# Green Campus Construction Evaluation System Postprint

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## Abstract

Campuses are important components of society and serve as vital cradles and foundations for cultivating talent and providing developmental support to the nation. By harnessing campuses as drivers of social development, resource utilization efficiency can be enhanced, issues such as energy shortages and environmental pollution can be mitigated, and sustainable social development can be promoted. As part of public infrastructure, campuses feature diverse facilities, dense populations, and high energy and resource consumption, generating substantial pollution and energy consumption. Green campus construction has attracted widespread attention. This paper completes the overall framework design and development of a green campus evaluation system by comparing domestic and international green evaluation systems and integrating the 'Green Campus Evaluation Standard' with a focus on scoring criteria applicable to computer technology platforms, discusses the functions of the various subsystems of the green campus evaluation system, and the application of this system will promote green campus construction.

## Full Text

## Preamble

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**Green Campus Construction Evaluation System**

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**Abstract:** Campus is an important component of society and a crucial cradle and base for nurturing talent and providing developmental support for the nation. By leveraging campuses as a driving force for social development, we can improve resource utilization efficiency and alleviate energy shortages and environmental pollution, thereby promoting sustainable social development. As part of public infrastructure, campuses are characterized by diverse facilities, dense populations, and substantial energy and resource consumption, generating considerable pollution and energy usage. Green campus construction has attracted widespread attention. This paper compares domestic and international green evaluation systems and, based on the *Green Campus Evaluation Standard*, focuses on scoring criteria applicable to computer technology platforms. It completes the overall framework design and construction of a green campus evaluation system and discusses the functions of its various subsystems. The system' s application will promote green campus construction.

**Keywords:** Green; Campus; Evaluation; System

## 1. Overview of Green Campus Construction

According to the 2014 National Education Development Statistical Bulletin, China had 514,000 schools of all levels and types in 2014, with 260 million students enrolled. The total building area of school premises reached 2.99 billion square meters, averaging approximately 11.5 $m^2$ per capita. With high population density and diverse facilities, campuses are major consumers of social energy. Data from the National Energy Administration shows that total electricity consumption in society reached 5,523.3 billion kWh in 2014, a year-on-year increase of 3.8%. University per capita energy consumption indicators in China are significantly higher than the national average for residents. Preliminary statistics indicate that university students' per capita energy and water consumption are 4 times and 2 times the national per capita averages, respectively. This substantial resource consumption has gradually drawn attention to campus energy conservation, emission reduction, and natural ecological environment construction, revealing enormous energy-saving potential and the capacity to provide low-carbon action plan standards and experience for society.

Internationally, the UK, as the first country to propose a low-carbon economy and formulate sustainable development plans, has accumulated considerable successful experience in green campus initiatives. In 2005, led by Nottingham Trent University (NTU) and supported by the Higher Education Funding Council for England (HEFCE), the UK developed the EcoCampus evaluation standard and award system. EcoCampus is a phased environmental management and award system specifically designed for higher education and adult education institutions. It provides a modular, step-by-step improvement approach for Environmental Management Systems (EMS) development according to BS8555 and ISO14001 standards. The system recognizes institutions with outstanding

performance in environmental sustainability and provides technical support to resource-limited or inexperienced educational institutions.

In China, Tsinghua University first proposed the concept of creating a "Green University" in 1997. Subsequently, other domestic universities introduced "ecological" concepts into campus construction. For example, Guangzhou University implemented ecological priority principles in planning and environmental creation, conducting vegetation surveys and green space system planning to maximize natural ecological environment protection. However, the concept of "green campus" remains underapplied in Chinese campuses, with understanding still limited to greening and beautification stages.

Domestic scholars continuously draw on foreign advanced experience to research "green campuses." Zang Shuliang et al. consider green campuses as complete artificial green ecosystems formed under scientific ecological theory support. Zhang Fang understands green campuses as ecologically virtuous cyclic university environments constructed under sustainable development concepts. Chen Yuetang views green campuses as artificially created ecosystems with distinctive culture and connotation formed through rational planning, design, and construction under ecological principles. Jiang Wenjie et al. define green campuses as artificial ecosystems planned, constructed, managed, and operated using ecological principles to achieve efficient energy utilization. Although scholars' definitions vary, they all implement sustainable development principles.

