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Investigation on the Interference Degree of Photovoltaic Access to the Communication Environment in the Platform Area Based on the Complex Low-voltage Platform Area Simulation Platform

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In recent years, rapid social developments have steadily increased the demand for various kinds of energy required for production, and the problems of energy shortage and environmental pollution are also becoming increasingly serious. Therefore, 'green' development and the protection of the earth's ecological environment are urgent issues that must be addressed by today's societies. Solar photovoltaic (PV) power generation has attracted people's attention because it can effectively reduce the consumption of natural resources. Also, nowadays, people's communication demands are greater. However, the communication environment in the low-voltage platform area is often affected by various interferences. Therefore, in this current study, a simulation platform is proposed based on complex low-voltage platform area. On this platform, the impact of PV access on the interference degree of the communication environment in the platform area was discussed, and relevant comparative experiments and questionnaires were designed. The experimental results showed that in the traditional platform area communication environment, the result of 17 times was better call quality, and the result of 31 times was average call quality. The number of poor call quality was the highest, at 52; the communication rate affected by interference was unstable and fluctuated between 20b/s-60b/s. The lowest value obtained by the experiment was 20.41b/s, and the highest value was 59.5b/s; in the communication environment of the PV access platform area, the call quality was good for 77 times, and the call quality was average for 15 times. Only eight calls had poor quality. The communication rate was stable at between 80b/s and 90b/s and a high communication rate was maintained. Experimental results indicated that PV access could effectively optimize the call quality of the communication environment in the platform area, and improve the communication rate so as to enhance the impact of interference on the communication environment in the platform area. Thaim of this current study was to effectively promote the application of PV access in the communication environment of the platform area by examining the impact of PV access on the interference degree of the communication environment of the platform area under different interferences in the complex low-voltage platform area simulation platform, thus providing a means of improving the interference degree of the communication environment of the platform area and contributing to the smooth communication of the platform area.
Keywords: complex low-voltage platform area, communication interference, photovoltaic access, communication environment

1. INTRODUCTION

With the ongoing development of society and the increase in manufacturing, the amount of energy consumed in China, and

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globally, is becoming increasingly serious. The continuous and excessive consumption of non-renewable energy sources has given rise to a range of problems associated with environmental issues and energy demands. Today, "environmental pollution" and "energy crisis" are common issues raising concerns in local communities as well as globally. As an important source of renewable energy, solar power has been widely promoted, and solar PV power generation is connected to the power communication system because of its advantages. The access of PV in the low-voltage platform area can, to some extent, control the communication interference of the communication environment in the platform area, and the research on the interference degree of PV access in the communication environment in the platform area has very practical significance. The aim of this current study is to determine the impact of PV access on the degree of interference of the communication environment in the platform area based on the complex low-voltage platform area simulation platform. This paper contributes to the literature on the control of interference in the communication environment of the platform area.

Because the communication environment has great social significance, it has attracted the attention of many scholars. Smaliukiene et al. (2021) said that through intelligent applications, young people's communication environment in the network shapes their social sensitivity [1]. Riaz et al. (2018) indicated that geometric channel modeling was always one of the hotspots in the research of wireless communication systems, and it was applied in various communication environments [2]. Luo (2020) provided an effective solution to the target search problem of swarm robots in the limited communication environment [3]. Yamanaka and Takahashi (2020) posited that only experts in wireless communication could manage channel switching, adding and removing devices, etc. [4]. Zhang (2020) believed that no matter what measures were taken, the spread of malicious information in the communication environment could not be completely eliminated [5]. Kiseleva (2018) studied the specific impact of communication environment and communication environment on the value orientation of adolescents under the condition of information dominance [6]. Noh and Kyoo-Sung (2018) studied the management system for small and medium-sized manufacturers to ensure production quality in the wireless communication environment [7]. Dai (2020) stated that effective solutions for the application of unmanned aerial vehicle base stations to provide wireless communication services were emerging [8]. With the increasing demand for communication, communication interference has also become the focus of attention. However, previous research did not deeply explore the problem of communication interference, and difficulties were still being encountered in some application scenarios.

Communication interference has become a hot topic, attracting much scholarly research. Wang (2021) indicated that the random characteristics of wireless channel fading and possible co-channel interference had a great impact on efficiency and wireless communication performance [9]. Rao (2021) proposed a jamming resource allocation method based on maximum strategy entropy depth reinforcement learning for the optimization of jamming resource allocation in communication network countermeasures [10]. Mao et al. (2019) analyzed the problem of interference resource allocation in communication scenarios [11]. Zhang et al. (2019) first studied the mutual information waveform design method when the orthogonal frequency division multiplexing radar system and the Gaussian mixture jamming communication system coexisted [12]. Considering asynchronous data transmission, Dehkordi and Trialli (2020) proposed a new framework for analyzing on-chip communication with crosslinked co-channel interference and noise [13]. Hossain (2019) believed that the random process of interference absorption in wireless communication was a hundred femtosecond transmission process of probability density function modulation receiver [14]. Maity (2019) believed that the human body antenna effect caused the human body to receive environmental interference that affected transmission [15]. In the current platform area communication environment, communication can be affected by many types of interference, and the smoothness of the platform area communication plays a significant role in maintaining the stability of the equipment [16–17]. This current study investigated the role of PV access in maintaining stability.

