core indicators account for 60% of the total [13,26,30].

4.2. Selectable Path

Under different situational modes, the construction industry can choose one, two, or more combinations of paths to achieve high-quality development [22,26].

Path 1: A quality improvement path combining standardization, industrialization, and technology, driven by a profit-oriented mindset. This path aims to strengthen the standard system, develop economies of scale, pilot industrial production, and form a quality-oriented energy resource allocation method.

Path 2: Enhancing efficiency by implementing modularization, informatization, and intelligent empowerment. This path aims to accelerate the establishment of an information management platform for the construction industry; make full use of the BIM model, Guanglianda pricing software, dynamic material flow analysis, etc.; focus on monitoring key nodes; fully empower the upstream and downstream supply chains of the construction industry; and achieve a modern, convenient, and efficient project management model [28,31].

Path 3: A path driven by innovation that fosters collaboration and connection among different types, levels, and fields. Our approach involves integrating green finance, leveraging big data and information platforms, and continuously improving the dynamic monitoring system for carbon emissions and energy consumption; this is done in alignment with the industry's national strategy, user requirements, and internal development needs [24].

Path 4: Introducing green, circular, and new development concepts into the sustainable development path of the whole life cycle. Low-carbon concepts are integrated into various stages of the construction industry, including planning, designing, construction, building materials production, transportation, operation, and maintenance. This integration aims to improve the quality of construction products and services, reduce energy consumption and greenhouse gas emissions, and ensure the safe and orderly development of the construction industry.

5. Countermeasures and Suggestions

We aim to improve the policy and standard systems and strengthen policy tool implementation. The objective is to establish and improve the policy system, standard system, industry technical standards, and product design specifications that support the construction industry. This involves assigning professionals to organize preliminary research, interpret policies, evaluate feedback, increase law enforcement supervision, and impose penalties for illegal violations. An important step is to establish a robust system for supervising and assessing projects and imposing penalties on projects and products that do not meet the standards involved.

We must increase investments in energy-saving and efficiency-increasing technologies and optimize energy resource allocation efficiency. To fully improve the efficiency of energy resource utilization, accelerate the adoption of prefabricated and industrialized construction, make up for shortcomings, and achieve balanced development, it is important to actively promote renewable energy sources such as solar and wind energy. At the same time, it is important to use local, current, and favorable terrain, climate, environment, and policy mechanisms. Additionally, recycling and reuse of waste, secondary utilization, and 'scrap' should be carried out throughout the whole life cycle of buildings to reduce secondary carbon emissions with the most optimal path.

The standards for monitoring carbon emissions and energy consumption within buildings must be continuously improved, as well as dynamic monitoring capabilities. The '1 + N' platform mode is recommended for buildings with high energy consumption, numerous property rights users, and complex structures. This mode involves owners taking charge of 'self-construction', users participating, and third-party management, while also promoting data sharing to increase data support. Using a BIM information management platform and remodeling, the material flow of the whole life cycle of the building is dynamically analyzed.

In addition to standardizing the disclosure of environmental information, the guidance of green finance should be strengthened. The acceleration of the innovation of green building financial products derivatives, the enrichment of financial instruments such as green credit, and the provision of differentiated consumption incentives associated with good low-carbon behavior and high efficiency of technological reform are all important priorities. One of our suggestions that stems from this research is to increase support for the capital flow of construction enterprises to prevent corporate 'greenwashing' behavior. Another suggestion is to improve the construction of ESG standard management, information disclosure, regulatory responsibility, and guidance supervision. Another idea is that information is money and efficiency values should be given full play and systemic financial risks should be prevented in advance [12,31].

