Research on Green Building Design Concepts and Spatial Optimization in Improving the Human Living Environment

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Abstract: Problems regarding the provision of quality human habitats are being pushed to prominence given their unprecedented scale and pace, 2023. Architectural design has long faced the two major challenges of satisfying housing needs and achieving ecological conservation for sustainable development. Green building is an effective way to improve the living environment of human beings, which refers to the organic combination of resource conservation, environmental protection and human health and comfort. Nature: Energy Saving & environmental protection of building itself; Harmonious coexistence between human and nature, space & Function This paper investigates the contributions and approaches of spatial optimization to foster living environment from green building design principle perspective. That is the future of functional spatial optimization, ecological embeddedness, case demonstration and intelligent technology application to reveal green architecture for improving living quality adequacy, biological environment adaptability and sustainable development urbanization expansion. So the only way to upgrade living environment in future trends is combine with spatial optimization and green building performance requirements, because it can offer quite high reference values for raw implementations of livable & ecological & smart urban develop goals.

1. Introduction

The accelerate urbanization and socioeconomic development that qualify the world of 21st century should promote the considerations, whether human living environments are of quality or not, therefore make public awareness and academic voice speak out to this subject [1]. Urban sustainability—the idea that cities should be inhabited without compromising the wellbeing of future generations—is threatened by factors such as population density, overconsumption of resources and environmental pollution—all directly relating to how well a population lives [2]. One of the ways green building has increasingly come to the forefront as a real way to make it right back into living environments. Green building has designed intertwine energy saving, environmental sustainability and comfort [3]. They use rational design and construction processes to minimize adverse impacts on the natural world while creating good living spaces for people [4]. An important part of the green building philosophy is the spatial optimization: scientifically allocated and rationally constructing internal and external spaces. This model enhances the comfort and functional strength of residence while appropriately improving ecological environment value and resource utilization efficiency [5]. With many research episodes and practices in the field of green buildings and spatial optimization conducted both domestically and abroad, this line of evidence reveals that it is a significant part to the field of sustainable urban development. That is, how to combine regional characteristics with resident needs in the actual design and application of the process, which further explores the fusion path of green building design concept and spatial optimization strategy, it is an important problem need [6]. The focus of this paper is on principles behind green building designs and their role in enhancing human habitat. By way of spatial optimization, to investigate implementation models and pragmatic paths for future generations urban systems and living environments.

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2. The Essence and Development Trends of Green Building Design Principles

Green building is the model for sustainable development which emphasizes energy efficiency, natural environment protection and comfort [7]. Which is reflected in resource savings, energy efficiency and small environmental impact; it also brings to the - a good living place. It pursues not only functional performance in the building but also emphasizes environmental benefits in embedding it into a life cycle (Hilmer, 2005): It achieves optimal energy use and minimizes environmental pollution by using energy-efficient technology, environmentally friendly materials, and renewable energy sources in the design, construction and operation process [8]. It concentrates on establishing viable contexts where humanity and the natural world could thrive together, for sustainable individual enhancement Constructive Power Equilibrium

$$E_{total}=E_{heating}+E_{cooling}+E_{lighting}+E_{appliances} \quad (1)$$

The principles of sustainable development have become more broadly established, and green building has developed into all-encompassing. It now covers not only energy conservation and emissions reduction, but also development in the aspect of overall environmental performance, including resource conservation and utilization of comprehensive green building materials and layout optimization as well as coupling with ecological environment. Green building is not just about technology; it represents a value orientation of human-centred design and ecological preference. Through this process, comfort and health have become design metrics with air circulation, natural lighting and temperature/humidity control manifesting the overall advantages of green buildings for sustainable human habitation [9].

For foreign, the development of green building concept has gradually developed a relatively perfect evaluation system and implementation standards, such as the United States LEED certification, British BREEAM system and Chinese Green Building Evaluation Standard. These frameworks that standardize green building principles yet enable exchange and synthesis of ideas and practices to evolve regionally [10]. Furthermore, the adapting trend of international norms has further highlighted that the green building has become one of the strategic target focus for world construction industry and as a result it shows even more civilised and diversified trend.

