Analysis on application scheme of electronic fence technology in power grid infrastructure project based on Beidou Navigation Positioning Technology

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Abstract. This paper takes the electronic fence technology of power grid infrastructure project based on Beidou Positioning Technology as the research object, summarizes the use situation and characteristics of this type of electronic fence technology, carries out technical and economic comparison, comprehensively considers the different use needs in the whole life cycle process of substation project infrastructure construction, operation and maintenance, expansion and technological transformation, and considers the purchase cost, installation difficulty, etc. This paper summarizes the technical advantages and engineering pilot application experience of this type of electronic fence technology. Taking one 220kV substation construction project as an example, this paper comprehensively considers other types of electronic fence technology, carries out technical analysis and economic comparison, and provides guidance for the deepening application of electronic fence technology in power grid infrastructure project based on Beidou Positioning Technology in the future.

1. Introduction

With the continuous development of science and technology, the perception ability and informatization degree of infrastructure projects are increasing day by day. The application of electronic fence technology in power grid infrastructure projects can make up for the shortcomings and bottlenecks of traditional physical fence. As an effective supplement to traditional physical fence, it can solve the pain points and difficult problems of infrastructure projects, which is conducive to the realization of high-quality development of power grid infrastructure. The goal is to improve the level of safety control and intelligence of power grid infrastructure project.

According to the situation and characteristics of power grid infrastructure project, in order to prevent the operators of the power grid infrastructure project from mistakenly entering the live area and strengthen the construction safety risk management, the construction safety risk management should be carried out between the dangerous area and the personnel activity area, between the live equipment area and the construction operation area, between the construction operation area and the non-construction operation...
area, between the underground crossing entrance and exit area, and between the equipment and material stacking area. It has become a necessary safety measure for engineering construction to fully use "safety fence" to implement effective isolation and protection measures of the infrastructure project. But at this stage, although the traditional "safety fence" can prevent the occurrence of safety accidents and protect the personal safety of construction personnel to a certain extent, there are also many unavoidable problems.

1) The traditional "safety fence" has poor prevention and control. The traditional installation of "safety fence" is not reliable, the site staff can easily open or cross, and only rely on the person in charge of the site work or video supervision to prevent construction safety risks.

2) Traditional "safety fence" has no precision positioning. The traditional "safety fence" is only installed manually without accurate positioning, which can not play the role of accurate enclosure.

3) The reliability of traditional "safety fence" is low. The traditional "safety fence" hanging on the "stop, high pressure danger!" The safety signs such as "work here" and "work here" are easily affected by the outside world, resulting in the overturning or falling off of the signs, which may cause the operators to enter the electrified or high-risk areas by mistake.

4) The traditional "safety fence" has no timeliness. The traditional "safety fence" is lack of real-time monitoring means, and it is unable to give real-time alarm to operators' violation behaviors such as crossing the fence, and it is also unable to record operators' behavior such as moving the fence without permission, and it is lack of advance warning of construction safety risks.

At present, the electronic fence technology based on Beidou Positioning Technology has been used in several power transmission and transformation projects of power system[1]. An applied study of intelligent IoT technologies was conducted in [1], in which Beidou navigation satellite system is applied for staff and vehicle positioning. An unified spatial-temporal information support framework is constructed based on Beidou system, and the typical applications of Beidou system in smart grid, such as high-precision time service, positioning and navigation, and short message communication, are analyzed in [2]. Combined with the resource conditions of State Grid Shandong Electric Power Company, the solution of the ground-based augmentation system of Beidou precision service network is given based on the research on the site selection of base station, the construction of observation pier, system power supply, system lightning protection, communication access and safety protection in [3]. At present, it is carried out the test application in the construction stage of some transmission and transformation projects in Fujian power grid of China. Under the background of "special action to improve quality and efficiency" of State Grid Corporation of China, it is necessary to carry out technical analysis and economic comparison on the basis of demonstrating technical feasibility, comprehensively considering purchase cost, installation difficulty and other factors, and comprehensively considering other types of electronic fence technology, so as to provide support for further promotion and application in the future.

2. Analysis of electronic fence technology based on Beidou Positioning Technology

2.1. Technical definition, Development trend and Application

Electronic fence technology based on Beidou Positioning Technology refers to the realization of electronic fence function by using the precise positioning function provided by Beidou satellite.

The existing electronic fence technology based on Beidou satellite positioning information realizes the intelligent integration of traditional physical fence and electronic fence by installing the Beidou fence warning device on the physical fence. Beidou fence warning device has Beidou Positioning Function and sound light alarm function, which can be installed on the physical fence. Once the physical fence moves, the electronic fence can follow. The technology can automatically set up electronic fence, no wiring, less construction difficulty, and can be interconnected with the management platform data, providing on-site sound and light alarm, sound and light prompt, electronic fence perception, information management and other functions. At the same time, the electronic fence system is also equipped with Beidou centimeter level accurate positioning intelligent safety helmet to cooperate with
the electronic fence, so as to realize the intelligent alarm of personnel entering and leaving the electronic fence, prompt the risk area in real time, and provide auxiliary operation[4].

Figure 1. Function diagram of electronic fence technology based on Beidou satellite positioning information

At present, the electronic fence technology based on Beidou positioning information has been developed in the market, and the twin electronic fence product has been used in many power transmission and transformation projects.

2.2. Analysis of advantages and disadvantages

The advantages of electronic fence technology based on Beidou positioning information are mainly reflected in the following aspects: (1) the positioning accuracy of x-axis and y-axis is less than or equal to 0.1m, reaching sub meter level, which can meet the needs of safety management and control of substation infrastructure construction or operation and maintenance site. (2) It’s easy to install and remove. The Beidou electronic fence warning device is small in size and light in weight. It can be used in combination with the original physical fence, which is convenient and fast, and conforms to the original operation and maintenance habits.

