buildings

Article

Research on High-Quality Carbon Reduction Pathways for Green Buildings under the Dual Carbon Background

Xing Wei [1,2], Zhi He [2,3,4], Yitong Li [1,2] and Xiaoping Li [1,2,*]

1 National Engineering Research Center of Building Technology, Beijing 100013, China; weixing688@126.com (X.W.); lytcjwd@163.com (Y.L.)
2 China Academy of Building Research, Beijing 100013, China; hezhi0207@163.com
3 School of Architecture and Design, Harbin Institute of Technology, Harbin 150006, China
4 Key Laboratory of Cold Region Urban and Rural Human Settlement Environment Science and Technology, Ministry of Industry and Information Technology, Harbin 150090, China
* Correspondence: lixpcabr@163.com

Abstract: Carbon peaking and carbon neutrality strategies bring both opportunities and challenges to the development of green buildings. In this context, the development of high-quality green buildings requires a focus on improving carbon reduction effects throughout their entire lifespan. Based on a systematic review of the achievements and existing problems in the development of green buildings in China over the past thirty years, this article benchmarks the new trends in green building standards in developed countries abroad, dissects the new requirements for the development of green buildings in China under the new situation, and proposes a high-quality carbon reduction pathways from four aspects: theoretical research, policy systems, technical systems, and software platforms. Finally, it proposes implementation suggestions for collaborative development from four dimensions: theoretical methods for calculating carbon emissions, green finance policies, a full-process carbon reduction technology system, and carbon emission accounting tools.

Keywords: carbon peaking and carbon neutrality; green buildings; high-quality development; high-quality carbon reduction; pathways

Citation: Wei, X.; He, Z.; Li, Y.; Li, X. Research on High-Quality Carbon Reduction Pathways for Green Buildings under the Dual Carbon Background. *Buildings* **2024**, *14*, 2082. https://doi.org/10.3390/buildings14072082

Academic Editor: Apple L.S. Chan

Received: 20 June 2024
Revised: 3 July 2024
Accepted: 5 July 2024
Published: 7 July 2024

1. Current Status of Green Building Development (Introduction)

In the 1990s, the concept of green building was first introduced to China, and since then, the relationship between energy conservation and green building has grown. In September 2004, the Ministry of Housing and Urban-Rural Development established the "National Green Building Innovation Award", which catalyzed the country's first steps toward becoming green [1]. Following the "Tenth Five-Year Plan" for pilot implementation, the "Eleventh Five-Year Plan" for creating a system's foundation, the "Twelfth Five-Year Plan" for providing incentives to support the popularization of green building, and the "Thirteenth Five-Year Plan" for transitioning from advocacy to popularization of green building, China has made certain achievements in green building, but there are also practical problems that need to be solved.

1.1. The Development of Green Buildings Has Achieved Both Quantity and Quality

Firstly, the scale of green buildings continues to expand. Driven by policies and led by standards, the annual construction volume of green buildings in China has increased from 4 million square meters in 2012 to 1.9 billion square meters in 2021 [2], growing by nearly 500 times in ten years. The cumulative completed scale also increased significantly. By 2020, the cumulative green building area in China exceeded 6.6 billion square meters [3], and further increased to 8.5 billion square meters in 2021 [4] (Figure 1), of which public buildings account for more than half, reaching 51.5%. Residential buildings followed, accounting for 47.4%, while industrial buildings account for a small percentage, just 0.8%.

In addition, after nearly two decades of development, green buildings have basically achieved universal popularization, and the proportion of green buildings in new urban buildings nationwide will reach 77% in 2020, 84% in 2021 [4], and more than 90% in the first half of 2022 [5]. According to the goals and tasks of the Ministry of Housing and Urban-Rural Development's "14th Five-Year Plan" Building Energy Efficiency and Green Building Development Plan, this proportion will reach 100% in 2025.