Based on these principles, green campuses are considered important components of ecological gardens and ecological city construction, representing an inevitable trend for 21st-century university campus environment construction and development. Green plant configuration design and artificial plant community construction not only determine the effective functioning of campus green ecological functions but also constitute important pathways and means for building green campuses. In 1953, anthropologist Julian Steward proposed the concept of "ecological culture" in *Evolution and Process*, leading increasing scholars to focus on ecological planning and application, introducing "ecological" concepts into campus planning and construction. In recent years, "ecological campuses" have been continuously attempted internationally. For example, the Jubilee Campus of the University of Nottingham transformed a derelict bicycle factory site into a vibrant green campus, linking green campus construction with lean practices. North Carolina State University' s new campus designed a drainage system considering downstream water impacts while protecting important local tree species and natural areas, increasing native plant communities to replace turf and restore local biodiversity.

Ecological campuses and green campuses are distinct concepts: ecological campuses apply ecological principles to construct artificial ecosystems, while green campuses typically refer to schools fully embodying environmental protection concepts in campus construction, management, and daily behaviors of campus personnel. Consequently, ecological campus evaluation and green campus evaluation have different focuses—ecological campus evaluation emphasizes overall

environmental energy input-output assessment and systematic ecological construction, while green campus evaluation focuses on the embodiment and implementation of green concepts in campus construction and operation. However, both share the core principle of sustainable development.

## 2. Green Construction Evaluation Index System

Different scholars have varying perspectives on constructing green campus evaluation index systems. Xu Liyan, after analyzing popular color performance of buildings domestically and internationally, proposed a green Olympics evaluation system with resource consumption, environmental load, indoor environmental quality, and outdoor physical environmental quality as evaluation indicators. Chen Yuetang et al. constructed an evaluation index system for Hunan Agricultural University' s green campus based on three aspects: structure, function, and coordination. Using Northeastern University as an example, researchers proposed analyzing campus energy consumption through ecological footprint methods, including energy, food waste treatment, and other aspects. Kim et al. used case studies to illustrate green campus applications and implementation, constructing corresponding management organizations. Jiang Xinpei et al. combined Analytic Hierarchy Process and fuzzy comprehensive evaluation methods with expert analysis to determine index weights.

In the UK, a team led by Dr. Peter Redfern at Nottingham Trent University developed the EcoCampus system based on obstacles hindering green campus construction: lack of awareness of ISO and EMAS standards, insufficient staff knowledge and capabilities, scarcity of implementation tools, time consumption, process complexity, increased documentation workload, unrecognized achievements, and lack of social support and incentives. The system addresses these factors by providing solutions, enabling institutions to gradually meet international standards from basic levels, thereby shaping positive images, enhancing competitive advantages, achieving cost savings in key areas, optimizing energy use, realizing sustainable development, addressing climate change challenges, improving management levels, better controlling risks, and adapting to international laws and regulations. The system covers pollution, waste, energy, water, transportation, carbon emissions, legal compliance, and procurement, guiding assessment and awards through four stages: Planning (Bronze), Implementation (Silver), Operation (Gold), and Review and Correction (Platinum).

Currently, campus building facilities are extensive and involve wide-ranging energy management. This paper, based on China' s *Green Campus Evaluation Standard* and drawing on mature domestic and international index systems, has developed an index system suitable for computer-based green campus evaluation. Computer system design involves systematic complexity arising from interdependent requirements and high system utilization while processing complexity. The construction of computer evaluation indexes follows systematic and concise scientific principles. Based on the evaluation indexes in *Green Campus Evaluation Standard* (CSUS/GBC04-2013), we have adapted them for computer system

evaluation: land saving and outdoor environment indexes are summarized as "ecological environment" ; energy saving and energy utilization, water saving and water resource utilization, and material saving and material resource utilization are summarized as "resource utilization" ; indoor environmental quality is summarized as "environmental quality" ; construction management and operation management remain unchanged; and innovation items are added following Hong Kong' s HKBEAM. The overall evaluation index framework is shown in [Figure 1: see original paper]. The evaluation reference standards are divided into "design evaluation" and "operation evaluation." Evaluation indexes consist of prerequisite items and scoring items—prerequisite items are evaluated as "satisfied" or "not satisfied," while scoring items are graded.

