Applied Science and Innovative Research
ISSN 2474-4972 (Print) ISSN 2474-4980 (Online)
Vol. 8, No. 1, 2024
www.scholink.org/ojs/index.php/asir

Original Paper

Research on Large-scale Energy Storage of Chinese Power System Based on Demand Analysis

Yongwen Wang[1], Haiyang Yu[1] & Lihong Jiang[1]

[1] Changzhou Zhixu New Energy Power Technology Co., LTD, China

This paper is the research result of Changzhou Zhixu New Energy Electric Power Technology Co., LTD.

Received: December 3, 2023 Accepted: December 22, 2023 Online Published: December 26, 2023

doi:10.22158/asir.v8n1p1 URL: http://doi.org/10.22158/asir.v8n1p1

Abstract

With the construction and development of a low carbon and environmental protection society, China is promoting the construction of a clean, low carbon, safe and efficient energy supply system, the most critical of which is to promote the rapid construction of new energy installed capacity. However, with the continuous expansion of the new energy installed capacity, the random volatility of the power supply has become an important factor that puzzles the power balance of the current power system, not only formed a larger peak pressure, but also became one of the important factors restricting the development of new energy. At the same time, the new energy power electronic equipment has weak supporting characteristics, which also makes the proportion of new energy power system continues to increase, and has a high impact on security. In this context, this paper carries out a demand analysis, firstly discussing the demand for large-scale energy storage in the development of new energy for power system, and secondly analyzing the demand for large-scale energy storage in the safe operation of large power grid, so as to promote the construction of GW-level electrochemical energy storage power station and effectively deal with the power imbalance and safety problems.

Keywords

Power system, Demand analysis, Large-scale energy storage

1. Introduction

In the new era of China's energy production and consumption revolution, vigorously developing new energy is an important way to promote the optimization of the energy structure and achieve clean and low-carbon development, which can not only meet the construction needs of a clean, low-carbon, safe and efficient energy system, but also promote the transformation and development of China's economy

and society. However, the continuous expansion of the installed scale of new energy has also brought many difficulties and problems, especially in the new energy volatility and intermittenity to promote the power side of the peak load, frequency modulation pressure continues to increase, while the proportion of direct current continues to increase, but also make the system frequency stability control is insufficient, its moment of inertia vacancy. Therefore, at present, we must improve the flexibility of the power system as the development direction, not only to establish a guarantee for the efficient consumption of new energy, but also to create a good environment for the safe and stable operation of the power system. In this regard, promoting the construction of GW-level electrochemical energy storage power station has become an important measure to solve the above problems. This paper proposes the necessity and significance of the development of large-scale energy storage in China's power system at the level of demand analysis.

First, the development of new energy on the power system large-scale energy storage demand analysis.

2. The Necessary Demand for Large-scale New Energy Grid-connected Operation

China's large-scale development of clean energy and electricity load there is a reverse distribution problem, of which more than 80% of land wind energy, more than 70% of water energy and 60% of solar energy resources are from the western and northern regions of China, and more than 70% of the country's electricity load concentrated in the central and eastern regions of China. Therefore, the establishment of a large power grid and a large market has become an important basis for China to consume new energy power nationwide.

Based on the data at the end of 2019, the "three North" region is the main region of wind power installed capacity in China, with a cumulative installed capacity of 146 million kilowatts, and its wind power installed capacity accounts for more than 70% of the country. Inner Mongolia, Hebei, Shanxi, Shandong, Jiangsu, Ningxia, Gansu and other provinces have installed capacity of more than 10 million kilowatts, especially Inner Mongolia is the most prominent, more than 30 million kilowatts of wind power installed capacity, followed by Hebei, wind power installed capacity of more than 15 million kilowatts. In 2019, China's total installed capacity of new energy has reached 21 percent of the total, and it has become the second largest power source in the country. In some regions, such as Gansu and Qinghai provinces, new energy power has become the primary source of electricity.

