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Talking about the Intelligent Development of Hydropower

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Abstract

In recent years, with the continuous emergence of big data, artificial intelligence, cloud computing and other technologies, the construction of digital and intelligent hydropower stations has become the theme of the current hydropower construction. This paper first expounds the development of global hydropower resources. Hydropower plays a vital role in the reform of the new energy power system. Then, the related concepts of intelligent hydropower system and intelligent application design of hydropower station are introduced. By analyzing the exploration and problems encountered by European and American countries in the field of hydropower, some experience and lessons are provided for the construction of hydropower in my country. This paper introduces the development status and challenges of hydropower intelligence related technologies in my country, and makes an outlook on the future development direction of hydropower stations.

Keywords

Hydropower Station; Intelligent Power Generation; Internet; Water Resources.

1. Preface

As an economical and clean renewable energy source, hydropower can be used for power generation while taking into account social benefits such as agricultural irrigation, flood control and water transportation. Hydropower projects can save energy consumption such as coal, oil and natural gas, and play an important role in achieving carbon peaking and carbon neutrality goals and promoting national energy transformation. At the same time, hydropower is a relatively flexible renewable energy, with strong load tracking ability and adjustment performance, and it can be easily switched on and off, so it can work well with intermittent wind and solar power. Period, hydropower can ease the complexity of grid operation. At present, the technology of hydropower generation is relatively mature, and all countries in the world regard hydropower as the preferred choice for new energy development and infrastructure construction. According to the prediction of the International Energy Agency and the International Hydropower Association, the theoretical reserves of global hydropower are 36 trillion to 128 trillion kW·h/a, the technically developable amount is 8 trillion to 26 trillion kW·h/a, and the economic development is possible. The amount is 8 trillion to 21 trillion kW·h/a.

With the development and promotion of smart grid, the construction of intelligent hydropower is also gradually launched. The general goal of smart hydropower is to further improve the automation level of production and management of hydropower stations, improve the level of safe operation of equipment, and improve the economic benefits of the whole plant through intelligent transformation. Smart hydropower should be based on an integrated, unified and reliable software and hardware platform. By adopting advanced sensing and measurement technology, it can automatically obtain information on power station operation and equipment status, and apply reliable control methods, data analysis technology and intelligent decision support. technology, realize the safe and economical operation of reservoirs and units, improve the efficiency of hydropower stations, and maximize benefits.

2. Hydropower Development at Home and Abroad

The International Energy Agency (IEA) "World Energy Outlook 2020" and the International Renewable Energy Agency (IRENA) "Global Energy Transition: 2050 Roadmap" proposed that the world's installed hydropower capacity target will double by 2050, or 850 million kilowatts , in order to promote the role of hydropower in future clean energy and achieve the goal of net zero carbon emissions on the premise of ensuring the ecological health of the river. Due to its long-term and flexibility advantages, hydropower has an important role to play in zero-carbon energy and zero-carbon economic strategies. The report shows that global hydropower will account for 17% of all energy in 2020, more than all other renewable energy sources combined.

As of 2019, hydropower accounted for about 6% of electricity production in the United States, 64% of electricity production in Canada, and 12% of electricity production in Mexico. In 2017, the newly installed capacity in the United States came from the upgrading of existing facilities or the new pumped storage power station. According to the development goals of the US Department of Energy, by 2050, 13 million kW of new installed capacity will be added through reconstruction or expansion, and 36 million new pumped storage power stations will be installed. kW, and finally achieve the goal of adding 50 million kW. In addition, in 2018, the U.S. government approved $105 million in funding for the construction or renovation of hydropower infrastructure, including $35 million for pumped-storage power generation projects and $70 million for ocean energy and tidal power generation projects. Canada has set a goal of reducing greenhouse gas emissions by 30% by 2030 compared to 2005, and water storage projects currently under construction include the Keeyask Power Station (Keeyask, to be completed in 2021) in the south-central region, and Project C in British Columbia. (SiteC, to be completed in 2024) and the Lat Falls Hydropower Project (MuskratFalls, to be completed in 2020). Hydropower accounts for the highest proportion of renewable energy in Mexico. It is estimated that the economically exploitable hydropower capacity in Mexico is about 27 million kW, and the current development level is about 45%. According to Mexico's energy development goals, clean energy will account for 35% of total electricity production in 2024 and increase to 50% in 2050.

