Innovative Paths and Strategies for Property Management in the Context of Dual-Carbon Strategy

Litao Su[1], Qiang Wang[2], Shuo Shi[3], Yingang Feng[4], Liping Geng[4], Haiyang Du[4], Dongkui Zhang[4], Dan Wang[4], Xiaojuan Wang[3,*]

[1]China Information and Communication Technology Group Co., Ltd, Wuhan, 430000, China
[2]Information Science & Intelligence (Beijing) Intelligent Technology Co. Ltd, Beijing, 100000, China
[3]Central University of Finance and Economics, Beijing 100000, China
[4]DATANG CARERA（BEIJING）INVESTMENT CO., LTD, Beijing, 100000, China

Abstract. In the context of China's strategy to promote carbon peaking and carbon neutrality, the construction industry has come under the spotlight for its higher carbon emissions. Property management plays an important role in the operation phase of buildings. Therefore, it is of great significance to innovate property management paths and strategies for energy saving and emission reduction in the property sector. In this paper, we will first discuss the concept and connotation of "dual-carbon" strategy, as well as the relationship between property management and carbon emissions. Secondly, it discusses the challenges faced by property management under the "dual-carbon" strategy and the benefits of accomplishing the transformation, in order to explain the necessity and value of innovative property management. Then, the three innovative paths of property management, namely intelligent building and energy management, application and promotion of renewable energy, and carbon footprint monitoring and assessment, are discussed and the key strategies are proposed from certain perspectives. Then, successful case of property management is introduced, and the experiences for their success are summarized. Finally, based on the above innovation paths, key strategies and successful cases, suggestions are made from three perspectives: policies and regulations, enterprises and owners, and technology and talents.

1 Introduction

Climate change is a major issue facing all humankind today, and climate change, characterized by global warming and an increase in extreme weather, is affecting the sustainable development of the planet. The burning of fossil fuels and the release of carbon dioxide from human production and consumption activities are contributing to continued global warming, posing a serious threat to the ecological security of the planet and to the survival of humankind itself. Environmental risks account for five of the top ten critical global risks in the Global Risks Report 2022, with the failure of climate actions topping the list.

In response to global warming, in December 2015, nearly 200 parties from around the world signed the Paris Agreement, which sets out to limit the increase in global average temperature to no more than 2 degrees Celsius from the pre-industrial temperature rise and to work towards limiting it to no more than 1.5 degrees Celsius, as well as to provide for a unified arrangement for global action to combat climate change after 2020.

China has actively responded to the Paris Climate Change Agreement and formulated the strategic goal of "double carbon". 2021, the CPC Central Committee and the State Council issued the "Opinions on the Complete and Accurate Implementation of the New Development Philosophy and Doing a Good Job in Carbon Peak and Carbon Neutral Work", which is aimed at China's carbon peak and carbon neutral goals for the time planning and strategic deployment. General Secretary Xi attaches great importance to carbon peak and carbon neutral work, emphasizing that carbon peak and carbon neutral is a broad and profound economic and social systemic change, and incorporating carbon peak and carbon neutral into ecological civilization construction.

The construction industry is the key target of China's "dual-carbon" work. According to China Building Energy Consumption and Carbon Emission Research Report (2022),[1] the total carbon emission of the whole process of building in 2020 will be 5.08 billion tons of carbon dioxide, accounting for 50.9% of the total national carbon emission. Among them, the carbon emission in the operation stage of the building accounts for 42.52% of the total carbon emission in the whole process of the building. Property management should realize green and low-carbon transformation, thus making positive contributions to energy saving and emission reduction in the operation phase of buildings.

* Corresponding author: 1546994122@qq.com

This paper analyses the carbon emissions from 3 stages of the whole building process, summarizes the role of property management modes on the carbon emission reduction of the building operation stage and even the whole process of the property. On this basis, this paper explores the strategy of low-carbon transformation of property management, and provides suggestions for systematic upgrading of the overall property management system, so as to help the national "double-carbon" goal.

2 Dual-carbon strategy and property management

2.1 Concept and implications of a dual-carbon strategy

On September 22, 2020, President Xi Jinping announced at the 75th session of the UN General Assembly that China would strive to peak carbon dioxide emissions by 2030, and work towards the goal of carbon neutrality by 2060.1 China's carbon neutrality goal is to achieve carbon dioxide emissions by 2030, and to achieve carbon neutrality by 2060.