The in-depth promotion of renovation and the establishment of an effective management mechanism over the long term should be accelerated. Our research indicates the urgent need to accelerate the establishment of basic information ledgers in older urban communities. We should focus on screening equipment and facilities and service facilities with high energy consumption and large carbon emissions. Additionally, we should explore innovative investment and financing models, optimize project management models, and systematically promote high-energy-consuming facilities, such as external wall insulation and enclosure insulation. It is crucial to optimize energy industrial structure, improve building material production processes and construction technology, and transition to more sustainable transportation methods for building materials and accessories. Lastly, we should adopt low-carbon and intelligent renewable energy sources to guide existing buildings' sustainable and low-carbon development.

In conclusion, it is imperative to strengthen the cultivation of green consumption behavior and provide guidance for green production and lifestyle choices. We must adopt green product information disclosure and green building materials certification to enable consumers to directly experience the beneficial impact of emission and carbon reduction. Through engaging in community public welfare activities, celebrating shopping mall anniversaries, utilizing major consumption platforms during 'consumption season', and promoting public welfare campaigns, we can increase publicity, cultivate awareness of carbon reduction, and systematically formulate action goals and strategies through various frequencies, channels, and modes. This will enable us to achieve a modern, sustainable, zero-carbon, resilient construction industry with Chinese characteristics.

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Appendix A

Table A1. A comprehensive evaluation index table of China's construction industry's high-quality development.

First-Level Indicators	Second-Level Indicators	Specific Index Weight Types	Weight	Types
Comprehensive quality efficiency	Development scale	Industrial added value.		Positive
		Construction industry value added.	6 (core)	Positive

Table A1. *Cont.*

First-Level Indicators	Second-Level Indicators	Specific Index Weight Types	Weight	Types
Comprehensive quality efficiency	Growth rate	Industrial added value growth.		Positive
		Construction industry value-added growth rate.	6 (core)	Positive
	Profit and loss	The operating income profit margin of industrial enterprises that are larger than their designated size.		Positive
		The loss of industrial enterprises above the designated size.		Reversed
	Factor	The per mu output of factor industrial land.		Positive
		The total labor productivity of industrial enterprises that are larger than their designated size.		Positive
		The proportion of new construction enterprise loans to total new loans.	6 (core)	Positive
		Industrial enterprise investment accounted for the proportion of fixed asset investment.		Positive
Innovation	Innovation investment	Research and experimental development funds accounted for a significant portion of regional GDP.	6 (core)	Positive
		The proportion of R&D personnel in industrial enterprises that are larger than their designated size to the number of construction enterprises.		Positive
		The proportion of internal expenditure of R&D funds in the business income of construction enterprises that are larger than their designated size.		Positive
	Achievement transformation	The proportion of construction enterprises that are larger than their designated size with R&D institutions at the innovation level.		Positive
		The proportion of the added value of the technical construction industry to the added value of the above-scale construction industry.		Positive
		The annual growth rate of contract turnover in the technology market.		Reverse
		The ratio of effective invention patents to operating income, measured in billions, for industrial enterprises that exceed their designated size.		Positive
Coordination	Enterprise structure	The number of construction enterprises above the billion level.		Positive
		The number of small-scale construction enterprises.		Positive
		Listings of manufacturing companies.		Positive
	Product structure	The output value of high-tech products accounts for the proportion of the total output value of industries larger than their designated size.		Positive
	Industrial structure	Advanced construction industry value added above the industrial added value ratio scale.	6 (core)	Positive
		The proportion of private industrial output value in industrial output value.		Positive

Table A1. *Cont.*

First-Level Indicators	Second-Level Indicators	Specific Index Weight Types	Weight	Types
Green	Green production	The proportion of clean production enterprises in the total number of enterprises.		Positive
		General industrial solid waste utilization rate.		Positive
	Resource utilization industrial	Unit value-added energy consumption reduction rate.	6 (core)	Positive
Open	International trade	Industrial enterprises' import delivery value growth rate.	6 (core)	Positive
	Absorb foreign capital	The proportion of the actual use of foreign capital in the construction industry.		Positive
		The growth rate of the total industrial output value of foreign and Hong Kong, Macao, and Taiwan enterprises.		Positive
	Regional cooperation	Chinese investment agreement for overseas construction enterprises.		Positive
Shared	Social justice	Labor remuneration accounted for the proportion of industrial-added value.	6 (core)	
		Number of construction workers.		
		The ratio of tax payments made by industrial enterprises to the overall tax revenue of a region.		
Characteristic index	Park construction	The average investment intensity of industrial land in the park.		
		The industrial-added value of the park accounts for the proportion of the global industrial-added value.	6 (core)	
	Characteristic industries to cultivate	New industries added value and accounted for a proportion of GDP.		
	Integrated development	The number of homestays above the scale.		