The utilization rate of renewable energy in European countries is generally high. In early 2018, the European Parliament voted to increase the share of renewable energy from 27% to 35% by 2040, with hydropower being the single largest source of renewable electricity in European countries. As of 2017, the total installed hydropower capacity in Europe reached 248.56 million kW, and the installed hydropower capacity in Norway, France, Italy, Spain, Switzerland, Sweden, Austria and Germany all exceeded 10 million kW. Norway is one of the countries with the most abundant water resources per capita in the world, with an exploitable capacity of about 38 million kW and a development level of about 84%. . Norway's hydropower development attaches great importance to environmental protection, and implements the development permit system and the unified planning and development management system for the river basin.

At present, my country ranks first in the world in terms of hydropower installed capacity and hydropower generation, and the construction scale, dam engineering technology and related basic theoretical research of extra-high dams and cascade reservoirs that have been built and under construction are world-leading. From 2015 to 2021, my country's hydropower installed capacity will increase from 320 million kW to 391 million kW. In the current power structure in China, hydropower accounts for about 20%. While my country is vigorously developing new energy, hydropower will also be further developed. The government actively promotes the application of pumped storage technology, and has issued the "Medium and Long-Term Development Plan for Pumped Storage (2021-2035)". In March 2022, the National Development and Reform Commission and the National Energy Administration issued the "14th Five-Year Plan for Modern Energy System", proposing that under the background of the comprehensive transformation of world energy, my country should accelerate the construction of low-carbon, intelligent, diversified, and more A polarized "modern energy system"; as the longest-developed, largest and most technologically mature renewable clean energy, hydropower is the source of other renewable energy sources such as wind power, solar power, biomass power, tidal power and ocean power. Boosters, hydropower will complement other renewable energy sources and play a key role in promoting carbon peaking, carbon neutrality goals, and building a new power system with new energy as the mainstay.

Overall, the total installed hydropower capacity in the world will continue to increase. With the rapid development of emerging technologies such as big data, cloud computing, and the Internet of Things, and the advancement of information technology, communication technology, and industrial manufacturing technology, the digitalization and intelligent construction of hydropower generation will be a new direction for the sustainable development of the hydropower industry.

3. What is Smart Hydro

With the comprehensive development of smart grid construction and the vigorous popularization of smart technology in the power industry, the process of intelligentization of hydropower stations has also received increasing attention. At present, the construction of hydropower stations in my country mainly refers to the mode of "unattended (few people on duty)", and many large hydropower stations also operate in this mode.

So what is smart hydropower? Smart hydropower stations are characterized by adapting to the coordination requirements of smart grid sources and networks, information digitization, communication networking, integration standardization, operation and management integration, business interaction, operation optimization, and intelligent decision-making. The equipment automatically completes basic functions such as acquisition, measurement, control, and protection, and has intelligent application components such as economic operation based on an integrated platform, online analysis and evaluation decision support, and multi-system linkage of security protection, so as to achieve safe, reliable, cost-effective, and efficient production and operation. Friendly interaction and green environmental goals.