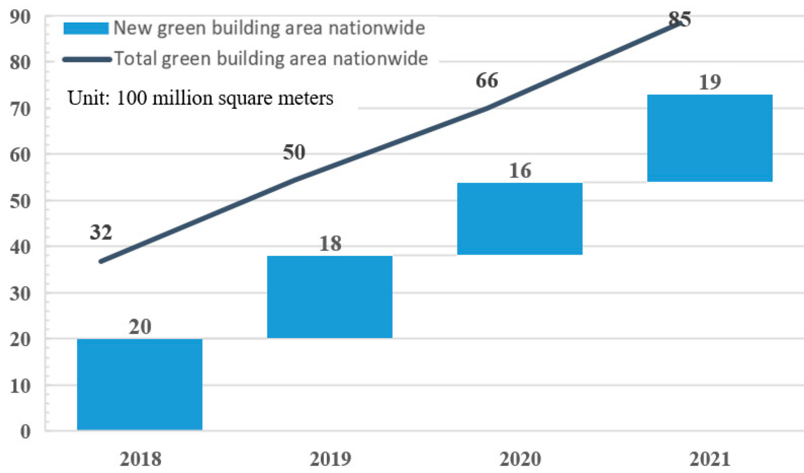

Figure 1. Statistics of national green building area from 2018 to 2021.

Secondly, the development of green-labeled buildings has been rapid. After the release of the Evaluation Standard for Green Building GB/T50378-2006 [6], China formally launched green building evaluation and certification work in 2008, with the number of green building labeling projects increasing year by year, and the quality of their performance improving. According to the Ministry of Housing and Urban-Rural Development's "Thirteenth Five-Year Plan for Building Energy Efficiency and Green Building Development", as of 2015, the number of star-rated green building projects reached 4071, with a floor area of about 470 million m^2 [7]. Thanks to the promulgation of incentive and subsidy policies by the state and various provinces and municipalities, the total number of labeled building projects reached 4% of the 2008~2015 figure, and the performance quality has been improved. The total number of building projects increased 3–4 times in the 8 years from 2008 to 2015. As of 2019, the number of green building labeling projects nationwide had reached 19,992 [8].

1.2. Green Building Development Still Faces Practical Problems

Firstly, the proportion of operation identification projects is low, and the operation effect of green buildings is poor. The energy-saving and carbon-reduction effects of green buildings depend on the operation stage. Reducing carbon emissions needs to be characterized by a real reduction in energy and resource consumption, which highlights the necessity of the identification and evaluation of green building operations. According to the research of Wang Qingqin, Zhou Haizhu, and other teams of the China Academy of Building Research Co., LTD., Beijing, China, as of 2017, the proportion of green building operation identification projects in China is only about 5% [1]. According to the data combing results of Academician Liu Jiaping's team at Xi'an University of Architecture and Technology and Junlu.com, operation sign projects accounted for less than 8% of the 704 green building signs evaluated nationwide in 2022 [9].

Secondly, under the downward trend of industry investment, there is insufficient motivation for identification applications. In recent years, real estate investment has been affected by multiple factors, including the overall decline in new projects. Although green building has become the basic requirement of new projects, the proportion of green buildings in new construction is also increasing. However, the green labeling of buildings did not achieve the same trend of growth. In addition to the government's special requirements regarding government investment in large-scale public buildings, autonomous voluntary construction of high-star projects is very few. In particular, after the Assessment Standard for Green Building GB/T50378-2019 [10] canceled the design logo, and the subsidy policy was reduced around the world, the willingness of construction bodies to declare green building labeling has been greatly reduced. In recent years, green financial policies have been introduced, but the input of green financial products in the field of urban and rural construction is slightly weak. The data of the Climate Bonds Initiative show that in 2019, about 30% of the funds raised by green bonds around the world flowed into the field of green buildings, while in China, this proportion was only 3% [11]. The power of high-quality development of green buildings is obviously insufficient.

2. Development Experience and New Trends of Foreign Green Building Standards

The construction of green buildings started nearly 30 years earlier in foreign countries than in China, and the promulgation of typical national evaluation standards has promoted the continuous enrichment and in-depth development of green buildings. In recent years, with the acceleration of the international response to climate change, green building evaluation standards have led to further new requirements.

