Research on Standard System in Energy Field Based on BIM Intelligent Construction

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Abstract. With the rapid development of information technology, BIM technology is driving the digital and intelligent transformation of the entire lifecycle in construction projects within the energy sector, enhancing project collaboration efficiency and information support. By reviewing existing standards, it is pointed out that the current intelligent construction standard system remains incomplete, especially in terms of data standards, construction management standards, and standardization in the operation and maintenance phases. This study analyzes the current state of standardization in the energy sector's intelligent construction with BIM, focusing on business sectors such as power, transportation, municipal, and residential construction. It establishes a BIM-based intelligent construction standard system to further improve the standard system, promote interoperability between Chinese and international standards, and play a more significant role in the international standardization process.

Keywords: intelligent construction, standard system, BIM, energy industry

1 Introduction

With the rapid advancement of global information and digital technologies, the energy sector is undergoing a profound transformation. As a core technology in the industry, Building Information Modeling (BIM) is driving the transition of construction projects from traditional design, construction, and operation models towards digitalization and intelligence. The application of BIM technology provides precise information support and collaboration tools at each stage of a building project's lifecycle, and also enhances project visualization, construction efficiency, quality control, and overall operation management through digital means.

Globally, the adoption of BIM technology and intelligent construction is advancing rapidly. In developed countries, particularly in Europe and the United States, significant progress has been made in the application of BIM technology [1]. As one of the birthplaces of BIM, the U.S. construction industry was an early adopter, establishing

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initial BIM standards in the late 1990s, such as the National BIM Standard (NBIMS). Later, the UK government released the Government Construction Strategy in 2011, requiring that all government projects meet BIM Level 2 standards by 2016, establishing the UK as a pioneer in global BIM standardization.

With strong support from national policies, the promotion of BIM technology in China has been steadily increasing, especially since the 13th Five-Year Plan, where BIM has been identified as a key technology for the digital transformation of the construction industry [2]. The domestic BIM standards system is gradually improving, with industry regulations and standards being introduced to support the application of BIM technology. However, compared with international advanced levels, BIM standardization in China is still in its early stages, and the depth and breadth of relevant standards need further enhancement.

Without unified standards, issues such as information exchange, data coordination, and cross-sector collaboration between projects can encounter technical barriers, leading to inefficiencies and increased costs. Therefore, standardization is particularly important in the global application of BIM. In the promotion and application of BIM technology domestically, there are challenges with the lack of BIM data standards and insufficient implementability of existing standards [3].

This study establishes a BIM-based intelligent construction standard system centered on business sectors in the energy domain, including power, transportation, municipal, and housing construction, and promotes its exemplary application in projects.

2 Construction of Standard System Based on BIM

The structure of BIM-based intelligent construction standard system consists of four parts, namely, “A general and basic”, “B key technology”, “C management standard”, “D application standard”, mainly reflecting the composition relationship of each category of standard system, as shown in Figure 1. “D application standards”, mainly reflecting the composition of each category of the standard system, as shown in Figure 1.

