

Retraction

Retracted: Digital Twin-Based Ecogreen Building Design

Complexity

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] Y. Liu, Y. Sun, A. Yang, and J. Gao, "Digital Twin-Based Ecogreen Building Design," *Complexity*, vol. 2021, Article ID 1391184, 10 pages, 2021.

Research Article

Digital Twin-Based Ecogreen Building Design

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The high operation cost of green building, insufficient informationization and automation management capability, and the lack of effective operation cost control seriously restrict the development of the industry and the realization of green goals. In order to solve the problem of insufficient capability of green building operation cost management, based on the digital twin technology in the manufacturing field, we analyze the characteristic requirements and theoretical basis of green building operation cost management for system, propose a green building operation cost management system based on digital twin, and refine the design of each structural layer of this system. It is necessary to set up a series of lines, although it takes a certain amount of time. There are four types of applications, namely, the number of types of applications, the completion of the effective number, the comparison of functions, and the implementation capabilities. The study shows that the proposed system framework can improve the efficiency and quality of green building operation cost management through technology upgrade and process optimization. The implementation of digital twin and human-machine collaboration is an advanced stage in the development of digital architecture because virtual things and real things, materials, and numbers are mutually promoting processes. The inspiration of this technological view for architecture is that digital twin and human-machine collaboration not only allow the interaction between virtual and reality and emphasize the feedback of actual construction to virtual simulation but also promote a kind of mutual promotion of human and machine thinking and construction ability.

1. Introduction

The construction industry is highly energy-intensive, labor-intensive, and capital-intensive. According to statistics, from design and construction to demolition, buildings consume about 40% of the total energy of the earth and form about 40% of the total waste of the earth [1]. Therefore, green buildings have received more and more attention and importance from more and more countries to achieve the goals of energy, water, land, and material conservation in buildings and to implement the concept of sustainable development. In the green building evaluation standard, the concept of green building is as follows: a high-quality building that can achieve the ecological goals of reducing pollution, protecting the environment, saving resources, and providing people with an efficient and healthy use space during the whole life of the building [2]. Its evaluation index consists of five parts: safety and durability, health and

comfort, convenience of life, resource conservation, and environmental livability. At present, many projects are designed and constructed according to the standards of green buildings and have obtained the relevant logo certification. However, in the operation stage, many green buildings lack efficient operation management and real-time status data, which often fail to achieve the expected goals and lead to a large amount of wasted financial and human resources [3].

In the lifetime cost of public buildings, operation and management costs account for about 85%, and the high operation costs make the property teams feel the pressure [4]. Therefore, green buildings should not only adopt new green and energy-saving technologies and new energy sources but also solve the operation cost control problem and find the optimal solution between economic, social, and environmental benefits. The current research on green building operation cost management mainly focuses on

incremental cost analysis [5–7], operation efficiency evaluation index construction [8–10], energy consumption management [11–13], and BIM-based whole life cycle management [14–16] in four aspects. However, there is a lack of real-time monitoring and management research on the operation status of equipment and facilities, and the various types of data and their measurement of operational cost-effectiveness are mainly done manually, which cannot be fully computerized and automated, and lack visualization, real-time processing of information technology, and support at the operation level. Since the manufacturing and construction industries share many common features in terms of technology and management modes, learning some advanced technologies and methods from the manufacturing industry will be a good guide to improve the efficiency and quality of the construction industry. Digital twin technology has been developing rapidly in industrial manufacturing in recent years, and its popular definition is as follows: digital twin refers to digitally creating a virtual model of a physical entity, which is a perfect mapping of the entity, not only simulating the entity's behavior in the real environment with the help of data but also making command operations on the entity, making the production process run under the guidance of the plan. To build digital twins at the asset, system, and cluster levels, manufacturers and operators can use digital twins to characterize the full lifecycle of assets, respectively, to better understand, predict, and optimize the performance of each asset [17]. Siemens uses digital twin technology to help manufacturing companies digitally manage their products from design to manufacturing [18]. With the development of information technology, information technology tools represented by software maps, digital query systems, and spatial analysis techniques are increasingly integrated with city planning. Information technology is widely used for the development of intelligent systems for urban traffic, disaster prevention, and nighttime lighting, as well as analysis of urban topography, climatic conditions, and environmental factors.

