Functional localization analysis on pumped storage station under the new situation of energy transformation

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Abstract. The functional localization of pumped storage station is analysed in this paper on the basis of summarize of the new situation and industrial advantages. It is a special power supply with the characteristics of peak shaving, valley filling, frequency modulation, phase modulation, emergency reserve and black start and so on. With the continuous acceleration of energy structural adjustments in China, the new energy power supply development rapidly, the demand for pumped storage station is increasingly urgent and its future growth is very broad.

1. Introduction
The development of pumped storage power stations has a history of more than 100 years since the birth of the world’s first pumped storage power station in Switzerland in 1882. Especially since the 1960s, the pumped storage power stations of the world have developed rapidly. The pumped storage industry of China started in 1968, After more than 50 years of development, the current capacity in operation is 31.79 GW, accounting for 1.5% of the installed power capacity, and the scale under construction is 46.05 GW.

As a large, fast, flexible adjustment of power supply, the pumped storage station bears through energy storage, peak shaving, valley filling and cooperate with new energy power generation and grid integrated management tools, but in china, the function of pumped storage station is mainly concentrated in the aspects of the peak shaving, valley filling, frequency modulation, phase modulation, emergency reserve and black start.

The grid size, power structure, supply and demand structure and load structure have changed in recent years, the prominent structural contradictions in power grid, large scale integration of new energy into power grid, the rapid development of ultra-high voltage remote transmission, the System security, stability, economic operation of power grid is facing huge challenges.

2. New situation of pumped storage station
On the whole, the new situation of pumped storage station are as follows:

(1) With the development of large-scale pumped storage stations, from the resource endowment of the remaining pumped storage stations, the resource development conditions of the remaining pumped storage stations are relatively poor, and the sensitive factors are relatively large.

(2) In order to promote local economic development, relevant parties will take more and more expectation of development of region on pumped storage station development, and the difficulty of
resettlement of immigrants is continuously improved, which makes the cost of pumped storage station development rising constantly.

(3) In recent years, the other energy storage facilities have developed rapidly, especially the electrochemical energy storage capacity expansion is very fast, and the construction costs is falling fast, which gradually formed a strong competition for the future development of pumped storage station. However, from factors such as total cost, safety, storage capacity and service life, it is to be further observed for impact on the pumped storage industry.

3. Industrial advantages of pumped storage station
In the future, with the continuous expansion of new energy, the dismissal problems will be more prominent in China. The more and more new energy have deeply changed the power structure, the vulnerability and complexity of the power system are also increasing, bringing new challenges. According to power development plan, the nuclear power construction is also constantly increasing. The coastal areas of East China have the conditions to build large-scale nuclear power station, in the principle of safe development, nuclear power station has also maintained a healthy development trend. From safe and economic consideration, nuclear power station should work smoothly, and the smooth operation of the nuclear power units also needs flexibly power supply. In recent years, the ultra-high voltage remote transmission development rapidly. At present, the maximum power transmission capacity of ultra-high voltage is 8-12 GW. The unipolar lock may cause a significant increase in the frequency of regional grids, and must take corresponding security measures, and the malfunction may have great power impact on the delivery, which is easy to trigger feed grid frequency stability problem.

The pumped storage station has the characteristics of flexible operation, fast start, tracking load capacity and so on. Combined with new energy, the pumped storage station can significantly improve new energy resource utilization, effectively relieve the abandonment of new energy; combined with nuclear power station, the pumped storage station can guarantee the stable operation of nuclear power units and improve the operational benefits, safety, and economics; combined with ultra-high voltage, the pumped storage station can enhance the power system to respond to the accident, safeguard the safe and reliable operation of the power system as a support of the power supply.

Table 1. Comparison of pumped storage station and other energy storage modes

| Energy storage method         | Power level          | Life (year) | Cycles          | Construction cost (yuan/kW) | environmental impact                        |
|------------------------------|----------------------|-------------|-----------------|-----------------------------|---------------------------------------------|
| Mechanical energy storage    | pumped storage station | 0.5-36GW   | 30-60           | Unlimited in the equipment usage | 4000-13000 | construction destroys ecology, landscapes Natural gas combustion emission pollutant Burning fossil raw material |
| Compressed air               | 0.05-15GW            | 40          | Unlimited in the equipment usage | 2700-5400                      |
| Flywheel                     | 0-0.20GW             | 20+         | 20000           | 1600-2200                    |
| Electromagnetic energy storage | Superconducting Capacitor | 0-100kW   | >20            | 100000                      | 1300-2000 Strong magnetic field Pollutant |
| Super capacitor              | 0-100kW              | 0-5         | 50000           | 1300-2500                    | 600-1500 Pollutant                          |
| Sodium sulfur battery        | 0-0.03GW             | 10-15       | 3000-45000      | 6000-15000                   | high temperature, Pollutant Pollutant       |
| Liquid flow battery          | 0-1GW                | 5-15        | 8000-15000      | 3500-10000                   |                                             |

Although the initial investment funds of pumped storage station is huge relatively, the operation and maintenance of the equipment is simple, and the operation and maintenance cost is low. In recent years, the production cost of new pumped storage station from 4500 to 5500 yuan / kW. According to same charge and discharge time as pumped storage station, the latest energy storage power station cost data
is 11000 to 13000 yuan / kW, It is 2 to 3 times that of pumped storage station, among them, the battery cost is about 60%, and other hardware and software construction costs account for 40%. Electrochemical energy storage is favourable due to its fast reaction speed and the short construction cycle, but the equipment capacity is relatively small and the operating period is short, and there is a certain safety risk, so it is still unable to promote in a short period.

4. Pumped storage station provides support for future energy structures transformation

From the global perspective, it is a common path to development renewable energy to effectively respond to climate change. According to 2020 renewable energy installed statistics, in 2019, the global renewable energy industry added 1.76 billion kW, accounting for 72% of the global new electricity installed, and solar and wind energy accounted for 90% of new renewable energy. At the same time, the global renewable energy proportional to 34.3% from 34.7% of 2018.

According to the balance analysis of energy supply and demand, in order to meet the total control goal of national energy consumption, it is expected that the installed capacity of nuclear power, wind power and solar power station in China will reach 160 GW, 500 GW and 550 GW in 2030; The installed capacity of nuclear power and wind power and solar power station will reach 340 GW, 12 GW and 1.4 GW respectively in 2050.

With the continuous improvement of power grid safety, economic operation requirements and new energy increase rapidly in the electricity market, Pumped storage station can be overturned to optimize energy, power layout and power system security, economic operation, the necessity for development and construction is increasingly day by day.

In order to meet the distributed development of renewable energy and promote the development of renewable energy, the emphasis on pumping energy storage projects is increasing. With the continuous construction of high-voltage transmission, power loss is expected to decrease, the dominant position of pumped storage station in energy storage is still stable. The pumped storage station is the most important way for power side energy storage, and its future growth is very broad.

5. Conclusion

The pumped storage station unit is flexible, and the reaction is fast, and can achieved double capacity for peak shaving and valley filling, and can converse variety working conditions. It is a special power supply with the characteristics of peak shaving, valley filling, frequency modulation, phase modulation, emergency reserve and black start and so on. With the continuous acceleration of energy structural adjustments in China, the new energy power supply development rapidly, the demand for pumped storage station is increasingly urgent. With the advantages of mature technological, economical, large regulating capacity, long service life and so on, the pumped storage station is a high-quality regulating power supply in the system. It is the most important way for power side energy storage, and its future growth is very broad.

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