3.1 Structure of Smart Hydropower Station

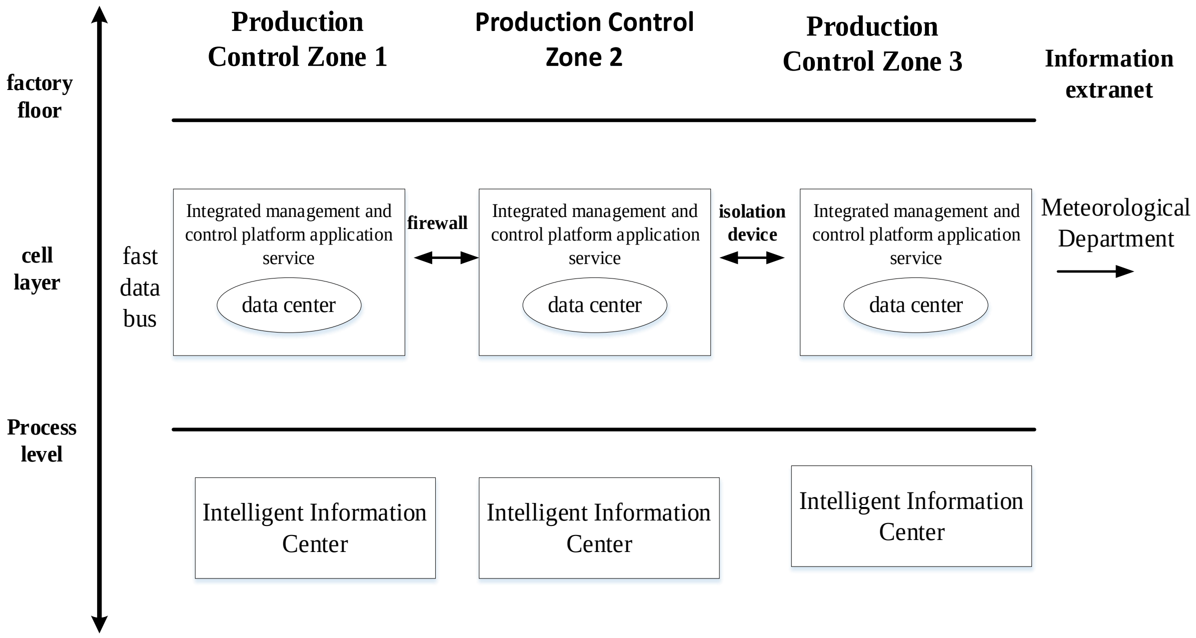

Figure 1. Architecture of Smart Hydropower System

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In 2016, the National Energy Administration issued the "Technical Guidelines for Smart Hydropower Plants", which stipulated the system structure of smart hydropower plants. The intelligent hydropower station is vertically divided into process layer, unit layer, and station layer, and horizontally divided into production control area I, production control area II, and management information area. The architecture diagram of the smart hydropower station system is shown below.

3.2 Intelligent Application Design of Hydropower Station

In the process of building a smart hydropower station, it can be started from the following parts.

(1) Intelligent construction

The intelligent construction management of hydropower projects is the management and control of the hydraulic structure, construction equipment and materials, construction environment and on-site personnel, and integrates the perceived engineering environment information, construction process information, monitoring feedback information, construction resources such as personnel activity trajectory, etc. Similar engineering data, automatically collected and transmitted into the engineering data center, through the integration of monitoring data and simulation analysis, early warning of hydraulic structure safety status and construction management activities, intelligent online closed control of deviations, and reduced engineering construction process. It can effectively control the safety of construction site personnel and project quality, and achieve the purpose of improving production efficiency and ensuring project safety. Focusing on the management elements such as resource input, technological process, business process, structural behavior, project progress and physical cost in engineering construction, with the real working behavior safety of the building structure in the whole life cycle as the core, and the multi-dimensional progress joint management of coupled structural safety The main line, focusing on the intelligent control of the process and process chain, has built an intelligent management method that deeply integrates real-time dynamic analysis, coupled simulation prediction and interactive collaborative control of key intelligent construction technologies, and provides high-quality products that meet the needs of all stakeholders.

(2) Intelligent security

In the process of intelligent construction of hydropower, the safety of personnel and equipment is a crucial part. To this end, an intelligent safety management and control system based on hydropower engineering is constructed [1]. Based on the existing intelligent identification and feedback early warning system, supplemented by the newly developed intelligent identification and feedback early warning technology, and based on the closed-loop intelligent control principle of "comprehensive perception, real analysis, and real-time control" as the basic requirement, the entire safety system can be To a certain extent, it has "intelligence", which can automatically grasp, analyze and judge and effectively deal with various security problems and emergency measures of the system. Intelligent safety is divided into three stages: "pre-event source management, in-process management, and event result management". Through intelligent closed-loop control of "comprehensive perception, real analysis, and real-time control", the safety elements of engineering construction "perception, identification, judgment, and real-time control" are studied. The intelligent management and control system of push, rectification, closure and improvement" realizes all-weather investigation and management of hidden dangers.

The framework of intelligent safety management and control system established based on intelligent safety includes:

1) Comprehensive perception: access verification, personnel and vehicle positioning and tracking, image recognition, sensor perception and intelligent monitoring system, etc.;

2) Real analysis: establishment of a construction market management system, potential safety hazards WeChat system, safety data standard database, expert database, hidden danger case database, accident case database, etc;

3) Real-time control: send warnings to mobile terminals, push them to supervisors, conduct targeted training, and form images for rectification records.