Digital tools open the doorway from the real material space to the virtual digital world and add the role of machines and data to the simple binary relationship between humans and objects, making the subject-object relationship in architecture more complex and multidimensional. In this process of disciplinary transformation, it is particularly important to explore the technical view of human-machine collaboration in the symbiosis of the virtual and the real. In general, the application of digital twin in the field of urban construction management has just started and is basically at the stage of system framework design, with instantiated applications yet to be realized. In addition, the application of the digital twin for green building operation cost management has not been considered yet. Therefore, this paper proposes a green building operation cost management system based on digital twin to address the lack of green building operation cost management capability in China and

develops a system prototype based on this system framework to verify the feasibility of the system framework.

2. Ecological Green Building Design System Construction

2.1. Green Building Design. Green neighborhood urban design is a neighborhood-level urban design that takes green neighborhoods as the research object, takes the design principles of green neighborhoods as the guidance, takes the research contents of green neighborhoods as the purpose, comprehensively studies the requirements of urban planning, architecture, and other disciplines for green neighborhoods, combines information, energy saving, environmental protection, and other technical means, and reflects the green, ecological, and humanistic concepts. As a mesolevel green neighborhood urban design research has profound practical significance, it is mainly through the study of different ecological environment elements and different spatial environment elements of the neighborhood, to realize the ecological urban design at the neighborhood level, drive the overall ecology of the city with the relative ecology of the neighborhood, and then realize the harmonious coexistence between urban development and natural environment. This is the inevitable trend of urban development, from design combined with nature to design obedient to nature, and green neighborhood urban design is adhering to this concept, seeking the correct law of harmonious coexistence between human and nature in green neighborhood urban design. The design obedience to nature is a kind of natural law of “sincerity within and from outside,” which is the true meaning of design that calls the academic community to reflect on reality and return to nature [19]. For the BIM management, there is a lack of real-time monitoring and management research on the operation status of equipment and facilities, and the various types of digital twin are mainly done manually, which cannot be fully computerized and automated.

As the research on ecological cities and green neighborhoods continues to deepen, the concept of green neighborhood urban design will also continue to expand and deepen. The green neighborhood urban design defined in this paper mainly studies the research content most closely related to urban design, and it is not necessary to elaborate on all aspects covered by green neighborhoods one by one. At the same time, the concept is based on the existing research on ecourban design strategies and methods, taking green neighborhoods as the research object, absorbing and borrowing useful methods and technical means from other disciplines, and combining traditional excellent urban design methods to explore ecourban design strategies and methods at the mesoneighborhood level. The process of forming and refining this concept requires attention to the following aspects, as shown in Figure 1:

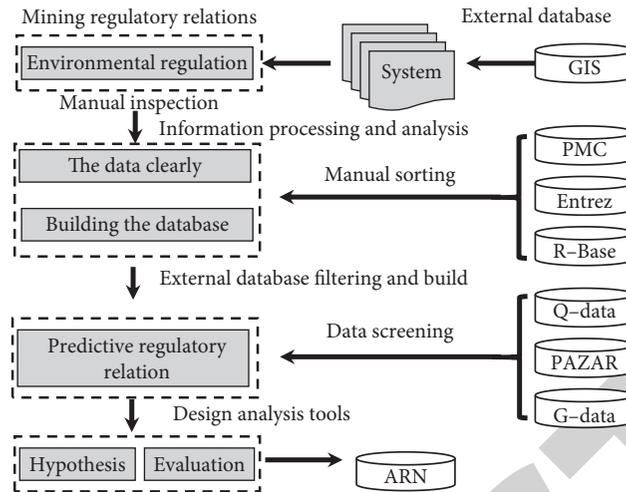


FIGURE 1: Ecocity design strategies and methods at the neighborhood level.

- (1) It is necessary to start from the ecological and spatial environmental elements affecting green neighborhoods, construct the technical system of green neighborhood urban design, and determine the technical route and research content of green neighborhood urban design.
- (2) To establish an organic connection between ecological and environmental elements of green neighborhoods and urban design systems, to investigate and study the current conditions of neighborhoods, to optimize the use of natural elements of neighborhoods, and to maintain the ecological security pattern of neighborhoods.
- (3) To propose effective urban design strategies and methods for green neighborhoods under different ecological environment elements and different spatial environment elements.
- (4) Focus on the application of information technology, energy-saving technology, and other key information technology to build a green neighborhood sustainable development pointer system and green neighborhood management system.

2.2. Technical Applications of the Digital Twin. With the development of information technology, information technology means represented by software maps, digital query systems, and spatial analysis techniques are increasingly integrated with urban planning. Information technology is widely used in the analysis of urban topography, climate conditions, and environmental elements as well as the construction of intelligent systems for urban traffic, disaster prevention planning, and night lighting, which has promoted the development of ecological city design theory and practice. Among them, spatial information technology represented by 3S technology (Global Positioning System (GPS), Geographic Information System (GIS), and Remote Sensing (RS)), environmental simulation and analysis

technology, and database analysis model are relatively representative research contents, which have important technical support for the realization of the goal of green neighborhood, as shown in Figure 2.

