# Practice and application of bim based carbon neutral temporary construction facility in UHV power grid project

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**Abstract.** With the development of low-carbon economy, carbon neutrality has become a widely concerned topic. As an important infrastructure related to national economic security and social development, the energy consumption and greenhouse gas emissions in the construction of UHV power grid project have been paid more and more attention. Therefore, this paper aims to explore the application of BIM based carbon neutral temporary construction facilities in UHV power grid projects. This paper first introduces the basic situation of UHV power grid engineering, including its importance, current situation and development trend. Then, aiming at the problems of energy consumption and greenhouse gas emissions existing in the construction process of UHV power grid project, this paper puts forward the application scheme of carbon neutral temporary construction facilities based on BIM technology. The program mainly includes the following four aspects: energy monitoring, energy management, carbon neutrality and energy conservation and emission reduction. In this paper, the concrete realization methods and technical principles of these four links are introduced respectively, and the practical cases are expounded in detail. Finally, the advantages and application prospects of BIM carbon neutral temporary construction facilities are analyzed and evaluated in this paper. It is found that this scheme can effectively reduce the energy consumption and greenhouse gas emissions during the construction of UHV power grid project, and also improve the sustainability and economic benefits of the project construction. Therefore, this paper believes that the application scheme of carbon neutral temporary construction facilities based on BIM technology will be an important development direction of UHV power grid construction, with broad market prospects and application value. In summary, this paper conducts an in-depth study on the application of BIM based carbon neutral temporary construction facilities in UHV power grid projects, puts forward corresponding application schemes, and analyzes and evaluates its advantages and application prospects. It is hoped that this study can be used as a reference for the low-carbon development of other engineering construction fields.

**Keywords:** BIM technology; Carbon neutral; Temporary construction; Uhv project



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# 1 Introduction

With the gradual development of low-carbon economy and sustainable development, how to effectively reduce the impact of the construction industry on the environment has become an important issue. In this process, BIM technology and its application are widely regarded as one of the solutions. In UHV power grid projects, BIM technology can help enterprises to carry out the practice and application of carbon neutral temporary construction facilities.

# 2 The role of bim technology in UHV power grid projects

First of all, BIM technology optimizes building design through digital means, which can greatly reduce waste and energy consumption in the construction process. As one of the mainstream projects in the field of large-scale infrastructure construction, the construction process of UHV power grid project often requires a large number of construction machinery and manpower, and these machinery and manpower will produce a large amount of greenhouse gases such as carbon dioxide, seriously affecting the environment. BIM technology can control the working time and path of construction machinery and make reasonable use of the site through the setting of virtual environment, thus reducing the carbon dioxide emission during construction[1].

Secondly, BIM technology can reduce the noise pollution and dust pollution generated in the construction process through intelligent management of temporary construction facilities, so as to reduce the impact on the environment. The management of temporary construction facilities is a crucial part of UHV power grid project, because a large number of construction materials and equipment need to be stored and protected in time during the construction process, and need to meet the needs of construction personnel's life and work. BIM technology can grasp the number and use of facilities in time through the digital management of temporary construction facilities, so as to carry out reasonable use and layout of facilities, thus reducing noise pollution and dust pollution in the construction process.

Finally, BIM technology can also optimize the utilization of human resources and resources in the construction process of UHV power grid project through a collaborative and intelligent way, and can greatly shorten the construction project cycle. BIM technology has the characteristics of collaboration and intelligent technology, so it can realize the effective collaboration between the building designer, the construction party and the stakeholders. The complexity and diversity of UHV power grid construction make the collaboration and communication among various stakeholders particularly important. BIM technology can enable all stakeholders to fully understand the situation of the entire power grid construction through real-time data sharing and collaboration functions, so as to jointly plan and implement the power grid construction and reduce the waste of resources in the process of power grid construction.

The practice and application of BIM technology in the construction of UHV power grid projects can help reduce the impact on the environment during the construction process, optimize the operational efficiency of construction projects, shorten the con-

struction project cycle, and optimize the utilization of resources. It is a building technology that conforms to the concept of sustainable development.