The 2018 version of the UK BREEAM system adds an operational phase assessment, focusing on post-occupancy assessment of the building environment, energy, and water resources, and at the same time increases the weighting of "health and comfort" performance indicators. BREEAM In-Use V6.0.0, the first comprehensive and systematic assessment framework for the green management, operation, and maintenance performance of centralized residential communities, was released in 2020, with a 6-star certification set as the highest certification level [12,13]. In November 2021, the net-zero-carbon building certification assessment system was released. This quantitatively validated the whole-life carbon emissions of buildings and assessed their management systems. In 2023, in conjunction with the new situation of the ESG assessment, the whole-life carbon and energy scores were taken as a key point, and the requirements of the provisions related to carbon reduction were further improved. In 2018, the U.S. LEED V4.1 system for the first time introduced energy indicators for assessing costs and greenhouse gas emissions, and increased energy performance requirements [14]. In order to encourage green buildings to reach the net-zero goal during construction and operation, the new LEED Zero certification system was formally launched in November 2018, including "LEED Zero Carbon Certification", 'LEED Zero Energy Certification', "LEED Zero Water Certification LEED Zero Water Certification", and 'LEED Zero Waste Certification', reflecting the trend of a deep shift from green energy saving to net zero carbon and low carbon. The German DGNB system, which was released in 2020, consists of six core elements (environmental quality, economic quality, socio-cultural and functional quality, technological quality, process quality, and location quality) totaling 38 evaluation clauses, and applies to the climatic and economic environmental characteristics of many countries around the world outside the EU, with a wide range of applications. The Singapore Green Mark system is the first green building rating system established specifically for tropical climates, and the 2019~2021 revision cycle has reconstructed a new evaluation system with energy efficiency, whole-life carbon emissions, and resilience as the first-level indicators [15]. It innovatively included forward-looking requirements such as whole-life carbon emissions, green leasing, carbon offsets, and digital twins, such as the requirement for buildings to develop a transition plan for achieving the 2030 net-zero carbon emission target, and to increase the evaluation requirements in terms of the boundary and depth of carbon calculation. The Canada Green Building Council (CAGBC) released the Zero Carbon Building Standard in May 2017, becoming the first GBC in the world to release a national zero-carbon building standard. The standard was subsequently split into the Zero Carbon Building Design Standard and the Zero Carbon Building Operational Standard [16], which were updated separately. The French Built Environment Code (RE2020) mandates whole-life carbon calculations for buildings, proposes building carbon emission limits and pure water use targets, promotes water conservation, and reduces carbon emissions from pure water production. In addition, major cities such as London, Paris, Boston, and Los Angeles have signed the Zero Carbon Building Commitment, which aims to achieve zero carbon standards for all new buildings by 2030 and to make all buildings zero carbon by 2050 [17]. It can be seen that focusing on the low-carbon development and carbon reduction effect of green buildings has become the latest consensus in developed countries, as shown in Figure 2.

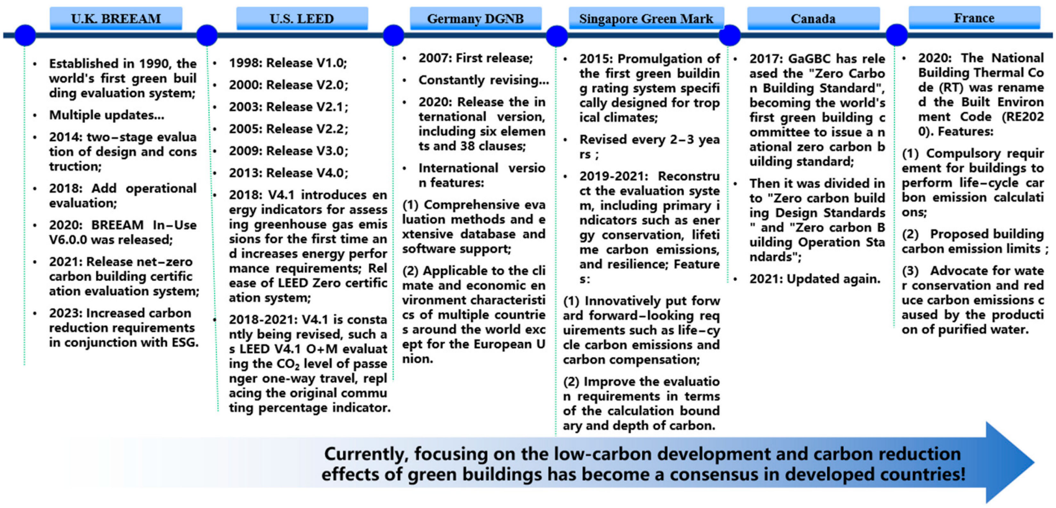

Figure 2. Development history of typical green building evaluation systems in developed countries.

