Research on Energy Saving and Emission Reduction of Ecological Environment of Modern Green Art Museum

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Abstract. The art gallery is a public place that exhibits works of art, cultivates popular culture and art, and cultivates sentiment. The art gallery is the embodiment of a city's cultural level, and it is also important spiritual support for facing a well-off society and realizing the great rejuvenation of the Chinese nation. The development of a city is concentrated in pieces of unique and charming artworks, which are witnesses to the times' changes. Therefore, designing an art museum that can meet all cultural functions and be energy-saving, green, and environmentally friendly becomes more and more important. Based on this research background, the thesis conducts environmental protection design of the art museum to realize the control of the project site planning and the unique climate adaptability design of the art museum, which helps to ensure that the design project from the macro to the micro-level better reflects the energy-saving design. The effect plays a positive role in promoting the development of art gallery design theory and is of great significance to improving the practice methods of green public art gallery design.

Keywords: Art venues, energy-saving, and environmental protection, ecological environment, energy-saving and emission reduction, green.

1. Introduction
With the continuous improvement of the Chinese national economy and the continuous deepening of the integration of global art museum decoration materials and environmental protection concepts, the concepts of green, energy-saving, and environmental protection have been deeply rooted in the people's hearts. Due to the lack of understanding of the importance of passive design by architects, some art museum projects failed to select appropriate passive design strategies following the climate characteristics and project characteristics in the early stage of the project, relying on complex systems and expensive technology and equipment.: This is easy to mislead the art gallery design and technology. Reasonably guide natural ventilation and the use of renewable energy such as solar energy to achieve design methods that reduce the museum's energy consumption and improve the indoor environment quality [1]. The art gallery's design conforms to nature but is also affected and restricted by the regional environment and has obvious regional and climate adaptability. Analyze the relevant knowledge of art museum technology and science and the simulation results to provide a basis for the evaluation and quantitative effect of green art museum wind environment design.
2. Analysis and interpretation of museum projects

2.1. Analysis and interpretation of urban space
As an important place for urban public life and communication activities, the outer urban space of large public buildings should be public and communicative, allowing more citizens to enter freely and fully enjoy the fun of outdoor activities and social interactions. Therefore, in design, we should create more diverse outdoor venues to meet the needs of various civic activities, and at the same time, we should achieve pleasant and comfortable outdoor landscape conditions. For the passive design strategy, organizing the site's natural ventilation and reducing the heat island effect caused by high-density cities are the key points.

2.2. Analysis and interpretation of using functions
In the context of modern humanity and society and satisfying the traditional functions of exhibiting and collecting works of art, art museums should also proceed from a people-oriented perspective to achieve greater openness and experience and break the traditional closed and homogeneous space model. Create a more diverse, free, and open internal space form, allowing users to get a more diverse visit experience [2]. Therefore, there is more freedom in the organization of the internal use of functions and spaces, which requires the separation and reorganization of various functional groups. Such splitting and reorganization are very beneficial to passive design strategies, and the design has more form variability to meet the needs of passive strategy and space combination.

3. Art gallery electrical system design

3.1. General requirements
The electricity used for the safety protection system and the important electronic computer system are particularly important loads in the first-class load; fire-fighting electrical equipment, emergency lighting, aisle lighting, duty lighting, guard lighting, electricity used in the collection warehouse, electronic information equipment room, Electricity loads such as passenger elevators, sewage pumps, and domestic water pumps are Class I loads; electricity for exhibitions, escalators, and constant temperature and humidity air conditioners are Class II loads; other loads are Class III loads. Two 10kV incoming lines and a single busbar are used for a segmented power supply. The two mains supply each other as a backup and supply power at the same time. The two incoming switches and tie switches are equipped with mechanical and electrical interlocking. Only two of the switches can be closed at any time. A total of 4x2000kVA transformers are installed. The transformers are selected from low-loss, low-noise, energy-saving dry-type transformers to meet the energy efficiency requirements of the "Energy Efficiency Limits and Energy Efficiency Grades of Three-phase Distribution Transformers." To meet fire protection requirements and primary load requirements, a generator set with a common power of 1000kW was set up as an emergency power supply. For the particularly important load in the first-level load, in addition to one man and one generator power supply, UPS is also set up as a backup power supply to improve the reliability of the power supply. EPS is set in the standby lighting and evacuation lighting distribution box as a backup power source to meet power supply continuity requirements.