# 3 Case study

## 3.1 Project background

"To achieve carbon peak by 2030 and carbon neutrality by 2060" is a major strategic decision made by the CPC Central Committee after careful consideration. It bears on the sustainable development of the Chinese nation and the building of a community with a shared future for mankind. Zhejiang Province issued the "Zhejiang Province Carbon peak Carbon neutral science and Technology innovation action Plan" clearly put forward: by 2025, the initial construction of our province's green low-carbon technology innovation system, seize the commanding heights of carbon peak carbon neutral technology; By 2030, focusing on the strategic goal of carbon neutrality, the key core technologies of green and low-carbon industries will reach the international advanced level and seize the commanding heights of carbon neutrality technology[2]. Previously, the Ministry of Housing and Urban-Rural Development and other ministries jointly issued the "Guiding Opinions on Promoting the Coordinated Development of Intelligent Construction and Building Industrialization", which clarified the key tasks of promoting the coordinated development of intelligent construction and building industrialization by strengthening technological innovation and improving the level of information technology.

The temporary construction project of power transmission and transformation project refers to the non-permanent buildings (structures) and other facilities used in office, living and production that serve the construction project and are constructed or dismantled along with the progress of the construction project. In the process of engineering construction, temporary construction as a temporary office and living place of the construction line builders, with the sustainable development of our country's economy, according to the structural form and material selection differences, it is basically divided into temporary shed, color steel plate temporary construction, prefabricated cabin temporary construction, and the light steel structure modular wisdom temporary construction. The key technologies related to smart temporary construction mainly include the Internet of Things, big data, cloud computing and other technologies. Through the combination of these emerging information technologies and traditional temporary construction, it is conducive to improving the construction quality, promoting the safety management and prevention of the construction process, eliminating the unsafe factors in a timely manner, and improving the wisdom and digital level of the construction process.

## 3.2 Main principles of BIM technology application

Man-machine collaboration is the key to intelligent temporary construction. Its goal is to combine artificial intelligence, Internet of things and other technical means to achieve man-machine collaboration and improve construction efficiency and quality.

In the process of realizing man-machine collaboration, the following points should be paid attention to:

(1) Adopt advanced human-computer interaction technology, such as speech recognition, natural language processing, image recognition, etc., to facilitate the interaction between users and the system.

(2) Establish a sound intelligent auxiliary system, including intelligent monitoring, intelligent scheduling, intelligent optimization, etc., to help users make decisions and management.

(3) Strengthen man-machine security and privacy protection, including data encryption, identity authentication, access control, etc., to protect users' security and privacy.

The essence of visualization technology is to represent a variety of data processed in computer science as observable graphics, in order to realize the purpose of analyzing data and knowledge information according to different perspectives[3]. In general, visualization technology is through the display of visual information to reflect the state of data, extract statistical information and data analysis, so as to achieve the function of computer visualization. Visualization technology has different applications in different industries, such as it can be used to establish complex models, simulate complex processes in the system, help users more intuitive view images, animations, etc., can also be used to analyze complex data.

With the popularization of computer vision and augmented reality methods, visualization technology has been widely used in many industries, to bring users a more intuitive interactive experience, its future development prospects are very broad. Today, it is drawn and visualized in a more intelligent and automated way, which can not only be used to display and correctly describe complex things, but also serve as an important tool and resource for sharing data, thus making data analysis more efficient.

### 3.3 Smart temporary construction management platform

Based on the connotation of the Internet of Things, combined with the characteristics of the temporary construction of power infrastructure projects, based on the establishment of the full time and space management platform of the temporary construction site based on the Internet of Things technology, through the comprehensive perception of the project by information sensing equipment, through the specific network to achieve the ubiquitous interconnection, information exchange, communication, processing and analysis of relevant elements (including facilities, equipment, environment, personnel, etc.) in the use of the temporary construction process[4]. To realize integrated computing of intelligent identification, positioning, tracking, monitoring, control, management and decision-making. The establishment of the platform has broken through the traditional management mode of personnel monitoring, mastered the management blind spots that are difficult to know and control in the management process, and achieved a high degree of integration of information space, construction site, building structure and management space through the Internet of Things technology, overcoming the "information gap" between the construction site, security

management information and decision management. Effectively enhance the ability of digital temporary construction management and security.