Where does this leave us moving into the future of green building? Expect smarter technologies to be integrated alongside even more sustainability and green city living. Technologies for monitoring energy consumption and environmental impacts such as IoT, big data and AI will become finer grained. The concept of carbon neutrality adds even more momentum, so green buildings are now positioned to play a greater part in combating climate change and building low-carbon societies. As new green building concepts have grown, its role will be key to enhancing human habitat and enabling sustainable development.

3. Pathways to Spatial Optimization in Human Environment Improvement

Spatial optimization could therefore be seen as a bridge from the green building philosophy to improve human living environments between theory and practice. Without going into abstraction, the occupancy and integration of ecological resources can achieve not only functionality and comfort of living space — creating ownership in human-built environments through social learning approaches — but also the transformation of natural affinity regarding ecological scheming nature of steering structure natura sigalling through revaluation process interactive produce space to science, mainly rational action to spatial organization. With intelligent technology evolving, the optimization of space does not just restrict to spatial layouts but slowly going towards dynamic smart personalization. It optimizes rational allocation of functional space :

$$DF=\frac{E_{in}}{E_{out}}\times 100\% \quad (2)$$

3.1 Functional Space Optimization and Human-Centered Design

Functional Space Optimization (FSO), whose primary goal is to maximize use of space and configuration, is the most powerful and foundational step to a better human living environment. Zoning — a decades-old, one-dimensional classification separating uses into discrete siloed pinky sectors for only residential development and blue-collar commercial development — does not accommodate the newer complexities of resident inventory life and use. Thus spaces should ideally be designed to be spatially flexible and adaptable (in terms of use) during the design process if they are to afford reasonably degrees of variability about family structures, living scenarios and usage frequencies. This reduces the wastage of space and enhances the efficiency of your living module.

One such case is design by keeping the human into account. Humancentered design for residents should focus on filling physiological, psychological and behavioural needs of diverse types of users. The children activities needs to be safe space, elderly people need barrier-free living space, and the new generation pursues openness and social attributes. Figure 1: comfort is better achieved through well-planned spaces and scale management with a focus on inclusivity and flexibly.

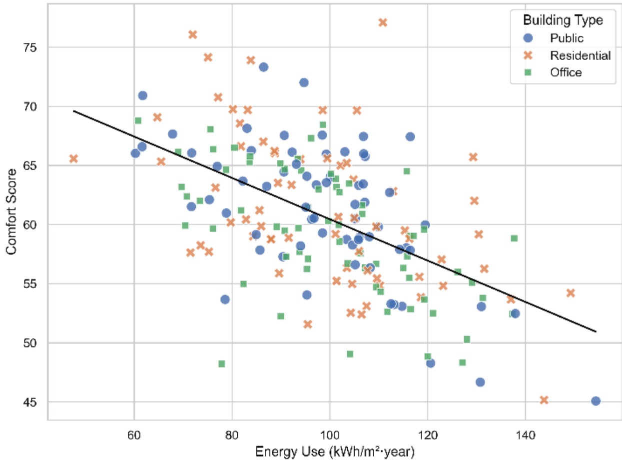

Figure 1 Energy consumption vs comfort score

The functional space optimization must also highlight the integrated cases across families and public service sectors. Humans have become inhabitat of a united whole now, and the environment of modern life is no longer just the scope of human activity in a single household unit but rather include community public space. Design for inclusion interstitial community space like shared interaction zone/third place encouraging neighbourhood level social interactions lead to social integration within the strata. The spatio-temporal relationship between domestic space and community space not only maximizes the synergy of this kind of living spatial pattern, but also can better reflect the humanistic value connotation behind the green building pursuit. Ventilation Airflow Rate

$$Q = V \times n \quad (3)$$

Ecologically viable building and energy-saving techniques should be balanced with aesthetics, each-functional public places, and human-centered design. Through using the natural conditions to objectively arrange active and passive zone in layout design, reasonably configure available lighting and ventilation pathway even how effective utilizing natural environment dispute indoor air heat transfer efficiency narrow weather from one part to another should help alleviate purifying pressure maintain domestic gas gradually skincare. Instead, it is a method of systematic design involving humanistic care, social interaction and environmental benefits in functional space optimization are not just spatial arrangement issues alone- which represents the essential route to realize that integration between green building with better living environments.

