Research on Power Demand Response of A Certain Area Power Grid for New Energy Consumption

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Abstract—With the rapid growth of new energy installation scale, new energy consumption is facing more and more pressure and challenge. Based on the characteristics of a certain provincial power grid, this paper starts from the point of view of promoting clean energy consumption, guiding electric heating load and other adjustable loads to optimize electricity consumption, relieving peak-shaving pressure of power grid, and strengthening the emergency regulation ability of the certain power grid, the power demand response of provincial power grid is designed and realized. This mode and methods have universal application value for provincial power grid with high proportion of new energy installation.

1. Introduction
In recent years, the scale of new energy installation in a certain provincial power grid has increased rapidly, which is restricted by the grid structure and load, and the phenomenon of abandoning wind and light in local time period has an extremely adverse effect on the energy saving of the power grid[1-2]. In order to deal with this unfavorable situation, it has the point of view of source network load linkage, combined with the characteristics of the provincial power grid, follows the objective law of market economy and electric power operation, uses market mechanism and economic lever to guide users to improve the fine management level of electricity consumption, promotes the flexible mechanism of demand-side and supply-side participation in power balance, and constructs a provincial power demand response mode suitable for new energy consumption[3-6].

2. Characteristics and work objectives of a provincial power grid for power demand response
The demand for electricity in the certain power grid has maintained a rapid growth, the peak and valley difference of power consumption has increased year by year, and the peak-shaving pressure of power grid has been increasing. The main features are as follows: first, the power balance is tight when the
load peak, and the power gap may occur in the local period. Second, the proportion of wind power generation installed is on the high side, the situation of new energy consumption is grim in the low period, and thermal power is approaching the minimum safe operation limit, which affects the safety of power grid. Third, the seasonal difference is remarkable, the air conditioning load increases year by year in summer, and the heating power in winter leads to the load gap in southern area grid, which lacks effective control means. Fourth, the user-side electric heating, energy storage and other adjustable load resources increase obviously, which provides the basic conditions for the implementation of the source network load storage interactive peak-shaving[7-8].

The power demand response targets of a provincial power grid are:
1. Establish and improve the demand response system. The system includes market mode, response rules, technical structure, data management, etc., to realize the interconnection and interaction between electricity and power grid, to promote the optimal allocation of power resources, to promote the scientific load management and the individuation of power service.
2. Cut peak load. The demand response capacity of peak-time average load is about 5%. When the backup capacity of power network is insufficient, local overload or peak-valley difference is too large, the peak-shifting filling and valley filling can be realized by guiding users to carry out demand response, reducing peak-valley difference, improving power grid load rate and operation efficiency, and improving power grid safety level.
3. Promote renewable energy consumption. To establish an incentive mechanism for renewable energy consumption, encourage users to take the initiative to increase the load for the purpose of filling the valley, improve the flexibility of the power system at lower cost and more environmentally friendly, adapt to the volatility of renewable energy, and fully guarantee the normal absorption of renewable energy.
4. Alleviate the contradiction between supply and demand of local power grid. Taking demand response as an important means of orderly power management, priority is given to alleviating the contradiction between supply and demand by carrying out demand response, ensuring the normal development of production and management activities of enterprises as far as possible, and maintaining the stability of power supply order.
5. Guide users to optimize the load. The construction of enterprise electric energy management system is carried out to realize on-line monitoring of power lines and equipment participating in the response. Combined with monitoring data and energy efficiency analysis, the power load optimization of users is carried out to improve the level of power management.

3. The Main Basis and Working Principle of Power Demand Response in a Provincial Power Grid
The demand response of a provincial power grid is based on the principle of "safety and reliability, fairness and equality, openness and transparency ", follows the objective law of market economy and electric power operation, uses market mechanism and economic lever, vigorously promotes the market main body to participate in the response. According to the three dimensions of "economic agreement demand response first, emergency real-time demand response second, orderly power management guarantee bottom ", based on serving new energy generation enterprises and users such as electric heating, widely mobilize all kinds of subjects to participate in power demand response, promote peak cutting and valley filling, promote renewable energy consumption, promote users to optimize electricity consumption, and realize the friendly interaction between power storage and power demand response in the power grid[9].

The provincial power grid power demand response principles are:
1. Government-led multi-party participation. Give full play to the leading role and administrative policy guidance of the government in the implementation of demand response, organize users to actively participate in the work of demand response, and form a win-win model with extensive participation.
2. Safety-oriented, market operation. Under the premise of meeting the requirements of safety production, ensure the safety of power grid operation, user safety production. In the way of
marketization, users are guided to participate in the system adjustment, the price is encouraged to participate in the demand response, the necessary administrative means are used to protect the bottom, the load balance and the peak filling are realized.

3. Voluntary participation, energy saving and efficient. Based on the actual needs of the power grid and the actual situation of user composition, the safe operation level of power supply in the power grid is improved by cutting the peak and filling the valley by the users, giving play to the role of resource allocation and improving the efficiency of energy utilization.

4. Research on Power Demand Response Mode of a Provincial Power Grid

According to its characteristics, the power demand response of a provincial power grid can be divided into emergency real-time demand response, economical agreed demand response and new energy demand response.

