Research on large-scale intermittent new energy grid connected control technology based on power demand

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Abstract. In recent years, with the increasing Power demand, new energy power has been continuously developed. As the main types of new energy power generation, wind power and photovoltaic power generation have strong randomness and correlation under the influence of natural conditions. The safe and efficient utilization of large-scale new energy power is the core content and basic goal of smart grid construction, while intermittent new energy is developing rapidly, there are also many problems. New energy resources and load centers show obvious reverse distribution characteristics. The fundamental reason that hinders the large-scale absorption of intermittent power in power grid lies in its randomness and volatility. It is necessary to study advanced prediction technology and control technology and make dynamic changes according to certain laws. The structure design of the new energy system of the large power grid can ensure that the power of wind, solar and other new energy can be connected to the grid to the maximum extent, the mathematical parameters and control strategies are correct and reliable, and the energy storage system can realize the dynamic tracking interaction with the power of the large power grid.

1. Introduction
With the global climate change, the deterioration of ecological environment and the consumption of fossil energy, the use of world energy is undergoing significant and profound changes [1]. The limited delivery of large-scale new energy is a long-standing problem. In the planning and construction of new energy base, it is mainly considered from the wind, light resources, local infrastructure conditions and land use conditions. The change of the output power of the new energy station will affect the power and voltage distribution of the system, bring difficulties to the reactive power balance and voltage adjustment, and then affect the safe and stable operation of the system [2]. Therefore, reactive power optimization can improve the safety of system operation. According to the characteristics of intermittent energy, the key to the economic scheduling problem with large-scale intermittent energy is to reasonably introduce wind power, photovoltaic power and its corresponding factors into the original scheduling mode [3]. Systematic, accurate and scientific identification of smart grid vulnerability sources caused by large-scale renewable energy, and evaluation of its vulnerability by smart grid vulnerability index can ensure the safe and stable operation of smart grid under the new situation and promote the sustained and healthy development of China's power industry [4]. Favorable conditions have made wind power generation and photovoltaic power generation the most promising alternative to conventional fossil energy power generation. Electricity consumption mainly includes resistive loads such as lighting and resistive loads
such as motors. Energy storage interaction refers to energy exchange with large power grids according to certain rules by physical, chemical, electromagnetic and other energy storage methods. When the main converter station is fully loaded or out of operation, the remaining unbalanced power is borne by the converter station adopting adaptive droop control, and the unbalanced power in the system is reasonably distributed according to the power margin of the converter station [5].

As an efficient, clean and flexible power generation technology, new energy generation has become one of the key technologies in smart grid. The installed capacity of large-scale energy grid connected power supply is large, mainly for "outward power transmission". In case that the power generation conditions are not satisfied at night or without wind, it is also necessary to obtain power from the grid to meet the operation of the power station itself [6]. The start-up and shutdown of new energy power supply is related to many factors such as natural conditions, user demand, policies and regulations, power market, etc. With the rapid development of intermittent new energy, there are also many problems: new energy resources and load centers show obvious reverse distribution characteristics [7]. The scheduling and operation of new energy power supply are often controlled by the property owner of power supply, while the property owner of new energy power supply is not the power grid company [8]. Scholars in the power industry have introduced the concept of capacity reliability, which means the ratio of the capacity of conventional units replaced by intermittent power supply to the installed capacity of intermittent power supply under the condition that the reliability level of the power system is consistent before and after the intermittent power supply is connected to the grid [9]. The advantage of master-slave control is that converter stations controlled by constant DC voltage can balance the power variation in the system and maintain the DC voltage near the rated value, which is especially suitable for application in DC distribution networks with frequent power variation. It has a wide range of engineering applications on the power generation side of new energy sources and the load side of power grids. Therefore, this paper studies the large-scale intermittent new energy grid-connected control technology based on power demand [10].

2. Energy and electricity system basic features

2.1. The stability of power grid is affected
Electric power system is an electric energy production and consumption system composed of power generation, transmission, distribution and utilization. Its function is to convert primary energy in nature into electric energy through power generation power plant. When large-scale new energy sources are centralized and connected to the grid, power transmission imbalance of each line will inevitably occur, which may lead to a certain line in the system reaching the transmission power limit. Wind farms in the same area are affected by the same meteorological conditions under the same wind source, and their output is not independent of each other, which has a certain correlation. The main characteristics of new energy system are that new energy power is directly incorporated into the grid, fluctuating power and load are balanced by wide area of energy storage device, and key nodes are centralized power compensation. In view of the problem of reactive power and voltage control in new energy cluster, the bus of Collection Substation in wind farm cluster is used as the voltage center point to control the output of reactive power regulating devices in each wind farm in order to reduce the network loss of the system and improve the qualified rate of voltage. Under the condition that the historical output sequence of each wind farm is known, the discrete probability distribution of each wind farm's output is calculated. Based on the nonlinear fitting method to process the statistical data, the output distribution function of each wind farm is obtained as the edge distribution of the function. To improve the old and aging situation of the power distribution network in the past and effectively improve the operation efficiency of the power grid.