3. New Requirements for Green Building Development in China

3.1. The Strategy of "Carbon Peak and Carbon Neutral" Puts Forward In-Depth Development Requirements for Green Buildings

After the goal of "carbon peak and carbon neutral" was proposed, the state and various ministries and commissions have been systematically constructing the "1 + N" policy system, with "1" being the guidance on carbon neutrality, and "N" including the national-level peak carbon action program and the implementation programs for key fields and industries. The "1" is the peak carbon neutral guideline, and the "N" includes the national-level peak carbon action program and the implementation programs for key fields and industries. After more than three years, the "1 + N" series of policies have been released one after another, and the policy orientation of energy conservation and carbon reduction has become increasingly clear. In the Carbon Peak Implementation Program for Urban and Rural Construction, it is clearly proposed that "by 2025, new buildings in cities and towns will fully implement green building standards, with the proportion of star-grade green buildings reaching more than 30%, and new government-invested public buildings for public welfare and large-scale public buildings will all reach one-star or above" [18]. Typical provinces and cities have put forward higher development requirements. In Beijing, "by 2025, new residential buildings to implement green building two-star and above standards, new public buildings strive to fully implement green building two-star and above standards". In Shenzhen, "Since 1 July 2022, the construction and operation of new buildings should be no less than one-star green building standards, and large public buildings and state office buildings should be no less than two-star".

3.2. "Good House" Leads the Construction of High-Quality Green Building Products

Minister Ni Hong of the Ministry of Housing and Urban-Rural Development put forward an "endeavor to let the people live in a better house". What makes a good house? It should be green, low-carbon, intelligent, and safe. "Green" is the core meaning of "good house", but also the primary connotation. The "good house" has given birth to the new momentum of green building quality improvement. From the above overview of the status quo of green building in China, we can see that the proportion of green building operation labeling projects is very low, and the green building operation effects have deviated significantly from the original design intentions. How these problems can be solved while ensuring the quality of green buildings is a key issue that needs to be tackled urgently in the construction of a "good house".

4. High-Quality Development Path for Green Buildings

4.1. Connotation of High-Quality Development

Under the new situation, those responsible for the development of high-quality green buildings should pay more attention to "operational effectiveness", "process carbon reduction", "diversified integration", and "health perception", to realize whole-life carbon reduction and overall quality improvement.

"Operational effectiveness": To completely change the erroneous concept of "focusing on design but not on operation", strengthen the positive design, carry out integrated technology application and systematic operation management, and measure the real operation level based on actual operation data [19].

"Process carbon reduction": Based on the unified green building carbon emission calculation method and quantitative indicators to build the whole process of low-carbon technology system, and realize the synergistic application of low-carbon technology and green building design, construction, and operation.

"Diversified integration": To highlight the inclusiveness of green building, with richer connotations and extensions, and more in-depth synergistic application of building information modeling (BIM), the Internet, green building materials, and intelligent elements.

"Healthy Perception": Human-oriented, to enhance the healthy and comfortable performance of green buildings, and to create indoor comfort, safety, and durability, and outdoor convenience and a humanistic environment that can be perceived by the public.

4.2. High-Quality Development Path

In the context of "carbon peak and carbon neutral", it is necessary and urgent for green buildings to achieve high-quality carbon reduction, and it is necessary to seek paths from four aspects: methods, policies, technologies, and platforms. Based on theoretical innovation, policy construction, technology application, and software platform initiatives should be comprehensively promoted. A development path and a collaborative promotion mechanism have been formed, featuring solid basic theory, supporting policies and institutions, supporting technology systems, and optimizing platform tools, as shown in Figure 3.

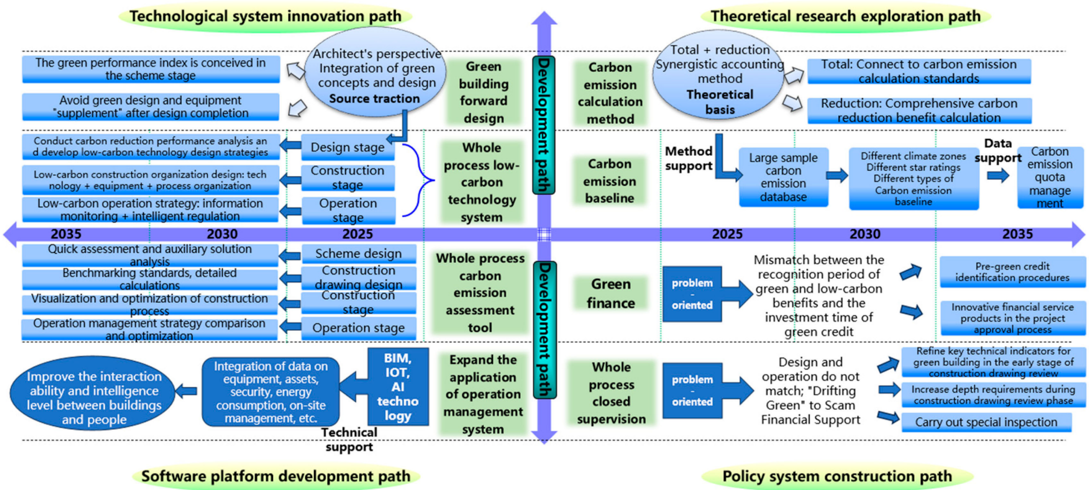

Figure 3. High-quality carbon reduction path for green buildings.