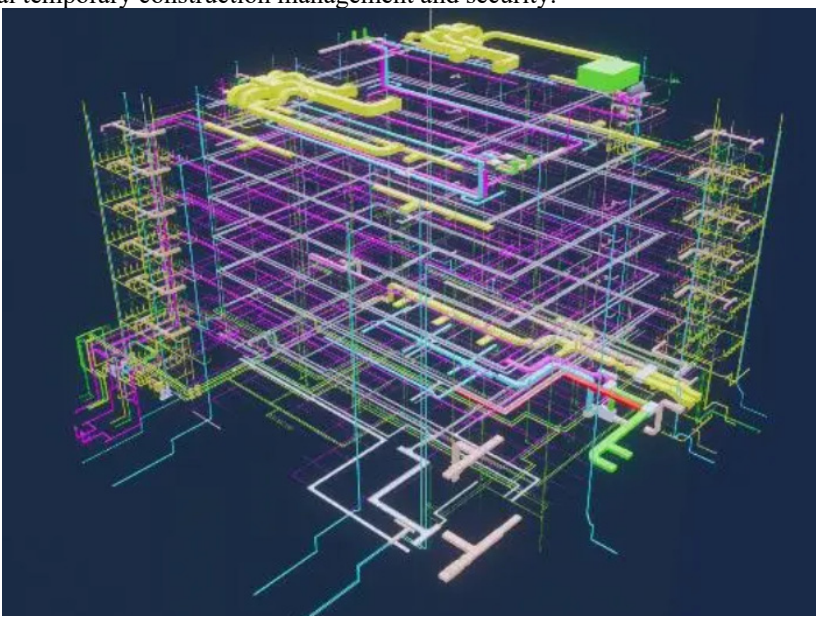

**Fig. 1.** Network architecture diagram of "Internet of Things +" smart temporary construction system

See Figure 1，The intelligent building mainly monitors and manages the mechanical and electrical equipment in the building. With the development of science and technology, the concept of smart buildings has been extended to include not only the monitoring, control and management of traditional electromechanical equipment, but also intelligent lighting, automation and energy management of floors and rooms. The smart temporary construction management visualization platform is an intelligent temporary construction management solution based on big data technology and Internet of Things technology. It has the following key technologies:

Unified identity authentication: Based on the qualification, category, role, work arrangement and other types of information of users and equipment, to achieve unified identity authentication of personnel and related equipment, "know people, know things, know time", and strengthen the accurate control of temporary construction facilities.

Dynamic view display: Through Internet technology, big data technology, artificial intelligence technology, etc., the system will mine and analyze the data surrounding the provisional construction, realize the grasp of the global provisional construction information, and display the information of the provisional construction process activities in real time on the visual interface, forming situational awareness and dynamic analysis[5]. Finally, the digital control system is built by the large screen command terminal, mobile application and backstage web page management terminal.

Intelligent control: to achieve automatic identification and control, so that the intelligent control program can make timely prediction according to the status of temporary construction resources, find problems in advance, realize intelligent operation, improve temporary construction projects, and enhance security protection capabilities.

Through the combination of these emerging information technologies and traditional temporary construction, the research on the modular smart temporary construction of light steel structure is conducive to improving the construction quality, promoting the safety management and prevention of the construction process, eliminating unsafe factors in time, and improving the intelligence and digital level of the construction process. Make it faster: real-time temporary construction process supervision and management, help to achieve more efficient and fast operation of temporary construction; More accurate: relying on historical data and the latest site, real-time reflection of temporary construction situation and changing trends, to ensure more accurate command of temporary construction; Safer: realize the status identification of the whole process and the tracking of the person in charge, achieve all-round safety tracking, and improve the safety of temporary construction; More controllable: through the perfect management system, the construction of standardized and controllable temporary construction activities, effectively improve the controllability of temporary construction management.