In order to determine the positive effect of PV access on the interference of communication environment in the platform area, comparative experiments and questionnaires were conducted in this study. The experimental results showed that the handover success rate affected by interference was not stable in the traditional platform area communication environment. Generally, the handover success rate was between 35% and 45%, and there were four times when the handover success rate exceeded the normal range (68.8%, 61.8%, 66.66% and 67.49%). In the communication environment of the PV access platform area, the handover success rate was relatively high and stable at between 70% and 80%, indicating that the handover success rate could be improved in the communication environment of PV access platform area.

The results of the questionnaire survey showed that 101 participants believed that the communication rate was improved after the PV was connected to the communication environment in the complex low-voltage platform area simulation platform. Ninety-nine participants said that the call quality was optimized; the majority (105) of participants believed that the connection rate was improved; and 96 people said that the handover success rate increased. showed that PV access could effectively improve the communication environment in the platform area, resulting in better communication quality.

2. CORRELATION EVALUATION BETWEEN PV ACCESS IN COMPLEX LOW-VOLTAGE PLATFORM AREA SIMULATION PLATFORM AND INTERFERENCE DEGREE OF COMMUNICATION ENVIRONMENT IN THE PLATFORM AREA

The current platform area communication system relies on a smooth communication pipeline in order to quickly and

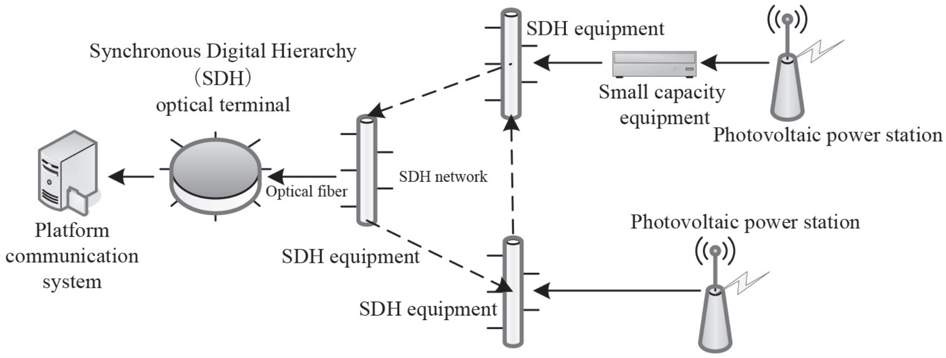

Figure 1 Flow chart of communication environment of PV access platform area.

accurately convey the information of the control center to the distribution terminals in each platform area. In addition, the equipment operation status of the distribution terminal depends on the implementation data transmission to the control center [18]. Therefore, the guarantee of a smooth communication pipeline is crucial for the communication environment in the platform area. However, the traditional substation communication environment is greatly affected by interference and cannot meet the needs of large-scale distribution communication networks. Therefore, it is proposed that PV power generation be integrated into the substation communication environment to reduce the impact of interference on the substation communication network. Figure 1 is the flow chart showing PV access to the substation communication environment.

As shown in Figure 1, the PV power station connects the PV power with the Synchronous Digital Hierarchy (SDH) equipment, and then transmits the communication optical fiber to the SDH optical transceiver and finally to the platform area communication system to create a smooth communication environment. Sometimes, the PV power generated by the PV power station cannot be directly transferred to the SDH equipment, and needs to be converted by small-capacity equipment.

Despite the rapid development of PV power generation, the PV industry still does not have substantive development conditions. Sometimes the smooth access of PV is affected by many factors, so a complex low-voltage platform area is designed as a simulation platform.

When multiple loads are connected to the same distribution line at the same time, the PV connection experiences some loss of voltage. Generally speaking, the transmission distance of the line is short. The reason for designing complex low-voltage platform area as a simulation platform is explored. The capacitance of low-voltage platform area is low. Therefore, in the equivalent circuit of low-voltage platform area, there is a voltage vector at the head end as follows:

$$U_a = (U_b + \Delta U) + \theta U_l \tag{1}$$

where, U_a represents the first terminal voltage vector in the equivalent circuit; U_b represents the terminal voltage vector in the equivalent circuit; transverse voltage loss is expressed by ΔU; the longitudinal power loss is represented by θU_l.

