

China's Three Gorges Reservoir Area of Intelligent Substation Project Supervision Work Method Is Discussed in This Paper

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Abstract

The ecological environment promotes the construction of smart grids, while the smart substation is the key to the construction of smart grids. Based on the supervision of the Zigui 220 KV smart substation project in the Three Gorges Reservoir Region of China, this paper studies how to well create the supervision for the smart substation project construction. With the research focus of "four-control, two-management and one-coordination" in the supervision and according to the problems and experience in the project construction, some reasonable suggestions are put forward, and then the accumulated methods and experience by supervisors when they are engaged in the supervision for the smart substation project construction are summarized.

Keywords

Ecological Environment, Smart Grids, Smart Substation, Project Supervision

1. Introduction

Smart Substation, as an important foundation for the construction of strong smart grids, has developed vigorously in the past two years for the substantial supports from China's government. How to play the role of power project supervision and how to carry out the work creatively so as to meet the requirements of smart grid construction, based on these problems, the author goes down to the project construction supervision personally, summarizes the experience of smart substation supervision based on typical cases, explores and concludes some new methods for new problems, and provides some practical significance for the supervision of smart substation project.

2. Special Requirements for the Three Gorges Reservoir Region in China: Ecological Environment and Smart Grids

2.1. The Ecological Environment Is the Lifeblood for the Development of the Three Gorges Reservoir Region

The Three Gorges Reservoir Region, located in the combining site of the upper and middle reaches of the

How to cite this paper: Xiong, H.R. (2016) China's Three Gorges Reservoir Area of Intelligent Substation Project Supervision Work Method Is Discussed in This Paper. *Journal of Power and Energy Engineering*, **4**, 27-36. <u>http://dx.doi.org/10.4236/jpee.2016.42004</u> Yangtze River, is the key development areas for propelling the economic development of the Yangtze River Basin from east to west. The development of the Three Gorges Reservoir Region has important strategic significance for implementing the develop-the-west strategy and promoting the development of the Yangtze River Economic Belt [1]. However, it's also important to strengthen the comprehensive improvement of the environment and protect the ecological environment while pursuing the economic development, so as to achieve the win-win situation between environment and development, and the harmony between human and nature. Zigui County, sit in the center of the reservoir region, is the site of the Three Gorges Dam.

2.2. Smart Grids Are Brought into China's "13th Five-Year Plan"

On March 5th, 2016, the Fourth Session of the Twelfth National People's Congress of China opened in Beijing, as shown in **Figure 1**. In the government work report, Chinese Premier Li Keqiang proposed that it should play the key role of effective investment in the steady growth and adjusting structure, a group of "13th Five-Year Plan" major projects should be started this year to construct the hydropower, nuclear power, ultra-high voltage power transmission, smart grids and other major projects [2].

3. The Construction of Smart Substation Is Responsive to the Requirements of the Ecological Environment in the Reservoir Area of China

To develop economy, the power shall be firstly developed. The Three Gorges Reservoir Region shares the Three Gorges hydropower station as well as the county-level small hydropower stations, so the power transmission is particularly important. Smart substations are the important foundation for constructing the strong smart grids [3].

Smart substations, adopting the advanced, reliable, integrated, low-carbon, environmental intelligent equipment, and based on the requirements of digitized information, networked communication platform and standardized information sharing, automatically complete the basic functions of information collection, measurement, control, protection, calculation and monitoring, and support the real-time automatic control, intelligent regulation, online analysis and decision, cooperative interaction and other advanced features of grids.

The essential advantages of smart substation are mainly embodied in the digitized process equipment and networked information transmission.

4. Focal and Difficult Points in the Supervision of Smart Substation Construction in the Three Gorges Reservoir Region in China

4.1. The Supervision at the Design Phase Shall Be Intervened as Early as Possible, So as to Master the Overall Situation of the Project Construction

The design stage of engineering project will have a significant impact on the quality, investment, progress and other aspects of the whole project. Great many facts show that the project design plays a critical role in improv-



Figure 1. Chinese President Xi Jinping visits the Three Gorges Reservoir Region.

ing the project investment benefits, guaranteeing the project quality and shortening the construction period. The important significance of carrying out the design supervision lies in emancipating the mind, change the concept, paying attention to the supervision at the design stage, promoting the investment benefits of the construction project and improving the construction level.

On November 20th, 2014, the Zigui 220 KV smart substation project in the Three Gorges Reservoir Region of China started the design. In practice, the expert group has been assigned to intervene in the design of smart substations at the early stage of the project by our supervisors.