Energy-saving technology refers to the development of technical measures that can save resources and energy according to their characteristics and usage. According to the type of energy saving, energy-saving technology has covered many fields such as electricity saving, water saving, coal saving, and gas saving. Its specific energy-saving technology methods mainly include green building energy-saving technology, transportation energy saving, lighting energy-saving technology, photovoltaic solar power generation technology, ground source heat pump technology, exhaust air heat return technology, water source heat pump technology, and circulating water pump energy-saving technology. According to the characteristics of the technology, it can be divided into low energy-saving technology and high energy-saving technology.

Spatial information technology, also known as “3S” technology, emerged in the 1960s and includes GPS, GIS, and RS. 3S technology can be widely used in environments with complex topography, especially in mountainous cities. By extracting data from the topography and geomorphology, green water system, residential land, and road distribution within the neighborhood, physical elements such as elevation, slope, and slope direction of the base can be determined, and the specific location of natural vegetation and water bodies can be accurately obtained, thus providing effective guidance for the planning and design of the neighborhood.

The construction activities are carried out in the lot with gentle terrain and suitable slope, and the overall building space form is stacked back along the mountain contour, and the building form, scale, and color are borrowed from the traditional architectural styles to form an architectural vocabulary in line with the regional culture [20–29]. The scale of the street space takes into account the traffic, human psychological comfort, and disaster prevention needs,

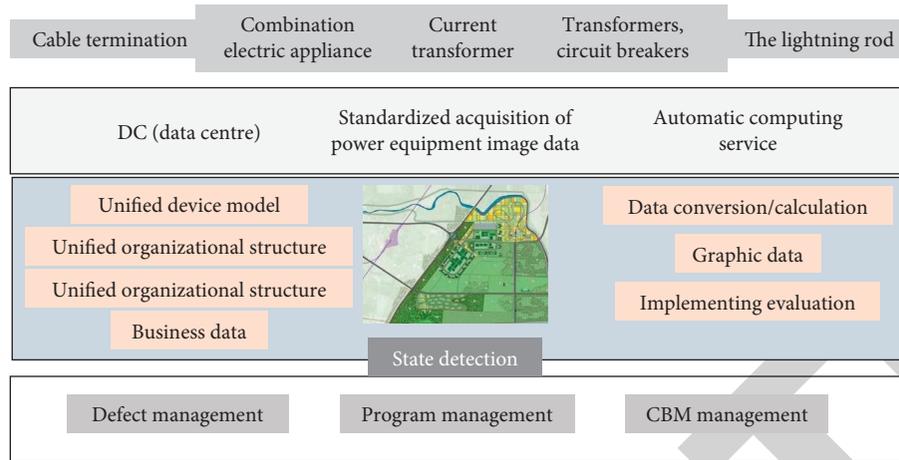


FIGURE 2: Environmental simulation analysis techniques and database analysis model.

forming two types of horizontal and vertical street space forms. The environmental design fully considers the need for disaster prevention and the overall layout of the building, street, and environment according to the distribution of the current vegetation, showing the subtle, introverted, and elegant style of the mountain architecture. In the architectural design, it pays attention to the combination of modern technology and traditional technology, in terms of building layout, structure, materials, architectural cultural connotation, and so on, inherits the excellent technology and methods of traditional regional architecture of western Sichuan and Qiang-Tibet, and integrates the innovative steel structure building technology (patented technology of square steel pipe concrete shaped column structure), which effectively improves the disaster prevention ability of the building.

Ecological urban design is closely related to the climate and environment, and reasonable consideration of environmental conditions in design will provide the basis for sustainable development of neighborhoods, while failure to pay attention to the influence and constraints of the environment on design may result in serious consequences that are difficult to recover. Since ancient times, the concept of integrating nature into design has become a consensus in urban construction, such as the ancient Chinese idea of “the unity of heaven and man.” Since modern society, urban planning and architecture still follow some universal principles, such as the application of the wind rose diagram in planning and design, but its application can only play a relatively rough, directional guidance. At present, cities in many countries and regions around the world have carried out research on urban environmental climate maps, which are used to guide urban planning and design through a comprehensive analysis of the environmental climate conditions in the study area and linking environmental climate with urban planning. The use of urban environmental climate maps makes the understanding of environmental climate in planning and design more scientific, accurate, and convenient. The climate zoning results shown in the urban environmental climate map are based on a series of

environmental surveys and simulations of the study area. The environmental surveys mainly include field research and spatial observation methods using 3S technology, which mainly analyze the built environment; while the environmental simulation technology calculates and simulates the wind, thermal, light, and sound environments of the built or proposed areas (including experimental methods and computer numerical simulation methods), so as to derive its impact on the environmental comfort of urban neighborhoods and to propose further improvement measures guided by the analysis results.