2.2. Active power control of wind farm and photovoltaic power plant cluster
The inherent intermittence and fluctuation of wind power generation and solar power generation are the bottleneck of the development of new energy resources, and the surplus energy will be stored in the
valley of power utilization. There are differences in new energy development modes and different energy conversion processes. Even if an energy inversion system is implemented, there are still slight deviations in current and voltage parameters. Moreover, the current power prediction accuracy is not high, making it difficult for new energy sources to participate in power grid dispatching control like conventional power sources. In order to improve the generation efficiency of distributed generation, many units use maximum power tracking control instead of constant power control. When the external resource conditions change, its output power will inevitably change. The output voltage modulation ratio constraint, that is, the operation range boundary corresponding to the upper limit value of the point voltage does not change much. The steady-state operation range of converter station shows the characteristics of downward movement with the increase of tap position of coupling transformer. The unbalanced power in the system will cause the DC side voltage to change. The converter station with droop control automatically adjusts the active power output according to the changed DC voltage, so that the system power can reach the balance again.

Power transmission efficiency the average value of the transmission efficiency of the power grid in the process of transmitting power from the power generation node to the load node. Since the transmission power will be affected by the line impedance, the electrical distance between the two nodes is still the first choice representing the actual distance between the power generation node and the load node. When new energy is connected to the grid from different access points, the output of the same conventional unit will be different. Therefore, the optimal scheduling scheme of conventional units in the system will also affect the access capacity of new energy sources. Under certain power supply system conditions, periodic current fluctuations of integer multiples of non-working frequency may occur in some power loads, which is to continue the concept of harmonic wave without losing its generality. When the system is running at the power point under consideration, if the above constraint conditions can be satisfied at the same time, the power point is the power point satisfying the conditions, and the opposite number of the power corresponding to all the power points satisfying the conditions. When modeling photovoltaic power plants, the time-period characteristics of their output should be considered. When the output of photovoltaic power station is processed in different periods, the corresponding period load model is needed when it is applied to the reliability evaluation of photovoltaic power generation capacity, so it is necessary to analyze the period characteristics of daily load curve. The control strategy can effectively use the wind energy resources to generate the maximum power, and keep the wind turbine rotor from stalling, so as to optimize the utilization of wind energy. When the unbalanced power is within the regulation range of the main converter station, the main converter station shall adjust it separately. When the main converter station is fully loaded or out of operation, the redundant unbalanced power shall be adjusted by the converter station with droop control.

In order to meet the real-time supply and demand balance of the power system, we must rely on the complementary characteristics of various energy sources and require the complementary power sources to have fast response speed. The multi-objective optimization module obtains the optimal solution set by differential evolution algorithm: the optimal solution set is transferred to the multi-attribute decision-making module, the weight of each objective is determined by information entropy method, the relative closeness between each alternative scheme and the ideal solution is sorted by method, the regulation capability of large-capacity high-load energy load connected to the power grid is utilized, the high-load energy load participates in coordinated control, and the regulation characteristics of new energy sources, conventional power sources, power grids and high-load energy loads are studied. In the process of making the dispatching plan, the predicted value $i=1$ of wind power and photovoltaic is usually regarded as negative load, and the net load predicted value of the system can be obtained after subtracting the predicted value from the predicted value of the load:

$$P_{ij} = x'_{ij} / \sum_{i=1}^{n} x'_{ij}$$  (1)
On the other hand, the combination coefficient satisfying the principle of maximum entropy can be obtained only when the requirement of maximum entropy is met. On this basis, the uncertainty of the combination coefficient vector can be reduced to the greatest extent:

\begin{equation}
    e_j = -k \sum_{i=1}^{m} (p_{ij} \ln p_{ij}) \tag{2}
\end{equation}

However, as the prediction error of wind power and photovoltaic is not independent, it is necessary to consider the correlation of \( J = 1 \) between the prediction error of wind power and photovoltaic, then the formula becomes:

\begin{equation}
    w_j = g_j / \sum_{j=1}^{n} g_j \tag{3}
\end{equation}

3. Coordinated control of large-scale new energy grid connected operation

3.1. Capacity reliability under different PV generation permeability

The power control system of new energy station is the execution unit of large-scale new energy coordinated control. Its control performance directly affects whether the large-scale new energy coordinated control can achieve the expected goal. In the case of centralized power supply of high-power energy, it will cause a great impact on the transmission network, and the power fluctuation will suddenly increase, which may lead to the increase of voltage fluctuation of the grid, thus losing stability. The permeability level of photovoltaic power generation is an important factor affecting its credible capacity. The capacity benefit of photovoltaic power generation should be considered in the planning of power system including photovoltaic power station in combination with its access level. The capacity reliability under different penetration rates of photovoltaic power generation is shown in Table 1 and Figure 1. The negative sequence component in the unbalanced system is too large, which may lead to the protection of negative sequence current and misoperation of automatic devices, threatening the safe operation of the power grid. The sum of the output power of the conventional power supply with constant output power and the fluctuating wind energy and solar energy power supply is larger than the load power at the same time, and then the power difference is applied to the converter of the energy storage system through the control system. However, in order to ensure the reliability, the loss of load risk of the system should be reduced. At this time, only the loss of load risk caused by excessive prediction error should be considered.