4.1.1. The Smart Primary Electrical Equipment Is Optimally Selected

In the Zigui 220 KV smart substation project in the Three Gorges Reservoir Region of China(see **Figure 2**), the application of photoelectric technology allows the substation primary equipment to be smart, the intelligentization of the process level makes it a reality to use the optical signal communication technology between the bay layer and process layer, for which the key lies in the application of optical principle or the electronic transformer of Faraday magneto-optical effect in the power system [4]. The Faraday-magneto-optical-effect-based transformer, in the magnetic field generated by the primary current conductor, installs the closed-loop bulk magneto-optic glass as the sensing element, and gets the primary current amount through the fiber optic signal transmitting to the secondary processing system. The adoption of optoelectronic technology will eliminate the concerns about the secondary loads of the conventional CT, so unlike the conventional CT, multiple secondary coils are also no longer required [5].

4.1.2. The Integrated Monitoring System Based on the Unified Information Platform Shall Be Perfected, So as to Play the Supervisory Role of Supervision [6]

The integrated smart system framework of the Zigui 220 kV substation in the Three Gorges Reservoir Region could obtain the unified information data of the full view in the substation and convert it into normal information by using the advanced measurement technology, including leakage current of arrester, the voltage phase of arrester, GIS partial discharge values, SF6 micro-water content information, leakage current of insulator, smart video surveillance, wireless temperature and humidity, switching value, water-logging wireless sensor network, heating and ventilation, plumbing and drainage, fire protection, security, access control, etc. Various kinds of IED information are acquired by the underlying sensor, and enter into the IEC61850 process bus after being processed by each subsystem, and finally enter into the centralized control center at the substation control layer passing through the internal control host, providing some data supports for making some decisions about the substation.

4.2. The Supervision at the Construction Stage Shall Be Attached Great Importance to and the Professional Capacity Construction of the Team Shall Be Strengthened

It is necessary to strengthen the professional capacity construction of the supervision team of the Zigui 220 kV



Figure 2. The primary electrical equipment 10 kV switch cabinet of the Zigui 220 kV smart substation project in the Three Gorges Reservoir Region of China is installed smoothly.

substation in the Three Gorges Reservoir Region of China, assign the professionals with rich experience and strong business competence to serve as the on-site supervisors, strengthen the standardization construction of the supervision project department, give full play to the role of supervision in the on-site management, control and coordination, and improve the quality of supervision.

4.2.1. The Cross-Operations in the Zigui 220 kV Smart Substation in the Three Gorges Reservoir Region Are Frequent, and the Safe Production Needs to Sustain Enormous Pressures

The installation of smart equipment is at the middle and late stage of the project, when the building electric, electrical installation and debugging members, manufacturers, and some other small-field professionals are easy to work simultaneously in the same construction area, so the cross-operations are numerous. Meanwhile, the AC/DC system of the substation has been started, and some construction environment has been charged. These problems bring a lot of security risks to the construction site and bring great difficulties to the supervision project department for safety control.

4.2.2. The New Equipment and New Technology of the Zigui 220 KV Smart Substation in the Reservoir Area Appear, and the Pressure of Quality Control Is Increased

The intelligent equipment are quite different from the traditional construction methods in online monitoring, communications, measurement and other fields. If the electrical supervisors are unfamiliar with the new technology and new equipment, they will not be able to achieve the high-level quality control. For example, when the SF6 micro-water online monitoring device, as shown in **Figure 3**, made a mistake in the installation process, the leakage of SF6 gas will easily occur and cause the gas pressure to give an alarm [7].

4.2.3. Smart Components Are Installed Locally, and the Protection Difficulty of Finished Products Is Increased

The Zigui 220 kV substation in the reservoir area uses the innovative program that smart components are placed and installed locally in the intelligent control cabinet, achieving the protection, measurement, control, online monitoring and other functions of primary equipment. Such equipment in traditional substations is installed in the relay room and master-control room. After the smart control cabinet is installed locally, some construction is still on around the primary equipment, so the finished products will be easily damaged, while the long rework-cycle will have a great impact on the project schedule.

4.2.4. Too Many Sensors and Optical Cables Cause Management Difficulties

A great many state detection points are added to the auxiliary system of the Zigui 220 kV smart substation in the reservoir area, such as the SF6 micro-water detection, GIS partial discharge online monitoring, etc., and sensors on site are greatly increased. There are 20 base stations and 379 various sensors in the whole substation. However, the information in the unified information platform framework is mostly transmitted based on the optical cables or coaxial cables. The optical cables in the Zigui 220 kV substation in the reservoir area reach 15,620



Figure 3. The Zigui 220 kV smart substation in the Three Gorges Reservoir Region of China—SF6 circuit breaker and electric disconnecting switch.

meters, among which 28 are long optical cables and over 1000 are short. The optical cable laying caused by numerous sensors in the process layer becomes the difficulty of project management.