The defects of the electronic fence technology based on Beidou positioning information are mainly reflected in the following aspects: (1) at present, the electronic fence technology can not achieve indoor positioning. (2) The weight of the helmet with Beidou high-precision positioning function is 0.5kg, and that of the helmet with ordinary positioning function is 0.45kg. Compared with the traditional helmet of 0.35kg, the weight is increased, which affects workers' operation.

3. Example analysis

3.1 Project overview

Considering that the construction site of substation expansion project is a multi-type, dynamic and three-dimensional operation site, the temporary production facilities, the variability of operation environment and the mobility of man-machine form a dynamic collection of man, machine and material, and there are a lot of potential safety hazards. The 220kV substation construction project usually has a wide working area and is close to live equipment. The construction period is heavy and the risk level is high. However, the traditional fence is limited by many parts, lack of flexibility, lack of early warning function and other congenital defects, which makes it difficult to guarantee the safety of the construction site in real time. Therefore, it’s necessary to use electronic fence technology to conduct three-dimensional defense on the construction site, realize fence area setting and cross-border warning, and comprehensively guarantee the construction safety on site.
Therefore, this part takes one 220kV substation construction project as an example, aiming at the electronic fence technology based on Beidou Positioning Technology, completes the preliminary configuration of equipment, and makes a technical and economic comparative analysis.

Figure 2.Aerial view of construction project of one 220kV substation in Fujian Province

### 3.2 Equipment configuration

There are many Beidou base stations around the location of chosen 220kV substation construction project, and the positioning signal is strong. Therefore, the project only needs to configure the safety helmet with Beidou Positioning Terminal and rent the server for the on-site staff. The Equipment configuration of "Beidou" scheme is shown in Table 1.

| Equipment                      | Model / Parameter                  | Quantity | Unit | Unit price / yuan | Total price / yuan |
|--------------------------------|------------------------------------|----------|------|-------------------|--------------------|
| Safety helmet                 | With Beidou Positioning Function   | 30       | /    | 2,600             | 78,000             |
| Software: network client      | Software kit                       | 1        | Set  | 30,000            | 30,000             |
| Server leasing                | Alibaba cloud server               | 12       | Month | 4,000             | 48,000             |
| Labor: on site guidance,       | /                                  | 1        | /    | 30,000             | 30,000             |
| debugging, coaching and        |                                    |           |      |                   |                    |
| training.                      |                                    |           |      |                   |                    |
| **Total**                      |                                    |           |      |                   | **186,000**        |

*aThe software is in the form of network client, and one set can be purchased and shared in one grid.
bThe server is rented and calculated by 12 month.

### 3.3 Economic comparison of various positioning technologies

The 220kV substation construction project in case study adopts outdoor design scheme. According to the analysis results of the example, the electronic fence technology based on Beidou positioning technology, the electronic fence technology based on video image and AI analysis, and the one based on ultra wide band(UWB) positioning can meet the use requirements of the construction stage of the project[4]. The purchase costs of various technologies are shown in Table 2.

| Economic analysis | "Video + AI" scheme | "UWB" scheme | "Beidou" scheme |
|-------------------|---------------------|--------------|-----------------|
| **Unit:10 thousand yuan** |                      |              |                 |
| Economic analysis |                     |              |                 |
| Cost of purchasing hardware | 17 | 12.35 | 12.6 |
|----------------------------|----|-------|------|
| Cost of purchasing software | /  | 2.3   | 3    |
| The cost of developing algorithms | /  | 3.45 | /    |
| Cost of purchasing auxiliary materials | 3.02 | 4 | / |
| Cost of labor | 3 | 3.35 | 3 |
| Other expenses | / | / | / |
| Total | 23.02 | 25.45 | 18.60 |

Figure 3. Trend of the cost of the electronic fence Technology

According to the calculation of existing known conditions, in the 220kV substation construction project in case study, "Beidou" scheme has the best economy, followed by "video + AI" scheme, and "UWB" scheme has the worst economy. It's worth noted that the cost of "video + AI" scheme includes four high-definition PTZ intelligent ball machines. If the equipment in the intelligent auxiliary system of the substation project is directly used, the cost of 120,000 yuan can be further saved. The cost of the technology is only 110,200 yuan, and the economy is the best. It is necessary to purchase one set of network client of "Beidou" scheme in the whole power grid of one province. As the technology is further extended to more power transmission and transformation projects in the province, the cost will be further saved and the advantages will be further highlighted, as shown in Figure 3.

4. Summary and Prospect

Taking common and used electronic fence technology in power grid infrastructure projects as research object, the paper comprehensively considers different use needs in the whole life cycle of substation project infrastructure construction, operation and maintenance, expansion and technical transformation, summarizes the application situation and characteristics of existing electronic fence technology, compares technical advantages. The main conclusions are as follows:

1) When selecting the electronic fence technology, it is necessary to comprehensively consider the deployment of Beidou Positioning base stations around the power grid infrastructure project. If the number of Beidou Positioning base stations near the project area is insufficient, the electronic fence technology based on UWB positioning technology can be selected.

2) The purchase cost of the server network client of electronic fence technology based on Beidou positioning technology is relatively high. It is recommended to purchase a set uniformly, and realize the positioning function of power transmission and transformation projects in the whole province through sharing, so as to reduce the relevant purchase cost.
(3) In order to solve the problem that Beidou satellite can not realize indoor positioning function, considering the existing technical level, it is suggested that the outdoor part of the infrastructure project can adopt electronic fence technology based on Beidou satellite positioning information, and the indoor part can adopt electronic fence technology based on UWB positioning technology.

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