APPLICATION OF THERMAL ENERGY STORAGE TECHNOLOGY IN POWER GRID TOPOLOGY

by

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In order to solve the problem of grid topology optimization, the author proposes the application of renewable energy and energy storage technology in the grid topology. The author first defines the grid graph data model, then designs a grid topology analysis framework, and finally realizes several grid topology analysis applications on this basis. The experimental results show that graph database can better support the concurrent analysis of large-scale users, and the average time required for analysis is significantly less and the advantages are greater. When the number of users reached 200, it took 0.07 seconds for graph database and 0.13 seconds for relational database. In conclusion, the power grid topology analysis method based on renewable energy and energy storage technology can greatly improve the performance and meet the needs of practical scheduling.

Key words: *power grid topology, data model, renewable energy sources, energy storage technology*

Introduction

Because of the large distribution of wind power generation and photovoltaic power supply, the power scheme will affect the synchronous stability of the grid. In the past, people believed that the process from generating electricity to using electricity was developed in a short period of time. Therefore, if the power plant is a power plant, the storage equipment will be connected to the system as a *switching station* to convert the energy [1]. In recent years, with the increasing pressure from energy consumption and environmental governance, human society's demand for energy systems is constantly renewed. Controlling electricity costs, replacing aging infrastructure, improving the flexibility and reliability of the power system, reducing carbon dioxide emissions and mitigating climate change, and increasing power requirements, such as reliable power support for remote areas, mean that the transformation of the energy mix has become key to the energy revolution.

Therefore, wind, solar and other renewable energy will gradually replace fossil energy, and continue to increase their proportion in energy consumption. Large-scale deployment, however, with time scales of intermittent renewable energy sources, not only useful for accurate forecasting and delivery of electric power, but also will appear during the exchange of energy and electric power running security problems and the energy quality, which makes the traditional distribution network of centralized balance mechanism unable to accept this renewable energy resource [2, 3]. Energy is an essential resource for human survival and plays an import-

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ant role in social development. Its importance is obvious. Since renovated and opened, China's economy has developed rapidly and its dependence on energy has increased, resulting in the following conditions in China's consumption electricity:

- China's annual electricity consumption has been steadily increasing, and the total electricity consumption in 2017 increased by 2.9 compared with the previous year.
- Energy standards are still declining, and coal is still the highest energy standard.
- Power distribution is uneven. The north is mainly coal, the south has many water resources, and the west is rich in oil resources.
- Low energy consumption. China is only ranked 74th in the world in terms of energy efficiency. The cost of electricity of traditional thermal power generation is about 12 times less than that of developed countries such as Europe.
- The use of electricity is not related to the environment, and excessive use of electricity will cause *greenhouse effect*, acid rain, fires and other phenomena, causing environment.

Faced with the defects and problems of the aforementioned traditional energy sources, renewable energy has been widely used in power generation, such as hydrogen energy*, etc.* Renewable energy is rich in resources and high energy consumption, which is environment-friendly energy. Distributed renewable energy technology for power generation is increasingly used in power systems. The distribution of electricity can solve the problem of uneven distribution of electricity, and use different forms of electricity according to local conditions to achieve efficient use of electricity. However, due to the uncertainty and uncertainty of its output, distributed generation in the form of renewable energy has a significant impact on energy consumption and energy consumption. The power quality and the network loss have a great impact on its application and development. To solve the problem of the large number of people and different types of electricity distribution network, micro grid has been introduced in the electric power, which makes the traditional grid to be converted to a smart grid.

The structure and function of the electric grid have become more and more complex. The terminal energy transport shows a new pattern of rapid growth, with good flexibility and diversification [4], fig. 1.