5. Working Methods and Experience of the Three Gorges Reservoir Region Smart Substation Project Supervision

5.1. Promote the Management and Technical Innovation and Enhance the Supervision Capability

The design of the Zigui 220 kV smart substation (see **Figure 4**) adopts the smart primary equipment, realizing the online detection, fault diagnosis, condition-based maintenance and smart-control operations, and adopts the smart substation power system, realizing the informatization, automation and interaction of low voltage AC power. The DC integrated system integrates the direct current power supply, inverter power supply and the communication power supply system together, forming the only DC power supply and highlighting the characteristics of smart substation. This substation has many optical cables, but few electric cables, high-level automation, small land occupation and large greenbelts, reflecting the significantly "resource saving, environment friendly, industrialized" characteristics.

Only the innovative management could support the innovative technology and promote the project in a good and fast manner.

5.2. Implement the Standard Process, Strengthen Civilized Construction and Improve the Supervision Means of Smart Substation

In response to the high-standard construction requirements of the Zigui 220 kV smart substation (**Figure 5**), the supervision, from the very beginning, adheres to the high starting point, high demand and implements the infrastructure management system of "daily pre-control, weekly comment and monthly coordination", realizes the programmed work, synchronized management, standardized data and digitized archives, presenting more than 20 construction technology new highlights. It's necessary to strengthen the employee training, organize to learn "China's state grid power transmission project construction technology demonstration", implement the prevention requirements of quality defects, unify technological standards, implement the process-based construction and ensure the excellent quality at a time.

There are many highlights of the Zigui 220 kV substation in the process innovation. Please see the **Figure 6**. The supervisors suggest the construction unit investing more than 200,000 RMBs in processing and shaping the steel formwork. The substation wall, main transformer and supporting frame adopt the drywall and chamfering technology with the smooth and straight mortar joint as well as beautiful surface, avoiding the clash damage. The bricks of the outer firewall are laid using the computer, and the wall adopts the ganged brick technology with smooth wall and straight lines. After the cement slurry pointing is changed to the special joint filling agent, the brick surface is with clear texture and beautiful shape. The bottom-layer concrete is hardened firstly and the



Figure 4. The Zigui 220 kV smart substation in the Three Gorges Reservoir Region of China main transformer is installed normally and the customized management is normative.



Figure 5. The Zigui 220 kV smart substation in the Three Gorges Reservoir Region of China—the outdoor framework is straight, and the height and direction of grounding wires are same.



Figure 6. The Zigui 220 kV smart substation in the Three Gorges Reservoir Region of Chinacarrying out "the first pilot base" and the "model construction method".

upper-layer pavement is later casted, so as to avoid the pollution and damage of early construction to the pavement and ensure the beautiful road cutting process, smooth and no-crack road surface and no ponding. The factory-production composite product trench covers are adopted, which have smooth and no-crack surface, uniform color and firm texture, and ensure no cables are exposed. The support ends are added with sheaths, the cable laying is neatly and straight, the secondary connection is in straight lines.

5.3. Complete the Project Environment and Social Environment Survey Well, Improve the Supervision Planning and Ensure the Supervision Objectives

Through the investigation on the natural environment of the project, the geographical location, landform, environment conditions, station road, outgoing line conditions, water, off-site drainage (sewage discharge), station power supply (construction power supply), material supply, hydrological conditions, meteorological conditions, engineering geological conditions [7] of the project site could be mastered initially, laying a foundation for car-

rying out the project supervision and management latterly.

The supervision objectives shall be defined, including quality, safety and civilized construction, progress, investment, scientific and technological innovation, environmental protection objectives. **Figure 7** gives us a good example.

5.4. Improve the Supervision Organization and Define the Supervision Responsibilities

The supervision project department is established, the grass-roots party construction is strengthened, and the on-site temporary party branch and the technical support group are built.

According to the supervision responsibility and supervision depth entrusted by the project entity, different professional structure and technical title structure are optimized, forming the supervision organization with overall high quality [8] and ensuring that the supervision department personnel suit to the supervision task of the Zigui 220 kV smart substation project.

In accordance with the characteristics of tight construction period and high quality requirements of the Zigui 220 kV substation project and combined with the overall project schedule and project construction and organization design, the input supervision personnel is duly adjusted, the dynamic configuration is implemented, achieving lean production and high performance and ensuring the supervision services to be in place and effective.