In October 2021, the Central Committee of the Communist Party of China and the State Council issued the "Opinions on the Complete and Accurate Implementation of the New Development Concept and Doing a Good Job in Carbon Peaking and Carbon Neutrality" and the "Action Plan for Peak Carbon by 2030", which jointly constructed the top-level design of China's carbon peaking and carbon neutrality "1+N" policy system, and the relevant policies on key areas of carbon emissions and at the provincial and municipal levels have been introduced one after another. Relevant policies in key areas of carbon emission and at provincial and municipal levels have been introduced one after another.

In August 2022, the Ministry of Science and Technology (MOST), the National Development and Reform Commission (NDRC), the Ministry of Industry and Information Technology (MIIT), and other nine departments issued the "Implementation Plan for Scientific and Technological Support for Carbon Peak Achievement and Carbon Neutrality (2022-2030)", which puts forward the scientific and technological support initiatives for realizing the goal of carbon peak achievement by 2030.

2.2 The relationship between property management and carbon emissions

The whole building process includes the building materials production stage, the building construction stage and the building operation stage. Among them, the carbon emissions from the building operation stage accounted for 42.52% of the carbon emissions from the whole building process in 2020, while the national carbon emissions from the whole building process accounted for more than 50% of the national carbon emissions. Property management is the operation and maintenance for the building operation stage, so its innovative path and strategy will have a great impact on the carbon emissions in the building operation stage, and if its low-carbon transformation process links the building materials production, building design and building construction stages, it will realize the carbon emission reduction in the whole process of building.[2]

According to Zhao Linfu (2021), green property management includes five elements: energy saving management, water saving management, waste classification management, environmental greening management and pollution prevention management.[3] Among them, energy saving management and pollution prevention management are closely related to carbon emissions. Energy conservation management targets the intelligent upgrading of three high energy-consumption systems, namely the central air-conditioning system, the water supply equipment system and the public lighting system, and the improvement of related energy-saving technologies. The energy-saving technologies involved in the Green Building Evaluation Standards (GB/T50378-2019) that are related to direct carbon emissions mainly include air conditioning temperature control technologies, lighting technologies, greening technologies for building materials, drainage technologies and landscape greening technologies. Pollution prevention and control management in reducing carbon emissions is mainly to optimize the energy structure, increase the proportion of clean energy use, improve the efficiency of energy use, and improve the recycling rate of materials.

3 The need and value of innovation in property management

3.1 The Challenges of Property Management in a Dual-Carbon Context

Property management underperforms on both energy consumption and carbon emissions. Property service enterprises should pay attention to the reduction of both energy consumption and carbon emissions in property management, and focus on lower carbon emissions per unit of energy consumption. This requires enterprises to optimize their energy structure, increase the proportion of clean energy and improve energy utilization.

3.2 The value and benefits of innovative property management

3.2.1 Innovative property management can bring positive impact on carbon emission reduction

Property service enterprises should focus on green concepts when carrying out property management innovation, and complete green and low-carbon transformation in addition to improving property safety and quality. Currently, China's two green building rating standards, namely the Green Building Evaluation

Standard (GB/T50378-2019) and the Green Retrofit Standard for Existing Buildings (GB/T51141-2015), establish a five-level indicator system based on safety and durability, health and comfort, convenience of life, resource conservation and environmental liveability, where the secondary indicators contain entries that are closely related to carbon emission reduction The secondary indicators contain entries closely related to carbon reduction.[4]

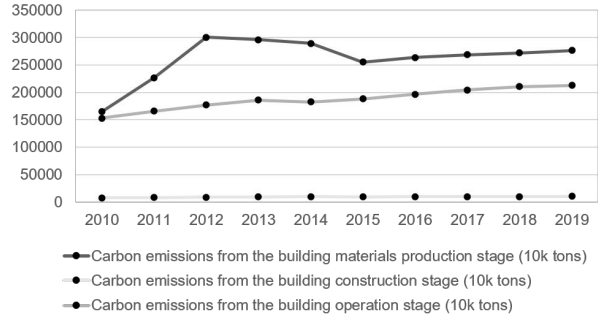

Fig. 1. Carbon emissions from each stage of the building process.
Data resource: Building Energy and Emissions Database