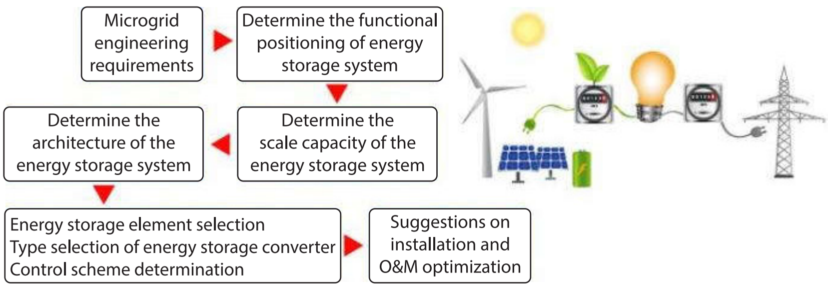

Figure 1. Renewable energy and energy storage technologies

Literature review

Network topology information connects power supply, transmission, transmission, and distribution networks, power consumers, and critical businesses such as power transmission, generation, and management. Network topology documentation describes the characteristics of the network, such as the network topology model created by the physical network relationships, client relationships, and network assets. Accurate and simultaneous large amounts of electronic data, data analysis data, and smart metering. Based on this, the data was created his. This informationpology is the basis of business, and good analysis of this information can promote the integration of marketing and distribution.

In order to use electricity, we consider the main characteristics of energy conservation is the energy level and its working time, and the working time of energy storage is different from the main characteristics of the prepare electricity. The main cost and special features of the system and energy storage technology. The negative energy storage energy will replace the old model of the existing energy supply, promote the balance, and play an important role in the production of electricity [5]. However, with the development of good management of operation, maintenance, operation and deployment of power grids, the topological analysis of power grids is increasing:

– Due to the rapid increase in the consumption of electricity, the electric power users will make a geometrical increase in the power grid, as well as the topological data of the power grid.
– The distribution of work and business is connected and improved control continues to the end of the power network, business visits are more frequent, the growth of users, the main heart of the power network topology analysis.
– The use of power grid scheduling and the request to present real-time power grid information continue to improve the need for timely updating of power grid topology information and improve the performance of power grid topology.

The use of new technologies to analyze and study power grid data has become a pressing issue for power grid operations and asset management topology [6].

Methods

Characteristics of energy storage technology

Energy storage technology mainly refers to the storage of electrical energy. The energy storage can be used as an emergency power source, and can also be used for energy storage when the grid load is low. The power generated when the grid load is high can be used to reduce peaks and valleys and reduce the grid. Energy can be used in many forms, including electricity, chemical, collision energy, electrical energy, electrical energy, heat and cold, latent heat and energy. Energy storage has a complex transformation store forms of energy into simpler or economic forms. Currently, the majority of energy storage is only the production of energy, whether natural or absorbed. Some technologies provide short-term energy storage, while others can be used for longer periods of time.

Currently, the largest large-scale energy storage type is pumped storage, which requires the construction of upstream and downstream water. The pump equipment is in the working state of the motor when the load is low, pumping the water from the bottom water to the water supply to the water supply to the storage, and the equipment can be in the working state of the generator during peak hours, using the water stored in the upstream for the production of electricity. Its conversion power is about 70-75. However, because of the need to focus on site selection, long construction time, slow management and other factors, the support size and technology pumped down are just some. Currently, the total installed capacity of the world's pumped storage power plants is 90 million kilowatts, accounting for approximately three of the world's installed power generation capacity. Compressed air energy storage is another energy storage method that can realize large commercial applications [7-9].

Optimization control of power grid network topology

The main objective of grid topology optimization control is to maximize the available transmission capacity of the grid under various operation scenarios, each of which contains multiple continuous-time sections, the time interval of the section is 5 minutes, the optimization problem needs to consider the daily load variation, day-ahead generation schedule and real-time generation schedule adjustment, qualified range of bus voltage, maintenance plan, *etc.* The control decision includes the topology adjustment of the power network, that is, the splitting and closing of the bus, the opening and closing of the line and the arrangement and combination of the two. In the control process, it is not considered to increase the available transmission capacity of the system by changing the generator output and cutting load.

Considering the actual system running conditions and dispatcher operating habits, the following hard constraints must be met in all operating scenarios:

- Electricity demand must be met at any time, that is, real-time balance between generation and load.
- The number of power plants tripping shall not exceed 1.
- The change of topology structure cannot form islands in the power grid.
- The system (AC) power flow should always converge.