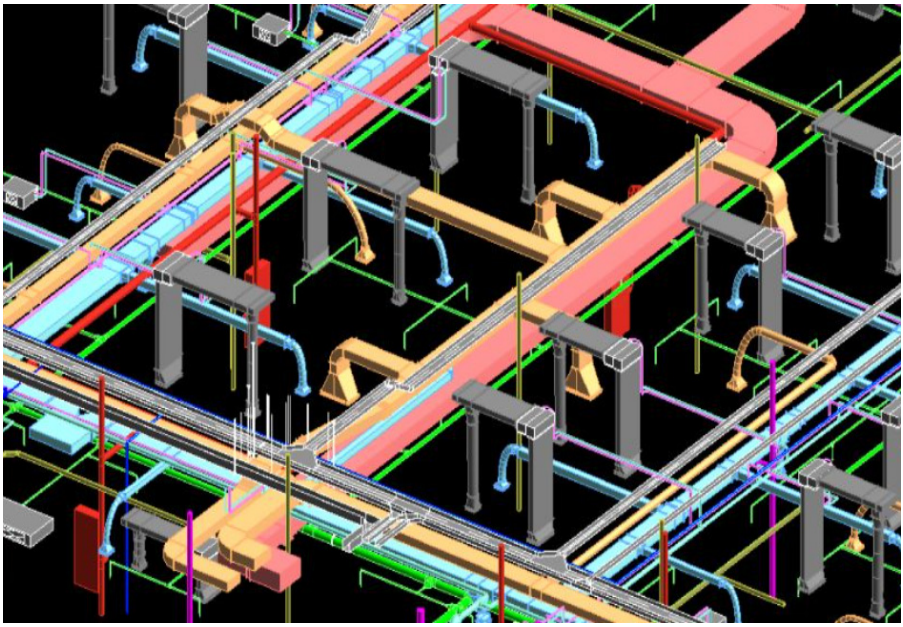

**Fig. 2.** Interface of smart temporary construction platform

See Figure 2，as shown in Figure 2, there are a variety of construction interfaces for smart buildings, including air conditioning interfaces, lighting interfaces, construction interfaces, and so on.

### 3.4 Integrate a variety of cutting-edge technologies to build a "smart temporary construction" template

Take the lead in establishing a relatively complete substation (converter station) project modular smart construction system, including intelligent sensing layer, network transmission layer, support platform layer, intelligent application layer, among which intelligent sensing layer includes geomagnetic parking sensing equipment, photosensitive equipment, temperature and humidity equipment, rain sensing equipment, human body sensing equipment, face recognition equipment, meteorological equipment, water sensing equipment[6]; The network transmission layer mainly relies on 5G and intelligent gateway technology; The support platform is mainly MySQL and big data processing center; The intelligent application layer includes DC power supply system, photovoltaic energy storage system, mobile charging equipment, intelligent motor, intelligent curtain, intelligent gate and so on. The template realizes the comprehensive real-time monitoring of personnel, water and electricity, vehicles, weather and environment in the project, and greatly saves the power use of smart temporary construction of the project department by relying on photovoltaic solar energy, provides a reliable visual platform for the company to carry out work, and realizes the upgrade of the traditional extensive management mode to information intensive management mode.

### 3.5 Automatic collection of massive data, release labor costs

Relying on various kinds of intelligent terminals of the Internet of Things and cooperating with the application of end, edge and cloud technologies[7], we can realize the integration and wireless of on-site iot system equipment, change the way of obtaining original information, free the managers of intelligent project construction from heavy traditional management methods, and realize the automation of data information acquisition and professional intelligent management. It comprehensively improves the ability of perception and control of information in the whole scene of temporary construction facilities, improves the efficiency and quality of data collection, provides guarantee for subsequent intelligent control, and provides data reference for the intelligent temporary construction design of technical personnel.

### 3.6 Centralized integration of environmental factors, multi-dimensional dynamic aid decision-making

Based on the situation display of the visualization platform, the system automatically collects, analyzes and integrates the situation of the day's temporary construction, breaks through the limitations of time and space, and dynamically displays pictures, videos, data and other information in the system monitoring window[8]. Management personnel can make management adjustments to power, hydropower, vehicles and personnel according to the data and find unreasonable rectification, effectively reduce the energy expenditure of smart temporary construction, and meet the national requirements of "carbon neutral and carbon peak".

Project change is the most important factor affecting the accuracy of cost management, and the visa management in the construction process, especially the visa management related to change, is also the management difficulty in the traditional construction stage. BIM software can realize more automatic negotiation between the two sides and facilitate the construction unit to provide change information to the construction unit for visual model construction. And the cost generated for this effective estimation, convenient for engineering cost personnel to carry out timely data analysis.

The realization of the change process is to query the engineering quantity by displaying the construction quantity of different room combinations. The comparative query of the engineering change of project A is to change the account in this module and modify the relevant engineering quantity according to the actual situation. At the same time, click the position of the red arrow, you can also view the change status, the reason for the change, and match the change amount determined by the output of the relevant contract. Under this page, the four-party audit page can carry out the query of different construction subjects to realize the automatic switch of the audit stage, automatically read the corresponding submission results and the amount after the audit changes. So as to complete the whole change review process.