According to Formula (1), the mode of the head end voltage can be obtained as follows:

$$U_a = \sqrt{(U_b + \Delta U)^2 + \theta U_l{}^2} \tag{2}$$

There is usually Formula (3) as follows:

$$U_b + \Delta U \geq \theta U_l \tag{3}$$

Formula (4) is as follows:

$$\Delta U \approx U_a - U_b \tag{4}$$

When the resistance of the equivalent circuit is R_x and the reactance is R_y, the impedance R_z can be obtained with:

$$R_z = R_x + nR_y \tag{5}$$

The end load is defined as follows:

$$U_a = U_b + \frac{T_{l1} - nT_{l2}}{U_b}(R_x + nR_y) \tag{6}$$

The real part of the head end voltage can be obtained with:

$$U_a = U_b + \frac{T_{l1}R_x + T_{l2}R_y}{U_b} \tag{7}$$

According to Formula (4), the voltage loss is calculated with:

$$\Delta U = U_a - U_b = \frac{T_{l1}R_x + T_{l2}R_y}{U_b} \tag{8}$$

The higher the head voltage, the greater is the voltage loss. Therefore, a complex low-voltage platform area simulation platform is built as the research platform.

The current situation indicates that PV power generation has made great progress. In actual operations, distributed and centralized power generation has been well constructed. Distributed power generation can be achieved within a couple of weeks, from installation to use, and has also undergone major changes in terms of utilization and scale. On the other hand, centralized power generation is different from distributed power generation. In the power supply scope of the transformer, that is, in the low-voltage platform area, PV power generation relies on stable input power to ensure the smooth progress of power communication. After the PV access to the platform area communication system, the network management information between various devices can be interconnected. Therefore, all kinds of data can be input into the platform area communication system together with the PV access.

Since interference has different degrees of impact on the communication environment in the platform area, the use of PV access to the platform area communication system in the complex low-voltage platform area simulation platform can effectively reduce the interference level. Due to interference, the low communication rate in the platform area leads to network delay of the communication terminal, slow download speed, long data transmission time and slow communication rate. PV access can use optical energy to improve the transmission speed of optical fibers, thereby increasing the communication rate and reducing the impact of interference on the communication rate. When affected by interference, the handover signaling of platform area communication cannot be established normally, and the PV access can establish reliable signaling through the energy of PV power generation, thus increasing the handover success rate; affected by interference, the call quality of the communication environment in the platform area would also be affected. The call process is noisy, intermittent and unclear. PV access can effectively improve the call quality. In a word, the implementation of PV access to the communication environment in a complex low-voltage platform area can effectively reduce the impact of interference on the communication network indicators, and improve the call quality and data transmission rate of the communication network.

3. COMPARATIVE EXPERIMENT AND QUESTIONNAIRE SURVEY ON INTERFERENCE DEGREE OF PLATFORM AREA COMMUNICATION ENVIRONMENT IN COMPLEX LOW-VOLTAGE PLATFORM AREA SIMULATION PLATFORM

3.1 Comparative Experiment on Interference Degree of Platform Area Communication Environment in Complex Low-voltage Platform Area Simulation Platform

In order to test the effect of PV access on the interference degree of the communication environment in the platform area, a comparative experiment was carried out on the complex low-voltage platform area simulation platform. The interference level generated in the traditional platform area communication environment was compared with that generated in the PV access platform area communication environment. The traditional platform area communication environment was the control group, and the PV access platform area communication environment was the experimental group. The different impacts of the communication degree under the two kinds of platform area communication environments were compared, including communication rate, call quality, handover success rate, communication system capacity and connection rate, so as to determine the impact of the PV access platform area communication environment on the degree of interference of the platform area communication environment.

(1) Comparison of communication rates

In order to determine the impact of PV access on the degree of interference of the platform area communication environment, the communication rates under the two platform area communication environments in the experiment were compared. By comparing the communication rate in the traditional station communication environment with that in the PV access station communication environment, the impact of PV access on the interference degree of the station communication environment was ascertained. Figure 2 shows the comparison results of 30 communication rates in two station communication environments.

The data comparison chart in Figure 2 shows that PV access can control the degree of interference of the communication environment in the platform area.

Figure 2A shows the communication rate of the control group. In the traditional platform area communication environment, the communication rate affected by interference was unstable and fluctuates between 20b/s-60b/s. The lowest value in the experiment is 20.41b/s, and the highest value is 59.5b/s. Figure 2B shows the communication rate of the experimental group. In the communication environment of the PV access platform area, the communication rate is stable and maintains a high communication rate, and its value is stable between 80b/s-90b/s. These results show that PV access can effectively improve the communication rate of the communication environment in the platform area and maintain a certain stability, thereby appropriately regulating and blocking the interference in the communication environment in the platform area.