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(3) Intelligent diagnosis

When diagnosing the fault of the hydropower unit, the intelligent diagnosis technology is used to accurately judge the operating status of the unit, and to understand the cause of the unit failure in detail. Combined with the relevant data of fault detection, the structure, operating environment and unit parameters of the unit are summarized in detail. , and based on this information, analyze and judge the failures that have occurred or are about to occur in the hydropower infrastructure, clarify the cause, nature, development trend, etc. of the failure, and propose targeted troubleshooting measures to timely repair the failure of hydropower infrastructure equipment. , to ensure that the hydropower unit equipment can be restored to normal operation. The expert system diagnosis method, artificial neural network diagnosis method, Bayesian network method, and immune system-based fault diagnosis method based on artificial intelligence technology and computer technology are proposed , turbine failures, etc., can be judged efficiently and accurately to reduce the probability of failure of the hydroelectric unit.

(4) Intelligent integrated platform

Smart hydropower stations should be built on an integrated, unified, and reliable software and hardware platform. By adopting advanced sensing and measurement technologies to automatically obtain power station operation and equipment status information, and applying reliable control methods, data analysis technologies, and intelligent decision support technology, realize the safe and economical operation of reservoirs and units, improve the efficiency of hydropower plants, and maximize benefits.

In the intelligent integrated management and control platform, through the IEC61850 interconnection with various automation systems and data acquisition, data sharing and comprehensive application with other automation systems and management information systems are realized. The intelligent integrated management and control platform provides various back-end services and front-end visual interfaces to meet the needs of users for information retrieval, graphic interaction, and business applications. It can realize the safe and economical operation of hydropower plants. Among them, the integrated management and control platform for hydropower stations is divided into a unified data sharing platform, an intelligent infrastructure platform and an intelligent application platform. The intelligent infrastructure platform mainly provides technical support for the development, operation and management of various applications; while the intelligent application platform provides an artificial intelligence algorithm model, establishes an expert knowledge base, integrates and continuously improves the past experience, ideas and methods of experts in various fields, rolling Analyze data and alarms generated by various intelligent applications.

(5) Intelligent management and monitoring

In the specific process of the operation of the hydropower station, many emergencies may occur, and it is very important to respond quickly to the emergencies. The rapid response and rapid coordination are the advantages of intelligent equipment compared with manual control. With the development and innovation of "Internet +" technology, information technology concepts such as cloud computing and big data have been introduced into the informatization construction of hydropower stations. Remote centralized supervision of hydropower stations.

The intelligent management and monitoring of hydropower includes a hydropower station information management system and a hydropower station monitoring system based on big data. The hydropower information management system based on big data combines the feedback data of each electromechanical equipment with the experience data of power station production management, analyzes the current operating status and hidden troubles of each equipment, facilitates the timely elimination of faults, and saves the burden of comprehensive equipment inspection. work and improve the work efficiency of power station personnel. At the same time, it is not limited to a single power station. Through network information transmission, multiple power stations can be networked and shared equipment operation data. The larger the amount of data, the higher the credibility of cloud computing results. The intelligent hydropower station monitoring system can intelligently monitor

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the operation status of the equipment, and can realize the collection of a large number of equipment operation data, thereby realizing all-round centralized monitoring and control of the hydropower station. The perfect intelligent analysis system can intelligently analyze and make decisions on the common faults that may occur in the current hydropower station, without the intervention of the operation management personnel, can also intelligently analyze some serious faults, and list the timely disposal according to the current equipment fault conditions plan, make optimal decisions, and realize the "unattended" mode in the true sense, allowing the hydropower station to automatically manage and operate. In addition, the use of the autonomous monitoring system can also monitor the water level information. In the rainy summer, the river may be flooded, and the autonomous water level monitoring is very important to prevent floods and dyke bursts. Using its forecasting and analysis function can reduce the loss of manpower and material resources.

4. Exploration and Challenges in Foreign Hydropower Field

Due to the early development and construction of hydropower stations in Europe and the United States, some early hydropower equipment began to age. In order to improve the operation performance of hydropower stations, prolong their service life, and increase power generation efficiency, European and American countries are carrying out large-scale modernization of their existing hydropower stations. Its hydropower facilities renewal and renovation projects mainly focus on upgrading and updating electromechanical equipment and increasing the installed capacity of power stations. Keep the hydropower industry competitive by improving power plant efficiency through cost optimization.