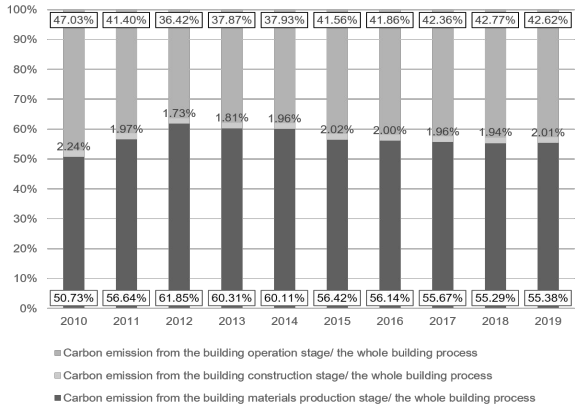

Fig. 2. Percentage of carbon emission at each stage.
Data resource: Building Energy and Emissions Database

As shown in Figure 1, from the viewpoint of carbon emissions, carbon emissions in the construction phase have been at a low level from 2010 to 2019, and carbon emissions in the production phase of building materials and the operation phase of buildings are both at a high level and showing an upward trend. Among them, carbon emissions from the materials production stage declined significantly in 2015, decreasing from 2895,688,200 tons in 2014 to 2552,484,200 tons in 2015, a year-on-year decrease of 11.85%, and the upward trend has levelled off since then. And the carbon emissions from the building operation stage basically maintained a growth rate of about 4%. As shown in Figure 2, from the point of view of the proportion of carbon emissions at each stage, the building operation stage of the building alone has been increasing since 2012, growing from 38% in 2012 to 43% in 2019. This shows that reducing carbon emissions in the operation phase is the key to reducing carbon emissions in the whole life cycle of buildings.

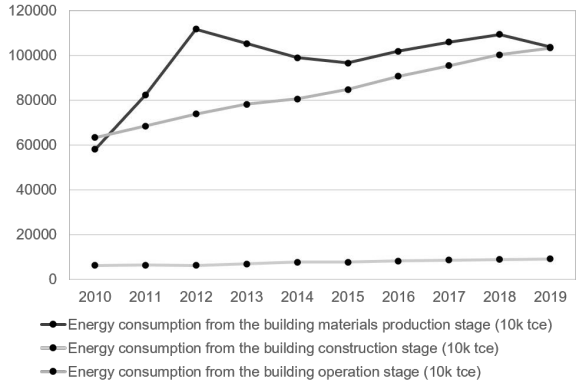

Fig. 3. Energy consumption from each stage of the building process.
Data resource: Building Energy and Emissions Database

As shown in Figure 3, from the point of view of energy consumption, the energy consumption of the building materials production stage was at the highest level among the three stages from 2011 to 2018, and a reduction in energy consumption was realized since the peak of energy consumption in 2013, while the energy consumption of the building operation stage has been growing at a fast rate and exceeded the energy consumption of the building materials production stage in 2019. This shows that reducing energy consumption in the building operation phase is the key to reducing total building energy consumption.

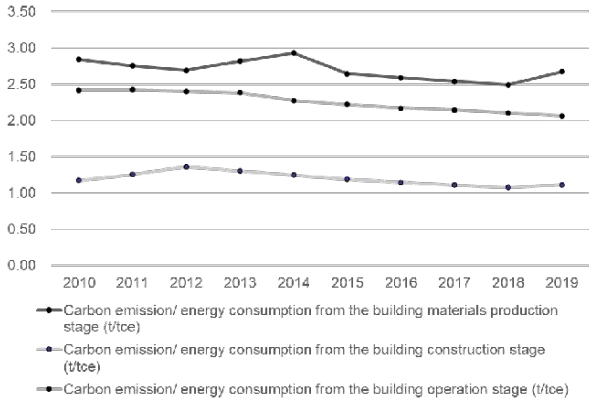

Fig. 4. Carbon emission/ energy consumption from each stage of the building process.
Data resource: Building Energy and Emissions Database

As shown in Figure 4, from the viewpoint of the ratio of energy consumption to carbon emissions, the ratio has been decreasing during the building operation stage of the building, which indicates that the energy structure has been optimized and the use of clean energy has increased during this stage. Combined with the high and continuous growth of carbon emissions and energy consumption in this stage, only working on energy and increasing the use of clean energy cannot completely solve the problem, but requires systematic innovation and change in property management.