2.3. *Evaluation System of Green Ecological Residential Community.* The single-factor evaluation index is the simplest environmental quality index. It is generally defined using the following equation:

$$K_i = \frac{A_i}{B_i}, \quad (1)$$

where A_i is the i th evaluation factor in the environment of the observed value. B_i is the standard value of the i th evaluation factor.

The single-factor environmental quality index is a dimensionless number, which indicates the extent to which the observed value of an evaluation factor in the environment is relative to the environmental quality evaluation criteria. The value of K_i is relative to an evaluation criterion and changes when the evaluation criterion is changed. Therefore, when comparing environmental quality indices horizontally, it is important to note whether they have the same evaluation criteria.

These indices are mainly used for the evaluation of nonpolluting ecological factors in the environment because the ecological factors are very territorial and it is difficult to establish uniform national standards on a large scale. These factors are evaluated by using the environmental quality of locations within the evaluation area that is far away from the population and not affected by human influence or by the environmental quality of areas designated by environmental

experts. For example, soil environmental quality often uses regional soil background or background values to calculate the calculation of soil pollution index. In the ecological assessment, the calibration value of the location with better environmental quality is often used as the evaluation criterion to calculate the calibration relative quantity coefficient as the evaluation index, and the expression is

$$Q_i = \frac{A_i}{A_{k,i}}, \quad (2)$$

where A_i is the vegetation growth, biomass, species volume, and soil organic matter storage. $A_{k,i}$ is the vegetation calibration growth, calibration biomass, calibration species, and calibration soil organic matter storage. Q_i is the calibrated growth coefficient, calibrated relative biomass, calibrated relative species volume, and calibrated relative storage volume.

As A_i is usually smaller than $A_{k,i}$, the Q value is smaller than 1. Unlike the pollution index, the larger the Q value, the better the environmental quality. The smaller the Q value, the worse the quality of the environment. The so-called calibration value is relative to the environmental quality of the control point. In addition, there are some socioeconomic development indicators in the comprehensive evaluation of environmental quality that can be evaluated with reference to the development goals of the country or location. For example, the evaluation standard of population growth uses the national population growth rate. Soil erosion should meet the basic control target of soil erosion in the regional plan, which requires the relative size of the incidence rate of a certain epidemic disease and the average incidence rate announced by the state.

Relative percentages of environmental quality are now increasingly used in landscape ecology assessment and biodiversity assessment. Since these values are already relative percentages themselves, they can be directly used as evaluation indices for that single factor. For example, landscape ecology evaluates ecological quality through spatial structure analysis and function and stability analysis. Among them, the landscape diversity index is calculated as

$$p = \frac{\sum_{l=1}^N (I(q, x))}{m}, \quad (3)$$

where p is the percentage area of a certain type of landscape. q is the number of landscape types.

The larger the value, the better the landscape diversity. The ecological stability evaluation is calculated by four single-factor indices, which are ecological adaptability of land (the score is given by the size of ecological adaptability of land; the score is 0–100), vegetation cover (the actual cover of land is used as the weight value; the threshold value is divided by 100 according to the actual cover), the resistance to degradation assignment (the community resistance to degradation is assigned to 100 when it is strong, 80 when it is stronger, 60 when it is average, and 0 when it is below average), and the resilience assignment (the community resilience is assigned to 100

when it is strong, 80 when it is stronger, and 60 when it is average). These indicators are scored by environmental experts using their comprehensive ability and are themselves relative percentages, which can be directly quoted as the evaluation index of the single factor.

This type of index calculation does not directly use the evaluation criteria, but based on the relationship between pollution parameters and pollution hazards in the measured data, an index calculation formula similar to the empirical formula is established to obtain the dimensionless single-factor pollution index. Green's proposed SO_2 pollution index and soot concentration are expressed as pollution indices using smoke coefficients that indirectly measure the content of particulate matter in the air, which are defined as follows:

SO_2 pollution index:

$$qS(\text{SO}_2) = 84S^{0.431}. \quad (4)$$

COH pollution index:

$$qS(\text{COH}) = 84S^{0.431}, \quad (5)$$

where S is the concentration of the measured pollutant. q is the average reference value.

