Sustainability assessment of a Low-carbon Park building Based on Life cycle assessment(LCA)-Carbon emission method

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Abstract: The data shows that the greatest electricity consumption occurs during the first three months of the year, accounting for approximately 31.4% of the total electricity consumption. This is attributed to the high energy consumption associated with heating air conditioners during cold weather conditions. Similarly, the corresponding carbon dioxide emissions follow a similar pattern, with a peak observed in the first quarter of every year. Therefore, it is important to focus on reducing carbon emissions during this period. These findings highlight the need for energy-efficient heating and cooling systems that can help reduce the negative impact on the environment while promoting sustainability. By adopting renewable energy sources and improving energy efficiency in building systems, we can work towards creating more sustainable and environmentally friendly built environments.

1. Introduction

1.1 Background

In the face of global temperature changes, sustainable urban systems need to focus on. As an integral part of urban systems, the ecological and sustainable design of building systems is becoming increasingly important. As a complex system, building systems involve various factors that can be broadly classified into three categories: material flow, information flow, and energy flow. Additionally, low-carbon design of building systems is currently a popular research topic[1-4]. The Chinese government has implemented a series of policies and measures to encourage the development of low-carbon industries. These measures include the formulation of policy documents advocating energy conservation, emission reduction, and low-carbon development, establishing low-carbon demonstration zones and industrial parks, and strengthening research, development, and application of clean energy and environmental protection technologies. Chinese low-carbon industrial parks are typically regions that gather low-carbon industry enterprises and resources, aiming to promote the research, application, and dissemination of low-carbon technologies. These parks provide infrastructure and support services, attracting many low-carbon businesses to settle in. Within these parks, one can find enterprises and projects related to renewable energy, energy conservation, environmental protection, and clean technologies. Overall, the development of low-carbon industrial parks in China benefits from government policy support and market demand. With increasing global attention on the low-carbon economy, it is expected that China's low-carbon industrial parks will continue to grow and play an important role in promoting sustainable development and addressing climate change.

1.2 Literature review

Different researchers have conducted multidimensional analyses on the sustainability of building systems. Some researchers have applied the life cycle theory to the field of architecture, aiming to analyze the sustainability of building systems. Some scholars have combined building information systems with the life cycle theory to support ecological building design. The ecological exergy approach is also a valuable perspective that can effectively validate the sustainability performance of building systems. In pursuit of carbon neutrality targets, researchers from around the world have conducted various analyses of building systems from a low-carbon perspective, involving areas such as low-carbon building design, zero-carbon buildings, low-carbon building materials, low-carbon building operation modes, and carbon sink analysis. Ecological low-carbon industrial park buildings are a special type of building complex that can integrate various low-carbon technologies and perspectives for analysis to determine their carbon emission status[5-18].

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2. Case and Method

2.1 Building case introduction

The building is situated at No. 26, Hufu Road, Gusu District, Suzhou City, Jiangsu Province, adjacent to the Tiger Hill Scenic Spot. The project aims to design a low-carbon industrial park comprising of three categories: Huqiu Academy (8600 m2), catering hotel (1518 m2), and residential land (1000 m2). The focus on developing a low-carbon industrial park highlights the importance of reducing negative environmental impacts associated with building design and operation. By utilizing sustainable practices and materials and promoting renewable energy sources, we can work towards creating more environmentally friendly and sustainable built environments that minimize our negative impact on the environment while promoting long-term sustainability(Table 1).

Table 1 Basic situation

No.	Picture	Data	Power consumption
1		8600 m^2	Start of use: January Operation period: Open for 365 days a year Air conditioning operation period: The air conditioning runs for 10 months in a year. Summer: Cooling typically starts in late April and ends in late October, lasting for 6 months. Winter: Heating typically starts in early November and ends in late March, lasting for 4 months. Air conditioning control methods: Central air conditioning and split air conditioning. Front desk centralized control: Areas such as the lobby, restaurant, and entertainment rooms. Guest self-control: Guest room air conditioning, which is equipped with panel-style wired controllers. Space lighting: Independent switches are used to manage each area. Public areas: Emergency lighting is on 24 hours a day, and other lights are controlled by timed switches based on the work schedule. Indoor guest rooms: Each guest can turn on/off the lights in their own room. Outdoor lighting: Landscape lighting is automatically controlled by the control system and the operating time is adjusted automatically according to the season and light intensity. The main operating period is roughly from 18:00 to 23:00.
2		1518 m^2	
3		1000 m^2	

2.2 Methodology

The calculation formula of the carbon emission calculation model for the whole life cycle of buildings is as follows:

$$E_{\lambda} = E_{\sigma} + E_t + E_c + E_o + E_d$$

Where E_{λ} =the total carbon emission; E_{σ} =the carbon emission of material production stage; E_t = the carbon emission of transport stage; E_c = the carbon emission of construction; E_o = the carbon emission of operationalphase; E_d = the carbon emission of demolition stage.