3.2. Power monitoring system
Power intelligent monitoring system includes modes such as a centralized monitoring system. The centralized monitoring system has a hierarchical and distributed communication layer, bay layer, and station control layer, including intelligent power distribution meters, integrated microcomputer protection, intelligent electronic equipment, and other devices [3]. All devices use the communication protocol to manage the communication management machine through the shielded twisted pair, and the background is connected to the Ethernet to run. The HMI is the control screen, real-time operating status, control, and modification of the system configuration.
The communication layer mainly collects and measures the power distribution system's operating parameters and then transmits the data to the monitoring system. The equipment used includes multifunctional relay protection devices, intelligent network multi-parameter measurement and control instruments, etc. By configuring these devices and equipment, they can run independently without relying on the host computer.

The bay layer's main function is to complete the communication connection with the main control computer, data exchange, communication protocol conversion, etc., to achieve system compatibility and scalability. Connect and share data with the system through Ethernet switches, data servers, and gateway servers.

The station control layer is located in the central control room or duty room, equipped with high-performance computers, uninterruptible power supplies, alarm devices, etc. Power monitoring software is installed in the main control computer to realize the man-machine interface and management functions. As shown in Figure 1.

![Power Monitoring System Diagram](image)

**Figure 1.** Power monitoring system

### 3.3. Characteristics of a power monitoring system in smart buildings

The characteristics of the power monitoring system in smart buildings are: through the power smart monitoring system, technicians can control the current and another status in real-time, and timely and accurately grasp the operation status of on-site information, templates, and other equipment. Carry out accurate troubleshooting and handling of faults, and reasonably arrange maintenance work according to faults and equipment usage [4]. The power intelligent monitoring system can reduce energy costs, detect the baseline, power consumption, and load when power consumption is abnormal, formulate simple power consumption loads between regions, and check out the losses caused by power quality problems. The power intelligent monitoring system can evaluate whether the settings of power grids, transformers, switchboards, power distribution cabinets, etc. are reasonable, and reflect the quality and operation of power resources based on the evaluation results so that owners can make corresponding decisions based on the use and operation of power resources. Power intelligent monitoring systems can extend the service life of electrical equipment through maintenance methods. For power quality, the intelligent power monitoring system can detect the operation of low-quality power, give an alarm.
to the low-quality power, and remind the staff to deal with it, and monitor the power operation in the smart building in real-time. The power intelligent monitoring system replaces the manual power monitoring system and realizes the intelligent automation of power measurement, management, control, fault analysis, signal management, power operation, etc., through the computer communication network, and improves the transparency of the power distribution system. It has superior safety and reliability, and its management level is increasingly modernized. Because of the power monitoring system's openness, the communication in the intelligent building becomes fast and convenient, and the automatic interconnection of information and communication is realized, such as office automation in the intelligent building, communication network automation, automatic alarm system, etc. The intelligent building power monitoring system network is shown in Figure 2.

![Figure 2. Schematic diagram of the intelligent building power monitoring system network](image)

4. Photovoltaic power generation

The art gallery is designed as a three-star green building. To meet the requirements of green energy saving, solar thin-film modules are installed on the roof of the building and the curtain walls of the four facades in the south, east, north, and west to maximize solar energy use. The number of solar photovoltaic modules installed on the roof is 2,970, 21,008 on the curtain wall, and the total installed capacity is 228.51kWp. The grid-connected inverter converts the DC power generated by the solar modules into three-phase AC power and then connects to the low-voltage grid side through the AC power distribution cabinet. According to the power consumption of the museum, photovoltaic power generation consumes power on the low-voltage side immediately, thereby saving electricity consumption [5]. Simultaneously, the communication and monitoring system equipped with this system consists of a reliable PC, data collector (inverter integration), transmission cables and other related accessories, and real-time monitoring of photovoltaic system operating conditions and related data. The system also has a friendly human-computer interaction function. Using an LCD liquid crystal display, it can monitor and display the system's DC working voltage and current, AC working voltage and current, display daily power generation, total power generation, and other information. The system also has overvoltage, loss of voltage, overload and overcurrent, leakage, short circuit protection, and reverse polarity protection. The grid protection device built in the grid-connected inverter has an anti-islanding protection unit (MSD), effectively preventing islanding. The monitoring
system collects real-time operating parameters (current, voltage, frequency, power, power generation, etc.), operating conditions and fault alarm information, environmental parameters (air temperature, component temperature, radiance) of the inverter on the DC side and AC side of the inverter through the computer. After the data is processed by the computer, it can output power generation statistics, energy-saving and emission reduction data, as well as various power curves, voltage curves, and power generation curves. All the above data can be selectively displayed on the display device in real-time, and the data can be automatically saved, and reports can be printed, as shown in Figure 3.