Compared with the data at the end of September 2023, China's renewable energy installed capacity of about 1.384 billion kilowatts, an increase of 20%, accounting for about 49.6% of China's total installed capacity, has exceeded the thermal power installed capacity, including hydropower installed capacity of 419 million kilowatts, wind power installed capacity of 400 million kilowatts, photovoltaic power installed capacity of 521 million kilowatts, The installed capacity of biomass power generation is 43 million kW. It is not difficult to find that in just a few years, the installed capacity of new energy in China has increased rapidly, resulting in a significant increase in the daily fluctuation of new power, and the difficulty of the power system for the balance of space and time of power generation has also

been further improved. And large-scale energy storage can not only provide a powerful means of peak regulation for China's power system, but also form a flexible, reliable and rapid response mechanism, providing the corresponding frequency adjustment and inertia support methods, to achieve the effective reduction of new energy abandonment rate, and reduce the risk of system frequency exceeding the limit and instability. Therefore, in order to continue to increase the installed capacity of new energy, while maintaining the efficient consumption of new energy power and the safe and stable operation of the power system, it is necessary to promote the construction and development of large-scale energy storage.

2.1 The Basic Needs of Energy Storage Configuration

In the process of new energy power system construction, in order to further improve the system adjustment capacity, its basic needs should be explored through the configuration of energy storage analysis and calculation methods. The process needs at least four links to complete, one should be for power configuration analysis and calculation, the second should be for capacity configuration analysis and calculation, the third to implement security and stability of the check measures, the fourth to economic evaluation. For the new energy power system, the power selected during the configuration of energy storage must meet the maximum value of the new energy blocked power and load limiting power under the cumulative probability requirements. The energy configured for energy storage must also meet the requirements of new energy utilization, load suppression, and the maximum single charge/discharge power required to be reduced in this process. In the process of power system configuration energy storage analysis and calculation, it is also necessary to further consider the operation characteristics of the power system, not only to fully consider the basic characteristics of new energy resources in the system, but also to consider the maximum adjustment capacity of conventional power supply, demand response resources, established energy storage and other systems in the process of adjusting resources. At the same time, the analysis and calculation process of power system configuration energy storage also needs perfect data support, mainly including time series data and non-time series data. Among them, the former needs to include boot mode, new energy generation power, load, runoff hydropower power and other factors, requiring a time resolution of at least 60 minutes, and the data length should be at least more than 1 year; The latter should include conventional power supply, demand response resources, built energy storage and other system adjustment resources related performance parameters, but also need to record its planned power grid connected capacity data. Due to the existence of moderate load growth factors, taking into account the impact of China's pumped storage construction and thermal power flexibility transformation and other related content, combined with the above research programs and calculation methods, to the final stage of China's 14th Five-Year Plan, China needs to build at least 20GW of electrochemical energy storage power station to meet the energy storage configuration needs of China's new energy power system.

Second, the safety operation of large power grid large-scale energy storage demand analysis of power system.

2.2 UHV Power Grid Transition Demand

China is currently facing the objective status quo of the installed scale of new energy power and the reverse distribution of power load, while in the stage of large-scale centralized development of wind power and solar energy, and in this situation and situation, green energy in the western region in order to reasonably and efficiently transport to the central and eastern regions, it needs a long-distance, high-power transmission system. Thus to ensure the effective intersection of power production center and load center. In this respect, UHVDC transmission technology has become an important means to solve the above problems, which can not only effectively alleviate the practical problem of the inverse distribution of power installed scale and power load, but also improve the efficiency, safety and stability of power transmission.