(2) Comparison of call quality

Then, the call quality of the two platform area communication environments used for the experiments was compared. The difference between the quality judgment of 100 calls in the traditional platform area communication environment and the quality judgment of 100 calls in the PV access platform area communication environment indicated the different degree of interference on the platform area communication environment, thus showing the impact of PV access on the interference degree of the platform area communication environment. Figure 3 shows the results for 100 call-quality tests under two kinds of platform area communication environments.

Figure 3 shows that PV access has a control effect on the interference degree of the communication environment in the platform area.

Figure 3A shows the results of the control group's evaluation of call quality. In the traditional platform area communication environment, the call quality affected by interference is not high. Of the 100 experimental results, 17 of the calls were of good quality. The quality of 31 calls was average, and 52 were poor quality.

Figure 3B shows the judgment results for the call quality of the experimental group. In the communication environment of the PV access platform area, the call quality was generally relatively good. In 77 of the 100 tests, results showed the

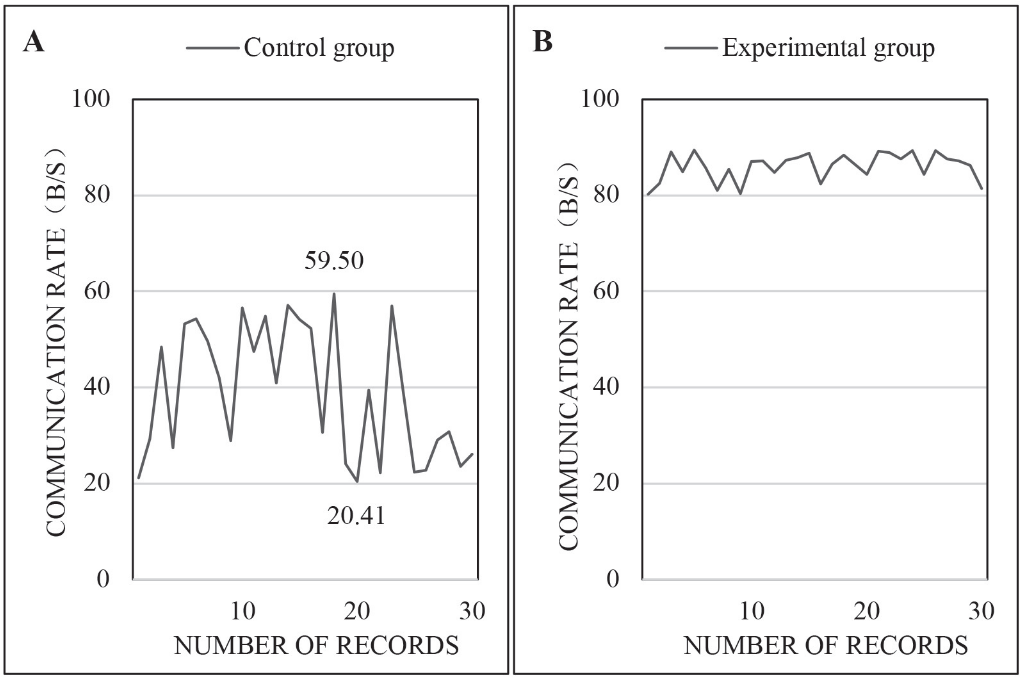

Figure 2 Comparison of communication rates. (A) showed the communication rate of the control group. (B) showed the communication rate of the experimental group.