For SO_2 and smog coefficient, it is suggested that the daily average values of the desired, alert, and limited levels are used as the construction criteria, and the two pollution indices of SO_2 and smog coefficient are expressed in the form of power functions. From the developmental point of view, this index is less adaptable with respect to the ever-improving environmental quality standards, and the coefficients used are artificially subjective in their designation, as shown in Table 1. These single-factor indices are now less frequently used.

The summation-type subindex is a composite index obtained by summing several comparable single-factor evaluation indices. According to the way of summation, it can be divided into the following categories. Simple summation-type environmental quality index is a composite index obtained by summing several single-factor indices. Its calculation formula is

$$Q = \sum_{i=1}^k Q_i. \quad (6)$$

The vector summation environmental quality score index is a composite score index in which multiple single-factor evaluation indices are vector summed. Its calculation formula is

$$Q = \sqrt{\sum_{i=1}^k Q_i}. \quad (7)$$

The weighted summation environmental quality subindex is a simple summation or vector summation of each single-factor evaluation index multiplied by a weighting factor according to the environmental characteristics of different evaluation factors. The calculation formula is

TABLE 1: Measured pollutant concentration changes.

Pollutants	Pollution index	Concentration (mmol/L)	Changes
SO ₂	A++	0.7325	23
COH	A+	0.9944	24
CO	A++	0.4205	12
SO ₃	A	0.5951	42
PM2.5	B	0.7187	12

$$Q = \frac{\sum_{i=1}^k a_i Q_i}{\sum_{i=1}^k Q_i},$$

$$Q = \sqrt{\frac{\sum_{i=1}^k a_i Q_i}{\sum_{i=1}^k Q_i}}. \quad (8)$$

Depending on the chosen weighting factors, this type can be derived into mean-type subindices and weighted root mean square-type subindices. Most subindexes use this method, such as the Water Quality Index, Nanjing Air Quality Index, and Canadian Air Quality Index proposed by the Ohio River Sanitation Commission. The first two of these three summation methods can be regarded as the special case of the third method of weighting coefficients, the mean method of finding subindices can be summarized as the special case of weighting coefficients, and the ecological stability evaluation subindex mentioned above is the average of four single-factor indices. Its calculation formula is

$$P = \frac{\sum_{i=1}^k a_i p_i}{4}. \quad (9)$$

Compared with simple summation, the vector summation can highlight the contribution of the larger one more. In the case of pollution indices, the contribution of the pollutants with severe exceedances to the subindex is greater, which is more in line with the principle of designing indices (Table 2).

3. Results and Analysis

Compared with ordinary residential communities, green ecological residential communities are equipped with green energy collection and utilization devices, sewage treatment and reuse facilities, the use of advanced high thermal performance wall materials, and low-polluting decorative materials and sometimes have to spend a lot of money to build waste disposal facilities, ecological landscape wetlands, and so on. In this way, although the ecological residential community is more scientific, its construction, maintenance, and management costs are bound to be greater than the ordinary community; the price of housing is inevitably high. In this era of outrageous prices, the high price will make home buyers frown in front of the ecological community, which also adds to the burden of developers. We tend to emphasize only the initial investment but rarely consider the economic benefits and other good effects after completion, which is obviously short-sighted thinking. In the face of green ecological residential community, we must take the

TABLE 2: Pollution index.

Pollutants	Statistics	Significance	Index
SO ₂	0.534	2	1.1024
COH	0.157	2	1.2346
CO	0.876	2	1.2876
SO ₃	0.133	2	1.6844
PM2.5	0.534	2	0.9276

consciousness of sustainable development, with a long-term vision to understand the problem, to make a fair and comprehensive economic evaluation. For developers, the construction cost of some facilities in the ecological community may be high, but after years of operation, it will pay for itself and even make a profit, and the positive ecological effect generated in the process is truly priceless. For home buyers, the price of the ecological community may be high, but if you can use the money to buy back health, then everyone will be willing to pay. The United Nations proposed “never die of ignorance,” which embodies the dialectical relationship between health and economy.