Taking the data at the end of 2022 as an example, China has built 20 DC UHV lines in operation, with an annual electricity transmission capacity of 563.8 billion KWH, of which 316.6 billion KWH of new energy is generated, an increase of 10.3% year-on-year. At the same time, new energy accounted for 56.2 percent of the total DC UHV line transmission power. The State Grid operates 16 DC UHV lines, of which the total transmission power of DC UHV lines is 481.3 billion KWH, and the new energy power is 234.1 billion KWH, accounting for 48.6 percent of the total transmission power. China Southern Power Grid operates four DC UHV lines, which deliver 82.6 billion KWH of electricity, all of which are new energy. It is not difficult to find that in the process of construction of large-capacity DC UHV lines, the development of high-proportion new energy power system has entered a new stage, which has prompted great changes in the pattern of power supply and grid in China. At present, the proportion of new energy units with low inertia and weak support in China's power system continues to increase, and the trans-regional transmission system also provides part of the conventional power supply support for the receiving end of the grid through the large-capacity DC UHV program, which gradually reduces the proportion of traditional synchronous generators in China's power grid system. At the same time, the associated support capacity and primary frequency modulation capacity of the synchronous power grid are also declining, which makes its frequency support and regulation ability difficult to cope with the impact of the power imbalance caused by the current large capacity DC lock, which may cause problems such as increased frequency drop depth and frequency recovery difficulty, making the security and stability of the power system under new threats. In addition, in the trans-regional AC-DC hybrid power grid, if the phenomenon of trans-regional DC blocking occurs, there is also the possibility of large-scale power flow transfer on the AC contact line of a large range, which will bring major problems that are difficult to deal with for the trans-regional synchronous interconnection grid, resulting in instability and even disconnection accidents. For example, on September 19, 2015, there was a bipolar block problem in the high-voltage DC line network of Jinsute, which made the instantaneous power loss of East China power grid reach 4.9 million kilowatts, and the power load level of the power grid in the region reached 150 million kilowatts on the same day, while the power capacity of the network was 170 million kilowatts. This event is essentially due to the

decline in the primary frequency modulation capacity of other power sources, resulting in a rapid decline in the system frequency, reaching 49.56Hz, which in turn has serious consequences for the operation of the power grid.

2.3 UHV Power Grid Security Improvement Demand

With the continuous development of new energy power in China, the national grid pattern and power supply structure are undergoing great changes, but at the same time, the original grid security and stability are in a continuous deterioration process. Therefore, to do a good job of grid security defense in the new form, it is necessary to have the ability to rapidly inhibit the impact of ultra-high power energy within hundreds of milliseconds, and its order of magnitude reaches millions to tens of millions of kilowatts. Therefore, in the current security guarantee construction process of UHV power grid construction, priority must be given to building a flexible, reliable and fast response power system, so as to have large-scale power regulation resources and capabilities. Large-scale energy storage is obviously an important way to solve the above problems, and electrochemical energy storage can complete the link from full charge to full discharge within hundreds of milliseconds. For example, the current lithium-ion battery energy storage system, its full charge to full discharge conversion time is not more than 1 second, the large-scale energy storage power station built by this can have millisecond level power regulation and response capabilities, and even can reach more than 50 times the performance of traditional lighter electric units. Relevant studies have shown that in the receiving end of the power grid system, a GW level of electrochemical energy storage power station can be configured, so that the power grid frequency safety control system can be built. Electrochemical energy storage can mainly be used in the original cutting pump function of the frequency safety control system, which can provide alternative or optimized solutions for frequency control measures such as precise load cutting, in which the cutting pump refers to the pumping and storage unit in the pumping state. Through the power grid frequency safety control system can not only reduce the impact of uneven power configuration, and then provide security for the system frequency; And it can realize the virtual inertia control of power source under the demand of GW electrochemical energy storage at the receiving end, and complete a frequency modulation control at the same time. In addition, in the process of frequency drop or frequency recovery, the response system still has a rapid response ability, and provides the corresponding frequency change rate and deviation, so as to achieve the effect of fast active power support. On this basis, the effect of effectively reducing and reducing the frequency drop amplitude of the system can be achieved, and the frequency recovery characteristics can be improved, and the stability protection at the frequency level can be provided for the overall operation of the system. In the cross-region AC-DC hybrid receiving power grid, it is more prone to the problem of power Angle transient stability, which requires the configuration of GW level electrochemical energy storage, which can further improve the effectiveness of the power grid security and stability control system, especially in the event of large DC lock-out events can respond immediately and discharge quickly, thus providing power support in emergency situations. And then the equivalent replacement of

load cutting security and stability control measures, showing the release of the transmission capacity of cross-region DC and AC liaison lines.