![Figure 1. Capacity reliability under different PV generation permeability](image-url)
Table 1. Capacity reliability under different PV generation permeability

| Numble | Time amplitude | Capacity credit |
|--------|----------------|-----------------|
| Permeability 15% | 456 | 456 |
| Permeability 20% | 789 | 213 |
| 3 | 213 | 654 |

3.2. High-load Energy Load Participating in Coordinated Control

After the large-capacity energy is connected to the grid, it will have a definite impact on the stable operation of the grid, especially when a grid-connected fault occurs, the change of the power limit value of the synchronous unit will have an impact on the recovery of the power angle value of the synchronous unit. The steady-state operation range of converter station refers to the operation range of the opposite number of power on the complex power plane, so when increasing, the operation range boundary constrained by the equivalent new energy cluster outlet voltage amplitude will move upward. Different from the conclusion that the credible capacity of wind power increases with the increase of permeability, this paper will point out that the credible capacity of photovoltaic power station will not change with the increase of installed capacity of power station after reaching a certain constraint boundary. The increase of new energy grid-connected capacity has little impact on the total power demand in China, and the total power demand will maintain a stable growth trend. Dynamic interactive active power with intermittent new energy systems can realize the balanced scheduling of active power for 24 hours, thus solving the power fluctuation imbalance problem of new energy sources and loads such as wind energy and solar energy. Reduce the impact of new energy grid-connected on the system's volatility, and carry out technical verification demonstration platforms for the complementary use of multiple energy sources through grid dispatch. It can play a role in smoothing fluctuations such as peak regulation, frequency regulation and voltage regulation during the generation and transmission of new energy. In order to realize that when one converter station is fully loaded, the other converter stations are also fully loaded at the same time, making full use of the active power capacity of the converter station, and limiting the DC voltage to the allowable range. As a supplement to the power control system of the new energy station, it cooperates with the power control system of the new energy station to form a comprehensive control system of the new energy station, thereby improving the control performance of the new energy station.

In order to meet the requirements of the new Energy and electricity mode, electrical equipment should have the ability to acquire, analyze and process accurate and reliable grid data information (such as frequency, voltage, etc.) in real time and to respond to changes in grid operating conditions in a timely and correct manner. The interactive power of the power grid needs to apply appropriate control strategies to the converter to ensure that the energy storage system can dynamically follow the system power shortage and realize dynamic compensation with the system power through the regulation and control of the converter. The lower limit of the voltage is easy to meet, and the point voltage may exceed its upper limit as the voltage amplitude of the balance node of the AC system increases. With the increase of soft direct AC voltage reference value, the reactive power flowing through the point corresponding to the point voltage upper limit value gradually increases. Analyzing from the measurement means, the current transformer with wider frequency band can be used as the measurement equipment, or the proportion of fundamental wave and harmonic wave can be measured through power prediction, and when the harmonic value exceeds a certain threshold value, the electric energy can be suppressed without affecting the overall electric energy quality. Payload capacity is an indicator that measures the contribution of traditional power sources to power system capacity. It can also be used to measure intermittent power sources such as wind and photovoltaic power generation.

4. Conclusion

In this paper, the large-scale intermittent new energy grid-connected control technology for power demand is studied. The large-scale grid-connection of intermittent power generation in the world will have a significant impact on the safe and economic operation of the power grid. With the rapid
development of new energy resources, the power grid's absorptive capacity for new energy resources must be improved more rapidly. The grid-connected control technology of new energy resources urgently needs to study more deeply the changes of output power after the large-scale new energy clusters are connected to the grid, which will affect the power and voltage distribution of the system and bring difficulties to reactive power balance and voltage adjustment. In the process of energy power dispatching, if the new energy power generation contained in the power system has a low correlation, the impact of its correlation can be ignored. If it has a high correlation, the impact on the power system dispatching plan should be fully considered to improve the security of the system dispatching. The power management department can accurately find out the weak links of the power system by measuring the impact of renewable energy grid connection on the vulnerability of the power system, so as to take targeted prevention and control measures to reduce the level of system risk and vulnerability. The influence of DC voltage error between several converter stations on power regulation can be reduced by adding DC voltage limit regulation. Promote the cost reduction of conventional power and new energy power generation generally, this means that technological progress is an important guarantee for large-scale grid connected power generation of new energy.

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