4.2.1. Theoretical Research Exploration Path: Increasing Carbon Emission Calculation Methods and Baseline Research

The first is the construction of green building carbon emission calculation method. The premise of carbon reduction in green buildings is to have a scientific carbon emission calculation method. Otherwise, carbon reduction will remain in the qualitative concept and crude estimation stage. The carbon emission calculation method is not only the premise of systematically analyzing the carbon reduction effect of various green technologies, but also the basis of constructing the green technology combination strategy based on the actual carbon reduction effect. However, at present, there is a lack of a unified calculation method for carbon emissions of green buildings in China, and the calculation boundary of carbon emissions is not unified. How to determine the calculation method covering five major performance and multiple indicators is still a theoretical research gap. In October 2022, the General Administration of Market Regulation and other ministries and commissions in China issued documents, proposing the following development goal: "By 2025, the carbon peak carbon neutral standard measurement system is basically established" [20]. As a starting point for the implementation of individual carbon reduction in the field of construction, green buildings should systematically sort out the list of influencing factors for carbon emission calculation of green buildings based on the whole life cycle, and pay close attention to forming a carbon emission calculation method based on all factors and "total + reduction" coordination. The "total" dimension is based on the essential attributes of buildings and is consistent with the national building carbon emission calculation standards. The "reduction" dimension should consider the connotation of green building and the comprehensive carbon reduction benefit based on the connotation and element attributes of green building.

The second is to establish a carbon emission baseline for green buildings. At present, due to the lack of carbon emission calculation methods and statistical data limitations, the overall carbon emission level of green buildings is not clear, and the carbon emission characteristics and differences of green buildings in different regions, of different types, and with different stars, are also fuzzy. In particular, the "General Code for Energy Efficiency and Renewable Energy Application in Building" GB55015-2021 [21] puts forward clear mandatory requirements for building carbon emission intensity, and relevant standards such as green building design and evaluation need to be coordinated with it. To solve the above key problems, resource integration should be accelerated based on the calculation method of green building carbon emissions, the effectiveness evaluation and "cleaning" of green building data should be carried out based on the green building identification project declaration platform and project data resources, and the green building carbon emissions database covering different climate zones, different building types, and different star levels should be further analyzed and formed. Furthermore, based on the large sample data, statistical analysis and data mining methods are applied to scientifically delineate the carbon emission baseline line of green buildings by region, type, and grade, and form a binding carbon emission index accordingly, providing a concrete starting point for the implementation of the shift from dual control of energy consumption to dual control of carbon emission. In addition, based on the previous management of energy consumption quotas for public buildings in some provinces and cities in China, it is proposed to further promote the management of green building carbon emission quotas as a whole to support the revision of the green building series standards, the future quantitative supervision of the industry, and to provide basic data support for carbon trading in the construction field.

4.2.2. Paths for Building Policy Regimes: Enhancing Green Financial Support and Strengthening Closure Management

Firstly, we should strengthen landing support for green finance. Green building has become a basic requirement for urban green and low-carbon development, which has shifted from government incentive to popularization to market-led development, and green financial means play an important role in this transformation. The UK released the

Green Finance Strategy in 2019, with the core elements of financial greening and financing greening. The European Central Bank system purchased green bonds through the Public Sector Purchase Program (PSPP) and the Corporate Sector Purchase Program (CSPP) and vigorously promoted the development of green bonds. However, the current application of green finance in the field of green building still needs to solve some landing support problems in China. For example, the 2019 version of the assessment standard requires that the green building evaluation should be carried out one year after the completion and acceptance of the construction project and operation, but banking financial institutions generally provide financing for green building projects before the project is completed. As a result, there is a mismatch between the recognition period of green low-carbon benefits and green credit input, and green building projects cannot be effectively recognized before financing, thus failing to obtain financing support. Therefore, it is suggested to reconstruct the green financial service scheme, innovate financial service products in the project approval process, explore the pre-green credit identification process, coordinate the administrative approval and credit identification of green buildings, and solve the time mismatch problem between credit investment and green building identification, so as to effectively reduce the financing cost of development enterprises.