(1) Germany

In 2015, Voith AG commissioned RWTH Aachen University to conduct in-depth research on the development prospects of pumped storage power stations in Germany. The conclusions show that more efficient use of wind and solar power, reduced fossil fuel consumption, and safe and reliable power generation are the roles that pumped storage power plants will play for Germany in 2050. The study shows that when the renewable energy power generation accounts for 60%, if the installed capacity of the pumped storage system reaches 15GW, the new power generation can be increased by 2TW·h. At the same time, the stable and reliable energy storage capacity provided by pumped hydro storage can be as high as 13GW. If the proportion of renewable energy power generation continues to increase, the number of thermal power plants that need to be built and operated in Germany will be further reduced , thereby reducing power generation costs. Experts from the Institute of Power Plant and Energy Research at RWTH Aachen University believe that the pumped storage power station will provide strong support for the market integration of renewable energy in Europe after 2030, and the pumped storage system can further help Germany transition to renewable energy.

(2) United Kingdom

In 2015, Siemens UK established a partnership with Hualingfu Hydraulic Research, combining Siemens' engineering expertise with Hualingfu's rich industry experience to ensure the right solution for the hydropower industry to achieve optimal performance, Meet the challenges of the future and ultimately ensure the safety of UK dam structures. Siemens provides information technology and monitoring technology, and cooperates with Hualingfu in key areas, including providing more reliable data for asset investment decisions, more complete emergency planning functions, and advanced preventive maintenance to greatly reduce passive maintenance costs. Hualingfu provides feasible solutions to complex hydropower-related challenges through advanced physical modeling laboratories and digital modeling tools. Technology partners provide real-time infrastructure monitoring of dams (RTIM-d), which involves a detailed assessment of issues affecting the dam site, followed by the design and specification of predetermined third-party sensor systems, as well as continuous intelligent monitoring and modular consequences modeling tools to ensure smarter asset management. Improve the oversight, asset management, and safety of hydropower infrastructure

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through the development and delivery of software for reservoir safety, asset reliability, breach and evacuation modeling .

(3) America

In 2015 , the U.S. Department of Energy (DoE) released a comprehensive roadmap, The Hydro Vision : America's First New Chapter in Renewable Energy. Its findings suggest that by 2050, the scale of hydropower generation and storage in the United States can increase from the current 101GW to nearly 150GW. If this growth can be achieved, it will help the United States develop a low-carbon economy, while taking advantage of renewable energy. The report highlights the current and future benefits of hydropower to public health and the environment. The value that hydropower can generate includes avoiding losses from greenhouse gas emissions , medical and economic costs due to air pollution, and saving water for cooling steam and thermal power plants. In 2017, the U.S. House of Representatives introduced and passed the Hydropower Modernization Act of 2017 . The bill says it will double hydroelectric power generation without adding a single hydropower plant by upgrading and improving the efficiency of existing hydropower plants. In 2019, the National Hydropower Association (NHA) released a report proposing a series of initiatives to revitalize the nation's hydropower over the next 30 years . Emphasize the role of hydropower in achieving U.S. clean energy goals through market design with the goal of realizing the maximum value of hydropower, a“technology neutral”policy based on emission reduction goals, allowing reinvestment in existing hydropower plants, etc. Renewable energy is integrated into the grid.

The United States clarifies the development direction of hydropower based on "optimization" , "growth" and "environmental protection" , and analyzes the important obstacles to the development of the domestic hydropower industry, including: lengthy approval procedures, conflicting development priorities, and low decision-making efficiency , etc . To this end, the United States has implemented a series of improvement measures: In 2013, the Hydropower Regulatory Efficiency Act was officially passed, which aims to improve and simplify the approval process for small hydropower projects; in 2016, the Energy Policy Modernization Act further simplified the hydropower approval process, And designated the Federal Energy Regulatory Commission to be responsible for approval; in 2018, the United Nations Natural Resources Commission passed the Bureau of Reclamation Pumped Storage Development Act, which aims to develop non-state-owned pumped storage projects in the United States for grid stability and other (intermittent) The development of renewable energy brings huge benefits.