The corresponding on-site supervision personnel shall be equipped according to the characteristics at different construction stages of the Zigui 220 kV substation project. The number of supervision personnel at different construction stages shall be different, and the supervision force invested at the construction peak period and low-tide period shall be different.

In consideration of the characteristics during the civil construction period that many electrical devices shall be coordinated with the civil construction (such as grounding and laying, constructing the electrical embedded pipes for structures, etc.), some supervisors shall be arranged for coordination during the civil construction period.

At the latter electrical installation period, part of civil construction supervisors are retained for coordination to settle the last civil construction task and left problems (as shown in **Figure 8**).

5.5. Implement the Supervision System and Guarantee the Project Quality

The supervision system is an effective way to control the project quality, including the preparation, approval and management system of planning documents of the project supervision department, the project supervision department staff training management system, project management implementation planning (construction, organization and design), program review system, project start, pause and restart supervision system, the notice is-



Figure 7. The Zigui 220 kV smart substation in the Three Gorges Reservoir Region of China—the connecting line and the down lead is installed tidily with same radians and good appearance.



Figure 8. The Zigui 220 kV smart substation in the Three Gorges Reservoir Region of China—the warning signs outside the main control room are obvious and eye-catching.

suance and reply system of supervision engineer, the construction condition review system of subprojects, progress control and supervision system. It's obviously to see from **Figure 9**, the upper surface of foundation is level, the tower feet and the base contact closely.

5.6. Determine the Critical Paths of the Project and Ensure the Project Progress

At the civil construction stage [9], three critical paths (the control building, main transformer base, structures and equipment foundation) shall be followed. At the electrical construction stage, the scheduling of structure and equipment installation, main transformer installation, control and protection equipment installation and system debugging shall be followed tightly. The layout and planning shall be carried out in advance.

The "long-term planning, monthly arrangement, weekly balance and daily implementation" system and the monthly and weekly report system of project progress shall be established, striving to form the "planning-implementation-check-correction-adjustment" effective mechanism, achieving the "having plans, arranging skillfully, checking regularly, emphasizing implementation" and completing the dynamic management during the implementation of plans.

The daily ten-minute meeting system shall be established, irrespective of time and place, emphasizing the timely communication, cooperation spirit and problem solving.

The prompt reply system shall be established, promoting the problem-solving tracking table, supervising and inspecting in time, and solving problems [10]. The supply plan of construction personnel, engineering materials, construction machinery and other resources should meet the needs of the construction schedule. The construction schedule should satisfy the construction conditions provided by the construction unit (capitals, construction drawings, construction site, materials, etc.).

5.7. Strengthen the Safety Supervision on Site, and Guarantee the Safety Supervision

The project supervision system implemented in the construction field is "three-control, two-management, and one-coordination"; and the project supervision system implemented in the electric power construction is "four-control, two-management, and one-coordination". The Article 17 of Regulations for Supervision of State Grid Corporation Power Transmission Project Construction ([2012] No.1588) clearly provides that the "main supervision contents of the power transmission project construction include the project safety supervision, quality control, schedule control, cost control and project environmental supervision, water and soil conservation supervision". That is to say, "safety control" is changed into "safety supervision".

The prepense construction safety risk control and stand-by supervision at the planning stage: the safety supervision shall be clarified at the preparation stage [12] (as shown in **Figure 10**) and implemented at the construc-



Figure 9. The Zigui 220 kV smart substation in the Three Gorges Reservoir Region of China—the upper surface of foundation is level, the tower feet and the base contact closely.



Figure 10. The Zigui 220 kV smart substation in the Three Gorges Reservoir Region of China the safety tools and instrument are stored in a tidy and standard manner.

tion stage. To the operation process with three-level or above risk for the project, the safety stand-by supervision shall be implemented and supervised and inspected in accordance with the requirement that "the managers of power grid project with three-level or above construction safety risk shall be on duty" [13].

5.8. Collect Information in Time and Arrange Archives by Category

The sound archive management system shall be established. The information management of the supervision department shall be taken charge by the specially-assigned person. It's necessary to strengthen the training, supervision and guidance, organization and coordination, inspection and assessment, and perfect the collection, collation, preparation and reporting of the project information, regularly compile and submit the engineering bulletin, monthly, weekly and daily supervision reports, and notify the information in time about the project quality, investment, progress and safety etc., use well the capital construction management information system and satisfy the main contents of the capital construction management and control assessment.

6. Conclusion

The ecological environment requires the smart grids, smart grids are inseparable from the smart substation, and

the construction of smart substation requires the good supervision, so the supervision of electric power project shall adapt to the new situation, achieve new development, pursue new leap, improve the level of supervision services, and make due contributions in the tide of promoting the changes of energy technology.

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