Secondly, we should strengthen oversight and management of the entire process. Still taking green finance as an example, at present, green building projects to obtain pre-financing mainly rely on the green building star pre-certification issued by a third-party review institution, or a "green building" pre-evaluation mark or registration letter issued by local housing and urban and rural construction departments to apply for credit support. However, there are many uncertainties about whether projects are strictly implemented in accordance with the requirements of green design in the actual construction or completion and operation stages. In addition, the special acceptance of green buildings is only carried out in some cities, the relevant supervision mechanism is imperfect, and the information disclosure of the whole process of the project is insufficient, which makes it difficult for banking financial institutions to grasp the construction and operation of the project promptly. Moreover, it is not possible to correct the non-compliant behavior of the financing party promptly, nor can it guarantee the green effect after completion, resulting in a high risk of "green bleaching" of credit financing projects. Therefore, it is suggested to strengthen the closed management of the whole process of green building and deepen the technical requirements of green building in the review stage of construction drawings, not only for the "whether or not to judge" part of the green design section of construction drawings. At the same time, efforts should be made to explore the "pass forward" in the project construction planning permit stage, or even in earlier stages. In addition, to clear the basic requirements of green building stars, the key technical indicators of green buildings should be refined. We should also strengthen the role of supervision and law enforcement during the construction process, reduce green design changes, and strictly check and accept green buildings. By grasping the "one end and one end" concept and strengthening the process of supervision, we can form the whole process of closed management.

4.2.3. Path for Technology System Innovation: Establishing a Whole-Process Quality Enhancement Low-Carbon Technology System

Firstly, we should strengthen the positive design of green buildings. A total of 50% to 80% of carbon emission reduction decisions related to building carbon emissions occur in the design stage [8]. Therefore, the design stage is the key to carbon reduction at the source of green buildings, and the key to maximizing carbon reduction benefits at the lowest cost throughout the life cycle [22]. The purpose of strengthening the positive design of green buildings is to enhance the deep integration of green building concepts and architectural design. The core idea is to let architects be familiar with and conceive green performance indicators in the scheme design stage, apply green technology to the whole process of architectural design at an earlier stage, and further use the concept of "green" to help guide the creative process. Carrying out forward design can effectively avoid having to "supplement" the green design after the completion of the design, as well as avoid the increase in equipment and facility costs caused by "insufficient design in the early stage and equipment in the later stage", thus deviating from the original intention of green building development.

The second is to develop a low-carbon technology system for the whole process of green building. The application of low-carbon technology systems through the core stage of design, construction, operation, and maintenance is the basis of carbon reduction in green buildings. In the design stage, carbon reduction performance analysis should be carried out on multiple core elements such as site layout, building layout, building form design, equipment, and material selection, and further put forward applicable technology combination strategies that adapt to different climate zones, different building types, different star levels, and different carbon reduction contribution degrees. The construction phase focuses on low-carbon construction technology selection, clean machinery and equipment selection, construction technology, flow construction organization management, etc., to form a green low-carbon construction organization design. In the operation stage, we should focus on the characteristics of energy consumption and resource consumption in the building operation process, use information monitoring, intelligent regulation, and other means. We should also establish collaborative application strategies for low-carbon operation key technologies and green buildings from multiple dimensions, such as environmental protection, energy conservation, carbon reduction, and service improvement. In addition, the technological system should consider the differences in the characteristics of green buildings under different resource conditions in different countries. Taking France and China as examples, the majority of electricity in France comes from nuclear power, and the carbon emission factor is equivalent to one-tenth of the carbon emission factors released in North China in 2019. Therefore, the proportion of hidden carbon and operating carbon in materials and equipment is significantly different in China. The key focus and technical strategies for carbon reduction in green buildings differ greatly, and targeted differentiation is needed.

4.2.4. Path for Software Platform Development: Enhancement of Software Platform Informatization Management Support Capability

Firstly, we should develop carbon emission assessment calculation tools for the whole process of green building. The carbon emission calculation method and reference line solve the original and basic problems, and the application of low-carbon technology solves the application and practical problems. However, the carbon emission reduction effect of green buildings at each stage needs carbon emission calculation tools to quantify and judge, quickly evaluate the carbon emission of green buildings, and further provide a decision-making basis for design, construction, and operation. Specifically, platform development in the scheme design stage focuses on "rapid assessment", which calculates the carbon emissions in each stage of the whole life cycle and the effect of greening carbon sinks based on tools, and assists designers in comprehensively analyzing the carbon reduction potential of various schemes. In the construction drawing design stage, the national energy-saving and low-carbon series standards should be standardized, and specific indicators such as the production and transportation of building materials, construction, operation, demolition, and carbon sink should be predicted in detail. In the construction phase, attention should be paid to construction visualization, and construction technology should be optimized based on carbon emissions. In the operation stage, a comparative analysis of operation management strategies is carried out based on carbon emission accounting. The operation plan, especially the operation strategy of equipment units, is then optimized in order to guide green and low-carbon operations.