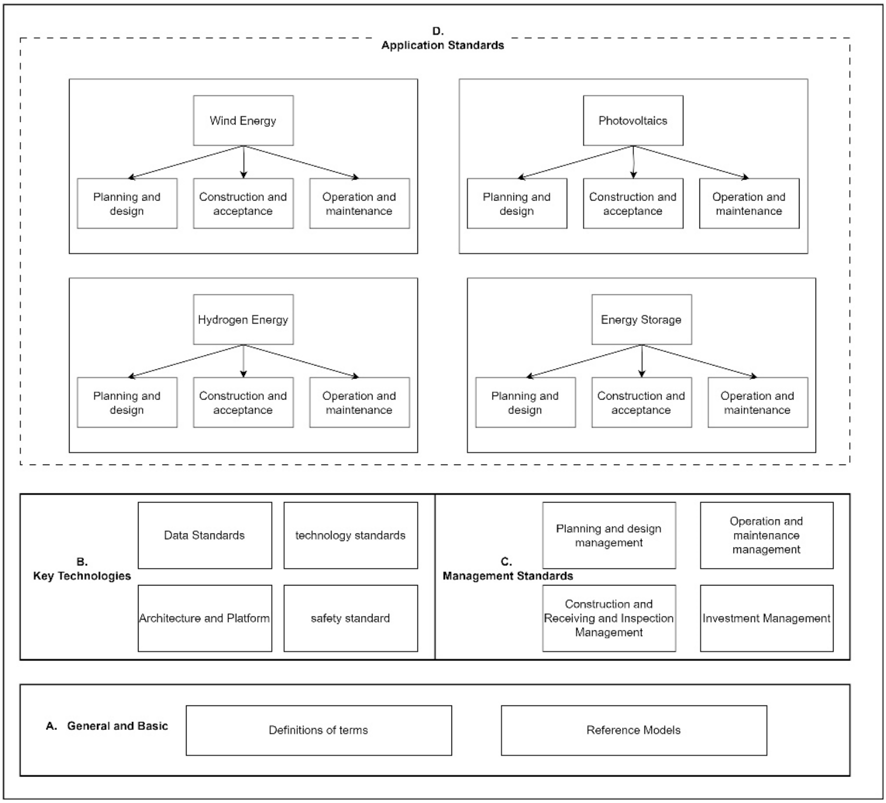

Fig. 1. BIM-Based Intelligent Construction Standard System Structure

3 Analysis of Standardization in the Energy Sector Based on BIM

Given the dispersed nature of intelligent construction standard data sources and the distinct characteristics of the data, a hierarchical keyword retrieval strategy was adopted, focusing on retrieving standard names and expanded content in the main text. At the first level, four keywords directly related to intelligent construction were selected: informatization, digitalization, intelligence, and smart. At the second level, seven keywords with indirect relevance to intelligent construction were introduced, including BIM, Internet of Things, robotics, artificial intelligence, smart construction sites, cloud computing, and big data. At the third level, nine keywords were chosen, covering multiple fields such as wind power, energy storage, power grid, photovoltaics, hydrogen energy, municipal, transportation, residential construction, and equipment.

To extensively collect relevant standard information in the field of intelligent construction, multiple methods were employed, including querying the national standard information platform, searching web content through major search engines, consulting relevant books and resources, and conducting in-depth searches within literature databases. Through the comprehensive use of these approaches, a total of 513 standard documents closely related to intelligent construction were successfully obtained, both domestically and internationally. The following discussion addresses these documents from three aspects: standard levels, types of standards, and the stages of intelligent construction.

3.1 Analysis of Standard Levels

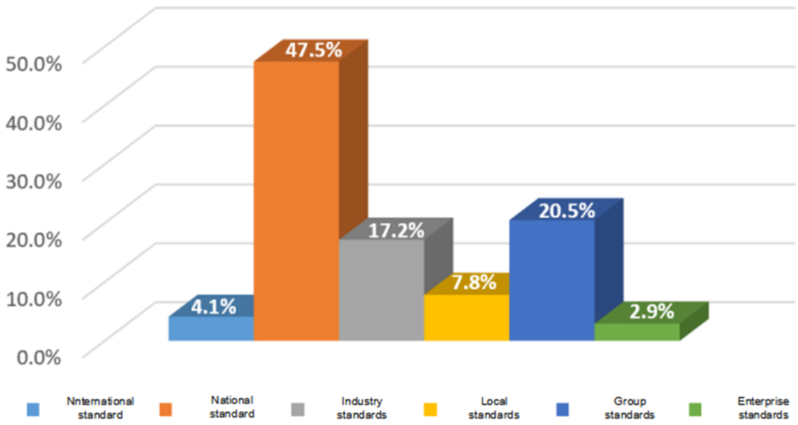

Fig. 2. Classification of Intelligent Construction Standards by Scope of Application

Based on standard queries, a total of 21 international standards, 243 national standards, 88 industry standards, 40 local standards, 105 group standards, and 15 enterprise standards were retrieved (as shown in Figure 2). This indicates that national standards are relatively well-developed, and international standards for intelligent construction are also being further researched and formulated. Enterprises still need to develop intelligent construction standards tailored to their specific characteristics.

3.2 Analysis of Standard Categories

From the standard queries, 32 general and foundational standards, 136 key technology standards, 307 application standards, and 37 management standards were identified (as shown in Figure 3). This shows that application standards are relatively well-developed, but there is a need to strengthen the formulation of management standards for intelligent construction.

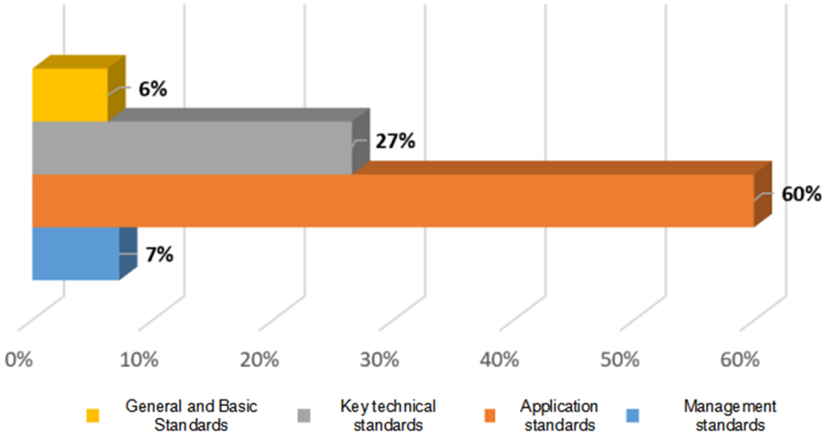

Fig. 3. Classification of Intelligent Construction Standards by Category

3.3 Analysis of Standards by Phase

Intelligent construction encompasses the full lifecycle of a project, including four key stages: design, manufacturing, construction, and operation and maintenance (O&M). A detailed review of 513 intelligent construction-related standards reveals that the design phase has the most standards, with 239 in total; the manufacturing phase follows with 54 standards; the construction phase has 99 standards; and the O&M phase also has a significant number, totaling 121 standards (as shown in Figure 4).