For neighborhood land layout, flexible division can be made according to the development and construction requirements, using the smallest unit of the neighborhood to form a flexible layout mode that can be divided or combined. A flexible neighborhood land division can better protect the land for the slow walking system and public green space in the neighborhood. The Sino-Singapore Tianjin Ecocity plan defines 400 m × 400 m as the basic unit of the neighborhood and innovatively introduces the concept of urban slow walking system, reserving a 20 m wide green zone as a pedestrian space within the neighborhood, in an attempt to relieve the pressure of urban motor vehicles (Eco0, Eco1, Eco2, and Eco3, as shown in Figure 3). To ensure that the slow walking system in the neighborhood is not encroached upon, land optimization can be carried out by adjusting the road network structure of the neighborhood. Following the principle of ecological priority and moderate flexibility, a minimum unit of 100 m × 100 m is divided, and the two-dimensional scale of the neighborhood can be large or small according to the specific situation. While satisfying the traffic demand of the neighborhood, the native green areas and new green areas are preserved as much as possible and can be directly connected with the external space of the city to form urban greenways, thus satisfying the comprehensive requirements of planning concept, development, construction, and humanization and providing a safe, livable, and energetic living environment for citizens.

The ecocity has also encountered certain problems in the implementation of green transportation. The first manifestation is the low percentage of green travel, mainly due to the low type of local employment opportunities and the low attractiveness to talents, resulting in a substandard employment-housing balance number. From the perspective of urban design, the lack of flexibility in the division of the two-dimensional planning scale of the block has led to a low land mix, and the public facilities of the block generally cannot serve the public, making it difficult to form an attractive block. During the construction process, the original Eco

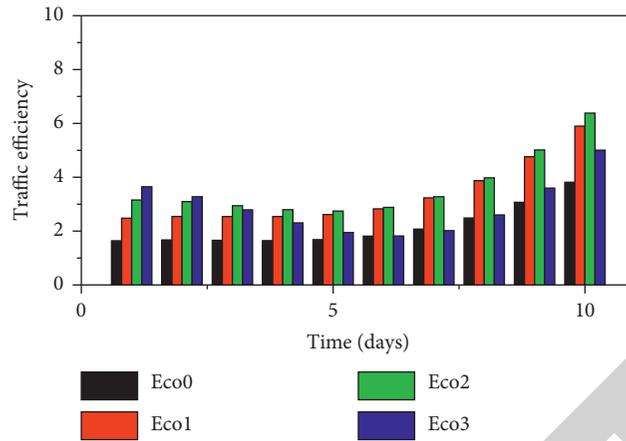


FIGURE 3: City motor vehicle traffic.

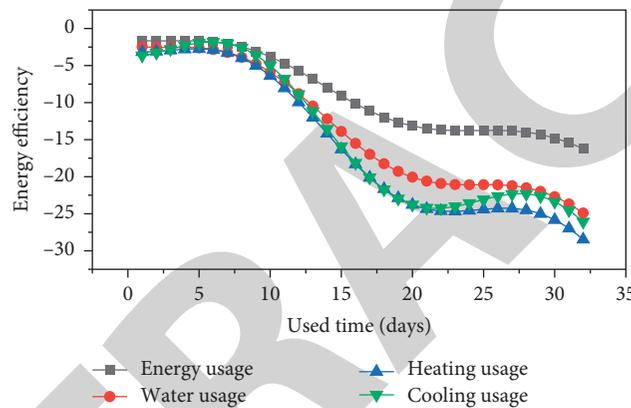


FIGURE 4: Change in usage of Eco Valley.

Valley concept became a single-function urban strip park and was blocked by the private communities on both sides, facing the problem of low utilization rate (Figure 4).

In summary, the transportation improvement strategy for green neighborhoods needs to be based on effectiveness and the establishment of a healthy, efficient, and pleasant green transportation system. In the urban design of green neighborhoods, the transit-led development mode is strengthened, and the functional mix of the neighborhood is increased. In the specific planning, it is necessary to consider the definition of the scope of the work-living balance, reduce the phenomenon of pendulum travel, and try to increase the employment opportunities within the range of suitable transit travel. To determine the process of controlling in the cyber model and feedback the adjustment instructions, transportation system and open space pedestrian system that meets the basic requirements of public transport and green scale and green travel. On the premise of not affecting the comfort of the neighborhood, increase the functional mix of the neighborhood and the development capacity of the public center, set up high-rise office or commercial facilities, and form a comprehensive service center with mixed functions through a three-dimensional development mode (Figure 5). At the same time, it is also necessary to meet the

comfort and green and ecological requirements of the green neighborhood, such as meeting the green space rate standards and spatial scale requirements.