The second step is to expand the scope of the application of green building operation management systems. The 50–70-year operation process of a building is an important stage of energy consumption and carbon emissions. The green building operation management system focuses on efficient operation and process energy saving and carbon reduction, and is the core tool to implement the whole process of carbon reduction in green buildings. The operation management system uses advanced BIM, IOT, artificial intelligence technology, etc., to rapidly integrate equipment, assets, security, energy consumption, and site management data that operate independently in the property management process, to achieve real-time supervision and management of buildings, and to improve the interaction ability and intelligence level of buildings and people. The "Building Energy Efficiency Cloud Solution", jointly released by China Academy of Building Research Co., Ltd., and Huawei, implements automatic fault diagnosis, intelligent optimization, and unified operation of park facilities through information means and cloud service mode, and has been applied in several parks. Taking the MOMA project of Beijing Wan'guo City as an example, the "Energy efficiency Cloud" system improves the project operation and maintenance efficiency by about 30% and reduces the comprehensive energy consumption by more than 15% through unified monitoring and operation of the building's rooftop radiation energy system, domestic hot water system, and replacement fresh air system [23].

5. Conclusions

Since the implementation of the "carbon peak and carbon neutral" strategy, China's economy and society have undergone extensive and profound changes. The construction of new people-oriented urbanization, greening, low-carbon initiatives, and the digital transformation of the traditional construction industry have all resulted in higher requirements for the development of green buildings. Responding to climate change and "carbon reduction" is an eternal issue, and we need to build a systematic path based on theoretical research, policy systems, technical systems, and software platforms, and make continuous efforts. This paper focuses on the demand for green building carbon reduction, based on the current situation in China, foreign experience, and the analysis of the new situation at home. It comprehensively puts forward a high-quality green building carbon reduction path that is based on research into the carbon emission calculation method and baseline, and specific measures such as policy systems, technology application systems, and platform support systems are coordinated and promoted. This paper proposes a development path that focuses on enhancing green finance support and strengthening closed management, establishing a low-carbon technology system for improving the quality of the entire process, and enhancing the information management support capability of software platforms in order to provide a reference for the future vertical deepening of the development of green building and low carbonization recommendations.

Author Contributions: X.W.: Writing, review, and editing; Z.H.: Writing, review, editing, and visualization; Y.L.: Conceptualization and investigation; X.L.: Investigation, resources, and methodology; All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the Research Fund of the Chinese Academy of Building Research (Project Name: Research on Low-carbon and carbon-neutral Design Methods and Key Technologies for Residential Buildings and Public Buildings (20222001330730006)).

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Zhou, H.; Wang, W.; Wei, H.; Meng, C.; Wei, X.; Li, Y. Demand analysis and prospect of high-quality development of green buildings in China. *Build. Sci.* **2018**, *9*, 148–153.
2. China Construction News Network. China Construction: The Status of Pillar Industries is Increasingly Prominent. Available online: http://www.chinajsb.cn/html/202302/16/32060.html (accessed on 27 May 2024).
3. The Government of China. Notice of the Ministry of Housing and Urban-Rural Development on Issuing the "14th Five-Year Plan" Building Energy Efficiency and Green Building Development Plan. Available online: https://www.gov.cn/zhengce/zhengceku/2022-03/12/content_5678698.htm (accessed on 27 May 2024).