The scoring rate for each of the five index categories, Q1, Q2, Q3, Q4, and Q5, should be calculated as the ratio of the actual score obtained by the evaluated campus to the theoretically achievable total score. Q6 represents innovation item scores. Considering relative differences in the importance of various indexes, weights are introduced when calculating the total score. Therefore, the total scoring rate should be the weighted scoring rate of the five index categories plus the additional scoring rate of bonus items (Q6): $\mathbf{Q = W1Q1 + W2Q2 + W3Q3 + W4Q4 + W5Q5 + Q6}$. This constitutes the final total score, where index weights are set with reference to the *Green Campus Evaluation Standard*. When the total green building score reaches 50, 60, and 80 points respectively, the green building rating is one-star, two-star, and three-star respectively.

## 3. Design and Development of Green Campus Construction Evaluation System

### 3.1 Design Purpose of Green Campus Construction Evaluation System

Green campus evaluation can guide public attention toward environmental sustainability while campuses disseminate environmental protection concepts externally, enabling more people to continuously focus on energy conservation and emission reduction. By establishing a small-scale ecological system on campus and educating students on ecological concepts, the concept of sustainable development can be promoted throughout society. The green campus evaluation index system demonstrates that evaluation work is a highly comprehensive systematic task. Implementing evaluation requires not only evaluation results but also generates large amounts of valuable data. Therefore, designing and developing a green campus construction evaluation system is necessary.

### 3.2 Functional Design of Green Campus Construction Evaluation System

Green campus construction evaluation is divided into "design evaluation" and "operation evaluation" —two independent evaluation stages. The green campus construction evaluation system is used to assess the overall green construc-

tion system of campuses, mainly comprising three components: basic database, project scoring and grading, and result publication and analysis. The overall system framework is shown in [Figure 2: see original paper].

### 3.3 Architecture Design of Green Campus Construction Evaluation System

The system framework forms the foundation for implementing the green campus evaluation system, based on the functions to be achieved and overall planning for implementation and operation. Referring to software architecture layering principles, the overall structure is planned as shown in [Figure 3: see original paper].

**(1) User Interface Layer**
This layer is primarily responsible for interacting with users, realizing human-computer interaction. Evaluation objects are responsible for inputting data materials, scoring experts review and score the provided materials, and system maintenance personnel have full system authority, responsible for daily maintenance and data processing. In this system, this layer is implemented through Web Form interfaces.

**(2) Data Access Layer**
According to instructions from the business logic layer, this layer communicates with corresponding databases and processes data feedback to the business logic layer. This layer provides a unified data access interface, completely encapsulating the database within the platform. The data access layer directly manages database connections and communication, making the database transparent to other layers, minimizing security risks while maximizing data processing efficiency.

**(3) Database**
This mainly includes the entire evaluation system foundation formed by inputting evaluation criteria systems, expert information databases, and project information databases.

### 3.4 Subsystem Functions of Green Campus Construction Evaluation System

The system is developed using JAVA language and stable SQL Server database technology, built on a distributed multi-layer structure based on J2EE and Web Services. It uses platform-independent XML data transmission and interaction technology to achieve separation between business model resources and system implementation technology, ensuring technology independence.

**3.4.1 Basic Database** The basic database includes evaluation index maintenance, scoring expert database, evaluation standards, and document downloads. Evaluation index input includes project basic information, ecological environment, resource utilization, environmental quality, operation management, edu-

cation promotion, and innovation items. The evaluation indexes in this system can be divided into qualitative and quantitative indicators. Qualitative indicators do not require specific algorithms for data analysis and are generally determined through expert assessment indexes or design drawings and textual descriptions. Quantitative indicators require professional algorithms for analysis or software extraction and analysis of specific performance values of campus buildings, which are then scored according to scoring standards.