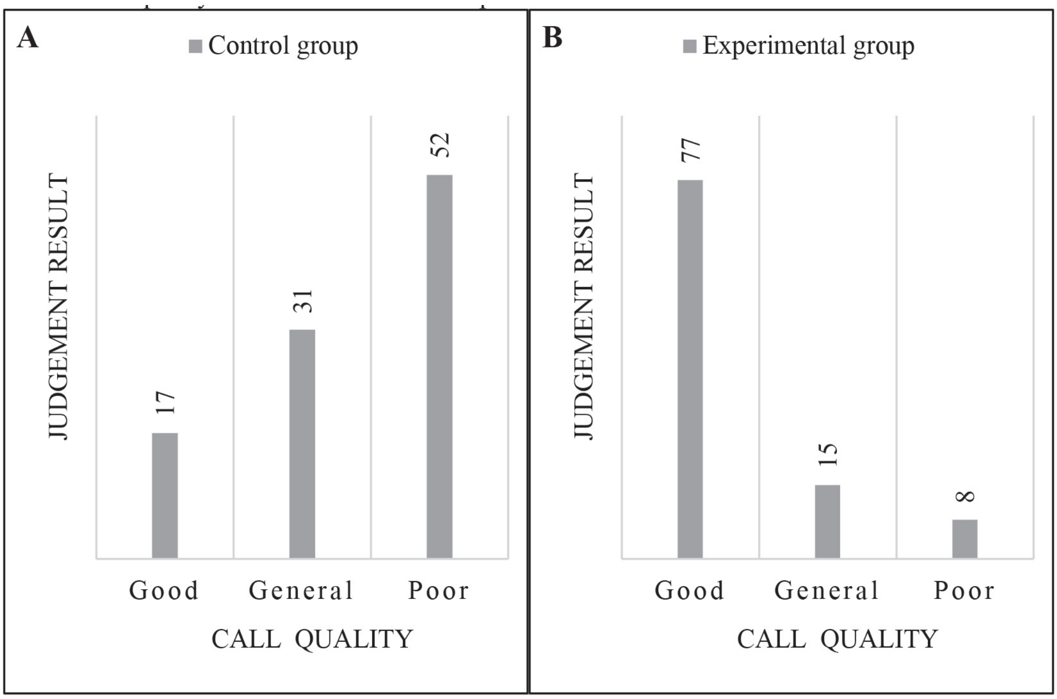

Figure 3 Call quality judgment result. (A) showed the judgment results of call quality in the control group. (B) showed the judgment results of the call quality of the experimental group.

call quality was relatively good. This was 60 times more than that of the control group in the traditional platform area communication environment. The result of 15 times was average call quality. The number of bad calls was only 8, accounting for 8% of the total number of experiments. This was 44 times less than that of the control group in the traditional platform area communication environment.

As can be seen, PV access can effectively optimize the call quality of the communication environment in the platform area and improve the impact of interference on the communication environment in the platform area, which made the communication in the platform area smoother and more convenient.

(3) Comparison of handover success rate

Then, the handover success rate of the two station communication environments in the experiment was compared. Affected by the handover signaling, when the station communication environment was disturbed, the handover

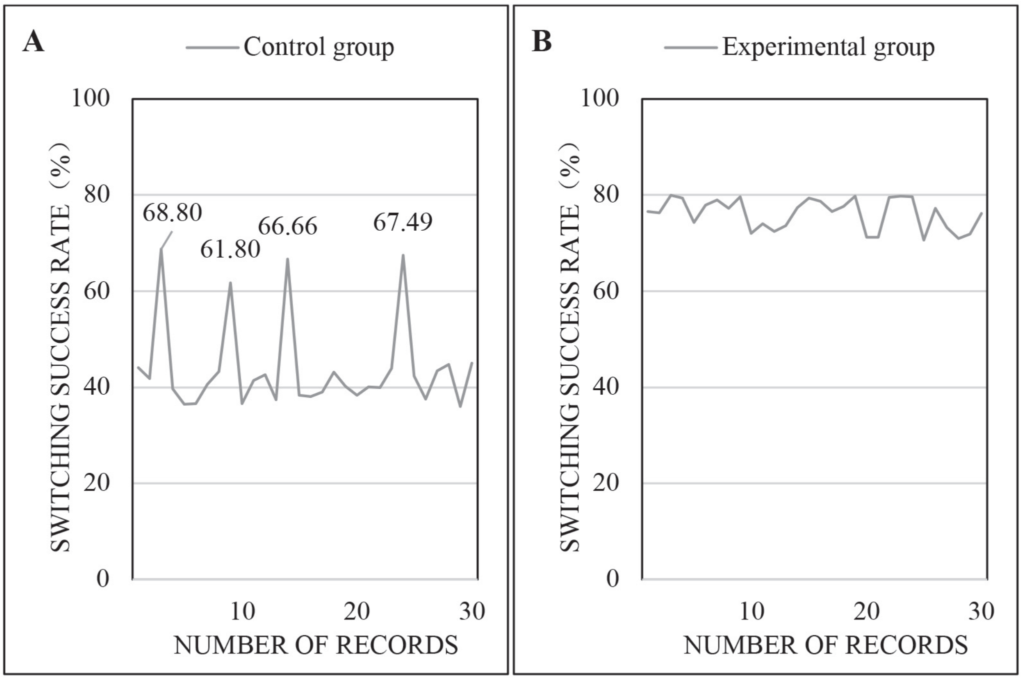

Figure 4 Comparison of switching success rates. (A) shows the switching success rate of the control group. (B) shows the handover success rate of the experimental group.

signaling could not be established normally, and the handover success rate was relatively low. Therefore, the record of handover success rate can accurately indicate the impact of interference on the communication environment in the platform area, thus ascertaining the impact of PV access on the communication environment in the platform area. Figure 4 shows the comparison of 30 handover success rates under two kinds of communication environment in the platform area.