4. People's Forum. How to Do Well in the "Addition and Subtraction Method" for Building Energy Conservation. Available online: http://www.rmlt.com.cn/2022/0915/656208.shtml (accessed on 27 May 2024).
5. Ministry of Housing and Urban Rural Development of the People's Republic of China. Green Building, Polish the "Low Carbon Environmental Protection" New Business Card. Available online: https://www.mohurd.gov.cn/xinwen/gzdt/202207/20220727_767350.html (accessed on 27 May 2024).
6. *GB/T50378-2006*; Evaluation Standard for Green Building. Ministry of Housing and Urban Rural Development: Beijing, China; China Architecture & Building Press: Beijing, China, 2006. (In Chinese)
7. Ministry of Housing and Urban Rural Development of the People's Republic of China. Notice of the Ministry of Housing and Urban Rural Development on Issuing the "13th Five-Year Plan" for Building Energy Conservation and Green Building Development. Available online: https://www.mohurd.gov.cn/gongkai/zhengce/zhengcefilelib/201703/20170314_230978.html (accessed on 27 May 2024).
8. Liu, J.; Wang, Y.; Wang, Y.; Wang, D. Problems and Suggestions in the Development of Green Building Design Standard System. *Bull. Natl. Nat. Sci. Found. China* **2023**, *3*, 360–363.
9. Junlv. Industry Status: Green Construction Operation Sign Only Accounts for 6% of the Total Number of Sign Projects, Heavy Design Light Operation! Available online: https://baijiahao.baidu.com/s?id=1759708820544589241&wfr=spider&for=pc (accessed on 27 May 2024).
10. *GB/T50378-2019*; Assessment Standard for Green Building. Ministry of Housing and Urban Rural Development: Beijing, China; China Architecture & Building Press: Beijing, China, 2019. (In Chinese)
11. Song, J. Restrictive Factors and Countermeasures of Green Finance Supporting the Devel-opment of Green Buildings. *Rural Financ. Res.* **2022**, *11*, 20–27.
12. Baidu. Lensy Green Living Was Awarded the World's First BREEAM In-Use V6 Residential Project 6-Star Certification. Available online: https://baijiahao.baidu.com/s?id=1719722492936770295&wfr=spider&for=pc (accessed on 27 May 2024).
13. Chen, K.; Hu, R.; Hu, G.; Chi, B. Comparative Research on Evaluation Systems of Green Building Operation in China, U.S., U.K. *Constr. Technol.* **2022**, *11*, 1–6.
14. LEED Energy and Environmental Design Pioneer. Strengthening Greenhouse Gas Emissions and Climate Change Issues, Upgrade LEED v4 Again! Available online: https://mp.weixin.qq.com/s/hCLoCPSACseJ7HGQ0st0VQ (accessed on 27 May 2024).
15. Deng, Y.; Li, J.; Meng, C.; Dai, R. Analysis and Enlightenment from Singapore's Green Mark 2021. *Build. Sci.* **2023**, *4*, 205–212.
16. Guo, Z.; Wang, Q.; Meng, C.; Chen, Y. Practice and inspiration of zero carbon buildings in Canada. *Heat. Vent. Air Cond.* **2023**, *2*, 57–63.
17. Yang, J.; Gao, C.; Yu, Z.; Peng, L.; Chen, M. Review on Development of Zero Carbon Buildings in France. *Constr. Sci. Technol.* **2023**, *17*, 55–59.
18. Ministry of Housing and Urban Rural Development of the People's Republic of China. Notice of the Ministry of Housing and Urban Rural Development and the National Development and Reform Commission on Issuing the Implementation Plan for Carbon Peaking in the Field of Urban and Rural Construction. Available online: https://www.mohurd.gov.cn/gongkai/zhengce/zhengcefilelib/202207/20220713_767161.html (accessed on 27 May 2024).
19. Wang, Q.; Han, J.; Liang, H.; Yang, L.; Lin, B. Research and Application of Standard System Establishment and Performance Improvement Technology of Green Building. *Constr. Sci. Technol.* **2021**, *13*, 20–23.
20. The Government of China. Notice on Issuing the Implementation Plan for Establishing and Improving the Carbon Peak and Carbon Neutrality Standard Measurement System. Available online: https://www.gov.cn/zhengce/zhengceku/2022-11/01/content_5723071.htm (accessed on 27 May 2024).
21. *GB55015-2021*; General Code for Energy Efficiency and Renewable Energy Application in Building. Ministry of Housing and Urban Rural Development: Beijing, China; China Architecture & Building Press: Beijing, China, 2021. (In Chinese)
22. Twinn, R.; Desai, K.; Box, P. Next Zero Carbon Buildings: A Framework Definition. Available online: https://www.semanticscholar.org/paper/Net-zero-carbon-buildings:-a-framework-definition-Twinn-Desai/853539583e2a5c8374f3ab8a8b459180a8bb27e3 (accessed on 27 May 2024).
23. Pengpai News. China Building Science Conference Releases "Building Energy Efficiency Cloud Solution". Available online: https://www.thepaper.cn/newsDetail_forward_13292892 (accessed on 27 May 2024).