The scoring expert database inputs basic expert information and reviews historical scoring records, providing reference for project evaluation. Standard document downloads mainly include the *Green Campus Evaluation Standard* and related documents. The common materials download module is an auxiliary module for users, providing resources and standard documents to assist experts in scoring. This information collects previous green campus evaluation research cases and results, as well as relevant green campus standards, which are classified and organized into the system' s common materials download module. When experts need information, they can enter this module, select required cases or standards from the list, download and review them, providing reference opinions for their scoring process. This module provides users with more reference information, facilitates scoring work, and greatly improves work efficiency.

**3.4.2 Project Scoring and Grading** This module's main function is to fill in various source documents and evaluation data and manage information. Based on actual project conditions, personnel fill in project data in the scoring system, after which the process moves to the expert scoring stage. Various information in the system is uniformly managed and processed to ensure accuracy, uniqueness, and security. All project scoring standards follow the *Green Campus Evaluation Standard* (CSUS/GBC04-2013).

For modules requiring on-site expert evaluation, scoring standards can be accessed from the system anytime. Based on evaluation standard document information, team members can select files for review. After reviewing project materials, experts select their evaluation results in a scoring table displayed in the system—for example, "satisfied" or "not satisfied" for prerequisite items, or specific scores for scoring items. These selections serve as expert evaluation results for subsequent use.

Scoring result processing is a crucial part of the system, primarily responsible for summarizing various index results and determining the campus' s green rating. After scoring, scoring tables are submitted to the server, and the system summarizes scores according to set evaluation indexes to calculate a final total score. During system design, evaluation indexes are reasonably configured to facilitate data processing and result summarization, which is essential for obtaining results.

**3.4.3 Result Application and Publication** This module allows querying historical data by region and city to display project rating levels. Data analysis

and comparison can reveal differences in scores between regions. Two projects can also be directly selected for comparative analysis, and analysis result reports can be downloaded.

### 3.5 Case Demonstration

The login interface is shown in [Figure 4: see original paper]. Users log into the system with accounts and passwords assigned according to different permission levels. System administrators have full permissions.

Under the basic database–expert database interface, experts ensure scientific rigor of evaluation work by filling in basic personal information such as name, gender, ID number, workplace, and professional title, as shown in [Figure 6: see original paper].

Under project scoring and grading–project basic information function, project basic information is filled in, which can then be viewed and modified. The project is the evaluation object, and its basic information forms the most fundamental data for system establishment, as shown in [Figure 7: see original paper].

System administrators maintain evaluation indexes under the basic database–evaluation index maintenance function, constructing the entire evaluation system' s index framework. As shown in [Figure 5: see original paper], this functional sub-module allows viewing index categories, classifications, contents, evaluation methods, and standards, with functions for adding, deleting, modifying, and viewing as needed.

After basic information is entered, evaluation object data is filled in according to the evaluation index system, as shown in [Figure 8: see original paper]. Based on several indexes from the planning and ecology sections of the evaluation index system, data is filled in according to the evaluation object' s actual conditions, with functions for data deletion, modification, and viewing.

After project data input, experts enter the expert scoring module to score projects. According to scoring rules, experts review project data and assign scores, as shown in [Figure 9: see original paper].

After expert scoring, each sub-item score is summarized into a total score record table with a rating level, as shown in [Figure 11: see original paper].

After total score calculation, the result publication and application interface can display scoring results. Clicking Wuhan on the map shows all scored projects in the Wuhan area on the right side, with results viewable and a pie chart showing regional rating levels based on statistical results, as shown in [Figure 12: see original paper].

Through green campus evaluation, overall environmental awareness can be enhanced, promoting sustainable development of campus ecological systems. Campuses play educational and leading roles in society, driving sustainable develop-

ment across society. Developing and implementing a green campus construction evaluation system is an important tool to ensure efficient, scientific, and orderly green campus construction evaluation.

However, China' s green environmental protection work started late with insufficient promotion, and public environmental awareness is not strong. The campus green evaluation system remains imperfect, with non-unified evaluation process management systems. China still has considerable room for improvement in campus green evaluation management systems and evaluation methods.

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*Note: Figure translations are in progress. See original paper for figures.*