Main types and applications of hybrid power generation system

Main types and applications of hybrid power generation system

Hao Qing *

[1]School of North China Electric Power University, Baoding, China

*Corresponding author e-mail: 2653150050@qq.com

Abstract. With the development of new power generation technologies, including renewable energy and efficient and clean fuels, combined power generation has become an effective way to reduce environmental pollution and improve energy efficiency. Because different energy forms are naturally strong in time and geography. Complementary, different types of renewable energy combined power generation, can Make up for each other's intermittent losses of energy and improve the grid. The extent of intermittent renewable energy consumption. Research in many developed countries has matured, but China is still in its infancy. Based on this, this paper introduces the development and research of the combined power supply system at home and abroad, and expounds the main types and applications of the combined power generation system.

1. Introduction

As an important part of the strategic adjustment of energy and the transformation of power development patterns, in recent years, renewable energy generation technologies, represented by wind and solar energy, have developed rapidly around the world. But at present energy supply is still dominated by fossil fuels. Now the problem of environmental pollution has to be solved urgently, and the development of clean energy that can replace primary energy has become imperative. Among them, the joint power generation system has become a new research direction. Various energy sources complement each other, further improving the efficiency of power generation, while clean and environmentally friendly, and will not cause serious atmospheric pollution such as that generated by the combustion of fossil fuels. The use of different types of renewable energy in combined power generation systems can compensate each other for the shortcomings brought about by the intermittent energy generation, and increase the degree of absorption of intermittent renewable energy by the grid. Therefore, the high utilization value and high possibility of multiple forms of energy complementary power generation will be an energy utilization method with great potential in the future.

2. Main types of hybrid power generation systems

2.1. Hybrid wind/pv/storage power generation system

2.1.1. Presenting background. Wind energy and light energy are quite complementary in terms of natural resources and utilization time. On the basis of a single wind system, the addition of energy storage devices plays a significant role in the improvement of the entire wind power generation system [1]. The negative impact of wind power characteristics on the power grid is becoming more and more prominent. It is a feasible way to combine energy storage with wind power and photovoltaic to form a wind and light storage combined power generation system.

2.1.2. System structure. The core function of the National Landscape Storage and Demonstration Project lies in the joint power generation panoramic monitoring system. The system realizes the friendly interaction and intelligent dispatch of wind power, photovoltaic power generation, energy storage power generation and smart grid transmission by uniformly distributing wind, light and power generation resources. It is mainly composed of wind farm, photovoltaic power station, energy storage system and monitoring system at various levels [2].

The entire cogeneration system is divided into three layers: the joint scheduling layer, the station monitoring layer, and the equipment layer. Among them, the joint scheduling layer is the bridge between the superior dispatching center and the combined power generation system, and provides operational analysis support for the superior dispatch; at the same time, as the control center of the whole system, the intelligent analysis and decision-making realizes wind power, photovoltaic, and energy storage. Coordinated control.

2.1.3. Development and application. It can be seen from the above that wind and light power generation will be affected by natural climatic conditions, that is, there is great intermittentness, and the output power of the two is not controllable, so it is necessary to control the overall output power of the system. For the combined power generation system, the capacity of the energy storage device itself and its response speed are very important, and the device is required to have a smooth output characteristic. Therefore, in practical applications, it is necessary to select the best energy storage device power and capacity [3].

At present, China has carried out research on wind and light storage combined power generation. After continuous research, the State Grid Corporation has built the first national-level wind and light storage demonstration project in a certain city. The project is supported by technical means, which realizes the complementage of wind power, photovoltaic power generation and energy storage devices and the power grid. It basically masters the technology of renewable energy grid-connected power generation and operation, and further improves the grid's ability to accept renewable energy grid-connected power generation.