Through relevant operations, the cost personnel can attach the change drawings to mark the location of the change in the model, and automatically upload the node model and other information, which is convenient for other team members to find, and also convenient for the supervision and construction party to intuitively observe. While the change visa management is carried out, it is also necessary to scan the data to automatically generate pictures and add the corresponding reasons for the change visa. So as to improve the comprehensiveness of data upload, effectively prevent the loss and defacement of data[9]. This practice is also convenient for the cost department to carry out remote supervision and management, improve the accuracy of the implementation of the operation, check the work of the on-site cost management personnel, and timely communication to deal with some urgent problems.

After the change information is confirmed by the relevant subject department, it can be summarized into the contract, and presented on the web page for dynamic feedback, and compiled into a visual data chart. During the execution of the contract, every cost issue related to the cost change can be recorded in this way, forming a dynamic cost management chain. In the BIM software, you can query all the information of the change visa in real time, and enter the total price of the contract in time. The model reflecting dynamic investment can make every cost have data to follow, and realize the fine cost control of the whole process. In this process, every relevant subject can participate, saving the cost control personnel a lot of basic work. The communication in all aspects is more coordinated and smooth, which improves the work efficiency and improves the work quality.

In the settlement stage, different participants, especially the owner, the construction party and the supervisor, need to settle according to the comprehensive unit price or price adjustment method signed in the unit price contract, including the settlement of the project volume, the actual and unoccurred project volume need to be settled separately. The calculation of the quantity of works needs to be applied to the 3D

model in the BIM software, which can be modified through the design changes during construction[10]. For example, when the owner and the construction party find that the first layer masonry quantity of A project does not match the design situation when checking the quantity of works, the cost personnel of the two sides can combine their own calculation model, repeatedly calculate the quantity of works to determine the construction information, and make comparison and modification one by one after finding the anomaly. After modifying the construction, they can update their own related quantities. To complete the accounting work of the completion stage.

As long as the modified component is summarized and calculated, the project quantity can be updated, which greatly facilitates the cooperation between different construction participants. As for the change of the comprehensive unit price of the bill of quantities, BIM software can be used to conduct a comprehensive summary of the market price, including the weighted average calculation result of the market change of the material price. Then a system file can be prepared according to the contract, so as to have a comprehensive calculation of the market changes. For example, select the sample time in the data box, from January 2022 to June 2022, and select the market price excluding tax for the latest three periods. You can view the changes in market prices in different months, and you can also query the changes in market prices according to the categories of commodities, such as commercial concrete, pump and other equipment and materials, which greatly facilitates cost management.

The acceptance accounting of the completion stage plays an important role in the actual data of the project cost. Both parties will conduct the final review of the document quotation and determine the final project price. When compiling the relevant forms, the construction unit needs to submit all the relevant documents of the whole process. Including the change of the visa during the construction, the document cost of the visa, etc., need to be calculated, which is the focus of whether the contract price can be finally settled, and also the focus of the audit of the project. The owner also needs to focus on monitoring these contents according to the contract price during the audit, and every change needs to be carefully carried out by checking evidence. The project completion accounting based on BIM software adopts the method of dynamic management, which can automatically carry out the completion settlement after the system payment approval process is completed, eliminating the offset of manual deposit input. It can compare the curve of actual investment and planned investment on the axis of the visual chart, and complete the automatic information entry of the completion accounting. In general, the target cost calculation based on BIM technology is a prominent feature of dynamic management in the whole process and the whole life cycle, and can provide good technical support for the project completion accounting.

See table 1 ,From the perspective of the effect of technology application, combined with the bidding price of construction cost and the summary table of construction cost after the construction party's review, it can be seen that the overall efficiency of applying BIM technology to construction cost control exceeds 95%, and the cost result of project bidding and bidding stage is 48661396.36 yuan, including the residential part, the commercial part, measures and other expenses. The result of unilateral cost is 1,462.89 yuan /m2. The cost result of the project settlement stage is 48431326.34

yuan, including the residential part, the commercial part, the measure fee and other fees, coordination service fee, etc., and the unilateral cost result is 1457.29 yuan /m2.