In addition, according to the China Building Energy Consumption and Carbon Emission Research Report (2022), in 2020, carbon emissions from the building materials production stage of the whole building process

decreased by 7.1% year-on-year, and those from the construction stage decreased by 1.5%, while those from the operation stage increase by 1.5% year-on-year, which is the only stage among the three stages with year-on-year carbon emissions growth. This shows that to realize the low-carbon development of the whole process of construction, it is inevitable to focus on the low-carbon development of the building operation stage, and the green low-carbonization of the building operation stage requires innovation in the property management mode. In conclusion, it is of great significance for property service enterprises to innovate property operation and management pathways to realize "double-carbon" goal.

3.2.2 Innovative property management can bring economic benefits

The whole life cycle includes the processes of building materials selection, building design, building construction, operations management. CHEN Si-qin (2009) pointed out that the construction cost and operation and maintenance cost is the relationship between one and the other, and the operation and maintenance cost is 7.7 times of the construction cost. Therefore, property service enterprises can reduce the whole life cycle cost and bring economic benefits by docking with the project designers in advance, presetting the construction and operation programs, and investing costs in systematic upgrading of properties and improvement of green building technology. [5]

In terms of building materials, CHEN Si-qin (2009) pointed out that 60% of ecological building materials can be recycled, while many existing building materials cannot be recycled, which not only results in a waste of resources, but also increases the cost of cleaning up old materials and the cost of purchasing new materials. In terms of energy, the new property management can be digitized and intelligently transformed, using Internet of Things, artificial intelligence and other technologies to save electricity and energy consumption, reducing the cost of energy consumption.

Property service enterprises innovate in property management, apply energy-saving technologies, and utilize intelligent systems to help owners save the consumption of water and electricity and other resources, thus reducing the expenditure on water and electricity and other living expenses, and making owners the beneficiaries. Property service enterprises are recognized by owners, customer stickiness increases, market competitiveness increases, and enterprises are inspired to further green and low-carbon transformation in property management, thus forming a virtuous cycle.

Overall, for property service enterprises, the short-term operating costs of innovating property operation and management modes will increase due to research innovations, design innovations, system upgrades, and operation and maintenance. However, in the long run, the green and low-carbon transformation of property operation and management will bring innovations in technology and products and services, which will increase the core competitiveness of the enterprise, make it the choice of more customers, and bring performance to the enterprise. For the owners, innovative property operation and management can reduce the expenditure of water, electricity and energy; for the society, innovative property operation and management can reduce the waste of building materials, energy and other resources, and enhance the recyclability of resources and the sustainability of properties, with obvious increase in social and economic benefits.

4 Property management innovation path

4.1 Intelligent Buildings and Energy Management

Wang Rongming (2023) summarizes intelligent building technologies as BIM technology, Internet of Things (IoT) technology, 3D printing technology, intelligent weak power technology, cloud computing and big data technology. [6] Among them, BIM technology is the prerequisite for the application of other intelligent building technologies, which is of great significance in the architectural design and construction phases, and has an impact on the logistics operation and management industry in the later stages; 3D printing technology mainly plays a role in the architectural design phase; and IoT technology plays a fundamental role in the building operation and maintenance phase, which is complemented by other intelligent building technologies, and jointly completes the optimization of the technologies in the operation of properties.

In addition, the intelligent building energy management system based on IoT technology can play the role of rational allocation of energy. Intelligent building energy management system is generally composed of three parts, i.e., perception layer, network layer and management layer. In these three parts, the system can be integrated with intelligent building technologies such as Internet of Things (IoT) technology, intelligent weak power technology, cloud computing and big data technology. The perception layer connects the intelligent equipment on site with the system through the Internet of Things, and transmits the data collected by the equipment, etc. to the network layer, which realizes the incoming, transforming and sending of the data, and carries out data storage and management in the application layer through the Internet of Things cloud computing.

4.2 Promotion and application of renewable energy

4.2.1 Electricity generation

Renewable energy power generation includes solar power, hydroelectric power, wind power and bioenergy power. The development and utilization of solar energy is the main focus, and solar energy can be collected through high-efficiency thermal collection devices.

Renewable energy can be applied to power generation for public lighting systems, such as lawn lamps and street lamps.