If the previous four constraints are not met at any time, the scenario ends immediately, that is, the task *fail*s. At the same time, the real-time optimization control problem contains a *soft* constraint, that is, a certain *cooling time* is required for the physical equipment in the process of line opening and closing and bus splitting operation, it is considered as 15 minutes, during which the equipment cannot operate continuously for more than two times. If the *soft* constraints are not met, there are consequences other than immediate *task failure*. The aforementioned hard and soft constraints make the problem to be solved more practical and conform to the actual application scenario, the quantitative indicators to evaluate the control strategy of power grid topology optimization:

$$c_s = \sum_{i=1}^{N} \max\left\{0, 1-\left(\frac{P_i}{P_i^{\text{lim}}}\right)^2\right\} \tag{1}$$

$$c_\text{c} = \begin{cases} 0, & \text{task failure} \\ \sum_{j=1}^{n_\text{c}} c_x^j, & \text{other} \end{cases} \tag{2}$$

$$c_\text{t} = \sum_{k=1}^{\pi_\text{c}} c_x^k \tag{3}$$

where c_s, c_c, and c_t are the single sectional score, single scene score and total score, respectivel, N, n_s, and n_c – the number of transmission-lines, sections and scenarios of the power grid, respectively, P_i and P_i^{lim} – the power flow value and line limit value of line i, respectively, and j and k – the section number and scene number of a scene, respectively [10].

Analysis of power grid topology

The topology search topic of the power grid topology data is the basis of many power grid business application analysis. Its main function is to control the width and depth of the research image by setting certain conditions, in order to obtain the topology image of the relevant equipment. The relevant procedures are:

- Determine the light or sub light where the target is, start focus, search depth, direction, stop event, *etc*.

- Use the initial center tool to make the vertex of the image wide according to the direction (not shown or pointed) and the depth in the search mode.
- If the analysis reaches the depth related to the search, stop the analysis.
- If the analysis is based on the site, do not analyze the branch.
- Return to the keyboard after stopping the analysis.

Analysis of power outage range

Power metering is a business in the power grid. Its main role is to simulate power, avoid accidents, and provide support for the power grid industry [11]. Its main features are:

- Determining the pictures and drawings to be sure, including the original grid material.
- The initial device is used for general topology search, the depth is 1, and the search device is stored in line.
- The grid material in the column should be identified with different width according to the situation.
- When the diffusion focus reaches the switch cabinet, it is considered as the closed state of the switch cabinet. If the generator is closed, continue to check the branch and if the generator is connected, stop checking the branch.
- When the diffusion focus reaches the energy point (the energy with more energy than the first energy can still be classified as the power point), the focus diffusion is complete.
- Return all electrical equipment in the branch without electrical equipment (including pressure gauge).

Experimental analysis

In order to verify the power grid topology analysis model based on the author's configuration data, we have done some tests based on the power grid topology data of the State Power Corporation of China. The topological information of the index has reached 1 billion vertical lines and two billion non-points, the image sequence used is the Tiger Image. At the same time, it is compared with the original topology data stored as the relative Oracle 11g data on the same device [12].

Results and discussion

Table 1 shows the lack of search terms at the top of the search engine, it can be seen that the search time is longer as the number of searches increases. At the same time, when the number of rays reaches ten thousand levels, the average search time of a vertex increases continuously.

On the same device, the comparison of conditional topology search time between graph database and relational database is shown in fig. 2, it can be seen that with the increase of search vertices, the graph database search time is significantly reduced, showing great advantages.

Figure 3 shows the average analysis time comparison between graph database and relational database for multi-user concurrent analysis of power outage range and device connectivity. It can be seen that the average time needed for the measurement of power and the connection between the instruments of the light meter is short. When the number of users reaches 200, the time was 0.07 seconds for graph database and 0.13 seconds for relational database [13, 14].