**Table 1.** Summary of construction cost

| Serial NUMBER | Divisional item name of the project | Gross area ($m^2$) | Closing price (yuan) | Single cost (Yuan/$m^2$) |
|---|---|---|---|---|
| 1 | Residential | 30953.64 | 44207688.41 | 1333.58 |
| 1.1 | Civil parts | 30953.64 | 41777463.20 | 1336.76 |
| 1.2 | Installation section | 30953.64 | 830225-22 | 26.82 |
| 2 | Business | 2310.33 | 3776498.04 | 1644.58 |
| 2.1 | Civil parts | 2310.33 | 3654784.38 | 1581.93 |
| 2.2 | Installation section | 2410.33 | 121633.66 | 42.65 |
| 3 | Additional construction cost | 36265.97 | 2677289.91 | 85.00 |
| 3.1 | Business section | 2310.33 | 208998.71 | 88.00 |
| 3.2 | Residential section | 30953.64 | 2476291.20 | 83.00 |
| 4 | Other expenses | | 3544 | 3544 |
| 4.1 | Coordinating service charges | | 342.23 | 342.23 |
| 4.2 | Spot work and mechanical bench work | | | |
| 5 | Engineering cost | 35893.22 | 48431326.34 | 1457.29 |

In the cost management and control of the project, the compilation and management of data, files and completion model are carried out in real time through the BIM management collaborative platform, and the BIM model is finally formed. These data and information are loaded into the BIM platform to complete the final accounts of the entire project. As can be seen from the results of data analysis, the settlement of project A was smooth, the owner and the construction side reached an agreement with the supervisor, and the settlement did not exceed the budget. A construction project involves a lot of participants, including subcontractors, material suppliers, consulting units, etc. Besides the above three units, these units are also highly satisfied with the cost control. Through the summary of a large number of information flows, the network information flow provided by BIM platform avoids the situation of information crossing and information asymmetry. It enables each participant to upload, modify and view the required data within the scope of their authority, reducing the management redundancy caused by long information flow and information crossing. BIM system can be used for secondary editing and query, improving work efficiency.

The settlement of A project is to track and audit a series of construction materials and relevant data after the completion and acceptance, and audit the settlement documents submitted by the contractor, so as to control the settlement price of the project within the investment target and complete the overall construction process[11]. The completion model, equipment information, data settlement and delivery data contained in the project can be automatically audited in the BIM software to avoid disputes and disputes caused by traditional manual audit. At the same time, this automatic audit method can also increase the agreement between the settlement audit

amount and the actual cost to more than 98%, reflecting the truth and accuracy of cost management.

## 4 Technical outlook

In the construction process of UHV projects, BIM technology effectively combines geographic information systems and can directly simulate sites and buildings. With the support of the powerful modeling function of BIM software, the construction unit can quickly obtain the analysis results of the site environment, and help the project designer to reasonably design and evaluate the construction conditions of the site, so as to select the most suitable wind power construction location. At the same time, in the application of BIM technology, designers of different professions can use the same platform to carry out data transmission and sharing. Once the data at a certain stage has changed, designers in other departments can quickly obtain relevant information, which is convenient to adjust the next construction plan, and improve the overall work efficiency.

In the construction process of UHV projects, it is easy to be affected by many factors, which directly increase the difficulty of site construction, which is usually mainly manifested in the following aspects: first, natural conditions. The natural conditions of the mountain itself are relatively special, and the impact on wind power construction is also the most direct, which is the primary factor to be considered in construction. Second, the related equipment of wind power generation has a large volume, which is difficult to carry out transportation and construction in the mountains; Third, due to the complex mountainous terrain, wind power generation construction location is more scattered, it is difficult to ensure the normal operation of machinery; Fourth, the multiple impacts of climate factors. The reasonable application of BIM technology to the construction technology of UHV projects can effectively solve these problems. In the specific practice process, construction units can use BIM software to build corresponding engineering models, carry out simulated construction, timely find possible problems, and put forward targeted solutions.

For the construction of UHV projects, the application value of BIM technology in UHV project construction technology mainly includes three aspects: First, it can realize project visualization with the help of three-dimensional models, and simulate the construction sequence. The construction unit can coordinate the construction materials and site location according to the construction schedule requirements to avoid unnecessary construction contradictions. At the same time, it can accurately control the consumption of materials, rationally arrange the construction process of wind power space operation, and avoid the conflict of construction teams during construction. Secondly, based on the BIM model, the construction unit can also analyze the problems existing in the construction at this stage and make corresponding modifications to ensure the orderly progress of the later construction. Third, the construction unit can simulate the construction situation virtually through the three-dimensional data model, check the possible collision in the construction process, and optimize the corresponding engineering design scheme to avoid the waste of resources in the con-

struction process. Construction personnel can use the optimized three-dimensional design scheme to carry out construction adjustment and improve construction quality.