According to the operation needs of the power grid, the power demand response can be divided into peak cutting demand response and valley filling demand response. Among them, peak cutting demand response refers to the need for users to reduce the power load within a specified period of time, and valley filling demand response refers to the need for users to increase the power load within a specified period of time.

According to the way and response time of guiding user response, power demand response can be divided into economical agreed demand response and emergency real-time demand response. Among them, the agreed demand response refers to the demand response that is invited before the response date, and the real-time demand response refers to the demand response that receives the relevant platform instruction and begins to execute within 5 minutes.

In order to make effective use of the area power grid's new energy power generation during the trough period, a provincial power grid has regularly responded to the demand for new energy issuance at the trough, guiding power users to adjust production plans (including electric vehicle charging green electricity trading, etc.) and increasing the load of electricity in the valley. Improve the area power grid new energy absorption capacity[10].

4.1. Emergency real-time demand response

After confirming the organization's implementation of real-time demand response, a provincial power grid demand response center directly completes the real-time response solicitation, response capability confirmation and response execution process with the power user (load integrator) power management system (production management system, automation system, control system) through its business support platform.

When the power supply and demand of the power grid are seriously unbalanced due to the sudden situation, the provincial (municipal) power (power supply) company issues the real-time demand response control index information to the demand response center.

After receiving the information of the control index, the demand response center automatically determines the response range and generates the real-time demand response instruction through the platform system, and sends it through the network to the control terminal with automatic response ability or the power management system of the client (production management system, automation system, control system).

The user (load integrator) who participates in the demand response shall implement the demand response in the agreed period and control the load according to the agreement.

For the agreed demand response, the provincial (municipal) electric power (power supply) company may, according to the actual operation of the power grid, propose to suspend the demand response execution, and the demand response center shall coordinate the user (load integrator) to cancel the execution.

Its flow chart is shown in Fig1.
4.2. Economical Contract Demand Response and New Energy Additional Demand Response

Economical agreed demand response is a few hours before the response day or response period. Power users (load integrators) will receive a response invitation from the power grid demand response center through business support platform, mobile phone APP, etc., informing the response time period and response requirements. After determining the participating response, the power user (load integrator) can negotiate and determine the planned response quantity, and adjust the power load to complete the response process in the response period. The power grid demand response Center can carry out multiple rounds of response solicitation according to the actual situation.

According to the forecast of the blocking capacity of new energy generation on the next day, the demand response of new energy issuance on the next day is put forward by the power grid electric power trading center or electric power dispatching control center. According to this capacity, the power grid demand response center sends out daily response invitation through business support platform, mobile phone APP and so on, informing the response time period and response requirement. After determining the participating response, the power user (load integrator) determines the planned response, and adjusts the power load to complete the response process during the response period.

A provincial power grid agreed demand response and new energy demand response implementation workflow detailed in figure 2.
4.3. Implementation of Economic Contract Demand Response and New Energy Additional Demand Response

1. New energy demand response 2 days ahead of schedule: the power supply company released the new energy demand response capacity through the demand response center before 17:00 two days before the response date. After receiving the capacity information, the demand response center determines the scope of the response solicitation to issue the response solicitation to the contracted user or the load aggregator.

2. Response day before the release of solicitation: power supply companies in response day before 17:00, through the demand response center to release local demand response control index information. After receiving the index information, the demand response center determines the scope of the response solicitation and issues the response solicitation to the contracted user or the load aggregator through the power demand side management online monitoring platform, mobile phone APP, etc.

3. The first 4 hours of the response period to issue an invitation (including 4 hours): for the solicitation time less than 4 hours from the execution of the agreed demand response, if the solicitation user in the first half of the implementation of the feedback whether to participate, it is deemed to give up participation. Other processes with solicitation time of more than 4 hours may be agreed demand response.

4. Response execution: determine that the user (load integrator) participating in the demand response shall implement the demand response in the agreed period and control the load according to the agreement. According to the actual situation of power grid operation, the agreed demand response power company may propose to suspend the demand response execution, and the demand response center shall coordinate the user (load integrator) to cancel the execution after reporting to the government department for confirmation.

5. Application of Administrative Measures in Implementing Demand Response

When the safety of power grid operation is obviously affected, or when the market-oriented means cannot solve the practical difficulties such as power grid peak shaving and new energy consumption, the following administrative means can be considered to guide the implementation of the power grid demand response.
For example, during the low load operation of electric power network during the Spring Festival and other holidays, if the peak-shaving difficulties caused by new energy and heating load fluctuation cannot be solved by market means, the government may guide the enterprises equipped with self-provided power plants to reduce self-generation, and use electricity from the power grid according to the prescribed requirements from the point of view of ensuring the safe operation of the power grid.

6. Conclusion
Demand response refers to the user responding to the price or incentive signal, changing the normal power consumption mode and ensuring the balance of power supply and demand, so as to realize the optimization of electricity consumption and the comprehensive optimal allocation of system resources. By means of market model, price mechanism and compensation mechanism, demand response promotes end users to participate in market operation and price decision. Combined with the characteristics of a provincial power grid, this paper puts forward the demand response of new energy issuance, combines the economic agreed demand and the emergency real-time demand response, and constructs a provincial power grid power demand response system. The system is suitable for provincial power grid with large scale of new energy installation.

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