Analysis on the Development Prospect of small and medium-sized pumped Storage Power stations in East China

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Abstract. Small and medium-sized pumped storage power stations have the advantages of short construction period, fast action, relatively low requirements for topography, relatively easy location, relatively low investment, easy layout in load center, flexible operation and fast start-up speed. They can cooperate with the operation of small hydropower, wind power and photovoltaic power to alleviate the grid connection problems caused by the randomness, intermittence and volatility of output. They can improve the landscape absorption capacity of East China Power Grid and promote the development of renewable energy. They can also better meet the needs of regional operation of the power grid, connect to the 110kV or 220kV power grid nearby, save 500kV line corridors and investment, improve the guarantee rate of power supply in local areas, reduce power outages, power limits and power generation can not be delivered and other problems. As an important tool to achieve energy conservation and emission reduction, they can promote the development of low-carbon economy and meet the requirements of energy storage technology and industrial development in China.

1. Introduction
From a global point of view, the first pumped storage power station in the world is the Netra pumped storage power station in Zurich, Switzerland, which was built in 1882, with an installed capacity of only 515kW. Among the pumped storage power stations built before the 1960s, except for the San Masenzza pumped storage power station in Italy (installed capacity 370MW, which was put into operation in 1952), all of them are pumped storage power stations with installed capacity smaller than 300MW. After 1960, the pumped storage power station developed rapidly with the success operation of the reversible unit of the combination of turbine and pump, the huge increment in the proportion of nuclear power in the power grid, the increase demand for peak regulation capacity in the grid. In 1960, the capacity of pumped storage power stations in the world was about 3500MW, and Western Europe accounted for the majority. In 1970, it rapidly increased to 16000MW. Due to the massive development of pumped storage energy in the United States, Japan and other countries, it increased rapidly to 46000MW in 1980. According to incomplete statistics, by 2019, more than 40 countries and regions in the world have built pumped storage power stations, of which small and medium-sized pumped storage power stations account for more than 17%.
From a domestic point of view, the research and development of pumped storage power stations in China began in the 1960s. In 1968, a reversible unit with installed capacity of 11MW was installed in Gangnan Hydropower Station in Hebei. By the end of 2019, the total installed capacity of pumped storage power stations in China is 30150 MW, of which small and medium-sized pumped storage power stations account for about 5%.

According to the energy development planning and energy conservation and emission reduction requirements of East China, there will be large-scale investment in new energy sources such as photovoltaic power and wind power in the future. The problems such as the lack of primary energy, the rapid development of new energy and the non-peak regulation of small hydropower pose a challenge to the safe and stable operation of East China Power Grid. In order to improve the quality and reliability of power supply, ensure the safe operation of power grid, optimize the power structure, and make effective use of new energy and water resources, it is very necessary to build pumped storage power stations.

2. Development characteristics of small and medium-sized pumped storage power stations

With the development of large-scale wind power, photovoltaic power, nuclear power, and long-distance and large-capacity power transmission, the construction of domestic pumped storage power plants will usher in new development opportunities. The domestic pumped storage power stations that been built or under construction, or planned to be constructed are mainly large-scale pumped storage power stations. Most of the installed capacity of a single station is more than 1000MW. Small and medium-sized pumped-storage power stations is Anhui Fo-zi-ling Power Station and so on. Large-scale pumped storage power plants play an obvious role in regional power grids and provincial and municipal power grids, mainly responsible for peak and valley filling, frequency modulation, phase modulation, accident backup and blackout of load center and play the role of security power supply, but can not take into account the small and medium cities with difficulties in the development of line corridors, and the edge of the power grid.

From the analysis of construction and operation practice, small and medium-sized pumped storage power stations have many advantages:

1. Short construction period and easy to identify suitable site locations.

The construction period of large pumped storage power stations is relatively long. It takes at least 10 to 15 years from planning to completion, while medium and small pumped storage power stations only take about 4 to 5 years. Due to the constraints of topography and geological conditions, ecological red lines, etc., it is becoming more and more difficult to identify suitable site locations to built pumped storage power stations. Compared with large-scale pumped storage power stations, small and medium-sized pumped storage power stations are relatively easy to locate. Due to the relatively small scale, low requirements for regulating storage capacity, relatively simple hydraulic structures, and easier identification of suitable site locations are required. There are many mountains in East China, and the unique natural and geographical conditions create favorable conditions for the construction of small and medium-sized pumped storage.

2. Provide power support for the power grid in East China.

Most of the power supplies in East China are unstable power sources such as small and medium-sized conventional hydropower and photovoltaic power and wind power with poor regulation performance. The power grid lacks supporting power sources. With the rapid development of wind power, photovoltaic power, long-distance and large-capacity power transmission, various types of pumped storage power stations in the area will also usher in new development opportunities; the construction of a certain scale of small and medium-sized pumped storage power stations in East China will not only improve the development of small and medium hydropower, photovoltaic power and wind power in East China, the utilization of stable power can also make it play an effective regulation role in the power grid, achieve complementary advantages and rational layout effects with large pumped storage power stations, and can independently coordinate various distributed power sources in East
China to solve distributed poor power supply quality and low reliability of energy and provide effective power support for the grid.

(3) Adapt to the requirements of the hierarchical and zoned operation of the power grid.