2.2. Hybrid solar-geothermal power generation system

2.2.1. Presenting background. Solar energy and geothermal energy can be combined to generate electricity, which can complement each other, improve power generation efficiency, and reduce solar power generation costs. There are many potential synergies between geothermal energy and solar energy in China. Geothermal-solar cogeneration technology can use solar energy to increase the depreciation of geothermal resources, which can be economical and can exert the potential energy of geothermal and solar energy.

2.2.2. System structure. In previous studies, scholars have tried many ways to combine energy in solar-geothermal energy combined power generation systems. In general, they can be divided into the following two categories [4].

The first method is a combined power generation system based on geothermal energy. In the conventional geothermal power generation system, since the geothermal water temperature is not high enough, the use of flash or dual-work power generation is inefficient, resulting in waste of geothermal resources. If a solar collector is added to the existing geothermal power generation system, not only the steam production and steam temperature are increased, but also the power generation of the system is increased, and the geothermal water is reduced while keeping the system power generation constant. The mass flow rate can extend the service life of the geothermal reservoir.

In the second way, the solar power-based combined power generation system needs to be heated into the solar collector because the temperature of the geothermal water is generally lower than the temperature that the solar collector can reach. Therefore, in the solar power generation system, Geothermal water can only provide heat to the working fluid coming out of the condenser, increase the temperature of the fluid entering the solar collector, increase the steam production and steam temperature of the solar collector, and increase the power generation of the system [5].

2.2.3. Development and application. Internationally, scholars mainly analyzed the technical and economic performance of the solar-geothermal energy combined power generation system based on the Rankine cycle, and analyzed the feasibility of implementing combined power generation retrofit for subcritical and supercritical geothermal power stations. In China, there have been flash geothermal and trough solar power generation systems, duplex geothermal and trough solar power generation systems, and recently the Kelina cycle based cogeneration system [6].

Solar-geothermal combined power generation is another way to use new energy and represents a new direction for future energy. At present, the research on the system is not only in the theoretical research stage, but there are few practical cases, and the technology is still difficult to meet the requirements.

2.3. Hybrid solar-biogas power generation system

2.3.1. Presenting background. The use of biomass energy to generate electricity as a clean and efficient power generation technology has been fully developed and applied. It is a new research direction to improve environmental pollution and promote the development of circular economy [7]. Biogas and solar energy are both abundant natural resources in rural areas of China. Combining biogas with light and heat is feasible in the vast rural areas of China, and truly achieves energy conservation and environmental protection.

2.3.2. System structure. The photothermal-biogas combined power generation system has a double guarantee in the process of continuous power generation. Among them, the biogas boiler is the first guarantee, and the storage battery and the heat storage tank are the second guarantee, thus improving the reliability of the system power supply. Compared with the CPC-PV/T power generation system and the biogas power generation system, the photovoltaic/photothermal and biogas combined power generation system is a green energy utilization technology that completely escapes from fossil energy [8].

2.3.3. Development and application. In recent years, Photovoltaic/Thermal (PV/T) systems, which integrate optoelectronics and photothermal utilization technologies, have become new hotspots in solar power generation technology research. However, the actual power generation process may be unstable. To this end, many scholars have proposed joint power generation technology that combines PV/T systems with other systems. Although there are few reports on the combined power generation technology of PV/T system and biogas system, there have been many studies. In the production and life

of agriculture, the combination of biogas and light and heat can bring huge economic benefits and environment. Protection plays a big role. It is worth our further research.

2.4. Hybrid offshore wind and tidal power generation system

2.4.1. Presenting background. The ocean contains enormous energy. The main forms of development and utilization of ocean energy include offshore wind power, tidal power generation, tidal energy generation and wave power generation. However, there are some bottlenecks in the development of offshore wind power, mainly due to the high installation and maintenance costs and large fluctuations in output. The connection of offshore wind power to the grid will directly affect the voltage stability and power balance of the terrestrial power grid. Rahman et al. [9] proposed an offshore wind power tidal power generation system (HOTT), which gives a novel system layout and power generation control method, which can effectively reduce the total system cost and improve the output stability. In the above, by controlling the speed of the power motor and the inverter frequency, the power motor is smoothly switched between the power generation state and the motor state, thereby compensating for the fluctuation of the wind power, and the output power of the system is smoother.