The intensive use of resources and energy is the core design principle of green neighborhoods, and for the characteristics of water quality shortage in Tianjin Ecocity, the protection and recycling of water resources are the core components of energy conservation. Therefore, in the urban design of green neighborhoods, it is necessary to consider the use of design means to realize water recycling and intensive use of water bodies and to explore the ecological restoration of polluted water bodies, the mode of fractionated water supply, and the comprehensive use of unconventional water resources. At the same time, technology development and use of renewable and clean energy such as green building energy conservation, solar, and wind energy are actively promoted to improve the efficiency of resource and energy utilization (Figure 6). In the urban design of green neighborhoods, it is necessary to determine sustainable energy development goals, pay attention to shaping neighborhood spatial forms that meet green and energy-saving needs in terms of land use, transportation systems, and open spaces, and form compact and intensive development patterns oriented by public transportation and

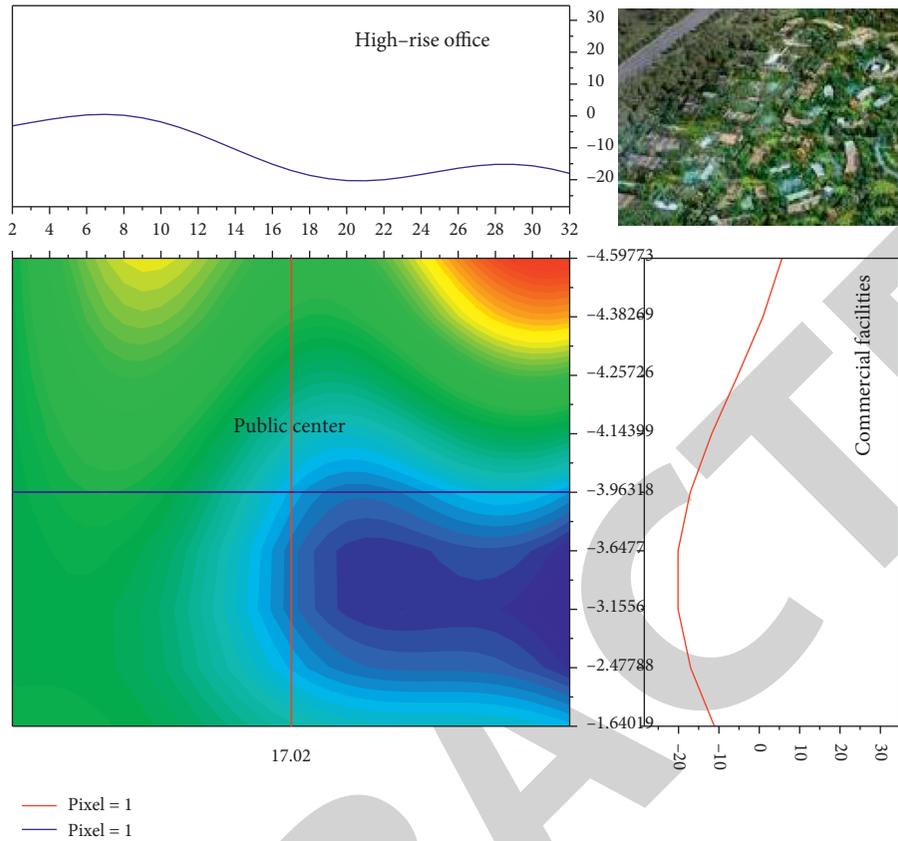


FIGURE 5: Functional changes in Eco Valley.

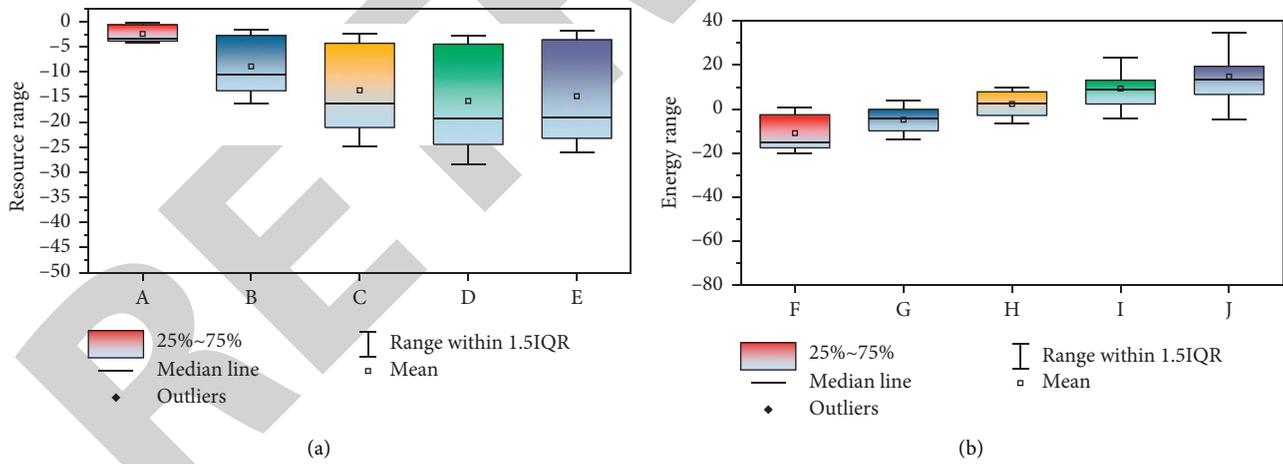


FIGURE 6: Comparison of resource and energy use efficiency.

pedestrian systems to meet the basic requirements of green scale and green travel.