Self-manufacture according to the requirements of the article.

References

1. Lucon, O.; Ürge-Vorsatz, D.; Zain Ahmed, A. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, MA, USA; New York, NY, USA, 2014.
2. Zou, J.; Wang, K. *China Urban Greenhouse Gas Emission Inventory*; China Environmental Science Press: Beijing, China, 2013.
3. Liu, J.L. *Research on China's Mid and Long Term Low Carbon Development Strategic Goals and Road Map*; Renmin University of China: Beijing, China, 2017.
4. International Energy Agency. Transition to Sustainable Buildings: Strategies and Opportunities to 2050 [EB/OL]. 27 June 2013. Available online: https://www.oecd-ilibrary.org/transition-to-sustainable-buildings_5k44zbqfgk34.pdf?itemId=/content/publication/9789264202955-en&mimeType=pdf (accessed on 2 August 2018).
5. Zhang, S.; Yang, Y.; Wen, Z.; Peng, M.; Zhou, Y.; Hao, J. Sustainable development trial undertaking: Experience from China's innovation demonstration zones. *J. Environ. Manag.* **2022**, *318*, 115370. [CrossRef] [PubMed]
6. Building Energy Research Center of Tsinghua University. Comparison of Energy Consumption and Carbon Emissions from Building Operation between China and Other Countries. In *Decarbonize Urban Heating System*; Springer: Singapore, 2024. [CrossRef]
7. Yu, J.; Shao, C.; Xue, C.; Hu, H. China's aircraft-related CO_2 emissions: Decomposition analysis, decoupling status, and future trends. *Energy Policy* **2020**, *138*, 111215. [CrossRef]
8. Qi, S.J.; Zhang, Y.B. Research on the influencing factors and reduction strategies of carbon emission of construction industry in China. *Soft Sci.* **2013**, *27*, 39–43.