4.2.2 Heat energy generation

Heat can be generated through solar, geothermal, etc. According to Liu Hanzhang (2019) solar water heating system can save more than 10 kWh of thermal energy per day per household on average. [7] Ground source heat can overcome the obstacles to heat pumping from air sources and is therefore more efficient. It can provide heat in the winter through the heat pump for intelligent building, and at the same time accumulate part of the coldness preparing for the summer; and summer can make the building's heat transfer back to the earth, while the earth to accumulate a certain amount of heat and then for winter use. This helps to reduce the energy consumption of the air conditioning system to control the temperature.

4.2.3 Water consumption

Efficient utilization of water resources can be accomplished through water recycling and utilization techniques. Utilizing the rainwater collection system, rainwater is efficiently collected and then utilized. Domestic wastewater is collected, filtered and decontaminated for irrigation or recycled as green water for intelligent buildings. Water recycling can reduce the sewage load and sewage costs, making efficient use of water resources.

4.3 Carbon footprint monitoring and assessment

Carbon footprint assessment and detection can be accomplished by constructing a BIM-LCA system.

BIM technology can be used to record the carbon footprint. At present, BIM technology can store all data in the whole process of construction into the database and realize the sharing and transmission of information. The government can connect the BIM software of each logistics service enterprise with the management platform, and save the data of the whole process of the building, including the data related to carbon emissions, into the database of the platform. Based on the data related to carbon emissions, a carbon footprint assessment system can be established to record and assess the carbon footprint in real time.

The LCA（Life Cycle Assessment） method can be used for carbon footprint assessment. LCA is a method used to assess the environmental impact of a product, service or process throughout its life cycle, and is considered by the European Commission to be the most appropriate method for measuring environmental impact. [8] LCA often consists of four phases: goal and scope definition, life cycle invention, environmental impact assessment and interpretation. [9] Companies usually start by sorting out and counting data on the manufacturing paths of their products, verifying the energy used by their suppliers for the production of raw materials, calculating the emissions from transportation processes, and then defining and calculating the energy used within their own factories.

5 Innovative Strategies for Property Management

5.1 Policy and regulatory support

CHEN Si-qin (2009), pointed out that there are economic externality problems in green building, which need to be regulated by policy incentives.[6] In the case of economic externalities, there is a contradiction between the needs and interests of various subjects, and the market is not able to effectively allocate resources, which requires certain policy interventions to adjust.

Requiring property service enterprises to disclose information on energy consumption and carbon emissions on time, and evaluating or rewarding or penalizing the effects of emission reduction can help promote low-carbon transformation of enterprises. At the same time, it can also improve the enterprise carbon trading policy, after the disclosure of relevant information for carbon quota trading, help to incentivize enterprises to save energy and reduce emissions.

In the process of exploring the green and low-carbon upgrading of property management modes, property service enterprises need to invest a large amount of capital and thus have financing needs. The government can formulate green incentive policies to give financing support to enterprises that meet certain green operation standards. At present, there are building green bonds, REITs, green building loans and other financial policies, which play a role in stimulating and helping property service enterprises in green transformation.

The government can formulate tax reduction policies and provide tax reduction programs for enterprises that meet green and low-carbon standards. The government can also provide financial subsidies to enterprises that pass the operational scheme to support the implementation of operational management optimization.

The government can subsidize owners who purchase green operation buildings to stimulate the general public's desire to purchase green buildings, which can increase the market competitiveness of green and low-carbon property service enterprises, and at the same time achieve the purpose of promoting the green and low-carbon transformation of more property service enterprises.

5.2 Key strategies for enterprises and owner engagement

Mechanisms for cooperation between enterprises and developers. Coordination between preliminary building design and later property operation. The property service enterprises will interface with the relevant persons in charge at the stages of building materials selection, architectural design and building construction, and

optimize the system levels and system-to-system connections as far as possible, so as to maximize the coordination with the later operations such as energy saving, intelligent regulation and control, and reduction of the later costs, and to avoid limitations of the later innovative property management caused by the poor design in the early stage.

Cultivation of green logistics operations management awareness for enterprises and owners. Publicize and guide enterprises and property owners on the concept of green property operation. Property service enterprises generally have the problem of not recognizing the concept of green property management. Owners do not pay much attention to property management, and only care about issues such as rent and house price, but lack awareness of property operation, not to mention the association between property operation and green low-carbon thinking. Therefore, we should help enterprises to understand the concept of green property operation and upgrade the system and technology instead of stopping at the surface of greening; we should publicize the concepts of green building and green operation to the owners, so that the owners can better cooperate with the enterprises and consider the green and low-carbon factors when they are renting housing.