Apart from human factors, in the face of sudden natural disasters, how to alleviate the negative impact of the decline in hydropower generation is not only an issue that deserves attention not only in the United States but also in other countries . In 2021, the U.S. Energy Information Administration (EIA) issued an announcement stating that due to the extreme dry weather swept across the United States in summer, hydropower generation in many places has declined for several months, and many western states such as Washington and California that mainly rely on hydropower are in short supply. , the regional power grid is under great pressure. U.S. hydropower generation is expected to decline by 14% year-over-year in 2021. In August 2020, California, home to 13 percent of the U.S.’s installed hydropower capacity, was forced to shut down the Edward Hyatt hydroelectric plant after the water level in Lake Oroville fell to historic lows. As of November, California's hydropower capacity had fallen to a 10-year low. In this regard, the California State Energy Commission said, " The biggest challenge we face is to find a suitable resource or combination of resources to provide energy and power output capabilities comparable to hydropower. "

5. Research and Application of Intelligent Hydropower in China

Before the development of smart hydropower in my country, many scholars have done research on the application of intelligent technology in the field of hydropower. Liao Zhong et al. applied the intelligent control algorithm to the process control of the hydroelectric unit , and designed the BP network intelligent PID control system. Through the identification network BPNI and the control

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network BPNC, the working conditions of the hydroelectric unit were identified online and the controller parameters were adjusted in real time. , effectively improve the dynamic and static performance of the unit. Literature expounds the application of intelligent robot welding technology in large-scale hydropower components, and conducts in-depth exploration from thick plate multi-layer multi-pass automatic welding technology, complex surface welding forming technology, and different surface quantitative surfacing technology . Traditional manual welding and intelligent robots have strong advantages in welding efficiency and quality, operating environment, manufacturing cost and cycle, and special position welding, and have been widely used in the welding of seat rings, runner bodies, and runners. use. Reference studied the ecological compensation of water resources in the Danjiangkou Basin, discussed the ecological compensation problems and prospects of the Danjiangkou Reservoir, and discussed the ecological compensation mechanism for the prevention and control of water pollution in the Danjiangkou Reservoir area and its upper reaches, and established the ecological compensation standard for the construction of large-scale reservoirs. The evaluation model provides a reference for the evaluation of ecological compensation standards for water conservancy and hydropower project construction.

China's hydropower intelligence research was carried out relatively late, but it has achieved certain excellent results so far . Zhang Shijun and others discussed the construction ideas of intelligent hydropower in the direction of plant-level monitoring information management system (SIS) for hydropower plants, and proposed a hydropower SIS system based on Windows operating platform, PI real-time database platform and Microsoft .NET technology. Reference starts from the application of international hydropower engineering informatization standards in China, and puts forward suggestions for the construction of China's hydropower informatization standard system through comparative analysis with the hydropower industry informatization standard system in developed countries with hydropower technology . Scholars such as Zhong Denghua proposed a smart dam based on the digital dam framework , using the new generation of information technologies such as the Internet of Things, intelligent technology, cloud computing and big data as the basic means to establish a dynamic and refined perceptible, analyzable, Controllable and intelligent dam construction and operation management system . By designing the basic architecture of the smart dam's information real-time perception module, connected real-time transmission module, intelligent real-time analysis module, and intelligent real-time management decision-making system , it can achieve independent information collection, intelligent reconstruction analysis, intelligent decision-making, and integrated visualization . Compared with the digital dam, it has surpassed other aspects. By the end of 2020, more than half of China's to-be-developed hydropower resources are concentrated in high-altitude watersheds, and the national " 14th Five-Year Plan " and the long-term goal of 2035 make it clear that the development of hydropower resources in the lower reaches of the Yarlung Zangbo River will be implemented. For this reason , Fan Qixiang put forward corresponding countermeasures for the challenges faced by hydropower projects in intelligent construction in high-altitude areas in China. Based on the basic principles of control, resource utilization and value creation, the closed-loop control theory of high-altitude intelligent construction is proposed. In 2019, after nearly a year of trial operation, the remote control project of the flood discharge gate of Yunnan Huadian Ahaihai Hydropower Station successfully entered the formal operation stage and opened a new model of smart hydropower. According to the plan of " unmanned duty , few people on duty " , Ahaihai Hydropower Station completed the transformation of the flood discharge gate connected to the centralized control remote control and passed the acceptance, and was connected to the centralized control remote control for trial operation. During the trial operation, the opening and closing operation of the flood gate was carried out remotely by the centralized control personnel, and the equipment site was operated by the power station operation and the on-site hydraulic personnel. The success rate was 100% under a large number of operations , and there was no danger to personal, equipment, flood control and shipping safety. In other situations, the “ shake adjustment ” mode of the flood discharge gate improves the convenient adjustment of the opening of the flood discharge gate, realizes the precise control of the flood discharge flow, and optimizes the power generation efficiency of the unit.