![Figure 3. Photovoltaic monitoring system diagram](image)

5. Environmentally friendly materials for museum building materials

Material is the material cornerstone for the survival and development of human society. It involves all aspects of human life. Whether it is economic activities, scientific and technological activities, personal food, clothing, housing, and transportation, they are inseparable from materials. In modern life, buildings are closely related to materials. Building materials, the proportion of capital construction costs accounts for more than 50%-60%. Therefore, in advocating environmental protection and energy-saving and limited construction funds, scientific and reasonable selection and use of building materials can reduce construction costs, save energy, and protect the environment. We should use non-toxic, non-polluting, and non-radioactive building materials produced from industrial and municipal wastes in terms of material selection. This cannot only reduce construction costs but also help protect the environment and human health. For example, recycled paper, recycled plastics, recycled metals, and recyclable concrete can save limited natural resources; while using materials with lightweight, heat resistance, heat insulation, and high energy conversion rate can reduce the energy consumption of a system, with limited savings Energy; high-strength, wear-resistant materials, and reusable materials to reduce system resource consumption and improve resource utilization [6]. Traditional wall materials are mainly sintered clay solid bricks (red bricks), which are self-heavy, consume a lot of energy in production, and consume many arable land and farmland. China currently destroys nearly 100,000 mu of land to produce this kind of red bricks every year. The wall materials of energy-saving buildings are made of clay bricks, hollow bricks, aerated concrete, and lightweight panels and composite panels mixed with industrial waste residues. These materials are not only energy-saving and environmentally friendly but also use industrial waste residues to protect farmland.

5.1. Internal function design

In terms of the building's vertical functional space relationship, the use of the museum has been integrated and reorganized from three aspects: mass to professional, public to private, and the degree
of passive design strategy adjustment (Figure 4)). The overhead courtyard, sky courtyard, and roof garden are connected with the lighting atrium through the building from top to bottom and become the most important climate regulation system inside the building, which can fully organize the natural ventilation of the building at all levels. The collection storage area can use the stable temperature environment below the ground to realize the energy saving of air conditioning in the collection storage room, and the external air pre-cooled through the ground overhead green courtyard and sky courtyard can enter the room through the atrium "chimney effect" to achieve pre-cooling displacement ventilation effect. The use function combined with the sky courtyard and the overhead courtyard is mostly for the masses, with strong publicity, and the comfortable range of the indoor environment is wider than that of the main exhibition area. The relative concentration is conducive to the adoption of passive design measures for climate adjustment. The composite greening and water storage roof can also achieve effective roof insulation and cooling. The main display area located between the roof garden and the sky courtyard layer can use the upper and lower functions as a buffer space with the external environment to further reduce the ambient temperature outside the exhibition space and better realize the air conditioning and energy saving of the exhibition hall.

![Diagram](image)