Businesses communicate with owners to connect. Through the owners' committee, the property service enterprise and the owners can communicate with each other, break the information barrier, and discuss the decision-making together. Both play the role of owners of enterprises to supervise, but also make owners more understanding, cooperate with the work of enterprises, so that the property to realize the green operation.

5.3 Technical and human resources support

Apply big data and artificial intelligence technology to enhance the intelligent decision-making capability of the property management hub, and develop from the Informa ionization construction stage to the intelligent operation stage.

Utilize intelligent building technologies such as BIM technology, Internet of Things technology, intelligent weak power technology, cloud computing technology, etc., to build intelligent regulation and control system. Give full play to the visualization attributes of BIM technology and the ability to intelligently manage the whole cycle of the building; give full play to the advantages of Internet of Things technology in connecting multiple devices and timely transmission of various data; give full play to the management and control performance of intelligent weak power technology on multiple operating systems; and give full play to the advantages of cloud computing and big data technology in sharing and analysing the data of building resources.

Establish an organizational structure for green operation management and set up dedicated posts. Improve salary and remuneration to attract talents.

6 Case study: successful property management innovation practices

6.1 Typical Cases

Under the guidance of the national "dual-carbon" goal, Country Garden integrates the concept of sustainable development into the whole process of construction, and actively explores green and low-carbon transformation in the processes of green construction, green building, green construction, green operation and green leasing. Country Garden practices energy saving, emission reduction and consumption reduction, makes breakthroughs in key technologies of zero-energy and zero-carbon buildings, and upgrades platforms and systems through digitalization and intelligence to promote dual-control of energy consumption and carbon emissions and sustainable development.

Below is the introduction of Country Garden passive house representative project - Taizhou Nine Zhangs House: Taizhou Nine Zhangs House is the first large-scale passive low-energy green building district in Taizhou, and won the "13th Five-Year" National Key Research and Development Program of near-zero energy consumption residential building demonstration project. The project introduces low-carbon, energy-saving and green concepts from Germany, and has passed the Passive House Institute (PHI) Passive House Certification, China Passive Ultra-low Energy Green Building Certification, and China Green Building 2-star Certification.

The project adopts a variety of passive technologies: advanced thermal insulation of the external wall, through the thicker outer insulation material package, so that the heat transfer of the external wall is in a uniform and constant state; the use of doors and windows with good airtightness and heat insulation. The heat transfer coefficient is $\leqslant 0.85 W/m^2K$, and the airtightness level should not be lower than the requirement of grade 8, so as to prevent heat loss as much as possible; adopt highly efficient new air heat recovery system, which integrates heating, cooling, heat recovery, dehumidification, haze removal function, and air-source heat pump, with 24-hour constant temperature, humidity, and oxygen; adopt the technology of no cold and heat bridge; improve the overall airtightness of the building, such as adopting high airtightness and high waterproof external windows + external hanging installation + tarpaulin method.

Due to the characteristics of building materials and operation system, passive building can ensure fresh air, low noise, no humidity, maintain the appropriate temperature for human body, reduce the frequency of air conditioning and heating, and reduce the use of energy by 90%.

6.2 Analysis of lessons learned from successful cases

Selected as one of China's top 100 property service companies for many consecutive years, Country

Garden's various initiatives in green property management are worthy of reference.

6.2.1 Saving energy and improving energy utilization efficiency

a. Country Garden improves high-energy-consuming equipment. The hotel lighting equipment saves 5,000MWh of electricity in a whole year.

b. The application of new magnetic levitation central air-conditioning technology saves 150kWh of electricity in the central air-conditioning system and 1,300kWh of electricity in the whole lifecycle.

c. Photovoltaic power generating panels are laid on the roofs of the hotels to make full use of solar energy.

6.2.2 Saving water resources and avoiding water pollution

a. Use sanitary ware with high water efficiency and equipped with water-saving pipes and fittings;

b. Select corrosion-resistant and durable materials for pipes and valves with good tightness.

c. Develop rainwater collection and utilization system and use the recycled rainwater for public water use in construction sites.

d. Adopt water-saving system combining sprinkler irrigation and drip irrigation, and improve the utilization rate of water resources for greening and irrigation in the public areas.

e. Residents' domestic sewage is disinfected and treated by a three-stage septic tank and reaches the tertiary discharge standard before being incorporated into municipal sewage pipelines.