2.4.2. System structure. Due to the harsh marine environment, the load of wind power generation devices and tidal current power generation devices requires a stable platform; considering the reliability and safety of the devices, a pile-type foundation platform structure with a higher base strength is generally used. The base of the base platform is installed in a water level with a height that allows the top to leave the surface. The wind power generation device is located above sea level, installed at the top of the platform, and the tidal current power generation device is below the sea surface, installed at the bottom of the platform, and if necessary, raised to the sea surface for maintenance [10].

2.4.3. Development and application. Literature [11] pointed out that the wind-powered combined power generation system has more application value in the case of meeting the set maximum annual capacity shortage ratio; the stability also analyzes the sensitivity of wind speed and tidal current velocity, indicating wind power, tidal independent power generation and wind power. The tidal power generation system is applicable in many cases.

Nowadays, countries have started research on the tidal power generation system. However, the research is still in its infancy, and there are still many problems to be further explored. For example, the dynamic characteristics of power grid failures, typhoon weather and other uncontrollable conditions are still areas that need further solution.

2.5. Other types of hybrid power generation systems

2.5.1. Hybrid light-tidal power generation system. In order to better develop the circular economy and save energy resources, it is also an effective way to analyze the combined power generation system of tidal energy and light energy through modeling and design [12]. The left end of the system designed in the paper is the concentrating unit absorbs light energy, the middle is the connection and gear transmission structure, and the rightmost end is the rotary paddle type tidal absorbing generator set, which realizes the joint power generation of two kinds of energy through mutual cooperation. At present, the photovoltaic power generation industry and the adaptive tidal energy industry have received wide attention, new energy devices are emerging, and the realization of solar energy tidal power combined power generation will also be realized.

2.5.2. Hybrid Solar-biomass power generation system. Solar and biomass energy combined with thermal power generation uses solar energy and biomass energy to generate electricity, without the additional emissions of CO_2, thus meeting the requirements of green power plants. However, the advantages and disadvantages of biomass direct combustion technology and solar thermal power

generation technology are obvious [13]. When there is no solar radiation or radiation is weak, the water in the heat exchange system cannot be heated, and the water supply pipe of the solar heat collecting and absorbing conversion system is required. The road is cut off and the other two subsystems are operated in conjunction. Another solar-biomass cogeneration system employs a thermochemical mixing program [14] in which biomass gasification is driven by concentrated solar energy and gasified syngas as a solar fuel is used to generate electricity in a combined cycle. The result is solar energy - electrical energy efficiency can reach 29.36%.

In addition, there are hybrid wind and firewood power generation system, hybrid wind and solar power generation system, hybrid solar-fuel cell power generation system, etc., because the hybrid power generation system adopts the domestic mature new energy power generation technology and relatively mature application. The energy conversion technology, all countries are actively researching and developing, and use it as soon as possible in production and life.

3. Conclusion

The power of the hybrid power generation system varies with time. For example, the combined power generation system involving solar energy, wind energy and tidal energy has randomness and intermittentness, and the initial investment is high. For example, the wind and light storage demonstration project mentioned above is not promoted because The price is expensive and the installation is difficult; at the same time, the large area, the system maintenance and maintenance difficulties are a series of defects of the combined power generation system. Therefore, the problem that must be solved in the study of the combined power generation system is the design of the variable power generator set, so that the system can operate at different time periods while reducing the cost of construction.

Although the geothermal energy is widely distributed, the power generation efficiency is low. The flash geothermal power generation system alone has a power generation efficiency of only 1.4% [15] and is not easy to be directly used. The wind energy and light energy are intermittent and subject to natural environmental factors. The impact of how to improve power generation efficiency and better complement other forms of energy is the problem that geothermal energy needs to solve in joint power generation research.