**Figure 4.** The functional relationship diagram of the gallery section

5.2. **Optimization of internal space environmental quality**

The design conducted computer simulation verification and optimization on the natural ventilation effect of the atrium space. Through the comparison of the simulation results of multiple atriums with different proportions, it was found that the atrium height exceeded the 4-story 26m elevation, and the effect of hot-press ventilation was significantly improved. To determine the atrium height as 33m, it can provide the necessary space conditions for the hot pressure ventilation. The verification results show that in the transitional season, when the outdoor temperature is lower than 32°C, the hot-pressure ventilation will form a ventilation effect of no less than 2 times/h in the atrium area, improving the thermal comfort of the upper movable platform. Simultaneously, according to the basic scale requirements, the internal form and external landscape of the atrium also need to be optimized in combination with form and function [7]. The atrium plane form with a circular shape and vertical scaling and variable cross-section is adopted to reduce the influence of the boundary on the airflow and promote the movement of airflow; the use of overhead, aerial, and roof green landscape configurations to achieve pre-cooling and purification of natural ventilation (Figure 5).
6. Lighting system
The showroom adopts suitable new light sources such as thin-tube and straight-tube fluorescent lamps, compact fluorescent lamps, and LEDs. Cultural relics are displayed and collected, the interiors of the collection warehouses, and the light-sensitive exhibits use non-ultraviolet light sources and shading devices. The exhibition hall's general lighting chooses light sources with little or no ultraviolet rays [8]. The showroom's entrances and exits use thin-tube, straight-tube fluorescent lamps, compact fluorescent lamps, or LED light source spotlights. The exhibition hall area above 12m installation height adopts energy-saving low-power metal halide lamps or LED spotlights. Generally, the color temperature of the exhibition hall's direct lighting source should be less than 5300K; the color temperature of the light-sensitive exhibition hall and cultural relics showroom should be less than 3300K. In places where the display of paintings, colored fabrics, and other exhibits require high color discrimination, the color rendering index Ra of the lighting source should not be less than 90; in places with low color discrimination requirements, the color rendering index Ra of the lighting source should not be less than 80.

7. Museum energy consumption and carbon emissions
The coal, natural gas, liquefied petroleum gas, and other fuel consumption in the tertiary energy consumption of the museum's terminal energy consumption and domestic consumption are included in the hot water energy consumption of the museum; the power consumption is the electricity consumption of various electrical appliances in the museum [9]. The CO₂ generated by fuel consumption and the CO₂ generated by the electricity used in the production of art galleries are included in building CO₂ emissions. Calculate the total amount and intensity of the museum's energy consumption and emissions based on the area and population of the museum:

\[
EC = \Sigma_i F_{si} + \Sigma_s P_s \\
EM = \Sigma_i F_{si} \cdot ef_s + \Sigma_s P_s \cdot ef_p \\
\]

\[
PI_s = \frac{P_s}{a_s} \\
FI_s = \frac{\Sigma_i F_{si}}{rp} \\
EM - PI_s = \frac{P_s \cdot ef_p}{a_s} \\
EM - FI_s = \frac{\Sigma_i F_{si} \cdot ef_i}{rp}
\]

(1)
In formulas (1): EC and EM are the total energy consumption of the museum and the total carbon emissions, respectively; $F_x$ is the energy consumption of the $i$-th fuel in the $x$-th building, $x$ is the museum building, and $i$ is the coal, natural gas, liquefied petroleum gas, and other fuels; $P_x$ is the electricity consumption of the $x$-class art gallery building; $e_f$ and $e_p$ are the CO$_2$ emission coefficients of fuel $i$ and electricity respectively; $PI_x, FI_x, EM - PI_x, EM - FI_x$ is the power consumption intensity of the $x$-class building, respectively. Fuel consumption intensity, electricity emission intensity, and fuel emission intensity. $A_x$ is the area of the art gallery, and $rp$ is the number of visitors to the art gallery.

In the context of energy conservation and environmental protection, it is assumed that the power consumption intensity, fuel consumption intensity, power emission intensity, and fuel emission intensity of the future museum will remain at the level of 2019, and the area and population of various buildings in the future are used to calculate the energy consumption and carbon emission. Under the policy scenario, according to the energy consumption structure of typical buildings, determine the proportion of energy consumption such as ventilation, lighting, hot water, and other energy consumption in the building energy consumption, combining the application objects, promotion potential, and energy-saving potential of energy saving and emission reduction technology, and comprehensive energy-saving and environmental protection. The total energy consumption and emissions of various buildings under the scenario, and the analysis of building energy consumption and carbon emissions under the policy scenario.

8. Conclusion

When designing and constructing the museum, it is necessary to consider the local economic situation, the surrounding geography and spatial environment, choose an appropriate construction scale to avoid the pursuit of luxury, and maximize the use of original resources, protect the environment, and reduce energy consumption. It can save investment and reduce energy consumption, and control construction costs through various energy-saving measures. It can be seen that the scientific and reasonable planning of art museums to save energy, reduce emissions, and protect the natural environment during construction and use are the most vivid examples of low-carbon and sustainable development.

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