Combined with the natural vegetation and water bodies in the neighborhood, the design of the neighborhood water circulation system is guided by the concept of low impact. With the slow walking system as the core, the neighborhood unit is divided into 4 groups, and within each group, water storage units are set up in combination with group parks, and water collection areas are set up in combination with

neighborhood parks, which can take the form of rain gardens, grass planting ditches, water storage ponds, and so on. In the process of determining and controlling the network model, it is necessary to feed back adjustment instructions, transportation systems, and open space pedestrian systems that meet the basic requirements of public transportation, green scale, and green travel. Collected rainwater through the surface runoff first into the water storage unit and finally into the water collection area. The rainwater volume is

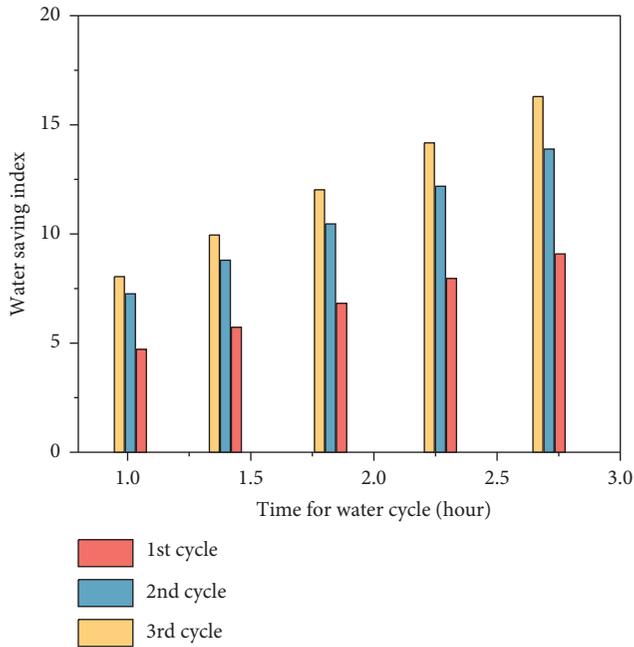


FIGURE 7: Water-saving index of the water cycle process.

controlled through the water catchment area, and some of the rainwater is retained as landscape water in the neighborhood, while the remaining water bodies can be remitted to the rivers or lakes nearby. In addition, combined with the green building design requirements, a water treatment system is set up inside the building to form a perfect water recycling mode (Figure 7).

Green building is an important element in the energy-saving design of green neighborhoods. Tianjin Ecocity proposes a system design approach for green buildings, covering roof gardens, floor heating systems, rainwater collection, water treatment, barrier-free design, solar lighting, water-saving equipment, and so on. The main focus is on passive energy-saving technologies, moderately exploring the application of new technologies and through the layout, orientation, structure, and skin design of the buildings themselves combined with environmental simulation technology and the use of recyclable energy to achieve the intensive use of resources. At the same time, the evaluation and grade of green buildings are divided through the development of green building evaluation standards, evaluation technical rules, and design guidelines, which lay a solid foundation for the implementation of green buildings.

4. Conclusion

Based on the concept of “digital twin” in the manufacturing industry, this paper analyzes the requirements and theoretical basis of the software system for green building operation cost management, proposes a green building operation cost management system based on digital twin, and develops a system prototype based on Bentley Systems using laser scanning and photogrammetry technology. A system prototype was developed based on Bentley Systems software using laser scanning and photogrammetry

technologies. The system establishes a digital twin ecosystem for securely sharing data connections through standardized data management and interoperability, which can provide owners, property managers, and government regulators with real and accurate real-time information related to the operating costs of green buildings, such as environment, ecology, buildings, equipment, and operation, and can correctly reflect the actual operating costs of green buildings, providing a good basis for green building operating cost control, management, and decision-making. At the same time, the relevant parties can directly control and manage the green building entities through the operation of the system according to their own authority, which is a good realization of the concept of “digital twin.”

Data Availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Consent

Informed consent was obtained from all individual participants included in the study references.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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