Due to the limited concurrency degree supported by the experimental relational database for topology analysis, the author only carried out large-scale user concurrency analysis experiment on the graph database, the comparison of large-scale user concurrency analysis

Table 1. Grid topology search data

The layer number	Number of vertices	Vertex order of magnitude	Search time [second]	Average search time per vertex [10^{-5} second]
2	302	The magnitude	0.012	3.974
3	3244	Thousand	0.016	0.493
4	27801	Wan	0.053	0.191
5	201343	One hundred thousand	0.214	0.106
6	1266186	One million	1.555	0.123
7	6440572	One million	11.600	0.180
8	22440486	Ten million	48.100	0.214
9	43438353	Ten million	91.500	0.211
10	49943166	Ten million	127.700	0.256
11	50884290	Ten million	139.100	0.273
12	55013445	Ten million	142.500	0.259

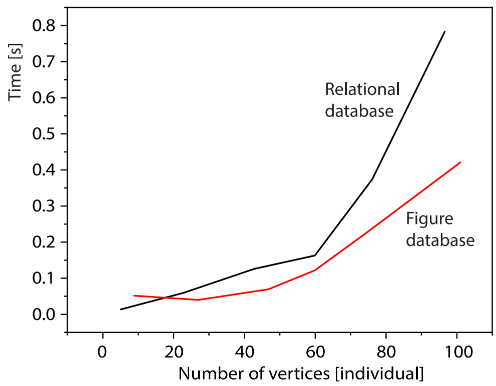

Figure 2. Comparison of topology search with conditions

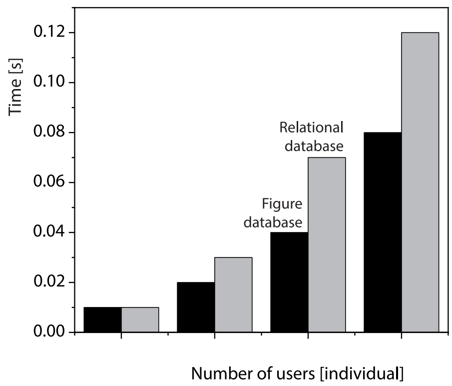

Figure 3. Comparison of device connectivity analysis

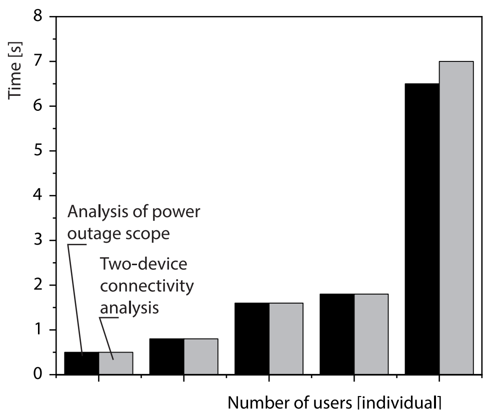

Figure 4. Comparison of large-scale user concurrency analysis

is shown in fig. 4. It can be seen that the graph database supports the concurrent analysis of large-scale users well. However, when the user size reaches 2000 and 3000, respectively, the corresponding average analysis time increases significantly [15].

Conclusions

With the emergence of many environmental problems, such as smog, renewable energy has gradually attracted the attention of all parties. Among them, energy storage technology is the most important in the renewable energy system. It affects all the connections between *electricity production, transmission, distribution and use* of renewable energy, which cannot only reduce the electricity demand in peak time, but also increase current energy consumption and equipment cost. At the same time, it can also ensure the stability and stability of the power grid, thereby improving energy efficiency and saving energy, so as to achieve stability and stability Freeze of business transactions. Currently, the energy storage technology is diverse and different, but they also have defects, such as charging less than the chemical battery, which will also damage the environment. However, pumped energy storage and compressed air and other types of energy storage need to be converted to make them less efficient, information about energy storage should use more construction costs. Therefore, through the current development process, energy storage can be developed effectively, which is good for renewable energy stations and sustainable energy, we need to use the technology of connecting various energy storage devices, and co-ordinate management and planning with each other. This is also a place that needs to be studied in depth.

With the advancement of smart grid development, grid technology is increasing rapidly, and related businesses, distribution, distribution and other business management are gradually connected and make it better. How to store and manage high speed information on the grid topology, and promote business, distribution, distribution and other services have become the main direction of the smart grid.

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