From the comparison of the data in Figure 4, it can be seen that PV access has a control effect on the degree of interference of the communication environment in the platform area.

Figure 4A shows the switching success rate of the control group. In the traditional platform area communication environment, the handover success rate affected by interference is not stable. In most cases, the handover success rate is between 35% and 45%, but there are four cases that exceed the general range in the experiment. The four handover success rates are 68.8%, 61.8%, 66.66% and 67.49% respectively, indicating that the handover success rate is not stable under the influence of interference.

Figure 4B shows the handover success rate of the experimental group. In the communication environment of PV access platform area, the handover success rate is high. In the experiment, it remains between 70% and 80%, and is stable all the time, without any floating beyond the range. It shows that the PV access platform area communication environment can improve the handover success rate.

As evident, PV access can effectively increase the handover success rate of the station communication environment and reduce the impact of interference on the station communication environment.

(4) Comparison of communication system capacity

Then, the capacity of the communication system in the two platform area communication environments in the experiment was compared. Communication capacity was affected by the number of channels. Therefore, by recording the difference between the number of channels in the traditional station communication environment and the number of channels in the PV access station communication environment, the difference in the capacity of the communication system and the different degree of interference on the station communication environment were ascertained, thus indicating the impact of PV access on the interference degree of the station communication environment.Figure 5 shows the capacity of the communication system under two kinds of platform area communication environments.

The data in Figure 5 shows the difference between the capacity of the communication system in the two environments. The number of channels can effectively indicate the capacity of the communication system. The data shows that PV access has a control effect on the degree of interference of the communication environment in the platform area.

Figure 5A shows the communication system capacity of the control group. In the traditional platform area communication environment, the capacity of the communication system affected by interference is not large because of the small number (3) of channels. Figure 5B shows the communication system capacity of the experimental group. In the communication environment of the PV access platform area, the number of channels is 13–10 more than that of the control group, indicating that the communication system capacity in the communication environment of the PV access platform area was larger.

Therefore, PV access can increase the communication system capacity of the communication environment in the platform area by increasing the number of channels, and reduce the impact of interference on the communication environment in the platform area.

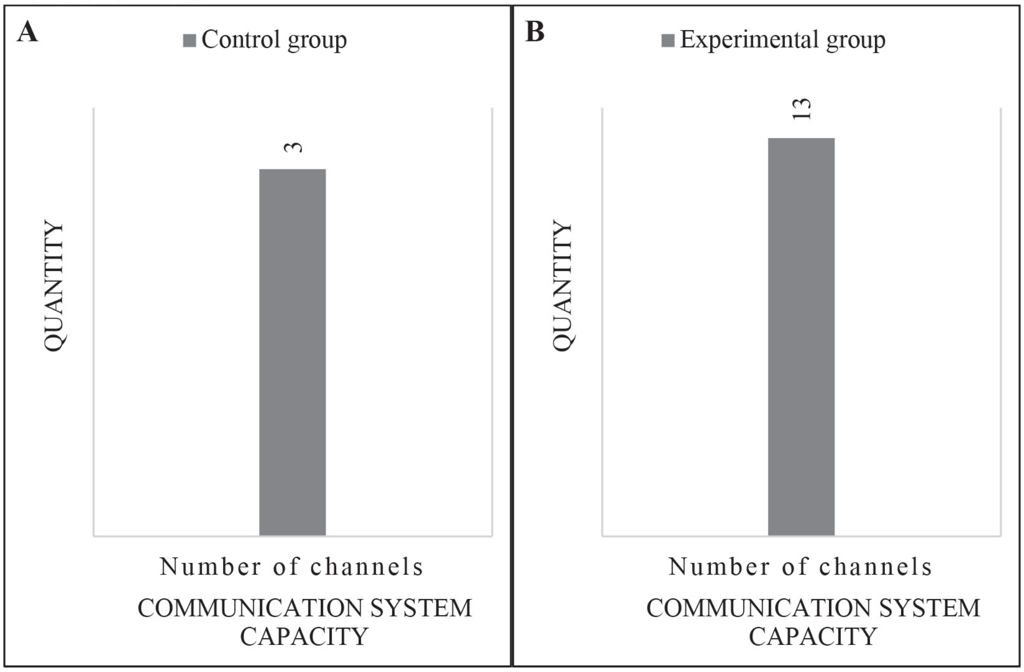

Figure 5 Communication system capacity comparison. (A) shows the communication system capacity of the control group. (B) shows the communication system capacity of the experimental group.