The load of all cities in East China has increased rapidly. If small and medium-sized pumped storage power stations with voltage levels of 220kV and below can be built into the power system, it can meet the Peak capacity requirements of the East China Power Grid, and it can also adapt to the hierarchical and zoned operation needs of 500kV, 220kV, and 110kV lines in the grid and access to the power system facilitate needs, save line corridors and investment, and reduce the burden of the grid. Flexibility is the essence of small and medium-sized pumped storage power stations. Many small pumped storage power stations have been built in countries such as China, Switzerland, and Italy, which have given full play to their flexible and changeable characteristics in the power grid and have good operating results.

(4) Relatively low investment and fast action.

Small and medium-sized pumped storage power stations have relatively simple hydraulic structures, small engineering volume, mature unit manufacturing technology, and relatively low investment. They can be put into use in a timely manner and give full play to their benefits. Compared with other power station, the effect is relatively fast. It is also a new idea to transform existing upstream and downstream cascade hydropower stations into pumped storage power stations in East China. Only new water inlet/outlet, water delivery system, factory buildings and other buildings are needed to reduce construction impact, flooding and resettlement. Construction changes the ecological and social environment, while saving investments in dam construction, reservoir inundation compensation, operation and maintenance management, and shortening construction period, which has certain advantages.

(5) Improve the guarantee rate of power supply in local areas.

East China lacks primary energy, photovoltaic power and wind power are developing rapidly, peaking power is relatively lacking, and there is a greater demand for safe and stable operation of the power grid. The construction of small and medium-sized pumped storage power stations can be used as the core to form an adjustable regional power supply network with surrounding small hydropower, wind power, photovoltaic power, etc., to improve the power supply quality in the area, and reduce power outages, power restrictions.

3. The development bottleneck of small and medium-sized pumped storage power stations

At present, the biggest problem of small and medium-sized pumped-storage power stations is the electricity price mechanism, which directly affects the benefit of power stations.

The implementation of the electricity price mechanism of domestic pumped storage power stations are as follows:

(1) The pumped storage power stations with approved electricity prices before 2004, such as single electricity price, two-part electricity prices, etc., still maintain the original electricity price model;

(2) The pumped storage power stations approved before 2004 but not priced the electricity price of the storage power station are approved by the National Development and Reform Commission;

(3) The pumped storage power stations newly put into production or not yet been approved are mainly based on the spirit of the development price [2014] No. 1763.

After the separation of power stations and grids in China, the pumped storage power stations currently in operation are all operated as an "independent legal person" with the establishment of a pumped storage power station company. However, a relatively mature electricity price mechanism has not yet been formed. At present, there are mainly three kinds of price mechanism: lease system electricity price, two-part electricity price and single power electricity price.

Small and medium-sized pumped storage power stations often adopt the single electricity price. If the power generation cannot be guaranteed, the benefits of the power station will be difficult to guarantee. The relatively low level of electricity price policy will restrict the future development of small and medium-sized pumped storage power stations. In addition, pumped-storage power stations that use a single electricity price calculation method can only guarantee economic benefits by striving for multiple
power generation methods. The operating time of the power plant units far exceeds the normal design value, operation and maintenance costs are greatly increased, and the power station enters a vicious circle and unhealthy track. It is extremely detrimental to their healthy and sustainable development.

To sum up, there is an urgent need for the country to further improve the electricity price mechanism of pumped storage to ensure the sustainable development of pumped storage power stations.

4. Conclusion

Rely on the previous solid work foundation and the planning and implementation of relevant renewable energy demonstration zones, The East China can encourage the implementation of new models of small and medium-sized pumped storage power stations where the conditions are available, and encourage the simultaneous planning and development of pumped storage power stations, wind power, photovoltaic power generation projects, study the feasibility and operating mechanism of the joint operation of them. The research can alleviate the pressure of power grid and increase the balance of power on-site Capacity and level of local consumption of renewable energy.

Small and medium-sized pumped-storage power stations can play an effective regulating role in the power grid, which are convenient to complement the advantages of large-scale pumped-storage power stations. If the country can establish a reasonable electricity price formation mechanism and fully mobilize the enthusiasm of local governments and enterprises to invest in the construction of pumped-storage power stations, small and medium-sized pumped-storage power stations in East China will have good development prospects.

References

[1] National Development and Reform Commission, National Energy Administration. The 13th Five-Year Plan for Electric Power Development (2016-2020) [EB/OL]. (2016-11-07) [2019-05-01].
[2] Zhang Ning, Zhou Tianrui, Duan Changgang, et al. Impact of large-scale wind farm integration on power system peak shaving [J]. Power System Technology, 2010, 34(1): 152-158.
[3] Wang Yaohua, Li Nan, Yuan Bo, et al. Discussion on "Reasonable Energy Abandonment" in Power System Planning with Large Proportion of New Energy [J]. China Electric Power, 2017, 50(11): 8-14.
[4] Shu Yinbiao, Zhang Zhigang, Guo Jianbo, et al. Analysis of key factors in new energy consumption and research on solutions [J]. Proceedings of the Chinese Society of Electrical Engineering, 2017, 37(1): 1-8.
[5] Lv Quan, Wang Wei, Han Shui, et al. Evaluation method of power grid curtailment based on peak regulation capability analysis [J]. Power System Technology, 2013, 37(7): 1887-1894.
[6] Li Hai, Zhang Ning, Kang Chongqing, et al. Contribution analysis method of factors affecting the consumption of renewable energy [J]. Proceedings of the Chinese Society of Electrical Engineering, 2019, 39(4): 1009-1018.