3.2 Integration of Natural Environments and Ecological Space Layout

Biophilic integration is more than an architectural styling exercise and a huge opportunity to enhance the human habitat across green building design with data stretched through October 2023. Thoughtful ecological spatial distribution, facilitates healthy co-existence of architecture and nature, making habitats more environmentally adaptable/sustainable. Creating architectural spaces that incorporate nature increases microclimatic conditions both inside and outside of the building, along with psychological improvement on residents ability to bond and feel comfortable, thus turning it into a much healthier and happier habitat.

It undoubtedly seems that ecological spatial planning preferring to mediate the consistency of landscape with architecture. Design processes should emphasise the role of co-constraints between natural landscapes and built environments, as opposed to merely relying on green space ratios or vegetation coverage. Vegetation on rooftops, balconies & facades plays a major role in cooling the urban heat island effect and acts as a buffer which enhances thermal insulation by trapping ice crystals. At the regional scale, a considerable improvement in ecosystem integrity can be obtained when including public green spaces proper scales, water features and biological corridors accompanied by opportunities for recreation, social interaction and nature experience. Thermal Comfort (Simplified PMV)

$$PMV=(0.303e^{-0.036M}+0.028)(M-W) \quad (4)$$

Natural lighting and ventilation systems are one of the technical approaches in ecological space design. In the oriented configuration of arrangement, composition and dimensioning of windows and spaces, atmospheric conditions induce natural lighting and minimum thermal ventilation as an alternative energy to reduce energy consumption electricity in artificial source utilization. Large-scale shading facilities (or so-called ventilation corridors), when designed according to local climate characteristics, can not only improve indoor thermal comfort but also achieve low energy consumption, thus achieving the dual goal of green buildings: “low energy consumption and high comfort.” It also in collaboration with Ecological first principles show environmental resource utilization and make green buildings a more viable option.

Ecological space planning not only involves the natural environment but also overpowers the structural integrity and linkage of interconnected component elements within any particular area. Ecological spaces should connect with the surrounding environment, transportation system and public service facilities at the urban level, so as to form an overall pattern of dual optimization of ecology and function. On a larger scale, spatial design focuses on developing microenvironments by introducing green in immediate living spaces so that residents encounter the peace and comfort of nature throughout their daily routines. Thus, it can be seen that integrating natural environment and ecological spatial planning is not only an important way for green building to better serve the living environment of human beings, but also a basic support for sustainable urban construction and ecological civilization.

3.3 The Application of Intelligent Technologies in Space Optimization

And by the fast development of information technology, intelligent solutions start to gradually apply for architectural design and space optimization which is becoming one important force in enhancing human living environment. They exploit the continuous management of space utilization while pursuing a comfort-energy economy at two distinct levels based on the principles of adaptive smart technologies via dynamical tuning. Using intelligence to transmute physical environments into perceived and dynamic interactive smart spaces with an experience that is indirectly optimizable (and therefore controllable) via knowledge transfer from green building principles will further advance the concept of living space integration as a complex adaptive systems evolution. Sustainability Index (SI)

$$SI=\frac{E_{saved}+W_{recycled}}{E_{used}+W_{consumed}} \quad (5)$$

One of the clearest examples of this, perhaps, are home automation systems. They continuously adjust to lifestyle and environmental changes by intelligently controlling lighting, heating, ventilation, security and appliances. As time and seasons passed, it would adjust lighting and temperature automatically to optimise comfort while also reducing wasted energy. They are well programmed and by remote control as they operate flexible places to suit various personal needs.