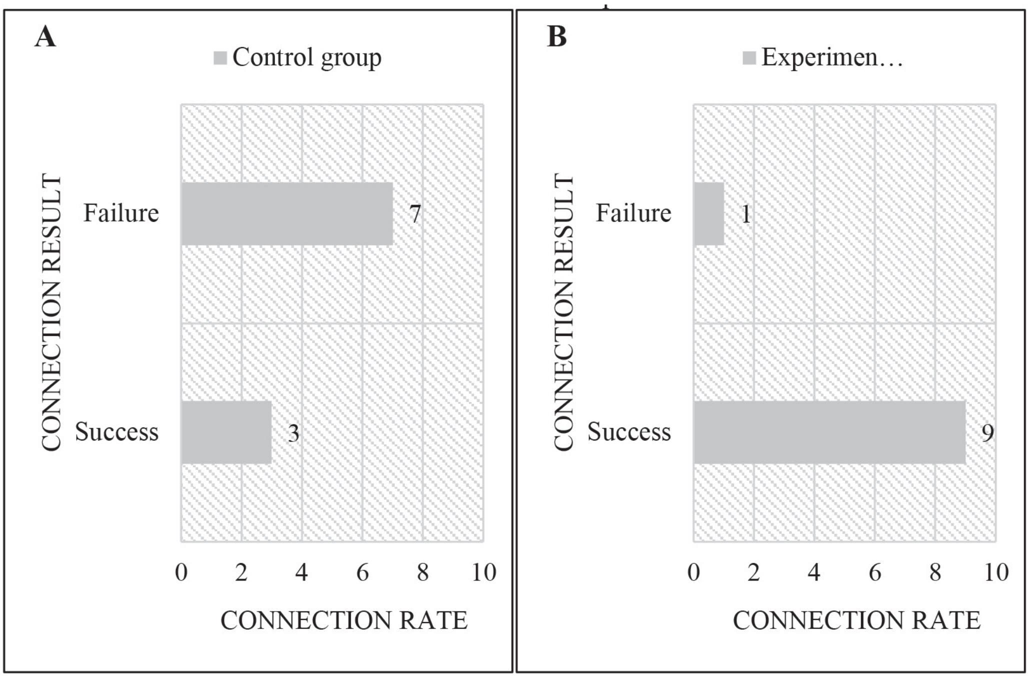

Figure 6 Comparison of communication connection rates. (A) shows the communication connection rate of the control group. (B) shows the communication connection rate of the experimental group.

(5) Comparison of connection rates

Then, the connection rates of the two platform area communication environments in the experiment were compared. Interference affects the establishment of signaling in the communication environment in the platform area, and failure to establish signaling affects the communication connection rate. Therefore, by comparing the success of the connection rate in the traditional platform area communication environment with the success of the connection rate in the PV access platform area communication environment, the impact of interference on the platform area communication environment in different degrees is determined, thus indicating the impact of PV access on the interference degree of the platform area communication environment. Figure 6 shows the comparison results of 10 communication connection rates under two kinds of platform area communication environments.

The data in Figure 6 shows the difference between the communication connection rates in the two environments. The number of successful communication connections shows the success probability of the communication connection

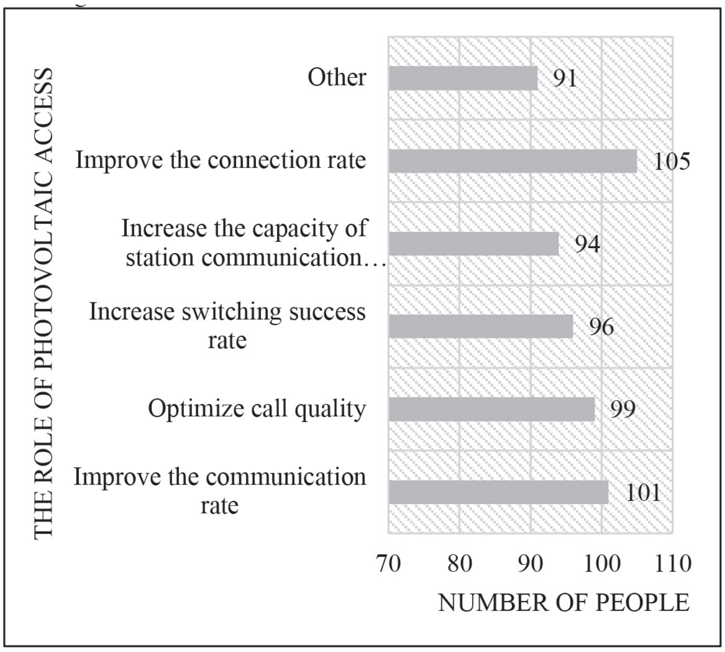

Figure 7 Questionnaire survey results.

rate. The data shows that PV access can control the degree of interference of the communication environment in the platform area.