3. Results and Discussion

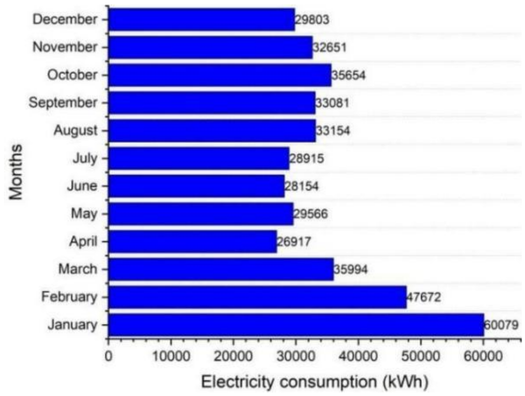

Figure 1 Comparison of building electricity consumption in industrial park

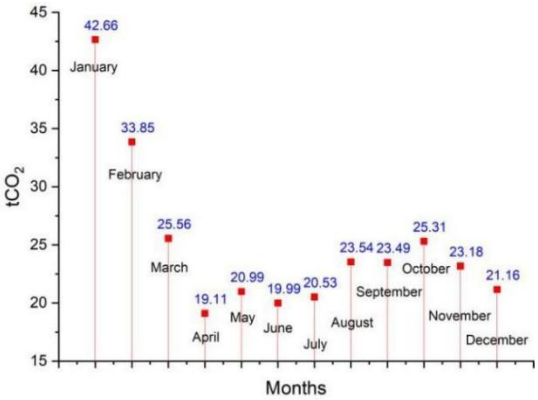

Figure 2 Comparison of building carbon emission in industrial park

In Figure 1 and Figure 2, based on the data presented, it is evident that the greatest power consumption occurs in the first three months, accounting for approximately 31.4% of the total electricity consumption. This is due to the high energy consumption of heating air conditioners during cold weather conditions. Similarly, the corresponding carbon dioxide emissions also follow a similar pattern. The highest carbon dioxide emissions were observed in January (42.66 tCO_2), followed by February (33.85 tCO_2) and March (25.56 tCO_2). These findings highlight the need for energy-efficient heating and cooling systems that can help reduce the negative impact on the environment while promoting sustainability. By adopting renewable energy sources and improving energy efficiency in building systems, we can work towards creating more sustainable and environmentally friendly built environments. Overall, the analysis of electricity consumption and carbon emissions provides valuable insights into the environmental impact of building systems and can guide the development of strategies to promote long-term sustainability and reduce our negative impact on the environment.

4. Improved Measures

The Chinese government is currently promoting the development of clean energy utilization as a means of promoting sustainability. By adopting clean energy sources such as solar, wind, and hydroelectric power energy, the building system can significantly reduce its negative impact on the environment and promote long-term sustainability. Among the three main types of clean energy in China, solar energy is the most popular way of harnessing renewable energy. By utilizing solar panels to generate electricity, building systems can significantly reduce their dependence on non-renewable energy sources and promote environmental sustainability. Overall, by adopting clean energy sources and improving energy efficiency in building design and operation, we can work towards creating more sustainable built environments that minimize our negative impact on the environment while promoting long-term sustainability. Continued research and innovation are needed to identify new solutions to improve the sustainability of building systems and promote the adoption of clean energy sources.

To enhance the sustainability of low-carbon industrial park buildings, the following paths can be taken:

1. Energy efficiency improvement: Reduce energy consumption by using efficient equipment and technologies such as LED lighting, energy-efficient HVAC systems, and smart energy management systems. Enhance building insulation and sealing to minimize energy losses.
2. Utilization of renewable energy: Meet a portion or all of the electricity demand through renewable energy sources like solar power and wind energy. Install facilities such as solar photovoltaic panels and wind turbines, integrating the buildings with renewable energy systems.
3. Water resource management: Adopt water-saving devices and technologies such as low-flow faucets and water-efficient toilets to reduce water usage. Collect and utilize rainwater for non-potable purposes like irrigation and flushing.
4. Building material selection: Choose environmentally friendly and renewable materials, giving priority to those with lower carbon emissions. Minimize resource extraction and pollutant emissions.
5. Waste management: Implement effective waste sorting and disposal systems including recycling, reusing, and proper waste treatment to minimize environmental impact.
6. Green transportation planning: Encourage low-carbon commuting methods such as walking, cycling, and public transportation. Provide convenient infrastructure like bicycle parking facilities and electric vehicle charging stations.
7. Building design and layout: Optimize building design by incorporating standards like Passive House to reduce energy demands. Plan building layouts strategically to minimize energy transmission losses and carbon dioxide emissions.
8. Environmental monitoring and assessment: Establish comprehensive environmental monitoring systems to track real-time energy consumption, water resource utilization, and waste management. Regularly evaluate the effectiveness of sustainability measures and make improvements accordingly.

By comprehensively employing these pathways, the sustainability of low-carbon industrial park buildings can be significantly improved, reducing their negative environmental impact while conserving resources and lowering operational costs.

5. Conclusions

The use of LCA-Carbon emission methodology provides valuable insights into the environmental impact of building systems, allowing architects and designers to make informed decisions to promote sustainability. By adopting a comprehensive approach that integrates sustainable practices and materials into building design and operation, we can work towards creating more environmentally friendly and sustainable built environments. The use of LCA-Carbon emission methodology can guide the development of strategies to reduce negative environmental impacts and promote long-term sustainability. Overall, continued research and innovation are needed to identify new solutions to improve the sustainability of building systems and reduce carbon emissions. By adopting sustainable practices and materials and promoting the adoption of renewable energy sources, we can work towards creating more sustainable built environments that minimize our negative impact on the environment while promoting long-term sustainability.

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