Smart Building level: Classification by smart technologies showing what the energy consumption and environmental management systems used to operate spaces efficiently. In such a type of building, real-time monitoring and dynamic regulation of energy use, water consumption, and the indoor air quality through sensors, IoT and big data technologies allow to create optimum spatial in which the desired microclimate (temperature/humidity) can be maintained. As shown in Figure 2, this kind of data-driven method on space management make full use of the resource consumption efficiency and set up a supporting scientific for consumption,operation maintenance reflection from green building , and establish a scientific basis for green building operation maintenance,showed in Figure 2 :

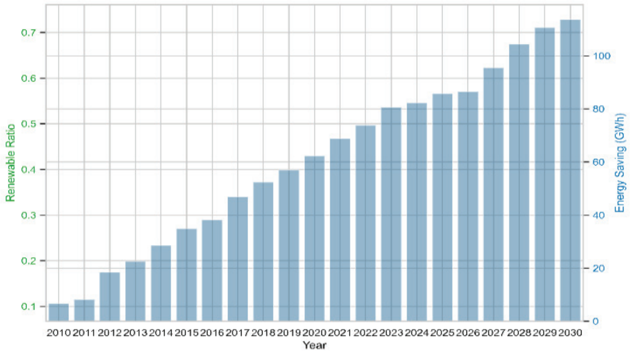

Figure 2 Renewable ratio vs year trend

The spatial optimization will become even intellective with artificial intelligence and big data. Intelligent algorithms will also look at how residents are behaving and environmental trends throughout the building to give spaces an active learning and self adjusting mechanism that shifts the paradigm from evolving an environment around people into a model where space instead preemptively adapts to people. It is leading the charge on connectivity solutions, connecting ever-greener buildings to more intelligent technologies and opening-up new possibilities for further improving our physical environments bringing comfort, energy-performance and sustainability to even a higher level.

4. Case Studies and Practical Exploration

That in the field of green building and space utilization practice both at home and abroad a number of representative case studies have been formed. These are cases you can learn from, they illustrate the power of green design ideas with applications in reality as well as what we need to do better in human habitat. Seattle Green Building, United States Efficient systems and natural daylighting in a comfortable indoor environment with energy-saving measures. By contrast in the UK, BedZED Zero Carbon Community still espoused holistic community planning which sought to demonstrate peaceful coexistence between man and nature through renewable energy and green transport.

On the domestic side, we also accomplished great success with implementation plan for China s green building action. For instance, in the Chinese capital's Olympic Village, solar photovoltaic systems and rainwater harvesting technology have been widely applied using green energy with space optimization. Shenzhen & Vanke Center Office Function and Residential Environment Modular Spatial Design and Ecological Landscape Integration, A fine balance of functionality and ecology. These instances illustrate that green buildings and spatial optimization can do help to improve life comfort while leading a positive influence on energy savings, emission reductions and ecological protection.

In practice, however, most projects that aspire to green building successfully share three commonalities, the first of which being…they take advantage of their natural conditions and regional characteristics in order to optimize site-specific design solutions. A second aspect that these solutions show is the interaction producer-consumer-oriented technology, where knowledge of specific design styles shows us new ways capable of generating techniques that should be clever but also focused on representing energy efficiency accompanied by multidimensionality — both in the encounters with space and in other human 45 focal points. Third, they build effective operation and maintenance systems through data-based monitoring and dynamic management to maintain green benefits during the whole life cycle. This will continue to evolve through such features which encourage the emergence of green buildings and provide frameworks for developing human habitats more effectively in the future. Space Optimization Objective Function

$$\min Z = \alpha \cdot C_{energy} + \beta \cdot C_{comfort} + \gamma \cdot C_{cost} \quad (6)$$

The case-analysis also unveils that while green building and space optimization could have technological advantages, itsimplementation continues to remain challenging clues from the higher construction costs, duplication of technology adoption byusers in some cases and varying levels of policy support. Future development requires a more active policy orientation, technological innovation, and the reinforcement of its public image in conjunction with a multi-stakeholder effort. To my constant summary and publication of practical experience, I think green building and space optimization will be one of the alternative means to improve human living environment on a large scale.