The application of BIM technology in UHV projects can give full play to the application advantages of BIM technology and effectively maintain the stable operation of UHV projects. Different professional technicians can use BIM technology to communicate with the construction technology of UHV projects, understand the applicability of different construction technologies, and optimize these technical contents according to the characteristics of mountains, so that BIM technology can realize the coordination and cooperation with wind power projects. At the same time, BIM technology can also be applied to the late management and maintenance of UHV projects, forming an important guarantee for subsequent operation. The maintenance personnel can directly use the BIM model to accurately understand the project structure and analyze which part of the structure has a problem, so as to quickly determine the location of the problem and select the appropriate technology to repair it.

## 5 Conclusion

Modular intelligent temporary construction has been comprehensively improved in security performance, high-quality performance, industrial performance, digital performance and intelligent performance. The iterative update of smart construction has become the new normal of China's economic development, and is the embodiment of the basic national policy of sustainable development. Vigorously promoting and applying the research results of smart construction projects is in line with the concept of "science and technology is the first productive force", and is in line with the basic national conditions of building a conservation-oriented society in China. At this stage, temporary construction can save material consumption, reduce costs, be more refined, and be more humanized, which must be the trend and trend of the development of The Times, contributing to the contemporary era and benefiting the future.

In the current era of rapid development of intelligent technology application, the combination of innovative science and technology and engineering construction is becoming more and more close, and the trend of technology to help high-level engineering construction is becoming more and more popular. With the further development of "Internet +", "Internet of Things", "artificial intelligence" and other technologies, the construction of "smart temporary construction" has become the mainstream direction of the current engineering construction innovation and development. And the application results of this topic is an important part of the construction of "smart temporary construction", with the help of science and technology to achieve lean management of engineering projects. Under the tide of scientific and technological innovation and construction industry reform, its scientific and technological achievements have shown a huge application prospect and are of great promotion value.

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## References:

1. Cui Yanjun, Tao Gang, Ding Weicui. Application of UHV Digital Control System based on BIM Technology in substation project [J]. Electric Power Survey and Design, 2023, (01):49-55.
2. Yang J D. Research on Intelligent Chemical Site construction of UHV transmission line project [J]. Construction Supervision, 2021, (08):47-50.]
3. Zhang Aifeng, Peng Dong, Xiang Fangyu. Engineering Control System of UHV Converter Station Based on BIM-5D Technology [J]. Electrical Measurement and Instrumentation, 20,57(24):125-132.
4. Ding Wei. Research on BIM Application in UHV Transmission Line Project Management [J]. Science and Technology Innovation and Application, 2017, (07):201.
5. WAN Jie. Improving Management and Control of UHV DC Converter Station Project Construction by Informatization [J]. Communications World,2017, (02):146-147.]
6. Li Yang, Chen Xude, Song Ming. Research on Improving Management and Control Ability by Informatization in UHV Converter Station Project Construction [J]. China High-Tech Enterprises,2016, (33):19-20.
7. Qian Yi, Wang Wanwan. Application of BIM in Valve Hall Engineering Design of UHV DC Converter Station [J]. Electric World,2016,57(09):4-8.
8. ZHOU Jingyu. Application and Research of BIM assisted by UHV Tower Measure inference [J]. Construction Supervision, 2014, (07):15-17+33.]
9. Kaustubh Vyas,J. G. Jamnani. Optimal Design of 1200 kV UHV AC Transmission Lines in India using Newly Developed Standalone MATLAB GUI[J]. International Journal of Recent Technology and Engineering (IJRTE),2019,8(2).
10. Ramchandra Reddy Annadi, Chandra Sekhar Patsa. Estimation of switching surge flashover rate of 1200-kV UHVAC transmission line considering switching overvoltage waveshape[J]. Electrical Engineering,2020,102(2).
11. Chaoqun Li, Song Xu, Zhuqing Xia, Xin Yang, Xixiu Wu. Research on Electromagnetic Radiation Model of Corona Discharge with UHV AC Transmission Lines[J]. IOP Conference Series: Materials Science and Engineering, 2019, 486(1).