Figure 6A shows the communication connection rate of the control group. In the traditional platform area communication environment, the communication connection rate of the communication environment affected by interference is not high. In 10 experiments, the number of successful communication connections is only 3, and the number of failed communication connections is 7. Figure 6B shows the communication connection rate of the experimental group. In the communication environment of PV access platform area, the communication connection rate of the communication environment is high. In the 10 experiments, the number of successful communication connections is 9, which is 6 times greater than the number of successful communication connections affected by interference in the traditional platform area communication environment. The number of communication connection failures is only one; it shows that the communication connection rate is higher in the communication environment of the PV access platform area.

It can be seen that PV access can increase the successful communication connection rate of the communication environment and reduce the impact of interference on the communication environment in the platform area.

3.2 Questionnaire Survey on Interference Degree of Platform Area Communication Environment in Complex Low-voltage Platform Area Simulation Platform

(1) Questionnaire reliability

In order to ascertain the impact of the communication environment on the interference degree in the simulation platform of PV access complex low-voltage platform area, 160 participants were asked to complete a questionnaire. Of these, 131 returned the questionnaire. After eliminating 24 questionnaires that contained errors or omissions, 107 questionnaires remained. The questionnaire responses were analyzed by means of Statistical Product and Service Solutions (SPSS) software, and the Cronbach coefficient of α was selected as the reliability coefficient. The reliability coefficient of this questionnaire was 0.897, indicating good reliability.

(2) Questionnaire results

This questionnaire was conducted to determine the impact of PV after being connected to the communication environment in the complex low-voltage platform area simulation platform. The results of the multiple-choice questionnaire are shown in Figure 7.

The questionnaire results shown in Figure 7 indicate that 101 people believe that the communication rate improved after the PV was connected to the communication environment in the complex low-voltage platform area simulation platform; 99 people believe that the call quality was optimized after the PV was connected to the communication environment in the complex low-voltage platform area simulation platform; 96 people believe that the handover success rate increased after the PV was connected to the communication environment in the complex low-voltage platform area simulation platform; 94 people believe that the capacity of the communication system in the background area of the communication environment in the complex low-voltage platform area simulation platform for PV access increased; 105 (98.13%) people believe that the connection rate would increase after PV was connected to the communication environment in the complex low-voltage platform area simulation platform, and another 91 people propose other functions, which were not shown. This shows that the impact of interference on the communication environment in the complex low-voltage platform area decreased after the PV was connected to it. The results of the questionnaire were consistent with the results of the comparative experiment. This showed that PV access could effectively improve the communication environment in the platform area and improve the quality of communication.

This study found that the traditional communication environment in the platform area was greatly affected by interference, and the problems of communication quality due to the impact of interference were not addressed successfully. However, PV access could provide an effective solution for these problems. Nowadays, when the green concept is being advocated, the complex low-voltage platform area needs to keep pace with the times, and guarantee the quality of communication so as to fully implement the environmental protection concept. PV access can not only effectively improve the communication quality and make the communication environment smoother; it can also contribute to energy conservation. The experimental data and the results of the questionnaire also proved that the degree of interference in the communication environment in the complex low-voltage platform area for PV access was reduced, and the communication quality was effectively improved, indicating the advantages of PV access and its very practical significance for the communication environment in the platform.

4. CONCLUSIONS

The degree of interference of PV access to the communication environment based on the complex low-voltage platform area simulation platform is an issue that required investigation. The experimental data showed that PV access to the communication environment in the platform area was an inevitable trend. A comparison of the experimental data showed that the PV access platform area communication environment can regulate and improve the communication rate, optimizing the call quality, increasing the handover success rate, increasing the capacity of the platform area communication system, and improving the connection rate. It can also maximize the advantages of PV access in the complex low-voltage platform area simulation platform. However, despite promising results, this study had several shortcomings. First, the experimental results could be less accurate given the short duration of this experiment as a result of time constraints; secondly, in terms of experimental data collection, experimental operations were conducted in a complex low-voltage platform area simulation platform, without considering the conditions of other stations. The amount of experimental data was small and not representative. Finally, given the ongoing and complex development of society, the changes and challenges that PV power generation could encounter in the future are still unknown. In this study, the research on the interference degree of PV power generation to the communication environment in the platform area was conducted only in the complex low-voltage platform area simulation platform to ensure that the PV access would not be affected by the voltage of the simulation platform. The impact of low-voltage and high-voltage stations on PV power generation was not explored in this paper. Therefore, the experimental results for the communication environment of the PV access platform area were limited to low-voltage conditions. In order to further understand the impact of PV access on the interference degree of the communication environment in the platform area, the analysis results could be verified in subsequent studies that address the shortcomings of this work.

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