In summary, in the context of the global energy crisis, the development and application of cogeneration technology has become an inevitable development trend. However, most of the research on the joint power generation system only stays in the theoretical research stage. Although a few have put into engineering practice (such as wind and light storage combined power generation system), the current research is just a simple pile of existing equipment technology, which is difficult to complete. Meet the system's special requirements for equipment. Therefore, there is still a long way to go for the research and development of combined power generation technology.

References

[1] Zhuang Yanni, Yang Xiuyuan, Jin Xincheng. Research on Operation Technology of Wind and Light Storage Combined Power Generation[J].Power Generation Technology, 2018, 39(04): 296-303.

[2] Han Xiaojuan, Ai Yaoyao, Li Xiangjun. The application value of energy storage in the power grid and its business model [J]. Power Generation Technology, 2018, 39(1): 77-83.

[3] Shi Yun, Zhang Huawei.Development and Application of Wind and Light Storage Combined Power Generation Technology[J].Mechanical & Electrical Technology,2016(02):146-148.

[4] Xu Qionghui, Gong Yulie, Luo Chao, Yao Yuan, Lu Zhenneng, MA Weibin.Research progress in solar-geothermal energy combined power generation system[J].New energy progress, 2016, 4(05):404-410.

[5] Daniel Álvaro,Rafael Arranz,José A. Aguado. Sizing and operation of hybrid energy storage systems to perform ramp-rate control in PV power plants[J]. International Journal of Electrical Power and Energy Systems,2019,107.

[6] Zhou Gang, Ni Xiaoyang, Li Jinfeng, et al. Geothermal and solar thermal power generation system without geographical constraints[J]. Journal of Earth Sciences-China University of Geosciences, 2006, 31(3): 394-398. DOI: 10.3321/j.
[7] Huang Lingzhi, Xu Tiechun, Li Jinhuai, Qin Wendi, Ye Yongwei. Analysis of common problems in biogas power generation and countermeasures[J]. South Agricultural Machinery, 2018, 49(22): 9-10.
[8] Design and simulation of a solar–wind–biogas hybrid system architecture using HOMER in India[J]. Sambeet Mishra,C.K. Panigrahi,D.P. Kothari. International Journal of Ambient Energy . 2016 (2)
[9] RAHMAN M L, SHIRAI Y. Hybrid offshore-wind and tidal turbine (HOTT) energy conversion I (6-pulse GTO rectifier and inverter) [C].IEEE International Conference on Sustainable Energy Technologies, singapore: IEEE, 2009
[10] Hu Ende. Construction scheme and simulation research of wind power combined power generation system [D]. Zhejiang University, 2017.
[11] Hu Ende, Yang Huan, Zhao Rongxiang, Zheng Taiying.Study on capacity allocation of offshore wind power tidal power generation system[J].Mechanical & Electrical Engineering, 2018, 35(01):62-67.
[12] Yuan Guangmin, Zhu Xing, Du Xinxin. Discussion on the Design and Analysis of Light Energy Tidal Energy Complementary Power Generation System[J].Science & Technology Economic Market, 2018(09):31-33.
[13] Geng Chunyu. Research on synergistic power generation and control of biomass energy and solar energy[D]. East China University of Science and Technology, 2016.
[14] Qibin Liu,Zhang Bai,Xiaohe Wang,Jing Lei,Hongguang Jin. Investigation of thermodynamic performances for two solar-biomass hybrid combined cycle power generation systems[J]. Energy Conversion and Management,2016,122.
[15] Seyed Ehsan Hosseini,Hasan Barzegaravval,Abdolsaeid Ganjehkaviri,Mazlan Abdul Wahid,M.N. Mohd Jaafar. Modelling and exergoeconomic-environmental analysis of combined cycle power generation system using flameless burner for steam generation[J]. Energy Conversion and Management,2017,135.