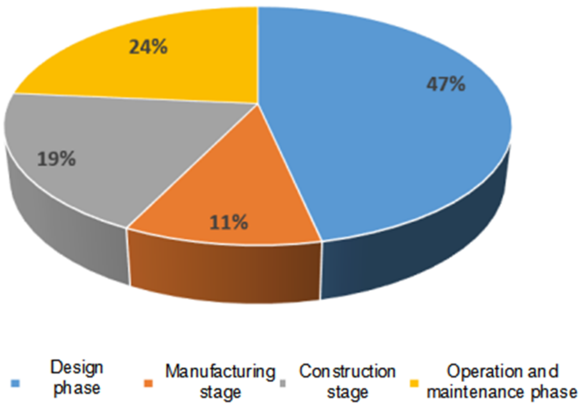

Fig. 4. Distribution of Domestic Intelligent Construction Standards Across Different Construction Phases

(1) Design Phase

As the initial step of intelligent construction, these BIM-based design standards provide crucial guidance and support for subsequent intelligent construction processes. However, in practical engineering projects, component design work in China remains largely at a preliminary stage of parametric design, not yet achieving true intelligent design.

(2) Manufacturing Phase

The "Intelligent Manufacturing Capability Maturity Model" is another important standard, providing a methodology for enterprises to incrementally improve intelligent manufacturing capabilities, which can guide the construction of intelligent factories and assess existing factories' capabilities in informatization, digitalization, and intelligence.

(3) Construction Phase

The standard system for the construction phase of intelligent construction is gradually being established. It includes BIM model construction application standards, general specifications for quality control of building and municipal engineering construction, BIM-based green construction monitoring information management protocols, construction safety inspection standards, and BIM construction application technical specifications.

(4) Operation and Maintenance Phase

To achieve standardized and regulated intelligent operation and maintenance, the existing standard system must be further expanded and refined to ensure comprehensive coverage of all aspects of intelligent operation and maintenance, providing comprehensive guidance for the technological application and engineering acceptance of intelligent building operation and maintenance.

4 Disscusion

The construction of a unified BIM-based intelligent construction standard system assists practitioners in design, manufacturing, construction, and operation/maintenance through standardized practices. Taking the power grid industry as an example, the application of unified BIM standards in China and abroad has demonstrated significant performance improvements. In China, the State Grid Corporation implemented a unified BIM standard in a major substation project in Qinghai Province, reducing design and construction costs by approximately 10%, decreasing design changes by 30%, and accelerating construction progress by 15% [4]. This standardization greatly improved project collaboration efficiency and minimized resource wastage caused by information incompatibility. Similarly, in the UK, the BS EN ISO 19650 standard was applied in the Manchester Power Transmission Project, improving design and construction efficiency by about 25%, enhancing safety risk identification by 20%, and reducing the accident rate by approximately 15% [5]. This standardized system ensures effective information exchange, supporting full lifecycle management of facilities and reducing energy consumption during the operation phase.

Standardizing BIM-based intelligent construction standards has a significant impact on cost, safety, and sustainability in the power grid industry. Firstly, standardization of BIM standards helps reduce redundant design and rework, improving information-sharing efficiency, and is expected to reduce project costs by approximately 5-

10%. Through standardized data and models, project stakeholders can collaborate more effectively, minimizing additional costs arising from misunderstandings or information loss. In terms of safety, unified standards support real-time monitoring and simulation analysis, aiding in the identification of high-risk areas before construction and reducing on-site accident risks. Studies indicate that standardized BIM management processes can increase safety risk identification rates by 20% and decrease accident rates by 15%. The standardized lifecycle management optimizes facility operation and maintenance, extending equipment lifespan and reducing resource waste. For energy management, a BIM-based facility management system can lower building operational energy consumption by approximately 10-15%, providing substantial advantages in promoting the sustainable development of the power grid industry.

5 Conclusion

The current construction of BIM-based intelligent construction standards remains incomplete. To advance the standardization process in the field of intelligent construction, there is an urgent need to accelerate the establishment and improvement of relevant standards from five key dimensions: national, industry, regional, organizational, and corporate levels. This study systematically reviews BIM intelligent construction standards in the energy sector by analyzing a large body of standards closely related to intelligent construction, synthesizing a structured framework for the standards system. The development of standards for intelligent construction should not only focus on enhancing "intelligence" but also emphasize alignment and integration with international standards. This approach will reduce technical and trade costs in international exchanges and help to strengthen China's influence on the global stage.

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