2.4 GW Level Energy Storage Power Station Construction Demand

In the process of construction of GW-level energy storage power station in China, its demand for large-scale energy storage of power system is relatively clear, which can be analyzed from the following three levels. First of all, for the construction of GW level energy storage power station, our country has rich experience in engineering construction and operation. According to the data at the end of June 2023, the cumulative installed capacity of electric energy storage projects that have been put into operation in China has reached 70.2GW, which mainly includes pumped storage, molten salt heat storage, new energy storage and other forms, an increase of 44%. Among the new forms of energy storage, the installed capacity of electrochemical energy storage is the largest, reaching 12.7GW, with a year-on-year growth of 67.7%. It is not difficult to find that China's GW level energy storage power station has been widely used in power system generation, transmission, power consumption and protection and other links, and has achieved good application results. China's continuous promotion of large-capacity energy storage to enhance new grid-connected friendly projects, large-capacity energy storage power station peak adjustment engineering, energy storage unit secondary frequency modulation engineering, all play an important role in the stable operation of our country's electric power system. For example, the national wind storage and transportation demonstration project, which not only realizes the energy storage configuration of 23 MW/89 MW ħ scale, but also can achieve the friendly characteristics of wind and solar complementary grid-connection. Jiangsu energy storage power Station has an energy storage scale of 101 MW/202 MW ħ, and has multiple functions such as peak regulation, frequency regulation, voltage regulation and emergency power support.

Secondly, the key to the wide application of electrochemical energy storage is also that China has a major breakthrough in the level of electrochemical energy storage technology, especially the rapid economic improvement, which can be widely used and achieve the effect of reducing costs. Specifically, the development of energy storage battery technology in recent years has significantly improved the safety, service life and energy density of batteries, while also reducing production and application costs. For example, lithium batteries, compared with five years ago, their energy density has nearly doubled, and the cycle life growth rate has more than doubled, the key is that the application cost has been significantly reduced by about 70%. It is precisely because China's electrochemical energy storage technology is at the world's advanced level, which provides an important premise for the construction of large-scale energy storage power stations.

In addition, China has a relatively perfect electrochemical energy storage grid-connected operation standard system. At present, China has built an electrochemical standard system covering basic general technology, planning and design requirements, equipment test specifications, construction acceptance specifications, grid-connected testing requirements, operation and maintenance programs and other six aspects, and based on this, a variety of national standards, industry standards and group standards have

been established. It has become a key guarantee for scientific norms and effective guidance of the development of the electrochemical energy storage industry and field.

3. Conclusion

In summary, in the process of rapid construction and rapid development of China's power system, the construction of large-scale energy storage power stations has become an inevitable trend. The construction of GW-level electrochemical energy storage power station can not only solve the new problems generated under the current background of new energy power development, but also provide the necessary security guarantee for the construction of the future grid pattern, ensure its long-term, stable and safe operation, and then promote the further development of the energy storage industry, and provide an important power base for the independent innovation and optimization of China's energy storage core technology. In addition, GW-level electrochemical energy storage power station is also the key achievement of China's adherence to the concept of green development, but also the implementation of the "four revolutions, one cooperation" national energy security development strategy of an important way, for China's power system construction, new energy development, energy storage technology update and popularization of the application has important practical significance and far-reaching historical significance.

References

Meng, G. J., Zhao, Y., Wu, T. et al. (2019). Research on Coordinated control strategy optimization of large-scale energy storage power Station participating in automatic power generation control of power system. *Journal of Renewable Energy*, *39*(02), 270-277.

Yang, R. R., Wang, S., Chen, J. J. et al. (2023). Design and research of large-scale Power side Energy Storage Access System. *Hydropower and New Energy*, *37*(06), 18-21.

Ye, J. P. (2023). Application Scenario of large-scale energy storage technology in new power system. *Application of Automation*, *64*(01), 43-45+49.

Zhang, L. X. (2016). Analysis on the application prospect of large-scale energy storage technology in electric power system. *Jiangxi Building Materials*, *2016*(15), 204+210.

Zheng, S., Lu, H., Li, W. B. et al. (2020). Research on the development of large-scale Energy Storage in Shandong Electric Power System. *Electrotechnical Engineering*, *2020*(24), 35-37+40.