5. Conclusion

This paper develops theories systematically through research to manifest the significance of green building design concepts in improving human living environments; approaches that integrate spatial function optimization, human-centered physical solution schemes, natural environment synergies and ecological space layout with intelligent technology applications. Green buildings, in the eyes of many studies, not only improve ecological quality (energy saving, emission reduction and environmental protection), but also enhance the comfortableness and utility of residence through scientific space optimization [4]. Therefore it plays a significant role in sustainable urban development. The green building case studies substantiate the positive demonstration effect of practical application, and provide paths and practices that relate to improvement of the quality of human habitat.

However, implementation of green buildings has not been promoted effectively due to untapped spatial optimization opportunity and regional imbalance along with imperfect utilized pattern leading to high costs of operation technology adoption. These problems are constraining broader application, while raising the standards for future research and practice.

In-depth study of sustainable building development in the future more to intelligent technology low-carbon based industrialization, guide ecological civilization construction direction. These new technologies will be applied to AI, IoT and big data to provide more accurate assistance in energy consumption management and green building spatial optimization . The carbon peak and carbon neutrality goals will additionally inject new momentum to the green buildings development. With the vigorous guidance of policies and consultation from technology, accompanied by citizen participation, green buildings will surely come to play an evermore active role in improving the human living environment, advancing urban ecological transformation and achieving sustainable development.

References

[1] Higashi H , Tanaka T .Simultaneous Design of FIR Filter Banks and Spatial Patterns for EEG Signal Classification[J].IEEE Transactions on Biomedical Engineering, 2013, 60(4):1100-1110. DOI:10.1109/TBME.2012.2215960.

[2] Miller G W , Mugler J P ,Sá, Rui C,et al.Advances in functional and structural imaging of the human lung using proton MRI[J].Nmr in Biomedicine, 2015, 27(12):1542-1556. DOI:10.1002/nbm.3156.

[3] Mariani G .OSCAR: An Optimization Methodology Exploiting Spatial Correlation in Multicore Design Spaces[J].IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, 2012, 31(5):740-753.DOI:10.1109/TCAD.2011.2177457.

[4] Li B , Gan L , Fu S ,et al.The Role of Effective Area in the Design of Weakly Coupled MCF: Optimization Guidance and OSNR Improvement[J].IEEE Journal of Selected Topics in Quantum Electronics, 2015, 22(2):81-87.DOI:10.1109/JSTQE.2015.2488281.

[5] Soares C F T , Petraglia A .Automatic Placement to Improve Capacitance Matching Using a Generalized Common-Centroid Layout and Spatial Correlation Optimization[J].IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, 2015, 34(10):1691-1695.

DOI:10.1109/TCAD.2015.2419624.

[6] Teng Y , Zhang M , Tong S .The Optimization Design of Sub-Regions Scanning and Vibration Analysis for Beaconless Spatial Acquisition in the Inter-Satellite Laser Communication System[J].IEEE Photonics Journal, 2018, 10(6):1-11.DOI:10.1109/JPHOT.2018.2884718.

[7] Yanfeng L , Tao L , Yaowen C ,et al.Optimization of Solar Water Heating System under Time and Spatial Partition Heating in Rural Dwellings[J].Energies, 2017, 10(10):1561-. DOI:10.3390/en10101561.

[8] Wen P H , Zhou J , Zheng L .Hybrid Methods of Spatial Credibilistic Clustering and Particle Swarm Optimization in High Noise Image Segmentation[J].International Journal of Fuzzy Systems, 2013, 10(3):174-184.DOI:doi:10.1007/s11263-007-0122-4.

[9] Cheng Y , Bao Y , Liu S ,et al.Thermal Comfort Analysis and Optimization Strategies of Green Spaces in Chinese Traditional Settlements[J].Forests, 2023, 14(7):16.DOI:10.3390/f14071501.

[10] Wu S , Tetzlaff D , Yang X ,et al.Disentangling the Influence of Landscape Characteristics, Hydroclimatic Variability and Land Management on Surface Water NO_3-N Dynamics: Spatially Distributed Modeling Over 30 yr in a Lowland Mixed Land Use Catchment[J].Water Resources Research, 2022(2):58.DOI:10.1029/2021WR030566.