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At present, there are still some practical difficulties in the intelligent construction of hydropower stations in my country, such as:

(1) The standards of hydropower station equipment are not uniform . Most of the small hydropower stations are privately operated, so in the process of design and construction, the equipment purchased often cannot be unified, and the construction standards are also inconsistent, such as transformer protection devices, governors, etc., which cannot be unified and standardized ;

(2) The management level and ability are backward . Lack of understanding of management techniques and methods, failure to strictly comply with the monitoring and operation record specifications of the power station, and high requirements for the knowledge reserve of smart hydropower stations by hydropower station managers . At the same time, most of the relevant intelligent monitoring equipment has not been installed in place, and some hydropower stations have little improvement in the information management and operation of the equipment, and there is still a lot of room for improvement ;

(3) The level of intelligence is low . The early intelligent equipment of hydropower stations has high cost, large volume and poor quality, and has not been widely used. It can only realize primary functions such as data storage and human-machine display , and cannot comprehensively collect and analyze data and analyze related data. Remote control of equipment. Power stations in some river basins are unattended and information management has not yet been solved, and the equipment of power stations in remote parts does not have the basic conditions for intelligence.

Some existing large-scale hydropower stations in China have initially carried out the transformation of intelligent hydropower systems. In the process of transformation, each hydropower station should formulate a transformation plan based on its own actual situation, and rebuild a set on the basis of retaining the original functions of the hydropower station. Intelligent management system . The main focus of the intelligent transformation and construction of hydropower stations is to improve the level of safety, stability and economic operation of hydropower stations, improve the level of monitoring of hydropower units, and realize the security, standardization and intelligence of hydropower units connected to the power grid. You can start from the following aspects :

(1) The monitoring system management platform is upgraded and updated, and the integrated management platform with intelligent monitoring function is used to replace the traditional monitoring system, so that the monitoring system can also become a management system ;

(2) According to actual needs, upgrade and transform auxiliary equipment, replace hard-wired connections with fieldbus, and improve the intelligence and controllability of electromechanical systems ;

(3) Enhance the data collection and processing capabilities of electromechanical equipment. Under the basic premise of having intelligent equipment, the automation components and measurement and control equipment are gradually transformed to further realize the intelligentization of field equipment.

The transformation and construction of intelligent hydropower stations should follow the global IEC61850 standard. For some existing hydropower stations, due to economic reasons and the characteristics of the equipment itself, intelligent transformation and construction may not be in place in one step. Hydropower stations can still use traditional PT (voltage transformers) and CT (current transformers), mainly by adding computer monitoring systems to merge units, switch controllers and intelligent equipment based on IEC61850. At the same time , the intelligent hydropower station system should also be well connected with meteorological, hydrological, security and other institutions to achieve data sharing, and realize the assessment of storage capacity and flow through climate, geological and other predictions, and improve the power generation efficiency of hydropower stations and the functions of flood control and disaster reduction .

6. Conclusion

As an inexhaustible and inexhaustible renewable resource, hydropower resources, the existing hydropower projects let us realize that the rational development and scientific management of hydropower stations not only has high power generation efficiency, but also has good sustainability effects . Adjust the water flow, play a role in controlling droughts and floods, and solve the problem of irrigation. However , the construction of hydropower plants and their power generation capacity will be limited by topography. In addition, rivers, lakes, etc. are easily affected by wind and water disasters, and power data is volatile, resulting in a certain degree of uncertainty in hydropower generation. The construction of hydropower stations will also have varying degrees of impact on animals, plants, residents, and soil fertility in the basin.

At present, the digital technology of hydropower stations is relatively mature. In the next step , under the premise of focusing on ecological environmental protection, we should strengthen the intelligentization of equipment, the research on digital sensors, intelligent components and unit-level controllers that comply with the IEC61850 standard, and further improve the operation and management of hydropower stations. intelligent scheduling. The future development direction of hydropower is " smart hydropower ". Therefore, it is necessary to comprehensively explore the mechanism and way of deep integration of hydropower and new-generation information technology and sensing technology, and continuously improve the level of intensification and intelligence of power plant management.

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