9. Shi, D.; Zhao, J.; Deng, Z. The reform mechanism and policy measures to promote high-quality development Institute of Industrial Economics. *Chin. Acad. Soc. Sci. Res. Financ. Issues* **2018**, *9*, 19–27. [CrossRef]
10. Building Energy Efficiency Research Centre of Tsinghua University. *China Building Energy Efficiency Annual Development Research Report 2023 (Urban Energy Systems Theme)*; China Architecture & Building Press: Beijing, China, 2023.
11. Zhang, J.; Liu, H.; Jianmn, J.; Zhang, J.; Dong, L. Calculation and value analysis of energy saving and emission reduction. *China Energy* **2009**, *31*, 26–29.
12. Zhao, J.; Shi, D.; Zhou, D. Research on the connotation of high-quality development.Research on Economics and Management. *Econ. Manag. Res.* **2019**, *40*, 15–17.
13. Pan, M.P. The Methodology Research and Application on Energy Consumption and Carbon Emissions of Highway Based on the Life Cycle Assessment. Master's Thesis, South China University of Technology, Guangzhou, China, 2011.
14. Cole, R.J. Building environmental assessment methods: Redefining intentions and roles. *Build. Res. Inf.* **2005**, *33*, 455–467. [CrossRef]
15. Zhang, L.; Wang, P.; Yang, Y.; Xing, C.; Tan, Y. Asphalt pavement energy of different design life based on LCA Consumed Emissions Analysis. *Mater. Guide* **2024**, *38*, 23080071.
16. Robert, J.; Barro. *Convergence and Modernization Revisited*; Working Paper; National Bureau of Economic Research: Cambridge, MA, USA, 2012.
17. Hoyos, D. The state of the art of environmental valuation with discrete choice experiments. *Ecol. Econ.* **2010**, *69*, 1595–1603. [CrossRef]
18. Hsu, A.; de Sherbinin, A.; Shi, H. Seeking truth from facts: The challenge of environmental indicator development in China. *Environ. Dev.* **2012**, *3*, 39–51. [CrossRef]
19. Rassier, D.G.; Earnhart, D. Effects of environmental regulation on actual and expected profitability. *Ecol. Econ.* **2015**, *112*, 129–140. [CrossRef]
20. Chan, E.H.W.; Qian, Q.K.; Lam, P.T.I. The market for green building in developed Asian cities-the perspectives of building designers. *Energy Policy* **2009**, *8*, 3061–3070. [CrossRef]
21. Marx, A.; Dusa, A. Crisp-Set Qualitative Comparative Analysis (csQCA), Contradictions and Consistency Benchmarks for Model Specification. *Methodol. Innov. Online* **2011**, *6*, 103–148. [CrossRef]
22. Liu, J.; Xiang, Q.; Wang, K.; Zou, J.; Kong, Y. Mid- to long-term low carbon development pathways of China's building sector. *Resour. Sci.* **2019**, *41*, 509–520.
23. Yu, T.; Duan, X.M.; Ge, C.Z.; Tian, X.; Li, X.L. Analysis on the status quo ofenvironmental information disclosure of listed companies based on keypollutant discharging units. *Chin. J. Environ. Manag.* **2018**, *6*, 107–112. [CrossRef]
24. Guan, D.; Hubacek, K.; Weber, C.L.; Peters, G.P.; Reiner, D.M. The drivers of Chinese CO_2 emissions from 1980 to 2030. *Glob. Environ. Chang.* **2008**, *18*, 626–634. [CrossRef]
25. Zhang, S.; Yu, R.; Wen, Z.; Xu, J.; Liu, P.; Zhou, Y.; Zheng, X.; Wang, L.; Hao, J. Impact of labor and energy allocation imbalance on carbon emission efficiency in China's industrial sectors. *Renew. Sustain. Energy Rev.* **2023**, *184*, 113586. [CrossRef]
26. Wu, Z.; Huang, H.; Chen, X.; Li, J.; He, Q.; Li, A.; Huang, J.; Lin, Y.; Liu, X.; Wang, J. Countermeasures for Low-Carbon Transformation of Construction Industry in China Toward the Carbon Peaking and Carbon Neutrality Goals. *Chin. J. Eng. Sci.* **2023**, *25*, 202–209. [CrossRef]
27. Lu, Y.; Abeysekera, I. Stakeholders' power, corporate characteristics, and social and environmental disclosure: Evidence from China. *J. Clean. Prod.* **2014**, *64*, 426–436. [CrossRef]
28. Huang, Y.; Liu, G.; Bo, Y.; Wang, J.; Cao, M.; Lu, X.; He, K. Beijing–Tianjin–Hebei coordinated development toward the carbon peaking and carbon neutrality goals. *Strategy Study CAE* **2023**, *25*, 160–172.
29. Chang, S.; Feng, G.; Cui, H.; Zhang, L.; Li, Q. Research on Carbon Emission Characteristics and Emission Reduction Potential Prediction of Construction Industry. *J. Shenyang Jianzhu Univ.* **2023**, *39*, 139–146.
30. Tapio, P. Towards a theory of decoupling: Degrees of decoupling in the EU and the case of road traffic in Finland between 1970 and 2001. *Transp. Policy* **2005**, *12*, 137–151. [CrossRef]
31. Lin, B.; Zhu, J. The role of renewable energy technological innovation on climate change: Empirical evidence from China. *Sci. Total Environ.* **2019**, *659*, 1505–1512. [CrossRef] [PubMed]