6.2.3 Establishing digital management platforms

a. Construct IT platforms, such as the development and operation integration platform, automated testing platform and other platforms to manage the whole process of the project and improve the integration level of the project life cycle.

b. Build RPA robots to realize the integrated and digital management of multiple business scenarios, such as land resource information and business data statistics.

c. Build the one-stop operation platform which enables one-stop operation of project management and improve management efficiency.

6.2.4 Establishing an open, transparent and sustainable supply chain

a. Work closely with different types of suppliers, such as architects, designers, service providers, contractors, etc., to ensure the integration of projects from development and design to operation and maintenance;

b. Formulates a series of systems, such as "Supplier Resource Management Process", "Supplier Penalty Mechanism", etc., to continually inspect and assess the hardware facilities and operational capabilities of suppliers;

c. Sets up the internal control group to continuously improve the process of supply chain responsibility fulfilment.

7 Suggestions for promoting innovation in property management in a dual-carbon context

7.1 Policy recommendations

Improve the green operation management system by improving the green operation management indexes and building the evaluation system of green operation management; appropriate economic subsidies are supposed to be given to consumers who purchase green buildings; green channels can be opened for enterprises that carry out green operation and management, and preferential tax and credit policies will be adopted, and risks will be shared with enterprises. [10] compulsory information disclosure to improve the transparency of operation and management information and open the reward and punishment mechanism; designate specialized departments or encourage third-party enterprises to conduct green operation and management performance evaluation and monitoring.

7.2 Advice for enterprises and owners

Solid multi-party partnership by establishing a strategic alliance and reach a consensus on cooperation with architects, designers, service providers, contractors, etc. for front-end operation and management design; Outsource non-core business of an enterprise to devote limited resources to the iterative upgrading of core business; experience sharing by building a green operation and management information sharing platform to share technology and management experience; deepen conceptual understanding of the green operation concept and internal transformation; strengthen communication between enterprises and owners that Enterprises publicize green operation concepts and proactively disclose operation data to owners, and owners monitor enterprises.

7.3 Technical and research recommendations

Improve the theoretical framework of green management, explore the correlation and improvement space within the operation management system, and overcome the systematic problems of green property management; Upgrade energy-saving and emission reduction technologies and materials and model the use of them; apply artificial intelligence to improve intelligent decision-making capabilities and seamlessly connect platforms with real-world scenarios; encourage industry-university-research linkage that enterprise practice and university research complement each other's strengths,

create talent training bases, and encourage colleges to send technical talents to enterprises.

References

1. Research Report on Energy Consumption and Carbon Emissions of Buildings in China, Construction and Architecture 2, 57-69(2023)
2. Y. Han, K. Kikuta, M. Hayashi, Research on the Whole Lifecycle Emission Reduction Effect of Buildings with Different Structures in Severely Cold Regions—A Case Study in China. Energies **16**, 5285(2023)
3. L. Zhao, Green property management development accelerates under "dual-carbon" targets. Housing & Real Estate **28**,38-39(2021)
4. Z. Chen, Practicing a green and low-carbon property management model that contribute to carbon neutrality. Property Aspect **7**, 94-95(2022)
5. S. Chen, Life Cycle Cost-benefit Analysis of Green Building Based on Economic & Development Countermeasures. Ecology & Intelligent buildings **37**, 53-56(2009)
6. R. Wang, Research on the application of intelligent building technology in modern construction engineering. Intelligent City. Intelligent City **9**, 26-28(2023)
7. H. Zhang, Application and discussion of renewable energy in intelligent buildings in Hunan province. Green Environmental Protection Building **10**, 32—35(2019)
8. M. Lavagna, A. Campioli, A.D. Valle, S. Giorgi, Design Strategies Toward Low-Carbon Buildings and Neighborhoods. The Use of LCA to Support a Project Proposal for Reinventing Cities. Lecture Notes in Networks and Systems, vol **482**(2022)
9. S.M. Jordaan, LCA Framework, Methods, and Application. Wells to Wire, 13-29(2021)
10. G. Liu, Y. Jie, Green building operations management in the context of carbon neutrality innovation path and strategy research. Construction Economy **43**, 98-104(2022)